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# O'KEEFE STREET SPS OPERATORS AND MAINTENANCE MANUAL 

Client:<br>Ipswich Water<br>Project:<br>O'Keefe Str SPS Switchboard Replacement

## Document No: 0007985-DF-001

Revision:
A

DOCUMENT CONTROL

| Rev | Date | Prepared | Checked | Approved | Initials <br> (Hardcopy) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| A | $09 / 07 / 2010$ | Johann Joubert | Jasenko Sabljic |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
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|  |  |  |  |  |  |

DOCUMENT REVISION

| Rev | Author | Date | Comments |
| :---: | :---: | :---: | :--- |
| A | Johann Joubert | $09 / 07 / 2010$ | Initial document creation for Ipswich Water |
|  |  |  |  |
|  |  |  |  |
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DEFINITIONS

| Term | Description |
| :--- | :--- |
| IW | Ipswich Water - owner/operator of system |
| iPS | i.Power Solutions - Principal Contractor |
| BW | Brisbane Water - Provider of the Standard Citect Include |
| BPS | Booster Pump Station |
| CMF | Central Monitoring Facility |
| GUI | Graphical User Interface |
| HMI | Human Machine Interface |
| I/O | Input/Output |
| IDC | Internet Display Client |
| RMF | Remote Monitoring Facility |
| RTU | Remote Terminal Unit |
| SCADA | Supervisory Control And Data Acquisition |
| WTP | Water Treatment Plant |
| WWTP | Waste Water Treatment Plant |
| VSD | Variable speed drive |
| SS | Soft Starter |

## 1 PROJECT SCOPE

### 1.1 Introduction

The Citect Operators Manual outlines the procedures for operating and interfacing with the Citect system and Switchboard at O'Keefe St SPS.

All required details for managing the day to day operations of the system are included herein such that an operator is able to use the system with minimal input from external sources.

### 1.2 Project Objectives

This Project consists of O'Keefe St SPS being controlled and monitored by a Kingfisher RTU/Citect SCADA system.

## 2 SYSTEM

### 2.1 System Topology

Ipswich Water has an existing SCADA system in place. The controls and monitoring equipment for the site shall be incorporated into the existing SCADA system. The Pump control and level monitoring of O'Keefe St SPS is carried out by the Telemetry SCADA system and a Kingfisher RTU is utilised to control the pumps and well level.

## 3 CITECT OPERATOR MANUAL

### 3.1 Introduction

This Operator Manual should be used to change the pump run set points, high level, low level, and overflow set points, flow set points, outflow pressure set points, to write and read notes associated with the site, to access the site I/O Configuration as well as to monitor the trends. The purpose of this manual is to outline the procedures required to perform the tasks mentioned above.

### 3.2 Start-up

On Start-up, Open the Navigation Menu in Citect, Sewerage Pump Stations, Bundamba 2 and select SP22 O'Keefe St as shown in the Figure 1 below.


Figure 1 - Citect Navigation to O'Keefe St SPS
This will navigate the system to the site page as shown in Figure 2 below.


Figure 2 - O'Keefe St SPS Page

### 3.3 Overview Standard Functionality RTU\#1

The site page is device oriented, where only most vital information is displayed. The intention is for the operator to click on the device for which additional information or control is required, this in turn will open up a popup page providing the additional functionality required. Table 1 below shows the characteristics of each of the devices that are shown on the sites main page:

Table 1 - O'Keefe St SPS Extended Functionality Information

| Item | Action | Description |
| :---: | :---: | :---: |
| RTU Symbol |  | 1. RTU number |
|  |  | 2. Time of last poll for this station |
|  |  | 3. Graphical display of Polling of the station Status |
|  |  | 4. Alarm clock if any alarms for this station |
|  |  | 5. If any personnel are on site. |
|  | Left Mouse Click | - Left Click will select RTU Pop Up |
|  | Left Mouse Click | - Click of "Force Poll" button initiates a force poll of the station RTU |
| Well |  | - Text Box Green when Normal, Red when in Alarm and also displays current status |
|  |  | - Displays Current well Level \% from Duty LIT |
|  |  | - Graphically displays current SP's for Pump Start and Stop Levels - i.e. Coloured Lines with vertical position relative to SP |
|  |  | - Alarm Clock visible if there are any current alarms for this station |
|  |  | - Well level displayed graphically |
|  | Left Mouse Click | - Left Click will select Well Pop Up |
| Pumps | Left Mouse Click |  |
|  | Current Status of Pump |  |
|  |  | - Either Manual, Normal, Running, Fault or FTS ( Fail to Start ) |
|  |  | - Large red icon ( Screw driver and Shifter ) across pump if the pump is " Inhibited" |
|  |  | - "White Hand" if in SCADA Manual control mode |
|  |  | - Red if pump is running |
|  |  | - Green if pump is normal |
|  |  | - Yellow if Pump Faulted |


|  |  | - Grey if Pump in LOCAL ( SITE ) select switch is either in Manual or the OFF Position (i.e. NOT in Auto ) |
| :---: | :---: | :---: |
|  | AMP Display | - Motor Amps |
|  | Speed Display | - Motor Speed as Hz |
|  | Mouse Click on Pump | - Will display relevant Pump Pop Up |
| Duty Control | Mouse Click | - Will display Duty Control pop up |
| Generator | Mouse Click | - Left Click will select Generator Pop Up |
|  |  | - Red if generator is running and on site ( Generator battery charger OK) |
|  |  | - Green if generator is ready and on site ( Generator battery charger OK) |
|  |  | - Yellow if generator faulted and on site ( Generator battery charger OK) |
|  |  | - Grey if generator is not on site (or disconnected i.e Tamper ) |
| Station Inhibit |  | - Station Inhibit, only visible if logged in with sufficient security level |
|  |  | - Selects either Normal Control or Inhibit Control by using push button |
| Force Poll | Mouse Click | Causes Master RTU to Poll the station RTU - All events and values are updated |
| Probe Test |  | Note:- Multitrode MRT Backup system installed with a single High level probe is installed in the well |
|  |  | - Displays current operating method for the probe test - either Auto or Manual |
|  |  | - Allows for manual control of the probe test |

### 3.4 RTU Popup Page

When the operator clicks on the RTU genie as shown in Figure 3 the device popup is displayed.


Figure 3 - RTU Genie

### 3.4.1RTU Operator Tab

The RTU popup shows initially the operator tab as shown in Figure 4 below. The description of each of the items is shown in Table 2 below.


Figure 4 - RTU Operator Tab

Table 2 - RTU Operator Tab Details

| Item | Table 2-RTU Operator Tab Details |
| :--- | :--- |
| Supply Voltage to <br> RTU | D.C. Voltage to RTU ( Range = 0 to 32 V ) |
| Batt Charging Current | Battery current - Negative if Discharging, Positive if <br> Charging ( Range $=$ Neg. 1 amp to Pos. 1Amp ) |
| Supply Current to <br> RTU | Current Draw of RTU ( Range =0 to 2 Amp ) |
| RTU Temperature | RTU Temperature ( Range =-20 to 80 Deg. C ) |
| Successful Messages | Number of successful messages today |
|  | Number of successful messages yesterday |


| Failed Messages | Number of Failed messages today |
| :--- | :--- |
|  | Number of Failed messages yesterday |
| Failed Packets | Number of Failed Packets today |
|  | Number of Failed Packets yesterday |
| \% Success Rate | \% Success Rate today |
|  | \% Success Rate yesterday |

### 3.4.2RTU Alarms Tab

If the Operator clicks on the Alarms Tab on the page the alarm information is displayed as shown in Figure 5. Description of the state of each alarm is shown in Table 3 below.


Figure 5 - RTU Alarms Tab

Table 3 - RTU Alarms Tab Details

| Item | Description |
| :--- | :--- |
| Communication | Healthy or Alarm |
| I/O Scan Enable | Healthy or Alarm |
| Ladder Logic Enable | Healthy or Alarm |
| Module Hardware | Healthy or Alarm |
| Battery Low | Healthy or Alarm |
| Loss of Supply | Healthy or Alarm |
| Yellow Triangle Push button | Displays Alarms if clicked |

### 3.4.3RTU Engineer Tab

Once the operator clicks on the Engineer Tab the following Figure 6 is displayed. The Table 4 below shows the description of each of the items.


Figure 6 - RTU Engineer Tab

Table 4 - RTU Engineer Tab Details

| Item | Description |
| :--- | :--- |
| Polling <br> Period ( <br> Seconds) | Cyclic time period that the master RTU regularly Polls this station. |
| Polling Offset <br> ( Seconds) | Time period, after the master RTU has been reset, that the <br> Master RTU waits before a regular cyclic poll is carried out to this <br> station |
| Poll Timer | The current value of the timer that runs in the master, which is <br> incremented up to the Polling Period on which the site polls. Once <br> it reaches the Polling Period it is reset to 0 to count again. |
| All Polling | Controls Force, Cyclic, Field Polling for this site. If disabled no <br> polling will be able to proceed. |
| Cyclic Polling | Enable or disable cyclic polling by the Master RTU |
| Set RTU <br> Time | When activated will Synchronise RTU Time with Citect server <br> time |

### 3.5 Well Popup Page

When the operator clicks on the Well genie as shown in Figure 7 the device popup is displayed.


Figure 7 - Well Genie

### 3.5.1Well Operator Tab

The Well popup shows initially the operator tab as shown in Figure 8 below. The description of each of the items is shown in the Table 5 below.


Figure 8 - Well Operator Tab

Table 5 - Well Operator Tab Details

| Item | Description |
| :---: | :---: |
| Level 1 <br> (Hydrostatic) | Displays Well Level \% for Hydrostatic LIT |
| Level 2 (Ultrasonic ) | Displays Well Level \% for Ultrasonic LIT |
| Duty Level | Displays which Level Sensor currently has control i.e Hydrostatic or Ultrasonic |
| Graph Button | Display Well Trend if clicked |
| Stop Watch Button | Displays Well Alarms if clicked |
| Auto | RTU determines which LIT is duty i.e. if Hydrostatic fails then Ultrasonic takes over as the duty LIT |
| Manual | If selected, either the Ultrasonic Lit or Hydrostatic LIT can be selected to be the Duty LIT |
| Duty Start | Well Level \% that Pump will Start - SP can be changed by selecting adjacent Pushbutton |
| Duty Stop | Well Level \% that Pump will Stop - SP can be changed by selecting adjacent Pushbutton |
| Duty Max <br> Speed Lvl | Well Level \% that Pump will Ramp up to $100 \%$ Speed i.e 50 Hz SP can be changed by selecting adjacent Pushbutton |
| Duty Min Speed | Minimum Speed that pump will run at, in Hertz - SP can be changed by selecting adjacent Pushbutton |
| Sby 1 Start | Well Level \% that Pump will Start - SP can be changed by selecting adjacent Pushbutton |
| Sby 1 Stop | Well Level \% that Pump will Stop - SP can be changed by selecting adjacent Pushbutton |
| Sby 1 Max <br> Speed Lvl | Well Level \% that Pump will Ramp up to $100 \%$ Speed i.e 50Hz SP can be changed by selecting adjacent Pushbutton |
| Sby 1 Min Speed | Minimum Speed that pump will run at, in Hertz - SP can be changed by selecting adjacent Pushbutton |
| Sby 2 Start | Well Level \% that Pump will Start - SP can be changed by selecting adjacent Pushbutton |
| Sby 2 Stop | Well Level \% that Pump will Stop - SP can be changed by selecting adjacent Pushbutton |
| Sby 2 Max <br> Speed Lvl | Well Level \% that Pump will Ramp up to $100 \%$ Speed i.e 50Hz SP can be changed by selecting adjacent Pushbutton |
| Sby 2 Min <br> Speed | Minimum Speed that pump will run at, in Hertz - SP can be changed by selecting adjacent Pushbutton |

### 3.5.2Well Alarms Tab

When the operator selects the Alarms tab the following Figure 9 is displayed on the popup. The Table 6 below shows the details of each of the items on the page.


Figure 9 - Well Alarms Tab

Table 6 - Well Alarms Tab Details

| Item | Description |  |
| :--- | :--- | :--- |
| Multitrode |  | High Probe Alarm - Digital input from Multitrode Probe - Starts <br> the pump |
|  | High Probe Level |  |
| Duty Level <br> Sensor <br> derived |  |  |
|  | High High Level | Duty Level - Derived High High Level Alarm |
|  | High High Level Sp | Duty Level - High High Level SP ( in \% of Well Level ) |
|  | High Level | Duty Level - Derived High Level Alarm |
|  | Low Level | Duty Level - High Level SP ( in \% of Well Level ) |
|  | Low Level SP | Duty Level - Low Level SP ( in \% of Well Level ) |
| Hydrostatic | Tx Fault | No Change alarm | | No Change in Level Alarm - LIT 1 ( Alarms if not enough |
| :--- |
| change in well level in given time period ) |

### 3.5.3Well Engineer Tab

When the operator selects the Engineer tab the following Figure 10 is displayed on the popup. The Table 7 shows the detailed information of each item.


Figure 10 - Well Engineer Tab

Table 7 - Well Engineer Tab Details

| Item | Description |
| :--- | :--- |
|  | Please NOTE : -The raw level is averaged over time. A level <br> event is transmitted when the averaged data is outside the <br> deviation SP. |
| Lev 1 Event Dev <br> SP | Amount of change in Well level \% to cause data to be <br> transmitted to SCADA - LIT 1 |
| Lev 1 Filter Time <br> SP | Number of seconds that level data is to be averaged over - LIT 1 |
| Level 2 Event Dev <br> SP | Amount of change in Well level \% to cause data to be <br> transmitted to SCADA - LIT 2 |
| Lev 2 Filter Time <br> SP | Number of seconds that level data is to be averaged over - LIT 2 |
| Inhibit Start set <br> point | Well level \% that duty pump will Start, When station is in Inhibit <br> Mode |
| inhibit Stop Set <br> point | Well level \% that duty pump will Stop, When station is in Inhibit <br> Mode |
| inhibit Min Run <br> Time | Minimum pump time when station is in Inhibit Mode |
| Inhibit max Speed | Well level \% that duty pump will be at Max speed, When station <br> is in Inhibit Mode |

### 3.6 Pump Popup Page

When the operator clicks on the Pump genie of the pump as shown in Figure 11 the device popup is displayed.


Figure 11 - Pump Genie

### 3.6.1Pump Operator Tab

The Well popup shows initially the operator tab as shown in Figure 12 below. The description of each of the items is shown in the Table 8 below.


Figure 12 - Pump Operator Tab

Table 8 - Pump Operator Tab Details

| Item | Description |  |
| :---: | :---: | :---: |
| Status | Auto | Pump in Auto |
|  | Manual | Pump in Manual or Off |
|  | Healthy | Pump is Faulted or Healthy |
|  | Stopped | Pump Running or Stopped |
|  | Not Available | Status of Pump availability |
|  | Power Healthy |  |
|  | Comms Healthy | Status of comms at site between RTU and VSD |
| Starts | Self Explanatory |  |
| Runtime Hours |  |  |
|  | Today | Number of Hrs pump has run for today |
|  | Yesterday | Number of Hrs pump has run yesterday |
|  | This Week | Number of Hrs pump has this week |
|  | Last Week | Number of Hrs pump has run last week |
|  | Total since Reset | Number of Hrs pump has run for since total has been reset |
|  |  | Total is reset from the Engineers tab |
|  |  | Note:- Daily totals commence at midnight and weekly totals commence at Saturday Midnight |
| Current Control Mode |  | Either Inhibit Auto or Manual |
|  | Inhibit | Pump Inhibited |
|  | Auto | Pump in Auto and controlled by the RTU |
|  | Manual | Pump in Manual and controlled by the Operator via Citect |
|  | Manual Speed SP | when in SCADA manual Pump speed can be set as a \% |

### 3.6.2Pump Alarms Tab

When the operator selects the alarms tab the information from Figure 13 is displayed. The details of each item are shown in Table 9 below.


Figure 13 - Pump Alarms Tab

Table 9 - Pump Alarms Tab Details

| Item | Description |  |
| :---: | :---: | :---: |
| Status | Fault | Pump is Faulted or Healthy |
|  | Fail to start | Pump has been issued a start command but is not running |
|  | Fail to start SP | FTS Delay time in seconds - time to allow pump to start up before alarming |
|  | Excessive starts | Excessive Starts Alarm |
|  | Excessive Starts SP | Time period for number of starts in seconds i.e number of starts in xxx Seconds |
|  | Excessive Hrs | Excessive Run Time Alarm |
|  | Excessive Hours SP | Number of MINUTES pump can run for before Excessive Hrs Run Alarm is triggered |
|  | Amp Alarm Time SP | Time in SECONDS that motor can run at Low or High amps before Alarm is triggered |
|  | low amps Alarm | Motor Low Amps Alarm - May indicate a pump impeller shaft failure or similar |
|  | Low Amps SP | Low Amps SP in \% of motor Full load current |
|  | High Amps Alarm | Motor High Amps Alarm - May indicate a seized pump impeller or similar |
|  | High Amps SP | High Amps SP in Amps |
|  | Fault Reset | Resets faults to ALL Pumps |
| Totals |  |  |
|  | Today | Total of Faults since midnight |
|  | Yesterday | Total of Faults from midnight to midnight from the previous day |
|  | This week | Total of Faults from the previous Saturday midnight to now |
|  | Last week | Total of faults from the previous week |
|  |  | Note:- Daily totals commence at midnight and weekly totals commence at Saturday Midnight |
|  | Total Since Reset | Total of Faults since "Total" has been reset to zero. Total can be reset from the " Engineer" tab |

### 3.6.3Pump Engineer Tab

When the operator selects the Engineer tab the information from Figure 14 is displayed. The details of each item are shown in Table 10 below


Figure 14 - Pump Engineer Tab

Table 10 - Pump Engineer Tab Details

| Item | Description |
| :--- | :--- |
| Total Hrs Reset | Resets Total Number of recorded Hrs for this pump |
| Total Starts Reset | Resets Total Number of recorded Starts for this pump |
| Total Faults Reset | Resets Total Number of recorded Faults for this pump |
| Event Deviation <br> SP | \% change required to trigger an event from this pump. i.e \% <br> change in any of the monitored parameters associated with this <br> pump before data is transmitted by the RTU |

### 3.7 Generator Popup Page

When the operator clicks on the Generator genie as shown in Figure 15 the device popup is displayed.


Figure 15 - Generator Genie

### 3.7.1Generator Operator Tab

The Generator popup shows initially the operator tab as shown in Figure 16 below. The description of each of the items is shown in the Table 11 below.


Figure 16 - Generator Operator Tab

Table 11 - Generator Operator Tab Details

| Item | Description |  |
| :---: | :---: | :---: |
| Status | Fault | Generator Faulted and ON Site |
|  | Ready | Generator Ready, Not Faulted and ON Site |
|  | Running | Generator Running |
|  | Stopped | Generator Stopped |
|  | Tamper | Generator On Charger Fault or On Site and Disconnected |
| Starts |  |  |
|  | Today |  |
|  | Yesterday |  |
|  | This Month |  |
|  | Last Month |  |
|  | Total Since Reset |  |
| Runtime Hrs |  |  |
|  | Today |  |
|  | Yesterday |  |
|  | This Month |  |
|  | Last Month |  |
|  | Total Since Reset |  |
| Faults |  |  |
|  | Today |  |
|  | Yesterday |  |
|  | This Month |  |
|  | Last Month |  |
|  | Total Since Reset |  |

### 3.7.2Generator Alarms Tab

When the operator selects the alarms tab the information from Figure 17 is displayed. The details of each item are shown in Table 12 below.


Figure 17 - Generator Alarms Tab

Table 12 - Generator Alarms Tab Details

| Item | Description |
| :--- | :--- |
| Fault | Display status of Generator, either Faulted or Healthy |
| Excessive starts | Excessive Starts Alarm |
| Excessive Starts <br> SP | Set Point for time period ( seconds) for the excessive number of <br> starts alarm i.e number of starts in $x$ Seconds |
| Excessive Hrs | Excessive Run Time Alarm |
| Excessive Hours <br> SP | Set point for number of MINUTES Generator can run for before <br> Excessive Hrs Run Alarm |

### 3.7.3Generator Engineer Tab

When the operator selects the engineer tab the information from Figure 18 is displayed. The details of each item are shown in Table 13 below.


Figure 18 - Generator Engineer Tab

Table 13 - Generator Engineer Tab Details

| Item | Description |
| :--- | :--- |
| Total Hrs Reset | Button Click Resets Total Hours |
| Total Starts Reset | Button Click Resets Total number of starts |
| Total Faults Reset | Button Click Resets Total number of faults |

### 3.8 INHIBIT CONTROL GENIE

The operation of the Inhibit Control Genie as shown in Figure 19 is displayed in the Table 14 below. It should be noted that it is only visible when the operator has signed into Citect.


Figure 19 - Inhibit Control Genie

Table 14 - O'Keefe St Inhibit Control Genie Details

| Item | Table 14 - O'Keefe St Inhibit Control Genie Details <br> Description |
| :--- | :--- |
| Status Display | Displays Current Mode - Either Normal Control or Inhibit Control |
| Toggle Control | Left Mouse Click will toggle the current control mode between <br> Normal or Inhibit |
|  | Note:- When in Inhibit mode the duty pump will <br> 1. Start and stop at a higher than normal well levels, these SP's <br> can be altered from the Well pop up ( Engineers tab ) <br> 2. Will run for a minimum time period |

### 3.9 Power Meter Genie

When the operator clicks on the Power Meter genie as shown in Figure 20 the device popup is displayed. The kWh reading for the day is displayed on the face of the meter.


Figure 20 - Power Meter Genie

### 3.9.1Power Meter Operator Tab

The Power Meter popup shows initially the operator tab as shown in Figure 21 below. The description of each of the items is shown in the Table 15 below.


Figure 21 - Power Meter Operator Tab

Table 15 - Power Meter Operator Tab Details

| Item | Description |  |
| :---: | :---: | :---: |
|  | Phase A Amps | Phase A Amps |
|  | Phase B Amps | Phase B Amps |
|  | Phase C Amps | Phase C Amps |
|  | Phase A Volts | Phase A Volts |
|  | Phase B Volts | Phase B Volts |
|  | Phase C Volts | Phase C Volts |
|  | Phase A Pwr Factor | Phase A Pwr Factor |
|  | Phase B Pwr Factor | Phase B Pwr Factor |
|  | Phase C Pwr Factor | Phase C Pwr Factor |
| Kilowatt Hours |  |  |
|  | Today |  |
|  | Yesterday |  |
|  | This Week |  |
|  | Last Week |  |

### 3.10 Probe Test Genie

The Probe Test Genie as shown in Figure 22 is displayed because this site uses a Multitrode MTR-5 relay as the pump control backup system. The operation of the Probe Test Genie is displayed in the Table 16 below.

## Probe Test

## Auto Control

Frobe Test Mode

> Start Probe test

Probe Test Cancel

Figure 22 - Probe Test Genie

Table 16 - Probe Test Genie Details

| Item | Description |
| :--- | :--- |
| Automatic Mode | Every 6hrs a automatic probe test is performed by the stations <br> RTU. <br> i.e. Midnight, 6am Noon and 6pm. |
| Manual Mode | A Probe test can be initiated from Citect |
|  | During a "Probe Test" a electrical earth is connected to the <br> Multitrode probe to simulate a high well level. <br> Probe Test <br> Operation |
| If the RTU does not receive a high level signal within a few <br> seconds a " Probe Test Failed" alarm is raised in Citect. |  |

### 3.11 Site Information / Notes

To open the Site information Notes or to edit the information click on 'Notes' Button (Notebook Symbol) on the site window as shown in the Figure 23 below.


Figure 23 - Open Site Information/Notes window

This will open up a window as shown in Figure 24 below.


Figure 24 - Site Information / Notes Window

### 3.12 Trends

To show the trends associated with the Well the 'Trends' button needs to be pressed for the device in question. The site has been designed to show all associated devices with the well when the well trends button is pressed. This is represented in Figure 25 below, where the user would click on the trend button. The next Figure 26 below shows the values of the site graphed over time for the well levels and the pump runs that directly impact the level in the well. This way the operator can analyse the performance of the site more effecintly.


Figure 25 - Open Trend Window


Figure 26 - Well Trend Window

## 4 HMI OPERATOR'S MANUAL

### 4.1 Introduction

The Magelis HMI has a 5.7 inch $320 \times 240$ pixel colour TFT touch screen, and is used to display site data and locally configure RTU set-points. The HMI is to depict a similar display as on the SCADA. The HMI is used to monitor the SPS site, set pump run set points, set high high level, high level, low level setpoints, monitor pump status and statistics, as well as to monitor trends and alarms. The HMI operates by a light touch to select different options. The purpose of this section of the manual is to outline the procedures required to perform the tasks mentioned above.

When opening the panel door the HMI backlight should be off. By touching the top right corner of the screen, one of two pages may be visible, either the Station Overview page or the Login/Logout screen. These screens are described in detail below. Other options will also be described after that.

### 4.2 Station Overview page

The Station Overview page as shown below shows the current site status, namely:

- The status of the pumps
- Well Level
- Stop and Start, High and High High level indications.
- General Site Alarms

Navigation buttons will open pages which will give access to additional functionality and information. Figure 27 below shows the Station Overview and the description of the selectable pushbuttons is shown in the Table 17 below. (The word "Selecting" in the document would imply touching the symbol or push-button on the screen).


Table 17 - HMI: Station Overview page Extended Functionality Information

| Item | Action | Description |
| :--- | :--- | :--- |
| Well |  | - Displays Current well Level \% from Duty LIT <br> Levels - i.e. Colloured triangles in vertical positions relative to <br> SPs |
|  |  | Current Status <br> of Pump |
| Pump |  | - Status Script above each pump - either Manual, Normal, <br> Running or Fault |
|  |  | - Large red icon ( Screw driver and Shifter ) across pump if the |
| pump ishibited" |  |  |

### 4.3 Login/Logout

When opening the panel door and after activating the screen by touching top right-hand corner of the HMI screen, the Login page may be displayed. If the Station Overview is displayed, the Login page can be opened by selecting the Login/Logout push button. The Operator logs in as follows.

- Select the field opposite Login Code - enter 9999 using the touch keypad
- Select the field opposite User Code - enter 9999 using the touch keypad
- Select Enter.

Selecting Enter will open the Station Overview page as discussed in 4.2. Figure 28 below shows the Login page.


Figure 28 - HMI Login page

### 4.4 Pump Status Page

Selecting a pump from the Station Overview page opens the Pump Status Page as seen in Figure 29 below. Table 18shows the descriptions for each of the items.


| Item | Description | Table 18 - HMI: Pump Status Page Details |
| :--- | :--- | :--- |
| Status | Mode | Pump in Auto, Manual or Not Auto (Off position).. This <br> depends on the Auto/Manual switch on the front of the control <br> panel. |
|  | Running | Either Stopped or Running |
|  | Available | Status of Pump availability |
|  | Inhibited | Displays either Normal or Inhibited. When inhibited it is <br> prevented from running. |
|  | Fault | Displays either Normal or Failed. Failed is a fault from the <br> VSD |
|  | High Amps Start | Displays either Normal or Failed. Pump had been issued a <br> Start command but is not running. |
|  | Low Amps | Displays either Normal or Failed. Motor High Amps Alarm |
| Navigation Normal or Failed. Motor Low Amps Alarm <br> Pushbuttons | Selecting a P/B - <br> Statistics or <br> Control | Opens the required page (each one discussed separately) |

### 4.4.1Pump Statistics Page

Selecting Statistics from the Pump Status Page (above) opens the Pump Statistics page as seen in Figure 30 below. Table 19 shows the descriptions for each of the items.


Figure 30 - HMI: Pump Statistics Page

Table 19 - HMI: Pump Control details

| Item | Description |  |
| :---: | :---: | :---: |
| Statistics | Hours Run Today(Hrs) | Number of Hrs pump has run for today |
|  | Hours Run Yesterday (Hrs) | Number of Hrs pump has run yesterday |
|  | Hours Run Total(Hrs) | Total number of Hrs pump has run. |
|  | Starts Today | Number of times the pump has started today |
|  | Starts Yesterday | Number of times the pump has started yesterday |
|  | Starts Total | Total number of times the pump has started. |
|  | Excessive Starts/Hour | Displays 'Normal' or 'Alarm'. Alarmed when the number of pump starts in the last hour exceeds the Excessive Starts setpoint. |
|  | Excessive Hours/Day | Displays 'Normal' or 'Alarm'. Alarmed when the number of pump starts for the day exceeds the Daily Excessive Starts setpoint. |
|  | VSD Speed (Hz) | The VSD Speed displayed in Hz |
|  | Current (A) | The current drawn by the VSD displayed in Amps |
| $\checkmark$ |  | Return to Station Overview |
| Navigation Pushbuttons | Selecting a P/B - <br> Status or Control | Opens the required page (each one discussed separately) |

### 4.4.2Pump Control Page

Selecting Control opens from the Pump Statistics page (above) opens the Pump Control Page as seen in Figure 31 below. Table 20 below shows the descriptions for each of the items.


Figure 31 - HMI: Pump Control Page

Table 20 - HMI: Pump Control details

| Item | Description | If status = "Stopped", the Start P/B option is displayed. <br> If status = "Running", the Stop P/B option is displayed |
| :--- | :--- | :--- |
|  | Start | Reset P/B is available to reset if the pump has Faulted |
|  | Inhibit | If status = "Normal", the Inhibit P/B option is displayed <br> If status = "Inhibited", the Normal P/B option is displayed |
|  | Excessive Starts <br> SP | Note:- When in Inhibit mode the duty pump will <br> 1. Start and stop at a higher than normal well levels, <br> tab) <br> 2. Will run for a minimum time period |
|  | Excessive Hrs SP <br> (min) | Number of MINUTES pump can run for before Excessive <br> Hrs Run Alarm is triggered |
|  | Low Current SP | Low Amps SP |
|  | High Current SP <br> (A) | High Amps SP in Amps |


| Navigation <br> Pushbuttons | Selecting a P/B - <br> Status or <br> Statistics | Opens the required page (each one discussed separately) |
| :--- | :--- | :--- |

### 4.5 Trends

Selecting Trends from the Station Overview page opens the Trend Page as seen in Figure 32 below. Table 21 shows the descriptions for each of the items.


Figure 32 - HMI: Station Trends

Table 21 - HMI: Station Trend Details

| Item | Description |  |
| :--- | :--- | :--- |
| Trends | Well | Trend of the Duty selected level - 1 hour trend |
|  | Pmp1 | Trend showing the run status of pump1 |
|  | Pmp2 | Trend showing the run status of pump2 |
|  |  | Return to Station Overview |

### 4.6 Alarms

Selecting Alarms from the Station Overview page opens the Station Alarm Page as seen in Figure 33 below. Table 22 shows the descriptions for of the Alarm Page layout and not all Alarms.


Figure 33 - HMI: Station Alarm Page

Table 22 - HMI: Station Alarm Details

| Item | Description |  |
| :---: | :--- | :--- |
| Alarms |  | Active alarms will be displayed as seen above |
|  |  | Return to Station Overview |

### 4.7 Devices Option Page

Selecting Devices from the Station Overview page opens the Devices Options Page as seen in Figure 34 below. Table 23 shows the descriptions for each of the items.


Table 23 - HMI: Devices Options page details

| Item | Description |  |
| :--- | :--- | :--- |
| Devices |  | Opens a page with the selection options. |
| Navigation <br> Pushbuttons |  |  |
| Selecting a P/B - <br> Power Meter, <br> RTU Data or <br> Generator | Opens the required page (each one discussed separately) |  |

### 4.7.1Power Meter Page

Selecting Power Meter from the Devices page opens the Power Meter Statistics Page as seen in Figure 35 below. Table 24 shows the descriptions for each of the items.


Table 24 - HMI: Power Meter Statistics Details

| Item | Description |  |
| :--- | :--- | :--- |
| Power Meter |  |  |
|  | KW Hr Total Today | Power consumed by the site today in Kilowatt Hours |
|  | KW Hr Total Yesterday | Power consumed by the site yesterday in Kilowatt Hours |
|  | KW Hr Total This Week | Power consumed by the site this week in Kilowatt Hours |
|  | KW Hr Total Last Week | Power consumed by the site last week in Kilowatt Hours |
| $\Omega$ |  | Return to Station Overview |

### 4.7.2RTU Data Page

Selecting RTU Data from the Devices page opens the RTU Statistics Page as seen in Figure 36 below. Table 25 shows the descriptions for each of the items.


Figure 36 - HMI: RTU Statistics Page

Table 25 - HMI: RTU Statistics Page Details

| Item | Description |  |
| :--- | :--- | :--- |
| RTU Data |  |  |
|  | Supply Voltage to RTU | Displays D.C. Voltage to RTU ( Range = 0 to 32 V )Hours |
|  | Batt Charging Current | Displays battery current - negative if discharging, positive <br> if charging ( Range = Neg. 1 amp to Pos. 1Amp ) |
|  | Supply Current to RTU | Displays current draw of RTU ( Range = 0 to 2 Amp ) |
|  | TRU Temperature | Displays RTU temperature ( Range = -20 to 80 Deg. C ) |
| $\Omega$ |  | Return to Station Overview |

### 4.7.3Generator Page

Selecting Generator from the Devices page opens the Generator Page as seen in Figure 37 below. Table 26 shows the descriptions for each of the items.


Figure 37 - HMI: Generator Page

Table 26 - HMI: Generator Details

| Item | Description |  |
| :--- | :--- | :--- |
| Generator |  | When a Generator is connected to the site the following <br> will be displayed |
|  | Status | Displays 'Running' or 'Stopped' status |
|  | Fault | Displays 'Normal' or 'Fault' status |
|  | Tamper | Displays 'Normal' or 'Tamper' status |
|  |  | Return to Station Overview |

### 4.8 Station Page

Selecting Station from the Station Overview page opens the Station Page as seen in Figure 38 below. Table 27 shows the descriptions for each of the items.


| Item | Description |  |
| :--- | :--- | :--- |
| Station |  |  |
|  | Station Status | Display 'Normal' or 'Fault'. |
| AC Power | Display 'Normal' or 'Failed' Failed implies Supply Authority page details <br> AC Power Failure |  |
| Reset | Station Fault Reset <br> P/B | P/B to reset the 'Station Fault'. |
|  | Selecting a P/B - <br> Pump Duty, <br> Station Inhibit, <br> Device <br> Communications <br>  <br> Alarm SP's | Opens the required page (each one discussed separately) |
| Navigation <br> Pushbuttons | Return to Station Overview |  |

### 4.8.1Pump Duty Page

Selecting Pump Duty from the Station page opens the 2 Pump Duty Configuration Page as seen in Figure 39 below. Table 28 shows the descriptions for each of the items.


Figure 39 - HMI: 2 Pump Duty Select Page

Table 28 - HMI: 2 Pump Duty Select Details

| Item | Description | Pump Duty Operation Selected |
| :--- | :--- | :--- |
| Pump Duty |  | Displaying 'Alternate' - implies that the pumps will <br> alternate after each pump stop providing Standby Pump is <br> available |
| Alternate | Alternate P/B selected |  |
| Duty 1 | Duty 1 P/B selected | Pump 1 will be the next pump to start |
|  |  | Note:-Once a pump has been selected as the Duty pump, <br> it will start next and continue to start as Duty |
|  |  | Return to Station Overview |
| - |  |  |

### 4.8.2Station Inhibit Page

Selecting Station Inhibit from the Station page opens the Station Inhibit Page as seen in Figure 40 below. Table 29 shows the descriptions for each of the items.


Figure 40 - HMI: Station Inhibit Page

Table 29 - HMI: Station Inhibit Details

| Item | Description | Table 29 - HMI: Station Inhibit Details |
| :--- | :--- | :--- |
| Station <br> Inhibit |  | Note:- When in 'Inhibited' mode the duty pump will.. <br> 1. Start and stop at a higher than normal well levels, <br> these SP's can be altered from the Well pop up <br> (Engineers tab) <br> 2. Will run for a minimum time period |
|  | Status | Displays either 'Normal' or 'Inhibited' |
| Inhibit <br> Station | Inhibit Station P/B - P/B <br> visible when status is <br> 'Normal' | Selects the Station into the 'Inhibit' Mode. 'Inhibit' status <br> then appears in Status window |
| UN-Inhibit <br> Station | UN-Inhibit Station P/B - <br> P/B visible when status <br> is 'Inhibited' | Return to Station Overview <br> S |
| Navigation <br> Pushbuttons | Selecting a P/B - <br> Status | Opens the required page (each one discussed <br> separately) |

### 4.8.3Device Communications Page

Selecting Device Communications from the Station page opens the Device Communications Page as seen in Figure 41 below. Table 30 shows the descriptions for each of the items.


Figure 41 - HMI: Device Communications Page

| Item | Description | Communications Status - HMI: Device Communications Details |
| :--- | :--- | :--- |
| Device <br> Communications |  |  |
|  | Power Meter | Displays 'Normal' or 'Failed' |
|  | Driver 1 | Displays 'Normal' or 'Failed' |
|  | Driver 2 | Displays 'Normal' or 'Failed' |
|  |  | Return to Station Overview |

### 4.8.4Well Level \& Alarm Setpoints Page

Selecting Well Level \& Alarm SPs from the Station page opens the Station - Level Settings Page as seen in Figure 42 below. Table 31 shows the descriptions for each of the items.


Figure 42 - HMI: Station Level Settings Page

Table 31 - HMI: Station - Level Settings Details

| Item | Description |  |
| :---: | :---: | :---: |
|  <br> Alarm SPs |  | Level Transmitter Duty |
|  | Mode is Auto or Mode in Manual | Automatic Level Control - The Hydrostatic Transmitter's reading is used to control the pumps. <br> Manual Level Control - The level transmitter to be used for pump control can be selected. |
|  | LIT 1 is Duty or <br> LIT 2 is Duty | LIT 1 Duty - when Mode is Auto and LIT1 is healthy. <br> LIT 2 Duty - when Mode is Manual and LIT2 is selected for pump control or when LIT1 is faulty. |
|  | Manual P/B <br> or <br> Auto P/B | Manual P/B displayed when Mode is Auto. When selected the Mode will change to Manual. <br> Auto P/B displayed when Mode is Manual. When selected the Mode will change to Auto. |
|  | LIT 1 P/B <br> or <br> LIT 2 P/B | LIT 1 P/B displayed when Mode is Manual and LIT 2 is Duty. <br> LIT 2 P/B displayed when Mode is Manual and LIT 1 is Duty. |
|  |  | Well Level |
|  | Hydrostatic LIT1 \% | Window shows Hydrostatic Level in percent |
|  | Ultrasonic LIT2 \% | Window shows Ultrasonic Level in percent |
| $\checkmark$ |  | Return to Station Overview |

### 4.9 Well Page

Selecting Well from the Station Overview page opens the Well Duty/Stby Level Configuration Page as seen in Figure 43 below. Table 32 shows the descriptions for each of the items.


Figure 43 - HMI: Well Duty/Stby Level Configuration page

Table 32 - HMI: Well Duty/Stby Level Configuration Page Details

| Item | Description | Pump Start Level \% |
| :--- | :--- | :--- |
| Well | Duty | Displays the Duty Pump Start Level. With the correct <br> authorisation, this SP can be changed when selecting this field. |
|  | Stby | Displays the Stby Pump Start Level. With the correct <br> authorisation, this SP can be changed when selecting this field. |
|  | Duty | Pump Stop Level \% |
|  | High High SP \% | Displays the Duty Pump Stop Level. With the correct <br> authorisation, this SP can be changed when selecting this field. <br> Displays the High High SP Level. With the correct <br> authorisation, this SP can be changed when selecting this field. |
|  | High SP \% | Displays the Stby Pump Stop Level. With the correct <br> authorisation, this SP can be changed when selecting this field. |
|  | Well Level Alarm Setpoints <br> SP can be changed when selecting this field. |  |
|  | Low SP \% | Displays the Low SP Level. With the correct authorisation, this <br> SP can be changed when selecting this field. |
|  |  | Return to Station Overview |

## 5 MAINTENANCE

### 5.1 Circuit Breaker Schedule

The following Table 33 specifies the details of all the circuit breakers within the Switchboard.

|  |  |  |
| :--- | :--- | :--- | :--- |

Table 33 - Circuit Breaker Schedule

### 5.2 Electrical Equipment and Routine Maintenance Schedule

The following Table 34 specifies the details of suggested maintenance schedule for the equipment on site.

It should be noted that this list is intended only as a guide and is not conclusive.

| Item |  | Model |  | Maintenance Operation |
| :---: | :---: | :---: | :---: | :---: |
| Electrical Terminals | General | N/A | 12 Mth | Check for loose or damaged connections |
| Generator change Over |  |  | 6 Mth | Test Operation |
| Motor Control Centre ( MCC ) |  |  | 12 Mth | Thermo graphic survey |
| Motor Control Centre ( MCC ) |  |  | 12 Mth | Clean and remove debris |
| Surge Filter |  |  | 3 Mth | Test for Earth Leakage Current |
| Surge Diverter |  |  | 3 Mth | Test for Earth Leakage Current |
| Wet Well High Level Probe | Multitrode | MTR | 3 Mth | Simulate well high level and check pump operation |
| Well level Transducers |  |  | 3 Mth | Compare both displayed levels |
| Power Supplies U078 |  |  | 6 Mth | Check Output Voltages - 24 Volt DC |
| Pit High Level Probe | Multitrode | MTR | 6 Mth | Test Functionality |
| Variable Speed Drives |  |  | 6 Mth | Clean fan Filters |
| Variable Speed Drives |  |  | 6 Mth | Test Operation |
| Pump Drive Motor |  |  | 6 Mth | Motor winding Insulation and earth test |
| RTU 1 Battery |  | 12 Volt 24 A/hr | 6 Mth | Load Test |
| 24v Power Supply Backup Battery |  | 12 Volt 7.2 A/hr | 6 Mth | Load Test |
| 12v Backup Battery |  | 12 Volt 20A/hr | 6 Mth | Load Test |
| Well and Pit Tamper Switches |  |  | 6 Mth | Test Operation |
| Signal Protector | Novaris | SL36 | 6 Mth | Test for Signal loss |
| Telemetry Coax Surge Protector |  |  | 6 Mth | Test for Signal loss |
| RCD Circuit Breaker | NHP | $\begin{aligned} & \text { DSRCBH-10- } \\ & \text { 30A } \end{aligned}$ | As per Ipswich Water's Policy | Test and record operation |
| RTU | Kingfisher |  | N/A |  |
| Radio | Trio | $\begin{aligned} & \text { ER450-53AO2- } \\ & \text { DHO } \end{aligned}$ | N/A |  |

Table 34 - Electrical Equipment and Routine Maintenance Schedule

## 1. Drawings

 CORNERS ROUNDED.
IRT AND ORT AND ALLOWED TO DRY.
FNSH COLOUR IS AS Follows
NCLIOSURE INTERNAL/EXTERNAL: "NATURAL FINSH"
EXIERNAL DOORS: "NATURAL FINSH
EQUPMENT PLATES . "GIOSS WHIE"
ESCUTCHEONS/ATERNAL DOORS: "GLOSS WHITE"
EXIERNAL PANEL ONLY TO BE PANTED on reauest. MIST GReEn.
OUTER Doors ARE AFFIXED USING H1 LONGI PNTIE HNGSS
ITTED WITH 3 POINT LOCKING MECHANSM, DOOR STIFFENNER AND KEY OCKABLE TYPE SHCK HANDLE (KEY REFEREENCE 92268).
HE ENCLOSURE IS WEATHERPROP R
ESCUTCHEONS ARE AFFIXED USING HI ISHORTI PNTILE HNGES. ESCUTCHEON
CATCHES TO BE QUARTER TURN "SL STTER ISERT" ATCHES TO BE QUAATER TURN "LLOTTED NSERT
alumnum.



## NOTES:

denotes item no. as shown on the bill of materials. THS Table Refer drawing 6754-E-01 sh. 1 to 12 FOR ELectrical schematic RREER DRAWNGG 6755-M-01 sh. 1 to 3 For detalls of Label list.


FRONT VIEW
FRONT VIEW REAR VIEW
door stays \& tamper switches are to be fitted to outer
10. $4 \times$ M10 HOLES In PLINTH FOR FIXING TO GROUND

Requided shrouong to P2X over exposed terMnals where
12. ALL VSD \& RTU ELV CABles Shall be kept away from power
3. CABLES AT LEAST BY 10cm AND NOT RUN IN THE SAME DUCT

TWISTED PARSS SCREEN \& FITEED WITH TRANSIENT BARRERER
4. ALL BOLTS INSIDE GENERATOR BOX SHALL BE STANLESS STEEL 316
15. PROVIDE FOLD OUT BDARD FOR LAPTOP USE
16. VSD CABLES GLANDS SHALL BE TO VSD SU

AND THE REST STANLESS STEEL
17. ALL SIMLAR EQUPMENT SHaLL BE FROM ONE SUPPLIER \& SAME PART
18. HMM DISP AY unt shal show both hyopostatic ad hitasone Level sianal and noicate which instrument is controlling the
19. Supply authority section to be padlockable type shcpi IPADLOCK: ENERGEX ELS 3850

## OPERATING PARAMETERS:

$$
\begin{aligned}
& \begin{array}{l}
\text { Rated voltage } \\
\text { Rated current }
\end{array} \\
& \begin{array}{l}
\text { Rated CURENT } \\
\text { RATED FREQuency }
\end{array} \\
& \text { nsulation level } \\
& \begin{array}{l}
\text { SHort time with } \\
\text { DURATION }
\end{array} \\
& \text { PeAK with stand } \\
& \begin{array}{l}
\text { PEAK WTH STAND } \\
\text { SAFETY MEASURE }
\end{array} \\
& \begin{array}{l}
\text { Segregation } \\
\text { IP Rated }
\end{array}
\end{aligned}
$$




SIDE VIEW


FRONT VIEW

R

| $\frac{0}{5}$ | IPSWICH WATER |  | ${ }^{\text {TTILE }}$ |
| :---: | :---: | :---: | :---: |
|  |  |  | O'KEEFE ST. 11 kW STARTER SEWERAGE PUMP STATION GENERAL ASSEMBLY |
|  | ${ }^{\text {reswich city square }}$ | Phone (07) 38107885 |  |



Page 59 of 2030

| EQUIPMENT LIST |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| TTEM | QTY | DESCRIPTION | SUPPLER | PART Number |
| 1 | 3 | CURRENT TRANSFORMER 75/5 | NHP | TABB 75/5 |
| 2 | 2 | Start push button (GREEN) | NHP | D7PF3 |
| 3 | 2 | STOP PUSH BUTTON (RED) | NHP | D7PF4 |
| 4 | 2 | EMERGENCY STOP PUSH BUTON | NHP | D7P-MT34 |
| 5 | 2 | N/O CONTACT BLOCK | NHP | D7P×10 |
| 6 | 4 | N/C CONTACT BLOCK | NHP | D7PX01 |
| 7 | 2 | RUNNING PILOT LIGHT GREEN LED | NHP | D7PP3PN76 |
| 8 | 2 | fault plot light red led | NHP | D7PP4PN7R |
| 9 | 1 | BACKUP PLOT LIGHT YELLOW LED | NHP | D7PP5PN7Y |
| 10 | 1 | MAIN SWTCH 3 POLE CHANGEOVER 125A | NHP | SC01253P |
| 11 | 12 | 4A 1 POLE MCB | NHP | DTCB10104C |
| 12 | 3 | 6A 1 POLE MCB | NHP | DTCB10006C |
| 13 | 3 | 10A 1 POLE MCB | NHP | DTCB10110C |
| 14 | 1 | 2 A 3 POLE MCB | NHP | DTCB10302C |
| 15 | 3 | 100A FUSE Holder | NHP | NC100FW |
| 16 | 2 | 25A 3 POLE MCB | NHP | DTCB10325D |
| 17 | 1 | 16 A 30mA 2 POLE MCB | NHP | DSRCB1630P |
| 18 | 3 | 100A FUSE | NHP | NoS100 |
| 19 | 1 | 21 WAY BUSCOMB | NHP | 1 CL 213 |
| 20 | 3 | BUSCOMB TERMINAL PIN 25 mm 2 | NHP | dtTAX25PN |
| 21 | 3 | 32A FUSE HOLDER | NHP | NV32FW |
| 22 | 3 | 32A FUSE | NHP | NNS32 |
| 23 | 9 | Control relay 240V ac 4 Pole | NHP | 55.34.0054 240VAC |
| 24 | 8 | CONTROL RELAY 24V DC 4 Pole | NHP | 55.34.0074 24VOC |
| 25 | 17 | CONTROL RELAY BASES 4 Pole | NHP | 94.04 |
| 26 | 17 | Control relay retaling clip | NHP | 94.71 |
| 27 | 1 | delay on timer 240V AC | NHP | DAAO1CM24 |
| 28 | 1 | DELAY OFF TIMER 24V DC | NHP | DBB010M24 |
| 29 | 2 | CONTACTOR 15kW 3 POLE 240V AC | NHP | CA73000240VAC |
| 30 | 2 | CONTACTOR AUX CONTACT $1 \mathrm{~N} / 01 \mathrm{~N} / \mathrm{C}$ | NHP | cSTPV11 |
| 31 | 2 | CUBICLE FAN | NHP | GKV2501220 |
| 32 | 3 | FILTER MATS | NHP | AVAFAGN25 |
| 33 | 1 | FLASHING LIGHT RED | NHP | MOR200-05R |
| 34 | 1 | FLASHING LIGHT GUARD | NHP | M050010 |
| 35 | 2 | CUBICLE LIGHT | IDEAL ELECTRICAL | PHITWG114/2005 |
| 36 | 2 | 10A GPO | IDEAL EleCtrical | 2015WE |
| 37 | 2 | MOUnTING block | IDEAL Electrical | 449AWE |
| 38 | 1 | 7 PIN OUTLET | IDEAL ELECTRICAL | 5650710 |
| 39 | 3 | METERNG ISOLATION LINKS | IPD | QLDSERVCE-K |
| 40 | 4 | SURGE DIVERTERS | ECO | TDS-MT-277 |
| 41 | 1 | SURGE REDUCTION FLTER | ECO | TDF-10A-240V |
| 42 | 4 | TRANSIENT BARRIERS | ECO | UTB-30SP |
| 43 | 2 | AUTO/OFF/MAN SELECTOR SWITCH | KRAUS NAIMER | CA10-A212-623-FT2 |
| 44 | 1 | 24Vdc Power Supply/Battery charger | RFI | SME240-24-5 |
| 45 | 2 | BATTERY 12V 12Ah | POwERHOUSE | GP12120 |
| 46 | 1 | BATTERY 12V 20Ah | PowERHOUSE | EVX200 |
| 47 | 1 | ELECTREX FLASH-D POWER METER | CONTROL LOGIC | PFA861118 |
| 48 | 1 | DIITAL DISPLAY | AMALGAMATED INSTUMENTS | PM6-LP-4C |
| 49 | 1 | magelis | SCHNEIDER | XBTGT2330 |
| 50 | 2 | 11kW VSD ALTIVAR | SCHNEIDER | ATV61HD11N4 |
| 51 | 2 | REMOTE MOUNTING KIT FOR GRAPHIC DISPLAY | SCHNEIDER | WW3AlP54KIT3M |
| 52 | 2 | MODBUS TCP DAISY CHAIN CARD | SCHNEIDER | WW3A33100 |
| 53 | 1 | CONNEXIUM UNIMAN SWTCH 5TX | SCHNEIDER | TCSESU053FNO |
|  | 1 | 2 CHANNEL SUBSCRBER RS 485 | SCHNEIDER | TSXSCA62 |
| 54 | 3 | REED SWITCH | NESS SECURITY | 100-222 |


| 55 | 25 | UK5N THROUCH TERMNAL | PHoenl Contact | 13004362 |
| :---: | :---: | :---: | :---: | :---: |
| 56 | 2 | 10 WAY PUSH IN BRIDEE LINK EB10-6 SUT UK5N | Phoenl Contact | 020139 |
| 57 | 5 | D-UK4/10 END CoVER SUT UK5N | Phoenl Contact | 3033220 |
| 58 | 51 | UKK5-MTK-P/P Double level termina wit discownect | PHOENIX CONTACT | 2800004 |
| 59 | 6 | 10 WAY fxed brioge link frio-6 Sut ukk5-MTk-P/P | PHOENIX CONTACT | 0203250 |
| ${ }^{60}$ | 10 | 286 Horzoovtal terwnal Markers 1-10 | Phoenl CONTACT | 1051016 |
| 61 | 3 | 286 HORZZONTAL TERMNAL MARKERS $11-20$ | PHOENX CONTACT | 1051016 |
| 62 | 3 | 286 Horz2ontal terundal markers 21-30 | PHOENIX CONTACT | 1051016 |
| ${ }^{63}$ | 3 | Z86 HORIZONTAL TERMNAL MARERERS 31-40 | Phoenl Contact | 1051016 |
| ${ }^{64}$ | 1 | MARECHAL GENERATOR ILET SOCKET 3 PhASE 250A | woELLER | 3988017 |
| ${ }^{65}$ | 1 | MARECHAL INCLINED SLEEVV FOR INLET | MoELLER | ${ }^{3924027}$ |
| ${ }^{66}$ | 1 | MARECHAL IP67 CAP For INLET | wotler | ${ }^{3124126}$ |
| ${ }^{67}$ | 1 | SUPPLY AUTHORTY M METERS | ENERCEEX |  |
| ${ }^{68}$ | 1 | HYorostaic level sensor | VEGA | VEGANELL 72 |
| 69 | 1 | HYOROSTATC LEVEL IISPLAY | vEGA | vegalis 12 |
| 70 | 1 | ULTRASONC LEVEL SENSOR | E\& H |  |
| 71 | 1 | RTU | KNGGFISHER |  |
| 72 | 1 | RADOO | TR10 | EER450 (Exisis) |
| ${ }^{73}$ | 0 | M |  |  |
| 74 | 1 | CARO READER | INOALA | FP32315 14599 |
| 75 | 0 | Flommeter |  |  |
| 76 | 1 | PuMP STATON ENCLOSURE | PS |  |
| 77 | 2 | BRASS EARTH \& NUUTRAL BAR | DORE ELECTRCS | 165524 |
| 78 | 2 | NEUTRAL FEET | OORE ELECTRICS | EN FEET |
| 79 | 1 | PADLOCKABELE HANDLE | DORE ELECTRCS | SHCPD |
| 80 | 3 | HANOLE KEYEED 92288 | DORE ELECTRCS | SHCK |
| 81 | 10 | GTM SMALL | RAMEEEC | 1631930000 |
| 82 | 28 | Tervinal eno stops | RavEEEC | 0383560000 |
| 83 | 1 | MULTTROOE Level relay | muLTITROEE | MTR 5 |
| 84 | 1 | MULTTROOE SENSOR PROBE | MULTTROOE | 0.2/1/SPX |
| ${ }^{85}$ | 2 | 2 M Patch Lead | CABAC |  |
| ${ }^{86}$ | 2 | 3M PATCH LEAD | CABAC |  |
| 87 | 1 | SM Patch LeAD | CABAC |  |
| 88 | 1 | R2-232/RS-485 Converter |  | CE-00290 |
| 89 | 1 | 10 A 1 POLE MCB D TPE | NHP | DTCB101100 |
| ${ }^{90}$ | 1 | Phase fall relay | SCHNEDER | RM17TE20 |
| 91 | 1 | 4 A 3 POLE MCB | NHP | DTCEB10304C |
| 92 | 1 | 20 A 3 Phase OUTLET | IDEAL ELECTRCAL | 566520 |















## 2. Testing





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Job No Job Name ITP Description

Component
Drawing Reference Drawing Reference Cable Schedule Technical Ref
 Contract / PO Number
O'KEEFE ST SPS. REPLACE MA,NS REOM POA TO SN/BO
 Item / Tag Number / Panel No
 Client Document Number

* Do not energise equipment during this stage of checks. All equipment is to be correctly tagged and isolated. * Do not begin any testing until the surrounding area is safe to work and appropriate Job Safety Analysis' or equivalent have been consulted.

| Cable checks: Each of the below tests are to be completed on the cables included in this test sheet. |  |
| :---: | :--- |
| A | Cable glands appropriate size, with shrouds and lock nuts tight. |
| B | Cable installed correctly, supported and protected from damage. |
| C | Cable numbers fitted and correct as per cable schedule. |
| D | All terminations completed and tested as per the termination drawing. |
| E | Cable schedule and termination drawing updated when required. |


| Note: | Insulation Resistance test the cables Core - Core and Core - Earth at 500 V (Minimum reading of only $25 \mathrm{M} \Omega$ allowed). |  |  |  |  |  |  |  |  |  |  |  |  | Complete? |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Cable Check passes? ( $\checkmark$ ) |  |  |  |  | Insulation Resistance Reading Recorded? (M $\Omega$ ) |  |  |  |  |  |  | $\Omega$ Value? |  |  |
| 415V Cable Number | A | B | C | D | E | R-B | R-W | B-W | R-E | W-E | B-E | Neutral | Earth Continuity | $\begin{aligned} & \hline \text { Yes } \\ & (V) \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { No } \\ & (\checkmark) \\ & \hline \end{aligned}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| MAIUS SDiS |  |  |  |  |  | $7200 \mathrm{~m} \Omega$ | $\geq 2000 \mathrm{~m} n$ | $720 \operatorname{con}^{2}$ | $>^{200404}$ | 200 | P200mor | - $>200 \mathrm{cia}$ |  | , |  |
|  |  |  |  |  |  |  | $\square$ |  |  |  |  |  |  |  |  |
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SP337 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OM Manual


Testing Officer Comments \& Notes:
New Actives + Neotral's
existing Carths.


> The work, or section of the work, described herein is complete according to the Contract Conditions and Specifications and is considered to have reached a stage equivalent to that of Practical Completion / Final
> Completion. Please formally approve and issue the release any retention or security held.

> Job No
> ITP Description
> Component
> Drawing Reference $7985-$ E-01
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> Technical Ref
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> Technical Ref



| ITEM No: | LOCATION / DESCRIPTION |
| :--- | :--- |


| ITEM No: | LOCATION / DESCRIPTION |
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| 1 | I/O sheet - FAT, Commissioning, Citect \& HMI Displays |

$$
\begin{array}{|l|l|}
\hline \text { ITEM No: } & \text { LOCATION / DESCRIPTION } \\
\hline 1 & \text { I/O sheet - FAT, Commissioning, Cit } \\
\hline 2 & \text { Manual Operation Test } \\
\hline 3 & \text { Auto Operation Test } \\
\hline 4 & \text { Multitrode Back-up Operation Test } \\
\hline 5 & \\
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\end{array}
$$

[^0]SUSTAIN GRUE SWITCHBOARD
ste d: SP 64 site name: Harrison st. 11 kK :EAT


Completed By Electrical Inspector
Name: Ratio Jiontado Date: $10 / 02 / 2010$

Signature:


GUSTAv E WY



Completed By Electrical Inspector
Name:
Signature:


SITE ID: $\qquad$ SITE NAME: $\qquad$

## ELECTRIGALINSPECTION

Prior to commencement of functional test confirm electrical inspector has completed checklist:
ga Sewage Pump Station - Factory Electrical inspection-Swichboard.doc
POINT TO POINT


POWER UP THE BOARD

| Check that the board powers up OK (Power Supplies and Switchboard Lights turn on). | Outcome |
| :--- | :---: |

PROGRAMTHERTU


RADIO

| Task | Outcome |
| :--- | :--- |
| Record the Base Station / Concentrator proposed for the Site |  |
| Check that the correct radio type has been installed <br> record transmitreceive frequencies $(S, S T$ | RX |

## MODEM

| Task | Outcome |  |
| :--- | :--- | :--- |
| Confirm that the Modem is powered up and that the RTU can <br> communicate to the Modem. | $N / A$ | - OK $\square$ |

## MOTOR STARTER

| Check that the motor starter is programmed and able to start the each pump | Outcome |
| :---: | :---: |

moDbus

| Confirm that the modbus link from the RTU to the Soft Starters. is operating correctly | Outcome |
| :--- | :---: |

## BATTERY

| Check that the battery is connected and charging (i.e. 24 V across the terminals). | Outcome |
| :---: | :---: |
| $\mathrm{OK}^{2} \mathrm{Q}$ |  |

## Completed By RTU Programmer

Name:


Date: $10 / 84 / 2010$
Signature:


SUSTAIN Enem FACTORY ACCEPTANCE TEST

| Task | Outcome- |
| :---: | :---: |
| Check that the RTU is running off battery when the mains supply is isolated | OK Q |

POINT TOPOINT

| Task | Outcome |
| :--- | :---: |
| Using the Physical I-O Spreadsheeet check each individual physical I-O |  |
| Wired to the RTU from beginning to end. |  |
| ie press the actual button and watch the I-O change in Isagraf. |  |
| Output lights and relays activate |  |
| Inject 4-20mA into the Analog Inputs | OK © |
| The I-O spreadsheet should be ticked and signed by the test and atteched to this FAT Test |  |
| Document. Also confirm that the display panel is showing the correct information during |  |
| each point to point check |  |

HARD WIRED EMERGENCY PUMPING MODE FUNCTIONALITY CHECK

| Task | Outcome |
| :--- | :---: |
| Turn off the RTU and perform the following steps to confirm that the emergency pumpng <br> mode is functioning correcly. |  |
| Simulate a wet well high level on the multitrode elecgtrode and ensure that the Overflow <br> Run Timer starts to time | OK |
| Simulate a wet well high level on the ultrasonic probe and ensure that the Overflow Run <br> Timer starts to time | OK |
| De-activate the Overfow relay and ensure that all pumps continue to run until the Overflow <br> Run Timer timer expires (4 mintes) and that all pumps ramp down when the timer expires | OK a/ |
| De-activate the Overfow relay and ensure that all pumps continue to run until the Overflow <br> Run Timer timer expires and that all pumps ramp down when the timer expires | OK |

Completed By RTU Programmer
Name:
Date: $\qquad$
Signature: $\qquad$

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20 / 7 / 10
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# 3. Functional Specification 

# IPSWICH WATER SEWERAGE PUMP STATION FUNCTIONAL SPECIFICATION 

Client: Ipswich Water<br>Project:<br>Sewerage Pump Station Control System Design

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

## DOCUMENT REFERENCE (Ipswich Water)

| Name | Ipswich Water Sewerage Pump Station Functional Specification |
| :---: | :--- |
| Number | 0005690-DF-00J |
| Rev | J |

DOCUMENT APPROVAL (Ipswich Water)

| Rev | Status | Name | Position | Date | Initial |
| :---: | :---: | :--- | :--- | :--- | :--- |
| $\mathbf{J}$ | Checked | Praveen <br> Gaddam | Technical Officer (Telementry) |  |  |
|  | Endorsed | Joseph <br> Tam | Operations Engineering Manager |  |  |
|  | Approved | Nimish <br> Chand |  <br> Operations |  |  |

## DOCUMENT REFERENCE (i.Power Solutions)

| Name | Ipswich Water Sewerage Pump Station Functional Specification |
| :---: | :--- |
| Number | 0005690-DF-00J |
| Rev | J |

## DOCUMENT APPROVAL (i.Power Solutions)

| Rev | Status | Name | Position | Date | Initial |
| :---: | :---: | :--- | :--- | :--- | :--- |
| A | Prepared | Matthew <br> Griffiths | Industry Manager, Water | $22 / 08 / 2007$ |  |
|  | Checked | Paul <br> McAllister | Control Systems Engineer | $22 / 08 / 2007$ |  |
| D | Prepared | Paul <br> McAllister | Control Systems Engineer | $07 / 04 / 2009$ |  |
|  | Checked | Matthew <br> Griffiths | Industry Manager, Water | $07 / 04 / 2009$ |  |
| F | Prepared | Matthew <br> Griffiths <br> Sabljic | Control Systems Engineer | $13 / 10 / 2009$ |  |
|  | Checked | Paul <br> McAllister | Control Systems Engineer | $13 / 10 / 2009$ |  |

[^1]Ipswich Water Sewerage Pump Station Control System Design Functional Specification

|  | Approved | Matthew <br> Griffiths | Industry Manager, Water | $13 / 10 / 2009$ |  |
| :---: | :---: | :---: | :---: | :---: | :--- |
| H | Prepared | Jasenko <br> Sabljic | Control Systems Engineer | $23 / 02 / 2010$ |  |
|  | Checked | Paul <br> McAllister | Control Systems Engineer | $24 / 02 / 2010$ |  |
|  | Approved | Mathew <br> Griffiths | Industry Manager, Water |  |  |
|  | Released <br> (RPEQ) | Gavin <br> Liston | Registered Professional Engineer <br> of Queensland - 7270 |  |  |
| J | Prepared | Paul <br> McAllister | Control Systems Engineer | $3 / 06 / 2010$ |  |
|  | Checked | Jasenko <br> Sabljic | Senior Control Systems Engineer | $16 / 06 / 2010$ |  |
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|  | Released <br> (RPEQ) | Gavin <br> Liston | Registered Professional Engineer <br> of Queensland - 7270 |  |  |

## DOCUMENT REVISION (i.Power Solutions)

| Rev | Author | Date | Comments |
| :---: | :---: | :---: | :--- |
| A | Matthew Griffiths | $26 / 02 / 2007$ | Preliminary issue |
| B | Paul McAllister | $18 / 03 / 2008$ | Modifications |
| C | Paul McAllister | $7 / 05 / 2008$ | Modifications |
| D | Paul McAllister | $7 / 04 / 2009$ | HMI and Power Meter added |
| E | Paul McAllister | $7 / 07 / 2009$ | Modifications to VSD Type and Speed Reference |
| F | Jasenko Sabljic | $13 / 10 / 2009$ | Addition of the Card Reader |
| G | Johann Joubert | $20 / 11 / 2009$ | Editing Document changes |
| H | Jasenko Sabljic | $23 / 02 / 2010$ | Change from 1,2,3,4 Pump to 1,2 Pump Station |
| I | Paul McAllister | $3 / 6 / 2010$ | SAFE-FSP Backup Control added. <br> All references to calculated Inflow and Out Flow <br> deleted. |
| J | Jasenko Sabljic | $16 / 06 / 2010$ | Alarm, Tag Naming Convention updated |

## DISTRIBUTION LIST (Ipswich Water)

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| 4 | Guy Mowat, System Optimisation Manager |
| 5 | Punu Gunasinghe, Acting Strategic Asset Manager |
| 6 | Richard Katt, Manager, Field Services |
| 7 | Sandy Veeren, Manager, Project Manager |
| 8 | Devon Wilson, Senior GIS Coordinator |
| 9 | Stephen Riddell, Senior Business Advisor |

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

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## DEFINITIONS

| Term | Description |
| :--- | :--- |
| IW | Ipswich Water - owner/operator of system |
| iPS | i.Power Solutions - Principal Contractor |
| BPS | Booster Pump Station |
| CMF | Central Monitoring Facility |
| GUI | Graphical User Interface |
| HMI | Human Machine Interface |
| I/O | Input/Output |
| IDC | Internet Display Client |
| RMF | Remote Monitoring Facility |
| RSSI | Received Signal Strength Indication |
| RTU | Remote Terminal Unit |
| RX | Radio Receiving Strength |
| SCADA | Supervisory Control And Data Acquisition |
| WTP | Water Treatment Plant |
| STP | Sewerage Treatment Plant |
| TFT | Thin Film Transistor |
| TX | Radio Transmission Strength |
| VSD | Variable speed drive |
| SS | Soft Starter |

[^2]
## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

## PROJECT SCOPE

### 1.1 Introduction

This Functional Specification includes a detailed specification of all the hardware and software developed, implemented and installed for a Standard Sewerage Pump Station at Ipswich Water.

All software requirements for the SCADA and RTUs are included herein such that further code can be developed. Also included within the Specification are the project phases and equipment locations.

### 1.2 Project Objectives

This Project consists of sewerage pump stations with 1 and 2 pumps, being controlled and monitored by a Kingfisher RTU/Citect SCADA system.
The works undertaken for the development and implementation of the Sewerage Pump Station Control System include:

- Design and supply of Hardware requirements
- Design and supply of RTU Software requirements
- Design and supply of CitectSCADA Software requirements
- Design and supply of FAT and SAT Testing documentation
- Design and supply of Switchboard drawings
- Design and supply of IO lists


## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 2.0 SEWERAGE PUMP STATION CONTROL SYSTEM DESIGN

### 2.1 System Topology

### 2.1.1 Telemetry Overview

The system is designed and installed to allow signals to pass between the Outstation RTU sites and the Master RTU site via each repeater. A SCADA system incorporating the entire water and sewerage system is installed at Karagaroo Reservoir (CMF SCADA and Master RTU), IGIC Building (Standby Master RTU), and the Bell St Control Room (RMF SCADA).

The Telemetry Diagram is shown on the drawing in Appendix A and this illustrates how each major component interconnects with the SCADA system.

### 2.2 System Hardware

The following sections outline the intelligent hardware components covered by this document.

### 2.2.1 Kingfisher Remote Terminal Units

Remote Terminal Units (RTUs) perform the following tasks:

- Interfacing with discrete and analogue signals via industry interface standards
- Processing of Inputs and Outputs
- Manage communications links and real-time data to maximise throughput and minimise transmission time
- Provide control of plant by executing SCADA operator commands and translating this to process outputs.
- Provide automated processing and conditioning of statistics and control systems based on I/O information in real-time.


### 2.2.1.1 RTU Functionality

Routine monitoring, alarming, logging, trending, and automatic testing of the radio network will be provided via the RTU in conjunction with the SCADA system including the following typical items:

- Communication statistics including
- percentage success rate
- successful message count
- failed message count
- failed packets count
- Battery voltage
- Battery charging current
- RTU temperature
- RTU current


## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 2.2.1.2 Kingfisher RTU Modules

The following RTU modules have been used in the System for this project:

| Component | Options |
| :--- | :--- |
| CP11 | TI |
| PS11 | C |
| IO-3 |  |
| DI-5 |  |
| BA6 |  |

Table 1 - Module Types Used in Project
The following sections detail the basic functionality of the power supply, the processor module and the backplane system.

### 2.2.1.3 Processor Module - CP11

The CP-11 processor module provides all processing, I/O scanning, logic, control and communications functions required in any of the RTU configurations that may be adopted. The processor module has up to three independent communications ports. Ports 2 and 3 can use plug-in option boards while Port 1 is fixed as a serial port, RS232C.

RTUs may have up to two CP-11 modules that can serve up to four backplanes in a hot standby configuration (note: one processor should be in an odd numbered backplane slot and the other in an even numbered backplane slot). One processor controls I/O module scanning and communications while the other redundant processor listens. The redundant processor module will take control under the following conditions:

- Failure of I/O module scan
- Failure of communications on selected ports
- Toolbox command
- Ladder command

The CP-11 has 1MB of flash memory for the storage of all operating code and selected system parameters, and 1MB of battery backed static RAM for all configuration and event storage data.

The CP-11 processor's specifications can be found in Appendix C2.

### 2.2.1.4 Backplane System - BA6

Table 2 below lists the revision number of the BA6 Backplane to be used in Kingfisher Series II system.

| Backplane Type | Revision Number |
| :--- | :--- |
| BA6 | 2.2 |

Table 2 - Backplane Types
Each backplane has power distribution and high-speed serial buses (one for I/O scanning and the other for communications to the communications modules). The backplanes have a hardcoded slot address for module addressing and a control line driven by the processor module to enable the isolated $24 \mathrm{~V}_{\mathrm{dc}}$ supplies on the modules with analogue I/O.
Backplanes can be stacked to expand I/O capabilities. Mounting options include rackmounting and surface mount. PC-1 processors must be located in slot position 1 on a BA4 backplane. Other processor modules including multi-communications modules can be located in any slot of the backplanes.

### 2.2.1.5 Power Supply Systems - PS-11

Each site has a PS-11 power supply. Their specifications can be found in Appendix C1.

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 2.2.2 Kingfisher Toolbox

Toolbox is a menu-driven software package (see Table 3 below) that allows users to configure and use Kingfisher Series II RTUs. It can also be used to monitor, set and display data values and read and write to/from hardware modules. Diagnostic tools are provided to determine system performance.

Toolbox allows for on-line and off-line configuration, which means that an RTU configuration can be created without a physical connection between the RTU and the PC. Configurations can be downloaded to the RTU remotely over the air or on-site locally. *.sdb and *.ll source files contain all the necessary configuration information for an RTU. Projects files are used for management of site information but do not influence configuration or operation of RTU software.

| RTU Configuration Software | Version |
| :--- | :--- |
| Toolbox | 1.45 d |

Table 3 - RTU Programming Software

### 2.2.3 RTU Equipment Requirements

### 2.2.3.1 RTU Software \& Firmware

RTU processor modules are loaded with the following versions of firmware:

| Module Type | Firmware Version | Description |
| :--- | :--- | :--- |
| CP11 | V144d.h32 | Base CPU Firmware |
| CP11 | modbus05.d32 | Firmware Module for Modbus TCP <br> communications |
| CP11 | rxupd04.d32 | Firmware Module for requesting messages from <br> another RTU |
| CP11 | txupdate.d32 | Firmware Module for transmitting messages to <br> another RTU |

Table 4 - Firmware Versions

### 2.2.3.2 RTU Environmental Specifications

Environmental specifications for reliable operation of the RTUs are as follows:

| Parameter | Measurement |
| :--- | :--- |
| Ambient Temperature | -20 to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Humidity | $5 \%$ to $98 \%$ RH non-condensing |
| Dielectric Strength | $3000 \mathrm{~V}, 1$ minute |
| Noise Immunity | IEEE 472 |

Table 5 - Environmental Specifications

### 2.2.4 Radio

The Radio performs the following tasks:

- Provides communication to the SCADA and other required RTU
- Monitors the Radio network (Forward and Reverse power, RSSI, Temperature and Losses)

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### 2.2.4.1 Requirements

The data from a radio path survey shall be used to establish if a suitable radio path exists. This data can also be used for the design of the radio path for calculating height of the antenna and losses. The minimum fade margin is 25 dbm .

### 2.2.4.2 Radio Hardware

The following Radio Hardware has been used in the System for this project:

| Brand | Model number |
| :--- | :--- |
| Trio Datacom Radio | ER450-53A02-EH0 |
| Trio Datacom <br> Diagnostics | Diags/E |
| Yagi Antenna | YB9-62 |
| Coaxia Cable | RG 213 |
| Critec Surge arrestor | LCSP-90m |

Table 6 - Radio Hardware in Project

### 2.2.4.3 Trio Datacom - ER450

The ER450 is a digital data radio that will operate at $19.2 \mathrm{kbits} / \mathrm{sec}$. The ER450 has the ability of being programmed locally and remotely. The ER450 requires 128bit AES encryption to ensure security.

Depending on the location of the site, site specific frequencies need to be programmed to allow communication back to the SCADA.

The following Radio Frequencies that have been used in the outstations for this project:

| Area | Frequencies |
| :--- | :--- |
| Keidges Rd. | Tx: 483.9 MHz <br>  <br>  <br> Rxassall 489.1 MHz <br> Tx: 482.35 MHz <br> Rx: 487.55 MHz $\mathrm{Rx}: 480.425 \mathrm{MHz}$ |

Table 7 - Frequencies Used in Project

### 2.2.4.4 Trio Datacom - ER450 Firmware

Radio shall be loaded with the following version of firmware:

| Module Type | Firmware Version | Description |
| :--- | :--- | :--- |
| ER450 | 4.2 .3 | Base Firmware |

Table 8 - Radio Firmware Versions

### 2.2.4.5 Trio Datacom - TC-TView

TView is a menu-driven software package (details in Table 9 on page 13) that allows users to configure, monitor and use the ER radios. Diagnostic tools are also provided to determine system performance.

TView allows local and remote configuration, which means that a Radio can be configured over the radio network. *.cfg files contain all the necessary configuration information for a

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

radio. These files should be registered for version control. Project files are used for management of site information but do not influence configuration or operation of RTU software.

| ER Radio Configuration <br> Software | Version |
| :--- | :--- |
| TView+ E Series Configurator | R3.5.9 |

Table 9 - Radio Programming Software

### 2.2.4.6 Trio Datacom - Diagnostics

TView+Diagnostics is a menu-driven software package that allows users to monitor the ER radios.

TView+Diagnostics logs the TX power, Temperature, RSSI, Voltage and RX Frequency error. A HMI interface is used to display the data and trends, the trends can be used to look at the data over time. Status and alarm logging /monitoring can also be configured for the radio network.

When a site is added to the system, the TView database must also be updated by adding the new details into the diagnostic database. This allows the new site to be included into the routine polling and monitoring of the diagnostics.

| ER Radio Diagnostic <br> Software | Version |
| :--- | :--- |
| TView+ Diagnostics Software | R3.15.8 |

Table 10 - Radio Diagnostic Software

### 2.2.4.7 UHF Directional Antenna Yagi (YB9-62)

The Yagi antenna shall consist of a minimum 9 element array but depending on the results of the Radio Path Survey a higher element antenna may be necessary to achieve the required minimum Fade Margin of 25 dBm . The antenna must have the drain hole pointing down and 2 coils of coax cable tied to the mounting bracket. The cable connection to the antenna must be taped with Scotch 23 rubber tape.

### 2.2.4.8 Coaxial Cable- RG-213

RG-213 is recommended unless the fade margin requirements are not met. In this case a higher gain coax cable would be needed to guarantee a minimum fade margin of 25 dBm .

### 2.2.4.9 Critec Surge Arrestor - LCSP-90m

LCSP-90m is a Coax Surge protector used to protect the radio from lightning surges. It is very important that the bulkhead is securely attached to the Switchboard and well earthed.

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 2.2.5 Instrumentation

Instrumentation performs the following tasks:

- Measurement of sewerage well processes
- Monitor the sewerage well for process control and alarming
- Supply analog and discrete signals to the RTU for processing
- Supply analog and discrete signals for visualization, alarming and control at the SCADA


### 2.2.5.1 Instrumentation Hardware

The following Instrumentation Hardware has been used in the System for this project:

| Brand | Model number | Description |
| :--- | :--- | :--- |
| Endress \& Hauser | FDU-92 \& FMU-90 | Ultrasonic Level Transmitter \& Sensor |
| Vega | VegaWell 72 \& VegaDis 12 | Suspension Pressure Transmitter |
| Multitrode | MTR | Latching Conductive Liquid Level Relay |

Table 11 - Module Types Used in Project

### 2.2.5.2 Hydrostatic Level Transmitter - VegaWell 72 and VegaDis 12

The Hydrostatic Level Sensor is calibrated using a hart communicator and is always scaled from the bottom of the Well at $0 \%$ to the Overflow point at $95 \%$. Also the RL is determined and scaled accordingly on the SCADA.

The Hydrostatic Level Sensor is the primary process control device.
The Hydrostatic Level Sensor is hung so that it is positioned in an open part of the well only 5 cm from the bottom of the well There is to be no obstructions within a 50 cm radius of the sensor. The hydrostatic sensor must be retrievable without entering the confined space. This can be done by coring a 105 mm hole into the top of the well and placing a mounting bracket on the top of the well. A lockable lid is used to cover the hole so that the transmitter can be accessed from the top of the well and removed to service the equipment. The transmitter cable is run into an instrument marshalling cubicle. All components used to support and cover the sensor must be made of aluminum or stainless steel.

### 2.2.5.3 Ultrasonic Level Transmitter and Sensor - FMU-90 \& FDU-92

The Ultrasonic Level Transmitter is calibrated using a hart communicator. It is always scaled from the bottom of the Well at $0 \%$ and to the Overflow point at $95 \%$. The RL is also determined and scaled accordingly on the SCADA. The Ultrasonic Transmitter is scaled to mirror the Hydrostatic Sensor. A deviation will create an alarm back at the SCADA.
The Ultrasonic Level Transmitter/Sensor is the secondary process control device.
The Ultrasonic Sensor is hung so that the transmitter is positioned to get a clear shot of the well, with no close obstructions. The Sensor is hung approximately 30 cm below the top of the well. The sensor must be retrievable without entering the confined space. This can be done by coring a 105 mm hole into the top of the well and placing a mounting bracket on the top of the well. A lockable lid is used to cover the hole so that the Sensor can be accessed from the top of the well and removed to be serviced. The Sensor's cable is run into an instrument marshalling cubicle. All components used to support and cover the Sensor must be made of aluminum or stainless steel.

### 2.2.5.4 Multitrode MTR Level probe - Wet Well Over Flow

The level probe is hung in the well at $90 \%$ and is used to trip a timer and the well is pumped down for a specific time. The level probe is the backup secondary control. The level probe

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| :--- | :--- | :--- |

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must be retrievable without entering the confined space. This can be done by coring a 105 mm hole into the top of the well and placing a mounting bracket on the top of the well. A lockable lid is used to cover the hole so that the level probe can be accessed from the top of the well and removed to service the equipment. The level probe cable is run into an instrument marshalling cubicle. All components used to support and cover the level probe must be made of aluminum or stainless steel.

### 2.2.6 Motor Control

Motor Control performs the following tasks:

- Monitor and control the pump well for process control and alarming
- Supply analog and discrete signals to the RTU for processing
- Supply analog and discrete signals for visualization, alarming and control at the SCADA
- Reduce Mains Power Current Loading
- Improve Harmonics performance
- Limit motor starting current
- Provide motor protection


### 2.2.6.1 Motor Controllers

The following Motor Controllers have been used in the System for this project:

| Brand | Model number |
| :--- | :--- |
| Emotron | Softstarter |
| Fuji | Frenic - Mega |
| Telemecanique | Altistart 48 Softstarter and TSXETG100 |
| Telemecanique | Altivar 71 VSD |

Table 12 Motor Control Types Used in Project

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 2.2.6.2 Emotron Softstarter -

Emotron Softstarter uses hard wired IO to control and communicates to the RTU.
The following data can be derived

| Ladder Name | Description |
| :---: | :---: |
| PMP'X'Current | Pump ' ${ }^{\prime}$ ' - Current |
| PMP'X'Run | Pump ' $\mathrm{X}^{\prime}$ - Running |
| PMP'X'Flt | Pump ' $\mathrm{X}^{\prime}$ - Fault |
| PMP'X'Start | Pump ' $\mathrm{X}^{\prime}$ - Start Cmd |

Table 13 - Emotron Softstarter Data
The softstarter is also hardwired to start independently from the RTU. The starter must be put into Manual on the front of the panel and then the start and stop push buttons are used to control the starter. The starter also can be controlled from the HMI on the front of the panel.

### 2.2.6.3 Fuji VSD - Frenic Mega

The Fuji VSD uses Modbus RTU communication protocol and a Modbus RS485 interface to communicate with the RTU.

The following data can be derived

| Ladder Name | Description |
| :---: | :---: |
| PMP'X'FltCode | Pump ' $\mathrm{X}^{\prime}$ - Fault Code |
| PMP'X'Speed | Pump ' $\mathrm{X}^{\prime}$ - Output Frequency / Speed |
| PMP'X'Torque | Pump ' $\mathrm{X}^{\prime}$ - Torque |
| PMP'X'Current | Pump ' $\mathrm{X}^{\prime}$ - Current |
| PMP'X'Voltage | Pump ' $\mathrm{X}^{\prime}$ - Voltage |
| PMP'X'Run | Pump ' $\mathrm{X}^{\prime}$ - Running |
| PMP'X'Flt | Pump ' $\mathrm{X}^{\prime}$ - Fault |

Table 14 - Fuji VSD Data
When the station is in "Remote" operation, the speed reference to the VSD is via a $4-20 \mathrm{~mA}$ analog signal from the RTU.

The VSD is also hardwired and configured to start independently from the RTU. The starter must be put into Manual on the front of the panel and then the start and stop push buttons are used to control the starter, the VSD HMI on the front of the panel is used to control the speed.
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## Telemecanique Softstarter - Altistart 48

The Telemecanique softstarter communicates with the RTU via Modbus RS485 interface. The softstarter uses Modbus RTU communication protocol.

The following data can be derived

| Ladder Name | Description |
| :---: | :---: |
| PMP'X' DrvThermSt | Pump ' $\mathrm{X}^{\prime}$ - Thermal State |
| PMP'X'Current | Pump ' $\mathrm{X}^{\prime}$ - Current |
| PMP ${ }^{\prime}$ 'FIt | Pump ' $\mathrm{X}^{\prime}$ - Last Fault |
| PMP'X'Power | Pump ' $\mathrm{X}^{\prime}$ - Power |
| PMP'X'Run | Pump ' $\mathrm{X}^{\prime}$ - Running |
| PMP'X'Flt | Pump ' $\mathrm{X}^{\prime}$ - Fault |

Table 15 - Altistart 48 Data
The softstarter is also hardwired and configured to start independently from the RTU. The starter must be put into Manual on the front of the panel and then the start and stop push buttons are used to control the starter. Also the starter can be controlled from the SS HMI on the front of the panel.

### 2.2.6.4 Telemecanique VSD - A/tivar 71

The Telemecanique VSD communicates with the RTU over Serial Modbus. The VSD uses Modbus RTU communication protocol and a Modbus RS485/RS232 interface to communicate with the RTU.

The following data can be derived

| Ladder Name | Description |
| :---: | :---: |
| PMP'X'FltCode | Pump ' ${ }^{\prime}$ ' - Fault Code |
| PMP'X'Speed | Pump ' $\mathrm{X}^{\prime}$ - Output Speed in Hz |
| PMP'X'Torque | Pump ' $\mathrm{X}^{\prime}$ - Torque |
| PMP'X'Current | Pump ' $\mathrm{X}^{\prime}$ - Current |
| PMP'X'Voltage | Pump ' $\mathrm{X}^{\prime}$ - Voltage |
| PMP'X'Power | Pump ' ${ }^{\prime}$ ' - Power |
| PMP'X'SupplyV | Pump ' $\mathrm{X}^{\prime}$ - Power supply Voltage |
| PMP'X'Run | Pump ' $\mathrm{X}^{\prime}$ - Running |
| PMP'X'Flt | Pump ' $\mathrm{X}^{\prime}$ - Fault |
| PMP ${ }^{\prime}$ 'DrvThermSt | Pump ' X ' - Drive Thermal State |

Table 16 - Altivar 71 Data
When the station is in "Remote" operation, the speed reference to the VSD is via a $4-20 \mathrm{~mA}$ analog signal from the RTU.

The VSD is also hardwired and configured to start independently from the RTU. The starter must be put into Manual on the front of the panel and then the start and stop push buttons are used to control the starter and a dial knob on the front of the panel is used to control the speed. Also the starter can be controlled from the VSD HMI on the front of the panel.

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## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 2.2.7 HMI - Magelis XBT GT2330

The Magelis HMI has a colour 5.7 inch $320 \times 240$ pixel TFT touch screen, and is used to display site data and locally configure RTU set-points. The HMI is to depict the same display on the SCADA.

The following pages will be available at the HMI display:

- Station Overview. Visual display of the state of the station, pumps, well, and flow.
- Setpoints. Used to set various cut-in and cut-out setpoints.
- Duty. Used to set the pump and site configuration.

Each pump will consist of the following pages:

- Pump Status.
- Pump Statistics (hours run etc)
- Pump Control (start pump, inhibit, reset faults).

The HMI operates by touch. It requires only a light touch to select each option.

### 2.2.7.1 Station Overview Page

From this page the user can instantly visualise the current site status, including:

- Pump status (running/stopped/failed/unavailable).
- Well Level and alarms (High/Low/etc)
- Current Well Setpoints (Cut-ins/Level/etc)
- Site general alarms

The operator may link to Pump Status/Statistics and Controls by selecting the pump in question. Navigation buttons to the following pages will also be provided:

- Site Config: Displays a page allowing configuration of Duty Settings, equipment at the site, and other site specific parameters (such as the Well Washing interval).
- Station: This page provides links to site phase power information, flow rates, and Modbus device communications information.
- RTU: This page provides RTU and communications information.


Figure 1 - HMI Overview Display

### 2.2.7.2 Pump Control Display

The control of the pump, the setting of the setpoints and fault reset are done on a separate window as shown in Figure 2:
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Figure 2 - Pump Control Display

### 2.2.7.3 Logout

To logout the user can either select the logout button on the Station Overview page, or by closing the RTU door.

### 2.2.7.4 Automatic Backlight Off

The HMI backlight will turn off and the login screen displayed if the RTU cabinet door is closed, or a ten (10) minute inactivity timer expires.

### 2.2.8 Power Meter - Electrex Zepto D6

The power meter is used to monitor site power for display and alarming at the SCADA and the local HMI. The power meter is 24 V DC supplied and communicates to the RTU via Modbus RS485. The following data can be derived

| Tag Name | Description |
| :--- | :--- |
| PWR0001AVoltage | Phase 1 Voltage (to Neutral) |
| PWR0001BVoltage | Phase 2 Voltage (to Neutral) |
| PWR0001CVoltage | Phase 3 Voltage (to Neutral) |
| PWR0001ACurrent | Phase 1 Current |
| PWR0001BCurrent | Phase 2 Current |
| PWR0001CCurrent | Phase 3 Current |
| PWR0001APF | Phase A Power Factor |
| PWR0001BPF | Phase B Power Factor |
| PWR0001CPF | Phase C Power Factor |
| PWR0001KWHTD | Kilowatts per Hour Today |
| PWR0001KWHYD | Kilowatts per Hour Yesterday |
| PWR0001KWHTW | Kilowatts per Hour this Week |
| PWR0001KWHLW | Kilowatts per Hour last Week |

Table 17 - Power Meter Data

The power meter is used to monitor site power usage and also display instantaneous values, for phase voltage and current on the Magelis HMI and on the SCADA. All data must be event logged and trended on the SCADA.

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### 2.2.9 Card Reader - Arch Mid Range 232 12B DEC FP3231S

The card reader is used to assist the operators in controlling the access to the site. Every person entering the site has a unique swipe card that is kept on the SCADA system. Once the card is swiped the details of the onsite personnel are displayed on the SCADA showing the Name, Type, and Mobile Phone details in conjunction with the entry time, exit time and time spent on site.


Figure 3 - Card Reader List

### 3.0 RTU CONFIGURATION



Figure 4 - Kingfisher RTU Toolbox

### 3.1 RTU Ladder File Configuration

Each RTU outstation consists of seven ladder files: I/O Mapping, Common Start, Devices, Card Reader, Controls, Common End and Functions. The main purpose of the seven ladder files is to enable IW engineers to create new sites, modify and trouble-shoot existing sites with minimal effort. The I/O Mapping and Controls ladder files are site specific while Common Start, Common End, Devices, Card Reader and Functions ladder files are common for all sites.

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### 3.2 RTU I/O Mapping Ladder File

The I/O mapping is site specific. It contains default values for control set-points (eg. High Level Alarm) and logic used for mapping physical I/O to internal RTU registers. All device fault DIs are timer debounced to prevent nuisance operation in situations where the digital inputs are faulty (eg. power failure due to transient faults, loose wire in switchboard), while other DIs are directly mapped to their matching RTU registers. AIs are filtered (sampled and time-averaged) to produce a more reliable indicator of their values.

### 3.3 RTU Common Start \& Common End Ladder Files

Common Start and Common End ladder files contain logic used for Outstation Master communications, hardware fault alarms, communications statistics and mapped system flags such as current day, time and month.

### 3.4 RTU I/O Devices Ladder File

The I/O Devices Ladder file is common for all sites. It contains a maximum number of I/O devices available that can exist in the field - this includes current devices and the potential addition of more devices (refer to Table 20 for the maximum number of devices).
The RTU code for each device is built from a set of function blocks that perform different operations. All statistics and device status flags e.g. 'Fail To Start', 'Available', 'Fault' 'Starts', 'Hours Run' are derived in the Devices Ladder file. Default values are stored in the I/O Mapping ladder file.

### 3.5 RTU Card Reader Ladder File

The "card reader" ladder file is for the card reader. The card reader code has been included as a separate ladder file so as to allow for ease of use.

### 3.6 RTU Controls Ladder File

The "Controls" ladder file is site specific as each site has different functionality. The logic inside evaluates conditions in the field and decides on when to start or stop pumps, assign Duty or Standby and open or close valves etc.

### 3.7 RTU Functions Ladder File

The "Functions" ladder file contains sub-routines which are called from other ladder files. Register addresses are substituted into the sub-routine parameters.

### 3.8 Master RTU Polling and Communications

### 3.8.1 Event Logging

Each Outstation produces two categories of event logs:
Category $1 \& 3$ Event Logs - are logs of digital and analog events for trend data.
Category 4 Event Logs - are logs of digital states used for alarm triggering.

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### 3.8.2 Sequential Polling

The Master RTU has been programmed to sequentially poll all outstations at independently set time intervals.

On a warm-start, the Master RTU loads predefined polling interval setpoints. From the SCADA, the operator may then vary the polling interval for any site. This can be very useful during alarm storms when the polling period can be increased to monitor a site more frequently. Upon a warm-start of the Master RTU the time intervals will be reset to their default values if the current value is invalid or zero.

### 3.8.3 Exception Polling

When an alarm is triggered in an outstation, a polling request is immediately submitted to the Master RTU. The Master RTU finishes polling the current site and then polls the Alarmed Site and receives all the realtime and event log data. On a change of state or deviation on status information the realtime data is updated in the Master and then returns to it's sequential polling.

### 3.8.4 Force Polling

When the operator presses the force polling button on the communications page or the popup page for the site the Master RTU will get the same polling request as with Exception polling from the site. The resulting action is identical.

### 3.8.5 Loss of Telemetry

The Master RTU keeps track of the communication attempts to each site. If the communication attempt fails for more than a predefined number of times an alarm is triggered by the master for the outstation to which communication was attempted.
If the radio port of the outstation is inactive for a set time period an event log is raised and a message is sent out from the dial-out modem if installed.

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### 4.0 SCADA SYSTEM DESIGN

### 4.1 Existing SCADA System

CitectSCADA Version 7.10 (Unlimited-point license) is currently installed on the CMF SCADA computer at Karagaroo Reservoir and the RMF SCADA computer at the Bell St. Control Room.
Currently the CMF SCADA and the RMF SCADA are running the same Citect project called "Telemetry".

### 4.1.1 Kingfisher Citect Driver

The Kingfisher Citect Driver Extension Module is designed to enable users to quickly and easily configure their Citect systems for the downloading of event logs from the RTUs, into either the Trend or Alarm system of Citect. The Extension Module is basically a .dll, Cicode programming code and a few devices. This module is designed to run on top of the Citect Kingfisher RTU driver, (kingfish.dll) which must be installed prior to running this module along with the project.

### 4.2 Operator Interface \& Access

User access is via a local login. Remote access is via the internet, using a secure VPN connection with RSA SecurID identification.

For the local and remote connections, the SCADA system initially provides the following basic levels of access:

| Access Level | Description |
| :--- | :--- |
| View Only | In this mode, the user can only view the selected screen and is not able to <br> alter any system attributes, equipment status, handle any alarms or <br> generate any reports. |
| Operator | In this mode, the user has access to the entire system with the exception <br> of the configuration of users, system permissions, and screens set-up. |
| Engineer | In this mode, the user has unrestricted access. |

Table 18 - Operator Interface Access Level Definitions
The user access levels specified above are fully configurable with respect to screen accessibility, permissions, and alarm handling to enable a variety of supervisor configured levels of access.

The 'View Only' mode is the default mode, and the access level automatically returns to 'View Only' from either of the two higher levels if the user is inactive for a period of 15 minutes or more.

### 4.3 System Screens

### 4.3.1 General

The system screens are based on a graphical user interface (GUI). The GUI screens allow a point-and-click interface to access the various screen levels. An overview of the entire SCADA system is provided as the top level display, which allows the Operator to click and zoom into individual regions. This overview screen can be found in Appendix B - SCADA Overview Screen.

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Once looking at individual regions, the Operator can access full details of individual sites as applicable to the number of I/O for that site. When viewing an individual site, the Operator is able to force poll the RTU at the selected site via a control button.

The details of each screen and the screen sub-levels are detailed below which simply shows each screen, their relationships and some of the more pertinent functions.

Finally, the SCADA HMI allows for trending of stated I/O values against times.

### 4.3.2 SCADA Symbols

Standard symbols have been developed in SCADA to represent various devices on the sites.

| SCADA Symbol | Device Name |
| :---: | :---: |
| Pump 1 |  |
| Normal |  |
|  | Pump (Softstarter) |
| 0 A |  |
| Pump 1 |  |
| Running |  |
|  | Pump (VSD) |
| $75 \%$ |  |
| Pump 1 |  |
| Running |  |
|  | Pump - Manual operation |
| $75 \%$ |  |
| Pump 1 |  |
| Unavail |  |
|  | Pump - Out of Service mode |
| 0 A |  |


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| SCADA Symbol | Device Name |
| :---: | :---: |
| Flow 1 |  |
| Normal | Flow Meter |
| $17 \mathrm{~L} / \mathrm{s}$ |  |
| Poolling |  |
|  | RTU |
| Force Poll |  |
| Site Trends |  |
| Site Alarms |  |
| Site Event |  |

Table 19 - Standard SCADA Symbols for I/O Devices

### 4.3.3 HMI Examples

The screen mimics show

- Alarms
- Communications
- Communications Main
- Communications Status Pop Up
- Overview Map
- Operator Log
- Drive Pop Up
- Site Statistics Page


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### 4.3.4 Communications Page

The SCADA system incorporates a Communications Page that displays the status of the time sequence polling of the RTUs. This includes the time at which each Outstation RTU is polled, as well as the time the Master RTU is polled. The Operator is also able to adjust the Master RTU poll time, and enable/disable the polling on all RTUs from the Communications Page.

The number of "OK Messages" and "Fail Messages" is displayed for the day for each RTU.
Each RTU has a poll status light, with each light having the following designation:

| Status Light Colour | Polling Status |
| :--- | :--- |
| Blue | RTU polling is disabled |
| Green | RTU polling is active |
| Yellow | RTU communication fault |
| Black | RTU polling is enabled but not active. |

Table 20 - RTU Polling Status
Each RTU has a Polling Control Popup containing a "disable / enable" button and a "force poll" button with each button having a "Confirm Action" attached. The Polling Control Popup also contains the Master Poll Time, the RTU Poll Time, and the Poll Status Light.

Each RTU also has a Status Popup which displays the following:

- RTU Power Supply information including:
- Temperature,
- RTU voltage,
- Current to the RTU
- Current to the battery
- Time and date of last information update
- Communication information including:
- Success Rate for Today, Yesterday, This Week and Last Week (measured in percentage),
- Successful Messages for Today, Yesterday, This Week and Last Week,
- Failed Messages for Today, Yesterday, This Week and Last Week,
- Failed Packets for 'Today', Yesterday, This Week and Last Week;
- "Synchronise Time" button with "Confirm Action" attached.

If communication between an Outstation RTU and the Master RTU fails, a digital alarm is generated.

### 4.3.5 SCADA Security

The SCADA system provides the following security:

- Local access to the SCADA system shall be protected via Citect password protection.
- VPN access shall be protected via the RSA SecurID Token.
- Access is to be at a level determined by operating system security and Citect passwords.
- Operational procedures have been developed to ensure security is not compromised, in particular allocation and renewals of passwords. Accordingly, reference should be made to Ipswich Water's operating procedures.


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### 4.4 Data Storage \& Retrieval

### 4.4.1 Logged Data

All logged data used to provide trends is time and date stamped. Where an Operator is involved with logging data, their identification is also included with the time and date stamp, and the Operator is also able to manually attach a text description to each piece of data stored in the database.

The SCADA system logs the following parameters for the various I/O devices and is displayed on a relevant, separate page:

| I/O Device | Logged Data | Name of Page Displayed |
| :---: | :---: | :---: |
| N/A | All changes of state in any of the digital I/O at the RTUs | Operator / Event Logs <br> (this page contains the last 7 days of logged events) |
|  | All alarm conditions including the handling of these alarms |  |
|  | All paged incidents, including the details of the paged message recipient |  |
|  | All operator actions that change the state of the system such as pump starts and alarm trigger levels |  |
|  | All administrator actions that alter the state of the login system, user permissions, screen updates and other system parameter changes |  |
| Pumps (all) | Number of starts Today, Yesterday, This Week, and Last Week | PMP Statistics |
|  | Run hours Today, Yesterday, This Week, and Last Week |  |
|  | Number of faults Today, Yesterday, This Week, and Last Week |  |
|  | Excess run time and excess starts alarm over a time period |  |
|  | Pump Run indication |  |
|  | Pump Current |  |
| Pumps (Altistart 48 Softstarter) | Thermal State | PMP Statistics |
|  | Active Power <br> Torque |  |
| Pumps (Fuji VSD) | Speed | PMP Statistics |
|  | Frequency |  |
|  | Torque |  |
|  | Voltage |  |
|  | Power |  |
| Pumps (Altivar 71 VSD) | Speed | PMP Statistics |
|  | Frequency |  |

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 Functional Specification| I/O Device | Logged Data | Name of Page Displayed |
| :---: | :---: | :---: |
|  | Torque |  |
|  | Voltage |  |
|  | Power Supply Voltage |  |
|  | Thermal State |  |
| Well Level Transmitters | Instantaneous Level throughout system for display and trending | Well Level |
| Flow Meters | Instantaneous flows throughout the system for display | Flowmeters |
|  | Trending of instantaneous flows throughout system |  |
|  | Totalised flows Today, Yesterday, This Week, and Last Week |  |
| RTU | Charging Voltage | RTU |
|  | Current |  |
|  | RTU Temperature |  |
|  | Supply Voltage |  |
| Generator | Number of starts Today, Yesterday, This Week, and Last Week | Generator |
|  | Run hours Today, Yesterday, This Week, and Last Week |  |
|  | Number of faults Today, Yesterday, This Week, and Last Week |  |
|  | Excess run time and excess starts alarm over a time period |  |
|  | Generator Run indication |  |
| Power Meter | Instantaneous site power usage | Power Meter |
|  | Trending of site instantaneous Power usage |  |
|  | Totalised KWh Today, Yesterday, This Week, and Last Week |  |
| Card Reader | Card Slot 1, 2, 3, 4, 5 | Card Log |
| HMI | Refer to HMI section |  |

Table 21 - SCADA I/O Device Data Logging

### 4.4.1.1 Trending \& Process Analyst

The Process Analyst allows operators to view trend and/or alarm tag data (both real-time and historical) for comparison and analysis during runtime.

The Process Analyst control interface typically consists of the following components:
Main toolbar: Contains commands for performing general operations in the Process Analyst, such as opening views and printing reports.
Pens: A Process Analyst pen represents the trend and/or alarm data. The Process Analyst supports three types of pen: analogue pen, digital pen, and alarm pen, with each pen having its own graphical representation. During run-time, most pen properties are configurable.

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Panes: Panes are used to group pens visually in the Process Analyst and are stacked vertically on the Process Analyst display. Every pen belongs to a single pane.

Chart background (not shown): The panes are drawn over the chart background. Depending on the layout of the pens, the background may be partially visible.
Date/time axis: Located at the top of a pane, the date/time (horizontal) axis displays the date or time (or both) of the data for the primary selected pen within a pane. Only the axis can be configured.

Vertical axis: Analogue pens have a vertical axis on the left-hand side of the pane to indicate data values.

Cursor: A cursor allows an Operator to determine value at a given point in time by dragging the cursor line to the point required.

Cursor labels: Display the value where the cursor intersects the trend value line.
Navigation toolbar: Contains commands to allow an Operator to travel forward or backward through trends, as well as other navigation-related tasks.
Object View: When displayed, the Object View appears under the navigation toolbar and displays information about your Process Analyst pens, such as name, color, scale, and so on.


Figure 5 - Typical Process Analyst screenshot

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### 4.4.2 Data Retrieval

The SCADA system is capable of retrieving all data that has been stored. On retrieval, the Operator is able to filter the data according to category, time and location for each RTU. All data is available for immediate access for a minimum period of 12 months after the data is stored to a trend. If data past this time period is required then the Historian Reports would need to be used instead.

### 4.5 Alarms

The SCADA system raises individual I/O alarms with the level of alarming set as follows:

| Alarm Level | Setting | Required Actions |
| :--- | :--- | :--- |
| Category 1 | Major Alarm | Requires Operator intervention and requires a paged <br> message to be sent after an adjustable, site specific delay. |
| Category 2 | Minor Alarm | Requires Operator intervention but does not require a <br> paged message to be sent |
| Category 3 | Event | Operator's acknowledgement not required before being <br> logged. |

Table 22 - Alarm Levels, Settings \& Required Actions

All analogue alarm set-points can be changed by selecting an appropriate object on the appropriate SCADA screen. All analogue alarms are included as per the site descriptions found later in this document.

### 4.5.1 RTU Alarms

The RTUs raise Category 1 alarms based on the events described as follows.

| Ladder Name | Description |
| :--- | :--- |
| Tamper | Tamper Alarm |
| BattLoAlm | Low Battery Alarm |
| CurrLoAlm | Low Charging Current Alarm |
| SupplyOK | RTU Supply/Battery OK |
| HWAlarm | RTU Module Hardware Alarm |
| LOSAlarm | RTU Loss of Supply Alarm |
| IOScan | RTU IO Scanning Disabled |
| LLEn | RTU Ladder Disabled |
| CommFail | Comms Fail - Inactivity from Polling Master |

Table 23 - Category 1 Alarms (Paged)

The RTUs raises Category 2 alarms based on the events described as follows.

| Ladder Name | Description |
| :--- | :--- |
| HWFItC1 | Hardware Fault Card 1 |
| HWFItC2 | Hardware Fault Card 2 |
| HWFItC3 | Hardware Fault Card 3 |
| HWFItC4 | Hardware Fault Card 4 |
| HWFItC5 | Hardware Fault Card 5 |
| HWFItC6 | Hardware Fault Card 6 |

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| Ladder Name | Description |
| :--- | :--- |
| IOBusFail | I/O Bus Fail |
| CBusFail | Comms Bus Fail |
| RamFIt | RTU RAM Fault |

Table 24 - Category 2 Alarms

The RTUs also have the following Category 3 Alarms (Events) described as follows.

| Ladder Name | Description |
| :---: | :---: |
| CommFail | Comms Fail - Inactivity from Polling Master |
| SyncRTC | Synchronise RTC from SCADA |
| ZEROComm | Zero Today performance stats |
| DisExRepB | Disable Exception Reporting on Port B |
| HWRpt | HW Exception Report |
| AIRpt | AI Exception Report |
| DIRpt | DI Exception Report |
| DAIRpt | Derived AI Exception Report |
| DDIRpt | Derived DI exception report |
| XsEvRpt | XS event Exception Report |
| XsHrRpt | XS Hour Exception Report |
| DORpt | DO Exception Report |
| SCADAWReq | SCADA Write Request |
| CtIDataRpt | TX Data Report |
| ForceRpt | Force Report to occur on analog |
| SPRpt | Setpoint Change Exception Report |
| NoRpt | Dummy flag for no reports |
| LogIndex | Long Pointer for Event Logs |
| XSTimer | Default XS Events timer period |
| PollPeriod | Master Polling Period |
| PollTimer | Master Polling Timer |
| QTBTxBuf | Quiet Time before TX buffer |
| PollTimed | Master Polling Duration |
| FailThresh | Comms alarm Packet Failure threshold SP |
| RXUpdLogs | Number of logs to upload per RTU SP |
| PIT_SP | No. of Pressure Meters |
| FIT_SP | No. of Flow Meters |
| PMP_SP | No. of Pumps |
| VLV_SP | No. of Valves |
| VSP_SP | No. of VSD Pumps |
| LVL_SP | No. of Levels |
| FITPulse_SP | No. of Flow Pulses |
| RAG_SP | No. of Rainfall |
| EventDev | Event Deviation |
| BattLoSP | Low Battery Setpoint |
| CurrLoSP | Low Charging Current Setpoint |
| CommOKTD | RTU - Successful Message Count TD |
| CommOKYD | RTU - Successful Message Count YD |
| CommBadTD | RTU - Failed Message Count TD |
| CommBadYD | RTU - Failed Message Count YD |
| PackBadTD | RTU - Failed Packet Count TD |
| PackBadYD | RTU - Failed Packet Count YD |
| SuccRate_TD | RTU - Success Rate TD |

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| Ladder Name | Description |
| :--- | :--- |
| SuccRate_YD | RTU - Success Rate YD |
| RTUnum | RTU Network Address Number |
| FirmW | Firmware Version |
| InactTimer | Local Inactivity timer buffer |

Table 25 Category 3 Alarms (Events)

### 4.5.2 Category 3 Alarms (Events)

The following events raise a Level 3 alarm.

| Ladder Name | Description |
| :---: | :---: |
| PMP'X'Run | Pump ' ${ }^{\text {' - Running }}$ |
| PMP'X'SStart | Pump ' $\mathrm{X}^{\prime}$ - SCADA Start Cmd |
| PMP'X'SStop | Pump ' $\chi^{\prime}$ - SCADA Stop Cmd |
| PMP'X'TotFltRst | Pump ' $\mathrm{X}^{\prime}$ - Fault Reset |
| PMP'X'TotHrsRst | Pump ' $\mathrm{X}^{\prime}$ - Hours Reset |
| PMP'X'TotStRst | Pump ' $\mathrm{X}^{\prime}$ - Starts Reset |

Table 26 - Category 3 Alarms (Events)

### 4.5.3 Category 2 Alarms

The following alarms can be viewed from the Alarms pages:

| Ladder Name | Description |
| :---: | :---: |
| PMP'X'Manual | Pump ' ${ }^{\prime}$ - Manual Mode |
| PMP ${ }^{\text {P'Ctrl }}$ | Pump ' $\mathrm{X}^{\prime}$ - Auto |
| PMP'X'Inhibit | Pump ' $\mathrm{X}^{\prime}$ - Inhibit |
| FIT'X'HA | Flow Meter ' $\mathrm{X}^{\prime}$ - High Flow Alarm |
| FIT'X'LA | Flow Meter ' X ' - Low Level Alarm |
| FIT'X'LPF | Flow Meter ' $\mathrm{X}^{\prime}$ - Transducer Fail |

Table 27 - Category 2 Alarms

### 4.5.4 Category 1 Alarms (Paged)

The following alarms can be viewed from the Alarms pages and are also paged to the Operator/s:

| Ladder Name | Description |
| :---: | :---: |
| PMP'X'RunXE | Pump ${ }^{\prime} \mathrm{X}^{\prime}$ - Excessive Starts |
| PMP'X'RunXH | Pump ' ${ }^{\text {' }}$ - Excessive Hours |
| PMP ${ }^{\text {P'FTS }}$ | Pump ' ${ }^{\text {' }}$ - Fail to Start |
| PMP'X'CurrLoAlm | Pump ' ${ }^{\text {' }}$ - Low Current |
| PMP'X'CurrHiAlm | Pump ' ${ }^{\text {' }}$ - High Current |
| PMP'X'Flt | Pump ' ${ }^{\text {' - Fault }}$ |
| PMP'X'Rdy | Pump ' ${ }^{\text {' - Ready }}$ |
| PMP'X'RunXH | Pump ' ${ }^{\text {' }}$ - Excessive Hours |
| PMP'X'RunXE | Pump ' ${ }^{\text {' }}$ - Excessive Starts |
| PMP'X'CommsFlt | Pump ' ${ }^{\text {' - Comms Failed }}$ |
| WEL'X'HiLvIAIm | Well ' ${ }^{\text {' }}$ - High Level Alarm |
| WEL'X'LoLvIAlm | Well ' X ' - Low Level Alarm |
| WEL'X'LPF | Well ' X ' - Transducer Fail |

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| Ladder Name | Description |
| :--- | :--- |
| WEL'X'NoChgAlm | Well 'X' - No Level Change Alarm |
| WEL'X'DevInLvIAlm | Well Levels Deviation Alarm |
| WEL'X'_ProbeTestFailed | Well Probe Test Failed |
| WEL'X'_HiHiLvIAlm | Well Duty sensor Hi Hi alarm |
| WEL'X'HiProbeAlm | Well 'X' High Probe - Digital from Multitrode |
| WEL'X'OFLvIAIm | Well 'X' Overflow Level-Digital from Multitrode FSP |
| GeneratorTamper | Generator - Tamper Alarm |
| NoPumpRunAlm | No Pump Run Alarm |
|  |  |

Table 28 - Category 1 Alarms (Paged)

### 4.6 Paging System

The CMF SCADA computer and the RMF SCADA computer currently have the Citect Pager installed to provide SMS alarm messages to the Operators in the event of an alarm. The paging system has been setup to run as a redundant system with the CMF operating as the primary alarm server. The primary pages the NextG phone and the redundant pages the operator's phone. The Alarms stated in Table 23 and Table 28 are required to be loaded into the paging database. These alarms are to be tested at commissioning.

### 4.7 Control \& Operation

### 4.7.1 Device Operation Modes

Each device within the system (with existing suitable I/O) generally has 3 modes of operation:

| Operation Mode | Description |
| :--- | :--- |
| Local | Allows field starting, stopping and motor speed control. <br> Primarily used for maintenance purposes or if the Telemetry <br> System is not operational. |
| Remote Manual | Allows starting and stopping remotely from the SCADA system. <br> This mode still incorporates the appropriate interlocks to <br> prevent dry running of pumps. |
| System Auto | Allows automatic control of the device. <br> This mode is the normal operation of devices whereby they are <br> started and stopped or open and closed automatically based <br> upon the control stated at the various sites. |

Table 29 - Operation Modes
The above modes are also applicable to most devices in the system, with each device having its own Control Popup. The following table outlines the graphical definitions for a pump.

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| Status Colour | Definition |
| :---: | :---: |
| Red | Pump (VSD) running at $75 \%$ at 10 Amps |
| Pump 1 |  |
| Running |  |
|  |  |
| 10 A |  |
| $75 \%$ |  |
| Green |  |
| Pump 1 | Pump (Softstarter) stopped, ready to run |
| Normal |  |
|  |  |
| Yellow |  |
| Pump 1 | Pump (Softstarter) fault |
| Fault |  |
|  |  |
| 0 A |  |
| Grey |  |
| Pump 1 | Pump (Softstarter) stopped, local mode operation |
| Manual |  |
|  |  |
|  |  |


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| Status Colour | Definition |
| :---: | :---: |
| Red with hand | Pump (VSD) in Remote Manual mode and running |
| Pump 1 |  |
| Running |  |
|  |  |
| 10 A |  |
| $75 \%$ |  |
| Grey with tools <br> Pump 1 |  |
| Unavail |  |
|  | Pump (Softstarter) Inhibited |
| 0 A |  |

Table 30 - Pump Status Colours
Typical device Control Popups with associated functionalities are shown in the following Figures.

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Figure 6 - Device Control Popup - 'Operator' tab with button functions

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Figure 7 - Device Control Popup - 'Alarms' tab with button functions


Figure 8 - Device Control Popup - 'Engineer' tab

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Figure 9 - Device Control Popup -Button functions

The Pump 3 in Figure 9 is Inhibited. Clicking on the 'Unihibit' button will return the device to operation.

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## Ipswich Water Sewerage Pump Station Control System Design Functional Specification



Figure 10 - Pump Control Popup - Auto button functions
Figure 10 shows the device in Automatic mode. Clicking on 'Manual' will put the device into Remote Manual mode where the pump can be started or stopped from SCADA. A detailed description is provided in Table 28.

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| Pump Control <br> Popup Button | Pump Operation / Status |
| :--- | :--- |
| Auto | Button 'greyed out' in System Auto mode <br> Button 'active' in Remote |
| Manual | Button 'greyed out' in Remote Manual mode <br> Button 'active' when in System Auto mode |
| Start | Starts the pump when in Remote Manual mode <br> Button 'greyed out' in System Auto mode |
| Stop | Stops the pump when in Remote Manual mode <br> Button 'greyed out' in System Auto mode |
| Reset Fault | Resets faults latched in the RTU. <br> Latching faults include 'Pump Failed to Start'. |
| Inhibit | Button always present except when pressed it <br> changes to 'Uninhibit'. <br> All other buttons become invisible. <br> Prevents pump from running, and device has <br> red tools crossed through it to indicate device is <br> inhibited. |
| Close Popup | Closes popup when pressed. |

Table 31 - Pump Status Buttons
Each of the Pump Control Popup buttons has a 'Confirm Action' attached before the command is initiated.

### 4.7.2 Menu Configuration

When new sites are created, the user must edit the Menu bar to be able to access these new pages.

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 5.0 SCADA SITE DETAILS

This section details the Sewerage System and the Sewerage sites it consists of, that the SCADA and RTU code was developed and implemented for.

### 5.1 Sewerage Station

### 5.1.1 General

Two level sensors are used to monitor the well, one Hydrostatic, the other Ultrasonic. The hydrostatic sensor is the primary control for the pumps and the ultrasonic sensor is a standby device. The standby is used to monitor the primary sensor and to take control if the primary sensor fails. The level sensors are also used to monitor the well level and alarm on either a low, high or a high high level.

Two digital devices are used as a backup failsafe used at the highest levels and are able to control the pumps regardless of the RTU state. A digital output ( If installed refer 5.1.4 ) on the standby level sensor is used to as the primary backup control for the pumps and the pumps will run for a predefined period.
Failing that, a level probe is used in parallel with the RTU pump run output to also trigger the pumps to run continuously. Once the level probe is cleared, the pumps will continue to run for a predefined period.

### 5.1.2 Controls - Sewerage Pump Station

### 5.1.2.1 Remote Manual

In remote manual mode the pumps will no longer start automatically on the level control. The control is done by manually starting and stopping the pumps from the Pump Pop up on Citect. So that the pumps do not run dry, the pumps will stop if the low level alarm is raised and the level transmitter is healthy.

### 5.1.2.2 System Auto

In Automatic mode the RTU controls the pumps dependant on the level position of the hydrostatic level sensor (primary process control device). The pumps are arranged as Duty and Standby. The setpoints are able to be configured from a popup on Citect. The Duty Pump Start and 100\% Speed cannot be set above the Standby Start and the Standby Stop cannot be set to below the Duty Stop. Once the default values are set they must be hard coded into the IOMapping section of ladder code. They will be able to be changed from the SCADA but on initial configuration they will always be configured to defaults. Set points are summarized in Table 32Error! Reference source not found.

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

| Device Operation | Parameter | Level Set-Point |
| :--- | :--- | :--- |
| Duty Pump Stop | Well Level | < default $10 \%$ |
| Duty Pump Start | Well Level | $>$ default 40 \% |
| Duty Pump Start <br> Min Speed | Well Level | default 75 \% |
| Duty Pump 100\% <br> Speed | Well Level | $>$ default $50 \%$ |
| Standby Pump Stop | Well Level | < default $15 \%$ |
| Standby Pump <br> Start | Well Level | $>$ default $55 \%$ |
| Standby Pump <br> Start Min Speed | Well Level | default 75 \% |
| Standby Pump <br> 100\% Speed | Well Level | $>$ default 65 \% |

Table 32-2 Pump Station Operating Set-Points

### 5.1.2.3 Flow Meters

Every site has an RTU analog input for an inflow meter and an outflow meter. If there is a flow meter on either inflow or outflow it can be selected from the popup. If flow meter on site is selected the flow today, Yesterday, This week and Last Week totals use the flow pulse of a configurable value.

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification



Figure 11 - Standard Sewage Pumping Station Level control

The level control can be put into two modes from the Citect Level control popup

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## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 5.1.2.5 Remote Manual Level Control

The level control can be put into remote manual and the level sensor that is to be used for control can be selected.

### 5.1.2.6 Automatic Level Control

The level control can be put into Auto, the Hydrostatic sensor will primarily be used to control the pumps. If the Hydrostatic sensor fails and the Ultrasonic sensor is healthy, the control will switch to the Ultrasonic sensor. Once the Hydrostatic sensor is not in fault, it will resume control of the pumps.

### 5.1.2.7 Duty and Standby Arrangement

The Duty pump is the pump currently running, or if there is no pumps running it is the next pump to start. The Standby pump will only start under the following conditions:
If the Duty pump cannot discharge the well
If the Duty pump has failed
If Duty pump has been made unavailable
If the Duty pump has been put into remote manual.
The Duty Pop-up will allow 3 modes in which you can select duty as detailed in Table 34 below.

| Device Operation | Description |
| :--- | :--- |
| Duty Pump Cycle | Duty pump cycles every time the <br> Duty pump stops |
| Pump 1 Always Duty | Pump 1 is always Duty, Pump 2 is <br> always Standby |
| Pump 2 Always Duty | Pump 2 is always Duty, Pump 1 is <br> always Standby |

Table 33 - Duty Pump Selection

### 5.1.2.8 Motor Control

In the RTU ladder code "I/O Monitoring" you are able to select the type of Motor Control that you require. There are 5 motor control modes that are able to be selected by setting a value of 1 to 5 . These modes (see Table 34) will enable their specific control and enable the correct setpoints to be used. This will also allow for the correct and extended data to be displayed on the popups and for the right pumps to be shown on the site page. Once the default values are set they must be hard coded into the IOMapping section of ladder code.

| Device Operation | Parameter | Level Set-Point |
| :--- | :--- | :--- |
| Emotron Softstarter | Motor Control Mode | 1 |
| VSD Fuji | Motor Control Mode | 2 |
| Softstarter <br> Telemecanique <br> Altistart 48 | Motor Control Mode | 3 |
| VSD Telemecanique <br> Altivar 71 | Motor Control Mode | 4 |
| DOL | Motor Control Mode | 5 |

Table 34 - Motor Control Set-Points

| Ipswich Water |
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### 5.1.2.9 DOL or Emotron Softstarter Control

When the well level rises above the Duty Pump Start Setpoint the Duty pump will start and pump down until the Duty Pump Stop setpoint is reached. If the Level rises above the Duty Pump Level setpoint the Duty pump will then start, if the level continues to rise above the Standby Pump Level Start setpoint the Standby pump will start. The Standby pump will stop when the well level falls below the Standby Pump Stop setpoint and the Duty pump will stop when the well level falls below the Duty Pump Stop setpoint. The pump symbol will be displayed on the site page and the corresponding popups will display the data for this particular motor control. This motor control utilises hardwired I/O to stop and start the pump, receive running, fault, pump current indication and fault reset.

### 5.1.2.10 Softstarter Telemecanique Altistart 48 Control

When the well level rises above the Duty Pump Start Setpoint the Duty pump will start and pump down until the Duty Pump Stop setpoint is reached. If the Level rises above the Duty Pump Level setpoint the Duty pump will then start, if the level continues to rise above the Standby Pump Level Start setpoint the Standby pump will start. The Standby pump will stop when the well level falls below the Standby Pump Stop setpoint and the Duty pump will stop when the well level falls below the Duty Pump Stop setpoint. The pump symbol will be displayed on the site page and the corresponding popups will display the data for this particular motor control. This motor control utilises Modbus TCP to receive fault, pump current indication, fault reset and additional data. The motor run command and run indication are both hard wired to the RTU.

### 5.1.2.11 VSD Fuji Control

When the well level rises above the Duty Pump Start Setpoint the Duty pump will start and will run the pump at the Duty Pump Start Min Speed and pump down until the Duty Pump Stop setpoint is reached and stop.

If the level continues to rise then the speed will increase proportionally until the Duty Pump $100 \%$ Speed Level is reached.
If the Level rises above the Standby Pump Level Start setpoint the Standby pump will start and will run the pump at the Standby Pump Start Min Speed and pump down until the Standby Pump Stop setpoint is reached and stop.

If the level continues to rise then the speed will increase proportionally until the Standby Pump 100\% Speed Level is reached.
The Standby pump will stop when the well level falls below the Standby Pump Stop setpoint and the Duty pump will stop when the well level falls below the Duty Pump Stop setpoint.

The pump symbol will be displayed on the site page and the corresponding popups will display the data for this particular motor control. This motor control utilises Modbus TCP to receive fault, pump current indication, fault reset and additional data. The motor run command and run indications are both hard wired to the RTU.

### 5.1.2.12 VSD Telemecanique A/tivar 71 Control

When the well level rises above the Duty Pump Start Setpoint the Duty pump will start and will run the pump at the Duty Pump Start Min Speed and pump down until the Duty Pump Stop setpoint is reached and stop.

If the level continues to rise then the speed will increase proportionally until the Duty Pump $100 \%$ Speed Level is reached.
If the Level rises above the Standby Pump Level Start setpoint the Standby pump will start and will run the pump at the Standby Pump Start Min Speed and pump down until the Standby Pump Stop setpoint is reached and stop.

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If the level continues to rise then the speed will increase proportionally until the Standby Pump 100\% Speed Level is reached.

The Standby pump will stop when the well level falls below the Standby Pump Stop setpoint and the Duty pump will stop when the well level falls below the Duty Pump Stop setpoint.
The pump symbol will be displayed on the site page and the corresponding popups will display the data for this particular motor control. This motor control utilises Serial\Modbus RTU to receive, fault, pump current indication and additional data. The motor run command and run indications are both hard wired to the RTU.

### 5.1.2.13 Pump Inhibit

An operator, from CITECT will be able to "inhibit" a pump from the normal Duty / Standby pump cycle.

### 5.1.2.14 Station Inhibit

An operator, from CITECT will be able to "inhibit" a station from the normal well level control operation. This is to delay pumping to a downstream station which could be unavailable due to failures or power outage.

By "inhibiting", the station will start at a higher than normal operational well level. The station Inhibit start and stop levels are configurable from CITECT.
When inhibited the Duty pump will not start until the inhibit high level ( default is $80 \%$ ). is reached and will run for a configurable minimum time period (default is 2 minutes ). The pump will continue to run until the well level is at the configurable pump stop level ( default is $75 \%$ ). Refer figure 11 for clarification.
Where the pump speed is controlled by a VSD, the speed will be at minimum at the start level and ramp up to $100 \%$ when the well level reaches the
CITECT configurable Station Max setpoint (Default is $85 \%$ ).
Only the Duty pump will run, the Standby pump start signal is disabled.

### 5.1.3 Alarm

The RTU Monitors the sewerage well, pumps and instrumentation:

### 5.1.3.1 Sewerage Well

### 5.1.3.1.1 Low Level Alarm

When the well level falls below the Low Level setpoint an alarm is sent to Citect and is a backup to stop the pumps at this level if the pumps are running and being controlled in remote manual.

When in MCC Local manual mode this alarm has NO effect on the pump run control.
The Low Level Setpoint must not be able to be set above the Duty Pump Stop Setpoint.

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Well Level | Low Level Alarm | Category 1 (Paged) |

### 5.1.3.1.2 High Level Alarm

When the well level rises above the High Level setpoint an alarm is sent to Citect. The High Level Setpoint must not be able to be set above the Standby Pump Start setpoint.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Well Level | High Level Alarm | Category 1 (Paged) |

### 5.1.3.1.3 High High Level Alarm

When the well level rises above the High High Level setpoint an alarm is sent to Citect. The High High Level Setpoint must not be able to be set below the High Level setpoint.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Well Level | High High Level <br> Alarm | Category 1 (Paged) |

### 5.1.3.1.4 Transmitter Fault Alarm

When the well level sensors go above 20 mA or below 4 mA they are in fault and an alarm is sent to Citect.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Well Level <br> Sensors | Transmitter Fault <br> Alarm | Category 1 (Paged) |

### 5.1.3.1.5 High Probe Level Alarm - Multitrode MTR6 Relay

When the well level rises up to the Multitrode Special Probe a relay in the MTR opens that starts the backup pumps and a digital input in Kingfisher will send an alarm to Citect. There is no setpoint as this is a hardwired digital input.

The alarm is disabled during the routine probe test period. (if applicable, Refer 5.1.4)

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Multitrode MTR | High Probe Level <br> Alarm | Category 1 (Paged) |

### 5.1.3.1.6 High Probe Level Alarm - Multitrode SAFE-FSP Relay

When the well level rises up to the middle stage of a 3 stage Multitrode Probe a relay in the SAFE-FSP opens that starts the backup pumps and a digital input in Kingfisher will sent an alarm to Citect. There is no setpoint as this is a hardwired digital input.

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The alarm is disabled during the routine probe test period. (if applicable, Refer 5.1.4)

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Multitrode <br> SAFE-FSP | High Probe Level <br> Alarm | Category 1 (Paged) |

### 5.1.3.1.7 Overflow Probe Level Alarm - Multitrode SAFE-FSP (If installed)

When the well level rises and trips the upper most contact on a 3 stage multitrode probe a Multitrode alarm relay is activated and an alarm is sent to Citect. There is no setpoint as this is a hardwired digital input.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Multitrode FSP | Overflow Probe Level <br> Alarm | Category 1 (Paged) |

### 5.1.3.1.8 No Change in Level Alarm

Due to the nature of sewerage well, the well level will trend in a repetitive pattern. If the well level doesn't change more than the Change in Level Setpoint in the specified time Period setpoint and alarm is sent to Citect. If the Time Period setpoints is set to 0 then the alarm will be disabled.

Both well levels (LIT1 \& LIT2) are monitored, and have individual citect configurable setpoints for "Change in level" and "Time period".

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Ultrasonic <br> Level Sensor | No Change Alarm | Category 1 (Paged) |
| Hydrostatic <br> Level Sensor | No Change Alarm | Category 1 (Paged) |

### 5.1.3.1.9 Deviation in Level Alarm

With the use of the two level sensors monitoring the well, the RTU compares their level readings. If the two level sensors differ by more than the Level Deviation setpoint, then an alarm is triggered and sent to Citect. If the Level Deviation setpoint is set to 0 then the alarm is disabled.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Well Level | Deviation in Level <br> Alarm | Category 1 (Paged) |

### 5.1.3.1.10 Pump Fault

A fault can be generated from a thermal overload, VSD/Softstarter fault and or a Water Void and an alarm is sent to Citect. This alarm will shut down its corresponding pump and will not restart until the problem is rectified and the alarm is reset remotely from Citect.

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| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Pump | Fault Alarm | Category 1 (Paged) |

### 5.1.3.1.11 Pump Fail to Start

When the RTU has tried to start the pump and the pump has not returned a running indication in a specified time (Fail to Start Setpoint) an alarm is sent to Citect. This alarm will shut down its corresponding pump and will not restart until the problem is rectified and the alarm is reset remotely from Citect or from the Reset on the VSD display module in front of the Switchboard.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Pump | Fail to Start Alarm | Category 1 (Paged) |

### 5.1.3.1.12 Pump Excessive Starts

When the amount of pump starts in the last hour has passed above the Excessive Starts setpoint and alarm is sent to Citect. This alarm is reset remotely from Citect.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Pump | Excessive Starts <br> Alarm | Category 1 (Paged) |

### 5.1.3.1.13 Pump Excessive Hours Run

When the pump has been running continuously and the amount of minutes has passed above the Excessive Hours Run setpoint and alarm is sent to Citect. This alarm is reset remotely from Citect.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Pump | Excessive Hours Run <br> Alarm | Category 1 (Paged) |

### 5.1.3.1.14 No Pumps Run

When no pumps are running and the amount of hours has passed above the No Pump Run setpoint and alarm is sent to Citect. This alarm is reset remotely from Citect.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Pump | No Pump Run Alarm | Category 1 (Paged) |

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## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 5.1.3.1.15 Pump Communications Fault

When Serial 485 RTU communication is lost to the corresponding motor control device (Fuji VSD, Altivar 71 VSD and Altistart 48 softstarter) an alarm is sent to Citect. This alarm is reset remotely from Citect.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Pump | Comms Fault Alarm | Category 1 (Paged) |

### 5.1.3.1.16 Pump Low Current Alarm

When the pump current is lower than a threshold Setpoint for a time period, an alarm is sent to Citect. Both the setpoint and time period are configurable from Citect. The time period is common for both high and low alarms.
This alarm is reset remotely from Citect.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Pump | Low current Alarm | Category 1 (Paged) |

### 5.1.3.1.17 Pump High Current Alarm

When the pump current is higher than a threshold Setpoint for a time period, an alarm is sent to Citect. Both the setpoint and time period are configurable from Citect. The time period is common for both high and low alarms.
This alarm is reset remotely from Citect.

| Device <br> Operation | Alarm | Alarm Type |
| :--- | :--- | :--- |
| Pump | High current Alarm | Category 1 (Paged) |

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### 5.1.4 Backup Control System

The backup control system is independent of the RTU control. It is to control the pumps should a failure to the RTU or any instrumentation occur.

There are two methods of back up control used. Most sites have a Multitrode MTR -5 controller installed while some use a Multitrode SAFE-FSP controller.

Stations that have a Multitrode SAFE-FSP controller installed and do not use the MTR digital output are

| S010 | SP12 | Nelson St |
| :--- | :---: | :--- |
| S015 | SP17 | Hudson St |
| S018 | SP20 | Sutton St |
| S041 | SP54 | Blackall St |

### 5.1.4.1.1 MTR-5 Operation

The MTR-5 Relay is configured to turn on a digital output from the pump relay at a preconfigured level (90\%). This will activate the backup control relay which will start the first pump and after a short period the second pump will start. Both pumps will pump for a preset time period. This time period must be set up on site and must be for the duration of one pump cycle.

The backup control system will automatically start the pump irrespective of the local Man/Off/Auto selector switch's selection - either in the Manual or Auto position. The pump will not start if the switch is in the OFF position.

When the Backup control relay is activated the red flashing light on top of the switchboard will be activated and an High Probe Level Alarm will be sent to Citect.

The MTR-5 probe is regularly tested by the RTU, the "Probe Test" operation is described in section 5.1.6.

### 5.1.4.1.2 SAFE-FSP Operation

The SAFE-FSP Backup Controller is wired directly to the pump controls and controls the pumps should a failure occur to the RTU or the level transmitters. The controller works independently of the RTU control.

A 3-sensor Multitrode probe - as the name implies - has 3 sensors mounted 150mm apart within the 500 mm length probe. They are named (starting from the bottom of the probe) LO Probe sensor, HI Probe sensor and AL Probe sensor. The FSP Backup Controller has 3 Output relays, DO1 (Level Alm/Pump Flt), DO2 (Pump Control) and DO3 (Probe/Failsafe Alm). Dip switch 6 determines the output sense of DO1 and DO3. The FSP has been set up with dip switch $6=$ OFF. This implies that the contacts are Closed and Open on alarm. This selection is crucial to the functionality of the hardwired relays in the switchboard fed from these contacts.

When the RTU is out of commission or perhaps if both level transmitters are faulty and the well level rises, the FSP works as follows:

There is no action when the LO PROBE sensor is activated.

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When the HI PROBE sensor is activated, DO2 is energized (Pump Control Active - K230-2 = On) which starts the pumps, Pump 1 first and 12 seconds later Pump 2. This also triggers the High Probe Level Alarm in Citect.

Should the level decrease so that the LO PROBE sensor de-activates, the pumps will continue to run for the period set by the delay-off timer (1 minute) before switching the pumps off.

However, should the level continue to rise and the AL PROBE sensor is activated, DO1 is energized (Level Alm). A Multitrode Overflow Probe Level Alarm will be raised for the Citect. This also activates the red flashing light on top of the switchboard.

The Backup Control system will automatically start the pumps if the local Man/Off/Auto select switch is in Auto position. A pump will not start if its switch is in the OFF position

### 5.1.5 Station Generator

The standby generator is able to run the station when mains power is not available. On the overview page an indication shows the status of the generator on each site

| Device Operation | Description |
| :--- | :--- |
| Tamper | Generator is on site and the supply <br> to the battery charger is functional |
| Ready | Generator is connected and ready <br> for operation |
| Fault | Generator has Faulted |
| Running | Generator is running |

Table 35 - Generator Status

On the site page in the RTU popup under the engineering tab generator on site can be set to 1 and then a generator symbol will appear on the site page. The symbol shows the state of the generator.

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### 5.1.6 Sewerage Well Probe Test

A probe test is used to test the surcharge imminent alarm. A periodic automatic test of the Multitrode single point electrode will be carried out for 2 seconds at midnight, 6 am, 12 noon and 6 pm . A RTU digital output will cause a circuit to ground on the return path of the electrode. This test is to confirm that the cable, Multitrode relay and RTU digital input are all functioning correctly.

Once the Probe test is completed, a "Probe Test Successful" alarm message will be sent to Citect and the probe test operation time will be updated.
If the Probe test fails then an alarm will be sent to Citect. This test will not effect the operation of the surcharge imminent pump operation.

The sewage pump probe test can be put into manual mode from the CITECT Level Control Popup.
The sewage pump probe test can be disabled from Citect.

### 5.1.7 Fault Resetting Inhibit

Once the fault reset button is pressed on any of the Popups, a Pump Remote Reset command is issued to the RTU and an alarm is sent to Citect.

The Reset operation will be locked out for 15 mins. This is used to reduce the risk of damaging a pump by pressing the reset button too many times.

### 5.1.8 Two Pump Sewerage Pump Station- Inputs/Outputs

The following RTU Inputs/Outputs are configured.

| CP-11 | Physical Slot 2 |
| :--- | :--- |
| Port 1 | Serial RS-232 to Card Reader |
| Port 2 | Serial RS-232 to Digital Radio |
| Port 3 | Ethernet to Magelis Screen |


| MC-11 | Physical Slot 3 |
| :--- | :--- |
| Port 1 | Serial RS-232 to Pumps |

Table 36 - RTU Inputs and Outputs

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### 5.1.9 IO List

| DI-5 | Physical Slot 4 | Alarm | Trend |
| :--- | :--- | :--- | :--- |
| DI Ch1 | Supply Authority Supply OK | Cat 1 |  |
| DI Ch2 | PS Mains OK | Cat 1 |  |
| DI Ch3 | Tamper Alarm OK | Cat 1 |  |
| DI Ch4 | Flow Meter Pulse |  | Yes |
| DI Ch5 | Wet Well Overflow Alarm | Cat 1 |  |
| DI Ch6 | Wet Well High Alarm | Cat 1 |  |
| DI Ch7 | Water Void | Cat 1 |  |
| DI Ch8 | Dry Well Flood | Cat 1 |  |
| DI Ch9 | Sump Pump Running |  | Yes |
| DI Ch10 | Sump Pump Fault | Cat 1 | Yes |
| DI Ch11 | Vent Fan Running |  | Yes |
| DI Ch12 | Vent Fan Fault | Cat 1 | Yes |
| DI Ch13 | Generator Running | Cat 1 | Yes |
| DI Ch14 | Generator Fault | Cat 1 | Yes |
| DI Ch15 | Generator Tamper OK | Cat 1 |  |
| DI Ch16 | Multitrode Probe Failsafe Alarm | Cat 1 |  |


| IO-3 | Physical Slot 5 | Alarm | Trend |
| :--- | :--- | :--- | :--- |
| AI Ch1 | Spare |  |  |
| AI Ch2 | Spare |  |  |
| AI Ch3 | Hydrostatic Level (Level 1) |  | Yes |
| AI Ch4 | Delivery Flow |  | Yes |
| AO Ch1 | Spare |  |  |
| DI Ch1 | Pump No. 1 Running | Cat1 | Yes |
| DI Ch2 | Pump No. 1 Fault |  |  |
| DI Ch8 | Pump No. 1 Auto Selected | Cat1 | Yes |
| DI Ch9 | Pump No.1 Water in Oil | Cat 1 | Yes |
| DO Ch1 | Pump No.1 Run Relay | Cat 1 | Yes |
| DO Ch2 | Spare | Cat 1 | Yes |
| DO Ch3 | Station Comms Fault |  |  |
| DO Ch4 | Station Fault Relay |  |  |

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

| IO-3 | Physical Slot 6 | Alarm | Trend |
| :--- | :--- | :--- | :--- |
| AI Ch1 |  |  |  |
| AI Ch2 | Spare |  |  |
| AI Ch3 | Ultrasonic Level (Level 2) |  | Yes |
| AI Ch4 | Delivery Pressure | Yes |  |
| AO Ch1 | Spare |  |  |
| DI Ch1 | Pump No. 2 Running | Cat 1 | Yes |
| DI Ch2 | Pump No.2 Fault |  |  |
| DI Ch3 | Pump No. 2 Auto Selected | Cat 1 | Yes |
| DI Ch4 | Pump No. 2 Water in Oil |  |  |
| DO Ch1 | Pump No.2 RUN Relay |  |  |
| DO Ch2 | Spare |  |  |
| DO Ch3 | Overflow Earth Test Relay | Cat 1 | Yes |
| DO Ch4 | Station Fault Reset |  |  |

Table 37-2 Pump Station IO Slot Allocation

### 5.1.10 Physical Slot Addressing

The RTU consists of the following cards:

- Slot 1 - PS-11
- Slot 2 - CP-11-TI
- Slot 3 - MC-11
- Slot 4 - DI-5
- Slot 5 - IO-3
- Slot 6 - IO-3
- Backplane - BA6


### 5.1.11 Analogue Measurements Scaling

The scaling for the analogue meters at 2 Pump Sewerage Pump Station is:

- Flow Meter = 0...' $x^{\prime}$ L/s
- Hydrostatic (Level 1 ) $=0$... $100 \%$
- Ultrasonic (Level 2) $=0 . . .100 \%$
- Pump No. 1 Current $=0$...' $x^{\prime}$ Amps
- Pump No. 2 Current $=0$...' $x^{\prime}$ Amps


### 5.1.12 Site Interlocks

Ipswich water has decided that it is unlikely that interlocking will be required on sewage pumping station. The standard drawings will therefore not include any interlocking in the hardwiring.
If interlocking is required (for either hydraulic or electrical reasons), this will be a site specific requirement outside the standard which is to be incorporated in both the electrical hard wiring and the RTU software to ensure the interlocking is effectively implemented.

## Ipswich Water Sewerage Pump Station Control System Design

 Functional Specification
### 6.0 APPENDIX A - TELEMETRY DIAGRAM



## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 7.0 APPENDIX B - SCADA OVERVIEW SCREEN



## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 8.0 APPENDIX C - RTU MODULE SPECIFICATIONS

### 8.1 Appendix C1 - PC-1 Processor

| Parameter | Specification |
| :---: | :---: |
| Processor | Intel 80C188 |
| Word size | 16-bit internal data bus 8-bit external data bus |
| Clock speed | 16 MHz |
| BIOS | Y |
| FLASH RAM | 128 K total. 28 K for firmware drivers. |
| Static CMOS RAM | 256 K |
| Realtime clock | Y |
| Watchdog timer | Y |
| Status indication | Y |
| Battery Life - module unpowered | 15 years (128 K) RAM 10 years (256 K) RAM |
| Communication Ports | 2 |
| Port 1 | (RS232) Serial, 300 to 115200 Baud |
| Port 2 | (Optional) Serial, Radio, 2-Wire Line or <br> 4-Wire Line <br> 300 to 115200 Baud (depending on <br> Baud type) |
| Modem Port 2 CCITT V23 (Optional) | 1200 Baud Communications Outstation / Master |
| Configuration Software | Toolbox |
| Diagnostics Software | Y |
| Basic Configuration | Automatic on power-up |
| RTU Address Range | 1-249 |
| Communications Protocol | Kingfisher, Modbus |
| Analogue Block Processing | Y |
| PID Block Processing | Y |
| Logic Processing | Ladder |
| CPUs per RTU | 1 |
| Internal Power Consumption | 120 mA from $+5 \mathrm{~V}_{\mathrm{dc}}$ |
| Auxiliary 24 V Converter | 10 Watts, 400 mA @ $24 \mathrm{~V}_{\mathrm{dc}}$ |
| I/O Bus Data Rate | $250 \mathrm{kBit} / \mathrm{s}$ |
| CM Bus Data Rate | $83 \mathrm{kBit} / \mathrm{s}$ |
| Cyclic Redundancy | Port 1 and 2 |
| Input Supply to PC-1 | $11.5-15 \mathrm{~V}_{\mathrm{dc}} @ 4 \mathrm{~A} \operatorname{Max}$ (50 W) Typically $13.8 \mathrm{~V}_{\mathrm{dc}}$ if backup battery connected |
| Output Supply from PC-1 | $\begin{aligned} & +5 \mathrm{~V}_{\mathrm{dc}} @ 1 \mathrm{~A}(5 \mathrm{~W} \text { to bus) } \\ & +12 \mathrm{VV}_{\mathrm{dc}} @ 4 \mathrm{~A} \mathrm{Max} \text { to bus* } \\ & +12 \mathrm{~V}_{\mathrm{dc}} @ 2 \mathrm{~A} \mathrm{Max} \text { to } \mathrm{Vr}^{*} \\ & +24 \mathrm{~V}_{\mathrm{dc}} @ 400 \mathrm{~mA}(10 \mathrm{~W}) \text { to Optional } \\ & \text { Auxiliary Output ( } 3 \mathrm{kV} \text { Isolation) } \end{aligned}$ |
| Backup Battery* | $12 \mathrm{~V}, 7$ AH typical, 26 AH max. |
| Deep Discharge Protection | RTU Shutdown at 10.6 V RTU Startup at 11.8 V |
| Supply Fuse | 8 A (Maximum current into the PC-1) |

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

| Parameter | Specification |
| :--- | :--- |
| Battery Fuse | 8 A (Maximum current into or out of the |
|  | battery) |
|  | 3 A polyphase |
| Combined Vr and $24 \mathrm{~V}_{\mathrm{dc}}$ Fuse | Battery Current $\pm 10 \%$ |
|  | PC-1 Supply Voltage $\pm 5 \%$ |
|  | PC-1 Supply Current $\pm 10 \%$ |
|  | PC-1 Temperature $\pm 5 \%$ |
|  | Battery Low N/A |
|  | Battery Charging N/A |
| Monitoring Item Accuracy | Battery Discharging N/A |
|  | Aux. 24 V present N/A |
|  | AC present (determined from Battery |
|  | Discharging signal) N/A |
| * Note: power output is dependent on power supply to the PC-1. Most PC-1s |  |
| are powered using the 35 W PSU-3 power supply. |  |
| \# The +24V converter is optional and must be ordered with the PC-1. |  |

Table 38 - PC-1 Processor Specifications

### 8.2 Appendix C2-CP-11 Processor

| Parameter | Specification |
| :--- | :--- |
| Processor | Intel 80C386EX |
| Word size | 32 -bit internal data bus <br> 16 -bit external data bus |
| Clock speed | Selectable 16-33 MHz (Default 25 MHz) |
| BIOS | Y |
| FLASH RAM | 1 MB total <br> 64 K for CP-11 drivers |
| Static CMOS RAM | 1 MB |
| Realtime clock | Y |
| Watchdog timer | Y |
| Status indication | Y |
| Battery Life - module unpowered | 10 years |
| Communication Ports | $1-3$ |
| Comm Port 1 (RS232) | 300 to 115200 Baud |
|  | Optional: not fitted, <br> RS232/RS485/RS422, PSTN, PLINE, <br> Radio, Video, Hart, Fibre-Optic |
| Comm Port 2 | Optional: not fitted, <br> RS232/RS485/RS422, PSTN, PLINE, <br> Radio, Video, Hart, Fibre-Optic |
| Comm Port 3 | Toolbox |
| Configuration Software | Y |
| Diagnostics Software | Toolbox |
| Complex Configuration | $1-249$ (expandable to 2000 by using |
| RTU Address Range | multiple masters) |
| Communications Protocol | Kingfisher, Modbus |
| Analogue Block Processing | Y |
| PID Block Processing | Y |
| Logic Processing | Ladder |
| CPUs per RTU | 1 or 2 |
| Internal Power Consumption | 275 mA from +5 Vdc bus on backplane |
|  |  |

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## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

| Parameter | Specification |
| :--- | :--- |
| $\mathrm{I} /$ O Bus Data Rate | $250 \mathrm{kBit} / \mathrm{s}$ |
| CM Bus Data Rate | $83 \mathrm{kBit} / \mathrm{s}$ |
| Operating Temperature | -20 to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \% \mathrm{RH}$ non-condensing |

Table 39 - CP-11 Processor Specifications

### 8.3 Appendix C3 - PS-11 Power Supply

| Parameter | Measurement |
| :---: | :---: |
| Input Supply | 90 to $260 \mathrm{~V}_{\mathrm{ac}} 50 / 60 \mathrm{~Hz}$ <br> Note: module can also be powered using 12 to 13.8 V when powered from backup battery terminals |
| Backup Battery | 12 V dc, 26 AH max., sealed lead-acid or NiCad |
| Outputs | +5 V @ 3 A Max. to Bus <br> +12 V @ 4 A Max. to Bus <br> $+12 \mathrm{~V} @ 4 \mathrm{~A}$ Max. to Battery <br> +13.8 V @ 4 A Max. to Radio <br> +24 V Isolated @ 400 mA Max. to Field (optional) <br> Maximum power output: 60 W |
| Isolation | 3 kV AC input/DC output 3 kV Isolated $24 \mathrm{~V}_{\text {dc }}$ output |
| Deep Discharge Protection | RTU Shutdown at $10.5 \mathrm{~V} \pm 0.2 \mathrm{~V}$ <br> RTU Startup at $11.8 \mathrm{~V} \pm 0.2 \mathrm{~V}$ |
| Supply Fuse | Slow blow internal |
| Battery Fuse | 1.6 A |
| Connector | Removable for AC/DC connections |
| LED indicators (Standard) | OK - Microprocessor Watchdog <br> Vsup - DC voltage present <br> Vb - Battery voltage present <br> 5V - 5V present <br> Vaux - Auxiliary converter present <br> Batt CHG - Battery charging <br> FL - Float charge <br> BO - Boost Charge <br> LO - Battery Low |
| Monitoring | Battery Current ( $\pm 10$ \%) <br> Battery Voltage* ( $\pm 2$ \%) <br> Supply Current* ( $\pm 10$ \%) <br> Temperature ( $\pm 1$ \%) <br> AC present <br> Battery low <br> Aux. 24 V present |
| Control Circuits | Aux 24 V on/off Radio Power on/off |
| * Note: The battery voltage is monitored when the input supply is disconnected. While the input supply is connected, the module will measure the regulated voltage and current output of its AC input circuit. |  |

Table 40 - PS-11 Processor Specifications

Sewerage Pump Station Control System Design

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

### 8.4 Appendix C4 - DI-5 Digital Input Module

| Parameter | Specification |  |
| :---: | :---: | :---: |
| Input Voltage Range | + 12 to 24 VDC (support reverse polarity) |  |
| Input per Module | 16 |  |
| Input Characteristics | Impedance | 2.7 k |
|  | On-state Voltage | $\begin{aligned} & +7.5 \text { to } 28 \text { VDC (support reverse } \\ & \text { polarity) } \end{aligned}$ |
|  | Off-state Current | + 3.5 VDC maximum |
|  | On-state Current | + 4.3 mA minimum |
|  | Off-state Current | + 1 mA Maximum |
|  | On response Time | Channels 1 and 2: $50 \mu \mathrm{~S}$ maximum Channels 3 and 4: $500 \mu \mathrm{~S}$ maximum Channels 5 to 16: 10 mS maximum |
|  | Off response Time | Channel 1 and 2: $50 \mu \mathrm{~S}$ maximum Channels 3 and 4: $500 \mu \mathrm{~S}$ maximum <br> Channels 5 to 16: 17 mS maximum |
| Isolation | Maximum working voltage in respect to system earth/ground must not exceed SELV limits (42.4 Vpeal/60 VDC) Transient voltage: 1.5 kV |  |
| Output Power | 12 VDC @ 250 mA (3 W) isolated, supplied by module |  |
| Operating Temperature | -20 to $50^{\circ} \mathrm{C}$ |  |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |  |
| Operating Humidity | 5 to 98\% RH non-condensing |  |
| Pulse Totalisation | Channels 1 to 4: 0-65535 Pulses |  |
| Pulse Rates / Frequency | Channels 1 and 2: 10 kHz maximum Channels 3 and 4: 255 Hz maximum |  |
| Hot Swap | Yes. Module can be swapped while RTU is running. Hot swap will not cause a Warm Start. Inputs are cleared in RTU memory while module is removed. |  |

### 8.5 Appendix C5 - IO-3 Combination Analog/Digital I/O Module

| Parameter |  |
| :--- | :--- |
| Specification |  |
| ANALOG INPUTS | 4 to 20 mA or 0 to 20 mA |
| Input Current Ranges | 1 to 5 V and 0 to $5 \mathrm{~V} *$ |
| Input Voltage Ranges * | 4 |
| Inputs per Module | Factory calibrated to $5 \mu \mathrm{~A}$ |
| Calibration | 2 mS (all four channels) |
| Update Rate | $+0.1^{\circ} \%$ @ $25^{\circ} \mathrm{C} .+0.25 \%$ @ -20 to $50^{\circ} \mathrm{C}$ |
| Accuracy | 12 bit (no sign bit) |
| Resolution | $<1$ Least Significant Bit |
| Linearity |  |

[^7]
## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

| Parameter | Specification |
| :---: | :---: |
| Isolation | - Maximum working voltage in respect to system earth/ground must not exceed SELV limits (42.4 Vpeak/60 VDC) <br> - Transient voltage: 1 kV |
| Common Mode Rejection | $>70 \mathrm{~dB}$ at DC; $>70 \mathrm{~dB}$ at 60 Hz |
| Cross-Channel Rejection | $>80 \mathrm{~dB}$ from DC to 1 kHz |
| Input Impedance | $250 \Omega$ standard <br> $10 \mathrm{k} \Omega$ optional - the internal load resistors can be factory removed if high impedance voltage inputs are required |
| Input Filter Response | 325 Hz |
| ANALOG OUTPUT |  |
| Output Current Range | 4 to 20 mA or 0 to 20 mA |
| Outputs per Module | 1 |
| Calibration | Factory calibrated to $68 \mu \mathrm{~A}$ per count |
| Supply Voltage (nominal) | +5 VDC and +12 VDC from backplane |
| Update Rate | 250 ms (all channels) Determined by I/O scan time, and is application dependent |
| Accuracy | $+0.2 \% @ 25^{\circ} \mathrm{C} .+0.5 \%$ @ -20 to $50^{\circ} \mathrm{C}$ |
| Resolution | 12 bit (no sign bit) |
| User Load | 0 to $850 \Omega$ |
| Output Load Capacitance | 2000 pF |
| Output Load Inductance | 1 H |
| Isolation | - Maximum working voltage in respect to system earth/ground must not exceed SELV limits (42.4 Vpeak / 60 VDC) <br> - Transient voltage: 1 kV |
| DIGITAL INPUTS |  |
| Input Voltage Range | 0 to $30 \mathrm{VAC/DC}$ |
| Inputs per Module | 4 |
| Isolation | - Maximum working voltage in respect to system earth/ground must not exceed SELV limits (42.4 Vpeak/60 VDC) <br> - Transient voltage: 1 kV |
| Input Current | 4 mA (typical) at rated voltage |
| Input Characteristics | On-State Voltage 11.5 to 30 VAC/DC |
|  | Off-state Voltage 0 to 4 VAC/DC |
|  | On-State Current 3.2 mA minimum |
|  | Off-state Current 1 mA Maximum |
|  | On response Time 10 ms Typical |
|  | Off response Time 17 ms typical |
| DIGITAL OUTPUTS |  |
| Outputs per Module | 4 |
| Commons | 1 (common supplies all 4 outputs) |
| Relay Type | SPNO (Single Pole, Normally Open) |
| Maximum Switched Voltage | $30 \mathrm{VDC}, 29$ VAC |
| Maximum Switched Current | 4 A per channel 5 A per channel |

Sewerage Pump Station Control System Design

## Ipswich Water Sewerage Pump Station Control System Design Functional Specification

| Parameter | Specification <br> Isolation |
| :--- | :--- |
| Maximum working voltage in respect |  |
| to system earth/ground must not |  |
| exceed SELV limits (42.4 Vpeak / 60 |  |
| VDC) |  |
| Transient Voltage: 3 kV |  |$|$

[^8]| Ipswich Water |
| :--- |
| Sewerage Pump Station Control System Design |
| 0005690-DF-001 Functional Spec.doc |

## 4. Vega

## VEGAWELL 72

## Product Information

## Content

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2 Type overview ..... 4
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## Take note of safety instructions for Ex applications

Please note the Ex specific safety information which you can find on our homepage www.vega.comlservicesldownloads and which comes with every instrument. In hazardous areas you should take note of the appropriate regulations, conformity and type approval certificates of the sensors and power supply units. The sensors must only be operated on intrinsically safe circuits. The permissible electrical values are stated in the certificate.

## 1 Description of the measuring principle

## Measuring principle

VEGAWELL 72 pressure transmitters work according to the hydrostatic measuring principle, which functions independently of the dielectric properties of the product and is not influenced by foam generation.

The sensor element of VEGAWELL 72 is the dry ceramic-capacitive CERTEC ${ }^{\circledR}$ measuring cell. Base element and diaphragm consist of high purity sapphire-ceramic ${ }^{\circledR}$.

The hydrostatic pressure of the product causes via the diaphragm a capacitance change in the measuring cell. This capacitance change is converted into an appropriate output signal.


Fig. 1: Configuration of the CERTEC ${ }^{\circledR}$ measuring cell with VEGAWELL 72
1 Diaphragm
2 Soldered glass bond
3 Base element
The advantages of the CERTEC ${ }^{\circledR}$ measuring cell are:

- Very high overload resistance
- No hysteresis
- Excellent long-term stability
- Completely front flush installation
- Good corrosion resistance
- Very high abrasion resistance


## Wide application range

VEGAWELL 72 is suitable for level measurement in deep wells and ballast tanks as well as for gauge measurement in open flumes. Typical media are drinking water and waste water as well as water containing abrasive substances. All signal outputs are available in $4 \ldots 20 \mathrm{~mA}$ and $4 \ldots 20 \mathrm{~mA} / \mathrm{HART}$.

In the $4 \ldots 20 \mathrm{~mA} / \mathrm{HART}$ - Pt 100 version, a temperature sensor Pt 100 in four-wire technology is optionally integrated in the transducer. Power supply or processing are carried out via an external temperature transducer.

## 2 Type overview

## VEGAWELL 72

Measuring cell:
Media:
Process fitting:
Material process fitting:
CERTEC ${ }^{\circledR}$
drinking water and waste water
straining clamp, screwed fitting, thread, flange

316L
Material, suspension cable: PE, PUR, FEP
Material transmitter:
316L, 316L with PE-coating, PVDF, Titanium
Diameter transmitter:

$$
\text { depending on material min. } 32 \mathrm{~mm}
$$

Measuring range:
Process temperature:
$20 \ldots+100$
Deviation:
Signal output:
Operation:
$<0.2 \%,<0.25 \%,<0.1 \%$

4 ... $20 \mathrm{~mA}, 4$... $20 \mathrm{~mA} /$ HART
depending on the version via VEGADIS 12 or PACTware/PC

## 3 Mounting instructions

## Mounting position

The following illustration shows a mounting example for VEGAWELL 72. The VEGA price list contains suitable mounting brackets under the section Accessories. With these parts, standard mounting arrangements can be realised quickly and reliably.


Fig. 2: Version with closing screw in a pump shaft
VEGAWELL 72 must be mounted in a calm area or in a suitable protective tube. This avoids lateral movements of the transmitter and the resulting corruption of measurement data.

i

## Note:

 As an alternative, we recommend using the instrument holder from the line of VEGA accessories, article no. BARMONT.B, to fasten the transmitter.The suspension cable contains apart from the connection cables and the suspension wire also a capillary for atmospheric pressure compensation. All versions can be shortened on site.

With VEGAWELL 72, the electronics is completely integrated in the transmitter. The cable end can be lead directly to a dry connection compartment. Pressure compensation is then carried out via the filter element of the capillaries.


## Note:

The pressure compensation housing VEGABOX 02 is recommended for connecting VEGAWELL 72.

It contains a high-quality ventilation filter and terminals. A protective cover is optionally available for use outdoors.

## Mounting versions

The following illustrations show the different mounting versions depending on the instrument type.

Mounting with straining clamp


Fig. 3: Straining clamp
1 Suspension cable
2 Suspension opening
3 Clamping jaws

Mounting with screwed fitting


Fig. 4: Threaded fitting
1 Suspension cable
2 Seal screw
3 Cone bushing
4 Seal cone
5 Threaded fitting
6 Seal

## Mounting with housing and thread



Fig. 5: Housing with thread G1½ A
1 Housing
2 Seal
3 Thread

## 4 Electrical connection

### 4.1 General requirements

The supply voltage range can differ depending on the instrument version. You can find exact specifications in chapter "Technical data".

The national installation standards as well as the valid safety regulations and accident prevention rules must be observed.

In hazardous areas you should take note of the appropriate regulations, conformity and type approval certificates of the sensors and power supply units.

### 4.2 Voltage supply

Supply voltage and current signal are carried on the same twowire cable. The requirements on the power supply are specified in chapter "Technical data".

The VEGA power supply units VEGATRENN 149AEx, VEGASTAB 690, VEGADIS 371 as well as VEGAMET signal conditioning instruments are suitable for power supply. When one of these instruments is used, a reliable separation of the supply circuits from the mains circuits according to DIN VDE 0106 part 101 is ensured.

### 4.3 Connection cable

## In general

An outer diameter of $5 \ldots 9 \mathrm{~mm}$ ensures the seal effect of the cable entry. If electromagnetic interference is expected, screened cable should be used for the signal lines.

The sensors are connected with standard two-wire cable without screen.


In Ex applications, the corresponding installation regulations must be noted for the connection cable.

### 4.4 Cable screening and grounding

If screened cable is necessary, the cable screen must be connected on both ends to ground potential. If potential equalisation currents are expected, the connection on the evaluation side must be made via a ceramic capacitor (e.g. $1 \mathrm{nF}, 1500 \mathrm{~V}$ ).

### 4.5 Wiring plan VEGAWELL 72-4 ... 20 mA

## Direct connection



Fig. 6: Wire assignment, suspension cable
1 blue (-): to power supply or to the processing system
2 brown (+): to power supply or to the processing system
3 Shielding
4 Breather capillaries with filter element

## Connection via VEGABOX 02



Fig. 7: Terminal assignment VEGABOX 02
1 To power supply or the processing system
2 Shielding

## Connection via housing



Fig. 8: Terminal assignment of the housing
1 To power supply or the processing system

[^9]
### 4.6 Wiring plan VEGAWELL 72-4 ... $20 \mathrm{~mA} /$ HART

## Direct connection



Fig. 9: Wire assignment, connection cable
1 brown (+): to power supply or to the processing system
2 blue (-): to power supply or to the processing system
3 yellow: is only required with VEGADIS 12, otherwise connect to minus or with VEGABOX 02 to terminal $3^{2)}$
4 Shielding
5 Breather capillaries with filter element

## Connection via VEGADIS 12



Fig. 10: Terminal assignment, VEGADIS 12
1 Voltage supply and signal output
2 Control instrument (4 ... 20 mA measurement)

Connection via housing


Fig. 11: Terminal assignment of the housing
1 To power supply or the processing system

### 4.7 Wiring plan VEGAWELL 72-4 ... $20 \mathrm{~mA} /$ HART - Pt 100

## Direct connection



Fig. 12: Wire assignment, connection cable
1 blue (-): to power supply or to the processing system
2 brown (+): to power supply or to the processing system
3 white: for processing of the integrated Pt 100 (power supply)
4 Yellow: for processing of the integrated Pt 100 (measurement)
5 Red: for processing of the integrated Pt 100 (measurement)
6 Black: for processing of the integrated Pt 100 (power supply)
7 Shielding
8 Breather capillaries with filter element

[^10]Connection via VEGABOX 02


Fig. 13: Terminal assignment VEGABOX 02
1 To power supply or the processing system (signal pressure transmitter)
2 To power supply or the processing system (connection cables resistance thermometer Pt 100)
3 Shielding ${ }^{3)}$

## Connection via VEGABOX 02 with integrated temperature sensor



Fig. 14: Terminal assignment VEGABOX 02
1 To power supply or the processing system (signal pressure transmitter)
2 For voltage supply or to processing system (resistance thermometer Pt 100) 3 Shielding ${ }^{4)}$

Connection via housing


Fig. 15: Terminal assignment of the housing
1 To power supply or the processing system (signal pressure transmitter) 2 For voltage supply or to processing system (resistance thermometer Pt 100) 3 Shielding ${ }^{5}$
${ }^{3)}$ Connect screen to ground terminal. Connect ground terminal on the outside of the housing as prescribed. The two terminals are galvanically connected.
4) Connect screen to ground terminal. Connect ground terminal on the outside of the housing as prescribed. The two terminals are galvanically connected.
5) Connect screen to ground terminal. Connect ground terminal on the outside of the housing as prescribed. The two terminals are galvanically connected.

## 5 Operation

## 5．1 Overview

VEGAWELL 724 ．．． 20 mA
VEGAWELL 72－4．．． 20 mA has no adjustment options．

VEGAWELL 724 ．．． 20 mA／HART
－Indication／Adjustment VEGADIS 12
－Adjustment software according to FDT／DTM standard，e．g． PACTware and PC
－HART handheld
VEGAWELL 724 ．．． 20 mA／HART－PT 100
－Adjustment software according to FDT／DTM standard，e．g． PACTware and PC
－HART handheld

## 5．2 Adjustment with VEGADIS 12

VEGADIS 12 is connected directly to the connection or suspen－ sion cable of VEGAWELL 72－4 ．．． $20 \mathrm{~mA} /$ HART．It is looped into the supply and signal circuit and requires no separate external energy．


Fig．16：Adjustment elements of VEGADIS 12
1 Rotary switch：choose the requested function
2 ［＋］key change value
3 ［－］key change value

## 5．3 Adjustment with PACTware

Connecting the PC to the signal cable


Fig．17：Connection of the PC to VEGADIS 12 or t the communication resistor
1 PC with PACTware
2 RS232 connection
3 VEGACONNECT
4 Communication resistor $250 \Omega$
5 Power supply unit
Necessary components：
－VEGAWELL 72
－PC with PACTware and suitable VEGA DTM
－VEGACONNECT with HART adapter cable
－HART resistor approx． $250 \Omega$
－Power supply unit

## Note：

With power supply units with integrated HART resist－ ance（internal resistance approx． $250 \Omega$ ），an additional external resistance is not necessary（e．g．VEGATRENN 149A，VEGAMET 381／624／625，VEGASCAN 693）．In such cases，VEGACONNECT can be connected paral－ lel to the $4 \ldots 20 \mathrm{~mA}$ cable．

## 6 Technical data

## Materials and weights

Materials, wetted parts

- Transmitter

316L, 316L with PE coating, 1.4462, 1.4462 with PE coating, PVDF, Ti-

- Protective cap tanium
PA, PE
- Diaphragm
- Measuring cell seal
sapphire ceramic ${ }^{\circledR}$ (99.9 \% oxide ceramic)
FKM (FDA and KTW approved), FFKM
- Suspension cable
- Cable gland on the transmitter PE (FDA and KTW-approved), FEP, PUR
- Cable seal with PE, PUR cable

316L

- Cable seal with FEP cable

KM
FEP

- Process fitting

316L

- Straining clamp
1.4301
- Unassembled threaded fitting

316L, PVDF

- Threaded connection on the housing

316L
Materials, non-wetted parts

- Housing
plastic PBT (Polyester), 316L
- type label support on cable

PE hard

- transport protection net

PE
Weight approx.

- Basic weight
0.8 kg (1.764 lbs)
- Suspension cable
$0.1 \mathrm{~kg} / \mathrm{m}(0.07 \mathrm{lbs} / \mathrm{ft})$
- Straining clamp
0.2 kg ( 0.441 lbs )
- Threaded fitting
0.4 kg ( 0.882 lbs)
- Plastic housing


## Input variable

| Measured value | Level |
| :--- | :--- |
| Measuring range | see product code |
| Recommended max. turn down | $10: 1$ |

## Output variable

$4 \ldots 20 \mathrm{~mA}$
Output signal
Signal resolution
Failure signal
Max. output current
Run-up time
Step response time
Fulfilled NAMUR recommendations
4 ... 20 mA/HART, 4 ... 20 mA/HART - PT 100
Output signal
Signal resolution
Failure signal
Max. output current
Run-up time
Step response time
Fulfilled NAMUR recommendations
$4 \ldots 20 \mathrm{~mA}$
$2 \mu \mathrm{~A}$
22 mA
22 mA
2 s
100 ms (ti: $0 \mathrm{~s}, 0 \ldots 63 \%$ )
NE 43
$4 \ldots 20 \mathrm{~mA} / \mathrm{HART}$
$2 \mu \mathrm{~A}$
< 3.6 mA ; 20.5 mA ; 22 mA ; unchanged (adjustable via PACTware)
22 mA
15 s
200 ms (ti: $0 \mathrm{~s}, 0 \ldots 63 \%)$
NE 43

## Additional output parameter - temperature

integrated resistance thermometer
Pt 100 according to DIN EN 60751
Range
Resolution
$-50 \ldots+100^{\circ} \mathrm{C}\left(-58 \ldots+212^{\circ} \mathrm{F}\right)$
$1^{\circ} \mathrm{K}$

## Deviation for 4 ... 20 mA version ${ }^{6}$

Specifications refer to the set span. Turn down (TD) = nominal
measuring range/set span.
6) Determined according to the limit point method according to IEC 60770, incl. non-linearity, hysteresis and non-repeatability.

## Deviation

- Turn down 1:1 up to 5:1 <0.2 \%
- Turn down > 10:1 <0.04\% x TD


## Deviation for $4 \ldots 20 \mathrm{~mA} / \mathrm{HART}$ and $4 \ldots 20 \mathrm{~mA} /$ HART - Pt 100 version $^{7}$ )

Applies to digital HART interface as well as to analogue current output $4 \ldots 20 \mathrm{~mA}$. Specifications refer to the set span. Turn down (TD) is the relation nominal measuring range/set span.

Deviation with version $<0.25$ \%

- Turn down 1:1 up to 5:1 <0.25 \%
- Turn down $>10: 1 \quad<0.25 \%$ x TD

Deviation with version $<0.1$ \%

- Turn down 1:1 up to 5:1 <0.1\%
- Turn down $>10: 1<0.02 \%$ x TD


## Influence of the product or ambient temperature

Applies to digital HART interface as well as to analogue current output $4 \ldots 20 \mathrm{~mA}$. Specifications refer to the set span. Turn down (TD) is the relation nominal measuring range/set span. Average temperature coefficient of the zero signal In the compensated temperature range of $0 \ldots+80^{\circ} \mathrm{C}$ $\left(+32 \ldots+176{ }^{\circ} \mathrm{F}\right)$, reference temperature $20^{\circ} \mathrm{C}\left(68^{\circ} \mathrm{F}\right)$. Average temperature coefficient of the zero signal

- Turn down 1:1 <0.05 \%/10 K
- Turn down 1:1 up to $5: 1 \quad<0.1 \% / 10 \mathrm{~K}$
- Turn down $>10: 1<0.15 \% / 10 \mathrm{~K}$

Outside the compensated temperature range
Average temperature coefficient of the zero signal

- Turn down $1: 1 \quad$ typ. $<0.05 \% / 10 \mathrm{~K}$

Thermal change of the current output
Applies also to the analogue $4 \ldots 20 \mathrm{~mA}$ current output and
refers to the set span.
Thermal change, current output $<0.15 \%$ at $-40 \ldots+80^{\circ} \mathrm{C}\left(-40 \ldots+176{ }^{\circ} \mathrm{F}\right)$

## Long-term stability (similar to DIN 16086, DINV 19259-1 and IEC 60770-1)

Applies to digital HART interface as well as to analogue current
output $4 \ldots 20 \mathrm{~mA}$. Specifications refer to the set span. Turn down
(TD) is the relation nominal measuring range/set span.
Long-term drift of the zero signal $<(0.1 \% \times$ TD $) /$ year

## Ambient conditions

Ambient temperature

- Connection cable PE

$$
\begin{aligned}
& -40 \ldots+60^{\circ} \mathrm{C}\left(-40 \ldots+140^{\circ} \mathrm{F}\right) \\
& -40 \ldots+85^{\circ} \mathrm{C}\left(-40 \ldots+185^{\circ} \mathrm{F}\right) \\
& -20 \ldots+80^{\circ} \mathrm{C}\left(-4 \ldots+176^{\circ} \mathrm{F}\right)
\end{aligned}
$$

- Connection cable PUR, FEP

Storage and transport temperature

## Process conditions

## Process pressure

Max. process pressure, transmitter

- with measuring ranges 0.1 bar (1.45 psig) or 0.2 bar (2.9 psig) max. 15 bar (217.6 psig) or max. 20 bar (290 psig) ${ }^{8)}$
- with meas. ranges from 0.4 bar ( 5.8 psig ) $25 \mathrm{bar}(363 \mathrm{psig})^{9}$

Pressure stage, process fitting

- Unassembled threaded fitting 316L: PN 3, PVDF: unpressurized
- Thread on the housing PN 3

[^11]| Suspension cable | Measuring cell seal | Product temperature |
| :--- | :--- | :--- |
| PE | FKM | $-20 \ldots+60^{\circ} \mathrm{C}\left(-4 \ldots+140^{\circ} \mathrm{F}\right)$ |
| PUR | FKM | $-20 \ldots+80^{\circ} \mathrm{C}\left(-4 \ldots+176^{\circ} \mathrm{F}\right)$ |
| PUR | FFKM | $-20 \ldots+80^{\circ} \mathrm{C}\left(-4 \ldots+176{ }^{\circ} \mathrm{F}\right)$ |
| FEP | FFKM | $-10 \ldots+80^{\circ} \mathrm{C}\left(+14 \ldots+176{ }^{\circ} \mathrm{F}\right)$ |


| Connection tube | Measuring cell seal | Product temperature |
| :--- | :--- | :--- |
| 316 L | FFKM | $-20 \ldots+80^{\circ} \mathrm{C}\left(-4 \ldots+212^{\circ} \mathrm{F}\right)$ |


| Transmitter protection | Measuring cell seal | Product temperature |
| :--- | :--- | :--- |
| PVDF | FFKM | $-10 \ldots+60^{\circ} \mathrm{C}\left(14 \ldots+140^{\circ} \mathrm{F}\right)$ |
| PE | FKM | $-20 \ldots+60^{\circ} \mathrm{C}\left(-4 \ldots+140^{\circ} \mathrm{F}\right)$ |
| PE | FFKM | $-10 \ldots+60^{\circ} \mathrm{C}\left(+14 \ldots+140^{\circ} \mathrm{F}\right)$ |

Vibration resistance mechanical vibrations with 4 g and $5 \ldots 100 \mathrm{~Hz}{ }^{10)}$

## Electromechanical data

Suspension cable

- Configuration
- Wire cross-section
- Wire resistance
- Tensile strength
- Max. length
- Min. bending radius
- Diameter approx.
- colour (non-Ex/Ex) - PE
- colour (non-Ex/Ex) - PUR, FEP

Cable entry, housing or VEGABOX 02/VEGADIS 12
Screw terminals
four wires, one suspension cable, one breather capillary, screen braiding, foil, mantle
$0.5 \mathrm{~mm}^{2}$ (AWG 20)
$\leq 0.036 \Omega / \mathrm{m}$
$\geq 1200 \mathrm{~N}$ (270 pound force)
$1000 \mathrm{~m}(3280 \mathrm{ft})^{11)}$
25 mm (with $25^{\circ} \mathrm{C} / 77^{\circ} \mathrm{F}$ )
8 mm ( 0.315 in )
black/blue
blue/blue
$1 \times$ cable gland $\mathrm{M} 20 \times 1.5$ (cable: $\varnothing 5 \ldots 9 \mathrm{~mm}$ ), $1 \times$ blind stopper $\mathrm{M} 20 \times 1.5$ for wire cross section $1.5 \mathrm{~mm}^{2}$ (AWG 16), screen up to $4 \mathrm{~mm}^{2}$ (AWG 12)

## Supply voltage-4... 20 mA

Supply voltage

- Non-Ex instrument 9.6 ... 36 V DC
- EEx-ia instrument
9.6 ... 29 V DC

Permissible residual ripple

- $<100 \mathrm{~Hz}$
$\mathrm{U}_{\mathrm{ss}}<1 \mathrm{~V}$
- 100 Hz ... 10 kHz
$\mathrm{U}_{\mathrm{ss}}<10 \mathrm{mV}$
Load
see diagram

[^12]

Fig. 18: Voltage diagram
1 meaningless
2 Voltage limit Ex instrument
3 Voltage limit non-Ex instrument
4 Supply voltage

## Supply voltage-4... $20 \mathrm{~mA} /$ HART

Supply voltage

| - Non-Ex instrument | $12 \ldots 36 \mathrm{~V} \mathrm{DC}$ |
| :--- | :--- |
| - EEx-ia instrument | $12 \ldots 29 \mathrm{VDC}$ |
| Permissible residual ripple |  |
| $-<100 \mathrm{~Hz}$ | $\mathrm{U}_{\text {ss }}<1 \mathrm{~V}$ |
| $-100 \mathrm{~Hz} \ldots 10 \mathrm{kHz}$ | $\mathrm{U}_{\text {ss }}<10 \mathrm{mV}$ |
| Load | see diagram |



Fig. 19: Voltage diagram $4 \ldots 20 \mathrm{~mA} / \mathrm{HART}$
HART load
Voltage limit Ex instrument
Voltage limit non-Ex instrument
4 Supply voltage

## Supply voltage-4... $20 \mathrm{~mA} / \mathrm{HART}$ - Pt 100

Supply voltage

| - Non-Ex instrument | $9.6 \ldots 36 \mathrm{~V} \mathrm{DC}$ |
| :--- | :--- |
| - EEx-ia instrument | $9.6 \ldots 30 \mathrm{~V} \mathrm{DC}$ |
| Permissible residual ripple |  |
| $-<100 \mathrm{~Hz}$ | $\mathrm{U}_{\mathrm{ss}}<1 \mathrm{~V}$ |
| $-100 \mathrm{~Hz} \ldots 10 \mathrm{kHz}$ | $\mathrm{U}_{\mathrm{ss}}<10 \mathrm{mV}$ |
| Load | see diagram |



Fig．20：Voltage diagram
1 HART load
2 Voltage limit Ex instrument
3 Voltage limit non－Ex instrument
4 Supply voltage

## Electrical protective measures

Protection

| －Transmitter | IP 68 （25 bar） |
| :--- | :--- |
| －Housing | IP 66／IP 67 |
| －VEGABOX 02，VEGADIS 12 | IP 65 |
| Overvoltage category | III |
| Protection class | III |

## Existing approvals or approvals applied for ${ }^{12)^{13}}$

ATEX
IEC
PTB
Ship approvals
Others

## ATEX II 2G EEx ia IIC T6

IEC Ex ia IIC T6
Ex－Zone 2
GL，LRS，ABS，CCS，RINA，DNV
WHG

## CE conformity

EMC（89／336／EWG）Emission EN 61326：1997／A1： 1998 （class B），susceptibility EN 61326：
LVD（73／23／EWG）
1997／A1： 1998
EN 61010－1： 1993

## Environmental instructions

VEGA environment management system certified according to DIN EN ISO 14001
You can find detailed information under www．vega．com．

[^13]You can find detailed information under www．vega．com．

## 7 Dimensions

VEGAWELL 72 - suspension cable


Fig. 21: VEGAWELL 72-4 ... $20 \mathrm{~mA} / H A R T$ - suspension cable
1 with straining clamp
2 Deep well version with unassembled threaded fitting G1 $1 / 2$ A (11/2 NPT) and closing cap
3 with PE plastic coating
4 Transmitter with screwed connection of PVDF
5 With thread G11/2 A (11/2 NPT) and housing

## 8 Product code

## VEGAWELL 52


${ }^{\text {1) }}$ Measuring cell seal FKM(Viton)
${ }^{2}$ Measuring cell seal Kalrez
${ }^{3)}$ Only in conjunction with HART® electronics

## ，尼固凨

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## $B(\in \mathbb{E x})=0$

You can find at www．vega．com
downloads of the following
－operating instructions manuals
－menu schematics
－software
－certificates
－approvals
and much，much more

## VEGADIS 61

## External indicating and adjustment unit



## Application area

VEGADIS 61 is suitable for measured value indication and adjustment of plics ${ }^{\circledR}$ sensors.

## Advantages

- DOT matrix display with 4-key adjustment and lighting
- Clear text indication with graphical support
- Indication of trend and echo curves
- Indicating and adjustment module pluggable in $90^{\circ}$ steps
- Can be mounted up to 25 m (cable length) away from the sensor


## Function

VEGADIS 61 is connected to the sensor with a screened four-wire standard cable up to 25 m long. Communication is carried out via this cable and the VEGADIS 61 is also powered by the sensor. An additional power supply is not necessary.

## Technical data

## General data

Materials

| - Housing | plastic PBT, Alu die-casting, 316L |
| :--- | :--- |
| - Inspection window in hous- | Polycarbonate (UL-746-C listed) |
| ing cover for indicating and |  |
|  |  |
| adjustment module |  |
| - Ground terminal | $316 \mathrm{Ti} / 316 \mathrm{~L}$ |
| Weight approx. | $0.35 \mathrm{~kg}(0.772 \mathrm{lbs})$ |


| Adjustment circuit |  |
| :---: | :---: |
| Connection to Data transmission | VEGA plics ${ }^{\circledR}$ sensors digital ( ${ }^{2} \mathrm{C}$-Bus) |
| Indicating and adjustment module |  |
| Indication | LC display in dot matrix |
| Adjustment elements Protection rating | 4 keys |
| - unassembled | IP 20 |
| - mounted into VEGADIS 61 without cover | IP 40 |
| Materials |  |
| - Housing | ABS |
| - Inspection window | Polyester foil |

## Electromechanical data

| Cable gland | 1 x cable gland M20×1.5 (cable: $\varnothing$ <br> $5 \ldots 9 \mathrm{~mm}$ ), $1 \times$ blind stopper M20 $\times 1.5$ or <br> 1 x closing cap $1 / 2$ NPT, 1 x blind stopper $1 / 2$ NPT |
| :---: | :---: |
| Spring-loaded terminals for wire cross-section up to | $2.5 \mathrm{~mm}^{2}$ (AWG 14) |
| Ambient conditions |  |
| Ambient temperature | $-20 \ldots+70^{\circ} \mathrm{C}\left(-4 \ldots+158^{\circ} \mathrm{F}\right)$ |
| Storage and transport temperature | $-40 \ldots+80^{\circ} \mathrm{C}\left(-40 \ldots+176{ }^{\circ} \mathrm{F}\right)$ |
| Electrical protective measur |  |
| Protection rating |  |
| - Housing plastic | IP 66/IP 67 |
| - Housing Aluminium, stainless steel | IP 66/IP 68 (0.2 bar) |
| Overvoltage category | III |

## Approvals

You can find detailed information on the existing approvals in the "configurator" on our homepage under www.vega.com/configurator.

## Operation

The adjustment of the connected sensor is menu-controlled via four keys on the front and one LC display.


Indicating and adjustment elements
1 LC display
2 Indication of the menu item number
3 Adjustment keys

## Electrical connection



Electronics and connection compartment
1 Spring-loaded terminals for connection to the sensor
2 Plug connector for VEGACONNECT (I 2 C interface)
3 Ground terminal for connection of the cable screen
You can find details on the electrical connection in the operating instructions of the instruments on our homepage under www.vega.com/downloads.

## Dimensions

## Information

You can find further information about the VEGA product line on our homepage www.vega.com.
In the download section under www.vega.com/downloads you'll find free operating instructions, product information, brochures, approval documents, instrument drawings and much, much more.


## Contact

You can find the VEGA agency serving your area on our homepage www.vega.com.

## 5. Radio

## User Manual E Series Data Radiot

ER450 Remote Data Radio EB450 Base Station EH450 Hot Standby Base Stations

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## SECTION 1

## Part A - Preface

## Part B - E Series Overview

## Part C - Applications

## Part D - System Planning and Design

## Part E-Getting Started

## Part F - Operational Features

## Part G - Commissioning

Part H - Maintenance

## Part A - Preface

## Warranty

All equipment supplied by Trio DataCom Pty Ltd is warranteed against faulty workmanship and parts for a period of twelve (12) months from the date of delivery to the customer. During the warranty period Trio DataCom Pty Ltd shall, at its option, repair or replace faulty parts or equipment provided the fault has not been caused by misuse, accident, deliberate damage, abnormal atmosphere, liquid immersion or lightning discharge; or where attempts have been made by unauthorised persons to repair or modify the equipment.

The warranty does not cover modifications to software. All equipment for repair under warranty must be returned freight paid to Trio DataCom Pty Ltd or to such other place as Trio DataCom Pty Ltd shall nominate. Following repair or replacement the equipment shall be returned to the customer freight forward. If it is not possible due to the nature of the equipment for it to be returned to Trio DataCom Pty Ltd, then such expenses as may be incurred by Trio DataCom Pty Ltd in servicing the equipment in situ shall be chargeable to the customer.

When equipment for repair does not qualify for repair or replacement under warranty, repairs shall be performed at the prevailing costs for parts and labour. Under no circumstances shall Trio DataCom Pty Ltd's liability extend beyond the above nor shall Trio DataCom Pty Ltd, its principals, servants or agents be liable for the consequential damages caused by the failure or malfunction of any equipment.

## Important Notice

## © Copyright 2005 Trio DataCom Pty Ltd All Rights Reserved

This manual covers the operation of the E Series of Digital Data Radios. Specifications described are typical only and are subject to normal manufacturing and service tolerances.

Trio DataCom Pty Ltd reserves the right to modify the equipment, its specification or this manual without prior notice, in the interest of improving performance, reliability or servicing. At the time of publication all data is correct for the operation of the equipment at the voltage and/or temperature referred to. Performance data indicates typical values related to the particular product.

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## Compliance Information

## Warning - RF Exposure

The radio equipment described in this user manual emits low level radio frequency energy. The concentrated energy may pose a health hazard depending on the type of antenna used. In the case of:

Non-directional antenna - DO NOT allow people to come within 0.5 metres ( 20 inches) of the antenna when the transmitter is operating

Directional antenna - DO NOT allow people to come within 6 metres ( 20 feet) of the antenna when the transmitter is operating.

## FCC Notice (Hot Standby Controller Only)

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction, equipment may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Re -orient to relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different to that which the receiver is connected.
- Consult the dealer or an experienced radio/television technician for assistance.


## IC Notice (Hot Standby Controller Only)

This Class B digital apparatus complies with Canadian ICES-003. Cet appariel numerique de la class $B$ est conforme a la norme NBM-003 du Canada.

## R\&TTE Notice (Europe) Applies to models Ex450-xx Exx-xxx

In order to comply with the R\&TTE (Radio \& Telecommunications Terminal Equipment) directive 1999/5/EC Article 3 (Low Voltage Directive $73 / 23 / E E C$ ), all radio modem installations must include an external in-line lightning arrestor or equivalent device that complies with the following specifications:

- DC Blocking Capability - 1.5 kV impulse (Rise Time 10 mS , Fall Time 700 mS ) (Repetition 10 Times) or $1.0 \mathrm{kV} \mathrm{rms} \mathrm{50Hz}$ sine wave for 1 minute.

Trio Datacom declares that the E Series radio modem is in compliance with the essential requirements and other relevant provisions of the Directive 1999/5/EC. Therefore Trio Datacom E Series equipment is labelled with the following CE-marking.

## Important Notices for Class I, Division 2, Groups A, B, C \& D Hazardous Locations

Applies to models ER450-xxxxx-xHx(CSA Marked)
This product is available for use in Class I, Division 2, Groups A, B, C \& D Hazardous Locations. Such locations are defined in Article 500 of the US National Fire Protection Association (NFPA) publication NFPA 70, otherwise known as the National Electrical Code and in Section 18 of the Canadian Standards Association C22.1 (Canadian Electrical Code).

The transceiver has been recognised for use in these hazardous locations by the Canadian Standards Association (CSA) International. CSA certification is in accordance with CSA Standard C22.2 No. 213-M1987 and UL Standard 1604 subject to the following conditions of approval:

1. The radio modem must be mounted in a suitable enclosure so that a tool is required to gain access for disconnection of antenna, power and communication cables.
2. The antenna, DC power and interface cables must be routed through conduit in accordance with the National Electrical Codes.
3. Installation, operation and maintenance of the radio modem should be in accordance with the radio modem's user manual and the National Electrical Codes.
4. Tampering or replacement with non-factory components may adversely affect the safe use of the radio modem in hazardous locations and may void the approval.
5. A power connector retainer with thumbwheel screw as supplied by Trio Datacom MUST be used.

## . WARNING EXPLOSION HAZARD

Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous. Substitution of components may impair suitability for Class I, Division 2. Refer to Articles 500 through 502 of the National Electrical Code (NFPA 70) and Section 18 of CSA C22.1 for further information on hazardous locations and approved Division 2 wiring methods.

## WEEE Notice (Europe)



This symbol on the product or its packaging indicates that this product must not be disposed of with other waste. Instead, it is your responsibility to dispose of your waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of your waste equipment at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For more information about where you can drop off your waste equipment for recycling, please contact the dealer from whom you originally purchased the product.

Dieses Symbol auf dem Produkt oder seinem Verpacken zeigt an, daß dieses Produkt nicht mit anderer Vergeudung entledigt werden darf. Stattdessen ist es Ihre Verantwortlichkeit, sich Ihre überschüssige Ausrüstung zu entledigen, indem es rüber sie zu einem gekennzeichneten Ansammlungspunkt für die Abfallverwertung elektrische und elektronische Ausrüstung übergibt. Die unterschiedliche Ansammlung und die Wiederverwertung Ihrer überschüssigen Ausrüstung zu der Zeit der Beseitigung helfen, Naturresourcen zu konservieren und sicherzugehen, daß es in gewissem Sinne aufbereitet wird, daß menschliche Gesundheit und das Klima schützt. Zu mehr Information ungefähr, wo Sie weg von Ihrer überschüssigen Ausrüstung für die Wiederverwertung fallen können, treten Sie bitte mit dem Händler in Verbindung, von dem Sie ursprünglich das Produkt kauften.

## Related Products

ER450 Remote Data Radio MR450 Remote Data Radio EB450 Base/Repeater Station EH450 Hot Standby Base Station

## Other Related Documentation

 and ProductsE Series Quick Start Guides TVIEW+ Management Suite Digital Orderwire Voice Module (EDOVM) Multiplexer Stream Router (MSR)

## Revision History

| Issue 5 | February 2004 | Additional radio and programmer <br> information |
| :--- | :--- | :--- |
| Issue 6 | February 2005 | Additional information for <br> Hazardous Locations. |
| Issue 7 | May 2005 | Various Updates |
| Issue 8 | Jan 2006 | WEEE Updates |
| Issue 9 | Mar 2006 | E Series Gen II Updates |
| Issue 10 | Mar 2007 | Order Matrix Updated |

## Part B - E Series Overview

## Definition of E Series Data Radio

The E Series is a range of wireless modems designed for the transmission of data communications for SCADA, telemetry and any other information and control applications that utilise ASCII messaging techniques. The E Series uses advanced "digital" modulation and signal processing techniques to achieve exceptionally high data throughput efficiency using traditional licensed narrow band radio channels.

These products are available in many frequency band and regulatory formats, to suit spectrum bandplans, in various continental regions. The range is designed for both fixed point to point (PTP), and multiple address (MAS) or point to multipoint (PMP) systems.

## E Series Product Range

The E Series range consists of the basic half duplex "Remote" radio modem, an extended feature full duplex Remote radio modem, and ruggedised Base Station variants, including an optional Hot Standby controller to control two base station units in a redundant configuration.

Frequency band variants are indicated by the band prefix and model numbering. (See Model Number Codes)


ER450 Remote Radio


EB450 Base / Repeater Station


EH450 Hot Standby Base Station

## E Series - Features and Benefits

## Common Features and Benefits of the $E$ Series Data Radio (Generation II)

- Up to 19200 bps over-air data rates using programmable DSP based advanced modulation schemes.
- Designed to various International regulatory requirements including FCC, ETSI and ACA.
- Superior receiver sensitivity.
- Fast data turnaround time $<10 \mathrm{mS}$.
- 128 -bit AES encryption.
- Flash upgrade-able firmware - insurance against obsolescence.
- Multi-function bi-colour Tx/Rx data LEDs showing Port activity (breakout box style), as well as LEDs indicating Tx, Rx, RF Signal, Data Synchronisation and DC Power status of the radio.
- Rugged N type antenna connectors on all equipment.
- High temperature transmitter foldback protection.
- Two independent configurable data ports and separate system port.
- $\quad$ Higher port speeds to support increased air-rate (up to 57600 bps on Port A and 38400bps on Port B).
- Compatible with most industry standard data protocols. eg: MODBUS, DNP-3, IEC 870, SEL Mirrored Bits, etc.
- Independent system port for interruption free programming and diagnostics (in addition to two (2) user ports).
- $\quad 9600 \mathrm{bps}$ in 12.5 kHz radio channels with ETSI specifications.
- Compatible with legacy systems (Non Packet Digital and Bell 202 Modes)
- Remote over-the-air configuration of any radio from any location.
- Multistream ${ }^{\text {TM }}$ simultaneous data streams allows for multiple vendor devices / protocols to be transported on the one radio network.
- Flexible data stream routing and steering providing optimum radio channel efficiency - complex data radio systems can be implemented with fewer radio channels.
- The ability to duplicate data streams - that is, decode the same off-air data to two separate ports.
- Multi-function radio capable of dropping off one stream to a port and forward on or repeat (store and forward) the same or other data.
- Stand-alone internal store and forward operation - buffered store and forward operation even in the ER remote units.
- Unique integrated C/DSMA collision avoidance technology permits simultaneous polling and spontaneous reporting operation in the same system.
- Digital receiver frequency tracking for long term data reliability.
- Network wide non intrusive diagnostics which runs simultaneously with the application.
- Network wide diagnostics interrogation which can be performed from anywhere in the system including any remote site.
- Diagnostics will route its way to any remote or base / repeater site regardless of how many base / repeater stations are interconnected.
- Full range of advanced features available within Network Management and Remote Diagnostics package - BER testing, trending, channel occupancy, client / server operation, etc.
- On board memory for improving user data latency - increased user interface speeds.
- Full CRC error checked data - no erroneous data due to squelch tails or headers.
- Radio utilises world standard HDLC as its transportation protocol.
- Various flow control and PTT control mechanisms.
- Configurable backward compatibility with existing D Series modulation scheme for use within existing networks.
- Digital plug in order wire option for commissioning and occasional voice communications without the need to inhibit users application data.


## Features and Benefits of ER450 Remote

 Data Radio- Optional full duplex capable remote - separate $T x$ and $R x$ ports for connection to an external duplexer.
- New compact and rugged die cast case with inbuilt heatsink.
- Low power consumption with various sleep modes.
- Rugged N type antenna connectors.
- Data Port "breakout box" style flow LEDs for easier troubleshooting.


## Features and Benefits of EB450 Standard Base / Repeater Station

- Competitively priced high performance base.
- Incorporates a rugged 5W power amplifier module.


## Features and Benefits of EH450 Hot Standby Base / Repeater Station

- Individual and identical base stations with separate control logic changeover panel.
- ALL modules are hot swapable without any user downtime
- Flexible antenna options - single, separate Tx \& Rx, two Tx and two Rx.
- Both on-line and off-line units monitored regardless of active status.



## Standard Accessories

| Part Number | Description |
| :--- | :--- |
| Duplexers |  |
| DUPLX450BR | Duplexer BAND REJECT 400-520 MHz for <br> use with Base / Repeater / Links. For Tx / Rx <br> frequency splits >9MHz. (Fitted Externally <br> for a Link, Internally or Externally for Base / <br> Repeater) |
| DUPLX450PC | Duplexer BAND REJECT 400-520 MHz for <br> use with Base / Repeater / Links. For Tx / Rx <br> frequency splits <9MHz. (Fitted Externally <br> for a Link, Internally or Externally for Base / <br>  <br> Repeater) |
| DUPLX450BP | Duplexer PSEUDO BAND PASS Cavity 400- <br> 520 MHz for External use with Base / Repeater |
| / Links. |  |

## Notes:

1. Frequencies must be specified at time of order.
2. Interconnecting (Feeder Tail) cables must be ordered separately for Externally fitted Duplexers.

## Antennas

ANT450/9A
Antenna Yagi 6 Element 9dBd Aluminium 400520 MHz c/w mtg clamps
ANT450/9S Antenna Yagi 6 Element 9dBd S/Steel 400-520

ANT450/13A Antenna Yagi15 Element 13dBd Aluminium 400520 MHz c/w mtg clamps.
ANT450/13S Antenna Yagi 15 Element 13 dBd S/Steel 400520 MHz c/w mtg clamps.
ANTOMNI/4 Antenna Omnidirectional Unity Gain Side Mount Dipole $400-520 \mathrm{MHz}$ c/w galv. clamp
ANT450/D/N Antenna Omnidirectional Unity Gain Ground Independent Dipole $400-520 \mathrm{MHz} \mathrm{c} / \mathrm{w} 3 \mathrm{~m}$ cable, mounting bracket \& N connector
ANT450/6OM Antenna Omnidirectional 6dBd $400-520 \mathrm{MHz}$ c/w mtg clamps
ANT450/90M Antenna Omnidirectional 9dBd $400-520 \mathrm{MHz}$ $\mathrm{c} / \mathrm{w} \mathrm{mtg}$ clamps

## Note:

1. Frequencies must be specified at time of order.

## Power Supplies

| PS13V82A | Power Supply 13.8V 2A 240VAC |
| :--- | :--- |
| PS13V810A | Power Supply Switch Mode 240VAC 13.8V 10A <br> for Base Stations - Battery Charge Capability |

Part Number Description
RF Cables and Accessories

| NM/NM/TL23 | Feeder Tail - N Male to N Type Male 50 cm fully sweep tested RG-223 |
| :---: | :---: |
| NM/NM/TLL23 | Feeder Tail - N Male to N Type Male 1 metre fully sweep tested RG-223 |
| RFCAB5M | 5.0m RG-58 type Antenna Feeder Cable terminated with N type Male Connectors |
| RFCAB5M2 | 5.0 m RG-213 type Antenna Feeder Cable terminated with N type Male Connectors |
| RFCAB10M | 10.0m RG-213 type Antenna Feeder Cable terminated with N type Male Connectors |
| RFCAB20M | 20.0m RG-213 type Antenna Feeder Cable terminated with N type Male Connectors |
| RFCAB20M4 | 20.0 m LDF4-50 type ( $1 / 2^{\prime \prime}$ foam dialectric) Antenna Feeder Cable terminated with N type Male Connectors |
| LGHTARRST | Lightning Surge Arrestor In-line N Female to N Female |

## Multiplexers

MSR/9 Multiplexer/Stream Router - 9 Port with RS-232 Ifaces, Manual and software.

Network Management Diagnostics
DIAGS/E Network Management and Remote Diagnostics Facilities per Radio - E Series

DIAGS/EH Network Management and Remote Diagnostics Facilities - E Series for EH450

Software

| TVIEW+ | Configuration, Network Management and |
| :--- | :--- |
|  | Remote Diagnostics Software |
| TVIEW+ESeries | E Series Programming Cable and configuration |
|  | software |

Other
EDOVM Digital Order Wire Voice Module

ERFD450 ER450.... Conversion to Full Duplex Operation (N Type - Tx Port, SMA - Type Rx Port) Note: Requires external duplexer
ERFDTRAY 19" Rack Tray for Mounting of ER450 Full Duplex Radio and External Band Reject Duplexer

## Part C - Applications

## Generic Connectivity

The E Series has been designed for SCADA and telemetry applications, and any other applications that use an ASCII communications protocol, and which connect physically using the RS232 interface standard (although converters can be used to adapt other interfaces such as RS422/485, RS530/V35, G703 etc).

Any protocol that can be displayed using a PC based termina program operating via a serial communications port is suitable for transmission by the E Series radio modems.

An ASCII protocol is any that consists of message strings formed from ASCII characters, that being defined as a 10 or 11 bit block including start and stop bits, 7 or 8 data bits and optional parity bit(s). Port set-up dialog that includes the expressions " $\mathrm{N}, 8,1$ ", or $\mathrm{E}, 7,2^{\prime \prime}$ or similar indicate an ASCII protocol

Most of the dominant telemetry industry suppliers utilise proprietary ASCII protocols, and also common 'open standard" industry protocols such as DNP3, MODBUS, TCP/IP, and PPP. These are all ASCII based protocols.

## Industries and Applications

The E Series products are widely used in point-to-point and point-to-multipoint (multiple access) applications for remote interconnection of PLCs, RTUs, dataloggers, and other data monitoring and control devices - including specialist utility devices (such as powerline ACRs). In addition, other applications such as area wide security and alarm systems, public information systems (traffic flow and public signage systems) and environmental monitoring systems.

## Application Detail

## SCADA Systems

This is where one or more centralised control sites are used to monitor and control remote field devices over wide areas. Examples include regional utilities monitoring and controlling networks over entire shires or a greater city metropolis. Industry sectors include energy utilities (gas and electricity distribution), water and sewerage utilities, catchment and environment groups (rivers, dams and catchment management authorities).

## Telemetry Systems

Dedicated telemetry control systems interconnecting sequential devices either where cabling is not practical or distances are considerable

Examples include:

- ore conveyor or slurry pipeline systems
- water systems (pump and reservoir interlinking)
- broadcast industry (linking studio to transmitter) etc.


## Systems Architecture

## Point-to-Point

This simple system architecture provides a virtual connection between the two points, similar to a cable. Dependent of the hardware chosen, it is possible to provide a full duplex connection (i.e. data transfer in both directions simultaneously) if required.


## Point-to-Multipoint Systems

In a multiple access radio system, messages can be broadcast from one (master) site to all others, either using a half duplex radio system or from any site to all others, using a simplex radio channel.

Half duplex systems often utilise a full duplex master, to make the system simpler and for faster operation.

In either case, it will be necessary for the application to support an addressing system, since the master needs to be able to select which remote device it with which it wishes to communicate. Normally, the radio system is allowed to operate "transparently", allowing the application's protocol to provide the addressing, and thus control the traffic. Where the application layer does not provide the addressing, the E Series can provide it using SID codes ${ }^{\text {™ }}$


## (See Part F - Operational Features)

## Digipeater Systems

This configuration is used where all sites are required to communicate via a repeater site. A repeater site is used because it has a position and/or height advantage and thus provides superior or extended RF coverage. The radio modem at the repeater does not have to be physically connected to the application's master site. Information from the application's master is transmitted to the repeater via radio, and the repeater then relays this information to the other field sites. In this scenario, the repeater is the master from an RF point of view, and the application master is effectively a "remote" from an RF point of view, even though it is controlling the
data transfer on the system.

## Backbone Store and Forward Systems

Store and forward is used as a way of extending RF coverage by repeating data messages from one site to another.

This can be done globally using the inbuilt data repeating functions, or selectively using intelligent address based routing features available in some PLC/RTU protocols.

In this case it is necessary for all units on the system to operate

Digipeater System


Backbone Store and Forward System
Typical Store and Forward System


## Part D - System Planning and Design

## Selecting Antennas

## Understanding RF Path Requirements

A radio modem needs a minimum amount of received RF signal to operate reliably and provide adequate data throughput.

In most cases, spectrum regulatory authorities will also define or limit the amount of signal that can be transmitted, and the transmitted power will decay with distance and other factors, as it moves away from the transmitting antenna

It follows, therefore, that for a given transmission level, there will be a finite distance at which a receiver can operate reliably with respect to the transmitter.

Apart from signal loss due to distance, other factors that will decay a signal include obstructions (hills, buildings, foliage), horizon (effectively the bulge between two points on the earth), and (to a minimal extent at UHF frequencies) factors such as fog, heavy rain-bursts, dust storms, etc.

In order to ascertain the available RF coverage from a transmitting station, it will be necessary to consider these factors. This can be done in a number of ways, including
(a) using basic formulas to calculate the theoretically available signal - allowing only for free space loss due to distance,
(b) using sophisticated software to build earth terrain models and apply other correction factors such as earth curvature and the effects of obstructions, and
(c) by actual field strength testing

It is good design practice to consider the results of at least two of these models to design a radio path.

## Examples of Predictive Path Modelling

## Clear line of site

Radio path with good signal levels, attenuated only by free space loss.


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## Obstructed Radio Path

This path has an obstruction that will seriously degrade the signa arriving at the field site.


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## Effect of Earth Curvature on Long Paths

This path requires greater mast height to offset the earth curvature experienced at such a distance ( 73 km ).


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There are basically two types of antennas - omni-directional and directional.

Omnidirectional antennas are designed to radiate signal in a 360 degrees segment around the antenna. Basic short range antennas such as folded dipoles and ground independent whips are used to radiate the signal in a "ball" shaped pattern. High gain omni antennas such as the "co-linear" compress the sphere of energy into the horizontal plane, providing a relatively flat "disc" shaped pattern which goes further because all of the energy is radiated in the horizontal plane.

Directional antennas are designed to concentrate the signal into "beam" of energy for transmission in a single direction (i.e. for point-to-point or remote to base applications).
Beamwidths vary according to the antenna type, and so can be selected to suit design requirements. The most common UHF directional antenna is the yagi, which offers useable beam widths of $30-50$ degrees. Even higher "gain" is available using parabolic "dish" type antennas such as gridpacks.

## Antenna Gain



Onmi directional 360 degree signal


Directional Concentrated beam

By compressing the transmission energy into a disc or beam, the antenna provides more energy (a stronger signal) in that direction, and thus is said to have a performance "gain" over a basic omni antenna. Gain is usually expressed in dBd , which is referenced to a standard folded dipole. Gain can also be expressed in dBi, which is referenced to a theoretical "isotropic" radiator. Either way, if you intend to send and receive signals from a single direction, there is advantage in using a directional antenna - both due to the increased signal in the wanted direction, and the relatively decreased signal in the unwanted direction (i.e. "interference rejection" properties).

## Tuning the Antenna

Many antennas are manufactured for use over a wide frequency range. Typical fixed use antennas such as folded dipoles and yagis are generally supplied with the quoted gain available over the entire specified band range, and do not require tuning. Co-linear antennas are normally built to a specific frequency specified when ordering.

With mobile "whip" type antennas, it is sometimes necessary to "tune" the antenna for the best performance on the required frequency. This is usually done by trimming an antenna element whilst measuring VSWR, or simply trimming to a manufacturer supplied chart showing length vs frequency. These antennas would normally be supplied with the tuning information provided.

## Antenna Placement

When mounting the antenna, it is necessary to consider the following criteria:

The mounting structure will need to be solid enough to withstand additional loading on the antenna mount due to extreme wind, ice or snow (and in some cases, large birds).

For omni directional antennas, it is necessary to consider the effect of the mounting structure (tower mast or building) on the radiation pattern. Close in structures, particularly steel structures, can alter the radiation pattern of the antenna. Where possible, omni antennas should always be mounted on the top of the mast or pole to minimise this effect. If this is not possible, mount the antenna on a horizontal outrigger to get it at least 1-2m away from the structure. When mounting on buildings, a small mast or pole $(2-4 \mathrm{~m})$ can significantly improve the radiation pattern by providing clearance from the building structure.

For directional antennas, it is generally only necessary to consider the structure in relation to the forward radiation pattern of the antenna, unless the structure is metallic, and of a solid nature. In this case it is also prudent to position the antenna as far away from the structure as is practical. With directional antennas, it is also necessary to ensure that the antenna cannot move in such a way that the directional beamwidth will be affected. For long yagi antennas, it is often necessary to install a fibreglass strut to stablilise the antenna under windy conditions.

## Alignment of Directional Antennas

This is generally performed by altering the alignment of the antenna whilst measuring the received signal strength. If the signal is weak, it may be necessary to pre-align the antenna using a compass, GPS, or visual or map guidance in order to "find" the wanted signal. Yagi antennas have a number of lower gain "lobes" centred around the primary lobe. When aligning for best signal strength, it is important to scan the antenna through at least 90 degrees, to ensure that the centre (strongest) lobe is identified.

When aligning a directional antenna, avoid placing your hands or body in the vicinity of the radiating element or the forward beam pattern, as this will affect the performance of the antenna.

## RF Feeders and Protection

The antenna is connected to the radio modem by way of an RF feeder. In choosing the feeder type, one must compromise between the loss caused by the feeder, and the cost, flexibility, and bulk of lower loss feeders. To do this, it is often prudent to perform path analysis first, in order to determine how much "spare" signal can be allowed to be lost in the feeder. The feeder is also a critical part of the lightning protection system.

All elevated antennas may be exposed to induced or direct lightning strikes, and correct grounding of the feeder and mast are an essential part of this process. Gas discharge lightning arresters should also be fitted to all sites.

Note: All ETSI installations require the use of a lightning surge arrestor in order to meet EN6095. See Part A - Preface for lightning arrestor specifications.

| Common Cable Types | Loss per meter <br> $@ 450 \mathrm{MHz}$ | Loss per 10 m <br> $@ 450 \mathrm{MHz}$ |
| :--- | :---: | :---: |
| RG58C/U | 0.4426 dB | 4.4 dB |
| RG213/U | 0.1639 dB | 1.6 dB |
| FSJ1-50 (1/4" superflex) | 0.1475 dB | 1.5 dB |
| LDF4-50 (1/2" heliax) | 0.0525 dB | 0.52 dB |
| LDF5-50 (7/8" heliax) | 0.0262 dB | 0.3 dB |



## Data Connectivity

## The V24 Standard

The E Series radio modems provide two asynchronous V24 compliant RS232 ports for connection to serial data devices.

There are two types of RS232 interfaces - DTE and DCE.
DTE stands for data terminal equipment and is generally applied to any intelligent device that has a need to communicate to another device via RS232. For example: P.C. Comm ports are always DTE, as are most PLC and RTU serial ports.

DCE stands for data communication equipment and is generally applied to a device used for sending data over some medium (wires, radio, fibre etc), i.e. any MODEM.

The standard interface between a DTE and DCE device (using the same connector type) is a straight through cable (i.e. each pin connects to the same numbered corresponding pin at the other end of the cable).

The "V24" definition originally specified the DB25 connector standard, but this has been complicated by the emergence of the DB9 (pseudo) standard for asynch devices, and this connector standard has different pin assignments.

The wiring standard is "unbalanced", and provides for three basic data transfer wires (TXD, RXD, and SG - signal ground).

Hardware Handshaking
Hardware handshake lines are also employed to provide flow control, however (in the telemetry industry) many devices do not always support all (or any) flow control lines.

For this reason, the E Series modems can be configured for full hardware flow control, or no flow control at all (simple 3 wire interface).

Note: that when connecting devices together with differing handshake implementations, it is sometimes necessary to "loop" handshake pins in order to fool the devices handshaking requirements.

In telemetry applications (particularly where port speeds can be set to the same rate as the radio systems over-air rate) then flow control, and therefore handshaking, is usually NOT required. It follows that any devices that CAN be configured for "no flow control" should be used in this mode to simplify cabling requirements.

Handshaking lines can generally be looped as follows:
DTE (terminal) - loop RTS to CTS, and DTR to DSR and DCE.
DCE (modem) - loop DSR to DTR and RTS (note-not required for $E$ Series modem when set for no handshaking).



RS232 Connector Pin outs (DCE)
Port A and B, Female DB9


## Power Supply and Environmental Considerations

## General

When mounting the equipment, consideration should be given to the environmental aspects of the site. The cabinet should be positioned so that it is shaded from hot afternoon sun, or icy cold wind. Whilst the radios are designed for harsh temperature extremes, they will give a longer service life if operated in a more stable temperature environment. In an industrial environment, the radio modems should be isolated from excessive vibration, which can destroy electronic components, joints, and crystals.

The cabinet should provide full protection from moisture, dust, corrosive atmospheres, and residues from ants and small vermin (which can be corrosive or conductive). The radio modem will radiate heat from the in-built heatsink, and the higher the transmitter duty cycle, the more heat will be radiated from the heatsink. Ensure there is sufficient ventilation in the form of passive or forced air circulation to ensure that the radio is able to maintain quoted temperature limits.

## Power Supply

The power supply should provide a clean, filtered DC source. The radio modem is designed and calibrated to operate from a 13.8 VDC regulated supply, but will operate from $10-16$ volts (filtered) DC

The power supply must be able to supply sufficient current to provide clean filtered $D C$ under the full current conditions of the radio modem (i.e. when transmitting full RF power). See Section L - Specifications for more details of the power supply requirements.


Caution: There is NO readily serviceable internal fuse, and therefore the radio modem MUST be externally fused with a fuse and fuse holder (ER450: 3 amp fast-blow fuse, EB450: 5 amp fast-blow fuse).

## Solar Applications

In solar or battery-backed installations, a battery management unit should be fitted to cut off power to the radio when battery levels fall below the minimum voltage specification of the radio. In solar applications, a solar regulation unit MUST ALSO be fitted to ensure that the radio (and battery) is protected from excessive voltage under full sun conditions.

When calculating solar and battery capacity requirements, the constant current consumption will be approximately equal to the transmit current multiplied by the duty cycle of the transmitter, plus the receive current multiplied by the (remaining) duty cycle of the receiver.

The Tx/Rx duty cycle will be entirely dependent on the amount of data being transmitted by the radio modem, unless the device has been configured for continuous transmit, in which case the constant current consumption will be equal to the transmit current only (at $100 \%$ duty cycle).

Note: Operation below the minimum specified supply voltages could result in poor radio performance. If the supply voltage falls below 7.2 V dc the radio will shut down. Normal radio startup will not occur until 10 Vdc is supplied.

## Site Earthing

Ensure that the chassis mounting plate, power supply (-) earth, RTU terminal device, and lightning arrester, are all securely earthed to a common ground point to which an earth stake is attached. Please pay particular attention to 24 Vdc PLC systems using DC-DC converters to supply 13.8 Vdc .

Physical Dimensions - Remote Data Radio - ER450


Physical Dimensions - Base Station - EB450


Physical Dimensions - Hot Standby Base Station - EH450


## Part E-Getting Started

## ER450 Quick Start Guide

## Introduction

Welcome to the ER450 Quick Start Guide. This guide provides step-by-step instructions, with simple explanations to get you up-and-running.


## Mounting and Environmental Considerations

The ER450 radio comes complete with a mounting cradle and is attached to a panel or tray by means of screws or bolts, using the hole slots provided.

Note: In high power or high temperature applications, it is desirable to mount the radio with the heatsink uppermost to allow ventilation for the heatsink.

The radio should be mounted in a clean and dry location, protected from water, excessive dust, corrosive fumes, extremes of temperature and direct sunlight. Please allow sufficient passive or active ventilation to allow the radio modem's heatsink to operate efficiently.

## Typical Radio Setup



## ER450 Connections Layout



## Connecting Antennas and RF Feeders

The RF antenna system should be installed in accordance with the manufacturers notes.

The RF connector used on the E Series radios are N Type female connectors. Always use good quality low loss feeder cable, selected according to the length of the cable run. Ensure all external connections are waterproofed using amalgamating tape.

Preset directional antennas in the required direction using a compass, GPS, or visual alignment and ensure correct polarisation (vertical or horizontal).


## Communications Ports

## System Port - RJ45

The System Port (available front and rear on EB/EH450) is a multifunction interface used for:

- Programming / Configuration of the radio
- Remote Diagnostics connections

To access these functions use theTVIEW + Cable assembly (RJ45 Cable and RJ45 to DB9 Adaptor).

The TVIEW+ Cable is a standard CAT 5 RJ-45 (Male) to RJ-45 (Male) patch cable. It is intented for RS232 serial communications only and should not be connected directly into an ethernet port of a PC. The Cable must be used in conjunction with the RJ-45 to DB9 Adaptor.

TVIEW+ Adaptor Configuration:

| System <br> Port | Description | DB9 Female |
| :--- | :--- | :--- |
| Pin 1 | System port data out (RS232) | Pin 2 |
| Pin 2 | System port data in (RS232) | Pin 3 |
| Pin 3 | Factory Use Only - Do not connect | No Connection |
| Pin 4 | Shutdown | No Connection |
| Pin 5 | Programming Use Only (Grounded) | Pin 5 |
| Pin 6 | Factory Use Only - Do not connect | No Connection |
| Pin 7 | Ground | Pin 5 |
| Pin 8 | External PTT | No Connection |

Special user pinouts:

- $\quad$ Shutdown (Pin 4) - Active low for power save function
- External PTT (Pin 8) - Provides a manual PTT override facility for enabling the transmitter. For testing this can be activated by connecting PTT (Pin 8 ) to Gnd (Pin 7).



## User Interfaces - Ports A \& B

Each user port (A \& B) is wired as a RS232 DCE, configurable for no handshaking (3-wire) interface, or for hardware or software (X-on/X-off) flow control. In most systems flow control is not required, in which case only 3 wires need to be connected between the radio and the application device.

## Typical pins used:

- Pin $2(\mathrm{RxD})$ - data output from the radio modem,
- Pin 3 (TxD) - data input to the radio modem,
- $\quad$ Pin 5 (SG) - signal ground.

See Part D - System Planning and Design - Data Connectivity, for further details of other cable configurations.

## RS232 Connector Pin outs (DCE)

Port A and B, Female DB9

6 DSR - output
7 RTS - input
8 CTS - output
9 Port A - not used
Port B - RSSI output


Radio (DCE) - Connection to RTU / PLC or Computer (DTE, DB9)


## Activating the Transmitter

In most systems, the transmitter by default is controlled automatically by the radio when it has data to transmit.

In some systems, such as full duplex point-to-point links or full duplex point-to-multipoint base stations, it is desirable to run the transmitter all the time (hot keyed).

Two mechanisms are provided to do this:

- the radio modem can be configured to transmit continuously whenever powered, or
- the radio modem can be configured to transmit whenever an external RTS signal (Pin 7 ) is applied to one (or either) user ports. (To simulate an external RTS input, loop pins 6 to 7 ).

To operate in these modes, the radio must be configured via the programming software.
A. Caution: When the radio is configured to transmit continuously, ensure an RF load is present BEFORE applying power to the unit.

## Power Supply Requirements

The E Series radio modem is designed and calibrated to operate from a filtered 13.8 Vdc regulated supply, but will operate from a $10-16 \mathrm{Vdc}(11-16 \mathrm{Vdc}$ for EB450 \& EH450) range. See Section L - Specifications for more details on power supply requirements
. Caution: There is NO readily serviceable internal fuse, and therefore the radio modem MUST be externally fused with a fuse and fuse holder (ER450: 3 amp fast-blow fuse, EB450: 5 amp fast-blow fuse).


The radio is designed to self protect from permanent damage if the voltage exceeds 16 Vdc or if reverse polarity is applied. The radio may need to be returned for service if this occurs.

The radio modem can also be damaged if there is any potential difference between the chassis-ground, RS232 signal ground, power (-) input, or antenna coaxial shield. Before connecting any wiring, ensure all components are earthed to a common ground point (please pay particular attention to 24V PLC power systems where converters are used).

Connect the antenna and RS 232 plugs BEFORE applying power to the unit.

Lastly, before inserting the power plug, please re-check that the polarity and voltage on the power plug is correct using a multimeter.

## TVIEW+ Management Suite

## Radio Configuration

This TVIEW+ Management Suite allows a number of features including: Configuration (Local - serial, or Remote - over-the-air), Remote Diagnostics Facilities and Firmware Upgrades.

The configuration wizard can be used to provide Quick Start generic templates for the types of systems architecture you wish to employ.

Example: Local configuration session -
1 Attach the programming cable from the PC to the System Port of the radio

2 Launch TVIEW+ \& Select "Programmer"
3 Select "Read" the radio
4 Change the configuration as required
5 Select "Write" the parameters back to the radio
Refer to Parts I \& J - TVIEW + Management Suite for detailed operation of advanced features.


## Optimising the Antenna for best RX signal

Once the unit is operational, it is important to optimise the antenna tuning.

In the case of a directional antenna, it will be necessary to align the antenna for the best received signal.

This can be done by using the ( $0-5 \mathrm{~V} \mathrm{Vc}$ ) output on Pin 9 of Port B to indicate signal strength (RSSI). This voltage can be converted to dBm using the chart below.



## LED Indicators \& Test Outputs



## Radio is Powered

If all the LEDs are off, no power is reaching the radio modem.
Successful power-up is indicated by the "PWR" LED indicating a continuous (healthy) GREEN state. Note that this LED is turned RED when the transmitter is active.


## Radio Errors

Internal radio management software monitors many aspects of the radio hardware. Under certain circumstances radio faults may prevent normal operation. In the event that these fault conditions occur, the radio will enter an ERROR state and this will be indicated by flashing ALL LEDs RED, then flashing a pattern of GREEN LEDs. The pattern of all GREEN LEDs represents the specific type of error that has occurred. See Table below.

| Port A | Port B | Synch/ <br> RXSig | Pwr/TX | Error Diagnosis |
| :--- | :--- | :--- | :--- | :--- |
| OFF | OFF | OFF | ON | External Supply Voltage <br> out of spec. (1) |
| ON | OFF | ON | OFF | RXVCO Out of Lock. (2) |
| ON | OFF | OFF | ON | TXVCO Out of Lock. (3) |

All other patterns indicate serious hardware errors. Please record this pattern and return the result with the service return information.

Note (1): If external voltage is too high (>16Vdc) radio damage may occur. If the external voltage is too low ( $<10 \mathrm{Vdc}$ ) the radio may not operate within specifications.

Note (2) and (3): If the radio receiver or transmitter frequencies are programmed outside the specified frequency ranges (model type dependent), then normal radio operation may not be possible. In this case, use TVIEW+ to set the receiver and/or transmitter frequencies to be within the specified range. If this error occurs and the frequencies are within the specified frequency ranges (model type dependent), the radio will need to be returned for service.

## Received Signal Indicator

## LED Legend



The "RX/SYNC" LED is used to indicate the state of the receiver If the LED is off, no signal is being received.

A RED indication shows that an RF carrier is being received, but no data stream can be decoded. This will briefly happen at the very start of every valid received transmission or may indicate the presence of interference, or another user on the channel.

A continuous GREEN indication shows that the modem is locked and synchronised to the incoming signal, and has excellent Bit Error Rate (BER). Any losses of synchronisation (BER errors) are shown as a visible RED flicker of the LED.

Note: This might only be apparent on a PTMP slave when only receiving.


## Data Flow "breakout" LEDs

There are also two LEDs to indicate data flow into and out of the two user ports.

Input data to be transmitted is shown as a RED flash, and received data to be output to the port is shown as a GREEN flash.

If data is alternately flowing in and out quickly, then the indicator appears orange.

## Verifying Operational Health

It is possible to verify the operation of the radio modem using the indicators provided by the unit. The state of the transmitter and receiver, and data flow can be interpreted by the indicator LEDs (see below).

Note: Port A and Port B's RxD and TxD will be Active on Data Flow

Full Duplex - PTP Master or Slave


Full Duplex - PTMP Master Tx


Half Duplex - PTMP Slave Rx


Half Duplex - Master or Slave (Tx)


Half Duplex - Master or Slave (Rx)


## EB450 Quick Start Guide

## Introduction

Welcome to the Quick Start Guide for the EB450 Base / Repeater Data Radio. This guide provides step-by-step instructions, with simple explanations to get you up-and-running


## Mounting and Environmental Considerations

The EB450 Base Station is housed in a $2 R \mathrm{C} 19$ " rack enclosure. The 4 mounting holes on the front panel should be used to secure the unit to the rack

The radio should be mounted in a clean and dry location, protected from water, excessive dust, corrosive fumes, extremes of temperature and direct sunlight. Please allow sufficient passive or active ventilation to allow the radio modem's heatsink to operate efficiently.

All permanent connections are made at the rear of the unit. This includes: Power, Antenna, Communications Ports, Digital I/O and System Port. The front panel has an additional System Port connection point for easy access.

## Full Duplex Considerations

The EB450 is designed for continuous full duplex transmission. An automatic thermostatically controlled fan will operate whenever the internal temperature exceeds 50 degrees Celsius.

## External Duplexer Considerations

The EB450 is normally supplied with separate Tx and Rx ports for connection to an external duplexing system.

Depending on the frequency band of operation and the Tx/Rx frequency split, internal band reject duplexers are available.

Connecting_Antennas and RF Feeders
See ER450 Quick Start Guide

## Communications Ports

See ER450 Quick Start Guide Section
Power Supply and Protection
See ER450 Quick Start Guide Section
TVIEW+ Management Suite - Radio Configuration

See ER450 Quick Start Guide Section
Optimising the Antenna for VSWR and best RX signal

See ER450 Quick Start Guide Section

## Typical Radio Setup



## Digital Inputs and Outputs

The EB450 provides a facility for two channels of digital user inputs and outputs (Digital User I/O). Information on how to control and monitor this I/O using TVIEW+ Diagnostics can be found in Part J - TVIEW+ Management Suite - Remote Diagnostics \& Network Controller.

All user I/O is optocoupled for isolation between the EB450 and uses equipment. When using the I/O facility the I/O electrical characteristics and ratings must be observed. Failure to observe these ratings may result in equipment damage.

## Inputs

Two User Inputs are available. They have identical interface characteristics. Each input has an internal resistance of 470 Ohms. Some form of switching contact (ie: switch, relay) is normally used to change the state of the input. Both an isolated and non-isolated input configuration is possible.


TVIEW+ Diagnostics will recognise an input as being ON when the switch is closed. If the switch is open (or not connected) TVIEW+ diagnostics will recognise the inputs as being OFF.

## Outputs

Two User Outputs (Open Collector) are available. They have identical interface characteristics. The maximum current allowed through each output is 20 ma . External resistors must be used keep the current below this value.

Each output has an internal resistance of 100 Ohms. Ohms law can be used to calculate the resistance required for a specific voltage (keeping the current below 20 mA ). Nominally 1 k Ohm is used for a +13 v 8 supply and 330 Ohms for a +5 v supply.

When the OUTPUT is OFF, $\mathrm{V}=\mathrm{Vs}$. No current will flow when output is off.

When the OUTPUT is $\mathrm{ON}, \mathrm{V}=$ nominally 2.3 volts . Current is set by resistor.


## LED Indicators \& Test outputs

## Radio is Powered

If all the LEDs are off, no power is reaching the radio modem.
Successful power-up is indicated by the "PWR" LED indicating a continuous (healthy) GREEN state. Note that this LED is turned RED when the transmitter is active.


LED Legend

## Hardware Error

A hardware error is indicated on the status LEDs by all LEDs flashing RED at a rate of 1 Hz . This indicates internal communications to the exciter inside the basestation has been lost and the base station needs to be returned to repair.

## Received Signal Indicator

The "RX/SYNC" LED indicates the state of the receiver.
If the LED is off, no signal is being received.
A RED indication shows that an RF carrier is being received, but no data stream can be decoded. This will briefly happen at the very start of every valid received transmission or may indicate the presence of interference, or another user on the channel.

A continuous GREEN indication shows that the modem is locked and synchronised to the incoming signal, and has excellent Bit Error Rate (BER). Any losses of synchronisation (BER errors) are shown as a visible RED flicker of the LED.

Note: This might only be apparent on a PTMP slave when only receiving.


## Data Flow "breakout" LEDs

There are also two LEDs to indicate data flow into and out of the two user ports.

Input data to be transmitted is shown as a RED flash, and received data to be output to the port is shown as a GREEN flash.

If data is alternately flowing in and out quickly, then the indicator appears Orange.

## Bar Graph Indicators

The bar graph indicators on the front panel provide variable information regarding the performance of the Base Station. To enable / disable the bar graph display depress the Display ON / OFF button. The display will turn off automatically after 5 minutes.

## DC Supply:

Indicates the supply input voltage at the exciter module. Typically 13.8 Vdc .

Indication: <10Vdc no LED's on, 10-10.9Vdc LED's RED, 1115.6 Vdc All LED's GREEN, >=15.7Vdc last LED RED.

## Tx Power:

Indicates forward RF power output as measured at the TX antenna port. Typically +37 dBm .

Indication: <20dBm no LED's on, 20-40.6dBm (11.5W) LED's GREEN, >=40.7dBm last LED RED.

## Tx Drive:

Indicates exciter drive level. Typically +20 dBm .
Indication: <10dBm no LED's on, 10.0-25.9dBm LED's GREEN, >=26.0dBm last LED RED.

## Rx Sig:

Indicates receive signal strength. Typically -85 to -65 dBm .
Indication: <-120dBm no LED's on, -120 to -110.1dBm LED's RED, $>=-110 \mathrm{dBm}$ LED's GREEN.

## RxFreq. Offset:

Indicates offset of receiver AFC - useful in determining frequency drift. Typically 0kHz.

Indication: Single GREEN LED to indicate current value, $<-3.6 \mathrm{kHz}$ or $>+3.6 \mathrm{kHz}$ LED is RED. No signal, all LED's OFF.
Note: 5 second peak hold circuitry.


## Test Mode

The Bar Graph indicators have a Test Mode, which cycles all LED's for correct operation (before returning to their normal operation). To activate this mode, simply depress the ON / OFF button while applying power to the unit.

## EH450 Quick Start Guide

## Introduction

Welcome to the Quick Start Guide for the EH450 Hot Standby Base / Repeater Station. This section provides additional step-bystep instructions to install, commission and operate the EH450 Hot Standby Base Station. This document should be read in conjunction with the EB450 Base Station Quick Start Guide.

The EH450 is a fully redundant, hot standby digital data radio base / repeater station providing automatic changeover facilities.

The EH450 is designed as a modular solution, comprising 2 identical EB450 base station units (standard) linked to a central, fail-safe monitoring and changeover controller (Hot Standby Controller). Either base station may be taken out for maintenance without the need for any system down time. The automatic changeover is triggered by out of tolerance (alarm) conditions based on either RF and/or user data throughput parameters.


## Features and Benefits

- Individual and identical base stations with separate control logic changeover panel
- Modules are hot swapable without user downtime
- Flexible antenna options - single, separate $T x$ \& $R x$, two $T x$ and two Rx
- Both on-line and off-line units monitored regardless of active status
- Also refer to the common Features and Benefits list of the E Series Data Radio


Base / Repeater Unit


Hot Standby Controller Unit

## Rear View



## Operational Description

The Hot Standby Controller (HSC) unit is a 1 RU rack mounted module that interfaces to two physically separate base stations (each 2RU rack mounted modules) via a number of RF and data cables.

Both base stations are operating simultaneously and both units are constantly receiving signals, however only data from one base station, the "online" base station is directed to the user equipment. The online base station is the only base station transmitting at any time. The Hot Standby Controller has the following functions:

- Diplex the transmit and receive paths (Assuming internal duplexer fitted), TX Only.
- Amplify and split the incoming signal two ways so both base stations receive at once.
- Monitor status reports from both base stations to identify faults and swap over the online base station if required.
- Switch the antenna via internal coaxial relay duplexer to the online base station transmitter and inhibit the offline base station from transmitting.
- Switch the User A and B data ports through to the online base station.

An optocoupler based switch in the base station controller directs data to and from ports A and B on the rear panel directly to ports A and $B$ on the on-line base station without any involvement from the Hot Standby controller microcontrollers (apart from selecting the on-line base). This provides protection of the system from failure of the microcontroller

As well as ports $A$ and $B$, each base has a system port. The system port of each base station is interfaced to the microcontroller on the Hot Standby controller. This allows the microcontroller in charge of selecting the base station to receive diagnostic messages from each base station to decide their health.

The base station has it's own system port on the rear panel and this is interfaced to the Hot Standby Controller Module. The HSC will route diagnostics at the rear panel system port to and from the system ports of the base stations.

## . Warning

The base station front panel system port has priority over the rear panel port, which is used for communication between the base station and the Hot Standby Controller. This is to permit service personnel to reconfigure the base station module without disconnection from the Hot Standby Controller. It should be noted however, that when the front panel port is accessed, a changeover
event will occur due to lost communications with the Hot Standby Controller.

## Mounting and Environmental Considerations

The EH450 Hot Standby Base Station is housed as a 5 RU 19" rack mounted set, encompassing $2 \times 2 R U$ Base Station units and $1 \times$ 1 RU Hot Standby Controller unit. The mounting holes on the front panels should be used to secure the units to the rack.

The unit should be mounted in a clean and dry location, protected from water, excessive dust, corrosive fumes, extremes of temperature and direct sunlight. Please allow sufficient passive or active ventilation to allow the radio modem's heatsink to operate efficiently.

All permanent connections are made at the rear of the unit. This includes: Power, Antenna, Communications Ports, Digital I/O and System Port. The front panel has an additional System Port connection point for easy access.

The Base Station front panel system ports must not be used while in this configuration.

## Communications Ports

The A \& B Data Ports and System Ports of each Base Station connect directly to the Hot Standby Controller units corresponding ports with the cables provided. Ensure all clamping screws on the Data Port cables are firmly secured and the System Port cables are clipped in correctly. See figure below for further details.

Note: Only the front or rear User System Port can be used at any one time on the Hot Standby Controller.

Note: RF Connectors not used on ETSI version


## Power Supply and Protection

The EH450 has facilities for dual power supplies to provide for a redundant system. A separate power supply should be used for

The Hot Standby Controller units A \& B Data Ports connect directly to you application device and the System Port connects directly to your local PC. See ER450 Quick Start Guide Section for further each of the Base Station units. The Hot Standby Controller unit has connections for dual power supplies and it is recommended that the power supplies from each of the Base Stations also be used to power the Hot Standby Controller unit. See Figure below for further details.


## Connecting_Antennas and RF Feeders

There are 3 primary antenna connection options. All connectors used are standard N Type sockets. See figures below for further details.


## Front Panel Operation



## Switches

## Select Switch

The 3 position switch ( 1 / Auto / 2 ) on the front panel provides the following functionality:

- Position 1: base station 1 is forced into operation
- Position Auto: changeover hardware will select the online base station
- Position 2: base station 2 is forced into operation

The select switch is also used to identify the target base station for configuration programming.
Adjacent to the select switch are two LEDs: These LEDs indicate the current active base station.

## Select LEDs

- Green - Auto Mode
- Red - Remote Force
- Amber - Local Force

2 Green Firmware Download
2 Amber Test Mode
2 Red Fatal Error - refer User Manual

## Reset Switch

This is a momentary close switch which when depressed will reset all LED alarm indications.

## System Port

There are two system port connection points, one on the rear panel and one on the front panel. Both have the same functionality and can be used for local diagnostics, firmware front panel downloads and hot standby controller testing. To access the system port use the diagnostic/programming cable supplied.

Note: When connection is made to front panel system rear system port is disabled.

## Alarm Status LEDs

There are 10 alarm LEDs on the front panel, five for base 1 and five for base 2. These LEDs provide a general indication of base station status. More detailed base station status information is available by using the diagnostic utility software.

The indicated alarms for each base station are:

| Freq. | => | Frequency Error |
| :--- | :--- | :--- |
| RxSig | => | Receive Signal (RF) Error |
| Data | => | Receive Data Error |
| TxPower | => | Transmit Power (RF) Error |
| Supply | => | DC Voltage Error |

The status of each alarm is represented as follows:

| OFF | => | Unknown |  |
| :---: | :---: | :---: | :---: |
| Green | => | No Error |  |
| Red |  | => | Current (active) Error |
| dition |  |  |  |
| Amber | => | Recovered | Error condition |

Any active or recovered error LEDs will turn to green after the reset alarms switch has been pushed or remotely reset.

## Part F - Operational Features

## Multistream functionality (SID codes)

The E Series sends data messages in packets. A feature of the E Series is that an address can be embedded in each packet. This address is called the stream identifier code (SID).

By configuring a user serial port for a specific SID code, it is possible to steer messages to similarly configured ports between radio modems. In effect, it is possible to use the multiple serial ports available on the E Series, to enable multiple protocols to share the same RF channel. The SID codes also facilitate the use of other features such as TView diagnostics. Unique selective routing, repeating, and data splitting functions available in the radio modems configuration allow data steering and bandwidth management in complex systems.

See Part I - TView+ Management Suite - Programmer and Part J - TView Remote Diagnostics and Network Controller for details.

## Collision Avoidance (digital and RFCD based)

Where multiple "unsynchronised" protocols coexist on a common "multiple access" radio channel, there is always a possibility that both "hosts" may poll different "remote" devices at the same time. If both devices attempt to answer back to the single master radio at the same time, it follows that a collision could occur on the radio channel.

To facilitate the operation of multiple protocol operation on the radio channel, a transparent collision management system has been implemented : See Part I - TView+ Management Suite - Programmer for details.

## Digital Collision Avoidance System

If the "multiple access master" has been configured for full duplex operation, it is possible to use the inbuilt collision avoidance signalling system.

Once the master radio receives a valid incoming data stream from a remote, a flag within the "outbound" data stream is used to alert all other remote devices that the channel has become busy. Remote devices wishing to send data will buffer the message until the channel status flag indicates that the channel is clear. A pseudo-random timing value is added to the retry facility to ensure that waiting remotes do not retry at the same time.

## RF Carrier Detect RSSI based Collision Avoidance

In half duplex systems, the receiver's RF carrier detect is used to inhibit the transmitter whilst a signal is being received

## Digipeater Operation

A feature of the E Series radio modems is the ability to internally repeat data packets to provide stand alone repeater facilities without the need for external intelligence.

This is done by programming "SID Codes" to "Repeat" a stream or range of streams. Wizard templates can be used to simplify setup of this and other features

See Part I - TVIEW+ Management Suite for details.

## TVIEW+ Diagnostics

The E Series has an inbuilt remote configuration and diagnostics utility.
This facility allows transparent remote access to the key configuration and operating parameters of the radio.

See the TView+ Diagnostics User Manual for more information.

## Poor VSWR Sensing

To protect the transmitter, forward and reverse power are measured on each transmission.

If a VSWR of 3:1 or greater is measured, transmitter output power is reduced to +31 dBm .

## Part G - Commissioning

Check DC power connector for correct voltage ( $10-16 \mathrm{VDC}$ ) and polarity, BEFORE plugging in the power connector.

## Power-up

Upon power up, the radio will self test and shortly after the green power LED will be displayed

Failure of the power LED to light indicates no power, or failure of the fuse due to incorrect polarity or over-voltage.

Other failure such as fatal internal errors will initiate error modes as detailed in Part E - Getting Started: LED Indicators and Test Outputs.

## LED Indicators

Will depend on the system architecture. If the device is a remote site receiving a base station with a constant carrier, then the RXSIG/SYNC LED should be green to indicate healthy reception of the wanted signal.

If the site has been configured as a constantly transmitting base station, then the PWR/TX LED should show red.

In other types of systems, TX and RX bursts would be indicated by the RX or TX LED's as above.

Data flow to and from the user ports is indicated by the TXD/RXD LEDs for each port.
(See Part E - Getting Started: LED Indicators and Test Outputs.)

## Data Transfer Indications

Bi-colour LEDs are provided to indicate RS232 data being transmitted and received on each data port. A RED flash indicates a byte (or bytes) of incoming data from the serial line which will be transmitted to air, and a green flash indicates a byte of data received "off air" being released onto the serial line

If data is being sent to the radio modem and the Data LED does not flash RED, this may indicate a wiring or configuration problem. Check that the TX and RX data lines are correctly wired (see Part E - Getting Started: LED Indicators and Test Outputs).

Also check that character set and parity settings (i.e. N,8,1 etc) are set identically at the terminal and the radio modem. Note that some incorrect settings of the character set parameter can still produce transmittable data, even though the data will not be understood by the application.

## Antenna Alignment and RSSI Testing

Once the RXSIG LED is lit, it is possible to confirm RX signal strength and align a directional antenna by monitoring the RSSI output.

This DC voltage appears at Pin 9 of Port B.
A ground reference can be obtained from chassis ground or Pin 5 of Port A or B.

The chart below shows Pin 9 voltage as it relates to signal strength.


## Testing

Once communications has been established, it is possible to confirm the packet error rate performance of the radio path, and thus estimate the BER figure.

There are a number of tools provided to do this. The easiest is to use the "indicative packet error test" provided within the TVIEW+ Diagnostics under "statistical performance tools". Alternatively, it is possible to use hyper terminal, or other packet test instruments or PC programs to run end to end or perform "loopback" testing.

Please note that when using a "loopback plug" some understanding of the packetising process is necessary, since each "test message' must be carried in a single packet for meaningful results to be obtained.

Note also that in PTMP systems, allowance must be made for collision potential if other data is being exchanged on the system.

## VSWR Testing

VSWR testing is achieved using specialized VSWR testing equipment, or a "Thruline" power meter that measures forward and reverse power.

VSWR is the ratio between forward and reflected transmitter power, and indicates the health and tuning of the antenna and feeder system.

VSWR should be better than 3 to 1 , or expressed as a power ratio, $<6 \mathrm{~dB}$ or no more than $25 \%$. To activate the radio's transmitter for VSWR testing, use:

## Part H - Maintenance

## Routine Maintenance Considerations

The E Series hardware itself does not require routine maintenance. However all radio products contain crystal frequency references, and the stability of these crystals changes with time. The effect of this is that the product will slowly drift off frequency, and eventually it will require re-calibration. E Series radios are designed with high quality, low drift specification references, to ensure a long maintenance free lifespan. The length of this lifespan will depend on the severity of temperature extremes in the operating environment, but is normally $3-5$ years. Extended frequency drift can be detected using TVIEW+ Diagnostics "Freq error" parameter.

Generally, re-calibration is achieved by replacing the radio in the field with a spare, and returning the radio to a service centre for re-calibration and specification testing at moderate cost.

Routine maintenance should be performed on external equipment subject to greater environmental stresses including antennas, RF feeder cables, backup batteries and cooling fans (if required). This maintenance should include testing of site commissioning figures such as received signal strength, VSWR, P/S voltage etc.

## Part I - TVIEW+ Management Suite Programmer

## Introduction

This manual covers the installation and operation of the E Series TVIEW+ Management Suite which incorporates 3 utilities:

- Programmer for configuration of the radio RF parameters, system parameters and data ports
- Diagnostics* for real-time monitoring and logging of radio performance parameters
- Firmware Update for loading new firmware releases into the radio data modem

All utilities can be run on any IBM compatible computer running Windows 2000® and above. This section describes use of the programmer and firmware Update utilities in detail. Users should refer to the separate WinDiags User Manual for information about this utility.

The programmer is used to set configuration parameters within the ER450 data radio modem and EB450 base station. The utility permits configuration of modems connected directly to the PC as well as over the air to a remote unit. Configuration parameters can be saved to a disk file for later retrieval, or used for clone programming of other modems.

All configuration parameters are held in non-volatile memory (NVRAM) on the Data Radio Modem. Configuration is fully programmable via the Systems Port using the programming adaptor and cable supplied. Disassembly of the unit is not required for any reason other than for servicing.

The diagnostics utility permits monitoring and logging of radio performance parameters for both E Series* as well as M Series* data radio modems and base stations. It supports homogeneous systems of radios as well as mixed systems of both E and M series radios.

The firmware update utility permits field upgrade of the firmware in an ER450 data radio modem, EB450 base station and EH450 hot standby unit connected directly to the PC. A special serial adaptor cable is required to be connected to Port $B$ to load firmware into the unit.

## Installation

## Unit Connection

## Programmer and Diagnostics Utilities

The unit is connected to the PC using the supplied DB9-RJ45 adaptor cable (part no. TVIEW+ Cable) for local configuration changes or diagnostic monitoring. The cable should be connected to the RJ45 System Port of the unit and a valid PC serial port (e.g. COM 1) DB9 connector.
(See Part E - Getting Started: Communications Ports)

## Firmware Update Utility

The unit to be updated with firmware connects to the PC using the DB9-DB9 adaptor (part no. DRPROG). The cable should be connected to the DB9 Port B connector on the unit and a valid PC serial port (See Appendix C for details) DB9 connector.

## Software

Please take a moment to read this important information before you install the software.

The installation of this Software Suite is a 2 step process.
Step 1 completes the typical installation of the TVIEW + Management Suite and will install the Programming Software together with the E Series Documentation.
Step 2 installs the Diagnostic Software and is optional. This step is only required if your radios have Remote Diagnostics enabled.

## STEP 1: Installation - TVIEW+ Management Suite

Note: If a previous version of the TVIEW+ Management Suite has been installed on your PC, you must uninstall it via Control Panel "Add/Remove Programs".

- Close down all other programs currently running.
- Place the CD-ROM in the drive on the PC.
- Using Windows Explorer locate the files on the CD-ROM.
- In Windows Explorer double click on the file called TVIEW+_(Version\#)_install.exe
- After the installer starts follow directions.


## STEP 2: Installation - TView Diagnostic Software (Optional)

Note: If a previous version of the "TView WinDiags" software has been installed on your PC, you must uninstall it via Control Panel "Add/Remove Programs".

- Close down all other programs currently running.
- Place the CD-ROM in the drive on the PC
- Using Windows Explorer open the "Diagnostics" directory on the CR-ROM.
- Double click on the file called setup.exe
- After the installer starts follow directions.


## Other:

The current E Series Manuals are supplied and installed as part of the TVIEW+ Management Suite installation in Adobe Acrobat format.

Adobe Acrobat Reader is provided on the CD-ROM for installation if required.

## TVIEW+ Front Panel

When started the TVIEW+ front panel appears. The larger buttons permit each of the three utilities to be started. The diagnostics button may be greyed out if this utility has not been installed or found in the correct file directory. Access to local help and an exit facility are provided by the remaining 2 buttons.


## Programmer

## Main Window

When first started the programmer is in file mode as indicated by the mode field at the bottom right of the panel shown below. In this mode it is possible to open a previously saved configuration file, or configure various programming options and save the configuration to a file.

Note: Modulation type is not available in this mode.
To commence programming a unit (radio remote or base station) a session must first be established by using the "READ" function. This function reads the current configuration from the unit and displays it in the main window. The "mode" displays changes to local or remote depending on the type of session selected at the read function. Several options in the main window may be blanked out until a session has been established with a unit.

Note: Changing any item on the menu will in general not take effect until data is written back to the unit using the "WRITE" function.

The procedure to follow for normal programming of unit is:

- Read unit
- Configure parameters (or Open a previously saved configuration file)
- Write unit

Several modems of the same radio type can be programmed with the same configuration using the clone facility described in Clone Mode. It is important to note that when using this facility the cloned radio should be of the same type to ensure it does not operate outside its capability.


## Pull Down Menus and Toolbar Buttons

The items on the pull-down menus can be selected either directly with a mouse or using the ALT key in combination with a HOT KEY (e.g. ALT-F to select the file menu). Several of the functions within each menu are also available on the toolbar (click once to select).

Exit (also available on the toolbar)
This function terminates the program. The user is requested to confirm this selection before exiting the application.

## Modem Menu

This radio menu allows configuration data to be read from and written to the unit (remote radio or base station) using the selected PC serial port connection (see Settings menu). The action of reading the configuration establishes a session with the unit. Communications is maintained with the unit to ensure that the session remains open. If the session has been lost due to data transmission errors or disconnection of the programming cable it will need to be re-established to ensure any updated configuration is written successfully to the unit.

Read (also available on the toolbar)
This function establishes a session with the unit, reads configuration data from the unit and displays it in the programmer main window. When selected a dialogue window appears prompting the user to choose whether the unit to read is local (connected directly to the serial port or remote (connected over the air to the unit connected to serial port). Unit no. (Serial no.) must be entered and the stream SID code is "on" (default $=0$ )). After configuration data is read from the unit it is available for editing and writing back to the unit or saving to a file. The progress of data transfer to or from the unit is indicated by a message window as well as a rotating indicator in the bottom right hand corner of the main window.


Write (also available on the toolbar)
This function writes configuration data displayed in the main window to the unit and reboots the unit. When selected a dialogue window appears prompting the user to confirm whether to proceed. A progress indicator in the bottom right hand corner of the main window is displayed while data is being read. This selection is only available if a session has been previously established and maintained with the unit.


This dialog provides a facility for reversing any remote configuration changes that cause unexpected results resulting in the device reverting to previous configuration if contact is lost.

Choose "Make changes and resume contact" to safeguard changes. Some parameter changes (such as frequency change) will, by definition, automatically result in lost contact.

Choose "Make changes anyway and finish" to complete intentional changes which will result in lost contact.


After configuration data has been written, the session with the unit is closed and the programmer reverts to file mode.

Note: In general, any change made on the programmer screen must be written to the unit (using the write function) to become permanently stored. However, changes to Power adjust, Mute adjust and $7 \mathrm{x} /$ Rx trim take immediate effect to allow test and adjustment prior to permanent storage via the write function.
Cancel Session (also available on the toolbar)
This function closes the session with unit and puts the programmer back into file mode. All configuration changes are discarded including changes to Power Adjust, Mute Adjust and Tx/Rx Trim.

## Wizard (also available on toolbar)

This function permits the user to select standard configurations after the configuration from a unit has been read or a file opened


The user is prompted via a series of dialogue windows to select the desired configuration that can then be written to the unit (remote radio or base station).


## Clone Mode

This function permits writing of the same configuration data to several units. This feature is normally used for configuring data radio modems connected locally.

The procedure is:

- Read the configuration from the first unit.
- Configure the parameters (or open a previously saved configuration file).
- Select Clone Mode (Modem menu).
- Write the configuration to the first unit.
- The changes will take effect when unit is repowered.
- Connect the next unit.
- Write the next unit which establishes a session and recognises the unit serial number and type, which then configures the unit
- Repower the unit for changes to take effect
- Repeat the last 3 steps for the remaining units.


## Settings

This menu permits selection of the PC serial port (COM1 to COM4) to be used for communications with the unit. COM1 is the default selection and if a different port is to be used it must be set before establishing a session by reading the configuration from a unit. Whilst a session is established with a unit this menu can not be accessed.

## Help

This menu permits selection of help information using the Contents key. Warnings regarding use of the programmer software using the Warnings key and version detail using the About key.

| Port A Configuration |  |  |  | Port B Configuration |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Character Layer | Packet Layer | Handrhaking |  | Packet Layer | Handshaking |
| \% 9600 N 0.1 | If stansed | \% Nome |  | c. standard | Yon |
| C) $4800 \mathrm{NB,1}$ | C Moogus | C Hargeare |  | C MODDUS | CHardware |
| - Oustom | custiom | C xeevicar |  | custom | C Xonocrif |
| 3860, $\mathrm{N}, 8,1$ | afict munatier otr | koranced | $384000 \times 8.1$ | Etv Pmanason: on | Adranted |

## Port A and Port B Configuration

Data from these two user ports is multiplexed for transmission over the air. Each port can be configured separately for the Character layer (Data speed, number of data bits, number of stop bits, parity), Packet layer and Handshaking (flow control). Port B must be enabled if required by setting the check box at the top of its configuration section.

The following description is common to both ports.

## Character Layer

There are two standard formats and a custom format that can be selected by checking the appropriate control button to the left of the description. The standard formats are:

- $9600, \mathrm{~N}, 8,1$ (data speed $=9600$ bps, no parity, 8 data bits, 1 stop bit)
- 4800,N,8,1 (data speed = 4800 bps, no parity, 8 data bits, 1 stop bit)

A non-standard format can be selected via the Custom button that displays a dialogue box to permit selection of data speed, parity, number of data bits and stop bits. Once selected the OK button should be used to complete the selection. The custom selection is also displayed in the main window below the Custom button.


## Packet Layer (Packet Modes Only)

There are two standard configurations and a custom configuration which can be selected by checking the appropriate control button to the left of the description. There are essentially two basic modes of operation for the packet assembler and disassembler (PAD).

The first is where the PAD operates in a standard mode with data received at the port being immediately sent over the radio channel.

The second is a store and forward or delayed mode where whole data packets are received from the port before being sent over the radio channel.

In both cases data is sent over the radio channel in variable length frames and delineation of these frames is dependent on the configuration selected as well as the characteristics of the data stream received at the data port.

The packet layer configuration options which can be selected are:

## Standard (live framing)

With standard live framing data received from the host by the modem is immediately placed into a frame and transferred onto the radio channel. This minimises "store and forward" delays in the data transmission.

If a stream of characters is received by the modem, then several characters at a time may be placed into the same frame. The number of characters in the frame depends mainly on the respective baud rates of the user port and the primary channel baud rate of the modem, as well as the level of overheads experienced on the radio channel and the user data stream.

The number of data bits associated with the user data stream will also have an effect on the average size of a frame. For instance the number of stop bits, and number of data bits per character.

The system designer must choose the best compromise of all the above items to ensure the most efficient method of data transmission.

Note: The first few characters are always packetised and sent by itself regardless of all the above variables.

## Modbus

This selection configures the PAD driver with options automatically set to implement the MODBUS protocol, e.g. 5 mSec timer.

## Custom

Other configurations of the PAD driver can be selected via the Custom button which displays a dialogue box to permit selection of several configuration options as follows:

## SLIP / DIAGNOSTICS

SLIP is a well known protocol for transferring binary data packets over a data link. Each data packet is delineated by <FEND> characters, and a substitution mechanism exists that allows these characters to be included in the data packet. Appendix B describes the SLIP protocol which is used extensively in UNIX ${ }^{T M}$ based systems, and is closely associated with TCP/IP networks.


The diagnostics controller package uses the SLIP protocol to communicate between base station and remote modems.

## DNP-3 / IEC870

This selection configures the PAD driver to implement the DNP-3 Protocol and IEC870 Protocol.

## Pull Down Menu Selection

The PAD driver can be configured for a number of vendor specific protocols by selecting the desired option.

## Custom Format

This selection permits PAD driver to be configured in a variety of ways and requires a greater understanding of the system design.

For the modem to successfully transmit its packets (or frames) of data over the radio channel, it must be told on what basis to delineate data packets received at the data port. Once the end of a data packet has been received at the port the data frame is closed and transmission over the radio channel commences. Delineation of data packets can be configured to occur via any combination of:

- A pre-defined minimum time delay between packets received at the port. Typically the time delay would reflect the absence of a couple of characters in the data stream at the specified user port baud rate.
- Limiting the maximum number of characters which can be put in the data frame sent over the radio channel.
- Receipt of a selected end of message (EOM) character at the port. An ASCII carriage return (character 13) is often used for this purpose.

As each data frame to be transmitted over the radio channel has overhead data consisting of checksums and SID codes. The system designer must determine the best compromise between the ratio of overhead versus user data which depends on packet size and user data packet transmission latency.

The fields which can be configured are:

- Character Input timer: Set the input timer value in ms or enter zero to disable. Range 0-255.
- Maximum Frame Size: Set the maximum number of characters or enter zero to disable. Range 0-4095.
- Minimum Frame Size: Set the maximum number of characters or enter zero to disable. Range 1-255. Only available when AES Encryption is on.
- EOM Character: Select the check box to the left of the description to enable and enter the EOM character as a decimal value. Range 0-255.
- LIVE Framing: Select the check box to the left of the description to enable live framing mode.

Note : When AES encryption has been turned ON, the packet layer is modified to suit the fixed format requirements of AES encryption. This may result in changes to the data latency and throughput in some modes.

## Handshaking (Packet Modes Only)

If the standard PAD is selected (i.e. any settings apart from SLIP/Diagnostics), then flow control can be either hardware handshaking, XON/XOFF protocol or none.

Note: Handshaking is not supported when using Bell 202 modes. The XON/XOFF flow control is not supported when using the SLIP/Diagnostics protocol.
The Handshaking section of the screen allows the selection of either of the handshaking methods as well as allowing handshaking to be disabled.
Details of the two handshaking methods are given below.

## Hardware

The modem acts as Data Communications Equipment (DCE) and supplies to the host controller the following interface signals:

| Data Set Ready | (DSR) |
| :--- | :--- |
| Data Carrier Detect | (DCD) |
| Clear To Send | (CTS) |
| Receive Data Output | (RXD) |

The host controller must act as Data Terminal Equipment (DTE) and supplies to the modem the following interface signals :

| Data Terminal Ready | (DTR) |
| :--- | :--- |
| Request To Send | (RTS) |
| Transmit Data Input | (TXD) |
| DCD |  |

DCD
DCD has several modes of operation. It is set to TRUE when data is being transferred from the modem to the host - RXD line active. The signal is asserted approximately 500 ms before the start bit of the first character in the data stream and remains for approximately 1 character after the last bit in the data stream. The other modes of operation are dependent on the advanced settings.

- DSR

DSR is permanently set to TRUE.

- CTS

The CTS is a signal from the modem to the host informing the host that the modem is able to accept incoming data on the TXD line. It responds to the actions of the RTS line similar to the operation of a "standard" line modem.

The CTS is FALSE if the RTS line is FALSE. Once the RTS line is set to TRUE (signalling that the host wants to send some data to the modem on the TXD line), then the CTS will be set TRUE within 1 ms , if the modem is capable of accepting more data.
The CTS line will be set to FALSE if the transmit buffer in the modem exceeds 4075 bytes, or the number of queued frames exceeds 29 to ensure that no overflow condition can occur.

- RTS

The RTS line is used for two reasons. The first is to assert the CTS line in response to RTS. The RTS line can also be used to key up the transmitter stage of the modem.

## - DTR

The DTR line is used for flow control of data being sent from the modem to the host controller. When the host is able to accept data it sets this line to TRUE, and if data is available within the modem, it will be sent to the host. If the host cannot accept any more data, then it sets the DTR to FALSE, and the modem will stop all transmissions to the host.

- Xon/Xoff

If the flow control mechanism is XON/XOFF then the modem uses the standard ASCII control codes of $\operatorname{DC} 1\left\{{ }^{\wedge} \mathrm{Q}=11\right.$ (Hex) $=17$ (Dec) $\}$ for XON and DC3 $\left\{{ }^{\wedge} \mathrm{S}=13(\mathrm{Hex})=19\right.$ (Dec) $\}$ for XOFF. The DTR input line is totally ignored.
Note: There is no substitution mechanism employed in the XON/XOFF protocol, so care must be taken when transferring binary data to ensure that invalid flow control characters are not generated.

## Advanced

This button provides access to the advanced features of the port configuration. When selected a dialogue box appears which permits selection of the source for the port $\operatorname{DCD}$ output signal.

## 2Pott A DCD Function

C Disabled
© RF Carrier Detect
C. Data Detert (Ratasflan Cantrin)

## OK

Cance

## Disabled

This selection disables the DCD output on the port. This selection is not permissible if hardware based flow control has been selected.

## RF Carrier Detect

This selection causes DCD to be asserted at the onset of a an RF signal that is higher than the mute setting. This will generally occur several milliseconds before data is transmitted from the port.

## Data Detect (RS485 Flow Control)

This selection causes DCD to be asserted when data is about to be transmitted from the port. This option is not available if handshaking is set to "None" or "Xon/Xoff".

## RF Parameters

This section of the main window permits adjustment of transmitter and receiver, radio channel modulation scheme, frequency trim and advanced features.

RF Parameters

| Transmitter |  | Tx/Rx Trim Adjust |
| :---: | :---: | :---: |
| Frequency | Power Adjust |  |
| 460.0 | $\mathrm { MHz } \longdiv { 2 0 . 0 } \mathrm { dBm }$ | $\sqrt{0} \mathrm{~Hz}$ |



## Transmitter

The transmitter can be configured for transmit frequency and power level.

## Frequency

The required transmit frequency in MHz can be entered in the display field. The programmer checks that the selected frequency is in the range for the particular model of radio and provides warnings if it is not.

## Power Adjust

The currently selected transmit power is displayed below the button in dBm . The power level can be adjusted by selecting this button which displays a dialogue box. The up/down keys, or a typed in value, can be used to select the required power level in dBm steps.


There are two methods for setting the power.

## - Using Factory Calibration

To use the factory calibration of the radio the desired power is set immediately using the OK button in the dialogue box. This method permits the transmit power to be set without energising the transmitter. Note that although the transmit power has been adjusted it must be written to NVRAM using the modem "Write" function to ensure it is retained after a power on reset.

- Using a Power Meter

To overcome manufacturing variations in the power setting a more accurate setting of power can be achieved by the selecting the "Test With Meter" button in the dialogue box. This displays another dialogue box warning the user that the transmitter is about to be energised and that the power meter used should be able to handle at least 10 Watts from the modem.

Selecting OK in this warning dialogue box will energise the transmitter which will also be indicated by the red transmit LED on the unit. The power is adjusted using the up/down keys until the required power level is obtained. Selecting OK will retain the power setting and turn the transmitter off.

Note: Although the transmit power has been adjusted it must be written to NVRAM using the modem "Write" function to ensure it is retained after the modem is rebooted.

Selecting "stop test" will stop and leave you in power adjust box. "Cancel" will stop test and take you back to the main window.

## Receiver

The receiver can be configured for receive frequency and mute level.

## Frequency

The required receive frequency in MHz can be entered in the display field. The programmer checks that the selected frequency is in the range for the particular model of radio and provides warnings if not.

## Mute Adjust

The currently selected mute level is displayed in the main window below the button in dBm . The mute level can be adjusted by selecting this button which displays a dialogue box. The up/down

keys, or a typed in value, can be used to select the required mute level in dBm steps. Whilst a session is in progress with a unit the mute level adjustment is live. Selecting OK will retain the mute level setting. Note that although the mute level has been adjusted it must be written to NVRAM using the modem "Write" function to ensure it is retained after the modem is rebooted.

Whilst the modem is capable of receiving extremely weak radio signals, and successfully extracting the data content from the waveforms the mute level should be set to assist the modem in filtering out unwanted signals. Unwanted signals can be the result of background noise or interference. The mute level should be set at a level above these unwanted signals and at a level low enough to detect the wanted signal. Detection of a received signal above the mute level is indicated by the "RxSig" LED on the unit.

## Modulation

The radio modem utilises a DSP to control the modulation of transmit signals and demodulation of received signals. This provides greater flexibility in the ability of the radio modem to support new modulation schemes whilst maintaining compatibility with existing modulation schemes.

The currently selected modulation scheme is displayed in the main window below the select button. The modulation scheme can be adjusted by selecting this button which displays a dialogue box. The desired modulation scheme can then be selected from the pull-down menu in the dialogue box and retained using the OK button.

| - IModufotion Selection |  |  |  | [ |
| :---: | :---: | :---: | :---: | :---: |
| 9600.12 SikH ACA 4 Level. |  |  |  | $\square$ |
| Dass epeed <br> Channet $\theta$ oridendst | 2600 |  |  |  |
|  | 12.5kHz |  |  |  |
| Country of Approyal | ACA |  |  |  |
| Modulation Type | 4 Livel |  |  |  |
| Retord Numberf | 15 |  |  |  |
|  |  | OK | Cancel |  |

The type of modulation available for selection is dependent on the model of radio. Modulation types are sorted using the following criteria : Country of Approval (FCC, ETSI, ACA), Radio Channel Bandwidth ( 12.5 kHz or 25 kHz ), Radio Mode (E Series, M Series, D Series or Legacy) and over the air speed (2400bps, 4800bps, $9600 \mathrm{bps}, 19 \mathrm{k} 2 \mathrm{bps})$.

Only modulation schemes suitable for the radio model in use are available for selection. Please consider the following notes when choosing a modulation:

Country of Approval :
FCC : for use in North America and other countries who use FCC approved radios.

ACA : for use in Australia only.
ETSI : for use in Europe and other countries who use ETSI approved radios.

Legacy Modulation Schemes: Some modulation types are specifically for backwards compatibility. These include Bell 202 modes and D Series compatibility modes. These legacy modes should only be chosen when backward compatibility is required as their performance is inferior to the generic modulation schemes (bandwidth and RF sensitivity).

## Tx/Rx (Frequency) Trim

The currently selected frequency trim, which is common to both transmitter and receiver, is displayed in the main window below the button in Hz . The frequency trim can be adjusted live by selecting this button which displays a dialogue box. The up/down keys can be used to select the required frequency offset in steps pre-determined by the radio modem. Selecting OK will retain the frequency trim setting. Note that although the frequency trim has been adjusted it must be written to NVRAM using the modem "Write" function to ensure it is retained after the modem is rebooted.


This facility permits correction for drifts in the frequency reference caused by component aging. For example, a standard crystal may vary in fundamental frequency operation over 1 year by one part per million. An adjustment range of $\pm 10 \mathrm{ppm}$, displayed in Hz , has been allowed for and if this is insufficient the unit should be returned to the dealer/factory for re-calibration.

## Advanced



This button permits setting of advanced features. When selected a dialogue box appears which permits configuration of various parameters.

## Non-Packet Mode Setup (Non-Packet and Bell 202 Mode Only)

CTS Delay : the amount of time between RTS enabled to CTS active.

PTT Hold : the amount of time the transmitter will remain enabled after RTS is disabled.

PTT Delay : the amount of time between RTS enabled and the transmitter becoming active.

Transmit Tail Suppression : Minimises garbage characters at end of transmission.

## Receiver Full Duplex

This check box should only be ticked when the radio is operating in "full duplex" mode and with a "full duplex" hardware platform. For standard half-duplex remotes this option should not be ticked. For other modes please consult the factory for further information.

Note: This parameter is set in the factory to the correct state and should not be altered without factory consultation.

## System Parameters

This section of the main window configures the PTT control, collision avoidance, stream setup for routing of data, advanced features and provides unit information.

## PTT (Press To Talk) Control (Packet Modes Only)

RF transmission can be configured to occur permanently, automatically on data received at Port A or Port B, or RTS being asserted on Port A or Port B. A PTT timeout facility can be configured to limit the period for which the transmitter is enabled. Each option is selected by setting the control to the left of the description on the main window. When PTT is active the " $T x$ " LED on the unit is illuminated and RF power is being fed to the antenna.

## Permanent Tx

This will cause the transmitter to be permanently enabled (keyed) and displays another dialogue box warning the user that the transmitter will be energised immediately after the configuration is written to the unit. Selecting OK confirms this setting. The other PTT selections are disabled when this option is selected.

Note: This option is only available for full duplex units when being programmed locally.

## Auto On Data

This will cause the transmitter to be enabled (keyed) automatically on data received at Port A or Port B and included in a complete frame for transmission over the radio channel. The maximum period for which the transmitter will be enabled is limited by the PTT timeout setting.

## From Port A RTS

This will cause the transmitter to be enabled (keyed) on Port A RTS being asserted. The maximum period for which the transmitter will be enabled is limited by the PTT timeout setting. Applications which rely on establishing a link ahead of data being transferred require this method of activation.

## From Port B RTS

This will cause the transmitter to be enabled (keyed) on Port B RTS being asserted. The maximum period for which the transmitter will be enabled is limited by the PTT timeout setting. Applications which rely on establishing a link ahead of data being transferred require this method of activation.

## PTT Timeout

The PTT timeout facility is used to disable the transmitter if it exceeds the designated time. The timeout value can range from 1 to 255 seconds and the facility is disabled by setting a zero value.

The timeout value chosen for this should be set according to system requirements which may include:

- Prevention of a remote unit remaining keyed up and locking out all other remote units in a point to multipoint system.
- Limiting the period a remote unit remains keyed up to prevent battery drain in a low power application.

Note: If a PTT timeout occurs before completion of a data transmission data will be lost.

## Stream Setup (E\&M Modes Only)

This button brings up a dialogue box to permit editing of Stream IDentifier (SID) codes which are used by the modem as the addressing mechanism for data stream routing. A SID code can be placed at the start of each data frame as it is sent over the radio channel. The receiving modems use this code to determine how to route the data message. The modem supports simultaneous operation of both Port "A" and Port "B" over the one radio link, along with the inclusion of a diagnostics data stream.

Each port is independent and supports multiple options which are described in the following sections.

The following diagram illustrates the structure of the stream routing function for each data port.

## User Port

This option is selected by clicking on the User Port button and filling in the RXSID and TXSID fields to the right. The radio comes preconfigured with default values.

In User Port mode all SID code operations are performed transparently to the user data. Data placed into a user port which has been assigned a specified SID code, will only be received by a modem at the other end of the radio link that has a user port assigned with the same SID code. The SID code is added by the radio modem to the user data stream and removed by the radio modem when user data is outputted to a data port.

In this way, Port "A" and Port "B" can be assigned different SID codes, thereby separating the data streams.

Two SID codes values are available for each user port RXSID and TXSID. The RXSID codes apply to the data being received by the modem, and the TXSID codes apply to the data being transmitted by the modem. This allows for different transmit and receive codes if required, but generally they would be both the same.

A situation where Tx and Rx SID codes may be different is in a repeater configuration. In this type of application all data messages sent to the repeater will be "repeated". Thus by having different Tx and Rx codes, a control unit will not "hear" its own transmission, and remotes will not hear the reply from any other remote. For more information please consult the Trio E Series training material available as a power point slide from our website at www.trio.com.au

The diagnostics facility (when installed) also uses SID codes. The diagnostics data simply uses a different data stream to the user data, but is processed internally by the modem. If access to the diagnostics facility is required, similar to when the diagnostics utility is used with the modem, then the data port concerned and the diagnostics stream, must have the same SID codes assigned to them. Alternatively the System port can be used, which is 19.2K, Slip.

## Trunk Streams

In the Trunk Streams mode, data that is inputted into the modem for transmission must have a SID code appended to the start of the data packet. This mode requires the use of a "SLIP" interface as configured using the packet layer.

Trunk Steam mode is normally used in conjunction with Trio Diagnostics software, when connection to a MSR Stream Router or when connecting radios together such as a back-to-back connections as used in multiple point to point links.

In Trunk Stream mode a range of SID codes can be transmitted and received via a data port. This range is specified when this mode is selected. In a typical application, such as a back to back connection as used in a multiple point to point links, where all data (including diagnostics) from one radio needs to be "trunked" through to the other radio, the range used is 0 to 255 . Trunked mode allows a configurable selection of data streams to be "trunked" to other equipment yet the data remains separated as the SID codes are appended to each packet of data outputted.


# Part I - TVIEW+ Management Suite - Programmer 

| Translate and Repeat Streams |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type |  | From | To | Type |  | From | To |
| Disabled | - | 10 | 0 | Disabled | - | 0 | 0 |
| Disabled | $\checkmark$ | 0 | 0 | Disabled | - | a | 0 |
| Disabled | $\checkmark$ | 0 | 0 | Disabled. | - | 0 | 0 |
| Disabled | $\cdots$ | 0 | 0 | Disabled |  | 0 | 0 |
| Disabled | $\cdots$ | 0 | 0 | Disabled | $\checkmark$ | 10 | 0 |
| Disabled | $\nabla$ | 0 | 0 | Disabled |  | 0 | 0 |
| Disabled | $\pm$ | a | 0 | Disabled |  | 0 | 0 |
| Disabled | - | 0 | 0 | Disabled |  | 0 | 0 |
| Disabled | * | 0 | 0 | Disabled |  | 1 | 0 |
| -Tip <br> Disable both data ports to allow up to 2 repeat stream entries. |  |  |  |  |  |  |  |
|  |  |  | OK | Cancel |  |  |  |

## Repeat/Translate Configuration

The modem is capable of operating in a repeater mode. Each user port can be configured as a separate repeater. The associated user ports are effectively disconnected from the "outside world" when in repeater mode. Data received from the radio channel is passed directly to the transmitter, and placed back onto the radio channel. This feature requires a firmware revision of R2.12.1 or later.

The repeater must receive a complete frame of data before it is retransmitted. In some systems this store and forward delay may be significant, and careful selection of maximum frame sizes configured at the source unit must be considered to minimise the delay.
To enable the mode select "Repeat Range" in the Type field and specify the range of SID codes for which will be repeated.

## Translate Streams

This function is similar to repeat streams however it also translates the SID code from one value to another as the repeating function occurs.

This mode can be used to uncontrolled data repeating in system where more than one repeater is required, such as store and forward systems or pipe-lines.

## Diagnostics Setup (Packet Modes Only)



## Polled Diagnostics

The Diagnostics Processor can be configured to listen for diagnostics on a range of SID codes. The factory default is SID code 0 (From Stream 0 To Stream 0). The diagnostics responses are sent back over the same stream as the questions.

## Diagnostics Repeat

This option can be toggled on and off by clicking the button. Some applications will require that a repeater unit in a point to multipoint system repeats diagnostics frames only.

This will be the case when the system diagnostics controller is connected to a remote unit in the system, and it polls the system population from this point. The master unit must retransmit any diagnostic frames that are not addressed to itself onto the remainder of the population.

## Automatic Diagnostic Reports

This option allows the configuration of automatic diagnostics. This feature requires a firmware revision of R2.12.1 or later. This option automatically appends diagnostics messages when user data is transmitted. This option can be toggled on and off by clicking the "Enable" button.

Minimum Report Interval : Specifies the amount of time before a diagnostics message is appended to the next user data message.

Diagnostic Stream: Specifies the SID code used for the automatic diagnostics message.

Controller Destination Address: Specifies the address of the Diagnostics Controller Software that is receiving the automatic messages and displaying them. This value must match that specified in the TVIEW diagnostics software configuration.

## Advanced

The Advanced button can be used to install diagnostics into the E Series radio if it was not purchased with the original order. Enter the 8 digit key-code supplied by Trio to enable diagnostics. If diagnostics is already installed this option will be "greyed out".

## Encryption Setup (Packet Modes Only)



128 bit AES Encryption can be enabled in the radio. AES Encryption is a feature available in the E Series Generation II product (firmware pack 4.x.x and above). Radios that have 128-bit AES encryption enabled can only communicate with other radios that have AES encryption enabled and use the same encryption key.

AES Encryption is enabled by selecting the Enabled button and entering an "Encryption key". The "Encryption key" must be between 8 and 16 characters long. The key can contain ASCII or hexadecimal characters. When entering hexadecimal characters, the format must be " $0 x D D$ " where DD is a sequence of hexadecimal digits. ( $0-9, A-F$ ).

When a radio configuration is read from a radio that already has AES encryption enabled, the encryption key will be shown as "**************" in the programmer to indicated encryption is enabled. Since there is no mechanism to see the encryption in plain text you must ensure the encryption key is recorded in a safe and secure place for future reference.

Note : When AES encryption is enabled in the radio, both Port A \& B packet layer settings may be modified to ensure compatibility with AES encryption mode.

Note : AES encryption is subject to export restrictions and may not be available in all countries.

## Collision Avoidance (Packet Modes Only)



In a point to multipoint system the master unit (usually a base station) can transmit at any time and the remotes will all receive the broadcast signal. However, if more than one remote unit transmits at a time, then a collision will occur during the multiple transmissions, resulting in a loss of data from one or more units.
Two collision avoidance mechanisms have been included in the modem. The standard (Digital) method utilises a signalling channel which is embedded in overhead data transmitted over the radio channel. The second method utilises detection of a carrier signal to postpone transmission of data. Both methods require configuration of several options for successful operation.

The desired option for collision avoidance is selected by checking the control button to the left of the description on the main window.

## None

When selected this turns off all collision avoidance mechanisms.
This should only be used in point to point applications.

## Digital

This is the standard method of collision avoidance and utilises a channel busy indication bit in the signalling channel transmitted to all remotes for control. When selected a dialogue box appears and several options must be configured:

- Mode - "Master" or "Remote". When the master unit receives a valid transmission from a remote unit it sets the channel busy indication bit. This busy bit is interpreted by the other remotes to not transmit. Once the transmission from the first remote ends the master unit resets the busy bit to indicate the channel is now clear to transmit on. The master unit, which is normally a base station, takes about 5 ms to detect a transmission from a remote unit and set the channel busy indication bit on the radio channel. During this period collision of remote transmissions can still occur and is unavoidable.
Note: The master must be permanently keyed.
- Backoff Method - "Retry after Tx Attempt" or "Delay before Tx Attempt". The method chosen is system dependent and can only be configured if the mode is "remote". The former is best used when data responses from remotes are largely asynchronous. The latter is best used when this is not the case.
- Backoff Timing - "Maximum Slots", "Time per Slot". This can only be configured if the mode is "remote". When a remote is ready to transmit data but it finds the busy bit from the master set it holds back its transmission for a random "backoff" time after which it tries to transmit data again. This ensures that modems waiting to be allowed to transmit do not re-attempt to do so at the same time. The "Maximum Slots" (1 to 16 ) and the "Time per Slot" ( 1 to 255 ms ) are used to calculate the backoff time by multiplying the slot time by a random number between 1 and the maximum slot number. For example if the time per slot is 30 ms and the maximum slots is 4 , the random backoff times can be 30 , 60,90 or 120 ms .

As the channel busy indication bit is critical for reliable operation default interpretation of this bit is defined in the remote units. If the master modem stops transmission (or has not yet started) the remote will interpret that the channel is busy and will not transmit until the master comes on line.

## Carrier Detect

This method of collision avoidance utilises a carrier transmitted to all remotes to indicate that the radio channel is busy. When selected a dialogue box appears and several options must be configured:

- Mode - "Master" or "Remote". When the master unit receives a valid transmission from a remote unit it transmits a carrier signal to indicate busy. Of course the master will also initiate a transmission if it has data to send. The transmitted carrier is interpreted by the other remotes to not transmit. Once the transmission from the first remote ends the master unit stops transmission to indicate the channel is now clear to transmit on. The master unit, which is normally a base station, takes about 5 ms to detect a transmission from a remote unit and transmit a carrier signal. During this period collision of remote transmissions can still occur and is unavoidable.

Note: The master can only be a full duplex unit and cannot be permanently transmitting. For half duplex and simplex systems all units should be set as "Remote" (no Master).

- Backoff Timing - "Maximum Slots", "Time per Slot". This can only be configured if the mode is "remote". When a remote is ready to transmit data but it detects a carrier signal from the master set it holds back its transmission for a random "backoff" time after which it tries to transmit data again. This ensures that modems waiting to be allowed to transmit do not re-attempt to do so at the same time. The "Maximum Slots" ( 1 to 16 ) and the "Time per Slot" ( 1 to 255 ms ) are used to calculate the backoff time by multiplying the slot time by a random number between 1 and the maximum slot number. For example if the time per slot is 30 ms and the maximum slots is 4 , the random backoff times can be 30 , 60,90 or 120 ms .


## Unit Information



The information displayed is intended to assist the user to identify the radio modem as well as support should their services be needed.

Radio Model refers to the type of unit. The ER450 is a remote unit and the EE450 is a exciter inside a base station unit. Gen II will be noted where Gen II hardware is detected.

Radio Type refers to the frequency band supported by the radio as well as the channel bandwidth. For example 51A02 is a type 51 band with a 25 kHz channel.

Diags Installed is set to yes or no depending on whether the diagnostics key has been set in the unit.

Serial Number is unique to each unit and is set within the unit at time of production as well as included on the label fixed to the unit.

Firmware Pack refers to the firmware package version installed in the radio. There are several components associated with microcontroller and DSP firmware installed and a single version number is used to identify them.

## Unit Information - Details

| -SUnit Details | $\times$ |
| :---: | :---: |
| Controller Code Revsion D4.10.0 |  |
| OBP Cade Revizion | R2.3.25 |
| Processor Board io | 123456-mm-bubb- 00-00-0269 |
| RF Deck10 | 55247-ER450-51F01-200-816-1308 |
| Proquetion Bulla coce | 1308 |
| - -artware | Fuill Duptox |
| Unit Type | Remoto |
| TriFraguency Ronge | 447.5. 487.5 MHz |
| RxFrequency Range | 4500.465 .0 MHz |
| AES Encrution Avaliable | yes |
|  | OK |

More detailed information is also available to assist in identifying components installed in the unit (remote, base station or hot standby).

The additional information provided is:

- Controller Rev refers to the microcontroller firmware component version for the radio.
- DSP Code Rev refers to the DSP firmware component version for the radio.
- Processor Board ID refers to the processor board identification number and hardware revision information for the radio.
- RF Deck ID refers to the RF deck board identification number and hardware revision information inside the radio.
- Production Build Code refers to the automated production test and calibration sequence used during manufacture of the radio.
- Hardware indicates whether the radio is half or full duplex.
- Unit Type indicates whether the unit is recognised as a remote or base station.
- Tx and RX Frequency Range indicates the frequency range for which the radio is capable of being operated in.

In the case of a base station unit the following additional information is provided:

- Base Firmware Pack refers to the firmware package version installed in the base station (front panel) controller which is separate to the radio installed. There are several components associated with this firmware package and a single version number is used to identify them.
- Base Controller Rev refers to the microcontroller firmware component version for the base station.


## Messages

The message window provides a log of error messages occurring during use of the programmer utility. Several error messages may occur as a result of a selection.

## Status Bar

The status bar is located at the bottom of the main window and provides information regarding communication actions occurring with the radio data modem.

Additional fields located on the status bar include:

- Unit ID refers to the identification label used by the diagnostics utility. This is currently the same as the unit's serial number.
- Mode refers to the type of session established. It can be a File, Local indicating a local port connection to the unit or Remote indicating communications is via a radio channel.


## Appendix A - Firmware Updates

## Firmware Update Overview

Firmware updates are performed on a unit connected locally to the PC. It is recommended that all cabling to the unit be disconnected prior to commencing firmware update to minimise any interruption to the process or disturbances of signals on cables still connected. All other TView+ Management Suite utilities should also be exited during the firmware update process.

The procedure to update the firmware is different for both $E$ Series Generation I and Generation II radios. Please ensure you have the latest release of the TView+ Management Suite before you attempt a firmware upgrade. This can be obtained from the Trio website at http://www.triodatacom.com/scada supp.php

## Firmware Update for E Series Remote Radios - Gen II (Serial No 56000 or above)

1. Click on the "E Series Firmware Update" Start the firmware update utility from the TView+ front panel.
2. Connect the TView+ E Series diagnostics/programming cable from the PC Serial (COM) port to the systems port on the radio as shown below. Select the appropriate COM Port if required.

3. Select the "Device Type" as "Radio - E Series Gen II" from the options on the top right of the firmware update main window.
4. Select the file containing the firmware update package using the "Open Firmware Package" button at the bottom of the main window. After opening the file, the browse window will close and a description of the firmware package will appear in the main window.
5. Initiate the firmware updating process using the "Write" button at the bottom of the main window. Another information window will appear. Wait until the firmware update process indicates the firmware update is "Done". The radio is now ready to use.


## Firmware Update for E Series Base Station Exciters - Gen II (Serial No 56000 or above)

1. Click on the "E Series Firmware Update" Start the firmware update utility from the TView+ front panel.
2. Connect the TView $+E$ Series diagnostics/programming cable from the PC Serial (COM) port to the systems port on the base station front panel. Select the appropriate COM Port if required.
3. Select the "Device Type" as "Exciter - E Series Gen II" from the options on the top right of the firmware update main window.
4. Select the file containing the firmware update package using the "Open Firmware Package" button at the bottom of the main window. After opening the file, the browse window will close and a description of the firmware package will appear in the main window.
5. Initiate the firmware updating process using the "Write" button at the bottom of the main window.
6. Depress the Base Station F/W Update switch on the Front Panel of the Base Station using a suitable probe. This switch is located below the "Display ON/OFF" button and to the left of the Systems Port. In order to depress the switch a small object such as a paperclip is required.

Note:The base station will display all LEDs as AMBER indicating the firmware update is in progress.
7. Another information window will appear. Wait until the firmware update process indicates the firmware update is "Done".
8. Remove DC power to the base station and re-apply power to ensure the base station returns to normal operating mode.
Firmware Update for E Series Remote Radios and Base Station Exciters - Gen I (Serial No 56000 or below)

1. Start the firmware update utility from the TView+ front panel.
2. Disconnect power from the unit by turning off the power supply or removing the power connector to the unit.
3. Connect an E Series Gen I Firmware Update cable from the PC serial (COM) Port to Port B on the radio as shown below.

4. Select the unit type from the options on the top right of the firmware update main window. Please note that "Exciter" refers to the radio contained inside the base station.

Note: The firmware update of a base station exciter will result in the base station flashing all LEDs RED with the fan on. This error condition will only occur whilst the firmware update is in progress.
5. Select the file containing the firmware update package using the "Open Firmware Package" button at the bottom of the main window. After opening the file, the browse window will close and a description of the firmware package will appear in the main window.
6. Initiate the firmware updating process using the "Write" button at the bottom of the main window. Another logging window will appear
7. Reconnect power to the unit when prompted in the logging window. The status LEDs on the unit including power should all be extinguished and the transfer of firmware should commence. If this does not occur steps $6 \& 7$ should be repeated

Note: Remote radio status LEDs including power will all be off.
8. The logging window will display the progress of each firmware block transferred and when complete a success dialogue box appears. Type OK to close this dialogue box and type "Exit" in the main window to exit the firmware update utility
9. Disconnect the cable from Port B and re power the unit to enable the new firmware.

## Base Station Display Firmware Update

## Installation Instructions:

1. Update of the front panel firmware uses the firmware update utility supplied with the TView+ Management Suite.
2. Start the firmware update utility from the TView+ front panel.
3. In the firmware update utility select device type as "Base Station Front Panel"
4. Select the file containing the firmware update package using the "Open Firmware Package" button at the bottom of the main window. After opening the file the browse window will close and a description of the firmware package will appear in the main window.
5. Ensure that the base station is powered.
6. Connect the "TView+ cable" to the front or rear system port of the base station.
7. On the base station front panel depress and hold the "Display On/Off" button, then momentarily depress the firmware update switch using a suitable probe before releasing the "Display On/Off" button. The firmware update switch is located behind the small hole (not labelled) in the front panel below the "Display On/Off" button. Note: Display Status LEDs will be lit in this Mode.
8. Initiate the firmware update process using the "Write" button at the bottom of the main window. Another logging window will appear.
9. The logging window will display the progress of each firmware block transferred and when complete a success dialogue box appears. Click OK to close this dialogue box and click "Exit" in the main window to exit the firmware update utility.

Note: If a mismatch occurs between selected file and device type, an error message will appear
10. Re power the base station to enable the new firmware.

## Hot Standby Controller Firmware Update

Installation Instructions:

1. Update of the hot standby firmware uses the firmware update utility supplied with the TView+ Management Suite.
2. Start the firmware update utility from the TView+ front panel.
3. In the firmware update utility select device type as "Hot Standby Controller".
4. Select the file containing the firmware update package using the "Open Firmware Package" button at the bottom of the main window. After opening the file the browse window will close and a description of the firmware package will appear in the main window.

5. Ensure that the hot standby controller is powered.
6. Connect the "TView+ cable" to the front or rear system port of the hot standby controller.
7. On the hot standby controller front panel, depress and hold the "Reset Alarms" button, then momentarily depress the firmware update switch using a suitable thin probe. Now release the "Reset Alarms" button. The two LEDs either side of the "Select" switch should turn green indicating the hot standby controller is in firmware updating mode.

Note : The firmware update switch is located behind the small hole (not labelled) in the front panel to left of "Reset Alarm" button.
8. Initiate the firmware update process using the "Write" button at the bottom of the main window. Another logging window will appear.
9. The logging window will display the progress of each firmware block transferred and when complete a success dialogue box appears. Click OK to close this dialogue box and click "Exit" in the main window to exit the firmware update utility.

Note: If a mismatch occurs between selected file and device type, an error message will appear.
10. Repower the hot standby controller to enable the new firmware.

## Part J - Specifications

# Remote Data Radio - ER450 

E Series - Generation II



Local regulatory conditions may determine the performance and suitability of individual versions in different countries. It is the responsibility of the buye to confim thes regulatory conditions. Performance data indicates typical values related to the described

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Radio
Frequency Range: $370-520 \mathrm{MHz}$ (various sub-frequency bands available)
Frequency Splits: Various Tx/Rx frequency splits - programmable
Channel Selection: Dual synthesizer 6.25 kHz channel step

Channel Spacing: 12.5 or 25 kH
Frequency Accuracy: $\pm 1 \mathrm{ppm}(-30$ to $+60 \mathrm{C})$ (-22 to 140F) ambient

Aging: <= 1ppm/annum
Operational Modes: Simplex, Half duplex or Full duplex*
Configuration: All configuration via Windows based software

## Compliances:

ETSI EN300113, EN301489, EN60950
FCC PART 15, PART 90
IC RS119, ICES-001
ACA AS4295-1995 (Data)
CSA Class I, Division II, Groups (A,B,C,D) for Hazardous Locations ANSI/UL equivalent

## Transmitter

Tx Power: $0.05-5 \mathrm{~W}(+37 \mathrm{dBm}) 1 \mathrm{~dB}$ User configurable with over-temperature and reverse power protection

Modulation: User configurable narrow band digitally filtered binary GMSK or 4 level FSK

Tx Keyup Time: <1mS

Timeout Timer: Programmable 0-255 seconds

Tx Spurious: <= -37 dBm
PTT Control: Auto (Data) / RTS line (Port A or B) / System Port Override

Receiver
Sensitivity: - 118 dBm for 12 dB SINAD
Selectivity: Better than 60 dB
Intermodulation: Better than 70 dB
Spurious Response: Better than 70 dB
AFC Tracking: Digital receiver frequency tracking

Mute: Programmable digital mute

Diagnostics (Optional)
Network wide operation from any remote terminal.

Non intrusive protocol - runs simultaneously with the application.

Over-the-air re-configuration of user parameters

Storage of data error and channel occupancy statistics

In-built Error Rate testing capabilities

## Connections

User Data Ports: $2 \times$ DB9 female ports wired as DCE (modem)

System Port: RJ45 for diagnostic configuration and re-programming

Antenna: N female bulkhead. Separate N (Tx) and SMA (Rx) connectors for full duplex.*

Power: 2 pin locking, mating connector supplied
LED Display: Multimode Indicators for Pwr, Tx, Rx, Sync, TxD and RxD data LEDs (for both port A and B)

Modem
Data Serial Port A: RS232, DCE, 600-57,600 bps asynchronous

Data Serial Port B: RS232, DCE, 300-38,400 bps asynchronous

System Port: RS232, 19,200 bps asynchronous

Flow Control: Selectable hardware / software / 3 wire interface

## RF Channel Data Rate:

4800/9600/19,200 bps Half / Full duplex*
Data Buffer: 16 kbyte of on-board RAM
Bit Error Rate:
< 1x10-6 @ - 110 dBm (4800 bps) < 1x10-6@-108dBm (9600 bps) < 1x10-6 @-106 dBm (19,200 bps) Encryption: 128-bit AES encryption
Collision Avoidance: Trio DataCom's unique supervisory channel C/DSMA collision avoidance system

## NORTH AMERICA

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Multistream ${ }^{\text {TM: }}$ : Trio DataCom unique simultaneous delivery of multiple data streams (protocols)

Data Turnaround Time: <10mS
Firmware: Field upgradeable Flash memory
General
Power Supply: 13.8 Vdc nominal
(10-16 Vdc)
Transmit Current: 750 mA nom. @ 1 W
1600 mA nom. @ 5 W
Receive Current: <125 mA nom
Sleep Mode: External control, < 1 mA
Dimensions: Rugged Diecast Enclosure
$170 \times 150 \times 42 \mathrm{~mm}$
$6.7 \times 5.9 \times 1.65$ inches
With Mounting Plate
$190 \times 150 \times 47 \mathrm{~mm}$
$7.5 \times 5.9 \times 1.85$ inches
Mounting: Fitted Mounting Plate
Weight: 1.27 kg (2.8lbs.)

## Options

ERFD450 Full Duplex Operation with
separate N ( Tx ) and SMA (Rx) connectors

DUPLX450BR External Duplexer, Band Reject (for single antenna operation)

EDOVM Digital Order Wire Voice Module
NEMA 4/R Stainless Steel Enclosure
(IP65, NEMA 4 rated)
TVIEW+TM Configuration, Network
Management and Diagnostic Windows GUI Software
DIAGS/E Network Management and
Remote Diagnostics Facilities per Radio Modem

Related Products
EB450 Base Station
EH450 Hot Standby Base Station
MSR/9 Port Stream Router Multiplexer
MR450 Remote Data Radio

* With ERFD450 full duplex option plus external duplexer for single antenna operation

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# Digital Data Base Station - EB450 

## E Series - Generation II

Radio
Frequency Range: $380-520 \mathrm{MHz}$ (various sub-frequency bands available)
Frequency Splits: Various Tx/Rx frequency splits - programmable
Channel Selection: Dual synthesizer, 6.25 kHz channel step

Channel Spacing: 12.5 or 25 kHz
Frequency Accuracy: $\pm 1$ ppm ( -30 to 60C (-22 to 140F) ambient
Aging: <= 1ppm/annum
Operational Modes: Full and Half duplex, Simplex (Optional Internal or external duplexer available for single antenna operation)
Configuration: All configuration via Windows based software

## Compliances:

ETSI EN300 113, EN301 489, EN60950
FCC PART 15, PART 90
IC RS119, ICES-001
ACA AS4295-1995(Data)

## Transmitter

Tx Power: $5 \mathrm{~W}(+37 \mathrm{dBm}) \pm 1 \mathrm{~dB}$
User configurable with over-temperature and reverse power protection


Modulation: User configurable narrow band digitally filtered GMSK or 4 Level FSK

Tx Keyup Time: < 2 mS
Timeout Timer: Programmable 0-255 seconds

Tx Spurious: <=-37 dBm
PTT Control: Auto (on Data) / RTS line (Port A or B) / System Port Override

## Receiver

Sensitivity: - 118 dBm for 12 dB SINAD
Selectivity: Better than 60 dB
Intermodulation: Better than 70 dB
Loal reguatory conditions may determine the performance and suitability of individual versions in different countries. It is the responsibility of the buyer to confirm these regulatory conditions. Performance data indicates typical values related to the described unit.

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Diagnostics (Optional)
Network wide operation from any remote terminal.
Non intrusive protocol - runs simultaneously with the application.

Over-the-air re-configuration of user parameters.

Storage of data error and channel occupancy statistics.
In-built Error Rate testing capabilities.

## Connections

User Data Ports: $2 \times$ DB9 female ports wired as DCE (modem)
System Port: RJ45 (front and rear) for diagnostics, configuration and programming

## Antenna:

$2 \times \mathrm{N}$ female bulkhead (separate Tx and Rx ports)
$1 \times \mathrm{N}$ female bulkhead (with optional internal duplexer)
Power: 2 pin locking, mating connector supplied
LED Display: Multimode Indicators for Pwr, Tx, Rx, Sync, TxD and RxD data LEDs (for both port A and B)

## Modem

Data Serial Port A: RS232, DCE, 600-57,600 bps asynchronous
Data Serial Port B: RS232, DCE, 300-38,400 bps asynchronous
System Port: RS232, 19,200 bps asynchronous
Flow Control: Selectable hardware/software/3 wire interface

RF Channel Data Rate:
4800/9600/19,200 bps Full duplex
Data Buffer: 16 kbyte of on-board RAM

## Bit Error Rate:

< 1x10-6 @ - 110 dBm (4800 bps)
< $1 \times 10^{-6} @-108 \mathrm{dBm}(9600 \mathrm{bps})$
$<1 \times 10^{-6} @-106 \mathrm{dBm}(19,200 \mathrm{bps})$
Encryption: 128-bit AES encryption

Collision Avoidance: Trio DataCom's unique supervisory channel C/DSMA collision avoidance system

Multistream ${ }^{\text {™ }: ~ T r i o ~ D a t a C o m ' s ~ u n i q u e ~}$ simultaneous delivery of multiple data streams (protocols)
Data Turnaround Time: <10mS
Firmware: Field upgradeable Flash memory

## General

Power Supply: 13.8 Vdc nominal (11-16 Vdc)

Transmit Current:
1.3 A nominal @ 1 W
2.5 A nominal @ 5 W

## Receive Current: < 350 mA

Dimensions: 19" 2 RU rack mount
$485 \times 90 \times 420 \mathrm{~mm}$ (Including heatsink) $19 \times 3.5 \times 16.5$ inches
Weight: 5 kg ( 11 lbs ) (excluding optional duplexer)

## Digital I/O:

2 Inputs monitered by TVIEW+
Diagnostics Software
2 Outputs user configurable by
TVIEW+ Diagnostics Software

## Options

DUPLX450Bx Internal / External Duplexers, Band Reject and Band Pass
EDOVM Digital Order Wire Voice Module

TVIEW+TM Configuration, Network
Management and Diagnostic Windows GUI Software

DIAGS/E Network Management and
Remote Diagnostics Facilities per Radio Modem

Related Products
EH450 Hot Standby Base Station
ER450 Remote Data Radio
MR450 Remote Data Radio
MSR9 Port Stream Router
Multiplexer

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# Digital Hot Standby Base - EH450 

E Series - Generation II




## Part K - Support Options

## Website Information

The Trio DataCom website support contains links to e-mail and telephone support, technical notes, manuals, software updates.

Please go to www.triodatacom.com

## E-mail Technical Support

E-mail your questions to support@triodatacom.com
When e-mailing questions to our support staff, make sure you tell us the exact model number (and serial number if possible) of the Trio equipment you are working with. Include as much detail as possible about the situation, and any tests that you have done which may help us to better understand the issue. If possible, please include your telephone contact information should we wish to further clarify any issues.

## Telephone Technical Support

Telephone technical support is available.

## Head Office

Phone (+61) 397750505 during Eastern Australian business hours ( $9 \mathrm{am}-5 \mathrm{pm}$ ).

## North America

Phone +403 2193625 or Toll Free 8668448746 (TRIO)

## Service Department

The Service department may be contacted by e-mail to service@triodatacom.com , or by telephone.


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Innovative and sophisticated


The YB Series are high gain yagi antennas which will provide excellent point to point communication in RF control, short or long haul link and other applications calling for highly directional antennas. YB Series antennas exhibit narrow beamwidths and high front to back ratios to help minimise potential interference to and from other systems.

The feed element of each antenna is of full folded dipole construction thus offering maximum bandwidth and reliability. The dipole element is welded to the boom to ensure low intermodulation performance and maximum durability. The passive elements are through mounted to the circular boom section and welded at each side to further minimise the potential for both corrosion and generation of intermodulation products. The alodined protective finish provides a conductive surface to ensure effective earthing of the antenna when mounting.

Constructed with 2 to 16 elements, YB Series yagi antennas offer a choice of gain and beamwidth characteristics and can be configured in stacks or bays for higher gain applications in either horizontally or vertically polarised systems. Application details on phasing and mounting yagi antennas are included in the technical notes section of this catalogue.

Yagi antennas rest at ground potential to provide excellent lightning protection and reduced precipitation static noise.

Termination is via an ' N ' female coaxial connector fitted to a short Durathene cable tail. Durathene polyethylene jacketed cable provides superior resistance to weathering and abrasion and is less susceptible to bird attack than standard PVC sheathed cables.

For extreme climatic or corrosive applications, the stainless steel YBSS Series or black ruggedised RDA Series yagis should be considered.

- All welded construction for maximum and reliable performance
- Narrow beamwidths \& high front to back ratios effective in reducing interference
- Alodine finish provides an excellent conductive surface for earthing
- Can be configured in stacks or bays for higher gain applications using PH and PHE series phasing harnesses




## Electrical

| Model Number | YB02-99 | YB03-99 | YB6-65 | YB6-61 | YB6-62 | YB6-75 | YB6-99 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal Gain dBi (dBd) | 5 (3) | 8 (6) | 11 (9) |  |  |  |  |
| Frequency MHz | 300-600 | 350-600 | 400-420 | 450-480 | 480-520 | 580-600 | 350-600 |
| Tuned Bandwidth | 5\% |  | Full band |  |  |  | 5\% |
| VSWR (Return Loss) | <1.5 : 1 ( 14 dB ) |  |  |  |  |  |  |
| Nominal Impedance $\boldsymbol{\Omega}$ | 50 |  |  |  |  |  |  |
| Vertical Beamwidth | $77^{\circ}$ | $63^{\circ}$ | $47^{\circ}$ |  |  |  |  |
| Horizontal Beamwidth | $161^{\circ}$ | $98^{\circ}$ | $56^{\circ}$ |  |  |  |  |
| Front / Back Ratio dB | 9 | 13 | 18 (Typical) |  |  |  |  |
| Input Power W | 100 |  |  |  |  |  |  |

## Mechanical

| Model Number | YB02-99 | YB03-99 | YB6-65 | YB6-61 | YB6-62 | YB6-75 | YB6-99 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Construction | All welded aluminium with alodined finish |  |  |  |  |  |  |
| Length $m$ | 0.6 | 0.7 | 0.9 | 1.0 | 0.8 | 0.8 | 1.3 |
| Weight kg | 0.4 | 0.5 | 0.7 | 0.7 | 0.6 | 0.6 | 0.8 |
| Termination | N female with short 9008 cable tail |  |  |  |  |  |  |
| Mounting Area | $100 \mathrm{~mm} \times 25 \mathrm{~mm}$ diam. alodined aluminium |  |  |  |  |  |  |
| Suggested Clamps | 1 X UNV |  |  |  |  |  |  |
| Projected ${ }^{\text {No ice }}$ | 283 | 337 | 485 | 477 | 394 | 349 | 600 |
| Area cm ${ }^{2}$ With ice | 676 | 811 | 1169 | 1099 | 967 | 857 | 1367 |
| Wind Load (Thrust) @ 160km/h N | 33 | 40 | 57 | 56 | 47 | 41 | 71 |
| Wind Gust Rating km/h | >240 |  |  |  |  |  |  |
| Torque @160 km/h Nm | 6 | 10 | 22 | 24 | 16 | 13 | 42 |

## $300-600 \mathrm{MHz}$

YB Series


## Electrical

| Model Number | YB9-65 | YB9-61 | YB9-62 | YB9-99 | YB16-65 | YB16-70 | YB16-71 | YB16-63 | YB16-72 | YB16-99 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal Gain dBi (dBd) | 13 (11) |  |  |  | 14 (12) |  |  |  |  |  |
| Frequency MHz | 400-420 | 450-480 | 480-520 | 400-600 | 400-420 | 450-470 | 470-490 | 480-500 | 500-520 | 400-600 |
| Tuned Bandwidth | Full band |  |  | 5.0\% | Full band |  |  |  |  | 5.0\% |
| VSWR (Return Loss) | $<1.5: 1$ (14dB) |  |  |  |  |  |  |  |  |  |
| Nominal Impedance $\boldsymbol{\Omega}$ | 50 |  |  |  |  |  |  |  |  |  |
| Vertical Beamwidth | $46^{\circ}$ |  |  | $42^{\circ}$ | $34^{\circ}$ |  |  |  |  |  |
| Horizontal Beamwidth | $54^{\circ}$ |  |  | $48^{\circ}$ | $36^{\circ}$ |  |  |  |  |  |
| Front / Back Ratio dB | 18 (Typical) |  |  |  |  |  |  |  |  |  |
| Input Power W | 100 |  |  |  |  |  |  |  |  |  |

## Mechanical

| Model Number | YB9-65 | YB9-61 | YB9-62 | YB9-99 | YB16-65 | YB16-70 | YB16-71 | YB16-63 | YB16-72 | YB16-99 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Construction | All welded aluminium with alodined finish |  |  |  |  |  |  |  |  |  |
| Length $m$ | 2.0 | 1.8 | 1.6 | 2.0 | 2.5 | 2.3 | 2.3 | 2.2 | 2.2 | 2.5 |
| Weight kg | 1.2 | 1.0 | 1.0 | 1.2 | 1.7 | 1.5 | 1.5 | 1.4 | 1.4 | 1.7 |
| Termination | N female with short 9008 cable tail |  |  |  |  |  |  |  |  |  |
| Mounting Area | $100 \mathrm{~mm} \times 25 \mathrm{~mm}$ diam. alodined aluminium |  |  |  |  |  |  |  |  |  |
| Suggested Clamps | 1 X UCR1 |  |  |  | 1 X UCR1 + $1 \times \mathrm{M}-4528$ bracing kit |  |  |  |  |  |
| Projected ${ }^{\text {N }}$ No ice | 859 | 771 | 694 | 859 | 1186 | 1048 | 1030 | 989 | 981 | 1186 |
| Area cm ${ }^{2}$ With ice | 2078 | 1842 | 1640 | 2078 | 2983 | 2666 | 2617 | 2530 | 2507 | 2983 |
| Wind Load (Thrust) @ 160km/h N | 102 | 91 | 82 | 102 | 141 | 124 | 122 | 117 | 116 | 141 |
| Wind Gust Rating km/h | 207 | 220 | 240 | 207 | 147 | 165 | 165 | 173 | 173 | 147 |
| Torque @160 km/h Nm | 92 | 75 | 60 | 92 | 165 | 130 | 128 | 117 | 116 | 165 |

## Product Brief

## High Power Lightning Filter IS-CF50D Series

Safeguarding your communications equipment with the ultimate in protection is assured when you select PolyPhaser's newest microwave filter protectors. Featuring an innovative design and fully weatherised, the IS-CF50D is engineered for systems requiring up to 750 watts maximum continuous power including Cellular and Paging. These units will keep your valuable wireless customers connected, due to the integrated connector housings, DC blocked filter design and the industry's best passband VSWR, as well as extremely low insertion loss.

## Features

- Industrys best RF performance
- Compact, integrated connector housing
- Fully weatherised
- DC blocked
- Industry's lowest throughput energy
- Maintenance free
- Multi-strike capability
- Universal flange mounting bracket



## Technical Specifications <br> (per qualification testing)

Surge:
VSWR:
Insertion Loss:
Frequency Range:
Power:
Operational Temp. Range:

20kA IEC 1000-4-5 8/20 Waveform
$\leq 1.1$ to 1
$\leq 0.1 \mathrm{~dB}$
800 MHz 1.0 GHz
300 W continuous
$-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$

Throughput Energy<br>$\leq 0.5 \mu \mathrm{~J}$ for 3 kA @ $8 / 20 \mu \mathrm{~s}$ Waveform

## Let-Through Voltage

$\leq \pm 3$ volts for $3 \mathrm{kA} @ 8 / 20 \mu \mathrm{~s}$ Waveform


RFI has been serving the needs of the wireless communications market for over 30 years. First founded as a manufacturer of antenna systems, RFI has grown to be a key player in the development, manufacturing, distribution and integration of wireless technology products.

Our long and successful history as a manufacturer has seen RFI utilize some of the worlds best Mil-Spec cable and connectors in our own products. RFI's engineering experience can now be shared with our customer base through distribution partnerships with some of the worlds most reputable suppliers, affording us a huge catalogue range. Additionally we can develop custom cables and connectors for application specific requirements and encourage you to contact us with any non-standard enquiries for these items.

We also distribute our own RFI branded cables sourced from some of the most - modern and technically advanced manufacturing plants in Taiwan and China. Our polyethylene (PE) dielectric cables such as 8058, 9006 and 8213 are certified to be free of lead, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE), as well as the other banned substances under the European RoHS regulations.

The lastest information is always on our website and we encourage you to utilise it when needed or alternatively contact one of our sales specialists for any further information you may require.

## Trademarks

The Abstract Diamond Pattern device is a registered trademark of R F Industries Pty Ltd RFI is R F Industries Pty Ltd

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## table of contents



## 50 Ohm

## Braided Coaxial Cables

Our polyethelene (PE) dielectric cables such as 8058 and 8213 have recently (July 2006) been certified to be free of lead and other banned substances under the European RoHS regulations.

ANDREW:
CINTA


## 50/75 Ohm

## Braided Coaxial Cables

## Andrew Corrugated

## Corrugated Heliax ${ }^{\circledR}$ Coaxial Cables

RFI is the only Australian Distributor for Andrew Corporation. Heliax ${ }^{\circledR}$ coaxial cables are superior to equivalent braided cables and feature:

- Excellent Intermodulation - Phase stability

Performance

- Low attenuation
- Complete RF shielding
- High power capability

| Cable Type | Jacket O.D. mm | Construction |  |  |  |  | Impedance Ohms | Nominal Velocity \% | Type of Jacket |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Dielectric | Centre Conductor | Shield |  |  |  |  |  |
|  |  |  |  | No. | Type | Coverage |  |  |  |
| FSJ1-50 Heliax ${ }^{\circledR}$ | 7.4 | Cellular Polyethylene (Foam) | $\begin{gathered} 1 \times \mathrm{CCA} \\ 1.9 \mathrm{~mm} \end{gathered}$ | 1 | Corrugated Solid BC | 100\% | 50 | 84 | Black Polyethylene UV stabilised |
| LDF1-50 Heliax ${ }^{\oplus}$ | 8.8 | Low Density Polyethylene (Foam) | $\begin{aligned} & 1 \times \mathrm{CCA} \\ & 2.6 \mathrm{~mm} \end{aligned}$ | 1 | Corrugated Solid BC | 100\% | 50 | 86 | Black Polyethylene UV stabilised |
|  | 10.5 | Cellular Polyethylene (Foam) | $\begin{gathered} 1 \times \mathrm{CCA} \\ 2.8 \mathrm{~mm} \end{gathered}$ | 1 | Corrugated Solid BC | 100\% | 50 | 83 | Black <br> Polyethylene UV stabilised |
|  | 11.2 | Low Density Polyethylene (Foam) | $\begin{gathered} 1 \times \mathrm{CCA} \\ 3.1 \mathrm{~mm} \end{gathered}$ | 1 | Corrugated Solid BC | 100\% | 50 | 88 | Black <br> Polyethylene UV stabilised |
| FSJ4-50 Heliax ${ }^{\circledR}$ | 13.2 | Cellular Polyethylene (Foam) | $\begin{gathered} 1 \times \mathrm{CCA} \\ 3.6 \mathrm{~mm} \end{gathered}$ | 1 | Corrugated Solid BC | 100\% | 50 | 81 | Black Polyethylene UV stabilised |
|  | 16.0 | Low Density Polyethylene (Foam) | $\begin{gathered} 1 \times \mathrm{CCA} \\ 4.6 \mathrm{~mm} \end{gathered}$ | 1 | Corrugated Solid BC | 100\% | 50 | 88 | Black <br> Polyethylene UV stabilised |
| AVA5-50 Heliax | 27.94 | Low Density Polyethylene (Foam) | $1 \times B C$ (Hollow) 9.4 mm | 1 | Corrugated Solid BC | 100\% | 50 | 91 | Black <br> Polyethylene UV stabilised |
|  | 15.49 | Polyethylene Foam | $\begin{aligned} & 1 \times \mathrm{CCA} \\ & 5.11 \mathrm{~mm} \end{aligned}$ | 1 | Smoothwall Alluminium | 100\% | 50 | 88 | Black Polyethylene UV Stabilised |
|  | 27.68 | Polyethylene Foam | $1 \times B C$ foam filled 9.5 mm | 1 | Smoothwall Alluminium | 100\% | 50 | 88 | Black Polyethylene UV Stabilised |
|  | 39.87 | Polyethylene Foam | $1 \times B C$ foam filled 14.1 mm | 1 | Smoothwall Alluminium | 100\% | 50 | 89 | Black <br> Polyethylene UV Stabilised |
| FXL-1873 | 50.29 | Polyethylene <br> Foam | $1 \times B C$ foam filled 18 mm | 1 | Smoothwall Alluminium | 100\% | 50 | 88 | Black <br> Polyethylene UV Stabilised |

## DC \& Speaker Cables

## DC Power Cables

| Cat. No. | Description | Roll Size <br> m | Area of Conductor $\mathrm{mm}^{2}$ | Conductor No./Diameter mm |
| :---: | :---: | :---: | :---: | :---: |
| 3T-30 | 3 mm Twin Fig 8 | 30 | 1.13 | 16/0.3 |
| 3T-100 | 3 mm Twin Fig 8 | 100 | 1.13 | 16/0.3 |
| 4T-30 | 4mm Twin Fig 8 | 30 | 1.84 | 26/0.3 |
| 4T-100 | 4mm Twin Fig 8 | 100 | 1.84 | 26/0.3 |
| 5S-30 | 5 mm Single (Red or Black) | 30 | 2.90 | 41/0.3 |
| 5S-100 | 5 mm Single (Red or Black) | 100 | 2.90 | 41/0.3 |
| 6S-30 | 6 mm Single (Red or Black) | 30 | 4.59 | 65/0.3 |
| 6S-100 | 6 mm Single (Red or Black) | 100 | 4.59 | 65/0.3 |
| 3DS-100 | 3mm Twin Double Sheath | 100 | 1.13 | 16/0.3 |
| 4DS-30 | 4mm Twin Double Sheath | 30 | 1.84 | 26/0.3 |
| 4DS-100 | 4mm Twin Double Sheath | 100 | 1.84 | 26/0.3 |
| 5DS-30 | 5 mm Twin Double Sheath | 30 | 2.90 | 41/0.3 |
| 5DS-100 | 5 mm Twin Double Sheath | 100 | 2.90 | 41/0.3 |
| 6DS-30 | 6 mm Twin Double Sheath | 30 | 4.59 | 65/0.3 |
| 6DS-100 | 6 mm Twin Double Sheath | 100 | 4.59 | 65/0.3 |
| FPC6B-100 | $6 \mathrm{~mm}^{2}$ Single Core Black | 100 | 6.00 | 192/0.2 |
| FPC6R-100 | $6 \mathrm{~mm}^{2}$ Single Core Red | 100 | 6.00 | 192/0.2 |
| FPC10B-100 | $10 \mathrm{~mm}{ }^{2}$ Single Core Black | 100 | 10.00 | 322/0.2 |
| FPC10R-100 | $10 \mathrm{~mm}^{2}$ Single Core Red | 100 | 10.00 | 322/0.2 |

## Speaker Cables

| Cat. No. | Description | Roll Size <br> $m$ | Conductor Description <br> $m m$ |
| :--- | :---: | :---: | :---: |
| SPK-14 | Light Duty Fig 8 | 100 | $14 / 0.14$ |
| SPK-24 | Heavy Duty Fig 8 | 100 | $24 / 0.2$ |


|  |  |  |  |
| :---: | :---: | :---: | :---: |
| 4T-100 |  |  |  |
|  | 6DS-100 |  |  |

## Cable Assemblies

| Model No. | Connector A | Cable Type | Cable Length m | Connector B |
| :---: | :---: | :---: | :---: | :---: |
| 92-01AM-0.5 | TNC Plug | RG223 | 0.5 | MPL Plug |
| 92-01AN-0.5 | TNC Plug | RG223 | 0.5 | UHF Plug |
| 92-01D-0.5 | N Plug | RG223 | 0.5 | N Plug |
| 92-01D-1 | N Plug | RG223 | 1 | N Plug |
| 92-01H-0.5 | TNC Plug | RG223 | 0.5 | BNC Plug |
| 92-01H-1 | TNC Plug | RG223 | 1 | BNC Plug |
| 92-01L-0.5 | TNC Plug | RG223 | 0.5 | TNC Plug |
| 92-01L-1 | TNC Plug | RG223 | 1 | TNC Plug |
| 92-01N-0.5 | N Plug | RG223 | 0.5 | SMA Plug |
| 92-01N-1 | N Plug | RG223 | 1 | SMA Plug |
| 92-04B-0.5 | N Plug | RG214 | 0.5 | BNC Plug |
| 92-04B-1 | N Plug | RG214 | 2 | BNC Plug |
| 92-04D-0.5 | N Plug | RG214 | 0.5 | N Plug |
| 92-04D-1 | N Plug | RG214 | 1 | N Plug |
| 92-04D-2 | N Plug | RG214 | 2 | N Plug |
| 92-04G-0.5 | N Plug | RG214 | 0.5 | N Jack |
| 92-04G-1 | N Plug | RG214 | 1 | N Jack |
| 92-06AE-0.5 | BNC Plug | RG58 | 0.5 | BNC Jack |
| 92-06AE-1 | BNC Plug | RG58 | 1 | BNC Jack |
| 92-06B-0.5 | N Plug | RG58 | 0.5 | BNC Plug |
| 92-06B-1 | N Plug | RG58 | 1 | BNC Plug |
| 92-07A-0.5 | BNC Plug | 9006 | 0.5 | BNC Plug |
| 92-07A-1 | BNC Plug | 9006 | 1 | BNC Plug |
| 92-07B-0.5 | N Plug | 9006 | 0.5 | BNC Plug |
| 92-07B-0.1 | N Plug | 9006 | 1 | BNC Plug |
| 92-07D-0.5 | N Plug | 9006 | 0.5 | N Plug |
| 92-07D-1 | N Plug | 9006 | 1 | N Plug |

## Cable Assemblies

| Model No. | Connector A | Cable Type | Cable Length $m$ | Connector B |
| :---: | :---: | :---: | :---: | :---: |
| 92-07D-1.5 | N Plug | 9006 | 10.5 | N Plug |
| 92-07D-3 | N Plug | 9006 | 3 | N Plug |
| 92-07D-5 | N Plug | 9006 | 0.5 | N Plug |
| 92-07G-0.5 | N Plug | 9006 | 0.5 | N Jack |
| 92-07G-1 | N Plug | 9006 | 1 | N Jack |
| 92-07L-0.5 | N Plug | 9006 | 0.5 | TNC-RG Plug |
| 92-07L-1 | N Plug | 9006 | 1 | TNC-RG Plug |
| 92-07M-0.5 | N Plug | 9006 | 0.5 | BNC-RG Plug |
| 92-07M-1 | N Plug | 9006 | 1 | BNC-RG Plug |
| 92-07P-0.5 | $N$ Plug | 9006 | 0.5 | SMA-RG Plug |
| 92-07P-0.1 | N Plug | 9006 | 1 | SMA-RG Plug |
| 92-09D-0.5 | N Plug | CNT-400 | 0.5 | N Plug |
| 92-09D-1 | N Plug | CNT-400 | 1 | N Plug |
| 92-09D-3 | N Plug | CNT-400 | 3 | N Plug |
| 92-09D-10 | N Plug | CNT-400 | 10 | N Plug |
| 92-09D-15 | N Plug | CNT-400 | 15 | N Plug |
| 92-09D-20 | N Plug | CNT-400 | 20 | N Plug |
| 92-09G-0.5 | N Plug | CNT-400 | 0.5 | N Jack |
| 92-09G-1 | N Plug | CNT-400 | 1 | N Jack |
| 92-09G-3 | N Plug | CNT-400 | 3 | N Jack |
| 92-09G-10 | N Plug | CNT-400 | 10 | N Jack |
| 92-09G-15 | N Plug | CNT-400 | 15 | N Jack |
| 92-09G-20 | N Plug | CNT-400 | 20 | N Jack |
| 92-09W-1 | N Jack | CNT-400 | 1 | N Jack |
| 92-09W-10 | N Jack | CNT-400 | 10 | N Jack |
| 92-09W-15 | N Jack | CNT-400 | 15 | N Jack |
| 92-09W-20 | N Jack | CNT-400 | 20 | N Jack |

Notes
$\begin{array}{ll}\text { Notes } & \\ \text { RT } & \text { Reverse Thread } \\ \text { RG } & \text { Reverse Gender }\end{array}$
BH Bulk Head Mount

MC90
9006 RG58 A/U style similar to XXX195 cables
9014 RG58 thin net cable

## Cable Assemblies



ANDREW:

| Model No. | Connector A | Cable Type | Cable Length m | Connector B |
| :---: | :---: | :---: | :---: | :---: |
| S-1780 | N Plug | RG316 | 0.28 | MC90 |
| S-1782 | N Plug | 9006 | 0.3 | SMA Plug |
| S-1784 | N Plug | 9006 | 3 | SMA Plug |
| S-1785 | N Plug | 9006 | 3 | SMA RT Plug |
| S-1786 | N Plug | 9006 | 0.5 | SMA RG Plug |
| S-1787 | N Plug | 9006 | 0.5 | SMA Plug |
| S-1788 | MMCX RA Plug | RG316 | 0.3 | SMA Jack |
| S-1793 | MMCX Plug | RG174 | 0.145 | SMA Plug |
| S-1794 | MC 90 | RG174 | 0.3 | SMA Jack |
| S-1795 | SMA RG Plug | 9006 | 3 | SMA RG Plug |
| S-1800 | MCX RA | RG174 | 0.12 | BNC Jack |
| S-1801 | MCX RA | RG174 | 0.12 | TNC Jack |
| S-1806 | N Plug | 9014 | 0.3 | SMA RA Plug |
| S-1807 | N Plug | 9014 | 0.45 | SMA RA Plug |
| S-1808 | SMA RA Plug | RG316 | 0.3 | SMA BH Jack |
| S-1809 | TNC Plug | RG316 | 0.3 | TNC BH Jack |
| S-1811 | FME BH Plug | RG316 | 0.3 | FME Jack |
| S-1812 | FME Plug | RG174 | 0.15 | MC90 |

BH Bulk Head Mount
RA Right Angle


## 7-16 DIN



| Model. No. | Description | Cable Type | Centre Conductor | Crimp Set* or Tool |
| :---: | :---: | :---: | :---: | :---: |
| 7-16 DIN Plugs |  |  |  |  |
| 400PDM | Clamp Tri Metal Plated | CNT-400, LMR-400 | Solder | BCPT3400 |
| L4TDM-PS | Positive Stop | LDF4-50 | Captive | CPT-L4ARC1/MCPT-L4 |
| AL5DM-PSA | Positive Stop | AVA5-50, AL5-50 | Captive | CPT-78U/MCPT-78 |
| AL7DM-PSA | Positive Stop | AVA7-50, AL7-50 | Captive | CPT-158U |
| F1PDM | Clamp Self Flare | FSJ1-50 | Solder | CPT-LI/MCPT1412 |
| F4PDMV2-C | Self Flare | FSJ4-50 | Captive | CPT-F4/MCPT1412 |
| F4PDR-C | Right Angle Self Flare | FSJ4-50 | Captive | CPT-F4/MCPT1412 |
| 12EZDM | Clamp Tri Metal Plated | FXL-540 | Captive | 540-EZPT/12HPT |
| 78EZDM | Clamp Tri Metal Plated | FXL-780 | Captive | 780-EZPT/78HPT |
| 114EZDM | Clamp Tri Metal Plated | FXL-1480 | Captive | 1480-PT/158-HPT |
| 158EZDM | Clamp Tri Metal Plated | FXL-1873 | Captive | 1873-PT/158-HPT |
| Jacks |  |  |  |  |
| 400PDF | Clamp Tri Metal Plated | CNT-400, LMR-400 | Solder | BCPT3400 |
| L4TDF-PS | Positive Stop | LDF4-50 | Captive | CPT-L4ARCI/MCPT-L4 |
| AL5DF-PSA | Positive Stop | AVA5-50, AL5-50 | Captive | CPT-78U/MCPT-78 |
| AL7DF-PSA | Positive Stop | AVA7-50, AL7-50 | Captive | CPT-158U |
| F4PDF-C | Self Flare | FSJ4-50 | Captive | CPT-F4/MCPT1412 |
| 716-01 | Panel Mount Crimp | RG142 | Solder | RCT-5859 |
| 716-04 | Panel Mount - Low PIM | Solder Pot | Solder |  |
| 12EZDF | Clamp Tri Metal Plated | FXL-540 | Captive | 540-EZPT/12HPT |
| 78EZDF | Clamp Tri Metal Plated | FXL-780 | Captive | 780-EZPT/78HPT |
| 114EZDF | Clamp Tri Metal Plated | FXL-1480 | Captive | 1480-PT/114HPT |
| 158EZDF | Clamp Tri Metal Plated | FXL-1873 | Captive | 1873-PT/158HPT |
| 716-A911-004 | Panel Mount-1" Sq. Flange | Solder Pot | Solder |  |
| Adapters |  |  |  |  |
| 716-10 | Female to Female Barrel |  |  |  |
| CA-TNFDF | DIN Female to N Female |  |  |  |
| CA-TNFDM | DIN Male to N Female |  |  |  |
| Other 7-16 DIN connectors to suit most popular cables available on request <br> * See Page 24 for Crimp Tools Matrix and Page 25 for Cable Prep Tools <br> ** All listed N connectors feature the standard 50 Ohm interface dimensions. 75 Ohm interface dimensional connectors and an expanded range of other N connectors are available. Contact your nearest sales office for details. |  |  |  |  |

N Connectors are medium size threaded couplers which will operate between DC to 11 GHz . Offering consistent low broadband VSWR, they have proved very popular over the years in mobile radio applications and are often used in high vibration installations. Their threaded design guaranteeing a stable connection.


| Model. No. | Description | Cable Type | Centre Conductor | Crimp Set* or Tool |
| :---: | :---: | :---: | :---: | :---: |
| Cable Jacks |  |  |  |  |
| N-28 | Clamp - Nickel | RG213, RG214 | Solder, captive | CST-213 |
| N-30 | Clamp - Nickel | RG58, 9001, 9006 | Solder, captive | CST-399 |
| N-96 | Crimp - Silver plated | RG142, RG223 | Crimp, captive | A |
| N-98 | Crimp - Silver plated | RG58, 9001, 9006 | Crimp, captive | A |
| N-118 | Crimp - Nickel | RG213 | Crimp, captive | C |
| N-200 | Crimp, White Bronze plated | CNT400, LMR400 | Spring finger | D |
| 400PNF-C-CR | Crimp Tri Metal Plated | CNT-400, LMR-400 | Spring Finger | BCPT-3400/RCT-214 |
| N-202 | Crimp, Nickel plated | CNT400, LMR400 | Spring finger | D |
| N-204 | Crimp, Nickel plated | CNT400, LMR400 | Solder, captive | D |
| N-210 | Crimp, Silver plated | RG59 | Crimp, captive | B |
| N-285 | Crimp, Silver plated | RG214 | Crimp, captive | D |
| L4TNF-PS | Ring Flare | LDF4-50, RXL4-50 | Captive, spring finger | EASIAX ${ }^{\circledR}$ Plus |
| AL5NF-PSA | One Piece Ring Flare | AVA5-50/AL5-50 | Captive, spring finger | EASIAX ${ }^{\circledR}$ Plus |
| 12EZNF | Clamp Tri Metal Plated | FXL-540 | Captive | 540-EZPT/12 HPT |
| 78EZNF | Clamp Tri Metal Plated | FXL-780 | Captive | 780-EZPT/78 HPT |
| 114EZNF | Clamp Tri Metal Plated | FXL-1480 | Captive | 1480-EZPT/114 HPT |
| 158EZNF | Clamp Tri Metal Plated | FXL-1873 | Captive | 1873-EZPT/158 HPT |
| AL7NF-PS | Ringflare | AVA7-50/AL7-50 | Captive, spring finger | CPTL7 |
| F4PNF-C | Clamp, Self Flare | FSJ4-50 | Captive, spring finger | EASIAX ${ }^{\text {® }}$ |
| Panel Mount Jacks |  |  |  | Mounting size and direction |
| N-09 | Flange Mount, nickle plated |  | Solder pot, captive | 11 mm (front) 16mm (rear) |
| N-12 | Bulkhead mount |  | Solder pot, captive | 13 mm (front) |
| N-20 | Bulkhead mount, silver plated |  | Solder pot, captive | 13 mm (front) |
| N-38 | Cable mounted, bulkhead, RG213 |  | Solder pot, captive | 16 mm (front) 13.5 mm across flat |
| 400PNF-BHC | Clamp Tri Metal Plated B/H |  | Spring Finger | BCPT-3400 |
| N-120 | Flange mount, silver plated |  | Solder pot, captive | 16 mm (front) 15 mm (rear) |
| N-213 | Cable mounted flange, nickle plated RG213 |  | Crimp, captive | 18 mm (front) 16 mm (rear) |
| N-237 | Cable mounted flange, nickle plated RG58 |  | Solder, captive | 13 mm (front) 16 mm (rear) |
| N-288 | Cable mounted bulkhead nickel plated RG58, 9001, 9006 |  | Crimp, captive | 16 mm (rear) 13.7 mm across flats |
| Adaptors |  |  |  |  |
| N-10 | F-F barrel |  |  |  |
| N-48 | F-F-F Tee adaptor |  |  |  |
| N-49 | M-F-F Tee adaptor |  |  |  |
| N-243 | M-M barrel, Nickel plated |  |  |  |
| N-245 | M-F Right angle adaptor, nickel plated |  |  |  |

* See Page 24 for Crimp Tools Matrix and Page 25 for Cable Prep Tools
** All listed N connectors feature the standard 50 Ohm interface dimensions. 75 Ohm interface dimensional connectors and an expanded range of other N connectors are available. Contact your nearest sales office for details.


## N Series

Available in crimp, clamp, spring finger, solder and a variety of finishes including silver and white bronze.


| Model. No. | Description | Cable Type | Centre Conductor | Crimp Set* or Tool |
| :---: | :---: | :---: | :---: | :---: |
| Cable Plugs |  |  |  |  |
| 400PNM | Clamp Tri Metal Plated | CNT-400, LMR-400 | Solder | BCPT-3400 |
| F4PNMV2-HC | Self Flare | FSJ4-50 | Captive, Spring finger | MCPT-1412 |
| F4PNR-C | Right Angle Self Flare | FSJ4-50 | Captive, Spring finger | MCPT-1412 |
| L4TNM-PS | Ringflare | LDF4-50 | Captive, Spring finger | MCPT-L4 |
| AL5NM-PSA | Self Flare | AVA5-50/AL5-50 | Captive, Spring finger | MCPT-78 |
| AL7NM-PSA | Ringflare | AVA7-50/AL7-50 | Captive, Spring finger | CPTL7 |
| 12EZNM | Clamp Tri Metal Plated | FXL-540 | Captive | 540-E2PT/12HPT |
| 78EZNM | Clamp Tri Metal Plated | FXL-780 | Captive | 780-E2PT/78HPT |
| 114EZM | Clamp Tri Metal Plated | FXL-1480 | Captive | 1480-PT/114HPT |
| 158EZNM | Clamp Tri Metal Plated | FXL-1873 | Captive | 1873-PT/158HPT |
| Cable Jacks |  |  |  |  |
| 400PNF | Clamp Tri Metal Plated | CNT-400, LMR-400 | Solder | BCPT-3400 |
| * See Pages 24 for Crimp Tools Matrix |  |  |  |  |


N-118

N-30

N-204

N-288

N-28
AL5NM-PS

L4TNM-PS

N-119

N-284

N-201

## N Series

| Model. No. | Description | Cable Type | Centre Conductor | Crimp Set* or Tool |
| :---: | :---: | :---: | :---: | :---: |
| Cable Plugs |  |  |  |  |
| N-07 | Clamp - Silver Plated | RG213 | Solder, captive | - |
| N-15 | Clamp - Nickel | RG58, 9001, 9006 | Solder, captive | - |
| N-41 | Right angle clamp | RG58, 9001, 9006 | Solder, captive | - |
| N-87 | Crimp - Silver plated | RG142, RG223 | Crimp, captive | A |
| N-88 | Crimp - Nickel | RG58, 9001, 9006 | Crimp, captive | A |
| N-89 | Crimp - Silver plated | RG58, 9001, 9006 | Crimp, captive | A |
| N-95 | Right angle crimp | RG58 | Crimp, captive | A |
| N-114 | Crimp - Nickel | RG213 | Crimp, captive | C |
| N-119 | Crimp - Nickel plated | RG214 | Crimp, captive | D |
| N-201 | Crimp - White bronze plated | CNT400, LMR400 | Spring finger | D |
| N-203 | Crimp - Nickel plated | CNT400, LMR400 | Spring finger | D |
| N-205 | Crimp - Nickel plated | CNT400, LMR400 | Solder, captive | D |
| N-223 | Crimp - Nickel plated | RG142, RG223 | Crimp, captive | A |
| N-258 | Right angle clamp | RG213, RG214 | Solder, captive | - |
| N-284 | Crimp | RG214 | Crimp, captive | D |
| NP-10DFB | Clamp - Nickel | 9005 | Solder | - |
| L4TNM-PC | Ringflare, Positive Stop | LDF4-50, RXL4-50 | Captive, spring finger | CPT-L4ARCI/MCPT-L4 |
| L4TNR-HC | Right angle clamp, Postive Stop | LDF4-50, RXL4-50 | Captive, spring finger | CPT-L4ARCI/MCPT-L4 |
| F1PNM-HC | Hex Head, Self-Flare | FSJ1-50 | Captive, spring finger | CPT-LI/MCPT-1412 |
| F2PNM-HC | Hex Head, Self-Flare | FSJ2-50 | Captive, spring finger | MLPT-3812 |
| F4PMV2-C | Hex Head, Crush-Flare | FSJ4-50 | Captive, spring finger | CPT-F4/MCPT-1412 |
| 400PNM-H-CR | Crimp Tri Metal Plated Hex | CNT-400, LMR-400 | Solder | D |
| 400PNM-HC-CR | Crimp Tri Metal Plated Hex | CNT-400, LMR-400 | Spring finger | D |
| * See Page 24 for Crimp Tools Matrix and Page 25 for Cable Prep Tools |  |  |  |  |

## UHF Series



One of the first coaxial connectors developed the UHF connector will operate between DC to 600 MHz . A low cost threaded connector, the UHF series is popular in CB and lower frequency mobile radio applications. Available in twist on, crimp and solder clamp versions.

| Model. No. | Description | Cable Type | Centre Conductor | Crimp Set* or Tool |
| :---: | :---: | :---: | :---: | :---: |
| Cable Plugs |  |  |  |  |
| UHF-21 | Clamp - Silver plated | RG58, 9001, 9006 | Solder | CST-399 |
| UHF-44 | Crimp - Nickel | RG58, 9001, 9006 | Crimp, captive | A |
| UHF-66 | Clamp - Right-angle plug | RG58 | Solder, captive | CST-399 |
| UHF-104 | Twist on nickel | RG58, 9001, 9006 | Crimp, captive | A |
| UHF-119 | Crimp - Nickel | RG58, 9001, 9006 | Crimp, captive | A |
| UHF-204 | Screw thread nickel | RG58, 9001, 9006 | Solder, captive | CST-399 |
| UHF-45 | Crimp - Nickel | RG59 | Crimp, captive | B |
| UHF-46 | Crimp - Nickel | RG213 | Crimp, captive | C |
| UHF-27 | Twist on - Nickel | RG213, RG214 | Solder | CST-213 |
| UHF-04 | Clamp - Silver plated | RG213, RG214 | Solder, captive | CST-213 |
| MP10FB | Solder - Nickel plated | 9005, 10DFB | Solder | - |

* See Page 24 for Crimp Tools Matrix and Page 25 for Cable Prep Tools

UHF connectors are non-constant impedance connectors suited for use at frequencies not exceeding 300 MHz . However, to ensure maximum performance at higher frequencies all UHF Series male connectors feature a high strength PTFE dielectric with the exception of the "CB style" connectors UHF-104, UHF-204 and UHF-27.


UHF-04


UHF-46


UHF-21


UHF-66


UHF-27


UHF-104


UHF-44


UHF-204


| Model. No. | Description | Cable Type |  | Centre Conductor |
| :---: | :---: | :---: | :---: | :---: |
| Cable Jacks |  |  |  |  |
| UHF-36 | Solder - Nickel plated | RG213, RG214 | Solder |  |
| Panel Mount Jacks |  |  |  | Mounting size and direction |
| UHF-67 | Flange Mount | RG58 | Clamp | 9.5 mm (front) |
| UHF-28 | Bulkhead - Nickel plated |  | Solder pot | 12.5 mm (front) |
| UHF-60 | Flange Mount - Nickel plated |  | Solder pot | 15 mm (front) 16 mm (rear) |
| UHF-117 | Bulkhead - Nickel plated |  | Solder pot | 16mm (front) |
| MBC | Bulkhead Nickel plated | RG58 | Screw fit/Solder | 16mm (rear) |
| MBC-WD | Bulkhead Nickel Plated water resistant | RG58/RG174 | Crimp/solder | 16 mm (rear) |
| Adaptors |  |  |  |  |
| UHF-14 | Double female barrel |  |  |  |
| UHF-15 | Double female bulkhead - Nickel plated |  |  |  |
| UHF-32 | T-Adaptor (2 female) - Nickel plated |  |  |  |
| UHF-116 | Double male barrel - Nickel plated |  |  |  |
| UHF-16 | 90 degree, male/female - Nickel plated |  |  |  |
| UHF connectors are non-constant impedance connectors suited for use at frequencies not exceeding 600 MHz . However, to ensure maximum performance at higher frequencies all UHF Series female connectors feature a high strength PTFE dielectric with the exception of the "CB style" UHF-15, UHF-32 and UHF-60. |  |  |  |  |



UHF-36


UHF-14


UHF-67


UHF-15


UHF-116


UHF-16


## TNC Series



TNC connectors will operate from $D C$ to 11 GHz . TNC connectors are widely accepted mobile phone 1 installations and also for wireless data applications. Their threaded design offers a precision fit, positive mating and support against vibration.

Available in crimp and solder clamp styles as well as silver or nickel plating. All feature gold plated centre conductors. Reverse gender plugs and jacks have been developed for WiFi applications.
ANDREW:

| Model. No. | Description | Cable Type | Centre Conductor | Crimp Set* or Tool |
| :---: | :---: | :---: | :---: | :---: |
| Cable Plugs |  |  |  |  |
| TNC-01 | Solder - Nickel plated | RG58, 9001, 9006 | Solder | CST-399 |
| TNC-26 | Crimp - Nickel plated | RG58, 9001, 9006 | Crimp, captive | A |
| TNC-26RG | Reverse gender - Nickel plated | RG58, 9001, 9006 | Crimp | A |
| TNC-26RT | Reverse thread - Nickel plated | RG58, 9001, 9006 | Crimp | A |
| TNC-223 | Crimp - Nickel plated | RG223 | Crimp, captive | A |
| TNC-207 | Crimp - Nickel plated | CNT-400 | Solder | D |
| TNC-207RG | Reverse gender crimp - Nickel plated | CNT-400 | Solder | D |
| BR400PTM-C | Clamp - Silver plated | BR-400 | Spring Finger, captive | D |
| Cable Jacks |  |  |  |  |
| TNC-86 | Crimp - Nickel plated | RG58, 9001, 9006 | Crimp, captive | A |
| TNC-86RG | Reverse gender crimp - Nickel plated | RG58, 9001, 9006 | Crimp, captive | A |
| TNC-206RG | Crimp - Nickel plated | CNT-400 | Solder | D |
| Panel Mount Jacks |  |  |  | Mounting size and direction |
| TNC-33 | Bulkhead - Nickel plated |  | Solder pot, captive | 9.5 mm (rear) |
| TNC-88 | Cable mount, bulkhead - Nickel plated | RG58, 9001, 9006 | Crimp, captive | 13mm (front) A crimp set |
| Adaptors |  |  |  |  |
| TNC-11 | Double female barrel - Nickel plated |  |  |  |
| TNC-15 | 90 degree male/female - Nickel plated |  |  |  |
| TNC-42 | Double female bulkhead - Nickel plated |  |  |  |
| * See Page 24 for Crimp Tools Matrix and Page 25 for Cable Prep Tools |  |  |  |  |



TNC-01


TNC-33



TNC-26RG


TNC-206RG


TNC-26RT


TNC-207RG

## BNC Series

BNC connectors are similar to the TNC series but instead of a thread they use a bayonet coupling mechanism allowing a quicker connect/disconnect. BNC connectors are generally used within an operating range of DC to 4 GHz and are popular with many wireless applications requiring frequent connection and disconnection such as test equipment. Also available in reverse gender versions.


## Miscellaneous

## Mini-UHF Series

Mini-UHF connectors gained popularity in cellular mobile telephone applications as a low cost miniature threaded coupler. Capable of operation from DC to 2.5 GHz they are a small,
 lightweight and cost effective solution for many wireless requirements.

SMA Series
SMA connectors are a miniature coaxial connector used for higher specification requirements with a precision threaded coupling mechanism. They are a light weight, high strength connector capable of operation up to 12 GHz . Available in nickel or gold plated bodies all feature gold plated pins and Teflon dielectric. Reverse gender connectors provide connection options to many $\mathrm{Wi}-\mathrm{Fi}$ and Wireless LAN installations.

## FME Series

A low cost lightweight threaded solution for high vibration installations, the FME connector series have gained popularity worldwide in cellular mobile applications, and are also known as rotating nipple connectors. They are generally used up to 1.8 GHz
 and can be mated to a range of adapters to match different connector series in an installation.

## MMCX Series

Designed for the smallest of applications, MMCX connectors provide reliable performance up to 6 GHz . They mate using a snap on mechanism which also provides precision performance in the latest wireless applications such as GPS tracking and telematics. All connectors feature gold plated bodies, pins and Teflon dielectric.


## Miscellaneous

| Model. No. | Description | Cable Type | Centre Conductor | Crimp Set* |
| :---: | :---: | :---: | :---: | :---: |
| Cable Plugs |  |  |  |  |
| FME-150 | FME Crimp - Nickel plated | RG174, RG316, RG179 | Crimp, captive | E |
| MCX-02 | MCX Crimp - Gold plated | RG174, RG316, RG179 | Solder | E |
| MMCX-01 | MMCX Crimp - Gold plated | RG174, RG316, RG179 | Solder | E |
| MMCX-02 | MMCX Crimp - Gold plated | RG174, RG316, RG179 | Crimp | E |
| SMA-174 | SMA Crimp - Gold plated | RG174, RG316, RG179 | Crimp | E |
| FME-116 | FME Plug to Plug adaptor - Nickel plated | RG58, 9001, 9006 | Captive | - |
| FME-120 | FME Nipple, crimp, male - Nickel plated | RG58, 9001, 9006 | Crimp | A |
| MPL-604 | Mini UHF crimp - Nickel plated | RG58, 9001, 9006 | Crimp, captive | A |
| MPL-605 | Mini UHF crimp - Black chrome | RG58, 9001, 9006 | Crimp, captive | A |
| SMA-40 | SMA Crimp black - Chrome | RG58, 9001, 9006 | Crimp | A |
| SMA-104 | SMA Crimp, Pulse - Nickel plated | RG58, 9001, 9006 | Crimp | A (centre - 1.09 mm ) |
| SMA-104KN | SMA Knurled nut interface - Black chrome | RG58, 9001, 9006 | Crimp | A (centre - 1.09 mm ) |
| SMA-104RG | SMA Reverse gender - Nickel plated | RG58, 9001, 9006 | Crimp | A (centre - 1.09 mm ) |
| SMA-104RT | SMA Reverse thread - Gold plated | RG58, 9001, 9006 | Crimp | A (centre - 1.09 mm ) |
| Cable Jacks |  |  |  |  |
| FME-140 | FME Crimp - Nickel plated | RG174, RG316, RG179 | Crimp, captive | E |
| MMCX-03 | MMCX Crimp - Gold plated | RG174, RG316, RG179 | Solder | E |
| FME-101 | FME Crimp - Nickel plated | RG58, 9001, 9006 | Crimp | A |
| MPL-86 | Mini UHF - Nickel plated | RG58, 9001, 9006 | Crimp | A |
| SMA-186 | SMA Crimp - Gold plated | RG58, 9001, 9006 | Crimp | A (centre - 1.09 mm ) |
| Panel Mount Jacks |  |  |  |  |
| SMA-05 | SMA Bulkhead - Gold plated | - | Solder pot | 6.4 mm (front) |
| SMA-06 | SMA Cable mount bulkhead - Gold plated | RG174, RG316, RG179 | Crimp | 6.4 mm (rear) |
| SMA-07 | SMA Cable mount bulkhead - Gold plated | RG58, 9001, 9006 | Crimp | 6.4 mm (rear) |
| SMA-08 | Press mount jack | RG174, RG316, RG179 | Solder pot | 6.85 mm (diameter over knurl) |
| QMA-01 | Press mount jack | - | Solder pot | 6.85 mm (diameter over knurl) (rear) |
| *See Page 24 for Crimp Tools Matrix |  |  |  |  |

## Inter Series Adaptors

Inter Series Adaptors

|  |  | N |  | UHF |  | BNC |  | TNC |  | FME |  | SMA |  | MPL |  | 716 DIN |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Plug | Jack | Plug | Jack | Plug | Jack | Plug | Jack | Plug | Jack | Plug | Jack | Plug | Jack | Plug | Jack |
| N | Plug | N-243 | - | A-01 | A-03 | - | - | - | - | A-89 | - | - | - | - | - | CA-PNMDM | CA-PNMDM |
|  | Jack | - | N-10 | - | - | A-06 | A-29 | A-18 | - | - | - | A-74 | A-98 | - | - | CA-PNFDM | CA-PNFDF |
| UHF | Plug | A-01 | - | UHF-116 | - | - | A-08 | - | - | A-76 | - | - | - | - | - | - | - |
|  | Jack | A-03 | - | - U | UHF-14 | A-09 | - | - | - | - | - | - | - | A-97 | - | - | - |
| BNC | Plug | - | A-06 | - | A-09 | BNC-51 | - | - | A-19 | A-91 | - | - | - | - | - | - | - |
|  | Jack | - | A-29 | - | - | - | BNC-41 | A-20 | - | - | - | - | A-20 | A-80 | - | - | - |
| TNC | Plug | - | A-18 | - | - | - | A-20 | - | - | A-86 | - | - | A-78 | - | - | - | - |
|  | Jack | - | - | - | - | A-19 | - | - | TNC-11 | - | - | A-82 | A-85 | A-83 | - | - | - |
| FME | Plug | A-89 | - | A-76 | - | A-91 | - | A-86 | - | FME-116 | - | A-88 | - | - | - | - | - |
|  | Jack | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SMA | Plug | - | A-74 | - | - | - | - | - | A-82 | A-88 | - | - | - | - | - | - | - |
|  | Jack | - | A-98 | - | - | - | A-90 | A-78 | A-85 | - | - | - | - | - | - | - | - |
| MPL | Plug | - | - | - | A-97 | - | A-80 | - | A-83 | A-87 | - | - | A-77 | - | - | - | - |
|  | Jack | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| $\begin{aligned} & 716 \\ & \text { DIN } \end{aligned}$ | Plug | CA-PNMDM | CA-PNFDM | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  | Jack | CA-PNMDF | CA-PNFDF | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| AK-30 Technicians Adapter Kit Standard Connectors |  |  |  |  |  |  |  | AK-40 Technicians Adapter Kit Miniature and Sub Miniature |  |  |  |  |  |  |  |  |  |
| The AK-30 coaxial kit allows virtually any test adaptor to be made up in seconds. |  |  |  |  |  |  |  | The variety of terminations on equipment in service is rapidly increasing. MMCX and SMB connectors are now commonplace and the AK-40 adaptor kit contains the parts you need to interface to these connectors. |  | The variety of terminations on equipment in service is rapidly increasing. MMCX and SMB connectors are now commonplace and the AK-40 adaptor kit contains the parts you need to interface to these connectors. |  |  |  |  |  |  |  |
| Quantity |  |  |  |  |  | Quantity |  |  |  |  |  | Quantity |  |  |  |  |  |
| 6 |  | Joiners |  |  |  | 6 |  | Joiners |  |  |  |  |  |  |  |  |  |
| 2 |  | UHF |  | Plug |  | 1 |  | UHF |  | Plug |  | 1 |  | MMCX |  | Plug |  |
| 2 |  | UHF |  | Jack |  | 1 |  | UHF |  | Jack |  | 1 |  | mmCX |  | Jack |  |
| 2 |  | Mini UHF |  | Plug |  | 1 |  | Mini UHF |  | Plug |  | 1 |  | SSMB |  | Plug |  |
| 2 |  | Mini UHF |  | Jack |  | 1 |  | Mini UHF |  | Jack |  | 1 |  | SSMB |  | Jack |  |
| 2 |  | N |  | Plug |  | 1 |  | N |  | Plug |  | 1 |  | MCX |  | Plug |  |
| 2 |  | N |  | Jack |  | 1 |  | N |  | Jack |  | 1 |  | MCX |  | Jack |  |
| 2 |  | BNC |  | Plug |  | 1 |  | BNC |  | Plug |  | 1 |  | SMC |  | Plug |  |
| 2 |  | BNC |  | Jack |  | 1 |  | BNC |  | Jack |  | 1 |  | SMC |  | Jack |  |
|  |  | TNC |  | Plug |  | 1 |  | TNC |  | Plug |  | 1 |  | SMB |  | Plug |  |
| 2 |  | TNC |  | Jack |  | 1 |  | TNC |  | Jack |  | 1 |  | SMB |  | Jack |  |
| 2 |  | SMA |  | Plug |  | 1 |  | FME |  | Plug |  | 1 |  | SMA |  | Plug |  |
| 2 |  | SMA |  | Jack |  | 1 |  | FME |  | Jack |  | 1 |  | SMA |  | Jack |  |

$\square$

Coaxial Crimp Tools


Cutting and Stripping Tools and Accessories

| Part No. | Description | Illustration |
| :---: | :--- | :---: |
| CST-001 | Cable stripping tool for 32 to 8 AWG <br> wires. Adjustable length stop, <br> integrated cable cutter, strips single or <br> twin wires. Swedish precision tool. |  |
|  |  | CST-001 |

## Cable Preparation Tools and Accessories

ANDREW


## Accessories

## Cable Clamps

## ANDREW:

| Item | Part No. | Description |
| :---: | :---: | :---: |
| KwikClamp | Ideal for installing multiple runs (1, 2 or 3) on towers where space is limited. Self clamping hangers eliminate the need for drilling or adapters. |  |
|  | L4CLAMP-RDN-1 | Multi-run hanger, self clamp (1 run) suits LDF4-50 |
|  | L4CLAMP-RDN-2 | Multi-run hanger, self clamp (2 runs) suits LDF4-50 |
|  | L5CLAMP-RDN-1 | Multi-run hanger, self clamp (1 run) suits LDF5-50 |
|  | L5CLAMP-RDN-2 | Multi-run hanger, self clamp (2 runs) suits LDF5-50 |
|  | L6CLAMP-RDN-1 | Multi-run hanger, self clamp (1 run) suits LDF6-50 |
|  | L6CLAMP-RDN-2 | Multi-run hanger, self clamp (2 runs) suits LDF6-50 |
|  | L7CLAMP-RDN-1 | Multi-run hanger, self clamp (1 run) suits LDF7-50 |
|  | L7CLAMP-RDN-2 | Multi-run hanger, self clamp (2 runs) suits LDF7-50 |
| Angle Adapter Kits | Ideal for mounting | gers and Click-On hangers to angle tower members up to 22mm thick |
|  | 31768A | Suits all sizes of hangers. (pack of 10) |
|  | UA-3 | Suits snap in hangers. (pack of 10) |
| Galvanised Angle Adapter Kits | 247763 | Galvanised and non-marring. For mounting $1 / 2^{\prime \prime}$ to $21 / 4^{\prime \prime}$ cable to angle tower members up to 19 mm thick |
| Compact Angle | Compact, lightweig | pter suitable for use with single runs up to $2-1 / \mathbf{4}^{\prime \prime}$ in diameter. |
|  | 243684-M | Suits all sizes of cables, including FSJ and LDF series (pack of 10) |
| Cold Shrink | Simply slips over the | and compressess around the interface using a pull tab applicator. |
|  | 241474-4 | Suits $1 / 2^{\prime \prime}$ to $1 / 2^{\prime \prime} \mathrm{N}$ connectors |
|  | 241474-5 | Suits $7 / 8^{\prime \prime}$ to $7 / 8^{\prime \prime} \mathrm{N}$ connectors |
| Feed Thru Glands | FTN-4 | Nylon, suits $1 / 2^{\prime \prime}$ cable including LDF4-50 |
|  | FTB-4 | Brass, suits $1 / 2^{\prime \prime}$ cable including LDF4-50 |
|  | 40656A-3 | Neoprene gasket, suits $1 / 2^{\prime \prime}$ cable including LDF4-50 |
| $\cdots$ | FTN-5 | Nylon, suits $7 / 8$ " cable including LDF5-50 |
|  | FTB-5 | Brass, suits $7 / 8$ " cable including LDF5-50 |
|  | 40656A-1 | Neoprene gasket, suits $7 / 8^{\prime \prime}$ cable including LDF5-50 |
|  | 40656A-5 | Neoprene gasket, suits $11 / 4$ " cable including LDF6-50 |
|  | 40656A-2 | Neoprene gasket, suits 15/8" cable including LDF7-50 |
| Hoisting Grip | 43094 | Suits LDF4-50 cable |
|  | 19256B | Suits LDF5-50 cable |
|  | 29961 | Suits LDF5-60 cable |
|  | 24312A | Suits LDF7-50 cable |

## Accessories

Grounding and Hanger Kits
ANDREW:

| Item | Part No. | Description |
| :---: | :---: | :---: |
| Universal Grounding Kit | UG1215-06B1 | Universal grounding kit for $1 / 2$ " - $15 / 8^{\prime \prime}$ cable |
| Sure Ground ${ }^{\text {M }}$ Grounding Kits | SG12-06B2A | SureGround ${ }^{\text {TM }}$ grounding kit with standard weatherproofing butyl rubber sealing tape, 2 hole lug for $1 / 2^{\prime \prime}$ cable - LDF4-50 |
|  | SGL78-06B2A | SureGround ${ }^{\text {TM }}$ grounding kit with standard weatherproofing butyl rubber sealing tape, 2 hole lug for $7 / 8^{\prime \prime}$ cable - LDF5-50 |
|  | SGPL5-06B2 | SureGround ${ }^{\text {TM }}$ Plus grounding kit with weatherproofing rubber boot , 2 hole lug for $7 / 8^{\prime \prime}$ cable - LDF5-50 |
|  | SG114-06B2A | SureGround ${ }^{\text {TM }}$ grounding kit with standard weatherproofing butyl rubber sealing tape, 2 hole lug for $11 / 4^{\prime \prime}$ cable - LDF6-50 |
|  | SG158-06B2A | SureGround ${ }^{\text {TM }}$ grounding kit with standard weatherproofing butyl rubber sealing tape, 2 hole lug for $15 / /^{\prime \prime}$ cable - LDF7-50 |
|  | SGPL7-06B2 | SureGround ${ }^{T w}$ Plus grounding kit with weatherproofing rubber boot, 2 hole lug for $15 / \mathbf{z}^{\prime \prime}$ cable - LDF7-50 |
| Hanger Kits | 43211A | Standard Hanger Kit for $1 / 2^{\prime \prime}$ cable including, LDF4-50 (pack of 10) |
|  | 42396A-5 | Standard Hanger Kit for $7 / 8^{\prime \prime}$ cable including, LDF5-50 (pack of 10) |
|  | 42396A-1 | Standard Hanger Kit for 111/" cable including, LDF6-50 (pack of 10) |
|  | 42396A-2 | Standard Hanger Kit for 15/8" cable including, LDF7-50 (pack of 10) |
| Click-On Hange | Stackable Click-on hangers install in minutes and provide perfect fit, especially in confined spaces |  |
|  | L4CLICK | Click-On hanger kit for $1 / 2^{\prime \prime}$ cable, including LDF4-50 (pack of 10) |
|  | L5CLICK | Click-On hanger kit for $7 / 8^{\prime \prime}$ cable, including LDF5-50 (pack of 10) |
|  | L6CLICK | Click-On hanger kit for $11 / 4^{\prime \prime}$ cable, including LDF6-50 (pack of 10) |
|  | L7CLICK | Click-On hanger kit for 15/8" cable, including LDF7-50 (pack of 10) |
| Snap Stack Hangers | Stackable Click-on hangers install in minutes and provide perfect fit, especially in confined spaces |  |
|  | SSH-12 | Snap-In hanger kit for $1 / 2^{\prime \prime}$ cable LDF4-50 (pack of 10 ) |
|  | SSH-78 | Snap-In hanger kit for $7 / 8^{\prime \prime}$ cable LDF5-50 (pack of 10 ) |
|  | SSH-114 | Snap-In hanger kit for $11 / 4^{\prime \prime}$ cable LDF6-50 (pack of 10) |
|  | SSH-158 | Snap-In hanger kit for 15/8" cable LDF7-50 (pack of 10) |

## Reference

Crimp Tool Dimensions

| Crimp Set | Hex Dimensions <br> (Outer Conductor) | Hex/Square Dimensions <br> (Centre Conductor) | Typical Cable Sizes <br> Using Crimp Set |
| :--- | :---: | :---: | :---: |
| A | 5.41 | 1.69 | RG58, 9001, 9006, RG142, RG223, RG400 |
| B | 6.48 | 1.69 | RG59, RG62 |
| C | 10.54 | 2.54 | RG213 |
| D | 10.9 | 2.54 | RG214, RG63 |
| E | 3.25 | 0.72 | RG174, RG63, RG179 |

Cross Reference to Crimp Dies

| Cable Type | ERMA Crimp <br> Code | Hex <br> $m m$ | Hex <br> inch | Centre Crimp <br> $m m$ | Centre Crimp <br> inch | Length <br> $m m$ | RFI Ref | RCT-330K |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| RG58C/U | HFD | 5.41 | 0.213 | 1.69 | 0.067 | 8 | RCT-5859 | A or G |
| RG59C/U | XH | 6.48 | 0.255 | 1.69 | 0.067 | 8 | RCT-5859 | A or G |
| RG62A/U | XH | 6.48 | 0.255 | 1.69 | 0.067 | 8 | RCT-5859 | A or G |
| RG63B/U | HIA | 10.9 | 0.429 | 2.54 | 0.100 | 10 | RCT-214 | K |
| RG142B/U | HFD | 5.41 | 0.213 | 1.69 | 0.067 | 8 | RCT-5859 | A or G |
| RG174A/U | XCF | 3.25 | 0.128 | 0.72 | 0.028 | 8 | RCT-174 | J outer only |
| RG178B/U | XB | 2.67 | 0.105 | 0.72 | 0.028 | 8 | RCT-174 | J outer only |
| RG179B/U | XCF | 3.25 | 0.128 | 0.72 | 0.028 | 8 | RCT-174 | J outer only |
| RG213/U | HIA | 10.54 | 0.415 | 2.54 | 0.100 | 10 | RCT-213 | K |
| RG214/U | HIA | 10.9 | 0.429 | 2.54 | 0.100 | 10 | RCT-214 | K |
| RG223/U | HFD | 5.41 | 0.213 | 1.69 | 0.067 | 8 | RCT-5859 | A or G |
| RG316/U | XCF | 3.25 | 0.128 | 0.72 | 0.028 | 8 | RCT-174 | J outer only |
| RG400/U | HFD | 5.41 | 0.213 | 1.69 | 0.067 | 8 | RCT-5859 | A or G |

## Technical Information

Nominal attenuation of 30.5 metres (100ft)

| Cable Type | RFI Part Number | 70-85 MHz | 148-174 MHz | 400-520 MHz | 806-960 MHz | 2.4-2.45 GHz | 5.8-5.85 GHz |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| RG178B/U | 8178 | 12.4 dB | 17.0 dB | 30.4 dB | 40.8 dB | - | - |
| RG179 | 8179 | 9.2 dB | 11.5 dB | 17.0 dB | 22.3 dB | - | - |
| RG174/U | 8174 | 7.8 dB | 10.8 dB | 19.2 dB | 26.9 dB | - | - |
| RG58C/U | 8058 | 4.6 dB | 7.1 dB | 13.5 dB | 18.2 dB | - | - |
| CELLFOAM ${ }^{\text {™ }}$ | 9001 | 4.1 dB | 5.6 dB | 9.8 dB | 13.2 dB | - | - |
| CELLFOIL ${ }^{\text {m }}$ | 9006 | 2.8 dB | 4.2 dB | 6.9 dB | 9.0 dB | 20 dB | 30 dB |
| RG142B/U | 8142 | 3.3 dB | 4.9 dB | 8.9 dB | 12.0 dB | 25 dB | 45 dB |
| RG223/U | 8223 | 4.2 dB | 5.7 dB | 10.0 dB | 13.7 dB | 25 dB | 45 dB |
| RG59B/U | 8059 | 3.1 dB | 4.9 dB | 9.0 dB | 13.2 dB | - | - |
| RG62A/U | 8062 | 2.3 dB | 3.4 dB | 5.9 dB | 8.0 dB | - | - |
| RG11/U | 8011 | 1.8 dB | 2.5 dB | 4.8 dB | 6.6 dB | - | - |
| RG213/U | 8213 | 2.0 dB | 2.6 dB | 5.0 dB | 7.4 dB | 14 dB | 26dB |
| RG214/U | 8214 | 1.9 dB | 2.6 dB | 5.0 dB | 7.4 dB | 14dB | 26 dB |
| 10D-FB Type | 9005 | 0.9 dB | 1.2 dB | 2.4 dB | 3.1 dB | - | - |
| RG8 Type | CNT-400 | 1.2 dB | 1.7 dB | 3.1 dB | 4.5 dB | 7.0 dB | 10.6 dB |
| 1/4"Superflex | FSJ1-50 | 1.3 dB | 2.2 dB | 4.2 dB | 5.6 dB | 9.9 dB | 15.8 dB |
| 3/8" Superflex | FSJ2-50 | 1.1 dB | 1.5 dB | 2.8 dB | 3.8 dB | 6.9 dB | 10.9 dB |
| 1/2" Superflex | FSJ4-50 | 0.8 dB | 1.3 dB | 2.4 dB | 3.4 dB | 5.9 dB | 10.2 dB |
| 1/4" HELIAX $^{\text {® }}$ | LDF1-50 | 1.1 dB | 1.5 dB | 2.7 dB | 3.6 dB | 5.8 dB | 11.2 dB |
| 3/8" HELIAX ${ }^{\text {® }}$ | LDF2-50 | 0.9 dB | 1.3 dB | 2.3 dB | 3.3 dB | 5.7 dB | 9.5 dB |
| 1/2" HELIAX ${ }^{\text {® }}$ | LDF4-50 | 0.6 dB | 0.8 dB | 1.6 dB | 2.2 dB | 3.7 dB | 5.9 dB |
| 7/8"HELIAX ${ }^{\text {® }}$ | AVA5-50 | 0.3 dB | 0.4 dB | 0.8 dB | 1.1 dB | 2.0 dB | 3.3 dB |
| 1114"HELIAX ${ }^{\text {® }}$ | AVA6-50 | 0.23 dB | 0.3 dB | 0.6 dB | 0.8 dB | 1.35 dB | - |
| 15/8" HELIAX ${ }^{\text {® }}$ | AVA7-50 | 0.16 | 0.24 | 0.43 | 0.61 | 1.1 dB | - |

## Technical Information

VSWR Conversion Chart

| VSWR | Return loss $d B$ | $\begin{aligned} & \text { Transmission } \\ & \text { loss } d B \end{aligned}$ | Reflected power \% |
| :---: | :---: | :---: | :---: |
| 1.00 |  | 0.000 | 0.0 |
| 1.01 | 46.1 | 0.000 | 0.0 |
| 1.02 | 40.1 | 0.000 | 0.0 |
| 1.03 | 36.6 | 0.001 | 0.0 |
| 1.04 | 34.2 | 0.003 | 0.0 |
| 1.05 | 32.3 | 0.003 | 0.1 |
| 1.06 | 30.7 | 0.004 | 0.1 |
| 1.07 | 29.4 | 0.005 | 0.1 |
| 1.08 | 28.3 | 0.006 | 0.1 |
| 1.09 | 27.3 | 0.008 | 0.2 |
| 1.10 | 26.4 | 0.010 | 0.2 |
| 1.11 | 25.7 | 0.012 | 0.3 |
| 1.12 | 24.9 | 0.014 | 0.3 |
| 1.13 | 24.3 | 0.016 | 0.4 |
| 1.14 | 23.7 | 0.019 | 0.4 |
| 1.15 | 23.1 | 0.021 | 0.5 |
| 1.16 | 22.6 | 0.024 | 0.5 |
| 1.17 | 22.1 | 0.027 | 0.6 |
| 1.18 | 21.7 | 0.030 | 0.7 |
| 1.19 | 21.2 | 0.033 | 0.8 |
| 1.20 | 20.8 | 0.036 | 0.8 |
| 1.21 | 20.4 | 0.039 | 0.9 |
| 1.22 | 20.1 | 0.043 | 1.0 |
| 1.23 | 19.7 | 0.046 | 1.1 |
| 1.24 | 19.4 | 0.050 | 1.1 |
| 1.25 | 19.1 | 0.054 | 1.2 |
| 1.26 | 18.8 | 0.058 | 1.3 |
| 1.27 | 18.5 | 0.062 | 1.4 |
| 1.28 | 18.2 | 0.066 | 1.5 |
| 1.29 | 17.9 | 0.070 | 1.6 |
| 1.30 | 17.7 | 0.075 | 1.7 |
| 1.32 | 17.2 | 0.083 | 1.9 |
| 1.34 | 16.8 | 0.093 | 2.1 |
| 1.36 | 16.3 | 0.102 | 2.3 |
| 1.38 | 15.9 | 0.112 | 2.5 |
| 1.40 | 15.6 | 0.122 | 2.8 |


| VSWR | Return loss dB | Transmission loss $d B$ | Reflected power \% |
| :---: | :---: | :---: | :---: |
| 1.42 | 15.2 | 0.133 | 3.0 |
| 1.44 | 14.9 | 0.144 | 3.3 |
| 1.46 | 14.6 | 0.155 | 3.5 |
| 1.48 | 14.3 | 0.166 | 3.7 |
| 1.50 | 14.0 | 0.177 | 4.0 |
| 1.52 | 13.7 | 0.189 | 4.3 |
| 1.54 | 13.4 | 0.201 | 4.5 |
| 1.56 | 13.2 | 0.213 | 4.8 |
| 1.58 | 13.0 | 0.225 | 5.1 |
| 1.60 | 12.7 | 0.238 | 5.3 |
| 1.62 | 12.5 | 0.250 | 5.6 |
| 1.66 | 12.1 | 0.276 | 6.2 |
| 1.68 | 11.9 | 0.289 | 6.4 |
| 1.70 | 11.7 | 0.302 | 6.7 |
| 1.72 | 11.5 | 0.315 | 7.0 |
| 1.74 | 11.4 | 0.329 | 7.3 |
| 1.76 | 11.2 | 0.342 | 7.6 |
| 1.78 | 11.0 | 0.356 | 7.9 |
| 1.80 | 10.9 | 0.370 | 8.2 |
| 1.82 | 10.7 | 0.384 | 8.5 |
| 1.84 | 10.6 | 0.398 | 8.7 |
| 1.86 | 10.4 | 0.412 | 9.0 |
| 1.88 | 10.3 | 0.426 | 9.3 |
| 1.90 | 10.2 | 0.440 | 9.6 |
| 1.92 | 10.0 | 0.454 | 9.9 |
| 1.94 | 9.9 | 0.468 | 10.2 |
| 1.96 | 9.8 | 0.483 | 10.5 |
| 1.98 | 9.7 | 0.497 | 10.8 |
| 2.00 | 9.5 | 0.512 | 11.1 |
| 2.50 | 7.4 | 0.881 | 18.4 |
| 3.0 | 6.0 | 1.249 | 25.0 |
| 4.0 | 4.4 | 1.938 | 36.0 |
| 5.0 | 3.5 | 2.553 | 44.4 |
| 10 | 1.7 | 4.810 | 66.9 |
| 20 | 0.9 | 7.413 | 81.9 |

## Technical Information

## Facts about cable

## Velocity of Propagation (VoP)

Velocity of Propagation (VoP, or VP) for a coaxial cable characterizes the speed at which a signal at which a signal will propagate within that cable. It is expressed as a percentage, being the ratio of a signal's transmission speed in the cable compared to the speed of light in free space (i.e. the speed of light).

Thus, transmission in free space would have a VP of 1 ( $100 \%$ ), whereas the VP of various cables is largely determined by the dielectric constant of the coaxial cable dielectric. (In fact, VP equals the reciprocal of the square root of the dielectric constant of the material). As a comparison, a standard polyethylene dielectric cable will typically have a VP of $66 \%$, or be as high as $80 \%$ if the dielectric is a foam based polyethylene/

Generally speaking, a higher VP for will deliver lower attenuation for an alternative dielectric, due to lower dielectric losses, but many other factors will impact on total cable attenuation (size and conductor construction). VP is a particularly important parameter in the preparation of phase critical cable lengths as the time/phase delay will vary significantly with the VP of the cable chosen.

|  | CABLE DIELECTRIC TIME DELAY (NS/FT) | VELOCITY SPEED OF LIGHT <br> (\%) |
| :---: | :---: | :---: |
| Solid Polyethylene | 1.54 | 65.9 |
| Foam Polystyrene | 1.12 | 91.0 |
| Air Space Polyethylene | 1.15-1.21 | 84-88 |
| Solid Teflon | 1.46 | 69.4 |
| Air Space | 1.13-1.20 | 85-90 |

Modified coaxial structures using a helical wrapped centre conductor are available with time delays ranging from 10 to 100 nanoseconds per foot. Balanced helical structures are also available with time delays, up to 50 nanoseconds per foot.

## Operating Temperature Range

1. The operating temperature range of flexible coaxial cable is determined primarily by the operating temperature range of the dielectric and jacketing materials. Note that only silver plated conductors are suitable for long term use at temperatures over $80^{\circ} \mathrm{C}$.
2. The table below details the operating temperature limits of the most commonly used dielectrics and jacket types.

DIELECTRIC MATERIAL

| Polytetraflouroethylene (PTFE) | $-250^{\circ} \mathrm{C}$ to $+250^{\circ} \mathrm{C}$ |
| :--- | ---: |
| Polyethylene | $-65^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}$ |
| Foamed Polyethylene | $-65^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}$ |
| Foamed or Solid Ethylene Propylene | $-40^{\circ} \mathrm{C}$ to $+105^{\circ} \mathrm{C}$ |
| JACKETS | $-70^{\circ} \mathrm{C}$ to <br> $+200^{\circ} \mathrm{C}$ |
| Fluorinated Ethylene Propylene (FEP) | $-50^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ |
| Polyvinylchloride (PVC) | $-100^{\circ} \mathrm{C}$ to $+125^{\circ} \mathrm{C}$ |
| Polyurethane | $-60^{\circ} \mathrm{C}$ to $+120^{\circ} \mathrm{C}$ |
| Nylon | $-40^{\circ} \mathrm{C}$ to $+105^{\circ} \mathrm{C}$ |
| Ethylene Polyethylene | $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ |
| Crosslinked Polyolefin | $-70^{\circ} \mathrm{C}$ to $+200^{\circ} \mathrm{C}$ |
| Silicone Rubber |  |

## Flexibility

Coax cables with stranded centre conductors and braided outer conductors are used in applications where the cable is required to flex while in service or where cable is subject to vibration. Most braided cable will withstand up to 1000 flexes when bent through a 180 degree arc for a bend radius of 20 times the diameter of the cable.

Semi flexible cables with solid or corrugated outer conductors should not be bent more than ten times through a 180 degree arc over a bend radius of 20 times the diameter of the cable.

Reels used for transporting of coaxial cable should have a hub diameter of 20 times the diameter of the cable for braided cable and 40 times the

## Technical Information

diameter of the cable for semi flexible Heliax style cables. The following table gives recommended hub diameters and bend radius for popular coax cables.

| CABLE TYPE | HUB DIAMETER <br> $(\mathrm{mm})$ | MINIMUM <br> BEND RADIUS <br> $(\mathbf{m m})$ |
| :--- | :---: | :---: |
| RG58 | 100 | 10 |
| RG142 | 100 | 10 |
| RG223 | 100 | 10 |
| RG213 | 200 | 25 |
| RG214 | 200 | 25 |
| CNT-400 | 200 | 25 |
| LDF4-50 | 600 | 125 |
| RXL4-1 | 600 | 125 |
| AVA5-50 | 1000 | 250 |
| AL5-50 | 1000 | 250 |

## Environmental Factors

The life expectancy of coax cable depends on a variety of factors including the jacket material, exposure to sunlight, humidity, galvanic action, salt water exposure, and exposure to heat and flame.

For cables that are likely to be exposed to sunlight the use of UV stable PVC jacketed cables or Polyethelene jacketed cables is recommended.

All jacket materials exhibit a finite vapour transmission rate. Large temperature extremes can result in condensation appearing in cables. The use of a flooding compound can prevent moisture accumulation in cables.

Cable intended for underground burial should be placed in conduit to prevent damage. Exceptions to this are some Andrew ${ }^{\text {TM }}$ cables that have been manufactured with Polyethelene jackets and a flooding compound between the jacket and braid.
suppressant. They incorporate halide based chemicals, such as chlorine, as their fire suppressants. When PVC burns, it gives off a halide gas, which rapidly absorbs oxygen, thereby starving the fire, causing it to self extinguish. Unfortunately the by products of this process can be hazardous to humans. In high concentrations, chlorine gas is quite toxic. Additionally, when combined with oxygen and water vapour, a by product is hydrochloric acid.

Plenum rated cables use fluoropolymers such as Teflon to suppress flames they emit very low levels of smoke, and no toxic fumes or vapours.

Low smoke zero halogen (LSZH) rated cables use metal hydroxide chemicals to suppress flames. Metal hydroxides give off water vapour when exposed to fire, which suppresses the propagation of fire along a burning cable.

## Flame Resistance

PVC jacketed cables are inherently fire

## Technical Information

## Cable Preparation Details - Standard Crimp



Cable Preparation

1. Straighten the end of the cable -200 mm .
2. Slide crimp sleeve onto cable
3. Strip jacket, braid and dielectric to dimensions shown


## Crimp Centre Contact to Cable Centre Conductor

1. Insert cable centre conductor into centre contact until it butts against cable dielectric.
2. Crimp centre contact.


## Attach Cable to Connector Body

1. Insert cable assembly into rear of connector body, with all braid wires on outside of inner ferrule.
2. Gently push cable assembly forward until contact snaps into place in insulator.

All braid wires on outside of inner ferrule


## Final Assembly

1. Slide crimp ferrule forward until flush with connector body and crimp.
2. Crimp using RCT-213 for RG213 connectors or RCT-214 for RG214 connectors. RCT-5859 for RG58 connectors


## Technical Information

Cable Preparation Details - Clamp Style 1


## Preparation of cable

1. Slide nut and gasket on to cable.
2. Strip jacket to 10 mm
3. Slit cable jacket in two places, $180^{\circ}$ apart
| 10 mm |


## Solder centre pin to cable centre conductor

1. Fold back braid and fit braid clamp between dielectric and braid. Trim braid around braid clamp
2. Remove dielectric flush with front of braid clamp

3. Slide on rear insulator and centre pin (these parts must butt)
4. Solder centre pin to centre conductor

## Install front insulator

1. Install front insulator over centre pin


## Final Assembly

1. Mount cable assembly and fittings in to connector body
2. Screw and tighten nut


## Technical Information

Cable Preparation Details - Clamp Style 2


## Preparation of cable

1. Slide nut, washer and gasket on to cable.
2. Strip jacket to dimensions shown.


## Solder centre pin to cable centre conductor

1. Insert cable centre conductor in to centre contact until it butts against cable dielectric.
2. Solder centre contact.


## Install braid clamp

1. Place braid clamp over cable braid
2. Comb braid wires out straight and fold back over front shoulder of braid clamp.
3. Trim braid wires flush with edge of braid clamp


## Final Assembly

1. Mount cable assembly and fittings into connector body
2. Screw and tighten nut


## Technical Information

| Metric Unit Prefixes |  |  |  |
| :---: | :---: | :---: | :---: |
| PREFIX | SYMBOL | POWER OF 10 | NUMERICAL VALUE |
| exa | E | $10^{18}$ | 1,000,000,000,000,000,000 |
| peta | P | $10^{15}$ | 1,000,000,000,000,000 |
| tera | T | $10^{12}$ | 1,000,000,000,000 |
|  |  | $10^{11}$ | 100,000,000,000 |
|  |  | $10^{10}$ | 10,000,000,000 |
| giga | G | $10^{9}$ | 1,000,000,000,000 |
|  |  | $10^{8}$ | 1,000,000,000,000 |
|  |  | $10^{7}$ | 1,000,000,000,000 |
| mega | M | $10^{6}$ | 1,000,000,000,000 |
|  |  | $10^{5}$ | 100,000 |
| myria | my | $10^{4}$ | 10,000 |
| kilo | k | $10^{3}$ | 1,000 |
| hecto | h | $10^{2}$ | 100.0 |
| deka | da | $10^{1}$ | 10.0 |
|  |  | $10^{\circ}$ | 1.0 |
| deci | d | $10^{-1}$ | . 1 |
| $\underline{\text { centi }}$ | c | $10^{-2}$ | . 01 |
| milli | m | $10^{-3}$ | . 001 |
|  |  | $10^{-4}$ | . 0001 |
|  |  | $10^{-5}$ | . 00001 |
| micro | $\mu$ | $10^{-6}$ | . 000001 |
|  |  | $10^{-7}$ | . 0000001 |
|  |  | $10^{-8}$ | . 00000001 |
| nano | n | $10^{-9}$ | . 000000001 |
|  |  | $10^{-10}$ | . 0000000001 |
|  |  | $10^{-11}$ | . 00000000001 |
| pico | p | $10^{-12}$ | . 000000000001 |
|  |  | $10^{-13}$ | . 0000000000001 |
|  |  | $10^{-14}$ | . 00000000000001 |
| femto | f | $10^{-15}$ | . 000000000000001 |
|  |  | $10^{-16}$ | . 000000000000001 |
|  |  | $10^{-17}$ | . 00000000000000001 |
| atto | a | $10^{-18}$ | . 000000000000000001 |

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| AVA5-50 Heliax ${ }^{\text {® }}$ | 4 | 92-07A-1 | 6 | L4A-PDMDM-2M | 9 | N-204 | 13 |
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| 4T-30 | 5 | 92-07D-5 | 7 | F4A-PDMDM-5M | 9 | 114EZNF | 13 |
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## Technical Information

## Coaxial Systems Formulae




## Abbreviations

## Dielectric

| FEP |  |
| :--- | :--- |
| PE | Solid Fluorinated Ethylene Propylene |
| PTFE | Solid Polyethylene |
| PEF | Foamed Polyethylene |
| Conductors |  |
| and Braid Material |  |

BC Bare Copper

BerC Beryllium-Copper alloy
CAT Corrugated Aluminium Tube
CCA Copper Clad Aluminium
ccs Copper Clad Steel
CCT Corrugated Copper Tube
SPC Silver Plated Copper
sCCS Silver Plated Copper Clad Steel
TC Tinned Copper
Jacket Material

| FEP | Fluorinated Ethyl Propylene |
| :--- | :--- |
| PE | Polyethylene |
| PTFE | Polytetrafluroethylene |
| PVC1 | Black polyvinylchloride |
| PVC2 | Black polyvinylchloride, <br> non contaminating |
|  |  |

RF Industries (RFI)

SYDNEY (Head Office) PO Box 4762

# 7 TRIO 

The TRIO Datacom ER450 is an advanced high speed digital data radio modem designed for the most complex and demanding requirements in both Point-to-Point and Point-to-Multipoint (Multiple Address Radio) SCADA and Telemetry systems.
Normally used as a half duplex high performance Remote Data Radio for communicating with the full duplex

## Radio and Modem

- True $19,200 \mathrm{bps}$ over-air data rates in 12.5 kHz FCC channels (also 9600 bps ) Fully integrated radio, modem and data_ multiplexer
- 128-bit AES encryption
(export restrictions may apply)
-12.5 or 25 kHz channel operation
- Fast data turnaround
- Simplex, Half Duplex and Full Duplex (Full Duplex with ERFD450 option)
- Compatible with legacy systems (Non Packet Digital and Bell 202 Modes)
- Full specification operation from -30 to + 60C
- Hazardous Environment Certification Class I, Division II (Groups A,B,C and D)
- Compact, rugged diecast alloy housing
- Low power consumption with sleep mode operation
- Field upgradable firmware
- Multi-function LED Display
- Digital orderwire option
- DIN Rail mounting kit option
- VSWR protection

Network Management and Remote

## Diagnostics

(ll conjunction with TVIEW+w Software)

- Remote fully transparent Network Management and Diagnostics
- Network wide operation from any radio modem
Full SCADA style features such as database, trending and networking - Over-the-air modem reconfiguration - Full graphical presentation (HMI)


ER450

## Radio

Frequency Range: $370-520 \mathrm{MHz}$
(various sub-frequency
bands available)
Frequency Splits: Various Tx/Rx frequency splits - programmable Channel Selection: Dual synthesizer, 6.25 kHz channel step

Channel Spacing: 12.5 or 25 kHz
Frequency Accuracy: $\pm 1$ ppm ( -30 to $+60 C)(-22$ to 140F) ambient
Aging: <= 1ppm/annum
Operational Modes: Simplex, Half duplexor Full duplex*
Configuration: All configuration via
Windows based software

## Compliances:

ETSI EN300113, EN301489, EN60950
FCC PART 15, PART 90
IC RS119, ICES-001
ACA AS4295-1995 (Data)
CSA Class I, Division II, Groups ( $\mathrm{A}, \mathrm{B}, \mathrm{C}, \mathrm{D}$ ) for Hazardous Locations ANSI/UL equivalent)

Local regulatory conditions may determine the performance and suitability of individual versions in different countries. It is the responsibility of the buyer to confirm these regulatory conditions. Performance data indicates typical values related to the described unit.

Information subject to change without notice.
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- Export restrictions may apply

Note: Not all product features are available in every mode of operation.

Transmitter
Tx Power: 0.05 - 5W (+37 dBm) 1 dB User configurable with over-temperature and reverse power protection
Modulation: User configurable narrow band digitally filtered binary GMSK or 4 level FSK
Tx Keyup Time: <1mS
Timeout Timer: Programmable 0-255seconds
Tx Spurious: <=-37 dBm
PTT Control: Auto (Data) / RTS line
(Port A or B) / System Port Override

Receiver
Sensitivity: - 118 dBm for 12 dB SINAD
Selectivity: Better than 60 dB
Intermodulation: Better than 70 dB
Spurious Response: Better
than 70 dB
AFC Tracking: Digital receiver frequency tracking
Mute: Programmable digital mute

Diagnostics
Network wide operation from any remote terminal.

Non intrusive protocol - runs simultaneously with the application.

Over-the-air re-configuration of user parameters.

Storage of data error and channel occupancy statistics.

In-built Error Rate testing capabilities.

## Connections

User Data Ports: $2 \times$ DB9 female ports wired as DCE (modem)
System Port: RJ45 for diagnostic, configuration and re-programming Antenna: N female bulkhead. Separate $N(T x)$ and SMA (Rx) connectors for full duplex.* Power: 2 pin locking, mating connector supplied
LED Display: Multimode Indicators for Pwr, Tx, Rx, Sync, TxD and RxD data LEDs (for both port A and B)

## Modem

Data Serial Port A: RS232, DCE, 600-57,600 bps asynchronous
Data Serial Port B: RS232, DCE,
300-38,400 bps asynchronous
System Port: RS232, 19,200 bps asynchronous
Flow Control: Selectable hardware / software / 3 wire interface
RF Channel Data Rate:
4800/9600/19,200 bps
Half / Full duplex*
Data Buffer: 16 kbyte of on-board RAM

## Bit Error Rate:

< 1x10-6@ - 111 dBm ( 4800 bps )
< 1x10-6 @ - 110 dBm (9600 bps) < 1x10-6 @ - 106 dBm ( $19,200 \mathrm{bps}$ )

* Please check with your local TRIO Datacom representative.

Encryption: 128-bit AES encryption Collision Avoidance: TRIO Datacom's unique supervisory Channelshare ${ }^{\text {TM }}$ collision avoidance system
Multistream ${ }^{\text {TM }: ~ T R I O ~ D a t a c o m ' s ~}$ unique simultaneous delivery of multiple data streams (protocols)
Data Turnaround Time: $<10 \mathrm{mS}$
Firmware: Field upgradable
Flash memory

This device is OPEN type equipment that must be used within suitable end-use system enclosure, the interior of which is accessible only through the use of a tool. The suitability of the enclosure is subject to investigation by the local Authority Having Jurisdiction at the time of installation.

General
Power Supply: 13.8 Vdc nominal
( $10-16 \mathrm{Vdc}$ )
Temp Range: -30degC to $+60 \operatorname{deg} C$
Transmit Current: 750 mA nom. @ 1 W 1600 mA nom. @5 W
Receive Current: <125 mA nom
Shutdown Mode: External control,
$<10 \mathrm{~mA}$
Dimensions: Rugged
Diecast Enclosure
$170 \times 150 \times 42 \mathrm{~mm}$
$6.7 \times 5.9 \times 1.65$ inches
With Mounting Plate
$190 \times 150 \times 47 \mathrm{~mm}$
$7.5 \times 5.9 \times 1.85$ inches
Mounting: Fitted Mounting Plate
Weight: 1.27 kg (2.8lbs.)

Options
ERFD450 Full Duplex Operation
with separate $N(T x)$ and SMA
(Rx) connectors
DUPLX450BR External Duplexer, Band
Reject (for single
antenna operation)
NEMA 4/R Stainless Steel Enclosure
(IP65, NEMA 4 rated)
TVIEW+ ${ }^{\text {TM }}$ Configuration, Network
Management and Diagnostic
Windows GUI Software
DIN Rail mounting kit
Part Number: ER-DIN-KIT*
*Not offered in all countries.


Related Products
EB450 Base Station
EH450 Hot Standby Base Station
MSR/9 Port Stream Router Multiplexer
MR450 Remote Data Radio

* With ERFD450 full duplex option plus external duplexer for single antenna operation


## 6. Endress \& Hauser



Technical Information

## Prosonic S FMU90

## Transmitter in housing for field or top-hat rail mounting for the ultrasonic sensors FDU91/91F/92/93/95/96



## Application for level measurement

- Continuous, non-contact level measurement of fluids, pastes, sludge and powdery to coarse bulk materials with 1 or 2 ultrasonic sensors
- Measuring range up to 70 m (depending on sensor and material measured)
- Level limit detection (up to 6 relays)
- Pump control (alternating); rake control
- Option: additional pump control functions (pump function test, ...)
- Calculations: average, difference, sum


## Application for flow measurement

- Flow measurement in open channels and measuring weirs with 1 or 2 ultrasonic sensors
- Simultaneous measurement of level and flow in a stormwater overflow basin with only 1 sensor
- Flow measurement with back water detection (2 sensors) or sludge detection
- Up to 3 totalizers and 3 (resettable) counters; optionally resettable via digital inputs
- Counting or time pulse output for control of external units


## Your benefits

- Simple, menu-guided operation with 6-line plain text display; 15 languages selectable
- Envelope curves on the display for quick and simple diagnosis
- Easy operation, diagnosis and measuring point documentation with the supplied "ToF-Tool FieldTool Package" operating program.
- Option: four digital inputs (e.g. for pump feedback) and one external temperature input
- Time-of-flight correction via integrated or external temperature sensors
- Linearisation (up to 32 points, freely configurable)
- Linearisation tables for the most common flumes and weirs pre-programmed and selectable
- Online calculation of the flume-/weir-flows via integrated flow curves
- Pre-programmed pump control routines
- System integration via HART or PROFIBUS DP
- Automatic detection of the sensors FDU9x
- The sensors of the former series FDU8x can be connected (for certificates see note on page 8)


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## Function and system design

## Measuring principle



BD: blocking distance; D: distance from sensor membrane to fluid surface; $\mathbf{E}$ : empty distance $\mathbf{F}$ : span (full distance); L: level; $\mathbf{V}$ : volume (or mass); $\mathbf{Q}$ : flow

The sensor transmits ultrasonic pulses in the direction of the product surface. There, they are reflected back and received by the sensor. The transmitter Prosonic $S$ measures the time $t$ between pulse transmission and reception. From $t$ (and the velocity of sound $c$ ) it calculates the distance $D$ from the sensor membrane to the product surface:
$D=c \cdot t / 2$
From D results the desired measuring value:

- level L
- volume V
- flow Q across measuring weirs or open channels


## Blocking distance

The span F may not extend into the blocking distance BD. Level echos from the blocking distance can not be evaluated due to the transient characteristics of the sensor. The blocking distances of the individual sensors are given in the following documents:

- TI 396F for the sensors FDU 91/91F/92/93/95/96
- TI 189F for the sensors FDU 80/80F/81/81F/82/83/84/85/86


## Time-of-flight correction

In order to compensate for temperature dependent time-of-flight changes, a temperature sensor is integrated in the ultrasonic sensors.
Optionally, the Prosonic S FMU90 has an input for an external temperature sensor
(FMU90-********B***). The following sensor can be connected:

- Pt100
- FMT131 from Endress+Hauser

The external sensor mus be used for the heated version of the ulstrasonic sensor FDU91.

Interference echo suppression The interference echo suppression feature of the Prosonic $S$ ensures that interference echos (e.g. from edges, welded joints and installations) are not interpreted as a level echo.

## Pump control

individaully configurable for each pump:

- pump switching delay, e.g. to prevent overlaod of the power supply system
- backlash time and backlash interval, e.g. for complete draining of shafts or channels
- crust reduction at pump shaft walls by fine adjustment of the switch point


## Linearisation

## Pre-programmed linearisation curves

## Types of vessels

- horizontal, cylindrical tank
- spherical tank
- tank with pyramidal bottom
- tank with conical bottom
- tank with flat, inclined bottom

Flow curves for flumes and weirs ${ }^{1)}$

- Khafagi-Venturi flume
- ISO-Venturi flume
- $\mathrm{BST}^{2}$-Venturi flume
- Parshall flume
- Palmer-Bowlus flume
- Rectangular weir
- Rectangular constricted weir
- $\mathrm{NFX}^{3}$ rectangular weir
- $\mathrm{NFX}^{3}$ rectangular constricted weir
- Trapezoidal weir
- V-notch weir
- BST $^{2}$ V-notch wier
- $\mathrm{NFX}^{3}$ V-notch weir

The pre-programmed linearisation curves are calculated on-line.

## Linearisation formula for flow measurements ${ }^{1}$

$\mathrm{Q}=\mathrm{C}\left(\mathrm{h}^{\alpha}+\gamma \mathrm{h}^{\beta}\right)$
" h " is the upstream level. The parameters $\alpha, \beta, \gamma$ and C can be freely programmed by the user.

## Linearisation table

consisting of up to 32 linearisation points; to be entered manually or half-automatically.

| Special functions | limit detection |
| :--- | :--- |
| - rake control |  |
| - alternating pump control or control according to pump rate (standard) |  |
| - option: additional pump control functions ${ }^{4}$ : |  |
|  | - Alternation accordint to runtime or starts |
|  | - pump feedback via the optional digital inputs; stand-by pump configurable |
|  | - pump function test after resting time |
|  | - storm function to prevent unnecessary pump running times |
|  | - flush control for regular pump shaft cleaning |
|  | - pump control according to tariff times via digital input |
|  | - output of operating hours alarm or pump alarm |
|  | - recording of pump data (operating hours, number of starts, last running time) |
|  | - totalising of the flow volume with (resettable) counters and (non-resettable) totalisers ${ }^{1}$ |
|  | - triggering of a sampler by time or quantity pulses ${ }^{1}$ |
|  | low flow cut off ${ }^{1}$ |
|  | - backwater detection in flumes ${ }^{1}$ |
|  | - sludge detection in flumes ${ }^{1}$ |
|  | - trend detection |

Datalog functions

- Peak hold indicator of the min./max. levels or flows and the min./max. temperatures at the sensors
- Indication of the tast 10 alarms
- Trend indication of the outputs on the on-site display
- Indication of the operating hours

[^14]Application examples for level measurements

Level measurement with limit detection and alarm output


Order code e.g.: FMU90 - *1*** $131^{* * * *}$ (1 input, 3 relays, 1 outputs)

Rake control
(differential measurement)


Order code e.g.: FMU9O - *1***212****
(2 inputs, 1 relay, 2 outputs)

Average level measurement


Order code e.g.: FMU90 - *1***212**** (2 inputs, 2 outputs)

Alternating pump control (up to 6 pumps)


Order code e.g.: FMU90 - *1***131****
(1 input, 3 relays)

## Conveyor belt



Application examples for flow measurements

Pulses for volume counter + time pulses (e.g. for sampler)


Order code e.g.: FMU90 - *2*** $131^{* * * *}$
(1 input, 3 relays, 1 output)

## Stormwater overflow bassin

Simultaneous measurement of level L and flow O with 1 sensor.


Order code e.g.: FMU90 - *2*** $112^{* * * *}$
(1 input, 2 outputs)

Flow measurement with backwater alarm or sludge detection
If the ratio "downstream level:upstream level" rises above or falls below a critical value, an alarm will be generated.


Order code e.g.: FMU90 - *2***212**** (2 inputs, 1 relay, 2 outputs)

## System integration HART



In the standard version a HART signal is superimposed onto the first output current. In order to use the HART communication, the circuit must contain a communication resistor of $250 \Omega$.

## Operating options

- via the operating and display module at the Prosonic $S$ (if present)
- via the service interface of the Prosonic $S$ with the Commubox FXA291 and the operating program "ToF Tool - FieldTool Package" or "FieldCare"
- via the HART protocol, e.g. with the Commubox FXA191 or FXA195 and the operating program "ToF Tool - FieldTool Package" or "FieldCare"
- via the HART handheld terminal DXR375


## System integration PROFIBUS DP



## Operating options

- via the display and operating module at the Prosonic S
- via the service interface with the Commubox FXA291 and the operating program "ToF Tool - FieldTool Package" or "FieldCare"
- via PROFIBUS DP with Profiboard or Proficard and the operating program "ToF Fool - FieldTool Package" or "FieldCare"


## Input

## Sensor inputs

Depending on the instrument version, 1 or 2 of the sensors FDU91, FDU91F, FDU92, FDU93, FDU95 and FDU96 can be connected. The Prosonic $S$ identifies these sensors automatically.

| Sensor | FDU91 <br> FDU91F | FDU92 | FDU93 | FDU95 | FDU96 |
| ---: | :---: | :---: | :---: | :---: | :---: |
| max. range $^{1)}$ in liquids | 10 m | 20 m | 25 m | - | - |
| ${\text { max. } \text { range }^{1} \text { in solids }}^{2}$ | 5 m | 10 m | 15 m | 45 m | 70 m |

1) This table gives the maximum range. The range depends on the measuring conditions. For an estimation see Technical Information TI 396F, chapter "Input".

In order to support existing installations, the sensors of the former series FDU8x can be connected as well. The type of sensor must be entered manually.

| Sensor | FDU80 <br> FDU80F | FDU81 <br> FDU81F | FDU82 | FDU83 | FDU84 | FDU85 | FDU86 |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| max. range $^{1)}$ in liquids | 5 m | 9 m | 20 m | 25 m | - | - | - |
| max. range $^{1}$ in solids | 2 m | 5 m | 10 m | 15 m | 25 m | 45 m | 70 m |

1) This table gives the maximum range. The range depends on the measuring conditions. For an estimation see Technical Information TI 189F, chapter "Planning Recommendations".


Warning!
The sensors FDU83, FDU84, FDU85 and FDU86 with an ATEX, FM or CSA certificate are not certified for connection to the transmitter FMU90.

External limit switches (option)

Optionally, the Prosonic S FMU90 has four inputs for external limit switches (FMU90-********B***).

## Switching options

- external passive limit switch (NC/NO switch)
- 0 : $<8 \mathrm{~V} ; 1:>16 \mathrm{~V}$

Usage (examples)

- pump feedback (for FMU90-*3******B***) and FMU90-*4******B***)
- pump tariff control (for FMU90-*3****** ${ }^{* * * *}$ ) and FMU90-*4****** ${ }^{* * *}$ )
- start/stop/reset of daily counters (for flow measurements)
(for FMU90-*2****** ${ }^{\star * *}$ and FMU90-* $4^{\star * * * * * * B * * *) ~}$
- min/max level detection, e.g. by Liquiphant

Optionally, the Prosonic S FMU90 has an input for an external temperature sensor (FMU90-********B***)

## Connectable sensors

- Pt100 (3-wire or 4-wire connection)

A Pt100 with 2-wire connection may not be used due to its insufficient accuracy.

- FMT131(from Endress+Hauser, see chapter "Accessories")

Usage (example)

- Time-of-flight correction for a heated sensor (FDU91-***B*).


## Output

## Analogue outputs

| Number | 1 or 2, depending on instrument version |
| :---: | :---: |
| Output signal | configurable at the instrument: <br> - $4 \ldots 20 \mathrm{~mA}$ with HART ${ }^{1)}$ <br> - 0 ... 20 mA without HART |
| Signal on alarm | for setting $4 \ldots 20 \mathrm{~mA}$, selectable: <br> - $-10 \%(3,6 \mathrm{~mA})$ <br> - 110\% (22 mA) <br> - HOLD (last current value is held) <br> - user specific <br> for setting 0 ... 20 mA : <br> - 110\% (21,6 mA) <br> - HOLD (last current value is held) <br> - user specific |
| Output damping | freely selectable, $0 \ldots 1000 \mathrm{~s}$ |
| Load | max. $600 \Omega$, influence negligible |
| max. ripple | $\mathrm{U}_{\text {SS }}=200 \mathrm{mV}$ at $47 \ldots 125 \mathrm{~Hz}$ (measured at $500 \Omega$ ) |
| max. noise | $\mathrm{U}_{\text {eff }}=2,2 \mathrm{mV}$ at $500 \mathrm{~Hz} . . .10 \mathrm{kHz}$ (measured at $500 \Omega$ ) |

1) The HART signal is assigned to the first analogue output. The second analogue output does not carry a HART signal.

## Relay outputs

| Number | 1,3 or 6; depending on the instrument version |
| :---: | :---: |
| Type | potential-free relay, SPDT, can be inverted |
| Assignable functions | - limit (inband, out-of-band, trend, level limit) <br> - counting pulse ${ }^{1}$ (pulse width adjustable) <br> - time pulse ${ }^{1}$ (pulse width adjustable) <br> - alarm/diagnosis <br> (e.g. indication of backwater ${ }^{1)}$, sludge ${ }^{1}$, echo loss etc.) <br> - pump control (alternating/fixed limit/pump rate) <br> - for FMU90-* $3 * * * * * * * * * * ~ a n d ~ F M U 90-* 4 * * * * * * * * * *): ~$ <br> additional pump control (standby pump, storm function to avoid unnecessary run times of the pumps, pump function test, flush control to clean pump shafts, operating hours alarm, pump alarm) <br> - rake control (difference or relative measurement) <br> - fieldbus relay (to be switched direclty from the Profibus DP-bus) |
| Switching power | - DC voltage: $35 \mathrm{~V}_{\mathrm{DC}}, 100 \mathrm{~W}$ <br> - AC voltage: $4 \mathrm{~A}, 250 \mathrm{~V}, 100 \mathrm{VA}$ at $\cos \varphi=0,7$ |
| State on error | selectable: <br> - HOLD (last value is held) <br> - energized <br> - de-energized <br> - present value is used |
| Behaviour after power failure | switch-on delay selectable |
| LEDs ${ }^{2)}$ | A yellow LED on the front panel is allocated to each relay, which lights if the relay is energized. <br> The LED of an alarm relay lights during normal operation. <br> The LED for a pulse relay briefly flashes at every pulse. |

1) for instrument versions with flow software (FMU90 - *2**********)
2) for instrument versions with display and operating module

## PROFIBUS DP interface

| Profile | 3.0 |
| :---: | :---: |
| Transmittable values | - main value (level or flow, depending on the instrument version) <br> - distances <br> - counters <br> - temperatures <br> - average/difference/sum <br> - relay states <br> - rake control <br> - pump control |
| Function blocks | - 10 Analog Input Blocks (AI) <br> - 10 Digital Input Blocks (DI) <br> - 10 Digital Output Blocks (DO) |
| Supported baud rates | - 9.6 kbaud <br> - 19.2 kbaud <br> - 45,45 kbuad <br> - 93.75 kbaud <br> - 187.5 kbaud <br> - 500 kbaud <br> - 1.5 Mbaud <br> - 3 Mbaud <br> - 6 Mbaud <br> - 12 Mbaud |
| Service Access Points (SAPs) | 1 |
| ID number 1540 (hex) | 1540 (hex) = 5440 (dec) |
| GSD file | EH3x1540.gsd |
| Addressing | via dip switches at the instrument or via software (e.g. FieldCare) Default address: 126 per software |
| Termination | can be activated/deactivated in the instrument |
| Locking | The device can be locked by hardware or software. |

## Auxiliary energy

## Supply voltage/

Power consumption/
Current consumption

| Instrument version | Supply voltage | Power consumption | Current consumption |
| :--- | :--- | :--- | :--- |
| AC voltage <br> $\left(\right.$ FMU90 $\left.-* * * * A^{* * * *}\right)$ | $90 \ldots 253 \mathrm{~V}_{\mathrm{AC}}(50 / 60 \mathrm{~Hz})$ | max. 23 VA | max. 100 mA at $230 \mathrm{~V}_{\mathrm{AC}}$ |
| DC voltage <br> $\left(\right.$ FMU90 $\left.-* * * * \mathrm{~B}^{* * * *}\right)$ | $10,5 \ldots 32 \mathrm{~V}_{\mathrm{DC}}$ | max. 14 W (typically 8 W$)$ | max. 580 mA at $24 \mathrm{~V}_{\mathrm{DC}}$ |

Galvanic isolation
The following terminals are galvanically isolated from each other:

- auxiliary energy
- sensor inputs
- analogue output 1
- analogue output 2
- relay outputs
- bus connection (PROFIBUS DP)


## Fuse

- 2 A T /DC
- $400 \mathrm{mAT} / \mathrm{AC}$
accesible in the terminal compartment


## Electrical connection

Terminal compartment of the field housing

The field housing has a separate terminal compartment. It can be opened after loosening the four screws of the lid.


For easier wiring, the lid can be completely removed by unplugging the display plug (1) and pulling off the hinges (2):


| Cable entries of the field | On the bottom of the housing the following openings for cable entries are prestamped: |
| :--- | :--- |
| housing | M20x1,5 (10 openings) |
| - M16x1,5 (5 openings) |  |
| - M25x1,5 (1 opening) |  |

A suitable cutting device must be used for cutting out the openings.

Terminal compartment of the DIN-rail housing

## Single instrument



The catch can be unlocked by slightly pressing onto the clip. Then, the cover of the terminal compartment can be opened.

Several instruments mounted side by side


1. Open the catch of the cover (e.g. by a screwdriver).
2. Pull the cover out by approx. 2 cm .
3. The cover can now be opened.

## Note!

- The cables can be inserted into the housing from above or from below.
- The pictures show the smallest housing version but are valid for the larger versions as well.
- If the instruments are mounted next to each other and if the sensor cables run in parallel, the synchronization terminals (39 and 40) must be interconnected (see sections "Terminal assignment" and Synchronization line").


## Terminal assignment

Pluggable spring-force terminals for connection of the cables are supplied in the terminal compartment. Rigid conductors or flexible conductors with cable sleeve can directly be inserted and are contacted automatically.

| Conductor cross section | $0,2 \mathrm{~mm}^{2}-2,5 \mathrm{~mm}^{2}$ |
| :--- | :--- |
| Cable and sleeve cross section | $0,25 \mathrm{~mm}^{2}-2,5 \mathrm{~mm}^{2}$ |
| min. stripping length | 10 mm |

The terminal configuration depends on the instrument version ordered. There is a basic terminal area, which is present in every instrument version. Additonal optional terminal areas are only present if the respective option has been selected in the product structure.

| Terminal area |  | present for the following instrument versions |
| :---: | :---: | :---: |
| Basic area | A | for all versions |
| Optional areas | B | for instrument versions with 2 sensor inputs and/or 2 analogue outputs (FMU90 - *****2****** and/or FMU90 - ******* $2^{* * * *) ~}$ |
|  | C | for instrument versions with 3 or 6 relays (FMU90 - ****** $3 * * * * *$ oder FMU90 - ************) |
|  | D | for instruments with external switch inputs and external temperature input (FMU90 - ********B***) |
|  | E | for instrument versions with PROFIBUS DP interface (FMU90 - *******3****) |


| A | B | C | D | E |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |

Terminals of the Prosonic S; the terminals depicted in grey are not present in every instrument version.
A: Basic terminal area; B-E: Optional terminal areas (present if the respective option has been selected in the product structure)

Note!
The depicted switching states of the relays refer to the de-energized state.

| Terminals | Meaning | Terminal area | Remarks |
| :---: | :---: | :---: | :---: |
| Auxiliary energy |  |  |  |
| 1,2 | - L (für AC version) <br> - L+ (for DC version) | A | depending on instrument version: <br> - 90 ... $253 \mathrm{~V}_{\mathrm{AC}}$ <br> - 10,5 ... $32 \mathrm{~V}_{\mathrm{DC}}$ |
| 2 | - N (for AC version) <br> - L- (for DC version) | A |  |
| 3 | Potential equalization | A |  |
| Fuse |  | A | depending on instrument version: <br> - 400 mAT (for AC) <br> - 2 A T (for DC) |
| Analog outputs (not available for Profibus DP instruments) |  |  |  |
| 4, 5 | Analog output 1; <br> 4 ... 20 mA with HART/ <br> 0 ... $20 \mathrm{~mA} \mathrm{w} / \mathrm{o}$ HART | A | not present for the PROFIBUS DP version |
| 41, 42 | Analog output 2 (optional); <br> 4 ... $20 \mathrm{~mA} /$ <br> 0 ... 20 mA | B | only for the version with two analog outputs; no HART signal at this output |
| Relay outputs |  |  |  |
| 6, 7, 8 | Relay 1 | A |  |
| 50, 51, 52 | Relay 2 (optional) | C | only for the versions with 3 or 6 relays |
| 53, 54, 55 | Relay 3 (optional) | C | only for the versions with 3 or 6 relays |
| 56, 57, 58 | Relay 4 (optional) | C | only for the version with 6 relays |
| 59, 60, 61 | Relay 5 (optional) | C | only for the version with 6 relays |
| 62, 63, 64 | Relay 6 (optional) | C | only for the version with 6 relays |
| Bus communication (only available for Profibus DP instruments) |  |  |  |
| 65 | PROFIBUS A (RxT/TxD - N) | D | only for the PROFIBUS DP version |
| 66 | PROFIBUS B (RxT/TxD - P) | D |  |
| Synchronization |  |  |  |
| 39, 40 | Synchronization | A | see section 4.6, "Synchronization line" |
| Level inputs |  |  |  |
| 9 (YE), <br> 10 (BK), <br> 11 (RD) | Sensor 1 (FDU8x/9x) <br> YE: yellow strand BK: black strand RD: red strand | - A: for versions with 1 sensor input <br> - B: for versions with 2 sensor inputs ${ }^{1)}$ |  |
| $\begin{aligned} & 12 \text { (YE), } \\ & 13 \text { (BK), } \\ & 14 \text { (RD) } \end{aligned}$ | Sensor 2 (FDU8x/9x) (optional) <br> YE: yellow strand <br> BK: black strand <br> RD: red strand | B | only for the version with 2 sensor inputs |
| external switch inputs |  |  |  |
| 71, 72, 73 | external switch input 1 | D | $0:<8 \mathrm{~V}$ or 72 and 73 interconnected <br> $1:>16 \mathrm{~V}$ or 72 and 73 not interconnected |
| 74, 75, 76 | external switch input 2 | D | $0:<8 \mathrm{~V}$ or 75 and 76 interconnected <br> 1: $>16 \mathrm{~V}$ or 75 and 76 not interconnected |
| 77, 78, 79 | external switch input 3 | D | $0:<8 \mathrm{~V}$ or 78 and 79 interconnected <br> 1: $>16 \mathrm{~V}$ or 78 and 79 not interconnected |
| 80, 81, 82 | external switch input 4 | D | $0:<8 \mathrm{~V}$ or 81 and 82 interconnected <br> $1:>16 \mathrm{~V}$ or 81 and 82 not interconnected |
| temperature input |  |  |  |
| 83, 84, 85 | temperature input: <br> - PT100 <br> - FMT131 (Endress+Hauser) | D | see section <br> "Connection of a temperature sensor" |

1) In this case, terminals $9 / 10 / 11$ are not present on terminal area $A$.


Warning!
When using the public supply mains, an easily accesible power switch must be installed in the proximity of the device. The power switch must be marked as a disconnector for the device (IEC/EN 61010)
Note!

- In order to avoid interference signals, the sensor cables should not be laid parallel to high voltage or electric power lines.
- The cables may not be laid in the proximity to frequnecy converters.

Additional elements on the terminal areas

| Designation | Meaning/Remarks |
| :--- | :--- |
| Fuse | Fuse: 2 A T /DC or $400 \mathrm{~mA} \mathrm{T/AC}$ |
| Display | Connection of the display or the remote display and operating module |
| Service | Service interface for connection of a PC/Notebook via Commubox FXA291 |
| R er | Locking switch |
| Term. | Bus termination (only applicable for instruments with PROFIBUS interface) |
| Address | Bus address (only applicable for instruments with PROFIBUS interface) |

## Terminals

Pluggable spring-force terminals for connection of the cables are supplied in the terminal compartment. Rigid conductors or flexible conductors with cable and sleeve can directly be inserted and are contacted automatically.

| Conductor cross section | $0,2 \mathrm{~mm}^{2}-2,5 \mathrm{~mm}^{2}$ |
| :--- | :--- |
| Cable and sleeve cross section | $0,25 \mathrm{~mm}^{2}-2,5 \mathrm{~mm}^{2}$ |
| min. stripping length | 10 mm |

## Connection of the sensors

 FDU9x
(A): Terminal box (recommended or cable lengths > 30 m ); (B): Grounding at the terminal box; (C): Grounding at the transmitter or in the control room; (1): Terminals for sensor input 1 at the FMU9x; (2): Terminals for sensor input 2 at the FMU9x (optional)

For details refer to Technical Information TI 396F.

## Synchronization line

- If wiring several Prosonic S (FMU90/FMU95) which are mounted in a common cabinet and if the sensor cables run in parallel, the synchronization terminals (39 and 40) must be interconnected.
- Up to 20 instruments can be synchronized in this way.
- If there are more than 20 instruments, groups must be formed, each containing a maximum of 20 instruments. For the instruments within each group, the sensor cables may run in parallel. The sensor cables of different groups must be seperated from each other.
- Usual commercial screened cable can be used for synchronization
- max. length: 10 m between the individual instruments
- cross section: $2 \times\left(0.75-2.5 \mathrm{~mm}^{2}\right)$
- for lengths up to 1 m , an unscreened cable can be used; for lenghts exceeding 1 m , screening is required. The screen must be connected to ground
- Instruments of the Prosonic FMU86x family can be connected to the synchronization line as well. In this case a maximum of 10 instruments can be connected to each synchronisation line.


Connection of the separate display and operating module


For the version of the Prosonic $S$ with a separate display for panel mounting, a pre-assembled connecting cable $(3 \mathrm{~m})$ is supplied. The cable must be connected to the display plug of the Prosonic S .
Note!
Minimum diameter for cable bushing: 2 cm

Connection of external switches (for FMU90-********B***)


The maximum short-circuit current at 24 V is 20 mA .

## Connection of a temperature sensor



A: Non-Ex area (FMT131-R); B: Ex area (FMT131-J) with grounding in the FMU90;
C: Ex area (FMT131-J) with crounding at a terminal box
BK: black; YE: yellow; YEGN: yellow-green

Note!
For details refer to the Operating Instructions KA019F.
Pt100
(connectable to FMU90-********B***)


A: Pt100 with 3-wire connection; B: Pt100 with 4-wire connection (one connector remains unused)


Note!
A Pt100 with 2-wire connection may not be used due to its insufficient measuring accuracy.
Warning!
A Pt100 may not be connected in explosion hazardous areas. A FMT131 must be used instead.

## Performance characteristics

| Reference operating | - Temperature $=24 \pm 5^{\circ} \mathrm{C}$ |
| :--- | :--- |
| conditions | - Pressure $=960 \pm 100 \mathrm{mbar}$ |
|  | - Relative humidity $=60 \pm 15 \%$ |
|  | - Ideally reflecting surface, sensor vertically aligned |
|  | (e.g. calm, plane liquid surface of $1 \mathrm{~m}^{2}$ ) |
|  | - No interference echoes within the signal beam |
|  | - Settings of the application parameters: |
|  | - tank shape $=$ flat ceiling |
|  | - medium property $=$ liquid |
|  | - process condition $=$ calm surface |


| Measuring uncertainty ${ }^{\mathbf{5})}$ | $\pm 0,2 \%$ of the maximum span of the sensor |
| :--- | :--- |
| Typical accuracy ${ }^{\mathbf{0})}$ | $\pm 2 \mathrm{~mm}+0,17 \%$ of the measured distance |
| Measured value resolution | 1 mm with FDU91 |
| Measuring frequency | max. 3 Hz <br> The exact value depends on the settings of the application parameters and the instrument version. |
|  | Note! <br> The maximum measuring frequency is obtained for "empty E" $\leq 2 \mathrm{~m}$ and "process condition" $=$ "test: no filter". |

## Ambient conditions

| Ambient temperature | $-40 \ldots 60^{\circ} \mathrm{C}$ <br> The functionality of the LC display becomes restricted at $\mathrm{T}_{\mathrm{U}}<-20^{\circ} \mathrm{C}$. <br> If the device is operated outdoors in strong sunlight, a protective cover should be used (s. chapter "Accessories"). |
| :---: | :---: |
| Storage temperature | $-40 \ldots 6{ }^{\circ} \mathrm{C}$ |
| Climate class | - Field housing: according to DIN EN 60721-3 4K2/4K5/4K6/4Z2/4Z5/4C3/4S4/4M2 (DIN 60721-3 4K2 corresponds to DIN 60654-1 D1) <br> - Housing for DIN rail mounting: according to DIN EN 60721-3 3K3/3Z2/3Z5/3B1/3C2/3S3/3M1 (DIN 60721-3 3K3 corresponds to DIN 60654-1 B2) |
| Vibration resistance | - Housing for DIN rail: DIN EN 600068-2-64 / IEC 68-2-64; 20 ... $2000 \mathrm{~Hz} ; 0,5\left(\mathrm{~m} / \mathrm{s}^{2}\right)^{2} / \mathrm{Hz}$ <br> - Field housing: DIN EN 600068-2-64 / IEC 68-2-64; 20 ... $2000 \mathrm{~Hz} ; 1,0\left(\mathrm{~m} / \mathrm{s}^{2}\right)^{2} / \mathrm{Hz}$ |
| Ingress protection | - Field housing: IP66 / NEMA 4x <br> - Housing for DIN rail: IP20 <br> - separate display: <br> - IP65 / NEMA 4 (front panel , if mounted in cabinet door) <br> - IP20 (rear panel, if mounted in cabinet door) |
| Electromagnetic compatibility (EMC) | - Interference emmission to EN 61326; Equipment class A <br> - Interference immunity to EN 61326; Annex A (Industrial) and NAMUR recommendation EMC (NE21) |

[^15]
## Mechanical construction

## Housing versions

- Field housing; optionally with integrated display and operating module
- Housing for top-hat rail mounting; optionally with intergrated display and operating module
- Housing for top-hat rail mounting with separated display and operating module for cabinet door mounting


## Dimensions of the field housing



Dimensions in mm
A: Mounting help (supplied); can also be used as drilling template ; B: Field housing; C: minimum mounting distance

The dimensions of the field housing are the same for all instrument versions.
To open the housing, a minimum mounting distance of 55 mm is required on the left.
Note!
The mounting help must be mounted on a plane surface and must not become bent. Otherwise the mounting of the field housing may be difficult or impossible.

Dimensions of the DIN-rail housing

The dimensions of the DIN-rail housing depend on the instrument version. The version determines, which terminal areas the Prosonic S contains. The dimensions are influenced by the following features of the product structure (see chapter 2.3):

- 60: Level Input
- 70: Switch Output
- 80: Output

In order to determine the dimensions of a specific version, perform the following steps (see the example on page 23):

1. Using the product structure, determine the options of the features 60,70 and 80 of the instrument version in question.

2. Using the following table, determine how many optional terminal areas this instrument version contains.

| Feature and option of <br> the product structure | corresponds to the following <br> terminal area | present? <br> yes =1 <br> no =0 |
| :--- | :--- | :--- |
| feature 60; option 2 <br> and/or <br> feature 80, option 2 | 2 sensor inputs <br> and/or <br> 2 analogue outputs |  |
| feature 70, option 3 or 6 | 3 o 6 relays |  |
| feature 80, option 3 | PROFIBUS DP interface |  |
| feature 90, option B | inputs for external switches and <br> external temperature sensor |  |

3. The appropriate dimensions are given in the following diagram:

Sum = 0 (only basic terminal area)


Dimensions in mm

Sum =1, 2 or 3
(1-3 optional terminal areas)


Dimensions in mm

Sum $=4$
(4 optional terminal areas)


Dimensions in mm

Example

|  | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| FMU90 - | R | 1 | 2 | A | A | 2 | 3 | 2 | A | A | 1 | A |


| feature and option of <br> the product structure | corresponds to the following <br> terminal area | present? |
| :--- | :--- | :---: |
| feature 60; option 2 <br> and/or <br> feature 80, option 2 | 2 sensor inputs <br> and/or <br> 2 analogue outputs | 1 (yes) |
| feature 70, option 3 or 6 | 3 or 6 relays | 1 (yes) |
| feature 80, option 3 | PROFIBUS DP interface | 0 (no) |
| feature 90, option B | inputs for external switches and <br> external temperature sensorr | 0 (no) |

Sum $=2$
=> $104 \mathrm{~mm} \times 150 \mathrm{~mm} \times 140 \mathrm{~mm}$

Dimensions of the separate display and operating module


Dimensions in mm

| Weight | Housing version Weight <br> Field housing approx.. $1,6 \ldots 1,8 \mathrm{~kg}$; depending on instrument version <br> Housing for DIN rail approx. $0,5 \ldots 0,7 \mathrm{~kg}$; depending on instrument version (s. section: "Dimensions of the DIN-rail <br> housing") <br> separate display and <br> operating module approx. 0,5 kg |  |
| :--- | :--- | :--- |

Materials

- Field housing: PC
- Housing for DIN rail: PBT


## Human interface

## Display and operating module


(a): name of the parameter; (b): value of the parameter, including unit; (c): display symbols; (d): softkey symbol; (e): LED indicating the operating state; (f): LEDs indicating the switching states of the relays; (g): keys

## Display (Examples)



Display of a function including help text and descriptive graphic

## envelope curve IK129



Display of the envelope curve including the mapping. The level echo and the empty distance are marked.

## Keys (softkey operation)

The function of the keys depends on the current position within the operating menu (softkey functionality). The key functions are indicated by softkey symbols in the bottom line of the display.

## LEDs

- 1 LED (a) indicates the operating state ("normal operation", "alarm" or "warning")
- 6 LEDs (b) indicate the switching state of the relays (LED glows if the respective relay is energised)


## Illuminated display

An illuminated display is available as an option (s. feature 40 of the product structure)

## Operating menu

Basic setup

The Prosonic S has got a dynamical operating menu. Only those functions are visible which are relevant for the instrument version and installation environment at hand.

Locking of the instrument The instrument can be locked against parameter changes in the following ways:
The operating menu contains basic setups for easy commissioning of level and flow measurements. The basic setups guide the user through the complete commissioning procedure.

- Locking switch in the terminal compartment
- Key combination at the operating module
- Input of a locking code via software (e.g. "ToF Tool" or "FieldCare")


## Certificates and Approvals

| CE mark | The measuring system meets the legal requirements of the EC-guidelines. Endress + Hauser confirms the <br> instrument passing the required tests by attaching the CE-mark. |
| :--- | :--- |
| Ex approval | The available certificates are listed in the ordering information. Note the associated safety instructions (XA) and <br> control or installation drawings (ZD). <br> Note! <br> Sensors FDU9x with Ex-approval can be connected to the transmitter FMU90 without Ex-approval. |
| External standards and <br> guidelines | EN 60529 <br> Protection class of housing (IP code) |
|  | EN 61326 <br> Electromagnetic compatibility (EMC requirements) |
|  | NAMUR <br> Standards committee for measurement and control in the chemical industry |
| US Standard UL 61010-1 |  |

## Ordering information

## Product structure

| 10 | Approval |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | R Non-hazarous area <br> J ATEX II 3D <br> N CSA General Purpose |  |  |  |  |  |  |  |
| 20 |  | Application |  |  |  |  |  |  |
|  |  | 1 Level + pump control, alternating <br> 2 Flow + totalizer + level + sample control + preprogrammed OCM flow curves <br> 3 Level + additional pump control <br> 4 Universal instrument (Level + Flow + Additional pump control) |  |  |  |  |  |  |
| 30 |  | Housing, material |  |  |  |  |  |  |
|  |  | $\begin{array}{\|l\|l} \hline 1 & \text { Field mounting PC, IP66 NEMA 4x } \\ 2 & \text { DIN rail mounting PBT, IP20 } \end{array}$ |  |  |  |  |  |  |
| 40 |  | Operation |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 50 |  | Power supply |  |  |  |  |  |  |
|  |  | A $90-253 \mathrm{VAC}$ <br> B $10,5-32 \mathrm{VDC}$ |  |  |  |  |  |  |
| 60 |  | Level input |  |  |  |  |  |  |
|  |  | 1 1 x sensor FDU9x/8x <br> 2 2 x sensor FDU9 $/ 8 \mathrm{x}$ |  |  |  |  |  |  |
| 70 |  | Switch output |  |  |  |  |  |  |
|  |  | 1 1 x relay, SPDT <br> 3 3 x relay, SPDT <br> 6 6 x relay, SPDT |  |  |  |  |  |  |
| 80 |  | Output |  |  |  |  |  |  |
|  |  |  |  |  | 1 $1 \times 0 / 4-20 \mathrm{~mA}$ HART <br> 2 $2 \times 0 / 4-20 \mathrm{~mA} \mathrm{HART}$ <br> 3 PROFIBUS DP |  |  |  |
| 90 |  |  |  |  | Additional input |  |  |  |
|  |  |  |  |  | A w/o additional input <br> B $4 x$ limit switch +1 x temperature PT100/FMT131 |  |  |  |
| 100 |  |  |  |  |  | Datalog function |  |  |
|  |  |  |  |  |  | A ${ }^{\text {Basic version }}$ |  |  |
| 110 |  |  |  |  |  | Languages |  |  |
|  |  |  |  |  |  |  | 1 de, <br> 2 en, <br> 3 en, | en, nl, fr, es, it, pt ru, pl, cs zh, $\mathrm{ja}, \mathrm{ko}$, th, id |
| 120 |  |  |  |  |  |  |  | ditional option |
|  |  |  |  |  |  |  | A | Basic version |
| FMU90- |  |  |  |  |  |  |  | complete product designation |

(*): meaning of the language code:
cs: Czech; de: German; en: English; es: Spanish; fr: French; id: Bahasa (Indonesia, Malaysia); it: Italian; ja: Japanese; ko: korean; nl: Dutch; pl: Polish; pt: Portuguese; ru: Russian; th: Thai; zh: Chinese

## Scope of delivery

- Instrument according to the version ordered
- Operating program: ToF Tool - FieldTool Package
- Operating Instructions (depending on communication version, see chapter "Supplementary documentation")
- for certified instrument versions: Safety Instructions (XAs) or Control Drawings (ZDs) (s. chapter "Supplementary documentation")
- field housing units for flow measurement FMU90-*21********* are delivered with 2 screws for plombing the device


## Accessories

| Commubox FXA191 HART | For intrinsically safe communication with ToF Tool/FieldCare via the RS232C interface. For details refer to <br> TI237F/00/en. |
| :--- | :--- |
| Commubox FXA195 HART | For intrinsically safe communication with ToF Tool/FieldCare via the USB interface. For details refer to <br> TI404F/00/en. |
| For intrinsically safe communication with ToF Tool/FieldCare via the service interface (IPC) of the instrument <br> and the USB interface of a PC/Notebook. <br> Ordering Code: 51516983 |  |
| Protection cover for the field <br> housing | - Material: 316Ti/1.4571 <br> - is mounted by the mounting help of the Prosonic S <br> - Order-Code: 52024477 |

## Mounting plate for the field

## housing

- suited for the mounting help of the Prosonic S
- for $1^{\prime \prime}-2$ tubes
- Dimensions: $210 \mathrm{~mm} \times 110 \mathrm{~mm}$
- Material: 316Ti/1.4571
- fixing clips, screws and nuts are supplied
- Order code: 52024478


A: mounting help of the field housing

## Mounting bracket



| Height | Material | Order Code |
| :--- | :--- | :--- |
| 700 mm | galv. steel | $919791-0000$ |
| 700 mm | 316 Ti | $919791-0001$ |
| 1400 mm | galv. steel | $919791-0002$ |
| 1400 mm | 316 Ti | $919791-0003$ |

Adaption plate for remote display

Used to mount the remote display into the opening ( $138 \mathrm{~mm} \times 138 \mathrm{~mm}$ ) of the remote display module of the Prosonic FMU860/861/862).

Order-Code: 52027441
(2) Note!

The adapter plate will be mounted directly in the old remote display of the FMU86x series. The housing of the remote display of FMU860/861/862 is the holder for the adapter plate and the new remote display of the FMU90/95 in the format $96 x 96 \mathrm{~mm}$.

(a): remote display of the Prosonic $S$ with adaption plate; (b): opening of the remote display FMU860/861/862

Option:
Adaption plate $160 \times 160 \mathrm{~mm}$, thickness 3 mm , aluminum, opening $96 \times 96 \mathrm{~mm}$ for remote display of the FMU90.
Can be used to replace the FMU86x remote display or DMU2160/2260.
Ordering Code: TSPFU 0390
Please contact your Endress+Hauser representative.

## Overvoltage protection

## HAW56x

## Application examples

| Measurement signal | Measurement point requirements | Connection diagram |
| :---: | :---: | :---: |
| - Current output 1 $0 / 4$ to 20 mA <br> - Current output 2 $0 / 4$ bis 20 mA <br> Transducer Prosonic S FMU90 with 2 Prosonic FDU9x sensors | - $2 \times$ HAW $560+562$ for 0/4 to 20 mA signals <br> - $2 \times$ HAW561 for power supply to the transducer <br> - $2 \times$ HAW560 +566 for the sensor signal line |  |
| - Current output $0 / 4$ to 20 mA <br> Prosonic S FMU90 transducer with Prosonic FDU9x level measurement sensors | - $1 \times$ HAW560 +562 for $0 / 4$ to 20 mA signals <br> - $2 \times$ HAW561 <br> for power supply to the transducers <br> - $1 \times$ HAW560 +566 <br> for the sensor signal line |  |


| Measurement signal | Measurement point requirements | Connection diagram |
| :---: | :---: | :---: |
| no current output (only relay outputs) <br> Prosonic S FMU90 transducer with Prosonic FDU9x level measurement sensor | - $1 \times$ HAW560 + 1 x HAW566 for signal line. Use gas discharge tube for indirect shield earthing. <br> - $2 \times$ HAW561 for power supply line |  |

Note!
HAW560 with the HAW562 module can also be used to protect the signal line of the external temperature probe FMT131 (Ex or Non-Ex version).

## Electrical connection

HAW561 and 561K


A fixed allocation of the phase and ground terminal is not allocated (pole security). The unit is fitted on both ends with a multi function connection terminal. This gives the opportunity to simultaneously connect a cable as well as a fork ferrule from standard busbars.
Connection of the unit is as in the diagram above. Dependent on the cabling, up to four units will be required.
HAW562/562Z, HAW565 and HAW566


Connection of the unit as in the diagram. The ground connection is made using the DIN rail. For the signal cable screen connection on the HAW565 unit a special EMC spring terminal is supplied.
For indirect screening (as required if connecting the Prosonic S signal line to an HAW566) a gas-discharge arrester is supplied. It must be inserted into the provided plug-in bay on the HAW560.

Product overview

| Oreder code | Unit |
| :--- | :--- |
| 51003569 | Surge arrester HAW561K <br> For low voltage users 24/48V, single pole, requirement class C, basic component with <br> plugged in protection unit, defect display, 18 mm housing width |
| 51003570 | Surge arrester HAW561 <br> For standard voltage users 115/230 V, single pole, requirement class C, basic component <br> with plugged in protection unit, defect display, 18 mm housing width |
| 51003571 | Surge arrester module carrier HAW560 <br> Two pole through terminated for fitting surge arrester modules for units in information <br> technology, 12 mm housing width, colour grey |
| 51003572 | Surge arrester module HAW562 <br> For protection of 2 single lines, e.g. 2 asymmetrical single lines, <br> e.g.: 0/4 to 20 mA, Profibus PA, 12 mm housing width, colour grey |
| 51003573 | Surge arrester module HAW565 <br> For protection of 2 single lines, e.g. 2 asymmetrical single lines with high frequency signal <br> transmission, e.g.: Profibus DP, RS 485, 12 mm housing width, colour grey |
| 51003574 | Surge arrester module carrier HAW560Z <br> Two pole through terminated for fitting surge arrester modules for units in information <br> technology in Ex areas, 12 mm housing width, colour blue |
| 51003575 | Surge arrester module HAW562 <br> For protection of 2 single lines, e.g. 2 asymmetrical single lines in Ex areas, <br> e.g.: 0/4 to 20 mA, Profibus PA, 12 mm housing width, colour blue |
| 71028875 | Surge arrester module HAW566 <br> Protection for 2 signal inputs, e.g. 2 asymmetrical inputs, e.g. Prosonic S signal <br> 12 mm housing with, colour grey |

For details see Technical Information TI093R.

## Temperature sensor FMT131



A: Temperature sensor FMT131; B: weather protector

## Product structure

| 010 | Approval |  |  |
| :---: | :---: | :---: | :---: |
|  | R R | $\left\lvert\, \begin{array}{ll} \text { No } \\ \text { ATI } \\ \mathrm{FM} \\ \mathrm{CS} \\ \mathrm{CS} \end{array}\right.$ | n-hazardous area EX II 2G EEx m II T6/T5 Cl.I Div. 1 Gr. A-D A General Purpose A Class I Div. 1 |
| 020 | Cable length |  |  |
|  |  | 1 2 3 3 4 5 5 6 7 7 8 A | $5 \mathrm{~m} / 16 \mathrm{ft}$ $10 \mathrm{~m} / 32 \mathrm{ft}$ $15 \mathrm{~m} / 49 \mathrm{ft}$ $20 \mathrm{~m} / 65 \mathrm{ft}$ $25 \mathrm{~m} / 82 \mathrm{ft}$ $30 \mathrm{~m} / 98 \mathrm{ft}$ $\mathrm{w} / \mathrm{o}$ cable, gland Pg16, IP66 $\ldots \mathrm{m}$ $\ldots \mathrm{ft}$ |
| FMT131- |  |  | \| complete product designation |

## Weather protection cover for FMT131

Order code: 942046-0000

## Supplementary documentation

| Innovation booklet | IN 003 |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Ultrasonic measurement - the solution for your application |  |  |  |
| Technical Information | TI 396F |  |  |  |
|  | Technical Information for the ultrasonic sensors FDU91/FDU92/FDU93/FDU95/FDU96 |  |  |  |
| Operating instructions <br> (for transmitter FMU90) | Depending on the instrument version, the following operating instructions are supplied with the Prosonic S FMU90: |  |  |  |
|  | Operating instructions | Output | Application | Instrument version |
|  | BA 288F |  | - level measurement <br> - alternating pump control <br> - screen and rake control | $\begin{aligned} & \text { FMU90 - ******* } 1 \text { **** } \\ & \text { FMU90 - *******2*** } \end{aligned}$ |
|  | BA 289F | HART | - flow measurement <br> - backwater and dirt detection <br> - totalizers and counters | $\begin{aligned} & \text { FMU90 - *2***** } 1 * * * * \\ & \text { FMU90 - *4***** } 1 * * * \\ & \text { FMU90 - *2*****2*** } \\ & \text { FMU90 - *4*****2*** } \end{aligned}$ |
|  | BA 292F | PROFIBUS DP | - level measurement <br> - alternating pump control <br> - screen and rake control | FMU90 - *******3**** |
|  | BA 293F | PROFIBUS DP | - flow measurement <br> - backwater and dirt detection <br> - totalizers and counters | $\begin{aligned} & \text { FMU90 - *2*****3**** } \\ & \text { FMU90 - *4*****3**** } \end{aligned}$ |

These operating instructions describe installation and commissioning of the respective version of the Prosonic S. It contains those functions from the operating menu, which are required for a standard measuring task. Additional functions are contained in the "Descripiton of Instrument Functions" (BA 290F, see below).

## Description of Instrument Functions

## BA290F

contains a detailed description of all functions of the Prosonic $S$ and is valid for all instrument versions. A PDF file of this document can be found

- on the CD-ROM of the "ToF-Tool - FieldTool Package", which is supplied together with the instrument
- in the internet at "www.endress.com"

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Technical Information

## Prosonic S FMU90

## Transmitter in housing for field or top-hat rail mounting for the ultrasonic sensors FDU91/91F/92/93/95/96



## Application for level measurement

- Continuous, non-contact level measurement of fluids, pastes, sludge and powdery to coarse bulk materials with 1 or 2 ultrasonic sensors
- Measuring range up to 70 m (depending on sensor and material measured)
- Level limit detection (up to 6 relays)
- Pump control (alternating); rake control
- Option: additional pump control functions (pump function test, ...)
- Calculations: average, difference, sum


## Application for flow measurement

- Flow measurement in open channels and measuring weirs with 1 or 2 ultrasonic sensors
- Simultaneous measurement of level and flow in a stormwater overflow basin with only 1 sensor
- Flow measurement with back water detection (2 sensors) or sludge detection
- Up to 3 totalizers and 3 (resettable) counters; optionally resettable via digital inputs
- Counting or time pulse output for control of external units


## Your benefits

- Simple, menu-guided operation with 6-line plain text display; 15 languages selectable
- Envelope curves on the display for quick and simple diagnosis
- Easy operation, diagnosis and measuring point documentation with the supplied "ToF-Tool FieldTool Package" operating program.
- Option: four digital inputs (e.g. for pump feedback) and one external temperature input
- Time-of-flight correction via integrated or external temperature sensors
- Linearisation (up to 32 points, freely configurable)
- Linearisation tables for the most common flumes and weirs pre-programmed and selectable
- Online calculation of the flume-/weir-flows via integrated flow curves
- Pre-programmed pump control routines
- System integration via HART or PROFIBUS DP
- Automatic detection of the sensors FDU9x
- The sensors of the former series FDU8x can be connected (for certificates see note on page 8)


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## Function and system design

## Measuring principle



BD: blocking distance; D: distance from sensor membrane to fluid surface; E: empty distance $\mathbf{F}$ : span (full distance); L: level; $\mathbf{V}$ : volume (or mass); $\mathbf{Q}$ : flow

The sensor transmits ultrasonic pulses in the direction of the product surface. There, they are reflected back and received by the sensor. The transmitter Prosonic $S$ measures the time $t$ between pulse transmission and reception. From $t$ (and the velocity of sound $c$ ) it calculates the distance $D$ from the sensor membrane to the product surface:
$D=c \cdot t / 2$
From D results the desired measuring value:

- level L
- volume V
- flow Q across measuring weirs or open channels


## Blocking distance

The span F may not extend into the blocking distance BD. Level echos from the blocking distance can not be evaluated due to the transient characteristics of the sensor. The blocking distances of the individual sensors are given in the following documents:

- TI 396F for the sensors FDU 91/91F/92/93/95/96
- TI 189F for the sensors FDU 80/80F/81/81F/82/83/84/85/86


## Time-of-flight correction

In order to compensate for temperature dependent time-of-flight changes, a temperature sensor is integrated in the ultrasonic sensors.
Optionally, the Prosonic S FMU90 has an input for an external temperature sensor
(FMU90-******** $\mathrm{B}^{* * *}$ ). The following sensor can be connected:

- Pt100
- FMT131 from Endress+Hauser

The external sensor mus be used for the heated version of the ulstrasonic sensor FDU91.

Interference echo suppression The interference echo suppression feature of the Prosonic $S$ ensures that interference echos (e.g. from edges, welded joints and installations) are not interpreted as a level echo.

## Pump control

individaully configurable for each pump:

- pump switching delay, e.g. to prevent overlaod of the power supply system
- backlash time and backlash interval, e.g. for complete draining of shafts or channels
- crust reduction at pump shaft walls by fine adjustment of the switch point


## Linearisation

## Pre-programmed linearisation curves

## Types of vessels

- horizontal, cylindrical tank
- spherical tank
- tank with pyramidal bottom
- tank with conical bottom
- tank with flat, inclined bottom

Flow curves for flumes and weirs ${ }^{1)}$

- Khafagi-Venturi flume
- ISO-Venturi flume
- $\mathrm{BST}^{2}$-Venturi flume
- Parshall flume
- Palmer-Bowlus flume
- Rectangular weir
- Rectangular constricted weir
- $\mathrm{NFX}^{3}$ rectangular weir
- $\mathrm{NFX}^{3}$ rectangular constricted weir
- Trapezoidal weir
- V-notch weir
- BST $^{2}$ V-notch wier
- $\mathrm{NFX}^{3}$ V-notch weir

The pre-programmed linearisation curves are calculated on-line.

## Linearisation formula for flow measurements ${ }^{1}$

$\mathrm{Q}=\mathrm{C}\left(\mathrm{h}^{\alpha}+\gamma \mathrm{h}^{\beta}\right)$
" h " is the upstream level. The parameters $\alpha, \beta, \gamma$ and C can be freely programmed by the user.

## Linearisation table

consisting of up to 32 linearisation points; to be entered manually or half-automatically.

| Special functions | limit detection |
| :--- | :--- |
| - rake control |  |
| - alternating pump control or control according to pump rate (standard) |  |
| - option: additional pump control functions ${ }^{4}$ : |  |
|  | - Alternation accordint to runtime or starts |
|  | - pump feedback via the optional digital inputs; stand-by pump configurable |
|  | - pump function test after resting time |
|  | - storm function to prevent unnecessary pump running times |
|  | - flush control for regular pump shaft cleaning |
|  | - pump control according to tariff times via digital input |
|  | - output of operating hours alarm or pump alarm |
|  | - recording of pump data (operating hours, number of starts, last running time) |
|  | - totalising of the flow volume with (resettable) counters and (non-resettable) totalisers ${ }^{1}$ |
|  | - triggering of a sampler by time or quantity pulses ${ }^{1}$ |
|  | low flow cut off ${ }^{1}$ |
|  | - backwater detection in flumes ${ }^{1}$ |
|  | - sludge detection in flumes ${ }^{1}$ |
|  | - trend detection |

Datalog functions

- Peak hold indicator of the min./max. levels or flows and the min./max. temperatures at the sensors
- Indication of the tast 10 alarms
- Trend indication of the outputs on the on-site display
- Indication of the operating hours

[^16]Application examples for level measurements

Level measurement with limit detection and alarm output


Order code e.g.: FMU90 - *1*** $131^{* * * *}$ (1 input, 3 relays, 1 outputs)

Rake control
(differential measurement)


Order code e.g.: FMU9O - *1***212**** (2 inputs, 1 relay, 2 outputs)

Average level measurement


Order code e.g.: FMU90 - *1***212**** (2 inputs, 2 outputs)

Alternating pump control (up to 6 pumps)


Order code e.g.: FMU90 - *1***131****
(1 input, 3 relays)

## Conveyor belt



Application examples for flow measurements

Pulses for volume counter + time pulses (e.g. for sampler)


Order code e.g.: FMU90 - *2*** $131^{* * * *}$
(1 input, 3 relays, 1 output)

## Stormwater overflow bassin

Simultaneous measurement of level L and flow Q with 1 sensor.


Order code e.g.: FMU90 - *2*** $112^{* * * *}$
(1 input, 2 outputs)

Flow measurement with backwater alarm or sludge detection
If the ratio "downstream level:upstream level" rises above or falls below a critical value, an alarm will be generated.


Order code e.g.: FMU90 - *2***212**** (2 inputs, 1 relay, 2 outputs)

## System integration HART



In the standard version a HART signal is superimposed onto the first output current. In order to use the HART communication, the circuit must contain a communication resistor of $250 \Omega$.

## Operating options

- via the operating and display module at the Prosonic $S$ (if present)
- via the service interface of the Prosonic $S$ with the Commubox FXA291 and the operating program "ToF Tool - FieldTool Package" or "FieldCare"
- via the HART protocol, e.g. with the Commubox FXA191 or FXA195 and the operating program "ToF Tool - FieldTool Package" or "FieldCare"
- via the HART handheld terminal DXR375


## System integration PROFIBUS DP



## Operating options

- via the display and operating module at the Prosonic S
- via the service interface with the Commubox FXA291 and the operating program "ToF Tool - FieldTool Package" or "FieldCare"
- via PROFIBUS DP with Profiboard or Proficard and the operating program "ToF Fool - FieldTool Package" or "FieldCare"


## Input

## Sensor inputs

Depending on the instrument version, 1 or 2 of the sensors FDU91, FDU91F, FDU92, FDU93, FDU95 and FDU96 can be connected. The Prosonic $S$ identifies these sensors automatically.

| Sensor | FDU91 <br> FDU91F | FDU92 | FDU93 | FDU95 | FDU96 |
| ---: | :---: | :---: | :---: | :---: | :---: |
| max. range $^{1)}$ in liquids | 10 m | 20 m | 25 m | - | - |
| ${\text { max. } \text { range }^{1} \text { in solids }}^{2}$ | 5 m | 10 m | 15 m | 45 m | 70 m |

1) This table gives the maximum range. The range depends on the measuring conditions. For an estimation see Technical Information TI 396F, chapter "Input".

In order to support existing installations, the sensors of the former series FDU8x can be connected as well. The type of sensor must be entered manually.

| Sensor | FDU80 <br> FDU80F | FDU81 <br> FDU81F | FDU82 | FDU83 | FDU84 | FDU85 | FDU86 |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| max. range $^{1)}$ in liquids | 5 m | 9 m | 20 m | 25 m | - | - | - |
| max. range $^{1}$ in solids | 2 m | 5 m | 10 m | 15 m | 25 m | 45 m | 70 m |

1) This table gives the maximum range. The range depends on the measuring conditions. For an estimation see Technical Information TI 189F, chapter "Planning Recommendations".


Warning!
The sensors FDU83, FDU84, FDU85 and FDU86 with an ATEX, FM or CSA certificate are not certified for connection to the transmitter FMU90.

External limit switches (option)

Optionally, the Prosonic S FMU90 has four inputs for external limit switches (FMU90-********B***).

## Switching options

- external passive limit switch (NC/NO switch)
- 0 : $<8 \mathrm{~V} ; 1:>16 \mathrm{~V}$

Usage (examples)

- pump feedback (for FMU90-*3******B***) and FMU90-*4******B***)
- pump tariff control (for FMU90-*3****** ${ }^{* * * *}$ ) and FMU90-*4****** ${ }^{* * *}$ )
- start/stop/reset of daily counters (for flow measurements)
(for FMU90-*2****** ${ }^{\star * *}$ and FMU90-* $4^{\star * * * * * * B * * *) ~}$
- min/max level detection, e.g. by Liquiphant

Optionally, the Prosonic S FMU90 has an input for an external temperature sensor (FMU90-********B***)

## Connectable sensors

- Pt100 (3-wire or 4-wire connection)

A Pt100 with 2-wire connection may not be used due to its insufficient accuracy.

- FMT131(from Endress+Hauser, see chapter "Accessories")

Usage (example)

- Time-of-flight correction for a heated sensor (FDU91-***B*).


## Output

## Analogue outputs

| Number | 1 or 2, depending on instrument version |
| :---: | :---: |
| Output signal | configurable at the instrument: <br> - $4 \ldots 20 \mathrm{~mA}$ with HART ${ }^{1)}$ <br> - 0 ... 20 mA without HART |
| Signal on alarm | for setting $4 \ldots 20 \mathrm{~mA}$, selectable: <br> - $-10 \%(3,6 \mathrm{~mA})$ <br> - 110\% (22 mA) <br> - HOLD (last current value is held) <br> - user specific <br> for setting 0 ... 20 mA : <br> - 110\% (21,6 mA) <br> - HOLD (last current value is held) <br> - user specific |
| Output damping | freely selectable, $0 \ldots 1000 \mathrm{~s}$ |
| Load | max. $600 \Omega$, influence negligible |
| max. ripple | $\mathrm{U}_{\text {SS }}=200 \mathrm{mV}$ at $47 \ldots 125 \mathrm{~Hz}$ (measured at $500 \Omega$ ) |
| max. noise | $\mathrm{U}_{\text {eff }}=2,2 \mathrm{mV}$ at $500 \mathrm{~Hz} . . .10 \mathrm{kHz}$ (measured at $500 \Omega$ ) |

1) The HART signal is assigned to the first analogue output. The second analogue output does not carry a HART signal.

## Relay outputs

| Number | 1,3 or 6; depending on the instrument version |
| :---: | :---: |
| Type | potential-free relay, SPDT, can be inverted |
| Assignable functions | - limit (inband, out-of-band, trend, level limit) <br> - counting pulse ${ }^{1}$ (pulse width adjustable) <br> - time pulse ${ }^{1}$ (pulse width adjustable) <br> - alarm/diagnosis <br> (e.g. indication of backwater ${ }^{1)}$, sludge ${ }^{1}$, echo loss etc.) <br> - pump control (alternating/fixed limit/pump rate) <br> - for FMU90-* $3 * * * * * * * * * * ~ a n d ~ F M U 90-* 4 * * * * * * * * * *): ~$ <br> additional pump control (standby pump, storm function to avoid unnecessary run times of the pumps, pump function test, flush control to clean pump shafts, operating hours alarm, pump alarm) <br> - rake control (difference or relative measurement) <br> - fieldbus relay (to be switched direclty from the Profibus DP-bus) |
| Switching power | - DC voltage: $35 \mathrm{~V}_{\mathrm{DC}}, 100 \mathrm{~W}$ <br> - AC voltage: $4 \mathrm{~A}, 250 \mathrm{~V}, 100 \mathrm{VA}$ at $\cos \varphi=0,7$ |
| State on error | selectable: <br> - HOLD (last value is held) <br> - energized <br> - de-energized <br> - present value is used |
| Behaviour after power failure | switch-on delay selectable |
| LEDs ${ }^{2)}$ | A yellow LED on the front panel is allocated to each relay, which lights if the relay is energized. <br> The LED of an alarm relay lights during normal operation. <br> The LED for a pulse relay briefly flashes at every pulse. |

1) for instrument versions with flow software (FMU90 - *2**********)
2) for instrument versions with display and operating module

## PROFIBUS DP interface

| Profile | 3.0 |
| :---: | :---: |
| Transmittable values | - main value (level or flow, depending on the instrument version) <br> - distances <br> - counters <br> - temperatures <br> - average/difference/sum <br> - relay states <br> - rake control <br> - pump control |
| Function blocks | - 10 Analog Input Blocks (AI) <br> - 10 Digital Input Blocks (DI) <br> - 10 Digital Output Blocks (DO) |
| Supported baud rates | - 9.6 kbaud <br> - 19.2 kbaud <br> - 45,45 kbuad <br> - 93.75 kbaud <br> - 187.5 kbaud <br> - 500 kbaud <br> - 1.5 Mbaud <br> - 3 Mbaud <br> - 6 Mbaud <br> - 12 Mbaud |
| Service Access Points (SAPs) | 1 |
| ID number 1540 (hex) | 1540 (hex) = 5440 (dec) |
| GSD file | EH3x1540.gsd |
| Addressing | via dip switches at the instrument or via software (e.g. FieldCare) Default address: 126 per software |
| Termination | can be activated/deactivated in the instrument |
| Locking | The device can be locked by hardware or software. |

## Auxiliary energy

## Supply voltage/

Power consumption/
Current consumption

| Instrument version | Supply voltage | Power consumption | Current consumption |
| :--- | :--- | :--- | :--- |
| AC voltage <br> $\left(\right.$ FMU90 $\left.-* * * * A^{* * * *}\right)$ | $90 \ldots 253 \mathrm{~V}_{\mathrm{AC}}(50 / 60 \mathrm{~Hz})$ | max. 23 VA | max. 100 mA at $230 \mathrm{~V}_{\mathrm{AC}}$ |
| DC voltage <br> $\left(\right.$ FMU90 $\left.-* * * * \mathrm{~B}^{* * * *}\right)$ | $10,5 \ldots 32 \mathrm{~V}_{\mathrm{DC}}$ | max. 14 W (typically 8 W$)$ | max. 580 mA at $24 \mathrm{~V}_{\mathrm{DC}}$ |

Galvanic isolation
The following terminals are galvanically isolated from each other:

- auxiliary energy
- sensor inputs
- analogue output 1
- analogue output 2
- relay outputs
- bus connection (PROFIBUS DP)


## Fuse

- 2 A T /DC
- $400 \mathrm{mAT} / \mathrm{AC}$
accesible in the terminal compartment


## Electrical connection

Terminal compartment of the field housing

The field housing has a separate terminal compartment. It can be opened after loosening the four screws of the lid.


For easier wiring, the lid can be completely removed by unplugging the display plug (1) and pulling off the hinges (2):


| Cable entries of the field | On the bottom of the housing the following openings for cable entries are prestamped: |
| :--- | :--- |
| housing | M20x1,5 (10 openings) |
| - M16x1,5 (5 openings) |  |
| - M25x1,5 (1 opening) |  |

A suitable cutting device must be used for cutting out the openings.

Terminal compartment of the DIN-rail housing

## Single instrument



The catch can be unlocked by slightly pressing onto the clip. Then, the cover of the terminal compartment can be opened.

Several instruments mounted side by side


1. Open the catch of the cover (e.g. by a screwdriver).
2. Pull the cover out by approx. 2 cm .
3. The cover can now be opened.

## Note!

- The cables can be inserted into the housing from above or from below.
- The pictures show the smallest housing version but are valid for the larger versions as well.
- If the instruments are mounted next to each other and if the sensor cables run in parallel, the synchronization terminals (39 and 40) must be interconnected (see sections "Terminal assignment" and Synchronization line").


## Terminal assignment

Pluggable spring-force terminals for connection of the cables are supplied in the terminal compartment. Rigid conductors or flexible conductors with cable sleeve can directly be inserted and are contacted automatically.

| Conductor cross section | $0,2 \mathrm{~mm}^{2}-2,5 \mathrm{~mm}^{2}$ |
| :--- | :--- |
| Cable and sleeve cross section | $0,25 \mathrm{~mm}^{2}-2,5 \mathrm{~mm}^{2}$ |
| min. stripping length | 10 mm |

The terminal configuration depends on the instrument version ordered. There is a basic terminal area, which is present in every instrument version. Additonal optional terminal areas are only present if the respective option has been selected in the product structure.

| Terminal area |  | present for the following instrument versions |
| :---: | :---: | :---: |
| Basic area | A | for all versions |
| Optional areas | B | for instrument versions with 2 sensor inputs and/or 2 analogue outputs (FMU90 - *****2****** and/or FMU90 - ******* $2^{* * * *) ~}$ |
|  | C | for instrument versions with 3 or 6 relays (FMU90 - ****** $3 * * * * *$ oder FMU90 - ************) |
|  | D | for instruments with external switch inputs and external temperature input (FMU90 - ********B***) |
|  | E | for instrument versions with PROFIBUS DP interface (FMU90 - *******3****) |


| A | B | C | D | E |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |

Terminals of the Prosonic S; the terminals depicted in grey are not present in every instrument version.
A: Basic terminal area; B-E: Optional terminal areas (present if the respective option has been selected in the product structure)

Note!
The depicted switching states of the relays refer to the de-energized state.

| Terminals | Meaning | Terminal area | Remarks |
| :---: | :---: | :---: | :---: |
| Auxiliary energy |  |  |  |
| 1,2 | - L (für AC version) <br> - L+ (for DC version) | A | depending on instrument version: <br> - 90 ... $253 \mathrm{~V}_{\mathrm{AC}}$ <br> - 10,5 ... $32 \mathrm{~V}_{\mathrm{DC}}$ |
| 2 | - N (for AC version) <br> - L- (for DC version) | A |  |
| 3 | Potential equalization | A |  |
| Fuse |  | A | depending on instrument version: <br> - 400 mAT (for AC) <br> - 2 A T (for DC) |
| Analog outputs (not available for Profibus DP instruments) |  |  |  |
| 4, 5 | Analog output 1; <br> 4 ... 20 mA with HART/ <br> 0 ... $20 \mathrm{~mA} \mathrm{w} / \mathrm{o}$ HART | A | not present for the PROFIBUS DP version |
| 41, 42 | Analog output 2 (optional); <br> 4 ... $20 \mathrm{~mA} /$ <br> 0 ... 20 mA | B | only for the version with two analog outputs; no HART signal at this output |
| Relay outputs |  |  |  |
| 6, 7, 8 | Relay 1 | A |  |
| 50, 51, 52 | Relay 2 (optional) | C | only for the versions with 3 or 6 relays |
| 53, 54, 55 | Relay 3 (optional) | C | only for the versions with 3 or 6 relays |
| 56, 57, 58 | Relay 4 (optional) | C | only for the version with 6 relays |
| 59, 60, 61 | Relay 5 (optional) | C | only for the version with 6 relays |
| 62, 63, 64 | Relay 6 (optional) | C | only for the version with 6 relays |
| Bus communication (only available for Profibus DP instruments) |  |  |  |
| 65 | PROFIBUS A (RxT/TxD - N) | D | only for the PROFIBUS DP version |
| 66 | PROFIBUS B (RxT/TxD - P) | D |  |
| Synchronization |  |  |  |
| 39, 40 | Synchronization | A | see section 4.6, "Synchronization line" |
| Level inputs |  |  |  |
| 9 (YE), <br> 10 (BK), <br> 11 (RD) | Sensor 1 (FDU8x/9x) <br> YE: yellow strand BK: black strand RD: red strand | - A: for versions with 1 sensor input <br> - B: for versions with 2 sensor inputs ${ }^{1)}$ |  |
| $\begin{aligned} & 12 \text { (YE), } \\ & 13 \text { (BK), } \\ & 14 \text { (RD) } \end{aligned}$ | Sensor 2 (FDU8x/9x) (optional) <br> YE: yellow strand <br> BK: black strand <br> RD: red strand | B | only for the version with 2 sensor inputs |
| external switch inputs |  |  |  |
| 71, 72, 73 | external switch input 1 | D | $0:<8 \mathrm{~V}$ or 72 and 73 interconnected <br> $1:>16 \mathrm{~V}$ or 72 and 73 not interconnected |
| 74, 75, 76 | external switch input 2 | D | $0:<8 \mathrm{~V}$ or 75 and 76 interconnected <br> 1: $>16 \mathrm{~V}$ or 75 and 76 not interconnected |
| 77, 78, 79 | external switch input 3 | D | $0:<8 \mathrm{~V}$ or 78 and 79 interconnected <br> 1: $>16 \mathrm{~V}$ or 78 and 79 not interconnected |
| 80, 81, 82 | external switch input 4 | D | $0:<8 \mathrm{~V}$ or 81 and 82 interconnected <br> $1:>16 \mathrm{~V}$ or 81 and 82 not interconnected |
| temperature input |  |  |  |
| 83, 84, 85 | temperature input: <br> - PT100 <br> - FMT131 (Endress+Hauser) | D | see section <br> "Connection of a temperature sensor" |

1) In this case, terminals $9 / 10 / 11$ are not present on terminal area $A$.


Warning!
When using the public supply mains, an easily accesible power switch must be installed in the proximity of the device. The power switch must be marked as a disconnector for the device (IEC/EN 61010)
Note!

- In order to avoid interference signals, the sensor cables should not be laid parallel to high voltage or electric power lines.
- The cables may not be laid in the proximity to frequnecy converters.

Additional elements on the terminal areas

| Designation | Meaning/Remarks |
| :--- | :--- |
| Fuse | Fuse: 2 A T /DC or $400 \mathrm{~mA} \mathrm{T/AC}$ |
| Display | Connection of the display or the remote display and operating module |
| Service | Service interface for connection of a PC/Notebook via Commubox FXA291 |
| R er | Locking switch |
| Term. | Bus termination (only applicable for instruments with PROFIBUS interface) |
| Address | Bus address (only applicable for instruments with PROFIBUS interface) |

## Terminals

Pluggable spring-force terminals for connection of the cables are supplied in the terminal compartment. Rigid conductors or flexible conductors with cable and sleeve can directly be inserted and are contacted automatically.

| Conductor cross section | $0,2 \mathrm{~mm}^{2}-2,5 \mathrm{~mm}^{2}$ |
| :--- | :--- |
| Cable and sleeve cross section | $0,25 \mathrm{~mm}^{2}-2,5 \mathrm{~mm}^{2}$ |
| min. stripping length | 10 mm |

## Connection of the sensors

 FDU9x
(A): Terminal box (recommended or cable lengths > 30 m ); (B): Grounding at the terminal box; (C): Grounding at the transmitter or in the control room; (1): Terminals for sensor input 1 at the FMU9x; (2): Terminals for sensor input 2 at the FMU9x (optional)

For details refer to Technical Information TI 396F.

## Synchronization line

- If wiring several Prosonic S (FMU90/FMU95) which are mounted in a common cabinet and if the sensor cables run in parallel, the synchronization terminals (39 and 40) must be interconnected.
- Up to 20 instruments can be synchronized in this way.
- If there are more than 20 instruments, groups must be formed, each containing a maximum of 20 instruments. For the instruments within each group, the sensor cables may run in parallel. The sensor cables of different groups must be seperated from each other.
- Usual commercial screened cable can be used for synchronization
- max. length: 10 m between the individual instruments
- cross section: $2 \times\left(0.75-2.5 \mathrm{~mm}^{2}\right)$
- for lengths up to 1 m , an unscreened cable can be used; for lenghts exceeding 1 m , screening is required. The screen must be connected to ground
- Instruments of the Prosonic FMU86x family can be connected to the synchronization line as well. In this case a maximum of 10 instruments can be connected to each synchronisation line.


Connection of the separate display and operating module


For the version of the Prosonic $S$ with a separate display for panel mounting, a pre-assembled connecting cable $(3 \mathrm{~m})$ is supplied. The cable must be connected to the display plug of the Prosonic S .
Note!
Minimum diameter for cable bushing: 2 cm

Connection of external switches (for FMU90-********B***)


The maximum short-circuit current at 24 V is 20 mA .

Connection of a temperature sensor

The Prosonic S FMU90 transmitter has an optional input for an external temperature probe (in the product structure: feature 90 "Additional input", olption B). The following probes can be connected:

- a FMT131 temperature probe from Endress+Hauser
- a Pt100 temperature probe

Note!
After connecting an external temperature sensor, the following is required:

1. The type of the connected sensor (Pt100 or FMT131) must be selected in "sensor management/ext. temp. sensor" in the "sensor type" parameter.
2. The external temperature sensor must be assigned to an ultrasonic sensor in "sensor management/FDU sensor/US sensor N " in the "temp. measurement" parameter.
Note!
If the option "alarm" has been selected for the case of an error in external temperature sensor, this alarm is indicated by the alarm relay.

FMT131 (Endress+Hauser)
(connectable to FMU90-********B***)

A: Non-Ex area (FMT131-R); B: Ex area (FMT131-J) with grounding in the FMU90;
C: Ex area (FMT131-J) with crounding at a terminal box
BK: black; YE: yellow; YEGN: yellow-green

Note!
For details refer to the Operating Instructions KA019F.

Pt100
(connectable to FMU90-********B***)


A: Pt100 with 3-wire connection; B: Pt100 with 4-wire connection (one connector remains unused)

Note!
A Pt100 with 2-wire connection may not be used due to its insufficient measuring accuracy.
Warning!
A Pt100 may not be connected in explosion hazardous areas. A FMT131 must be used instead.

## Performance characteristics

| Reference operating conditions | - Temperature $=24 \pm 5^{\circ} \mathrm{C}$ <br> - Pressure $=960 \pm 100 \mathrm{mbar}$ <br> - Relative humidity $=60 \pm 15 \%$ <br> - Ideally reflecting surface, sensor vertically aligned (e.g. calm, plane liquid surface of $1 \mathrm{~m}^{2}$ ) <br> - No interference echoes within the signal beam <br> - Settings of the application parameters: <br> - tank shape = flat ceiling <br> - medium property $=$ liquid <br> - process condition = calm surface |
| :---: | :---: |
| Measuring uncertainty ${ }^{5}$ | $\pm 0,2 \%$ of the maximum span of the sensor |
| Typical accuracy ${ }^{(0)}$ | $\pm 2 \mathrm{~mm}+0,17 \%$ of the measured distance |
| Measured value resolution | 1 mm with FDU91 |
| Measuring frequency | $\text { max. } 3 \mathrm{~Hz}$ <br> The exact value depends on the settings of the application parameters and the instrument version. <br> Note! <br> The maximum measuring frequency is obtained for "empty E" $\leq 2 \mathrm{~m}$ and "process condition" = "test: no filter". |
| Influence of the vapor pressure | The vapor pressure at $20^{\circ} \mathrm{C}\left(68^{\circ} \mathrm{F}\right)$ gives a hint on the accuracy of the ultrasonic level measurement. If the vapor pressure at $20^{\circ} \mathrm{C}\left(68^{\circ} \mathrm{F}\right)$ is below 50 mbar , ultrasonic level measurement is possible with a very high accuracy. This is valid for water, aqueous solutions, water-solid-solutions, dilute acids (hydrochloric acid, sulfuric acid, ...), dilute bases (caustic soda, ...), oils, greases, slurries, pastes, ... <br> High vapor pressures or outgassing media (ethanol, acetone, ammonia, ...) can influence the accuracy. If conditions like these are present, please contact the Endress+Hauser support. |

## Ambient conditions

| Ambient temperature | $-40 \ldots 60^{\circ} \mathrm{C}$ <br> The functionality of the LC display becomes restricted at $\mathrm{T}_{\mathrm{U}}<-20^{\circ} \mathrm{C}$. <br> If the device is operated outdoors in strong sunlight, a protective cover should be used (s. chapter "Accessories"). |
| :---: | :---: |
| Storage temperature | $-40 \ldots 6{ }^{\circ} \mathrm{C}$ |
| Climate class | - Field housing: according to DIN EN 60721-3 4K2/4K5/4K6/4Z2/4Z5/4C3/4S4/4M2 (DIN 60721-3 4K2 corresponds to DIN 60654-1 D1) <br> - Housing for DIN rail mounting: according to DIN EN 60721-3 3K3/3Z2/3Z5/3B1/3C2/3S3/3M1 (DIN 60721-3 3K3 corresponds to DIN 60654-1 B2) |
| Vibration resistance | - Housing for DIN rail: DIN EN 600068-2-64 / IEC 68-2-64; 20 ... $2000 \mathrm{~Hz} ; 0,5\left(\mathrm{~m} / \mathrm{s}^{2}\right)^{2} / \mathrm{Hz}$ <br> - Field housing: DIN EN 600068-2-64 / IEC 68-2-64; 20 ... $2000 \mathrm{~Hz} ; 1,0\left(\mathrm{~m} / \mathrm{s}^{2}\right)^{2} / \mathrm{Hz}$ |
| Ingress protection | - Field housing: IP66 / NEMA 4x <br> - Housing for DIN rail: IP20 <br> - separate display: <br> - IP65 / NEMA 4 (front panel, if mounted in cabinet door) <br> - IP20 (rear panel, if mounted in cabinet door) |

[^17]Electromagnetic compatibility - Interference emmission to EN 61326; Equipment class A
(EMC) - Interference immunity to EN 61326; Annex A (Industrial) and NAMUR recommendation EMC (NE21)

## Mechanical construction

## Housing versions

- Field housing; optionally with integrated display and operating module
- Housing for top-hat rail mounting; optionally with intergrated display and operating module
- Housing for top-hat rail mounting with separated display and operating module for cabinet door mounting


## Dimensions of the field housing



Dimensions in mm
A: Mounting help (supplied); can also be used as drilling template ; B: Field housing; C: minimum mounting distance

The dimensions of the field housing are the same for all instrument versions.
To open the housing, a minimum mounting distance of 55 mm is required on the left.
Note!
The mounting help must be mounted on a plane surface and must not become bent. Otherwise the mounting of the field housing may be difficult or impossible.

Dimensions of the DIN-rail housing

The dimensions of the DIN-rail housing depend on the instrument version. The version determines, which terminal areas the Prosonic S contains. The dimensions are influenced by the following features of the product structure (see chapter 2.3):

- 60: Level Input
- 70: Switch Output
- 80: Output

In order to determine the dimensions of a specific version, perform the following steps (see the example on page 25):

1. Using the product structure, determine the options of the features 60,70 and 80 of the instrument version in question.

|  | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| FMU90-- |  |  |  |  |  |  |  |  |  |

2. Using the following table, determine how many optional terminal areas this instrument version contains.

| Feature and option of <br> the product structure | corresponds to the following <br> terminal area | present? <br> yes =1 <br> no =0 |
| :--- | :--- | :--- |
| feature 60; option 2 <br> and/or <br> feature 80, option 2 | 2 sensor inputs <br> and/or <br> 2 analogue outputs |  |
| feature 70, option 3 or 6 | 3 o 6 relays |  |
| feature 80, option 3 | PROFIBUS DP interface |  |
| feature 90, option B | inputs for external switches and <br> external temperature sensor |  |

3. The appropriate dimensions are given in the following diagram:

Sum = 0 (only basic terminal area)


Dimensions in mm

Sum =1, 2 or 3
(1-3 optional terminal areas)


Dimensions in mm

Sum $=4$
(4 optional terminal areas)


Dimensions in mm

Example

|  | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| FMU90 - | R | 1 | 2 | A | A | 2 | 3 | 2 | A | A | 1 | A |


| feature and option of <br> the product structure | corresponds to the following <br> terminal area | present? |
| :--- | :--- | :---: |
| feature 60; option 2 <br> and/or <br> feature 80, option 2 | 2 sensor inputs <br> and/or <br> 2 analogue outputs | 1 (yes) |
| feature 70, option 3 or 6 | 3 or 6 relays | 1 (yes) |
| feature 80, option 3 | PROFIBUS DP interface | 0 (no) |
| feature 90, option B | inputs for external switches and <br> external temperature sensorr | 0 (no) |

Sum $=2$
=> $104 \mathrm{~mm} \times 150 \mathrm{~mm} \times 140 \mathrm{~mm}$

Dimensions of the separate display and operating module


Dimensions in mm

| Weight | Housing version Weight <br> Field housing approx.. $1,6 \ldots 1,8 \mathrm{~kg}$; depending on instrument version <br> Housing for DIN rail approx. $0,5 \ldots 0,7 \mathrm{~kg}$; depending on instrument version (s. section: "Dimensions of the DIN-rail <br> housing") <br> separate display and <br> operating module approx. 0,5 kg |  |
| :--- | :--- | :--- |

Materials

- Field housing: PC
- Housing for DIN rail: PBT


## Human interface

## Display and operating module


(a): name of the parameter; (b): value of the parameter, including unit; (c): display symbols; (d): softkey symbol; (e): LED indicating the operating state; (f): LEDs indicating the switching states of the relays; (g): keys

## Display (Examples)



Display of a function including help text and descriptive graphic

## envelope curve IK129



Display of the envelope curve including the mapping. The level echo and the empty distance are marked.

## Keys (softkey operation)

The function of the keys depends on the current position within the operating menu (softkey functionality). The key functions are indicated by softkey symbols in the bottom line of the display.

## LEDs

- 1 LED (a) indicates the operating state ("normal operation", "alarm" or "warning")
- 6 LEDs (b) indicate the switching state of the relays (LED glows if the respective relay is energised)


## Illuminated display

An illuminated display is available as an option (s. feature 40 of the product structure)

## Operating menu

Basic setup

The Prosonic S has got a dynamical operating menu. Only those functions are visible which are relevant for the instrument version and installation environment at hand.

Locking of the instrument The instrument can be locked against parameter changes in the following ways:
The operating menu contains basic setups for easy commissioning of level and flow measurements. The basic setups guide the user through the complete commissioning procedure.

- Locking switch in the terminal compartment
- Key combination at the operating module
- Input of a locking code via software (e.g. "ToF Tool" or "FieldCare")


## Certificates and Approvals

| CE mark | The measuring system meets the legal requirements of the EC-guidelines. Endress+Hauser confirms the <br> instrument passing the required tests by attaching the CE-mark. |
| :--- | :--- |
| Ex approval | The available certificates are listed in the ordering information. Note the associated safety instructions (XA) and <br> control or installation drawings (ZD). <br> Measuring systems for use in hazardous environments are accompanied by separate "Ex documentation", <br> which is an integral part of this Operating Manual. Strict compliance with the installation instructions and <br> ratings as stated in this supplementary documentation is mandatory. <br> a Ensure that all personnel are suitably qualified. <br> - Observe the specifications in the certificate as well as national and local standards and regulations. <br> The transmitter may only be installed in suitable areas. <br> Sensors with a certificate for hazardous areas may be connected to a transmitter without a certificate. <br> Warning! <br> For FM approvals: <br> Unauthorized substitution of components may impair the suitability for Division 1 or Division 2. <br> Warning! <br> Do not disconnect equipment unless the area is known to be non-hazardous. <br> Note! <br> The sensor must be installed and used in a way that eliminates any danger. Possible installation positions: in <br> tanks, vessels, silos, over stockpiles, open channels, weirs or other bins. |
| Note! |  |
| Sensors FDU9x with Ex-approval can be connected to the transmitter FMU90 without Ex-approval. |  |

## Ordering information

## Product structure


(*): meaning of the language code:
cs: Czech; de: German; en: English; es: Spanish; fr: French; id: Bahasa (Indonesia, Malaysia); it: Italian; ja: Japanese; ko: korean; nl: Dutch; pl: Polish; pt: Portuguese; ru: Russian; th: Thai; zh: Chinese

## Scope of delivery

- Instrument according to the version ordered
- Operating program: ToF Tool - FieldTool Package
- Operating Instructions (depending on communication version, see chapter "Supplementary documentation")
- for certified instrument versions: Safety Instructions (XAs) or Control Drawings (ZDs) (s. chapter "Supplementary documentation")
- field housing units for flow measurement FMU90-*21********* are delivered with 2 screws for plombing the device


## Accessories

| Commubox FXA191 HART | For intrinsically safe communication with ToF Tool/FieldCare via the RS232C interface. For details refer to <br> TI237F/00/en. |
| :--- | :--- |
| Commubox FXA195 HART | For intrinsically safe communication with ToF Tool/FieldCare via the USB interface. For details refer to <br> TI404F/00/en. |
| For intrinsically safe communication with ToF Tool/FieldCare via the service interface (IPC) of the instrument <br> and the USB interface of a PC/Notebook. <br> Ordering Code: 51516983 |  |
| Commubox FXA291 <br> Pousing | - Material: 316Ti/1.4571 <br> - Order-Code: 52024477 |

## Mounting plate for the field

## housing

- suited for the mounting help of the Prosonic $S$
- for $1^{\prime \prime}-2$ tubes
- Dimensions: $210 \mathrm{~mm} \times 110 \mathrm{~mm}$
- Material: 316Ti/1.4571
- fixing clips, screws and nuts are supplied
- Order code: 52024478


A: mounting help of the field housing

## Mounting bracket



| Height | Material | Order Code |
| :--- | :--- | :--- |
| 700 mm | galv. steel | $919791-0000$ |
| 700 mm | 316 Ti | $919791-0001$ |
| 1400 mm | galv. steel | $919791-0002$ |
| 1400 mm | 316 Ti | $919791-0003$ |

Adaption plate for remote display

Used to mount the remote display into the opening ( $138 \mathrm{~mm} \times 138 \mathrm{~mm}$ ) of the remote display module of the Prosonic FMU860/861/862 (Display size: 144 x 144 mm ).

Order-Code: 52027441
(4) Note!

The adapter plate will be mounted directly in the old remote display of the FMU86x series. The housing of the remote display of FMU860/861/862 is the holder for the adapter plate and the new remote display of the FMU90/95 in the format $96 \times 96 \mathrm{~mm}$.

(a): remote display of the Prosonic $S$ with adaption plate; (b): opening of the remote display FMU860/861/862

Option:
Adaption plate 160x160 mm, thickness 3mm, aluminum, opening 92 x 92 mm for remote display of the FMU90 (size of the display: $96 \times 96 \mathrm{~mm}$ ).
Can be used to replace the FMU86x remote display or DMU2160/2260.
Order Code: TSPFU 0390
Please contact your Endress+Hauser representative.

## Overvoltage protection

## HAW56x

## Application examples

| Measurement signal | Measurement point requirements | Connection diagram |
| :---: | :---: | :---: |
| - Current output 1 0/4 to 20 mA <br> - Current output 2 $0 / 4$ bis 20 mA <br> Transducer Prosonic S FMU90 with 2 Prosonic FDU9x sensors | - $2 \times$ HAW560 + 562 for $0 / 4$ to 20 mA output signal <br> - $2 \times$ HAW561 for power supply to the transducer <br> - $2 \times$ HAW560 +566 for the sensor signal Use gas discharge tube for indirect shield earthing. |  |
| - Current output $0 / 4$ to 20 mA <br> Prosonic S FMU90 transducer with Prosonic FDU9x level measurement sensors | - $1 \times$ HAW $560+562$ for $0 / 4$ to 20 mA output signal <br> - $2 \times$ HAW561 for power supply to the transducers <br> - $1 \times$ HAW560 + 566 for the sensor signal Use gas discharge tube for indirect shield earthing. |  |


| Measurement signal | Measurement point requirements | Connection diagram |
| :---: | :---: | :---: |
| no current output (only relay outputs) <br> Prosonic S FMU90 transducer with Prosonic FDU9x level measurement sensor | - $1 \times$ HAW560 + 1 x HAW566 for sensor signal. Use gas discharge tube for indirect shield earthing. <br> - $2 \times$ HAW561 for power supply |  |

Note!
HAW560 with the HAW562 module can also be used to protect the signal line of the external temperature probe FMT131 (Ex or Non-Ex version).

## Electrical connection

Power supply: HAW561 and 561K


A fixed allocation of the phase and ground terminal is not allocated (pole security). The unit is fitted on both ends with a multi function connection terminal. This gives the opportunity to simultaneously connect a cable as well as a fork ferrule from standard busbars.
Connection of the unit is as in the diagram above. Dependent on the cabling, up to four units will be required.
Sensor signal: HAW560 with HAW560


Connection of the unit as in the diagram. The ground connection is made using the DIN rail.
For indirect screening (as required if connecting the Prosonic S signal line to an HAW566) a gas-discharge arrester is supplied. It must be inserted into the provided plug-in bay on the HAW560:


## Output signal



Connection of the unit as in the diagram. The ground connection is made using the DIN rail.

Product overview

| Oreder code | Unit |
| :--- | :--- |
| 51003569 | Surge arrester HAW561K <br> For low voltage users 24/48V, single pole, requirement class C, basic component with <br> plugged in protection unit, defect display, 18 mm housing width |
| 51003570 | Surge arrester HAW561 <br> For standard voltage users 115/230 V, single pole, requirement class C, basic component <br> with plugged in protection unit, defect display, 18 mm housing width |
| 51003571 | Surge arrester module carrier HAW560 <br> Two pole through terminated for fitting surge arrester modules for units in information <br> technology, 12 mm housing width, colour grey |
| 51003572 | Surge arrester module HAW562 <br> For protection of 2 single lines, e.g. 2 asymmetrical single lines, <br> e.g.: 0/4 to 20 mA, Profibus PA, 12 mm housing width, colour grey |
| 51003573 | Surge arrester module HAW565 <br> For protection of 2 single lines, e.g. 2 asymmetrical single lines with high frequency signal <br> transmission, e.g.: Profibus DP, RS 485, 12 mm housing width, colour grey |
| 51003574 | Surge arrester module carrier HAW560Z <br> Two pole through terminated for fitting surge arrester modules for units in information <br> technology in Ex areas, 12 mm housing width, colour blue |
| 51003575 | Surge arrester module HAW562 <br> For protection of 2 single lines, e.g. 2 asymmetrical single lines in Ex areas, <br> e.g.: 0/4 to 20 mA, Profibus PA, 12 mm housing width, colour blue |
| 71028875 | Surge arrester module HAW566 <br> Protection for 2 signal inputs, e.g. 2 asymmetrical inputs, e.g. Prosonic S signal <br> 12 mm housing with, colour grey |

For details see Technical Information TI093R.

## Temperature sensor FMT131



A: Temperature sensor FMT131; B: weather protector

## Product structure

| 010 | Approval |  |  |
| :---: | :---: | :---: | :---: |
|  | R R | $\left\lvert\, \begin{array}{ll} \text { No } \\ \text { ATI } \\ \mathrm{FM} \\ \mathrm{CS} \\ \mathrm{CS} \end{array}\right.$ | n-hazardous area EX II 2G EEx m II T6/T5 Cl.I Div. 1 Gr. A-D A General Purpose A Class I Div. 1 |
| 020 | Cable length |  |  |
|  |  | 1 2 3 3 4 5 5 6 7 7 8 A | $5 \mathrm{~m} / 16 \mathrm{ft}$ $10 \mathrm{~m} / 32 \mathrm{ft}$ $15 \mathrm{~m} / 49 \mathrm{ft}$ $20 \mathrm{~m} / 65 \mathrm{ft}$ $25 \mathrm{~m} / 82 \mathrm{ft}$ $30 \mathrm{~m} / 98 \mathrm{ft}$ $\mathrm{w} / \mathrm{o}$ cable, gland Pg16, IP66 $\ldots \mathrm{m}$ $\ldots \mathrm{ft}$ |
| FMT131- |  |  | \| complete product designation |

## Weather protection cover for FMT131

Order code: 942046-0000

## Supplementary documentation

| Innovation booklet | IN 003 |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Ultrasonic measurement - the solution for your application |  |  |  |
| Technical Information | TI 396F |  |  |  |
|  | Technical Information for the ultrasonic sensors FDU91/FDU92/FDU93/FDU95/FDU96 |  |  |  |
| Operating instructions (for transmitter FMU90) | Depending on the instrument version, the following operating instructions are supplied with the Prosonic $S$ FMU90: |  |  |  |
|  | Operating instructions | Output | Application | Instrument version |
|  | BA 288F | HART | - level measurement <br> - alternating pump control <br> - screen and rake control | $\begin{aligned} & \text { FMU90 - ******* } 1 \text { **** } \\ & \text { FMU90 - *******2*** } \end{aligned}$ |
|  | BA 289F |  | - flow measurement <br> - backwater and dirt detection <br> - totalizers and counters | $\begin{aligned} & \text { FMU90 - *2***** } 1 * * * * \\ & \text { FMU90 - *4***** } 1 * * * \\ & \text { FMU90 - *2*****2**** } \\ & \text { FMU90 - *4*****2*** } \end{aligned}$ |
|  | BA 292F | PROFIBUS DP | - level measurement <br> - alternating pump control <br> - screen and rake control | FMU90 - *******3**** |
|  | BA 293F |  | - flow measurement <br> - backwater and dirt detection <br> - totalizers and counters | $\begin{aligned} & \text { FMU90 - *2*****3**** } \\ & \text { FMU90 - *4*****3**** } \end{aligned}$ |

These operating instructions describe installation and commissioning of the respective version of the Prosonic S. It contains those functions from the operating menu, which are required for a standard measuring task. Additional functions are contained in the "Descripiton of Instrument Functions" (BA 290F, see below).

## Description of Instrument Functions

## BA290F

contains a detailed description of all functions of the Prosonic $S$ and is valid for all instrument versions. A PDF file of this document can be found

- on the CD-ROM of the "ToF-Tool - FieldTool Package", which is supplied together with the instrument
- in the internet at "www.endress.com"


## Safety Instructions

## XA326F

Safety Instructions for ATEX II 3D

Endress+Hauser
Instruments International AG
Kaegenstrasse 2
4153 Reinach
Switzerland

Tel. +41617158100
Fax +41617152500
www.endress.com
info@ii.endress.com

## 7. NHP

## Miniature general purpose relay

## Flat pin



Coil specifications

| Nominal voltage ( $\left.\mathrm{U}_{\mathrm{N}}\right)^{1}$ ) | $\begin{array}{r} (50 / 60 \mathrm{~Hz}) \mathrm{AC} \\ \mathrm{DC} \end{array}$ | $\begin{aligned} & 12,24,32,48,110,240 \\ & 12,24,48,110 \end{aligned}$ | $\begin{aligned} & 12,24,32,48,110,240 \\ & 12,24,32,48,110 \end{aligned}$ |
| :---: | :---: | :---: | :---: |
| Rated power AC/DC |  | $1.5 \mathrm{VA} / 1 \mathrm{~W}$ |  |
| Operation range | ( 50 Hz ) AC | (0.8...1.1) $\mathrm{U}_{\mathrm{N}}$ |  |
|  | $D C$ | (0.8...1.1) $\mathrm{U}_{\mathrm{N}}$ |  |
| Holding voltage AC/DC |  | $0.8 \mathrm{U}_{\mathrm{N} / 0.5} \mathrm{U}_{\mathrm{N}}$ |  |
| Must drop-out voltage AC/DC |  | 0.2 $\mathrm{U}_{\mathrm{N} / 0.1} \mathrm{U}_{\mathrm{N}}$ |  |

Technical data


Notes: The equipment on this page is rated $230 / 400 \mathrm{~V}$ and is suitable for use on $240 / 415 \mathrm{~V}$ systems as per AS 60038:2000.
${ }^{1}$ ) Please contact NHP for other voltages.

## Relay bases and Accessories

Bases for series 55 relays



|  |  |  |  |
| :--- | :--- | :--- | :--- |
| Cat. No. | 94.72 | 94.74 | 94.06 |
| Description | DIN rail mounting base open <br> terminals. Accepts 99-01 series <br> LED modules. | DIN rail mounting base open <br> terminals. Accepts 99-01 series <br> LED modules. | Jumper link 6 way maximum <br> $10 \mathrm{~A}, 250 \mathrm{~V}$. |
| Relay to suit | Flat pin $2 \mathrm{C} / 0(8$ pin $)$ <br> $55.32 \ldots$ | Flat pin $4 \mathrm{C} / 0$ (14 pin) <br> $55.34 \ldots$ | $94.02,94.04$ <br> $55.34 \ldots$ |
| Retaining clip | 94.71 | 94.71 |  |



Notes: Please refer to page 9-29 and 9-30 for recommended LED and diode plug-in modules. Refer to page 9-35 for relay base dimensions.

## Relay base dimensions (mm)

55 Series
Cat No. 94.02, 94.04


## Relay dimensions (mm)

55 Series
Cat. No. 55.32, 55.34


Refer catalogue KS-I


ISO 325 PY

## ISO Switch

## General information and catalogue number construction

NHP offers a comprehensive range of isolating switches designed with safety in mind. In stand-alone and enclosed formats, this switch range are padlockable and available in yellow/red or grey/black making it ideal for any electrical isolation requirement, such as repair, maintenance, installation and inspection.

## Catalogue number construction



## switch



## ISO Switch

## Safety isolating switches

## Polycarbonate enclosed rotary switches

Large padlockable red/yellow or
grey/black handles
High IP 65 rating
Easy to install and operate

- Comprehensive range, 25 to 200 A models
- High breaking capacity with 12.5 mm contact air gap

3 Pole ISO Switch


ISO 325 PY
Rated Motor application, 415 V AC 23 operational
current @
415 V AC 21
25 A
63 A

80 A
100 A
160 A

200 A
Motor application, 415 V AC 23

| Power | Current | rotor | Terminat | capacity |
| :--- | :--- | :--- | :--- | :--- |
| rating | rating | M rating | $\mathrm{mm}^{2}$ | type |

Cat. No. ${ }^{1}$ )

|  | ISO 325P |
| :---: | :---: |
|  | ISO 340P |
|  | ISO 363P |
|  | ISO 380P |
|  | ISO 3100P |
|  | ISO 3160P |
|  | ISO 3200P |

## 4 Pole ISO Switch



| 25 A | 7.5 kW | 16 |
| :--- | :--- | :--- |


| 40 A | 11 kW | 20 A |
| :--- | :--- | :--- |
| 63 A | 15 kW | 25 A |
| 80 A | 22 kW | 40 A |
| 100 A | 30 kW | 63 A |

ISO 480 PY


6 Pole ISO Switch

| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | U3 | ISO 625P_ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | U3 | IS0 640P |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | U3 | ISO 663P |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | U3 | ISO 680P |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | U3 | ISO 6100P_ |
| 160 A | 45 kW | 80 A | 640 A | 70 Cu | U4 | ISO 6160P_ |
| 200 A | 75 kW | 135 A | 1080 A | 70 Cu | U4 | ISO 6200P_ |

Notes: $\quad{ }^{1}$ ) _ = Add Y suffix for Yellow/Red handle, or G for Grey/Black.
Refer to page 11-115 for catalogue no. construction.
Enclosure dimensions are on page 11-122. 8 pole versions available on indent basis only. Ask NHP for further details.

## ISO Switch

Safety isolating switches

## Aluminium enclosed rotary switches

Large padlockable red/yellow or
grey/black handles
High IP 65 rating
Easy to install and operate

- Comprehensive range, 25 to 200 A models
- High breaking capacity with 12.5 mm contact air gap
- Easy snap-on fitting of auxiliary switches


## 3 Pole ISO Switch

| Rated | M | ation, | V AC 23 |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| operational current @ 415 V AC 21 | Power rating | Current rating | Locked rotor M rating | Terminal capacity $\mathrm{mm}^{2}$ | Enclosure type | Cat. No. ${ }^{1}$ ) |
| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | A23 | ISO 325 M |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | A23 | ISO 340 M |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | A23 | ISO 363M |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | ALF32 | ISO 380 M |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | ALF32 | ISO 3100M |
| 160 A | 45 kW | 80 A | 840 A | 70 Cu | ALF32 | ISO 3160M |
| 200 A | 75 kW | 135 A | 1080 A | 70 Cu | ALF32 | ISO 3200M |

ISO Switch 3 pole aluminium A23 type enclosures now have $4 \times$ M25 and $1 \times$ M20 threaded cable gland entries for enhanced flexibility.


4 Pole ISO Switch

| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | A23 | ISO 425M |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | A23 | ISO 440M |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | A23 | ISO 463M |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | ALF32 | ISO 480M |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | ALF32 | ISO 4100M |



ISO 625 MG

## 6 Pole ISO Switch



Notes: $\quad{ }^{1}$ ) _ = Add Y suffix for Yellow/Red handle, or G for Grey/Black.
Refer to pg 11-115 for catalogue no. construction.
Enclosure dimensions are on page 11-122.
8 pole versions available on indent basis only. Ask NHP for further details.

## ISO Switch

## Safety isolating switches

Stainless steel enclosed rotary switches

- Large padlockable red/yellow handles
- High IP 66 rating
- Easy to install and operate
- Stainless steel 316
- Comprehensive range, 25 to 200 A models
- High breaking capacity with 12.5 mm contact air gap
- Easy snap-on fitting of auxiliary switches


## 3 Pole ISO Switch



ISO 325 SSY


ISO 380 SSY


ISO 3160 SSY


ISO Switch-stainless steel enclosed are ideal for food processing industries where hygiene and corrosion resistance is a requirement.

## 4 Pole ISO Switch

Cat. No. ${ }^{1}$ )

| $\underline{25 A}$ | 7.5 kW | 16 A | 250 A | 16 Cu | H23 | i ISO 425SSY |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | H23 | i ISO 440SSY |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | H23 | i ISO 463SSY |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | H32 | i ISO 480SSY |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | H32 | i ISO 4100SSY |

## 6 Pole ISO Switch

Cat. No. ${ }^{1}$ ) Price \$

| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | H32 | i ISO 625SSY |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | H32 | i ISO 640SSY |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | H32 | i IS0 663SSY |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | H32 | i IS0 680SSY |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | H32 | i ISO 61005SY |

Notes: $\quad{ }^{1}$ ) Refer to pg 11-115 for catalogue no. construction. Enclosure dimensions are on page 11-123. 8 pole versions available on indent basis only. Ask NHP for further details.
i Available on indent only.


ISO Switch

## Safety isolating switches

## Toggle and rotary switches

- Compact and easy to fit into panelboards and loadcentres
- DIN rail mounting with front plate IP terminal cover
- Padlockable toggle and rotary operated switches
Highly visible yellow/red operating
handles on rotary switches
Large terminal capacity
Robust construction and reliable switching
performance


ISO 340 T


EVA $3250{ }^{2}$ )


ISO 325 R


## 3 Pole Toggle switch

| Rated | Mo | tion, | C 23 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| operational current @ 415 V AC 21 | Power rating | Current rating | Locked rotor M rating | Termina capacity $\mathrm{mm}^{2}$ | Cat. No. ${ }^{1}$ ) |
| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | ISO 325T |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | ISO 340T |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | ISO 363T |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | ISO 380T |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | ISO 3100T |
| 160 A | 45 kW | 80 A | 840 A | 70 Cu | ISO 3160T |
| 200 A | 75 kW | 135 A | 1080 A | 70 Cu | ISO 3200T |
| 250 A | - | - | - | 120 Cu | EVA $3250{ }^{2}$ ) |

4 Pole Toggle switch
Cat. No. ${ }^{2}$ )

| 250 A | - | - | - | 120 Cu | EVA 4250 |
| :--- | :--- | :--- | :--- | :--- | :--- |

3 Pole Rotary switch, with direct operating handle

|  |  |  |  | Cat. No. ${ }^{2}$ ) |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | ISO 325R |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | IS0 340R |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | ISO 363R |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | IS0 380R |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | IS0 3100R |

4 Pole Rotary switch, with direct operating handle

|  |  |  |  | Cat. No. ${ }^{2}$ ) |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | IS0 425R |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | IS0 440R |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | ISO 463R |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | IS0 480R |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | IS0 4100R |

## ISO Switch

## Safety isolating switches

## Rotary switches

- Compact design and easy to fit
- DIN rail mounting switch, optional snap-on auxiliary switches
- Padlockable rotary door interlock handle

Highly visible yellow/red or grey/black
operating handles
Large terminal capacity
Robust construction and reliable
switching performance

3 Pole Rotary switch without shaft or door interlock handle ${ }^{1}$ )
 Rated Motor application, 415 V AC 23

| operational <br> current @ 415 V AC 21 | Power rating | Current rating | Locked rotor M rating | Terminal capacity $\mathrm{mm}^{2}$ | Cat. No. |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | ISO 325 |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | ISO 340 |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | ISO 363 |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | ISO 380 |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | ISO 3100 |
| 160 A | 45 kW | 80 A | 840 A | 70 Cu | ISO 3160 |
| 200 A | 75 kW | 135 A | 1080 A | 70 Cu | ISO 3200 |



ISO 3160-ISO 3200

4 Pole Rotary switch without shaft or door interlock handle ${ }^{1}$ )

| 25 A | 7.5 kW | 16 A | 250 A | 16 Cu | ISO 425 | i |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 40 A | 11 kW | 20 A | 270 A | 16 Cu | ISO 440 | i |
| 63 A | 15 kW | 25 A | 320 A | 16 Cu | ISO 463 | i |
| 80 A | 22 kW | 40 A | 480 A | 35 Cu | ISO 480 | i |
| 100 A | 30 kW | 63 A | 504 A | 35 Cu | IS0 4100 | i |

Note: $\quad{ }^{1}$ ) To create a door interlock handle switch assembly, simply order the required parts and add the prices. (See accessories/spares page)
i) Available on indent


Refer catalogue KSI ISO SWitch

## Accessories and spares



## ISO Door mount kit



## ISO COM

Changeover kit includes the handle and the necessary shafts, switches not included.

Direct Handle ISO DHG 3 P/4 P
ISO DHY 3 P/4 P

ISO LTK large terminal kit


ISO 6+8 PM


ISO Switch

## Enclosure dimensions (mm)

Polycarbonate enclosures


Aluminium enclosures


Cable gland selection guide

| ISO Switch knockout hole size | Fibox |  | Thorsmans self-sealing cable glands | Metric size |
| :---: | :---: | :---: | :---: | :---: |
|  | Moulded cable glands and lock nuts | Conduit conversion adaptors |  |  |
| $\emptyset 20.5$ mm | PS 11 / PS 11 B | PG 16-20 mm plastic | TET 7-10 /C | M 20 |
| $\emptyset 25.5 \mathrm{~mm}$ | PS 16 / PS 16 B | PG 21-20 mm plastic | TET 10-14/C | M 25 |
| $\emptyset 32.5 \mathrm{~mm}$ | PS 21 / PS 21 B | - | TET 14-20/C | M 32 |

Note: $\quad$ Cable glands are also available from Section 12, refer to table for selection.

ISO Switch
Enclosure dimensions (mm)
Stainless steel enclosures


H23


H32


H02

ISO Switch
Switch dimensions (mm)
Toggle switches with terminal covers and barriers
EVA 3250



Toggle switches
ISO 325T-ISO 3100T
ISO 3160T-ISO 3200T
Rotary switch with direct handle
ISO 325R-ISO 3100R
ISO 425R-ISO 4100R


Rotary operated switches

ISO 325-ISO 3100


ISO 3160-ISO 3200


ISO 425-ISO 4100


## ISO Switch

## Technical data - ratings chart

NHP ISO Switch Isolating / Load-break switches

| Rated thermal current Ithe (A) |  |  | 25 A | 40 A | 63 A | 80 A | 100 A | 160 A | 200 A | 250 A |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  | (EVA 3250) |
| Rated insulation voltage Ui (V) |  |  | 690 V | 690 V | 690 V | 690 V | 690 V | 690 V | 690 V | 690 V |
| Rated operational current $\mathrm{I}_{\mathrm{e}}(\mathrm{~A})$ <br> AC ratings | AC 21 | 400/415 V | 25 A | 40 A | 63 A | 80 A | 100 A | 160 A | 200 A | 250 A |
|  |  | 500 V | 25 A | 40 A | 63 A | 80 A | 100 A | 160 A | 200 A | - |
|  |  | 690 V | 25 A | 40 A | 63 A | 80 A | 100 A | 160 A | 200 A | - |
|  | AC 22 | 400/415 V | 16 A | 25 A | 40 A | 63 A | 80 A | 125 A | 160 A | 250 A |
|  |  | 500 V | 16 A | 25 A | 40 A | 63 A | 80 A | 125 A | 160 A | - |
|  |  | 690 V | 16 A | 25 A | 40 A | 63 A | 80 A | 125 A | 160 A | - |
|  | AC 23 | 400/415 V | 16 A | 25 A | 32 A | 40 A | 63 A | 80 A | 135 A | 200 A |
|  |  | 500 V | 16 A | 25 A | 32 A | 40 A | 40 A | 80 A | $125 A^{1}$ ) |  |
|  |  | 690 V | 16 A | 25 A | 32 A | 40 A | 40 A | 80 A | $125 \mathrm{~A}^{1}$ ) | - |
| Rated operational power <br> (kW) <br> AC ratings | AC 23 | 230 V | 4 kW | 5.5 kW | 7.5 kW | 11 kW | 15 kW | 30 kW | 37 kW | 55 kW |
|  |  | 400/415 V | 7.5 kW | 11 kW | 15 kW | 22 kW | 30 kW | 45 kW | 75 kW | 90 kW |
|  |  | 500 V | 7.5 kW | 15 kW | 22 kW | 30 kW | 30 kW | 55 kW | 75 kW | - |
|  |  | 690 V | 11 kW | 22 kW | 30 kW | 37 kW | 37 kW | 55 kW | 90 kW | - |

Rated fused short circuit current

| Back-up fuse |  | (A) | 63 A | 63 A | 63 A | 80 A | 80 A | 160 A | 160 A | 250 A |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| RMS value |  | $\mathrm{I}_{\mathrm{k}}(\mathrm{kA})$ | 50 kA | 50 kA | 50 kA | 50 kA | 50 kA | 50 kA | 50 kA | 50 kA |
| Peak value |  | I (kA) | 5.4 kA | 6.6 kA | 7.2 kA | 8.3 kA | 8.7 kA | 13.7 kA | 15 kA | 21 kA |
| Rated short circuit making capacity |  | $\mathrm{Icm}_{\mathrm{cm}}(\mathrm{kA})$ | 5.4 kA | 6.6 kA | 7.2 kA | 8.3 kA | 8.7 kA | 13.7 kA | 15 kA | 21 kA |
| Rated short time withstand current |  | $\mathrm{I}_{\mathrm{cw}}(\mathrm{kA})$ | 0.9 kA | 1 kA | 1.1 kA | 1.6 kA | 1.7 kA | 2.8 kA | 3 kA | 6 KA |
| Rated breaking capacity $\mathrm{I}_{\mathrm{cn}}(\mathrm{~A})$ <br> AC ratings | AC 23 | 400/415 V | 250 A | 270 A | 320 A | 480 A | 504 A | 840 A | 1080 A | 1600 A |
|  |  | 500 V | 160 A | 250 A | 320 A | 380 A | 504 A | 840 A | 1000 A | - |
|  |  | 690 V | 130 A | 160 A | 200 A | 260 A | 320 A | 840 A | 1000 A | - |
| Rated operational current <br> Ie: (Amps / poles in series) DC ratings | DC 21 | 48 V | $16 \mathrm{~A} / 3 \mathrm{P}$ | $25 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $63 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 110 V | $16 \mathrm{~A} / 3 \mathrm{P}$ | $25 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $63 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 220 V | $16 \mathrm{~A} / 3 \mathrm{P}$ | $25 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $63 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 440 V | $16 \mathrm{~A} / 4 \mathrm{P}$ | $25 \mathrm{~A} / 4 \mathrm{P}$ | $40 \mathrm{~A} / 4 \mathrm{P}$ | $63 \mathrm{~A} / 4 \mathrm{P}$ | $80 \mathrm{~A} / 4 \mathrm{P}$ | $125 \mathrm{~A} / 4 \mathrm{P}$ | $160 \mathrm{~A} / 4 \mathrm{P}$ | - |
|  | DC 22 | 48 V | $16 \mathrm{~A} / 3 \mathrm{P}$ | $25 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $63 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ |  |
|  |  | 110 V | $16 \mathrm{~A} / 3 \mathrm{P}$ | $25 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $63 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 220 V | $16 \mathrm{~A} / 3 \mathrm{P}$ | $25 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $63 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 440 V | $16 \mathrm{~A} / 4 \mathrm{P}$ | $10 \mathrm{~A} / 4 \mathrm{P}$ | $16 \mathrm{~A} / 4 \mathrm{P}$ | $25 \mathrm{~A} / 4 \mathrm{P}$ | $32 \mathrm{~A} / 4 \mathrm{P}$ | $50 \mathrm{~A} / 4 \mathrm{P}$ | $63 \mathrm{~A} / 4 \mathrm{P}$ | - |
|  | DC 23 | 48 V | $16 \mathrm{~A} / 3 \mathrm{P}$ | $25 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $63 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 110 V | $16 \mathrm{~A} / 3 \mathrm{P}$ | $25 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $63 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 220 V | $10 \mathrm{~A} / 3 \mathrm{P}$ | $16 \mathrm{~A} / 3 \mathrm{P}$ | $20 \mathrm{~A} / 3 \mathrm{P}$ | $32 \mathrm{~A} / 3 \mathrm{P}$ | $40 \mathrm{~A} / 3 \mathrm{P}$ | $100 \mathrm{~A} / 4 \mathrm{P}$ | $125 \mathrm{~A} / 3 \mathrm{P}$ | - |
| Rated breaking capacity <br> Icn (Amps / poles in series) <br> DC ratings | DC 23 | 48 V | $64 \mathrm{~A} / 3 \mathrm{P}$ | $100 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | $253 \mathrm{~A} / 3 \mathrm{P}$ | $320 \mathrm{~A} / 3 \mathrm{P}$ | $500 \mathrm{~A} / 3 \mathrm{P}$ | $640 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 110 V | $64 \mathrm{~A} / 3 \mathrm{P}$ | $100 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | $253 \mathrm{~A} / 3 \mathrm{P}$ | $320 \mathrm{~A} / 3 \mathrm{P}$ | $500 \mathrm{~A} / 3 \mathrm{P}$ | $640 \mathrm{~A} / 3 \mathrm{P}$ | - |
|  |  | 220 V | $40 \mathrm{~A} / 3 \mathrm{P}$ | $64 \mathrm{~A} / 3 \mathrm{P}$ | $80 \mathrm{~A} / 3 \mathrm{P}$ | $128 \mathrm{~A} / 3 \mathrm{P}$ | $160 \mathrm{~A} / 3 \mathrm{P}$ | $400 \mathrm{~A} / 3 \mathrm{P}$ | $500 \mathrm{~A} / 3 \mathrm{P}$ | - |
| Electrical life (number of operations) |  |  | 3000 | 3000 | 3000 | 3000 | 3000 | 2000 | 2000 | 2000 |
| Mechanical life (number of operations) |  | $\mathrm{Cu}\left(\mathrm{mm}^{2}\right)$ | 50000 | 50000 | 50000 | 50000 | 50000 | 16000 | 16000 | 16000 |
| Terminal capacity |  | ( Nm ) | 1.5-16 | 1.5-16 | 1.5-16 | 2.5-35 | 2.5-35 | 6-70 | 6-70 | M8 $\times 25$ |
| Maximum terminal torque |  |  | 1.8 | 1.8 | 1.8 | 2.5 | 2.5 | 4.5 | 4.5 | - |

[^18]${ }^{2}$ ) $=$ Bolt size.

## IME 娄

## IME Metering systems

## Analogue meters

## Voltmeters Direct connect with scale

AC moving iron voltmeters - $90^{\circ}$ instruments (RQ type)
Cat. No.

- RQ48E VAC_V
- RQ72E VAC_V
- RQ96E VAC_V
- RQ144E VAC_V


## Specifications

- Accuracy class 1.5
- RMS Measurement
- 600 V operational voltage
- Frequency $45-65 \mathrm{~Hz}$
- Rated Burden 1.1VA


RQ72E VAC 500V

- Operating temperature range $0-50^{\circ} \mathrm{C}$
- Overload protection $2 \times \mathrm{Un}$ for 5 sec .
- Suitable for mounting on ferromagnetic materials
- Self-extinguishing housing
- IP 52 rated front panel - IP 20 housing - IP 00 terminals

Voltage measurement ranges:
$0-50 \mathrm{~V}, 0-150 \mathrm{~V}, 0-300 \mathrm{~V}, 0-500 \mathrm{~V}$.

| Overall dimensions (mm) and weight - RQ/90 ${ }^{\circ}$ and $\mathrm{AQ} / 240^{\circ}$ Instruments |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Cat. No. | A | B | C | D | E | Weight (g) |
| RQ48 | $48 \times 48$ | $44.5 \times 44.5$ | 40 | 22 | 45 | 100 |
| RQ72 | $72 \times 72$ | $66.5 \times 66.5$ | 44 | 12 | 68 | 150 |
| RQ96 | $96 \times 96$ | $91 \times 91$ | 44 | 12 | 92 | 210 |
| RQ144 | $144 \times 144$ | $137 \times 137$ | 53.5 | 12 | 138 | 450 |

$R Q / 90^{\circ}$


RQ48
$\mathrm{RQ} / 90^{\circ}$


AQ $/ 240^{\circ}$


RQ72-144

## IME 圈

## IME Metering systems

## Analogue meters

## Hour run meters

Cat. No.

- RQ48.0
- RQ72.0
- RQ96.0


## Specifications

- 7 digit - 5 whole numbers +2 decimal numbers numerator
- Rated burden approx. 3VA
- Operating temperature range $0-50^{\circ} \mathrm{C}$
- Front frame with flange for 50 mm circular cut-out on RQ48.0 models


Faston terminals, fork lug or $2 \times 4 \mathrm{~mm}^{2}$ wire termination on RQ48.0 models

- Self-extinguishing housing
- IP 52 rated front panel - IP 20 housing - IP 00 terminals

Operating voltages:
24 V AC, 110 V AC, 240 V AC, 415 V AC.

| Overall dimensions (mm) and weight - RQ/90 ${ }^{\circ}$ and $\mathrm{AQ} / 240^{\circ}$ Instruments |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Cat. No. | A | B | C | D | E | Weight (g) |
| RQ48 | $48 \times 48$ | $44.5 \times 44.5$ | 40 | 22 | 45 | 100 |
| RQ72 | $72 \times 72$ | $66.5 \times 66.5$ | 44 | 12 | 68 | 150 |
| RQ96 | $96 \times 96$ | $91 \times 91$ | 44 | 12 | 92 | 210 |



RQ48
$\mathrm{RQ} / 90^{\circ}$

$\mathrm{AQ} / 240^{\circ}$


Miniature circuit breakers

## Din-T10 series 10 kA MCB

Standard AS/NZS $4898{ }^{1}$ )
Approval No. N17481
Short circuit breaking capacity - 10000 Amps
Current range $0.5-63$ Amps 1,2,3 and 4 pole
Sealable and lockable handle
Modular design
Available in curve type B, C and D
Mounts on CD chassis (250 A and 355 A )


DTCB10
1 pole
1 pole 1 module

| In (A) | C - Curve 5-10 I $_{\boldsymbol{n}}$ |
| :--- | :--- |
| 0.5 | DTCB10105C |
| 1 | DTCB10101C |
| 2 | DTCB10102C |
| 3 | DTCB10103C |
| 4 | DTCB10104C |
| 6 | DTCB10106C |
| 10 | DTCB10110C |
| 13 | DTCB10113C |
| 16 | DTCB10116C |
| 20 | DTCB10120C |
| 25 | DTCB10125C |
| 32 | DTCB10132C |
| 40 | DTCB10140C |
| 50 | DTCB10150C |
| 63 | DTCB10163C |

Short circuit capacity 10 kA

| In (A) | $0.5-63$ |
| :--- | :--- |
| 1 P | 240 V AC |
| $2 P$ | $240 / 415 \mathrm{~V} \mathrm{AC}$ |
| $3 P$ | $240 / 415 \mathrm{~V} \mathrm{AC}$ |
| 4 P | $240 / 415 \mathrm{~V} \mathrm{AC}$ |


| Use at DC |  |  |
| :--- | :--- | :--- |
|  | $\mathbf{1} \mathbf{P}$ | $\left.\mathbf{2 ~ P}^{\mathbf{2}}\right)$ |
| Short circuit | 25 kA | 30 kA |
| Max voltage | 48 V DC | 110 V DC |

2 pole 2 modules

| 0.5 | DTCB10205C |
| :--- | :--- |
| 1 | DTCB10201C |
| 2 | DTCB10202C |
| 4 | DTCB10204C |
| 6 | DTCB10206C |
| 10 | DTCB10210C |
| 13 | DTCB10213C |
| 16 | DTCB10216C |
| 20 | DTCB10220C |
| 25 | DTCB10225C |
| 32 | DTCB10232C |
| 40 | DTCB10240C |
| 50 | DTCB10250C |
| 63 | DTCB10263C |

Notes: ${ }^{1}$ ) A range of UL standard MCBs is available on indent. (ref DTCBUL10__ C).
${ }^{2}$ ) 2 pole MCB connected in series.
The line side is the "OFF" (bottom) side of the MCB, and connects to CD chassis tee-offs.

Available on indent only.

## Miniature circuit breakers

Din-T10 series 10 kA MCB (cont.)

3 pole 3 modules

| In (A) |
| :--- |
| 0.5 |
| 1 |



| 4 pole 4 modules $^{1}$ ) |
| :--- |
| 6 |
| 10 |
| DTCB10406C |
| 13 |
| 16 |
| DTCB10410C |
| 20 |
| DTCB10413C |
| 25 |
| DTCB10416C |
| 32 |
| DTCB10420C |
| 50 |
| DTCB10425C |
| 63 |

Notes: ${ }^{1}$ ) All poles include overcurrent and short circuit protection.
i) Available on indent only.

# Din-T MCBs Technical data 

## Characteristics according to BS EN 60898

Miniature Circuit Breakers are intended for the protection of wiring installations against both overloads and short-circuits in domestic or commercial wiring installations where operation is possible by uninstructed people

Tripping characteristic curves


## Magnetic release

An electromagnet with plunger ensures instantaneous tripping in the event of short-circuit. The NHP Din-T range has 3 different types, following the current for instantaneous release: types B, C and $D$ curve.

| Icn <br> (A) | Test <br> current | Tripping <br> time | Applications |
| :---: | :---: | :---: | :--- |
| B | $3 \times$ In | $0.1<\mathrm{t}<45 \mathrm{~s}(\mathrm{In} \leq 32 \mathrm{~A})$ | Only for resistive loads eg: |
|  | $5 \times$ In | $0.1<\mathrm{t}<90 \mathrm{~s}(\mathrm{In}>32 \mathrm{~A})$ | - electrical heating |
|  |  | $\mathrm{t}<0.1 \mathrm{~s}$ | - water heater |
|  |  | - stoves. |  |


| C | $\begin{aligned} & 5 \times \text { In } \\ & 10 \times \text { In } \end{aligned}$ | $\begin{gathered} 0.1<t<15 \mathrm{~s}(\mathrm{In} \leq 32 \mathrm{~A}) \\ 0.1<\mathrm{t}<30 \mathrm{~s}(\mathrm{In}>32 \mathrm{~A}) \\ \mathrm{t}<0.1 \mathrm{~s} \end{gathered}$ | Usual loads such as: <br> - lighting <br> - socket outlets <br> - small motors |
| :---: | :---: | :---: | :---: |
| D | $\begin{aligned} & 10 \times \text { In } \\ & 20 \times \text { In } \end{aligned}$ | $\begin{gathered} 0.1<\mathrm{t}<4 \mathrm{~s}(* *)(\mathrm{In} \leq 32 \mathrm{~A}) \\ 0.1<\mathrm{t}<8 \mathrm{~s}(\mathrm{In}>32 \mathrm{~A}) \\ \mathrm{t}<0.1 \mathrm{~s} \end{gathered}$ | Control and protection of circuits having important transient inrush currents (large motors) |

## Thermal release

The release is initiated by a bimetal strip in the event of overload. The standard defines the range of releases for specific overload values. Reference ambient temperature is $30^{\circ} \mathrm{C}$.

| Test <br> current | Tripping <br> time |
| :---: | :---: |
| $1.13 \times$ In | $\mathrm{t} \geq 1 \mathrm{~h}($ In $\leq 63 \mathrm{~A})$ |
|  | $\mathrm{t} \geq 2 \mathrm{~h}(\mathrm{In}>63 \mathrm{~A})$ |
| $1.45 \times$ In | $\mathrm{t}<1 \mathrm{~h}(\mathrm{In} \leq 63 \mathrm{~A})$ |
|  | $\mathrm{t}<2 \mathrm{~h}(\mathrm{In}>63 \mathrm{~A})$ |
| $2.55 \times$ In | $1 \mathrm{~s}<\mathrm{t}<60 \mathrm{~s}(\operatorname{In} \leq 32 \mathrm{~A})$ |
|  | $1 \mathrm{~s}<\mathrm{t}<120 \mathrm{~s}($ In $>32 \mathrm{~A})$ |

Rated short-circuit breaking capacity (Icn)
Is the value of the short-circuit that the MCB is capable of withstanding in the following test of sequence of operations: 0-t-CO.

After the test the MCB is capable, without maintenance, to withstand a dielectric strength test at a test voltage of 900 V . Moreover, the MCB shall be capable of tripping when loaded with 2.8 In within the time corresponding to 2.55 In but greater than 0.1 s .

Service short-circuit breaking capacity (Ics)
Is the value of the short-circuit that the MCB is capable of withstanding in the following test of sequence of operations: $0-\mathrm{t}-\mathrm{CO}-\mathrm{t}-\mathrm{CO}$.

After the test the MCB is capable, without maintenance, to withstand a dielectric strength test at a test voltage of 1500 V . Moreover, the MCB shall not trip at a current of 0.96 In. The MCB shall trip within 1 h when current is 1.6 In .

0 - Represents an opening operation
C - Represents a closing operation followed by an automatic opening.
t - Represents the time interval between two successive short-circuit operations: 3 minutes.

The relation between the rated short-circuit capacity (Icn) and the rated service short-circuit breaking capacity (Ics) shall be as follows:

| Icn (A) | Ics (A) |
| :---: | :---: |
| $\leq 6000$ | 6000 |
| $>6000$ | 0.75 Icn min. 6000 |
| $\leq 10000$ | 0.75 Icn min. 7500 |
| $>10000$ |  |

In both sequences all MCBs are tested for emission of ionized gases during short-circuit (grid distance), in a safety distance between two MCBs of 35 mm when devices are installed in two different rows in the enclosure. This performance allows the use of any NHP/Terasaki enclosure.


## Din-T MCBs Technical data

Tripping curves according to EN 60898

The following tables show the average tripping curves of the Terasaki Din-T MCBs based on the thermal and magnetic characteristics.

Curve C


## Din-T MCBs Technical data

## Din-T 10

## 10 kA

C curve


## Din-T MCBs Technical data

## Influence of ambient air temperature on the rated current

The maximum value of the current which can flow through an MCB depends on the nominal current of the MCB, the conductor cross-section and the ambient air temperature.
The values shown in the table below are for devices in free air. For devices installed with other modular devices in the same switchboard, a correction factor (K) shall be applied relative to the mounting situation of the MCB, the ambient temperature and the number of main circuits in the installation.

| No of devices | K $^{1}$ ) |
| :---: | :--- |
| 2 or 3 | 0.9 |
| 4 or 5 | 0.8 |
| 6 or 9 | 0.7 |
| $>10$ | 0.6 |

## Calculation example

Within a distribution board consisting of eight 2 Pole, $16 \mathrm{~A}, ~ ' \mathrm{C}$ ' curve type MCBs, with an operating ambient temperature of $45^{\circ} \mathrm{C}$, which is the highest temperature the MCB can operate at without unwanted tripping?

## Calculation

The correction factor $\mathrm{K}=0.7$, for use in an eight circuit installation: $16 \mathrm{~A} \times 0.7=11.2 \mathrm{~A}$
As the MCB is working at $45^{\circ} \mathrm{C}$ it shall be given another factor ( $90 \%=0.9$ ):
In at $45^{\circ} \mathrm{C}=$ In at $30^{\circ} \mathrm{C} \times 0.9=11.2 \mathrm{~A} \times 0.9=10.1 \mathrm{~A}$.

Note: ${ }^{1}$ ) Applicable for MCBs working at maximum rated currents.

The thermal calibration of the MCBs was carried out at an ambient temperature of $30^{\circ} \mathrm{C}$. Ambient temperatures different from $30^{\circ} \mathrm{C}$ influence the bimetal and this results in earlier or later thermal tripping.


10 A


16-40 A


50-63 A


## Din-T MCBs Technical data

## Effects of frequency on the tripping characteristic

All the MCBs are designed to work at frequencies of $50-60 \mathrm{~Hz}$, therefore to work at different values, consideration must be given to the variation of the tripping characteristics. The thermal tripping does not change with variation of the frequency but the magnetic tripping values can be up to $50 \%$ higher than the ones at $50-60 \mathrm{~Hz}$.

## Tripping current variation

| 60 Hz | $\mathbf{1 0 0 ~ H z}$ | $\mathbf{2 0 0 ~ H z}$ | $\mathbf{3 0 0} \mathrm{~Hz}$ | $\mathbf{4 0 0 \mathrm { Hz }}$ |
| :---: | :---: | :---: | :---: | :---: |
| 1 | 1.1 | 1.2 | 1.4 | 1.5 |

## Power losses

The power losses are calculated by measuring the voltage drop between the incoming and the outgoing terminals of the device at rated current.

## Power loss per pole

| In <br> $(\mathrm{A})$ | Voltage drop <br> $(\mathrm{V})$ | Energy loss <br> $(\mathrm{W})$ | Resistance <br> $(\mathrm{mOhm})$ |
| :---: | :---: | :---: | :---: |
| 0.5 | 2.230 | 1.115 | 4458.00 |
| 1 | 1.270 | 1.272 | 1272.00 |
| 2 | 0.620 | 1.240 | 310.00 |
| 3 | 0.520 | 1.557 | 173.00 |
| 4 | 0.370 | 1.488 | 93.00 |
| 6 | 0.260 | 1.570 | 43.60 |
| 8 | 0.160 | 1.242 | 19.40 |
| 10 | 0.160 | 1.560 | 15.60 |
| 13 | 0.155 | 2.011 | 11.90 |
| 16 | 0.162 | 2.586 | 10.10 |
| 20 | 0.138 | 2.760 | 6.90 |
| 25 | 0.128 | 3.188 | 5.10 |
| 32 | 0.096 | 3.072 | 3.00 |
| 40 | 0.100 | 4.000 | 2.50 |
| 50 | 0.090 | 4.500 | 1.80 |
| 63 | 0.082 | 5.160 | 1.30 |
| 80 | 0.075 | 6.000 | 0.90 |
| 100 | 0.075 | 7.500 | 0.75 |
| 125 | 0.076 | 9.500 | 0.60 |

## Limitation curves

## Let-through energy $\mathrm{I}^{2} \mathrm{t}$

The limitation capacity of an MCB in short-circuit conditions, is its capacity to reduce the value of the let-through energy that the short-circuit would be generating.

## Peak current Ip

Is the value of the maximum peak of the short-circuit current limited by the MCB.


[^19]
## Din-T MCBs Technical data

## Use of standard MCB for DC use

For MCBs designed to be used in alternating current but used in installations in direct current, the following should be taken into consideration:

- For protection against overloads it is necessary to connect the two poles to the MCB. In these conditions the tripping characteristic of the MCB in direct current is similar to alternating current.


## Use in DC selection table

- For protection against short-circuits it is necessary to connect the two poles to the MCB. In these conditions the tripping characteristic of the MCB in direct current is $40 \%$ higher than the one in alternating current.


## Use of special MCB Din-T DC for DC use.

## (UC = Universal current)

For MCBs designed to work in both alternating and direct current, it is necessary to respect the polarity of the terminals since the device is equipped with a permanent magnet.

| Series | Rated <br> current (A) | 48 V 1 pole <br> Icu (kA) | 110 V 2 poles in series <br> Icu (kA) | 250 V 1 pole <br> Icu (kA) | 440 V 2 poles in series <br> Icu (kA) |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: |
| Din-T 10 | $0.5 \ldots . .63 \mathrm{~A}$ | 25 | 30 | - | - |

Installation of Din-T DC MCBs in direct current

## Din-T MCBs Technical data

## Text for specifiers

## MCB Series Din-T 10

■ According to EN 60898 standard

- For DIN rail mounting according to DIN EN 50022; EN 50022; future EN 60715; IEC 60715 (top hat rail 35 mm )
- Grid distance 35 mm
- Working ambient temperature from $-25^{\circ} \mathrm{C}$ up to $+50^{\circ} \mathrm{C}$
- Approved by CEBEC, VDE, KEMA, IMQ.
- 1 pole is a module of 18 mm wide
- Nominal rated currents are: 0.5/1/2/3/4/6/10/13/16/20/25/32/40/50/63 A
- Tripping characteristics: $\mathrm{B}, \mathrm{C}, \mathrm{D}$ ( B curve Din-T 10 only).
- Number of poles: 1 P, 1 P+N, 2 P, 3 P, 3 P+N, 4 P

■ The short-circuit breaking capacity is: 6/10k A, energy limiting class 3

- Terminal capacity from 1 up to $35 \mathrm{~mm}^{2}$ rigid wire or 1.5 up to $25 \mathrm{~mm}^{2}$ flexible wire.
- Screw head suitable for flat or Pozidrive screwdriver
- Can be connected by means of both pin or fork busbars
- The toggle can be sealed in the ON or OFF position
- Rapid closing
- Both incoming and outgoing terminals have a protection degree of IP 20 and they are sealable
- Isolator function thanks to Red/Green printing on the toggle.
■ Maximum voltage between two phases; $440 \mathrm{~V} \sim$
■ Maximum voltage for utilisation in DC current: 48 V 1 P and 110 V 2 P
- Two position rail clip
- Mechanical shock resistance 40 g (direction $\mathrm{x}, \mathrm{y}, \mathrm{z}$ ) minimum 18 shocks 5 ms half-sinusoidal acc. to IEC 60068-2-27
■ Vibration resistance: 3 g (direction $\mathrm{x}, \mathrm{y}, \mathrm{z}$ ) minimum 30 min . according to IEC 60068-2-6
- Extensions can be added on both left or right hand side
- Auxiliary contact
- Shunt trip
- Undervoltage release
- Motor operator
- Panelboard switch
- Add-on RCD can be coupled.


## Din-T MCBs Technical data



Din-T MCBs + RCDs Technical data
Miniature circuit breakers - Din-T 10

Dimensions in mm.
3


Miniature circuit breakers

## Din-Safe-M add-on earth leakage modules

■ Standard AS/NZS 61009

- Approval No. N11974
- Offers protection against overcurrent, earth leakage and short circuit faults when added to Din-T MCB
- Test button
- Indication of trip position


DSRCM
Technical data

| Model | Voltage (V) |
| :--- | :--- |
| $1 P+N$ | 240 VAC |
| $3 P+N$ | 415 V AC |
| $3 P$ | 415 V AC |


| Terminal capacity <br> In (A) | $\left(\mathbf{m m}^{\mathbf{2}}\right)$ |
| :--- | :--- |
| up to 32 | 16 |
| 63 | 25 |

Notes:
$\left.{ }^{1}\right) 1 \mathrm{P}+\mathrm{N}$ and $3 \mathrm{P}+\mathrm{N}$ type supply neutral is connected by 'pigtail' cable.
${ }^{2}$ ) Dimensions of Din-Safe-M unit only; add MCB dimensions for total installed width.
${ }^{3}$ ) "MCB rating" refers to the max. MCB size the module can be fitted to.
${ }^{4}$ ) A, B, C, D refers to dimensional diagrams
${ }^{5}$ ) Not suitable for Din-T 10H.
i Available on indent only.


DTCB10


After fitting

Note: Nuisance tripping may be experienced in VFD and motor starting applications refer NHP.

## Miniature circuit breakers

## Din-Safe-M add-on earth leakage modules (cont.)

The Din-Safe-M package contains all the necessary parts to combine the earth leakage module and the Din-T MCB to form a combination MCB/RCD.

All parts required to complete this unit are supplied - including protection caps, clips and assembly instruction sheet.
Din-Safe-M module and MCB combination offer the following functions:

- Protection against earth leakage faults thus protecting against:
- indirect contact
- direct contact
- fire
- Trip Sensitivities ( $\mathrm{I} \triangle \mathrm{n}$ ):
- 30 mA
- 100 mA
- 300 mA

- Overload protection.


## Operation

The combined Din-T MCB/Din-Safe-M earth leakage module has two operating toggles which indicate the reason for the trip:

- When an overload or short circuit occurs the Din-T MCB will operate. In this case the Din-Safe-M toggle will remain in the ON position.
- If an earth leakage occurs both toggles will move to the OFF position. In order to reset the MCB the Din-Safe-M unit must be reset first.
- In both instances - if the cause of the trip operation has not been rectified, a trip operation will occur as soon as the MCB is turned to the ON position. The trip free mechanism of the MCB ensures that a successful trip operation takes place even when the toggle is held in the ON position.


## Test button

The built-in test facility simulates an earth fault ensuring correct operation of MCB + RCD components.

Testing is recommended monthly.


Fitting of Din-T auxiliary and alarm switches or Din-T shunt are not affected and will function as normal.

# Din-T MCBs + RCDs Technical data 

## What is an RCD?

The RCD (Residual Current Device) is a device intended to protect people against indirect contact, the exposed conductive parts of the installation being connected to an appropriate earth electrode. It may be used to provide protection against fire hazards due to a persistent earth fault current, without operation of the overcurrent protective device.

RCDs having a rated residual operating current not exceeding 30 mA are also used as a means for additional protection in case of failure of the protective means against electric shock (direct contact).

## Working Principle

The main components of an RCD are the following:
■ The core transformer: which detects the earth fault current.
■ The relay: when an earth fault current is detected, the relay reacts by tripping and opening the contacts.

- The mechanism: element to open and close the contacts either manually or automatically.
- The contacts: to open or close the main circuit.

The RCD constantly monitors the vectorial sum of the current passing through all the conductors. In normal conditions the vectorial sum is zero ( $\mathrm{I} 1+\mathrm{I} 2=0$ ) but in case of an earth fault, the vectorial sum differs from zero (I1+I2=Id), this causes the actuation of the relay and therefore the release of the


## Definitions related to RCDs

RCCB = Residual Current Circuit Breaker without overcurrent protection.
RCBO = Residual Current Circuit Breaker
with overcurrent protection.

## Breaking capacity

A value of AC component of a prospective current that an RCCB is capable of breaking at a stated voltage under prescribed conditions of use and behaviour.
Residual making and breaking capacity ( $\mathrm{I} \Delta \mathrm{m}$ )
A value of the AC component of a residual prospective current which an RCCB can make, carry for its opening time
and break under specified conditions of use and behaviour.

Conditional residual short-circuit current (I $\Delta \mathrm{c}$ )
A value of the AC component of a prospective current which an RCCB protected by a suitable SCPD (short-circuit protective device) in series, can withstand, under specific conditions of use and behaviour.
Conditional short-circuit current (Inc)
A value of the AC component of a residual prospective current which an RCCB protected by a suitable SCPD in series, can withstand, under specific conditions of use and behaviour.

## Residual short-circuit withstand current

Maximum value of the residual current for which the operation of the RCCB is ensured under specified conditions, and above which the device can undergo irreversible alterations.

## Prospective current

The current that would flow in the circuit, if each main current path of the RCCB and the overcurrent protective device (if any) were replaced by a conductor of negligible impedance.

## Making capacity

A value of AC component of a prospective current that an RCCB is capable to make at a stated voltage under prescribed conditions of use and behaviour.
Open position
The position in which the predetermined clearance between open contacts in the main circuit of the RCCB is secured.

Closed position
The position in which the predetermined continuity of the main circuit of the RCCB is secured.

## Tripping time

The time which elapses between the instant when the residual operating current is suddenly attained and the instant of arc extinction in all poles.
Residual current ( $\mathrm{I} \Delta \mathrm{n}$ )
Vector sum of the instantaneous values of the current flowing in the main circuit of the RCCB.

Residual operating current
Value of residual current which causes the RCCB to operate under specified conditions.

Rated short-circuit capacity (Icn)
Is the value of the ultimate short-circuit breaking capacity assigned to the circuit breaker. (Only applicable to RCBO)

Conventional non-tripping current (Int)
A specified value of current which the circuit breaker is capable of carrying for a specified time without tripping. (Only applicable to RCBO)
Conventional tripping current (It)
A specified value of current which causes the circuit

## Din-T MCBs + RCDs Technical data

RCDs classification according to EN 61008/61009
RCDs may be classified according to:
The behaviour in the presence of DC current
(types for general use).

- Type AC
- Type A

The time-delay (in the presence of residual current)

- RCDs without time delay: type for general use
- RCDs with time delay: type $S$ for selectivity

Type AC $\square$ $\left.{ }^{1}\right)^{2}$ )
The type AC RCDs are designed to release with sinusoidal residual currents which occur suddenly or slowly rise in magnitude.


| Residual current | Tripping time |
| ---: | :--- |
| $0.5 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathbf{t}=\infty$ |
| $1 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathbf{t}=<\mathbf{3 0 0} \mathrm{ms}$ |
| $2 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<\mathbf{1 5 0 \mathrm { ms }}$ |
| $5 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathbf{t}=\leq \mathbf{4 0} \mathrm{ms}$ |



Tripping curve type AC
${ }^{1}$ ) Standard in Australia
${ }^{2}$ ) Type A acceptable in Australia

Tripping curve type A
${ }^{3}$ ) Standard in New Zealand
${ }^{4}$ ) DSRCBH is type A.

## Din-T MCBs + RCDs Technical data

Nuisance tripping

All DinSafe RCDs have a high level of immunity to transient currents, against current impulses of $8 / 20 \mu \mathrm{~s}$ according to EN 61008/61009 and VDE 0664.T1.
Type A, AC..................................................................... 3000 A 8/20 $\mathrm{\mu}$
Tys

RCDs have a high level of immunity against alternating currents of high frequency according to EN 61008/61009.


## Din-T MCBs + RCDs Technical data

## Din-Safe-M add-on earth leakage modules

## Assembly

To assemble the Din-T MCB and the Din-Safe-M unit follow the steps below:
Place the MCB and Din-Safe-M unit on a flat surface. Be sure that both the MCB and the Din-Safe-M toggles are in the On position.
Slide the two units towards each other and insert the connecting link or links into the MCB tunnel terminal. Do not put any pressure onto the metal pin of the Din-Safe-M unit.

Push in the connecting clip, locking the unit together.
Check that the MCB trips when the toggle on the Din-Safe-M is moved to the OFF position.

Tighten the connections between the MCB and the Din-Safe-M and fit the insulating covers supplied.
After power is applied check unit operation with test button provided on Din-Safe-M module.
If pigtail and N are reversed, the breaker will trip as soon as load is energised.
Reset Din-Safe-M module before switching MCB 'ON'.
If the unit is feeding three phase load (no neutral) use 3 phase models only.

Din-Safe-M space requirements

| Type | Without MCB fitted neutral not switched | MCB fitted neutral not switched | MCB fitted neutral switched |
| :---: | :---: | :---: | :---: |
| $1 \mathrm{P}+\mathrm{N} 32 / 63$ | modules ( 36 mm ) | 3 modules ( 54 mm ) | 4 modules ( 72 mm ) |
| $3 P+N 32 A$ | 2 modules ( 36 mm ) | 5 modules ( 90 mm ) | 6 modules ( 108 mm ) |
| $3 \mathrm{P}+\mathrm{N} 63 \mathrm{~A}$ | 3 modules ( 54 mm ) | 6 modules ( 108 mm ) | 7 modules ( 126 mm ) |
| 3 P 63 A | 3 modules ( 54 mm ) | 6 modules ( 108 mm ) | N/A |

Din-Safe-M $1 P+N$ with 1 pole MCB
(Neutral not switched)


Din-Safe-M 1P + N with 2 pole MCB (Switching active + neutral)


Din-Safe-M 3P + N with 3 pole MCB (Neutral not switching)


Din-Safe-M 3P + N with 4 pole MCB (Switching active + neutral)


## Din-T MCBs + RCDs Technical data

## Easy DIN-rail extraction

RCCBs can easily be removed from the DIN rail when installed with busbars, by taking into consideration the following instructions.

Pin and fork busbar - bottom terminals

Pin busbar - top terminals
(1) Open the terminals totally
(2) Unclick the DIN rail clip
(3) Lift the RCCB up and turn the top side inwards
(4) Turn the bottom side inwards and remove the RCCB from the DIN rail


# Din-T MCBs + RCDs Technical data <br> Power losses 

The power losses are calculated by means of measuring the voltage drop between the incoming and the outgoing terminal of the device at rated current. Power loss per pole:

| In (A) | 6 | 10 | 13 | 16 | 20 | 25 | 32 | 40 | 50 | 63 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Z (m0hm) | 45.4 | 17.4 | 13.7 | 11.9 | 8.7 | 6.9 | 4.8 | 3.6 | 2.9 | 2.4 |
| Pw (W) | 1.6 | 1.7 | 2.3 | 3.0 | 3.5 | 4.3 | 4.9 | 5.8 | 7.3 | 9.6 |

## Din-T MCBs + RCDs Technical data

## Text for specifiers

## Add-on RCD DinSafe (DSRCM)

- According to EN 61009 standard.
- Intended to detect residual sinusoidal currents (type AC) or residual pulsating direct currents (type A).
■ Resistance against nuisance tripping according to VDE 0664 T1 and EN 61009.
- Working ambient temperature from $-25^{\circ} \mathrm{C}$ up to $+40^{\circ} \mathrm{C}$ for type A and from $-5^{\circ} \mathrm{C}$ up to $+40^{\circ} \mathrm{C}$ for type AC.
- Approved by CEBEC, VDE, KEMA, IMQ, etc.

■ Add-on RCD widths are:

- 2 P-2 modules 32 A \& 63 A
- 3 P-2 modules 32 A \& 4 modules 63 A
- 4 P - 2 or 4 modules 32 A \& 4 modules 63 A
- Nominal rated currents are: 0.5-63 A \& 80-125 A
- Nominal residual currents are: 30, 100, 300, 500, 1000 mA .
- The test circuit is protected against overloads.
- The short-circuit capacity depends on the associated MCB:
- Din-T6 $\qquad$ 6000 A
- Din-T10 .10000 A
- The residual making and breaking capacity depends on the associated MCB:
- Din-T6 .......... 6000 A
- Din-T10 ........ 7500 A
- Terminal capacity:
- 2 P - 2 modules 32 A \& 63 A ........................ 35 mm $^{2}$
- 3 P-2 modules 32 A.................................... 16 mm ${ }^{2}$
- 3 P-4 modules 63 A................................... 35 mm $^{2}$
- 4 P - 2 modules 32 A................................... 16 mm ${ }^{2}$
- 4 P- 4 modules 32 A \& 4 modules 63 A ...... 35 mm $^{2}$
- The devices $10,30,100 \mathrm{~mA}$ type A or AC always have vertical selectivity with devices 300 mA type S .
- The selective types have a delayed tripping time in comparison with the instantaneous ones (type A, AC) with sensitivity lower than 300 mA .
- Both incoming and outgoing terminals (MCB+Add-on RCD) have a protection degree of IP 20 and are sealable.
- A codification system between MCB and RCD avoids incorrect assembly (i.e. MCB 50 A coupled with RCD 32 A).
- Auxiliary contacts can be added on the left hand side of the MCB.
- It can be released by means of a shunt trip or undervoltage release.
- It can be remotely controlled by means of a motor operator. The toggles of the MCB and RCD are independent, so it is possible to identify the reason that the device has tripped.


## Din-T MCBs + RCDs Technical data

 Overview Din-Safe RCDs
## Device type definition

| Rating/description |  |  | Cat. No. | DSRCM ADD-ON MODULE |
| :---: | :---: | :---: | :---: | :---: |
| Standards |  |  |  | IEC 61009-1 |
| Magnetic tripping characteristics |  |  |  | C-D |
| Residual tripping characteristic ${ }^{1}$ ) |  |  |  | AC, A |
| Tripping time at I $\triangle$ n | Insta | ntaneous | ms | <300 |
|  | Selec |  | ms | - |
| Rated current |  |  | A | 32,63 |
| Rated residual current I In |  |  | mA | 30, 100, 300 |
| Calibration temperature |  |  | ${ }^{\circ} \mathrm{C}$ | 30 |
| Number of poles versus modules |  |  |  | 1 |
| Rated voltage Un |  | 2 PaC | V | 240/415 |
|  |  | 3 PAC | V | 400 |
|  |  | 4 PaC | V | 400 |
| Frequency |  |  | Hz | 50/60 |
| Maximum service voltage Ubmax |  |  | V | $2 \mathrm{P}=265$ / $4 \mathrm{P}=455$ |
| Minimum service voltage Ubmin |  |  | v | $2 \mathrm{P}=117$ / $4 \mathrm{P}=190$ |
| Power supply |  |  |  | Top |
| Selectivity class |  |  |  | 3 |
| Rated making and breaking capacity (Im) |  |  | A | - |
| Residual making and breaking capacity (İm) |  |  | A | see MCB |
| Conditional short-circuit capacity (Inc) |  |  | A | - |
| Conditional residual short-circuit capacity (IDC) |  |  | A | - |
| Short-circuit capacity (Icn) |  |  | A | see MCB |
| Grid distance (safety distance between two devices) |  |  | mm | 35 |
| Isolator application |  |  |  | no |
| Insulation degree |  | Insulation voltage | V (DC) | 500 |
|  |  | Shock voltage (1.2/50 ms) | s) kV | 8 |
|  |  | Insulation resistance | (m0hm) | 1000 |
|  |  | Dielectric strength | V | 2500 |
| Shock resistance (in $\mathrm{x}, \mathrm{y}, \mathrm{z}$ direction)(IEC 60077/16.3) |  |  |  | $40 \mathrm{~g}, 18$ shocks 5 ms |
| Vibration resistance (in $x, y, z$ direction; IEC 60068-2-6) |  |  |  | $5 \mathrm{~g}, 30 \mathrm{~min}, 0 . .80 \mathrm{~Hz}$ |
| Endurance |  | electrical at Un, In |  | 10000 |
|  |  | mechanical at Un, In |  | 20000 |
| Protection degree (outside/inside electrical enclosure) |  |  |  | IP 20 / IP 40 |
| Self extinguish degree (according to UL 94) |  |  |  | V2 |
| Tropicalisation (according to IEC 60068-2, DIN 40046) ${ }^{\circ} \mathrm{C} / \mathrm{RH}$ |  |  |  | +55/95 \% |
| Pollution degree (acc. IEC 60947-1) |  |  |  | 3 |
| Operating temperature |  |  | ${ }^{\circ} \mathrm{C}$ | AC (-5..+60); A(-25..+60) |
| Storage temperature |  |  | ${ }^{\circ} \mathrm{C}$ | -25..+70 |
| Terminals capacity | Rigid cable min/max (Top) |  | $\mathrm{mm}^{2}$ | 1/25 |
|  | Flexible cable $\mathrm{min}^{*} / \mathrm{max}$ (Top) |  | $\mathrm{mm}^{2}$ | 1/16 |
|  | Rigid cable min/max (bottom) |  | $\mathrm{mm}^{2}$ | 1/35 |
|  | Flexible cable $\mathrm{min}^{*} / \max$ (bottom) $\mathrm{mm}^{2}$ <br> (*Flexible cable $0.75 / 1 / 1.5 \mathrm{~mm}^{2}$ with cable lug) |  |  | 1/25 |
| Torque |  | Top/Bottom | Nm | -/4.5 |
| Add-on devices (side add-on) |  | Auxiliary contacts |  | yes (coupled to MCB) |
|  |  | UVT |  | yes (coupled to MCB) |
|  |  | Shunt trip |  | yes (coupled to MCB) |
|  |  | Motor operator |  | yes (coupled to MCB) |
|  |  | Panelboard switch |  | - |
| Busbars systems |  | Pin |  | - |
|  |  | Fork |  | yes |
| Accessories |  |  |  |  |
| Dimensions, weights, packaging |  |  | \# Poles | 2-3-4 |
|  |  | (HxDxW) $86 \times 68 \times W$ | mm | 72/90/108/125/144 |
|  |  | Weight/unit | g | $2 \mathrm{P}=250 / 3 \mathrm{P}=320 / 4 \mathrm{P}=340$ |
|  |  | Package/unit |  | 1 |
| Note: $\left.\quad{ }^{1}\right)$ Refer catalogue section for types. <br> ${ }^{2}$ ) Making sure that $\mathrm{N}-\mathrm{L}$ and both flying leads are disconnecte |  |  |  |  |

## Din-T MCBs + RCDs Technical data

Din-Safe-M clip-on earth leakage module (DSRCM)
Diagram (A)
$1 \mathrm{P}+\mathrm{N}$


Diagram (B)
$3 \mathrm{P}+\mathrm{N}$


Diagram (C)
$3 \mathrm{P}+\mathrm{N}$


Diagram (D)


Miniature circuit breakers
Din-Safe MCBs (RCBO)

| Standard AS/NZS 61009Approval N17482Short circuit, overcurrent and earth leakage protectionHandle sealable and padlockableDIN Rail mounting |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Din-Safe MCB with pigtail |  |  |  |  |  |  |
| No of Poles | Amp rating (A) | Voltage (V) | Short circuit (kA) | Phase ${ }^{1}$ ) | Trip Sens. <br> (mA) | Cat. No |
| 2 | 6 | 110/240 | 10 | 1+N | 30 | DSRCB0630P |
| 2 | 10 | 110/240 | 10 | 1+N | 30 | DSRCB1030P |
| 2 | 16 | 110/240 | 10 | $1+\mathrm{N}$ | 30 | DSRCB1630P |
| 2 | 20 | 110/240 | 10 | 1+N | 30 | DSRCB2030P |
| 2 | 25 | 110/240 | 10 | 1+N | 30 | DSRCB2530P |
| 2 | 32 | 110/240 | 10 | 1+N | 30 | DSRCB3230P |
| 2 | 40 | 110/240 | 10 | 1+N | 30 | DSRCB4030P |

$\begin{array}{ccc}\text { Din-Safe MCB standard terminal configuration } \\ \text { Amp } & \text { Short } & \text { Trip }\end{array}$

| No of Poles | rating <br> (A) | Voltage (V) | circuit <br> (kA) | Phase ${ }^{2}$ | Sens. $\left.{ }^{2}\right)(\mathrm{mA})$ | Cat. $\mathrm{No}^{3}$ ) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | 6 | 110/240 | 10 | 1+N | 10 | 1) DSRCB0610A |
| 2 | 6 | 110/240 | 10 | 1+N | 30 | DSRCB0630 |
| 2 | 10 | 110/240 | 10 | 1+N | 10 | DSRCB1010A |
| 2 | 10 | 110/240 | 10 | $1+\mathrm{N}$ | 30 | DSRCB1030 |
| 2 | 10 | 110/240 | 10 | 1+N | 100 | DSRCB10100 |
| 2 | 16 | 110/240 | 10 | 1+N | 10 | DSRCB1610A |
| 2 | 16 | 110/240 | 10 | 1+N | 30 | DSRCB1630 |
| 2 | 16 | 110/240 | 10 | 1+N | 100 | DSRCB16100 |
| 2 | 20 | 110/240 | 10 | 1+N | 10 | DSRCB2010A |
| 2 | 20 | 110/240 | 10 | $1+\mathrm{N}$ | 30 | DSRCB2030 |
| 2 | 20 | 110/240 | 10 | $1+\mathrm{N}$ | 100 | DSRCB20100 |
| 2 | 25 | 110/240 | 10 | $1+\mathrm{N}$ | 30 | DSRCB2530 |
| 2 | 32 | 110/240 | 10 | $1+\mathrm{N}$ | 30 | DSRCB3230 |
| 2 | 40 | 110/240 | 10 | $1+N$ | 30 | DSRCB4030 |

## Application

Din-Safe MCB is a combined MCB/RCD providing thermal overload, short circuit and earth leakage protection in the one integral unit.
Din-Safe MCBs are suitable for use in residential, commercial and light industrial applications.

## Terminal configuration



Notes: ${ }^{1}$ ) Unprotected neutral, not switched.
${ }^{2}$ ) Unprotected neutral, switched.
${ }^{3}$ ) Fits Din-T chassis (special configuration) refer page TBA.
${ }^{4}$ ) Some type "A" RCDs are stocked. Refer NHP. Nuisance tripping may be experienced in VFD and motor starting applications refer NHP. i Available on indent only.

## Din-T MCBs + RCDs Technical data

Tripping curves according to EN 60898

The following tables show the average tripping curves of the Terasaki Din-T MCBs based on the thermal and magnetic characteristics.

Curve C


# Din-T MCBs + RCDs Technical data 

## What is an RCD?

The RCD (Residual Current Device) is a device intended to protect people against indirect contact, the exposed conductive parts of the installation being connected to an appropriate earth electrode. It may be used to provide protection against fire hazards due to a persistent earth fault current, without operation of the overcurrent protective device.
RCDs having a rated residual operating current not exceeding 30 mA are also used as a means for additional protection in case of failure of the protective means against electric shock (direct contact).

## Working Principle

The main components of an RCD are the following:
■ The core transformer: which detects the earth fault current.

- The relay: when an earth fault current is detected, the relay reacts by tripping and opening the contacts.
- The mechanism: element to open and close the contacts either manually or automatically.
- The contacts: to open or close the main circuit.

The RCD constantly monitors the vectorial sum of the current passing through all the conductors. In normal conditions the vectorial sum is zero $(\mathrm{I} 1+\mathrm{I} 2=0)$ but in case of an earth fault, the vectorial sum differs from zero ( $\mathrm{I} 1+\mathrm{I} 2=\mathrm{Id}$ ), this causes the actuation of the relay and therefore the release of the main contacts.


## Definitions related to RCDs

RCCB = Residual Current Circuit Breaker without overcurrent protection.
RCBO = Residual Current Circuit Breaker with overcurrent protection.

## Breaking capacity

A value of AC component of a prospective current that an RCCB is capable of breaking at a stated voltage under prescribed conditions of use and behaviour.

Residual making and breaking capacity ( $\mathrm{I} \Delta \mathrm{m}$ )
A value of the AC component of a residual prospective current which an RCCB can make, carry for its opening time and break under specified conditions of use and behaviour.

## Conditional residual short-circuit current (I $\Delta \mathbf{c}$ )

A value of the $A C$ component of a prospective current which an RCCB protected by a suitable SCPD (short-circuit protective device) in series, can withstand, under specific conditions of use and behaviour.

## Conditional short-circuit current (Inc)

A value of the AC component of a residual prospective current which an RCCB protected by a suitable SCPD in series, can withstand, under specific conditions of use and behaviour.

## Residual short-circuit withstand current

Maximum value of the residual current for which the operation of the RCCB is ensured under specified conditions, and above which the device can undergo irreversible alterations.

## Prospective current

The current that would flow in the circuit, if each main current path of the RCCB and the overcurrent protective device (if any) were replaced by a conductor of negligible impedance.

## Making capacity

A value of AC component of a prospective current that an RCCB is capable to make at a stated voltage under prescribed conditions of use and behaviour.

## Open position

The position in which the predetermined clearance between open contacts in the main circuit of the RCCB is secured.

## Closed position

The position in which the predetermined continuity of the main circuit of the RCCB is secured.

## Tripping time

The time which elapses between the instant when the residual operating current is suddenly attained and the instant of arc extinction in all poles.

## Residual current ( $\mathrm{I} \Delta \mathrm{n}$ )

Vector sum of the instantaneous values of the current flowing in the main circuit of the RCCB.

## Residual operating current

Value of residual current which causes the RCCB to operate under specified conditions.

## Rated short-circuit capacity (Icn)

Is the value of the ultimate short-circuit breaking capacity assigned to the circuit breaker. (Only applicable to RCBO)

## Conventional non-tripping current (Int)

A specified value of current which the circuit breaker is capable of carrying for a specified time without tripping. (Only applicable to RCBO)

## Conventional tripping current (It)

A specified value of current which causes the circuit breaker to trip within a specified time.
(Only applicable to RCBO)

## Din-T MCBs + RCDs Technical data <br> RCDs classification according to EN 61008/61009

RCDs may be classified according to:
The behaviour in the presence of DC current
(types for general use).

- Type AC
- Type A

The time-delay (in the presence of residual current)
■ RCDs without time delay: type for general use

- RCDs with time delay: type $S$ for selectivity


## Type AC <br>  $\left.{ }^{1}\right)^{2}$ )

The type AC RCDs are designed to release with sinusoidal residual currents which occur suddenly or slowly rise in magnitude.


| Residual current | Tripping time |
| :---: | :---: |
| $0.5 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=\infty$ |
| $1 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<300 \mathrm{~ms}$ |
| $2 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<150 \mathrm{~ms}$ |
| $5 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=\leq 40 \mathrm{~ms}$ |



Tripping curve type AC
$\left.{ }^{1}\right)$ Standard in Australia
${ }^{2}$ ) Type A acceptable in Australia

\section*{| Type A | $\cong$ | ${ }^{3}$ | ${ }^{4}$ ) |
| :--- | :--- | :--- | :--- |}

Certain devices during faults can be the source of nonsinusoidal earth leakage currents (DC components) due to the electronic components e.g. diodes, thyristors etc.
Type A RCDs are designed to ensure that under these conditions the residual current devices operate on sinusoidal residual current and also with pulsating direct current(*) which occur suddenly or slowly rise in magnitude.
(*) Pulsating direct current: current of pulsating wave form which assumes, in each period of the rated power frequency, the value 0 or a value not exceeding 0.006 A DC during one single interval of time, expressed in angular measure of at least $150^{\circ}$.

|  | Residual current | Tripping time |
| :--- | :--- | :--- |
| 1. For sinusoidal residual current |  |  |
|  | $0.5 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=\infty$ |
| $1 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<300 \mathrm{~ms}$ |  |
| $2 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<150 \mathrm{~ms}$ |  |
| $5 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=\leq 40 \mathrm{~ms}$ |  |

2. For residual pulsating direct current

|  | At point of wave $0^{\circ}$ |  |
| :---: | :---: | :---: |
|  | $0.35 \times \mathrm{I} \Delta \mathrm{n}$ | $t=\infty$ |
|  | $1.4 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<300 \mathrm{~ms}$ |
|  | $2.8 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<150 \mathrm{~ms}$ |
|  | $7 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=\leq 40 \mathrm{~ms}$ |
| At point of wave $90^{\circ}$ |  |  |
|  | $0.25 \times \mathrm{I} \Delta \mathrm{n}$ | $t=\infty$ |
|  | $1.4 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<300 \mathrm{~ms}$ |
|  | $2.8 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<150 \mathrm{~ms}$ |
|  | $7 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=\leq 40 \mathrm{~ms}$ |
| At point of wave $135{ }^{\circ}$ |  |  |
| $1 \quad 1$ | $0.11 \times \mathrm{I} \Delta \mathrm{n}$ | $t=\infty$ |
|  | $1.4 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<300 \mathrm{~ms}$ |
| $\times 1$ | $2.8 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=<150 \mathrm{~ms}$ |
|  | $7 \times \mathrm{I} \Delta \mathrm{n}$ | $\mathrm{t}=\leq 40 \mathrm{~ms}$ |



## Din-T MCBs + RCDs Technical data

## Nuisance tripping

All DinSafe RCDs have a high level of immunity to transient currents, against current impulses of $8 / 20 \mu \mathrm{~s}$ according to EN 61008/61009 and VDE 0664.T1.

Type A, AC . 250 A 8/20 $\mu \mathrm{s}$

Type S. 3000 A 8/20 $\mu \mathrm{s}$

RCDs have a high level of immunity against alternating currents of high frequency according to EN 61008/61009.


## Din-T MCBs + RCDs Technical data

## Use of an RCBO Din-Safe (DSRCB)



## TEST-BUTTON

To ensure the correct functioning of the RCBO, the test button $T$ shall be pressed frequently. The device must trip when the test button is pressed.


CONTACT POSITION INDICATOR
Printing on the toggle to provide information of the real contact position.


O-OFF
Contacts in open position. Ensure a distance between contacts > 4 mm .


## I-ON

Contacts in closed position. Ensure continuity in the main circuit.

ACCESS TO THE MECHANISM FOR EXTENSIONS It is possible to add an auxiliary contact, shunt trip, undervoltage release or motor operator, following the stack-on configuration of the extensions in section 4.


ALL CABLES MUST BE CONNECTED TO THE RCBQ All conductors, phase and neutral, that constitute the power supply of the installation to be protected, must be connected to the RCBO to either upper or lower terminals according to the following diagram.


TOGGLE
To manually switch the RCBO ON or OFF

## Din-T MCBs + RCDs Technical data

## Product related information

Influence of air ambient temperature on the rated current

## Influence of temperature on RCBOs (DinSafe DSRCB)

The thermal calibration of the RCBO was carried out at an ambient temperature of $30^{\circ} \mathrm{C}$. Ambient temperatures different from $30^{\circ} \mathrm{C}$ influence the bimetal and this results in earlier or later thermal tripping




## Din-T MCBs + RCDs Technical data

## Tripping current as a function of the frequency

All RCDs are designed to work at frequencies of $50-60 \mathrm{~Hz}$, therefore to work at different values, we must consider the variation of the tripping sensitivity according to the tables below. It should be taken into consideration that there is a no tripping risk when pushing the test-button, due to the fact that such action is made by means of an internal resistor with a fixed value.
RCBO DSRCB ${ }^{3}$ )

| Type AC ${ }^{1}$ ) | 10 Hz | 30 Hz | 50 Hz | 100 Hz | 200 Hz | 300 Hz | 400 Hz |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 30 mA | 0.62 | 0.65 | 0.80 | 0.91 | 1.24 | 1.55 | 1.88 |
| 100 mA | 0.74 | 0.71 | 0.80 | 0.95 | 1.16 | 1.38 | 1.59 |
| 300 mA | 0.80 | 0.74 | 0.80 | 0.97 | 1.19 | 1.44 | 1.64 |
| 500 mA | 1.10 | 0.81 | 0.80 | 0.89 | 1.18 | 1.38 | 1.68 |
| Type $A^{2}$ ) |  |  |  |  |  |  |  |
| 30 mA | 8.17 | 3.13 | 0.75 | 1.70 | 3.10 | 3.52 | 3.67 |
| 100 mA | 6.81 | 2.71 | 0.75 | 1.43 | 2.35 | 2.58 | 2.71 |
| 300 mA | 6.20 | 2.16 | 0.75 | 0.49 | 0.87 | 0.74 | 0.95 |
| 500 mA | 4.34 | 1.53 | 0.75 | 0.39 | 0.59 | 0.62 | 0.64 |

Notes: ${ }^{1}$ ) The standard NHP/Terasaki type is the "type AC" in Australia, Type "A" in New Zealand.
${ }^{2}$ ) The standard NHP/Terasaki DSRCBH single pole RCBO is "type A" in Australia and New Zealand.
${ }^{3}$ ) The numbers in the table above are multipliers, e.g. A "DSRCD" at 50 hz has an 0.8 multiplier. Therefore a 30 mA , "type $A C$ " RCD will trip at $(0.8 \times 30 \mathrm{~mA}) 24 \mathrm{~mA}$.

## Power losses

The power losses are calculated by means of measuring the voltage drop between the incoming and the outgoing terminal of the device at rated current. Power loss per pole:

## RCBO-DinSafe MCB DSRCB

| In (A) | $\mathbf{4}$ | $\mathbf{6}$ | $\mathbf{1 0}$ | $\mathbf{1 3}$ | $\mathbf{1 6}$ | $\mathbf{2 0}$ | $\mathbf{2 5}$ | $\mathbf{3 2}$ | $\mathbf{4 0}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Z (m0hm) | 125 | 53 | 16.5 | 11.9 | 9.8 | 7.1 | 5.6 | 4.7 | 3.6 |
| Pw (W) | 2.0 | 1.9 | 1.6 | 2.0 | 2.5 | 2.8 | 3.5 | 4.8 | 5.8 |

## Din-T MCBs + RCDs Technical data

RCBO (DSRCB) let-through energy $I^{2} t$
The benefit of an RCBO in short-circuit conditions, is its ability to reduce the value of the let-through energy that the short-circuit would be generating.

Din-Safe DSRCB

Curve C


RCBO - Din-Safe (DSRCB)

RCBO - Din-Safe (DSRCB)


Dimensions in mm

## Din-T MCBs + RCDs Technical data

## Text for specifiers

## RCBO DinSafe (DSRCB)

- The residual making and associated MCB:
- Din-T6 $\qquad$ 6000 A
- Din-T10 ........ 7500 A
- According to EN 61009 standard.
- Intended to detect residual sinusoidal currents (type AC) or residual pulsating direct currents (type A).
- Resistance against nuisance tripping according to VDE 0664 T1 and EN 61009.
- Working ambient temperature from $-25^{\circ} \mathrm{C}$ up to $+40^{\circ} \mathrm{C}$ for type A and from $-5^{\circ} \mathrm{C}$ up to $+40^{\circ} \mathrm{C}$ for type AC . Approved by CEBEC, VDE, KEMA, IMQ, etc.
- The RCBO $1 \mathrm{P}+\mathrm{N}$ is 2 modules wide or 1 module wide.
- The neutral pole is on the left hand side. The N pole closes first of all poles and opens last of all poles.
- Nominal rated currents are: 4 up to 40 A.
- Characteristic B \& C
- Nominal residual currents are: 10, 30, 100, 300, 500, 1000 mA .
- The test circuit is protected against overloads.
- The short-circuit capacity is 10 kA , with selectivity class 3.
- The making and breaking capacity is 500 A .
- The residual making and breaking capacity is 7500 A .
- Terminal capacity from 1 up to $25 \mathrm{~mm}^{2}$ rigid in the top terminals and from 1 up to $35 \mathrm{~mm}^{2}$ in the bottom terminals.
- The devices 10, 30, 100 mA type A or AC always have vertical selectivity with devices 300 mA type S .
- Both incoming and outgoing terminals have a protection degree of IP 20.
- Isolator function due to Red/Green printing on the toggle.
- Auxiliary contacts can be added on the right hand side.
- RCBOs can be released by means of a shunt trip or undervoltage release.
- RCBOs can be remotely controlled by means of a motor operator.


## Din-T MCBs + RCDs Technical data

Overview Din-Safe RCDs

Device type definition
Rating/description
Cat. No.

| Standards |
| :--- |
| Magnetic tripping characteristics |

Residual tripping characteristic ${ }^{1}$ )

| Tripping time at $\mathrm{I} \Delta \mathrm{n}$ | Instantaneous | ms |
| :--- | :--- | :--- |
|  | Selective | ms |


| Selective | ms | - |
| :--- | :--- | :---: |
| Rated current | A | $4,6,10,13,16,20,25,32,40$ |
| Rated residual current $\mathrm{I} \Delta \mathrm{n}$ | mA | 10,30 |
| Calibration temperature | ${ }^{\circ} \mathrm{C}$ | 30 |
| Number of poles versus modules |  | 1 |


| Number of poles versus modules |  |  | 1 |
| :---: | :---: | :---: | :---: |
| Rated voltage Un | 2 PAC | V | 110, 240 (1 P+N) |
|  | 3 PAC | V | - |


| 4PAC | V |  |
| :--- | :--- | :--- |
| Frequency | Hz |  |
| Maximum service voltage Ubmax | V |  |
| Minimum service voltage Ubmin | V |  |


| Power supply | Top/Bottom |
| :--- | :---: |
| Selectivity class | 3 |
| Rated making and breaking capacity (Im) | A |
| Residual making and breaking capacity (I m ) | A |


| Residual making and breaking capacity (I $\Delta \mathrm{m}$ ) | A |
| :--- | :--- |
| Conditional short-circuit capacity (Inc) | A |


| Conditional residual short-circuit capacity (I $\Delta \mathrm{c}$ ) | A |
| :--- | :--- |
| Short-circuit capacity (Icn) | A |

Grid distance (safety distance between two devices) mm

| Isolator application | yes |  |
| :--- | :--- | :---: |
| Insulation degree | Insulation voltage $\quad \mathrm{V}(\mathrm{DC})$ | 500 |
|  | Shock voltage $(1.2 / 50 \mathrm{~ms}) \mathrm{kV}$ | 6 |


| Insulation resistance (m0hm) | 1000 |  |
| :--- | :--- | :---: |
| Dielectric strength V | 2500 |  |
| Shock resistance (in $\mathrm{x}, \mathrm{y}, \mathrm{z}$ direction)(IEC $60077 / 16.3$ ) | $40 \mathrm{~g}, 18$ shocks 5 ms |  |
| Vibration resistance (in $\mathrm{x}, \mathrm{y}, \mathrm{z}$ direction; IEC $60068-2-6$ ) | $1.5 \mathrm{~g}, 30 \mathrm{~min}, 0 \ldots 80 \mathrm{~Hz}$ |  |
| Endurance | electrical at Un, In | 10000 |
| mechanical at Un, In | 20000 |  |
| Protection degree (outside/inside electrical enclosure) | IP $20 / \mathrm{IP} 40$ |  |
| Self extinguish degree (according to UL 94) | V2 |  |


| Tropicalisation (according to IEC $60068-2$, DIN 40046) | ${ }^{\circ} \mathrm{C} / \mathrm{RH}$ | $+55 / 95 \%$ |
| :--- | :--- | :---: |
| Pollution degree (acc. IEC 60947-1) | 3 |  |

.

| Operating temperature | ${ }^{\circ} \mathrm{C}$ | $-25 . .+60$ |
| :--- | :---: | :---: |
| Storage temperature | ${ }^{\circ} \mathrm{C}$ | $-5 \ldots+70$ |



Note: $\quad{ }^{1}$ ) Refer catalogue section for types.
${ }^{2}$ ) Making sure that N-L and both flying leads are disconnected.

## Timers

True delay on release Types DBBO1, PBBO 1


- Time range 0.1 to 600 s - capacitor powered
- 4 time ranges selectable by DIP-switches
- Knob-adjustable time setting
- Automatic start after drop-out of power supply
- Repeatability: $\leq 0.2 \%$
- Output: 8 A SPDT or 8 A DPDT relay
- For mounting on DIN-rail in accordance with DIN/EN 50022 or Plug-in
- 22.5 mm Euronorm or 36 mm Plug-in module housing
- Combined AC and DC power supply
- LED indication for relay status and power supply ON


## Product Description

Multi voltage true delay on release timer with 4 time ranges from 0.1 to 600 s selectable by DIP-switches.

Ordering key
Housing Function
Type
Item number
Output
Power Supply

## Type Selection

| Mounting | Output |  | Housing |
| :--- | :--- | :--- | :--- |
|  |  |  | D - Housing |
| For DIN-rail |  | SPDT |  |
| Plug-in | DPDT |  | D Housing |
|  | SPDT |  | P Housing |
|  | DPDT |  | P-Housing |

## Time Specifications

| Time ranges Selectable by DIP-switches |  |
| :---: | :---: |
|  | 0.1 to 1 s |
|  | 1 to 10 s |
|  | 6 to 60 s |
|  | 60 to 600 s |
| Repeatability | $\leq 0.2 \%$ |
| Time variation |  |
| Within rated power supply | $\leq 0.05 \%$ |
| Within ambient temperature | $\leq 0.2 \%$ |
| Reset | Power supply applied for min. 200 ms |

## Output Specifications

| Output | SPDT or DPDT relay |
| :---: | :---: |
| Rated insulation voltage | 250 VAC (RMS) |
| Contact Ratings (AgNi) | $\mu$ |
| Resistive loads AC 1 | 8 A @ 250 VAC |
| DC 12 | 5A@ 24 VDC |
| Small inductive loads AC 15 | 2.5 A @ 250 VAC |
| DC 13 | 2.5 A @ 24 VDC |
| Mechanical life | $\geq 2 \times 10^{6}$ operations |
| Electrical life AC1 | $\geq 10^{5}$ operations (at max load) |
| Operating frequency | < 3600 operations / h |
| Dielectric strength Dielectric voltage Rated impulse withstand voltage | 2 kVAC (RMS) <br> 4 kV (1.2/50 $\mu \mathrm{s}$ ) |

## Supply Specifications

| Power supply | Overvoltage cat. III |
| :---: | :---: |
| Rated operational voltage | (IEC 60664, IEC 60038) |
| through terminals: |  |
| (DBB01) A1, A2 | 24 to 240 VAC/DC |
| (PBB01) 2, 10 | +10\% -15\%, 45 to 65 Hz |
| Voltage interruption | $\leq 40 \mathrm{~ms}$ |
| Rated operational power |  |
| AC supply: | 2.2 VA |
| DC supply: | 0.6 W |

## Range/Time Setting

| Adjust the time range set- | below. |
| :--- | :--- |
| ting the DIP-switches 1 and | Centre knob: |
| 2 as shown below. | Time setting on relative |
| To access the DIP-switches | scale: 1 to 10 with respect |
| open the plastic cover using | to the chosen range. |
| a screwdriver as shown |  |

General Specifications

| Power ON delay | $\leq 200 \mathrm{~ms}$ |
| :--- | :--- |
| Power OFF delay | $\leq 100 \mathrm{~ms}$ |
| Indication for <br> Power supply status <br> Output status | LED, green <br> LED, yellow (flashing when <br> timing) |
| Environment | (EN 60529) |
| Degree of protection | IP 20 |
| Pollution degree | 3 (DBB01), 2 (PBB01) |
| (IEC 60664) |  |
| Operating temperature | -20 to $600^{\circ} \mathrm{C}$, R.H. $<95 \%$ |
| Storage temperature | -30 to $80{ }^{\circ} \mathrm{C}$, R.H. $<95 \%$ |
| Weight | Approx 120 g |
| Screw terminals | (DBB01) |
| Tightening torque | Max 0.5 Nm according to |
| IEE 60947 |  |

## Mode of Operation

## When the power supply is Note:

applied the relay operates. When the power supply is interrupted the time period starts and, at the end of the set time period, the relay releases.
If power supply is reapplied before the realy releases the time is reset and the relay remains ON.

DBB01, PBB01 shoud not be operated by pulses shorter than 200 ms . For these puroposes the relays DMB01 or PMB01, operated by external contact function, should be used.

## Wiring Diagrams



## Operation Diagram



## Timers

Delay on Operate Type DAA01, PAA01


Time range 0.1 s to 100 h

- Knob selection of time range
- Knob adjustable time setting
- Automatic start
- Repeatability: $\leq 0.2 \%$
- Output: 8 A SPDT or $2 \times 8$ A SPDT relays
- For mounting on DIN-rail in accordance with DIN/EN 50022 or Plug-in
- 22.5 Euronorm or 36 mm plug-in module housing
- Combined AC and DC power supply
- LED indication for relay status and power supply ON


## Product Description

Multi-voltage delay on operate timer with 7 selectable time ranges within 0.1 s and

100 h. For mounting on DIN rail (DAA01) or plug-in (PAA01).

Ordering Key
Housing
Function
Type
Item number
Output
Power supply

DAA 01 C M24

## Supply Specifications

Power supply
Rated operational voltage through terminals:


Time Setting
Centre knob:
Time setting on relative scale: 1 to 10 with respect to the chosen range

## Lower knob:

Setting of time range

## Operating Diagram



## General Specifications

| Power ON delay | $\leq 100 \mathrm{~ms}$ |
| :--- | :--- |
| Reaction time <br> Instantaneous contact | $<20$ ms from power ON |
| Indication for <br> Power supply status <br> Output status | LED, green <br> LED, yellow <br> (flashing when timing) |
| Environment | (EN 60529) |
| Degree of protection <br> Pollution degree | IP 20 <br> 3 (DAA01), 2 (PAA01) <br> (IEC 60664) |
| Operating temperature <br> Storage temperature | $-20^{\circ}$ to +60 ${ }^{\circ} \mathrm{C}$, R.H. $<95 \%$ |
| Weight | Approx. 130 g |
| Screw terminals (DAA01) | Max. 0.5 Nm according to |
| Tightening torque | IEC 60947 |

## Mode of Operation

The yellow LED, flashing when timing, is ON as soon as the relay turns ON.

The second relay can operate as instantaneous or delayed changeover contact. The selection is made by a DIP-switch placed under the plastic door on the device's front.

The set delay period begins as soon as the power supply
is connected. At the end of the set delay the relay operates and does not release until the power supply is interrupted for at least 200 ms . If the power supply is interrupted for at least 200 ms before the relay operates the time is set to zero and the circuit is ready for a new time period.

## Wiring Diagrams



## Features



CS 7-22E


CS 7-31E


CS 7-40E

Auxiliary contact 2 pole top mount

O Complies with IEC 947
O High contact reliability
O Basic 4 pole relay can be increased to 6 or 8 pole by clip-on contacts
O Choice of front mount or side mount additional contacts
O Electronic compatible contacts


Control relay CS 7C complete with DC control ${ }^{2}$ )


Top mounting auxiliary contact blocks ${ }^{3}$ )

| N/O | N/C | Diagram | Reference | Suit CS 7 | Cat. No. |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1 | $\left.\left.\right\|_{54} ^{53}\right\|_{62} ^{61}$ | 11 | All | CS 7-PV-11 |
| 0 | 2 | $+\left._{52}^{51}\right\|_{62} ^{61}$ | 02 | All | CS 7-PV-02 |
| 2 | 0 | $\left.\left.\right\|_{54} ^{53}\right\|_{64} ^{53}$ | 20 | All | CS 7-PV-20 |
| 1+1E | $1+1 \mathrm{~L}$ | $\left.\left.\left.\left.\right\|_{54} ^{53}\right\|_{62} ^{61}\right\|_{72} ^{61}\right\|_{84} ^{71}$ | L22 | All | CS 7-PV-L22 |
| 3 | 1 | $\left.\left.\left.\left.\right\|_{54} ^{53}\right\|_{62} ^{51}\right\|_{74} ^{61}\right\|_{84} ^{73}$ | 31 | All | CS 7-PV-31 |
| 4 |  | $\left.\left.\left.\left.\right\|_{54} ^{\mid 53}\right\|_{64} ^{\mid 63}\right\|_{74} ^{63}\right\|_{84} ^{83}$ | 40 | All | CS 7-PV-40 |

Notes: ${ }^{1}$ ) Add coil voltage, standard voltages $24,32,110,240,415 \mathrm{~V} 50 \mathrm{~Hz}$.
${ }^{2}$ ) Add coil voltage, standard voltages $24,36,48,110$ and 240 V DC.
${ }^{3}$ ) Other contact blocks type CA 7-P can be used providing terminal numbers are acceptable (refer CA 7 contactor auxiliaries).
240/415 V rated coils are suitable for use on 230/400 V in accordance with AS 60038 : 2000

## Technical information

Ratings to IEC 947

| Relay |  | CS 7 | Relay and accessories |
| :---: | :---: | :---: | :---: |
| AC 1 resistive load |  |  |  |
| switching $3 \varnothing$ |  |  |  |
| Ambient temperature $40{ }^{\circ} \mathrm{C}$ |  |  |  |
| $l e$ | ［A］ | 25 | 10 |
| 230／240 V | ［kW］ | 10 | － |
| 400／415 V | ［kW］ | 17 | － |
| 690 V | ［kW］ | 30 | － |
| Ambient temperature $60{ }^{\circ} \mathrm{C}$ |  |  |  |
| $l_{e}$ | ［A］ | 20 | 6 |
| 230／240 V | ［kW］ | 8 | － |
| 400／415 V | ［kW］ | 14 | － |
| 690 V | ［kW］ | 24 | － |
| AC motor switching AC 2，AC 3，AC 4 |  |  |  |
| 230／240 V | ［A］ | 11.5 | － |
| 400／415 V | ［A］ | 9 | － |
| 690 V | ［A］ | 5 | － |
| 230／240 V | ［kW］ | 3 | － |
| 400／415 V | ［kW］ | 4 | － |
| 690 V | ［kW］ | 4 | － |

AC switching of electromagnetic loads
AC 15 at rated voltage

| 24 V | ［A］ | 16 | 6 |
| :---: | :---: | :---: | :---: |
| 48 V | ［A］ | 16 | 6 |
| 110 V | ［A］ | 14 | 6 |
| 230／240 V | ［A］ | 10 | 3 |
| 400／415 V | ［A］ | 5 | 2 |
| 500 V | ［A］ | 2.5 | 1.5 |
| 600 V | ［A］ | 1.8 | 1.2 |
| 690 V | ［A］ | 1 | 0.7 |
| Short circuit protection | Fuse gG |  |  |
| Co－ordination type＇2＇ | ［A］ | 10 | 10 |
| Number of switching operations |  |  |  |
| Mechanical | ［Mill］ | 15 | 15 |
| AC 15 （230／240 V， 3 A） | ［Mill］ | 1.5 | 1.5 |
| Weight with AC coil | ［kg］ | 0.39 | － |
| Terminals for auxiliary contacts |  | $\stackrel{\text { 芹 }}{\stackrel{\text { を }}{4}}$ | $\stackrel{\text { 腎 }}{2}$ |
| Terminal size to IEC 947－1 |  | $2 \times \mathrm{A} 4$ | $2 \times \mathrm{A} 4$ |
| Flexible wire with sleeve | 1 wire［ $\mathrm{mm}^{2}$ ］ | 1．．． 4 | 0．5．．．2．5 |
| 氖 | 2 wire［ $\mathrm{mm}^{2}$ ］ | 1．．． 4 | 0．75．．．2．5 |
| Stranded／solid core | 1 wire［ $\mathrm{mm}^{2}$ ］ | 1．5．．． 6 | 0．5．．．2．5 |
| $\square=\square$ | 2 wire［ $\mathrm{mm}^{2}$ ］ | 1．5．．． 6 | 0．75．．．2．5 |
| Tightening torque | ［ Nm ］ | 1．．．2．5 | 1．．．1．5 |

Note：$\quad 240 / 415 \mathrm{~V}$ rated coils are suitable for use on $230 / 400 \mathrm{~V}$ in accordance with AS $60038: 2000$

## Technical information

| Control circuit |  | CS 7 |
| :---: | :---: | :---: |
| Operating limits |  |  |
| AC $50 / 60 \mathrm{~Hz}$ | Pick-up [ $\mathrm{x} \mathrm{U}_{\mathrm{s}}$ ] | 0.85...1.1 |
|  | Drop-out [ $\mathrm{x} \mathrm{U}_{\mathrm{s}}$ ] | 0.3...0.6 |
| Pick-up and hold |  |  |
| AC 50/60 Hz | Pick-up [VA/W] | 70/50 |
|  | Hold [VA/W] | 8/2.6 |
| Operating times |  |  |
| AC $50 / 60 \mathrm{~Hz}$ | Make [ms] | 15... 30 |
|  | Break [ms] | 10... 60 |

General data CS 7

Rated insulation voltage $U_{i}$

| IEC | 690 V |
| :---: | :---: |
| UL, CSA | 600 V |
| Rated impulse voltage withstand Uimp | 8k V |
| Test voltage |  |
| 1 minute (to IEC 947-4) | 2500 V |
| Rated voltage $\mathrm{U}_{e}$ |  |
| AC | 110, 230/240, 400/415, 500, 690 V |
| DC | 24, 48, 110, 220, 440 V |
| Rated frequency of coil | $50 / 60 \mathrm{~Hz}$, DC |
| Ambient temperature |  |
| Storage | $-55 \ldots+80^{\circ} \mathrm{C}\left(-67 \ldots 176{ }^{\circ} \mathrm{F}\right)$ |
| Operation at nominal current | $-25 \ldots+60^{\circ} \mathrm{C}\left(-13 \ldots 140^{\circ} \mathrm{F}\right)$ |
| Maximum with $15 \%$ AC 1 current reduction $>60^{\circ} \mathrm{C}$ | $-25 \ldots+70{ }^{\circ} \mathrm{C}\left(-13 \ldots 158{ }^{\circ} \mathrm{F}\right)$ |
| Climatic withstand | Cyclicly changing humid atmosphere to |
|  | IEC 68-2-30 and DIN 50 016, 56 |
| Maximum altitude | 2000 m NN, to IEC 947-4 |
| Protection class |  |
| IP 2LX (IEC 529 and DIN 40050) | In connected condition |
| Protection against contact | Finger and back of hand to VDE 0106, Part 100 |

Note: $\quad 240 / 415 \mathrm{~V}$ rated coils are suitable for use on $230 / 400 \mathrm{~V}$ in accordance with AS $60038: 2000$

## Dimensions

CS 7 (AC)
Dimensions in (mm)


CS 7 (DC)
Dimensions in (mm)


Relay

| Type | a | b | c | c1 | c2 | od | d1 | d2 |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :--- |
| CS 7 (AC) | 45 | 81 | 80.5 | 75.5 | 6 | 4.5 | 60 | 35 | $\left.{ }^{1}\right)$ |

## Accessories

| Contactor with |  | [mm] |
| :--- | :--- | ---: |
| Front mounting auxiliary contact | 2 or 4 pole | $\mathrm{c} / \mathrm{c} 1+39$ |
| Side mounting auxiliary contact | 1 or 2 pole | $\mathrm{a}+9$ |
| Pneumatic timing module |  | $\mathrm{c} / \mathrm{c} 1+58$ |
| Electronic timing module | Coil mounting | $\mathrm{b}+24$ |
| Mechanical interlock | Mounts between contactors | $\mathrm{a}+9$ |
|  |  | $\mathrm{c} / \mathrm{c} 1+61$ |
| Interface | Coil mounting | $\mathrm{b}+9$ |
| Suppressor | Coil mounting | $\mathrm{b}+3$ |
| With inscriptions | Labels | +0 |
|  | Label support system V4/V5 | +5.5 |

Note: ${ }^{1}$ ) DIN rail mounting to 35 mm to EN 50022.

## Mounting position



Technical Information

## Electrical Data

|  |  |  | CA7-9 | CA7-12 | CA7-16 | CA7-23 | CA7-30 | CA7-37 | CA7-43 | CA7-60 | CA7-72 | CA7-85 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Rated Insulation Voltage $\boldsymbol{U}_{\mathbf{i}}$ |  |  |  |  |  |  |  |  |  |  |  |  |
| IEC, AS,BS,SEV, VDE 0660 |  | [V] |  | 690V |  |  |  |  |  |  |  |  |
| UL; CSA |  | [V] |  | 600 V |  |  |  |  |  |  |  |  |
| Rated Impulse Voltage $\boldsymbol{U}_{\text {imp }}$ |  | [kV] |  |  |  |  |  | 8kV |  |  |  |  |
| Rated Voltage $\boldsymbol{U}_{\mathrm{e}}$-Main Contacts |  |  |  |  |  |  |  |  |  |  |  |  |
| AC 50/60Hz |  | [V] |  | 115, 200, 208, 230, 240, 380, 400, 415, 460, 500, 575, 690V |  |  |  |  |  |  |  |  |
| DC |  | [V] |  | 24, 48, 110, 115, 220, 230, 300, 440V |  |  |  |  |  |  |  |  |
| Operating Frequency for AC Loads |  | [Hz] |  | $50 . . .60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |
| Switching Motor Loads |  |  |  |  |  |  |  |  |  |  |  |  |
| Standard IEC Ratings |  |  |  |  |  |  |  |  |  |  |  |  |
| AC-2, AC-3, AC-4 | 230 V | [A] | 12 | 15 | 20 | 26.5 | 35 | 38 | 44 | 62 | 72 | 85 |
| DOL Reversing | 240 V | [A] | 12 | 15 | 20 | 26.5 | 35 | 38 | 44 | 62 | 72 | 85 |
| $50 \mathrm{~Hz} / 60^{\circ} \mathrm{C}$ | 400 V | [A] | 9 | 12 | 16 | 23 | 30 | 37 | 43 | 60 | 72 | 85 |
|  | 415 V | [A] | 9 | 12 | 16 | 23 | 30 | 37 | 43 | 60 | 72 | 85 |
|  | 500 V | [A] | 7 | 10 | 14 | 20 | 25 | 30 | 38 | 55 | 67 | 80 |
|  | 690 V | [A] | 5 | 7 | 9 | 12 | 18 | 21 | 25 | 34 | 42 | 49 |
|  | 230 V | [kW] | 3 | 4 | 5.5 | 7.5 | 10 | 11 | 13 | 18.5 | 22 | 25 |
|  | 240 V | [kW] | 3 | 4 | 5.5 | 7.5 | 10 | 11 | 13 | 18.5 | 22 | 25 |
|  | 400 V | [kW] | 4 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 32 | 40 | 45 |
|  | 415 V | [kW] | 4 | 5.5 | 7.5 | 11 | 15 | 20 | 22 | 32 | 40 | 45 |
|  | 500 V | [kW] | 4 | 5.5 | 7.5 | 13 | 15 | 20 | 25 | 37 | 45 | 55 |
|  | 690 V | [kW] | 4 | 5.5 | 7.5 | 10 | 15 | 18.5 | 22 | 32 | 40 | 45 |
| UL/CSA/IEC |  |  |  |  |  |  |  |  |  |  |  |  |
| DOL Reversing | 115 V | [A] | 9.8 | 9.8 | 16 | 24 | 24 | 34 | 34 | 56 | 56 | 80 |
| $\begin{array}{cc} \underset{\mathbf{0}}{60 \mathrm{~Hz} / 60^{\circ} \mathrm{C}} & 1 \emptyset \\ & \\ & \\ & \\ & \\ & 0 \emptyset \end{array}$ | 230 V | [ A ] | 10 | 12 | 17 | 17 | 28 | 28 | 40 | 50 | 68 | 68 |
|  | 115 V | [HP] | 1/2 | 1/2 | 1 | 2 | 2 | 3 | 3 | 5 | 5 | 7-1/2 |
|  | 230 V | [HP] | $11 / 2$ | 2 | 3 | 3 | 5 | 5 | 7-1/2 | 10 | 15 | 15 |
|  | 200 V | [ A ] | 7.8 | 11 | 17.5 | 17.5 | 25.3 | 32.2 | 32.2 | 48.3 | 62.1 | 78.2 |
|  | 230 V | [A] | 6.8 | 9.6 | 15.2 | 22 | 28 | 28 | 42 | 54 | 68 | 80 |
|  | 460 V | [A] | 7.6 | 11 | 14 | 21 | 27 | 34 | 40 | 52 | 65 | 77 |
|  | 575 V | [A] | 9 | 11 | 17 | 17 | 27 | 32 | 32 | 52 | 62 | 62 |
|  | 200 V | [HP] | 2 | 3 | 5 | 5 | 7-1/2 | 10 | 10 | 15 | 20 | 25 |
|  | 230 V | [HP] | 2 | 3 | 5 | 7-1/2 | 10 | 10 | 15 | 20 | 25 | 30 |
|  | 460 V | [HP] | 5 | 7-1/2 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 |
|  | 575 V | [HP] | 7-1/2 | 10 | 15 | 15 | 25 | 30 | 30 | 50 | 60 | 60 |
| Maximum Operating Rate (at max. amps) | AC2 | [ops/hr] | 450 | 450 | 450 | 400 | 400 | 400 | 400 | 300 | 250 | 200 |
|  | AC3 | [ops/hr] | 700 | 700 | 700 | 600 | 600 | 600 | 600 | 500 | 500 | 500 |
|  | AC4 | [ops/hr] | 200 | 150 | 120 | 80 | 80 | 70 | 70 | 70 | 60 | 50 |

Approved by Lloyd's register of shipping.

## Electrical Data

CA7-9 CA7-12 CA7-16 CA7-23 CA7-30 CA7-37 CA7-43 CA7-60 CA7-72 CA7-85

Switching Motor Loads (continued)

| AC-4 | 230 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 200,000 Op. Cycles | 240 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
| 50 Hz | 400 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 415 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 500 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 690 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 230 V | [kW] | 0.75 | 1.5 | 2.2 | 2.2 | 3 | 3.7 | 4 | 6.3 | 7.5 | 11 |
|  | 240 V | [kW] | 0.75 | 1.5 | 2.2 | 2.2 | 3 | 4 | 4 | 7.5 | 7.5 | 11 |
|  | 400 V | [kW] | 1.8 | 3 | 4 | 4 | 5.5 | 6.3 | 7.5 | 13 | 15 | 20 |
|  | 415 V | [kW] | 1.8 | 3 | 4 | 4 | 5.5 | 6.3 | 7.5 | 13 | 17 | 20 |
|  | 500 V | [kW] | 2.2 | 3.7 | 5.5 | 5.5 | 7.5 | 7.5 | 10 | 15 | 20 | 25 |
|  | 690 V | [kW] | 3 | 5.5 | 7.5 | 7.5 | 10 | 11 | 15 | 22 | 25 | 32 |
| 60 Hz | 115 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 230 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 115 V | [HP] | 1/8 | 1/4 | 1/3 | 1/2 | 1/2 | 3/4 | 1 | 2 | 2 | 3 |
|  | 230 V | [HP] | 1/3 | 1/2 | 1 | 1-1/2 | 2 | 2 | 2 | 3 | 5 | 5 |
|  | 200 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
| $3 \emptyset$ | 230 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 460 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 575 V | [A] | 4.3 | 6.6 | 9 | 10 | 12 | 14 | 16.5 | 25.5 | 31 | 38 |
|  | 200 V | [HP] | 3/4 | 1 | 2 | 2 | 3 | 3 | 3 | 7-1/2 | 7-1/2 | 10 |
|  | 230 V | [HP] | 1 | 1-1/2 | 2 | 3 | 3 | 3 | 5 | 7-1/2 | 10 | 10 |
|  | 460 V | [HP] | 2 | 3 | 5 | 5 | 7-1/2 | 10 | 10 | 15 | 20 | 25 |
|  | 575 V | [HP] | 3 | 5 | 7-1/2 | 7-1/2 | 10 | 10 | 10 | 20 | 25 | 30 |
| Maximum Operating Rate |  |  | 250 | 250 | 220 | 200 | 200 | 200 | 200 | 120 | 120 | 120 |
| Wye-Delta (Star Delta) | 230 V | [kW] | 5.5 | 7.5 | 10 | 13 | 17 | 20 | 22 | 32 | 37 | 45 |
| 50 Hz | 240 V | [kW] | 5.5 | 7.5 | 10 | 13 | 18.5 | 20 | 22 | 32 | 40 | 50 |
|  | 400 V | [kW] | 7.5 | 10 | 13 | 20 | 25 | 32 | 40 | 55 | 63 | 80 |
|  | 415 V | [kW] | 7.5 | 11 | 15 | 22 | 25 | 37 | 40 | 55 | 63 | 80 |
|  | 500 V | [kW] | 7.5 | 11 | 15 | 22 | 25 | 32 | 45 | 63 | 80 | 90 |
|  | 690 V | [kW] | 7.5 | 10 | 13 | 18.5 | 25 | 32 | 40 | 55 | 63 | 80 |
|  | 200 V | [HP] | 5 | 5 | 7-1/2 | 7-1/2 | 10 | 15 | 20 | 30 | 40 | 50 |
| 60 Hz | 230 V | [HP] | 5 | 7-1/2 | 10 | 10 | 15 | 20 | 25 | 40 | 50 | 60 |
|  | 460 V | [HP] | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 75 | 100 | 125 |
|  | 575 V | [HP] | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 75 | 100 | 125 |

AC Elevator Control Ratings

| UL / CSA | Max FLC | $[\mathrm{A}]$ | 8.0 | 11.0 | 16.0 | 21.0 | 27.0 | 31.0 | 37.0 | 43.0 | 54.0 |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 500,000 operations | 200 V | $[\mathrm{~A}]$ | 7.8 | 11.0 | 11.0 | 17.5 | 25.3 | 25.3 | 32.2 | 32.2 | 48.3 |
|  | 230 V | $[\mathrm{~A}]$ | 6.8 | 9.6 | 15.2 | 15.2 | 22.0 | 28.0 | 28.0 | 42.0 | 54.0 |
|  | 460 V | $[\mathrm{~A}]$ | 7.6 | 11.0 | 14.0 | 21.0 | 27.0 | 27.0 | 34.0 | 40.0 | 52.0 |
|  | 575 V | $[\mathrm{~A}]$ | 6.1 | 9.0 | 11.0 | 17.0 | 22.0 | 27.0 | 32.0 | 41.0 | 52.0 |
|  | 200 V | $[\mathrm{HP}]$ | 2 | 3 | 3 | 5 | $7-1 / 2$ | $7-1 / 2$ | 10 | 10 | 15 |
|  | 230 V | $[\mathrm{HP}]$ | 2 | 3 | 5 | 5 | $7-1 / 2$ | 10 | 10 | 15 | 20 |
|  | 460 V | $[\mathrm{HP}]$ | 5 | $7-1 / 2$ | 10 | 15 | 20 | 20 | 25 | 30 | 40 |
|  | 575 V | $[\mathrm{HP}]$ | 5 | $7-1 / 2$ | 10 | 15 | 20 | 25 | 30 | 40 | 50 |

## Electrical Data

|  |  |  | CA7-9 | CA7-12 | CA7-16 | CA7-23 | CA7-30 | CA7-37 | CA7-43 | CA7-60 | CA7-72 | CA7-85 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| AC-1 Load, 30 Switching Ambient Temperature $40^{\circ} \mathrm{C}$ | $I_{\text {th }}$ | [A] | 32 | 32 | 32 | 32 | 65 | 65 | 85 | 100 | 100 | 100 |
|  | 230 V | [kW] | 13 | 13 | 13 | 13 | 26 | 26 | 34 | 40 | 40 | 40 |
|  | 240 V | [kW] | 13 | 13 | 13 | 13 | 27 | 27 | 35 | 42 | 42 | 42 |
|  | 400 V | [kW] | 22 | 22 | 22 | 22 | 45 | 45 | 59 | 69 | 69 | 69 |
|  | 415 V | [kW] | 23 | 23 | 23 | 23 | 47 | 47 | 61 | 72 | 72 | 72 |
|  | 500 V | [kW] | 28 | 28 | 28 | 28 | 56 | 56 | 74 | 87 | 87 | 87 |
|  | 690 V | [kW] | 38 | 38 | 38 | 38 | 78 | 78 | 102 | 120 | 120 | 120 |
| Ambient Temperature $60^{\circ} \mathrm{C}$ | $t_{\text {th }}$ | [A] | 32 | 32 | 32 | 32 | 65 | 65 | 80 | 100 | 100 | 100 |
|  | 230 V | [kW] | 13 | 13 | 13 | 13 | 26 | 26 | 32 | 40 | 40 | 40 |
|  | 240 V | [kW] | 13 | 13 | 13 | 13 | 27 | 27 | 33 | 42 | 42 | 42 |
|  | 400 V | [kW] | 22 | 22 | 22 | 22 | 45 | 45 | 55 | 69 | 69 | 69 |
|  | 415 V | [kW] | 23 | 23 | 23 | 23 | 47 | 47 | 57 | 72 | 72 | 72 |
|  | 500 V | [kW] | 28 | 28 | 28 | 28 | 56 | 56 | 69 | 87 | 87 | 87 |
|  | 690 V | [kW] | 38 | 38 | 38 | 38 | 78 | 78 | 95 | 120 | 120 | 120 |
| Maximum Operating Rate |  |  | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 300 | 600 | 600 | 600 |
| Continuous Current (UL/CSA) |  |  |  |  |  |  |  |  |  |  |  |  |
| General Purpose Rating ( $40^{\circ}$ ) | Open | [A] | 25 | 25 | 30 | 30 | 45 | 55 | 60 | 90 | 90 | 100 |
|  | Enclosed | [A] | 25 | 25 | 30 | 30 | 55 | 60 | 75 | 90 | 90 | 100 |
| Maximum Operating Rate |  |  | 1,400 | 1,400 | 1,200 | 1,200 | 1,200 | 1,000 | 1000 | 700 | 700 | 600 |
| Lighting Loads (1) |  |  |  |  |  |  |  |  |  |  |  |  |
| Elec.Dischrg.Lamps-AC-5a, single compensated | Open | [A] | 22.5 | 25 | 28 | 29 | 40.5 | 45 | 77 | 81 | 85 | 90 |
|  | Enclosed | [A] | 22.5 | 25 | 28 | 29 | 37 | 41 | 57 | 57 | 81 | 90 |
| Max. capacitance at prospective short circuit current available at the contactor | 10kA | [ $\mu \mathrm{f}$ ] | 1,000 | 1,000 | 1,000 | 1,000 | 2,700 | 2,700 | 3,200 | 4,000 | 4,000 | 4,700 |
|  | 20kA | [ $\mu \mathrm{f}]$ | 500 | 500 | 500 | 500 | 1,350 | 1,350 | 1,600 | 2,000 | 2,000 | 2,350 |
|  | 50kA | [ $\mu \mathrm{f}$ ] | 200 | 200 | 200 | 200 | 540 | 540 | 640 | 800 | 800 | 940 |
| Incandescent Lamps - AC -5b |  |  |  |  |  |  |  |  |  |  |  |  |
| Switching power transformers AC-6a |  |  |  |  |  |  |  |  |  |  |  |  |
| 50 Hz |  |  |  |  |  |  |  |  |  |  |  |  |
| Inrush |  |  |  |  |  |  |  |  |  |  |  |  |
| Rated transformer current |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | [A] | 10.9 | 10.9 | 10.9 | 10.9 | 20 | 20 | 23 | 40.8 | 40.8 | 40.8 |
| $\mathrm{n}=30$ | 230 VAC | [kVA] | 4.3 | 4.3 | 4.3 | 4.3 | 8 | 8 | 9.2 | 16 | 16 | 16 |
|  | 240 VAC | [kVA] | 4.5 | 4.5 | 4.5 | 4.5 | 8.3 | 8.3 | 10 | 17 | 17 | 17 |
|  | 400 VAC | [kVA] | 7.5 | 7.5 | 7.5 | 7.5 | 14 | 14 | 16 | 28 | 28 | 28 |
|  | 415 VAC | [kVA] | 7.8 | 7.8 | 7.8 | 7.8 | 14 | 14 | 17 | 29 | 29 | 29 |
|  | 500 VAC | [kVA] | 9.4 | 9.4 | 9.4 | 9.4 | 17 | 17 | 20 | 35 | 35 | 35 |
|  | 690 VAC | [kVA] | 13 | 13 | 13 | 13 | 24 | 24 | 27 | 49 | 49 | 49 |
| $\mathrm{n}=20$ |  | [A] | 16.3 | 16.3 | 16.3 | 16.3 | 30 | 30 | 34.5 | 61.3 | 61.3 | 61.3 |
|  | 230 VAC | [kVA] | 6.5 | 6.5 | 6.5 | 6.5 | 12 | 12 | 13.7 | 24.4 | 24.4 | 24.4 |
|  | 240 VAC | [kVA] | 6.8 | 6.8 | 6.8 | 6.8 | 12.5 | 12.5 | 14.3 | 25.5 | 25.5 | 25.5 |
|  | 400 VAC | [kVA] | 11.3 | 11.3 | 11.3 | 11.3 | 20.8 | 20.8 | 23.9 | 42.5 | 42.5 | 42.5 |
|  | 415 VAC | [kVA] | 11.7 | 11.7 | 11.7 | 11.7 | 21.6 | 21.6 | 24.8 | 44.1 | 44.1 | 44.1 |
|  | 500 VAC | [kVA] | 14.1 | 14.1 | 14.1 | 14.1 | 26 | 26 | 29.9 | 53.1 | 53.1 | 53.1 |
|  | 690 VAC | [kVA] | 19.5 | 19.5 | 19.5 | 19.5 | 35.9 | 35.9 | 41.2 | 73.3 | 73.3 | 73.3 |
| $\mathrm{n}=15$ |  | [A] | 22 | 22 | 22 | 22 | 40 | 40 | 46 | 82 | 82 | 82 |
|  | 230 VAC | [kVA] | 2.3 | 2.3 | 2.3 | 2.3 | 4.3 | 4.3 | 5.0 | 8.8 | 8.8 | 8.8 |
|  | 240 VAC | [kVA] | 2.4 | 2.4 | 2.4 | 2.4 | 4.5 | 4.5 | 5.2 | 9.2 | 9.2 | 9.2 |
|  | 400 VAC | [kVA] | 4.1 | 4.1 | 4.1 | 4.1 | 7.5 | 7.5 | 8.6 | 15.3 | 15.3 | 15.3 |
|  | 415 VAC | [kVA] | 4.2 | 4.2 | 4.2 | 4.2 | 7.8 | 7.8 | 8.9 | 15.9 | 15.9 | 15.9 |
|  | 500 VAC | [kVA] | 5.1 | 5.1 | 5.1 | 5.1 | 9.4 | 9.4 | 10.8 | 19.1 | 19.1 | 19.1 |
|  | 690 VAC | [kVA] | 7.0 | 7.0 | 7.0 | 7.0 | 12.9 | 12.9 | 14.9 | 26.4 | 26.4 | 26.4 |

(1) CA7 ratings for lighting loads are provided for technical reference. For cUL rated and labeled devices, see CAL7 contactors listed in this section.

## Electrical Data

## CA7-9 CA7-12 CA7-16 CA7-23 CA7-30 CA7-37 CA7-43 CA7-60 CA7-72 CA7-85

| Switching power transformers AC-6a |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 60 Hz |  |  |  |  |  |  |  |  |  |  |  |  |
| Inrush | $=\mathrm{n}$ |  |  |  |  |  |  |  |  |  |  |  |
| Rated transformer current |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | [ A ] | 10.9 | 10.9 | 10.9 | 10.9 | 20 | 20 | 23 | 40.8 | 40.8 | 40.8 |
| $\mathrm{n}=30$ | 200 VAC | [kVA] | 3.8 | 3.8 | 3.8 | 3.8 | 6.9 | 6.9 | 8.0 | 14.1 | 14.1 | 14.1 |
|  | 208 VAC | [kVA] | 3.9 | 3.9 | 3.9 | 3.9 | 7.2 | 7.2 | 8.3 | 14.7 | 14.7 | 14.7 |
|  | 240 VAC | [kVA] | 4.5 | 4.5 | 4.5 | 4.5 | 8.3 | 8.3 | 9.6 | 17 | 17 | 17 |
|  | 480 VAC | [kVA] | 9.1 | 9.1 | 9.1 | 9.1 | 16.6 | 16.6 | 19.1 | 33.9 | 33.9 | 33.9 |
|  | 600 VAC | [kVA] | 11.3 | 11.3 | 11.3 | 11.3 | 20.8 | 20.8 | 23.9 | 42.4 | 42.4 | 42.4 |
|  | 660 VAC | [kVA] | 12.5 | 12.5 | 12.5 | 12.5 | 22.9 | 22.9 | 26.3 | 46.6 | 46.6 | 46.6 |
|  |  | [A] | 16.3 | 16.3 | 16.3 | 16.3 | 30 | 30 | 34.5 | 61.3 | 61.3 | 61.3 |
| $\mathrm{n}=20$ | 200 VAC | [kVA] | 5.6 | 5.6 | 5.6 | 5.6 | 10.4 | 10.4 | 12 | 21.2 | 21.2 | 21.2 |
|  | 208 VAC | [kVA] | 5.9 | 5.9 | 5.9 | 5.9 | 10.8 | 10.8 | 12.4 | 22.1 | 22.1 | 22.1 |
|  | 240 VAC | [kVA] | 6.8 | 6.8 | 6.8 | 6.8 | 12.5 | 12.5 | 14.3 | 25.5 | 25.5 | 25.5 |
|  | 480 VAC | [kVA] | 13.6 | 13.6 | 13.6 | 13.6 | 24.9 | 24.9 | 28.7 | 51 | 51 | 51 |
|  | 600 VAC | [kVA] | 16.9 | 16.9 | 16.9 | 16.9 | 31.2 | 31.2 | 35.9 | 63.7 | 63.7 | 63.7 |
|  | 660 VAC | [kVA] | 18.6 | 18.6 | 18.6 | 18.6 | 34.3 | 34.3 | 39.4 | 70.1 | 70.1 | 70.1 |
|  |  | [A] | 22 | 22 | 22 | 22 | 40 | 40 | 46 | 82 | 82 | 82 |
| $\mathrm{n}=15$ | 200 VAC | [kVA] | 7.5 | 7.5 | 7.5 | 7.5 | 13.9 | 13.9 | 15.9 | 28.4 | 28.4 | 28.4 |
|  | 208 VAC | [kVA] | 7.8 | 7.8 | 7.8 | 7.8 | 14.4 | 14.4 | 16.6 | 29.5 | 29.5 | 29.5 |
|  | 240 VAC | [kVA] | 9 | 9 | 9 | 9 | 16.6 | 16.6 | 19.1 | 34.1 | 34.1 | 34.1 |
|  | 480 VAC | [kVA] | 18.1 | 18.1 | 18.1 | 18.1 | 33.3 | 33.3 | 38.2 | 68.2 | 68.2 | 68.2 |
|  | 600 VAC | [kVA] | 22.6 | 22.6 | 22.6 | 22.6 | 41.6 | 41.6 | 47.8 | 85.2 | 85.2 | 85.2 |
|  | 660 VAC | [kVA] | 24.9 | 24.9 | 24.9 | 24.9 | 45.7 | 45.7 | 52.6 | 93.7 | 93.7 | 93.7 |

DC-1 Switching - $60^{\circ} \mathrm{C}$

|  | 24VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 80 | 80 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 48VDC | [A] | 20 | 20 | 20 | 20 | 25 | 25 | 30 | 40 | 40 | 40 |
| 1 Pole | 60VDC | [A] | 20 | 20 | 20 | 20 | 25 | 25 | 30 | 40 | 40 | 40 |
|  | 110VDC | [A] | 6 | 6 | 6 | 6 | 8 | 8 | 9 | 11 | 11 | 11 |
|  | 220VDC | [A] | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 2 | 2 | 2 |
|  | 440VDC | [A] | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 |
|  | 24VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 80 | 80 |
|  | 48VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 80 | 80 |
| 2 Poles in Series | 60VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 80 | 80 |
|  | 110VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 80 | 80 |
|  | 220VDC | [A] | 8 | 8 | 8 | 8 | 10 | 10 | 10 | 15 | 15 | 15 |
|  | 440VDC | [A] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.5 | 1.5 | 1.5 |
|  | 24VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 63 | 90 | 90 | 100 |
|  | 48VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 63 | 90 | 90 | 100 |
| 3 Poles in Series | 60VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 63 | 90 | 90 | 100 |
|  | 110VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 63 | 90 | 90 | 100 |
|  | 220VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 80 | 80 |
|  | 440VDC | [A] | 3 | 3 | 3 | 3 | 3.5 | 3.5 | 4 | 5 | 5 | 5 |

DC-2, 3, 5 Switching - $60^{\circ} \mathrm{C}$

| Starting, reverse current braking, reversing, DC-5, $60^{\circ} \mathrm{C}$ | 24VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 63 | 90 | 90 | 100 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 48VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 70 | 80 |
|  | 60VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 70 | 80 |
| Shunt Wound | 110VDC | [A] | 20 | 20 | 25 | 25 | 30 | 30 | 35 | 70 | 70 | 80 |
| 3 Poles in Series | 220VDC | [A] | 6 | 6 | 6 | 10 | 15 | 15 | 20 | 25 | 25 | 30 |
|  | 440VDC | [A] | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Series-wound Motors |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 Poles in Series | 24VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 63 | 90 | 90 | 100 |
|  | 48VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 70 | 80 |
|  | 60VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 50 | 70 | 70 | 80 |
|  | 110VDC | [A] | 20 | 20 | 25 | 25 | 30 | 30 | 35 | 70 | 70 | 80 |
|  | 220VDC | [A] | 6 | 6 | 6 | 10 | 15 | 15 | 20 | 25 | 25 | 30 |
|  | 440VDC | [A] | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |

Technical Information

Electrical Data

|  |  |  | CA7-9 | CA7-12 | CA7-16 | CA7-23 | CA7-30 | CA7-37 | CA7-43 | CA7-60 | CA7-72 | CA7-85 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Capacitor Ratings (1) <br> Capacitor Switching AC-6b-50 Hz <br> Single Capacitor $-40^{\circ} \mathrm{C}$ |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 230 V | [kVar] | 8 | 8 | 8.5 | 9 | 14 | 14 | 24 | 28 | 28 | 28 |
|  | 240 V | [kVar] | 8 | 8 | 8.5 | 9 | 14 | 14 | 25 | 29 | 29 | 29 |
|  | 400 V | [kVar] | 8 | 8 | 10 | 12.5 | 20 | 24 | 35 | 48 | 48 | 48 |
|  | 415 V | [kVar] | 8 | 8 | 10 | 12.5 | 20 | 25 | 35 | 50 | 50 | 50 |
|  | 500 V | [kVar] | 8 | 8 | 10 | 12.5 | 20 | 25 | 35 | 50 | 55 | 60 |
|  | 690 V | [kVar] | 8 | 8 | 10 | 12.5 | 20 | 25 | 35 | 50 | 55 | 60 |
| Single Capacitor - $60^{\circ} \mathrm{C}$ | 230 V | [kVar] | 8 | 8 | 8.5 | 9 | 12.5 | 12.5 | 18 | 28 | 28 | 28 |
|  | 240 V | [kVar] | 8 | 8 | 8.5 | 9 | 12.5 | 12.5 | 18 | 29 | 29 | 29 |
|  | 400 V | [kVar] | 8 | 8 | 10 | 12.5 | 20 | 21.5 | 30 | 42 | 48 | 48 |
|  | 415 V | [kVar] | 8 | 8 | 10 | 12.5 | 20 | 22 | 30 | 42 | 50 | 50 |
|  | 500 V | [kVar] | 8 | 8 | 10 | 12.5 | 20 | 25 | 30 | 42 | 50 | 55 |
|  | 690 V | [kVar] | 8 | 8 | 10 | 12.5 | 20 | 25 | 30 | 42 | 50 | 55 |
| Capacitor Bank - $40^{\circ} \mathrm{C}$ (2) | 230 V | [kVar] | 5 | 5 | 8 | 9 | 12.5 | 14 | 20 | 28 | 28 | 28 |
|  | 240 V | [kVar] | 5 | 5 | 8 | 9 | 12.5 | 14 | 20 | 29 | 29 | 29 |
|  | 400 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 48 | 48 |
|  | 415 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |
|  | 500 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |
|  | 690 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |
| Capacitor Bank - $60^{\circ} \mathrm{C}$ (2 | 230 V | [kVar] | 5 | 5 | 8 | 9 | 12.5 | 12.5 | 18 | 28 | 28 | 28 |
|  | 240 V | [kVar] | 5 | 5 | 8 | 9 | 12.5 | 12.5 | 18 | 29 | 29 | 29 |
|  | 400 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 48 | 48 |
|  | 415 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |
|  | 500 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |
|  | 690 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |
| Capacitor Switching -60Hz |  |  |  |  |  |  |  |  |  |  |  |  |
| Single Capacitor - $40^{\circ} \mathrm{C}$ | 200 V | [kVar] | 5 | 5 | 8 | 9 | 12.5 | 14 | 20 | 28 | 28 | 28 |
|  | 230 V | [kVar] | 5 | 5 | 8 | 9 | 12.5 | 14 | 20 | 29 | 29 | 29 |
|  | 460 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |
|  | 600 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 60 |
| Capacitor Bank - $40^{\circ} \mathrm{C}$ (2) | 200 V | [kVar] | 5 | 5 | 8 | 9 | 12.5 | 12.5 | 18 | 28 | 28 | 28 |
|  | 230 V | [kVar] | 5 | 5 | 8 | 9 | 12.5 | 12.5 | 18 | 29 | 29 | 29 |
|  | 460 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |
|  | 600 V | [kVar] | 5 | 5 | 8 | 10 | 15 | 20 | 25 | 40 | 50 | 50 |

(1) CA7 capacitor ratings are provided for technical reference. For cUL rated and labeled devices, see CAQ7 contactors listed in this section.
(2) CA7-9...CA7-30 $=\mathrm{L} \min .30 \mu \mathrm{H}$; CA7-37...CA7-85 $=\mathrm{L}$ min. $6 \mu \mathrm{H}$

## Electrical Data

|  |  |  | CA7-9 | CA7-12 | CA7-16 | CA7-23 | CA7-30 | CA7-37 | CA7-43 | CA7-60 | CA7-72 | CA7-85 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Resistance and Watt Loss $I_{e} A C 3$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Resistance per power pole |  | [ $\mathrm{m} \Omega$ ] | 2.7 | 2.7 | 2.7 | 2.0 | 2.0 | 2.0 | 1.5 | 0.9 | 0.9 | 0.9 |
| Watt Loss - 3 power poles |  | [W] | 0.66 | 1.2 | 2.1 | 3.2 | 5.4 | 8.2 | 8.3 | 9.7 | 14.0 | 19.5 |
| Coil and 3 power poles | AC | [W] | 3.3 | 3.8 | 4.7 | 6.2 | 8.4 | 11.2 | 11.5 | 11 | 13.8 | 17.5 |
|  | DC | [W] | 6.7 | 7.2 | 8.1 | 12.4 | 14.6 | 17.4 | 18.4 | 11 | 13.8 | 17.5 |
| Coil only | AC | [W] | 2.6 | 2.6 | 2.6 | 3.0 | 3.0 | 3.0 | 3.2 | 4.5 | 4.5 | 4.5 |
|  | DC | [W] | 6.0 | 6.0 | 6.0 | 9.2 | 9.2 | 9.2 | 10.0 | 4.9 | 4.9 | 4.9 |
| Short-Circuit Coordination |  |  |  |  |  |  |  |  |  |  |  |  |
| Max. Fuse or circuit breaker ratings |  |  |  |  |  |  |  |  |  |  |  |  |
| DIN Fuses -gG, gL |  |  |  |  |  |  |  |  |  |  |  |  |
| Available Fault Current |  | [A] | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA |
| Type "1" (690V) 3 |  | [A] | 50 | 50 | 50 | 80 | 125 | 125 | 160 | 250 | 250 | 250 |
| Type "2" (690V) * |  | [A] | 25 | 35 | 35 | 40 | 80 | 80 | 100 | 160 | 160 | 160 |
| BS 88 Fuses |  |  |  |  |  |  |  |  |  |  |  |  |
| Available Fault Current |  | [A] | 80 KA | 80 KA | 80 KA | 80 KA | 80 KA | 80 KA | 80 KA | 80 KA | 80 KA | 80 KA |
| Type "1" (690V) 3 |  | [A] | 25 | 32 | 35 | 50 | 63 | 80 | 100 | 100 | 125 | 160 |
| Type "2" (690V) 3 |  | [A] | 25 | 32 | 35 | 50 | 63 | 80 | 100 | 100 | 125 | 160 |
| Class K1, RK1 Fuses |  |  |  |  |  |  |  |  |  |  |  |  |
| Available Fault Current |  | [A] | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA |
| Type "2" (600V) 3 |  | [A] | 15 | 20 | 20 | 30 | 40 | 50 | 50 | 80 | 100 | 100 |
| cUL Short-Circuit Ratings |  |  |  |  |  |  |  |  |  |  |  |  |
| Class K1, RK1, K5, and RK5 Fuses |  |  |  |  |  |  |  |  |  |  |  |  |
| Available Fault Current |  | [A] | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA |
| cUL Max. Rating (600V) © Type 1 |  | [A] | 35 | 40 | 70 | 90 | 110 | 125 | 150 | 200 | 250 | 300 |
| Class CC \& CSA HRCI Fuses |  |  |  |  |  |  |  |  |  |  |  |  |
| Available Fault Current |  | [A] | 100 KA | 100 KA | 100 KA | 100 KA | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ |
| cUL Max. Rating (600V) (2 Type 2 |  | [A] | 15 | 20 | 30 | 30 | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ |
| Class J CSA \& HRCI-J Fuses |  |  |  |  |  |  |  |  |  |  |  |  |
| Available Fault Current |  | [A] | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA |
| cUL Max. Rating (600V) (2 Type 2 |  | [A] | 15 | 20 | 30 | 30 | 50 | 50 | 70 | 80 | 100 | 150 |
| Inverse-Time Circuit Breaker (1) |  |  |  |  |  |  |  |  |  |  |  |  |
| Available Fault Current |  | [A] | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 10 KA | 10 KA |
| cUL Max. Rating 480V (2) Type 1 |  | [A] | 30 | 30 | 50 | 50 | 125 | 125 | 125 | 250 | 250 | 250 |
| cUL Max. Rating 600V (2 Type 1 |  | [A] | ~ | $\sim$ | $\sim$ | $\sim$ | 125 | 125 | 125 | 250 | 250 | 250 |
| Short Time Current Withstand Ratings |  |  |  |  |  |  |  |  |  |  |  |  |
| $l_{\text {cw }} 60^{\circ} \mathrm{C}$ | 10 s | [A] | 170 | 170 | 170 | 215 | 300 | 304 | 375 | 700 | 700 | 700 |
| Off Time Between Operations |  | [Min.] | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |

(1) When used as a Branch Circuit Protection device, NEC 430-152 defines the maximum rating of an Inverse-time circuit breaker to be sized at $250 \%$ of the motor nameplate FLA for most applications.
(2 UL Listed Combination. (UL File E41850) Per UL508A, NEC409 abd CSA 22.2 No. 14
for contactor and fuses or circuit breaker only.
3 Per IEC 60947-1 for contactor and fuses only.

Technical Information

## Electrical Data

Short Circuit Coordination $I_{e}$ AC3
Type 2 Coordination Combinations (contactor, overload and fuses) — Per UL 508 and IEC 60947-4-1

| Contactor | Overload Relay | Withstand <br> Rating | Maximum <br> Voltage | Max. Amp Rating <br> (UL Class CC or J Fuses) |
| :---: | :---: | :---: | :---: | :---: |
|  | CEP7-M/A/B32-0.32... | 100 kA | 600 V | 1 |
|  | CEP7-M/A/B32-1.0... | 100 kA | 600 V | 2 |
|  | CEP7-M/A/B32-2.9... | 100 kA | 600 V | 6 |
|  | CEP7-M/A/B32-5.. | 100 kA | 600 V | 10 |
|  | CEP7-M/A/B32-12... | 100 kA | 600 V | 15 |
| CA7-12... | CEP7-M/A/B32-12... | 100 kA | 600 V | 20 |
| CA7-16... | CEP7-M/A/B32-32... | 100 kA | 600 V | 20 |
| CA7-23... | CEP7-M/A/B32-32... | 100 kA | 600 V | 30 |
| CA7-30... | CEP7-M/A/B37-37... | 100 kA | 600 V | 40 |
| CA7-37... | CEP7-M/A/B37-37... | 100 kA | 600 V | 50 |
| CA7-43... | CEP7-M/A/B45-45... | 100 kA | 600 V | 50 |
| CA7-60... | CEP7-M/A/B85-85... | 100 kA | 600 V | 80 |
| CA7-72... | CEP7-M/A/B85-85... | 100 kA | 600 V | 100 |
| CA7-85... | CEP7-M/A/B85-85... | 100 kA | 600 V | 100 |

UL Listed Combinations (contactor, overload and circuit breaker) - Per UL 508

| Contactor | Overload Relay | Withstand Rating | Maximum Voltage | Max. Amp Rating <br> (UL Listed Circuit Breaker) |
| :---: | :---: | :---: | :---: | :---: |
| CA7-9... 12 | CEP7-M/A32-2.9... 12 | 5kA | 480V | 30 |
|  | CT7-24-0.16... 10 |  |  |  |
| CA7-12 | CT7-24-16 |  |  |  |
| CA7-16... 23 | CEP7-M/A32-2.9... 32 | 5 kA | 480V | 50 |
|  | CT7-24-0.16... 16 |  |  |  |
| CA7-23 | CT7-24-24 |  |  |  |
| CA7-30... 37 | CEP7-M/A37-12... 37 | 5 kA | 600 V | 125 |
|  | CT7-24-16...CT7-45-30 |  |  |  |
| CA7-37 | CT7-45-45 |  |  |  |
| CA7-43 | CEP7-M/A45... 45 | 5kA | 600V | 125 |
|  | CT7-45-30... 45 |  |  |  |
| CA7-60 | CEP7-M/A85... 85 | 5 kA | 600V | 250 |
|  | CT7-75-30... 60 |  |  |  |
| CA7-72 | CEP7-M/A85... 85 | 10kA | 600 V | 250 |
|  | CT7-75-30... 75 |  |  |  |
| CA7-85 | CEP7-M/A85... 85 | 10kA | 600V | 250 |
|  | CT7-75-30...CT7-100-90 |  |  |  | Technical Information

## Short Circuit Ratings

Standard Fault Short Circuit Ratings per UL508 and CSA 22.2 No. 14

| CEP7 Second Generation <br> Cat. No. |  |  |  |  |  | Max. avail- <br> able fault <br> current (kA) | Conditional <br> S.C. current, <br> Iq (kA) | S.C.P.D. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | ED1AB, EEAB <br> ED1BB, EEBB | 1 |  | Suitable for use <br> with fuses only |  |  |  |  |
|  | ED1CB, ED1DB, <br> ED1EB, EECB, <br> EEDB, EEEB, EEED, <br> EEFD, EEPB, EERB, <br> EESB, EETD | 5 | 600 | Not restricted <br> to |  |  |  |  |
|  | EEEE, EEFE, EEGE, <br> EEUE | 10 |  |  |  |  |  |  |

IEC Short Circuit Ratings per EN60947-4-1

| CEP7 Second Generation Cat. No. |  | Prospective S.C. current, Ir (kA) | Conditional S.C. current, Iq (kA) | Max. voltage (V) | S.C.P.D. |
| :---: | :---: | :---: | :---: | :---: | :---: |
| CEP7 | $\begin{aligned} & \hline \text { ED1AB, EEAB } \\ & \text { ED1BB, EEAB } \\ & \hline \end{aligned}$ | 1 | 100 | 690 | Suitable for use with fuses only |
|  | $\begin{aligned} & \hline \text { ED1CB, ED1DB, } \\ & \text { EECB, EEDB, } \\ & \text { EEPB, EERB } \end{aligned}$ | 1 |  |  | Not restricted to |
|  | ED1EB, EEEB, EEED, EEFD, EEEE, EEFE, EESB, EETD | 3 |  |  |  |
|  | EEGE, EEUE | 5 |  |  |  |

High Fault Short Circuit Ratings per UL508 and CSA 22.2 No. 14

| CEP7 Second Generation Cat. No. |  | Contactor Cat. No. | Max. starter FLC (A) | Max. available fault current (kA) | Max. voltage (V) | UL Class J and CSA HRCI-J fuse (A) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CEP7 | ED1AB, EEAB | CA7-09 | 0.5 | 100 | 600 | 3 |
|  | ED1BB, EEBB |  | 1 |  |  | 6 |
|  | ED1CB, ED1DB, ED1EB, EEEB, EECB, EEDB | CA7-09 | 09 |  |  | 20 |
|  |  | CA7-12 | 12 |  |  | 20 |
|  |  | CA7-16 | 16 |  |  | 30 |
|  |  | CA7-23 | 23 |  |  | 30 |
|  | EEED, EEFD | CA7-30 | 30 |  |  | 50 |
|  |  | CA7-37 | 37 |  |  | 50 |
|  |  | CA7-43 | 43 |  |  | 70 |
|  | EEEE, EEFE EEGE | CA7-60 | 60 |  |  | 80 |
|  |  | CA7-72 | 72 |  |  | 100 |
|  |  | CA7-85 | 85 |  |  | 150 |

IEC Type 1 and Type II Fuse Coordination with CA7 Series contactors per EN60947-4-1

| CEP7 Second Generation Cat. No. |  | Contactor Cat. No. | Max. starter FLC (A) | Prospective S.C. current, Ir (kA) | Conditional S.C. current, Iq (kA) | Max. voltage (V) | Type I with Class J fuse <br> (A) | Type II with Class J fuse <br> (A) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CEP7 | ED1AB, EEAB | CA7-09 | 0.5 | 1 | 100 | 600 | 3 | 3 |
|  | ED1BB, EEBB |  | 1 |  |  |  | 6 | 6 |
|  | $\begin{gathered} \text { ED1CB, ED1DB, } \\ \text { EECB, EEDB } \end{gathered}$ | CA7-09 | 09 | 1 |  |  | 20 | 15 |
|  |  | CA7-12 | 12 |  |  |  | 20 | 20 |
|  |  | CA7-16 | 16 |  |  |  | 30 | 30 |
|  |  | CA7-23 | 23 |  |  |  | 30 | 30 |
|  | ED1EB, EEEB | CA7-09 | 09 | 3 |  |  | 20 | 15 |
|  |  | CA7-12 | 12 |  |  |  | 20 | 20 |
|  |  | CA7-16 | 16 |  |  |  | 30 | 30 |
|  |  | CA7-23 | 23 |  |  |  | 30 | 30 |
|  | EEED, EEFD | CA7-30 | 30 | 3 |  |  | 50 | 50 |
|  |  | CA7-37 | 37 |  |  |  | 50 | 50 |
|  |  | CA7-43 | 43 |  |  |  | 70 | 70 |
|  | EEEE, EEFE | CA7-60 | 60 | 3 |  |  | 80 | 80 |
|  |  | CA7-72 | 72 |  |  |  | 100 | 100 |
|  |  | CA7-85 | 85 |  |  |  | 150 | 150 |
|  | EEGE | CA7-60 | 60 | 5 |  |  | 80 | 80 |
|  |  | CA7-72 | 72 |  |  |  | 100 | 100 |
|  |  | CA7-85 | 85 |  |  |  | 150 | 150 |

## Electro－Mechanical Data

|  |  |  | CA7－9 | CA7－12 | CA7－16 | CA7－23 | CA7－30 | CA7－37 | CA7－43 | CA7－60 | CA7－72 | CA7－85 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Service Life |  |  |  |  |  |  |  |  |  |  |  |  |
| Mechanical | AC | ［Mil．］ | 13 | 13 | 13 | 13 | 13 | 13 | 12 | 10 | 10 | 10 |
|  | DC | ［Mil．］ | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 10 | 10 | 10 |
| Electrical AC－3（400V） | AC | ［Mil．］ | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.0 | 1.0 | 1.0 | 1.0 |
| Shipping Weights |  |  |  |  |  |  |  |  |  |  |  |  |
| AC－CA7 |  | ［kg］ | 0.39 | 0.39 | 0.39 | 0.39 | 0.48 | 0.49 | 0.51 | 1.45 | 1.45 | 1.45 |
|  |  | ［Lbs．］ | 0.86 | 0.86 | 0.86 | 0.86 | 1.06 | 1.08 | 1.12 | 3.20 | 3.20 | 3.20 |
| AC－CAU7 |  | ［kg］ | 0.85 | 0.85 | 0.85 | 0.85 | 1.08 | 1.08 | 1.15 | 3.14 | 3.14 | 3.14 |
|  |  | ［Lbs．］ | 1.89 | 1.89 | 1.89 | 1.89 | 2.39 | 2.39 | 2.54 | 6.92 | 6.92 | 6.92 |
| DC－CA7 |  | ［kg］ | 0.60 | 0.60 | 0.60 | 0.73 | 0.85 | 0.85 | 1.00 | 1.47 | 1.47 | 1.47 |
|  |  | ［Lbs．］ | 1.32 | 1.32 | 1.32 | 1.61 | 1.87 | 1.87 | 2.20 | 3.24 | 3.24 | 3.24 |
| DC－CAU7 |  | ［kg］ | 1.27 | 1.27 | 1.27 | 1.53 | 1.81 | 1.81 | 2.13 | 3.22 | 3.22 | 3.22 |
|  |  | ［Lbs．］ | 2.81 | 2.81 | 2.81 | 3.39 | 4.00 | 4.00 | 4.70 | 7.10 | 7.10 | 7.10 |
| Terminations－Power |  |  |  |  |  |  |  |  |  |  |  |  |
| Description |  |  |  |  | $\stackrel{\text { 号 }}{4}$ | $\stackrel{\text { 毕 }}{\stackrel{y}{4}}$ |  |  | $\frac{\stackrel{4}{\wedge}}{\square}$ |  |  |  |
|  |  |  | One saddleclamp per pole： cross，slotted or Pozidrive No．2／blade No． 3 screw |  |  |  | Dual connection；one saddleclamp and one box lug per pole；cross， slotted or Pozidrive No．2／blade No． 4 screw |  |  | Dual connection； two box lugs per pole Allen Head：4mm，5／32 |  |  |
| 56 | 1 Wire | $\left[\mathrm{mm}^{2}\right]$ | $1 . . .4$ | $1 . . .4$ | $1 . . .4$ | $1 \ldots 4$ | $\text { 2.5... } 10$ | $\text { 2.5... } 10$ | 2．5．．． 16 | 2．5．．． 35 | 2．5．．． 35 | $\text { 2.5... } 35$ |
|  | 2 Wires | $\left[\mathrm{mm}^{2}\right]$ | $1 . . .4$ | $1 . . .4$ | $1 . . .4$ | $1 . . .4$ | $\text { 2.5... } 10$ | $\text { 2.5... } 10$ | 2．5．．． 10 | 2．5．．． 25 | 2．5．．． 25 | $2.5 . . .25$ |
| 36050 | 1 Wire | $\left[\mathrm{mm}^{2}\right]$ | $\text { 1.5... } 6$ | 1.5...6 | $1.5 \ldots 6$ | 1.5...6 | $\text { 2.5... } 16$ | $\text { 2.5... } 16$ | $2.5 \ldots . .25$ | $2.5 \ldots . .50$ | $\text { 2.5... } 50$ | $2.5 . . .50$ |
|  | 2 Wires | $\left[\mathrm{mm}^{2}\right]$ | $1.5 \ldots 6$ | 1．5．．． 6 | $1.5 \ldots 6$ | 1．5．．． 6 | $\text { 2.5... } 16$ | $\text { 2.5... } 16$ | $\text { 2.5... } 16$ | $2.5 \ldots 35$ | $\text { 2.5... } 35$ | $\text { 2.5... } 35$ |
|  | 1 Wire | [AWG] | 16．．． 10 | 16．．． 10 | 16．．． 10 | 16．．． 10 | 14．．． 4 | $14 . .4$ | 14．．． 4 | 14．．． 1 | 14．．． 1 | 14．．． 1 |
|  | 2 Wires | [AWG] | 16．．． 10 | 16．．． 10 | 16．．． 10 | 16．．． 10 | 14．．． 4 | $14 . .4$ | 14．．． 4 | 14．．． 1 | 14．．． 1 | 14．．． 1 |
| Torque Requirement |  | ［ Nm ］ | 1．0．．．2．5 | 1．0．．．2．5 | 1．0．．．2．5 | 1．0．．．2．5 | 2．5．．．3．5 | 2．5．．． 4 | 2．5．．． 4 | 3．5．．． 6 | 3．5．．． 6 | 3．5．．． 6 |
|  |  | ［Lb－in］ | 9．．． 22 | 9．．． 22 | 9．．． 22 | 9．．． 22 | 22．．． 31 | 22．．． 35 | 22．．． 35 | 31．．． 53 | $31 . .53$ | 31．．． 53 |
| Terminations－Control |  |  |  |  |  |  |  |  |  |  |  |  |
| Description |  |  |  | $\stackrel{\text { 毕 }}{\square}$ |  | nation Screw | Head： | Slotted， |  |  |  | $\stackrel{\text { 芹 }}{\stackrel{y}{4}}$ |
| Coils | 1 or 2 | ［ $\mathrm{mm}^{2}$ ］ | 1．5．．． 6 |  |  |  |  |  |  |  |  |  |
| Wires |  | ［AWG］ | 16．．． 12 |  |  |  |  |  |  |  |  |  |
| Control Modules | 1or 2 | ［ $\mathrm{mm}^{2}$ ］ | 1．5．．． 6 |  |  |  |  |  |  |  |  |  |
| Wires |  | ［AWG］ | 16．．． 12 |  |  |  |  |  |  |  |  |  |
| Torque Requirement |  | ［ Nm ］ | 1．．．2．5 |  |  |  |  |  |  |  |  |  |
|  |  | ［Lb－in］ | 9．．． 13 |  |  |  |  |  |  |  |  |  |
| Degree of Protection－contactor |  |  | IP 2LX per IEC 529 and DIN 40050 （with wires installed） |  |  |  |  |  |  |  |  |  |
| Protection Against Accidental Contact |  |  | Safe from touch by fingers and back－of－hand per VDE 0106；Part 100 |  |  |  |  |  |  |  |  |  |

## Environmental and General Specifications

| Ambient Temperature |  |
| :---: | :---: |
| Storage | $-55 \ldots+80^{\circ} \mathrm{C}\left(-67 \ldots 176^{\circ} \mathrm{F}\right)-\left[\right.$ CRI7E Electronic Interface $-50 \ldots+80^{\circ} \mathrm{C}\left(-58 . .176^{\circ} \mathrm{F}\right)$ ］ |
| Operation | $-25 . . .+60^{\circ} \mathrm{C}\left(-13 . . .140^{\circ} \mathrm{F}\right)$ |
| Conditioned 15\％current reduction after AC－1 at $>60^{\circ} \mathrm{C}$ | $-25 \ldots+70^{\circ} \mathrm{C}\left(-13 . . .158^{\circ} \mathrm{F}\right)$ |
| Altitude at installed site | 2000 meters above sea level per IEC 947－4 |
| Resistance to Corrosion／Humidity | Damp－alternating climate：cyclic to IEC 68－2， 56 cycles <br> Dry heat：IEC $68-2,+100^{\circ} \mathrm{C}\left(212^{\circ} \mathrm{F}\right)$ ，relative humidity $<50 \%, 7$ days． <br> Damp tropical：IEC $68-2,+40^{\circ} \mathrm{C}\left(104^{\circ} \mathrm{F}\right)$ ，relative humidity $<92 \%, 56$ days． |
| Shock Resistance | IEC 68－2：Half sinusoidal shock $11 \mathrm{~ms}, 30 \mathrm{~g}$（in all three directions） |
| Vibration Resistance | IEC 68－2：Static $>2 \mathrm{~g}$ ，in normal position no malfunction $<5 \mathrm{~g}$ |
| Pollution Degree | 3 |
| Operating Position | Refer to Dimension Pages |
| Standards | IEC947－1／4，EN 60947；UL 508；CSA 22．2，No． 14 |
| Approvals | CE，UL，CSA |

## Lug Kit and Paralleling Link Specifications

|  |  | $\begin{gathered} \text { CA7-P- } \\ \text { KN23 / KL23 } \end{gathered}$ | CA7－P－K37 | CA7－P－K43 | CA7－P－K85 | CA7－P－B23 | CA7－P－B37 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Approvals |  |  |  | UL Listed；CSA Certified；C UL508；CSA 22．2 No．14；IEC 60947－4 IP2LX Finger Protection |  |  |  |
| Conformity to Standards |  |  |  |  |  |  |  |
| Protection Against Accidental Contact |  |  |  |  |  |  |  |
| Terminations |  | $\stackrel{\square}{\square}$ | $\stackrel{\square}{\square}$ | $\square$ | $\square$ | 号 |  |
| Description |  | Cross，slotted or Pozidrive screw |  | Allen Head； 5mm，3／16 | Allen Head； <br> 7 mm，15／32 |  |  |
| Wire Size |  |  |  |  |  |  | 35．．． 70 |
| Y退迢 1 Wire | ［ $\mathrm{mm}^{2}$ ］ | 4．．． 16 | 4．．16 | 6．．． 35 | 10．．． 70 | 35．．． 70 |  |
|  | ［ $\mathrm{mm}^{2}$ ］ | $4 . . .25$ | $4 . .25$ | 6．．． 50 | 10．．． 95 | 35．．． 95 | 35．．． 95 |
| $\bigcirc C_{2}^{\infty} 1$ Wire | ［AWG］ | 10．．． 4 | 10．．． 4 | 8．．． 2 | 8．．2／0 | 0．．．2／0 | 0．．．2／0 |
| Torque Requirement | ［ Nm ］ | 2．．． 3 | 2．．． 3 | $3 . .6$ | 8．．． 12 | 6．．． 12 | 6．．．． 12 |
|  | ［Lb－in］ | 18．．． 27 | 18．．． 27 | 27．．． 54 | 72．．． 108 | 54．．． 108 | 54．．． 108 |

## Coil Data

|  |  |  | CA7－9 | CA7－12 | CA7－16 | CA7－23 | CA7－30 | CA7－37 | CA7－43 | CA7－60 | CA7－72 | CA7－85 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Voltage Range |  |  |  |  |  |  |  |  |  |  |  |  |
| AC： $50 \mathrm{~Hz}, 60 \mathrm{~Hz}, 50 / 60 \mathrm{~Hz}$ | Pickup | $\left[\mathrm{xU}_{s}\right]$ |  | 0．85．．．1．1 |  |  |  |  |  |  |  |  |
|  | Dropout | $\left[x U_{s}\right]$ |  | 0．3．．．0．6 |  |  |  |  |  |  |  |  |
| DC | Pickup | $\left[\mathrm{xU} \mathrm{U}_{\text {s }}\right.$ ］ |  | $0.8 \ldots 1.1$（9V coils $=0.65 \ldots 1.3 ; 24 \mathrm{~V}$ coils $=0.7 \ldots 1.25)$ |  |  |  |  |  |  |  |  |
|  | Dropout | $\left[\mathrm{XU}_{s}\right]$ |  | 0．1．．．0．6 |  |  |  |  |  |  |  |  |
| Coil Consumption |  |  |  |  |  |  |  |  |  |  |  |  |
| AC： $50 \mathrm{~Hz}, 60 \mathrm{~Hz}, 50 / 60 \mathrm{~Hz}$ | Pickup | ［VA／W］ | 70／50 | 70／50 | 70／50 | 70／50 | 80／60 | 80／60 | 130／90 | 200／110 | 200／110 | 200／110 |
|  | Hold－in | ［VA／W］ | 8／2．6 | 8／2．6 | 8／2．6 | 9／3 | 9／3 | 9／3 | 10／3．2 | 16／4．5 | 16／4．5 | 16／4．5 |
| True DC Coils（CA7C） | Pickup | ［W］ | 6.5 | 6.5 | 6.5 | 9.2 | 9.2 | 9.2 | 10.1 | ～ | ～ | ～ |
|  | Hold－in | ［W］ | 6.5 | 6.5 | 6.5 | 9.2 | 9.2 | 9.2 | 10.1 | $\sim$ | $\sim$ | $\sim$ |
| Two Winding DC Coils | Pickup | ［W］ | 120 | 120 | 120 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| CA7Y \＆CA7D | Hold－in | ［W］ | 1.1 | 1.1 | 1.1 | 1.2 | 1.2 | 1.2 | 1.3 | 4.5 | 4.5 | 4.5 |
| Operating Times |  |  |  |  |  |  |  |  |  |  |  |  |
| AC： $50 \mathrm{~Hz}, 60 \mathrm{~Hz}, 50 / 60 \mathrm{~Hz}$ | Pickup | ［ms］ | 15．．． 30 | 15．．． 30 | 15．．． 30 | 15．．． 30 | 15．．． 30 | 15．．． 30 | 15．．． 30 | 20．．． 40 | 20．．． 40 | 20．．． 40 |
|  | Dropout | ［ms］ | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 |
| with RC Suppressor | Dropout | ［ms］ | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 | 10．．． 60 |
| True DC Coils（CA7C） | Pickup | ［ms］ | 40．．． 70 | 40．．．70 | 40．．．70 | 40．．． 70 | 50．．． 80 | 50．．． 80 | 50．．． 80 | ～ | ～ | ～ |
| without Suppression | Dropout | ［ms］ | 7．．． 15 | 7．．． 15 | 7．．． 15 | 7．．． 15 | 7．．． 15 | 7．．． 15 | 7．．． 15 | $\sim$ | $\sim$ | $\sim$ |
| with Integrated Suppression | Dropout | ［ms］ | 14．．． 20 | 14．．． 20 | 14．．． 20 | 17．．． 23 | 17．．． 23 | 17．．． 23 | 17．．． 23 | ～ | ～ | ～ |
| with External Suppression | Dropout | ［ms］ | 70．．． 95 | 70．．． 95 | 70．．． 95 | 80．．． 125 | 80．．． 125 | 80．．． 125 | 80．．． 125 | $\sim$ | $\sim$ | $\sim$ |
| Two Winding DC Coils（CA7Y／D） | Pickup | [ms] | 17．．． 26 | 17．．． 26 | 15．．． 27 | 15．．． 27 | 15．．． 27 | 15．．． 27 | 15．．． 27 | $20 . . .40$ | $20 . . .40$ | $20 \ldots 40$ |
| with Internal Suppression | Dropout | ［ms］ | 9．．． 20 | 9．．． 20 | 14．．． 24 | 14．．． 24 | 14．．． 24 | 14．．． 24 | 14．．． 24 | 20．．． 35 | 20．．． 35 （ | 20．．． 35 （ |

[^20]Technical Information

Electrical Data

|  | $\begin{gathered} \text { CA7-9- } \\ \text { M40(31; 22) } \end{gathered}$ | $\begin{gathered} \text { CA7-12- } \\ \text { M40(31; 22) } \end{gathered}$ | $\begin{gathered} \text { CA7-16- } \\ \text { M40(31; 22) } \end{gathered}$ | $\begin{gathered} \text { CA7-23- } \\ \text { M40(31; 22) } \end{gathered}$ | CA7-40-M22 | CA7-40-M40 | CA7-90-M22 | CA7-90-M40 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Rated Insulation Voltage $\boldsymbol{U}_{\mathbf{i}}$ |  |  |  |  |  |  |  |  |
| IEC, AS, BS, SEV, VDE 0660 | 690 V |  |  |  |  |  |  |  |
| UL; CSA | 600 V |  |  |  |  |  |  |  |
| Rated Impulse Voltage $\boldsymbol{U}_{\text {imp }}$ | 8 kV |  |  |  |  |  |  |  |
| Rated Voltage $\boldsymbol{U}_{\mathrm{e}}$ - Main Contacts |  |  |  |  |  |  |  |  |
| AC 50/60Hz | $115,200,208,230,240,380,400,415,460,500,575,690 \mathrm{~V}$ |  |  |  |  |  |  |  |
| DC | $24,48,110,115,220,230,300,440 \mathrm{~V}$ |  |  |  |  |  |  |  |
| Operating Frequency for AC Loads | $50 . .60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |

## Switching Motor Loads

| Standard IEC Ratings |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| AC-2, AC-3, AC-4 | 230 V | [A] | 12 | 15 | 20 | 26.5 | 38 | 38 | 85 | 85 |
| DOL \& Reversing | 240v | [A] | 12 | 15 | 20 | 26.5 | 38 | 38 | 85 | 85 |
| $50 \mathrm{~Hz} / 60^{\circ} \mathrm{C}$ | 400 V | [A] | 9 | 12 | 16 | 23. | 37 | 37 | 85 | 85 |
|  | 415 V | [A] | 9 | 12 | 16 | 23 | 37 | 37 | 85 | 85 |
|  | 500 V | [A] | 7 | 10 | 14 | 20 | 29 | 30 | 80 | 80 |
|  | 690 V | [A] | 5 | 7 | 9 | 12 | 9 | 21 | 22 | 49 |
|  | 230 V | [kW] | 3 | 4 | 5.5 | 7.5 | 11 | 11 | 25 | 25 |
|  | 240 V | [kW] | 3 | 4 | 5.5 | 7.5 | 11 | 11 | 25 | 25 |
|  | 400 V | [kW] | 4 | 5.5 | 7.5 | 11 | 18.5 | 18.5 | 45 | 45 |
|  | 415 V | [kW] | 4 | 5.5 | 7.5 | 11 | 18.5 | 18.5 | 45 | 45 |
|  | 500 V | [kW] | 4 | 5.5 | 7.5 | 13 | 18.5 | 20 | 55 | 55 |
|  | 690 V | [kW] | 4 | 5.5 | 7.5 | 10 | 7.5 | 18.5 | 18.5 | 45 |
| UL/CSA/IEC |  |  |  |  |  |  |  |  |  |  |
| DOL \& Reversing | 115 V | [A] | 7.2 | 9.8 | 16 | 24 | 34 | 34 | 80 | 80 |
| $60 \mathrm{~Hz} / 60^{\circ} \mathrm{C} \quad 10$ | 230 V | [A] | 18 | 12 | 17 | 17 | 28 | 28 | 68 | 68 |
|  | 115 V | [HP] | 1/2 | 1/2 | 1 | 2 | 3 | 3 | 7-1/2 | 7-1/2 |
|  | 230 V | [HP] | 1-1/2 | 2 | 3 | 3 | 5 | 5 | 15 | 15 |
|  | 200 V | [ A ] | 7.8 | 11 | 17.5 | 17.5 | 32.2 | 32.2 | 78.2 | 78.2 |
|  | 230 V | [A] | 6.8 | 9.6 | 15.2 | 22 | 28 | 28 | 80 | 80 |
|  | 460 V | [A] | 7.6 | 11 | 14 | 21 | 34 | 34 | 65 | 77 |
|  | 575 V | [A] | 9 | 11 | 17 | 17 | 17 | 32 | 22 | 52 |
|  | 200 V | [HP] | 2 | 3 | 5 | 5 | 10 | 10 | 25 | 25 |
|  | 230 V | [HP] | 2 | 3 | 5 | 7-1/2 | 10 | 10 | 30 | 30 |
|  | 460 V | [HP] | 5 | 7-1/2 | 10 | 15 | 25 | 25 | 50 | 60 |
|  | 575 V | [HP] | 7-1/2 | 10 | 15 | 15 | 15 | 30 | 20 | 50 |
| Maximum Operating Rate (at max. amps) | AC2 | [ops/hr] | 450 | 450 | 450 | 400 | 400 | 400 | 200 | 200 |
|  | AC3 | [ops/hr] | 700 | 700 | 700 | 600 | 600 | 600 | 500 | 500 |
|  | AC4 | [0ps/hr] | 200 | 150 | 120 | 80 | 70 | 70 | 50 | 50 |

## Electrical Data



Incandescent Lamps AC-5b,

| Electrical endurance 100,000 operations |  |  | 12 | 16 | 18 | 22 | 18 | 25 | 60 | 75 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| DC-1 Switching -60 ${ }^{\circ} \mathrm{C}$ | 24VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 80 | 80 |
|  | 48VDC | [A] | 20 | 20 | 20 | 20 | 25 | 25 | 40 | 40 |
| 1 Pole | 60VDC | [A] | 20 | 20 | 20 | 20 | 25 | 30 | 40 | 40 |
|  | 110VDC | [A] | 6 | 6 | 6 | 6 | 10 | 10 | 11 | 11 |
|  | 220VDC | [A] | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.8 | 1.8 |
|  | 440VDC | [A] | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 |
|  | 24VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 80 | 80 |
|  | 48VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 80 | 80 |
| 2 Pole in Series | 60VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 80 | 80 |
|  | 110VDC | [A] | 25 | 25 | 32 | 32 | 45 | 45 | 80 | 80 |
|  | 220VDC | [A] | 8 | 8 | 8 | 8 | 10 | 10 | 15 | 15 |
|  | 440VDC | [A] | 1 | 1 | 1 | 1 | 1 | 1 | 1.5 | 1.5 |
|  | 24VDC | [A] | 25 | 25 | 32 | 32 | $\sim$ | 48 | ~ | 100 |
|  | 48VDC | [A] | 25 | 25 | 32 | 32 | ~ | 48 | ~ | 100 |
| 3 Poles in Series | 60VDC | [A] | 25 | 25 | 32 | 32 | ~ | 48 | ~ | 100 |
|  | 110VDC | [A] | 25 | 25 | 32 | 32 | ~ | 48 | $\sim$ | 100 |
|  | 220VDC | [A] | 25 | 25 | 32 | 32 | $\sim$ | 48 | ~ | 80 |
|  | 440VDC | [A] | 3 | 3 | 3 | 3 | $\sim$ | 3.5 | $\sim$ | 5 |
|  | 24VDC | [A] | 25 | 25 | 32 | 32 | $\sim$ | 60 | $\sim$ | 110 |
|  | 48VDC | [A] | 25 | 25 | 32 | 32 | $\sim$ | 60 | $\sim$ | 110 |
| 4 Poles in Series | 60VDC | [A] | 25 | 25 | 32 | 32 | $\sim$ | 60 | $\sim$ | 110 |
|  | 110VDC | [A] | 25 | 25 | 32 | 32 | $\sim$ | 60 | $\sim$ | 110 |
|  | 220VDC | [A] | 25 | 25 | 32 | 32 | $\sim$ | 60 | $\sim$ | 100 |
|  | 440VDC | [A] | 8 | 8 | 8 | 8 | $\sim$ | 10 | $\sim$ | 15 |

(1) CA7 ratings for lighting loads are provided for technical reference. For cUL rated and labeled devices, see CAL7 contactors listed in this section.

## Electrical Data

|  |  | $\begin{gathered} \text { CA7-9- } \\ \text { M40(31; 22) } \end{gathered}$ | $\begin{gathered} \text { CA7-12- } \\ \text { M40(31; 22) } \end{gathered}$ | $\begin{gathered} \text { CA7-16- } \\ \text { M40(31; 22) } \end{gathered}$ | $\begin{gathered} \text { CA7-23- } \\ \text { M40(31;22) } \end{gathered}$ | CA7-40-M22 | CA7-40-M40 | CA7-90-M22 | CA7-90-M40 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Resistance and Watt Loss $l_{\mathrm{e}}$ AC3 |  |  |  |  |  |  |  |  |  |
| Resistance per power pole | [m $\Omega$ ] | 2.7 | 2.7 | 2.7 | 2.0 | 2.0 | 1.5 | 0.8 | 0.7 |
| Watt Loss - 4 power poles | [W] | 2.8 | 2.8 | 2.8 | 2.0 | 11.3 | 8.4 | 13.5 | 11.8 |
| Coil and 4 power poles AC | [W] | 13.7 | 13.7 | 13.7 | 10.8 | 26.1 | 37.4 | 36.0 | 56.3 |
| DC (true) | [W] | 17.6 | 17.6 | 17.6 | 17.4 | 32.6 | 43.9 | ~ | ~ |
| DC (2 winding) | [W] | $\sim$ | $\sim$ | ~ | ~ | $\sim$ | ~ | 32.5 | 52.8 |
| Short Circuit Coordination |  |  |  |  |  |  |  |  |  |
| DIN Fuses -gG, gL |  |  |  |  |  |  |  |  |  |
| Available Fault Current | [A] | 100 KA | 100 KA | 100 KA | 100 KA | 50 KA | 50 KA | 50 KA | 50 KA |
| Type "1" (690V) 3 | [A] | 50 | 50 | 50 | 80 | 160 | 160 | 250 | 250 |
| Type "2" (690V) 3 | [A] | 25 | 35 | 35 | 40 | 100 | 100 | 160 | 160 |
| BS 88 Fuses |  |  |  |  |  |  |  |  |  |
| Available Fault Current | [ A ] | 80 KA | 80 KA | 80 KA | 80 KA | ~ | $\sim$ | ~ | ~ |
| Type "1" (690V) 3 | [A] | 25 | 32 | 35 | 50 | ~ | ~ | ~ | ~ |
| Type "2" (690V) 3 | [A] | 25 | 32 | 35 | 50 | ~ | $\sim$ | $\sim$ | $\sim$ |
| Class K1, RK1 Fuses |  |  |  |  |  |  |  |  |  |
| Available Fault Current | [ A ] | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA |
| Type "2" (600V) 3 | [A] | 15 | 20 | 20 | 30 | 70 | 70 | 100 | 100 |
| cUL Short-Circuit Ratings |  |  |  |  |  |  |  |  |  |
| Class K1, RK1, K5, and RK5 Fuses |  |  |  |  |  |  |  |  |  |
| Available Fault Current | [ A ] | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 10 KA | 10 KA |
| cUL Max. Rating (600V) © Type 1 | [A] | 35 | 40 | 70 | 90 | 125 | 125 | 300 | 300 |
| Class CC \& CSA HRCI Fuses |  |  |  |  |  |  |  |  |  |
| Available Fault Current | [ A ] | 100 KA | 100 KA | 100 KA | 100 KA | ~ | $\sim$ | $\sim$ | $\sim$ |
| cUL Max. Rating (600V) © Type 2 | [A] | 15 | 20 | 30 | 30 | $\sim$ | $\sim$ | $\sim$ | ~ |
| Class J CSA \& HRCI-J Fuses |  |  |  |  |  |  |  |  |  |
| Available Fault Current | [ A ] | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA | 100 KA |
| cUL Max. Rating (600V) © Type 2 | [A] | 15 | 20 | 30 | 30 | 704 | 704 | 1504 | 1504 |
| Inverse-Time Circuit Breaker 1 |  |  |  |  |  |  |  |  |  |
| Available Fault Current | [A] | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 5 KA | 10 KA | 10 KA |
| cUL Max. Rating 480V (2 Type 1 | [A] | 30 | 30 | 50 | 50 | 125 | 125 | 250 | 250 |
| cUL Max. Rating 600V 2 Type 1 | [A] | $\sim$ | $\sim$ | $\sim$ | ~ | 125 | 125 | 250 | 250 |
| Short Time Current Withstand |  |  |  |  |  |  |  |  |  |
| Ratings |  |  |  |  |  |  |  |  |  |
| $I_{\text {cw }} 60^{\circ} \mathrm{C}$ | [A] | 170 | 170 | 170 | 215 | 304 | 304 | 700 | 700 |
| Off Time Between Operations | [Min.] | 20 | 20 | 20 | 20 | 5 | 5 | 5 | 5 |

(1) When used as a Branch Circuit Protection device, NEC 430-152 defines the maximum rating of an Inverse-time circuit breaker to be sized at $250 \%$ of the motor nameplate FLA for most applications.
(2) UL Listed Combination. (UL File E41850) Per UL508A, NEC409 abd CSA 22.2 No. 14 for contactor and fuses or circuit breaker only.
(3) Per IEC 60947-1 for contactor and fuses only.
(4) UL Testing not complete a the time of printing this catalog.

## Mechanical Data

|  |  |  | $\begin{aligned} & \text { CA7-9- } \\ & \text { M40(31; 22) } \end{aligned}$ | $\begin{aligned} & \text { CA7-12- } \\ & \text { M40(31; 22) } \end{aligned}$ | $\begin{aligned} & \text { CA7-16- } \\ & \text { M40(31; 22) } \end{aligned}$ | $\begin{aligned} & \text { CA7-23- } \\ & \text { M40(31; 22) } \end{aligned}$ | CA7-40-M22 | CA7-40-M40 | $\begin{gathered} \text { CA7-90- } \\ \text { M22 } \end{gathered}$ | $\begin{gathered} \text { CA7-90- } \\ \text { M40 } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Service Life |  |  |  |  |  |  |  |  |  |  |
| Mechanical | AC | [Mil.] | 13 | 13 | 13 | 13 | 10 | 10 | 10 | 10 |
|  | DC | [Mil.] | 13 | 13 | 13 | 13 | 10 | 10 | 10 | 10 |
| Shipping Weights |  |  |  |  |  |  |  |  |  |  |
| AC - CA7 |  | [kg] | 0.39 | 0.39 | 0.39 | 0.39 | 0.51 | 0.51 | 1.45 | 1.45 |
|  |  | [Lbs.] | 0.86 | 0.86 | 0.86 | 0.86 | 1.12 | 1.12 | 3.20 | 3.20 |
| DC - CA7 |  | [kg] | 0.60 | 0.60 | 0.60 | 0.73 | 1.00 | 1.00 | 1.47 | 1.47 |
|  |  | [Lbs.] | 1.32 | 1.32 | 1.32 | 1.61 | 2.20 | 2.20 | 3.24 | 3.24 |



Environmental and General Specifications

| Ambient Temperature Storage | $-55 \ldots+80^{\circ} \mathrm{C}\left(-67 \ldots 176^{\circ} \mathrm{F}\right)-\left[\right.$ CRI7E Electronic Interface $-50 \ldots+80^{\circ} \mathrm{C}\left(-58 \ldots . .176^{\circ} \mathrm{F}\right)$ ] |
| :---: | :---: |
| Operation | $-25 \ldots+60^{\circ} \mathrm{C}\left(-13 . .140^{\circ} \mathrm{F}\right)$ |
| Conditioned $15 \%$ current reduction after AC-1 at $>60^{\circ} \mathrm{C}$ | $-25 \ldots+70^{\circ} \mathrm{C}\left(-13 . . .158^{\circ} \mathrm{F}\right)$ |
| Altitude at installed site | 2000 meters above sea level per IEC 947-4 |
| Resistance to Corrosion/Humidity | Damp-alternating climate: cyclic to IEC 68-2, 56 cycles <br> Dry heat: IEC $68-2,+100^{\circ} \mathrm{C}\left(212^{\circ} \mathrm{F}\right)$, relative humidity $<50 \%, 7$ days. <br> Damp tropical: IEC $68-2,+40^{\circ} \mathrm{C}\left(104^{\circ} \mathrm{F}\right)$, relative humidity $<92 \%, 56$ days. |
| Shock Resistance | IEC 68-2: Half sinusoidal shock $11 \mathrm{~ms}, 30 \mathrm{~g}$ (in all three directions) |
| Vibration Resistance | IEC 68-2: Static $>2 \mathrm{~g}$, in normal position no malfunction $<5 \mathrm{~g}$ |
| Pollution Degree | 3 |
| Operating Position | Refer to Dimension Pages |
| Standards | IEC947-1/4, EN 60947; UL 508; CSA 22.2, No. 14 |
| Approvals | CE, UL, CSA |

Coil Data (CA7 4-Pole)

|  |  |  | $\begin{gathered} \text { CA7-9- } \\ \text { M40(31; 22) } \end{gathered}$ | $\begin{aligned} & \text { CA7-12- } \\ & \text { M40(31; 22) } \end{aligned}$ | $\begin{aligned} & \text { CA7-16- } \\ & \text { M40(31; 22) } \end{aligned}$ | $\begin{aligned} & \text { CA7-23- } \\ & \text { M40(31; 22) } \end{aligned}$ | $\begin{gathered} \text { CA7-40- } \\ \text { M22 } \end{gathered}$ | $\begin{gathered} \text { CA7-40- } \\ \text { M40 } \end{gathered}$ | $\begin{gathered} \text { CA7-90- } \\ \text { M22 } \end{gathered}$ | $\begin{gathered} \hline \text { CA7-90- } \\ \text { M40 } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Voltage Range |  |  |  |  |  |  |  |  |  |  |
| AC: $50 \mathrm{~Hz}, 60 \mathrm{~Hz}, 50 / 60 \mathrm{~Hz}$ | Pickup | $\left[\mathrm{x} U_{s}\right.$ ] |  |  | 0.85...1.1 |  |  |  |  |  |
|  | Dropout | $\left[x U_{s}\right]$ |  |  | 0.3...0.6 |  |  |  |  |  |
| DC | Pickup | $\left[x U_{s}\right]$ |  |  | 0.8...1.1 (9V coils $=0.65 . . .1 .3 ; 24 \mathrm{~V}$ coils $=0.7 \ldots .1 .25)$ |  |  |  |  |  |
|  | Dropout | $\left[\mathrm{x} U_{s}\right]$ |  |  | 0.1...0.6 |  |  |  |  |  |
| Coil Consumption |  |  |  |  |  |  |  |  |  |  |
| AC: $50 \mathrm{~Hz}, 60 \mathrm{~Hz}, 50 / 60 \mathrm{~Hz}$ | Pickup | [VA/W] | 70/50 | 70/50 | 70/50 | 70/50 | 130/90 | 130/90 | 400/240 | 400/240 |
|  | Hold-in | [VA/W] | 8/2.6 | 8/2.6 | 8/2.6 | 9/3 | 12/3.6 | 12/3.6 | 24/9 | 24/9 |
| True DC Coils (CA7C) | Pickup | [W] | 6.5 | 6.5 | 6.5 | 9.2 | 10.1 | 10.1 | $\sim$ | ~ |
|  | Hold-in | [W] | 6.5 | 6.5 | 6.5 | 9.2 | 10.1 | 10.1 | $\sim$ | $\sim$ |
| Two Winding DC Coils | Pickup | [W] | ~ | ~ | ~ | ~ | ~ | ~ | 325 | 325 |
| CA7Y \& CA7D | Hold-in | [W] | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ | 5.5 | 5.5 |
| Operating Times |  |  |  |  |  |  |  |  |  |  |
| AC: $50 \mathrm{~Hz}, 60 \mathrm{~Hz}, 50 / 60 \mathrm{~Hz}$ | Pickup | [ms] | 15... 30 | 15... 30 | 15... 30 | 15... 30 | 15... 30 | 15... 30 | 20... 30 | 20... 30 |
|  | Dropout | [ms] | 10... 60 | 10... 60 | 10... 60 | 10... 60 | 10... 60 | 10... 60 | 20... 40 | 20... 40 |
| with RC Suppressor | Dropout | [ms] | 10... 60 | 10... 60 | 10... 60 | 10... 60 | 10... 60 | 10... 60 | 20... 40 | 20... 40 |
| True DC Coils (CA7C) | Pickup | [ms] | 40... 70 | 40... 70 | 40... 70 | 40... 70 | 50... 80 | 50... 80 | ~ | ~ |
| without Suppression | Dropout | [ms] | 7... 15 | 7... 15 | 7... 15 | 7... 15 | 7... 15 | 7... 15 | $\sim$ | $\sim$ |
| with Integrated Suppression | Dropout | [ms] | 14... 20 | 14... 20 | 14... 20 | 17... 23 | ~ | ~ | $\sim$ | $\sim$ |
| with External Suppression | Dropout | [ms] | 70... 95 | 70... 95 | 70... 95 | 80... 125 | $\sim$ | $\sim$ | $\sim$ | $\sim$ |
| Two Winding DC Coils | Pickup | [ms] | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ | 15... 20 | 20... 25 |
| with Internal Suppression | Dropout | [ms] | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ | $\sim$ | 20... 25 | 20... 25 |

Technical Information - Auxiliary Contact Data

|  | Mounted <br> Standard <br> Auxiliary | Built-in Auxiliary Contacts in Contactor CA7-9...CA7-23 | Front Mounted Auxiliary Contacts CA7-PV, CS7-PV, CZE/A7, CV7 | Front Mounted Bifurcated Auxiliary Contacts | Side Mounted Auxiliary Contacts CA-PA, CM7 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Electrical Contact Ratings - NEMA |  | A600, P600 |  |  | A600, Q600 |
| Min. Contact Rating |  | $17 \mathrm{~V}, 10 \mathrm{~mA}$ | A600, Q600 |  | 17V, 10 mA |
| Contact Ratings - IEC AC-15 (solenoids, contactors) rated voltage IEC 60947-5-1 | 24V | 10 A | 6 A | 3 A | 6 A |
|  | 48 V | 10 A | 6 A | 3 A | 6 A |
|  | 120 V | 10 A | 6 A | 3 A | 6 A |
|  | 240 V | 10 A | 5 A | 3 A | 5 A |
|  | 400V | 6 A | 3 A | 2 A | 3 A |
|  | 480V/500V | 2.5 A | 1.6 A | 1.2 A | 1.6 A |
|  | 600 V | 1 A | 1 A | 0.7 A | 1 A |
|  | 690 V | 1 A | 1 A | 0.7 A | 1 A |
| AC-12 (Control of resistive loads) IEC 60947-5-1 | $I_{\text {th }}$ | 20 A | 10 A | 10 A | 10 A |
|  | 230 V | 8 kW |  |  |  |
|  | 400 V | 14 kW |  |  |  |
|  | 690 V | 24 kW |  |  |  |
|  | $I_{\text {th }}$ | 20 A | 6 A | 6 A | 6 A |
|  | 230 V | 8 kW |  |  |  |
|  | 400 V | 14 kW |  |  |  |
|  | 690 V | 24 kW |  |  |  |
| DC-12 Switching DC Loads / $<1 \mathrm{~ms}$, Resistive Loads IEC 60947-5-1 | 24 V | 12 A | 12 A | 6 A | 6 A |
|  | 48 V | 9 A | 9 A | 3.2 A | 3.2 A |
|  | 110 V | 3.5 A | 3.5 A | 0.45 A | 0.45 A |
|  | 220 V | 0.55 A | 0.55 A | 0.18 A | 0.18 A |
|  | 440 V | 0.2 A | 0.2 A | 0.1 A | 0.1 A |
| DC-13 IEC 60947-5-1, Solenoids and contactors | 24 V | 5 A | 5 A | 2.5 A | 5 A |
|  | 48 V | 3 A | 3 A | 1.5 A | 3 A |
|  | 110 V | 1.2 A | 1.2 A | 0.6 A | 1.2 A |
|  | 220 V | 0.6 A | 0.6 A | 0.3 A | 0.6 A |
|  | 440 V | 0.3 A | 0.15 A | 0.15 A | 0.15 A |

## Auxiliary Contacts

| Built-in Auxiliary Contacts in Contactor CA7-9...CA7-23 |  |  | Front Mounted Auxiliary Contacts CA7-PV, CS7-PV, CZE/A7, CV7 | Side Mounted Auxiliary Contacts CA-PA, CM7 |
| :---: | :---: | :---: | :---: | :---: |
| Continuous Current Rating per UL/CSA |  |  |  |  |
| Rated Voltage AC | [V] | 600 max. | 600 max. | 600 max. |
| Continuous Rating $\quad 40^{\circ} \mathrm{C}$ | [A] | 10 A general purpose | 10 A general purpose | 10 A general purpose |
|  |  | Heavy pilot duty (A600) | Heavy pilot duty (A600) | Heavy pilot duty (A600) |
| Continuous Rating DC | [ A ] | 5A, 600 max. | 2.5A, 600 max. | 2.5A, 600 max. |
|  |  | Standard pilot duty (P600) | Standard pilot duty (Q600) | Standard pilot duty (Q600) |
| Short-Circuit Protection -gGFuse |  | 20 | 10 | 10 |
| Rated Impulse Voltage $U_{\text {imp }}$ | [kV] | 8 | 8 | 6 |
| Insulation Voltage (between control and load circuit) per DIN < VDE 0103, Part 101 (NAMUR recommendation) | [V] | 380 | 440 | 440 |
| Mechanically Linked Contacts (per IEC60947-5-1 ©Annex L (SUVA Third-party certified) |  | Mutually unrestricted between all NO and NC contacts | Mutually unrestricted between all NO \& NC contacts. CZE \& CV7 not mechanically linked with contactor main contacts | Mutually unrestricted between all NO and NC contacts |
| Terminals |  |  |  |  |
| Terminal Type |  | $\xrightarrow[4]{4}$ | $\stackrel{4}{4}$ | $\stackrel{\text { 毕 }}{\square}$ |
| Maximum Wire Size per IEC 947-1 |  | 2xA4 | $2 \times A 4$ | $2 \times A 4$ |
| Flexible with Wire-End Fernule | [ $\mathrm{mm}^{2}$ ] | 1... 4 | 0.5...2.5 | 0.5...2.5 |
|  | [ $\mathrm{mm}^{2}$ ] | 1... 4 | 0.75...2.6 | 0.75...2.6 |
| Solid/Stranded- <br> Conductor | [ $\mathrm{mm}^{2}$ ] | 1.5... 6 | 0.5...2.5 | 0.5...2.5 |
|  | [ $\mathrm{mm}^{2}$ ] | 1.5... 6 | 0.75...2.6 | 0.75...2.6 |
| Recommended Tightening Torque | [ Nm ] | 1... 2.5 | 1... 15 | 1... 15 |
| Max. Wire Size per UL/CSA | [AWG] | 16... 10 | 18... 14 | 18... 14 |
| Recommended Tightening Torque | [lb-in] | 9... 22 | 9... 13 | 9... 13 |

## Accessories

| Latch Attachment Release, CV7-11 |  |  |
| :--- | :---: | :---: |
| Coil Consumption | [VA/W] | AC $45 / 40$ |
|  | $[\mathrm{~W}]$ | DC 25 W |
| Contact Signal Duration | $[\mathrm{min} / \mathrm{max}]$ | $0.03 \ldots \mathrm{~s} . .15 \mathrm{~s}$ |
| Time Attachment |  |  |
| Reset Time | $[\mathrm{ms}]$ | 10 |
| at min. time setting | $[\mathrm{ms}]$ | 70 |
| at max. time setting |  | $\pm 10 \%$ |
| Repeat Accuracy |  |  |

## Positively-Guided Contacts ( Mechanically-linked)

 SUVA Certified- Restricted guidance guarantees without restrictions from contactor to auxiliary contact and auxiliary contact to contactor. $\mathbf{0}$

Contact Ratings (Per NEMA/UL A600 \& Q600)

| Standard | Circuit <br> Voltage | Make <br> (Amps/VA) | Break <br> (Amps/VA | Continuous <br> Amps |
| :---: | :---: | :---: | :---: | :---: |
| A600 | 120 AC | $60 \mathrm{~A} / 7200 \mathrm{VA}$ | $6 \mathrm{~A} / 720 \mathrm{VA}$ |  |
|  | 240 AC | $30 \mathrm{~A} / 7200 \mathrm{VA}$ | $3 \mathrm{~A} / 720 \mathrm{VA}$ | 10 |
|  | 480AC | $15 \mathrm{~A} / 7200 \mathrm{VA}$ | $1.5 \mathrm{~A} / 720 \mathrm{VA}$ |  |
| Q600 | 125DC | $12 \mathrm{~A} / 7200 \mathrm{VA}$ | $1.2 \mathrm{~A} / 720 \mathrm{VA}$ |  |
|  | 250DC | $0.55 \mathrm{~A} / 69 \mathrm{VA}$ | $0.55 \mathrm{~A} / 69 \mathrm{VA}$ |  |
|  | $301-600 \mathrm{DC}$ | $0.1 \mathrm{~A} / 69 \mathrm{VA}$ | $0.27 \mathrm{~A} / 69 \mathrm{VA}$ | 25 |
|  |  | $0.1 \mathrm{~A} / 69 \mathrm{VA}$ |  |  |

## Determining Contact Life

To determine the contactor's estimated electrical life, follow these guidelines:

1. Identify the appropriate Utilization Category from Table A.
2. On the following pages, choose the graph for the Utilization Category selected.
3. Locate the Rated Operational Current $\left(l_{\mathrm{e}}\right)$ along the bottom of the chart and follow the graph lines up to the intersection of the appropriate contactor's life-load curve.
4. Read the estimated contact life along the vertical axis.

Table A - IEC Special Utilization Categories, AC Ratings ©


## Legend

Ue Rated operational voltage
$\boldsymbol{U}$ Voltage before make
Ur Recovery voltage
le Rated operational current
I Making current
Ic Breaking current
L Inductance of test circuit
R Resistance of test circuit

- Utilization categories and test conditions for AC \& DC. For contactors according to IEC 158-1, starters according to IEC 292-1 ... 4 and control switches according to IEC 337-1 and IEC 337-1A.
(2) With a minimum value of 1000 A for $/$ or $l c$.
(3) With a minimum value of 800 A for lc .
(4) With a minimum value of 1200 A for $l$.
© Plugging is understood as stopping or reversing the motor rapidly by reversing the motor primary connections while the motor is running. Inching [or jogging] is understood as energizing a motor once or repeatedly for short periods to obtain small movements of the driven mechanism.

Table A - IEC Special Utilization Categories, DC Ratings ©

| Category | Typical Applications | Rated Current | Conditions for testing electrical life |  |  |  |  |  | Ops. | Conditions for testing making and breaking capacity |  |  |  |  |  | Ops. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Make |  |  | Break |  |  |  | Make |  |  | Break |  |  |  |
|  |  |  | I/le | U/ue | cos | Ic/le | Ur/Ue | cos |  | I/le | U/ue | cos | I/le | U/ue | cos |  |
| DC-1 | Non-inductive or slightly inductive loads, resistance furnaces | All Values | 1 | 1 | 1 | 1 | 1 | 1 |  | 1.5 (2) | $1.1{ }^{2}$ | 12 | 1.50 | 1.1 2 | 12 |  |
| DC-2 | Shunt-motors: <br> Starting, switching off motors during running | All Values | 2.5 | 1 | 2 |  | 0.1 | 7.5 |  | 4 | 1.1 | 2.5 | 4 | 1.1 | 2.5 |  |
| DC-3 | Shunt motors: <br> Starting, plugging, inching | All Values | 2.5 | 1 | 2 | 2.5 | 1 | 2 |  | 4 | 1.1 | 2.5 | 4 | 1.1 | 2.5 |  |
| DC-4 | Series-motors: <br> Starting , switching off motors during running | All Values | 2.5 | 1 | 7.5 |  | 0.3 | 10 |  | 4 | 1.1 | 15 | 4 | 1.1 | 15 |  |
| DC-5 | Series-motors: <br> Starting, plugging, inching | All Values | 2.5 | 1 | 7.5 | 2.5 | 1 | 7.5 |  | 4 | 1.1 | 15 | 4 | 1.1 | 15 |  |
| DC-15 | Electromagnets for contactors, valves, solenoid actuators | All Values | 1 | 1 | $6 \times \mathrm{P}$ (3 | 1 | 1 | $6 \times \mathrm{P}$ (3) |  | 1.1 | 1.1 | $6 \times \mathrm{P}$ 8 | 1.1 | 1.1 | $6 \times P$ 8 |  |

## Legend

Ue Rated operational voltage
$\boldsymbol{U}$ Voltage before make
Ur Recovery voltage
Ie Rated operational current
I Making current
Ic Breaking current
L Inductance of test circuit
R Resistance of test circuit
(1) Utilization categories and test conditions for AC \& DC. For contactors according to IEC 158-1, starters according to IEC 292-1 ... 4 and control switches according to IEC 337-1 and IEC 337-1A.
(2) Only according to VDE.
(3) $P=$ Ue $x$ le rated power [W]. The value " $6 \times \mathrm{P}$ " has been derived from an empiric relationship which covers most magnetic loads for DC up to an upper limit of $\mathrm{P}=50 \mathrm{~W}$.

## Predicting Electrical Life

Sprecher + Schuh contractors are designed for superior performance in a wide variety of applications, by giving consideration to the specific load, utilization category and required electrical life, you can purchase exactly the type
and size of contactor required. This assures reliable operatimon and high value the ability to very closely match the contactor to the application.
(1)

Identify they appropriate utilization category. For this example, we will determine CA7 contact life for inching and plugging squirrel-cage motors. ©

| Utilization <br> Category | Definition |  |
| :---: | :--- | :--- |
| AC-1 | Resistance Furnaces | Non inductive or slightly inductive loads, Resistive <br> Furnaces |
| AC-2 | Slip-ring motors | Starting and stopping of running motors |
| AC-3 | Squirrel-cage motors | Starting and stopping of running motors |
| AC-4 | Squirrel-cage motors | Starting, plugging, and inching <br> (Plugging is understood as stopping or reversing the <br> motor rapidly by reversing the motor primary connec- <br> tons while the motor is running. Inching [or jogging] is <br> understood as energizing a motor once or repeatedly for <br> short periods to obtain small movements of the driven <br> mechanism.) |
| A |  | Electromagnets for contactors, valves, solenoid actuators |

Choose the graph for the utilization category selected. (a graph pertaining to most Utilization Categories can be found in each contactor section.)

Locate the Rated Operational Current (le) along the bottom of the chart and follow the graph lines up to the intersecton of the appropriate contactor's life-load curve.
(4)

Read the estimated contact life along the vertical axis. (2)

(1) A comprehensive list of Utilization Categories can be found in each contactor section, however, these are the primary categories used in most industrial motor applications.
(2) The life-load curves shown here are based on Sprecher+Schuh tests according to the requirements defined in IEC 60947-4-1. Since contact life in a given application is dependent on environmental conditions and duty cycle, actual application contact life may vary from that indicated by the curves shown here.

## Life-Load Curves

- Locate the Rated Operational Current $\left(l_{\mathrm{e}}\right)$ along the bottom of the chart and follow the graph lines up to the intersection of the appropriate contactor's life-load curve.
- Read the estimated contact life along the vertical axis.

NOTE: The life-load curves shown here are based on Sprecher+Schuh tests according to the requirements defined in IEC 60947-4-1. Since contact life in any given application is dependent on environmental conditions and duty cycle, actual application contact life may vary from that indicated by the curves shown here.
( 575 V applications use $90 \%$ of curve value.


## Life-Load Curves

- Locate the Rated Operational Current $\left(l_{\mathrm{e}}\right)$ along the bottom of the chart and follow the graph lines up to the intersection of the appropriate contactor's life-load curve.
- Read the estimated contact life along the vertical axis.

AC-3
(to 575)


## AC-4

(to 690V)

Starting with inching and plugging; $U_{e}=230 \ldots . .690$ VAC


NOTE: The life-load curves shown here are based on Sprecher+Schuh tests according to the requirements defined in IEC 60947-4-1. Since contact life in any given application is dependent on environmental conditions and duty cycle, actual application contact life may vary from that indicated by the curves shown here. Technical Information

## Life-Load Curves



## Contact Life for Mixed Utilization Categories

 AC-3 and AC-4In many applications, the utilization category cannot be defined as either purely $\mathrm{AC}-3$ or $\mathrm{AC}-4$. In those applications, the electrical life of the contactor can be estimated with the following equation:

$$
\mathrm{L}_{\text {mixed }}=\mathrm{L}_{\mathrm{ac3}} /\left[1+\mathrm{P}_{\mathrm{acc}} \mathrm{X}\left(\mathrm{~L}_{\mathrm{ac3}} / \mathrm{L}_{\mathrm{ac} 4}-1\right)\right] \text {, where: }
$$

$\mathrm{L}_{\text {mixed }}$ Approximate contact life in operations for a mixed AC-3/AC-4 utilization category application.
$\mathrm{L}_{\mathrm{ac} 3}$ Approximate contact life in operations for a pure AC-3 utilization category (from the AC-3 life-load curve).
$\mathrm{L}_{\mathrm{ac} 4} \quad$ Approximate contact life in operations for a pure AC-4 utilization category (from the AC-4 life-load curve).
$\mathrm{P}_{\text {act }} \quad$ Percentage of AC-4 operations


NOTE: The life-load curves shown here are based on Sprecher+Schuh tests according to the requirements defined in IEC 60947-4-1. Since contact life in any given application is dependent on environmental conditions and duty cycle, actual application contact life may vary from that indicated by the curves shown here.

## Operating Rates

The estimated contact life shown in the life-load curves is based on the standard operating rates shown in Table B below. For applications requiring a higher operating frequency, the maximum operating power (Pn in kW or HP) for a given contactor must be reduced to maintain the same contact life.
To find a contactor's maximum operating power, for an operating rate greater than shown in Table B, follow these guidelines:

1. Identify the appropriate curve for the contactor and utilization category from Table B.
2. Locate the appropriate Maximum Operating Rate curve on the following pages.
3. Locate the intersection of the curve with the application's operating rate ( $\mathrm{ops} / \mathrm{hr}$.) found on the vertical axis.
4. Read the percent of maximum operating power (Pn) of the contactor from the horizontal axis.
5. Multiply the \% maximum power by the standard power rating.

Example: The contactor selected for an AC-4 utilization category application is a CA7-16 (10HP at 460V), however, the application requires an operating rate of $200 \mathrm{ops} / \mathrm{hr}$., compared to the standard operating rate of $120 \mathrm{ops} / \mathrm{hr}$. as shown in Table B.

1. Locate the AC-4 Maximum Operating Rate curve on the following pages.
2. Locate the intersection of $200 \mathrm{ops} / \mathrm{hr}$ on the CA7-16 curve. The data shows that the maximum operating power of the CA7-16 contactor in this application is $60 \%$.
3. Therefore, the maximum horsepower that can be switched by the CA7-16 contactor in this application is $6 \mathrm{HP}(0.60 \times 10 \mathrm{HP})$.

## Table B - Standard Operating Rates by Contactor and Utilization Category

| Contactor | AC-1 Max. ops/hr. | AC-2 <br> Max. ops/hr. | AC-3 Max. ops/hr. | AC-4 Max. ops/hr. | AC-4 @ $I_{\mathrm{e}}$ for 200K ops. Max. ops/hr. |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Operating Parameters and Start Time |  |  |  |  |
|  |  |  | 40\% Duty Cycle 250ms 1 | 250ms | 250ms |
| CA-9 | 1000 | 500 | 700 | 200 | 400 |
| CA-12 | 1000 | 500 | 700 | 150 | 300 |
| CA-16 | 1000 | 500 | 700 | 120 | 240 |
| CA-23 | 1000 | 400 | 600 | 80 | 160 |
| CA-30 | 1000 | 400 | 600 | 80 | 160 |
| CA-37 | 1000 | 400 | 600 | 70 | 140 |
| CA-43 | 1000 | 400 | 600 | 70 | 140 |
| CA-60 | 800 | 300 | 500 | 70 | 140 |
| CA-72 | 800 | 250 | 500 | 60 | 120 |
| CA-85 | 600 | 200 | 500 | 50 | 140 |

[^21] Technical Information

## Operating Rate Curves

## AC-1

Non or slightly inductive loads, resistance furnaces; $U_{e}=230 \ldots 690 \mathrm{VAC}$



Technical Information

## Operating Rate Curves

## AC-3

Squirrel-cage motors: starting, switching off motors during running; $U_{e}=230 . . .460$ VAC Relative operating time $40 \%$, Starting time $t_{A}=0.25 \mathrm{~s}$


AC-4
Squirrel-cage motors: starting, plugging, inching; $U_{e}=\mathbf{2 3 0} \ldots 460$ VAC Starting Time $t_{\mathrm{A}}=0.25 \mathrm{~s}$


Series CA7, CAU7, CAQ7, CNX, CAN7 and CAL7 (Contactors, Reversing Contactors \& Special Use Contactors)


## Reversing Contactors, Capacitor Contactors \& Accessories (+...)

| Contactors with... |  | Dim. [mm] | Dim. [inches] |
| :--- | :--- | :--- | :--- |
| auxiliary contact block-front mounting | 2-, or 4-pole | $\mathrm{c} / \mathrm{c} 1+39$ | $\mathrm{c} / \mathrm{c} 1+1-37 / 64$ |
| (CAQ7) capacitor switching deck -front mounting | $\mathrm{c} / \mathrm{c} 1+39$ | $\mathrm{c} / \mathrm{c} 1+1-37 / 64$ |  |
| auxiliary contact block-side mounting | 1-, or 2 pole | $\mathrm{a}+9$ | $\mathrm{a}+23 / 64$ |
| pneumatic timing module |  | $\mathrm{c} / \mathrm{c} 1+58$ | $\mathrm{c} / \mathrm{c} 1+2-23 / 64$ |
| electronic timing module | on coil terminal side | $\mathrm{b}+24$ | $\mathrm{~b}+15 / 16$ |
| reversing contactor w-mech.interlock | on side of contactor | $\mathrm{a}+9+\mathrm{a}$ | $\mathrm{a}+23 / 64+\mathrm{a}$ |
| mechanical latch |  | $\mathrm{c} / \mathrm{c} 1+61$ | $\mathrm{c} / \mathrm{c} 1+2-31 / 64$ |
| interface module | on coil terminal side | $\mathrm{b}+9$ | $\mathrm{~b}+23 / 64$ |
| surge suppressor | on coil terminal side | $\mathrm{b}+3$ | $\mathrm{~b}+1 / 8$ |
|  | label sheet <br> marking tag sheet with clear cover <br> Labeling with... | +0 <br> +0 | +0 |



AC contactors


## Series CA7 with Two Winding DC Coil



- Dimensions are in millimeters (inches)
- Dimensions not intended for manufacturing purposes


|  | Catalog Number | a | b | c | c1 | c2 | $\emptyset d$ | d1 | d2 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| AC <br> Contactors | CA7-9Y...CA7-23Y | $\begin{gathered} 54 \\ (2-9 / 64) \end{gathered}$ | $\begin{gathered} 90 \\ (3-35 / 64) \end{gathered}$ | $\begin{gathered} 80.5 \\ (3-11 / 64) \end{gathered}$ | $\begin{gathered} 75.5 \\ (3-3 / 32) \end{gathered}$ | $\begin{gathered} 6 \\ (1 / 4) \end{gathered}$ | $\begin{gathered} 2-4.5 \\ (2-3 / 16) \end{gathered}$ | $\begin{gathered} 60 \\ (2-23 / 64) \end{gathered}$ | $\begin{gathered} 35 \\ (1-25 / 64) \end{gathered}$ |
|  | CA7-30Y, CA7-37Y | $\begin{gathered} 54 \\ (2-9 / 64) \end{gathered}$ | $\begin{gathered} 90 \\ (3-35 / 64) \end{gathered}$ | $\begin{gathered} 97.5 \\ \text { (4) } \end{gathered}$ | $\begin{gathered} 92.6 \\ (3-49 / 64) \end{gathered}$ | $\begin{gathered} 6.5 \\ (17 / 64) \end{gathered}$ | $\begin{gathered} 2-4.5 \\ (2-3 / 16) \end{gathered}$ | $\begin{gathered} 60 \\ (2-23 / 64) \end{gathered}$ | $\begin{gathered} 35 \\ (1-25 / 64) \end{gathered}$ |
|  | CA7-43Y | $\begin{gathered} 63 \\ (2-31 / 64) \end{gathered}$ | $\begin{gathered} 90 \\ (3-35 / 64) \end{gathered}$ | $\begin{gathered} 100.5 \\ (4-7 / 64) \end{gathered}$ | $\begin{gathered} 95.6 \\ (3-7 / 8) \end{gathered}$ | $\begin{gathered} 6.5 \\ (17 / 64) \end{gathered}$ | $\begin{gathered} 2-4.5 \\ (2-3 / 16) \end{gathered}$ | $\begin{gathered} 60 \\ (2-23 / 64) \end{gathered}$ | $\begin{gathered} 45 \\ (1-25 / 32) \end{gathered}$ |
|  | CA7-60D...CA7-85D <br> CAN7-72D, CNX-218D | $\begin{gathered} 81 \\ (3-3 / 16) \end{gathered}$ | $\begin{gathered} 131 \\ (5-5 / 32) \end{gathered}$ | $\begin{gathered} 117 \\ (4-49 / 64) \end{gathered}$ | $\begin{gathered} 111.5 \\ (4-35 / 64) \end{gathered}$ | $\begin{gathered} 8.5 \\ (21 / 64) \end{gathered}$ | $\begin{gathered} 4-5.4 \\ (4-7 / 32) \end{gathered}$ | $\begin{gathered} 100 \\ (3-15 / 16) \end{gathered}$ | $\begin{gathered} 55 \\ (2-11 / 64) \end{gathered}$ |
|  | CA7-90D | $\begin{gathered} 95 \\ (3-3 / 4) \end{gathered}$ | $\begin{gathered} 122 \\ (4-51 / 64) \end{gathered}$ | $\begin{gathered} 117 \\ (4-49 / 64) \end{gathered}$ | $\begin{gathered} 111.5 \\ (4-35 / 64) \end{gathered}$ | $\begin{gathered} 8.5 \\ (21 / 64) \end{gathered}$ | $\begin{gathered} 4-5.4 \\ (4-7 / 32) \end{gathered}$ | $\begin{gathered} \hline 100 \\ (3-15 / 16) \end{gathered}$ | $\begin{gathered} 55 \\ (2-11 / 64) \end{gathered}$ |

Reversing Contactors, Capacitor Contactors \& Accessories (+...)

|  | Contactors with... | Dim. [mm] | Dim. [inches] | Mounting Position |
| :---: | :---: | :---: | :---: | :---: |
| auxiliary contact block-front mounting | 2-, or 4-pole | $\mathrm{c} / \mathrm{c} 1+39$ | c/c1 +1-37/64 | - ¢ |
| auxiliary contact block- left side mounting | 1-, or 2 pole | a +9 | $a+23 / 64$ | - |
| pneumatic timing module |  | c/c1 + 58 | c/c1 + 2-23/64 | - $\rightarrow$------ |
| electronic timing module | on coil terminal side | b +24 | $b+15 / 16$ |  |
| mechanical latch |  | c/c1 + 61 | c/c1 +61 | Two Winding DC contactors |
| interface module | on coil terminal side | b +9 | c/c1 + 2-31/64 |  |
| Labeling with... | label sheet <br> marking tag sheet with clear cover marking tag adapter for V7 Terminals | $\begin{aligned} & +0 \\ & +0 \\ & +5.5 \end{aligned}$ | $\begin{aligned} & +0 \\ & +0 \\ & +7 / 32 \end{aligned}$ |  |

## sprecher +



| Catalog Number | With Contactor | AC Operated Contactor |  |  |  | DC Operated Contactor |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | h1 | h2 | h3 | h4 | h1 | h2 | h3 | h4 |
| CA7-P-KN23 / | CA7-9... 16 | $\begin{gathered} 61.6 \\ (2-27 / 64) \end{gathered}$ | $\begin{gathered} 78.6 \\ (3-3 / 32) \end{gathered}$ | $\sim$ | $\sim$ | $\begin{gathered} 87.2 \\ (3-7 / 16) \end{gathered}$ | $\begin{gathered} 104.2 \\ (4-3 / 32) \end{gathered}$ | $\sim$ | $\sim$ |
| KL23 | CA7-23 | $\begin{gathered} 61.6 \\ (2-27 / 64) \end{gathered}$ | $\begin{gathered} 78.6 \\ (3-3 / 32) \end{gathered}$ | $\sim$ | $\sim$ | $\begin{gathered} 105.2 \\ (4-9 / 64) \end{gathered}$ | $\begin{gathered} 122.2 \\ (4-13 / 16) \end{gathered}$ | $\sim$ | $\sim$ |
| CA7-P-K37 | CA7-30 \& 37 | $\begin{gathered} 67.6 \\ (2-21 / 32) \end{gathered}$ | $\begin{gathered} 84.6 \\ (3-21 / 64) \end{gathered}$ | $\begin{gathered} 71.5 \\ (2-13 / 16) \end{gathered}$ | $\begin{gathered} 88.5 \\ (3-31 / 64) \\ \hline \end{gathered}$ | $\begin{aligned} & 111.2 \\ & (4-3 / 8) \end{aligned}$ | $\begin{gathered} 128.2 \\ (5-3 / 64) \end{gathered}$ | $\begin{gathered} 115.1 \\ (4-17 / 32) \end{gathered}$ | $\begin{gathered} 132.1 \\ (5-13 / 64) \end{gathered}$ |
| CA7-P-K43 | CA7-43 | $\begin{gathered} 69.0 \\ (2-23 / 32) \end{gathered}$ | $\begin{gathered} 85.0 \\ (3-11 / 32) \end{gathered}$ | $\begin{gathered} 74.5 \\ (2-15 / 16) \end{gathered}$ | $\begin{gathered} 90.5 \\ (3-9 / 16) \end{gathered}$ | $\begin{gathered} 112.6 \\ (4-7 / 16) \end{gathered}$ | $\begin{gathered} 128.6 \\ (5-1 / 16) \end{gathered}$ | $\begin{gathered} 118.1 \\ (4-21 / 32) \end{gathered}$ | $\begin{gathered} 134.1 \\ (5-9 / 32) \end{gathered}$ |
| CA7-P-K85 | CA7-60... 85 | $\begin{gathered} 79.7 \\ (3-1 / 8) \end{gathered}$ | $\begin{aligned} & 104.7 \\ & (4-1 / 8) \\ & \hline \end{aligned}$ | $\begin{gathered} 86.7 \\ (3-13 / 64) \\ \hline \end{gathered}$ | $\begin{aligned} & 111.7 \\ & (4-3 / 8) \end{aligned}$ | $\begin{gathered} 79.7 \\ (3-1 / 8) \end{gathered}$ | $\begin{aligned} & 104.7 \\ & (4-1 / 8) \\ & \hline \end{aligned}$ | $\begin{gathered} 86.7 \\ (3-13 / 64) \end{gathered}$ | $\begin{aligned} & 111.7 \\ & (4-3 / 8) \\ & \hline \end{aligned}$ |

## CA7 Contactors with Paralleling Links

- Dimensions are in millimeters (inches)
- Dimensions not intended for manufacturing purposes


| Catalog Number | With Contactor | AC Operated Contactor |  |  |  | DC Operated Contactor |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | h1 | h2 | h3 | h4 | h1 | h2 | h3 | h4 |
| CA7-P-B2 | CA7-9... 16 | $\begin{gathered} 65.1 \\ (2-9 / 16) \end{gathered}$ | $\begin{gathered} 90.1 \\ (3-9 / 16) \end{gathered}$ | $\sim$ | $\sim$ | $\begin{aligned} & 90.7 \\ & (1 / 4) \end{aligned}$ | $\begin{gathered} 104.2 \\ (2-3 / 16) \end{gathered}$ | $\sim$ | $\sim$ |
| CA7-P-B23 | CA7-23 | $\begin{gathered} 65.1 \\ (2-9 / 16) \end{gathered}$ | $\begin{gathered} 90.1 \\ (3-9 / 16) \end{gathered}$ | $\sim$ | $\sim$ | $\begin{gathered} 108.7 \\ (4-9 / 32) \end{gathered}$ | $\begin{gathered} 133.7 \\ (5-17 / 64) \end{gathered}$ | $\sim$ | $\sim$ |
| CA7-P-K37 | CA7-30 \& 37 | $\begin{gathered} 69.0 \\ (2-23 / 32) \end{gathered}$ | $\begin{gathered} 94.0 \\ (3-45 / 64) \end{gathered}$ | $\begin{gathered} 74.5 \\ (2-15 / 16) \end{gathered}$ | $\begin{gathered} 99.5 \\ (3-29 / 32) \end{gathered}$ | $\begin{gathered} 112.6 \\ (4-7 / 16) \end{gathered}$ | $\begin{gathered} 137.6 \\ (5-13 / 32) \end{gathered}$ | $\begin{gathered} 118.1 \\ (4-21 / 32) \end{gathered}$ | $\begin{gathered} 143.1 \\ (5-5 / 8) \end{gathered}$ |

## N|-

BS compact fuse links
Complies with BS 88
Reduced dimensions
Low watts loss

|  | Clip-in offs |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Rating (A) | $\begin{aligned} & \text { BS } 88 \\ & \text { ref. } \end{aligned}$ | Overall length (mm) | Overall Dia. (mm) | Cat. No. ${ }^{1}$ ) |
|  | 2 | F1 | 60 | 14 | NNS 2 |
| PROVIDE | 4 |  |  |  | NNS 4 |
| SUPERIOR SII | 6 |  |  |  | NNS 6 |
| protkction | 10 |  |  |  | NNS 10 |
|  | 16 |  |  |  | NNS 16 |
|  | 20 |  |  |  | NNS 20 |
|  | 25 |  |  |  | NNS 25 |
|  | 32 |  |  |  | NNS 32 |
|  | 20M25 |  |  |  | NNS 20M25 |
|  | 20 M 32 |  |  |  | NNS 20M32 |
|  | 20 | F2 | 68 | 17 | NES 20 |
|  | 25 |  |  |  | NES 25 |
| NNS 2 | 32 |  |  |  | NES 32 |
|  | 40 |  |  |  | NES 40 |
|  | 50 |  |  |  | NES 50 |
|  | 63 |  |  |  | NES 63 |

Bolted pattern offset tags

| Rating (A) | BS 88 ref. | Fixing centres (mm) | Cat. No. ${ }^{1}$ ) |
| :---: | :---: | :---: | :---: |
| 2 | A1 | 44.5 | NNIT 2 |
| 4 |  |  | NNIT 4 |
| 6 |  |  | NNIT 6 |
| 10 |  |  | NNIT 10 |
| 16 |  |  | NNIT 16 |
| 20 |  |  | NNIT 20 |
| 25 |  |  | NNIT 25 |
| 32 |  |  | NNIT 32 |
| 20M25 |  |  | NNIT 20M25 |
| 20M32 |  |  | NNIT 20M32 |
| 32M40 |  |  | NNIT 32M40 |
| 32M50 |  |  | NNIT 32M50 |
| 32M63 |  |  | NNIT 32M63 |
| 2 | A2 | 73 | NTIA 2 |
| 4 |  |  | NTIA 4 |
| 6 |  |  | NTIA 6 |
| 10 |  |  | NTIA 10 |
| 16 |  |  | NTIA 16 |
| 20 |  |  | NTIA 20 |
| 25 |  |  | NTIA 25 |
| 32 |  |  | NTIA 32 |
| 32M40 |  |  | NTIA 32M40 |
| 32M50 |  |  | NTIA 32M50 |
| 32M63 |  |  | NTIA 32M63 |

Note: $\left.\quad{ }^{1}\right)^{\prime} M^{\prime}$ in catalogue No. denotes motor starting type.

Refer catalogue NF

## BS compact fuse links



NOS 100M125


NTFP125
Bolted pattern offset tags (cont.)

| Rating (A) | BS 88 Ref | Fixing centres (mm) | Cat. No. ${ }^{1}$ ) |
| :---: | :---: | :---: | :---: |
| 35 | A3 | 73 | NTIS 35 |
| 40 |  |  | NTIS 40 |
| 50 |  |  | NTIS 50 |
| 63 |  |  | NTIS 63 |
| 63 M 80 |  |  | NTIS 63M80 |
| 63 M 100 |  |  | NTIS 63M100 |
| 80 | HYBRID A3 | 73 | NOS 80 |
| 100 |  |  | NOS 100 |
| 100M125 |  |  | NOS 100M125 |
| 100 M 160 |  |  | NOS 100M160 |
| 80 | A4 | 94 | NTCP 80 |
| 100 |  |  | NTCP 100 |
| 100M125 |  |  | NTCP 100M125 |
| 100M160 |  |  | NTCP 100M160 |
| 125 | HYBRID A4 | 94 | NTFP 125 |
| 160 |  |  | NTFP 160 |
| 200 |  |  | NTFP 200 |
| 200M250 |  |  | NTFP 200M250 |



NTB 16


NTBC 20

Bolted pattern centre tags

| 2 | - | 97 | NTB 2 |
| :---: | :---: | :---: | :---: |
| 4 |  |  | NTB 4 |
| 6 |  |  | NTB 6 |
| 10 |  |  | NTB 10 |
| 16 |  |  | NTB 16 |
| 20 |  |  | NTB 20 |
| 25 |  |  | NTB 25 |
| 32 |  |  | NTB 32 |
| 40 |  |  | NTB 40 |
| 50 |  |  | NTB 50 |
| 63 |  |  | NTB 63 |
| 63 M 80 |  |  | NTB 63M80 |
| 63 M 100 |  |  | NTB 63M100 |
| 2 | B1 | 111 | NTBC 2 |
| 4 |  |  | NTBC 4 |
| 6 |  |  | NTBC 6 |
| 10 |  |  | NTBC 10 |
| 16 |  |  | NTBC 16 |
| 20 |  |  | NTBC 20 |

Note: ${ }^{1}$ ) ${ }^{\prime} M^{\prime}$ in catalogue number denotes motor starting type

## NT-I COMPACT FUSES

## BS compact fuse links

Refer catalogue NF


NTF 200


NTM 400


NTLT 710


NTXU 1250

| Rating (A) | BS 88 Ref. | Fixing centres (mm) | Cat. No. ${ }^{1}$ ) |
| :---: | :---: | :---: | :---: |
| 25 | B1 | 111 | NTBC 25 |
| 32 |  |  | NTBC 32 |
| 40 |  |  | NTBC 40 |
| 50 |  |  | NTBC 50 |
| 63 |  |  | NTBC 63 |
| 63M80 |  |  | NTBC 63M80 |
| 63M100 |  |  | NTBC 63M100 |
| 80 | B1 | 111 | NTC 80 |
| 100 |  |  | NTC 100 |
| 100M125 |  |  | NTC 100M125 |
| 100M160 |  |  | NTC 100M160 |
| 100M 200 |  |  | NTC 100M200 |
| 125 | B2 | 111 | NTF 125 |
| 160 |  |  | NTF 160 |
| 200 |  |  | NTF 200 |
| 200M 250 |  |  | NTF 200M250 |
| 200M 315 |  |  | NTF 200M315 |
| 250 | B3 | 111 | NTKF 250 |
| 315 |  |  | NTKF 315 |
| 315M 400 |  |  | NTKF 315M400 |
| 250 |  | 133 | NTKM 250 |
| 315 |  |  | NTKM 315 |
| 355 | B4 | 111 | NTMF 355 |
| 400 |  |  | NTMF 400 |
| 355 | C1 | 133/184 | NTM 355 |
| 400 |  |  | NTM 400 |
| 450 | C2 | 133/184 | NTTM 450 |
| 500 |  |  | NTTM 500 |
| 560 |  |  | NTTM 560 |
| 630 |  |  | NTTM 630 |
| 450 |  | 165/229 | NTT 450 |
| 500 |  |  | NTT 500 |
| 560 |  |  | NTT 560 |
| 630 |  |  | NTT 630 |
| 710 | C3 | 133/184 | NTLM 710 |
| 800 |  |  | NTLM 800 |
| 710 |  | 165/229 | NTLT 710 |
| 800 |  |  | NTLT 800 |
| 1000 | D1 | 149 | NTXU 1000 |
| 1250 |  |  | NTXU 1250 |

Note: ${ }^{1}$ ) ${ }^{\prime} M^{\prime}$ in catalogue number denotes motor starting type.

## DIN and BS fuse link selection chart

## BS Fuses

| Switch-fuses |  |  |  |  |  |  |  | Fuse type Cat. No. Prefix |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 800 | 630 | 400 | 315 | 250 | 200 | 160 | 125 |  |
|  |  |  |  |  |  |  |  | NNS_ |
|  |  |  |  |  |  |  |  | NNIT_ |
|  |  |  |  |  |  | $\checkmark$ | $\checkmark$ | NTIA |
|  |  |  |  |  |  | $\checkmark$ | $\checkmark$ | NTIS |
|  |  |  |  |  |  | $\checkmark$ | $\checkmark$ | NOS |
|  |  |  |  |  |  | $\checkmark$ |  | NTCP |
|  |  |  |  |  |  |  |  | NTFP_ |
|  |  |  |  |  |  |  |  | NTSLOO_ |
|  |  | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |  | NTBC |
|  |  | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |  | NTC |
|  |  | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |  | NTF_ |
|  |  | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |  |  | NTKF_ |
|  |  |  |  |  |  |  |  | NTSL3 |
|  |  | $\checkmark$ |  |  |  |  |  | NTMF_ |
| $\checkmark$ | $\checkmark$ |  |  |  |  |  |  | NTM |
| $\checkmark$ | $\checkmark$ |  |  |  |  |  |  | NTTM |
| $\checkmark$ |  |  |  |  |  |  |  | NTLM |


| NHP HRC fuse holders |  |  |  |  |  |  |  |  | Fuse type <br> Cat. No. |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :--- |
|  |  |  |  |  |  |  |  |  |  |
|  | 200 | 100 | 63 | 32 | 20 | 63 | 32 | 20 | Prefix |

DIN Fuses

| Switch-fuses |  |  |  |  |  | Fuse type <br> Cat. No. |
| :--- | :---: | :---: | :---: | :---: | :---: | :--- |
| 800 | 630 | 400 | 250 | 160 | 125 | Prefix |

Legend:
$\checkmark$ Fuse links fit direct.
${ }^{1}$ ) Fuses require 100MFLK adaptor, see page 11-107.
${ }^{2}$ ) 'M' type (motor rated) NTIS not suitable for NC63_. Use NC100 fuse holder.

# BS compact fuse links <br> Bolted pattern - Centre tag 

## Motor rated fuse links

BS 88 aligns with international fuse specification IEC 269. Special motor rated fuse links are listed and are available in various barrel sizes, in each case fitted with special fuse elements. Their selection frequently permits the use of lower rated switch and/or fusegear than would be the case if using Class gG fuse links. This range of fuse-links has been ASTA certified for a breaking capacity of 80 kA at 415 V AC .
NHP Compact industrial bolted pattern fuse links conform with BS 88: Part 2: 1998 and have been ASTA certified for a breaking capacity of 80 kA at 415 V AC or 550 V AC and have utilisation categories gG .
NHP Compact fuse-links are suitable for back-up protection in motor circuits, having excellent time delay characteristics with low fusing factor and high rupturing capacity.
Fuses for use in motor circuits should be selected in accordance with the requirements for the protection of motor control gear as specified by the control gear manufacturer.
As a guide, the following table shows the minimum fuse sizes that may be associated with motors based on the assumption that the starting conditions for typical 3 phase 4 pole 415 V motors are; $8 \times$ FLC for 6 secs [DOL] and $4 \times$ FLC for 12 secs [Star-delta].

Fuse link selection for motor circuit protection

| Moto kW | hp | Approx. <br> FLC (A) | DOL starting fuse link (A) | Motor rated fuse-link (A) | Start assisted standard fuse link (A) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0.19 | 0.25 | 0.7 | 4 |  | 2 |
| 0.37 | 0.5 | 1.3 | 6 |  | 4 |
| 0.55 | 0.75 | 1.6 | 6 |  | 4 |
| 0.75 | 1.0 | 1.8 | 10 |  | 4 |
| 1.1 | 1.5 | 2.6 | 10 |  | 6 |
| 1.5 | 2.0 | 3.4 | 10 |  | 10 |
| 2.2 | 3.0 | 5.0 | 16 |  | 10 |
| 3.0 | 4.0 | 6.5 | 16 |  | 10 |
| 4.0 | 5.5 | 8.0 | 20 | 20 M 25 | 16 |
| 5.5 | 7.5 | 11.0 | 25 | 20 M 32 | 16 |
| 7.5 | 10 | 15 | 40 | 32M40 | 25 |
| 11.0 | 15 | 22 | 50 | 32 M 50 | 32 |
| 15.0 | 20 | 28 | 63 | 32M63 | 40 |
| 18.5 | 25 | 36 | 80 | $63 M 80$ | 50 |
| 22 | 30 | 39 | 80 | 63 M 80 | 63 |
| 30 | 40 | 52 | 100 | 63M100 | 63 |
| 37 | 50 | 69 | 160 | 100M160 | 80 |
| 45 | 60 | 79 | 160 | 100M160 | 100 |
| 55 | 75 | 96 | 200 |  | 160 |
| 75 | 100 | 125 | 200 | 200M250 | 160 |
| 90 | 125 | 156 | 250 | 200M250 | 160 |
| 110 | 150 | 189 | 315 |  | 200 |
| 132 | 175 | 224 | 355 |  | 250 |
| 150 | 200 | 255 | 355 |  | 250 |
| 160 | 220 | 275 | 400 |  | 315 |
| 185 | 250 | 318 | 450 |  | 315 |
| 200 | 270 | 339 | 500 |  | 355 |
| 220 | 300 | 374 | 560 |  | 400 |
| 257 | 350 | 450 | 630 |  | 450 |
| 295 | 400 | 500 | 710 |  | 500 |
| 315 | 430 | 535 | 710 |  | 560 |
| 355 | 483 | 580 | 800 |  | 630 |
| 400 | 545 | 646 | 800 |  | 710 |
| 450 | 612 | 725 | 1000 |  | 800 |

## NHP compact <br> fusts

## Fuse equivalent chart

This chart is designed to help choose the correct fuse to fit a particular switch-fuse (or vice versa) and to help choose the correct replacement fuse. Some data is from other manufacturers publications and as such cannot be guaranteed by NHP. Beware that some motor start fuses are in a larger body size than a normal fuse. It is wise to consult the fuse manufacturer's data to determine their particular fuse sizes (i.e. A2-C3).
Fuse manufacturer's part numbers - Australian/British standard

| BS Ref. | Amps | I-HP ${ }_{\text {FuSPs }}^{\text {compr }}$ | EATON/ MEM | Holec | Alstom GEC | Bussmann | PDL | Siemens |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| F1 | 2... 32 | NNS | SN2 | NS | NS | NSD | N20C | 3NW NS |
| F2 | 20... 63 | NES | SP | MES | ES | ESD | N63E | 3NW ES |
| A1 | 2... 32 | NNIT | SA2 | NIT | NIT | NITD | N20B | 3NW NIT |
| A2 | 2... 32 | NTIA | SB3 | TIA | TIA | AAO | N32B | 3NW TIA |
| A3 | 35... 63 | NTIS | SB4 | TIS | TIS | BAO | N63B | 3NW TIS |
| Hybrid (A3) | 80... 100 | NOS | S0 | - | OS | OSD | NOSD | 3NW OS |
| Hybrid (A3) | 125... 160 | NTSLOO | - | - | - | - | - | - |
| A4 | 80... 100 | NTCP | SD5 | TCP | TCP | CEO | N100B | 3NW TCP |
| Hybrid (A4) | 125... 200 | NTFP ${ }^{1}$ ) | SD6 | TFP | TFP | DEO | N200B | 3NW TFP |
| - | 2...32/40... 63 | NTB | SE3/SE4 | TB | TB | $A C / B C$ | N_TB | 3NW TB |
| B1 | 2...32/40... 63 | NTBC | SF3/SF4 | TBC | TBC | AD/BD | N63B | 3NW TBC |
| B1 | 80... 100 | NTC | SF5 | TC | TC | CD | N100B_C | 3NW TC |
| B2 | 125... 200 | NTF | SF6 | TF | TF | DD | N200B_C | 3NW TF |
| B3 | 250... 315 | NTKF | SF7 | TKF | TKF | ED | N315B_C | 3NW TKF |
| - | 250... 315 | NTKM | SG7 | TKM | TKM | EFS | N315B_C | 3NW TKM |
| B4 | 355... 400 | NTMF | SF8 | TMF | TMF | ED | N400B_C | 3NW TMF |
| Hybrid (B4) | 450... 630 | NTSL3 | - | - | - | - | - | - |
| C1 | 355... 400 | NTM | SH8 | TM | TM | EF | N404B_C | 3NW TM |
| C 2 | 450... 630 | NTTM | SH9 | TTM | TTM | FF | N504B_C | 3NW TTM |
| - | 450... 630 | NTT | SY9 | TT | TT | FG | N630B_C | 3NW TT |
| C3 | 710... 800 | NTLM | SH10 | TLM | TLM | GF | N804B_C | 3NW TLM |
| - | 710... 800 | NTLT | SY10 | TLT | TLT | GG | B804B_C | 3NW TLT |
| D1 | 1000... 1250 | NTXU | SJ11 | TXU | TXU | GH | N_U44 | 3NW TXU |
| DIN pattern |  |  |  |  |  |  |  |  |
| 00 | 6... 160 | N00 | NHOO | - | NHG-00 | NH00G | - | 3NA5 |
| 1 | 25... 250 | N1 | NH01 | - | NHG-1 | NH1G | - | 3NA4 144 |
| 2 | 80... 400 | N2 | NH02 | - | NHG-2 | NH2G | - | 3NA4 260 |
| 3 | 315... 800 | N3 | NH03 | - | NHG-3 | NH3G | - | 3NA1 |
| Fuse holders |  |  |  |  |  |  |  |  |
| Clip-in | 20A | NV20FW | V20FF | - | $\mathrm{SC2OH}$ | - | FC20FW | - |
|  | 32A | NV32FW | V32FF | - | SC32H | 32NNSF | NC32FW | 3NW 32NNSF |
| Front wired | 20A | N20FW | 20MFB | - | RSM20H | - | FB20FW | 3NWCM20FC |
|  | 32 A | NC32FW | 32MFB | 200846 | RSM32H | - | FB32FW | 3NW CM32F |
|  | 63 A | NC63FW | 63MFB | LCF63FCFC | RSM63H | - | FB63FW | 3NW CM63F |
|  | 100 A | NC100FW | 100MFB | - | RSM100H | - | FB100FW | 3NW CM100F |
|  | 200A | NC200FW | 200MFB | - | RSM200H | - | FB200FW | 3NW 200DF |
| Stud/ | 20A | N20SFW | 20MFD | - | RSM20PH | - | FB20SF | - |
| front wired | 32 A | NC32SFW | 32MFD | LCF32FCBC | RSM32PH | - | FB32SF | - |
|  | 63 A | NC63SFW | 63MFD | LCF63FCBC | RSM63PH | - | FB63SF | - |
|  | 100 A | NC100SFW | 100MFD | - | RSM100PH | - | FB100SF | - |
|  | 200A | NC200SFW | 200MFD | - | RSM200PH | - | FB200SF | - |

Note: $\quad{ }^{1}$ ) This hybrid type fuse is actually an A4 size fuse, but as it is over 100 amps it cannot be called an A4 fuse to AS 2005.


#### Abstract

NHP Compact 415 V fuse-links are available in ratings from 2A up to 1250A and advanced design techniques mean that watts loss figures have been substantially reduced whilst protection characteristics remain unchanged.


All NHP Compact HRC fuse-links are manufactured using precision assembly methods to ensure that their performance will conform with the published characteristics within very close tolerances.
Cartridge barrels are extruded under vacuum to prevent the occurrence of air pockets. Each fuse is then fully filled, using a vibratory method, with specially prepared, dried and graded powdered silica. The end caps are press fitted on to the precision ground barrels ensuring a very tight fit.
Fuse elements are accurately shaped and manufactured for consistency and reliability.
All NHP Compact fuse-links are subjected to a resistance test to prove correct assembly.
NHP Compact HRC fuse-links, other than motor rated patterns, have utilisation categories gG .
Schedules of equivalent fuse-links made by certain other manufacturers are included in the following pages. No claim is made of identical performance under all conditions, the schedules being provided to assist on the selection of fuse-links having similar ratings, dimensions and fixing centres. Characteristic curves and associated data are provided to aid accurate discrimination.

## Motor rated fuse-links

BS88 now aligns with the international fuse specification IEC 269. The concept of "fusing factor" has been replaced with "utilisation category". Class Q1 fusing factor is now referred to as " $\mathrm{gG}^{\prime}$ " and motor rated fuse-links are referred to as " $\mathrm{gM}^{\prime}$ ". Special motor rated fuse-links are also listed and are available in various barrel sizes, in each case fitted with special fuse elements. Their selection frequently permits the use of lower rated switch and/or fusegear than would be the case using Class gG fuse-links. This range of fuse-links has been ASTA certified for a breaking capacity of 80 kA at 415 V AC.
NHP Compact industrial bolted pattern fuse-links conform with BS 88: Part 2: 1988 and, have been ASTA certified for a breaking capacity of 80 kA at 415 V AC or 550 V AC and have utilisation categories gG.
NHP Compact fuse-links are suitable for back-up protection in motor circuits, having excellent time delay characteristics with low fusing factor and high rupturing capacity.
Fuses for use in motor circuits should be selected in accordance with the requirements for the protection of motor control gear as specified by the control gear manufacturer.

As a guide, the following table shows the minimum fuse sizes that may be associated with motors based on the assumption that the starting conditions for typical 3 phase 4 pole 415 V motors are; $8 \times$ F.L.C. for 6 secs [D.O.L.] and $4 \times$ F.L.C. for 12 secs [Star Delta].
Should more specific information be required to assist on individual projects please contact your nearest NHP office or distributor.

| fuse-link selection for motor circuit protection |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Motor rating |  | Approx f.l.c. amps | D.O.L. standard fuse-link amps | Starting motor circuit fuse-link | Assisted start standard fuse-link amps |
| kW | hp |  |  |  |  |
| 0.19 | 0.25 | 0.7 | 4 |  | 2 |
| 0.37 | 0.5 | 1.3 | 6 |  | 4 |
| 0.55 | 0.75 | 1.6 | 6 |  | 4 |
| 0.75 | 1.0 | 1.8 | 10 |  | 4 |
| 1.1 | 1.5 | 2.6 | 10 |  | 6 |
| 1.5 | 2.0 | 3.4 | 10 |  | 10 |
| 2.2 | 3.0 | 5.0 | 16 |  | 10 |
| 3.0 | 4.0 | 6.5 | 16 |  | 10 |
| 4.0 | 5.5 | 8.0 | 20 | 20M25 | 16 |
| 5.5 | 7.5 | 11.0 | 25 | 20M32 | 16 |
| 7.5 | 10 | 15 | 40 | 32M40 | 25 |
| 11.0 | 15 | 22 | 50 | 32M50 | 32 |
| 15.0 | 20 | 28 | 63 | 32M63 | 40 |
| 18.5 | 25 | 36 | 80 | 63M80 | 50 |
| 22 | 30 | 39 | 80 | 63M80 | 63 |
| 30 | 40 | 52 | 100 | 63M100 | 63 |
| 37 | 50 | 69 | 160 | 100M160 | 80 |
| 45 | 60 | 79 | 160 | 100M160 | 100 |
| 55 | 75 | 96 | 200 |  | 160 |
| 75 | 100 | 125 | 200 | 200M250 | 160 |
| 90 | 125 | 156 | 250 | 200M250 | 160 |
| 110 | 150 | 189 | 315 |  | 200 |
| 132 | 175 | 224 | 355 |  | 250 |
| 150 | 200 | 255 | 355 |  | 250 |
| 160 | 220 | 275 | 400 |  | 315 |
| 185 | 250 | 318 | 450 |  | 315 |
| 200 | 270 | 339 | 500 |  | 355 |
| 220 | 300 | 374 | 560 |  | 400 |
| 257 | 350 | 450 | 630 |  | 450 |
| 295 | 400 | 500 | 710 |  | 500 |
| 315 | 430 | 535 | 710 |  | 560 |
| 355 | 483 | 580 | 800 |  | 630 |
| 400 | 545 | 646 | 800 |  | 710 |
| 450 | 612 | 725 | 1000 |  | 800 |



## HRC

High rupturing capacity (HRC) or High breaking capacity denotes the ability of a fuse-link to interrupt extremely high fault currents, usually up to 80 kA .

Current limiting fuse-link
A fuse-link that limits the circuit current during it's operation to a value much lower than the peak value of the prospective current. In practice, the terms HRC and current limiting are synonymous.
Rated breaking capacity
The highest value of fault current that a fuse-link has been tested to interrupt eg. 80kA.

## Rated voltage

The maximum system voltage that the fuse-link is designed to interrupt. Rated voltages may be in AC, DC, or both.

## Current rating

The value of current that a fuse-link will carry continuously without deterioration under specified conditions.

Minimum fusing current
The minimum value of current that will cause melting of the fuse element.

## Power dissipation

The power released in a fuse-link carrying rated current under a specified condition, usually expressed in watts.

Time current characteristics (refer table 1) A curve detailing the pre-arcing or operating time as a function of prospective current.
Let through characteristics ( $\left.\mathrm{I}^{2} \mathrm{t}\right)$ (refer table 2) A curve or chart showing values 'pre-arcing' and 'operating' let through energies as a function of prospective current, $I^{2} t$ is proportional to energy in Amp ${ }^{2}$ seconds.
Cut off characteristics (refer table 3)
A curve detailing the cut off current as a function of prospective current. Cut off current being the maximum instantaneous value of current let through by the fuse-link during operation.


Discrimination achieved

## Discrimination (refer tables 4 and 5)

Discrimination is the ability of fuse-links to operate selectively and to disconnect only the parts of the circuit that are subject to faults. Discrimination can be checked by ensuring that the time current characteristics, including their tolerances, do not overlap at any point and that the total let through energy ( $\mathrm{I}^{2} \mathrm{t}$ ) of the downstream (or minor) fuse-link does not exceed the pre-arcing energy $\left(\mathrm{I}^{2} \mathrm{t}\right)$ of the upstream (or major) fuse-link at the applied system voltage. Discrimination is normally achieved with the ratio of 1.6 between upstream and downstream fuses.


Typical time current curves


Operating and pre-arcing $I^{2} t$ values


Cut off characteristics


Discrimination NOT achieved

Cross reference guide


NNS-Type staggered contacts b
Overall Overall

| Current rating A <br> Normal Motor | Overall length mm | Overall dia. mm | NHP <br> Cat No. | Cross reference |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | MEM | GEC/Lawson | Siemens | Brush/ Hawker | Bussman/ Dorman Smith |
| 2 |  |  | NNS2 | 2SN2 | NS2 | 3NW NS2 | 2F06 | NSD2 |
| $4->$ |  |  | NNS4 | 4SN2 | NS4 | 3NW NS4 | 4F06 | NSD4 |
| 6 |  |  | NNS6 | 6SN2 | NS6 | 3NW NS6 | 6F06 | NSD6 |
| 10 |  |  | NNS10 | 10SN2 | NS10 | 3NW NS10 | $10 \mathrm{FO6}$ | NSD10 |
| 16 |  |  | NNS16 | 16SN2 | NS16 | 3NW NS16 | 16F06 | NSD16 |
| 20 | 60 | 14 | NNS20 | 20SN2 | NS20 | 3NW NS20 | $20 \mathrm{FO6}$ | NSD20 |
| $20 \quad 25$ |  |  | NNS 20M25 | 20SN2M25 | NS20M25 | 3NW M25 | 20M25F06 | NSD20M25 |
| 2032 |  |  | NNS 20M32 | 20SN2M32 | NS20M32 | 3NW M32 | 20M32F06 | NSD20M32 |
| 25 |  |  | NNS25 | 25SN2 | NS25 | 3NW NS25 | 25F06 | NSD25 |
| $32-\quad$ |  |  | NNS32 | 32SN2 | NS32 | 3NW NS32 | 32F06 | NSD32 |

NES-Type staggered contacts breaking capacity 80kA at 415V AC to ASTA certified to BS 88: Part 6: 1988

$\left.\left.\begin{array}{l}\begin{array}{l}20 \\ 25 \\ 32 \\ 40 \\ 50 \\ 63\end{array} \\ \hline\end{array}\right\} \begin{array}{ll} & \\ 68 & 17 \\ \end{array}\right\}$
NES20
NES25
NES32
NES40
NES50
NES63
20SP
25SP
32SP
40SP
50SP
63SP

| - | - |
| :--- | :--- |
| - | - |
| - | - |
| 40ES | 3NWES40 |
| 50ES | 3NWES50 |
| 63ES | 3NWES63 |


| - | ESD20 |
| :--- | :--- |
| - | ESD25 |
| - | ESD32 |
| 40G05 | $3 S D 40$ |
| $50 G 05$ | ESD50 |
| 63G05 | ESD63 |


| Industrial bolted pattern. Offset contacts ASTA certified to BS 88: Part 2: 1988. Complies with IEC 269 Parts 1 and 2. Tested to 80kA at 415V AC |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  | Cross reference |  |  |
| Current | ating A | Fixing | BS88 | NHP |  |  |  | Brush/ | Bussman/ |
| Normal | Motor | centres | ref | Cat No. | MEM | GEC/Lawson | Siemens | Hawker | Dorman Smith |
| 2 |  |  |  | NNIT2 | 2SA2 | NIT2 | 3NWNIT2 | 2F21 | NITD2 |
| 4 | - |  |  | NNIT4 | 4SA2 | NIT4 | 3NWNIT4 | 4F21 | NITD4 |
| 6 | - |  |  | NNIT6 | 6SA2 | NIT6 | 3NWNIT6 | 6F21 | NITD6 |
| 10 | - |  | A1 | NNIT10 | 10SA2 | NIT10 | 3NWNIT10 | 10F21 | NITD10 |
| 16 | - |  |  | NNIT16 | 16SA2 | NIT16 | 3NW NIT16 | 16F21 | NITD16 |
| 20 | - |  |  | NNIT20 | 20SA2 | NIT20 | 3NWNIT20 | 20F21 | NITD20 |
| 20 | 25 | 44.5 |  | NNIT20M25 | 20SA2M25 | NIT20M25 | 3NWNIT20M25 | 20M25F21 | NITD20M25 |
| 20 | 32 |  |  | NNIT20M32 | 20SA2M32 | NIT20M32 | 3NWNIT20M32 | 20M32F21 | NITD20M32 |
| 25 | - |  | - | NNIT25 | 25SA2 | - | 3NWNIT25 | 25F21 | NITD25 |
| 32 | - |  | - | NNIT32 | 32SA2 | - | 3NWNIT32 | 32F21 | NITD32 |
| 32 | 40 |  | - | NNIT32M40 | 32SA2M40 | - | 3NWNIT32M40 | - | - |
| 32 | 50 |  | - | NNIT32M50 | 32SA2M50 | - | 3NWNIT32M50 | - | - |
| 32 | 63 |  | - | NNIT32M63 | 32SA2M63 | - | 3NWNIT32M63 | - | - |
| 2 |  |  |  | NTIA2 | 2SB3 | TIA2 | 3NWTIA2 | 2 H 07 | AA02 |
| 4 | - |  |  | NTIA4 | 4SB3 | TIA4 | 3NWTIA4 | 4H07 | AA04 |
| 6 | - |  |  | NTIA6 | 6SB3 | TIA6 | 3NWTIA6 | 6 H 07 | AA06 |
| 10 | - |  |  | NTIA10 | 10SB3 | TIA10 | 3NWTIA10 | 10H07 | AA010 |
| 16 | - |  |  | NTIA16 | 16SB3 | TIA16 | 3NWTIA16 | 16H07 | AA016 |
| 20 |  | 73 | A2 | NTIA20 | 20SB3 | TIA20 | 3NWTIA20 | $20 \mathrm{HO7}$ | AA020 |
| 25 | - |  |  | NTIA25 | 25SB3 | TIA25 | 3NWTIA25 | 25 H 07 | AA025 |
| 32 | - |  |  | NTIA32 | 32SB3 | TIA32 | 3NWTIA32 | 32 H 07 | AA032 |
| 32 | 40 |  |  | NTIA32M40 | 32SB3M40 | TIA32M40 | 3NWTIA32M40 | 32 M 40 H 07 | AA032M40 |
| 32 | 50 |  |  | NTIA32M50 | 32SB3M50 | TIA32M50 | 3NWTIA32M50 | 32M50H07 | AA032M50 |
| 32 | 63 |  |  | NTIA32M63 | 32SB3M63 | TIA32M63 | 3NWTIA32M63 | 32M63H07 | AA032M63 |
| 35 | - |  |  | NTIS35 | 35SB4 | TIS35 | 3NWTIS35 | $35 \mathrm{KO7}$ | BA035 |
| 40 | - |  |  | NTIS40 | 40SB4 | TIS40 | 3NWTIS40 | $40 \mathrm{KO7}$ | BA040 |
| 50 |  |  |  | NTIS50 | 50SB4 | TIS50 | 3NWTIS50 | $50 \mathrm{KO7}$ | BA050 |
| 63 | - | 73 | A3 | NTIS63 | 63SB4 | TIS63 | 3NWTIS63 | $63 \mathrm{KO7}$ | BA063 |
| 63 | 80 |  |  | NTIS63M80 | 63SB4M80 | TIS63M80 | 3NWTIS63M80 | 63M80K07 | BA063M80 |
| 63 | 100 |  |  | NTIS63M100 | 63SB4M100 | TIS63M100 | 3NWTIS63M100 | 63M100K07 | BA063M100 |
| 80 | - |  |  | NOS80 | 80S0 | OS80 | 3NWOS80 | 80K07R | OSD80 |
| 100 | - |  |  | NOS100 | 100S0 | OS100 | 3NWOS100 | 100K07R | OSD100 |
| 100 | 125 | 73 |  | NOS100M125 | - | OS100M125 | - | 100M125K07R | OSD100M125 |
| 100 | 160 |  |  | NOS100M160 | - | OS100M160 | - | 100M160K07R | OSD100M160 |
| 80 | - |  |  | NTCP80 | 80SD5 | TCP80 | 3NWTCP80 | 80L14 | CE080 |
| 100 | - |  |  | NTCP100 | 100SD5 | TCP100 | 3NWTCP100 | 100L14 | CE0100 |
| 100 | 125 | 94 | A4 | NTCP100M125 | 100SD5M125 | TCP100M125 | 3NWTCP100M125 | 100M125L14 | CE0100M125 |
| 100 | 160 |  |  | NTCP100M160 | 100SD5M160 | TCP100M160 | 3NWTCP100M160 | 100M160L14 | CE0100M160 |
| 125 | - |  |  | NTFP125 | 125SD6 | TFP125 | 3NWTFP125 | 125M14 | DE0125 |
| 160 | - |  |  | NTFP160 | 160SD6 | TFP160 | 3NWTFP160 | 160M14 | DE0160 |
| 200 | - |  |  | NTFP200 | 200SD6 | TFP200 | 3NWTFP200 | 200M14 | DE0200 |
| 200 | 250 | 94 |  | NTFP200M250 | 200SD6M250 | TFP200M250 | - | 200M250M14 | DE0200M250 |

NHP Compact industrial bolted pattern. Centre contacts, ASTA certified to BS 88: Part 2: 1988.
Complies with IEC 269 parts 1 and 2. Tested to 80kA at 415V AC. *550V AC.

| 0 |  |  |  |  |  |  | Cross reference |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current | rating A | Fixing | BS88 | NHP |  |  |  | Brush/ | Bussman/ |
| Normal | Motor | centres | ref | Cat No. | MEM | GEC/Lawson | Siemens | Hawker | Dorman Smith |
| 2 | - |  |  | NTB2* | 2SE3 | TB2 | 3NWTB2 | 2K08 | AC2 |
| 4 | - |  |  | NTB4* | 4SE3 | TB4 | 3NWTB4 | 4K08 | AC4 |
| 6 | - |  |  | NTB6* | 6SE3 | TB6 | 3NWTB6 | 6K08 | AC6 |
| 10 | - |  |  | NTB10* | 10SE3 | TB10 | 3NWTB10 | $10 \mathrm{K08}$ | AC10 |
| 16 | - |  |  | NTB16* | 16SE3 | TB16 | 3NWTB16 | $16 \mathrm{K08}$ | AC16 |
| 20 |  |  |  | NTB20* | 20SE3 | TB20 | 3NWTB20 | 20K08 | AC20 |
| 25 |  | 97 | - | NTB25* | 25SE3 | TB25 | 3NWTB25 | 25K08 | AC25 |
| 32 |  |  |  | NTB32* | 32SE3 | TB32 | 3NWTB32 | 32K08 | AC32 |
| 40 |  |  |  | NTB40* | 40SE3 | TB40 | 3NWTB40 | 40K08 | BC40 |
| 50 | - |  |  | NTB50* | 50SE3 | TB50 | 3NWTB50 | 50K08 | BC50 |
| 63 | - |  |  | NTB63* | 63SE3 | TB63 | 3NWTB63 | 63K08 | BC63 |
| 63 | 80 |  |  | NTB63M80 | 63SE4M80 | TB63M80 | 3NWTB63M80 | - | - |
| 63 | 100 |  |  | NTB63M100 | 63SE4M100 | TB63M100 | 3NWTB63M100 | - | - |
| 2 | - |  |  | NTBC2 | 2SF3 | TBC2 | 3NW TBC2 | 2K09 | AD2 |
| 4 | - |  |  | NTBC4 | 4SF3 | TBC4 | 3NW TBC4 | 4K09 | AD4 |
| 6 | - |  |  | NTBC6 | 6SF3 | TBC6 | 3NW TBC6 | 6K09 | AD6 |
| 10 | - |  |  | NTBC10 | 10SF3 | TBC10 | 3NW TBC10 | $10 \mathrm{KO9}$ | AD10 |
| 16 | - |  |  | NTBC16 | 16SF3 | TBC16 | 3NW TBC16 | $16 \mathrm{KO9}$ | AD16 |
| 20 | - |  |  | NTBC20 | 20SF3 | TBC20 | 3NW TBC20 | $20 \mathrm{KO9}$ | AD20 |
| 25 |  | 111 | B1 | NTBC25 | 25SF3 | TBC25 | 3NW TBC25 | 25K09 | AD25 |
| 32 | - |  |  | NTBC32 | 32SF3 | TBC32 | 3NW TBC32 | 32K09 | AD32 |
| 40 | - |  |  | NTBC40 | 40SF3 | TBC40 | 3NW TBC40 | 40K09 | AD40 |
| 50 | - |  |  | NTBC50 | 50SF3 | TBC50 | 3NW TBC50 | 50K09 | AD50 |
| 63 | - |  |  | NTBC63 | 63SF3 | TBC63 | 3NW TBC63 | 63K09 | AD63 |
| 63 | 80 |  |  | NTBC63M80 | 63SF4M80 | TBC63M80 | 3NW TBC63M80 | - | - |
| 63 | 100 |  |  | NTBC63M100 | 63SF4M100 | TBC63M100 | 3NW TBC63M100 | - | - |
| 80 |  |  |  | NTC80 | 80SF5 | TC80 | 3NW TC80 | 80L09 | CD80 |
| 100 | - | 111 | B1 | NTC100 | 100SF5 | TC100 | 3NW TC100 | 100L09 | CD100 |
| 100 | 125 |  |  | NTC100M125 | 100SF5M125 | TC100M125 | 3NW TC100M125 | 100M125L09 | CD100M125 |
| 100 | 160 |  |  | NTC100M160 | 100SF5M160 | TC100M160 | 3NW TC100M160 | 100M160L09 | CD100M160 |
| 100 | 200 |  |  | NTC100M200 | 100SF5M200 |  |  |  |  |
| 125 |  |  |  | NTF125 | 125SF6 | TF125 | 3NW TF125 | 125M09 | DD125 |
| 160 |  | 111 | B2 | NTF160 | 160SF6 | TF160 | 3NW TF160 | 160M09 | DD160 |
| 200 | - |  |  | NTF200 | 200SF6 | TF200 | 3NW TF200 | 200M09 | DD200 |
| 200 | 250 |  |  | NTF200M250 | 200SF6M250 | TF200M250 | 3NW TF200M250 | 200M250M09 | DD200M250 |
| 200 | 315 |  |  | NTF200M315 | 200SF6M315 | TF200M315 | 3NW TF200M315 | 200M315M09 |  |
| 250 | - $\}$ |  | B3 | NTKF250 | 250SF7 | TKF250 | 3NW TKF250 | 250N09 | ED250 |
| 315 | - $\}$ | 111 |  | NTKF315 | 315SF7 | TKF315 | 3NW TKF315 | 315N09 | ED315 |
| 315 | 400 |  |  | NTKF315M400 | 315SF7M400 |  | 3NW TKF315M400 |  |  |
| 250 | - | 133 | - | NTKM250 | 250SG7 | TKM250 | 3NW TKM250 | 250N11 | EFS250 |
| 315 | - $\quad$ |  |  | NTKM315 | 315SG7 | TKM315 | 3NW TKM315 | 315N11 | EFS315 |
| 355 | - | 111 | B4 | NTMF355 | 355SF8 | TMF355 | 3NW TMF355 | 355P09 | ED355 |
| 400 | - $\quad$ |  |  | NTMF400 | 400SF8 | TMF400 | 3NW TMF400 | 400P09 | ED400 |
| 355 | - | 133/ | C1 | NTM355 | 355SH8 | TM355 | 3NW TM355 | 355P11 | EF355 |
| 400 | - $\quad 1$ | 184 |  | NTM400 | 400SH8 | TM400 | 3NW TM400 | 400P11 | EF400 |
| 450 | - |  |  | NTTM450 | 450SH9 | TTM450 | 3NW TTM450 | 450R11 | FF450 |
| 500 | - | 133/ | C2 | NTTM500 | 500SH9 | TTM500 | 3NW TTM500 | 500R11 | FF500 |
| 560 | - | 184 |  | NTTM560 | 560SH9 | TTM560 | 3NW TTM560 | 560R11 | GF550 |
| 630 | - |  |  | NTTM630 | 630SH9 | TTM630 | 3NW TTM630 | 630R11 | GF630 |
| 450 |  | 165/ | - | NTT450 | 450SY9 | TT450 | 3NWTT450 | 450R12 | FG450 |
| 500 |  | 229 |  | NTT500 | 500SY9 | TT500 | 3NWTT500 | 500R12 | FG500 |
| 560 |  |  |  | NTT560 | 560SY9 | TT560 | 3NWTT560 | 560R12 | FG560 |
| 630 |  |  |  | NTT630 | 630SY9 | TT630 | 3NWTT630 | 630R12 | FG630 |
| 710 |  | 165/ | - | NTLT710 | 710 SY10 | TLT710 | 3NWTLT710 | 710 S12 | GG710 |
| 800 |  | 229 |  | NTLT800 | 800 SY10 | TLT800 | 3NWTLT800 | 800 S12 | GG800 |
| 710 | - | 133/ | C3 | NTLM710 | 710SH10 | TLM710 | 3NW TLM710 | 700S11 | GF710 |
| 800 | - $\quad$, | 184 |  | NTLM800 | 800SH10 | TLM800 | 3NW TLM800 | 800 S11 | GF800 |
| 1000 | - |  |  | NTXU1000 | 1000SJ11 | TXU1000 | - | 1000 U 44 | GH1000 |
|  | - | 149 | D1 |  |  |  |  |  |  |
| 1250 |  |  |  | NTXU1250 | 1250SH11 | TXU1250 | - | 1250 U44 | GH1250 |



| Dimensions (mm) |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Fuse | A | B | D | E | F | G | H | J | L |
| link | max. | max. | max. |  |  | nom. |  |  |  |
| type | mm | mm | mm | mm | mm | mm | mm | mm | mm |
| NTB | 57 | 21 | 114 | 13 | 1.6 | 97 | 7.2 | 11 | - |
| NTB...M... | 57 | 26 | 116 | 13 | 1.6 | 97 | 7.2 | 11 | - |
| NTBC | 57 | 21 | 134 | 16 | 2.0 | 111 | 8.7 | 16 | - |
| NTBC...M... | 58 | 26 | 136 | 16 | 3.2 | 111 | 8.7 | 16 | - |
| NTC | 66 | 36 | 135 | 19 | 3.6 | 111 | 8.7 | 16 | - |
| NTF | 76 | 41 | 137 | 19 | 3.6 | 111 | 8.7 | 16 | - |
| NTKF | 76 | 51 | 137 | 26 | 4.0 | 111 | 8.7 | 16 | - |
| NTMF | 81 | 58 | 136 | 26 | 5.2 | 111 | 8.7 | 16 | - |
| NTKM | 76 | 51 | 158 | 26 | 4.0 | 133 | 8.7 | 16 | - |
| NTM | 81 | 58 | 210 | 26 | 5.2 | 133/184 | 10.3 | 16 | 25.4 |
| NTTM | 83 | 74 | 210 | 26 | 6.5 | 133/184 | 10.3 | 16 | 25.4 |
| NTLM | 84 | 82 | 210 | 26 | 10 | 133/184 | 10.3 | 16 | 25.4 |
| NTT | 83 | 74 | 267 | 38 | 6.5 | 165 | 10.3 | 16 | 32 |
| NTLT | 84 | 82 | 267 | 38 | 10 | 165 | 10.3 | 16 | 32 |
| NTXU | 83 | 100 | 198 | 63.5 | 9.5 | 149 | 14.3 | 19 | 32 |



NTT, NTLT, NTM, NTTM, NTLM types


NTXU type



Fuse curves



## NHP Compact <br> BS fuses from 20 to 250 amps

## NHP Compact BS fuses cut-off current data from 20 to 630 amps

## Fuse curves




## NHP Compact BS

 fuses cut-off current data from 80 to 630 amps


NHP Compact DIN fuses
Pre-arcing and Total I²t energies, from 6 to 630 amps

NHP Compact DIN fuses cut-off current data from 6 to 500 amps



NHP Compact DIN fuses
Fuse curves
from 6 to 630 amps

## 8. Critec

## INSTALLATION INSTRUCTIONS



## 1. PREPARATION

DANGER: Possible electrical shock or burn hazard. Qualified personnel should only install this product. Failure to lockout electrical power during installation or maintenance can result in fatal electrocution or severe burns. Before making any connections to this electrical panel please ensure thatpower has been removed from all associated wiring, electrical panels, and other electrical equipment.

## !

## CAUTION NOTES:

1. The installation of this Universal Transient Barrier (UTB) should follow observe nationally recognized codes of authorities having jurisdiction to ensure correct and safe operation.
2. Check to ensure that the maximum continuous operating voltage UC of the UTB selected is higher than that expected on the circuit being protected.
3. It is important to ensure that the maximum line current rating IL of the UTB is not exceeded.
4. Check that the maximum operating frequency of the circuit does not exceed that of the UTB.
5. The ground (earth) terminal must be connected to a low impedance earth (<10 ohms) for correct operation.
6. Do not perform a "Flash Test" or use a Megger to test circuits that are protected with these UTB units. This may damage the $U T B(s)$ and affect the insulation readings being performed.
7. Do not attempt to open or tamper with the UTB unit in any way as this may compromise performance and will void warranty.

## 2. INTRODUCTION

The CRITEC Universal Transient Barrier (UTB) has been designed to protect equipment from the damaging effects of surges on low voltage data, control and signaling lines. Damage can also occur when surges entering the equipment
via the mains power cabling. ERICO recommends the installation of additional surge protection on these mains circuits. The CRITEC DSD series compliments the UTB series for such applications.

UTB units are available in a number of different operating voltages to suit the specific application intended. The TA and SA models are intended to protect equipment connected to telephone subscriber lines.

## 3. ELECTRICAL CONNECTION

Please follow the sequence indicated:

1. First, ensure that power is removed from the area and the circuits to be connected.
2. Connect line side wiring to the UTB screw terminals marked $\operatorname{LINE}(a, b)$. The "line side" of the UTB is the "exposed side" where the surge is expected to originate.
3. Connect equipment side wiring to the UTB screw terminals marked EQUIP ( $a^{\prime}$ ', ${ }^{\prime}$ ). The "equipment side" of the UTB is the protected side and wires to the equipment being protected.
4.The UTB should be installed as close to the equipment being protected as possible. Where protecting long cable runs (< 30 meters), a UTB unit should be installed at either end of the cable.
4. Connect the UTB's ground screw terminal to a low impedance ground using as direct a path as possible. This "ground" should also be referenced to the equipment being protected. When the UTB is installed on a DIN rail, grounding of the unit can be achieved by connecting the rail to ground.

## 4. MOUNTING

UTBs are designed to clip to 35 mm (top hat) DIN rails (standard EN50022) set in the horizontal position with the UTB securing clips towards the bottom of the rail and the label text facing the correct way up.

## INSTALLATION INSTRUCTIONS

## 5. MAINTENANCE

Failure of a UTB is usually indicated by interruption of data or a fault on the signal (control) line. The UTB has been designed for simple plug-in modular replacement, without the need to disturb circuit wiring.

Before removing a UTB module from service, ensure that the power has been removed and if possible "locked out". Qualified personnel should only undertake replacement of UTB modules. Replacement plug-in modules are available.

NOTE: It is very important to ensure that the new module is of the same type and voltage as that being replaced.

Table 1. UTB operating specifications

| Operation: |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Model | UTB-5 | UTB-15 | UTB-30 | UTB-60 | UTB-110 | UTB-SA | UTB-TA |
| Nominal System Voltage Un | 5V-3V~ | 15V-10V~ | 30V-21V~ | 60V-42V~ | 154V-120V~ | Analog telephone circuits |  |
| Max. Continuous Operating Voltage Uc | 7V-5V~ | 18V-12V~ | 33V-23V~ | 64V-45V~ | 200V-150V~ | - |  |
| Max. Line Current $\mathrm{I}^{\text {L }}$ | 1.5A |  |  |  |  | 160mA |  |
| Frequency @ 3dB / 120? | <500kHz | $<1 \mathrm{MHz}$ | $<2 \mathrm{MHz}$ | $<4 \mathrm{MHz}$ | <2MHz | <15MHz |  |
| Connections | $6 \mathrm{~mm}^{2}$ (\#18AWG to \#10AWG). Grounding via terminal or DIN rail connection |  |  |  |  |  |  |

# Transient Discriminating MOVTEC 

## Features

- Transient

Discriminating (TD) Technology provides increased service life

- Primary protection - suitable for high exposure sites and point-ofentry protection applications
- TDS-MT configurable to L-L, L-N, L-G or N-G protection
- TDS-MTU provides simultaneous L-N, L-G \& N-G protection
- Small foot print - effective use of real estate
- 5 segment electronic status indication - displays percentage of capacity remaining
- CE, UL ${ }^{\oplus} 1449$

Edition 3 Listed

The TDS-MOVTEC family of surge diverters offers economical and reliable protection from voltage transients in even the most strenuous applications.
The small footprint provides integrators and OEMs with an effective use of real estate when installing within panels and equipment.
Transient Discriminating (TD) Technology, which meets the safety standards of UL® 1449 Edition 3, provides a superior life by eliminating the common temporary over-voltage failure mode of most SPDs. TD Technology is essential for any site where abnormal over-voltages can occur or where the possible catastrophic failure of traditional technologies can not be tolerated.

Alarm contacts are provided which may be used to shut down the system or to activate an external warning if the internal surge material is below
 optimum condition.

| Model | TDSMT120 | TDSMT277 | TDSMTU277 |
| :---: | :---: | :---: | :---: |
| Nominal Voltage, $\mathrm{U}_{\mathrm{n}}$ | 110-120 V | 230-277 V | 230-277 V |
| System Compatibility | TN-C, TN-S, TN-C-S, IT, TT |  |  |
| Max Cont. Operating Voltage, $\mathrm{U}_{\text {c }}$ | 170 VAC | 400 VAC |  |
| Stand-off Voltage | 240 V | 480 V |  |
| Frequency | $50 / 60 \mathrm{~Hz}$ |  |  |
| Operating Current @ U ${ }_{\text {n }}$ | 25 mA |  |  |
| Aggregate Surge Rating | $200 \mathrm{kA} \mathrm{8/20} \mathrm{\mu}$ |  | See table |
| Max Discharge Current, $I_{\text {max }}$ | $100 \mathrm{kA} \mathrm{8/20} \mu \mathrm{~s}$ |  | See table |
| Nominal Discharge Current, $\mathrm{I}_{\mathrm{n}}$ | $80 \mathrm{kA} 8 / 20 \mu \mathrm{~s}$ |  |  |
| Impulse Current, $\mathrm{l}_{\text {imp }}$ | $20 \mathrm{kA} \mathrm{10/350}$ - |  |  |
| Protection Modes | Single mode (L-L, L-N, L-G or N-G) |  | L-G, L-N, N-G |
| Technology | MOV/Silicon, TD Technology |  |  |
| Voltage Protection Level, $\mathrm{U}_{\mathrm{p}}$ | $\begin{aligned} & 760 \text { V @ } 20 \mathrm{kA} \\ & 480 \text { V @ } 3 \mathrm{kA} \\ & 330 \mathrm{~V} @ 500 \mathrm{~A} \end{aligned}$ | $\begin{aligned} & 980 \mathrm{~V} @ 20 \mathrm{kA} \\ & 750 \mathrm{~V} @ 3 \mathrm{kA} \\ & 700 \mathrm{~V} @ 500 \mathrm{~A} \end{aligned}$ | See table |
| Status | 5 segment LED bar graph per phase, Normally Open Contact |  |  |
| Dimensions H x D x W: mm (in) | $140 \times 45 \times 150$ ( $5.51 \times 1.77 \times 5.91$ ) |  |  |
| Weight: kg (lbs) | 0.6 (1.32) |  |  |
| Enclosure | UL94V-0 thermoplastic |  |  |
| Connection | $\leq 16 \mathrm{~mm}^{2}$ (\#6AWG) connecting to M6 bolt |  |  |
| Back-up Overcurrent Protection | 100 A |  |  |
| Temperature | $-35^{\circ} \mathrm{C}$ to $55^{\circ} \mathrm{C}\left(-31^{\circ} \mathrm{F}\right.$ to $\left.131^{\circ} \mathrm{F}\right)$ |  |  |
| Humidity | 0 \% to 90 \% |  |  |
| Approvals | AS3260, C-Tick, IEC® ${ }^{\text {® }}$ 950, UL ${ }^{\circledR} 1449$ Ed. 3 Recognized Component Type 2 |  |  |
| Surge Rated to Meet | ANSI®/EEE ${ }^{\oplus}$ C62.41.2 Cat A, Cat B, Cat C ANSI®/IEEE ${ }^{\oplus}$ C62.41.2 Scenario II, Exposure 3, $100 \mathrm{kA} 8 / 20 \mu \mathrm{~s}, 10 \mathrm{kA} \mathrm{10/350} \mathrm{\mu s}$ UL® 1449 Ed. 3 In 20 kA mode |  | ANSI®/IEEE® C62.41.2 Cat A, Cat B, Cat C |





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IEEE is a registered trademark of the Institute of Electrical and Electronics Engineers, Incorporated. UL is a registered trademark of Underwriters Laboratories, Inc

## WARNING

ERICO products shall be installed and used only as indicated in ERICO's product instruction sheets and training materials. Instruction sheets are available at www.erico.com and from your ERICO customer service representative. Improper installation, misuse, misapplication or other failure to completely follow ERICO's instructions and warnings may cause product malfunction, property damage, serious bodily injury and death.
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## www.erico.com

## Features

- Primary protection - suitable for high exposure sites and point-of-entry facility protection
- Modular design - allows easy replacement of surge modules
- 5 segment electronic status indication - displays percentage of capacity remaining
- Lug connection - allows Kelvin (in and out) connection of large cables
- Transient Discriminating (TD) Technology provides increased service life


## Transient Discriminating MOVTEC Protection Module

The Transient Discriminating MOVTEC Protection Module (TDS-MPM) integrates three TDS-MOVTEC units into one enclosure to simplify three phase protection applications.

The TDS-MPM is ideal for primary point-of-entry protection applications where it is connected to the main service panel.




[^22]

# Detailed Specifications for ERICO's TDS-MOVTEC SURGE DIVERTER TDS-MT-277 

## Applications

Lightning transients and surges are a major cause of expensive electronic equipment failure and business disruption. Damage may result in loss of computers, data and communications, loss of revenue, and loss of profits. The new TDSMOVTEC family of surge diverters offer economical and reliable protection from power transients in even the most strenuous applications.

Transient Discriminating Technology (TDS) introduces the first quantum leap in transient suppression technology for mains powered equipment. It offers a new level of safety and reliability, yet retains optimum protection levels critical for electronic equipment. TDS is an active frequency based device that discriminates between the slower mains voltages and the higher speed transients. When transient frequencies are detected the patented TDS "Quick-Switch" technology "switches in" robust protection devices to limit the transient to safe levels. The frequency discrimination circuit controlling the TDS "Quick-Switch" ensures that the device is virtually immune to the effects of the $50 / 60 \mathrm{~Hz}$ sustained overvoltages, allowing fault voltages of up to 480 Vrms without degradation, and providing over-voltage robustness in excess of the demanding new and emerging standards.

TDS technology is essential for any site where abnormal over-voltages can occur or where the possible catastrophic failure of traditional technologies due to overvoltage events can not be tolerated.

Since $75 \%$ of all lightning strikes comprise multiple strokes through the one air to ground channel, often as little as 30 milliseconds apart, conventional MOVs can rapidly accumulate heat and self destruct just when they are most needed. TDSMOVTECs are high capacity surge diverters and are the most advanced surge protection devices currently in place to offer low let through levels at sites with poor voltage regulation. Internal electronics continuously monitor TDSMOVTEC protection, and their status is displayed on a 5 -segment LED bar graph. Alarm contacts are provided which may be used to shut down the system or activate an external warning if the internal surge material is below optimum condition.

## Features

- Robust against abnormal over-voltage
- UL1449 Edition 2 compliant (pending)
- Single phase primary protection for extremly high exposure sites and point-of-entry protection applications
- Single mode protection, configurable to $\mathrm{Ph}-\mathrm{N}, \mathrm{Ph}-\mathrm{E}$ or N-E protection
- Small foot print for more effective use of realestate.
- Fail safe voltage free alarm contacts
- 5 segment electronic status indication ideal for poorly illuminated locations
- Long Service life
- Lug terminals for connection of large cables

SPECIFICATIONS<br><br>\section*{Operation:}<br>Nominal input voltage<br>Input frequency<br>Max. permissible abnormal over-voltage<br>Power systems<br>Earth leakage current<br>Protection:<br>Modes<br>Let through voltage @ 3kA $8 / 20 \mu \mathrm{~s}$<br>Let through voltage @ 20kA 8/20 $\mathrm{\mu s}$<br>Surge rating $8 / 20 \mu \mathrm{~s}$<br>Surge rating $10 / 350 \mu \mathrm{~s}$<br>Energy rating<br>Multipulse ${ }^{\text {TM }}$ capability<br>Aggregate surge material<br>Alarms and Indicators:<br>Protection status indication<br>User configurable alarm contacts<br>Breakdown isolation<br>MOVTEC alarm actuation point<br>Physicals:<br>Operating conditions<br>Enclosure style<br>Dimensions (W x D x H)<br>Weight<br>Encapsulation<br>Enclosure material<br>Surface finish<br>Wiring terminals<br>Warranty<br>Test standards:<br>Approvals<br>Surge rated to meet

220 - 277 Vrms
$50 / 60 \mathrm{~Hz}$
480 Vrms
TN-C, TN-S, TN-C-S (MEN), TT
$<2 \mathrm{~mA}$

Ph-N, Ph-E or N-E
<740V
<970V
100 kA
20kA
4800J
Yes
200kA 8/20~s

5-segment LED bar graph
Voltage free relay contact (NO)
4 kV
$\leq 60 \%$ status (two LEDs off)
-35 to $+55^{\circ} \mathrm{C}, 0-90 \%$ humidity
Proprietry
$45 \times 140 \times 140 \mathrm{~mm}$
600 g (approx.)
Shockguard
Flame Retardent UL94V-0
Highly Polished
M6 Swift Thread and Bolt
5 years

UL1449 Edition 2 (pending)
AS 3260, IEC 950
C-Tick
Certificate of suitability,
Electricity Regulator
ANSI/IEEE C62.41-1991 Cat A, Cat B, Cat C.
ANSI/IEEE C62.45-1987 Life cycle testing.
AS/NZS 1768-1991 Cat A, Cat.B, Cat C.
BS 6651:1992 Cat A, Cat B.
IEC801-5 Installation Class 5.
IEC 61643-1

Note: Other operating voltages and frequencies are available on application.
For specifications on other TDS products, refer to relevant Specifications Sheet
Exceeding nominal operating voltage while transient events occur may affect product life
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## Model Number

TDS-MT-277

## Description

TDS MOVTEC 220-277V 100KA

|  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Hobart | $\mathrm{ph}:+6136237-3200$ | fax:+61 $36273-0399$ | Adelaide | $\mathrm{ph}:+6188366-6555$ | fax:+61 8 8366-6556 |
| Sydney | $\mathrm{ph}:+6129479-8500$ | fax:+61 $29980-5092$ | Perth | $\mathrm{ph}:+6189358-1233$ | fax:+6189358-1404 |
| Melbourne | $\mathrm{ph}:+6139894-2677$ | fax:+61 $39894-3216$ | Singapore | $\mathrm{ph}:+65-763-2477$ | fax:+65 763-2397 |
| Canberra | $\mathrm{ph}:+6126257-3055$ | fax:+61 $26257-3127$ | Thailand | $\mathrm{ph}:+662627-9037-8$ | fax:+662 627-9168 |



## Detailed specifications for ERICO's

## TRANSIENT DISCRIMINATING FILTER, TDF-10A SERIES

## Applications

-ightning transients and surges are a major cause of expensive electronic zquipment failure and business disruption. Damage may result in loss of somputers, data commmunications, loss of revenue, and loss of profits. The new Transient Discriminating Filter ${ }^{\mathrm{TM}}$ family of TVSS devices offer sconomical and reliable protection from power transients with the convenence of easy installation on 35 mm DIN rail mountings.
[he TDF series has been specifically designed for process control applicaions to protect the switched mode power supply units on devices such as ${ }^{\prime}$ LC controllers, SCADA systems and motor controllers. Units are availible for $3 \mathrm{~A}, 10 \mathrm{~A}$ and 20A loads and in a range of clamping voltages ncluding $30 \mathrm{~V}, 150 \mathrm{~V}, 275 \mathrm{~V}$. The range is intended for use in conjunction vith ERICO's Universal Transient Barrier UTB's to provide a coordinated ıpproach to protection of both the power and data control circuits.

The TDF is a series connected single phase surge filter providing an tggregate surge capacity of $50 \mathrm{kA}(8 / 20 \mu \mathrm{~s})$ - 20 kA L-N \& L-G and 10kA V -G. The space efficient low pass filter, provides some 65 dB of attenuaion to voltage transients. Not only does this reduce the residual let hrough voltage, but it helps further reduce the steep rates of rise of volttge and current providing superior protection for sensitive electronic squipment.

## Features

- Compact design fits into most distribution boards and motor control centres
- High efficiency filtering - ideal for the protection of switched mode power supplies from large dv/dt and di/dt transients
- Three modes of protection L-N, L-G, N-G
- 35mm DIN rail mount - DIN 43880 profile matches common MCB's
- LED indication and opto-isolated output for remote status monitoring
- Transient Discriminating Technology ensures safe operation during abnormal over-voltage events
- UL1449 Edition 2 recognized
- Large 50kA surge capacity provides a high level of protection and long operational life
- 5 year limited warranty

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## PROCESS CONTROL TVSS PROTECTION

\author{

SPECIFICATIONS <br> Operation: <br> Models available <br> Nominal line voltage <br> Max Continuous Operating Voltage MCOV <br> Max Load Current <br> Input frequency <br> Earth leakage current <br> Protection: <br> Max aggregate surge rating <br> Protection modes <br> Max surge current/mode L-N <br> L-G <br> N-G <br>  <br> TDF-10A-120V <br> TDF-10A-240V <br> 120VAC/125VDC <br> 240VAC <br> 170 Vrms <br> 340Vrms <br> 10A <br> $50 / 60 \mathrm{~Hz}$ <br> $<0.2 \mathrm{~mA}$ <br> 50kA $8 / 20 \mu \mathrm{~s}$ <br> L-N, L-G and N-G <br> 20kA $8 / 20 \mu \mathrm{~s}$ <br> 20kA $8 / 20 \mu \mathrm{~s}$ <br> 10kA 8/20us <br> Series low pass LC filter <br> Transient Discriminating Technology <br> Thermal fusing <br> Filter: <br> Inductor <br> Capacitor type <br> Attenuation @ 100kHz L-N <br> Performance: <br> UL1449 SVR L-N <br> ANSI/IEEE C62.41 Cat B3-500A ringwave <br> Cat C1-3kA, $8 / 20 \mu \mathrm{~s}$ <br> Alarms and Indicators: <br> Protection status indication Physical Data: <br>  <br> | Dimensions(W x D x H) | 144mm x 88mm x x70mm |
| ---: | :--- |
| Weight | 750 g (approx) |
| Enclosure material | Flame Retardant UL94V-O |
| Connection means | Screw terminals |
| Wire size | $1.0 \mathrm{~mm}^{2}-6.0 \mathrm{~mm}^{2}$ |
| Mounting method | DIN T35 Rail |
| Enclosure style | DIN 43880 |
| Environmental rating | IP20 |
| Opearting temperature | $-30^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}$ |
| Humidity | $0-90 \%$ |
| Surface finish | Spark eroded finish |
| Warranty | 5 years |
| Test standards: |  |
| Approvals | UL1449 Ed 2, UL1283 recognised, CSA22.2 |
|  | C-Tick AS3260 |
| Surge rated to meet | ANSI/IEEE C62.41 Cat A, Cat B, Cat C |
|  | AS/NZS 1768-1991 Cat A, B, C |

}

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Part Number Description
TDF-10A-120V 120V 1 phase, 50kA 8/20 1 s, 10A series TVSS protector TDF-10A-240V 240 V 1 phase, 50kA $8 / 20 \mu \mathrm{~s}$, 10A series TVSS protector

| Hobart | ph:+61 $36237-3200$ | fax:+61 $36273-0399$ | Adelaide | ph:+61 88366-6555 | fax:+61 88366-6556 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Sydney | ph:+61 $29479-8500$ | fax:+61 $29980-5092$ | Perth | ph:+61 89358-1233 | fax:+61 89358-1404 |
| Melbourne | ph:+61 $39894-2677$ | fax:+61 $39894-3216$ | Singapore | ph:+65-763-2477 | fax:+65 763-2397 |
| Canberra | ph:+61 $26257-3055$ | fax:+61 $26257-3127$ | Thailand | ph:+ 662 627-9037-8 | fax:+662 627-9168 |

ERICO's coordinated approach to facility protection - CADWELD, CRITEC, ERITECH www.erico.com

## ENTE

## CRITEC ${ }^{\circledR}$ Surge Protection Products



## ERNㄷㅁ

Lightning strikes and the dangerous surges and transients induced by lightning, as well as surges caused by motor switching and power supply regulation problems, represent a direct threat to people, building facilities, electrical and electronic equipment.

ERICO ${ }^{\oplus}$ recognizes that no single technology can protect a facility from the damaging effects of lightning and induced transients, which can severely damage or destroy electronic systems. An integrated approach is required to provide effective direct strike protection and grounding, in combination with effective surge protection, so that valuable assets, data and personnel remain secure and safe.

In order to provide the optimum level of protection, ERICO has developed a Six Point Plan of Protection, incorporating direct strike protection and grounding and surge protection for power and data lines. This protection plan, combined with engineering and manufacturing excellence established over the last century, has helped position ERICO as a global supplier of premium performance protection products.


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## Introduction

By following the Six Point Plan of Protection, ERICO ${ }^{\star}$ customers are able to implement effective solutions to individual lightning, grounding and surge problems while retaining an integrated protection philosophy. The products and concepts outlined in this catalog relate to points $5 \& 6$ of the ERICO Six Point Plan.

Point 5 of the Six Point Plan advocates a coordinated approach to surge protection, where the first stage of defense is the installation of primary protection devices at the mains supply service entrance, followed by secondary protection at distribution branch panels and where necessary, at point-of-use applications.

Point 6 recognizes the need to provide effective surge protection on cables supplying telecommunications, signal and data management equipment.

## The ERICO ${ }^{\circledR}$ Six Point Plan of Protection

Capture the lightning strike.
Capture the lightning strike to a known and preferred attachment point using a purpose-designed air terminal system.

Convey this energy to ground.
Conduct the energy to the ground via a purpose-designed downconductor.
Dissipate energy into the grounding system.
Dissipate energy into a low impedance grounding system.
Bond all ground points together.
Bond all ground points to eliminate ground loops and create an equipotential plane.
Protect incoming AC power feeders.
Protect equipment from surges and transients on incoming power lines to prevent equipment damage and costly operational downtime.

Protect low voltage data/telecommunications circuits.
Protect equipment from surges and transients on incoming telecommunications and signal lines to prevent equipment damage and costly operational downtime.


## The Need for Coordinated Protection

## Critical Factors

Critical factors need to be considered when determining the need for facility protection. Many factors can be determined by answering the following questions:

- What is the risk to personnel?
- What is the risk of equipment damage?
- What are the consequences of equipment failure?
- Is the equipment associated with an essential service?
- How will equipment failure affect overall facility operation and revenue generation?
- What are the legal implications of providing inadequate protection?

The statistical nature of lightning and the broad spectrum of energy delivered by a lightning flash, the problems created by various power generation and distribution systems, and the continued trend to more sensitive and specialized electronics, requires careful selection of available technologies if adequate protection is to be provided.

## What are the costs of inadequate protection?

The costs that can result from inadequate protection are many and varied. The type of equipment within a facility will have a direct impact on the damage that can occur. Robust equipment, such as lighting and airconditioning systems, are often able to withstand impulses as high as 1500 volts and are not as sensitive to the rapid rate-ofrise exhibited by the pre-clamped surge waveform as are electronics. These systems are often not critical to the continuing operation of the site and therefore usually do not require the premium level of protection that is essential for more sensitive equipment.

However, significant damage can occur, even to the more robust systems, as a result of lightning induced surges resulting within a radius of several kilometers, or from switching induced surges.

Costs can range from degradation of electrical or electronic systems to data loss, equipment destruction or injury to personnel. Some of these costs can appear relatively minor but the loss of an essential service or revenues associated with a facility or plant shut down can be enormous.

According to the Insurance Information Institute, NY, (NY Press Release 11 August 1989): Lightning and over-voltage transients cause damage to property, electrical, electronic and communications equipment estimated to be more than US\$1.2 billion dollars per year in the US alone. This represents approximately $5 \%$ of all insurance claims in the US. Costs in more lightning prone regions of the world are even greater.

According to Holle, et al., Journal of Applied Met, Vol 35, No.8, August 1996: Insurance claims to lightning and over-voltage damage amount to US $\$ 332$ million annually in the US. On average this represents one claim for every 57 lightning strikes in the US.

## Sources of Transients and Surges

Although lightning is the most spectacular form of externally generated surges, it is only one source of over-voltage. Other sources include the switching of power circuits, the operation of electrical equipment by neighboring industries, the operation of power factor correction devices, and the switching and clearing of faults on transmission lines. It is important to note that lightning does not need to directly strike a power line for such damage to occur; a strike several hundred meters away can induce large damaging transients, even to underground cables.

It is estimated that 70 to $85 \%$ of all transients are generated internally, within one's own facility, by the switching of electrical loads such as lights, heating systems, motors and the operation of office equipment.

Modern industry is highly reliant on electronic equipment and automation to increase productivity and safety. The economic benefits of such devices are well accepted. Computers are commonplace and microprocessor-based controllers are used in most manufacturing facilities. Microprocessors can also be found embedded in many industrial machines, security \& fire alarms, time clocks and inventory tracking tools. Given the wide range of transient sources and the potential cost of disruption, the initial installed cost of surge protection can readily be justified for any facility.

As a guide, the cost of protection should be approximately $10 \%$ of the cost of the facility's economic risk.

## The Need for Coordinated Protection

Reliable protection of structures, industrial and commercial operations and personnel, demands a systematic and comprehensive approach to minimizing the threats caused by transient over-voltages. Grounding, bonding, lightning protection and surge protection all need to be considered for comprehensive facility electrical protection. Each of these are interdependent disciplines that need a holistic design approach to ensure the facility is not left with a vulnerable "blind spot". The investment in surge protection can be wasted if "blind spots" exist. For example, installing a surge protection device on the power supply to a programmable logic controller is of little value if the I/O lines are not also protected. In addition, an air terminal on the facility may capture the lightning energy but without a dependable ground
system, this energy cannot be safely dissipated. Equally, even the most expensive Surge Protection Devices (SPDs) are poor performers if a low impedance equipotential ground is not provided. These interdependent disciplines are best applied when looking at a total facility rather than at an individual piece of equipment or portion of the facility.

It is for these reasons that the ERICO ${ }^{\circledR}$ Six Point Plan of Protection was developed. The plan prompts the consideration of a coordinated approach to lightning protection, surge and transient protection and grounding, an approach that embraces all aspects of potential damage, from the more obvious direct strike to the more subtle mechanisms of differential earth potential rises and voltage induction at service entry points.


The Six Point Plan applied to a manufacturing facility. Surge and transient protection principles applied to a total facility rather than individual pieces of equipment.

## Selecting Surge Protection

RECOMMENDED SURGERATINGS (8/20нs)

$\mathrm{Ng}=$ strikes/km²/year.

| RECOMMENDED PRODUCTS |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | SES200 |  |  |  |
|  | TDS CRITEC ${ }^{\text {® }}$ | VTEC \& MPM |  |  |
|  | TDX200 |  |  |  |
|  |  | TDX100 |  |  |
|  |  |  | TDX50 |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  | DSD1150 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  | TDS150 \& | S350 |  |
|  |  | DSD140 \& | D340 |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  | DSF |

## Surge Protection And Surge Ratings

The stress, which an SPD will experience under surge conditions, is a function of many complex and interrelated parameters. These include:

- Location of the SPD(s) within the structure - are they located at the main distribution board or within the facility at secondary board, or even in front of the end-user equipment?
- Method of coupling the lightning strike to the facility for example, is this via a direct strike to the structures LPS, or via induction onto building wiring due to a nearby strike?
- Distribution of lightning currents within the structure for example, what portion of the lightning current enters the earthing system and what remaining portion seeks a path to remote grounds via the power distribution system and equipotential bonding SPDs?
- Type of power distribution system - the distribution of lightning current on a power distribution system is strongly influenced by the grounding practice for the neutral conductor. For example, in the TN-C system with its multiple earthed neutral, a more direct and lower impedance path to ground is provided for lightning currents than in a TT system.
- Additional conductive services connected to the facility these will carry a portion of the direct lightning current and therefore reduce the portion which flows through the power distribution system via the lightning equipotential bonding SPD.
- Type of waveshape - it is not possible to simply consider the peak current which the SPD will have to conduct, one also has to consider the waveshape of this surge. It is also not possible to simply equate the areas under the current-time curves (also


Protection zones defined by specific product application.
standard postulates that under a LPL I the magnitude of a direct strike to the structure's LPS may be as high as 200kA 10/350. While this level is possible, its statistical probability of occurrence is approximately $1 \%$. In other words, $99 \%$ of discharges will be less than this postulated 200 kA peak current level.

An assumption is made that $50 \%$ of this current is conducted via the building's earthing system, and $50 \%$ returns via the equipotential bonding SPDs connected to a three wire plus neutral power distribution system. It is also assumed that no additional conductive service exists. This implies that the portion of the initial 200 kA discharge experienced by each SPD is 25 kA .

Simplified assumptions of current dispersion are useful in considering the possible threat level, which the SPD(s) may experience, but it is important to keep in context the assumptions being made. In the example above, a lightning discharge of 200kA has been considered. It follows that the threat level to the equipotential bonding SPDs will be less than 25 kA for $99 \%$ of the time. In addition, it has been assumed that the waveshape of this current component through the SPD(s) will be of the same waveshape as the initial discharge, namely 10/350, while in reality the waveshape have been altered by the impedance of building wiring, etc.

Many standards have sought to base their considerations on field experience collected overtime. For example, the IEEE ${ }^{\circledR}$ guide to the environment C62.41.1 and the recommended practice C62.41.2 present two scenarios of lightning discharge and different exposure levels under each of these depending on the location where the SPD is installed. In this standard, Scenario II depicts a direct strike to the structure, while Scenario I depicts a nearby strike and the subsequent conducted current into a structure via power and data lines. The highest surge exposure considered feasible to an SPD installed at the service entrance to a facility under Scenario $I$ is 10kA 8/20, while under Scenario II it is considered to be 10kA 10/350 (exposure Level 3). referred to as the action integral) for SPDs under different waveshapes.

Many attempts have been made to quantify the electrical environment and "threat level " which an SPD will experience at different locations within a facility. The new IEC ${ }^{\text {SM }}$ standard on lightning protection, IEC 62305-4 "Protection against lightning - Part 4: Electrical and electronic systems within structures" has sought to address this issue by considering the highest surge magnitude which may be presented to an SPD based on the lightning protection level (LPL) being considered. For example, this

From the above, it is apparent that the selection of the appropriate surge rating for an SPD depends on many complex and interconnected parameters. When addressing such complexities, one needs to keep in mind that one of the more important parameters in selecting an SPD is its limiting voltage performance during the expected surge event, and not the energy withstand which it can handle.

## Advanced Technologies - The ERICO ${ }^{\circ}$ Advantage

## Triggered Spark Gap (TSG) Technology

One of the criticisms of traditional spark gap technology has been the high initiating voltage required to form the arc, typically as much as three to four thousand volts. Clearly this is inappropriate for sensitive AC supply where surges of several hundred volts can be lethal to equipment. ERICO® has addressed this problem by incorporating a triggering device, which senses the arrival of a transient and initiates a spark to ionize the region surrounding the spark gap electrodes. This enables the spark gap to operate on significantly lower transient voltages.

A second major criticism of traditional spark gaps has been their follow-current performance. Spark gaps have a low clamping voltage and can clamp a surge below the peak of the AC mains voltage, thereby causing significant follow-current to flow until the next zero crossing point is reached, and the arc is extinguished.

ERICO has incorporated a method of increasing the arc voltage thereby extinguishing it earlier and significantly reducing the follow-current. This feature is effective even on AC supplies with higher prospective fault current capacities and has the added benefit of preventing upstream fuses or circuit breakers from activating.


Activation of the Triggered Spark Gap.


Internal components of Triggered Spark Gap.

## Development of surge reduction filters

ERICO strives to employ the most suitable technology for each application across its range of SPDs, including high performance Surge Reduction Filters (SRFs). The CRITEC ${ }^{\circledR}$ SRF is the most recent development bringing together for the first time, TSG Technology with the benefits of series filtering.

## Fundamental breakthrough in filter design

Incorporating TSG Technology into a surge reduction filter has allowed a fundamental breakthrough in the overall design of the filter. Ferrous-cored inductors, which are much smaller than nonsaturating air-cored inductors required in MOV based surge reduction filters, have been used in the CRITEC TSG-SRF.

The use of ferrous-cored inductors is possible because the letthrough voltage from a TSG remains high for only a few microseconds. In comparison, the let-through voltage from a MOV based device remains between 600 V and 1000 V for the duration of the surge. This time can range up to 400 milliseconds for long tail pulses and determines how much energy the inductor will have to store before reaching saturation and becoming ineffective.

## What benefits flow from this technology?

The combination of TSG and series filtering provides the benefits of high surge capability, low let-through voltage and considerably reduced rate of voltage rise (dv/dt). Additional benefits of reduced size, weight and heat dissipation also result.


## Advanced Technologies - The ERICO ${ }^{\circledR}$ Advantage

## Thermal MOV Technology

MOV components have for many years been used in surge protection devices due to their excellent non-linear clamping characteristics and large energy handling capability. Unfortunately, MOVs can become a hazard should they overheat due to excess stress or aging lowering the clamping voltage. For this reason it is important to have a means of disconnection which safely isolates the MOV during abnormal conditions. In the past this has been achieved by the use of separate thermal disconnects that, due to the distance from the MOV, require significant MOV heat to cause their operation. In low cost designs, several MOVs may share a common thermal device, resulting in more than just the failed MOV from being disconnected. The new thermal protection utilized by ERICO ${ }^{\oplus}$, bonds the thermal disconnect directly to the substrate of each MOV beneath the epoxy coating. This more intimate thermal contact helps allow the MOV to be immediately and safely disconnected, allowing neighboring MOVs to continue to provide transient protection.


## Filtering Technology

Surge protection devices may include such a filtering stage to help condition the waveshape, thereby providing superior protection for sensitive electronics. This said, it is important to realize that a number of different topologies of filter circuit exist, each providing significantly different performance. At its simplest, a manufacturer may include a capacitor in parallel with the output. This will serve to reduce any fast ringing voltages and will also help absorb the energy in a small transient thereby providing a level of attenuation.

A far more effective approach is the series LC filter. This type of filter is connected after the surge limiting components and is in series with the supply powering the equipment. It consists of a series inductor and parallel capacitors. Surge protection devices of this nature are often referred to as "two port" devices since they have a distinct input and output side.

SPDs with filters offer two primary benefits:

1) They reduce the transient voltage reaching the equipment.
2) They reduce the rate-of-rise of the leading edge of the impulse. The residual leading edge spike after a standard SPD, although it may only be 500V in amplitude, can cripple electronics due to its extremely high rate-of-voltage rise of $3,000-12,000 \mathrm{~V} / \mathrm{\mu s}$. Effective filtering reduces this rate-of-rise to less than $100 \mathrm{~V} / \mu \mathrm{s}$. This slower change in voltage is better withstood by electronic equipment using switched mode power supplies. The filter also helps to attenuate small signal RFI/EMI noise problems.

Applied Cat B. Pulse


Applied voltage pulse.


Improved reduction in dv/dt with filtering incorporated.

## Advanced Technologies - The ERICO ${ }^{\circ}$ Advantage

## Transient Discriminating Technology

To meet the fundamental requirements of performance, longer service life and greater safety under real world conditions, ERICO has developed Transient Discriminating (TD) Technology.

This quantum leap in technology adds a level of "intelligence" to the Surge Protection Device enabling it to discriminate between sustained abnormal over-voltage conditions and true transient or surge events. Not only does this help ensure safe operation under practical application, but it also prolongs the life of the protector since permanent disconnects are not required as a means of achieving internal over-voltage protection.

## Traditional Technologies

Conventional SPD technologies utilize metal oxide varistors and/or silicon avalanche diodes to clamp or limit transient events. However, these devices are susceptible to sustained $50 / 60 \mathrm{~Hz}$ mains over-voltage conditions which often occur during faults to the utility system. Such occurrences present a significant safety hazard when the suppression device attempts to clamp the peak of each half cycle on the mains over-voltage. This condition can cause the device to rapidly accumulate heat and in turn fail with the possibility of inducing a fire hazard.

## The Core of TD Technology

The secret to ERICO's Transient Discriminating Technology is its active frequency discrimination circuit. This patented device can discriminate between a temporary over-voltage (TOV) condition


Active TD Technology

and a very fast transient, which is associated with lightning or switching-induced surges. When the transient frequencies are detected, the patented Quick-Switch within TD activates to allow the robust protection to limit the incoming transient. The frequency discriminating circuit that controls the Quick-Switch ensures that the SPD device is immune to the effects of a sustained 50 or 60 Hz TOV. This allows the device to keep operating, in order to help provide safe and reliable transient protection, even after an abnormal over-voltage condition has occurred.

## Meeting \& Exceeding UL® Standards

The CRITEC ${ }^{\circledR}$ range of surge protection devices from ERICO® employing TD Technology has been specifically designed to meet and exceed the new safety requirements of UL 1449 Edition 2. To meet the abnormal over-voltage testing of UL 1449 Edition 2, many manufacturers of SPD devices have incorporated fuse or thermal disconnect devices which permanently disconnect all protection from the circuit during an over-voltage event. Transient Discriminating Technology on the other hand will allow the SPD device to experience an abnormal overvoltage up to twice its nominal operating voltage and still remain operational even after this event! This allows the device to help provide safe, reliable and continuous protection to your sensitive electronic equipment. TD Technology is especially recommended for any site where sustained over-voltages are known to occur, and where failure of traditional SPD technologies cannot be tolerated.

The UL 1449 testing standard addresses the safety of a TVSS device under temporary and abnormal overvoltage conditions, but does not specifically mandate a design that will give a reliable, long length of service in the real world. Specifically, UL 1449 tests that the TVSS remains operational at $10 \%$ above nominal supply voltage, allowing SPD manufacturers to design products that permanently disconnect just above that. Most reputable manufacturer's designs allow for up to a $25 \%$ overvoltage, while ERICO's TD Technology gives even greater overhead.


## A Guide to Common Power Distribution Systems

Throughout the world a number of different power distribution systems are used that employ different grounding practices and methods of distributing the Neutral and Protective Earth conductors. The following pages are based on IEC ${ }^{\text {SM }} 60364$ and detail a number of the more common systems and ERICO's recommendation for the
selection and installation of SPDs on each of these. The individual product specification tables detail system suitability. It is recommended that users consult IEC61643-12 "Surge protective devices connected to low-voltage power distribution systems Selection and application principles," for additional information.

| Description | Source Configuration | Typica Vol | pply es |
| :---: | :---: | :---: | :---: |
| Single Phase <br> 1Ph, 2W+G |  | $\begin{aligned} & 110 \mathrm{~V} \\ & 120 \mathrm{~V} \\ & 220 \mathrm{~V} \\ & 240 \mathrm{~V} \end{aligned}$ | (L-N) |
| Single Phase <br> 1Ph, 3W+G <br> Also known as <br> Split phase or <br> Edison system |  | 120/240V | (L-N/L-L) |
| Three Phase WYE without neutral 3Ph Y, 3W+G |  | 480 V | (L-L) |
| Three Phase WYE with neutral 3Ph $\mathrm{Y}, 4 \mathrm{~W}+\mathrm{G}$ |  | $\begin{aligned} & \hline 120 / 208 \mathrm{~V} \\ & 220 / 380 \mathrm{~V} \\ & 230 / 400 \mathrm{~V} \\ & 240 / 415 \mathrm{~V} \\ & 277 / 480 \mathrm{~V} \\ & 347 / 600 \mathrm{~V} \end{aligned}$ | (L-N/L-L) |
| Delta <br> High leg <br> 3 Ph $\Delta, 4 W+G$ |  | 120/240V | (L-N/L-L) |
| Delta <br> Ungrounded <br> 3 Ph $\Delta, 3 W+G$ |  | $\begin{aligned} & 240 \mathrm{~V} \\ & 480 \mathrm{~V} \end{aligned}$ | (L-L) |
| Delta <br> Grounded corner <br> 3Ph $\Delta, 3 W+G$ |  | $\begin{aligned} & 240 \mathrm{~V} \\ & 480 \mathrm{~V} \end{aligned}$ | (L-L) |

## Power Distribution Systems and SPD Installation

The IEC ${ }^{\text {SM }} 60364$ series of standards characterizes low-voltage distribution systems by their grounding method and the arrangement of the neutral and protective earth conductors. The selection of SPDs must consider among other issues, the level of over-voltage that may temporarily occur within the distribution system due to ground faults. IEC 61643-12 details the temporary over-voltages that may occur during fault conditions for these systems. To conform with European wiring rules an SPD with a Uc rating equal to, or greater than, this
value should be selected. Effective protection does not require SPD's to be installed in all the modes detailed. The following diagrams provide guidance on the selection and installation of SPDs on the more common distribution systems. While three phase WYE systems are shown, similar logic can be applied to single phase, delta and other configuration sources.
Uo $=$ Line to neutral voltage of the system
Un = Nominal country specific system voltage (typically Uo $\times 1.10$ )

## TN-C System

In this, the neutral and protective earth conductor combine in a single conductor throughout the system. All exposed-conductive-parts are connected to the PEN conductor.


TN-S System
In this, a separate neutral and protective earth conductor are run throughout. The protective PE conductor can be the metallic sheath of the power distribution cable or a separate conductor. All exposed-conductive-parts of the installation are connected to this PE conductor.


SPDs shown connected L-PE and N-PE.
May also be connected L-N and N-PE.

## Power Distribution Systems and SPD Installation

## TN-C-S System

In this, a separate neutral and protective earth combine in a single PEN conductor. This system is also known as a Multiple Earthed Neutral (MEN) system and the protective conductor is referred to as the Combined Neutral Earth (CNE) conductor. The supply PEN conductor is earthed at a number of points throughout the network and generally as close to the consumer's point-of-entry as possible. All exposed-conductive-parts are connected to the CNE conductor.


## TT System

A system having one point of the source of energy earthed and the exposed-conductive-parts of the installation connected to independent earthed electrodes.


## A Guide to Using This Catalog



Where appropriate, the IEC term Protective Earth (PE) is used in place of regional terms Ground (G) or Earth (E).
Key to Symbols Used in Line Diagrams


## CRITEC ${ }^{\oplus}$ SES200

## Service Entrance Standard



- 200kA 8/20 primary protection - rated for service entrance applications
- NEMA-4X enclosure - for harsh environments
- Internal high interrupt capacity fusing - for added safety
- Modular design - allows easy replacement of surge modules
- Transient Discriminating (TD) Technology - provides increased service life
- Optional Filter and Surge Counter - for enhanced protection

The SES200 series of Transient Voltage Surge Suppressors deliver specification grade performance and features at an affordable price. The versatile and compact design provides high quality protection for a wide variety of commercial and industrial applications where sensitive electronic equipment is to be protected.
Internal electronics continuously monitor SPD protection, and the status is displayed on 5 segment LED bar graphs. Alarm contacts for remote monitoring are a standard feature.

The SES200 provides up to 200kA $8 / 20 \mu \mathrm{~s}$ per mode of surge material, making it ideal for the protection of service entrance panels and helping to ensure a long operational life under severe lightning conditions.

The replaceable surge modules provide protection to L-N and N -G modes, delivering effective protection from both common mode and differential transients in single phase and three phase WYE systems. Models for grounded delta power systems provide L-L protection.
Transient Discriminating (TD) Technology, which meets the safety standards of UL® 1449 Edition 2, provides a superior life by eliminating the common temporary over-voltage failure mode of most SPDs.

The SES is designed to mount adjacent to the service entrance panel with the connection being made via a small length of conduit.

SES200 metal enclosure option.



SES200 without filter or surge counter options.

Note: Ensure that installation of this model of the SES200 is not exposed to direct sunlight as solar radiation may cause internal temperatures to exceed the maximum specified and damage will result to the surge protective modules. A sun shield should be fitted if this unit is to be installed outdoors and exposed to sunlight.

## CRITEC ${ }^{\ominus}$ SES200


(1) Grounded systems only. SES200 240D should not be used on high leg or ungrounded systems
(2) Normally open contact, $250 \mathrm{~V} \sim 10 \mathrm{~A}, \leq 1.5 \mathrm{~mm}^{2}$ (\#16AWG) connecting wire
(3) Inquire for availability


## Transient Discriminating Protection Module



The Transient Discriminating CRITEC® MOVTEC Protection Module (TDS-MPM) integrates three TD-CRITEC MOVTEC units into one enclosure to simplify three phase protection applications.

- Primary protection - suitable for high exposure sites and point-of-entry facility protection
- Modular design - allows easy replacement of surge modules
- 5 segment electronic status indication - displays percentage of capacity remaining
- Lug connection - allows Kelvin (in and out) connection of large cables
- Transient Discriminating (TD) Technology provides increased service life

The TDS-MPM is ideal for primary point-of-entry protection applications where it is connected to the main service panel.

| Model | TDS MPM 277 |
| :---: | :---: |
| Nominal Voltage $U_{n}$ | 240/415V \& 277/480V |
| Distribution System | 3 Ph Y 4W+G |
| System Compatibility | TN-C, TN-S, TN-C-S \& TT |
| Max. Cont. Operating Voltage $U_{C}$ | 400/692V |
| Stand-off Voltage | 480/831V L-N, 440V N-PE |
| Frequency | $50 / 60 \mathrm{~Hz}$ |
| Operating Current @ Un | 25 mA |
| Aggregate Surge Rating | 200kA 8/20 ${ }^{\text {s (L-N) }}$ |
| Max. Discharge Current $\mathrm{Imax}^{\text {max }}$ | 100kA 8/20 $\mu \mathrm{L}$ L-N (NEMA-LS1) 130kA 8/20 $/$ s N-PE (NEMA-LS1) |
| Impulse Current limp | 20kA 10/350 1 s L-N 50kA 10/350 $\mu \mathrm{s}$ L-PE |
| Protection Modes | All modes protected |
| Technology | TD Technology and MOV/Silicon L-N Triggered Spark Gap N-PE |
| Voltage Protection Level $\mathrm{U}_{\mathrm{p}}$ <br> @ Cat B3, 3kA 8/20 $\mu \mathrm{s}$ <br> @ 20kA 8/20رs | L-N N-PE <br> $<750 \mathrm{~V}$ $<1.5 \mathrm{kV}$ <br> $<980 \mathrm{~V}$ $<2.3 \mathrm{kV}$ |
| Status | 5 segment LED bar graph per phase Normally open contact, 250V~/10A, $\leq 1.5 \mathrm{~mm}^{2}$ (\#16AWG) connecting wire |
| Dimensions | $241 \mathrm{~mm} \times 306 \mathrm{~mm} \times 170 \mathrm{~mm}$ (9.5" $\left.\times 12^{\prime \prime} \times 6.7^{\prime \prime}\right)$ approx. |
| Weight | 5 kg (11 lb) approx. |
| Enclosure | Metal, IP33 (NEMA-2) |
| Connection | $\leq 16 \mathrm{~mm}^{2}$ (\#6AWG) connecting to M6 bolt |
| Mounting | Wall mount |
| Back-up Overcurrent Protection | 100A |
| Temperature | $-35^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}\left(-31^{\circ} \mathrm{F}\right.$ to $\left.+131^{\circ} \mathrm{F}\right)$ |
| Humidity | 0\% to 90\% |
| Approvals | AS3260, IEC950, C-Tick |
| Surge Rated to Meet | ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C |
|  | ANSI/IEEE C62.41.2 Scenario II, Exposure 3, 100kA 8/20 $\mu \mathrm{s}$, 10kA 10/350 $\mu \mathrm{s}$ |





## Transient Discriminating CRITEC ${ }^{\circledR}$ MOVTEC



- Transient Discriminating (TD) Technology - provides increased service life
- Primary protection - suitable for high exposure sites and point-of-entry protection applications
- TDS-MT configurable to L-L, L-N, L-G or N-G protection
- TDS-MTU provides simultaneous L-N, L-G \& N-G protection
- Small foot print - effective use of real estate
- 5 segment electronic status indication - displays percentage of capacity remaining

The TDS-CRITEC MOVTEC family of surge diverters offers economical and reliable protection from voltage transients in even the most strenuous applications.
The small foot print provides integrators and OEMs with an effective use of real estate when installing within panels and equipment.
Transient Discriminating (TD) Technology, which meets the safety standards of UL 1449 Edition 2, provides a superior life by eliminating the common temporary over-voltage failure mode of most SPDs. TD Technology is essential for any site where abnormal over-voltages can occur or where the possible catastrophic failure of traditional technologies can not be tolerated.

Alarm contacts are provided which may be used to shut down the system or to activate an external warning if the internal surge material is below optimum condition.




TDS MT 120 TDS MT 277

| Model | TDS MT 120 | TDS MT 277 | TDS MTU | 277 |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal Voltage $\mathrm{U}_{\mathrm{n}}$ | 120V | 230 V \& 277V | 230V \& | 77 V |  |
| System Compatibility ${ }^{(1)}$ | TN-C, TN-C-S, TN-S, TT \& IT |  |  |  |  |
| Max. Cont. Operating Voltage $U_{C}$ | 170 V | 400V | 400V |  |  |
| Stand-off Voltage | 240 V | 480V | 480 V |  |  |
| Frequency | $50 / 60 \mathrm{~Hz}$ |  |  |  |  |
| Operating Current @ Un | 25 mA |  |  |  |  |
| Aggregate Surge Rating | 200kA 8/20رs | 200kA 8/20رs | $\begin{array}{\|l\|} \hline \text { L-N } \\ \text { 80kA } \end{array}$ | $\begin{aligned} & \hline \text { L-G } \\ & 80 \mathrm{kA} \end{aligned}$ | $\begin{aligned} & \mathrm{N}-\mathrm{G} \\ & 40 \mathrm{kA} 8 / 20 \mu \mathrm{~s} \end{aligned}$ |
| Max. Discharge Current $I_{\max }$ | 100kA 8/20رs | 100kA 8/20 ${ }^{\text {s }}$ | L-N <br> 40kA | $\begin{aligned} & \hline \text { L-G } \\ & 40 \mathrm{kA} \end{aligned}$ | $\begin{aligned} & \mathrm{N}-\mathrm{G} \\ & 20 \mathrm{kA} 8 / 20 \mu \mathrm{~s} \end{aligned}$ |
| Impulse Current limp | 20kA 10/350رs | 20kA 10/350رs |  |  |  |
| Protection Modes | Single mode (L-L, L-N, L-G or N-G) |  | L-N, L-G \& N-G |  |  |
| Technology | TD Technology MOV/Silicon |  |  |  |  |
| Voltage Protection Level Up <br> @ 500A 8/20 $\mu \mathrm{s}$ (UL SVR) <br> @ Cat B3, 3kA 8/20 <br> @ 20kA 8/20 15 | $\begin{aligned} & 330 \mathrm{~V} \\ & <480 \mathrm{~V} \\ & <760 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 700 \mathrm{~V} \\ & <750 \mathrm{~V} \\ & <980 \mathrm{~V} \end{aligned}$ | $\begin{array}{\|l\|} \hline \text { L-N } \\ 700 \mathrm{~V} \\ <760 \mathrm{~V} \\ <1200 \mathrm{~V} \\ \hline \end{array}$ | $\begin{aligned} & \text { L-G } \\ & 700 \mathrm{~V} \\ & <870 \mathrm{~V} \\ & <1290 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & \hline \text { N-G } \\ & 600 \mathrm{~V} \\ & <850 \mathrm{~V} \\ & <1200 \mathrm{~V} \\ & \hline \end{aligned}$ |
| Status | 5 segment LED bar graph per phase |  |  |  |  |
| Contacts | Normally open ${ }^{(2)}$ |  |  |  |  |
| Dimensions | $45 \mathrm{~mm} \times 150 \mathrm{~mm} \times 140 \mathrm{~mm}(1.8 " \times 5.9$ " $\times 5.5$ ") approx. |  |  |  |  |
| Weight | $0.6 \mathrm{~kg}(1.3 \mathrm{lb})$ approx. |  |  |  |  |
| Enclosure | UL94V-0 thermoplastic |  |  |  |  |
| Connection | $\leq 16 \mathrm{~mm}^{2}$ (\#6AWG) connecting to M6 bolt |  |  |  |  |
| Back-up Overcurrent Protection | 100A |  |  |  |  |
| Temperature | $-35^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}\left(-31^{\circ} \mathrm{F}\right.$ to $\left.+131^{\circ} \mathrm{F}\right)$ |  |  |  |  |
| Humidity | 0\% to 90\% |  |  |  |  |
| Approvals | UL Recognized, AS3260, IEC950, C-Tick |  |  |  |  |
| Surge Rated to Meet | ANSIIEEE C62.41.2 Cat A, Cat B, Cat C <br> ANSI/IEEE C62.41.2 Scenario II, <br> Exposure 3,100kA 8/20 H , <br> 10kA 10/350 |  | ANSI/EEE C62.41.2 Cat A, Cat B, Cat C |  |  |

TDS MTU 277
(1) Should not be connected in all modes of these systems. Refer to Power Distribution Systems and SPD Installation, Pages 11-12 (2) Normally open contacts, 250V~/10A, $\leq 1.5 \mathrm{~mm}^{2}$ (\#16AWG) connecting wire


## CRITEC ${ }^{\oplus}$ TDXM Modular Series

## TDX200 Transient Discriminating Panel Protectors



- CRITEC ${ }^{\circledR}$ Transient Discriminating (TD) Technology provides increased service life
- Modular design allows individual modes to be field replaceable, built-in disconnect and fusing eliminates need for external fusing.
- Built-in safety features include TD Technology, thermal protection and short circuit current cartridge fusing
- Compact NEMA-4 enclosure design can be flush mounted or installed in a small space.
- Status indication flag per mode, voltage presence LED's, audible alarm and voltage-free contacts providing remote status monitoring
- 200kA 8/20 maximum surge rating provides protection suitable for service entrance, main-distribution panels and highly exposed applications
- Available in various operating voltages to suit most common power distribution systems
- CE, UL ${ }^{\oplus}$ pending

The TDX200 Series of Transient Voltage Surge Suppressors are designed for critical protection applications. The 200kA $8 / 20 \mu \mathrm{~s}$ of surge protection exceeds the IEEE ${ }^{\oplus}$ C62.41.2 Scenario II single shot surge rating requirements for exposed service entrance locations - Exposure 3.


Typical installation.


TDX Replaceable Modules.

The NEMA-4 weather-tight housing allows the TDX to be installed on indoor or outdoor service panels. The preconfigured connecting leads simplify installation. The unique narrow construction allows the SPD to fit between adjacent panel boards and connect via a 90 -degree elbow. A flush mounting kit is also available for installing the SPD in drywall applications.


TDX200M Enclosure.


TDX Replaceable Module backplane fully removed.

## CRITEC ${ }^{\ominus}$ TDXM Modular Series

## TDX200 Transient Discriminating Panel Protectors

| Model | $\begin{aligned} & \hline \text { TDX200M } \\ & \text { 120/240 } \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \text { TDX200M } \\ & \text { 120/208 } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|l\|} \hline \text { TDX200M } \\ \text { 120/240D } \\ \hline \end{array}$ | $\begin{aligned} & \text { TDX200M } \\ & 277 / 480 \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { TDXM200M } \\ & \text { 277/480TT } \end{aligned}$ | $\begin{array}{\|l\|} \hline \text { TDX200M } \\ 347 / 600 \\ \hline \end{array}$ | $\begin{aligned} & \text { TDX200M } \\ & \text { 240D } \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \text { TDX200M } \\ & \text { 480D } \\ & \hline \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal Voltage $U_{\text {n }}$ (pole) | 120/240V~ | 120/240V~ | 120/240V~ | 277/480V~ | 277/480V~ | 347/600V~ | 240V~ | 480V~ |
| Distribution System ${ }^{(1)}$ | $\begin{aligned} & 1 \mathrm{Ph} \\ & 3 W+G \end{aligned}$ | $\begin{aligned} & 3 \mathrm{Ph} \\ & 4 \mathrm{~W}+\mathrm{G} \end{aligned}$ | 3 3h $\Delta$ 4W+G | $\begin{aligned} & 3 \mathrm{Ph} 4 \mathrm{~W}+\mathrm{G} \\ & \left(\& 3 \mathrm{~W}+\mathrm{G}^{2}\right) \end{aligned}$ | $\begin{aligned} & 3 \mathrm{Ph} \\ & 4 \mathrm{~W}+\mathrm{G} \end{aligned}$ | $\begin{aligned} & 3 \mathrm{Ph} \\ & 4 \mathrm{~W}+\mathrm{G} \end{aligned}$ | $\begin{aligned} & 3 P h \Delta \\ & 3 W+G \end{aligned}$ | $\begin{array}{\|l\|} \hline 3 P h \Delta \\ 3 W+G \\ \hline \end{array}$ |
| MCOV Uc | 170/340V~ | 170/295V~ | 170/340V~ | 310/536V ~ | 310/536V~ | 560/970V ~ | 275V ~ | 560V ~ |
| Stand off Voltage | 240/480V~ | 240/415V~ | 240/415V~ | 480/813V | 480/813V~ | 790/1370V ~ | 415V ~ | 790V ~ |
| Frequency | $50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |
| Short Circuit Current Rating | 200kAIC (Isc) |  |  |  |  |  |  |  |
| Technology Used | TD Technology with thermal disconnect Over-current Replaceable Cartridge Fusing |  |  |  |  |  |  |  |
| Protection |  |  |  |  |  |  |  |  |
| Maximum Discharge Current (Imax/per line) | 200kA 8/20 $/ \mathrm{s}$ |  |  |  |  |  |  |  |
| Nominal Discharge Current (In/per line) | 80kA 8/20 ${ }^{\text {s }}$ |  |  | 80kA 8/20 $/ \mathrm{s}$ |  |  |  |  |
| Protection Modes | L-N, L-G \& N-G |  |  |  | L-N, N-G | L-N, L-G \& N-G ${ }^{\text {L-L, L-G }}$ |  |  |
| Protection Level (L-N) Up @ 3kA | < 450V |  |  | < 800V |  |  |  |  |
| Protection Level (L-N) Up @ In | < 1.1 kV |  |  | < 1.2 kV |  |  |  |  |
| Alarms and Indicators |  |  |  |  |  |  |  |  |
| Status Indication | LED status indication per phase, mechanical flag per mode, all modes monitored Remote contacts, change-over, 400V~ / 3A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) terminals Audible Alarm <br> Optional Surge Counter (insert "S" in order code as follows, example TDX200S277/480) |  |  |  |  |  |  |  |
| Physical Data |  |  |  |  |  |  |  |  |
| Dimensions | $240 \mathrm{~mm} \times 130 \mathrm{~mm} \times 72 \mathrm{~mm} \quad 9.5^{\prime \prime} \times 5.125^{\prime \prime} \times 2.875^{\prime \prime}$ |  |  |  |  |  |  |  |
| Weight | 2 kg (4.4 lbs) approx. |  |  |  |  |  |  |  |
| Enclosure | Aluminum, IP 65 (NEMA-4) |  |  |  |  |  |  |  |
| Connection | Line: 600 mm of $5.26 \mathrm{~mm}^{2}$ ( $24^{\prime \prime}$ of \# 10 AWG) flying leads Neutral/ Ground: 900 mm of $5.26 \mathrm{~mm}^{2}$ ( $36^{\prime \prime}$ of \# 10 AWG) flying leads |  |  |  |  |  |  |  |
| Mounting | 3/4" straight nipple Optional flush mounting plate for drywall |  |  |  |  |  |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |  |  |  |  |  |  |  |
| Humidity | 0 to 90\% |  |  |  |  |  |  |  |
| Test Standards |  |  |  |  |  |  |  |  |
| Approvals | CE, IEC ${ }^{\text {TM }}$ 61643-1, UL 1449 Pending, C-Tick |  |  |  |  |  |  |  |
| Surge Rated to Meet | IEC 61643-1 Class II, ANSI/IEEE C62.41-1991 Cat A, Cat B, Cat C ANSI/IEEE C62.41.2 Scenario II, Exposure 3, 100kA 8/20 s , 10kA 10/350 s |  |  |  |  |  |  |  |
| Available Options | Flush Mount Kit (Order TDXM200FP) <br> Side Mount Kit (Order TDXM200SM) <br> Replacement Surge Module (Order TDS150150M or TDS150240M or TDS150277M or TDS150560M) <br> (please refer to installation instructions for the correct replacement surge module order code) <br> Replacement Fuse Cartridge (Order TDXFUSE) |  |  |  |  |  |  |  |

(1) Grounded systems only. 240D and 480D should not be used on high-leg or ungrounded systems.
(2) TDX200M277/480 can be used on "No Neutral" 480V Wye 3W+G systems.

Due to a policy of continual product development, specifications are subject to change without notice.


## CRITEC ${ }^{\ominus}$ TDXM Modular Series

## TDX100 Transient Discriminating Panel Protectors



- CRITEC ${ }^{\ominus}$ Transient Discriminating (TD) Technology provides increased service life
- Modular design allows individual modes to be field replaceable, built-in disconnect and fusing eliminates need for external fusing
- Built-in safety features include TD Technology, thermal protection and short circuit current cartridge fusing
- Compact NEMA-4 enclosure design can be flush mounted or installed in a small space
- Status indication flag per mode, voltage presence LEDs, audible alarm and voltage-free contacts providing remote status monitoring
- 100kA 8/20 maximum surge rating provides protection suitable for smaller main-distribution panels and an extended operational life
- Available in various operating voltages to suit most common power distribution systems
- CE, UL ${ }^{\oplus}$ pending

The TDX100 Series of Transient Voltage Surge Suppressors are designed for critical protection applications. The $100 \mathrm{kA} 8 / 20 \mu \mathrm{~s}$ of surge protection exceeds the IEEE ${ }^{\oplus}$ C62.41.2 Scenario II single shot surge rating requirements for exposed service entrance locations - Exposure 3.


Output contacts.


TDX Replaceable Cartridge
overcurrent fuse protection.

The NEMA-4 weather tight housing allows the TDX to be installed on indoor or outdoor service panels. The preconfigured connecting leads simplify installation. The unique narrow construction allows the SPD to fit between adjacent panel boards and connect via a 90degree elbow. A flush mounting kit is also available for installing the SPD in drywall applications.


TDX Replaceable Modules.


[^23]
## CRITEC ${ }^{\oplus}$ TDXM Modular Series

## TDX100 Transient Discriminating Panel Protectors

| Model | $\begin{array}{\|l\|} \hline \text { TDX100M } \\ \text { 120/240 } \\ \hline \end{array}$ | $\begin{aligned} & \hline \text { TDX100M } \\ & \text { 120/208 } \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { TDX100M } \\ & \text { 120/240D } \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|} \hline \text { TDX100M } \\ \text { 277/480 } \\ \hline \end{array}$ | $\begin{aligned} & \hline \text { TDX100M } \\ & \text { 277/480TT } \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \text { TDX100M } \\ & 347 / 600 \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { TDX100M } \\ & \text { 240D } \end{aligned}$ | $\begin{aligned} & \text { TDX100M } \\ & \text { 480D } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal Voltage $\mathrm{U}_{n}$ (pole) | 120/240V~ | 120/240V~ | 120/240V~ | 277/480V~ | 277/480V~ | 347/600V~ | 240V~ | 480V~ |
| Distribution System ${ }^{\text {(1) }}$ | $\begin{aligned} & 1 \mathrm{Ph} \\ & 3 \mathrm{~W}+\mathrm{G} \end{aligned}$ | $\begin{aligned} & 3 \mathrm{Ph} \\ & 4 \mathrm{~W}+\mathrm{G} \end{aligned}$ | $\begin{aligned} & 3 \mathrm{Ph} \Delta \\ & 4 \mathrm{~W}+\mathrm{G} \end{aligned}$ | $\begin{aligned} & 3 \mathrm{Ph} 4 \mathrm{~W}+\mathrm{G} \\ & \left(\& 3 \mathrm{~W}+\mathrm{G}^{22}\right) \end{aligned}$ | $\begin{aligned} & 3 \mathrm{Ph} \\ & 4 W+G \end{aligned}$ | $\begin{aligned} & 3 P h \\ & 4 W+G \end{aligned}$ | $\begin{aligned} & 3 \mathrm{Ph} \Delta \\ & 3 W+G \end{aligned}$ | $\begin{aligned} & 3 P h \Delta \\ & 3 W+G \end{aligned}$ |
| MCOV Uc | 170/340V~ | 170/295V~ | 170/340V~ | 310/536V | 310/536V | 560/970V ~ | 275V ~ | 560V ~ |
| Stand off Voltage | 240/480V~ | 240/415V~ | 240/415V~ | 480/813V~ | 480/813V~ | 790/1370V ~ | 415V ~ | 790V ~ |
| Frequency | $50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |
| Short Circuit Current Rating | 200kAIC (Isc) |  |  |  |  |  |  |  |
| Technology Used | TD Technology with thermal disconnect Over-current Replaceable Cartridge Fusing |  |  |  |  |  |  |  |
| Protection |  |  |  |  |  |  |  |  |
| Maximum Discharge Current (Imax/per line) | 100kA 8/20 $/ \mathrm{s}$ |  |  |  |  |  |  |  |
| Nominal Discharge Current (In/per line) |  |  |  |  |  |  |  |  |
| Protection Modes |  |  |  |  | L-N, N-G | L-N, L-G \& N | L-L, L-G |  |
| Protection Level (L-N) Up @ 3kA |  |  |  |  |  |  |  |  |
| Protection Level (L-N) Up @ In | $<1.1 \mathrm{kV}$ |  |  | <1.2kV |  |  |  |  |
| Alarms and Indicators |  |  |  |  |  |  |  |  |
| Status Indication | LED status indication per phase, mechanical flag per mode, all modes monitored Remote contacts, change-over, 400V~ / 3A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) terminals Audible Alarm <br> Optional Surge Counter (insert "S" in order code as follows, example TDX100S277/480) |  |  |  |  |  |  |  |
| Physical Data |  |  |  |  |  |  |  |  |
| Dimensions | $240 \mathrm{~mm} \times 84 \mathrm{~mm} \times 72 \mathrm{~mm} 9.5^{\prime \prime} \times 3.25^{\prime \prime} \times 2.875^{\prime \prime}$ |  |  |  |  |  |  |  |
| Weight | 1.4 kg ( 3.1 lbs ) approx. |  |  |  |  |  |  |  |
| Enclosure | Aluminum, IP 65 (NEMA-4) |  |  |  |  |  |  |  |
| Connection | Line: 600 mm of $5.26 \mathrm{~mm}^{2}$ ( $24^{\prime \prime}$ of \# 10 AWG) flying leads Neutral/ Ground: 900 mm of $5.26 \mathrm{~mm}^{2}$ ( $36^{\prime \prime}$ of \# 10 AWG) flying leads |  |  |  |  |  |  |  |
| Mounting | 3/4" straight nipple Optional flush mounting plate for drywall |  |  |  |  |  |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |  |  |  |  |  |  |  |
| Humidity | 0 to 90\% |  |  |  |  |  |  |  |
| Test Standards |  |  |  |  |  |  |  |  |
| Approvals | CE, IEC' ${ }^{\text {TM }}$ 61643-1, UL 1449 Pending, C-Tick |  |  |  |  |  |  |  |
| Surge Rated to Meet | IEC 61643-1 Class II, ANSI/IEEE C62.41-1991 Cat A, Cat B, Cat C ANSI/IEEE C62.41.2 Scenario III, Exposure 3, 100kA 8/20 hs , 10kA 10/350 s |  |  |  |  |  |  |  |
| Available Options | Flush Mount Kit (Order TDXM100FP) <br> Side Mount Kit (Order TDXM100SM) <br> Replacement Surge Module (Order TDS150150M or TDS150240M or TDS150277M or TDS150560M) <br> (please refer to installation instructions for the correct replacement surge module order code) <br> Replacement Fuse Cartridge (Order TDXFUSE) |  |  |  |  |  |  |  |

(1) Grounded systems only. 240D and 480D should not be used on high-leg or ungrounded systems.
(2) TDX100M277/480 can be used on "No Neutral" 480V Wye 3W+G systems.

Due to a policy of continual product development, specifications are subject to change without notice


## CRITEC ${ }^{\circ}$ TDXC Compact Series



- CRITEC ${ }^{\circledR}$ Transient Discriminating (TD) Technology provides increased service life
- Built-in safety features include TD Technology, thermal protection and short circuit current cartridge fusing
- Compact NEMA-4 enclosure design can be flush mounted or installed in a small space
- LED status indication flag and voltage-free contacts provide remote status monitoring
- 100kA 8/20 maximum surge rating provides protection suitable for smaller main-distribution panels and an extended operational life
- Available in various operating voltages to suit most common power distribution systems
- CE, UL ${ }^{\oplus}$ pending

The TDX100 Series of Transient Voltage Surge Suppressors are designed for critical protection applications. The $100 \mathrm{kA} 8 / 20 \mu \mathrm{~s}$ of surge protection exceeds the IEEE ${ }^{\oplus}$ C62.41.2 Scenario II single shot surge rating requirements for exposed service entrance locations - Exposure 3.

The NEMA-4 weather tight housing allows the TDX to be installed on indoor or outdoor service panels. The preconfigured connecting leads simplify installation. The unique narrow construction allows the SPD to fit between adjacent panel boards and connect via a 90-degree elbow. A flush mounting kit is also available for installing the SPD in drywall applications.


Typical installation.

## CRITEC ${ }^{\circledR}$ TDXC Compact Series

TDX100C Transient Discriminating Panel Protectors

| Model | $\begin{array}{\|l\|} \hline \text { TDX100C } \\ 120 \end{array}$ | $\begin{array}{\|l\|} \hline \text { TDX100C } \\ \text { 120/240 } \\ \hline \end{array}$ | $\begin{aligned} & \hline \text { TDX100C } \\ & 120 / 208 \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|} \hline \text { TDX100C } \\ \text { 120/240D } \\ \hline \end{array}$ | $\begin{aligned} & \text { TDX100C } \\ & 240 \end{aligned}$ | $\begin{array}{\|l\|} \hline \text { TDX100C } \\ \text { 277/480 } \\ \hline \end{array}$ | $\begin{array}{\|l\|} \hline \text { TDX100C } \\ 347 / 600 \\ \hline \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal Voltage $\mathrm{U}_{n}$ (pole) | 120V~ | 120/240V | 120/240V~ | 120/240V~ | 240V~ | 277/480V~ | 347/600V~ |
| Distribution System ${ }^{\text {(1) }}$ | 1Ph 2W+G | 1Ph 3W+G | 3Ph 4W+G | $3 \mathrm{Ph} \triangle 4 \mathrm{~W}+\mathrm{G}$ | 1Ph 2W+G | $3 \mathrm{Ph} 4 \mathrm{~W}+\mathrm{G}$ (\& $3 W+G^{2}$ ) | $3 \mathrm{Ph} 4 \mathrm{~W}+\mathrm{G}$ |
| MCOV Uc | 170V~ | 170/340V | 170/295V~ | 170/340V~ | 275V~ | 310/536V | 480V/830V ~ |
| Stand off Voltage | 240V~ | 240/480V~ | 240/415V~ | 240/415V | 415V~ | 480/813V | 600V/1040V ~ |
| Frequency | $50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |
| Short Circuit Current Rating | 200kAIC (ISC) |  |  |  |  |  |  |
| Technology Used | TD Technology with thermal disconnect Over-current Replaceable Cartridge Fusing |  |  |  |  |  |  |
| Protection |  |  |  |  |  |  |  |
| Maximum Discharge Current (Imax/per line) | 100kA 8/20us |  |  |  |  |  |  |
| Nominal Discharge Current (In/per line) | 40kA 8/20 ${ }^{\text {s }}$ |  |  |  | 40kA 8/20 ${ }^{\text {s }}$ |  |  |
| Protection Modes | All modes protected via L-N, L-G \& N-G |  |  |  |  |  |  |
| Protection Level (L-N) Up @ 3kA | < 450V |  |  |  | <800V |  | < 450V |
| Protection Level (L-N) Up @ In | <1.1kV |  |  |  | <1.2kV |  | <900V |
| Alarms and Indicators |  |  |  |  |  |  |  |
| Status Indication | LED status indication per phase, all modes monitored Remote contacts, change-over, 125V~/3A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) terminals |  |  |  |  |  |  |
| Physical Data |  |  |  |  |  |  |  |
| Dimensions | $155 \mathrm{~mm} \times 84 \mathrm{~mm} \times 72 \mathrm{~mm}$ ( $\left.6^{\prime \prime} \times 3.25^{\prime \prime} \times 2.875^{\prime \prime}\right)$ |  |  |  |  |  |  |
| Weight | $0.8 \mathrm{~kg}(1.75 \mathrm{lbs})$ approx. |  |  |  |  |  |  |
| Enclosure | Aluminum, IP 65 (NEMA-4) |  |  |  |  |  |  |
| Connection | Line: 600 mm of $5.26 \mathrm{~mm}^{2}$ ( $24^{\prime \prime}$ of \# 10 AWG) flying leads Neutral/ Ground: 900 mm of $5.26 \mathrm{~mm}^{2}$ ( $36^{\prime \prime}$ of \# 10 AWG) flying leads |  |  |  |  |  |  |
| Mounting | 3/4" straight nipple Optional flush mounting plate for drywall |  |  |  |  |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176{ }^{\circ} \mathrm{F}\right)$ |  |  |  |  |  |  |
| Humidity | 0 to 90\% |  |  |  |  |  |  |
| Test Standards |  |  |  |  |  |  |  |
| Approvals | CE, IECCM $61643-1$, UL 1449 Pending, C-Tick |  |  |  |  |  |  |
| Surge Rated to Meet | IEC 61643-1 Class II, ANS/IEEE C62.41-1991 Cat A, Cat B, Cat C ANSIIEEE C62.41.2 Scenario II, Exposure 2, 50kA 8/20 Hs |  |  |  |  |  |  |

(1) Grounded systems only. 240D and 480D should not be used on high-leg or ungrounded systems.
(2) TDX50C277/480 can be used on "No Neutral" 480V Wye 3W+G systems.

Due to a policy of continual product development, specifications are subject to change without notice.


## CRITEC ${ }^{\ominus}$ TDXC Compact Series

## TDX50 Transient Discriminating Panel Protectors



- CRITEC ${ }^{\circledR}$ Transient Discriminating (TD) Technology provides increased service life
- Built-in safety features include TD Technology, thermal protection and short circuit current cartridge fusing
- Compact NEMA-4 enclosure design can be flush mounted or installed in a small space
- LED status indication flag and voltage-free contacts provide remote status monitoring
- 50kA 8/20 maximum surge rating provides protection suitable for sub-distribution panels and a long operational life
- Available in various operating voltages to suit most common power distribution systems
- CE, UL ${ }^{\oplus}$ pending

The TDX50 Series of Transient Voltage Surge Suppressors for equipment, panel and motor protection applications are specifically designed to provide long life, even under the most adverse over-voltage conditions.

The NEMA-4 weather tight housing allows the TDX to be installed on indoor or outdoor service panels. The preconfigured connecting leads simplify installation. The unique narrow construction allows the SPD to fit between adjacent panel boards. A flush mounting kit is also available for installing the SPD in drywall applications.


Typical installation.

## CRITEC ${ }^{\circledR}$ TDXC Compact Series

## TDX50 Transient Discriminating Panel Protectors

| Model | $\begin{aligned} & \text { TDX50C } \\ & 120 \end{aligned}$ | $\begin{aligned} & \hline \text { TDX50C } \\ & 120 / 240 \\ & \hline \end{aligned}$ | $\begin{array}{\|l} \hline \text { TDX50C } \\ 120 / 208 \end{array}$ | $\begin{aligned} & \hline \text { TDX50C } \\ & 120 / 240 \mathrm{D} \end{aligned}$ | $\begin{aligned} & \hline \text { TDX50C } \\ & 240 \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \text { TDX50C } \\ & 277 / 480 \end{aligned}$ | $\begin{aligned} & \hline \text { TDX50C } \\ & 347 / 600 \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal Voltage $U_{\text {n }}$ (pole) | 120V~ | 120/240V~ | 120/240V~ | 120/240V~ | 240V~ | 277/480V~ | 347/600V~ |
| Distribution System ${ }^{(1)}$ | 1Ph 2W+G | 1Ph 3W+G | 3Ph 4W+G | $3 \mathrm{Ph} \triangle 4 \mathrm{~W}+\mathrm{G}$ | 1Ph 2W+G | $\begin{aligned} & 3 P h ~ 4 W+G \\ & \left(\& 3 W+G^{(2)}\right) \end{aligned}$ | 3Ph 4W+G |
| MCOV Uc | 170V~ | 170/340V~ | 170/295V | 170/340V~ | 275V~ | 310/536V | 480V/830V ~ |
| Stand off Voltage | 240V~ | 240/480V~ | 240/415V~ | 240/415V~ | 415V~ | 480/813V~ | 600V/1040V ~ |
| Frequency | $50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |
| Short Circuit Current Rating | 200kAIC (ISC) |  |  |  |  |  |  |
| Technology Used | TD Technology with thermal disconnect Over-current Replaceable Cartridge Fusing |  |  |  |  |  |  |
| Protection |  |  |  |  |  |  |  |
| Maximum Discharge Current (Imax/per line) | 50kA 8/20 $/ \mathrm{s}$ |  |  |  |  |  |  |
| Nominal Discharge Current (In/per line) | 20kA 8/20 $/ \mathrm{s}$ |  |  |  | 20kA 8/20 $/ \mathrm{s}$ |  |  |
| Protection Modes | All modes protected via L-N, L-G \& N-G |  |  |  |  |  |  |
| Protection Level (L-N) Up @ 3kA | < 450V |  |  |  | < 800V |  | < 450V |
| Protection Level (L-N) Up @ In | < 1.1 kV |  |  |  | < 1.2 kV |  | <900V |
| Alarms and Indicators |  |  |  |  |  |  |  |
| Status Indication | LED status indication per phase, all modes monitored Remote contacts, change-over, 125V~ / 3A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) terminals |  |  |  |  |  |  |
| Physical Data |  |  |  |  |  |  |  |
| Dimensions | $155 \mathrm{~mm} \times 84 \mathrm{~mm} \times 72 \mathrm{~mm}$ (6" $\left.\times 3.25^{\prime \prime} \times 2.875^{\prime \prime}\right)$ |  |  |  |  |  |  |
| Weight | 0.7 kg (1.5 lbs) approx. |  |  |  |  |  |  |
| Enclosure | Aluminum, IP 65 (NEMA-4) |  |  |  |  |  |  |
| Connection | Line: 600 mm of $5.26 \mathrm{~mm}^{2}$ ( $24^{\prime \prime}$ of \# 10 AWG) flying leads Neutral/ Ground: 900 mm of $5.26 \mathrm{~mm}^{2}$ ( $36^{\prime \prime}$ of \# 10 AWG) flying leads |  |  |  |  |  |  |
| Mounting | 3/4" straight nipple Optional flush mounting plate for drywall |  |  |  |  |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |  |  |  |  |  |  |
| Humidity | 0 to 90\% |  |  |  |  |  |  |
| Test Standards |  |  |  |  |  |  |  |
| Approvals | CE, IEC ${ }^{\text {TM }} 61643$-1, UL® 1449 Pending, C-Tick |  |  |  |  |  |  |
| Surge Rated to Meet | IEC 61643-1 Class II, ANSI/IEEE C62.41-1991 Cat A, Cat B, Cat C ANSI/IEEE C62.41.2 Scenario II, Exposure 2, 50kA 8/20 s |  |  |  |  |  |  |

[^24](2) TDX50277/480 can be used on "No Neutral" 480V Wye 3W+G systems.

Due to a policy of continual product development, specifications are subject to change without notice.



## CRITEC ${ }^{\oplus}$ TSG SRF (Single Phase)

## Triggered Spark Gap Surge Reduction Filters



> - Incorporates CRITEC TSG and TD Technologies - high performance protection

- High surge rating - ideal for exposed critical service entrance applications
- Surge Reduction Filters dramatically reduce let-through voltage - provides optimum protection
- Surge Reduction Filters reduce rate-of-voltage rise (dv/dt) - improved protection for electronic equipment
- Small size/weight - aids installation
- Escutcheon panel - improved safety

Triggered Spark Gap Surge Reduction Filters provide high-energy surge diversion, making them ideal for primary service protection applications. The units also provide efficient low pass filtering to substantially reduce the risk of physical equipment damage by reducing the rate-of-voltage rise.

| Model | TSG SRF140 | TSG SRF163 | TSG SRF1125 |
| :---: | :---: | :---: | :---: |
| Nominal Voltage $\mathrm{U}_{\mathrm{n}}$ | 240V |  |  |
| Distribution System | 1Ph 2W+G |  |  |
| System Compatibility | TN-C, TN-S, TN-C-S \& TT |  |  |
| Max. Cont. Operating Voltage $U_{c}$ Stand-off Voltage | 275 V |  |  |
| Frequency | 50/60Hz |  |  |
| Max. Line Current IL | 40A | 63A | 125A |
| Max. Discharge Current $I_{\max }$ | 130kA 8/20رs (NEMA-LS1 per mode) |  |  |
| Impulse Current limp | 50kA 10/350 $\mu \mathrm{s}$ |  |  |
| Protection Modes | All modes protected |  |  |
| Technology | Triggered Spark Gap In-line series low pass sine wave tracking filter 40kA 8/20 $\mathbf{N}$ s tertiary TD Technology MOV protection |  |  |
| Voltage Protection Level Up <br> @ Cat B3, 3kA 8/20 s <br> @ 20kA 8/20hs | $\begin{aligned} & \hline \text { L-N } \\ & <262 \mathrm{~V} \\ & <247 \mathrm{~V} \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { L-N } \\ & <262 \mathrm{~V} \\ & <247 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & \text { L-N } \\ & <413 \text { V } \\ & <392 \mathrm{~V} \end{aligned}$ |
| Filtering @100kHz | -40dB |  |  |
| Status | Primary Protection LED <br> Tertiary Protection LED <br> Change-over contact (Form C dry), 125V/~600mA. 4kV isolation |  |  |
| Dimensions (hxwxd) | $400 \mathrm{~mm} \times 300 \mathrm{~mm} \times 170 \mathrm{~mm}$ (15.7" $\left.\times 11.8^{\prime \prime} \times 6.7^{\prime \prime}\right)$ approx. |  |  |
| Weight | $11 \mathrm{~kg} \mathrm{(24} \mathrm{lb)} \mathrm{approx}$. |  | 13 kg (281b) app |
| Enclosure | Metal, IP55 (NEMA-12) |  |  |
| Heat Dissipation @ I | 13W | 13W | 19W |
| Connection Input Output | $\begin{aligned} & \leq 50 \mathrm{~mm}^{2}(1 / 0 A W G) \\ & \leq 35 \mathrm{~mm}^{2}(\# 2 \mathrm{AWG}) \end{aligned}$ |  | 8 mm stud <br> 8 mm stud |
| Mounting | Wall mount |  |  |
| Back-up Overcurrent Protection | See table |  | 125A |
| Temperature | $0^{\circ} \mathrm{C}$ to $+40^{\circ} \mathrm{C}\left(-32^{\circ} \mathrm{F}\right.$ to $\left.+104^{\circ} \mathrm{F}\right)$ |  |  |
| Humidity | 0\% to 90\% |  |  |
| Approvals | AS3100, C-Tick, Certificate of Suitability |  |  |
| Surge Rated to Meet | ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C ANSI/IEEE C62.41.2 Scenario II, Exposure 3, 100kA 8/20 s , 10kA 10/350 $\mu \mathrm{s}$ |  |  |



Back-up overcurrent protection for 40A and 63A rated units

| Supply <br> Rating | Min. Circuit <br> Breaker Rating | Min. Fuse <br> Rating |
| :--- | :--- | :--- |
| $500 \mathrm{~A}(<10 \mathrm{kAIC})$ | 100 A | 40 A |
| $750 \mathrm{~A}(<15 \mathrm{kAIC})$ | 100 A | 63 A |
| $1000 \mathrm{~A}(<20 \mathrm{kAIC})$ | 125 A | 80 A |
| $2000 \mathrm{~A}(<43 \mathrm{kAIC})$ | 160 A | 100 A |

## CRITEC ${ }^{\oplus}$ TSG SRF (Three Phase)

Asia/Australia
Triggered Spark Gap Surge Reduction Filters


- Incorporates CRITEC TSG and TD Technologies - high performance protection
- High surge rating - ideal for exposed critical service entrance applications
- Surge Reduction Filters dramatically reduce let-through voltages - provides optimum protection
- Surge Reduction Filters reduce rate-of-voltage rise (dv/dt) - improved protection for electronic equipment
- Small size/weight - aids installation
- Escutcheon panel - improved safety

Triggered Spark Gap Surge Reduction Filters provide high-energy surge diversion, making them ideal for primary service protection applications. The units also provide efficient low-pass filtering to substantially reduce the risk of physical equipment damage by reducing the rate-of-voltage rise.

The high-energy diversion ability of the spark gap has allowed the size and weight of the units to be considerably reduced.


## CRITEC ${ }^{\ominus}$ TSG



The TSG is a vented spark gap with triggering circuit that typically allows let-through voltage of less than 1500 V to be achieved. The superior follow current performance allows the TSG to be used on
"active" circuits such as L-L, L-N, L-PE as well as N-PE. The high surge rating is ideal for Neutral-Earth bonding of TT power systems, as per IEC 60364-5-534.



- Triggering air gap technology provides low let-through voltage - offers superior protection compared to traditional spark gaps
- Effective equipotential bonding - provides N-PE equilization protection bond on TT power distribution systems
- Meets IEC ${ }^{\text {SM }}$ 61643-1 test class I, II
- Can be used L-PE, or L-N due to follow current control

(1) Should not be connected in all modes of these systems. Refer to Power Distribution Systems and SPD Installation, Pages 11-12

Back-up overcurrent protection for non N-PE applications:

| Supply <br> Rating | Min. Circuit <br> Breaker Rating | Min. Fuse <br> Rating |
| :--- | :--- | :--- |
| $500 \mathrm{~A}(<10 \mathrm{kAIC})$ | 100 A | 40 A |
| $750 \mathrm{~A}(<15 \mathrm{kAIC})$ | 100 A | 63 A |
| $1000 \mathrm{~A}(<20 \mathrm{kAIC})$ | 125 A | 80 A |
| $2000 \mathrm{~A}(<43 \mathrm{kAIC})$ | 160 A | 100 A |

## Spark Gap Diverter



- Effective equipotential bonding - provides N-E protection bond on TT power distribution systems
- SGD1100 meets IEC ${ }^{\text {SM }}$ 61643-1 test class I, II
- SGD112 provides compact modular unit with remote contacts

The SGD1100 spark gap surge diverter has been specifically designed to provide equipotential bonding between the Neutral and Earth terminals of TT power distribution systems, as per IEC-60364-5-534. Its high surge rating makes it suitable to IEC zones 0A-1 and VDE classification B locations.

The SGD112 spark gap surge diverter is a compact modular SPD for applications where the lower surge ratings are acceptable.

| Model | SGD1100 2S NE | SGD112 1S NE |
| :---: | :---: | :---: |
| Item Number for Europe | 702400 | 702402 |
| System Compatibility | TN-S, TN-C-S \& TT for N-PE applications |  |
| Max. Cont. Operating Voltage Uc | 255 V |  |
| Frequency | 50/60Hz |  |
| Operating Current @ Un | $<0.5 \mathrm{~mA}$ |  |
| Max. Discharge Current $\mathrm{I}_{\text {max }}$ | 140kA 8/20رs | 40kA 8/20us |
| Impulse Current limp | 100kA 10/350 ${ }^{\text {s }}$ | 12kA 10/350 ${ }^{\text {s }}$ |
| Protection Modes | N-PE |  |
| Technology | Encapsulated Spark Gap |  |
| Short Circuit Current Rating $\mathrm{Isc}_{\text {c }}$ | 25kA |  |
| Follow Current Extinguishing Capability If | 200A @ Un | 100A@ Un |
| $\begin{aligned} & \text { Voltage Protection Level } U_{p} \\ & @ l_{n} \\ & @ l_{\text {imp }} \\ & \hline \end{aligned}$ | $\begin{aligned} & <1.2 \mathrm{kV} \\ & <0.6 \mathrm{kV} \end{aligned}$ | <1.6kV |
| Dimensions | $2 \mathrm{M} .90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 36 \mathrm{~mm}$ (3.5" $\times 2.6^{\prime \prime} \times 1.4^{\text {" }}$ ) approx. | $1 \mathrm{M}, 90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 17.5 \mathrm{~mm}$ (3.5" $\times 2.6^{\prime \prime} \times 0.68^{\prime \prime}$ ) approx. |
| Weight | $0.3 \mathrm{~kg}(0.66 \mathrm{lb})$ approx. | $0.12 \mathrm{~kg}(0.26 \mathrm{lb})$ approx. |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |  |
| Connection | $\leq 35 \mathrm{~mm}^{2}$ (\#2AWG) solid $\leq 25 \mathrm{~mm}^{2}$ (\#3AWG) stranded |  |
| Mounting | 35 mm top hat DIN rail |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |  |
| Humidity | 0\% to 90\% |  |
| Approvals | IEC 61643-1, CE |  |
| Surge Rated to Meet | IEC 61643-1 Class I, Class II ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C ANSI/IEEE C62.41.2 Scenario II, Exposure 3, 100kA 8/20 $\mathrm{\mu s}$, 10kA 10/350 $\mu \mathrm{s}$ | IEC 61643-1 Class II ANSIIIEEE C62.41.2 Cat A, Cat B, Cat C ANSI/IEEE C62.41.2 Scenario II, Exposure 1, 20kA 8/20нs |
| Replacement Module Module Item Number (Europe) |  | $\begin{aligned} & \text { SGD112 M } \\ & 702403 \end{aligned}$ |

(1) Should not be connected in all modes of these systems. Refer to Power Distribution Systems and SPD Installation, Pages 11-12


## TDS Surge Diverter - TDS1100 Series



- CRITEC ${ }^{\circledR}$ TD Technology with thermal disconnect protection
- Compact design fits into DIN distribution panel boards and motor control centers
- 35 mm DIN rail mount - DIN 43880 profile matches common circuit breakers
- Indication flag and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates replacement of a failed surge module
- 100kA 8/20 maximum surge rating provides protection suitable for sub-distribution panels and a long operational life
- Available in various operating voltages to suit most common power distribution systems

Surges and voltage transients are a major cause of expensive electronic equipment failure and business disruption. Damage may result in the loss of capital outlays, such as computers and communications equipment, as well as consequential loss of revenue and profits due to unscheduled system down-time.
The TDS1100 series of surge suppressors provide economical and reliable protection from voltage transients on power distribution systems. They are conveniently packaged for easy installation on 35 mm DIN rail within main distribution panelboards.

CRITEC ${ }^{\circledR}$ TD technology helps ensure reliable and continued operation during sustained and abnormal over-voltage events. Internal thermal disconnect devices help ensure safe or at end-of-life. A visual indicator flag provides user-feedback in the event of such operation. As standard, the TDS1100 provides a set of voltage-free contacts for remote signaling that maintenance is due.
The convenient plug-in module and separate base design facilitates replacement of a failed surge module without needing to undo installation wiring.

| Model | TDS11002SR150 | TDS11002SR240 | TDS11002SR277 | TDS11002SR560 |
| :---: | :---: | :---: | :---: | :---: |
| Nominal Voltage $U_{n}$ | 120-150V~ | 220-240V~ | 240-277V~ | 480-560V~ |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{c}}$ | 170V~ | 275V~ | 320V~ | 610V~ |
| Stand off Voltage | 240V~ | 440V~ | 480V~ | 700V~ |
| Frequency | 0-100Hz |  |  |  |
| Short Circuit Current Rating Isc | 25kAIC |  |  |  |
| Required Back-up Fuse | 125AgL, if supply > 100A |  |  |  |
| Technology Used | TD with thermal disconnect |  |  |  |
| Protection |  |  |  |  |
| Maximum Discharge Current Imax | 100kA 8/20رs |  |  |  |
| Nominal Discharge Current In | 50kA 8/20رs | 40kA 8/20رs | 40kA 8/20رs | 40kA 8/20رs |
| Protection Modes | Single mode (L-G, L-N or N-G) |  |  |  |
| Voltage Protection Level Up @ 3kA | < 400V | < 700V | < 800V | < 1.6 kV |
| Voltage Protection Level Up @ 20kA | < 650 | < 1000 | $<1.1 \mathrm{kV}$ | <2kV |
| Alarms and Indicators |  |  |  |  |
| Status Indication | Mechanical flag / remote contacts ( R model only) Change-over, 250V~ / 0.5A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) terminals |  |  |  |
| Physical Data |  |  |  |  |
| Dimensions | 2 modules wide, $90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 35 \mathrm{~mm}$ |  |  |  |
| Weight | 0.24 kg approx. |  |  |  |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |  |  |  |
| Connection | $\begin{aligned} & \leq 35 \mathrm{~mm}^{2} \text { (\#2AWG) solid } \\ & \leq 25 \mathrm{~mm}^{2} \text { (\#4AWG) stranded } \end{aligned}$ |  |  |  |
| Mounting | 35 mm top hat DIN rail |  |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |  |  |  |
| Humidity | 0 to 90\% |  |  |  |
| Test Standards |  |  |  |  |
| Approvals | CE, IEC ${ }^{\text {TM }}$ 61643-1, UL® 1449 Pending |  |  |  |
| Surge Rated to Meet | IEC 61643-1 Class I and II ANSI/IEEE C62.41-1991 Cat A, Cat B, Cat C |  |  |  |

Due to a policy of continual product development, specifications are subject to change without notice.

## CRITEC ${ }^{\circ}$ TDS150

## TDS Surge Diverter - TDS150 Series



- CRITEC ${ }^{\circledR}$ TD Technology with thermal disconnect protection
- Compact design fits into DIN distribution panelboards and motor control centers
- 35 mm DIN rail mount - DIN 43880 profile matches common circuit breakers
- Indication flag and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates replacement of a failed surge module
- 50kA $8 / 20$ maximum surge rating provides protection suitable for sub-distribution panels and a long operational life
- Available in various operating voltages to suit most common power distribution systems

Surges and voltage transients are a major cause of expensive electronic equipment failure and business disruption. Damage may result in the loss of capital outlays, such as computers and communications equipment, as well as consequential loss of revenue and profits due to unscheduled system down-time.
The TDS150 series of surge suppressors provide economical and reliable protection from voltage transients on power distribution systems. They are conveniently packaged for easy installation on 35 mm DIN rail within main distribution panelboards.

CRITEC ${ }^{\circledR}$ TD technology helps ensure reliable and continued operation during sustained and abnormal over-voltage events. Internal thermal disconnect devices help ensure safe or at end-of-life. A visual indicator flag provides user-feedback in the event of such operation. As standard, the TDS150 provides a set of voltage-free contacts for remote signaling that maintenance is due.
The convenient plug-in module, and separate base design, facilitates replacement of a failed surge module without needing to undo installation wiring.

| Model | TDS1501SR150 | TDS1501SR240 | TDS1501SR277 | TDS1501SR560 |
| :---: | :---: | :---: | :---: | :---: |
| Nominal Voltage Un | 120-150V~ | 220-240V~ | 240-277V~ | 480-560V~ |
| Max. Cont. Operating Voltage Uc | 170V~ | 275V~ | 320V~ | 610V~ |
| Stand off Voltage | 240V~ | 440V~ | 480V~ | 700V~ |
| Frequency | 0-100Hz |  |  |  |
| Short Circuit Current Rating Isc | 25kAIC |  |  |  |
| Required Back-up Fuse | 125AgL, if supply > 100A |  |  |  |
| Technology Used | TD with thermal disconnect |  |  |  |
| Protection |  |  |  |  |
| Maximum Discharge Current Imax | 50kA 8/20رs |  |  |  |
| Nominal Discharge Current In | 25kA 8/20رs | 20kA 8/20رs | 20kA 8/20رs | 20kA 8/20رs |
| Protection Modes | Single mode (L-G, L-N or N-G) |  |  |  |
| Voltage Protection Level Up @ 3kA | < 400V | < 700V | < 850V | < 1.7kV |
| Voltage Protection Level Up @ In | < 800V | $<1.1 \mathrm{kV}$ | < 1.2 kV | < 2.2 kV |
| Alarms and Indicators |  |  |  |  |
| Status Indication | Mechanical flag / remote contacts Change-over, 250V~ / 0.5A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) terminals |  |  |  |
| Physical Data |  |  |  |  |
| Dimensions | 1 module wide, $90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 17.5 \mathrm{~mm}$ |  |  |  |
| Weight | 0.12 kg approx. |  |  |  |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |  |  |  |
| Connection | $\begin{aligned} & \leq 35 \mathrm{~mm}^{2} \text { (\#2AWG) solid } \\ & \leq 25 \mathrm{~mm}^{2} \text { (\#4AWG) stranded } \end{aligned}$ |  |  |  |
| Mounting | 35 mm top hat DIN rail |  |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |  |  |  |
| Humidity | 0 to 90\% |  |  |  |
| Test Standards |  |  |  |  |
| Approvals | CE, IEC ${ }^{\text {TM }}$ 61643-1, UL ${ }^{\text {® }} 1449$ Pending |  |  |  |
| Surge Rated to Meet | IEC 61643-1 Class II <br> ANSI/IEEE C62.41-1991 Cat A, Cat B, Cat C |  |  |  |

[^25]
## CRITEC ${ }^{\circ}$ TDS350

## TDS Multi Phase Surge Diverter Series



Surges and voltage transients are a major cause of expensive electronic equipment failure and business disruption. Damage may result in the loss of capital outlays, such as computers and communications equipment, as well as consequential loss of revenue and profits due to unscheduled system down-time.
The TDS series of surge suppressors provide economical and reliable protection from voltage transients on power distribution systems. They are conveniently packaged for easy installation on 35 mm DIN rail within main distribution panelboards.

- CRITEC ${ }^{\circledast}$ TD Technology with thermal disconnect protection
- Compact design fits into DIN distribution panelboards and motor control centers
- 35 mm DIN rail mount - DIN 43880 profile matches common circuit breakers
- Indication flag and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates replacement of a failed surge module
- 50kA $8 / 20$ maximum surge rating provides protection suitable for sub-distribution panels and a long operational life
- Available in various operating voltages to suit most common power distribution systems


Due to a policy of continual product development, specifications are subject to change without notice.

## CRITEC ${ }^{\circledR}$ DSD1150 (150kA)

## DIN Surge Diverter



The DSD1150 series of surge suppressors provide economical and reliable protection to primary distribution panel boards and power distribution systems. They are intended for locations classified for devices tested to IEC61643-1 test class I (or VDE classification B). Internal thermal disconnect devices ensure safe isolation during
sustained and abnormal events on the distribution network, or at end-of-life. A visual indicator flag provides user-feedback in the event of such operation. In addition, a set of voltage-free contacts is provided for remote signaling if replacement is due.

| Model | DSD1150 2SR 275 |
| :---: | :---: |
| Item Number for Europe | 702420 |
| Nominal Voltage $U_{n}$ | 220-240V |
| System Compatibility ${ }^{(1)}$ | TN-C, TN-S, TN-C-S \& TT |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{c}}$ | 275V 350V=- |
| Frequency | 0 to 60Hz |
| Operating Current @ Un | <1mA |
| Nom. Discharge Current $\mathrm{I}_{\mathrm{n}}$ | 70kA 8/20 $/ \mathrm{s}$ |
| Max. Discharge Current $I_{\max }$ | 150kA 8/20رs |
| Impulse Current limp | 25kA 10/350 $/ \mathrm{s}$ |
| Protection Modes | Single mode |
| Technology | MOV with thermal disconnect |
| Short Circuit Current Rating $\mathrm{I}_{\text {sc }}$ | 25kA |
| Voltage Protection Level $U_{p}$ <br> @ Cat B3, 3kA 8/20 $\mu$ <br> @ $I_{n}$ | $\begin{aligned} & <850 \mathrm{~V} \\ & <1.6 \mathrm{kV} \end{aligned}$ |
| Status | Mechanical flag <br> Change-over contact (Form C Dry) 250V~/0.5A, max $1.5 \mathrm{~mm}^{2}$ <br> (\#14 AWG) connecting wire |
| Dimensions | 2 M. $90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 36 \mathrm{~mm}\left(3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 1.4\right.$ " $)$ approx. |
| Weight | 0.33 kg (0.76 lb) approx. |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |
| Connection | $\begin{aligned} & \leq 35 \mathrm{~mm}^{2} \text { (\#2AWG) solid } \\ & \leq 25 \mathrm{~mm}^{2} \text { (\#4AWG) stranded } \end{aligned}$ |
| Mounting | 35 mm top hat DIN rail |
| Back-up Overcurrent Protection | 250 Agl if supply $>250 \mathrm{~A}$ |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |
| Humidity | 0\% to 90\% |
| Approvals | IEC 61643-1, CE |
| Surge Rated to Meet | IEC 61643-1 Class I, Class II <br> ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C <br> ANSI/IEEE C62.41.2 Scenario II, Exposure 3, 100kA 8/20 s , 10kA 10/350 H |



[^26]
## DIN Surge Diverter



The DSD160 series of surge suppressors provide economical and reliable protection to sub-distribution panel boards. The convenient plug-in module and separate base design facilitates replacement of a failed surge module without needing to undo installation wiring. Internal thermal disconnect devices ensure safe isolation during
sustained and abnormal events on the distribution network, or at end-of-life. Visual indicator flags show $100 \%$ and $50 \%$ status with voltage-free contacts provide user-feedback in the event of reduction of capacity.

| Model | DSD160 1SR 275 |
| :---: | :---: |
| Item Number for Europe | 702460 |
| Nominal Voltage $U_{n}$ | 220-240V |
| System Compatibility ${ }^{(1)}$ | TN-C, TN-S, TN-C-S \& TT |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{C}}$ | 275V ~ 350V=-- |
| Frequency | 0 to 60Hz |
| Operating Current @ Un | $<1 \mathrm{~mA}$ |
| Max. Discharge Current $I_{\text {max }}$ | 60kA 8/20 $/$ |
| Nom. Discharge Current $\mathrm{I}_{n}$ | 30kA 8/20 $\mu \mathrm{s}$ |
| Impulse Current limp | 5kA 10/350رs |
| Protection Modes | Single mode |
| Technology | MOV with thermal disconnect |
| Short Circuit Current Rating $\mathrm{I}_{\text {Sc }}$ | 25kA |
| Voltage Protection Level $U_{p}$ <br> Cat B3, 3kA $8 / 20 \mu \mathrm{~s}$ © | $\begin{aligned} & <850 \mathrm{~V} \\ & <1.5 \mathrm{kV} \end{aligned}$ |
| Status | Mechanical flag with progressive indication Change-over contact (Form C dry) 250V~/0.5A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) connecting wire |
| Dimensions | $1 \mathrm{M}, 90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 17.5 \mathrm{~mm}\left(3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 0.68^{\prime \prime}\right)$ approx. |
| Weight | $0.12 \mathrm{~kg}(0.26 \mathrm{lb})$ approx. |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |
| Connection | $\leq 35 \mathrm{~mm}^{2}$ (\#2AWG) solid $\leq 25 \mathrm{~mm}^{2}$ (\#4AWG) stranded |
| Mounting | 35 mm top hat DIN rail |
| Back-up Overcurrent Protection | 160 Agl if supply $>160 \mathrm{~A}$ |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |
| Humidity | 0\% to 90\% |
| Approvals | IEC 61643-1, CE |
| Surge Rated to Meet | IEC 61643-1 Class I, Class II <br> ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C <br> ANSI/IEEE C62.41.2 Scenario II, Exposure 2, 50kA 8/20 1 s |
| Replacement Module Module Item Number for Europe | $\begin{aligned} & \text { DSD160 1SR 275M } \\ & 702465 \end{aligned}$ |


(1) Should not be connected in all modes of these systems. Refer Power to Distribution Systems and SPD Installation, Pages 11-12

## DIN Surge Diverter



The DSD140 series of surge suppressors provide economical protection to sub-distribution panel boards in locations classified for devices tested to IEC61643-1 test Class II (or VDE classification C). The convenient plug-in module and separate base design facilitates replacement of a failed surge module without needing to undo installation wiring.

- 35 mm DIN 43880 profile - matches common circuit breakers
- Indication flag - provide clear visual indication of life status
- Remote contacts (R models) - provide remote status monitoring
- 40kA 8/20 maximum surge rating provides protection suitable for sub-distribution panels and a long operational life
- Various operating voltages - to suit most common power distribution systems

| Model | $\begin{array}{\|l} \hline \text { DSD140 1S } 150 \\ \text { DSD140 1SR 150* } \\ \hline \end{array}$ | $\begin{aligned} & \text { DSD140 1S } 275 \\ & \text { DSD140 1SR 275* } \end{aligned}$ | DSD140 1SR 440* |
| :---: | :---: | :---: | :---: |
| Item Number for Europe | $\begin{aligned} & 702480 \\ & 702510 \end{aligned}$ | $\begin{aligned} & 702491 \\ & 702521 \end{aligned}$ | 702530 |
| Nominal Voltage Un | 120 V | 220-240V |  |
| System Compatibility ${ }^{(1)}$ | TN-C, TN-S, TN-C-S \& TT |  |  |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{c}}$ | 150V~200V- | 275V ~ 350V- | 440V~580V- |
| Frequency | 0 to 60Hz |  |  |
| Operating Current @ Un | $<1 \mathrm{~mA}$ |  |  |
| Max. Discharge Current $\mathrm{I}_{\text {max }}$ | 40kA 8/20 $\mu \mathrm{s}$ |  |  |
| Nom. Discharge Current In | 20kA 8/20 $\mu \mathrm{s}$ |  |  |
| Protection Modes | Single mode |  |  |
| Technology | MOV with thermal disconnect |  |  |
| Short Circuit Current Rating $\mathrm{I}_{\text {sc }}$ | 25kA |  |  |
| Voltage Protection Level Up <br> @ Cat B3, 3kA $8 / 20 \mu \mathrm{~s}$ <br> @ 5kA 8/20 <br> @ In | $\begin{aligned} & <480 \mathrm{~V} \\ & <550 \mathrm{~V} \\ & <0.7 \mathrm{kV} \end{aligned}$ | $\begin{aligned} & <850 \mathrm{~V} \\ & <1 \mathrm{kV} \\ & <1.4 \mathrm{kV} \end{aligned}$ | $\begin{aligned} & <1.4 \mathrm{kV} \\ & <1.75 \mathrm{kV} \\ & <2.2 \mathrm{kV} \end{aligned}$ |
| Status | Mechanical flag <br> *"́ㅡ" units only: Change-over contact (Form C dry) 250V~/0.5A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) connecting wire |  |  |
| Dimensions | $1 \mathrm{M}, 90 \times 68 \times 17.5 \mathrm{~mm}\left(3.5 \times 2.6 \times 0.68{ }^{\text {" }}\right)$ approx. |  |  |
| Weight | $0.12 \mathrm{~kg}(0.26 \mathrm{lb})$ approx. |  |  |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |  |  |
| Connection | $\begin{aligned} & \leq 35 \mathrm{~mm}^{2} \text { (\#2AWG) solid } \\ & \leq 25 \mathrm{~mm}^{2} \text { (\#4AWG) stranded } \end{aligned}$ |  |  |
| Mounting | 35 mm top hat DIN rail |  |  |
| Back-up Overcurrent Protection | 125 Agl if supply $>125 \mathrm{~A}$ |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |  |  |
| Humidity | 0\% to 90\% |  |  |
| Approvals | IEC 61643-1, CE |  |  |
| Surge Rated to Meet | IEC 61643-1 Class II <br> ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C <br> ANSI/IEEE C62.41.2 Scenario II, Exposure 1, 20kA 8/20 $\mu \mathrm{s}$ |  |  |
| Replacement Module Module Item Number for Europe | $\begin{aligned} & \text { DSD140M150 } \\ & 702436 \end{aligned}$ | $\begin{aligned} & \text { DSD140M275 } \\ & 702496 \end{aligned}$ | $\begin{aligned} & \text { DSD140M440 } \\ & 702506 \end{aligned}$ |

Contacts provided on " $R$ " models

(1) Should not be connected in all modes of these systems. Refer to Power Distribution Systems and SPD Installation, Pages 11-12

A visual indicator flag provides user-feedback if the internal thermal disconnector operates. The "R" series provides a set of voltagefree contacts for remote signaling that maintenance is due.


The DSD340 series of surge suppressors provide economical protection to sub-distribution panel boards in locations classified for devices tested to IEC61643-1 test Class II (or VDE Classification C). The single module units conveniently protect three phase systems with TNC, TNS and TT options.

- 35 mm DIN 43880 profile - matches common circuit breakers
- Indication flags - provide clear visual indication of life status
- Remote contacts - provide remote status monitoring
- 40kA 8/20 maximum surge ratings provide protection suitable for sub-distribution panels and a long operational life
- Various operating voltages - to suit most common power distribution systems

| Model | $\begin{array}{\|l} \hline \text { DSD340 } \\ \text { TNC275A } \\ \hline \end{array}$ | $\begin{aligned} & \text { DSD340 } \\ & \text { TNS275A } \end{aligned}$ | $\begin{aligned} & \text { DSD340 } \\ & \text { TT275A } \end{aligned}$ |
| :---: | :---: | :---: | :---: |
| Item Number | 702581 | 702591 | 702601 |
| Nominal Voltage $U_{n}$ | 220/380V-240/415V |  |  |
| System Compatibility | TNC | TNS | TT |
| Max. Cont. Operating Voltage $U_{c}$ | 275V ~ 350V=- |  |  |
| Frequency | 0 to 60Hz |  |  |
| Operating Current @ Un | $<1 \mathrm{~mA}$ |  |  |
| Max. Discharge Current $I_{\text {max }}$ | 40kA 8/20 $/$ s (per mode) |  |  |
| Nom. Discharge Current $\mathrm{In}_{n}$ | 20kA 8/20 ${ }^{\text {s }}$ (per mode) |  |  |
| Impulse Current limp | 5kA 10/350 ${ }^{\text {s }}$ (per mode) |  |  |
| Protection Modes | L-PE | L-PE \& N-PE | L-N \& N-PE |
| Technology | $\begin{aligned} & \mathrm{MOV} \\ & (3+0) \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { MOV } \\ & (4+0) \end{aligned}$ | $\begin{aligned} & \text { MOV. GDT } \\ & \text { N-PE }(3+1) \end{aligned}$ |
| Short Circuit Rating Isc | 25kA |  |  |
| Voltage Protection Level Up <br> @ Cat B3, 3kA 8/20 H <br> (1n | $\begin{aligned} & <850 \mathrm{~V} \\ & <1.4 \mathrm{kV} \end{aligned}$ | $\begin{aligned} & \text { L-PE } \\ & <850 \mathrm{~V} \\ & <1.4 \mathrm{kV} \end{aligned}$ | $\begin{aligned} & \mathrm{L}-\mathrm{N} \\ & <850 \mathrm{~V} \\ & <1.4 \mathrm{kV} \end{aligned}$ |
| Status | Mechanical flag Change-over contact (Form C dry), 250V~/0.5A, max $1.5^{2}$ (\#14AWG) con |  |  |
| Dimensions (Approx.) | $3 \mathrm{M} .90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 54 \mathrm{~mm}\left(3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 2.1^{\prime \prime}\right)$ approx. 4 M. $90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 72 \mathrm{~mm}\left(3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 2.8^{\prime \prime}\right)$ approx. |  |  |
| Weight (Approx.) | $0.4 \mathrm{~kg}(0.88 \mathrm{lb})$ |  |  |
| Enclosure Connection | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) $\leq 35 \mathrm{~mm}^{2}$ (\#2AWG) solid $\leq 25 \mathrm{~mm}^{2}$ (\#4AWG) stranded |  |  |
| Mounting | 35 mm top hat DIN rail |  |  |
| Back-up Overcurrent Protection | 125Agl if supply > 125A |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |  |  |
| Humidity | 0\% to 90\% |  |  |
| Approvals | IEC 61643-1, CE |  |  |
| Surge Rated to Meet | IEC 61643-1 Class II <br> ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C <br> ANSI/IEEE C62.41.2 Scenario II, Exposure 2, 50kA 8/20 $\mu \mathrm{s}, 5 \mathrm{kA} 10 / 350 \mu \mathrm{~s}$ |  |  |
| Replacement MOV Module | $\begin{aligned} & \text { DSD140M275 } \\ & 702496 \end{aligned}$ |  |  |
| Replacement GDT Module | $\begin{aligned} & \text { SGD112M } \\ & 702403 \end{aligned}$ |  |  |



TNS Configuration


TT Configuration

## CRITEC® DSD110 (10kA)

## DIN Surge Diverter



The DSD110 series of surge suppressors provide economical protection to small sub-distribution panel boards or locations classified for devices tested to IEC61643-1 test Class II or III (or VDE classification D). They are also ideal for the installation in wiring termination boxes at the equipment's final point-of-use.

- 35 mm DIN 43880 profile - matches common circuit breakers
- Indication flag - provide clear visual indication of life status
- 10kA 8/20 maximum surge rating - provides protection suitable for small sub-distribution panels or point-of-use applications
- Various operating voltages - to suit most common power distribution systems

| Model | DSD110 1S 275 |
| :---: | :---: |
| Item Number for Europe | 702560 |
| Nominal Voltage Un | 220-240V |
| System Compatibility ${ }^{(1)}$ | TN-S, TN-C, TN-S-C \& TT |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{c}}$ | 275V ~ 350V=-= |
| Frequency | 0 to 60Hz |
| Operating Current @ Un | $<1 \mathrm{~mA}$ |
| Max. Discharge Current $\mathrm{I}_{\max }$ | 10kA 8/20 $\mu \mathrm{s}$ |
| Nom. Discharge Current In | 5kA 8/20 ${ }^{\text {s }}$ |
| Protection Modes | Single mode |
| Technology | MOV with thermal |
| Short Circuit Current Rating $\mathrm{I}_{\text {sc }}$ | 25kA |
| Voltage Protection Level $U_{p}$ <br> @ Cat B3, 3kA 8/20 1 s <br> @ In | $\begin{aligned} & <930 \mathrm{~V} \\ & <1.0 \mathrm{kV} \end{aligned}$ |
| Status | Mechanical flag |
| Dimensions | $1 \mathrm{M}, 90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 17.5 \mathrm{~mm}\left(3.5 \times 2.6 \times 0.68{ }^{\prime \prime}\right)$ approx. |
| Weight | $0.12 \mathrm{~kg}(0.26 \mathrm{lb})$ approx. |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |
| Connection | $\begin{aligned} & \leq 35 \mathrm{~mm}^{2} \text { (\#2AWG) solid } \\ & \leq 25 \mathrm{~mm}^{2} \text { (\#4AWG) stranded } \end{aligned}$ |
| Mounting | 35 mm top hat DIN rail |
| Back-up Overcurrent Protection | 100Agl if supply $>100 \mathrm{~A}$ |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |
| Humidity | 0\% to 90\% |
| Approvals | IEC 61643-1, CE |
| Surge Rated to Meet | IEC 61643-1 Class III ANSI/IEEE C62.41.2 Cat A, Cat B |
| Replacement Module Module Item Number for Europe | $\begin{aligned} & \text { DSD110M275 } \\ & 702566 \end{aligned}$ |

(1) Should not be connected in all modes of these systems. Refer to Power Distribution Systems and SPD Installation, Pages 11-12

The convenient plug-in module and separate base design facilitates replacement of a failed surge module without the need to undo installation wiring.

## CRITEC ${ }^{\oplus}$ TDF

## Transient Discriminating Filter



## - In-line series protection

- High efficiency low pass sine wave filtering - ideal for the protection of switched mode power supplies
- Three modes of protection: L-N, L-PE \& N-PE
- 35 mm DIN rail mount - simple installation
- Transient Discriminating (TD) Technology provides increased service life
- LED status indication and opto-isolated output for remote status monitoring

The TDF series has been specifically designed for process control applications to protect the switched mode power supply units on devices such as PLC controllers, SCADA systems and motor controllers. Units are UL® Recognized and available for 3A, 10A and 20A loads and suitable for 110-120V ac/dc and 220-240Vac circuits.

The TDF is a series connected, single phase surge filter providing an aggregate surge capacity of $50 \mathrm{kA}(8 / 20 \mu \mathrm{~s})$ across L-N, L-PE, and N-PE. The low pass filter provides up to 65 dB of attenuation to voltage transients. Not only does this reduce the residual let-through voltage, but it also helps further reduce the steep voltage rate-of-rise providing superior protection for sensitive electronic equipment.

| Model | $\begin{aligned} & \text { TDF3A } \\ & 120 \mathrm{~V} \end{aligned}$ | TDF3A <br> 240V | TDF10A $120 \mathrm{~V}$ | TDF10A 240V | $\begin{aligned} & \text { TDF20A } \\ & 120 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & \text { TDF20A } \\ & 240 \mathrm{~V} \\ & \hline \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Item Number for Europe | 700001 | 700002 | 700003 | 700004 | 700005 | 700006 |
| Nominal Voltage $U_{n}$ | 120 V | 240 V | 120V | 240 V | 120 V | 240 V |
| Distribution System | $1 \mathrm{Ph} 2 \mathrm{~W}+\mathrm{G}, \mathrm{TN}$-S \& TN-C-S |  |  |  |  |  |
| Max. Cont. Operating Voltage Uc | 170 V | 340 V | 170V | 340 V | 170V | 340 V |
| Stand-off Voltage | 240V | 400V | 240V | 400 V | 240V | 400 V |
| Frequency | 0 to 60Hz | 50/60Hz | 0 to 60Hz | 0 to 60Hz | 0 to 60Hz | $50 / 60 \mathrm{~Hz}$ |
| Max. Line Current $\mathrm{I}_{\mathrm{L}}$ | 3A |  | 10A |  | 20A |  |
| Operating Current @ Un | 135 mA | 250 mA | 240 mA | 480 mA | 240 mA | 480 mA |
| Max. Discharge Current $I_{\max }$ | 20kA 8/20 $\mu \mathrm{s}$ L-N 20kA 8/20 $\mu \mathrm{s}$ L-PE 10kA $8 / 20 \mu \mathrm{~s}$ N-PE |  |  |  |  |  |
| Protection Modes | All modes protected |  |  |  |  |  |
| Technology | TD Technology <br> In-line series low pass sine wave filter |  |  |  |  |  |
| Voltage Protection Level $U_{p}$ <br> @ 500A, 8/20 $\mu \mathrm{s}$ (UL SVR) <br> @ Cat B3, 3kA 8/20 1 s | $\begin{aligned} & 500 \mathrm{~V} \\ & <250 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 700 \mathrm{~V} \\ & <600 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 500 \mathrm{~V} \\ & <250 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 700 \mathrm{~V} \\ & <600 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 500 \mathrm{~V} \\ & <250 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 700 \mathrm{~V} \\ & <600 \mathrm{~V} \end{aligned}$ |
| Filtering @100kHz | -62dB |  | -65dB |  | -53dB |  |
| Status | Green LED. On=Ok. Isolated opto-coupler output ${ }^{(1)}$ |  |  |  |  |  |
| Dimensions | $4 \mathrm{M} .90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 72 \mathrm{~mm}$ $8 \mathrm{M} .90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 144 \mathrm{~mm}$ <br> $\left(3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 2.8^{\prime \prime}\right)$ $\left(3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 5.6^{\prime \prime}\right)$ |  |  |  |  |  |
| Weight | $0.35 \mathrm{~kg}(0.77 \mathrm{lb}) \quad 0.75 \mathrm{~kg}(0.77 \mathrm{lb})$ |  |  |  | $0.8 \mathrm{~kg}(1.7 \mathrm{lb})$ |  |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |  |  |  |  |  |
| Connection | $1 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ (\#18AWG to \#10) |  |  |  |  |  |
| Mounting | 35 mm top hat DIN rail |  |  |  |  |  |
| Back-up Overcurrent Protection | 3 A |  | 10A |  | 20A |  |
| Temperature | $-35^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}\left(-31^{\circ} \mathrm{F}\right.$ to $\left.+131^{\circ} \mathrm{F}\right)$ |  |  |  |  |  |
| Humidity | 0\% to 90\% |  |  |  |  |  |
| Approvals | UL 1449, UL 1283, CSA 22.2, C-Tick, CE (NOM 3A, 120V) |  |  |  |  |  |
| Surge Rated to Meet | ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C |  |  |  |  |  |

(1) Opto-coupler output can be connected to DAR275V to provide Form C dry contacts, Page 39

## CRITEC ${ }^{\oplus}$ DSF

## DINLINE Surge Filter



The "two port" DSF series has been specifically designed for process control applications to protect the switched mode power supply units on devices such as PLC controllers, SCADA systems and motor controllers. The 30 V unit is suitable for 12 V and $24 \mathrm{Vac} / \mathrm{dc}$ signaling and control systems.

- In-line series protection
- EMI/RFI noise filtering - protects against industrial electrical noise
- Compact design - fits into motor control and equipment panels
- Three modes of protection: L-N, L-PE \& N-PE
- 35 mm DIN rail mount - simple installation
- LED power indicator

| Model | DSF6A 30V | DSF6A 150V | DSF6A 275V | DSF20A 275V |
| :---: | :---: | :---: | :---: | :---: |
| Item Number for Europe | 702090 | 701000 | 701030 |  |
| Nominal Voltage Un | 24V | 120 V | 240 V |  |
| Distribution System | 1Ph 2W+G |  |  |  |
| System Compatibility | TN-S \& TN-C-S |  |  |  |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{c}}$ | 30V~ 38=- | 150V~ | 275V~ |  |
| Frequency | 0 to 60 Hz | 50/60Hz |  |  |
| Max. Line Current IL | 6 A |  |  | 20A |
| Operating Current @ Un | 7 mA |  |  |  |
| Max. Discharge Current $I_{\text {max }}$ | 4kA 8/20 $/ 5$ per mode | 16kA 8/20 $/ \mathrm{s}$ per mode |  | 15kA 8/20 L L-PE 15kA 8/20 1 L L-N 25kA 8/20 $/$ s N-PE |
| Protection Modes | All modes protected |  |  |  |
| Technology | MOV <br> In-line series filter |  |  |  |
| Voltage Protection Level Up <br> @ Cat B3, 3kA 8/20 s | <110V | <400V | <750V | <710V |
| Filtering | -3dB @ 300kHz |  |  | -3dB @ 62kHz |
| Status | LED power indicator |  |  | Status indicator |
| Dimensions | $\begin{aligned} & 2 \mathrm{M} .90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 36 \mathrm{~mm} \\ & \left(3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 1.4^{\prime \prime}\right) \end{aligned}$ |  |  | $4 \mathrm{M} .90 \mathrm{~mm} x$ $68 \mathrm{~mm} \times 72 \mathrm{~mm}$ (3.5" x $2.6^{\prime \prime} \times 2.8^{\prime \prime}$ ) |
| Weight | $0.2 \mathrm{~kg}(0.44 \mathrm{lb})$ |  |  | $0.7 \mathrm{~kg}(1.5 \mathrm{lb})$ |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |  |  |  |
| Connection | $1 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ (\#18AWG to \#10AWG) |  |  |  |
| Mounting | 35 mm top hat DIN rail |  |  |  |
| Back-up Overcurrent Protection | 6A |  |  | 20A |
| Temperature | $-35^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}\left(-31^{\circ} \mathrm{F}\right.$ to $\left.+131^{\circ} \mathrm{F}\right)$ |  |  |  |
| Humidity | 0\% to 90\% |  |  |  |
| Approvals | CE, C-Tick, NOM | CE, C-Tick |  |  |
| Surge Rated to Meet | ANSI/IEEE C62.41.2 Cat A, Cat B |  |  |  |



The 6A DSF series incorporates a space efficient, low pass, series filter which provides attenuation to high frequency interference. The larger 20A model provides status indication and a higher surge rating, making this ideal for the protection of higher risk equipment.

## DIN Decoupling Inductor/ DINLINE Alarm Relay \& Surge Counter



- Use for decoupling of spark gaps and MOVs - allows correct coordination of different SPD technologies
- $35 \mathrm{~mm}^{2}$ tunnel terminals - accepts large cable size
- 63A model features top and bottom terminals flexible installation
- The DINLINE Alarm Relay (DAR) is used with TDF products where alarm contacts are required for remote signaling
- The TDS-SC Surge Counter provides a non-resettable record of the number of surges diverted

Decoupling inductors are installed between spark gap and MOV protection devices to help ensure correct coordination. As the decoupling inductors are installed in series with the load, two units are available, a compact unit for circuits up to 35A and a larger unit for 63A circuits.

The DAR (DINLINE Alarm Relay) can be connected to TDF units to provide potential free change-over alarm contacts. The TDS SC (Surge Counter) unit is designed to provide visual indication of the number of surges registered. It uses a current transformer through which the ground conductor connecting to one, or all, of the surge protection modules is fed. Current diverted by the operation of the surge module, which exceeds a 300A trip threshold, will be registered on the counter.




DDI 63

| Model | DDI 35 | DDI 63 | DAR275V | TDS SC |
| :---: | :---: | :---: | :---: | :---: |
| Item Number for Europe | 700465 | 700475 | 700900 | 701250 |
| Nominal Voltage Un | - | - | 20-110V---, 100-240V~ | - |
| System Compatibility(1) | - | - | TN-C, TN-S, TN-C-S \& TT |  |
| Max. Cont. Operating Voltage $U_{C}$ | 500V~ 200V--- |  | 275 V | - |
| Stand-off Voltage | - | - | 275 V | - |
| Operating Current @ Un | - | - | 20 mA | - |
| Frequency | 0 to 60 Hz |  |  | - |
| Max. Line Current $\mathrm{I}_{\llcorner }$ | 35 A @ $40^{\circ} \mathrm{C}$ | $63 \mathrm{~A} @ 40^{\circ} \mathrm{C}$ | - | - |
| Temperature Increase | $45^{\circ} \mathrm{C}$ @ max line current ( $\mathrm{I}_{1}$ ) |  | - | - |
| Inductance | $7.5 \mu \mathrm{H}$ | $15 \mu \mathrm{H}$ | - | - |
| Resistance | $4.5 \mathrm{~m} \Omega$ | $1.7 \mathrm{~m} \Omega$ | - | - |
| Technology | - | - | CT - trip threshold 300A 8/20 $/ \mathrm{s}$ |  |
| Status | - | - | Red/Green LEDs Change-over contact ${ }^{(1)}$ | Maximum count 9999 Non-resettable |
| Dimensions | $2 \mathrm{M} .90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 36 \mathrm{~mm}$ ( $3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 1.4$ " $)$ approx. | $4 \mathrm{M} .90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 72 \mathrm{~mm}$ ( $3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 2.8^{\prime \prime}$ ) approx. | 2 M . <br> $90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 36 \mathrm{~mm}$ <br> ( $3.5^{\prime \prime} \times 2.6^{\prime \prime} \times 1.4^{\prime \prime}$ ) |  |
| Weight | 0.45 kg (1 lb) approx. | 1 kg (2.2 lb) approx. | $0.2 \mathrm{~kg}(0.44 \mathrm{lb})$ |  |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |  |  |  |
| Connection | $\leq 35 \mathrm{~mm}^{2}$ (\#2AWG) solid $\leq 25 \mathrm{~mm}^{2}$ (\#4AWG) stranded |  | $1 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ (\#18AWG to \#10) |  |
| Mounting | 35 mm top hat DIN rail |  |  |  |
| Back-up Overcurrent Protection | 35A | 63A | $-{ }^{-}$ | - |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+70^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+158^{\circ} \mathrm{F}\right)$ |  | $-35^{\circ} \mathrm{C}$ to $+55^{\circ} \mathrm{C}\left(-31^{\circ} \mathrm{F}\right.$ to $\left.+131^{\circ} \mathrm{F}\right)$ |  |
| Humidity | 0\% to 90\% |  |  |  |
| Approvals | CE |  | $\begin{aligned} & \text { CSA22.2 } \\ & \text { C-Tick, AS 3260, CE } \end{aligned}$ | - |

[^27]
## CRITEC ${ }^{\circ}$ PLF

## Power Line Filter



PLFs are used to provide the final stage of surge protection to electrical and electronic equipment that connects via AC power plug. The effectiveness of this simple-to-install protection is assured by the virtue of being installed close to the equipment to be protected.

AC equipment which also connects to telephone circuits such as fax machines or computer modems, have special protection requirements. The PLF combination protection provides effective equipotential bonding between the power and data services, which is often not achieved when separate modules are used.

| Model | Model | Description |
| :---: | :---: | :---: |
|  | PLF A 2 | $2 \times$ Australian outlets |
|  | PLF A 2 RJ | $2 \times$ Australian outlets and RJ11 phone |
|  | PLF B 2 | $2 \times$ British outlets |
| Nominal Voltage $U_{n}$ | 230V |  |
| Distribution System | 1Ph 2W+G |  |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{C}}$ | 275 V |  |
| Frequency | $50 / 60 \mathrm{~Hz}$ |  |
| Max. Line Current @ Un | 10A |  |
| Operating Current @ Un | 840 mA |  |
| Leakage Current @ Un | $<0.2 \mathrm{~mA}$ |  |
| Aggregate Surge Rating | 80kA 8/20 $\mu \mathrm{s}$ |  |
| Max. Discharge Current $\mathrm{Imax}^{\text {max }}$ | 20kA $8 / 20 \mu \mathrm{~s}$ L-N20kA $8 / 20 \mu \mathrm{~s}$ L-PE20kA $8 / 20 \mu \mathrm{~s}$ N-PEPLF A 2 RJ Phone protection 20kA $8 / 20 \mu \mathrm{~s}(\mathrm{~L}+\mathrm{L})$-PE |  |
| Protection Modes | All modes protected |  |
| Voltage Protection Level $U_{p}$ <br> @ 500A 100kHz <br> @ Cat B3, 3kA 8/20 s | $\begin{aligned} & 50 \mathrm{~V} \\ & <600 \mathrm{~V} \end{aligned}$ |  |
| Filtering | -3dB @ 8kHz |  |
| Status | LED indicator |  |
| Dimensions | $275 \mathrm{~mm} \times 100 \mathrm{~mm} \times 72 \mathrm{~mm}\left(10 " \times 3.9^{\prime \prime} \times 2.8^{\prime \prime}\right)$ approx. $320 \mathrm{~mm} \times 100 \mathrm{~mm} \times 72 \mathrm{~mm}\left(12.5^{\prime \prime} \times 3.9^{\prime \prime} \times 2.8^{\prime \prime}\right)$ with phone protection |  |
| Weight | 1.5 kg ( 3.3 lb ) approx. |  |
| Enclosure | Aluminum |  |
| Connection | Power Cord, 2 m (6') |  |
| Mounting | Portable or wall mount |  |
| Temperature | $-25^{\circ} \mathrm{C}$ to $+70^{\circ} \mathrm{C}\left(13^{\circ} \mathrm{F}\right.$ to $\left.158^{\circ} \mathrm{F}\right)$ |  |
| Humidity | 0\% to 90\% |  |
| Approvals | Australian Power Authority approved |  |
| Surge Rated to Meet | ANSI/IEEE C62.41.2 Cat A, B, C |  |






- General purpose barrier - protection of low voltage circuits and transducers
- Separate plug and base design - facilitates ease of module replacement.
- 3 stage protection - fine over-voltage protection, helps ensure lowest residual surge voltages reach sensitive equipment
- Common-mode and differential-mode protection - protects against both possible surge conditions
- Ease of grounding - through DIN mounting rail or via terminal
- Surge rating to 20kA $8 / 20$ - ideal for exposed wiring
- Versions for use in hazardous areas
- EX series for use in intrinsically safe areas

The UTB series provides transient protection for equipment from surges induced onto balanced pair signal lines. They are well suited to the protection of industrial equipment such as PLCs and SCADA systems. Other uses include the protection of fire and security alarms and industrial monitoring and control equipment. The UTB employs a hybrid, three stage clamping circuit, to help ensure the best possible protection to sensitive electronic equipment while maintaining a minimum of line interference and insertion losses.
The UTB-TA and UTB-SA are specifically designed to protect telephone / modem circuits.
The UTB15EX and UTB30EX are BASEEFA approved versions for hazardous area applications (ATEX Category II 1G EEx ia IIC T4). They can be inserted without recertification into any IS loop where input $>1.3 \mathrm{~W}$.



## CRITEC ${ }^{\circ}$ UTB Compact Series

## Universal Transient Barrier



- Compact design universal transient barrier - protection of low-voltage circuits and transducers
- Compact, slimline single or two pair housing 12 mm wide
- 3 stage protection - fine over-voltage protection helps ensure lowest residual surge voltages reach sensitive equipment
- Common-mode and differential mode protection - protects against both possible surge conditions
- Ease of grounding - through DIN mounting rail or via terminal
- Surge rating to 20kA 8/20 - ideal for exposed wiring
- "PS" Power Supply design for compact protection of signal and power supply in one compact housing
- "MP" Multipurpose design suitable for course protection, signal ground to ground bonding or higher current applications

The UTB Compact series provides transient protection for equipment from surges induced onto balanced pair signal lines or low-voltage AC or DC power supplies. The compact series is well suited to applications where panel space is limited, yet provides similar protection performance when compared to the CRITEC ${ }^{\circledR}$ UTB Modular series. They are well suited to the protection of industrial equipment such as PLCs and SCADA systems.
The UTB S (single pair) and D (two pair) employs a hybrid, three stage clamping circuit, to help ensure the best possible protection to sensitive electronic equipment while maintaining a minimum of line interference and insertion losses.
The UTB PS (power supply) is specifically designed for applications where compact protection is required for one signal pair and one power supply, common in powered transducer applications.
The UTB MP (multipurpose) is generally designed for a variety of applications, including course protection, signal ground bonding or higher current applications.



Due to a policy of continual product development, specifications are subject to change without notice.


- General purpose barrier - protection of 12 / 24V DC systems and equipment
- Ease of grounding - through DIN mounting rail or via terminal
- Separate plug and base design - facilitates ease of module replacement
- Two stage protection - suitable for the protection of power supply feeds
- Large surge rating to 20kA 8/20 - suitable for exposed DC wiring

The DSD120 series provides high surge rating for circuits that are exposed to higher transient levels, such as those which exit the facility building.

| Model | DSD120 1S 12 | DSD120 1S 24 |
| :---: | :---: | :---: |
| Item Number for Europe | 702670 | 702680 |
| Nominal System Voltage $U_{n}$ | $12 \mathrm{~V}==$ | 24V=- |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{C}}$ | $15 \mathrm{~V}=-$ | 28V=- |
| Max. Line Current $\mathrm{I}_{\mathrm{L}}$ | 10A |  |
| Max. Discharge Current $\mathrm{Imax}_{\text {max }}$ | 20kA 8/20 $/$ |  |
| Protection Modes | Differential \& Common Mode |  |
| Technology | GDT \& Silicon |  |
| Voltage Protection Level $U_{p}$ <br> Cat B3, 3kA 8/20 | $\begin{array}{\|l} \hline(L-L) \\ <30 V \end{array}$ | $\begin{aligned} & (\mathrm{L}-\mathrm{L}) \\ & <40 \mathrm{~V} \end{aligned}$ |
| Loop Resistance | $<0.5 \Omega$ |  |
| Dimensions | $1 \mathrm{M} .90 \mathrm{~mm} \times 68 \mathrm{~mm} \times 17.5 \mathrm{~mm}$ (3.5" x $2.6^{\prime \prime} \times 0.7^{\prime \prime}$ ) approx. |  |
| Weight | $0.1 \mathrm{~kg}(0.24 \mathrm{lb})$ |  |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |  |
| Connection | $1 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ (\#18AWG to \#10AWG) |  |
| Mounting | 35 mm top hat DIN rail |  |
| Temperature | $-25^{\circ} \mathrm{C}$ to $+70^{\circ} \mathrm{C}\left(-13^{\circ} \mathrm{F}\right.$ to $\left.+158^{\circ} \mathrm{F}\right)$ |  |
| Humidity | 0\% to 90\% |  |
| Approvals | CE |  |
| Surge Rated to Meet | ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C |  |
| Replacement Module Module Item Number for Europe | $\begin{array}{\|l\|} \hline \text { DSD1201S12M } \\ 702675 \end{array}$ | $\begin{aligned} & \text { DSD1201S24M } \\ & 702685 \end{aligned}$ |



DSD 120


## CRITEC ${ }^{\ominus}$ DSD (DC)

## DIN Surge Diverter



The DSD140 2BR 24/48 surge protection device provides economical and reliable protection to DC power systems used in such applications as photovoltaic and telepower distribution. It is intended for locations classified for devices tested to IEC61643-1 test Class II (or VDE Classification C). Internal
thermal disconnect devices help ensure safe isolation at end-oflife. A visual indication flag provides user feedback in the event of such operation. In addition, a set of voltage-free contacts is provided for remote signaling if replacement is due.

| Model | DSD140 2BR 24/48 |
| :---: | :---: |
| Item Number for Europe | 702750 |
| Nominal System Voltage Un | $24 \mathrm{~V}=$ and $48 \mathrm{~V}=$ |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{C}}$ | $48 \mathrm{~V} \sim$ and $60 \mathrm{~V}=$ |
| Frequency | 0 to 60Hz |
| Max. Discharge Current $I_{\text {max }}$ | 40kA ( $8 / 20 \mu \mathrm{~s}$ ) |
| Nom. Discharge Current In | 20kA ( $8 / 20 \mu \mathrm{~s}$ ) |
| Protection Modes | Differential \& Common Mode |
| Technology | MOV with thermal |
| Short Circuit Rating Isc | 25 kA |
| Voltage Protection Level $U_{p}$ <br> @ Cat B3, 3kA 8/20 H <br> @ In | $\begin{aligned} & <120 \mathrm{~V} \\ & <300 \mathrm{~V} \end{aligned}$ |
| Status | Mechanical flag Change-over contact (Form C Dry) 250V=-=/0.5A, max $1.5 \mathrm{~mm}^{2}$ (\#14AWG) connecting wire |
| Dimensions | $2 \mathrm{M}, 90 \times 68 \times 36 \mathrm{~mm}$ (3.5" $\times 2.6$ " $\times 1.4$ ") approx. |
| Weight | $0.15 \mathrm{~kg}(0.33 \mathrm{lb})$ approx. |
| Enclosure | DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1) |
| Connection | $\leq 35 \mathrm{~mm}^{2}$ (\#2AWG) solid $\leq 25 \mathrm{~mm}^{2}$ (\#4AWG) stranded |
| Mounting | 35 mm top hat DIN rail |
| Back-up Fuse | 250Agl if supply >250A |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+80^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+176^{\circ} \mathrm{F}\right)$ |
| Humidity | 0\% to 90\% |
| Approvals | IEC 61643-1, CE |
| Surge Rated to Meet | IEC 61643-1 Class II <br> ANSIIIEEE C62.41.2 Cat A, Cat B, Cat C <br> ANSIIIEEE C62.41.2 Scenario II, Exposure 1, 20kA 8/20 $\mu \mathrm{s}$ |



## CRITEC ${ }^{\circ}$ RTP

## Remote Transmitter Protector



The RTP is designed for the protection of industrial $4-20 \mathrm{~mA}$ loop connected transducers. The stainless steel enclosure can be installed in-line with the field conduit, or fitted to the spare transducer connection port. Installation is simplified as the protection circuit

- Flexible installation - enclosure can be installed "dead ended," "T" configured or in-line
- 3 stage protection - fine over-voltage protection helps ensure lowest residual surge voltage reaches sensitive equipment
- Optimized for protection of 2-wire industrial 4-20mA loops - suitable for exposed locations
- Supports line currents up to 145 mA - protect 24 Vdc powered equipment
can be removed from the enclosure to connect field wiring to the screw terminals. The RTP employs a hybrid three stage clamping circuit to help ensure the best possible protection to sensitive field equipment.

| Model | RTP 3034 |
| :---: | :---: |
| Item Number for Europe | 700865 |
| Nominal System Voltage Un | 30V=-- 21 V ~ |
| Max. Cont. Operating Voltage UC | 33V--- 23V~ |
| Max. Line Current IL | 145mA |
| Frequency | 3dB @ 2MHz (120ת) |
| Max. Discharge Current $I_{\max }$ | 20kA 8/20رs |
| Protection Modes | Differential \& Common Mode |
| Technology | GDT, MOV \& Silicon |
| Voltage Protection Level $\mathrm{U}_{\mathrm{p}}$ | (L-L) |
| @ Cat B3, 3kA 8/20 ${ }^{\text {s }}$ | 44V |
| Loop Resistance | $14 \Omega$ |
| Dimensions | 3/4" diameter $\times 5$ " length ( $17 \mathrm{~mm} \times 127 \mathrm{~mm}$ ) approx. |
| Weight | 0.34 kg ( 0.75 lb ) approx. |
| Enclosure | 304 Stainless Steel |
| Connection | $\leq 2.5 \mathrm{~mm}^{2}$ (\#14AWG) |
| Mounting | 3/4" NPT thread (14 threads per inch) |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+65^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+149^{\circ} \mathrm{F}\right)$ |
| Humidity | 0\% to 90\% |
| Approvals | CE |
| Surge Rated to Meet | ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C |



## CRITEC ${ }^{\circ}$ SLP/HSP



- Single and multi stage protection - primary or combination primary/secondary protectors
- Single pair and 10 pair protectors
- Simple installation into Krone-LSA ${ }^{\oplus}$ disconnect block
- L-L \& L-G protection - for comprehensive protection
- HSP High Speed Protectors support 8Mbit/s digital and 12 MHz analog networks
${ }^{\text {® }}$ Krone-LSA is a registered trademark of Krone GmbH, Germany

DLT (\#702721) available where screw terminal connections are required ( $2.5 \mathrm{~mm}^{2}$ ).

The Subscriber Line Protector (SLP) and High Speed Protector (HSP) are designed for the protection of telecommunication and data circuits that terminate on 10 par Krone-LSA plus disconnect blocks. The DIN rail mount Data Line Termination (DLT) screw terminal block allows these protectors to be used in applications where disconnect blocks are not fitted.

The SLP1 K2 is a single pair protector, suited to protection of traditional voice circuits. The SLP10K1F is a 10 pair protector for voice and high speed data circuits.

The HSP series feature multiple protection stages providing enhanced protection. The K12, 36 and 72 are low voltage units suited to industrial/signalling applications. The K230 is suited to protection of sensitive voice and high speed data circuits.


## CRITEC ${ }^{\circ}$ SLP

## RJ11 Telephone Line Protection



SLP1RJ11


- RJ11 sockets - simple plug-in connection for 4 or 6 position RJ plugs
- 6.5" patch cord included - no additional cables required
- SLP RJ11 is UL® 497A Listed
- L-L \& L-G protection - for comprehensive protection
- Automatic over-current protection

The SLP1 RJ11 series of surge suppressors provide protection to telecommunication equipment connecting via RJ11 plugs. Designed for traditional (2 wire) telephone circuits, the product is also compatible with modems and ADSL circuits.

The SLP1 RJ11 is a UL Listed secondary protector intended for use in facilities where primary protective devices have been installed at the service entrance. The SLP1 RJ11A is a high-energy multi-stage primary protector intended for non UL applications where higher surge ratings are required.

| Model | SLP1 RJ11 | SLP1 RJ11A |
| :---: | :---: | :---: |
| Max. Cont. Operating Voltage $U_{C}$ | <280V |  |
| Max. Line Current $\mathrm{I}_{\mathrm{L}}$ | 160mA @ $25^{\circ} \mathrm{C}\left(77^{\circ} \mathrm{F}\right)$ | 120 mA |
| Max. Discharge Current $\mathrm{I}_{\max }$ | 500A 8/20رs | 20kA 8/20رs |
| Voltage Protection Level $U_{p}$ @ 5kV/125A 10/700us | $\begin{aligned} & 110 \mathrm{~V} \text { T-R } \\ & 500 \mathrm{~V}(\mathrm{~T}+\mathrm{R})-\mathrm{G} \end{aligned}$ |  |
| Dimensions | $76 \mathrm{~mm} \times 38 \mathrm{~mm} \times 28 \mathrm{~mm}$ (3.0" $\times 1.5$ " $\times 1.1$ " ) approx. |  |
| Weight | 50 g (1.8 oz) approx. |  |
| Connection | 6 position RJ, 2 pins protected$150 \mathrm{~mm}\left(6^{\prime \prime}\right) 0.8 \mathrm{~mm}^{2}(\# 18 A W G)$ with earth 4 mm ring lug$165 \mathrm{~mm}\left(6.5^{\circ}\right)$ patch cord included |  |
| Mounting | Adhesive backing |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $+65^{\circ} \mathrm{C}\left(-40^{\circ} \mathrm{F}\right.$ to $\left.+150^{\circ} \mathrm{F}\right)$ |  |
| Approvals | UL | A-Tick |

## CRITEC ${ }^{\circ}$ DEP/LAN

## Data Equipment Protector

- Premium 1500 Watt (>100 Amps 8/20) capability - robust protection
- Models to cover RS-232, RS-423, RS-422 and RS-485 protocols
- Provides both line to signal-ground and signal-ground to protectiveearth protection
- DEP RS232/25/25 protects all wires - circuit wiring/pin configuration does not need to be known
- Plug-in protection - simple to install

The DEP series has been designed to protect serial I/O interface equipment from the damaging effects of induced surges and transients. The DEP protectors are packaged in male-tofemale DB9 and DB25 cases for simple installation at the serial ports of terminal equipment. For RS232/423 circuits, DEP models will allow
peak working voltage of up to 15 volts, with 9 or 25 pin protection. For RS422/ 485 circuits, the DEP RS422/9/9 allows up to 9 volts working, and is packaged in a DB9 case. A flying earth lead is provided for connection to protective earth.

| Model | DEP RS232 25 25 | DEP RS232 99 | DEP RS422 99 |
| :--- | :--- | :--- | :--- |
| Item Number for Europe | 700630 | 700640 | 700650 |
| Max. Cont. Operating Voltage $\mathrm{U}_{\mathrm{C}}$ | $15 \mathrm{~V}=-=$ | 9 F | $15 \mathrm{~V}=-=$ |
| Protection Modes | All pins to pin 7 (SG) <br> SG to ground | All pins to pin 5 (SG) <br> SG to ground | All pins to pin 1 (SG) <br> SG to ground |
| Connection | DB25 Male/Female | DB9 Male/Female |  |

## Local Area Network Protector



The LAN-RJ45 series suits both 10BaseT and 100BaseT Unshielded Twisted Pair (UTP) Ethernet networks. The unit(s) features simple plug-in installation and provide Earth Potential Equalization (EPE). State-of-the-art protection technology to help ensure that high speed LAN data (Cat 5 ) is allowed to pass unhindered while

| Model | LAN RJ45 1 | LAN RJ45 24 |
| :---: | :---: | :---: |
| Item Number for Europe | 700526 | 700527 |
| Max. Cont. Operating Voltage $U_{\text {c }}$ | 66V=-- |  |
| Nom. Discharge Current $I_{\text {max }}$ | 500A 8/20رs |  |
| Frequency | 100Mbits <br> (100BaseT \& 10BaseT) |  |
| Voltage Protection Level $\mathrm{U}_{\mathrm{p}} @ \mathrm{I}_{\mathrm{n}}$ | $\begin{aligned} & 35 \mathrm{~V} \text { L-L } \\ & 350 \mathrm{~V} \text { L-G } \end{aligned}$ |  |
| Connection | RJ45 with 250 mm (10") patch cord | $24 \times$ RJ45 circuits |
| Mounting | Screw Mount | 19" rack mount |
| Approvals | CE |  |
| Surge Rated to Meet | IEC 61643-21 <br> ANSI/IEEE C62.41.2 Cat A |  |

transient over-voltages are attenuated to safe levels. The LANRJ451 is designed for the protection of single circuits such as workstations, while the LANRJ4524 is a 19" rack-mounted model for the protection of 24 circuits such as routers and other network equipment.


## Community Antenna Television Protector and Closed Circuit Television Protector



## CATV-HF Protector

- High frequency design - suitable for digital cable
- Weatherproof enclosure - install indoor or outdoor

CATV-F and CATV-MF Protector

- Traditional TV coax protector

CCTV-12 Protector

- Isolated ground - does not introduce unwanted noise
- Male-male adaptor included
- Suitable for coaxial LAN protection

| Model | CATV HF | CATV F | CATV MF | CCTV 12 |
| :---: | :---: | :---: | :---: | :---: |
| Item Number for Europe |  | 702535 | 702525 | 703000 |
| Spark Over/Max. Operating Voltage | 180V @10kV/us | Uc-60V~/85V- | UC-48V~/60V- | 30-36V (Uc=-= 12V~) |
| Max. Discharge Current $\mathrm{Imax}_{\max }$ | 5kA 8/20رs | 5kA 8/20رs | 5kA 8/20رs | 20kA 8/20رs |
| Frequency | 2GHz | 1 GHz | 1 GHz | 100MHz/16Mbits |
| Attenuation | $\begin{aligned} & \hline-1 \mathrm{~dB} @ 1 \mathrm{GHz} \\ & -2 \mathrm{~dB} @ 1 \mathrm{GHz} \end{aligned}$ | $\begin{aligned} & <0.5 \mathrm{~dB} \\ & 47 \mathrm{MHz}-860 \mathrm{MHz} \end{aligned}$ | $\begin{aligned} & <0.5 \mathrm{~dB} \\ & 47 \mathrm{MHz}-860 \mathrm{MHz} \end{aligned}$ |  |
| Impedance | 50-75, |  |  |  |
| Voltage Protection Level $U_{p}$ <br> @ 5kV/500A 8/20 | <90V | 600V @ 5kA | 600V @ 5kA | 60V |
| Dimensions | $96 \mathrm{~mm} \times 63 \mathrm{~mm} \times 31 \mathrm{~mm}$ (3.8" $\times 2.5^{\prime \prime} \times 1.25^{\prime \prime}$ ) approx. | $78 \mathrm{~mm} \times 17 \mathrm{~mm} \times 17 \mathrm{~mm}$ (3.1" x 0.7" $\times 0.7$ ") approx. | $70 \mathrm{~mm} \times 17 \mathrm{~mm} \times 17 \mathrm{~mm}$ ( 2.7 " $\times 0.7$ " $\times 0.7$ ") approx. | $90 \mathrm{~mm} \times 22 \mathrm{~mm} \times 28 \mathrm{~mm}$ ( $3.5^{\prime \prime} \times 0.86^{\prime \prime} \times 1.1^{\prime \prime}$ ) approx. |
| Weight | 115 g (4 oz) approx. | 30 g (1 oz) approx. | 26 g (1 oz) approx. | $60 \mathrm{~g} \mathrm{(2} \mathrm{oz)}$ |
| Enclosure | Outdoor | Indoor |  |  |
| Connection | F-Type, Female | F-Type, Female, 4.5 ground lead | RF 9.5 mm Coax (M/F). 120 mm (4.5") ground lead | BNC, Female ${ }^{(1)}$ |
| Mounting | Screw mount | In-line insertion |  |  |
| Temperature | $-25^{\circ} \mathrm{C}$ to $+70^{\circ} \mathrm{C}\left(-13^{\circ} \mathrm{F}\right.$ to $\left.+158^{\circ} \mathrm{F}\right)$ |  |  |  |
| Approvals |  | CE |  |  |

${ }^{(1)}$ Adapter supplied for female/male connection.

Asia/Australia
Europe
Coaxial Surge Protector
Latin America North America


| Model | CSP BNC 90 | CSP BNC 600 | CSP NMF 90 | CSP NMF 600 | CSP NB 90 | CSP NB 600 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Item Number for Europe | 700360 | 700405 | 700310 | 700355 | 700410 | 700455 |
| Spark Over Voltage @100V/s <br> @100V/us | $\begin{array}{\|l} 72-108 \mathrm{~V} \\ 450 \mathrm{~V} \end{array}$ | $\begin{aligned} & \text { 480-720V } \\ & 1100 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 72-108 \mathrm{~V} \\ & 450 \mathrm{~V} \\ & \hline \end{aligned}$ | $\begin{aligned} & 480-720 \mathrm{~V} \\ & 1100 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 72-108 \mathrm{~V} \\ & 450 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & \text { 480-720V } \\ & 1100 \mathrm{~V} \end{aligned}$ |
| Max. Discharge Current $I_{\text {max }}$ | 20kA 8/20 ${ }^{\text {s }}$ |  |  |  |  |  |
| AC Discharge Current | 100A 50/60Hz 9 cycles |  |  |  |  |  |
| Impulse Life | 400 impulses @ 500A 10/1000 ${ }^{\text {s }}$ |  |  |  |  |  |
| Frequency | DC to 3GHz typical |  |  |  |  |  |
| Capacitance | <1.5pF |  |  |  |  |  |
| Impedance | $50 \Omega$ |  |  |  |  |  |
| Insulation Resistance | $>10 \mathrm{G} \Omega$ |  |  |  |  |  |
| Dimensions | $\begin{aligned} & 29 \mathrm{~mm} \times 29 \mathrm{~mm} \times 57 \mathrm{~mm} \\ & \left(1.14^{\prime \prime} \times 1.14^{\prime \prime} \times 2.44^{\prime \prime}\right) \text { approx. } \end{aligned}$ |  |  |  | $\begin{aligned} & 29 \mathrm{~mm} \times 29 \mathrm{~mm} \times 67 \mathrm{~mm} \\ & \left(1.14^{\prime \prime} \times 1.14^{\prime \prime} \times 2.64^{\prime \prime}\right) \end{aligned}$ |  |
| Weight | $0.2 \mathrm{~kg}(0.44 \mathrm{lb})$ |  |  |  |  |  |
| Enclosure | IP20 (NEMA-1) |  |  |  |  |  |
| Connection | BNC, Male/Female |  | N-Type, Male/Female |  | N-Type Female/Female |  |
| Mounting | Removable mounting bracket and ground lead supplied $2 \times 4 \mathrm{~mm}$ holes, 10 mm centers |  |  |  |  |  |
| Temperature | $0^{\circ} \mathrm{C}$ to $+65^{\circ} \mathrm{C}\left(32^{\circ} \mathrm{F}\right.$ to $\left.150^{\circ} \mathrm{F}\right)$ |  |  |  |  |  |
| Approvals | CE |  |  |  |  |  |

90 V units suitable for transmitters up to $25 \mathrm{~W}, 600 \mathrm{~V}$ units suitable for transmitters up to 900 W

## CRITEC․ LCP/PEC

## Loadcell Protector



- 6 wires and shield protection - works with 4 or 6 wire systems
- Suitable for compression or tension cells
- Low series impedance - loadcells do not need recalibration
- NEMA-12 (IP-55) rated - suitable for outdoor use
- Protects against excitation over-voltage - prevents loadcell damage

| Model | LCP 01A |
| :--- | :--- |
| Item Number for Europe | 701610 |
| Max. Discharge Current $\mathrm{I}_{\max }$ | $300 \mathrm{~A} 8 / 20 \mu \mathrm{~s}$ (signal to shield) |
|  | $10 \mathrm{kA} 8 / 20 \mu \mathrm{~s}$ (shield to ground) |
| Technology | Silicon Avalanche Diode |
| Voltage Protection Level $\mathrm{U}_{\mathrm{p}}$ | 30 V (signal to shield) |
|  | $15 \mathrm{~V} 8 / 20 \mu \mathrm{~s}$ (signal to signal) |
|  | 90 V (shield to ground) |
| Loop Resistance | $<0.25 \Omega$ |
| Dimensions | $110 \mathrm{~mm} \times 75 \mathrm{~mm} \times 56 \mathrm{~mm}$ |
|  | $\left(4.3^{\prime \prime} \times 2.9^{\prime \prime} \times 2.2^{\prime \prime}\right)$ approx. |
| Weight | $0.25 \mathrm{~kg} \mathrm{(0.55} \mathrm{lb)}$ |
| Enclosure | $\mathrm{ABS}, \mathrm{IP55}(\mathrm{NEMA}-12)$ |
| Connection | Screw terminals for 4 or 6 |
|  | wire loadcells |
| Temperature | $-40^{\circ} \mathrm{C}$ to $\left.+80^{\circ} \mathrm{C} \mathrm{(-40}^{\circ} \mathrm{F} \mathrm{to}+176^{\circ} \mathrm{F}\right)$ |

## Potential Equalization Clamp



- High peak current capability - long service life
- Weatherproof enclosure - suitable for direct burial
- ATEX approved - suitable for use in potentially explosive atmospheres

The PEC is an equipotential bonding device that can be used to minimize damage in applications where separated ground systems are required. The PEC is ATEX approved, making the device suitable for use in explosion hazard areas such as the protection of pipeline insulated joints.

| Model | PEC100 |
| :--- | :--- |
| Item Number for Europe | 702900 |
| Spark Over Voltage | $350 \mathrm{~V}+/-15 \%$ @100V/s |
| Max. Discharge Current $I_{\max }$ | $100 \mathrm{kA} 8 / 20 \mu \mathrm{~s}$ |
| Technology | Gas Discharge Tube (Auto reset) |
| Insulation Resistance | $>1 \mathrm{G} \Omega$ |
| Capacitance | $<10 \mathrm{pF}$ |
| Voltage Protection Level $\mathrm{U}_{\mathrm{p}}$ | 800 V @ $1 \mathrm{kV} / \mu \mathrm{s}$ |
| Dimensions | $138 \mathrm{~mm} \times 25 \mathrm{~mm}\left(5.4^{\prime \prime} \times 1^{\prime \prime}\right)$ approx. |
| Weight | $0.5 \mathrm{~kg} \mathrm{(1.1} \mathrm{lb)} \mathrm{approx}$. |
| Enclosure | Suitable for outdoor or direct burial |
| Connection | 450 mm of $16 \mathrm{~mm}{ }^{2}\left(17{ }^{\prime \prime}\right.$ of \#5AWG) conductor |
| Temperature | $-20^{\circ} \mathrm{C} \mathrm{to}+60^{\circ} \mathrm{C}\left(-4^{\circ} \mathrm{F}\right.$ to $\left.+140^{\circ} \mathrm{F}\right)$ |
| Approvals | $\mathrm{CE}, \mathrm{ATEX}, \mathrm{BASEEFA}$ Approved |

## A Guide to Communication and Signaling Circuits

The selection of an SPD for communication and signaling circuits requires knowledge of the:

1) Maximum Continuous Operating Voltage (Uc)
2) Maximum line current ( $I_{L}$ )
3) Frequency
4) Termination (connector type and/or impedance)

Where a protocol is known, this often eliminates the need to verify product selection criteria 1-3, and occasionally 4. A number of different SPDs often meet the requirements as defined by the protocol, so the final choice of which SPD to use is often determined by its type of physical connection, number of lines to be protected, or its surge rating. Some protocols do not define the actual connector or pin configuration, and in some cases, not all lines defined by the protocol will be used. Please refer to the documentation provided with the equipment requiring protection to ensure the proposed protection modes are adequate and that the SPD's characteristics will not interfere with normal system operation.

| Protocol/Standard | Description | Applicable SPD Series |
| :---: | :---: | :---: |
| RS-232 (V.24) | Unbalanced, bi-directional communication circuit. Although standard allows +/- 25 V signaling, use of more than $+/-12 \mathrm{~V}$ is uncommon. | DEP RS232 2525 DEP RS232 99 UTB $15{ }^{(1)}$ |
| RS-422 (V.11) | Industrial version of RS-232. 0-5V balanced signaling. | $\begin{aligned} & \text { DEP RS422 } 99 \\ & \text { UTB 5 } \\ & \text { LAN RJ45 Series } \end{aligned}$ |
| RS-423 | Similar to RS-232 but +/- 5 V s signaling used. | DEP RS232 2525 <br> DEP RS232 99 <br> UTB $5^{(1)}$ <br> LAN RJ45 Series |
| RS-499 | Based on RS422, but defined DB-25 connector used. | DEP RS232 2525 |
| RS-485 | Similar to RS-422 but allows multiple devices to communicate. DB-9 connector is common. | DEP RS422 99 UTB $5^{(1)}$ |
| Ethernet <br> Cat 4 <br> Cat 5 <br> 10BaseT <br> 100Base T | Ethernet is the term used to describe a family of communication protocols. <br> - 10BaseT is a 10 MHz system using twisted pair or coax cables <br> - 100BaseT is a 100 MHz system using twisted pair cables <br> Cat 4 is a cable specification that allows operation up to 10BaseT, while Cat 5 allows operation up to 100BaseT frequencies. | LAN RJ45 Series |
| Token Ring |  | CCTV 12 |
| ArcNet | Registered service mark of ARCNET Architects | CCTV 12 |
| CCTV | Closed Circuit TV Signal, i.e. video signal | CCTV 12 |
| Cable TV | High speed analog or digital TV services | CATV HF |
| Antenna TV | Analog or digital TV services | CATV MF |
| $\begin{aligned} & \mathrm{T} 1 \\ & \text { E1 } \end{aligned}$ | T 1 is a European high speed telephone service (1.5 Mbit) E 1 is a 2 Mbit connection | For hardwired circuits refer to Note 2. |
| Telephone lines |  | UTB SA UTB TA SLP Series |
| 4-20mA current loop | Common industrial communications protocol used to interface with transducers etc | $\begin{aligned} & \text { UTB } 30 \\ & \text { RTP } 3034 \end{aligned}$ |
| Strain gauge Load cells | As used in weigh bridges etc. | LCP01A |

(1) The number of UTB's required is dependent on the number of wires being used in the signaling circuit. UTBs are design for balanced circuits and each UTB will protect one pair of wires. The UTB can also be used to protect two unbalanced circuits.
(2) "Wet" lines are sometimes found within a telecommunication carriers network. Wet lines superimpose DC power (60V, 40-160mA) to power remote repeaters. Two UTB SA units are recommended for such applications. "Dry" lines are typically found at the customer connection point where $2 \times$ UTB 15 are recommended
(3) The UTB TA is rated to 500A $8 / 20 \mu s$ and intended to meet US NEC requirements. The SLP1 RJ11 is rated to $500 \mathrm{~A} 8 / 20 \mu \mathrm{~s}$ and UL Listed. The UTB SA and SLP1RJ11A are rated to 20kA 8/20 $\mu$ s and specifically designed and approved for use on the Australian telecommunication network

## Glossary of Terminology

## 8/20us Current Waveshape

A current impulse with a virtual front time of $8 \mu \mathrm{~s}$ and a time to half-value of $20 \mu \mathrm{~s}$.

## Aggregate Surge Rating

The sum of the surge ratings of individual voltage limiting components, connected in parallel, in the device.
Note: This figure does not indicate the maximum discharge current $\left(I_{\max }\right)$ of the device. It does however provide an indication of the expected SPD life. Users should be aware that certain manufacturers may incorrectly claim the aggregate surge rating of MOV material used in their device as its $I_{\max }$. Non-perfect current sharing between parallel MOVs, and the inability of series over-current or thermal disconnects to carry the full surge current, generally means that the maximum discharge current which the SPD can withstand is less than its aggregate surge rating.

## Attenuation

The ability of an SPD to reduce electrical noise interference, measured in decibels. Attenuation varies with frequency, so it is usual to specify the attenuation of the SPD at a particular frequency; commonly 100 kHz .

## Backup Overcurrent Protection

An external overcurrent protective device installed prior to the SPD. Such a device may be required if the overcurrent limiting device on the service is larger than that required by the SPD or connecting wiring.

## Class I test

SPD tested with maximum impulse current ( $\mathrm{l}_{\mathrm{imp}}$ ) and nominal discharge current $\left(I_{n}\right)$.

## Class II test

SPD tested with maximum discharge current $\left(I_{\max }\right)$ and nominal discharge current $\left(I_{n}\right)$.

## Class III test

SPD tested with combination wave

## Distribution System

Defines the electrical power distribution system. The distribution system is usually described by configuration of the phases, neutral and ground conductor configuration on the secondary side of the supply transformer. Refer to pages 10-12 for further information.

## Follow Current ( $\mathbf{I}_{\mathrm{f}}$ )

The current supplied by the electrical power distribution system which flows through the SPD after a discharge current impulse. The follow current is significantly higher than the operating current, and is normally high for voltage switching type SPDs (e.g. spark gaps) since the arc voltage falls below the $A C$ supply voltage after firing.

## Impulse Current (limp)

Peak impulse current withstand with a $10 / 350 \mu \mathrm{~s}$ current waveshape. This is often used for the classification of SPDs tested to Test Class I, but is not the only acceptable waveshape.

## Insertion Loss

The insertion loss of an SPD is usually only stated for two port devices for use on low voltage data systems. It is a measure of the ratio of voltage at the output to the input at the device under test. The insertion loss is usually stated for a given frequency and measured in decibels.

## Leakage Current

The current flowing to the ground conductor when the SPD is connected to the nominal supply voltage $U_{n}$.

## Let-through Voltage

Another term often used to describe the measured limiting voltage.
Note: This measurement may be carried out with, or without, the presence of the nominal AC power $\left(U_{n}\right)$ being applied to the SPD. As such, the results may be different and the user should take cognizance of this in making any comparative assessments.

## Location Categories

Various standards attempt to define the electrical environment at which an SPD may be installed, into location categories or zones.
Note: The user should be aware that international consensus has not been reached on these classifications, nor on the size of expected surge activity, which may occur. Further, the user should note that the demarcation of these zones do not form literal boundaries, but are rather a gradual transition.

## Maximum Continuous Operating Voltage $\left(U_{C}\right)$

The maximum r.m.s. or d.c. voltage which may be continuously applied to the SPD's mode of protection without degradation or inhibiting its correct operation.

Note: Specifications given in the catalog generally are phase (L-N) voltages.

## Glossary of Terminology

## Maximum Discharge Current (I ${ }_{\text {max }}$ )

The maximum single shot current, having an $8 / 20 \mu$ s waveshape, which the SPD can safely divert.

## Measured Limiting Voltage

The maximum voltage measured across the SPD's terminals during the application of an impulse of specified waveshape and amplitude.

## Modes of Protection

SPDs may provide protection line-to-ground, line-to-neutral, neutral-to-ground or in combinations thereof. These paths are referred to as the modes of protection.
Note: The user is advised that not all modes require protection, and more is not necessarily better when selecting an SPD. As an example, the N-G mode is not required when the SPD is installed at the primary service entrance of a TN-C-S electrical distribution system, due to the Neutral-Ground bond at this point. The L-L mode is generally not provided for systems with neutral conductors since the L-N modes also protect the L-L modes. Similarly, the L-G mode can be protected via the L-N and N-G modes.

## Nominal Discharge Current ( $\mathrm{I}_{\mathrm{n}}$ )

The peak value of the current flowing through the SPD during the application an $8 / 20 \mu \mathrm{~s}$ waveshape.
Note: IEC 61643-1 requires SPDs tested to Test Class II, to withstand 15 impulses at $I_{n}$ followed by $0.1,0.25,0.5,0.75$ and 1.0 times $I_{\max }$

## Nominal (System) Voltage ( $\mathbf{U}_{\mathrm{n}}$ )

The L-N voltage by which an electrical power system is designated. Under normal system conditions, the voltage at the supply terminals may differ from the nominal voltage as determined by the tolerance of the supply system (normally $+/-10 \%$ ).

## One-port SPD

An SPD connected in shunt (parallel) with the circuit to be protected. A one port device may have separate input and output terminals, but without a specific series impedance between these terminals. This type of connection is also known as a Kelvin connection.

## Operating Current

The current drawn (per phase) by the SPD when energized at the nominal operating voltage $U_{n}$.
Note: For SPDs with integral series filtering, the total current drawn may be greater than the real rms current consumption (i.e. VA may be greater than Watts). This is due to the presence of the internal filtering capacitance.

## Over-current Protection

An over-current device, such as a fuse or circuit-breaker, which could be part of the electrical distribution system located externally and up-stream of the SPD. May provide protection to the SPD, the connecting wiring and provide a means of externally isolating the SPD.

## Protective Earth (PE)

The IEC 60364 series characterizes low-voltage distribution systems by their grounding methods and the configuration of the neutral and protective conductors. The Protective Earth is commonly referred to as "ground", or "earth", in many regions.

## Rated Load Current ( $I_{L}$ )

Maximum continuous rated current that can be supplied to a load connected to the protected output of an SPD. Normally only stated for two port, series connected, SPDs.

## Residual Voltage

In IEC terminology this refers to the peak value of the voltage that appears between the terminals of an SPD due to the passage of discharge current $I_{n}$. NZS/AS 1768 refers to this as the let-through voltage, a measurement obtained when the stated test impulse is superimposed on top of the nominal system voltage $U_{n}$.

## Secondary Surge Arrester

A loosely used term given to SPDs intended for operation on medium voltage systems ( $>1 \mathrm{kV}$ ). Within the USA, a secondary surge arrester defines an SPD Listed by Underwriters Laboratories Inc. for use on LV and MV systems at locations prior to the main overcurrent disconnect to the facility.
Note: Secondary Surge Arrester Listing is generally considered to have less demanding safety requirements than those for UL 1449 Transient Voltage Surge Arrester Listing.

## Short Circuit Current Rating (SCCR)

The short-circuit current rating of the SPD. Required by USA National Electric Code (NEC) for TVSS devices.

## SPD Disconnector

An IEC term used to describe a device (internal and/or external) for disconnecting an SPD from the electrical power system.
Note: This disconnecting device is not required to have isolating capability. It is to prevent a persistent fault on the system and is used to give an indication of the SPD failure. There may be more than one disconnector function, for example an over-current protection function and a thermal protection function. These functions may be integrated into one unit or performed in separate units.

## Glossary of Terminology

## Spark-over Voltage

The voltage at which a switching type SPD (generally of the spark gap type) will initiate conduction. This value is normally specified for a voltage increasing at $1 \mathrm{kV} / \mathrm{s}$.

## Stand-off Voltage

The maximum voltage, which can be applied to an SPD, without triggering it into a fully conductive state.
Note: This voltage is normally higher than the maximum continuous operating voltage $U_{c}$ of the SPD. It is not intended that the SPD be operated at this voltage.

## Status Indicator

A device(s) that indicates the operational status of the SPD, or of a particular mode of its protection.
Note: Such indicators may be local with visual and/or audible alarms and/or may have remote signaling and/or output contact capability.

## Suppressed Voltage Rating (SVR)

A special case of the measured limiting voltage specific to the UL 1449 Listing of an SPD.
Note: This test is performed using a small 500A $8 / 20 \mu$ s current limited impulse, and the clamping voltage recorded at the ends of 6 "connecting leads. The result obtained is rounded up to the nearest value given in a table.

## Surge Protection Device (SPD)

An IEC term used to describe a device intended to limit transient over-voltages and divert surge currents. It contains at least one non-linear component.

## Surge (Reduction) Filter

A two-port series filtering type of SPD specifically designed to reduce the rate-of-rise of voltage (dv/dt) of the pre-clamped waveform. Such a device normally contains a filter with low-pass performance.

## Transient Voltage Surge Suppressor (TVSS)

An SPD tested to meet the safety requirements of UL 1449-Standard for Transient Voltage Surge Suppressors. UL 1449 defines the basic safety requirements for TVSS devices installed on electrical circuits up to 600V. The United States National Electric Code (NEC) only permits TVSS devices to be installed after (downstream of) the main over-current disconnect to a facility.

## Two-port SPD

An SPD with two sets of terminals, input and output (line and equipment), and with a specific impedance inserted between these terminals. These are often referred to as series (in-line) connected SPDs and generally contain wave-shaping filters in addition to simple shunt-only protection.

## Voltage Protection Level ( $\mathbf{U}_{\mathrm{p}}$ )

Similar to the measured limiting voltage, the voltage protection level characterizes the performance of an SPD in limiting the voltage across its terminals.

Note: The voltage protection level is the measured limiting voltage recorded under a specified current magnitude and waveshape, and rounded up to the next highest voltage selected from a list of preferred values found in IEC 61643-1 Standard for surge protective devices connected to low-voltage power distribution systems. For SPDs tested to Test Class I, $U_{p}$ is generally stated using a $10 / 350 \mathrm{I}_{\mathrm{imp}}$ and for SPDs tested to Test Class II, using an $8 / 20 \mu \mathrm{I} \mathrm{I}_{\text {max }}$ -

## CRITEC ${ }^{\oplus}$ Surge Calculator and ERICO ${ }^{\circledR}$ Website

## ERICO Website

ERICO has updated its website to offer easier navigation giving customers the information that they need right at their fingertips. Now search the site via ERICO's well-known brand names, alphabetical product listing, or industry. The easy-toaccess Literature Library provides pertinent literature in an easy-to-download PDF format. In the News \& Events section, customers can find new product updates, press releases and lists of helpful seminars and tradeshows.

Other features include:

- Faster access to product information through improved navigation
- Product specifications
- A list of upcoming events and industry trade shows
- Locations and contact information for ERICO offices around the world



## CRITEC ${ }^{\circledR}$ Surge Selection Calculator

Available as a download from the ERICO ${ }^{\circledR}$ website, the CRITEC Surge Selection Calculator is an invaluable software tool to help the user choose the correct SPD for his application. The tool also includes:

- A comprehensive technical library of publication and a frequently asked section on surge protection.
- Electronic copies of specification sheets and installation prints
- Specification guides for contractors and system specifiers
- Electronic risk assessment calculators for a number of countries


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- Schematic drawings are illustrative only, and should not be relied on without further study for any particular application. Diagrams, products and recommendations may not comply with certain country's national codes. Detailed information and advice on the installation and usage of products is available from product brochures, installation and maintenance publications, or by direct contact with ERICO.


## ERICO ${ }^{\circledR}$ Facility Electrical Protection Literature



## Facility Electrical Protection Solutions Brochure

Discusses effective facility electrical protection. The catalog details the ERICO® Six Point Plan of Protection and goes on to cover lightning protection, grounding, bonding and surge protection in depth. Products and detailed drawings are included, as are industries to which the technologies are most applicable.

## ERITECH ${ }^{\oplus}$ Lightning Protection Catalogs

ERITECH ${ }^{\oplus}$ SYSTEM 2000 Lightning Protection Products catalog highlights products used in conventional lightning protection. Products detailed include conductors, ground rods and plates, clamps, splices, points and accessories.

ERITECH ${ }^{\oplus}$ SYSTEM 3000 Lightning Protection Products catalog details the active lightning protection process. Information on air terminals, downconductors and design software is included.

## ERITECH ${ }^{\circledR}$ Grounding Products Catalog

Details ERICO's extensive offering of ground rods and accessories, ground mesh and mats, signal reference grids, ground bars, ground receptacles, transient earth clamps, ground enhancement materials, and other grounding materials.

## CADWELD ${ }^{\circledR}$ Welded Electrical Connections Catalog

Covers the range of hardware required to make a CADWELD connection as well as detailed ordering information for molds, weld materials, fence and gate jumpers and the smokeless CADWELD EXOLON process.

## CRITEC ${ }^{\circledR}$ Surge Protection Products Catalog

Details the extensive range of CRITEC Surge Protection Devices for industries such as commercial \& industrial, process control \& automation and telecommunications. It includes information on AC protection products, data control and signal protection products, as well as point-of-use protection products.


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## 9. Multitrode



## Controls either one pump, alarm or solenoid.

The MultiTrode MTR is a latching conductive liquid level relay. When connected to a MultiTrode probe, the MTR controls the activation and de-activation of pumps, alarms and other monitoring and control equipment.

The relay senses the liquid via a safe extra-low voltage signal and latches. This state is maintained until the circuit is broken when the liquid passes the selected stop sensor. The relay then resets for the next operation. A single sensor may be used for alarms.

The MTR relay offers many features found in several discrete devices such as latching and time delay relays. Normally all of these devices must be installed individually. MultiTrode's MTR includes all of these features in one compact case, simplifying installation and reducing labour costs.

Use the MTR in any applications where level control is required, such as sumps, wells, bores, collection tanks, effluent pits, drainage ponds, pump stations, reservoirs, and sullage pits.

## After many years of field use, the simplicity and reliability of these units is unquestionable.

■ Safe, extra-low, sensing voltage: Ensures safety for operators and maintenance personnel .

- Charge or discharge: The modes of operation are selectable to either fill or empty a tank.

■ Dip Switch Programmable: All settings are easily selected from the front panel. Fixed settings ensure repetition and accuracy.

- 4 Sensitivities: Enable the relay to operate effectively in a wide range of conductive liquids.
- 8 Activation Delays. Used for staggering multiple pump starts or to overcome premature activation due to wave action or turbulence.

■ LED Indication. Power On (green) and Relay Activation (red) via high intensity LED indicators.

■ Battery Operation. As well as 24, 110, 240 and 4 I5VAC, the MTR Relay is also available in $10-30 \mathrm{VDC}$.

- Proven Reliability. The proven design of the relay ensures long-term reliability of the MultiTrode system.

■ I.S. application Perfect for I.S. application when used with MTISB.

■ DIN rail or screw mounting
Low installed cost

SAMPLE MTR APPLICATION


SAMPLE MTR APPLICATION


## Dip Switch Settings

| $\cdots \square$ |  |  |
| :---: | :---: | :---: |
| - |  |  |
|  | Sw 3, 4 | \& 5 Activation delays: |
| $\triangle \quad \square$ | - | $0,2.5,5,10,20,40,80,160 \mathrm{sec}$ |
| ¢ $\square$ | - |  |
|  | Sw 6 | Mode settings: Charge \& Discharge |

## Wiring Diagram

Sample Application


## Product Specifications

Mode of operation:
MTR
Charge/Discharge (Fill or Empty)

## Probe Inputs:

| Sensor inputs | MTR :2 / MTRA : 3 |
| :--- | :--- |
| Sensor voltage | $10 / 12 \mathrm{VAC}$ Nominal |
| Sensor current | 0.8 mA max. (per sensor) |
| Sensitivity | $1 \mathrm{k}, 4 \mathrm{k}, 20 \mathrm{k}, 80 \mathrm{k}$ |

Relay Outputs:
MTR relay output
MTR Output delay
Relay contact rating
Relay contact life
Terminal size

| Display LEDs: <br> MTR | $\frac{\text { Power On }}{\text { Green }} \frac{\text { Pump }}{\text { Red }}$ |
| :--- | :--- |

## Physical Product:

Dimensions (mm)
Mounting DIN Rail or $2 \times$ M4 Screws \#6
Enclosure Makrolon ( self extinguishing )
Power Supply:

| Supply Voltage AC | $24, \mathrm{IIO}, 240,415 \mathrm{VAC}-50 / 60 \mathrm{~Hz}$ |
| :--- | :--- |
| Power Consumption | 3.5 Watts max $\quad$ *(MTR only) |
| Suply Voltage DC | 12 or 24VDC, |
| Power Consumption | 3 watts max |

Environmental Range:
Centigrade
Fahrenheit
$-10^{\circ}$ to $+60^{\circ} \mathrm{C}$
N1653


LISTED 2 P27

All MultiTrode Products carry a two year warranty

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Tel:+61 359786900
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## The Liquid Level Sensor you don't need to clean.



Typical installation in the UK.

The most reliable and cost-effective level sensor for wastewater.
Lasts for over 20 years!

- Reduces maintenance costs.
- No more false readings or burnt-out pumps.
- Simple to install and guaranteed for 10 years.
- Cuts the risk of spills.


## Why is it so reliable?

No electronics and no moving parts means there is nothing to fail that's why it gets a 10-year warranty.

## How does it work?

The Probe works by using the conductive properties of the water itself to complete a circuit with a controller. It's mounted near the inflow, allowing the turbulence to keep it clean. Even if a build-up does occur it's usually conductive (in wastewater) and so the Probe keeps right on working.

When cleaning is required, the probe is installed off a mounting bracket that includes a cleaning device.



## Primary Level in Industrial Applications.

## Single Pump Control.

Works well in confined spaces and with a wide variety of effluents.


MTR with 2 single sensor probes


MTRA with 3 single sensor probes


SafeSmart-TL version with 3 -sensor probe


Two single sensor probes (e.g. from a sump pack), with optional extender bracket.

## 2 Pump Control.




MTDPC with 10-sensor probe

## How accurate is the Probe?

The probe gives 10\% resolution, more than enough for most pump stations.

## Why is it easier to install than other level devices?

All you do is hang the Probe on its own cable into your wet well, using the bracket we supply. Installation is simple - any one of your technicians could do it in an hour or so. What's more, you install the Probe relatively low down in the wet well, so compared to ball floats it allows the well to be cleaned out more thoroughly. That means less debris build-up, odors and pump clogs.

Why do we like the Probe? It's simple, safe, cuts maintenance time and makes life so much easier!

## Backup Control - Simple Spill Preventer.

The sump pack (MTR or MTRA with 2-single sensor probes) is ideal as a spill preventer. Instead of having a high level float wired as a high level alarm, the sump pack provides simple but effective backup control for those times when the primary control system has failed.

It keeps the well emptied, giving you more time to deal with the problem.

## Better Backup Control - Advanced Spill Preventer.

The SafeSmart family provides better backup control by reading the thermal state of the pump (via thermistors and thermal switches) to ensure the pump doesn't run while too hot, even under backup conditions.

## Specifications for ordering the Probe.

The mounting bracket is a standard accessory supplied with the multi-sensor probes (3-sensor and 10 -sensor probes) and is available as an optional extra on the single sensor probe.

ORDERING EXAMPLES AND INFORMATION

| Model Code | Probe Length | Number of Sensors | Sensor Separation |  |
| :--- | :--- | :--- | :--- | :---: |
| 0.2/1-xx | $0.2 \mathrm{~m} / 8 \mathrm{in}$ | 1 | N/A |  |
| $0.5 / 3-\mathrm{xx}$ | $0.5 \mathrm{~m} / 16 \mathrm{in}$ | 3 | $150 \mathrm{~mm} / 6 \mathrm{in}$ |  |
| 1.0/10-xx | $1.0 \mathrm{~m} / 40 \mathrm{in}$ | 10 | $100 \mathrm{~mm} / 4 \mathrm{in}$ |  |
| $1.5 / 10-\mathrm{xx}$ | $1.5 \mathrm{~m} / 60 \mathrm{in}$ | 10 | $150 \mathrm{~mm} / 6 \mathrm{in}$ |  |
| $2.0 / 10-\mathrm{xx}$ | $2.0 \mathrm{~m} / 80 \mathrm{in}$ | 10 | $200 \mathrm{~mm} / 8 \mathrm{in}$ |  |
| $2.5 / 10-\mathrm{xx}$ | $2.5 \mathrm{~m} / 96 \mathrm{in}$ | 10 | $250 \mathrm{~mm} / 10 \mathrm{in}$ |  |
| $3.0 / 10-\mathrm{xx}$ | $3.0 \mathrm{~m} / 115 \mathrm{in}$ | 10 | $300 \mathrm{~mm} / 12 \mathrm{in}$ |  |
| 6.0/10-xx | $6.0 \mathrm{~m} / 224 \mathrm{in}$ | 10 | $600 \mathrm{~mm} / 24 \mathrm{in}$ |  |
| $9.0 / 10-\mathrm{xx}$ | $9.0 \mathrm{~m} / 368 \mathrm{in}$ | 10 | $900 \mathrm{~mm} / 40 \mathrm{in}$ |  |



## MTDPC SPECIFICATIONS <br> MODE OF OPERATION:

## MTDPC

Simple 2-pump control, with operator interface. Suitable for empty (pump down) and fill (pump up) applications and for use with the MultiTrode probe.

The MTDPC integrates all basic control functions into one panel - with setpoints for two pumps with alternation, a fault input for each pump and an operator interface showing pump status at a glance.

- Level display, pump and fault status indication.
- Alternation or fixed sequence.
- Adjustable setpoints via the keypad.
- Adjustable sensitivities for a wide range of liquids.
- Cost-effective and simple to use.
- Pump auto / off / manual selection.
- Level simulator via keypad to test the control panel.


## Applications:

- Effluent and stormwater pits.
- Sullage pits.
- Water tanks.
- Car park pits.
- Wash down pits.
- Basement sumps.

WATER • WASTEWATER • PUMP STATION • TECHNOLOGY

Mode Fill or Empty (Charge or Discharge) Selectable via function switch
Pump Alternation Alternation or Fixed: Selectable via Keypad
LEVEL SENSING PROBE INPUTS:
Number of inputs 10
Output voltage 10VAC Nominal (open circuit)
Output current $\quad 0.8 \mathrm{~mA}$ max. (per sensor)
Sensitivity settings 1k, 4k, 20k and 80k Ohm Via function switch
Max cable length 50 m
BUTTONS:
Pump Mode: Auto / Off / Manual
Fault Resets: Pump 1, 2 and Level Alarms.
Configuration: Alternation / fixed sequence
Level and alarm setpoints
Level simulation

## FAULT INPUTS

Fault Input: $\quad$| Critical (Lockout) or Non-Critical (Auto Reset); |  |
| :--- | :--- |
|  | Selectable via function switch, one fault input per pump |

## RELAY OUTPUTS:

No. of relay outputs 2 pump N/O, 2 alarm (steady or flash) N/O 1 common alarm N/O
Relay contact rating 250VAC 5A Resistive, 2A Inductive
Relay contact life $\quad 10^{5} @ 2$ 2A Operations
DISPLAY:
LEDS Hi intensity (Red \& Green)
PHYSICAL PRODUCT:
Controller Dimensions 3 3/4"H x 3 3/4"W x $511 / 16$ " D (inches) $95 \mathrm{H} \times 95 \mathrm{~W} \times 145 \mathrm{D}$ (mm)
Material Aluminium and Polycarb
Mounting DIN Rail Mounted
Terminal size $\quad 2 \times 13$ AWG/2.5mm²
Keypad Dimensions $41 / 8^{\prime \prime} H \times 67 / 8^{\prime \prime} \mathrm{W} \times 1^{\prime \prime} \mathrm{D} / 105 \mathrm{H} \times 175 \mathrm{~W} \times 24 \mathrm{D}(\mathrm{mm})$
Material Polycarbonate
Mounting Panel Mounted
POWER SUPPLY:
Supply voltage AC MTDPC 3 110VAC nom. $50 / 60 \mathrm{~Hz}$ MTDPC 2 240VAC nom. 50/60Hz
Power Consumption 6VA max.
ENVIRONMENTAL RANGE:
Operating Temp. $\quad-10^{\circ} \mathrm{C}$ to $+60^{\circ} \mathrm{C}\left(+14^{\circ} \mathrm{F}\right.$ to $\left.140^{\circ} \mathrm{F}\right)$
Humidity $90 \%$ non condensing
RECOMMENDED PROBE 10-SENSOR PROBE


## MTIC

Connect the Mulitirode probe to a PLC/RTU or provide independent control.

The MTIC Indicator Controller provides continuous level indication and pump control from the Multitrode probe.

The 4-20mA output allows the probe to be connected to a PLC or dedicated pump controller system. The 10 Digital Outputs (one for each probe input) provide a mechanism for simple pump control without any other control device.

- 4-20mA output.
- 10 digital outputs.
- Bargraph for level indication.
- Control up to 3 pumps.


## MTIC SPECIFICATIONS

MODE OF OPERATION:

| Mode | Fill or Empty (Charge or Discharge) |
| :--- | :--- |
| PROBE INPUTS: |  |
| Sensor Inputs | 10 |
| Sensor Voltage | 10VAC Nominal |
| Sensor Current | 0.8 mA max (per sensor) |
| Sensitivity | $1 \mathrm{k}, 4 \mathrm{k}, 20 \mathrm{k}, 80 \mathrm{k}$ Ohms |

RELAY OUTPUTS:

| Selectable Delays | $0,5,10,15 \mathrm{sec}$ |
| :--- | :--- |
| Relay contact rating | $250 V A C 5$ Resistive, 2A Inductive |
| Relay contact life | $10^{5}$ Operations |
| Terminal size | $2 \times 2 \times 13$ AWG / 2.5mm² |
| ANALOG OUTPUT: | $4-20 \mathrm{~mA}$ RLoad $<940$ Ohms |
| Analog |  |
| DISPLAY: | 10 LED bargraph \& Power On |
| LEDS |  |

PHYSICAL PRODUCT:

| Dimensions | $3.78^{\prime \prime} \mathrm{H} \times 3.78^{\prime \prime} \mathrm{W} \times 5.12^{\prime \prime} \mathrm{D}$ (inches) $96 \mathrm{H} \times 96 \mathrm{~W} \times 130 \mathrm{D}(\mathrm{mm})$ |
| :---: | :---: |
| Mounting | Panel mounted through cut-out (brackets supplied) |
| Enclosure | Extruded alumium |
| POWER SUPPLY: |  |
| Supply Voltage AC | MTIC2 240V, $50 / 60 \mathrm{~Hz}$ |
|  | MTIC3 110V, $50 / 60 \mathrm{~Hz}$ |
| Power Consumption | 16 VA max. |
| Supply Voltage DC | MTIC5 24V |
|  | MTIC6 12 V |
| Power Consumption | 10W max. |
| ENVIRONMENTAL RANGE: |  |
| Operating Temp. | $-10^{\circ} \mathrm{C}$ to $+60^{\circ} \mathrm{C}$ ( $+14^{\circ} \mathrm{F}$ to $140^{\circ} \mathrm{F}$ ) |
| Humidity | 90\% non condensing |

RECOMMENDED PROBE 10-SENSOR PROBE


For the rare times when the primary control or primary level device fails, an independent backup control system reduces the risk of spills. SafeSmart Backup Controllers, used with a 3 -sensor probe (or 3 single-sensor probes), are the next generation of backup systems for wastewater lift stations.

Most utilities have been using a high level sensor into their primary control device, so if the primary control device fails the operations staff find out through a 'Comms Fail' alarm from the SCADA system. This puts time pressure on every aspect of the organization. A SafeSmart Backup Controller helps avoid this risk.

Complete back up controller including pump control, level alarms and pump sensor inputs:

- Perfect pump control for one pump (either primary or redundant control).
- One level alarm - either high or low.
- Manual (hand) operation from an external selector switch or (SAFE-TL only) keypad.
- Pump thermal protection (thermistor, thermal switch or Flygt FLS).
- Adjustable delays for pump start / stop and alarms.
- Failed Probe detection (requires new failsafe probe).
- Adjustable sensitivity for MultiTrode probe.
- Parallel operation with MultiSmart.

SAFE-TL also has:

- Seal and thermal protection from Flygt FLS input.
- Remote mount keypad.

SAFE-TL SPECIFICATIONS

| MODE | Start / Stop / High level or Low <br> Level Alarm |
| :--- | :--- |
| RELAY OUTPUTS | Pump, Alarm, Thermal / FLS |
| RELAY RATINGS | 5A Resistive, 2A Inductive, <br> 30VDC or 250VA <br> Contact Life 10 0 operations |
| PROBE INPUTS | Low / High / Alarm / Alarm <br> failsafe |
| PUMP INPUT | PTC thermistor or Thermal N/C <br> or Flygt FLS [note] Can work in <br> parallel with MultiSmart <br> pump controller |
| - Seal |  |

DIGITAL INPUTS - Manual (hand) mode
DIP SWITCHES - Empty or Fill mode

- High or Low level alarm
- Pump Activation Delay 0.5 or 10s
Seal Fault Operates D03 or Indicates LED only - Thermal Input to be Thermal

Only or Thermal
\& Seal (miniCAS)

- Thermal Reset is Manual or Auto
Probe Sensitivity 1k, 4k, 20k or 80k
DISPLAY LEDS - Power
- Level Alarm
- Pump Relay
- Thermal Fault

|  | - Seal Fault |
| :--- | :--- |
| POWER SUPPLY | $11-30 v$ DC @ 0.15A |


|  | $85-265 \mathrm{~V} 50 / 60 \mathrm{~Hz}, 3 \mathrm{VA}$ |
| :--- | :--- |
| PHYSICAL | DIN rail mounted |
| PRODUCT | $\left(4.2^{\prime \prime} \mathrm{H} \times 3.0^{\prime \prime \mathrm{W}} \times 0.7^{\prime \prime} \mathrm{D}\right.$ (inches) |
|  | $106 \mathrm{H} \times 75 \mathrm{~W} \times 17 \mathrm{D}(\mathrm{mm})$ |

ENVIRONMENTAL $-10^{\circ} \mathrm{C}$ to $+60^{\circ} \mathrm{C}$
RANGE $\left(+14^{\circ} \mathrm{F}\right.$ to $\left.140^{\circ} \mathrm{F}\right)$
Relative Humidity 5 to $90 \%$, non-condensing

ORDERING
INFORMATION SAFE-TL
RECOMMENDED PROBE ONE FAILSAFE
3-SENSOR PROBE



## SAFE-FS <br> SafeSmart Failsafe Level Alarm Relay.

The Safe-FS is the next generation of ultra-reliable high level alarming for lift stations and pump stations. It adds failsafe probe functionality, for example, for a situation where rats have been eating through cables. The -FS verifies that the high level alarm is always functioning. Level Alarm Relay for use with the new failsafe probe.

- Separate relays for level alarm \& loss of probe.
- N/O or N/C outputs.
- Adjustable delays.
- LED indication for power, level alarm, loss of probe alarm.

SAFE-FS SPECIFICATIONS

| MODE | High Level or Low Level Alarm |
| :---: | :---: |
| RELAY OUTPUTS | Level alarm N/O or N/C, 0.5 s or 10 s delay - Probe fail N/O or N/C, 0.5 s or 10 s delay [note] requires failsafe probe |
| RELAY RATINGS | - 5A Resistive, 2A Inductive, 30VDC or 250VA <br> - Contact Life $10^{5}$ operations |
| PROBE INPUTS | - Alarm sensor <br> - Failsafe for alarm sensor |
| DISPLAY LEDS | - Power On Green, flashes when low <br> - Level Alarm Red, flashes when alarm active <br> - Probe Alarm Red, flashes when alarm active |
| POWER SUPPLY | 11-30v DC @ 0.15A max |
| PHYSICAL PRODUCT | ( $4.2^{2 " H} \times 3.0^{\prime \prime} \mathrm{W} \times 0.7^{7 \mathrm{D}}$ (inches) DIN rail mounted $106 \mathrm{H} \times 75 \mathrm{~W} \times 17 \mathrm{D}(\mathrm{mm})$ |
| ENVIRONMENTAL |  |
| RANGE | $-10^{\circ} \mathrm{C}$ to $+60^{\circ} \mathrm{C}\left(+14^{\circ} \mathrm{F}\right.$ to $140^{\circ} \mathrm{F}$ ) Relative Humidity 5 to $90 \%$, non-condensing |
| ORDERING INFORMATION | SAFE-FS |
| RECOMMENDED PROBE ONE FAILSAFE SINGLE SENSOR PROBE |  |



## MTR family

Simple, reliable and effective - for use with Multitrode probes or in any control application.
The MTR family gives an ultra-reliable, maintenance free level control system. Use it with the MultiTrode conductive probes and it works in the worst kind of liquids:

- Wastewater.
- Stormwater.
- Industrial effluent.
- Sullage pits.

The adjustable conductivity settings and adjustable delays give it the flexibility that other systems lack.

The MTR controls one pump in fill (pump up) and empty (pump down) applications. The MTRA controls one pump and one alarm in empty only mode.

The MTR family is also available with single sensor probes as a package: MT-SSP

To order the Sump Pack, use the order code
MTSSP - relay part number - probe cable length in $m$.
E.g. MTSSP-MTR3-10 is the ordering code for the sump pack with MTR3 and 2-single sensor probes each with $10 \mathrm{~m} / 33 \mathrm{ft}$ of cable.

MTR SPECIFICATIONS
MODE OF OPERATION:

| MTR Mode MTRA Mode | Fill or Empty (Charge or Discharge) Empty ONIY |
| :---: | :---: |
| PROBE INPUTS: |  |
| Sensor inputs | MTR : $2 /$ MTRA : 3 |
| Sensor voltage | 10 / 12VAC Nominal |
| Sensor current | 0.8mA max. (per sensor) |
| Sensitivity | 1k, 4k, 20k, 80k |
| RELAY OUTPUTS: |  |
| MTR relay output | 2 contact sets : 1 N/0 \& $1 \mathrm{C} / 0$ |
| MTR output delay | $0,2.5,5,10,20,40,80,160 \mathrm{sec}$ |
| MTRA relay output | 2 relays : both N/0 |
| MTRA output delay | Pump: 0.5, 10; Alarm: 0.5, 15 sec |
| Relay contact rating | 250 VAC 5A Resistive, 2A Inductive |
| Relay contact life | $10^{5}$ Operations |
| Terminal size | $2 \times 13$ AWG/ $2.5 \mathrm{~mm}^{2}$ |
| DISPLAY |  |
| LEDs: | Power On Pump Alarm |
| MTR | Green Red |
| MTRA | Green Yellow Red |

PHYSICAL PRODUCT:

Dimensions
Mounting
Enclosure

POWER SUPPLY:
Supply Voltage AC

Power Consumption
Supply Voltage DC
Power Consumption
$2.7 / 8^{\prime \prime} \mathrm{H} \times 1.3 / 4^{\prime \prime} \mathrm{W} \times 4.1 / 2^{\prime \prime} \mathrm{D}$ (Inches)
$72 \mathrm{H} \times 45 \mathrm{~W} \times 114 \mathrm{D}(\mathrm{mm})$
DIN Rail or $2 \times \# 6$ Screws $/ 2 \times \mathrm{M} 4$ Screws
Makrolon (self-extinguishing)


ENVIRONMENTAL RANGE:
Operating Temp. $\quad-10^{\circ} \mathrm{C}$ to $+60^{\circ} \mathrm{C}\left(+14^{\circ} \mathrm{F}\right.$ to $\left.140^{\circ} \mathrm{F}\right)$
Humidity $90 \%$ non condensing
RECOMMENDED PROBE
MTR
2 single-sensor probes
MTRA 3 single-sensor probes, or a 3-sensor probe
A 10-sensor probe can also be connected to the sensors, when you need to have the versatility to change setpoints without going back into the pit.
All specifications subject to change without notice.

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## SAFESMART Backup Controller SAFE-FSP

## Installation \& Operation Manual



This Manual is the support documentation for the installation, commissioning and operation of the SafeSmart FSP Backup Controller

Document No. 00242600
Document Revision 1
Last updated 2 June 2009

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## 1 Warnings \& Cautions

### 1.1 Information to User

Read this manual prior to installing or operating the SafeSmart-FSP Backup Controller. It contains all the information necessary to configure it for maximum performance for your application. After reading, place the manual in a safe place for future reference.

### 1.2 Documentation Standards



## DANGER:

This symbol is used where non-compliance could result in injury or death.


## WARNING:

This symbol is used where non-compliance could result in incorrect operation, damage to or failure of the equipment.


## NOTE:

This symbol is used to highlight an issue or special case within the body of the manual.

### 1.3 Installation Notes



## WARNING:

The SafeSmart-FSP installation and wiring must be performed by qualified personnel.

## DANGER:

The SafeSmart-FSP has no user serviceable parts. To reduce the risk of electric shock leave all servicing to qualified Multitrode technical staff.

## 2 Introduction

The SAFE-FSP Backup Controller is a solid-state electronic level control module housed in a hi-impact plastic case with a DIN rail attachment on the back. It is used to control a pump (via a contactor or soft starter) in response to a liquid level sensor such as a MultiTrode probe.
The FSP Controller can be used as the primary source of control for a single pump or as a backup control device (for a single pump) when the primary control equipment fails. When using an FSP Controller as a backup controller, it only controls the pump in response to high or low level signals from dedicated level sensors.

A thermal sensor can be connected to the FSP Controller for pump protection. During operation, the LED indicators on the front panel display the current status including - Power, Pump On/Off, Level alarm, Thermal fault and Probe fault.

The FSP Backup Controller is designed to be easy to install and configure. All connections are clearly labelled on the side of the device and options are configured using a set of Dip switches on the front of the Controller.

## 3 Specifications

| Dimensions |  |
| :---: | :---: |
| Width | 22.5 mm (7/8") |
| Height | 101 mm (4") |
| Length (depth) | $120 \mathrm{~mm} \mathrm{(43/4")}$ |
| Environmental |  |
| Ambient Temperature | -10 to $60^{\circ} \mathrm{C}$ ( 14 to $140^{\circ} \mathrm{F}$ ) |
| Humidity | $5 \%$ to $90 \%$ non-condensing |
| AC Power Supply |  |
| Voltage Range | 85-265V AC |
| Frequency | $50 / 60 \mathrm{~Hz}$ |
| Power | 3.5W |
| DC Power Supply |  |
| Voltage Range | 12-30V DC |
| Current | 0.15 A max |
| Relay Outputs |  |
| Type | Form A |
| Current (Resistive) | 5A |
| Current (Inductive) | 2A |
| Voltage Rating DC | 30 V DC |
| Voltage Rating AC | 250 V AC |
| Thresholds* |  |
| Thermal Fault Present | > 4k ohms |
| Thermal Fault Cleared | <2k ohms |
| Thermal BU Input | 0.15 V DC |

Table 1 - SAFE-FSP Specifications

* Where applicable, values include a 56 ohm series resistor on the thermal input.


## 4 Installation

The FSP Backup Controller is designed to be mounted onto a standard DIN rail. The power supply, input and output connections are located on the top of the Controller housing.

The features of the Controller are listed below and are discussed in the following sections.

- Power Supply Options
- Four Configurations
- Operation Modes \& Probe Inputs
- Empty (Discharge) Mode
- Fill (Charge) Mode
- Level Alarm Fault
- Level Alarm (AL Probe)
- Pump Faults
- Thermal Pump Fault
- Probe Faults
- Failsafe Probe Fault
- Assumed Probe Fault
- Digital Output and Pump Sensor Connection Options
- Local or Remote Monitoring of Pump Status \& Faults
- MultiSmart Connections - Conductive Thermal Sensor
- MultiSmart Connections - FLS Thermal Sensor
- Manual (Hand) Operation
- Alarm Activation and Deactivation Delays
- Probe Sensitivity
- LED Status Summary
- DIP Switch Settings


## 5 Power Supply Options

The FSP Controller can be supplied power in the following ways:

- $85-240 \mathrm{~V}$ AC Supply Only
- 12 - 30V DC Supply Only
- $85-240 \mathrm{~V}$ AC with $12-14 \mathrm{~V}$ DC as Backup
- $15^{*}-30 \mathrm{~V}$ DC with $85-240 \mathrm{~V}$ AC as Backup
* When the DC supply is 15 V or greater, the DC supply is the primary source.

A Power LED (steady green) indicates when the Controller is powered. If the LED flashes, supply voltage is too low.

## NOTE:

If the power supply is below 24 VDC , the voltage alarm threshold is automatically set to 11.5 V . If the supply is 24 VDC or above, the voltage alarm threshold is automatically set to 23 V .

A switch or circuit-breaker and an over-current protection device must be included in the installation. The protection device must be in close proximity to the equipment, within easy reach of the operator, and be marked as the protection device for the equipment.
The input wiring and the switch/circuit-breaker/over-current device must be rated to at least the nominal input voltage being used. The recommended current ratings are below.

| Unit Supply <br> Range | Recommended Switch/Circuit- <br> Breaker/Overcurrent <br> Protection Device Rating | Minimum Supply <br> Wiring Rating |
| :---: | :---: | :---: |
| $85-180 \mathrm{VAC}$ | 0.1 A | 0.1 A |
| $180-265 \mathrm{VAC}$ | 0.05 A | 0.05 A |
| $12-20 \mathrm{VDC}$ | 0.3 A | 0.3 A |
| $20-30 \mathrm{VDC}$ | 0.15 A | 0.15 A |

Table 2 - Current Ratings


NOTE:
The MultiTrode probe uses an earth/ground return path for the signal. Ensure that the GROUND (DC-) terminal on the FSP Controller is also grounded.

SAFE-FSP Relay Manual

## 6 Operation Modes \& Probe Inputs

The SafeSmart-FSP Backup Controller can be configured to operate in either Empty (Discharge) or Fill (Charge) mode.

- Empty (Discharge) Mode - Dip Switch 1 = OFF
- Fill (Charge) Mode - Dip Switch $1=$ ON

The Controller has three (3) probe inputs, High, Low and Alarm. The Alarm probe input can be configured as a low or high level alarm.

- High Level Alarm - Dip Switch 2 = OFF
- Low Level Alarm - Dip Switch 2 = ON


### 6.1 Empty (Discharge) Mode

This mode is used to pump liquid out of a well once it reaches a preset level. (Figure 1) In this mode the Controller operates as follows:

- The pump activates when the liquid reaches the sensor in the high level probe.
- The pump continues to operate until the liquid level drops below the low level probe and the pump deactivation period expires.
- When a thermal fault occurs, the Pump Control output is deactivated regardless of the liquid level. The pump stops, the Pump Fault output (DO1) is deactivated and the Thermal LED flashes.


Figure 1 - Empty (Discharge) Mode


### 6.2 Fill (Charge) Mode

This mode is used to fill up a well with liquid when the level falls to a preset level. (Figure 2) In this mode the Controller operates as follows:

- The pump activates when the liquid falls just below the sensor in the low level probe.
- The pump continues to operate until the liquid level reaches the sensor in the high level probe and the pump deactivation period expires.
- When a thermal fault occurs the Pump Control output deactivates regardless of the liquid level. The pump stops, the Pump Fault output is deactivated and the Thermal LED flashes.


Figure 2 - Fill (Charge) Mode

## 7 Level Alarms (AL Probe)

A conductive level sensor is connected to the AL Probe input to detect when the liquid level has risen above or fallen below an acceptable level.

In Empty (Discharge) mode this is typically a high level alarm and is activated when the AL Probe input detects liquid and the activation delay has expired.
In Fill (Charge) mode this is typically a low level alarm and is activated when the AL Probe input is no longer detecting level (i.e. the level has dropped below the sensor) and the activation delay has expired.

When a level alarm is detected the Level Alarm output (DO1) changes state and the Level Alarm LED flashes at 1 Hz . The Level Alarm/Pump Fault output can be used to operate an alarm device such as a beacon.

The Level Alarm/Pump Fault output (DO1) can be configured as normally open or normally closed.

- $\quad$ Normally Closed Output - Dip Switch 6 = OFF
- Normally Open Output - Dip Switch 6 = ON


NOTE:
Dip Sw6 also has the same effect on the Probe/Failsafe Alarm output (DO3).

## 8 Thermal Pump Fault

The FSP Controller can detect thermal and FLS thermal faults. The FSP Controller can not detect a Seal fault. Types of sensors that maybe connected are FLS (Flygt Leakage Sensor), FLS10 or a thermal only sensor such as non-linear PTC thermistor or bi-metallic switch.

A thermal sensor is connected as illustrated in Figure 3. No Dip Switch setting change is required.


Figure 3 - Thermal Sensor Connection (Flygt and Non-Flygt Pumps)

When a thermal fault is detected, the pump stops, (DO2 is deactivated), the Level Alarm / Pump Fault output (DO1) changes state and the Thermal Fault LED begins to flash.
A thermal fault is automatically reset when the pump returns to normal operating temperature (i.e. the fault is no longer present). The flashing Thermal LED becomes steady and the pump is free to run.

A manual acknowledgement is required to clear the Thermal LED. A manual acknowledgement is performed by momentarily connecting Ground/Earth to the Manual (Hand) terminal. See Figure 4 below. (Note, the pushbutton switch is not supplied).


Figure 4 - Manual Thermal Fault Reset \& Manual (Hand) Operation

The Level Alarm/Pump Fault output (DO1) can be configured as normally open or normally closed.

- Normally Closed Output - Dip Switch $6=$ OFF
- Normally Open Output - Dip Switch $6=$ ON

©
NOTE:
Dip Sw6 also has the same effect on the Probe/Failsafe Alarm output (DO3).

## 9 Probe Faults

The FSP Controller detects two types of probe faults, a Failsafe Probe fault and an Assumed Probe fault. When either fault is detected the Probe/Failsafe Alarm output (DO3) changes state. This output can be configured as normally open or normally closed.

- Normally Closed Output - Dip Switch 6 = OFF
- Normally Open Output - Dip Switch $6=$ ON

NOTE:
Dip Sw6 also has the same effect on the Level Alarm/Pump Fault output (DO1).

### 9.1 Failsafe Probe Fault

MultiTrode probes are available with a failsafe connection to the top-most sensor to enable detection of a sensor fault. If a broken cable is detected to the top-most sensor, the Probe/FailSafe fault output (DO3) changes state, the Probe Fault LED flashes and the pump stops.

A Failsafe probe is typically used in discharge (empty) applications only. By its very nature the probes used in a charge or fill application are covered, so for example if the low level alarm probe goes open circuit, a low level alarm would be present immediately.

## NOTE:

If a non-failsafe probe is used, then a jumper must be connected between the Alarm Probe and the Failsafe Probe inputs to suppress erroneous probe faults.

## NOTE:

When using single sensor probes, the Failsafe Probe input should be connected to the highest probe in the system.

### 9.2 Assumed Probe Fault

For an Empty (Discharge) application, if a High Level probe is activated and the Low Level probe is deactivated, then the Controller assumes the Low Level probe is faulty. This condition is called an "Assumed Probe Fault" and the Probe Fault LED illuminates.

The Controller changes its pumping behaviour to a timed method until the fault condition is no longer present. So the pump continues to run for 60 s after the High Level probe has deactivated and during this time the Pump LED flashes.

For a Fill (Charge) application, if a High Level probe is activated and the Low Level probe is deactivated, then the Controller assumes the Low Level probe is faulty. This condition is called an "Assumed Probe Fault" and the Probe Fault LED illuminates.

The Controller changes its pumping behaviour to a timed method until the fault condition is no longer present. So the Controller waits for 60 seconds after the High Level probe has deactivated then starts the pump, and during this time the Pump LED flashes.

When an Assumed Probe fault occurs, the Probe/FailSafe fault output (DO3) changes state.

## 10 Digital Output and Pump Sensor Connection Options

### 10.1 Local or Remote Monitoring of Pump Status \& Faults

The FSP Controller's digital outputs can be wired into the inputs of a wide range of devices (e.g. a PLC, RTU or Dialler etc.) and the state of the pump monitored. The valid states and what they signify are tabled below.

|  |  |  |  | Pump Status |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| DO1 | DO2 | DO3 | DO1 | DO2 | DO3 |
| 0 | 0 | 0 | - | Off | - |
| 0 | 0 | 1 | - | Off | Y |
| 1 | 0 | 0 | Y | Off | - |
| 1 | 0 | 1 | Y | Off | Y |
| 0 | 1 | 0 | - | On | - |
| 0 | 1 | 1 | - | On | Y |
| 1 | 1 | 0 | Y | On | - |
| 1 | 1 | 1 | Y | On | Y |

Table 3 - FSP Controller Output States

* Dip Sw $6=$ On (Normally Open)


### 10.2 MultiSmart and FSP Controller Thermal Sensor Options

The FSP Controller can be used in conjunction with a MultiSmart Pump Station Manager.
The MultiSmart is indirectly connected to the thermal sensor via a relay within the FSP Controller. The Controller monitors this line and if it detects that the MultiSmart is no longer connected, the internal relay switches over and the FSP Controller drives the sensor.

The Controller monitors the voltage on the Thermal BU input to the MultiSmart. If the MultiSmart fails, the Controller takes over and controls the pump (but does not inhibit the MultiSmart pump control) and monitors for a thermal fault - thus providing backup control and thermal overload protection to the pump.

### 10.2.1 MultiSmart Connections - Conductive Thermal Sensor

The conductive thermal sensor is connected to the Thermal input. The Thermal BU (backup) is connected to a digital input on the MultiSmart (configured as a Motor OverTemp fault). See Figure 5 below.

The MultiSmart and FSP controller are both capable of responding to a thermal fault. When a thermal fault is detected, the pump stops, if running. A Motor OverTemp fault is displayed on the MultiSmart and a thermal fault is displayed on the Controller. The pump can not be restarted until the thermal fault clears. The FSP Controller automatically resets the fault when the fault condition is no longer present, this allows the pump to run again but only via the Controller The fault must be reset at the MultiSmart before the MultiSmart is able to run the pump again.


Figure 5 -Thermal Sensor Connections to a MultiSmart

### 10.2.2 MultiSmart Connections - FLS Thermal Sensor

The FLS sensor is connected to the Thermal input. The Thermal BU is connected to a digital input on the MultiSmart (configured as an FLS fault). (See Figure 6 below). The FSP Controller is not able to detect a seal fault however the MultiSmart can.

When an FLS thermal fault is detected, the pump stops, if running - shut down by the MultiSmart and/or the FSP Controller. An FLS Flygt Thermal fault is displayed on the MultiSmart and on the Controller. The pump can not be restarted until the thermal fault clears. The FSP Controller automatically resets the fault when the fault condition is no longer present, this allows the pump to run again but only via the Controller The fault must be reset at the MultiSmart before the MultiSmart is able to run the pump again.

When an FLS Seal fault occurs the FSP Controller is unable to detect it however the MultiSmart can and will display an FLS Flygt Seal fault. By default, the MultiSmart allows the pump to continue to run when a seal fault occurs.


Figure 6 - FLS Connections to a MultiSmart (Flygt Pump)

## 11 Manual (Hand) Operation

A momentary action pushbutton (not supplied) may be connected to the Manual (Hand) input and used to operate the pump directly. (See Figure 7). Once pressed the pump begins to operate immediately irrespective of the liquid level. A second momentary action pushbutton switch is required to switch the pump off. It is connected across the Off input and Ground/Earth.

## WARNING:



If operating the pump manually via the Manual (Hand) switch, the pump does NOT automatically turn off when the level falls below the low sensor. So ensure that the pump is switched off via the Pump Off switch before the level becomes critically low to avoid potential damage to the pump.


Figure 7 - Manual Pump Operation - On \& Off Switches

## 12 Pump Activation and Deactivation Delays

Activation delays are used to prevent spurious pump starts. The delay allows the level device to positively detect the liquid before operating the pump.
There are two delay periods for Pump Activation delay:

- $0.5 \mathrm{sec}-$ Dip Switch $3=$ OFF
- 30 sec - Dip Switch $3=$ ON

There are two delay periods for Pump Deactivation delay:

- 0.5 sec - Dip Switch 4 = OFF
- 30 sec - Dip Switch $4=$ ON


## 13 Alarm Activation and Deactivation Delays

Activation and Deactivation delays are used to prevent spurious level alarms. The delay allows the level device to positively detect the liquid before triggering the alarm.

There are two delay periods:

- $0.5 \mathrm{sec}-$ Dip Switch $5=$ OFF
- 10 sec - Dip Switch $5=$ ON

This delay applies to both the alarm activation and deactivation delay.

## 14 Probe Sensitivity

The Controller is used in conjunction with a conductive level sensing device, such as the MultiTrode probe. Conductive probes rely on conductivity through the liquid to earth in order to detect level. Highly conductive liquids, such as saltwater, generally require the Controller be set to a lower sensitivity than for low conductivity liquids, such as distilled water.
For most applications, the default probe setting of 20 k ohms is satisfactory but the Controller allows the operator to adjust its sensitivity as needed for specific conditions. The sensitivity is set using Dip Switches 7 and 8.

| Dip Sw 7 | Dip Sw 8 | Sensitivity | Typical Application |
| :---: | :---: | :---: | :--- |
| OFF | OFF | 1 k ohm | Concentrates Acids, Minerals, Alkalis |
| ON | OFF | 4 k ohm | Acids, Alkalis, Diluted Brine, Sea Water |
| OFF | ON | 20 k ohm | Sullage, Sewage Effluent, Town Water |
| ON | ON | 80 k ohm | Industrial Effluent, Purified Water* |

Table 4 - Probe Sensitivity

* Not recommended for use with purified de-ionised water or pristine rain water.


## 15 LED Status Summary

Five LEDs on the front of the Controller indicate the power, level alarm, pump status, thermal and probe fault status of the Controller.

| LED | Status | Indication |
| :--- | :--- | :--- |
| Power | Power on | Steady |
|  | Low voltage | Flashing |
| Level | Level alarm | Flashing |
| Pump | Pump on | Steady |
|  | Activation delay period | Flashing |
| Thermal | Manual ack required | Steady |
|  | Thermal fault active | Flashing |
|  | Standalone locked mode* | Flashing - Double |
| Probe | Assumed probe fault | Steady |
|  | Failsafe probe fault ** | Flashing |

Table 5 - LED Summary Status

* In Standalone Locked mode the FSP Controller ignores the THERMAL BU input. Standalone Locked mode occurs if the voltage on the THERMAL BU input is unstable (i.e. voltage is $<0.15 \mathrm{~V}$ and $>6 \mathrm{~V}$ in less than 0.5 s for 30 seconds). To exit Standalone Locked mode, press the Manual (Hand) button.
** Failsafe probe fault has higher priority than Assumed probe fault.


## 16 DIP Switch Settings

The Controller is configured using the DIP switches located on the front of the enclosure.

| DIP \# | Setting | Mode Description | Section |
| :---: | :---: | :--- | :---: |
| $\mathbf{1}$ | OFF | Empty (Discharge) Mode | 6 |
|  | ON | Fill (Charge) Mode | 6 |
| $\mathbf{2}$ | OFF | High Level Alarm | 6 |
|  | ON | Low Level Alarm | 6 |
| $\mathbf{3}$ | OFF | 0.5 sec Pump Activation Delay | 12 |
|  | ON | 30 sec Pump Activation Delay | 12 |
| $\mathbf{4}$ | OFF | 0.5 sec Pump Deactivation Delay | 12 |
|  | ON | 30 sec Pump Deactivation Delay | 12 |
| $\mathbf{5}$ | OFF | 0.5 sec Alarm Activation \& | 13 |
|  | ON | 10 sec Alarm Activation \& | 13 |
| $\mathbf{6}$ | OFF | N/C (Normally Closed) (DO3 \& DO1) | $7,8,9$ |
|  | ON | N/O (Normally Open) (DO3 \& DO1) | $7,8,9$ |
| $\mathbf{7}$ | $\mathbf{8}$ | Probe Sensitivity | 14 |
| OFF | OFF | 1k ohm |  |
| ON | OFF | 4k ohm |  |
| OFF | ON | 20k ohm |  |
| ON | ON | $80 k$ ohm |  |

Table 6 - Dip Switch Settings

## 17 Example Applications

### 17.1 Backup Operation

Following is an example an empty (discharge) application using the FSP Controller as backup to a pump controller (the primary control device). In this configuration the FSP Controller does not control the pump until the High Level probe is covered which should only occur if the pump controller fails.
If the level continues to rise and it reaches the Alarm probe, a high level alarm is tripped. This indicates that the pump for whatever reason is unable to cope and the level has risen to an excessively high level (and overflow is possibly imminent).
The Alarm and High Level probes are positioned higher than the highest activation point used by the pump controller.

EMPTY (DISCHARGE) MODE


```
Dip Sw 1 = Off (Empty Mode )
Dip Sw 2 = Off (High Level Alarm)
Dip Sw 3 = On (Pump Activation Delay = 30s)
Dip Sw 4 = Off (Pump Deactivation Delay = 0.5s)
Dip Sw 5 = Off (Alarm Delay = 0.5s )
Dip Sw6 = Off (N/C Level & Probe Alarms )
```

Figure 8 - Example of a Backup Application
If the pump controller is located at a site with no telemetry, a low level alarm could be configured (rather than a high level alarm). If the alarm trips, it indicates (by means of say a beacon) that the primary pump controller has most likely failed. However in this case no further alarm can be generated by the FSP Controller to indicate an excessively high level has been reached.

## NOTE:

The actual probe position is at the discretion of the end user, the only requirement for a discharge (empty) application is that the high probe must be positioned higher than the (highest*) activation setpoint. (* In some pump controllers, more then one activation setpoint may be defined).

### 17.2 Dual Thermal Fault Monitoring (with MultiSmart)

The following wiring diagram (Figure 9), illustrates an application where the FSP Controller and a MultiSmart pump controller operate in parallel.

The thermal sensor is connected to the FSP Controller and the Thermal Bu input is connected to the MultiSmart. This allows both devices to act on a thermal fault.

If a seal sensor is present it is connected to the MultiSmart.


Figure 9 - Dual Thermal Fault Monitoring

### 17.3 Simplex Pump Controller

In this example the FSP Controller is configured as the primary pump controller for a single pump. The FSP Controller takes no action until the High Level probe is covered. When it is covered, the Pump Control output (DO2) closes turning on the pump.
When the Alarm Level probe is covered, a high level alarm is generated and the Level Alarm/Pump Fault output (DO1) changes state.

The FSP Controller monitors the thermal sensor. If a seal sensor is present it is not connected to the FSP Controller.

The FSP Controller and associated probes can control a maximum of one pump. The wiring is illustrated in Figure 10 below.


Figure 10-Simplex Pump Controller


Figure 11 - SafeSmart SAFE-FSP Label.

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Visit www. multitrode.com for the latest information

## 10. Marechal



The DECONTACTOR ${ }^{\text {TM }}$ DS range is our widest range offering rated currents from 30 to 250 A. Polyester from 30 to 90 A and metal-bodied from 90 to 250 A it provides the user with many options - padlocking, auxiliary contacts etc.

This range is used in many diverse applications meeting the quality and performance standards demanded by manufacturing industries' engineers.

Advantages
Core range
DS1-30A
DS3-50A
DS6-90A
DS9-150A
DS2-250A
Dimensions

## Electrical features

- From $\mathbf{3 0}$ to 250 Amps - Voltage up to 1000 Volts AC and up to 250 Volts DC
- Integral switching device as defined in clause 2.8 of IEC/EN 60309-1 standard
- Equipped with silver-nickel butt-contacts and metal braid for added reliability and lifetime
- Socket-outlet safety shutter provides IP4X protection


The locked safety shutter prevents access to the electrical contacts of the socketoutlet when the plug is removed (IP4X protection against solid foreign objects and access to hazardous parts).
The socket-outlet contacts are kept clean and inaccessible (to 1 mm diameter wires) even when the socket-outlet lid is open.

- Unique keying system allows discrimination between 24 different power supplies (voltage, frequency, AC and DC current)
- Number of cycles under normal operation and overload conditions from 2 to 8 times (depending on rated current) more than those required by IEC/EN 60309-1 standard
- Versions with auxiliary contacts


## Mechanical features

- Automatic IP54/55 watertightness. 150 A and 250 A models available also in IP66/67
- Casings made of glass fibre reinforced polyester ( 30 to 150 A ) providing excellent electric insulation, high resistance to corrosive, UV and chemical agent environments and high mechanical resistance (IKo8 impact resistance)
- Casings made of anti-corrosion treated metal ( 90 to 250 A ) providing high temperature resistance and excellent mechanical resistance (IKog impact resistance)
- Ambient temperature: $-40^{\circ} \mathrm{C}$ to $+60^{\circ} \mathrm{C}$ (for temperatures outside this range, please contact us)
- Spring assisted terminals unaffected by vibration and thermal cycling
- Self-opening lid; self-returning lid on request


## Regulatory features

DS decontactors comply with:

- The IEC 60309-1 International standard and EN 60309-1 European standard (plugs and socket-outlets for industrial purposes),
- The European Low Voltage Directive (decree N95-1081 dated $3^{\text {rd }}$ October 1995),
- The French decree $\mathbf{N}^{\circ} \mathbf{8 8 - 1 0 5 6}$ dated $14^{\text {th }}$ November 1988 relating to workers' protection,
- The decrees relating to workers' protection in Belgium, Spain and Italy,
- The load breaking capacity according to utilisation categories AC22 and AC23 of IEC / EN 60947-3 (switch standard).
Also certified by VERITAS LCIE, UL, AS and CSA (French, American, Australian and Canadian inspection laboratories).

${ }^{\text {оесомтастог"m }}$ The range
Quickly find


## Marechal's modular system




Example : a wall mounting socket-outlet includes an active part, the socket-outlet (female) and an installation accessory,


the wall box. Each part has its own part number. Therefore, the order should have two part numbers.

## DS part number system

- Standard DS part numbers are made up of 7 characters. All part numbers start with a ' $\mathbf{3}$ '.
- The choice of an option or a version with auxiliary contacts results in adding a suffix (of 1 to 3 characters).

| $1^{\text {st }}$ character | $2^{\text {nd }}$ character | $3{ }^{\text {rd }}$ character | $4^{\text {th }}$ character | Characters from 5 to 7 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Range | Casing | Rated current | Usage | Supply voltage** | Frequency | Polarity |
| 3 = DS | 1 = Blue poly | 1 = DS1 (30A) | 4 = Socket-outlet | 08A $=20-24 \mathrm{~V}$ | 50 Hz | 2P |
|  | 4 = Grey poly | 3 = DS3 (50A) | 8 = Inlet | $033=190-230 \mathrm{~V}$ | 50 Hz | $3 \mathrm{P}+\mathrm{E}$ |
|  | 5 = Black poly | $\mathbf{6}$ = DS6 (90A) |  | $015=220-250 \mathrm{~V}$ | 50 Hz | $1 \mathrm{P}+\mathrm{N}+\mathrm{E}$ |
|  | 9 = Blue metal | $\mathbf{9}=$ DS9 (150A) |  | $013=380-440 \mathrm{~V}$ | 50 Hz | $3 \mathrm{P}+\mathrm{E}$ |
|  |  | $\mathbf{2}$ = DS2 (250A) |  | $017=380-440 \mathrm{~V}$ | 50 Hz | $3 \mathrm{P}+\mathrm{N}+\mathrm{E}$ |
|  |  |  |  | $193=660-690 \mathrm{~V}$ | 50 Hz | $3 \mathrm{P}+\mathrm{E}$ |
|  |  |  |  | $197=660-690 \mathrm{~V}$ | 50 Hz | $3 \mathrm{P}+\mathrm{N}+\mathrm{E}$ |
|  |  |  | A = Installation accessory | 013 = Handle |  |  |
|  |  |  |  | 027 = Inclined sleeve |  |  |
|  |  |  |  | 053 = Wall box |  |  |

** 24 different power supplies (voltage, frequency) and 12 polarities are available: see international standard and colour-code on page 8

## Check that the DS part number meets the need ...

Example : the need is for a $30 \mathrm{~A}, 400 \mathrm{~V}, 3 \mathrm{P}+E$ blue poly wall mounting socket.

- The DS with a 30 A rated current is DS1 (see pages 34 and 35).
- Order a 30 A socket-outlet (S) and a wall box (B).
- In the standard socket-outlet part numbers table, select the part number for a 400 V , $3 \mathrm{P}+$ E socket-outlet: $\mathbf{3 1 1 4} \mathbf{0 1 3}$
- In the standard wall box part number table, choose the accessory that suits you e.g. a $30^{\circ}$ blue poly wall box with a M20 threaded entry: 31 1A 053

You can check the two part numbers found:


## The DS core range

In the following table are described the most frequent configurations. Take a look:
if the required configuration is there, do not look further in the 'part number' pages.
Each configuration includes two part numbers: one for the active part (socket-outlet or inlet) and one for the installation accessory (wall box, inclined sleeve or handle).

| Wall mounting <br> socket | Inclined <br> socket | Coupler socket | Plug | Wall mounting <br> appliance inlet | Inclined <br> appliance inlet |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Socket-outlet | Socket-outlet | Socket-outlet | Inlet | Inlet | Inlet |
| B Wall box | Si Inclined sleeve | H Handle | H Handle | B Wall box | Si Inclined sleeve |

DS 130 A (poly)

| Voltage Polarity | Part Number |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $230 \mathrm{~V} \quad 1 \mathrm{P}+\mathrm{N}+\mathrm{E}$ | 3114015 | 3114015 | 3114015 | 3118015 | 3118015 | 3118015 |
| + installation accessory: | 31 1A 053 | 31 1A 027 | 31 1A 013 | 31 1A 013 | 31 1A 053 | 31 1A 027 |
| 400 V 3P+E | 3114013 | 3114013 | 3114013 | 3118013 | 3118013 | 3118013 |
| + installation accessory: | 311 A 053 | 31 1A 027 | 311 A 013 | 31 1A 013 | 311 A 053 | 31 1A 027 |
| 400V * 3P+N+E | 3114017 * | 3114017 * | 3114017 * | 3118017 | 3118017 | 3118017 |
| + installation accessory: | 311 A 053 | 31 1A 027 | 311 A 013 | 31 1A 013 | 31 1A 053 | 31 1A 027 |
| $\text { DS3 } 50 \text { A (p }$ | Example described at bottom of previous page |  |  |  |  |  |
| Voltage Polarity | Part Number |  |  |  |  |  |
| 230 V 1P+N+E | 3134015 | 3134015 | 3134015 | 3138015 | 3138015 | 3138015 |
| + installation accessory: | 313 A 053 | 313 A 027 | 313 A 013 | 31 3A 013 | 313 A 053 | 313 A 027 |
| 400 V 3P+E | 3134013 | 3134013 | 3134013 | 3138013 | 3138013 | 3138013 |
| + installation accessory: | 313 A 053 | 313 A 027 | 313 A 013 | 313 A 013 | 313 A 053 | 313 A 027 |
| 400 V * 3P+N+E | 3134017 * | 3134017 * | 3134017 * | 3138017 | 3138017 | 3138017 |
| + installation accessory: | 313 A 053 | 313 A 027 | 313 A 013 | 313 A 013 | 313 A 053 | 313 A 027 |


| DS 69 A (poly or metal) |  |  | Finding the metal version part number is easy! <br> When a part number is preceded by $\bullet$, a metal version is also available: To find its part number, just change the 31 into 39 ( $1=$ poly, $9=$ metal $)$. |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 400V 3P+E | - 3164013 | - 3164013 | - 3164013 | - 3168013 | - 3168013 | - 3168013 |
| + installation accessory: | - 31 6A 053 | - 31 6A 027 | 3164013 | 31 6A 013 | - 31 6A 053 | - 31 6A 027 |
| 400V * 3P+N+E | - 3164017 * | - 3164017 * | - 3164017 * | - 3168017 | - 3168017 | - 3168017 |
| + installation accessory: | - 31 6A 053 | - 31 6A 027 | 316 A 013 | 31 6A 013 | - 31 6A 053 | - 31 6A 027 |

## DS9 150 A (poly ormetal)

Voltage Polarity Part Number

| 400 V 3P+E | - 3194013 | - 3194013 | - 3194013 | - 3198013 | - 3198013 | - 3198013 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| + installation accessory: | 39 9A 053 | - 31 9A 027 | 659 O 013 D45 (E) | 659 O 013 D45 (E) | 399 9 053 | - 319 A 027 |
| 400V * 3P+N+E | - 3194017 * | - 3194017 * | - 3194017 * | - 3198017 | - 3198017 | - 3198017 |
| + installation accessory: | 39 9A 053 | - 31 9A 027 | 65 9A 013 D45 (E) | 659 O 013 D45 (E) | 39 9A 053 | - 31 9A 027 |

DS2 250 A (metal)

| Voltage Polarity | Part Number |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 400V 3P+E | 3924013 | 3924013 | 3924013 | 3928013 | 3928013 | 3928013 |
| + installation accessory: | 39 2A 053 | 39 2A 027 | 39 2A 013 (N) | 39 2A 013 (N) | 39 2A 053 | 39 2A 027 |
| 400V * 3P+N+E | 3924017 * | 3924017 * | 3924017 * | 3928017 | 3928017 | 3928017 |
| + installation accessory: | 39 2A 053 | 39 2A 027 | 39 2A 013 (N) | 39 2A 013 (N) | 39 2A 053 | 39 2A 027 |

[^28]
DECONTACTOR™ 30 A
Main features:

| - (socket-outlet) IP | 55 |
| :--- | ---: |
| - (socket-outlet + inlet) IP | 54 |
| -K (poly) | 08 |

- 

690V AC - 250V DC

- Rated currents (IEC / EN 60309-1)
- Rated currents and operating voltages
(load breaking capacity according to IEC / EN 60947-3)


## (S) Socket-outlet (female)



| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| $\mathbf{2 0 - 2 4 V}$ | $2 P$ | Polyester | $3114 \mathbf{0 8 A}$ |
| $\mathbf{1 9 0 - 2 3 0 V}$ | $3 P+E$ | Polyester | 3114033 |
| $\mathbf{2 2 0 - 2 5 0 V}$ | $1 \mathrm{P}+\mathrm{N}+\mathrm{E}$ | Polyester | 3114015 |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+\mathrm{E}$ | Polyester | 3114013 |
| Dual voltage* | $3 P+N+E$ | Polyester | 3114017 |

see front cover flap
Other voltages, polarities: see page 8

Socket-outlet (Umax 400 V ) with auxiliary contacts
With 2 auxiliary contacts (30A) Socket \# + 972

If you want to add an option to this kind of socket-outlet: call us at +33 (0) 145116000 .

| Socket-outiet options |  |
| :--- | :--- |
| IP67 watertightness | Socket \# + $\mathbf{6 0 0}$ |
| Device for self-ejecting coupler socket | Socket \# + $\mathbf{3 5 4}$ |
| Device for self-ejecting plug | Socket \# + 352 |
| Self-returning lid | Socket \# + $\mathbf{R}$ |
| $180^{\circ}$-opening lid | Socket \# + 10 |
| $180^{\circ}$-opening and self-returning lid | Socket \# + 18 |
| Padlocking shaft up to 3 padlocks 8 mm $\emptyset$ | Socket \# + 844 |
| Stop button | Socket \# + 453 |
| Rubber cover for polyester latch | Socket \# + 833 |

If you want to equip a socket with two or more options: call us at +33 (0) 145116000 .

## Socket-outlet accessories

Closing mechanism (finger draw plate) 31 1A 346

## (I) Inlet (male)



| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| $\mathbf{2 0 - 2 4 V}$ | $2 P$ | Polyester | 3118 08A |
| $\mathbf{1 9 0 - 2 3 0 V}$ | $3 P+E$ | Polyester | $3118 \mathbf{0 3 3}$ |
| $\mathbf{2 2 0 - 2 5 0 V}$ | $1 P+N+E$ | Polyester | $3118 \mathbf{0 1 5}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+E$ | Polyester | $3118 \mathbf{0 1 3}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+N+E$ | Polyester | $3118 \mathbf{0 1 7}$ |

Inlet (Umax 400 V ) with auxiliary contacts
With 2 auxiliary contacts (30A) Inlet\# + 972

Inlet options
IP67 watertightness
Inlet \# + 600

Inlet accessories

| IP67 cap | 31 1A 126 |
| :--- | :--- |
| Self-closing lid | 31 1A 226 |
| Closing mechanism (finger draw plate) | 31 1A $\mathbf{3 4 6}$ |
| Ejecting mechanism (shark fin) | 31 1A 338 |
| Tension cord | 31 1A 336 |

Advantages
Also see:
Core range
DS1-30 A
DS3-50A
DS6-90A
DS9-150A
DS2-250A
Dimensions

## Installation accessories



The boxes are supplied without any cable gland. The $70^{\circ}$ boxes are not drilled (drilled at extra cost).



| Handle | Straight <br> poly |
| :--- | :--- |
| Cable dia. <br> $5-21 \mathrm{~mm}$ | 311 A 013 |

Handle for flat or steel armoured cables on request.


Cable dias.



Straight metal with metal cable gland

Cable dias.

| $6-12 \mathrm{~mm}$ | 311 A 963 |
| :--- | :--- |
| $10-18 \mathrm{~mm}$ | 311 A 953 25M |



Straight poly flowerpot with metric threaded entry *

Entry

| M20 | 31 AA $253 \mathbf{4 1 7}$ |
| :--- | :--- |
| M25 | 31 AA 253418 |
| M32 | 31 AA 253419 |
| M40 | 31 AA 253420 |
| * Cable gland on request. |  |

Industrial - Domestic adapters


Domestic socket-outlet 10/16A 230V + marechal industrial inlet $1 \mathrm{P}+\mathrm{N}+\mathrm{E}, 10 \mathrm{~A} 230 \mathrm{~V}$ fuse protection

| Type | Material | Part number |
| :--- | :--- | :--- |
| UK | Poly | 3118015 D40 * |
| FR with safety shutter | Poly | 3118015 D16 |

*All these domestic socket-outlets are available to foreign standards : replace D40 by D11 for France, D30 for Germany, D06 for Italy, D08 for Switzerland, D67 for Australia, D80 for USA etc

## zoom <br>  <br> Wall boxes and $70^{\circ}$ sleeves

These wall boxes are designed for:
easy wiring, recommended for large conductor cross-sections (up to $5 \times 35 \mathrm{~mm}^{2}$ )
entries and exits either at top, bottom or sides
stock reduction, as the same wall box is common to several products The sleeves are angled $\left(70^{\circ}\right)$ to reduce the socket-outlet protrusion and impact risk (for lifts ...).

See full range of boxes on page 86


## DECONTACTOR™ 50 A




Main features:

- (socket-outlet) IP
- (socket-outlet + inlet) IP


54

- IK (poly)
- Umax

1000V AC - 250 V

- Rated currents (IEC / EN 60309-1)
- Rated currents and operating voltages
(load breaking capacity according to IEC / EN 60947-3)


## (5) Socket-outlet (female)



| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| $\mathbf{2 0 - 2 4 V}$ | 2P | Polyester | $3134 \mathbf{0 8 A}$ |
| $\mathbf{1 9 0 - 2 3 0 V}$ | $3 P+E$ | Polyester | $3134 \mathbf{0 3 3}$ |
| $\mathbf{2 2 0 - 2 5 0 V}$ | $1 P+N+E$ | Polyester | $3134 \mathbf{0 1 5}$ |
| 380-440V | $3 P+E$ | Polyester | $3134 \mathbf{0 1 3}$ |
| Dual voltage* | 3P+N+E | Polyester | $3134 \mathbf{0 1 7}$ |

* See front cover flap

Other voltages, polarities: see page 8
Socket-outlet (Umax 400 V ) with auxiliary contacts

| With 2 auxiliary contacts $(16 \mathrm{~A})$ | Socket \# + $\mathbf{9 7 2}$ |
| :--- | :--- |
| With 4 auxiliary contacts $(16 \mathrm{~A})$ | Socket \# + 264 |

If you want to add an option to this kind of socket-outlet: call us at +33 (0) 145116000 .

## Socket-outlet options

| IP67 watertightness | Socket \# + 600 |
| :--- | :--- |
| Device for self-ejecting coupler socket | Socket \# + 354 |
| Device for self-ejecting plug | Socket \# + 352 |
| Self-returning lid | Socket \# + $\mathbf{R}$ |
| $180^{\circ}$-opening lid | Socket \# + 10 |
| $180^{\circ}$-opening and self-returning lid | Socket \# + 18 |
| Padlocking shaft up to 3 padlocks 8mm $\emptyset$ | Socket \# + 844 |
| Stop button | Socket \# + 453 |
| Rubber cover for polyester latch | Socket \# + 833 |

If you want to equip a socket-outlet with two or more options: call us at +33 (0) 145116000 .

## (I) Inlet (male)



| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| $\mathbf{2 0 - 2 4 V}$ | $2 P$ | Polyester | $3138 \mathbf{0 8 A}$ |
| $\mathbf{1 9 0 - 2 3 0 V}$ | $3 P+E$ | Polyester | $3138 \mathbf{0 3 3}$ |
| $\mathbf{2 2 0 - 2 5 0 V}$ | $1 P+N+E$ | Polyester | $3138 \mathbf{0 1 5}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+E$ | Polyester | $3138 \mathbf{0 1 3}$ |
| $\mathbf{3 8 0 - 4 4 0}$ | $3 P+N+E$ | Polyester | $3138 \mathbf{0 1 7}$ |

Inlet (Umax 400 V ) with auxiliary contacts

| With 2 auxiliary contacts (16A) | Inlet \# + 972 |
| :--- | :--- |
| With 4 auxiliary contacts (16A) | Inlet \# + $\mathbf{2 6 4}$ |

Inlet options
IP67 watertightness Inlet \# + $\mathbf{6 0 0}$

Inlet accessories

| IP67 cap | 31 3A $\mathbf{1 2 6}$ |
| :--- | :--- |
| Self-closing lid | 31 3A $\mathbf{2 2 6}$ |
| Ejecting mechanism (shark fin) | 31 3A 338 |
| Tension cord | 31 1A 336 |

Advantages
Also see:
Full range of boxes page 86
Core range
DS1-30A
DS3-50 A
DS6-90A
DS9-150A
DS2-250A
Dimensions

## Installation accessories



The boxes are supplied without any cable gland. The $70^{\circ}$ boxes are not drilled (drilled at extra cost).
 cables on request.

## Perfect cable fit and

 broad tightening rangeA special anchoring system provides a perfect cable fit and a broad tightening range (multi-layer bush to choose best cable fit).



Main features:

| - (socket-outlet) IP | 55 |
| :--- | ---: |
| - (socket-outlet + inlet) IP | 54 |
| - IK (poly / metal) | $08 / 09$ |
| - Umax | 1000 V AC - 250 V DC |


| - Wiring (min - max) flexible | $10 / 25 \mathrm{~mm}^{2}$ |
| :--- | :--- |
| - Wiring (min - max) stranded | $16 / 35 \mathrm{~mm}^{2}$ |
| - Other wiring on request |  |
| max flexible / stranded |  |

- Rated currents (IEC / EN 60309-1)
- Rated currents and operating voltages
(load breaking capacity according to IEC / EN 60947-3)

| $90 \mathrm{~A} / 400 \mathrm{~V}$ | $90 \mathrm{~A} / 690 \mathrm{~V}$ |
| ---: | ---: |
| $90 \mathrm{~A} / 400 \mathrm{~V}$ | $63 \mathrm{~A} / 690 \mathrm{~V}$ |
| (AC23) | (AC22) |

$63 \mathrm{~A} / 1000 \mathrm{~V}$
(AC23)
(AC22)
$(-)$

## (5) Socket-outlet (female)



Padlocking shaft
(Padlock not supplied)


Stop button


Self-closing lid for inlet


Ejecting mechanism (shark fin)

## Tension cord

(I) Inlet (male)


| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| $\mathbf{1 9 0 - 2 3 0 V}$ | 3P+E | Polyester | $3168 \mathbf{0 3 3}$ |
|  |  | Metal | $3968 \mathbf{0 3 3}$ |
| $\mathbf{2 2 0 - 2 5 0 V}$ | 1P+N+E | Polyester | $3168 \mathbf{0 1 5}$ |
|  |  | Metal | $3968 \mathbf{0 1 5}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | 3P+E | Polyester | $3168 \mathbf{0 1 3}$ |
|  |  | Metal | $3968 \mathbf{0 1 3}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+N+E$ | Polyester | $3168 \mathbf{0 1 7}$ |
|  |  | Metal | $3968 \mathbf{0 1 7}$ |
| $\mathbf{6 6 0 - 6 9 0 V}$ | $3 P+E$ | Polyester | $3168 \mathbf{1 9 3}$ |
|  |  | Metal | $3968 \mathbf{1 9 3}$ |
| $\mathbf{6 6 0 - 6 9 0 V}$ | $3 P+N+E$ | Polyester | $3168 \mathbf{1 9 7}$ |
|  |  | Metal | $3968 \mathbf{1 9 7}$ |

Inlet with auxiliary contacts

| With 2 auxiliary contacts (5A) | Inlet \# + 972 |
| :--- | :--- |
| With 3 auxiliary contacts (5A) | Inlet \# + $\mathbf{2 6 3}$ |

Inlet options
IP67 watertightness Inlet\# + $\mathbf{6 0 0}$

Inlet accessories

| IP67 cap | 31 6A 126 |
| :--- | :--- |
| Self-closing lid | 31 6A 226 |
| Ejecting mechanism (shark fin) | 31 6A 338 |
| Tension cord | 31 1A 336 |

If you want to equip a socket-outlet with two or more options: call us at +33 (0) 145116000 .

* See front cover flap

Other voltages, polarities: see page 8

## Socket-outlet with auxiliary contacts

| With 2 auxiliary contacts (5A) | Socket \# + 972 |
| :--- | :--- |
| With 3 auxiliary contacts $(5 \mathrm{~A})$ | Socket \# + $\mathbf{2 6 3}$ |

If you want to add an option to this kind of socket-outlet: call us at +33 (0) 145116000 .

| Socket-outlet options |  |
| :--- | :--- |
| \|P67 watertightness | Socket \# + $\mathbf{6 0 0}$ |
| Device for self-ejecting coupler socket | Socket \# + $\mathbf{3 5 4}$ |
| Device for self-ejecting plug | Socket \# + $\mathbf{3 5 2}$ |
| Self-returning lid | Socket \# + $\mathbf{R}$ |
| $180^{\circ}$-opening lid | Socket \# + 10 |
| $180^{\circ}$-opening and self-returning lid | Socket \# + 18 |
| Padlocking shaft up to 3 padlocks 8mm $\emptyset$ | Socket \# + 844 |
| Stop button | Socket \# + 453 |
| Rubber cover for polyester latch | Socket \# + 833 |
| Rubber cover for metal latch | Socket \# + 835 |

Advantages

Also see:
Full range of boxes page 86
Dimensions page 44
Technical Manual page 150

Core range
DS1-30A
DS3-50A
DS6-90 A
DS9-150A
DS2-250A
Dimensions

## Installation accessories



The boxes are supplied without any cable gland. The $70^{\circ}$ boxes are not drilled (drilled at extra cost).


## Handle with built-in finger draw plate

This straight handle is recommended for in-line connections.

| Handle | Straight <br> poly |
| :--- | :--- |
| Cable dia. |  |
| $13-35 \mathrm{~mm}$ | 316 A 013 |
| $13-35 \mathrm{~mm}$ | 316 A 473 * |
|  |  |

* With built-in finger draw plate (for in-line connections)

Handle for flat or steel armoured cables on request.


Straight poly with for poly cable gland ejection option *


Straight metal with metal cable gland

Cable dia.

| 13-18 mm | $316 A 253$ 25P | $316 A 443$ 25P |
| :--- | :--- | :--- |
| $18-25 \mathrm{~mm}$ | $316 A 253$ 32P | $316 A 443$ 32P |
| $22-32 \mathrm{~mm}$ | $316 A$ 753 | $316 A 463$ |
| 30-38 mm | $316 A 253$ 50P | $316 A 443$ 50P |



Straight poly flowerpot with metric threaded entry *

Entry

| M25 | $316 A 253418$ |
| :--- | :--- |
| M32 | $316 A 253419$ |
| M40 | $316 A 253420$ |
| M50 | $316 A 253429$ |
| * Cable gland on request. |  |

zOpM
Self-ejection

Both DS sockets and plugs can be modified for self-ejection purposes e.g. for use on vehicles, movable vessels, trailers etc.


See page 168 for guidance notes or contact us with your application for assistance.

## ZOpM Protection against mechanical shock

The poly and metal versions do not offer the same level of protection against mechanical shock (IK). According to standard IEC / EN 50102, the poly version is IKo8, whereas the metal version achieves IKog (impact energy absorption up to 10 Joules).


Padlocking shaft
(Padlock not supplied)


Stop button


IP67 Inlet cap


Self-closing lid for inlet


Ejecting mechanism (plug release cam)

[^29]
## DECONTACTORTM ${ }^{\text {TM }}$ 150 A

Main features:

| - (socket-outlet) IP | 55 |
| :--- | ---: |
| - (socket-outlet + inlet) IP | 54 |
| - IK (poly / metal) | $08 / 09$ |
| - Umax | 1000 V AC - 250 V DC |


| - Wiring (min - max) flexible | $16 / 50 \mathrm{~mm}^{2}$ |
| :--- | :--- |
| - Wiring (min - max) stranded | $25 / 70 \mathrm{~mm}^{2}$ |
| - Other wiring on request |  |
| max flexible / stranded | $70 / 95 \mathrm{~mm}^{2}$ |

- Rated currents (IEC / EN 60309-1)
150A/400V
150A / 400V
125A / 690V $90 \mathrm{~A} / 690 \mathrm{~V}$
(AC22)
(AC22)
$90 \mathrm{~A} / 1000 \mathrm{~V}$
- Rated currents and operating voltages
(load breaking capacity according to IEC / EN 60947-3)


## (S) Socket-outlet (female)



| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| 190-230V | 3P+E | Polyester | $3194 \mathbf{0 3 3}$ |
|  |  | Metal | $3994 \mathbf{0 3 3}$ |
| 220-250V | 1P+N+E | Polyester | $3194 \mathbf{0 1 5}$ |
|  |  | Metal | $3994 \mathbf{0 1 5}$ |
| 380-440V | 3P+E | Polyester | $3194 \mathbf{0 1 3}$ |
|  |  | Metal | $3994 \mathbf{0 1 3}$ |
| Dual voltage* | 3P+N+E | Polyester | $3194 \mathbf{0 1 7}$ |
|  |  | Metal | $3994 \mathbf{0 1 7}$ |
| $\mathbf{6 6 0 - 6 9 0 V}$ | 3P+E | Polyester | $3194 \mathbf{1 9 3}$ |
|  |  | Metal | $3994 \mathbf{1 9 3}$ |
| $\mathbf{6 6 0 - 6 9 0 V}$ | 3P+N+E | Polyester | $3194 \mathbf{1 9 7}$ |
|  |  | Metal | $3994 \mathbf{1 9 7}$ |

* See front cover flap

Other voltages, polarities: see page 8

## Socket-outlet with auxiliary contacts

With 2 auxiliary contacts (5A) Socket \# + 972

If you want to add an option to this kind of socket-outlet: call us at +33 (0) 145116000 .

## Socket-outlet options

| IP66 / 67 watertightness | Socket \# + $\mathbf{6 0 0}$ |
| :--- | :--- |
| Device for self-ejecting coupler socket | Socket \# + $\mathbf{3 6 5}$ |
| Device for self-ejecting plug | Socket \# + $\mathbf{3 5 3}$ |
| Self-returning lid | Socket \# + |
| $180^{\circ}$ opening lid | Socket \# + 10 |
| $180^{\circ}$ opening and self-returning lid | Socket \# + 18 |
| Padlocking shaft up to 3 padlocks 8mm $\emptyset$ | Socket \# + 844 |
| Stop button | Socket \# + 453 |
| Rubber cover for polyester latch | Socket \# + 833 |
| Rubber cover for metal latch | Socket \# + 835 |

If you want to equip a socket-outlet with two or more options: call us at +33 (0) 145116000.

## (I) Inlet (male)



Metal version

| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| $\mathbf{1 9 0 - 2 3 0 V}$ | $3 P+E$ | Polyester | $3198 \mathbf{0 3 3}$ |
|  |  | Metal | $3998 \mathbf{0 3 3}$ |
| $\mathbf{2 2 0 - 2 5 0 V}$ | 1P+N+E | Polyester | $3198 \mathbf{0 1 5}$ |
|  |  | Metal | $3998 \mathbf{0 1 5}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+E$ | Polyester | $3198 \mathbf{0 1 3}$ |
|  |  | Metal | $3998 \mathbf{0 1 3}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+N+E$ | Polyester | $3198 \mathbf{0 1 7}$ |
|  |  | Metal | $3998 \mathbf{0 1 7}$ |
| $\mathbf{6 6 0 - 6 9 0 V}$ | $3 P+E$ | Polyester | $3198 \mathbf{1 9 3}$ |
|  |  | Metal | $3998 \mathbf{1 9 3}$ |
| $\mathbf{6 6 0 - 6 9 0 V}$ | $3 P+N+E$ | Polyester | $3198 \mathbf{1 9 7}$ |
|  |  | Metal | $3998 \mathbf{1 9 7}$ |

Inlet with auxiliary contacts
With 2 auxiliary contacts ( 5 A ) Inlet \# + 972

Inlet options

| IP66 / 67 watertightness | Inlet\# + $\mathbf{6 0 0}$ |
| :--- | :--- |
| Device for self-ejecting coupler socket | Inlet\# + 204 |
| Device for self-ejecting plug | Inlet\# + 204 |
|  |  |
| Inlet accessories |  |
| IP67 cap | 31 9A 126 |
| Self-closing lid | 31 9A 226 |
| Ejecting mechanism (plug release cam) | 39 9A 397 |
| Tension cord | 31 1A 336 |

Advantages

## Installation accessories



Handle for flat or steel armoured cables on request.

## zopm

New: easy closing mechanism
A new and simplified closing mechanism is now implemented on the DS9 and DS2 plugs and socket-outlets as standard equipment. This compact mechanism is a significant improvement compared to the previous optional closing lever. After the plug is connected, mechanism must be freed in order to let the plug travel back to parked position when the DECONTACTOR button is pressed.


The closing handles are into the socket-outlet.

The mechanism is freed allowing normal operation of the DECONTACTOR



## DECONTACTOR ${ }^{\text {TM }}$

 250 AMain features:

- (socket-outlet) IP
- (socket-outlet + inlet) IP
55
54
09

1000V AC-250V DC

- Umax

250A / 400
250A/400V
(AC22)

- Rated currents and operating voltages
(load breaking capacity according to IEC / EN 60947-3)

Socket-outlet (female)


| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| $\mathbf{1 9 0 - 2 3 0 V}$ | $3 P+E$ | Metal | $3924 \mathbf{0 3 3}$ |
| $\mathbf{2 2 0 - 2 5 0 V}$ | $1 P+N+E$ | Metal | $3924 \mathbf{0 1 5}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+E$ | Metal | $3924 \mathbf{0 1 3}$ |
| Dual voltage* | $3 P+N+E$ | Metal | $3924 \mathbf{0 1 7}$ |
| $\mathbf{6 6 0 - 6 9 0 V}$ | $3 P+E$ | Metal | $3924 \mathbf{1 9 3}$ |
| $\mathbf{6 6 0 - 6 9 0 V}$ | $3 P+N+E$ | Metal | $3924 \mathbf{1 9 7}$ |

* See front cover flap

Other voltages, polarities: see page 8

## Socket-outlet with auxiliary contacts

With 2 auxiliary contacts (5A) Socket \# + 972

If you want to add an option to this kind of socket-outlet: call us at +33 (0) 145116000.

Socket-outlet options

| IP66 / 67 watertightness | Socket \# + 600 |
| :--- | :--- |
| Device for self-ejecting coupler socket | Socket \# + 365 |
| Device for self-ejecting plug | Socket \# + 353 |
| Self-returning lid | Socket \# + $\mathbf{R}$ |
| $180^{\circ}$ opening lid | Socket \# + 10 |
| $180^{\circ}$ opening and self-returning lid | Socket \# + 18 |
| Padlocking shaft up to 3 padlocks 8 mm $\emptyset$ | Socket \# + 844 |
| Stop button | Socket \# + 453 |
| Rubber cover for metal latch | Socket \# + 835 |

If you want to equip a socket-outlet with two or more options: call us at +33 (0) 145116000 .

## (I) Inlet (male)



| Voltage | Polarity | Material | Part \# |
| :--- | :--- | :--- | :--- |
| $\mathbf{1 9 0 - 2 3 0 V}$ | $3 P+E$ | Metal | $3928 \mathbf{0 3 3}$ |
| $\mathbf{2 2 0 - 2 5 0 V}$ | $1 P+N+E$ | Metal | $3928 \mathbf{0 1 5}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+E$ | Metal | $3928 \mathbf{0 1 3}$ |
| $\mathbf{3 8 0 - 4 4 0 V}$ | $3 P+N+E$ | Metal | $3928 \mathbf{0 1 7}$ |
| $\mathbf{6 6 0 - 6 9 0}$ | $3 P+E$ | Metal | $3928 \mathbf{1 9 3}$ |
| $\mathbf{6 6 0 - 6 9 0}$ | $3 P+N+E$ | Metal | $3928 \mathbf{1 9 7}$ |

Inlet with auxiliary contacts
With 2 auxiliary contacts (5A) Inlet \# + 972

Inlet options

| IP66 / 67 watertightness | Inlet \# + 600 |
| :--- | :--- |
| Device for self-ejecting coupler socket | Inlet \# + 204 |
| Device for self-ejecting plug | Inlet \# + 204 |

Inlet accessories

| IP67 cap | 31 2A $\mathbf{1 2 6}$ |
| :--- | :--- |
| Ejecting mechanism (plug release cam) | 39 2A 397 |
| Tension cord | 31 1A 336 |

## Installation accessories



Handle for flat or steel armoured cables on request.


# DS range dimensions Socket-outlet plug 



A B $\emptyset$
DS1/DS24C $\quad 144 \quad 70 \quad 5-21$
$\begin{array}{llll}\text { DS3/DS37C } & 148 & 82 & 10-30\end{array}$
$\begin{array}{llll}\text { DS6/DS7C3 } & 175 & 98 & 13-36\end{array}$
DS9 $195 \quad 125 \quad 25-45$
$260 \quad 141$ 40-58

Plug connected (A1)/ disconnected (A0) in a socket-outlet


|  | A | BB | BH | C | D | E | H | YB | YBB | Z | ZB | Ød |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| DS1/DS24C | 65 | 50 | 45 | 69 | 58 | 48 | 15 | 65 | 108 | 121 | 76 | 5 |
| DS3/DS37C | 69 | 55 | 54 | 80 | 70 | 55 | 21 | 100 | 132 | 121 | 57 | 5 |
| DS6/DS7C3 | 76 | 63 | 60 | 98 | 80 | 66 | 27 | 110 | 152 | 146 | 87 | 5.5 |
| DS9 | 113 | 75 | 70 | 113 | 100 | 81 | 24 | 137 |  | 197 |  | 6 |
| DS2/DS7C9 | 110 | 75 | 92 | 131 | 118 | 98 | 38 | 115 |  | 213 |  | 6.5 |

Inlet

DS1/DS24C
DS3/DS37C
DS6/DS7C3
DS9
DS2/DS7C9


$$
\begin{array}{cccccccc}
\text { A } & \text { BB } & \text { BH } & \text { C } & \text { D } & \text { E } & \text { H } & \emptyset \text { d } \\
48 & 33 & 37 & 67 & 58 & 48 & 14 & 5 \\
52 & 38 & 45 & 78 & 70 & 55 & 18 & 5 \\
56 & 45 & 53 & 92 & 80 & 66 & 27 & 5.5 \\
71 & 61 & 64 & 113 & 100 & 81 & 26 & 6 \\
79 & 73 & 68 & 130 & 118 & 98 & 40 & 6.5
\end{array}
$$

Coupler
socket

Advantages

Core range
Core range
$D S_{1}-30 \mathrm{~A}$
DS3-50A
DS6-90A
DS9-150A
DS2-250A
Dimensions

Dimensions
$30^{\circ}$ wall mounting appliance inlet

$\begin{array}{llllllllll}\text { A } & \text { B } & \text { B' } & \text { CA } & \text { CP } & \text { D } & \text { E2 } & H & \emptyset d\end{array}$
DS1/DS24C

$$
111105
$$

84
DS3/DS37C $129 \quad 126 \quad 8060$
DS6/DS7C3 POLY $\begin{array}{lllllllllll}170 & 158 & 105 & 92 & 128 & 89 & 112 & 31 & 7.5\end{array}$
DS6/DS7C3 METAL $150121 \quad 127 \quad 92 \quad 130$
$\begin{array}{lllllllllll}\text { DS9 } & 203 & 153 & 320 & 183 & 113 & 285 & 163 & 116 & 50 & 7\end{array}$
$\begin{array}{lllllllllllc}\text { DS2/DS7C9 } & \left(60^{\circ}\right) & 267 & 233 & 400 & 226 & 130 & 315 & 202 & 154 & 50 & 10\end{array}$

Coupler socket connected (A1)/ disconnected (AO) in an inlet

|  | A1 | A0 |
| :--- | :---: | :---: |
| DS1/DS24C | 166 | 182 |
| DS3/DS37C | 174 | 190 |
| DS6/DS7C3 | 197 | 221 |
| DS9 | 246 | 275 |
| DS2/DS7C9 | 310 | 341 |

$\begin{array}{lll}\text { DS6/DS7C3 } & 197 & 221\end{array}$
DS9
310341

$70^{\circ}$ wall mounting appliance inlet


A B Ca D E E1 E2 H2 Ød
$\begin{array}{lllllllll}\text { DS1/DS24C } & 182 & 157 & 127 & 127 & 116 & 96 & 39 & 6.5\end{array}$
$\begin{array}{llllllllll}\text { DS3/DS37C } & 208 & 201 & 170 & 170 & 158 & 159 & 139 & 39 & 6.5\end{array}$
$\begin{array}{llllllllllll}\text { DS6/DS7C3 POLY } & 212 & 212 & 170 & 170 & 158 & 158 & 159 & 39 & 6.5\end{array}$
Coupler socke connected (A1)/ disconnected (Ao) in a $30^{\circ}$ wall mounting appliance inlet

BB: $180^{\circ}$ OPENING LID


|  | A1 | A0 | B | B1 | B0 | $B_{B}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| DS1/DS24C | 211 | 225 | 184 | 161 | 169 | 199 |
| DS3/DS37C | 232 | 246 | 215 | 184 | 192 | 215 |
| DS6/DS7C3 POLY | 283 | 304 | 248 | 220 | 232 | 254 |
| DS6/DS7C3 METAL | 268 | 289 | 248 | 193 | 205 |  |
| DS9 | 355 | 380 | 311 | 243 | 258 |  |
| DS2/DS7C9 (60 $)$ | 383 | 399 | 427 | 433 | 460 |  |

Coupler socket
connected (A1)/ disconnected (Ao) in a $70^{\circ}$ wall mounting appliance inlet


| DS1/DS24C | 193 | 199 | 221 | 260 | 276 | 151 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| DS3/DS37C | 225 | 217 | 249 | 313 | 334 | 180 |
| DS6/DS7C3 POLY | 245 | 261 | 282 | 338 | 362 | 210 |

$30^{\circ}$ inclined appliance inlet


D1: drilling $\emptyset$

|  | A | B | CA | CP | D | D1 | D2 | E1 | E2 | $\emptyset d$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| DS1/DS24C | 92 | 114 | 76 | 67 | 107 | 65 | 62 | 63 | 95 | 5.5 |
| DS3/DS37C | 100 | 120 | 76 | 66 | 107 | 65 | 68 | 63 | 95 | 5.5 |
| DS6/DS7C3 | 109 | 146 | 102 | 92 | 136 | 111 | 90 | 87 | 122 | 6.5 |
| DS9 | 153 | 159 | 140 | 113 | 142 | 110 | 100 | 124 | 124 | 7 |
| DS2/DS7C9 $\left(60^{\circ}\right)$ | 176 | 226 | 183 | 130 | 183 | 150 | 150 | 165 | 165 | 7 |

DS1/DS24C
DS3/DS37C
DS6/DS7C3

$\begin{array}{llllll}\text { A } & \text { B } & \text { CA } & \text { D } & \text { E1 } & \text { Ød }\end{array}$

$\begin{array}{llllll}104 & 157 & 127 & 127 & 116 & 4.5\end{array}$ $\begin{array}{llllll}130 & 201 & 170 & 170 & 159 & 4.5\end{array}$ $\begin{array}{lllllll}134 & 212 & 170 & 170 & 159 & 4.5\end{array}$


BB: $180^{\circ}$ OPENING LID

$\begin{array}{lllllll}192 & 206 & 184 & 170 & 178 & 199\end{array}$
$\begin{array}{lllllll}\text { DS3/DS37C } & 203 & 217 & 215 & 178 & 186 & 215\end{array}$
DS6/DS7C3 $\begin{array}{lllllll}229 & 250 & 248 & 212 & 224 & 254\end{array}$
DS9
DS2/DS7C9 (60 $\left.{ }^{\circ}\right)$
292308427347374

Coupler socket
connected (A1)/ disconnected (Ao)
in a $70^{\circ}$ inclined
appliance inlet
$\begin{array}{llllll}\text { A1 } & \text { A0 } & B & B 1 & B 0 & B B\end{array}$
DS1/DS24C
DS3/DS37C DS6/DS7C3 $\begin{array}{llllllll}167 & 183 & 282 & 338 & 362 & 210\end{array}$



| Stop button | Socket \# + 453 | Inlet accessories |  |
| :---: | :---: | :---: | :---: |
| Rubber cover for metal latch | Socket \# + 835 | IP67 cap | 31 2A 126 |
| If you want to equip a socket-outlet with two or more options: call us at +33 (0) 145116000 . |  | Ejecting mechanism (plug release cam) | 39 2A 397 |
|  |  | Tension cord | 31 1A 336 |


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| 1000-1/VOSL |  | (z20) <br> noot (Vogz <br> $1000 / 1092$ |  |  |
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## 11.Electrex

# SP337 End of AvonSt Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OM Manual ZEPTO D 

## INSTALLATION INSTRUCTIONS

## COPYRIGHT

Electrex is a trademark of Akse S.r.l. All rights reserved.
It is forbidden to duplicate, adapt, transcript this document without Akse written authorization, except when regulated accordingly by the Copyright Laws.

## WARRANTY

This product is covered by a warranty against material and manufacturing defects for a period of 24 months period from the manufacturing date.
The warranty does not cover the defects that are due to:

- Negligent and improper use
- Failures caused by atmospheric hazards
- Acts of vandalism
- Wear out of materials
- Firmware upgrades

Akse reserves the right, at its discretion, to repair or substitute the faulty products
The warranty is not applicable to the products that will result defective in consequence of a negligent and improper use or an operating procedure not contemplated in this manual.

## RETURN AND REPAIR FORMALITIES

Akse accepts the return of instruments for repair only when authorized in advance. The transport costs are at customer charge.

## RE-SHIPPING OF REPAIRED PRODUCT

The terms for re-shipment of repaired products are ex-works, i.e. the transport costs are at customer charge.
Products returned as detective but found to be perfectly working by our laboratories, will be charged a flat fee to account for checking and testing time irrespective of the warranty terms.

## SAFETY

This instrument was manufactured and tested in compliance with IEC 61010 class 2 standards for operating voltages up to 250 VAC rms phase to neutral.
In order to maintain this condition and to ensure safe operation, the user must comply with the indications and markings contained in the following instructions:

- When the instrument is received, before starting its installation, check that it is intact and no damage occurred during transport.
- Before mounting, ensure that the instrument operating voltages and the mains voltage are compatible then proceed with the installation.
- The instrument power supply needs no earth connection.
- The instrument is not equipped with a power supply fuse; a suitable external protection fuse must be foreseen by the contractor.
- Maintenance and/or repair must be carried out only by qualified, authorized personnel
- If there is ever the suspicion that safe operation is no longer possible, the instrument must be taken out of service and precautions taken againstits accidental use.
- Operation is no longer safe when:

1) There is clearly visible damage.
2) The instrument no longer functions.
3) After lengthy storage in unfavorable conditions.
4) After serious damage occurred during transport

The instruments must be installed in respect of all the local regulations.

## OPERATOR SAFETY

Warning: Failure to observe the following instructions may lead to a serious danger of death.

- During normal operation dangerous voltages can occur on instrument terminals and on voltage and current transformers. Energized voltage and current transformers may generate lethal voltages. Follow carefully the standard safety precautions while carrying out any installation or service operation.
- The terminals of the instrument must not be accessible by the user after the installation. The user should only be allowed to access the instrument front panel where the display is located.
- Do not use the digital outputs for protection functions nor for power limitation functions. The instrument is suitable only for secondary protection functions.
- The instrument must be protected by a breaking device capable of interrupting both the power supply and the measurement terminals. It must be easily reachable by the operator and well identified as instrument cut-off device.
- The instrument and its connections must be carefully protected against short-circuit.

Precautions: Failure to respect the following instructions may irreversibly damage to the instrument.

- The instrument is equipped with PTC current limiting device but a suitable external protection fuse should be foreseen by the contractor.
- The outputs and the options operate at low voltage level; they cannot be powered by any unspecified external voltage.
- The application of currents not compatible with the current inputs levels will damage to the instrument.

Further documentation may be downloaded from our web site www.electrex.it.
This document is owned by company AKSE that reserves all rights.

## DECLARATION OF CONFORMITY

Akse hereby declares that its range of products complies with the following directives EMC 89/336/EEC 73/23CE 93/68 CE and complies with the following product's standard CEI EN 61326 - IEC 61326 CEI EN 61010 - IEC 1010.
The product has been tested in the typical wiring configuration and with peripherals conforming to the EMC directive and the LV directive.

| MECHANICAL CHARACTERISTICS |  |
| :---: | :---: |
| Enclosure | Self-extinguishing plastic material class V0 |
| Protection degree | IP40 on front panel, IP20 terminals side |
| Dimensions | $105 \times 90 \times 58 \mathrm{~mm}$ (6 DIN modules) |
| VOLTAGE INPUT |  |
| Direct | Up to 300 Vrms phase-neutral or 519 Vrms phase to phase |
| With external PT(VT) | Primary: programmable (max. 400 kV ) Secondary: programmable (max. 300 V ) |
|  | Overload: 900 Vrms phase to phase for 1 sec |
| Power supply | 230/240Vac +/- 10\% 50/60Hz |
| Self consumption | <3VA |
| MODELS |  |
| PFA8611-02 | ZEPTO D6 RS485 230-240V <br> ENERGY ANALYSER |
| PFA8611-12 | ZEPTO D6 RS485 230-240V 1DI 2DO ENERGY ANALYSER Page 591 of 2030 |



ENTER THE SET UP MODE Hold the buttons "meas" and "cnt" for 2 seconds to enter in the set up modality.


QUIT THE SET UP MODE Hold the button "cnt" for 2 seconds to quit the set up modality.


## CONFIGURATION PAGES LIST

Once you are in the set up modality the password is asked. The standard password is 0000, to confirm it clik 4 times the "cnt" button, otherwise is necessary insert the new password (if previously changed).

| PAGE | ITEM DISPLAYED | AVAILABLE PARAMETERS | DEFAULT |
| :--- | :--- | :--- | ---: |
| PASSWORD PROTECTION | 000 |  |  |

## PR5 50000

If the instrument is a part of a RS485 network is necessary set up its RS485 address and correct baudrate.
If is a "stand alone" instrument you can skip the RS485 set up pressing twice for 2 seconds the button "meas". RS485

| RS485 Address | 1 ... 247 | 27 |
| :---: | :---: | :---: |
| Mar | H5 |  |
| Baudrate | 2400, 48 | 9600 |
| Data Bit | 7 or 8 | 8 |
| Parity | $\mathrm{N}=$ no p | N |
| Stop bit | 1 or 2 | 2 |
|  | $\square \square^{\square} \square^{\text {a }}$ |  |

The parameters that must be entered for correct readings in a LT electric grids are: kind of electric grid (net) (see note $\mathrm{n}^{\circ} 1$ ), CT Primary (Pri) and Secondary (Sec).
For HV electric grid is necessary set up also the VT settings.
ELECTRIC GRIG PARAMETERS (see note $\mathrm{n}^{\circ} \mathbf{1 )}$


"Err" MESSAGE
During the set up it could happen that the "err" message will show up in the display This only means that some not accepted parameters are saved in the configuration. The factory default parameters needs to be restored with the following procedure:


After a factory default restore the stored data won't be lost, just the configuration will be restored.

DIGITAL INPUTS AND OUTPUTS CONNECTION (Applicable only to type PFA8611-12)


| Digital Inputs |  |
| :--- | :--- |
| Supply voltage (external): | from 10 to 30 <br> Vdc |
| Current consumption: | from 2 to 10 mA |
| Max. count frequency | 10 or 100 Hz |
| N.B. For gas meters a galvanic separation is <br> needed per ATEX standards |  |


| Digital outputs (optocoupled NPN <br> transistor type per DIN 43864) <br> Maximum applicable voltage: <br> Maximum switchable current: 27 mA |
| :--- | :--- |

## DIGITAL INPUT AND OUTPUTS WIRING EXAMPLE




## 

Voltage connection
Use cables with max cross-section of $2,5 \mathrm{~mm}^{2}$ if flexible $4 \mathrm{~mm}^{2}$ if rigid and connect them to the terminals marked voltage input on the instrument according to the applicable diagrams that follow.
Current connection
It is necessary to use external CTs with a primary rating adequate to the load to be metered and with a 5 A or 1 A secondary rating. The number of CTs to be used ( 1,2 or 3 ) depends upon the type of network. Connect the CT output(s) to the terminals marked II, I2, I3 (current input) of the instrument according to the applicable diagrams that follow. Use cables with cross-section adequate to the VA rating of the CT and to the distance to be covered. The max cross-section for the terminals is $4 \mathrm{~mm}^{2}$.
N.B. The CT secondary must always be in short circuit when not connected to the instrument in order to avoid damages and risks for the operator.

Warning: The phase relationship among voltage and current signals, the P1-P2 orientation and the S1-S2 connection of the CT(s) must be carefully respected. All disregard of this rule or of the wiring diagram leads to severe measurement errors.


SINGLE PHASE 1PH-2W


POWER SUPPLY and SERIAL LINE CONNECTION
The instrument is fitted with a separate power supply. The power supply terminals are numbered (17) and (18). Use cables with max cross-section of $2,5 \mathrm{~mm}^{2}$ if flexible, $4 \mathrm{~mm}^{2}$ if rigid.
akse srl Via Aldo Moro, 3942100 Reggio Emilia Italy
Tel. +390522924244 Fax +39 0522924245 info@akse.it www.akse.it VAJ-Pulse Id TRY5ß 38 R.E.A. 194296 Cap. Soc. Euro 85.800,00 i.v.


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the energy saving technology
Active 04/08/201vgww.electrex.it - info@electrex.it

# SP337 End of AvonSt Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OM Manual ZEPTO D 

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| MECHANICAL CHARACTERISTICS |  |
| :--- | :--- |
| Enclosure | Self-extinguishing plastic material class V0 |
| Protection degree | IP40 on front panel, IP20 terminals side |
| Dimensions | $105 \times 90 \times 58 \mathrm{~mm}$ (6 DIN modules) |
| VOLTAGE INPUT | Up to 300 Vrms phase-neutral or 519 Vrms phase to phase |
| Direct | Primary: programmable (max. 400 kV) <br> Secondary: programmable (max. 300 V) |
| With external PT(VT) | Overload: 900 Vrms phase to phase for 1 sec |
|  |  |
| Power supply | 230/240Vac +/- 10\% 50/60Hz |
| Self consumption | <3VA |
| MODELS | ZEPTO D6 RS485 230-240V <br> ENERGY ANALYSER |
| PFA8611-02 | ZEPTO D6 RS485 230-240V 1DI 2DO <br> ENERGY ANALYSER |
| PFA8611-12 |  |



ENTER THE SET UP MODE Hold the buttons＂meas＂and ＂cnt＂for 2 seconds to enter in the set up modality．


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## CONFIGURATION PAGES LIST

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If is a＂stand alone＂instrument you can skip the RS485 set up pressing twice for 2 seconds the button＂meas＂． RS485

| RS485 Address | 1．．． 247 | 27 |
| :---: | :---: | :---: |
| Пロ® | ザ |  |
| Baudrate | 2400，4800，9600，19200， 38400 | 9600 |
| Data Bit | 7 or 8 | 8 |
| Parity | $\mathrm{N}=$ no parity，E＝eveb parity，O＝odd parity | N |
| Stop bit | 1 or 2 | 2 |
|  | $\square \square^{\square} \square^{1}$ |  |

The parameters that must be entered for correct readings in a LT electric grids are：kind of electric grid（net）（see note $\mathrm{n}^{\circ} 1$ ），CT Primary（Pri）and Secondary（Sec）．
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| Digital Inputs |  |
| :--- | :--- |
| Supply voltage（external）： | from 10 to 30 <br> Vdc |
| Current consumption： | from 2 to 10 mA |
| Max．count frequency | 10 or 100 Hz |
| N．B．For gas meters a galvanic separation is <br> needed per ATEX standards |  |


| Digital outputs（optocoupled NPN <br> transistor type per DIN 43864） <br> Maximum applicable voltage： <br> Maximum switchable current： 27 mA |
| :--- | :--- |

## DIGITAL INPUT AND OUTPUTS WIRING EXAMPLE




## 

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Use cables with max cross-section of $2,5 \mathrm{~mm}^{2}$ if flexible $4 \mathrm{~mm}^{2}$ if rigid and connect them to the terminals marked voltage input on the instrument according to the applicable diagrams that follow.
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N.B. The CT secondary must always be in short circuit when not connected to the instrument in order to avoid damages and risks for the operator.

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ひ ELEETMREM
the energy saving technology
Active 04/08/201vgww.electrex.it - info@electrex.it

# Zepto <br> Multimeter Power \& Energy Meter Analyzer 



Zepto is a microprocessor based Multimeter, Power \& Energy Meter and Analyzer with outstanding flexibility and accuracy designed to meet the most demanding applications of electrical parameters analyses and energy supply monitoring in the industrial and residential environment. The instrument combines the functions of multimeter, power\&energy meter and analyzer

## True-RMS

All the readings are "true-RMS" and they are obtained with a continuous sampling of the voltage and current waveforms in order to ensure the maximum metering accuracy of rapidly varying loads (e.g. spot welding). A sophisticated digital measurement method with a compensation system of the internal amplifiers' offsets ensures the maximum metering accuracy and stability irrespective of the signal level and the environmental working conditions.

## Simple to use

The high brightness red led displays provide a superior reading visibility, up to 7 m . away, also in presence of intense light. Three displays of 3 digits each with floating point allow the simultaneous reading of 3 parameters (or a 9 digit reading of the energy counters).


3 keys on the instrument front panel, make the instrument use simple and rational.

## Versatile in application

Zepto is suitable for virtually all type of electrical grid, 3- and 4 -wire, symmetrical and asymmetrical, balanced or unbalanced, single- and bi-phase, Low Tension and High Tension, with 1, 2 or 3 CTs as well as for 2 quadrant measurement.
A simple keyboard programming allows the setting of all the operational parameters such as grid type, LT/HT, CT and VT ratios (free setting) integration time ( $1-60 \mathrm{~min}$ ), digital output and alarms (thresholds, delays, hysteresis), digital input, RS485 serial communication.
The instrument set-up is password protected against undesired modifications.

## Zepto types

## All Zepto meters are available in 2 versions:

B Without digital inputs and outputs.
B With 1 digital input and 2 digital outputs.

## Digital input

Zepto 1DI 2DO is equipped, as standard feature, with an optically insulated digital input complete with programmable filter for input glitches. The digital input is set to operate for external pulse count of, example, water meters, gas meters (insulation to meet the ATEX requirements), quantity count, etc. The input may be alternatively configured to operate as

ON/OFF input (example for reading the ON/OFF state of machines and switches). The digital input requires an external $10-30 \mathrm{Vdc}$ power supply.

## Readings


(1) Mean value (rolling average) over the integration time (1.. 60 min . programmable).
(2) Energies displayed as 9 digits in floating-point readings; internal energy metering performed with 0,1 Wh minimum resolution and 99.999.999,9999 kWh maximum energy count before rollover.

## Digital outputs

Zepto 1DI 2DO is equipped, as standard feature, with two opticall insulated transistor outputs rated 27 Vdc 27 mA per DIN 43864 standards. The two outputs are factory set to the transmission of pulses proportional to the Active energy and the Reactive energy (pulse weight and length are user programmable). The outputs may be alternatively configured as outputs of the internal alarms (see Alarms) or as remote output devices controlled via serial line and Modbus commands.

Multimeter, Power \& Energy Meter and Analizer

## Alarms

Zepto 1DI 2DO is complete with 2 programmable alarms offering the maximum configuration flexibility for adapting to the most diverse requirements. Each alarm can be selected to link to any one of the parameters available, for example, either as a minimum and/or as a maximum. Linking of both alarms to the same parameter is also possible for operating as dual threshold alarm. The alarms configuration includes the option of precise setting of a delay time (1-99 sec), an hysteresis cycle (in \% of threshold value) and the polarity of the output contacts (NO, NC). The alarms state information is always available on serial communication as Modbus "coils". Due to the numerous combinations available, only a part of them are programmable by keyboard while are entirely programmable via serial port with the Energy Brain software or via serial port by means of Modbus Holding registers.

## Power Supply

Zepto is equipped with 230-240Vac power supply (transformer type). On request 115/120 Vac or 400 Vac transformer power supply.

## Serial communication

Zepto is equipped, as standard feature on all types, with an optoinsulated and over-voltage protected RS485 serial communication port. The protocol is a full compliant ModbusRTU suitable for communication with PLCs and with SCADA programs. The instrument data are read as numerical registers composed by mantissa and exponent in the IEEE format.
A transmission speed of up to 38.400 bps, with maximum 125 registers (equivalent to 62 parameters) per query with no waiting time between queries, ensure an unrivalled communication speed and dialogue efficiency.

Technical specification


## Functional characteristics <br> Measurement system: <br> True-RMS measurement up to the $31^{\text {st }}$ harmonic 2 quadrant measurement 12bit AD converter (6-channel) Continuous sampling of voltage and current waveforms ( 64 sampling per period, with PLL) <br> Automatic compensation of the offset <br> RS485 serial port : <br> Galvanically insulated <br> - $\quad 2.400$ to 38.400 bps programmable speed <br> - Built-in over-voltage protection <br> - Modbus-RTU protocol, full compliant <br> Digital Output: <br> - Galvanically insulated <br> - DIN 43864 (27Vdc, 27mA) <br> - Programmable functionality: pulse output, remote control. <br> Digital Input: <br> Galvanically insulated <br> - Programmable functionality: external pulse count, ON/OFF state detection <br> Programmable $10 / 100 \mathrm{~Hz}$ filter for input glitches suppression.

Front panel
Display: red led display
Display update interval: ................................................... 1s
Keyboard: ................................................................... 3 keys
the energy saving technology
Multimeter, Power \& Energy Meter and Analizer

## Electrical characteristics

| Connection: ..... single-, bi-phase \& 3-phase, LT and HT grids, balanced, unbalanced, 3- and 4-wire |
| :---: |
| Voltage inputs: |
| Direct:...............................up to 300 Vrms phase-neutral or 519 Vrms phase-phase |
| Via external VTs: |
| Primary: ..........................programmable (max. 400 kV ) |
| Secondary:....................... programmable (max. 300 V ) |
| Frequency: ................................................ $45 \div 65 \mathrm{~Hz}$ |
| Max voltage to ground:................................ 300 Vrms |
| Input burden: ............................................... < 0,3 VA |
| Input impedance ............................................ > 2 MS |
| Overlo |

Current Inputs:
with external CT:
Primary: $\qquad$ programmable (max. 10 kA )
Secondary: 1 or 5 A
Max current:
1,2 or 6 Arms
Input burden: < 0,7 VA
Overload: 40 Arms, 1 sec.

Digital Inputs (depending on type):
Power supply (external):
10 to 30 Vdc
Absorbed current: 2 to 10 mA
Max counting frequency: ..... 10 or 100 Hz (programmable)
Digital Outputs (depending on type):
Type (per DIN 43864): open collector (NPN)
Max voltage:
27 Vdc
Max current:..............................................................27mA
Power supply (separate from voltage inputs):
standard type:
$230 / 240 \mathrm{Vac}+/-10 \% 50 / 60 \mathrm{~Hz}$
Self consumption:
3VA
Galvanic insulation:
Power supply (separate):.......................................... 4 kV
RS485 serial port:................................................. $1,5 \mathrm{kV}$
Digital Input \& Outputs: :........................................ $1,5 \mathrm{kV}$

| Accuracy |
| :---: |
| Voltage: ............... $0,5 \%$ of reading +/- 1 digit from 40 to 300 V , min. reading: 10V |
| Current:.......................................... 0,5\% of reading +/- 1 digit from 0,02 to $1,2 \mathrm{~A}$ or from1,2 to 6A, min. reading: 10 mA |
| Frequency:................................... 0,02Hz from 45 to 65 Hz |
| Power: ......................................... 1\% of reading +/-1 digit |
| Active Energy:...........Class 1 complying with IEC EN 62053-21 |
| Reactive Energy:....... Class 2 complying with IEC EN 62053-21 |
| Standards |
| Safety: ...................... IEC EN 61010-1 CAT III-300V, class 2 |
| E.M.C.:................................................IEC EN 61326-1A |
| Accuracy:............................................. IEC EN 62053-21 |
| Digital Outpus:................................................DIN 43864 |
| Environmental conditions |
| Working temperature range: ...............................-10/+50 ${ }^{\circ} \mathrm{C}$ |
| Storage temperature range:...............................-15/+60 ${ }^{\circ} \mathrm{C}$ |
| Relative Humidity ..................... $\mathrm{RH}<95 \%$ non-condensing |
| Mechanical characteristics |
| Enclosure ............... Self-extinguishing plastic material class V0 |
| Protection degree ..... Front panel ..............................IP40) |
| Terminals side........................... IP20 |
| Size: $\quad$ Zepro D6 ... $105 \times 90 \times 58 \mathrm{~mm}$ (6 DIN modules) |
| Mount .......................................DIN rail |
| Zepto 96.............................. $96 \times 96 \times 72 \mathrm{~mm}$ |
| Mount ..........................................panel |
| Panel cut-out......................... $92 \times 92 \mathrm{~mm}$ |
| Terminals ............................................... screw connector |
| Max cable size: ......................... 2,5 mm ${ }^{2}$ (stranded cable) / |
| $4 \mathrm{~mm}^{2}$ (solid cable) |


| How to order |
| :--- |
| Type |
| Zepto D6 RS485 230-240V .....................PFA8611-02 |
| Zepto D6 RS485 230-240V 1DI 2DO ....... PFA8611-12 |
| Zepto 96 RS485 230-240V .................. PFA8C11-02 |
| Zepto 96 RS485 230-240V 1DI 2DO ....... PFA8C11-12 |

## NEEELCTRECK <br> the energy saving technology

Electrex is a trademark of Akse srl
Via Aldo Moro, 39-42100 Reggio Emilia (RE) - Italy
Tel : +39 0522924244 - Fax : +39 0522924245
www.electrex.it - email: info@electrex.it

Subject to modification without prior notice

[^30]
## 12.VSDs

## $\triangle$ CAUTION

Thank you for purchasing our FRENIC-Eco series of inverters.

- This product is designed to drive a three-phase induction motor. Read through this instruction manual and be familiar with the handling procedure for correct use.
- Improper handling might result in incorrect operation, a short life, or even a failure of this product as well as the motor.
- Deliver this manual to the end user of this product. Keep this manual in a safe place until this product is discarded.
- For how to use an optional device, refer to the installation and instruction manuals for that optional device.

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The information contained herein is subject to change without prior notice for improvement.

This manual is a supplement to the FRENIC-Eco Instruction Manual (INR-SI47-1059-E).
It contains pages that exclusively apply to the EMC filter \& DCR built-in IP54 type. For other pages not contained in this manual, refer to the FRENIC-Eco Instruction Manual. Note that the UL and CSA standards, standard keypad, and three-phase 200 V series are not applicable to the EMC filter \& DCR built-in IP54 type, so skip their related descriptions in the FRENIC-Eco Instruction Manual.

Read through this manual in conjunction with the FRENIC-Eco Instruction Manual and Multi-function Keypad "TP-G1" Instruction Manual (INR-SI47-0890-E) and be familiar with proper handling and operation of the EMC filter \& DCR built-in IP54 type.
The manuals are subject to change without notice. Be sure to obtain the latest editions for use.

## How this manual is organized

This manual is made up of chapters below.

## Chapter 1 BEFORE USING THE INVERTER

This chapter describes acceptance inspection and precautions for transportation and storage of the inverter.

## Chapter 2 Mounting and Wiring of the Inverter

This chapter provides operating environment, precautions for installing the inverter, wiring instructions for the motor and inverter.

## Chapter 3 OPERATION USING THE KEYPAD

This chapter describes inverter operation using the keypad.

## Chapter 5 FUNCTION CODES

This chapter provides a list of the function codes. Function codes to be used often and irregular ones are described individually.

## Chapter 8 SPECIFICATIONS

This chapter lists specifications including output ratings, control system, external dimensions and protective functions.

## Chapter 10 CONFORMITY WITH STANDARDS

This chapter describes standards with which the FRN-F1L series of inverters comply.

## Icons

The following icons are used throughout this manual.
Note
This icon indicates information which, if not heeded, can result in the inverter not operating to full efficiency, as well as information concerning incorrect operations and settings which can result in accidents.
Tip This icon indicates information that can prove handy when performing certain settings or operations.
[1] This icon indicates a reference to more detailed information.
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## $\triangle$ CAUTION

8．Use the wires listed in EN60204 Appendix C．

|  |  | Inverter type | MCCB or RCD／ELCB ＊1 <br> Rated current <br> （A） |  | Recommended wire size（ $\mathrm{mm}^{2}$ ） |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | Main power input＊2 ［L1／R，L2／S，L3／T］ Inverter＇s grounding［ |  |  |  | Control circuit |  |  |  |
|  |  |  |  |  | Screw | Europe type |  |  |  |  |
|  |  |  | $\begin{gathered} \hline \text { W/ } \\ \text { DCR } \end{gathered}$ | $\begin{aligned} & \text { W/o } \\ & \text { DCR } \end{aligned}$ |  |  | $\begin{gathered} \hline \text { W/ } \\ \text { DCR } \end{gathered}$ |  | $\begin{aligned} & \text { W/o } \\ & \text { DCR } \end{aligned}$ | base |  |  | $\begin{aligned} & \text { terminal } \\ & \text { block } \end{aligned}$ |
|  | 0.75 | FRN0．75F1L－4ロ | 5 | 5 | 2.5 | 2.5 |  | 2.5 | 2.5 | $\begin{gathered} 0.25 \\ \text { to } \\ 0.75 \end{gathered}$ | $\begin{gathered} 0.25 \\ \text { to } \\ 0.75 \end{gathered}$ | 2.5 | － |
|  | 1.5 | FRN1．5F1L－4口 |  | 10 |  |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1L－4ロ | 10 | 15 |  |  |  |  |  |  |  |  |  |
|  | $\begin{aligned} & 3.7 \\ & 4.0 * 3 \end{aligned}$ | $\begin{aligned} & \hline \text { FRN3.7F1L-4D } \\ & \text { FRN4.0F1L-4E } \end{aligned}$ |  | 20 |  |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1L－4D | 15 | 30 |  |  |  |  |  |  |  |  |  |
|  | 7.5 | FRN7．5F1L－4口 | 20 | 40 |  | 4.0 |  |  |  |  |  |  |  |
|  | 11 | FRN11F1L－4D | 30 | 50 | 4.0 | 6.0 | 4.0 | 4.0 |  |  |  |  |  |
|  | 15 | FRN15F1L－4D | 40 | 60 | 6.0 | 10 | 6.0 | 6.0 |  |  |  |  |  |
|  | 18.5 | FRN18．5F1L－4ロ |  | 75 |  | 16 | 10 | 10 |  |  |  |  |  |
|  | 22 | FRN22F1L－4D | 50 | 100 | 10 |  |  | 16 |  |  |  |  |  |
|  | 30 | FRN30F1L－4D | 75 | 125 | 16 | 25 | 16 | 25 |  |  |  |  |  |
|  | 37 | FRN37F1L－4D | 100 | 125 | 25 | 35 | 25 | 25 |  |  |  |  |  |
|  | 45 | FRN45F1L－4D |  | 150 |  | 50 | 35 | 35 |  |  |  |  |  |
|  | 55 | FRN55F1L－4D | 125 | 200 | 35 | 25x2 | 50 | 16x2 |  |  |  |  |  |
|  | 75 | FRN75F1L－4D | 175 |  | 25x2 | － | 25x2 | 25x2 |  |  |  |  |  |
|  | 90 | FRN90F1L－4口 | 200 |  | 95 |  | 95 | 120 |  |  |  |  |  |

＊1 The frame size and model of the MCCB or RCD／ELCB（with overcurrent protection）will vary，depending on the power transformer capacity．Refer to the related technical documentation for details．
＊2 The recommended wire size for main circuits is for the $70^{\circ} \mathrm{C} 600 \mathrm{~V}$ PVC wires used at an ambient temperature of $40^{\circ} \mathrm{C}$ ．
＊3 The applicable motor rating of FRN4．0F1L－4E to be shipped for EU is 4.0 kW ．
Note：A box（ $\square$ ）in the above table replaces an alphabetic character depending on the shipping destination．

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Chapter 1 BEFORE USING THE INVERTER

### 1.1 Acceptance Inspection

Unpack the package and check the following:
(1) An inverter and accessories below are contained in the package.

- FRENIC-Eco Instruction Manual
- Multi-function Keypad "TP-G1" Instruction Manual
- Supplementary Instruction Manual for EMC filter \& DCR built-in IP54 type (this manual)
(2) The inverter has not been damaged during transportation-there should be no dents or parts missing.
(3) The inverter is the model you ordered. You can check the model name and specifications on the main nameplate. (Main and sub nameplates are attached to the inverter and are located as shown on the following page.)

(a) Main Nameplate

TYPE FRN5. 5F1L-4E SER. No. 571320S0001
(b) Sub Nameplate

Figure 1.1 Nameplates
TYPE: Type of inverter


SOURCE: Number of input phases (three-phase: 3PH), input voltage, input frequency, input current
OUTPUT: Number of output phases, rated output capacity, rated output voltage, output frequency range, rated output current, overload capacity
SER. No.: Product number


If you suspect the product is not working properly or if you have any questions about your product, contact your Fuji Electric representative.

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### 1.2 External View and Terminal Blocks

(1) Outside and inside views


Figure 1.2 Outside and Inside Views of Inverters
Note: A box ( $\square$ ) in the above model names replaces an alphabetic character depending on the shipping destination.

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(2) Warning plates and label

## FRENIC-ECO



Warning Plate
(a) FRN0.75F1L-4D to FRN30F1L-4D


F

Warning Plate


Warning Label

Figure 1.3 Warning Plates and Label
Note: A box (ㅁ) in the above model names replaces an alphabetic character depending on the shipping destination.
(3) Terminal block location


Figure 1.4 Terminal Blocks Location
Note: A box (ㅁ) in the above model names replaces an alphabetic character depending on the shipping destination. Q-Pulse Id TMS 1380

## Chapter 2 MOUNTING AND WIRING OF THE INVERTER

### 2.1 Operating Environment

Install the inverter in an environment that satisfies the requirements listed in Table 2.1.

Table 2.1 Environmental Requirements

| Item | Specifications |
| :--- | :--- |
| Site location | Indoors |
| Ambient <br> temperature | -10 to $+40^{\circ} \mathrm{C}$ |
| Relative <br> humidity | 5 to $95 \%$ (No condensation) |
| Atmosphere | The inverter must not be exposed to direct sunlight, <br> corrosive gases, flammable gas, and oil mist. <br> The atmosphere can contain a small amount of salt. <br> $\left(0.01\right.$ mg/cm ${ }^{2}$ or less per year) <br> The inverter must not be subjected to sudden changes <br> in temperature that will cause condensation to form. |
| Altitude | $1,000 \mathrm{~m}$ max. (Note 1) |
| Atmospheric | 86 to 106 kPa |
| pressure |  |

### 2.2 Installing the Inverter

## (1) Clearance

Ensure that the minimum clearance indicated in Figure 2.1 is provided at all times. Since the clearance takes into account only the temperature rise, it is recommended in practice that much more clearance be provided for wiring and servicing.

## ■ When mounting two or more inverters

Horizontal layout is recommended when two or more inverters are to be installed in the same unit or enclosure. If it is necessary to mount the inverters vertically, install a partition plate or the like between the inverters so that any heat radiating from an inverter will not affect the one/s above.

Table 2.2 Output Current Derating Factor in Relation to Altitude

| Altitude | Output current <br> derating factor |
| :---: | :---: |
| 1000 m or lower | 1.00 |
| 1000 to 1500 m | 0.97 |
| 1500 to 2000 m | 0.95 |
| 2000 to 2500 m | 0.91 |
| 2500 to 3000 m | 0.88 |

(Note 1) If you use the inverter in an altitude above 1000 m , you should apply an output current derating factor as listed in Table 2.2.


Figure 2.1 Mounting Direction and Required Clearances

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### 2.3 Wiring



EMC filter input terminal block (enlarged)

Figure 2.6 Connecting Power Source Wires (FRN15F1L-4D)*

* A box ( $\square$ ) in the above model names replaces an alphabetic character depending on the shipping destination.
- Connect the main circuit power supply wires (L1/R, L2/S, L3/T, and grounding wire) to the EMC filter input terminal block.
- Do not disconnect the wires being connected to the main circuit terminal block (L1/R, L2/S, L3/T, $P 1$, and $P(+))$.

Follow the procedures given below. (In the following description, the inverter has already been installed.)

### 2.3.1 Opening and closing the front cover

(1) Remove the four screws from the front cover.
(2) Open the left-hinged front cover to the left as shown below.
3. Close the front cover and secure it with four screws.


Figure 2.7 Opening the Front Cover (FRN15F1L-4ロ)*

* A box (ㅁ) in the above model names replaces an alphabetic character depending on the shipping destination.

The table below shows the main circuit screw sizes，tightening torque and terminal arrangements．Note that the terminal arrangements differ according to the inverter types．Two terminals designed for grounding shown as the symbol， $\boldsymbol{3}$ in Figures A to D make no distinction between a power supply source（a primary circuit）and a motor （a secondary circuit）．

## （1）Arrangement of the main circuit terminals

Table 2．6 Main Circuit Terminal Properties

| Power <br> supply <br> voltage | Nominal applied motor （kW） | Inverter type | Input terminal |  |  |  | Output terminal |  |  |  | Refer to： |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Terminal screw size | Tightening torque （N•m） | Grounding screw size | Tightening torque （ $\mathrm{N} \cdot \mathrm{m}$ ） | Terminal screw size | Tightening torque （ $\mathrm{N} \cdot \mathrm{m}$ ） | Grounding screw size | Tightening torque （N•m） |  |
| Three－ phase 400 V | 0.75 | FRN0．75F1L－4口 | M4 | 1.4 | M4 | 1.4 | M4 | 1.8 | M4 | 1.8 | Figure A |
|  | 1.5 | FRN1．5F1L－4ロ |  |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1L－4D |  |  |  |  |  |  |  |  |  |
|  | $\begin{aligned} & 3.7 \\ & 4.0 \text { * } \end{aligned}$ | FRN3．7F1L－4口 FRN4．0F1L－4E |  |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1L－4ロ |  |  |  |  |  |  |  |  |  |
|  | 7.5 | FRN7．5F1L－4口 | M6 | 3.0 | M6 | 3.0 | M5 | 3.8 | M5 | 3.8 | Figure B |
|  | 11 | FRN11F1L－4口 |  |  |  |  |  |  |  |  |  |
|  | 15 | FRN15F1L－4D |  |  |  |  | M6 | 5.8 | M6 | 5.8 |  |
|  | 18.5 | FRN18．5F1L－4口 |  |  |  |  |  |  |  |  | Figure C |
|  | 22 | FRN22F1L－4口 |  |  |  |  |  |  |  |  |  |
|  | 30 | FRN30F1L－4D |  |  |  |  | M8 | 13.5 | M8 | 13.5 | Figure D |
|  | 37 | FRN37F1L－4D | M8 | 5.5 | M8 | 13.5 |  |  |  |  | Figure E |
|  | 45 | FRN45F1L－4D |  |  |  |  |  |  |  |  |  |
|  | 55 | FRN55F1L－4D |  | 6.6 |  |  |  |  |  |  | Figure F |
|  | 75 | FRN75F1L－4口 |  |  |  |  |  |  |  |  |  |
|  | 90 | FRN90F1L－4口 | M10 | 12 | M10 | 27 | M10 | 27 | M10 | 27 | Figure G |

Terminal R0，T0（Common to all types）：Screw size M3．5，Tightening torque 1．2 N．m
＊The applicable motor rating of FRN4．0F1L－4E to be shipped for EU is 4.0 kW ．
Note：A box（ロ）in the above table replaces an alphabetic character depending on the shipping destination．

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Figure A


Changing
Lamp


Figure B

Figure E


Figure G


| O | O | O |
| :--- | :--- | :--- |
| $11 / R$ | $\mathrm{~L} 2 / 3$ | $\mathrm{~L} 3 / \mathrm{T}$ |


| O | 0 |
| :--- | :--- |
| 0 | 0 O |

Chapter 3 OPERATION USING THE KEYPAD
This inverter is equipped with a multi-function keypad. For the operating procedure for the multi-function keypad, read the Multi-function Keypad "TP-G1" Instruction Manual (INR-SI47-0890-E), Chapter 3, which comes with the inverter.

### 5.1 Function Code Tables

F codes: Fundamental Functions

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default setting | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| F26 | Motor Sound (Carrier frequency) <br> (Tone) | 0.75 to 4 ( 37 to 90 kW$)^{* 1}$ | 1 | kHz | Y | Y | 2 | 5-41 |
| F27 |  | 0: Level 0 (Inactive) <br> 1: Level 1 <br> 2: Level 2 <br> 3: Level 3 | - | - | Y | Y | 0 |  |
| F29 | Analog Output [FMA] <br> (Mode selection) <br> (Output adjustment) | 0 : Output in voltage ( 0 to 10 VDC ) <br> 1: Output in current ( 4 to 20 mA DC ) | - | - | Y | Y | 0 | 5-42 |
| F30 |  | 0 to 200 | 1 | \% | $Y^{*}$ | Y | 100 |  |
| F31 | Analog Output [FMA] <br> (Function) | Select a function to be monitored from the followings. <br> Output frequency <br> Output current <br> Output voltage <br> Output torque <br> Load factor <br> Input power <br> PID feedback value (PV) <br> DC link bus voltage <br> Universal AO <br> Motor output <br> 14: Calibration analog output (+) <br> 15: PID process command (SV) <br> 16: PID process output (MV) | - | - | Y | Y | 0 |  |
| F33 | Pulse Output [FMP] *2 <br> (Pulse rate) <br> (Duty) | 25 to 6000 (Pulse rate at $100 \%$ output) | 1 | $\mathrm{p} / \mathrm{s}$ | $Y^{*}$ | Y | 1440 | 5-44 |
| F34 |  | 0: Output pulse rate (Fixed at $50 \%$ duty) <br> 1 to 200: Voltage output adjustment (Pulse rate is fixed at $2000 \mathrm{p} / \mathrm{s}$. Adjust the maximum pulse duty.) | 1 | \% | $Y^{*}$ | Y | 0 |  |
| F35 |  | Select a function to be monitored from the followings. <br> 0: Output frequency <br> 2: Output current <br> 3: Output voltage <br> 4: Output torque <br> 5: Load factor <br> 6: Input power <br> 7: PID feedback value (PV) <br> 9: DC link bus voltage <br> 10: Universal AO <br> 13: Motor output <br> 14: Calibration analog output (+) <br> 15: PID process command (SV) <br> 16: PID process output (MV) | - | - | Y | Y | 0 |  |

The shaded function codes ( $\square$ ) are applicable to the quick setup.
*1 If the carrier frequency is set at 1 kHz or below, estimate the maximum motor output torque at $80 \%$ or less of the rated motor torque.
*2 The control printed circuit board (control PCB) is equipped with either a screw terminal base or Europe type terminal block, supporting [FMP] or [FMI], respectively. The [FMP] enables F33 to F35, but the [FMI] enables only F34 and F35 so that F33 will not appear.

### 5.2 Overview of Function Codes

| F23 | Starting Frequency |
| :--- | :--- |
| F25 | Stop Frequency |

At the startup of an inverter, the initial output frequency is equal to the starting frequency. The inverter stops its output at the stop frequency.
Set the starting frequency to a level that will enable the motor to generate enough torque for startup. Generally, set the motor's rated slip frequency at the starting frequency F23.

If the starting frequency is lower than the stop frequency, the inverter will not output any power as long as the frequency command does not exceed the stop frequency.


| F26 | Motor Sound (Carrier frequency) |
| :--- | :--- |
| F27 | Motor Sound (Tone) |

- Motor sound (Carrier frequency) (F26)

F26 controls the carrier frequency so as to reduce an audible noise generated by the motor or inverter itself, and to decrease a leakage current from the main output (secondary) wirings.

| Carrier frequency (Inverter rated capacity: 37 to 90 kW ) | 0.75 to 4 kHz |
| :--- | :--- |
| Motor sound noise emission | High $\leftrightarrow$ Low |
| Motor temperature (due to harmonics components) | High $\leftrightarrow$ Low |
| Ripples in output current waveform | Large $\leftrightarrow$ Small |
| Leakage current | Low $\leftrightarrow$ High |
| Electromagnetic noise emission | Low $\leftrightarrow$ High |
| Inverter loss | Low $\leftrightarrow$ High | Chapter 8 SPECIFICATIONS

### 8.1 EMC filter \& DCR built-in IP54 type

### 8.1.2 Three-phase 400 V series

| Item |  |  | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Power supply voltage |  |  | Three-phase 400 V |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Type (FRN___F1L-4口) |  |  | 0.75 | 1.5 | 2.2 | $\begin{array}{\|l\|} \hline 3.7 \\ (4.0)^{*} 7 \end{array}$ | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 |
| Applicable motor rating (kW) |  |  | 0.75 | 1.5 | 2.2 | $\begin{array}{\|l\|} \hline 3.7 \\ (4.0)^{*} 7 \end{array}$ | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 |
|  | Rated capacity <br> (kVA) ${ }^{2} 2$ |  | 1.9 | 2.8 | 4.1 | 6.8 | 9.5 | 12 | 17 | 22 | 28 | 33 | 44 | 54 | 64 | 80 | 105 | 128 |
|  | © Rated voltage <br> (V)  |  | Three-phase, 380, $400 \mathrm{~V} / 50 \mathrm{~Hz}, 380,400,440,480 \mathrm{~V} / 60 \mathrm{~Hz}$ (with AVR function) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current <br> (A) |  | 2.5 | 3.7 | 5.5 | 9.0 | 12.5 | 16.5 | 23 | 30 | 37 | 44 | 59 | 72 | 85 | 105 | 139 | 168 |
|  | Overload capability |  | 120\% of rated current for 1 min |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases, voltage, frequency | Main power supply | Three-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Three-phase, 380 to $440 \mathrm{~V}, 50 \mathrm{~Hz}$ Three-phase, 380 to $480 \mathrm{~V}, 60 \mathrm{~Hz}$ |  |  |  |  |
|  |  | Auxiliary control power input | Single-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Single-phase, 380 to $440 \mathrm{~V}, 50 \mathrm{~Hz}$ Single-phase, 380 to $480 \mathrm{~V}, 60 \mathrm{~Hz}$ |  |  |  |  |
|  | Voltage/frequency variations |  | Voltage: +10 to $-15 \%$ (Voltage unbalance: $2 \%$ or less)*8, Frequency: +5 to $-5 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current (A) ${ }_{* 5}$ |  | 1.6 | 3.0 | 4.5 | 7.5 | 10.6 | 14.4 | 21.1 | 28.8 | 35.5 | 42.2 | 57.0 | 68.5 | 83.2 | 102 | 138 | 164 |
|  | Required power supply capacity (kVA) |  | 1.2 | 2.2 | 3.1 | 5.3 | 7.4 | 10 | 15 | 20 | 25 | 30 | 40 | 48 | 58 | 71 | 96 | 114 |
|  | Torque (\%) |  | 20 年 10 to 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | DC braking |  | Starting frequency: 0.0 to 60.0 Hz , Braking time: 0.0 to 30.0 s , Braking level: 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| EMC filter |  |  | Standard conformance: Immunity: 2nd Env. (EN61800-3: 1996+A11:2000) <br> Emission: Class A Group 1 (EN55011: 1998+A1: 1999+A2: 2002) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DC reactor (DCR) |  |  | Provided as standard |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Applicable safety standards |  |  | EN50178:1997 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure (IEC60529) |  |  | IP54 *9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cooling method |  |  | Natural cooling |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mass (kg) |  |  | 12.5 | 12.5 | 13 | 14 | 14 | 22 | 22 | 24 | 34 | 35 | 40 | 59 | 60 | 80 | 82 | 93 |

*1 Fuji 4-pole standard motor
*2 Rated capacity is calculated by assuming the output rated voltage as 440 V for three-phase 400 V series.
*3 Output voltage cannot exceed the power supply voltage.
*4 An excessively low setting of the carrier frequency may result in the higher motor temperature or tripping of the inverter by its overcurrent limiter setting. Lower the continuous load or maximum load instead. (When setting the carrier frequency (F26) to 1 kHz , reduce the load to $80 \%$ of its rating.)
*5 Calculated under Fuji-specified conditions.
*6 Average braking torque (Varies with the efficiency of the motor.)
*7 The applicable motor rating of FRN4.0F1L-4E to be shipped for EU is 4.0 kW .
*8 Voltage unbalance (\%) $=\frac{\text { Max. voltage }(\mathrm{V})-\text { Min. voltage }(\mathrm{V})}{\text { Three - phase average voltage }(\mathrm{V})} \times 67 \quad$ (IEC61800-3(5,2,3)
If this value is 2 to $3 \%$, use an $A C$ reactor (ACR).
*9 Excluding a cooling fan(s). (Only the models from 2.2 to 30 kW .)
Note: A box ( $\square$ ) in the above table replaces an alphabetic character depending on the shipping destination.

## 7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O

### 8.4.2 Running the EMC filter \& DCR built-in IP54 type

The diagram below shows a basic connection example for running the EMC filter \& DCR built-in IP54 type.

(Note 1) To protect wiring, insert a molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) (with overcurrent protection) of the type recommended for the inverter between the commercial power supply and the inverter. Do not use a circuit breaker with a capacity exceeding the recommended capacity.
(Note 2) In addition to an MCCB or ELCB, insert, if necessary, a magnetic contactor (MC) of the type recommended for the inverter to cut off the commercial power supply to the inverter. Furthermore, if the coil of the MC or solenoid comes into close contact with the inverter, install a surge absorber in parallel.
(Note 3) To put the inverter on standby by making the control circuit only active with the main circuit power supply being opened, connect this pair of wires to terminals [R0] and [T0]. Without connecting this pair of wires to these terminals, you can still run the inverter as long as the main wires of the commercial power supply to the main circuit are properly connected.
The (R0, T0) inputs are fed without passing an EMC filter. If necessary, externally connect a single-phase filter.
(Note 4) It is recommended that a three-phase 4-wire cable be used for motor wiring to protect the motor from noise. Its grounding wire should be connected to the grounding terminal F of the inverter.
(Note 5) The frequency command can be set either electronically by supplying a DC voltage signal (within the range of 0 to $10 \mathrm{~V}, 0$ to 5 V , or 1 to 5 V ) between terminals [12] and [11], or manually by connecting a frequency command potentiometer to terminals [13], [12], and [11].
(Note 6) For the wiring of the control circuit, use shielded or twisted wires. When using shielded wires, connect the shields to earth. To prevent malfunction due to noise, keep the control circuit wires as far away as possible from the main circuit wires (recommended distance: 10 cm or longer), and never put them in the same wire duct. Where a control circuit wire needs to cross a main circuit wire, route them so that they meet at right angles.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI 8.5 External Dimensions

### 8.5.1 EMC filter \& DCR built-in IP54 type




| Power supply voltage | Inverter type |
| :---: | :---: |
| Three-phase 400 V | FRN0.75F1L-4 $\square$ to FRN5.5F1L-4 $\square$ |

Note: A box (口) in the above table replaces an alphabetic character depending on the shipping destination.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI


| Power supply voltage | Inverter type |
| :---: | :---: |
| Three-phase 400 V | FRN7.5F1L-4ロ to FRN15F1L-4 |

Note: A box ( $\square$ ) in the above table replaces an alphabetic character depending on the shipping destination.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI


Note: A box ( $\square$ ) in the above table replaces an alphabetic character depending on the shipping destination.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI


| Power supply voltage | Inverter type |
| :---: | :---: |
| Three-phase 400 V | FRN37F1L-4 $\square$, FRN45F1L-4 $\square$ |

Note: A box ( $\square$ ) in the above table replaces an alphabetic character depending on the shipping destination.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI


| Power supply voltage | Inverter type |
| :---: | :---: |
| Three-phase 400 V | FRN55F1L-4ロ |

Note: A box ( $\square$ ) in the above table replaces an alphabetic character depending on the shipping destination.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI


| Power supply voltage | Inverter type |
| :---: | :---: |
| Three-phase 400 V | FRN75F1L-4ロ |

Note: A box ( $\square$ ) in the above table replaces an alphabetic character depending on the shipping destination.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI


| Power supply voltage | Inverter type |
| :---: | :---: |
| Three-phase 400 V | FRN90F1L-4 $\square$ |

Note: A box ( $\square$ ) in the above table replaces an alphabetic character depending on the shipping destination.

10．5 Conformity with the EMC Directive in the EU

## 10．5．1 General

The CE Marking on inverters does not ensure that the entire equipment including CE－marked products is compliant with the EMC Directive．Therefore，it is the responsibility of the equipment manufacturer to ensure that the equipment including the product（inverter）or connected with it actually complies with the standard and to put a CE Marking as the equipment．
In general，the user＇s equipment comprises a variety of products supplied from a number of manufacturers in addition to Fuji inverters．Therefore，the manufacturer of the final equipment needs to take responsibility for conformity．
In addition，to satisfy the requirements noted above，it is necessary to use a Fuji inverter in connection with an EMC－compliant filter（option）and install it in accordance with the instructions contained in this instruction manual． Install the Fuji inverter in a metal enclosure．

10．5．2 Leakage current from EMC filter \＆DCR built－in IP54 type
Table 10．1 Leakage Current from EMC Filter \＆DCR Built－in IP54 Type

| Power supply voltage | Inverter type | Leakage current（mA）＊1＊2 |  |
| :---: | :---: | :---: | :---: |
|  |  | Normal condition | Worst condition |
| Three－phase 400 V | FRN0．75F1L－4口 | 10.7 | 39.7 |
|  | FRN1．5F1L－4口 |  |  |
|  | FRN2．2F1L－4D |  |  |
|  | FRN3．7F1L－4ロ FRN4．0F1L－4E＊3 |  |  |
|  | FRN5．5F1L－4口 |  |  |
|  | FRN7．5F1L－4口 | 10.7 | 39.7 |
|  | FRN11F1L－4ロ |  |  |
|  | FRN15F1L－4ロ |  |  |
|  | FRN18．5F1L－4ロ | 3 | 105 |
|  | FRN22F1L－4ロ | 6 | 158 |
|  | FRN30F1L－4ロ | 3 | 105 |
|  | FRN37F1L－4ロ | 24.4 | 143 |
|  | FRN45F1L－4ロ |  |  |
|  | FRN55F1L－4ロ | 37 | 211 |
|  | FRN75F1L－4ロ |  |  |
|  | FRN90F1L－4ロ |  |  |

＊1 The values are calculated assuming the power supply frequency of 50 Hz for three－phase 400 V ．
＊2 The worst condition includes a phase loss in the supply line．
＊3 The applicable motor rating of FRN4．0F1L－4E to be shipped for EU is 4.0 kW ．
Note：A box（ $\square$ ）in the above table replaces an alphabetic character depending on the shipping destination．

## End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI

 10.5.3 Recommended installationInstall the inverter using the procedure given below. The wiring of the inverter and motor should be carried out by an electrical engineer. To conform with the EMC Directive, follow the procedure as closely as possible.


FRN0.75F1L-4 $\square$ to FRN5.5F1L-4 $\square$


Figure 10.2 (1) Connecting the Shields for Grounding
Note: A box (ㅁ) in the above model names replaces an alphabetic character depending on the shipping destination.


FRN18.5F1L-4 $\square$ to FRN22F1L-4


FRN30F1L-4D

Figure 10.2 (2) Connecting the Shields for Grounding

Note: $A$ box ( $\square$ ) in the above model names replaces an alphabetic character depending on the shipping destination.

1) Use a shielded cable for connection to the motor and make it as short as possible. Connect the shield layer of the motor cable firmly to the metal plate with the shield grounding clamp for grounding. Also, at the motor side, connect the shield layer electrically to the grounding terminal of the motor. (See Figure 10.2.)
2) Use a shielded cable for connection of control circuit lines of the inverter. As with the motor, connect the shield layer of the control circuit cable to the metal plate with the shield grounding clamp for grounding.
3) Outlet bushings required for wiring do not come with the inverter. They should be prepared by the user.

### 10.5.4 EMC-compliant environment and class

The table below lists the capacity and power supply voltage of the FRENIC-Eco and the EMC-compliant environment.

| Power <br> supply <br> voltage | Standards | Inverter capacity |
| :---: | :---: | :---: |
| Three- <br> phase <br> 400 V | Immunity | 0.75 to 90 kW |
|  | Emission | EN61800-3 Second environment (Industrial environment) |

## $\triangle$ WARNING

Before changing any internal wiring, turn OFF the power and wait more than five minutes for models of 30 kW or below, or ten minutes for models of 37 kW or above. Make sure that the LED monitor and charging lamp (on models of 37 kW or above) are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the $D C$ link bus voltage between the terminals $P(+)$ and $N(-)$ has dropped below the safe voltage (+25 VDC).
Otherwise electric shock could occur.

MEMO

## Designed For Fan and Pump Applications

FRENIC-ECa

## Instruction Manual

Supplementary for EMC Filter \& DCR Built-in IP54 Type
First Edition, September 2005
Second Edition, November 2005
Fuji Electric FA Components \& Systems Co., Ltd.

The purpose of this instruction manual is to provide accurate information in handling, setting up and operating of the FRENIC-Eco series of inverters. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

In no event will Fuji Electric FA Components \& Systems Co., Ltd. be liable for any direct or indirect damages resulting from the application of the information in this manual.

## FRENIC-ECO <br> Multi-function Keypad "TP-G1"

## $\triangle C A U T I O N$

Thank you for purchasing our Multi-function Keypad TP-G1.

- This product is designed to remotely control the FRENIC-Eco series of inverters. Read through this instruction manual and be familiar with the handling procedure for correct use.
- Improper handling blocks correct operation or causes a short life or failure.
- Deliver this manual to the end user of the product. Keep this manual in a safe place until the Multi-function Keypad is discarded.
- For the usage of inverters and optional equipment, refer to the instruction manuals prepared for the FRENIC-Eco series of inverters and its optional equipment.

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The information contained herein is subject to change without prior notice for improvement.

## Preface

Thank you for purchasing our Multi-function Keypad "TP-G1."
By installing a TP-G1 Multi-function Keypad directly on a FRENIC-Eco series inverter as an attached keypad or connecting them together using an optional Remote Operation Extension Cable (CB-5S, CB-3S, or CB-1S, depending on the distance), you can operate the inverter locally or remotely. In either mode, you can, in the same way as with a standard built-in keypad, run and stop the motor, monitor the running status, and set the function codes. In addition, you can perform "data copying": You can read function code data from an inverter, copy (write) it into another inverter, or verify it.

Before installing and using the Multi-function Keypad, read through this manual in conjunction with the FRENIC-Eco Instruction Manual and familiarize yourself with its proper use. Improper use may prevent normal operation or cause a failure or reduced life of the inverter.

## Related Publications

Listed below are other publications on the FRENIC-Eco to be consulted in conjunction with this manual as necessary.

- FRENIC-Eco User's Manual
- RS485 Communication User's Manual
- Catalog
- FRENIC-Eco Instruction Manual
- RS485 Communications Card "OPC-F1-RS" Installation Manual
- Relay Output Card "OPC-F1-RY" Instruction Manual
- Mounting Adapter for External Cooling "PB-F1" Installation Manual
- Panel-mount Adapter "MA-F1" Installation Manual
- FRENIC Loader Instruction Manual
(MEH456)
(MEH448a)
(MEH442)
(INR-SI47-0882-E)
(INR-SI47-0872)
(INR-SI47-0873)
(INR-SI47-0880)
(INR-SI47-0881)
(INR-SI47-0903-E)

The materials are subject to change without notice. Be sure to obtain the latest editions for use.

## - Safety precautions

Read this manual thoroughly before proceeding with installation, connections (wiring), operation, or maintenance and inspection. Ensure you have sound knowledge of the device and familiarize yourself with all safety information and precautions before proceeding to operate the inverter
Safety precautions are classified into the following two categories in this manual.

| AMNARNINS | Failure to heed the information indicated by this symbol may lead to dangerous conditions, possibly resulting in death or serious bodily injuries. |
| :---: | :---: |
| AOAUTION | Failure to heed the information indicated by this symbol may lead to dangerous conditions, possibly resulting in minor or light bodily injuries and/or substantial property damage. |

Failure to heed the information contained under the CAUTION title can also result in serious consequences. These safety precautions are of utmost importance and must be observed at all times.

Operation

## $\triangle$ WARNING

- Be sure to install the terminal block cover and the front cover before turning the power on. Do not remove the covers while power is applied.

Otherwise electric shock could occur.

- Do not operate switches/buttons with wet hands.

Doing so could cause electric shock.

- If the retry function has been selected, the inverter may automatically restart and drive the motor depending on the cause of tripping.
(Design the machinery or equipment so that human safety is ensured after restarting.)
- If the stall prevention function has been selected, the inverter may operate at an acceleration/deceleration time or frequency different from the set ones. Design the machine so that safety is ensured even in such cases.
Otherwise an accident could occur.
- The STOP key is effective only when function setting (Function code F02) has been established to enable the STOP key. Prepare an emergency stop switch separately. If you disable the STOP key priority function and enable operation by external commands, you cannot emergency-stop the inverter using the STOP key on the keypad.
- If an alarm reset is made with the operation signal turned on, a sudden start will occur. Ensure that the operation signal is turned off in advance.
Otherwise an accident could occur.
- If you enable the "restart mode after instantaneous power failure" (Function code F14 $=3,4$, or 5 ), then the inverter automatically restarts running the motor when the power is recovered.
(Design the machinery or equipment so that human safety is ensured after restarting.)
- If you set the function codes wrongly or without completely understanding this instruction manual and the FRENIC-Eco User's Manual (MEH456), the motor may rotate with a torque or at a speed not permitted for the machine.
An accident or injuries could occur.
- Do not touch the inverter terminals while the power is applied to the inverter even if the inverter stops. Doing so could cause electric shock.


## Wiring

## $\triangle$ WARNING

- Do not operate the switch with wet hands.

Doing so could cause electric shock.

- Before opening the cover of the inverter to install the multi-functional keypad, turn off the inverter and wait for at least five minutes for models of 30 kW or below, or ten minutes for models of 37 kW or above. Further, make sure that the LED monitor is turned off, the charger indicator is off, and the DC link circuit voltage between the terminals $P(+)$ and $N(-)$ has dropped below the safe voltage level (+25 VDC), using a circuit tester or another appropriate instrument.
Otherwise electric shock could occur.
- In general, the insulation property of the sleeve of the signal wire and that of the sheath of the signal cable are not sufficient for high voltages. Therefore, if a signal wire or cable comes into direct contact with a live part of the main circuit, the insulation may be broken, causing the signal wire to be exposed to the high voltage of the main circuit. Be sure to keep all signal wires and cables away from live parts of the main circuit.
Otherwise, an accident or electric shock could occur.


## Disposal

## $\triangle$ CAUTION

- For disposal, treat the Multi-functional Keypad as industrial waste.

Otherwise injuries could occur.

## Others

## $\triangle$ WARNING

- Never attempt to modify the Multi-function Keypad or inverter.

Doing so could cause electric shock or injuries.

## GENERAL PRECAUTIONS

Drawings in this manual may be illustrated without covers or safety shields for explanation of detail parts. Restore the covers and shields in the original state and observe the description in the manual before starting operation.

## How this manual is organized

This manual is made up of chapters 1 through 4

## Chapter 1 BEFORE USING THE MULTI-FUNCTION KEYPAD "TP-G1"

This chapter describes the points to check upon delivery and lists the inverters the Multi-function Keypad is designed to interface with.

## Chapter 2 INSTALLATION AND INTERCONNECTION

This chapter describes how to install the Multi-function Keypad and how to interconnect it with an inverter.

## Chapter 3 OPERATION USING THE MULTI-FUNCTION KEYPAD "TP-G1"

This chapter describes the operation of the inverter using the Multi-function Keypad. More specifically, this chapter gives an overview of the inverter's three operation modes (Running, Programming, and Alarm modes) and describes how to run and stop the inverter/motor, set function code data, monitor running status, view maintenance information and alarm data, and perform data copying.

## Chapter 4 SPECIFICATIONS

This chapter lists the general specifications such as operating environments, communication specifications and transmission specifications.

## Icons

The following icons are used throughout this manual.
This icon indicates information which, if not heeded, can result in the product not operating to full efficiency, as well as information concerning incorrect operations and settings which can result in accidents.
(4) This icon indicates a reference to more detailed information.

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## Chapter 1 BEFORE USING THE MULTI－FUNCTION KEYPAD＂TP－G1＂

## 1．1 Acceptance Inspection

Unpack the package and check the following：
（1）The package contains a Multi－function Keypad and its instruction manual（this book）．
（2）There have been no problems during transportation．In particular，no parts are damaged or have fallen out of place nor are there any dents on the body．
（3）The model name＂TP－G1＂is inscribed on the back of the Multi－function Keypad as shown in Figure 1.1

If you suspect the product is not working properly or if you have any questions about your product，contact your Fuji Electric representative．


Figure 1．1 Back of Multi－function Keypad TP－G1

## 1．2 Inverters with which the Multi－function Keypad Interfaces

The Multi－function Keypad＂TP－G1＂interfaces with the following Fuji inverters：

| Series | Type of inverter＊＊ | Remarks |
| :---: | :---: | :---: |
| FRENIC－Eco | FRND口ᄆF1s－口口 FRNDロロF1E－口ᄆ FRNDロロF1H－ロロ <br> （Each $\square$ has its meaning as shown below， represented by an alphanumeric character．） | The Multi－function Keypad is fully supported by inverters with a ROM version of F1S10300 or later．（You can check the inverter＇s ROM version by entering menu \＃5，＂5．＂ 7 ＂in＂Maintenance Information＂in Programming Mode．） <br> There are restrictions on the support for the Multi－function Keypad by inverters with a ROM version of F1S10300 or earlier．For details， consult your Fuji Electric representative． |



For the details of the Inverter type identification，refer to the FRENIC－Eco Instruction Manual （INR－SI47－0882－E），Chapter 1，Section 1.1 ＂Acceptance Inspection．＂

## Chapter 2 INSTALLATION AND INTERCONNECTION

### 2.1 Accessories and Parts Required for Interconnection

To install your TP-G1 Multi-function Keypad on the enclosure's panel instead of the inverter, you need the following accessories and parts:

| Accessories/Parts | Type or Specifications | Remarks |
| :--- | :--- | :--- |
| Remote Operation Extension Cable <br> (Note 1) | CB-5S, CB-3S, or CB-1S | You have a choice of three lengths: $5 \mathrm{~m}, 3$ <br> m , and 1 m. |
| Screws <br> (for mounting the Multi-function Keypad) | $\mathrm{M} \times \square$ (Note 2) | Provide 2 screws (to be provided by the <br> customer) beforehand. |

Note 1: Alternatively, you can use an off-the-shelf 10BASE-T/100BASE-TX LAN cable (straight type) that meets the ANSI/TIA/EIA-568A Category 5 standard (maximum length: 20 m ).
Recommended LAN Cable:
Manufacturer: Sanwa Supply, Co. Ltd.
Model: $\quad$ KB-10T5-01K (for 1 m )
KB-STP-01K (for 1 m ) (shielded cable, EMC-compliant)
Note 2: Use the screws of the length just right for the panel. (See Figure 2.7.)

### 2.2 Installing the TP-G1 Multi-function Keypad

### 2.2.1 Three ways of installation/use

You can install and/or use your TP-G1 in one of the following three ways:

- Install it directly on the inverter (see Figure 2.1).
- Install it on the front panel of enclosure (see Figure 2.2).

■ Use it remotely in your hand (see Figure 2.3).

(a) FRN15F1S-2」

(b) FRN37F1S-2」

Figure 2.1 Installing Multi-function Keypad Directly on Inverter


Figure 2.2 Installing Multi-function Keypad on Enclosure


Figure 2.3 Using Multi-function Keypad remotely in Your Hand

### 2.2.2 Installing the TP-G1 multi-function keypad

After completion of interconnection, follow the next steps to install the multi-function keypad in place. Be sure to turn off the power of the inverter beforehand.

## - Installing the TP-G1 directly on the inverter

(1) Remove the standard keypad mounted on the inverter.

Pull the standard keypad toward you while holding down the hook (as directed by the arrows in Figure 2.4 below).


Figure 2.4 Removing the Standard Keypad
(2) Mount the TP-G1 Multi-function Keypad onto the inverter.

Put your TP-G1 Multi-function Keypad in the original slot while engaging its bottom latches with the holes (as shown below), and push it onto the case of the inverter (arrow (2)) while holding it downward (against the terminal block cover) (arrow (1)).


Figure 2.5 Mounting the Multi-function Keypad
<Protection from abnormal vibration: for inverters with capacity of 30 kW or less>
In an environment with large ambient vibrations, the inverter may be exposed to them, causing abnormal vibrations on the Multi-function Keypad. If this happens, remove the terminal block cover and the front cover and fix, using the keypad fixing screws attached to the inverter, the Multi-function Keypad.
QD For the procedures for removing the covers, refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 2, Section 2.3.1" Removing and mounting the terminal block (TB) cover and the front cover."


Figure 2.6 Fixing the Multi-function Keypad

## E Installing the multi-function keypad on the enclosure panel

(1) Cut the panel out for a single square area and perforate two screw holes on the panel of the enclosure as shown in Figure 2.7.

*If the thickness of the enclosure is outside the range shown above, use screws of an appropriate length.


Dimensions of holes in enclosure (viewed from A)

Figure 2.7 Dimensions of Square Cut-out and Screw Holes
(2) Mount the Multi-function Keypad onto the enclosure with 2 screws as shown in Figure 2.8. (Recommended tightening torque: $0.7 \mathrm{~N} \cdot \mathrm{~m}$ )


Figure 2.8 Mounting Multi-function Keypad
(3) Remove the standard keypad mounted on the inverter (see Figure 2.4) and, using a Remote Operation Extension Cable or a LAN cable, interconnect the Multi-function Keypad and the Inverter (insert one end of the cable into the RS485 port with RJ-45 connector on the Multi-function Keypad and the other end into that on the inverter) (See Figure 2.9.).


Figure 2.9 Connecting Multi-function Keypad to the Inverter with Remote Operation Extension Cable or an off-the-shelf LAN Cable

## - Using the multi-function keypad in hand

Follow step (3) of "Installing the multi-function keypad on the enclosure panel" above.

## Chapter 3 OPERATION USING THE MULTI-FUNCTION KEYPAD

### 3.1 Key, LED, and LCD Monitors on the Keypad

The keypad allows you to start and stop the motor, view various data including maintenance information and alarm information, set function codes, monitor I/O signal status, copy data, and calculate the load factor.


Table 3.1 Overview of Keypad Functions

| Item | Monitor, LED <br> indicator or Key |  |
| :--- | :--- | :--- | :--- | :--- | :--- |

## Items Displayed on LED Indicators

| Type | Item | Description (information, condition, status) |
| :---: | :---: | :---: |
| Unit of Number Displayed on LED Monitor | Hz | Output frequency, frequency command |
|  | A | Output current |
|  | V | Output voltage |
|  | \% | Calculated torque, load factor, speed |
|  | r/min | Motor speed, set motor speed, load shaft speed, set load shaft speed |
|  | $\mathrm{m} / \mathrm{min}$ | Line speed, set line speed (Not applicable to FRENIC-Eco) |
|  | kW | Input power, motor output |
|  | X10 | Data greater than 99,999 |
|  | min | Constant feeding rate time, constant feeding rate time setting (Not applicable to FRENIC-Eco) |
|  | sec | Timer |
|  | PID | PID process value |
| Operating Status | FWD | Running (forward rotation) |
|  | REV | Running (reverse rotation) |
|  | STOP | No output frequency |
| Source of Operation | REM | Remote mode |
|  | LOC | Local mode |
|  | COMM | Communication enabled (RS485 (standard, optional), field bus option) |
|  | JOG | Jogging mode (Not applicable to FRENIC-Eco) |
|  | HAND | Keypad effective (lights also in local mode) |



### 3.2 Overview of Operation Modes

FRENIC-Eco features the following three operation modes:
$\square$ Running Mode: This mode allows you to enter run/stop commands in regular operation. You can also monitor the running status in real time.

- Programming Mode: This mode allows you to set function code data and check a variety of information relating to the inverter status and maintenance.
Alarm Mode: If an alarm condition occurs, the inverter automatically enters the Alarm Mode. In this mode, you can view the corresponding alarm code* and its related information on the LED and LCD Monitors.
* Alarm code: Indicates the cause of the alarm condition that has triggered a protective function. For details, refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 8, Section 8.5 "Protection Features."

Figure 3.1 shows the status transition of the inverter between these three operation modes.


Figure 3.1 Status Transition between Operation Modes

### 3.3 Running Mode

When the inverter is turned on, it automatically enters Running Mode. In Running Mode, you can:
[ 1] Run or stop the motor;
[2] Set the frequency command and others;
[3] Monitor the running status (e.g., output frequency, output current)

### 3.3.1 Running/stopping the motor

By factory default, pressing the (wor) key starts running the motor in the forward direction and pressing the key decelerates the motor to stop. The key is disabled. You can run or stop the motor using the keypad only in Running mode and Programming mode.

To run the motor in reverse direction, or to run the motor in reversible mode, change the setting of function code F02.
[D] For details of function code F02, refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 5.


Figure 3.2 Rotational Direction of Motor
Note) The rotational direction of IEC-compliant motor is opposite to the one shown here.

## Display of running status (on LCD monitor)

(1) When function code E45 (LCD Monitor (optional)) is set to " 0, " the LCD Monitor displays the running status, the rotational direction, and the operation guide.
(The indicators above the LCD Monitor indicate the unit of the number displayed on the LED Monitor; the indicators underneath the LCD Monitor indicate the running status and the source of Run command.)


Figure 3.3 Display of Running Status

The running status and the rotational direction are displayed as shown in Table 3.2.
Table 3.2 Running Status and Rotational Direction

| Status/Direction | Description |
| :---: | :--- |
| Running status | RUN: The Run command is present, or the inverter is driving the motor. <br> STOP: The Run command is not present, or the inverter is in stopped state. |
| Rotational direction | FWD: Forward <br>  <br>  <br> REV: Reverse <br> Blank: Stopped |

(2) When function code E45 (LCD Monitor (optional)) is set to "1," the LCD Monitor displays the output frequency, output current, and calculated torque in a bar chart.
(The indicators above the LCD Monitor indicate the unit of the number displayed on the LED Monitor; the indicators underneath the LCD Monitor indicate the running status and the source of Run command.)


The full scale (maximum value) for each parameter is as follows:
Output frequency: Maximum frequency
Output current: 200\% of inverter's rated current
Calculated torque: $200 \%$ of rated torque generated by motor
Figure 3.4 Bar Chart

## Switching the operation mode between remote and local

The inverter can be operated either in remote mode or in local mode. In remote mode, which applies to normal operation, the inverter is driven under the control of the data settings held in it, whereas in local mode, which applies to maintenance operation, it is separated from the system and is driven manually under the control of the keypad.

Remote mode: The sources for setting run and frequency commands is determined by various setting means switching signals such as function codes, switching of run command $1 / 2$, and link priority function.

Local mode: The sources for setting run and frequency commands is the keypad, regardless of the settings specified by function codes. The keypad takes precedence over the setting means specified by the run command $1 / 2$ or the link priority function.

What follows shows the setting means of run command using the keypad in the local operation mode.

Table 3.3 Run Commands from the Keypad in the Local Operation Mode

| If function code F02 is set to: | Setting means of the run command |
| :---: | :---: |
| 0: Keypad | You can run/stop the motor using the (fwd) / (rav) / (roe) key on the keypad. |
| 1: External signal |  |
| 2: Keypad (forward) | You can run/stop the motor using the (1) / (ro) key on the keypad. <br> You can run the motor in forward direction only. (The (AEV) key has been disabled.). |
| 3: Keypad (reverse) | You can run/stop the motor using the (®®) / (io9) key on the keypad. <br> You can run the motor in reverse direction only. (The (ewo) key has been disabled.) |

The source for setting run and frequency commands can be switched between Remote and Local modes by the (ex) key on the keypad. (This key is a toggle switch: Each time you press it for more than 1 second, the mode switches from Romote to Local or vice versa.)

The mode can be switched also by an external digital input signal. To enable the switching you need to assign (LOC) to one of the digital input terminals, which means that the commands from the keypad are given precedence (one of function codes E01 to E05, E98, or E99 must be set to "35"). By factory default, (LOC) is assigned to [ X 5 ].
You can confirm the current mode on the indicators (REM: Remote mode; LOC: Local mode).
When the mode is switched from Remote to Local, the frequency settings in the Remote mode are automatically inherited. Further, if the inverter is in Running mode at the time of the switching from Remote to Local, the Run command is automatically turned ON so that all the necessary data settings will be carried over. If, however, there is a discrepancy between the settings on the keypad and those on the inverter itself (e.g., switching from reverse rotation in the Remote mode to forward rotation in the Local mode using the keypad that is for forward rotation only), the inverter automatically stops.

The paths of transition between Remote and Local modes depend on the current mode and the value (ON/OFF) of (LOC), the signal giving precedence to the commands from the keypad, as shown in the state transition diagram (Figure 3.5) given below.
[10] For further details on how to set operation commands and frequencies in Remote and Local modes, refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4 "BLOCK DIAGRAMS FOR CONTROL LOGIC" (especially Section 4.3 "Drive Command Generator" block diagram).


Figure 3.5 Transition between Remote and Local Modes

### 3.3.2 Setting up the frequency and PID process commands

You can set up the desired frequency command and PID process command by using $\widehat{\theta}$ and $\otimes$ keys on the keypad.

You can also view and set up the frequency command as load shaft speed by setting function code E48.

## Setting the frequency command

## Using $\theta$ and $\otimes$ keys (factory default)

(1) Set function code F01 to " 0 : Keypad operation." This cannot be done when the keypad is in Programming mode or Alarm mode. To enable frequency setting by using $\otimes$ and $\otimes$ keys, first move the keypad in Running mode.
(2) Pressing the $(\triangle$ key causes the frequency command to be displayed on the LCD Monitor, with the lowermost digit blinking.


Figure 3.6 Setting the Frequency Command in Local Mode
(3) If you need to change the frequency command, press the $\widehat{\otimes} / \bigcirc$ key again. The new setting will be automatically saved into the inverter's internal non-volatile memory. It is kept there even while the inverter is powered OFF, and will be used as the initial frequency next time the inverter is powered ON.

- The frequency setting can be saved either automatically as mentioned above or by pressing the (2m) key. You can choose either way using function code E64.
- When you start specifying or changing the frequency command or any other parameter with the ( ) / key, the lowest digit on the display will blink and start changing. As you are holding the key down, blinking will gradually move to the upper digit places and the upper digits will be changeable.
- Pressing the sey moves the changeable digit place (blinking) and thus allows you to change upper digits easily.
- By setting function code C 30 to " 0 : Keypad operation ( $(\otimes) /($ key)" and selecting frequency command 2 as the frequency setting method, you can also specify or change the frequency command in the same manner using the ( $) /($ key.
- If you have set the function code F01 to "0: Keypad operation ( $(\mathcal{Q} / \circlearrowleft$ key)" but have selected a frequency setting other than frequency 1 (i.e., frequency 2 , set it via communications, or as a multistep frequency), then you cannot use the ( ) / key for setting the frequency command even if the keypad is in Running Mode. Pressing either of these keys will just display the currently selected frequency command.


To have the frequency command displayed as the motor speed, load shaft speed, or speed (\%), set function code E48 (speed monitor selection) to 3, 4, or 7, respectively, as shown in Table 3.6 Monitored Items.

Table 3.4 Available Means of Setting

| Symbol | Command sources | Symbol | Command sources | Symbol | Command sources |
| :--- | :--- | :--- | :--- | :--- | :--- |
| HAND | Keypad | MULTI | Multistep <br> frequency | PID-HAND | PID keypad <br> command |
| 12 | Terminal [12] |  |  | PID-P1 | PID process <br> command 1 |
| C1 | Terminal [C1] | RS485-1 | RS485 (standard) | PID-P2 | PID process <br> command 2 |
| $12+$ C1 | Terminal [12] + <br> Terminal [C1] | RS485-2 | RS485 (optional) | PID-U/D | PID UP/DOWN <br> process command |
| V2 | Terminal [V2] | BUS | Bus option | PID_LINK | PID <br> communication <br> process command |
| U/D | UP/DOWN control | LOADER | FRENIC loader | PID+MULTI | PID multistep <br> frequency <br> command |

## - Make setting under PID control

To enable PID control, you need to set function code J01 to 1 or 2.
Under the PID control, the items that can be set or checked with $Q$ and $\oslash$ keys are different from those under regular frequency control, depending upon the current LED monitor setting. If the LED monitor is set to the speed monitor, you may access manual speed commands (frequency command) with $\Theta$ and $\diamond$ keys; if it is set to any other value, you may access the PID process command with those keys.
(1) Refer to the FRENIC-Eco User's Manual (MEH456) for details on the PID control.

## Setting the PID process command with $Q$ and $\otimes$ keys

(1) Set function code J02 to "0: Keypad operation."
(2) Set the LED monitor to something other than the speed monitor ( $\mathrm{E} 43=0$ ) while the keypad is in Running Mode. You cannot modify the PID process command using the $(\widehat{)}$ / key while the keypad is in Programming Mode or Alarm Mode. To enable the modification of the PID process command by the Key, first switch to Running Mode.
(3) Press the $\Theta /($ key to have the PID process command displayed. The lowest digit will blink together with the dot on the LED monitor.


Figure 3.7 PID Process Commands
(4) To change the PID process command, press the / $\circlearrowleft$ key again. The PID process command you have specified will be automatically saved into the inverter's internal memory. It is kept there even if you temporarily switch to another means of specifying the PID process command and then go back to the means of specifying the PID process command via the keypad. Also, it is kept there even while the inverter is powered OFF, and will be used as the initial PID process command next time the inverter is powered ON.

Tip - Even if multistep frequency is selected as the PID process command ((SS4) $=\mathrm{ON})$, you still can set the process command using the keypad.

- When function code $J 02$ is set to any value other than 0 , pressing the $Q$ / key displays, on the 7 -segment LED monitor, the PID command currently selected, while you cannot change the setting.

- On the 7-segment LED monitor, the decimal point of the lowest digit is used to characterize what is displayed. The decimal point of the lowest digit blinks when a PID process command is displayed; the decimal point lights when a PID feedback value is displayed.



## Setting up the frequency command with $(\underset{)}{ }$ and keys under PID control

When function code F01 is set at "0: Keypad operation" and frequency command 1 (Frequency setting via communications link: Disabled; Multistep frequency setting: Disabled; PID control: Disabled) is selected as the manual speed command, you can modify the frequency setting using the / / key if you specify the LED monitor as the speed monitor while the keypad is in Running Mode. You cannot modify the frequency setting using the $\langle$, key while the keypad is in Programming Mode or Alarm Mode. To enable the modification of the frequency setting using the $Q / \otimes$ key, first switch to Running Mode. These conditions are summarized in Table 3.5 and the figure below. Table 3.5 shows the combinations of the parameters, while the figure below illustrates how the manual speed command (1) entered via the keypad is translated to the final frequency command (2).
The setting and viewing procedures are the same as those for usual frequency setting.
Table 3.5 Speed (Frequency) Command Manually Set with $O$ Key and Requirements

| Frequency command 1 (F01) | Frequency setting via communications link | Multistep frequency setting | PID control disabled | Display during $\widehat{\bigcirc}$ / key operation |
| :---: | :---: | :---: | :---: | :---: |
| 0 | Disabled | Disabled | PID enabled | PID output (as final frequency command) |
|  |  |  | Disabled | Manual speed setting by keypad (frequency setting) |
| Other than the above |  |  | PID enabled | PID output (as final frequency command) |
|  |  |  | Disabled | Manual speed command currently selected (frequency setting) |



## 3．3．3 LED monitor（Monitoring the running status）

The eleven items listed below can be monitored on the LED Monitor．Immediately after the inverter is turned ON， the monitor item specified by function code E43 is displayed．In Running Mode，press the key to switch between monitor items．The item being monitored shifts as you press the key in the sequence shown in Table 3．6．

Table 3．6 Items Monitored

| Page to be selected | Monitored Item | Example | Unit | Meaning of Displayed Value | Function code E43 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | Speed Monitor <br> Output frequency | Function code E48 specifies what to be displayed． |  |  | $\left\{\begin{array}{c} 0 \\ (\mathrm{E} 48=0) \end{array}\right.$ |
|  |  | $5 \pi 1270$ | Hz | Frequency actually being output（ Hz ） |  |
|  | Motor speed | N1517 | r／min | Output frequency $\times \frac{120}{\mathrm{P} 01}$ | （E48＝3） |
|  | Load shaft speed | 31777 | r／min | Output frequency（ Hz ）$\times$ E50 | （E48＝4） |
|  | Speed（\％） | 5077 | \％ | $\frac{\text { Output frequency }}{\text { Maximum frequency }} \times 100$ | （E48＝7） |
| 8 | Output current | 12.34 | A | Output of the inverter in current in rms | 3 |
| 9 | Input Power | M1， 25 | kW | Input power to the inverter | 9 |
| 10 | Calculated torque | 50 | \％ | Motor output torque in \％（Calculated value） | 8 |
| 11 | Output voltage | 2076 | V | Output of the inverter in voltage in rms | 4 |
| 12 | Motor output | 5.55 | kW | Motor output in kW | 16 |
| 13 | Load factor | 57 | \％ | Load rate of the motor in \％with the rated output being at $100 \%$ | 15 |
| 14 | PID process command （Note 1） | 117070 | － | PID process command／feedback value transformed to that of physical value of the object to be | 10 |
| 15 | PID feedback value （Note 1） | 5174 | － | Refer to the function codes E40 and E41 for details． | 12 |
| 16 | PID output（Note 1） | Mロップ | \％ | PID output in \％with the maximum output frequency（FO3）being at 100\％ | 14 |
| 18 | Analog input monitor （Note 2） | ロゴロ゙ィ | － | Analog input to the inverter converted per E40 and E41 <br> Refer to the function codes E40 and E41 for details． | 17 |



Figure 3．8 Selecting Items to be Monitored on LED Monitor
（Note 1）Displayed only if the inverter PID－controls the motor according to a PID process command specified by the function code J 01 （ $=1$ or 2 ）．While the 7 －segment LED monitor is displaying PID process command，PID feedback value，or PID output value，the dot（decimal point）at the lowest digit on it is lit or blinking respectively．
（Note 2）Analog input monitoring becomes active only when enabled by any data of the function codes E61，E62 or E63 （Select terminal function）．

### 3.4 Programming Mode

Programming Mode provides you with the functions of setting and checking function code data, monitoring maintenance information and checking input/output (I/O) signal status. The functions can be easily selected with a menu-driven system. Table 3.7 lists menus available in the Programming Mode.

Table 3.7 Menus Available in Programming Mode

| Menu \# | Menu | Main functions | Refer to: |
| :---: | :--- | :--- | :---: |
| 0 | Quick Setup | Displays only basic function codes that are pre-selected. | 3.4 .2 |
| 1 | Data Setting | Allows you to view and change the setting of the function code <br> you select. (Note) | 3.4 .1 |
| 2 | Data Checking | Allows you to view and change a function code and its setting <br> (data) on the same screen. Also allows you to check the function <br> codes that have been changed from their factory defaults. | 3.4 .3 |
| 3 | Drive Monitoring | Displays the running information required for maintenance or <br> test running. | 3.4 .4 |
| 4 | I/O Checking | Displays external interface information. | 3.4 .5 |
| 5 | Maintenance Information | Displays maintenance information including cumulative run time. | 3.4 .6 |
| 7 | Alarm Information | Displays four latest alarm codes. Also allows you to view the <br> information on the running status at the time the alarm occurred. | 3.4 .7 |
| 8 | Alarm cause | Displays the cause of the alarm. |  |
| 9 | Load Factor <br> Measurement | Allows you to read or write function code data, as well as to <br> verify it. | 3.4 .8 |
| 10 | User Setting | Allows you to measure the maximum output current, average <br> output current, and average braking power. |  |
| 11 | Communication <br> Debugging | Allows you to add or delete function codes covered by Quick <br> Setup. | Allows you to confirm the data of the function codes for <br> communication (S, M, W, X, and Z codes). |

(Note) The function codes for optional features (o code) are displayed only when they are installed. For details, refer to their instruction manuals.

Figure 3.9 shows the transitions between menus in Programming mode.


Figure 3.9 Menu Transition in Programming Mode
When there has been no key operation for about 5 minutes, the inverter automatically goes back to the Running mode and the back light goes OFF.

### 3.4.1 Setting function codes - "1. Data Setting"

Menu \#1 "Data Setting" in Programming Mode allows you to set function codes according to your needs.
Table 3.8 lists the function codes available on the FRENIC-Eco.
Table 3.8 Function Codes Available on FRENIC-Eco

| Function Code Group | Function Code | Function | Description |
| :---: | :--- | :--- | :--- |
| F code <br> (Fundamental functions) | F00 to F44 | Fundamental <br> functions | Fundamental functions used in operation of the <br> motor |
| E code <br> (Extension terminal <br> functions) | E01 to E99 | Terminal <br> functions | Functions concerning the selection of operation of <br> the control circuit terminals; Functions concerning <br> the display on the LED monitor |
| C code <br> (Control functions of <br> frequency) | C01 to C53 | Control <br> functions | Functions associated with frequency settings |
| P code <br> (Motor parameters) | P01 to P99 | Motor <br> parameters | Functions for setting up characteristics <br> parameters (such as capacity) of the motor |
| H code <br> (High performance <br> functions) | H03 to H98 | High-level <br> functions | Highly added-value functions; Functions for <br> sophisticated control |
| J code <br> (Application functions) | J01 to J22 | Application <br> functions | Functions for applications such as PID Control |
| y code <br> (Link functions) | y01 to y99 | Link <br> functions | Functions for controlling communications |
| o code <br> (Option functions) | o27 to o59 | Optional <br> functions | Functions for optional features (Note) |

(Note) The o code is displayed only when the corresponding optional feature is installed.
For details of the o code, refer to the Instruction Manual for the corresponding optional feature.

## Function codes requiring simultaneous keying

To modify the data for function code F00 (data protection), H03 (data initialization), or H97 (clear alarm data), simultaneous keying is needed, involving the key + the $(\mathcal{O}$ key, or the key + the key.

Modifying function code data during running: making the modification valid and saving the modification

Some function codes can be modified while the inverter is running, whereas others cannot. Further, depending on the function code, modifications may or may not become effective immediately. For details, refer to the "Change when running" column in 5.1 "Function Code Tables" in Chapter 5 of the FRENIC-Eco Instruction Manual (INR-SI47-0882-E).
DIl For details of function codes, refer to 5.1 "Function Code Tables" in Chapter 5 of the FRENIC-Eco Instruction Manual (INR-SI47-0882-E).
Figure 3.10 illustrates LCD screen transition for Menu item 1. DATA SET.


Figure 3.10 Screen Transition for Data Setting Menu

## Basic key operation

This section will give a description of the basic key operation, following the example of the function code data changing procedure shown in Figure 3.11.
This example shows you how to change function code F03 data (maximum frequency) from 58.0 Hz to 58.1 Hz .
(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the (rac) key to enter Programming Mode. The menu for function selection will be displayed.
(2) Using $\widehat{Q}$ and $\otimes$ keys, move the pointer to "1. DATA SET" and then press the key, which will display a list of function codes.
(3) Use $\triangle$ and $\oslash$ keys to select the desired function code group (in this example, F03:), and press the key, which will display the screen for changing the desired function code data.
(4) Change the function code data by using $\widehat{\sim}$ and keys. Pressing the place to shift (cursor shifting) (The blinking digit can be changed).
(5) Press the (쌔N $k e y$ to finalize the function code data.

The data will be saved in the memory inside the inverter. The display will return to the function code list, then move to the next function code (in this example, F04).
If you press the key before the key, the change made to data of the function code is cancelled. The data reverts to the previous value, the screen returns to the function code list, and the function code (F03) reappears.
(6) Press the key to return to the menu from the function code list.

Screen


Function code \#, name
*: Function code that has been changed from factory default Data
Allowable range
Operation guide


Data before change
Data after change
25. $0 \sim 120$. 0
$\Lambda V \rightarrow$ DATA ADJUS

Figure 3.11 Screen for Changing Function Code Data

Additional note on function code being selected
The function code being selected blinks, indicating the movement of the cursor (F03 blinks in this example).


Figure 3.12 Changing Function Code Data

### 3.4.2 Setting up function codes quickly using Quick setup - "0. QUICK SET"

Menu \#0 "QUICK SET" in Programming Mode allows you to quickly set up a fundamental set of function codes that you specify beforehand. Whereas at shipment from factory, only a predetermined set of function codes is registered, you can add or delete some function codes using "10. USER SET." The set of function codes covered by Quick Setup is held in the inverter (not the keypad). Therefore, if you mount your keypad onto another inverter, the set of function codes held in the new inverter is subject to Quick Setup. If necessary, you may copy the set of function codes subject to Quick Setup using the copy function ("8. DATA COPY").

If you perform data initialization (function code H03), the set of function codes subject to Quick Setup will be reset to the factory default
[1] For the list of function codes subject to Quick Setup by factory default, refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 5 "FUNCTION CODES."

LCD screen transition from the " 0 . QUICK SET" menu is the same as with "1. DATA SET."

## Basic key operation

Same as the basic key operation for "1. DATA SET."

### 3.4.3 Checking changed function codes -"2. DATA CHECK"

Menu \#2 "DATA CHECK" in Programming Mode allows you to check function codes (together with their data) that have been changed. The function codes whose data have been changed from factory default are marked with *. By selecting a function code and pressing the key, you can view or change its data.

LCD screen transition from the "2. DATA CHECK" menu is the same as with "1. DATA SET," except for the different screen listing function codes as shown below.


Figure 3.13 LCD Screen Listing Function Codes

## Basic kev operation

Same as the basic key operation for "1. DATA SET."

### 3.4.4 Monitoring the running status -"3. OPR MNTR"

Menu \#3 "OPR MNTR" allows you to check the running status during maintenance and test running. The display items for "Drive Monitoring" are listed in Table 3.9.

Table 3.9 Drive Monitoring Display Items

| Symbol | Item | Description |
| :--- | :--- | :--- |
| Fot1 | Output frequency | Output frequency |
| Fot2 |  | Reserved |
| lout | Output current | Output current |
| Vout | Output voltage | Output voltage |
| TRQ | Calculated torque | Calculated output torque generated by motor |
| Fref | Frequency <br> command | Frequency command |
| Running direction | FWD: Forward, REV: Reverse, Blank: Stopped |  |
| SYN | Motor shaft speed | Display value = (Output frequency Hz) $\times \frac{120}{\text { P01 }}$ |
| LOD | Load shaft speed | Display value = (Output frequency Hz) $\times$ (Function code E50) |
| LIN |  | Reserved |
| SV | PID process <br> command | The PID process command and PID feedback value are displayed after <br> converting the value to a virtual physical value (e.g., temperature or pressure) of <br> the object to be controlled using the function code E40 and E41 data (PID display <br> coefficients A and B). <br> Display value $=$ (PID process command/feedback value) $\times$ (Coefficient A - B) + B |
| PV | PID feedback <br> value | PID output value, displayed in \% (with Maximum frequency (F03) being 100\%). |
| MV | PID output value |  |

Figure 3.14 shows the LCD screen transition starting from the "OPR MNTR" menu.
O. QUICK SET

1. DATA SET
2. DATA CHECK
3. OPR MNTR
$\triangle V \rightarrow$ MENU SHIFF

Press key to finalize desired menu.
Output frequency
Reserved
Output current
Output voltage

Motor shaft speed Load shaft speed Reserved
Calculated torque Frequency command Running direction, status
$\mathbf{S V}=+0.00$
$P V=+0.00$
$M V=+0.0$
ㅇ PR M M TR $4 / 4$
Select desired menu by moving the pointer with ( key.
Common operation:
To confirm data, call the desired page using ( ) /(v) key.
Press (nise) key to return to Menu.

Figure 3.14 Menu Transition for "OPR MNTR"

## Basic kev operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the eroc key to enter Programming Mode. The menu for function selection will be displayed.

(3) Press the key to display the screen for Operation Monitor (1 page out of a total of 4 pages).
(4) Select the page for the desired item by using $(\underset{)}{ }$ and keys and confirm the running status information for the desired item.
(5) Press the (ㅍ⿰z) key to go back to the menu.

### 3.4.5 Checking I/O signal status - "4. I/O CHECK"

Menu \#4 "I/O CHECK" in Programming mode allows you to check the digital and analog input/output signals coming in/out of the inverter. This menu is used to check the running status during maintenance or test run. Table 3.10 lists check items available.

Table 3.10 I/O Check Items

| Item | Symbol | Description |
| :---: | :---: | :---: |
| Input signals at terminal block of control circuit | FWD, REV, X1-X5 | Shows the ON/OFF state of the input signals at the terminal block of the control circuit. <br> (Highlighted when short-circuited; normal when open) |
| Input signals coming via Communication link | FWD, REV, X1 - X5, XF, XR, RST | Input information for function code S06 (communication) (Highlighted when 1; normal when 0) |
| Output signals | Y1-Y3, Y5, 30ABC | Output signal information |
| I/O signals (hexadecimal) | DI | Input signal at terminal block of control circuit (in hexadecimal) |
|  | DO | Output signal (in hexadecimal) |
|  | LNK | Input signal via communication link (hexadecimal) |
| Analog input signals | 12 | Input voltage at terminal [12] |
|  | C1 | Input current at terminal [C1] |
|  | V2 | Input voltage at terminal [V2] |
| Analog output signals | FMA | Output voltage at terminal [FMA] |
|  | FMA | Output current at terminal [[FMA] |
|  | FMP | Average output voltage at terminal [FMP] |
|  | FMP | Pulse rate at terminal [FMP] |

## Basic.key operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the key to enter Programming Mode. The menu for function selection will be displayed.
(2) Select "4. I/O CHECK" by using $\Theta$ ) and keys (moving 期).
(3) Press the key to display the screen for I/O Checking (1 page out of a total of 6 pages).
(4) Select the page for the desired item by using $(\mathcal{Q})$ and $\otimes$ keys and confirm the I/O check data for the desired item.
(5) Press the key to go back to the menu.

Figure 3.15 shows the LCD screen transition starting from the " 4 . I/O CHECK" menu.


Figure 3.15 Menu Transition for "I/O CHECK"

## - Hexadecimal expression

Each I/O terminal is assigned to one of the 16 binary bits (bit 0 through bit 15). The bit to which no I/O terminal is assigned is considered to have a value of " 0 ." The $/ / O$ signals are thus collectively expressed as a hexadecimal number ( 0 through $F$ ).

In the FRENIC-Eco Series, digital input terminals [FWD] and [[REV] are assigned to bits 0 and 1, and [X1] through [X5] to bits 2 through 6, respectively. Each bit assumes a value of "1" when the corresponding signal is ON and a value of " 0 " when it is OFF(Note). For example, when signals [FWD] and [X1] are ON while all the other signals are OFF, the status is expressed as "0005H."
(Note) The ON/OFF state of each signal at terminals [FWD], [REV], and X1 through [X5] is to be interpreted according to the states of the source/sink switch as shown in Table 2.9 in Chapter 2 of the FRENIC-Eco Instruction Manual (INR-SI47-0882-E).

Digital output terminals [Y1] through [Y3] are assigned to bits 0 through 2. Each is given a value of "1" when it is short-circuited to [CMY], or a value of " 0 " when its circuit to [CMY] is open. The status of relay output terminal [ $\mathrm{Y} 5 \mathrm{~A} / \mathrm{C}$ ] is assigned to bit 4 , which assumes a value of "1" when the contact between [Y5A] and [Y5C] is closed. The status of relay output terminal [30A/B/C] is assigned to bit 8 , which assumes a value of " 1 " when the contact between [30A] and [30C] is closed or " 0 " when the contact between [30B] and [30C] is closed. For example, when terminal $[\mathrm{Y} 1$ ] is ON , terminals [ Y 2 ] and [ Y 3 ]] are OFF, the contact between [ Y 5 A ] and [Y5C] is opened, and the link between 30A and 30C is closed, the status is expressed as "0101H."

Table 3.11 Hexadecimal Notation

| $\begin{gathered} \text { D } \\ \text { Disp } \end{gathered}$ | Data played | Highest digit |  |  |  |  |  |  |  |  |  |  |  | Lowest digit |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Bit | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Input | signal | (RST) ${ }^{\text { }}$ | (XR) | (XF) | - | - | - | - | - | - | [X5] | [X4] | [X3] | [X2] | [X1] | [REV] | [FWD] |
| Outpu | ut signal | - | - | - | - | - | - | - | $\left\lvert\, \begin{gathered} {[30 \mathrm{~A} / \mathrm{B}} \\ / \mathrm{C}] \end{gathered}\right.$ | - | - | - | $\begin{gathered} {[Y 5 A} \\ / C] \end{gathered}$ | - | [Y3] | [Y2] | [Y1] |
|  | Binary | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
|  | Hex | 0005H |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

$-:$ unassigned

* (XF), (XR), (RST) are for communications. Refer to the subsection below.


## Displaying control I/O signal terminals under communication control

During control via communication, input commands sent via RS485 communications can be displayed in two ways depending on setting of the function code S06: "Display with ON/OFF of the LED segment" or "In hexadecimal format." The content to be displayed is basically the same as that for the control I/O signal terminal status display; however, (XF), (XR), and (RST) are added as inputs. Note that under communications control, I/O display is in normal logic (ON when active) (using the original signals that are not inverted)

Refer to the RS485 Communication User's Manual (MEH448a) for details on input commands sent through RS485 communications and the instruction manual of communication-related options as well.

### 3.4.6 Reading maintenance information - "5. MAINTENANC"

Menu \#5 "MAINTENANC" in Programming Mode allows you to view information necessary for performing maintenance on the inverter.

Table 3.12 lists the maintenance information display items.
Table 3.12 Display Items for Maintenance

| Symbol | Item | Description |
| :---: | :---: | :---: |
| TIME | Cumulative run time | Shows the cumulative run time during which the inverter was powered ON. <br> When the total time exceeds 65,535 hours, the counter will be reset to 0 and the count will start again. |
| EDC | DC link circuit voltage | Shows the DC link circuit voltage of the inverter's main circuit. |
| TMPI | Max. temperature inside the inverter | Shows a maximum temperature inside the inerter every hour. |
| TMPF | Max. temperature of heat sink | Shows the maximum temperature of the heat sink every hour. |
| Imax | Max. effective current | Shows the maximum current in rms every hour. |
| CAP | Capacitance of the DC bus capacitor | Shows the current capacitance of the DC bus capacitor as \% of the capacitance at factory shipment. Refer to the FRENIC-Eco Instruction Manual (INR-S147-0882-E), Chapter 7 "MAINTENANCE AND INSPECTION" for details. |
| MTIM | Cumulative motor run time | Shows the cumulative run time of the motor. <br> When the total time exceeds 65,535 hours, the counter will be reset to 0 and the count will start again. |
| TCAP | Cumulative run time of electrolytic capacitor on the printed circuit board | Shows the product of the cumulative time of voltage being applied to the electrolytic capacitor on the printed circuit board and a coefficient determined by the environmental condition. When the total time exceeds 65,535 hours, the counting will stop. <br> As a guide, 61,000 hours is considered as life. |
| TFAN | Cumulative run time of the cooling fan | Shows the cumulative run time of the cooling fan. When the total time exceeds 65,535 hours, the counting will stop. <br> As a guide, 61,000 hours is considered as life (This number varies with the capacity of the inverter.) |
| NST | Count of start-ups | Shows the total count of start-ups of the motor (count of times when the run command for the inverter was turned ON). When the total time exceeds 65,535 hours, the counter will be reset to 0 and the count will start again. |
| Wh | Input watt-hour Note 1) | Shows the input watt-hours of the inverter. Upon exceeding 1,000,000 kWh, the count goes back to 0 . |
| PD | Input watt-hour data Note 1) | Shows the input watt-hour data as input watt-hour (kWh) $x$ function code E51. (The range of display is 0.001 to 9,999 . Values exceeding 9,999 are expressed as 9,999 .) |
| NRR1 | Count of RS485-1 errors | Shows the cumulative count of RS485 communications card (standard) errors since first power ON. |
|  | RS485-1 error content Note 2) | Shows the latest error that has occurred with RS485 communications (standard) in a code. |
| NRR2 | Count of RS485-2 errors | Shows the cumulative count of RS485 communications card (option) errors since first power ON. |
|  | RS485-2 error content Note 2) | Shows the latest error that has occurred with RS485 communications (option) in a code. |
| NRO | Count of option errors | Shows the cumulative count of errors detected during optional communication with option installed. |
|  | Option error code | Shows the latest error that has been detected during optional communication in a code. |
| MAIN | ROM version of the inverter | Shows the ROM version of the inverter in 4 digits. |
| KP | ROM version of the keypad | Shows the ROM version of the keypad in 4 digits. |
| OP1 | ROM version of the option | Shows the ROM version of the option in 4 digits. |

Note 1) To reset the input watt-hour and input watt-hour data to 0, set function code E51 to "0.000."
Note 2) For details of errors, refer to the RS485 Communication User's Manual (MEH448a).

## Basic key operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the (88) key to enter Programming Mode. The menu for function selection will be displayed.

(3) Press the key to display the screen for Maintenance (1 page out of a total of 7 pages).
(4) Select the page for the desired item by using $\circlearrowleft$ ) and $\circlearrowleft$ keys and confirm the Maintenance data for the desired item.
(5) Press the key to go back to the menu.

Figure 3.16 shows the LCD screen transition starting from the "5. MAINTENANC" menu.


Figure 3.16 Menu Transition for "MAINTENANC"

### 3.4.7 Reading alarm information - "6. ALM INF"

Menu \#6 "ALM INF" in Programming Mode allows you to view the information on the four most recent alarm conditions that triggered protective functions (in alarm code and the number of occurrences). It also shows the status of the inverter when the alarm condition occurred.
Table 3.13 lists the details of the alarm information.
Table 3.13 Alarm Information Displayed

| Symbol | Item | Description |
| :---: | :---: | :---: |
| O/1 | Most recent alarm | Alarm code and count of occurrences |
| -1 | $2^{\text {nd }}$ recent alarm | Alarm code and count of occurrences |
| -2 | $3^{\text {rd }}$ recent alarm | Alarm code and count of occurrences |
| -3 | $4^{\text {th }}$ recent alarm | Alarm code and count of occurrences |
| Fot1 | Output frequency | Output frequency |
| lout | Output current | Output current |
| Vout | Output voltage | Output voltage |
| TRQ | Calculated torque | Motor output torque |
| Fref | Frequency command | Frequency command |
|  | Running direction | FWD: Forward, REV: Reverse, Blank: Stopped |
|  | Running status | IL: current limitation, LU: undervoltage, VL: voltage limitation |
| TIME | Cumulative run time | Shows the cumulative power-ON time of the inverter. <br> When the total time exceeds 65,535 hours, the display will be reset to 0 and the count will start again. |
| NST | Count of startups | Shows the cumulative count of times the motor has been started (the inverter run command has been issued). When the total count exceeds 65,535 , the display will be reset to 0 and the count will start again. |
| EDC | DC link circuit voltage | Shows the DC link circuit voltage of the inverter's main circuit. |
| TMPI | Temperature inside the inverter | Shows the temperature inside the inverter. |
| TMPF | Max. temperature of heat sink | Shows the maximum temperature of the heat sink. |
| TRM | Input signal status at terminal block of control circuit | ON/OFF status of input signals of the terminals [FWD], [REV], [X1] to [X5] (Highlighted when short-circuited; normal when open) |
| LNK | Terminal input signal status under communication control | ON/OFF status of input signals for function code S06 (Communication). [FWD], [REV], [X1] to [X5], (XF), (XR), (RST) (Highlighted when 1; normal when 0 ) |
| - | Output signal | Output signals to the terminals [Y1] to [Y3], [Y5], [30ABC] |
| 3 | Overlapping alarm 1 | Simultaneously occurring alarm codes (1) ("----" is displayed if no alarms have occurred.) |
| 2 | Overlapping alarm 1 | Simultaneously occurring alarm codes (2) <br> ("----" is displayed if no alarms have occurred.) |
| SUB | Error sub-code | Secondary error code for the alarm. |

Note When the same alarm occurs a number of times in succession (reoccurring alarm), the alarm information for the first occurrence is retained and the information for the subsequent occurrences is discarded. Only the number of consecutive occurrences will be updated.

## Basic kev operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the (Pag) key to enter Programming Mode. The menu for function selection will be displayed.
(2) Select "6. ALM INF" by using $\widehat{O}$ and keys (moving
(3) Press the key to get the Alarm list screen, which displays information on the four most recent alarm conditions (alarm code and the number of occurrences for each alarm condition).
(4) Select the alarm condition to be displayed, by using $\otimes$ and $\otimes$ keys.
(5) Press the key to display the alarm code on the LED Monitor and the screen for the status data at the time of the alarm ( 1 page out of a total of 7 pages) on the LCD Monitor.
(6) Select the page for the desired item by using $(\mathcal{)}$ and $(\checkmark$ keys and confirm the status data for the desired item.
(7) Press the key to return to the alarm list. Press the key again to return to the menu.

Figure 3.17 shows the LCD screen transition starting from the " 6 . ALM INF" menu.


Select desired menu by moving the pointer with key.

Press key to finalize desired menu.
Cause \& No. of occurrences of most recent alarm Cause \& No. of occurrences of $2^{\text {nd }}$ most recent alarm Cause \& No. of occurrences of $3^{\text {rd }}$ most recent alarm Cause \& No. of occurrences of $4^{\text {th }}$ most recent alarm Press key to return to Menu.

Select desired alarm by moving the cursor with (Q/D) key.

Press (190) key to finalize desired alarm info.

Figure 3.17 Menu Transition for "ALM INF"


Figure 3.17 Menu Transition for "ALM INF" (continued)

### 3.4.8 Viewing cause of alarm - "7. ALM CAUSE"

Menu \#7 "ALM CAUSE" in Programming Mode allows you to view the information on the four most recent alarm conditions that triggered protective functions (in alarm code and the number of occurrences). It also shows the cause of each alarm.

## Basic key operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the (acs) key to enter Programming Mode. The menu for function selection will be displayed.
(2) Select "7. ALM CAUSEF" by using $(\sim$ and $(\checkmark$ keys (moving
(3) Press the key to get the Alarm list screen, which displays information on the four most recent alarm conditions (alarm code and the number of occurrences for each alarm condition).
(4) Select the alarm condition to be displayed, by using $Q$ and $\otimes$ keys.
(5) Press the key to display the alarm code on the LED Monitor and the screen for the cause of the alarm (can be more than 1 page) on the LCD Monitor.
(6) Press $\bigcirc$ and $\boxtimes$ keys to view the previous/next page.
(7) Press the (\#yy to return to the alarm list. Press the key again to return to the menu.

Figure 3.18 shows the LCD screen transition starting from the "7. ALM CAUSE" menu.


Figure 3.18 Menu Transition for "ALM CAUSE"

### 3.4.9 Data copying - "8. DATA COPY"

Menu \#8 "Data Copying" in Programming Mode allows you to read function code data out of an inverter for which function codes are already set up and then to write such function code data altogether into another inverter, or to verify the function code data held in the keypad with the one in the inverter.
The keypad can hold three sets of function code data in three areas of its internal memory so that it can be used with three different inverters. You can read the function code data of an inverter into one of these memory areas or write the function code data held in one of these memory areas into the inverter you select. On the LCD screen, each set of function code data or memory area is given a name such as DATA 1 and DATA 2.

## Basic key operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the (rag) key to enter Programming Mode. The menu for function selection will be displayed.
(2) Select "8. DATA COPY" by using (
(3) Press the key to get the data copy index screen (list of data copy operations).
(4) Select the operation (read, write, verify, check), by using $\circlearrowleft$ and $\otimes$ keys (moving
(5) Press the (xati) key to finalize the choice of operation and then select the data set (or storage area) on the keypad.
(6) Press the key to finalize the selection and perform the operation of your choice (for details, refer to the LCD screen transition diagram below).
(7) Press the key to return to the menu.

Figure 3.19 shows the LCD screen transition starting from the "8. DATA COPY" menu.

## 1) Selecting Copy Operation



Figure 3.19 Menu Transition for "DATA COPY"
Table 3.14 List of DATA COPY Operations

| Operation | Description |
| :--- | :--- |
| Read: Read data | Reads out function code data from the inverter and stores it into the internal memory of <br> the keypad. |
| Write: Write data | Writes the data held in the selected memory area of the keypad into the inverter. |
| Verify: Verify data | Verifies the data held in the keypad's internal memory against the function code data in <br> the inverter. |
| Check: Check data | Checks the model information (format) and function code data held in the three memory <br> areas of the keypad. |

## 2) Read Operation



## List of data copy operations

Select desired operation by moving the cursor with $Q / \otimes$ key.

Press key to finalize desired operation

## Data selection screen

Select desired data by moving the cursor with $\Theta / \circlearrowleft$ key. To go back to List of data copy operations, press key.

Press key to finalize desired data.

## Confirmation screen

If "Read" is actually performed, the data read out from the inverter will overwrite the data held in this memory area in the keypad. If OK, press key.
To go back to Data selection screen, press (**y) key.
Press key to start Read operation.
"In progress" screen
A bar indicating progress appears in the bottom.

Upon completion, Completion screen automatically appears.

## Completion screen

Indicates that Read operation has completed successfully. To go back to List of data copy operations, press (xsy) key.

## Error screens


 operation under way will be aborted, and this Error screen will appear. (Note) Once aborted, all the data held in the keypad's memory would be deleted.

If a communication error is detected between the keypad and the inverter, this Error screen will appear.

Figure 3.20 Menu Transition for "READ"

Note If an ERROR screen or an ERROR Ver. Screen appears during operation, press the key to reset the error condition. When Reset is complete, the screen will go back to List of data copy operations.


## List of data copy operations

Select desired operation by moving the cursor with $\widehat{Q}$ key.

Press key to finalize desired operation.

## Data selection screen

Select desired data by moving the cursor with $\widehat{\omega} / \otimes$ key. To go back to List of data copy operations, press (rest key.

Press key to finalize desired data.

## Confirmation screen

If "Write" is actually performed, the selected data will overwrite the data held in the inverter. If OK, press key.
To go back to Data selection screen, press (※ys) key.

Press key to start Write operation.
"In progress" screen
A bar indicating progress appears in the bottom.

Upon completion, Completion screen automatically appears.

## Completion screen

Indicates that Write operation has completed successfully. To go back to List of data copy operations, press key.

Figure 3.21 Menu Transition for "WRITE"

## Error screens

## ERROR <br> DATA1 <br>  <br> DATA 3 <br> ■

If you press（⿵冂⿱一口䒑寸／key during Write operation，the operation under way will be aborted，and this Error screen will appear．（Note）Updating of the function code data in the inverter is incomplete，with some of it remaining old．Do not run the inverter in this state．Before running the inverter，redo the writing or perform initialization．

For safety considerations，the following situations are treated as an error：
－No valid data is found in the keypad＇s memory．（No Read operation has been performed since factory shipment；or，a Read operation has been cancelled or aborted．）
－The data held in the keypad＇s memory has an error．
－There is a mismatch in inverter＇s model number．
－A Write operation has been performed while the inverter is running．
－The inverter is data－protected
－The Write enable for keypad command（WE－KP）is OFF．

| $\begin{aligned} & \text { ERROR Ver. } \\ & \text { DATAI } \end{aligned}$ |  |
| :---: | :---: |
|  |  |
| DATA 3 |  |
|  | RES |

The function code data held in the keypad is incompatible with that in the inverter．（Either data may be non－standard；or a version upgrade performed in the past may have made the keypad or the inverter incompatible．Contact your Fuji Electric representative．）

Figure 3．21 Menu Transition for＂WRITE＂（continued）

Note
If an ERROR screen or an ERROR Ver．Screen appears during operation，press the（\＃y）key to reset the error condition．When Reset is complete，the screen will go back to List of data copy operations．

## 4）Verify operation



## List of data copy operations

Select desired operation by moving the cursor with $\otimes / \otimes$ key．

Press key to finalize desired operation．

## Data selection screen

Select data to be verified by moving the cursor with $\otimes / \otimes$ key．
To go back to List of data copy operations，press key．

Press key to finalize desired data．

## Confirmation screen

If OK，press key．
To go back to Data selection screen，press（A⿴囗十⿱幺⿲丶丶丶ry）key．

Press key to start Verify operation．
＂In progress＂screen
A bar indicating progress appears in the bottom．

When a mismatch is found，the Verify operation is halted，with the function code and its data displayed on the LCD Monitor． To resume the Verify operation from the next function code， press key again．

To resume Verify，press key．
＂In progress＂screen
A bar indicating progress appears in the bottom．

Upon completion，Completion screen automatically appears．

## Completion screen

Indicates that Verify operation has completed successfully． To go back to List of data copy operations，press（izi）key．

Figure 3．22 Menu Transition for＂VERIFY＂

## Error screens

| ERROR | If you press (ARC) / mey during Verify operation, the |
| :---: | :---: |
|  | operation under way will be aborted, and this Error screen will |
| DATA 2 | appear. (Note) |

DATA3
ח日

```
ERROR
DATAT \(\Leftrightarrow I \mathrm{NV}\)
DATA 2
DATA3
DAti= crary RES
```

If the keypad does not have any valid data, this Error screen will appear. (Note)

|  | ERROR Ve |
| :---: | :---: |
|  |  |
|  | DATA 2 |
|  | DATA3 |
|  | ERATA 大Gry RES |

The function code data held in the keypad is incompatible with that in the inverter. (Either data may be non-standard; or a version upgrade performed in the past may have made the keypad or the inverter incompatible. Contact your Fuji Electric representative.)

Figure 3.22 Menu Transition for "VERIFY" (continued)

Note If an ERROR screen or an ERROR Ver. Screen appears during operation, press the key to reset the error factor. When Reset is complete, the screen will go back to List of data copy operations.

## 5) Check operation



## List of data copy operations

Select desired operation by moving the cursor with $\theta / \theta$ key.

Press key to finalize desired operation.

## Data selection screen

Select data to be checked by moving the cursor with $\otimes / \otimes$ key.
To go back to List of data copy operations, press key.

Press (and key to finalize desired data.
"Check data" screen
Displays function codes and their data.
To check other function codes, press $\widehat{\otimes} /($ key. To go back to List of data copy operations, press key.

Figure 3.23 Menu Transition for "DATA CHECK"

## Error screen

| ERROR |  |
| :---: | :---: |
| DATA1 |  |
| DATA 2 |  |
| DATA3 |  |
| B AtA comer | RES |

If no valid data is found in the keypad, this Error screen will appear. (Note)

Figure 3.24 Error Screen for "DATA COPY"

Note
If an ERROR screen appears during operation, press the key to reset the error factor. When Reset is complete, the screen will go back to List of data copy operations.

### 3.4.10 Measuring load factor - "9. LOAD FCTR"

Menu \#9 "LOAD FCTR" in Programming Mode allows you to measure the maximum output current, the average output current, and the average braking power. There are two modes of measurement: "hours," in which the measurement takes place for a specified length of time, and "start to stop," in which the measurement takes place from the start of running to the stop.

Note If the "start to stop" mode is entered while the inverter is running, the measurement takes place until it is stopped. If the "start to stop" mode is entered while the inverter is stopped, the measurement will take place from the next start of running until it is stopped.

## Basic kev operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the (eng) key to enter Programming Mode. The menu for function selection will be displayed.
(2) Select " 9 . LOAD FCTR" by using ( $\bigcirc$ ) and $(\checkmark$ keys (moving
(3) Press the key to get the measurement mode selection screen.
(4) Select the measurement mode, by using ( $)$ and $(\checkmark$ keys (moving ).
(5) Press the key to start the measurement. For "start to stop" mode, you will be prompted to enter a run command via a confirmation screen. For details, refer to the LCD screen transition chart.
(6) Press the key to return to the menu.

Figure 3.25 shows the LCD screen transition starting from the " 9 . LOAD FCTR" menu.

## 1) Selecting measurement mode



Select desired menu by moving the pointer with $($ Q key. To finalize desired menu, press key.

## Mode selection screen

HOURS SET: Measurement takes place for specified duration START $\rightarrow$ STOP: Measurement takes place from start to stop. EXECUTING: Measurement is taking place according to the specified duration set in HOURS SET.
To return to Menu, press (Ex) key.

Figure 3.25 Menu Transition for Selecting Measurement Mode

## 2) Selecting "hours set" mode



Figure 3.26 Menu Transition for "LOAD FCTR" (hours set mode)

## 3) Selecting "start to stop" mode



## Mode selection screen

Select desired mode of measurement by moving the cursor with $(\theta) /($ key.

## Confirmation screen

If OK, press key.
To go back to Mode selection, press (\#x) key.

## Press key to signal "Ready."

Waiting for Run command (Standby for measurement) Upon receiving Run command, the measurement will start. If a Run command has already been received, this screen will be skipped.

Measurement will stop when the inverter is stopped or you press key.
Duration
Max. output current
[Display of measurement Average output current results]

Average braking power
To return to Mode selection, press (\#we) key.

Figure 3.27 Menu Transition for "LOAD FCTR" (start to stop mode)

## 4) Going back to Running mode

While the measurement of the load factor is in progress, you can go back to the running mode by pressing the (®®a) key (or, to the Mode selection screen by pressing the (अati) key).
In these cases, the measurement of the load factor will continue. You can go back to "9. LOAD FCTR" and confirm, on the Mode selection screen, that the measurement is in progress.
After the measurement has ended, you can view the results of the measurement by pressing the sing key on the Mode selection screen.

Note
The results of the measurement will be deleted when the inverter is powered OFF.

### 3.4.11 Changing function codes covered by Quick setup - "10. USER SET"

Menu \#10 "USER SET" in Programming Mode allows you to change the set of function codes that are covered by Quick setup.

## Basic key operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the (RA) key to enter Programming Mode. The menu for function selection will be displayed.
(2) Select "10. USER SET" by using $\widehat{\checkmark}$ and keys (moving in ).
(3) Press the key to get the list of function codes.
(4) Select the function codes to be added or deleted, by using $\otimes$ and $\otimes$ keys (moving (1)
(5) Press the key to perform the addition or deletion.
(6) Press the key to return to the menu.

Figure 3.28 shows the LCD screen transition starting from the "10. USER SET" menu.


Figure 3.28 Menu Transition for Changing Function Codes Covered by Quick Setup

### 3.4.12 Performing communication debugging - "11. COMM DEBUG"

Menu \#11 "COMM DEBUG" in Programming Mode allows you to view the data of communication-related function codes ( $S, M, W, X$, and $Z$ codes) to help debug programs for communication with an upper-level device.

## Basic key operation

(1) When the inverter is powered ON, it automatically enters Running Mode. In Running Mode, press the (ac) key to enter Programming Mode. The menu for function selection will be displayed.
(2) Select "11. COMM DEBUG" by using $\square$ and $\square$ keys (moving
(3) Press the key to get the list of communication-related function codes.
(4) Select the function code, by using $\qquad$ and keys (moving
(5) Press the key to check or change the function code.
(6) Press the key to return to the menu.

Figure 3.29 shows the LCD screen transition starting from the "11. COMM DEBUG" menu.


Figure 3.29 Menu Transition for Communication Debugging

### 3.5 Alarm Mode

When a protective function is triggered, resulting in an alarm, the inverter automatically enters the alarm mode, displaying the alarm code on the LED Monitor and the details of the alarm on the LCD Monitor as shown below.

If there is no overlapping alarm


Most recent cause; No. of consecutive occurrences Cause of alarm
Operation guide
Operation guide

Figure 3.30 Without Non-overlapping Alarm

## If there is an overlapping alarm



Most recent cause; No. of consecutive occurrences Cause of alarm
Operation guide
( $\boldsymbol{\Delta}$ is added if there is an overlapping alarm.)

Figure 3.31 With Overlapping Alarm

If there is an overlapping alarm, you can view more detailed information by pressing the $\Theta$ key. In the examples below, " $2=$ Er6" corresponds to the first overlapping occurrence, and " $3=\mathrm{Er} 6$ " to the second overlapping occurrence.

## Display of alarm history

In addition to the most recent (current) alarm, you can view three recent alarms and any overlapping alarms by pressing the $\widehat{Q} \vee$ key while the most recent one is being displayed.


Figure 3.32 Switching of Display of Overlapping Alarm History

- Display of running status information at the time of alarm

By pressing the key while an alarm code is displayed, you can view the output frequency, output current, and other data concerning the running status. The data you can view is the same as with "6. ALM INF." Use $\widehat{0}$ and $(>)$ keys for scrolling pages within the menu.

Pressing the key or the key while the running status information is displayed will take you back to the display of the alarm code.

## - Transition to Programming mode

By pressing the (คAढ) key while alarm information is displayed, you can switch to the Programming mode, in which you can use a variety of features such as changing function code data.

## Resetting alarm; transition to Running mode

When you remove the cause of the alarm and press the key, the alarm condition will be reset, and the inverter will go back to the Running mode.

Figure 3.33 summarizes the menu transition between these modes.


Figure 3.33 Menu Transition in/from Alarm Mode

### 3.6 Other Precautions

For using a multi-function keypad note that your key operation will be differed from ones on a standard keypad (TP-E1) for following points.

### 3.6.1 Function code setting for $\mathbf{F 0 2}$ (Run and operation)

The Rung / (nop) key controls to run/stop the motor on the standard keypad (TP-E1) while the rotation command input is required. On the contrary, the ( $\because$ ( F ) key on the multi-function keypad controls to run forward/reverse the motor without inputting any rotation command or stop it.
The function code F02 specifies the run command source to drive the motor.

| F02 data | Run command source |
| :--- | :--- |
| 0: Keypad | Pressing the / FWD / (ToP) key runs/stops the motor. |
| 1: Digital input | The terminal command (FWD) or (REV) runs/stops the motor. |
| 2: Keypad (Forward) | The <br> reverse. |
| 3: Keypad (Reverse) runs the motor forward or stops it, but does not run it |  |

If you select Local by the Remote/Local switching command, operation of the run command from the keypad will be changed by setting of the function code F02.
[1] For details, refer to "D Switching the operation mode between remote and local" in "3.3.1 Running/stopping the motor."

### 3.6.2 Remote/local operation

The multi-function keypad features the ( (150) key to switch the operation between remote and local modes.
[1] For details, refer to " Switching the operation mode between remote and local" in "3.3.1 Running/stopping the motor."

### 3.6.3 Tuning motor parameters

The LCD monitor of multi-function keypad shows the lead-through screen for tuning of motor parameters. To tune motor parameters follow screens below.

Entering into tuning motor parameters
Set data 1 or 2 into the function code P04 and press the key.


Turn on the run command

## FidM-TUN <br> 1:AT-STOP <br> EXECUTING

End of tuning
FiduM-TUN
1:AT-STOP
CLOSE BY RUN
COMMAND OFF
Turn off the run command

```
=66M-10
EG:7M-%R1
F% 8M-%X
F%9M-SELECT
\V->FN CODE SH
```

Press $\otimes$ / key to select the data either 1 or 2 being set to the function code P04.

Press key to select the tuning mode. Waiting for a run command.

Give the specific run command, Run forward or Run reverse. (Note 1)
Tuning the motor parameters. (Note 2)
(Note 1) The factory default setting is "Run forward" by using the wD key on the keypad. To tune the motor parameters in "Run reverse", change data of the function code F02.
(Note 2) - Time needed for tuning while the motor is stopped ( $\mathrm{PO} 0=1$ ) will be less than 40 seconds.

- In tuning while the motor is running ( $\mathrm{P} 04=2$ ), the inverter accelerates the motor up to around $50 \%$ of the base frequency, starts tuning of motor parameters, and decelerates to stop the motor after the end of tuning. Estimated time needed for tuning in this case will be (acceleration time $+10+$ deceleration time) seconds.


## Chapter 4 SPECIFICATIONS

### 4.1 General Specifications

Table 4.1 summarizes the general specifications of the Multi-function Keypad "TP-G1."
Table 4.1 General Specifications

| Item | Specifications | Remarks |
| :---: | :---: | :---: |
| Enclosure | Front side: IP40; Rear side: IP20 |  |
| Environment | Indoor only. <br> Shall be free from corrosive gases, flammable gases, dust, and direct sunlight. |  |
| Ambient temperature (during operation) | -10 to $+50^{\circ} \mathrm{C}$ |  |
| Ambient humidity | 5 to 95\% RH (no condensation) |  |
| Altitude | 1000 m or below |  |
| Vibration | 3 mm (max.) $: 2-9 \mathrm{~Hz}$ <br> $9.8 \mathrm{~m} / \mathrm{s}^{2}$ $: 9-20 \mathrm{~Hz}$ <br> $2 \mathrm{~m} / \mathrm{s}^{2}$ $: 20-55 \mathrm{~Hz}$ <br> $1 \mathrm{~m} / \mathrm{s}^{2}$ $: 55-200 \mathrm{~Hz}$ |  |
| Ambient temperature (during storage) | -25 to $+65^{\circ} \mathrm{C}$ |  |
| Ambient humidity (during storage) | 5 to 95\% RH (no condensation) |  |
| External dimensions | See the figure below. |  |
| Mass | 129 g |  |

External dimensions


### 4.2 Communication Specifications

Tables 4.2 and 4.3 summarize the communication specifications.
Table 4.2 Hardware Specifications

| Item | Specifications |  |
| :--- | :--- | :--- |
| No. of inverters <br> connected | One inverter for one Multi-function Keypad | Remarks |
| Connection cable | Shall meet the US ANSI/TIA/EIA-568A <br> Category 5 standard <br> (10BASE-T/100BASE-TX, straight). | A Remote Operation Extension Cable <br> is available as an option (CB-5S, <br> CB-3S, or CB-1S, depending on the <br> distance). |
| Maximum <br> communication distance | 20 m |  |
| Connector | RJ-45 connector | See Table 4.3. |

Table 4.3 RJ-45 Connector Pin Assignment

| Pin \# | Signal name | Description | Remarks |
| :---: | :---: | :---: | :---: |
| 1,8 | Vcc | DC power source for Multi-function Keypad (5 V) | Back of Multi-function Keypad |
| 2,7 | GND | Signal ground |  |
| 3,6 | NC | Unassigned (reserved) |  |
| 4 | DX - | RS485 communication data ( - ) |  |
| 5 | DX + | RS485 communication data ( + ) |  |
|  |  |  |  |

Note SW3 for the terminating resistor on the control circuit board in the inverter must be set to OFF (open).

### 4.3 Transmission Specifications

Table 4.4 summarizes the transmission specifications.
Table 4.4 Transmission Specifications

| Item | Specifications |  |
| :--- | :--- | :--- |
| Area code | No need to specify. | Remarks |
| Communication protocol | Modbus-RTU | There is no need to specify function <br> codes y01 through y10 for RS485 <br> communication, which will be ignored <br> anyway. |
| Synchronization system | Start-stop |  |
| Communication system | Half-duplex |  |
| Communication speed <br> (Baud rate) | 19200 bps |  |
| Parity | Even parity |  |
| Stop bit length | 1 bit |  |
| Error checking | CRC-16 |  |

MEMO

## Multi-function Keypad "TP-G1"

## Instruction Manual

First Edition, September 2004
Fuji Electric FA Components \& Systems Co., Ltd.

The purpose of this manual is to provide accurate information in the handling, setting up and operating of Multi-function Keypad "TP-G1" for the FRENIC-Eco series of inverters. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual

In no event will Fuji Electric FA Components \& Systems Co., Ltd. be liable for any direct or indirect damages resulting from the application of the information in this manual.

## Fuji Electric FA Components \& Systems Co., Ltd.



## Background

Today, with the accelerating of industrialization in the world; the demands of energy consumption had been increased tremendously. And most of the industries operators are now seriously looking into energy-saving in all means of equipment they use.
Since 1980, Fuji Electric FA has become a global specialist dedicated to the design, manufacture and supply of AC Frequency Inverter.
The global requirements for high performance, multifunction, protective features, easy operation, easy maintenance and energy-saving have increased to inverter systems.
In response to customer driven priorities for a simple, easy-to-use, energysaving and economical inverter, Fuji Electric FA has designed a new range of world-class product "FRENIC-Eco" series especially for the HVAC system.

> FRENIC-ECO, exclusively developed by Fuji Electric FA Components \& Systems Co., Ltd. to meet global interest in ecology, is a new leading-edge inverter best suited for HVAC applications of variable torque load.

## Concept

The FRENIC-Eco has the functions best-suited for the HVAC (Heating, Ventilating and Air Conditioning) market*, featuring small installation space, simple operation, wide model variations, and support international standards. The FRENIC-Eco contributes to energy-saving, labor-saving and system integration of variable torque load including fans and pumps, resulting in a total cost reduction.
*Chiller unit, Air handling unit (AHU), Fan coil unit (FCU), etc.

$W_{\text {bat kind of variations in the capacity, }}$ series and protective structure do you have?


## How much $\$$ is return for energy-saving on inverter investment?

## - Principle of energy-saving of inverter <br> <Selection of motor capacity in equipment design and energy-saving policy of inverter>



For motor selection, the equipment designer chooses a larger capacity motor than the actually required shaft power, which is taking into consideration of the safety factor. For this reason, airflow is adjusted with a damper and flow rate is adjusted with a valve.
If an inverter is used, the motor speed can be easily changed. Therefore the airflow and flowrate can be adjusted accordingly. The power consumption at this time can be much reduced based on the following theory.

## * Energy-saving effect caused by changing from damper control to inverter

Amount of energy-saving effect = Electricity cost with damper control - Electricity cost with inverter operation


## * Energy-saving effect caused by changing

 from valve control to inverterAmount of energy-saving effect = Electricity cost with valve control - Electricity cost with inverter operation


## - Return on investment of inverter

From the above theory, the investment can be collected in a half to three years.

* For details, we will estimate the investment effect in advance according to the operating condition of actual equipment (running hours, annual operation days, electricity rate, etc.). Contact Fuji Electric FA's sales office.
- Many successful energy-saving results
- 11 inverters installed in an intelligent building (18-stories high) have reduced the annual watt-hour by $382,000 \mathrm{kWh}$. 600 inverters installed in factory equipment of an automotive manufacturer have reduced the annual watt-hour by $6,000,000 \mathrm{kWh}$.
- A new energy-saving control method

The sum of the motor loss and inverter loss is controlled to become minimum. The optimized energy-saving control realizes cost depreciation in a shorter period when compared with competitors' models.

- No need for external wattmeter.

The electricity cost can be displayed at the inverter.
The cumulative watt-hours can be displayed. Further, enter a displaying coefficient to display the approximate electricity cost.

## $H_{\text {ow friendly is it? }}$

## - User-friendly keypad

Multi-function keypad

- The optional simple remote keypad is also prepared.


## Simple remote control

- Remote control is realized, using LAN cable.
- Optional 1-, 3- and 5-meter straight cables are prepared.


## Quick setup function

- Minimum essential 19 function codes are displayed.
- Codes can be added or deleted.


## Copying function

- Convenient to copy the same setting of function codes to two or more inverters



## 7-segment LED

- Enlarged 5-digit display
- Power monitor (power consumption, cumulative watt-hours, cumulative electricity cost, etc.)
- Maintenance data display (cooling fan running time, main circuit capacitor capacity, cumulative inverter running time, cumulative motor running time, No. of startup times, etc.)


## Easy-to-read LCD

- Full data with 5x13-character display
- The backlight assures good visibility even at dark places.


## REM/LOC key

- Simple remote/local mode change at keypad


## - User-friendly loader software is prepared.

Windows-compatible PC loader software realizes simple data editing and management operations such as data management, data copy and real-time historical trace. (An USB-RS485 converter is prepared)


## Is Maintenance Easy?

- Long-life cooling fans - 10 years*1, main-circuit capacitors - 10 years
Twice longer than earlier model (At ambient temperature: $40^{\circ} \mathrm{C}$ and $80 \%$ cont. load) ${ }^{*} 1$ : 10 years for 30 kW or less, 7 years for 37 kW or more
- Lifetime forecast of aging parts (cooling fans, main circuit capacitors, electrolytic capacitors on PC boards) When it is judged that any of the above items has almost reached the end of its life, a lifetime forecast signal can be output to the transistor output.
- Various cumulative running time is displayed at the keypad

Cumulative counts of running time helps secure maintenance of the equipment.
Together with the cumulative "inverter running time (power-ON hours to inverter)" and "cooling fan running time," the cumulative motor running time (inverter output-ON hours) and the number of startup are displayed. These data can be used for the maintenance of the equipment connected to the motor.

- Easy replacement of cooling fan

The cooling fan can be replaced easily.

- The alarm history for the 4 latest alarms is recorded The cause of inverter trip can be easily judged by using these data.



## What are the useful functions for fans and pumps?

## Sleep function with low limiter

Slow flowrate stopping function for stopping the fan or pump at speed lower than the lower limit is added to the lower limiter for keeping the lowest speed, to realize further energy-saving in conjunction with PID control.


## Early detection of load torque drop

Detects a load torque drop to issue an alarm.

- If a fault occurs on the load side due to a broken belt or the like in a belt drive system, the low torque state is detected to issue an alarm.



## Remotellocal controls selectable

The operation site can be switched easily.

- Through frequency setting $2 / 1$, run/stop command $2 / 1$ and local operation (keypad operation) switching, the operation site can be switched for both the run commands and frequency commands among remote, panel and independent inverter operation.
-The best frequency setting method can be selected among voltage, current, multistep frequency, UP/DOWN setting, communication and so on, to meet the requirements of various systems.



## Improved PID control function

Easier to use PID control function to control temperature, flowrate, and pressure. Balanceless/bumpless switching with the manual speed commands, slow flowrate stopping function, deviation alarm/absolute value alarm output, anti-reset wind-up function, PID output limiter, and integration reset/hold function, etc.


## Detection of command missing

A faulty state in the speed command can be detected to issue a signal.

## Analog input monitor

Analog signals can be sent to the inverter to allow status monitoring of peripheral equipment and issuance of commands to peripheral equipment.

## Electric power monitoring

Electric power monitoring such as power consumption,watt-hour, and its applied indication (e.g., electricity rate calculated by multiplying power rate) can be displayed.

## Long-life cooling fan

All the capacity models are now equipped with a longer-life cooling fan. Detects the temperature of the heat sink automatically to turn the cooling fan on or off.

> Long-life cooling fan $\binom{$ Load condition: $80 \%$ cont. }{ At ambient temperature: $40^{\circ} \mathrm{C}}$ For models 30 kW or less : 10 years For models 37 kW or more : 7 years

Cooling fan ON/OFF control Energy-saving, reduced wind noise, and long life

## Useful functions

Dew condensation protection function

- Motor protection during stoppage against dew condensation caused by abrupt temperature change.

Motor speed indication in percent
(Max. speed: 100\%)

- The motor speed can be indicated in a normalized percent value instead of Hz or $\mathrm{r} / \mathrm{min}$ to help the user recognize the status in the system.


## Dynamic Rotation of Pump Motors

With a fixed inverter-driven motor
This configuration consists of a motor driven by the inverter (M0) and motors driven by commercial power (M1 to M4).
The inverter-driven motor is fixed at M0 and is controlled for variable speed. When the inverter-driven motor M0 alone cannot sustain the desired discharge flowrate, the inverter mounts one or more motors driven by commercial power as necessary.


With a floating inverter-driven motor
In this configuration, all the motors can be driven by the inverter or commercial power. At the start of operation, each motor is driven by the inverter and is controlled for varying speed. When the first motor alone cannot sustain the desired discharge flowrate, it is switched to commercial-power operation, and the inverter drives the second motor.

$H_{o}$ ow about the power of your inverter? - Just compare the Eco with others! In FRENIC-Eco Series inverters developed exclusively for the HVAC (Heating, Ventilating and Air Conditioning) market, the decrease in the carrier frequency is the least for outputting the inverter rated output current, compared with competitors.' You can more easily use the Eco series than other companies products, as the Eco enables operation over the higher career frequency.


## $H_{\text {ow }}$ is the Harmonics characteristics?



What kind of networks are we supporting?
Serial Communication
RS-485, Johnson Control (Metasys) N2, Siemens Protocol P1*1, Lon Works*2 ... (Capable to connect to BMS)
Modbus-RTU, Field Bus-compatible DeviceNet*2, PROFIBUS-DP*2, Modbus PLUS*2, CC-Link*2 ${ }^{* 1}$ Available as separate series ${ }^{* 2}$ Option

## What are the protective functions?

Various protective functions back assured operation of the inverter.
Overcurrent protective function, short-circuit protection, ground fault protection, overvoltage protection, undervoltage protection, input phase loss protection, output phase loss protection, overheating protection, overload protection, external alarm input, fuse blown, charging circuit fault detection, motor protection (electronic thermal relay function, protection provided with PTC thermistor, overload early
warning), stall prevention, alarm relay output (for any fault), memory error, keypad communication error, CPU error, option communication error, option error, operation error, tuning error, RS-485 communication error, RS-485 communication error (optional), data saving upon undervoltage, retry function, surge protection, command loss detection function, momentary power failure protection function, active drive

## What kind of measures are taken for noise and isolation?

[^31]The common terminals on the control circuit are isolated from each other to reduce the effects of noise. The common terminals (terminal 11, CME and CMY) for digital input signals, transistor output signals and analog input signals are isolated from each other so that the noise immunity of the signals is improved.

## Technical Data

| Inverter type | Applicable <br> motor rating <br> (kW) | Rated <br> current <br> $(\mathrm{A})$ | Rated output <br> capacity <br> $(\mathrm{kVA})$ |
| :---: | :---: | :---: | :---: |
| FRN0.75F1S-2 $\square$ | 0.75 | 4.2 | 1.6 |
| FRN1.5F1S-2 $\square$ | 1.5 | 7.0 | 2.6 |
| FRN2.2F1S-2 $\square$ | 2.2 | 10 | 3.8 |
| FRN3.7F1S-2 $\square$ | 3.7 | 16.5 | 6.2 |
| FRN5.5F1S-2 $\square$ | 5.5 | $23.8(22.5)$ | 8.3 |
| FRN7.5F1S-2 $\square$ | 7.5 | $31.8(29)$ | 11 |
| FRN11F1S-2 $\square$ | 11 | $45(42)$ | 16 |
| FRN15F1S-2 $\square$ | 15 | $58(55)$ | 21 |
| FRN18.5F1S-2 $\square$ | 18.5 | $73(68)$ | 25 |
| FRN22F1S-2 $\square$ | 22 | $85(80)$ | 30 |
| FRN30F1S-2 $\square$ | 30 | $114(107)$ | 40 |
| FRN37F1S-2 $\square$ | 37 | $140(130)$ | 49 |
| FRN45F1S-2 $\square$ | 45 | $170(156)$ | 59 |
| FRN55F1S-2 $\square$ | 55 | $211(198)$ | 75 |
| FRN75F1S-2 $\square$ | 75 | $276(270)$ | 102 |
| FRN90F1S-2 $\square *$ | 90 | $322(320)$ | 121 |
| FRN110F1S-2 $\square *$ | 110 | $390(384)$ | 146 |


| Inverter type | Applicable <br> motor rating <br> (kW) | Rated <br> current <br> (A) | Required power <br> supply capacity <br> (kVA) |
| :--- | :---: | :---: | :---: |
| FRN0.75F1S-4 $\square$ | 0.75 | 2.5 | 1.9 |
| FRN1.5F1S-4 $\square$ | 1.5 | 3.7 | 2.8 |
| FRN2.2F1S-4 $\square$ | 2.2 | 5.5 | 4.1 |
| FRN3.7F1S-4 $\square$ | 3.7 | 9.0 | 6.8 |
| FRN5.5F1S-4 $\square$ | 5.5 | 12.5 | 9.5 |
| FRN7.5F1S-4 $\square$ | 7.5 | 16.5 | 12 |
| FRN11F1S-4 $\square$ | 11 | 23 | 17 |
| FRN15F1S-4 $\square$ | 15 | 30 | 22 |
| FRN18.5F1S-4 $\square$ | 18.5 | 37 | 28 |
| FRN22F1S-4 $\square$ | 22 | 44 | 33 |
| FRN30F1S-4 $\square$ | 30 | 59 | 44 |
| FRN37F1S-4 $\square$ | 37 | 72 | 54 |
| FRN45F1S-4 $\square$ | 45 | 85 | 64 |
| FRN55F1S-4 $\square$ | 55 | 105 | 77 |
| FRN75F1S-4 $\square$ | 75 | 139 | 105 |
| FRN90F1S-4 $\square$ | 90 | 168 | 128 |
| FRN110F1S-4 $\square$ | 110 | 203 | 154 |
| FRN132F1S-4 $\square$ | 132 | 240 | 182 |
| FRN160F1S-4 $\square$ | 160 | 290 | 221 |
| FRN200F1S-4 $\square$ | 200 | 360 | 274 |
| FRN220F1S-4 $\square$ | 220 | 415 | 316 |
| FRN280F1S-4 $\square$ | 280 | 520 | 396 |
| FRN315F1S-4 $\square$ | 315 | 585 | 445 |
| FRN355F1S-4 $\square$ | 355 | 650 | 495 |
| FRN400F1S-4 $\square *$ | 400 | 740 | 584 |
| FRN450F1S-4 $\square *$ | 450 | 840 | 640 |
| FRN500F1S-4 $\square *$ | 500 | 960 | 731 |

## External Dimensions

## IP20 enclosure (NEMA1)

Unit: mm


| Power supply |
| :---: | :---: |
| voltage |$\quad$ Type

note: A box ( $\square$ ) in the above table replaces $A$ or $K$ depending on the enclosure.
A: South East Asia and Oceania
K: Korea and Taiwan


| Power supply voltage | Type | Dimensions (mm) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | W3 | W4 | H | H1 | H2 | H3 | D | D1 | D2 | ¢ A | $\phi$ B |
| $\begin{gathered} \text { Three-phase } \\ 200 \mathrm{~V} \end{gathered}$ | FRN7.5F1S-2 $\square$ | 220 | 196 | 63.5 | 46.5 | 46.5 | 260 | 238 | 141.7 | 16 | 215 | 118.5 | 96.5 | 27 | 34 |
|  | FRN11F1S-2 $\square$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1S-2 $\square$ |  |  |  |  |  |  |  | 136.7 | 21 |  |  |  | 34 | 42 |
|  | FRN18.5F1S-2 | 250 | 226 | 67 |  |  | 400 | 378 | 166.2 | 2 |  | 85 | 130 |  |  |
|  | FRN22F1S-2 $\square$ |  |  | 67 | 58 | 58 |  |  |  |  |  |  |  |  |  |
|  | FRN30F1S-2 $\square$ |  |  | - | - | - |  |  | - | - |  |  |  | - | - |
|  | FRN7.5F1S-4 $\square$ | 220 | 196 | 63.5 | 46.5 | 46.5 | 260 | 238 | 141.7 | 16 | 215 | 118.5 | 96.5 | 27 | 34 |
|  | FRN11F1S-4 $\square$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Three-phase | FRN15F1S-4 $\square$ |  |  |  |  |  |  |  | 136.7 | 21 |  |  |  | 34 |  |
|  | FRN18.5F1S-4 $\square$ | 250 | 226 | 67 | 58 | 58 | 400 | 378 | 166.2 | 2 |  | 85 | 130 |  | 42 |
|  | FRN22F1S-4 $\square$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN30F1S-4 $\square$ |  |  | - | - | - |  |  | - | - |  |  |  | - | - |

note: A box ( $\square$ ) in the above table replaces $A$ or $K$ depending on the enclosure.
A: South East Asia and Oceania
K: Korea and Taiwan


| Power supply voltage | Type | Dimensions (mm) |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | H | H1 | D | D1 | D2 | D3 |
| Three-phase 200 V | FRN37F1S-2 ${ }^{\text {a }}$ | 320 | 240 | 550 | 530 | 255 | 115 | 140 | 4.5 |
|  | FRN45F1S-2 ${ }^{\text {FRN5F1S }}$ | 355 | 275 | 615 | 595 | 270 |  | 155 |  |
|  | FRN55F1S-2 |  |  | 740 | 720 |  |  |  |  |
| Three-phase oov | FRN37F1S-4] | 320 | 240 |  |  | 55 | 115 | 140 | 4.5 |
|  | FRN45F1S-4] | 320 |  | 550 | 530 | 255 |  |  |  |
|  | FRN75F1S-4] | 355 | 275 |  |  | 270 |  | 155 |  |
|  | FRN90F1S-4 ${ }^{\text {a }}$ |  |  |  |  |  |  |  |  |
|  | FRN110F1S-4 $\square$ |  |  | 740 | 720 | 300 | 145 | 155 | 6 |
|  | FRN132F1S-4] | 530 | 430 |  | 710 | 315 | 135 | 180 |  |
|  | FRN160F1S-4] |  |  |  |  |  |  |  |  |
|  | FRN200F1S-4 $\square$ <br> FRN220F1S-4 |  |  | 1000 | 970 | 360 | 180 | 180 |  |

note: A box ( $\square$ ) in the above table replaces A or K depending on the enclosure.
A: South East Asia and Oceania
K: Korea and Taiwan


| Power supply voltage | Type |
| :---: | :---: |
| Three-phase 200V | FRN0.75F1L-2 $\square$ |
|  | FRN1.5F1L-2 $\square$ |
|  | FRN2.2F1L-2 $\square$ |
|  | FRN3.7F1L-2 $\square$ |
|  | FRN5.5F1L-2 $\square$ |
| Three-phase 400V | FRN0.75F1L-4 $\square$ |
|  | FRN1.5F1L-4 $\square$ |
|  | FRN2.2F1L-4 $\square$ |
|  | FRN3.7F1L-4 $\square$ |
|  | FRN5.5F1L-4 $\square$ |

note: A box ( $\square$ ) in the above table replaces $A$ or $K$ depending on the enclosure.
A: South East Asia and Oceania
K: Korea and Taiwan


| Power supply voltage | Type | Dimensions (mm) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | H | H1 | H2 | H3 | H4 | D | C | S |
| $\begin{aligned} & \text { Three-phase } \\ & 200 \mathrm{~V} \end{aligned}$ | FRN7.5F1L-2 $\square$ | 300 | 200 | 50 | 600 | 580 | 10 | 550 | 25 | 280 | 10 | 15 |
|  | FRN11F1L-2 $\square^{\square}$ |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1L-2 $\square$ |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN18.5F1D-2 $\square$ | 350 | 290 | 30 | 800 | 780 |  | 750 |  | 320 |  |  |
|  | FRN22F1D-2 $\square$ |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN30F1D-2 $\square$ |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN37F1D-2 ${ }^{\text {a }}$ | 400 | 360 | 20 | 1100 | 1073 | 15 | $\frac{1030}{1310}$ | 35 |  | 15 | 18 |
|  | FRN45F1D-2 $\square$ | 450 | 400 | 25 | 1280 | 1250 | , | 1210 | 35 | 360 |  | 18 |
| Three-phase 400 V | FRN7.5F1L-4 $\square$ | 300 | 200 | 50 | 600 | 580 | 10 | 550 | 25 | 280 | 10 | 15 |
|  | FRN11F1L-4 $\square$ |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1L-4 $\square$ |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN18.5F1L-4 $\square$ | 350 | 290 | 30 | 800 | 780 |  | 750 |  | 320 |  |  |
|  | FRN22F1L-4 $\square$ |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN30F1L-4 $\square$ |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN37F1L-4 $\square^{\text {FRN45F1L-4 }}$ | 400 | 360 | 20 | 1100 | 1073 | 15 | 1030 | 35 |  | 15 | 18 |
|  | FRN55F1L-4 $\square$ |  | 400 | 25 | 1170 | 1140 |  |  |  |  |  |  |
|  | FRN75F1L-4 $\square$ | 450 |  |  |  |  |  | 100 |  | 350 |  |  |
|  | FRN90F1L-4 $\square$ | 450 |  |  |  |  |  | 1210 |  | 360 |  |  |

note: A box ( $\square$ ) in the above table replaces $A$ or $K$ depending on the enclosure.
A: South East Asia and Oceania
K: Korea and Taiwan

## Common Specifications

## Power supply specifications

- Input power supply

Three-phase 200V
Three-phase $400 \mathrm{~V} \quad 380$ to $480 \mathrm{~V} \pm 10 \%$
(For 37 kW or more, 380 to $440 \mathrm{~V} \pm 10 \%$ )

- Power supply frequency: $50 / 60 \mathrm{~Hz}$
- Power factor: 0.9 (with DC Reactor)


## Output ratings

- Output voltage: 0 to $240 \mathrm{~V}, 0$ to 460 V
- Output frequency: 0 to 120 Hz


## Output frequency

- Max. output frequency: 25 to 120 Hz
- Base frequency: 25 to 120 Hz
- Starting frequency: 0 to 60 Hz
-Carrier frequency: 0.75 to $15 \mathrm{kHz}, 0.75$ to $10 \mathrm{kHz}, 0.75$ to 6 kHz
- Accuracy:

Analog setting: Within $\pm 0.2 \%$ of max. output frequency (at $25^{\circ} \mathrm{C} \pm 10^{\circ} \mathrm{C}$ )
Keypad setting: Within $\pm 0.01 \%$ of max. output frequency
(at -10 to $+50^{\circ} \mathrm{C}$ )
-Resolution :
Analog setting: 1/1,000 of max. output frequency
Keypad setting: 0.01 Hz ( 99.99 Hz or less), $0.1 \mathrm{~Hz}(100.0 \mathrm{~Hz}$ or more)
Torque characteristics

- Overload capability: $120 \%$ ( 1 min .) of rated output current
- Starting torque: Up to $120 \%$
- Acceleration torque: $120 \%$
- Overload torque: 120\%

Digital input signal

- Number of points: 7
(Where the function codes are assigned to all the terminals including terminals FWD and REV.)
- Voltage level: 0 to 24 V
- Max. input voltage: 27 V

Analog input signal

- Number of points: 1
- Max. voltage level: 0 to 15 V (input impedance: $22 \mathrm{k} \Omega$ )
- Max. current level: 0 to 30mA (input impedance: 250』)


## Digital output signal

- Number of points: 3
- Max. voltage level: 0 to 15 V (input impedance: $22 \mathrm{k} \Omega$ )
- Max. current level: 0 to 30 mA (input impedance: 250 )


## Relay output signal

- Number of points: 2 (30a, 30b, 30c and Y5A, Y5B)
- Contact capacity: 250 V AC, $0.3 \mathrm{~A}, \cos \varnothing=0.3$ or 48 V DC, 0.5 A


## Analog output signal

- Number of points: 2
- Voltage output: Up to two measuring instruments with 0 to 10V DC (input impedance: $10 \mathrm{k} \Omega$ ) can be connected.
- Current output: A measuring instrument with $500 \Omega$ max. can be connected.


## Others

-Enclosure: IP20 or IP54

- Vibration:

Smaller than 75 kW : 3 mm (vibration width): 2 to 9 Hz ,
$9.8 \mathrm{~m} / \mathrm{s}^{2}: 9$ to $20 \mathrm{~Hz}, 2.0 \mathrm{~m} / \mathrm{s}^{2}: 20$ to $55 \mathrm{~Hz}, 1.0 \mathrm{~m} / \mathrm{s}^{2}: 55$ to 200 Hz
90 kW or more: 3 mm (vibration width): 2 to $9 \mathrm{~Hz}, 2.0 \mathrm{~m} / \mathrm{s}^{2}: 9$ to 55 Hz ,
$1.0 \mathrm{~m} / \mathrm{s}^{2}$ : 55 to 200 Hz

- Ambient temperature: - 10 to $50^{\circ} \mathrm{C}$ (Upon side-by-side installation without clearance: -10 to $40^{\circ} \mathrm{C}$ )
- Ambient humidity: 5 to $95 \%$ RH (No condensation)
- Altitude: 1,000m or less
- Ambient temperature for storage: -25 to $65^{\circ} \mathrm{C}$
- Ambient humidity for storage: 5 to $95 \%$ RH (No condensation)


## EMC Directive supported as standard

-IP54 (Built-in EMC filter and DC REACTOR)

- IEC61800-3
- Model 15 kW or less with integral EMC filter include filter for 2nd environment (200V input class) or Group 1 class A (400V input class)


## Product compliance

- Low Voltage Directive 73/23/EEC with supplements
- EMC Directive 89/336/EEC with supplements (Applying)
- Quality assuarance systems ISO9001 and Environmental ISO14001
$\bullet$ CE, UL and cUL approvals


## Sales \& Technical Support

Fuji Electric FA has a dedicated team of technical experts to serve you. They are specialised in HVAC.
We can analyze your system needs, and recommend the Drive solution best suited to your installation
In addition, Fuji Electric FA offers commissioning, training and technical applications support.

## Sales Subsidiary

## North \& South America

GE Fuji Drives USA, Inc.
1501 Roanoke Boulevard, Suite 435, Salem VA 24153, USA
TEL: (+1) 540 387-8588 FAX: (+1) 540 387-8580

## Europe

Fuji Electric GmbH
Lyoner Strasse 26, 60528, Frankfurt/Main, Germany
TEL: (+49) 69-6690290 FAX: (+49) 69-66902958
e-Mail info_inverter@fujielectric.de

## South East Asia, Oceania

Fuji Electric FA Singapore Private Ltd.
171 Chin Swee Road, 12-01/04 San Centre, Singapore 169877
TEL: (+65) 6533-0010 FAX: (+65) 6533-0021
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## Korea

Fuji Electric Korea Co.Ltd.
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## China

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# Fuji Electric FA Components \& Systems Co.,Ltd. 

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Fe
Variable Torque Load Inverters for Fans and Pumps
FRENIC-ECO Series

## 6000



FRENIC


FUJI HVAC INVERTERS


GREAT PERFGRMANCE THRGUGH DEDICATED DESIGNS wELCOME TO NEW GENERATION DF INVERTER FGR HEATING, VENTILATING \& AIR CUNDITIUNING.


## Exclusive fan and pump inverter eliminates

## Energy saving effects are even further enhanced

## Industry firs. Energy-saving operation function of a new system

In previous models, the energy saving operation function corresponded with the load state, and controlled operation to minimize loss of the motor itself. The newly developed FRENIC-Eco Series has shifted the focus from the motor to the inverter, recognizing that the inverter itself is an electrical product, and the new models are equipped with a new control system that minimizes the power consumed by the inverter itself (inverter loss) as well as the power loss in the motor itself.


Using this new system, energy savings is several percent improved over that of the previous models.
Kyoto Agreement, which was studied at the Conference on Prevention of Global Warming (COP3), was ratified by Russia in October 2004, and thereby put into effect on February 16, 2005. In the future, the related regulations are calling for a reduction in energy consumption of $1 \%$ or more each succeeding year, and therefore, we are aiming to build energy saving features into equipment as a whole.FRENIC-Eco is the inverter equipped with the industry's highest level of efficiency (low power loss).

## Power Monitor

Power-related data can be checked at the inverter unit's keypad.

| Items |
| :--- |
| Power (kW) |
| Cumulative power (kWh) |
| Cumulative power rates (yen/kWh) |

* Cumulative values can be reset. Cumulative power rates are shown with the power rate set at so much per kWh (display coefficient). Rates in other currency can also be displayed.

Energy saving effect compared with Fuji's previous models

(The effect varies dependent on the motor's characteristics.)

## Long life design that meets your expectation

Built with longer lasting replaceable components to give a longer sevice lifel.
The design life of replaceable components in each inverter model has been extended to 10 years. In addition, the capacity of the main circuit capacitors is measured and temperature compensation carried out to match the cumulative operating time of the electrolytic capacitors on the printed circuit board.

| Life-limited component name | Designed life |
| :--- | :---: |
| Main circuit capacitors | 10 years |
| Electrolytic capacitors on printed circuit board | 10 years |
| Cooling fan (Note) | 10 years |

## waste, saves energy and cuts costs.

## Maintenance is simplified for both the inverter and equipment



## Equipped with the optimum functions for HVAC (Air condifioning systems)

## Opeation is continued evenaterthe momentary poverfaliurethanks to the autoonesartfunction.

Even if a momentary power failure occurs, load inertia of a fan or blower, etc. is used to maintain the motor's operation while the motor's operating speed gradually drops, and enables the motor to restart operation without stopping. (The motor may stop on occasion due to the load's inertial moment.)


## Tripless operation through regenerated current avoidance control

Deceleration time is controlled to match the internal energy level generated in the inverter, and so deceleration and stopping is accomplished without tripping due to overload.


## The equipnents popading condition is delemined by yhe ow oroquededection funtion.

The inverter determines the load state of the connected motor and if it drops below a predetermined level, it judges that a "Low Torque" state exists and outputs a signal to that effect. In this way, any trouble that occurs in the equipment (such as a belt on a pulley breaking) can be grasped by the inverter.


## A pick-up function provides smooth starts.

If you desire to run a fan which the inverter is not currently running and which is turning free, this function will pick up on its motion regardless of the direction it is turning in and start it operating. Momentary switching is performed in the inverter from the commercial power supply and provides a convenient function when starting motors, etc.


## Even greater energy savings through the low water volume stop function

When there is pump operation accompanying "pressure drop" that occurs due to pressure loss or leakage, etc. in the piping, etc., or at times when the pump runs repeatedly to obtain a small volume of water, this function controls the pump's operation, preventing it from being driven with the water volume below a predetermined level, and thus reducing wasteful pump operation and saving even more energy.


## Also avoids operation signal trouble through the command loss detection function.

If the frequency signals ( 0 to $10 \mathrm{~V}, 4$ to 20 mA , multi-step speed operation signals, communications, etc.) that are connected to the inverter are blocked, signals are output as a "command loss," indicating that a frequency command was lost. In addition, output frequency when the command loss occurred can be set in advance, so even if a frequency signal line to equipment is broken due to machine vibration, etc., machine operation can be continued uninterruptedly.


## Simple circuit configuration using the commercial line switching sequence

Inverters are equipped with the commercial line start function that enables switching between the commercial line and the inverter by an external sequence. In addition, inverters are equipped with two types of built-in sequence for operation with commercial line; i.e., Fuji's standard sequence and the automatic switching sequence to the commercial line activated when the inverter alarm occurs.

Note: The latter sequence differs from the one for forcible switching to the commercial line during inverter breakdown.

## Inverters are equipped with full PID control functions.

Low water level stop function, deviation alarm and absolute value alarm outputs have been added to the PID regulator which performs such tasks as temperature, pressure and flow rate control. In addition, an anti-reset windup function that prevents PID control overshoot as well as a PID output limiter and integral hold/reset signal provide easy-to-adjust PID control functions.

## Simple Sequences through Universal DI/DO

Signals can be transmitted to a higher level controller or PC by connecting digital signals to an inverter from different types of sensors, such as a float switch used to judge the level in a water storage tank, which serve as peripheral devices to the inverter. In the case of small-scale equipment, even if a programmable logic controller (PLC) is not used, information can be sent to a higher-level system easily.


## Improved capability for handling regenerated energy

When the inverter slows down and stops the motor, if the braking energy regenerated by the motor exceeds the braking capacity of the inverter's main circuit capacitor, the inverter will trip. At such a time, if even a little excess energy trips the inverter, using this function you may be able to absorb the excess braking energy without connecting to a braking resistor.


## Continuous equipment operation through overload avoidance control

If the load on a fan or pulley increases due some foreign object getting wrapped around the shaft, etc., and the inverter's internal temperature rises suddenly or the ambient temperature rises to an abnormal level, etc., causing an inverter overload state, the motor's speed is lowered, reducing the load and enabling operation to continue.


## Elimination of display devices by use of the analog input monitor

Using the display coefficient of signals from devices such as flow rate or temperature sensors in air conditioning equipment, these signals can be converted into physical values such as temperature and pressure and displayed synthetically on the inverter's keypad without making the use of exclusive flow meters or air flow meters.

## Other convenient functions

## -Motor condensation prevention function

Prevents condensation of the motor from occurring in cases where the surrounding temperature changes suddenly while the motor is stopped.

## OMotor speed display with percent

The inverter's keypad displays the operating frequency ( Hz ) or the motor's rotational speed (r/min), but it can also display the maximum speed as $100 \%$, so it is easy to get a grasp of the equipment's operating state.

## Dynamic Rotation of Pump Motors

## OWith a fixed inverter-driven motor

This configuration consists of a motor driven by the inverter (M0) and motors driven by commercial power (M1 to M4).
The inverter-driven motor is fixed at M0 and is controlled for variable speed. When the inverter-driven motor M0 alone cannot sustain the desired discharge flowrate, the inverter mounts one or more motors driven by commercial power as necessary.


## -With a floating inverter-driven motor

In this configuration, all the motors can be driven by the inverter or commercial power. At the start of operation, each motor is driven by the inverter and is controlled for varying speed. When the first motor alone cannot sustain the desired discharge flowrate, it is switched to commercial-power operation, and the inverter drives the second motor.


## Consideration of the surrounding environment and panel design

## 

Fuji's standard series, including our DC reactors and zero phase reactors, complies with the inverter installation standards in the "Public Building and Construction Standards (Electrical Equipment Construction Manual)" issued in 2004 by Ministry of Land, Infrastructure and transports's Secretarial Office in charge of Government Buildings Department.
In addition, our integrated inverter/DC reactor units have built-in DC reactors and zero phase reactors, so they comply in the area of wiring. (See Note.)
Remark : In the Public Building Association's "Electric Construction Equipment Common Specifications (published in 1999) it stated that it is necessary to install a capacitance filter when installing inverters, but in the specifications published in 2001, it became unnecessary. Also, Fuji's inverter series, including the FRENIC-Eco series have built-in capacitance filters.
Note : $\quad 22 \mathrm{~kW}$ or lower capacity inverters comply with the above specifications as is. Those models with a capacity of 30 kW or greater can be made to comply with the specifications by adding an optional zero-phase reactor.


## Reduction of noise with an nhegrated EMC fiter |lt includes a CE mark which means thatitis compatible with EMC Directives and low voltage Directive.,

In models which include an integrated EMC filter ( 15 kW or lower capacity), through the installation along the lines of the installation procedures for integrated devices, these inverters comply with Europe's EMC Directives.

## Side-by-side installation saves space!

If multiple inverter units are to be used in a panel and the panel is designed accordingly, it is possible to mount these inverters side-byside horizontally, so the panel can be designed to take up less space. ( 5.5 kW or lower capacity inverters)


## Built-in in rush current suppressing resistors help reduce peripheral equipment capacities!

When the FRENIC-Eco series (Fuji's FRENIC-Mini Series and 11 Series) is used, the in rush current suppressing resistors built into the inverter as standard equipment suppress in rush current when motors are started, so compared to operation of motors with direct input, peripheral equipment with reduced capacity can be selected.

## Cooling outside the panel is made possible by an external cooling attachment!

Use of the external cooling attachment (optional on 30 kW or smaller inverters and standard on 37 kW or larger inverters) to cool the inverter outside the panel makes it possible to install a simple cooling system outside the panel.

## Operator-friendly features

## Inverters can be set up simply using Quick Setup.

The standard keypad can be used to select Quick Setup from the Menu mode. In Quick Setup, you can display 18 different function codes and set up the inverter simply.


A multi-function keypad is also available as an option.
■TP-G1 ■TP-G1-J1 ■TP-G1-C1

- Includes an easier to see LCD with backlight.
- It has a large 7 -segment, 5 -digit LED display.
- It is possible to add and delete quick setup items.
- A remote/local switching key has been newly added.
- Copying of up to 3 sets of data is possible.


| Option type | Display languages |  |  |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | English | German | French | Spanish | Italian | Chinese | Korean characerer | Japanese |  |
| TP-G1 | 0 | 0 | 0 | 0 | 0 | - | - | 0 |  |
| TP-G1-J1 | 0 | 0 | 0 | 0 | 0 | - | - | 0 |  |
| TP-G1-C1 | 0 | - | - | - | - | 0 | 0 | 0 |  |

## Personal computer loader software


*These pieces of software can be downloaded from the following Fuji Electric web site: https://web1.fujielectric.co.jp/Kiki-Info-EN/User/guestlogin.asp

## Network compatibility

 - It is compatible with the following networks by inserting the relevant option card.

[^32]
## Model List


*Semi-standard specification products are manufactured when orders are received.

How to read the model number


Note: When the lower three digits of the model number indicate a keypad (standard), no built-in option, and screw terminals (standard), the inverter is a standard type in the above model list. There may be some nonstandard models that we cannot manufacture.

Caution Use the contents of this catalog only for selecting product types and models. When using a product, read the Instruction Manual beforehand to use the product correctly

## Energy Savings with an Inverter

## How does using an inverter save me energy?

- If you run a fan or pump and you have damper (valve) control or control it with an inverter, the relation between the air flow (flow rate) and the required power, as well as the relation between the power supply frequency $\mathrm{fs}(\mathrm{Hz})$ and operating frequency with the inverter $f \mathrm{fNV}(\mathrm{Hz})$ are as shown in the table at right.
- If the air flow rate is low, the energy saving effect is particularly great.
- Formula (theoretical) for calculating the energy savings effect achieved by an inverter


Power charges when a damper is used: Mo [yen/year]
$=(P \times(1-B) \times Q+P \times B) \times \frac{1}{\eta_{M}} \times D \times H \times M$
■Power charges when an inverter is used: MINV [yen/year]

$$
=\left(P \times\left(\frac{f_{R U N}}{f_{S}}\right)^{3}\right) \times \frac{1}{\eta_{M}} \times \frac{1}{\eta_{I N V}} \times D \times H \times M
$$

P: Motor capacity (kW)
B: Damper reduction rate (\%)
Q: Air flow (\%)
Fruv: Inv
Inverter operating frequency (Hz)
$\mathrm{Fs}_{\mathrm{s}}$ : Power supply frequency ( Hz )
D: Annual operating days (day/year)
H : Operating hours per day (h/day)
M: Power charge unit price (kWh/yen)
(Note 1) The air flow rate $Q(\%)$ shows the air flow when the damper is closed (\%). The operating frequency fean (Hz) when using an inverter is being proportional to the air flow $Q$ (\%), so decide on


For example, if air flow Q: 60 (\%) = Power supply frequency fs: 50 (Hz)
$Q(\%)=f_{m}(H z) / f_{1}(H z)$
$60(\%)=f_{m}(\mathrm{~Hz}) / 50(\mathrm{~Hz}) \rightarrow \mathrm{f}_{\omega_{0}}(\mathrm{~Hz})=50(\mathrm{~Hz}) \times 0.6=30(\mathrm{~Hz})$
(Note 2) The air flow rate $Q$ (\%)does not show the damper's opening angle, but rather the air flow (\%) at the point when the opening angle is adjusted from the damper's fully open state. Depending on the type of damper, there may not be a proportional relation between the opening angle and the air flow, so exercise caution.

| Item | Relation between $f_{s}(\mathrm{~Hz})$ and finV (Hz) (Note 1) | Examples with actual numbers (Note 2) |  |
| :---: | :---: | :---: | :---: |
|  |  | fiww 45 HHz ( (10\%\%OWN) |  |
| Air flow or flow rate Q [ $\left.\mathrm{m}^{3} / \mathrm{min}\right]$ | $Q \propto\left(\frac{f_{\text {mp }}}{f_{s}}\right)$ | $Q=\frac{45}{50} \cdot Q=0.9 \cdot Q$ | $Q=\frac{30}{50} \cdot Q=0.6 \cdot Q$ |
| Head $\mathrm{H}(\mathrm{m})$ or pressure $\mathrm{H}[\mathrm{Pa}]$ | $H \propto\left(\frac{f_{\text {fov }}}{f_{s}}\right)^{2}$ | $H=\left(\frac{45}{50}\right)^{2} \cdot H=0.81 \cdot H$ | $H=\left(\frac{30}{50}\right)^{2} \cdot H=0.36 \cdot H$ |
| Shatt power or power consumption P $[W]$ | $P \propto\left(\frac{f m v}{f_{s}}\right)^{3}$ | $\mathrm{P}=\left(\frac{45}{50}\right)^{3} \cdot \mathrm{P}=0.729 \cdot \mathrm{P}$ | $\mathrm{P}=\left(\frac{30}{50}\right)^{3} \cdot \mathrm{P}=0.216 \cdot \mathrm{P}$ |

- Pump equipment


$$
=(P \times(1-B) \times Q+P \times B) \times \frac{1}{\eta_{M}} \times D \times H \times M
$$

- Power charge when an inverter is used: MINV [yen/year] $=\left((P-P \times A) \times\left(\frac{f_{R U N}}{f_{s}}\right)^{3}+P \times A\right) \times \frac{1}{\eta_{M}} \times \frac{1}{\eta_{I N V}} \times D \times H \times M$

P: Motor capacity (kW)
A: Actual head rate (\%)
B: Valve reduction rate (\%)
Q: Flow rate (\%)
Fruv: Inverter operating frequency ( Hz )
$F_{s:}$ : Power supply frequency ( Hz )
(Note 1) The actual head rate $\mathrm{A}(\%)$ is determined by the pump's load characteristics and is a rate that the power consumption (motor capacity) is multiplied by
See the following calculation formula.
Actual head rate $\mathrm{A}(\%)=\frac{\text { Loss head ( } m \text { ) }}{\text { Actual head ( } m \text { ) }}$
(Note 2) The flow rate $\mathrm{Q}(\%)$ value shows a volume (\%) when the flow rate is restricted by the closing of the valve. The operating frequency when an inverter is used fRUN $(\mathrm{Hz})$ is proportional to the flow rate $\mathrm{Q}(\%)$, so decide on a fRUN ( Hz ) so that the relationship $Q(\%)=f \mathrm{frun}(\mathrm{Hz}) / \mathrm{fs}(\mathrm{Hz})$ can be established. For example, if the flow rate $\mathrm{Q}: 50(\%)$ and the power supply frequency $\mathrm{fs}_{\mathrm{s}}$ is $50 \mathrm{~Hz}, \mathrm{Q}(\%)=$ frun $(\mathrm{Hz}) / \mathrm{f}_{\mathrm{s}}(\mathrm{Hz})$ $60(\%)=\operatorname{frun}(\mathrm{Hz}) / 50(\mathrm{~Hz}) \rightarrow$ frun (Hz) $=50(\mathrm{~Hz}) \times 0.6=30(\mathrm{~Hz})$
(Note 3) The flow rate $Q$ (\%) does not show the valve's opening angle, but rather the flow rate (\%) at the point when the opening angle is adjusted from the valve's fully open state. Depending on the type of valve, there may not be a proportional relation between the opening angle and the flow rate, so exercise caution.

## Energy Savings effect of replacing damper (valve) control with inverter control

Example: The energy savings effect on an office's air conditioning equipment if the operating pattern is as follows: Air flow: $85 \%$ for $2,000 \mathrm{hrs}$, and $60 \%$ for $2,000 \mathrm{hrs}$. Total $4,000 \mathrm{hrs} / \mathrm{year}$. Motor output is $15 \mathrm{~kW} \times 1$ unit.
-Under damper (valve) control, the required power is as follows:
$(15 \mathrm{~kW} \times 91 \% \times 2,000 \mathrm{hrs})+.(15 \mathrm{~kW} \times 76 \% \times 2,000 \mathrm{hrs})=50,.100 \mathrm{kWh}$ Air flow rate $85 \%$

Air flow rate 60\%
-If an inverter is used and the motor's rotational speed is controlled, the required power is as follows: ( $15 \mathrm{~kW} \times 61 \% \times 2,000 \mathrm{hrs}.)+(15 \mathrm{~kW} \times 22 \% \times 2,000 \mathrm{hrs})=24,.900 \mathrm{kWh}$ Air flow rate $85 \%$ Air flow rate 60\%
-The power saving effect when the power charges are $16.8 y \mathrm{y}$ n/kWh is $25,200 \mathrm{kWh} \times 16.8 \mathrm{yen}=420,000 \mathrm{yen} /$ year

- The amount of time it takes to amorize the equipment costift the inverter's cost is 450,000 yen is 450,000 yen $/ 420,000$ yen $=1.1$ years

[^33] the Enviommenal Acencry, the annual $\mathrm{CO}_{2}$ reduction amounts to
$25,200 \mathrm{kWh} \times 0.555 \mathrm{~kg} / \mathrm{kWh}=13,986 \mathrm{~kg} / \mathrm{year}$


Energy savings effect
$50,100 \mathrm{kWh}-24,900 \mathrm{kWh}=25,200 \mathrm{kWh} /$ year

## Examples of measurements with actual equipment

Exhaust fan (generating variable torque load)


- Motor capacity and inverter capacity
- Motor capacity : 22 (kW)
- Inverter model : FRN22F1S-2 (FRENIC-Eco)
-DC REACTOR : DCR2-22A
-Power reduction rate and energy saving effect amount

| Item | Operation using commercial power | Inverter-controlled operation |  |  |
| :--- | :---: | :---: | :---: | :---: |
| Operation frequency (Hz) | 50 | 45 | 40 | 35 |
| Average power use (kW) | 17.2 | 13.1 | 9.10 | 6.23 |
| Power reduction rate (\%) | - | $\mathbf{\Delta 3 0 . 7}$ | $\mathbf{\Delta 4 7 . 1}$ | $\mathbf{\Delta 6 3 . 8}$ |
| Annual power charge (yen) | $1,574,006$ | $1,198,807$ | 832,759 | 570,120 |
| Annual amount (yen) of energy saving effect | - | 375,199 | 741,247 | $1,003,886$ |
| Annual $\mathrm{CO}_{2}$ reduction volume (kg/year) | - | 16,930 | 33,447 | 45,298 |

-Operating conditions

- Annual operating days
- Working hours per day
- Power charge unit price

310 (days/year)
24 (hrs/day)
: 12.3 (yen/kWh)

## Cooling tower (generating variable torque load)



- Motor capacity and Inverter capacity

| - Motor capacity | $: 5.5(\mathrm{~kW})$ |
| :--- | :--- |
| - Inverter model | :FRN5.5F1S-2 (FRENIC-Eco) |
| - DC REACTOR | : DCR2-5.5 |

-Power reduction rate and energy saving effect amount

| Item | Opeaion usingommeraid pover | Inverter-controlled operation |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Operation frequency ( Hz ) | 60 | 45 | 40 | 35 |
| Average power use (kW) | 5.18 | 2.31 | 1.63 | 1.10 |
| Power reduction rate (\%) |  | ⑤5.4 | 468.5 | 478.8 |
| Annual power charge (yen) | 410,256 | 182,952 | 129,096 | 87,120 |
| Annual amount (yen) of energy savings effect | - | 227,304 | 281,160 | 323,136 |
| Annual $\mathrm{CO}_{2}$ reduction volume (kg/year) | - | 9,557 | 11,822 | 13,586 |

-Operating conditions

| - Annual operating days | $: 300$ (days/year) |
| :--- | :--- |
| - Working hours per day | $: 20$ (hrs/day) |
| - Power charge unit price | $: 13.2($ yen $/ \mathrm{kWh})$ |

## Mist collector (generating variable torque load)



| - Motor capacity and Inverter capacity |  |
| :--- | :--- |
| - Motor capacity | $: 3.7(\mathrm{~kW})$ |
| - Inverter Model | $:$ FRN3.7F1S-2 (FRENIC-Eco) |
| -DC REACTOR | : DCR2-3.7 |

- Power reduction rate and energy saving effect amount

| Item | Opeation sisingomnexid power | Inverter-controlled operation |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Operation frequency ( Hz ) | 60 | 45 | 40 | 35 |
| Average power use (kW) | 3.27 | 1.44 | 0.99 | 0.69 |
| Power reduction rate (\%) | - | -56.0 | $\triangle 69.7$ | 478.9 |
| Annual power charge (yen) | 260,161 | 114,566 | 78,764 | 54,896 |
| Annual amount (yen) of energy savings effect | - | 145,595 | 181,397 | 205,265 |
| Annual $\mathrm{CO}_{2}$ reduction volume (kg/year) | - | 5,281 | 6,580 | 7,446 |

-Operating conditions - Annual operating days

- Working hours per day
- Power charge unit price

260 (days/year)
20 (hrs/day)
15.3 (yen/kWh)

Conduct a search. You can study energy savings with the following types of equipment.


- Air conditioning fans •AHU
- Dust collectors
- Exhaust fans
- Mist -collectors
- Package air conditioners, etc.

- Cooling water pumps
- Cleaning pump
- Coolant pumps
- Circulating pumps
- Roots blowers
- Water cooler pumps, etc.


## Standard specifications

Three-phase 200V series

| Item |  |  |  | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type (FRN $\square \square \square \mathrm{F} 1 \mathrm{~S}-2 \mathrm{~A}$ ) |  |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 | 110 |
| Nominal applied motor (kW) |  |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 | 110 |
|  | Rated capacity (kVA) |  |  | 1.6 | 2.6 | 4.0 | 6.3 | 9.0 | 12 | 17 | 22 | 27 | 32 | 43 | 53 | 64 | 80 | 105 | 122 | 148 |
|  | Rated voltage (V) |  |  | Three-phase, 200 to 240 V (With AVR function) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current (A) *4 |  |  | 4.2 | 7.0 | 10.6 | 16.7 | $\begin{gathered} 23.8 \\ (22.5) \end{gathered}$ | 31.8 <br> (29) | $\begin{gathered} 45 \\ (42) \end{gathered}$ | 58 <br> (55) | 73 <br> (68) | $\begin{gathered} 85 \\ (80) \end{gathered}$ | $\begin{gathered} 114 \\ (107) \end{gathered}$ | $\begin{gathered} 140 \\ (130) \end{gathered}$ | $\begin{gathered} 170 \\ (156) \end{gathered}$ | $\begin{gathered} 211 \\ (198) \end{gathered}$ | $\begin{gathered} 276 \\ (270) \end{gathered}$ | $\begin{gathered} 322 \\ (320) \end{gathered}$ | $\begin{gathered} 390 \\ (384) \end{gathered}$ |
|  | Overload capability |  |  | 120\% of rated current for 1 min |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency |  |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases, voltage, frequency | Main power supply |  | Three-phase, 200 to $240 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Three-phase, 200 to $220 \mathrm{~V} / 50 \mathrm{~Hz}$ Three-phase, 200 to $230 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |  |  |
|  |  | Auxiliary control power input |  | Single-phase, 200 to $240 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ for the terminals |  |  |  |  |  |  |  |  |  |  | Single-phase, 200 to $220 \mathrm{~V} / 50 \mathrm{~Hz}$ Single-phase, 200 to $230 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |  |  |
|  |  | Auxiliary fan power input |  | - |  |  |  |  |  |  |  |  |  |  |  | Single-phase, 200 to $220 \mathrm{~V} / 50 \mathrm{~Hz}$ Single-phase, 200 to $230 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |  |
|  | Voltage/frequency variations |  |  | Voltage: +10 to $-15 \%$ (Voltage unbalance: $2 \%$ or less) ${ }^{* 7}$, Frequency: +5 to $-5 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current (A) | *8 | (with DCR) | 3.2 | 6.1 | 8.9 | 15.0 | 21.1 | 28.8 | 42.2 | 57.6 | 71.0 | 84.4 | 114 | 138 | 167 | 203 | 282 | 334 | 410 |
|  |  |  | (without DCR) | 5.3 | 9.5 | 13.2 | 22.2 | 31.5 | 42.7 | 60.7 | 80.1 | 97.0 | 112 | 151 | 185 | 225 | 270 | - | - | - |
|  | Required power supply capacity (kVA) *5 |  |  | 1.2 | 2.2 | 3.1 | 5.3 | 7.4 | 10 | 15 | 20 | 25 | 30 | 40 | 48 | 58 | 71 | 98 | 116 | 142 |
|  | Torque (\%) |  |  | 20 |  |  |  |  |  |  |  |  |  | 10 to 15 |  |  |  |  |  |  |
|  | DC injection braking |  |  | Starting frequency: 0.0 to 60.0 Hz , Braking time: 0.0 to 30.0 s , Braking level: 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DC reactor (DCR) |  |  |  | Option |  |  |  |  |  |  |  |  |  |  |  |  |  | Standard |  |  |
| Applicable safety standards |  |  |  | UL508C, C22.2 No.14, EN50178:1997 (Applying) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure (IEC60529) |  |  |  | IP20, UL open type |  |  |  |  |  |  |  |  |  | IP00, UL open type |  |  |  |  |  |  |
| Cooling method |  |  |  | Natural cooling |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mass (kg) |  |  |  | 3.1 | 3.2 | 3.3 | 3.4 | 3.4 | 5.8 | 6.0 | 6.9 | 9.5 | 9.7 | 11.5 | 23 | 33 | 34 | 41 | 75 | 120 |

1 Fuji 4-pole standard motor
*2 Rated capacity is calculated by assuming the output rated voltage as 220 V for three-phase 200 V series
*3 Output voltage cannot exceed the power supply voltage.
*4 An excessively low setting of the carrier frequency may result in the higher motor temperature or tripping of the inverter by its overcurrent limiter setting. Lower the continuous load or maximum load instead. (When setting the carrier frequency (F26) to 1 kHz , reduce the load to $80 \%$ of its rating.)
5 Obtained when a DC reactor (DCR) is used.
*6 Average braking torque (Varies with the efficiency of the motor.)
*7 Voltage unbalance (\%) $=\frac{\text { Max. voltage }(\mathrm{V})-\text { Min. voltage (V) }}{\text { Three-phase average voltage }(\mathrm{V})} \times 67($ IEC61800-3 (5.2.3)) If this value is 2 to $3 \%$, use in AC reactor (ACR option)
*8 Trial calculation done on assumption that the power capacity is 500 kVA (or 10 times the inverter capacity if the inverter capacity is larger than 50 kVA ) and the inverter is connected to the power supply of $\% \mathrm{X}=5 \%$.
*9 Use [R1, T1] terminals for driving AC cooling fans of an inverter powered by the DC link bus, such as by a high power factor PWM converter. (In ordinary operation, the terminals are not used.)
*10 When using the inverter at an ambient temperature higher than $40^{\circ} \mathrm{C}$ and at a carrier frequency of 3 kHz or over, select the inverter so that the current does not exceed the rated current specified in ( ) during continuous operation.

Three-phase 400V series

## $\bigcirc 0.75$ to 55kW

| Item |  |  |  |  | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type (FRN $\square \square \square \mathrm{F} 1 \mathrm{~S}-4 \mathrm{~A}$ ) |  |  |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 |
| Nominal applied motor (kW) *1 |  |  |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 |
|  | Rated capacity (kVA) *2 |  |  |  | 1.9 | 2.8 | 4.1 | 6.8 | 9.5 | 12 | 17 | 22 | 28 | 33 | 44 | 54 | 64 | 77 |
| $\begin{aligned} & \text { og } \\ & \stackrel{y}{\mid c} \end{aligned}$ | Rated voltage (V) *3 |  |  |  | Three-phase, 380 to 480 V (with AVR function) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| $\frac{\underline{L}}{\ddagger}$ | Rated current (A) *4 |  |  |  | 2.5 | 3.7 | 5.5 | 9.0 | 12.5 | 16.5 | 23 | 30 | 37 | 44 | 59 | 72 | 85 | 105 |
| Õ | Overload capability |  |  |  | $120 \%$ of rated current for 1 min |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency |  |  |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases, voltage, frequency | Main power supply |  |  | Three-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Three-phase, 380 to $440 \mathrm{~V} / 50 \mathrm{~Hz}$ Three-phase, 380 to $480 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |
|  |  | Auxil powe | iary contr input |  | Single-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Single-p Single-p | $\begin{aligned} & \text { ee, } 380 \\ & \text { ee, } 380 \end{aligned}$ | $0 \mathrm{~V} / 50 \mathrm{~Hz}$ $0 \mathrm{~V} / 60 \mathrm{~Hz}$ |
|  |  | Auxil <br> powe | iary fan r input | *9 | - |  |  |  |  |  |  |  |  |  |  |  |  | *10 |
|  | Voltage/frequency allowance |  |  |  | Voltage: +10 to -15\% (Voltage unbalance: $2 \%$ or less) ${ }^{\star 7}$, Frequency: +5 to $-5 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current (A) | *8 | (with DCR) |  | 1.6 | 3.0 | 4.5 | 7.5 | 10.6 | 14.4 | 21.1 | 28.8 | 35.5 | 42.2 | 57.0 | 68.5 | 83.2 | 102 |
|  |  |  | (without DCR) |  | 3.1 | 5.9 | 8.2 | 13.0 | 17.3 | 23.2 | 33.0 | 43.8 | 52.3 | 60.6 | 77.9 | 94.3 | 114 | 140 |
|  | Required power supply capacity (kVA) $*_{5}$ |  |  |  | 1.2 | 2.2 | 3.1 | 5.3 | 7.4 | 10 | 15 | 20 | 25 | 30 | 40 | 48 | 58 | 71 |
|  | Torque (\%) *6 |  |  |  | $20$ |  |  |  |  |  |  |  |  |  | $10 \text { to } 15$ |  |  |  |
|  | DC injection braking |  |  |  | Starting frequency: 0.0 to 60.0 Hz , Braking time: 0.0 to 30.0 s , Braking level: 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DC reactor (DCR) |  |  |  |  | Option |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Applicable safety standards |  |  |  |  | UL508C, C22.2 No.14, EN50178:1997 (Applying) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure (IEC60529) |  |  |  |  | IP20, UL open type |  |  |  |  |  |  |  |  |  | IP00, UL open type |  |  |  |
| Cooling method |  |  |  |  | Natural cooling |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |  |
| Mass (kg) |  |  |  |  | 3.1 | 3.2 | 3.3 | 3.4 | 3.4 | 5.8 | 6.0 | 6.9 | 9.4 | 9.9 | 11.5 | 23 | 24 | 33 |

## -75 to 560kW

| Item |  |  |  |  | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type (FRN $\square \square \square \mathrm{F} 1 \mathrm{~S}-4 \mathrm{~A}$ ) |  |  |  |  | 75 | 90 | 110 | 132 | 160 | 200 | 220 | 280 | 315 | 355 | 400 | 450 | 500 | 560 |
| Nominal applied motor (kW) $*_{1}$ |  |  |  |  | 75 | 90 | 110 | 132 | 160 | 200 | 220 | 280 | 315 | 355 | 400 | 450 | 500 | 560 |
|  | Rated capacity (kVA) *2 |  |  |  | 105 | 128 | 154 | 182 | 221 | 274 | 316 | 396 | 445 | 495 | 563 | 640 | 731 | 792 |
| $\begin{aligned} & \text { 合 } \\ & \stackrel{y}{n} \end{aligned}$ | Rated voltage (V) ${ }^{*}$ |  |  |  | Three-phase, 380 to 480 V (with AVR function) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| $\frac{\pi}{\#}$ | Rated current (A) *4 |  |  |  | 139 | 168 | 203 | 240 | 290 | 360 | 415 | 520 | 585 | 650 | 740 | 840 | 960 | 1040 |
| $\begin{aligned} & \text { ò } \\ & 0 \end{aligned}$ | Overload capability |  |  |  | $120 \%$ of rated current for 1 min |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency |  |  |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases, voltage, frequency | Main power supply |  |  | Three-phase, 380 to $440 \mathrm{~V}, 50 \mathrm{~Hz}$ or Three-phase, 380 to $480 \mathrm{~V}, 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | Auxiliary control power input |  |  | Single-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | $\begin{array}{\|l\|l\|} \hline \text { Auxil } \\ \text { powe } \end{array}$ | iary fan <br> er input |  | Single-phase, 380 to $440 \mathrm{~V} / 50 \mathrm{~Hz}$ Single-phase, 380 to $480 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Voltage/frequency variations |  |  |  | Voltage: +10 to -15\% (Voltage unbalance: $2 \%$ or less) ${ }^{* 7}$, Frequency: +5 to $-5 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current (A) | *8 | (with DCR) |  | 138 | 164 | 201 | 238 | 286 | 357 | 390 | 500 | 559 | 628 | 705 | 789 | 881 | 990 |
|  |  |  | (without | DCR) | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  | Required power supply capacity (kVA) *5 |  |  |  | 96 | 114 | 140 | 165 | 199 | 248 | 271 | 347 | 388 | 435 | 489 | 547 | 611 | 686 |
|  | Torque (\%) ${ }^{*} 6$ |  |  |  | 10 to 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | DC injection braking |  |  |  | Starting frequency: 0.0 to 60.0 Hz , Braking time: 0.0 to 30.0 s , Braking level: 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DC reactor (DCR) |  |  |  |  | Option |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Applicable safety standards |  |  |  |  | UL508C, C22.2 No.14, EN50178:1997 (Applying) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure (IEC60529) |  |  |  |  | IP00, UL open type |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cooling method |  |  |  |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mass (kg) |  |  |  |  | 34 | 42 | 45 | 63 | 67 | 96 | 98 | 162 | 165 | 282 | 286 | 355 | 360 | 360 |

*1 Fuji 4-pole standard motor
*2 Rated capacity is calculated by assuming the output rated voltage as 440 V for three-phase 400 V series.
*3 Output voltage cannot exceed the power supply voltage
*4 An excessively low setting of the carrier frequency may result in the higher motor temperature or tripping of the inverter by its overcurrent limiter setting. Lower the continuous load or maximum load instead. (When setting the carrier frequency (F26) to 1 kHz , reduce the load to $80 \%$ of its rating.)
${ }_{5}$ Obtained when a DC reactor (DCR) is used.
*6 Average braking torque (Varies with the efficiency of the motor.)
*7 Voltage unbalance (\%) $=\frac{\text { Max. voltage ( } \mathrm{V} \text { ) }- \text { Min. voltage ( } \mathrm{V} \text { ) }}{\text { Three-phase average voltage }(\mathrm{V})} \times 67$ (IEC61800-3) If this value is 2 to $3 \%$, use an AC reactor (ACR option).
*8 Trial calculation done on assumption that the power capacity is 500 kVA (or 10 times the inverter capacity if the inverter capacity is larger than 50 kVA ) and the inverter is connected to the power supply of $\% X=5 \%$.
*9 Use [R1, T1] terminals for driving AC cooling fans of an inverter powered by the DC link bus, such as by a high power factor PWM converter. (In ordinary operation, the terminals are not used.)
*10 Single-phase, 380 to $440 \mathrm{~V} / 50 \mathrm{~Hz}$ or Single-phase, 380 to $480 \mathrm{~V} / 60 \mathrm{~Hz}$

## Semi-standard specifications Built-in DC reactor series

Three-phase 200V series


## Three-phase 400V series


*1 Fuji's 4-pole standard motor
*3 Output voltage cannot exceed the power supply voltage
${ }_{*}{ }^{5} 5$ Then setting the carrier frequency to 1 kHz or less, reduce. the load to $80 \%$ of its rated value.
*5 The value is calculated on assumption that the inverter is connected with a power supply capacity of 500 kVA (or 10 times the inverter capacity if the inverter capacity exceeds 50 kVA ) and $\% \mathrm{X}$ is $5 \%$.
*6 Average braking torque without optional braking resistor (Varies with the efficiency of the motor.)
*7 Voltage unbalance $[\%]=\frac{\text { Max. voltage }[\mathrm{V}]-\text { Min. voltage }[\mathrm{V}]}{\text { Three-phase average voltage }[\mathrm{V}]} \times 67$ (compliant with IEC61800-3)
If this value is 2 to $3 \%$, use an AC REACTOR (ACR option).

* 8 It is used as an AC fan power supply input for applications combined with a high power-factor PWM converter with power regeneration function or the like (not used during normal operation). ${ }^{*} 9$ Use the inverter at the current given in () or below when the carrier frequency setting is higher than 3 kHz or the ambient temperature is $40^{\circ} \mathrm{C}$ or higher.


## Semi-standard specifications EMC filter built-in series

Three-phase 200V series


## Three-phase 400V series

| Item |  |  |  | Specifications |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type (FRN $\square \square \square \mathrm{F} 1 \mathrm{E}-4 \mathrm{~A}$ ) |  |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 |
| Applicable motor rating [kW] *1 |  |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 |
|  | Rated capacity [k |  | *2 | 1.9 | 2.8 | 4.1 | 6.8 | 9.5 | 12 | 17 | 22 |
|  | Voltage [V] *3 |  |  | Three-phase 200 to 240 V (with AVR function) |  |  |  |  |  |  |  |
|  | Rated current [A] *4 |  |  | 2.5 | 3.7 | 5.5 | 9.0 | 12.5 | 16.5 | 23 | 30 |
|  | Overload capability |  |  | 120\% of rated current for 1 min |  |  |  |  |  |  |  |
|  | Rated frequency [ Hz ] |  |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |
|  | Phases, voltage, frequency | Main power supply |  | Three-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |
|  |  | Auxiliary control power input |  | Single-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |
|  | Voltage/frequency variations |  |  | Voltage: +10 to - $15 \%$ (Voltage unbalance: $2 \%$ or less *7), Frequency: +5 to $-5 \%$ |  |  |  |  |  |  |  |
|  | Rated input current [A] *5 |  |  | 1.6 | 3.0 | 4.5 | 7.5 | 10.6 | 14.4 | 21.1 | 28.8 |
|  | Required power supply capacity [kVA] |  |  | 1.2 | 2.2 | 3.1 | 5.3 | 7.4 | 10 | 15 | 20 |
|  | Braking torque [\%] *6 |  |  | 20 |  |  |  |  |  |  |  |
|  | DC injection braking |  |  | Starting frequency: 0.0 to 60.0 Hz , Braking time: 0.0 to 30.0 s , Braking level: 0 to $60 \%$ |  |  |  |  |  |  |  |
| EMC filter unit |  | EMC filter |  | Provided (According to the compatible EMC standard, emission corresponds to class A (NE55011: 1998+A1: 1999+ A2: 2002) and immunity corresponds to 2nd ENV. (EN61800-3: 1996+A11: 2000). |  |  |  |  |  |  |  |
|  |  | DC REACTOR |  | Provided (Under 100\% load of rated output, the power factor is $86 \%$ or over.) |  |  |  |  |  |  |  |
| Applicable safety standards |  |  |  | UL508C, C22.2No.14, EN50178: 1997 (Approval pending) |  |  |  |  |  |  |  |
| Enclosure (IEC60529) |  |  |  | IP20, UL type |  |  |  |  |  |  |  |
| Cooling method |  |  |  | Natural cooling |  | Fan cooling |  |  |  |  |  |
| Weight / Mass [kg] |  |  |  | 6.0 | 6.3 | 6.5 | 6.9 | 6.9 | 14.8 | 14.5 | 15.2 |

## *1 Fuji's 4-pole standard motor

${ }^{*} 2$ Rated capacity is calculated by assuming the output rated voltage as 220 V for three-phase 200 V series and 440 V for three-phase 400 V series.
*3 Output voltage cannot exceed the power supply voltage.

* 4 When the carrier frequency is low, the temperature of the motor may increases rapidly or the inverter protection (current limit) may activate

When setting the carrier frequency to 1 kHz or less, reduce the load to $80 \%$ of its rated value.
${ }^{*} 5$ The value is calculated on assumption that the inverter is connected with a power supply capacity of 500 kVA (or 10 times the inverter capacity if the inverter capacity exceeds 50 kVA ) and \%X is $5 \%$.
*6 Average braking torque without optional braking resistor (Varies with the efficiency of the motor.)
${ }^{*} 7$ Voltage unbalance $[\%]=\frac{\text { Max. voltage }[\mathrm{V}]-\text { Min. voltage }[\mathrm{V}]}{\text { Three-phase average voltage }[\mathrm{V}]} \times 67$ (compliant with IEC61800-3)
If this value is 2 to $3 \%$, use an AC REACTOR (ACR option).

* 8 Use the inverter at the current given in ( ) or below when the carrier frequency setting is higher than 3 kHz or the ambient temperature is $40^{\circ} \mathrm{C}$ or higher


## Semi－standard specifications Waterproof（IP54）series

## Three－phase 200V series

| Item |  |  |  | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type（FRN $\square \square \square \mathrm{F} 1 \mathrm{~L} / \mathrm{D}-2 \mathrm{~A}$ ） |  |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 |
| Applicable motor rating［kW］＊1 |  |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 |
|  | Rated capacity［k |  | ＊ 2 | 1.6 | 2.6 | 4.0 | 6.3 | 9.0 | 12 | 17 | 22 | 27 | 32 | 43 | 53 | 64 |
|  | Voltage［V］ |  | ＊ | Three－phase 200 to 240 V （with AVR function） |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current［A］＊4＊9 |  |  | 4.2 | 7.0 | 10.6 | 16.7 | $\begin{array}{r} 23.8 \\ (22.5) \end{array}$ | $\begin{gathered} 31.8 \\ (29) \end{gathered}$ | $\begin{gathered} 45 \\ (42) \end{gathered}$ | $\begin{array}{r} 58 \\ (55) \end{array}$ | $\begin{gathered} 73 \\ (68) \end{gathered}$ | $\begin{array}{r} 85 \\ (80) \end{array}$ | $\begin{gathered} 114 \\ (107) \end{gathered}$ | $\begin{array}{r} 140 \\ (130) \end{array}$ | $\begin{gathered} 170 \\ (156) \end{gathered}$ |
|  | Overload capability |  |  | $120 \%$ of rated current for 1 min |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency［Hz］ |  |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases，voltage， frequency | Main power supply |  | Three－phase， 200 to $240 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Three－phase， 200 to $220 \mathrm{~V} / 50 \mathrm{~Hz}$ <br> Three－phase， 200 to $230 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |
|  |  | Auxiliary contr power input |  | Single－phase， 200 to $240 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Single－phas Single－phas | 0 to 220VV／50Hz 10230 V 60 Hz |
|  |  | Auxiliary fan power input | ＊ | － |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Voltage／frequency variations |  |  | Voltage：＋10 to－15\％（Voltage unbalance： $2 \%$ or less＊7），Frequency：+5 to－5\％ |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated input current［A］＊5 |  |  | 5.3 | 9.5 | 13.2 | 22.2 | 31.5 | 42.7 | 60.7 | 80.1 | 97.0 | 112 | 151 | 185 | 225 |
|  | Required power supply capacity［kVA］ |  |  | 1.9 | 3.3 | 4.6 | 7.7 | 11 | 15 | 22 | 28 | 34 | 39 | 53 | 65 | 78 |
|  | Braking torque［\％］ |  |  | 20 10 to 15 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | DC injection braking |  |  | Starting frequency： 0.0 to 60.0 Hz ，Braking time： 0.0 to 30.0 s ，Braking level： 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Applicable safety standards |  |  |  | UL508C，C22．2No．14，EN50178： 1997 （Approval pending） |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure |  |  |  | IP54（IEC60529）／UL TYPE12（UL50） |  |  |  |  |  |  |  |  |  |  |  |  |
| Cooling method |  |  |  | Natural cooling |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |
| Weight／Mass［kg］ |  |  |  | 11 | 11 | 12 | 12 | 12 | 18 | 18 | 19 | 27 | 27 | 29 | 47 | 63 |

## Three－phase 400V series

| Item |  |  | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type（FRNロロロF1L／D－4A） |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 |
| Applicable motor rating［kW］＊1 |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 |
|  | Rated capacity［kVA］ | ＊2 | 1.9 | 2.8 | 4.1 | 6.8 | 9.5 | 12 | 17 | 22 | 28 | 33 | 44 | 54 | 64 | 80 | 105 | 128 |
|  | Voltage［V］＊3 |  | Three－phase 380 to 480 V （with AVR function） |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current［A］＊4 |  | 2.5 | 3.7 | 5.5 | 9.0 | 12.5 | 16.5 | 23 | 30 | 37 | 44 | 59 | 72 | 85 | 105 | 139 | 168 |
|  | Overload capability |  | $120 \%$ of rated current for 1 min |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency［Hz］ |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases，voltage， frequency | Main power supply | Three－phase， 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Three－phase， 380 to $440 \mathrm{~V} / 50 \mathrm{~Hz}$ Three－phase， 380 to $480 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |  |
|  |  | Auxiliary control power input | Single－phase， 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Single－phase， 380 to $440 \mathrm{~V} / 50 \mathrm{~Hz}$ Single－phase， 380 to $480 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |  |
|  |  | Auxiliary fan power input |  |  |  |  |  |  |  |  |  |  |  |  |  | $\begin{aligned} & \text { Single-ph } \\ & \text { Single-ph } \end{aligned}$ | $\begin{aligned} & e, 380 \text { to } \\ & e, 380 \text { to } \end{aligned}$ | V／50Hz DV／60Hz |
|  | Voltage／frequency variations |  | Voltage：+10 to－15\％（Voltage unbalance： $2 \%$ or less＊7），Frequency：+5 to $-5 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated input current <br> ［A］ | Built－in DCR | － | － | － | － | － | － | － | － | － | － | － | － | － | － | 138 | 164 |
|  |  | Without DCR | 3.1 | 5.9 | 8.2 | 13.0 | 17.3 | 23.2 | 33.0 | 43.8 | 52.3 | 60.6 | 77.9 | 94.3 | 114 | 140 | － | － |
|  | Required power supply capacity［kVA］ |  | 2.2 | 4.1 | 5.7 | 9.1 | 12 | 17 | 23 | 31 | 37 | 42 | 54 | 66 | 79 | 97 | 96 | 114 |
|  | Braking torque［\％］＊6 |  | 20 |  |  |  |  |  |  |  |  |  | 10 to 15 |  |  |  |  |  |
|  | DC injection braking |  | Starting frequency： 0.0 to 60.0 Hz ，Braking time： 0.0 to 30.0 s，Braking level： 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Applicable safety standards |  |  | UL508C，C22．2No．14，EN50178： 1997 （Approval pending） |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure |  |  | IP54（IEC60529）／UL TYPE12（UL50） |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cooling method |  |  | Natural cooling |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Weight／Mass［kg］ |  |  | 11 | 11 | 12 | 12 | 12 | 18 | 18 | 19 | 27 | 27 | 29 | 47 | 47 | 63 | 75 | 87 |

[^34]＊2 Rated capacity is calculated by assuming the output rated voltage as 220 V for three－phase 200 V series and 440 V for three－phase 400 V series．
＊3 Output voltage cannot exceed the power supply voltage．
＊4 When the carrier frequency is low，the temperature of the motor may increases rapidly or the inverter protection（current limit）may activate．
When setting the carrier frequency to 1 kHz or less，reduce the load to $80 \%$ of its rated value．
＊5 The value is calculated on assumption that the inverter is connected with a power supply capacity of 500 kVA （or 10 times the inverter capacity if the inverter capacity exceeds 50 kVA ）and $\% \mathrm{X}$ is $5 \%$ ．
＊6 Average braking torque without optional braking resistor（Varies with the efficiency of the motor．）
＊7 Voltage unbalance $[\%]=\frac{\text { Max．voltage }[\mathrm{V}]-\mathrm{Min} . \text { voltage }[\mathrm{V}]}{\text { Three－phase average voltage［V］}} \times 67$（compliant with IEC61800－3）
If this value is 2 to $3 \%$ ，use an AC REACTOR（ACR option）
＊ 8 It is used as an AC fan power supply input for applications combined with a high power－factor PWM converter with power regeneration function or the like（not used during normal operation）．
＊ 9 Use the inverter at the current given in（）or below when the carrier frequency setting is higher than 3 kHz or the ambient temperature is $30^{\circ} \mathrm{C}$ or higher．

## Common specifications




## Protective Functions

| Function | Description |  |  | LED indication | Alarm output （30A，B，C）Note） | Related function code |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Overcurrent protection | The inverter is stopped for protection against overcurrent． |  | During acceleration | OI＇ | $\bigcirc$ |  |
| Short circuit protection | The inverter is stopped for protection against overcurrent caused by a short－circuit in the output circuit． |  | During deceleration | Di\％ |  |  |
| Grounding fault protection | The inverter is stopped upon start－up for protection against overcurrent caused by a grounding fault in the output circuit．If the power supply is turned on with the grounding fault， the protection may be invalidated．（3－phase 200 V 75 kW or less， 3 －phase 400 V 220 kW or less） |  | During constant speed operation | 015 |  |  |
|  | The inverter is stopped upon detection of a zero－phase current on the output current and for protection against overcurrent caused by a grounding fault in the output circuit． （3－phase 200 V 90 kW or more，3－phase 400 V 280 kW or more） |  |  | $E F$ | $\bigcirc$ |  |
| Overvoltage protection | An excessive voltage（3－phase 200 V series：400VDC， 3 －phase 400 V series： 800 VDC ）in the DC link circuit is detected and the inverter is stopped．If an excessive high input voltage is applied by mistake，the protection cannot be guaranteed． |  | During acceleration <br> During deceleration <br> During constant speed operation（when stopped） | $0$ | $\bigcirc$ |  |
| Undervoltage protection | The voltage drop（3－phase 200 V series： 200 VDC ， 3 －phase 400 V series： 400 VDC ）in the DC link circuit is detected to stop the inverter．However，when＂F14： 3,4 or 5 ＂is selected，an alarm is not issued even upon a voltage drop in the DC link circuit． |  |  | L＇， | $\Delta$ | F14 |
| Input phase loss protection | The input phase loss is detected to shut off the inverter output．This function protects the inverter from being damaged by adding extreme stress caused by a power phase loss or imbalance between phases．When the load to be connected is small or DC REACTOR is connected a phase loss is not detected． |  |  | 1 in | $\bigcirc$ | H98 |
| Output phase loss protection | Detects breaks in inverter output wiring at the start of operation and during running，to shut off the inverter output． |  |  | DPL | 0 | H98 |
| Overheating protection | Stops the inverter output upon detecting excess heat sink temperature in case of cooling fan failure or overload．Detects a failure（lock）of the internal circulation fan and stops the inverter（ 45 kW or above in 200 V series， 55 kW or above in 400 V series． |  |  | BHi | $\bigcirc$ | H43，H98 |
|  | The temperature inside the inverter unit in the event of cooling fan trouble and overload is detected to stop the inverter． |  |  | ロHコ | $\bigcirc$ |  |
| Overload protection | The temperature inside the IGBT is calculated from the detection of output current and internal temperature，to shut off the inverter output． |  |  | DiL | 0 |  |
| External alarm input | With the digital input signal（THR）opened，the inverter is stopped with an alarm． |  |  | ロHて | 0 | $\begin{aligned} & \text { E01 to E05 } \\ & \text { E98, E99 } \end{aligned}$ |
| Fuse blown | The wiring breakage of the main circuit fuse in the inverter is detected to stop the inverter．（3－phase 200V 90kW or more，3－phase 400 V 90 kW or more） |  |  | Fils | O |  |
| Charging circuit fault | The charging circuit fault in the inverter is detected to stop the inverter．（3－phase 200 V 45 kW or more， 3 －phase 400 V 55 kW or more） |  |  | PbI | $\bigcirc$ |  |
| Electronic <br>  thermal | －The standard motor is protected at all the frequencies． <br> －The inverter motor is protected at all the frequencies． <br> ＊The operation level and thermal time constant can be set． |  |  | Bit | O | F10 F11，F12 |
| －PTC thermistor | A PTC thermistor input stops the inverter to protect the motor． |  |  | 844 | O | H26，H27 |
| \％ | －The PTC thermistor is connected between terminals V2 and 11 to set switches and function codes on the control PC board． |  |  |  |  |  |
| $\begin{array}{\|l\|l} \hline \sum^{\circ} & \begin{array}{l} \text { Overload early } \\ \text { warning } \end{array} \\ \hline \end{array}$ | Warning signal is output at the predetermined level before stopping the inverter with the electronic thermal function to protect the motor． |  |  | － | － | E34，E35 |
| Stall prevention | This is protected when the instantaneous overcurrent limit works． |  |  | － | － | H12 |
|  | －Instantaneous overcurrent limit：operates when the inverter output current goes beyond the instantaneous overcurrent limiting level，and avoids tripping（during acceleration and constant speed operation）． |  |  |  |  |  |
| Alarm relay output （for any fault） | The relay signal is output when the inverter stops upon an alarm． ＜Alarm reset＞ <br> The key or digital input signal（RST）is used to reset the alarm stop state． ＜Storage of alarm history and detailed data＞ Up to the last 4 alarms can be stored and displayed． |  |  |  | $\bigcirc$ | $\begin{aligned} & \text { E20,E27 } \\ & \text { E01 to E05 } \\ & \text { E98, E99 } \end{aligned}$ |
| Memory error | Data is checked upon power－on and data writing to detect any fault in the memory and to stop the inverter if any． |  |  | $E r i$ | O |  |
| Keypad communication error | The keypad（standard）or multi－function keypad（optional）is used to detect a communication fault between the keypad and inverter main body during operation and to stop the inverter． |  |  | Ere | 0 | F02 |
| CPU error | Detects a CPU error or LSI error caused by noise． |  |  | Erz | 0 |  |
| Option communication error | When each option card is used，a fault of communication with the inverter main body is detected to stop the inverter． |  |  | $E r 4$ |  |  |
| Option error | When each option card is used，the option card detects a fault to stop the inverter． |  |  | $E r 5$ |  |  |
| Operation error | STOP key priority | Pressing the（soo key on the keypad or entering the digital input signal will forcibly decelerates and stops the motor even if the operation command through signal input or communication has been selected． |  | ErG | 0 | H96 |
|  | Start check | If the operation command is entered in the following cases，$E_{r} \zeta_{\square}$ will LED monitor to prohibit operation． <br> －Power－on <br> －Alarm reset（）key ON） <br> －The link operation selection＂LE＂is used to switch operation． | be displayed on the |  |  |  |
| Tuning error | When tuning failure，interruption，or any fault as a result of turning is detected while tuning for motor constant． |  |  | $E r 7$ | 0 | P04 |
| RS－485 communication error | When the connection port of the keypad connected via RS－485 communication port to detects a communication error，the inverter is stopped and displays an error． |  |  | ErB | $\bigcirc$ |  |
| Data save error upon undervoltage | When the undervoltage protection works，an error is displayed if data cannot be stored． |  |  | Err | O |  |
| RS－485 communication error（optional） | When an optional RS－485 communication card is used to configure the network，a fault of communication with the inverter main body is detected to stop the inverter． |  |  | ErP | 0 |  |
| LSI error | When an error occurred in the LSI on the power supply printed circuit board，the inverter stops． |  |  | ErH | 0 |  |
| Retry | When the motor is tripped and stopped，this function automatically resets the tripping state and restarts operation．（The number of retries and the length of wait before resetting can be set．） |  |  | － | － | H04，H05 |
| Surge protection | The inverter is protected against surge voltage intruding between the main circuit power line and ground． |  |  | － | － |  |
| Command loss detection | A loss（broken wire，etc．）of the frequency command is detected to output an alarm and continue operation at the preset frequency（set at a ratio to the frequency before detection）． |  |  | － | － | E65 |
| Momentary power failure protection | －A protective function（inverter stoppage）is activated upon a momentary power failure for 15 msec or longer． <br> －If restart upon momentary power failure is selected，the inverter restarts upon recovery of the voltage within the set time． |  |  | － | － | $\begin{aligned} & \text { F14 } \\ & \text { H13 to H16 } \end{aligned}$ |
| Active drive | The inverter output frequency is reduced to avoid tripping before heat sink overheating or tripping due to an overload（alarm indication： OH ior BL L Li ）． |  |  | － | － | H70 |

Note ：The item indicated with $\Delta$ in the alarm output（30A，B，C）column may not be issued according to some function code settings．

## External Dimensions

Main body of standard inverter ( 5.5 kW or smaller)


## Main body of standard inverter ( 7.5 to 30 kW )



| Power supply voltage | Type | Dimensions (mm) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | W3 | W4 | H | H1 | H2 | H3 | D | D1 | D2 | $\phi$ A | $\phi \mathrm{B}$ |
| Three-phase 200 V | FRN7.5F1S-2A | 220 | 196 | 63.5 | 46.5 | 46.5 | 260 | 238 | 141.7 | 16 | 215 | 118.5 | 96.5 | 27 | 34 |
|  | FRN11F1S-2A |  |  |  |  |  |  |  | 141.7 | 16 |  |  |  |  |  |
|  | FRN15F1S-2A |  |  |  |  |  |  |  | 136.7 | 21 |  |  |  | 34 | 42 |
|  | FRN18.5F1S-2A | 250 | 226 | 67 | 58 | 58 | 400 | 378 | 166.2 | 2 |  | 85 | 130 |  |  |
|  | FRN22F1S-2A |  |  | 67 | 58 | 58 |  |  |  | 2 |  |  |  |  |  |
|  | FRN30F1S-2A |  |  | - | - | - |  |  | - | - |  |  |  | - | - |
|  | FRN7.5F1S-4A | 220 | 196 | 63.5 | 46.5 | 46.5 | 260 | 238 |  | 16 | 215 | 118.5 | 96.5 | 27 | 34 |
|  | FRN11F1S-4A |  |  |  |  |  |  |  |  | 16 |  |  |  |  |  |
| Three-phase | FRN15F1S-4A |  |  |  |  |  |  |  | 136.7 | 21 |  |  |  | 34 | 42 |
| 400 V | FRN18.5F1S-4A | 250 | 226 | 67 | 58 | 58 | 400 | 378 | 166.2 | 2 |  | 85 | 130 |  |  |
|  | FRN22F1S-4A |  |  | - | - | - |  |  | 160.2 - | - |  |  |  | - | - |

## Main body of standard inverter ( 37 to 560 kW )



| Power supply voltage | Type | Dimensions (mm) |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | H | H1 | D | D1 | D2 | D3 | M | N |
| Three-phase 200 V | FRN37F1S-2A | 320 | 240 | 550 | 530 | 255 | 115 | 140 | 4.5 | $2 \mathrm{x} \phi 10$ | 10 |
|  | FRN45F1S-2A | 355 | 275 | 615 | 595 | 270 |  | 155 |  |  |  |
|  | FRN55F1S-2A |  |  |  |  |  |  |  |  |  |  |
|  | FRN75F1S-2A |  |  | 740 | 720 |  |  |  |  |  |  |
|  | FRN90F1S-2A | 530 | 430 | 750 | 720 | 380 | 240 | 140 | 6 | 2xф15 | 15 |
|  | FRN110F1S-2A | 680 | 580 | 880 | 850 | 395 | 255 |  |  | 3 x ¢15 |  |
| Three-phase 400 V | FRN37F1S-4A | 320 | 240 | 550 | 530 | 255 | 115 | 140 | 4.5 | $2 \times \phi 10$ | 10 |
|  | FRN45F1S-4A |  |  |  |  |  |  |  |  |  |  |
|  | FRN55F1S-4A | 355 | 275 |  |  | 270 |  | 155 |  |  |  |
|  | FRN75F1S-4A |  |  | 615 | 595 |  |  |  |  |  |  |
|  | FRN90F1S-4A |  |  | 740 | 720 | 300 | 145 | 155 | 6 | $2 \mathrm{x} \phi 10$ | 10 |
|  | FRN110F1S-4A |  |  |  |  |  |  |  |  |  |  |
|  | FRN132F1S-4A | 530 | 430 | 740 | 710 | 315 | 135 | 180 |  |  |  |
|  | FRN160F1S-4A |  |  |  |  | 360 | 180 | 180 |  |  |  |
|  | FRN200F1S-4A |  |  | 1000 | 970 |  |  |  |  |  |  |
|  | FRN220F1S-4A |  |  |  |  |  |  |  |  |  |  |
|  | FRN280F1S-4A | 680 | 580 | 1000 | 970 | 380 | 200 |  | 6 | 3 x ¢15 | 15 |
|  | FRN315F1S-4A |  |  | 1000 | 970 | 380 |  | 180 |  |  |  |
|  | FRN355F1S-4A |  |  | 1400 | 1370 | 440 | 260 |  |  |  |  |
|  | FRN400F1S-4A |  |  |  |  |  |  |  |  |  |  |
|  | FRN450F1S-4A | 880 | 780 |  |  |  |  |  |  | $4 \mathrm{x} \phi 15$ |  |
|  | FRN500F1S-4A |  |  |  |  |  |  |  |  |  |  |
|  | FRN560F1S-4A |  |  |  |  |  |  |  |  |  |  |

Inverter main body with built-in DCR (5.5kW or smaller)



| Power supply <br> voltage | Type |
| :---: | :--- |
|  | FRN0.75F1H-2A |
| Three-phase | FRN1.5F1H-2A |
| 200 V | FRN2.2F1H-2A |
|  | FRN3.7F1H-2A |
|  | FRN5.5F1H-2A |
|  | FRN0.75F1H-4A |
| Three-phase | FRN1.5F1H-4A |
| 400 V | FRN2.2F1H-4A |
|  | FRN3.7F1H-4A |
|  | FRN5.5F1H-4A |

Inverter main body with built-in DCR (7.5 to 30kW)


| Power supply voltage | Type | Dimensions (mm) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | W3 | W4 | H | H1 | D | D1 | D2 | $\phi$ A | $\phi \mathrm{B}$ |
| Three-phase 200 V | FRN7.5F1H-2A | 220 | 160 | 63.5 | 46.5 | 46.5 | 440 | 415 | 260 | 205.5 | 16 | 27 | 34 |
|  | FRN11F1H-2A |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1H-2A |  |  |  |  |  |  |  |  | 200.5 | 21 | 34 | 42 |
|  | FRN18.5F1H-2A | 250 | 190 | 66 | 59 | 59 | 600 | 575 |  | 202 | 7 |  |  |
|  | FRN22F1H-2A |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN30F1H-2A |  |  |  |  |  |  |  |  |  |  |  | 48 |
| Three-phase 400 V | FRN7.5F1H-4A | 220 | 160 | 63.5 | 46.5 | 46.5 | 440 | 415 | 260 | 205.5 | 16 | 27 | 34 |
|  | FRN11F1H-4A |  |  |  |  |  |  |  |  | 205.5 | 16 | 27 | 34 |
|  | FRN15F1H-4A |  |  |  |  |  |  |  |  | 200.5 | 21 | 34 | 42 |
|  | FRN18.5F1H-4A | 250 | 190 | 66 | 59 | 59 | 600 | 575 |  | 202 | 7 |  |  |
|  | FRN22F1H-4A |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN30F1H-4A |  |  |  |  |  |  |  |  |  |  |  | 48 |

## Inverter main body with built-in DCR (37 to 75kW)



Inverter main body with built-in EMC filter ( 5.5 kW or smaller)


| Power supply <br> voltage | Type |
| :---: | :---: |
|  | FRN0.75F1E-2A |
| Three-phase | FRN1.5F1E-2A |
| 200 V | FRN2.2F1E-2A |
|  | FRN3.7F1E-2A |
|  | FRN5.5F1E-2A |
|  | FRN0.75F1E-4A |
| Three-phase | FRN1.5F1E-4A |
| 400 V | FRN2.2F1E-4A |
|  | FRN3.7F1E-4A |
|  | FRN5.5F1E-4A |

Inverter main body with built-in EMC filter (7.5 to 15kW)


| Power supply voltage | Type | Dimensions (mm) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | H | H1 | D |
| Three-phase 200 V | FRN7.5F1E-2A | 220 | 160 | 440 | 415 | 260 |
|  | FRN11F1E-2A |  |  |  |  |  |
|  | FRN15F1E-2A |  |  |  |  |  |
| $\begin{gathered} \text { Three-phase } \\ 400 \mathrm{~V} \end{gathered}$ | FRN7.5F1E-4A | 220 | 160 | 440 | 415 | 260 |
|  | FRN11F1E-4A |  |  |  |  |  |
|  | FRN15F1E-4A |  |  |  |  |  |

Keypad (standard accessory)


Inverter main body of waterproof type (IP54) (5.5kW or smaller)


| Power supply <br> voltage | Type |
| :---: | :--- |
|  | FRN0.75F1L-2A |
| Three-phase | FRN1.5F1L-2A |
| 200 V | FRN2.2F1L-2A |
|  | FRN3.7F1L-2A |
|  | FRN5.5F1L-2A |
|  | FRN0.75F1L-4A |
| Three-phase | FRN1.5F1L-4A |
| 400 V | FRN2.2F1L-4A |
|  | FRN3.7F1L-4A |
|  | FRN5.5F1L-4A |

Inverter main body of waterproof type (IP54) (7.5kW to 90kW)


| Power supplyvoltage | Type | Dimensions (mm) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | H | H1 | H2 | H3 | H4 | D | C | S |
| Three-phase$200 \mathrm{~V}$ | FRN7.5F1L-2A | 300 | 200 | 50 | 600 | 580 | 10 | 550 | 25 | 280 | 10 | 15 |
|  | FRN11F1L-2A |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1L-2A |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN22F1D-2A | 350 | 290 | 30 | 800 | 780 |  | 750 |  | 320 |  |  |
|  | FRN30F1D-2A |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN37F1D-2A | 400 | 360 | 20 | 1100 | 1073 |  | 1030 |  |  | 15 | 18 |
|  | FRN45F1D-2A | 450 | 400 | 25 | 1280 | 1250 | 15 | 1210 | 35 | 360 |  |  |
|  | FRN7.5F1L-4A | 300 | 200 | 50 | 600 | 580 | 10 | 550 | 25 | 280 | 10 | 15 |
|  | FRN11F1L-4A |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1L-4A |  |  |  |  |  |  |  |  |  |  |  |
|  | $\begin{aligned} & \hline \text { FRN18.5F1L-4A } \\ & \hline \text { FRN22F1L-4A } \end{aligned}$ | 350 | 290 | 30 | 800 | 780 |  | 750 |  | 320 |  |  |
| Three-phase | FRN30F1L-4A |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN37F1L-4A | 400 | 360 | 20 | 1100 | 1073 | 15 | 1030 | 35 |  | 15 | 18 |
|  | FRN45F1L-4A | 400 | 360 |  |  |  |  |  |  |  |  |  |
|  | $\begin{aligned} & \hline \text { FRN55F1L-4A } \\ & \hline \text { FRN75F1L-4A } \end{aligned}$ | 450 | 400 | 25 | 117 | 1140 |  | 1100 |  | 350 |  |  |
|  | FRN90F1L-4A | 450 |  |  |  |  |  | 1210 |  | 360 |  |  |

## Wiring Diagram

The following diagram is for reference only. For detailed wiring diagrams, refer to the Instruction Manual.

## Keypad operation



## Operation by external signal inputs



■Run/Stop operation and frequency setting through external signals

## [Wiring procedure]

(1) Wire both the inverter main power circuit and control circuit.
(2) Set i (external signal) at function code $F \begin{cases}\text {. Next, set } i \\ \text { ( voltage input (terminal }\end{cases}$ 12) ( 0 to +10 VDC ) ), $己$ (current input (terminal C1) ( +4 to 20mADC)), or other value at function code $F O i$.

## [Operation method]

(1) Run/Stop : Operate the inverter across terminals FDW and CM shortcircuited, and stop with open terminals.
(2) Frequency setting: Voltage input ( 0 to +10 VDC ), current input ( +4 to 20 mADC ) Note1: When connecting a DC REACTOR (DCR option), remove the jumper bar from across the terminals $[\mathrm{P} 1]$ and $[\mathrm{P}(+)]$. The DCR is a standard accessory for 75 kW or larger capacity inverters. It must be connected when provided.
Note2: Install a recommended molded-case circuit-breaker (MCCB) or an earthleakage circuit-breaker (ELCB) (with an overcurrent protection function) in the primary circuit of the inverter to protect wiring. At this time, ensure that the circuit breaker capacity is equivalent to or lower than the recommended capacity.
Note3: Install a magnetic contactor (MC) for each inverter to separate the inverter form the power supply, apart from the MCCB or ELCB, when necessary. Connect a surge suppressor in parallel when installing a coil such as the MC or solenoid near the inverter.
Note4: Connect the control circuit with the main circuit power supply to bring the inverter in a waiting state. If this terminal is not connected, the inverter can still be operated with the application of main power.
Note5: Frequency can be set by connecting a frequency setting device (external potentiometer) between the terminals 11, 12 and 13 instead of inputting a voltage signal ( 0 to +10 V DC, 0 to +5 V DC or +1 to +5 V DC) between the terminals 12 and 11.
Note6: For the control signal wires, use shielded or twisted wires. Ground shielded wires. To prevent malfunction due to noise, keep the control circuit wiring away from the main circuit wiring as far as possible (recommended: 10 cm or more). Never install them in the same wire duct. When crossing the control circuit wiring with the main circuit wiring, set them at right angles.

## Terminal Functions

Terminal Functions

| ( | Symbol | Terminal name | Functions | Remarks | Related function code |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | L1/R,L2/S,L3/T | Power input | Connect a three-phase power supply. |  |  |
| Э | Ro,T0 | Auxiliary control power input | Connect a single-phase power supply. |  |  |
|  | R1,T1 | Auxiliary fan power input | There is no need to connect during normal operation. Use these terminals for applications combined with a high power-factor PWM converter with power regeneration function or the like. |  |  |
| $\sum^{\text {N/ }}$ | U,V,W | Inverter output | Connect a three-phase motor. |  |  |
|  | P(+), P1 | For DC REACTOR | Connect the DC reactor (DCR). |  |  |
|  | $\mathrm{P}(+), \mathrm{N}(-)$ | For DC bus connection | Used for DC bus connection. |  |  |
|  | өG | Grounding | Terminal for inverter grounding | Two terminals are provided. |  |
|  | 13 | Potentiometer power supply | Used for frequency setting device power supply (variable resistance: 1 to 5kS) (10V DC 10mA DC max.) |  |  |
|  | 12 | Voltage input <br> (Inverse operation) (PID control) <br> (Frequency aux. setting) <br> (Analog input monitor) | Used as a frequency setting voltage input. <br> 0 to +10 V DC/0 to $100 \%$ ( 0 to +5 V DC/0 to 100\%) <br> +10 to 0 V DC/0 to $100 \%$ <br> Ūsed for setting signal (PID process command value) or feedback signal. <br> Ūsed as additional auxiliary setting to various frequency settings. <br> The peripheral analog signal can be displayed on the keypad. (Displaying coefficient: valid) | Input impedance: $22 \mathrm{k} \Omega$ Maximum input: +15V DC | $\begin{aligned} & \hline \text { F18 } \\ & \text { C32 to C34 } \\ & \text { E61 } \end{aligned}$ |
|  | C1 | Current input <br> (Inverse operation) (PID control) <br> (Frequency aux. setting) <br> (Analog input monitor) | Used as a frequency setting current input. <br> 4 to $20 \mathrm{~mA} \mathrm{DC/0}$ to $100 \%$ <br> 20 to $4 \mathrm{~mA} \mathrm{DC/0}$ to $100 \%$ <br> Used for setting signal (PID process command value) or feedback signal <br> Used as additional auxiliary setting to various frequency settings. <br> The peripheral analog signal can be displayed on the keypad. (Displaying coefficient: valid) | Input impedance: $250 \Omega$ Maximum input: 30 mA DC | $\begin{aligned} & \hline \text { F18 } \\ & \text { C37 to C39 } \\ & \text { E62 } \end{aligned}$ |
|  | V2 | Analog setting voltage input $\qquad$ (Inverse operation) (PID control) <br> (For PTC thermistor) (Frequency aux setting) (Analog input monitor) | Used as a frequency setting voltage input. <br> 0 to +10 V DC/0 to $100 \%$ ( 0 to +5 V DC/0 to $100 \%$ ) <br> +10 to 0 V DC/0 to $100 \%$ <br> Used for setting signal (PID process command value) or feedback signal. <br> Connects PTC thermistor for motor protection. <br> Used as additional auxiliary setting to various frequency settings. <br> The peripheral analog signal can be displayed on the keypad. (Displaying coefficient: valid) | Input impedance: $22 \mathrm{k} \Omega$ Maximum input: +15V DC | F18 C42 to C44 E63 |
|  | 11 | Analog common | Common terminal for frequency setting signals (12, 13, C1, V2, FMA) | Isolated from terminals CM and CMY. Two terminals are provided. |  |
|  | X1 | Digital input 1 | The following functions can be set at terminals X1 to X5, FWD and REV for signal input. <br> <Common function> <br> - Sink and source are changeable using the built-in sliding switch. <br> - ON timing can be changed between short-circuit of terminals X1 and CM and open circuits of them. The same setting is possible between CM and any of the terminals among X2, X3, X4, X5, FWD, and REV. | ON state <br> Source current: 2.5 to 5 mA <br> Voltage level: 2 V <br> OFF state <br> Allowable leakage current: <br> Smaller than 0.5 mA <br> Voltage: 22 to 27 V | E01 |
|  | X2 | Digital input 2 |  |  | E02 |
|  | X3 | Digital input 3 |  |  | E03 |
|  | X4 | Digital input 4 |  |  | E04 |
|  | X5 | Digital input 5 |  |  | E05 |
|  | FWD | Forward operation command |  |  | E98 |
|  | REV | Reverse operation command |  |  | E99 |
|  | (FWD) | Forward operation command | The motor runs in the forward direction upon ON across (FWD and CM.The motor decelerates and stops upon OFF. | This function can be set only for the terminals FWD and REV. | C05 to C11 |
|  | (REV) | Reverse operation command | The motor uns in the reversedirection upon ON across (REV) and CM.The motor decolerates and stops upon OFF. |  |  |
|  | $\begin{aligned} & \text { (SS1) } \\ & \text { (SS2) } \\ & \text { (SS4) } \end{aligned}$ | Multistep freq. selection | 8 -step operation can be conducted with ON/OFF signals at (SS1) to (SS4). |  |  |
|  | (HLD) | 3-wire operation stop command | Used for 3-wire operation. <br> ON across (HLD) and CM: The inverter self-holds FWD or REV signal. OFF across (HLD) and CM: The inverter releases self-holding. |  |  |
|  | (BX) | Coast-to-stop command | ON across (BX) and CM: The inverter output is shut of immediately and the motor coasts to a stop. | No alarm signal will be output. |  |
|  | (RST) | Alarm reset | ON across (RST) and CM: Faults are reset. | Alarm reset signal width: 0.1 (s) or more |  |
|  | (THR) | Trip command (External fault) | OFF across (THR) and CM: The inverere output is shut off immediately and the motor coasts-to-stop. | Alarm signal Diti will be output. |  |
|  | (Hz2/Hz1) | Freq set 2/Freq. set 1 | ON across (Hz2/Hz1)and CM: Freq- set 2 is effective. |  | F01, F30 |
|  | (DCBRK) | DC braking command | ON across (DCBRK) and CM: Starts DC braking action. |  | F20 to 22 |
|  | (SW50) | Line/inverter switch( 50 Hz ) | OFF across (SW50) and CM: Starts at 50Hz. |  |  |
|  | (SW60) | Line/inverter switch $(60 \mathrm{~Hz}$ ) | OFF across (SW60) and CM: Starts at 60Hz |  |  |
|  | -(UP) | UP command | The output frequency rises while the circuit across (UP) and CM is connected. |  | F01, C30 |
|  | (DOWN) | DOWN command | The output frequency drops while the circuit across (DOWN and CM is connected. |  |  |
|  | --. (WE-KP) | Write enable for KEYPAD | The function code data can be changed from the keypad only when (WEE-KP) is ON. |  |  |
|  | (Hz/PID) | PID cancel | PID control can be canceled when the circuit across ( HzPID ) and CM is connected. (Operation proceeds according to the selected frequency setting method such as the multi-step frequency, keypad and analog input.) |  | $\begin{aligned} & \mathrm{Jo1} \text { to } 06 \\ & \mathrm{~J} 10 \text { to J19 } \end{aligned}$ |
|  | (IVS) | Inverse mode changeover | The frequency setting or PID control output signal (frequency setting) action mode switches between normal and inverse actions when the circuit across (IVS) and CM is connected. |  | C50, J01 |
|  | (IL) | Interlock | Connect an auxiliary contact of a switch installed between the inverter and motor. This signal is input upon momentary power failure to detect momentary power faiure, and the inverter restarts upon power recovery. |  | F14 |
|  | (LE) | Link enable (RS485, Bus) | Operation proceeds according to commands sent via RS485 communication or field bus (option) when the circuit across (LE) and CM is connected. |  | H30, y98 |
|  | (U-DI) | Universal DI | An abitrary digital input signal is transmitted to the host controller. |  |  |
|  | (STM) | Starting characteristic selection | ON across (STM) and CM: Starting at the pick-up frequency becomes valid. |  | H17, 009 |
|  | (STOP) | Forcible stop | OFF acoss (STOP) and CM: The inverter is forcibly stopped in the special deceleration time |  | H56 |
|  | (PID-RST) | PID dififerentition I integration reset | ON across (PID-RST) and CM: Resets differentiation and integration values of PID. |  | $\text { јо1 to } 06$ |
|  | (PID-HLD) | PID integral hold | ON across (PID-HLD) and CM: Holds integration values of PID. |  | J10 to J19 |
|  | (LOC) | Local (keypad) command selection | ON across (LOC) and CM: The operation commands and frequency setings given at the keypad become valid |  |  |
|  | (RE) | Operation permission | After an operation command is input, operation starts upon activation of (RE). |  |  |
|  | (DWP) | Dew prevention | ON across (DWP) and CM: A current flows through the motor to avoid motor temperature drop during inverter stoppage so that condensation will not occur. |  | $\begin{aligned} & \mathrm{j} 211 \\ & \mathrm{~F} 21, \mathrm{~F} 22 \end{aligned}$ |
|  | (ISW50) | Line/inverter switching sequence $(50 \mathrm{~Hz})$ | OFF across (ISW50) and CM: Line operation starts according to the switching sequence built in the inverter. (For 50 Hz commercial line) |  | -J22 ${ }^{-1}$ |
|  | (ISW60) | Line/inverter switching sequence $(60 \mathrm{~Hz}$ ) | OFF across (ISW60) and CM: Line operation starts according to the switching sequence built in the inverter. (For 60Hz commercial line) |  |  |
|  | (FR2/FR1) | Operation command 2/1 | ON across (FR2/FR1) and CM: The operation command switches to (FWD2) (REV2) side. |  | F̄ō |
|  | (FWD2) | Forward rotationstop command 2 | Forward peparation upon ON across (FWD) and CM. Deceleration and stop upon OFF. (Second operation command) |  |  |
|  | (REV2) | Reverse operationstop command 2 | Reverse operation upon ON across (REV) and CM. Deceleration and stop upon OFF. (Second operation command) |  |  |
|  | PLC | PLC terminal | Connect to PLC output signal power supply. Common for 24 V power. | +24V 50 mA max. |  |
|  | CM | Common | Common terminal for digital input signal | Isolated from terminals 11 and CMY .Two terminals are provided |  |

## Terminal Functions

| $\begin{aligned} & \hline . \overline{\overline{0}} \\ & : \sum_{0}^{0} \end{aligned}$ | Symbol | Terminal name | Functions | Remarks | Related function code |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | FMA | Analog monitor | The output style can be selected between DC voltage ( 0 to 10 V ) and DC current ( 4 to 20 mA ). One of the following items can be output in the selected output style. <br> - Output frequency. - Output current. • Output voltage. • Output torque. • Load factor. <br> - Input power. • PID feedback value. • DC link circuit voltage. • Universal AO. <br> - Motor output. - Analog output test. • PID command. • PID output | In the case of voltage output, up to two analog voltmeters (0 to 10Vdc, input impedance: 10k 2 ) can be connected. In the case of current output, analog ammeters (up to 500.) can be connected. Gain adjustment range: 0 to $200 \%$ | F29 to F31 |
|  | FMP | Pulse monitor | One of the following items can be output in a pulse frequency. <br> - Output frequency. • Output current. • Output voltage. • Output torque. • Load factor. <br> - Power consumption. • PID feedback value. • DC link circuit voltage. • Universal AO. <br> - Motor output. - Analog output test. • PID command. • PID output | Up to two analog voltmeters (0 to 10 Vdc , input impedance: $10 \mathrm{k} \Omega$ ) can be connected. (Driven at average voltage) Gain adjustment range: 0 to 200\% | F33 to F35 |
|  | (PLC) | Transistor output power | - Power supply for a transistor output load.(24Vdc 50mAdc Max.)(Note: Same termina as ligital input PLC terminal) | Short circuit across terminals CM and CMY to use. |  |
|  | Y1 | Transistor output 1 | The following functions can be set at terminals Y 1 to Y 3 for signal output. <br> - The setting of "short circuit upon active signal output" or "open upon active signal output" is possible. <br> - Sink/source support (switching unnecessary) | Max. voltage: 27 Vdc , max. current: 50 mA , leak current: 0.1 mA max., ON voltage: within 2 V (at 50 mA ) | E20 |
|  | Y2 | Transistor output 2 |  |  | E21 |
|  | Y3 | Transistor output 3 |  |  | E22 |
|  | (RUN) | Inverter running (speed exists) | An active signal is issued when the inverter runs at higher than the starting frequency. |  |  |
|  | (RUN2) | Inverter output on | Asignal is issued when the inverter runs at smaler than the starting frequency or when DC braking is in action. |  |  |
|  | (FAR) | Speed/freq- arrival | An active signal is issued when the output frequency reaches the set frequency. | Detection width (fixed): $2.5(\mathrm{~Hz})$ |  |
|  | (FDT) | Speed/freq. detection | An active signal is issued at output frequencies above a preset detection level. The signal is deactivated if the output frequency falls below the detection level. | Hysteresis width (fixed): 1.0 (Hz) | E31 |
|  | (LV) | Undervoltage detection | The signal is output when the inverter stops because of undervoltage. |  |  |
|  | (IOL) | Inverter output limit (limit on current) | The signal is output when the inverter is limiting the current. |  | F43, F44 |
|  | (IPF) | Auto-restarting | The signal is outputduring auto restart operation (ater momentary power failure and until completion of restar). |  | F14 |
|  | (OL) | Overload early warning (motor) | The signal is output when the electronic thermal relay value is higher than the preset alarm level. |  | F10 to F12 |
|  | (RDY) | Operation ready output | A signal is issued if preparation for inverter operation is completed. |  |  |
|  | (SW88) | Line-to-inverter switching | The magnetic contactor on the line side of line-to-inverter switching is controlled. |  |  |
|  | (SW52-2) | Line-to-inverter switching | The magnetic contactor on the inverter output side (secondary side) of line-to-inverter swith ing is controlled. |  |  |
|  | (SW52-1) | Line-to-inverter switching | The magnetic contactor on the inverter input side (primary side) of line-to-inverter switching is controlled. |  |  |
|  | (AX) | AX terminal function | The electromagnetic contactor on the inverter input side (primary side) is controlled. |  |  |
|  | (FAN) | Cooling fan ON/OFF control | The ON/OFF signal of the cooling fan is issued. |  | H06 |
|  | (TRY) | Retry in action | The signal is output during an active retry. |  | H04, H05 |
|  | (U-DO) | Universal DO | The signal transmitted from the host controller is issued. |  |  |
|  | (OH) | Heat sink overheat early warning | An early warning signal is issued before the heat sink trips due to an overheat. |  |  |
|  | (LIFE) | Lifetime alarm | Outputs alarm signal according to the preset lifetime level. |  | H42, H43, 498 |
|  | (REF OFF) | Command loss detection | A loss of the frequency command is detected. |  | E65 |
|  | (OLP) | Overload preventive control | The signal is output when the overload control is activated. |  | H70 |
|  | (ID) | Current detection | The signal is output when a current larger than the set value has been detected for the timer-set time. |  | E34, E35 |
|  | (PID-ALM) | PID alarm output | An absolute value alarm or deviation alarm under PID control is issued as a signal. |  | J11 to J13 |
|  | (PID-CTL) | Under PID control | The valid state of PID control is issued as a signal. |  |  |
|  | (PID-STP) | PID stop upon small water flow |  |  | J15 to J17 |
|  | (U-TL) | Low torque detection | A signal is issued if the torque falls below the preset low torque detection level for a set time. |  | E80, E81 |
|  | (RMT) | In remote mode | A signal is issued in the remote mode. |  |  |
|  | (AXX2) | Operation command input | A signal is issued if there is an operation command input and operation ready is completed. |  |  |
|  | (ALM) | Alarm relay output (for any faut) | An alarm relay output (for any fault) signal is issued as a transistor output signal. |  |  |
|  | CMY | Transistor output common | Common terminal for transistor output | The terminal is isolated from terminals 11 and CM. |  |
| - | Y5A,Y5C | General-purpose relay output | - Mutti-purpose relay output; signals similar to above-mentioned signals Y1 to Y3 can be selected. <br> - An alarm output is issued upon either excitation or no excitation according to selection. | $\text { Contact capacity: } 250 \mathrm{VAC}, 0.3 \mathrm{~A}, \cos \phi=0.3$ $+48 \mathrm{VDC}, 0.5 \mathrm{~A}$ | E24 |
|  | 30A,30B,30C | Alarm relay output (for any fault) | - A no-voltage contact signal (1c) is issued when the inverter is stopped due to an alarm. <br> - Multi-purpose relay output; signals simila to above-mentioned signals Y 1 to Y 3 can be selected. <br> - An alarm output is issued upon either excitation or no excitation according to selection. |  | E27 |
|  | $-$ | RJ45 connector for connection with the keypad | One of the following protocols can be selected. <br> - Modbus RTU <br> - Protocol exclusively for keypad (default selection) <br> - Fuji's special inverter protocol <br> - SX protocol for PC loader | Power ( +5 V ) is supplied to the keypad. | $\begin{array}{\|l} \mathrm{H} 30 \\ \text { y01 to y20 } \\ \text { y98, y99 } \end{array}$ |

## Terminal Arrangement

## - Main circuit terminals



## - Control circuit terminals (common to all models)



## Keypad Operations

## Keypad switches and functions

## LED monitor

When the motor is running or stopped:
The monitor displays parameters such as output frequency, set frequency, motor speed, load shaft speed, output voltage, output current, and input power.
Alarm mode:
The monitor shows the alarm description with a fault code
Program/Reset key
Used to change the mode.
Programming mode:
Used to shift the digit (cursor movement) to set data.
Alarm mode:
Resets a trip.

## Function/Data select key

Used to change the LED monitor and to store the function code and data.

## Operation mode display

## During keypad operation:

 (keypad operation), the green KEYPAD CONTROL LED lights up.

## During operation:

The green RUN LED lights up.

## Unit display

The unit of the data displayed at the LED monitor is indicated. Use the key to switch the displayed data.

## Run key

Used to start the operation.

## While the motor is stopped:

This key is invalid if the function code is set to $\qquad$ (operation by external signals)

Up/Down keys
During operation :Used to increase or decrease the frequency or motor speed.
In data setting
:Used to indicate the function code number or to change data set value.

Stop key
Used to stop the operation.
During operation:
This key is invalid if the function code by external signals).
The inverter stops when the function code 89 is set to $\square \square$ or प—

Monitor display and key operation

| Monitor, keys |  |  | Programming mode |  | Running mode |  | Alarm mode |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | STOP | RUN | STOP | RUN |  |
|  |  | Function <br> Display | Displays the function code or data. |  | Displays the output frequency, set frequency, loaded motor speed, required power, output current, and output voltage. |  | Displays the alarm description and alarm history. |
|  |  |  | ON |  | Blinking | ON | Blinking/ON |
|  |  | Function | The program mode is indicated. |  | Displays the unit of frequency, output current, required power, speed, and line speed. |  | None |
|  | PRG.MODE <br> $\square \mathrm{Hz} \square \mathrm{A}$ <br> $\mathrm{rlmin} \\| \mathrm{m} / \mathrm{min}$ <br> kW | Display | $\begin{aligned} & \text { PRG.MO } \\ & \text { ■ Hz } \\ & \text { romin } \end{aligned}$ | $\text { mind } \mathrm{kWON}$ |  |  | OFF |
|  | KEYPAD | Function |  | Operation selection | (keypad operation/termi | operation) is displayed. |  |
|  | CONTROL | Display |  |  | Lit in keypad operation m |  |  |
|  |  | Function | Absence of operation command is displayed. | Presence of operation command is displayed. | Absence of operation command is displayed. | Presence of operation command is displayed. | Stoppage due to trip is displayed. |
|  | $\square$ RUN | Display | $\square$ RUN unlit | $\square$ RUN lit | $\square$ RUN unlit | $\square$ RUN lit | If an alarm occurs during operation, unlit during keypad operation or lit during terminal block operation. |
|  | PRG | Function | Switches to running mo <br> Digit shift (cursor move | de <br> ment) in data setting | Switches to programming | mode | Releases the trip and switches to stop mode or running mode. |
| $\stackrel{n}{ }$ | ( ${ }_{\text {OUNC }}$ DAIA | Function | Determines the function and updates data. | code, stores | Switches the LED monito | display. | Displays the operation information. |
| ฐ |  | Function | Increases/decreases th and data. | he function code | Increases/decreases the motor speed and other | requency, ttings. | Displays the alarm history. |
|  | RUN | Function | Invalid |  | Starts running (switches to running mode (RUN)). | Invalid | Invalid |
|  | STOP | Function | Invalid | Deceleration stop (Switches to programming mode STOP). | Invalid | Deceleration stop (Switches to running mode STOP). | Invalid |

This keypad supports a full menu mode which allows you to set or display the following information:
Indication and setting change of changed function code, drive monitor, I/O check, maintenance information, and alarm information.
For concrete operation methods, refer to the FRENIC-Eco Instruction Manual or User's Manual.

## Function Settings

## Function Settings

## OF codes: Fundamental Functions

\begin{tabular}{|c|c|c|c|c|c|c|}
\hline Code \& Name \& Data setting range \& Increment \& Unit \& \[
\begin{gathered}
\text { Data } \\
\text { copying }
\end{gathered}
\] \& Default setting \\
\hline F00 \& Data Protection \& \begin{tabular}{l}
0 : Disable data protection \\
1 : Enable data protection
\end{tabular} \& - \& - \& Y \& 0 \\
\hline FOi \& Frequency Command 1 \& \begin{tabular}{l}
0 : Enable / \(^{\prime}\) keys on keypad \\
1 : Enable voltage input to terminal [12] ( 0 to 10 VDC) \\
2 : Enable current input to terminal [C1] ( 4 to 20 mADC ) \\
3 : Enable sum of voltage and current inputs to terminals [12] and [C1] \\
5 : Enable voltage input to terminal [V2] (0 to 10 VDC) \\
7 : Enable terminal command (UP) / (DOWN) control
\end{tabular} \& - \& - \& Y \& 0 \\
\hline \(F 02\) \& Run Command \& ```
0: (00)/ /00) keypad operation (Rotational direction conforms to the digital input signal)
1: External signal (digital input signal)
2: keypad operation (FWD)
3: (0N)/ keypad operation (REV)
``` \& - \& - \& Y \& 2 \\
\hline F03 \& Maximum Frequency \& 25.0 to 120.0 \& 0.1 \& Hz \& Y \& Refer to table below. \\
\hline F84 \& Base Frequency \& 25.0 to 120.0 \& 0.1 \& Hz \& Y \& Referer to table below. \\
\hline F05 \& Rated Voltage at Base Frequency \& 0 : Output a voltage in proportion to input voltage 80 to 240 V : Output a voltage AVR-controlled (for 3-phase 200 V series) 160 to 500 V : Output a voltage AVR-controlled (for 3-phase 400 V series) \& 1 \& V \& Y2 \& Refer to table below. \\
\hline FD7 \& Acceleration Time 1 \& 0.00 to 3600s Note: Entering 0.00 cancels the acceleration time, requiring external soft-start. \& 0.01 \& s \& Y \& 20.0 \\
\hline F08 \& Deceleration Time 1 \& 0.00 to 3600s Note: Entering 0.00 cancels the deceleration time, requiring external soft-stop. \& 0.01 \& s \& Y \& 20.0 \\
\hline F09 \& Torque Boost \& 0.0 to 20.0 (Percentage of the rated voltage at base frequency (F05)) Note: This setting is effective when \(\mathrm{F} 37=0,1,3\), or 4 . \& 0.1 \& \% \& Y \& Refer to table below. \\
\hline Fit \& \multirow[t]{3}{*}{\begin{tabular}{l}
Electronic Thermal Overload Protection for Motor (Select motorcharacteristics) (Overload detection level) \\
(Thermal time constant)
\end{tabular}} \& \begin{tabular}{l}
1 : For general-purpose motors with built-in self-cooling fan \\
2 : For separately excited motor fan
\end{tabular} \& - \& - \& Y \& 1 \\
\hline \(F i!\) \& \& \begin{tabular}{l}
0.00: Disable \\
1 to \(135 \%\) of the rated current (allowable continuous drive current) of the motor
\end{tabular} \& 0.01 \& A \& \[
\begin{aligned}
\& \mathrm{Y} 1 \\
\& \mathrm{Y} 2 \\
\& \hline
\end{aligned}
\] \& \(100 \%\) of the motor rated current \\
\hline \(F i z\) \& \& 0.5 to 75.0 \& 0.1 \& min \& Y \& 5 (22 kW or below) 10 (30 kW or above) \\
\hline Fi4 \& Restart Mode after Momentary Power Failure (Mode selection) \& \begin{tabular}{l}
0 : Disable restart (Trip immediately without restart) \\
1 : Disable restart (Trip after a recovery from power failure without restart) \\
3 : Enable restart (Continue to run, for heavy inertia or general loads) \\
4 : Enable restart (Restart at the frequency at which the power failure occurred, for general loads) \\
5 : Enable restart (Restart at the starting frequency, for low-inertia load)
\end{tabular} \& - \& - \& Y \& \[
\begin{gathered}
1 \\
(0){ }^{*} 2
\end{gathered}
\] \\
\hline Fi5 \& \multirow[t]{2}{*}{Frequency Limiter \(\begin{gathered}\text { (High) } \\ \text { (Low) }\end{gathered}\)} \& 0.0 to 120.0 \& 0.1 \& Hz \& Y \& 70.0 \\
\hline F is \& \& 0.0 to 120.0 \& 0.1 \& Hz \& Y \& 0.0 \\
\hline F is \& Bias (Frequency command 1) \& -100.00 to 100.00 *1 \& 0.01 \& \% \& Y \& 0.00 \\
\hline \(F 20\) \& \multirow[t]{3}{*}{DC Braking (Braking start frequency) (Braking level) (Braking time)} \& 0.0 to 60.0 \& 0.1 \& Hz \& Y \& 0.0 \\
\hline FEI \& \& 0 to 60 (Rated output current of the inverter interpreted as 100\%) \& 1 \& \% \& Y \& 0 \\
\hline F2e \& \& 0.00 : Disable 0.01 to 30.00 \& 0.01 \& S \& Y \& 0.00 \\
\hline F23 \& Starting Frequency \& 0.1 to 60.0 \& 0.1 \& Hz \& Y \& 0.5 \\
\hline F25 \& Stop Frequency \& 0.1 to 60.0 \& 0.1 \& Hz \& Y \& 0.2 \\
\hline F25 \& Motor Sound (Carrier frequency) \& \begin{tabular}{l}
0.75 to 15 ( 22 kW or below) *1 \\
0.75 to 10 ( 30 to 75 kW ) \\
0.75 to 6 ( 90 kW or above)
\end{tabular} \& 1 \& kHz \& Y \& \[
\begin{gathered}
2 \\
(15 / 10 / 6) * 2
\end{gathered}
\] \\
\hline \(F 27\) \& (Tone) \& \begin{tabular}{l}
0 : Level 0 (Inactive) \\
1 : Level 1 \\
2 : Level 2 \\
3 : Level 3
\end{tabular} \& - \& - \& Y \& 0 \\
\hline F29 \& \multirow[t]{2}{*}{\begin{tabular}{l}
Analog Output [FMA] \\
(Mode selection) (Output adjustment)
\end{tabular}} \& \begin{tabular}{l}
0 : Output in voltage ( 0 to 10 VDC ) \\
1 : Output in current ( 4 to 20 mADC )
\end{tabular} \& - \& - \& Y \& 0 \\
\hline F30 \& \& 0 to 200 \& 1 \& \% \& Y \& 100 \\
\hline F3i \& (Function) \& \begin{tabular}{l}
Select a function to be monitored from the followings. \\
0 : Output frequency \\
2 : Output current \\
3 : Output voltage \\
4 : Output torque \\
5 : Load factor \\
6 : Input power \\
7 : PID feedback value (PV) \\
9 : DC link bus voltage \\
10 : Universal AO \\
13 : Motor output \\
14 : Test analog output \\
15 : PID process command (SV) \\
16 : PID process output (MV)
\end{tabular} \& - \& - \& Y \& 0 \\
\hline F33 \& \multirow[t]{2}{*}{Pulse Output [FMP] *3

(Pulse rate)
(Duty)} \& 25 to 6000 (Pulse rate at 100\% output) \& 1 \& $\mathrm{p} / \mathrm{s}$ \& Y \& 1440 <br>

\hline F34 \& \& | 0 : Output pulse rate (Fixed at $50 \%$ duty) |
| :--- |
| 1 to 200 : Voltage output adjustment (Pulse rate is fixed at 2000 p/s. Adjust the maximum pulse duty.) | \& 1 \& \% \& Y \& 0 <br>

\hline
\end{tabular}

## Function Settings

Function Settings
OF codes: Fundamental Functions

| Code | Name | Data setting range | Increment | Unit | $\begin{gathered} \text { Data } \\ \text { copying*2 } \end{gathered}$ | Default setting |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| F35 | Terminal FMP (Function) | Select a function with the code number from the followings. <br> 0 : Output frequency <br> 2 : Output current <br> 3 : Output voltage <br> 4 : Output torque <br> 5 : Load factor <br> 6 : Input power <br> 7 : PID feedback value (PV) <br> 9 : DC link bus voltage <br> 10 : Universal AO <br> 13 : Motor output <br> 14 : Test analog output <br> 15 : PID process command (SV) <br> 16 : PID process output (MV) | - | - | Y | 0 |
| F37 | Load Selection/ Auto Torque Boost/ Auto Energy Saving Operation | 0 : Variable torque load (increasing in proportion to square of speed) <br> 1 : Variable torque load (Higher startup torque required) <br> 2 : Auto-torque boost <br> 3 : Auto-energy saving operation(Variable torque load) <br> 4 : Auto-energy saving operation(Variable torque load) (Higher startup torque required)Note:Apply this setting to a load with short acceleration time. <br> 5 : Auto-energy saving operation(Auto torque boost)/Note: Apply this setting to a load with long acceleration time. | - | - | Y | 1 |
| $F 43$ | Current Limiter <br> (Mode selection) | 0 : Disable (No current limiter works.) <br> 1 : Enable at constant speed (Disabled during acceleration and deceleration) <br> 2 : Enable during acceleration and at constant speed | - | - | Y | 0 |
| F44 |  | 20 to 120 (The data is interpreted as the rated output current of the inverter for $100 \%$.) | 1 | \% | Y | 110 |

E codes: Extension Terminal Functions


[^35]*3 When setting the carrier frequency at 1 kHz or below, lower the maximum motor load to $80 \%$ of the rated load.
<Changing, setting, and saving data during operation>
$\square$ : No data change allowed $\square$ : Change with $\triangle$ key, and set and save with key. $\square$ : Change and set with $\triangle$ key, and save with key.

E codes: Extension Terminal Functions


## Function Settings

Function Settings
OE codes: Extension Terminal Functions

*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is as follows:
"1" for -200 to -100, " 0.1 " for -99.9 to $-10.0, ~ " 0.01 "$ for -9.99 to $-0.01, ~ " 0.01 "$ for 0.00 to 99.99 , and " 0.1 " for 100.0 to 200.0
*2 Symbols used in the data copy column:
Y: Copied
Y1: Not copied if the inverter capacity differs.
Y : Not copied if the voltage series differs.
N : Not copied
*3 When setting the carrier frequency at 1 kHz or below, lower the maximum motor load to $80 \%$ of the rated load.
<Changing, setting, and saving data during operation>
$\square$ : No data change allowed $\square$ $\qquad$ Change with
key, and set and save with $\qquad$ Change and set with key, and save with

## C codes: Control Functions of Frequency

| Code | Name | Data setting range | Increment | Unit | $\begin{gathered} \text { Data } \\ \text { copying } \end{gathered}$ | Default setting |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| [Di | Jump Frequency 1  <br> 2  <br> 3 (Band) | 0.0 to 120.0 | 0.1 | Hz | Y | 0.0 |
| [02 |  |  |  |  | Y | 0.0 |
| $[03$ |  |  |  |  | Y | 0.0 |
| [04 |  | 0.0 to 30.0 | 0.1 | Hz | Y | 0.3 |
| [05 | Multistep Frequency 11 | 0.00 to 120.00 | 0.01 | Hz | Y | 0.00 |
| [06 |  |  |  |  | Y | 0.00 |
| [07 |  |  |  |  | Y | 0.00 |
| [08 |  |  |  |  | Y | 0.00 |
| [09 |  |  |  |  | Y | 0.00 |
| [10] |  |  |  |  | Y | 0.00 |
| [it |  |  |  |  | Y | 0.00 |
| 530 | Frequency Command 2 | 0 : Enable $\Delta^{\prime} \checkmark$ keys on keypad <br> 1 : Enable voltage input to terminal [12] (0 to 10 VDC) <br> 2 : Enable current input to terminal [C1] (4 to 20 mADC ) <br> 3 : Enable sum of voltage and current inputs to terminals [12] and [C1] <br> 5 : Enable voltage input to terminal [V2] (0 to 10 VDC) <br> 7 : Enable terminal command (UP) / (DOWN) control | - | - | Y | 2 |
| $\underline{[32}$ | Analog Input Adjustment for [12] (Gain) | 0.00 to 200.00 *1 | 0.01 | \% | Y | 100.0 |
| $[33$ | (Filter time constant) | 0.00 to 5.00 | 0.01 | S | Y | 0.05 |
| [34 | (Gain reference point) | 0.00 to 100.00 *1 | 0.01 | \% | Y | 100.0 |
| [37 | Analog Input Adjustment for [C1] (Gain) | 0.00 to 200.00 *1 | 0.01 | \% | Y | 100.0 |
| [38 | (Filter time constant) | 0.00 to 5.00 | 0.01 | s | Y | 0.05 |
| $[39$ | (Gain reference point) | 0.00 to 100.00 *1 | 0.01 | \% | Y | 100.0 |
| [42] | Analog Input Adjustment for [V2] (Gain) | 0.00 to 200.00 *1 | 0.01 | \% | Y | 100.0 |
| $[4]$ | (Filter time constant) | 0.00 to 5.00 | 0.01 | s | Y | 0.05 |
| [44 | (Gain reference point) | 0.00 to 100.00 *1 | 0.01 | \% | Y | 100.0 |
| [50 | Bias Reference Point (Frequency command 1) | 0.00 to 100.0 | 0.01 | \% | Y | 0.00 |
| [5i | Bias for PID command 1 (Bias value) | -100.0 to $100.00 * 1$ | 0.01 | \% | Y | 0.00 |
| [52] | (Bias reference point) | 0.00 to 100.00 *1 | 0.01 | \% | Y | 0.00 |
| $[53$ | Selection of Normal/ Inverse Operation (Frequency command 1) | 0 : Normal operation <br> 1 : Inverse operation | - | - | Y | 0 |

## codes: Motor Parameters

| Code | Name | Data setting range | Increment | Unit | $\begin{gathered} \text { Data } \\ \text { copying } 2 \end{gathered}$ | Default setting |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| PG | Motor (No. of poles) | 2 to 22 | 2 | Pole | $\begin{aligned} & \mathrm{Y} 1 \\ & \mathrm{Y} 2 \end{aligned}$ |  |
| 902 | (Rated capacity) | 0.01 to 1000 (where, the data of function code P99 is 0,3 , or 4 .) 0.01 to 1000 (where, the data of function code P99 is 1.) | $\begin{aligned} & 0.01 \\ & 0.01 \\ & \hline \end{aligned}$ | $\begin{aligned} & \mathrm{kW} \\ & \mathrm{HP} \\ & \hline \end{aligned}$ | $\begin{aligned} & \mathrm{Y} 1 \\ & \mathrm{Y} 2 \\ & \hline \end{aligned}$ | Rated capacity of motor |
| 903 |  | 0.00 to 2000 | 0.01 | A | Y1Y2 | Rated dreneiof Fiy ijaraxadmor |
| P04 | (Auto-tuning) | 0 : Disable <br> 1 : Enable (Tune \%R1 and \%X while the motor is stopped.) <br> 2 : Enable (Tune \%R1 and \%X while the motor is stopped, and no-load current while running.) | - | - | N | 0 |
| P05 | (No-load current) | 0.00 to 2000 | 0.01 | A | Y1Y2 | Redevilue offijistandadmovor |
| PO7 | (\%R1) | 0.00 to 50.00 | 0.01 | \% | Y1Y2 |  |
| P08 | (\%X) | 0.00 to 50.00 | 0.01 | \% | Y1Y2 | Raled value ofijustandadmior |
| 999 | Motor Selection | 0 : Characteristics of motor 0 (Fuji standard motors, 8-series and 9-series) <br> 1 : Characteristics of motor 1 (HP-rated motors) <br> 3 : Characteristics of motor 3 (Fuji standard motors, 6 -series and 9 -series) <br> 4 : Other motors | - | - | Y1Y2 | 0 |

## OH codes: High Performance Functions

| Code | Name | Data setting range | Increment | Unit | $\begin{array}{c\|} \hline \text { Data } \\ \text { copying } \end{array}$ | Default setting |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| H03 | Data Initialization | 0 : Disable initialization <br> 1 : Initialize all function code data to the factory defaults <br> 2 : Initialize motor parameters | - | - | N | 0 |
| H04 | Auto-resetting (Times) | $\begin{array}{\|l} \hline 0 \text { : Disable } \\ 1 \text { to } 10 \\ \hline \end{array}$ | 1 | Times | Y | 0 |
| H05 | (Reset interval) | 0.5 to 20.0 | 0.1 | s | Y | 5.0 |
| H05 | Cooling Fan ON/OFF Control | 0 : Disable (Always in operation) <br> 1 : Enable (ON/OFF controllable) | - | - | Y | 0 |
| H07 | Acceleration/Deceleration Pattern | $\begin{aligned} & 0 \text { : Linear } \\ & 1: \text { S-curve (Weak) } \\ & 2: \text { S-curve (Strong) } \\ & 3: \text { Curvilinear } \end{aligned}$ | - | - | Y | 0 |
| 409 | Select Starting Characteristics (Auto search for idling motor speed) | 0 : Disable <br> 3 : Enable (Follow Run command, either forward or reverse.) <br> 4 : Enable (Follow Run command, both forward and reverse.) <br> 5 : Enable (Follow Run command, inversely both forward and reverse.) | - | - | Y | 0 |
| Hil | Deceleration Mode | 0 : Normal deceleration <br> 1 : Coast-to-stop | - | - | Y | 0 |
| Hiz | Instantaneous Overcurrent Limiting (Mode selection) | 0 : Disable 1 : Enable | - | - | Y | 1 |

## Function Settings

## Function Settings

OH codes: High Performance Functions


[^36]
## OJ codes: Application Functions

| Code | Name | Data setting range | Increment | Unit | $\begin{gathered} \text { Data } \\ \text { copying+2 } \end{gathered}$ | Default setting |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| dil | PID Control (Mode selection) | 0 : Disable <br> 1 : Enable (normal operation) <br> 2 : Enable (inverse operation) | - | - | Y | 0 |
| 102 | (Remote process command) | 0 : Enable ${ }^{\prime}$ keys on keypad <br> 1 : PID process command 1 <br> 3 : Enable terminal command (UP) / (DOWN) control <br> 4 : Command via communications link | - | - | Y | 0 |
| 403 | P (Gain) | 0.000 to 30.000 *1 | 0.001 | Times | Y | 0.100 |
| 404 | 1 (Integral time) | 0.0 to 3600.0 * | 0.1 | s | Y | 0.0 |
| 405 | D (Differential time) | 0.00 to 600.00 *1 | 0.01 | s | Y | 0.00 |
| 405 | (Feedback filter) | 0.0 to 900.0 | 0.1 | S | Y | 0.5 |
| LiO | (Anti reset windup) | 0 to 200 | 1 | \% | Y | 200 |
| -i' | (Select alarm output) | 0 : Absolute-value alarm <br> 1 : Absolute-value alarm (with Hold) <br> 2 : Absolute-value alarm (with Latch) <br> 3 : Absolute-value alarm (with Hold and Latch) <br> 4 : Deviation alarm <br> 5 : Deviation alarm (with Hold) <br> 6 : Deviation alarm (with Latch) <br> 7 : Deviation alarm (with Hold and Latch) | - | - | Y | 0 |
| Lic | (Upper limit alarm (AH)) | 0 to 100 | 1 | \% | Y | 100 |
| 413 | (Lower limit alarm (AL)) | 0 to 100 | 1 | \% | Y | 0 |
| 415 | (Stop frequencyfor slow flowrate) | 0 : Disable1 to 120 | 1 | Hz | Y | 0 |
| ¢ 'is | (Slow flowrate level stop latency) | 1 to 60 | 1 | s | Y | 30 |
| Li7 | (Starting frequency) | 0 : Disable1 to 120 | 1 | Hz | Y | 0 |
| 4 Lig | (Upper limit of PIDprocess output) | 1 to 120 999: Depends on setting of F15 | 1 | Hz | Y | 999 |
| 419 | (Lower limit of PIDprocess output) | 1 to 120 999: Depends on setting of F16 | 1 | Hz | Y | 999 |
| L己 | Dew Condensation Prevention (Duty) | 1 to 50 | 1 | \% | Y |  |
| Uट2 | Commercial Power Switching Sequence | 0 : Keep inverter operation (Stop due to alarm) <br> 1 : Automatically switch to commercial-power operation | - | - | Y | 0 |

## Oy codes: Link Functions

| Code | Name | Data setting range | Increment | Unit | $\begin{gathered} \text { Data } \\ \text { copying } \end{gathered}$ | Default setting |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 401 | RS485 Communication (Station address) | 1 to 255 | 1 | - | Y | 1 |
| 402 | (Communications error processing) | 0 : Immediately trip and alarm $E r B$ <br> 1 : Trip and alarm $E_{r} B$ after running for the period specified by timer y03 <br> 2 : Retry during the period specified by timer y03. If retry fails, trip and alarm $\varepsilon_{r} B$. If it succeeds, continue to run. <br> 3 : Continue to run | - | - | Y | 0 |
| 403 | (Error processing timer) | 0.0 to 60.0 | 0.1 | s | Y | 2.0 |
| 404 | (Transmission speed) | $0: 2400 \mathrm{bps}$ $1: 4800 \mathrm{bps}$ $2: 9600 \mathrm{bps}$ $3: 19200 \mathrm{bps}$ $4: 38400 \mathrm{bps}$ | - | - | Y | 3 |
| 405 | (Data length) | $\begin{aligned} & 0: 8 \text { bits } \\ & 1: 7 \text { bits } \\ & \hline \end{aligned}$ | - | - | Y | 0 |
| 405 | (Parity check) | 0 : None <br> 1 : Even parity <br> 2 : Odd parity | - | - | Y | 0 |
| 407 | (Stop bits) | $\begin{aligned} & 0: 2 \text { bits } \\ & 1: 1 \text { bit } \\ & \hline \end{aligned}$ | - | - | Y | 0 |
| 408 | (No-response error detection time) | 0 (No detection), 1 to 60 | 1 | s | Y | 0 |
| 409 | (Response latency time) | 0.00 to 1.00 | 0.01 | s | Y | 0.01 |
| 410 | (Protocol selection) | 0 : Modbus RTU protocol <br> 1: FRENIC Loader protocol (SX protocol) <br> 2 : Fuji general-purpose inverter protocol | - | - | Y | 1 |

*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00 , the incremental unit is as follows:
"1" for -200 to $-100, " 0.1 "$ for -99.9 to $-10.0, ~ " 0.01$ " for -9.99 to $-0.01, ~ " 0.01 "$ for 0.00 to 99.99 , and " 0.1 " for 100.0 to 200.0
*2 Symbols used in the data copy column:
Y: Copied
Y1: Not copied if the inverter capacity differs.
Y2: Not copied if the voltage series differs.
N : Not copied
*3 When setting the carrier frequency at 1 kHz or below, lower the maximum motor load to $80 \%$ of the rated load.
<Changing, setting, and saving data during operation>
$\square$ : No data change allowed $\square$ : Change with $\triangle$ key, and set and save with key. $\square$ : Change and set with $\triangle \vee$ key, and save with

## Function Settings

## Function Settings

y codes: Link Functions

| Code | Name | Data setting range |  |  | Increment | Unit | $\begin{gathered} \text { Data } \\ \text { copying² } \end{gathered}$ | Default setting |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| git | RS-485 Communication 2 (Station address) | 1 to 255 |  |  | 1 | - | Y | 1 |
| $3 i 2$ | (Communications error processing) | 0 : Immediately trip and alarm $\varepsilon r^{P}$ ? <br> 1: Trip and alarm $E_{r} P$ after running for the period specified by timer y13. <br> 2 : Retry during the period specified by timer y13. If retry fails, trip and alarm $E_{r} P$. If it succeeds, continue to run. <br> 3 : Continue to run. |  |  | - | - | Y | 0 |
| 313 | (Error processing timer) (Transmission speed) | 0.0 to 60.0 |  |  | 0.1 | s | Y | 2.0 |
| 34 |  | $\begin{aligned} & \hline 0: 2400 \mathrm{bps} \\ & 1: 4800 \mathrm{bps} \\ & 2: 9600 \mathrm{bps} \\ & 3: 19200 \mathrm{bps} \\ & 4: 38400 \mathrm{bps} \\ & \hline \end{aligned}$ |  |  | - | - | Y | 3 |
| 315 | (Data length) <br> (Parity check) | $\begin{aligned} & 0: 8 \text { bits } \\ & 1: 7 \text { bits } \end{aligned}$ |  |  | - | - | Y | 0 |
| צ15 |  | 0 : None <br> 1 : Even parity <br> 2 : Odd parity |  |  | - | - | Y | 0 |
| 517 | (Stop bits) | $0: 2$ bits$1: 1$ bit |  |  | - | - | Y | 0 |
| 318 | (No-response error detection time) (Response latency time) (Protocol selection) | 0 : (No detection),$1 \text { to } 60$ |  |  | 1 | s | Y | 0 |
| 319 |  | 0 : Modbus RTU protocol |  |  | 0.01 | s | Y | 0.01 |
| 420 |  |  |  |  | - | - | Y | 0 |
| 498 | Bus Link Function <br> (Mode selection) |  | Frequency command | Run command | - | - | Y | 0 |
|  |  | 0: | Follow H3O data | Follow H30 data |  |  |  |  |
|  |  | 1: | Via field bus option | Follow H30 data |  |  |  |  |
|  |  | 2: | Follow H30 data | Via field bus option |  |  |  |  |
|  |  | 3: | Via field bus option | Via field bus option |  |  |  |  |
| 439 | Loader Link Function (Mode selection) |  | Frequency command | Run command | - | - | N | 0 |
|  |  | 0: | Follow H30 and y98 data | Follow H30 and y98 data |  |  |  |  |
|  |  | 1: | Via RS-485 link (Loader) | Follow H30 and y98 data |  |  |  |  |
|  |  | 2: | Follow H30 and y98 data | Via RS-485 link (Loader) |  |  |  |  |
|  |  | 3: | Via RS-485 link (Loader) | Via RS-485 link (Loader) |  |  |  |  |

*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00 , the incremental unit is as follows:
"1" for -200 to $-100, ~ " 0.1 "$ for -99.9 to $-10.0, ~ " 0.01 "$ for -9.99 to $-0.01, " 0.01$ " for 0.00 to 99.99 , and " 0.1 " for 100.0 to 200.0
*2 Symbols used in the data copy column.
Y: Copied
Y1: Not copied if the inverter capacity differs.
Y2: Not copied if the voltage series differs.
N : Not copied
*3 When setting the carrier frequency at 1 kHz or below, lower the maximum motor load to $80 \%$ of the rated load.
<Changing, setting, and saving data during operation>
$\square$ : No data change allowed $\square$ : Change with $\triangle$ key, and set and save with key. $\square$ : Change and set with $\triangle$ key, and save with key.

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## Peripheral Equipment Connection Diagrams



## Options



| Power supply voltage | Applicable motor rating (kW) | Inverter type | REACTOR type | Fig. | Dimension (mm) |  |  |  |  |  |  |  |  | Mass (kg) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | W | W1 | D | D1 | D2 | D3 | H | $\left\lvert\, \begin{gathered} \text { Mounting } \\ \text { hole } \end{gathered}\right.$ | $\begin{array}{\|c\|} \hline \text { Terminal } \\ \text { hole } \end{array}$ |  |
| 3-phase 200V | 0.75 | FRN0.75F1 $\square$-2A | DCR2-0.75 | A | 66 | 56 | 90 | 72 | 20 | - | 94 | $5.2 \times 8$ | M4 | 1.4 |
|  | 1.5 | FRN1.5F1 $\square$-2A | DCR2-1.5 | A | 66 | 56 | 90 | 72 | 20 | - | 94 | $5.2 \times 8$ | M4 | 1.6 |
|  | 2.2 | FRN2.2F1 $\square$-2A | DCR2-2.2 | A | 86 | 71 | 100 | 80 | 10 | - | 110 | $6 \times 11$ | M4 | 1.8 |
|  | 3.7 | FRN3.7F1 $\square$-2A | DCR2-3.7 | A | 86 | 71 | 100 | 80 | 20 | - | 110 | $6 \times 11$ | M4 | 2.6 |
|  | 5.5 | FRN5.5F1 $\square$-2A | DCR2-5.5 | A | 111 | 95 | 100 | 80 | 20 | - | 130 | $7 \times 11$ | M5 | 3.6 |
|  | 7.5 | FRN7.5F1 $\square$-2A | DCR2-7.5 | A | 111 | 95 | 100 | 80 | 23 | - | 130 | $7 \times 11$ | M5 | 3.8 |
|  | 11 | FRN11F1 $\square$-2A | DCR2-11 | A | 111 | 95 | 100 | 80 | 24 | - | 137 | $7 \times 11$ | M6 | 4.3 |
|  | 15 | FRN15F1 $\square$-2A | DCR2-15 | A | 146 | 124 | 120 | 96 | 15 | - | 180 | $7 \times 11$ | M6 | 5.9 |
|  | 18.5 | FRN18.5F1 $\square$-2A | DCR2-18.5 | A | 146 | 124 | 120 | 96 | 25 | - | 180 | $7 \times 11$ | M8 | 7.4 |
|  | 22 | FRN22F1 $\square$-2A | DCR2-22A | A | 146 | 124 | 120 | 96 | 25 | - | 180 | $7 \times 11$ | M8 | 7.5 |
|  | 30 | FRN30F1 $\square$-2A | DCR2-30B | B | $152 \pm 3$ | $90 \pm 1$ | $156 \pm 3$ | $116 \pm 2$ | 115 | $78 \pm 5$ | 130 | 8 | M8 | 12 |
|  | 37 | FRN37F1 $\square$-2A | DCR2-37B | B | $171 \pm 3$ | $110 \pm 1$ | $151 \pm 3$ | $110 \pm 2$ | 115 | $75 \pm 5$ | 150 | 8 | M8 | 14 |
|  | 45 | FRN45F1 $\square$-2A | DCR2-45B | B | $171 \pm 3$ | $110 \pm 1$ | $166 \pm 3$ | $125 \pm 2$ | 120 | $86 \pm 5$ | 150 | 8 | M10 | 16 |
|  | 55 | FRN55F1 $\square$-2A | DCR2-55B | C | $190 \pm 3$ | $160 \pm 1$ | $131 \pm 3$ | $90 \pm 2$ | 100 | $65 \pm 5$ | 210 | 8 | M12 | 16 |
|  | 75 | FRN75F1 $\square$-2A | DCR2-75C | D | 255 $\pm 10$ | 225 | $106 \pm 2$ | $86 \pm 1$ | 145 | $53 \pm 1$ | 145 | 6 | M12 | 11.4 |
|  | 90 | FRN90F1 $\square$-2A | DCR2-90C | D | $255 \pm 10$ | 225 | $116 \pm 2$ | 96 | 155 | $58 \pm 1$ | 145 | M6 | M12 | 14 |
|  | 110 | FRN110F1 $\square$-2A | DCR2-110C | D | $300 \pm 10$ | 265 | $116 \pm 4$ | 90 | 185 | $58 \pm 2$ | 160 | M8 | M12 | 17 |
| 3-phase 400V | 0.75 | FRN0.75F1 $\square$-4A | DCR4-0.75 | A | 66 | 56 | 90 | 72 | 20 | - | 94 | $5.2 \times 8$ | M4 | 1.4 |
|  | 1.5 | FRN1.5F1 $\square$-4A | DCR4-1.5 | A | 66 | 56 | 90 | 72 | 20 | - | 94 | $5.2 \times 8$ | M4 | 1.6 |
|  | 2.2 | FRN2.2F1 $\square$-4A | DCR4-2.2 | A | 86 | 71 | 100 | 80 | 15 | - | 110 | $6 \times 9$ | M4 | 2 |
|  | 3.7 | FRN3.7F1 $\square$-4A | DCR4-3.7 | A | 86 | 71 | 100 | 80 | 20 | - | 110 | $6 \times 9$ | M4 | 2.6 |
|  | 5.5 | FRN5.5F1 $\square$-4A | DCR4-5.5 | A | 86 | 71 | 100 | 80 | 20 | - | 110 | $6 \times 9$ | M4 | 2.6 |
|  | 7.5 | FRN7.5F1 $\square$-4A | DCR4-7.5 | A | 111 | 95 | 100 | 80 | 24 | - | 130 | $7 \times 11$ | M5 | 4.2 |
|  | 11 | FRN11F1 $\square$-4A | DCR4-11 | A | 111 | 95 | 100 | 80 | 24 | - | 130 | $7 \times 11$ | M5 | 4.3 |
|  | 15 | FRN15F1 $\square$-4A | DCR4-15 | A | 146 | 124 | 120 | 96 | 15 | - | 171 | $7 \times 11$ | M5 | 5.9 |
|  | 18.5 | FRN18.5F1 $\square$-4A | DCR4-18.5 | A | 146 | 124 | 120 | 96 | 25 | - | 171 | $7 \times 11$ | M6 | 7.2 |
|  | 22 | FRN22F1 $\square$-4A | DCR4-22A | A | 146 | 124 | 120 | 96 | 25 | - | 171 | $7 \times 11$ | M6 | 7.2 |
|  | 30 | FRN30F1 $\square$-4A | DCR4-30B | B | $152 \pm 3$ | $90 \pm 1$ | $157 \pm 3$ | $115 \pm 2$ | 100 | $78 \pm 5$ | 130 | 8 | M8 | 13 |
|  | 37 | FRN37F1 $\square$-4A | DCR4-37B | B | $171 \pm 3$ | $110 \pm 1$ | $150 \pm 3$ | $110 \pm 2$ | 100 | $75 \pm 5$ | 150 | 8 | M8 | 15 |
|  | 45 | FRN45F1 $\square$-4A | DCR4-45B | B | $171 \pm 3$ | $110 \pm 1$ | 165 $\pm 3$ | $125 \pm 2$ | 110 | $82 \pm 5$ | 150 | 8 | M8 | 18 |
|  | 55 | FRN55F1 $\square$-4A | DCR4-55B | B | $171 \pm 3$ | $110 \pm 1$ | $170 \pm 3$ | $130 \pm 2$ | 110 | $85 \pm 5$ | 150 | 8 | M8 | 20 |
|  | 75 | FRN75F1 $\square$-4A | DCR4-75C | D | $255 \pm 10$ | 225 | $106 \pm 2$ | $86 \pm 1$ | 125 | $53 \pm 1$ | 145 | 6 | M10 | 12.4 |
|  | 90 | FRN90F1 $\square$-4A | DCR4-90C | D | $256 \pm 10$ | 225 | $116 \pm 2$ | $96 \pm 1$ | 130 | $58 \pm 1$ | 145 | 6 | M12 | 14.7 |
|  | 110 | FRN110F1 $\square$-4A | DCR4-110C | D | $306 \pm 10$ | 265 | $116 \pm 4$ | $90 \pm 2$ | 140 | $58 \pm 2$ | 155 | 8 | M12 | 18.4 |
|  | 132 | FRN132F1 $\square$-4A | DCR4-132C | D | $306 \pm 10$ | 265 | $126 \pm 4$ | $100 \pm 2$ | 150 | $63 \pm 2$ | 160 | 8 | M12 | 22 |
|  | 160 | FRN160F1 $\square^{\text {- }}$-4A | DCR4-160C | D | $357 \pm 10$ | 310 | $131 \pm 4$ | $103 \pm 2$ | 160 | $65.5 \pm 2$ | 190 | 10 | M12 | 25.5 |
|  | 200 | FRN200F1 $\square$-4A | DCR4-200C | D | $357 \pm 10$ | 310 | $141 \pm 4$ | $113 \pm 2$ | 165 | $70.5 \pm 2$ | 190 | 10 | M12 | 29.5 |
|  | 220 | FRN220F1 $\square$-4A | DCR4-220C | D | $357 \pm 10$ | 310 | $146 \pm 4$ | $118 \pm 2$ | 185 | $73 \pm 2$ | 190 | 10 | M12 | 32.5 |
|  | 280 | FRN280F1 $\square^{\text {- }}$-4A | DCR4-280C | D | $350 \pm 10$ | 310 | 161 $\pm 4$ | 133 | 210 | $80.5 \pm 2$ | 190 | M10 | M16 | 36 |
|  | 315 | FRN315F1 $\square$-4A | DCR4-315C | D | $400 \pm 10$ | 345 | $146 \pm 4$ | 118 | 200 | $73 \pm 2$ | 225 | M10 | M16 | 40 |
|  | 355 | FRN355F1 $\square$-4A | DCR4-355C | E | $400 \pm 10$ | 345 | $156 \pm 4$ | $128 \pm 2$ | 200 | $78 \pm 2$ | 225 | M10 | - | 47 |
|  | 400 | FRN400F1 $\square$-4A | DCR4-400C | E | $445 \pm 10$ | 385 | $145 \pm 4$ | 117 | 213 | $72.5 \pm 2$ | 245 | M10 | - | 52 |
|  | 450 | FRN450F1 $\square$-4A | DCR4-450C | E | $440 \pm 10$ | 385 | $150 \pm 4$ | $122 \pm 2$ | 215 | $75 \pm 2$ | 245 | M10 | - | 60 |
|  | 500 | FRN500F1 $\square$-4A | DCR4-500C | E | $445 \pm 10$ | 390 | $165 \pm 4$ | $137 \pm 2$ | 220 | $82.5 \pm 2$ | 245 | M10 | - | 70 |
|  | 560 | FRN560F1 $\square$-4A | DCR4-560C | F | 270 | 145 | 208 | 170 | 200 | - | 480 | \$14 long hole | \$15 | 70 |

Note: Substitute " $\square$ " in the inverter model number with an aphabetic letter.
$\square-s$ (Standard type)
E (EMC filter built-in type)
H(DC REACTOR built-in type)
L or D (Waterproof type) of 2030

## OInterface card

DeviceNet interface card (OPC-F1-DEV)
Use this interface card to enter or monitor operation commands or frequency or to change or check the settings of function codes necessary for operation at the master station of DeviceNet.

- Number of connectable nodes: Max. 64 (including the master)
-MAC ID: 0 to 63
- Insulation: 500V DC (by photocoupler)
-Transmission speed: $500 \mathrm{kbps} / 250 \mathrm{kbps} / 125 \mathrm{kbps}$
- Network power consumption: Max. 50 mA at 24 V DC

RS-485 communications card (OPC-F1-RS)
Connect this card with a host (master) device such as a PC or PLC when you want to use FRENIC-Eco as a subordinate device (slave). (The card is added to RS-485 communications port built in FRENIC-Eco.)
Note: This option card cannot be connected to a keypad or a PC loader.

- Number of connectable devices: 31 inverters connected to one host
- Electric specification: EIA RS-485
-Synchronization method: Start/stop
-Communication method: Half-duplex
-Transmission speed (bps): 2400, 4800, 9600, 19200 and 38400
$\bullet$ Maximum communication distance: 500 m

Relay output card (OPC-F1-RY)
Use this option card to convert the transistor outputs issued from the terminals Y1 to Y3 of the main body of FRENIC-Eco into relay outputs. Note: FRENIC-Eco's terminals Y 1 to Y 3 cannot be used while this card is installed.

- Relay outputs: Built-in three circuits
-Contact: SPDT contact
-Contact capacity: 250 V AC, $0.3 \mathrm{~A} \cos \phi=0.3$
48 V DC, 0.5 A (resistance load)


## CC-Link card (OPC-F1-CCL)

By connecting this card with a CC-Link master unit, the baud rate can be extended up to 10 Mbps and the total transmission distance up to 1200 m .

- Number of connectable devices: Max. 42
-Communication method: CC-Link ver. 1.10 and 2.0
-Transmission speed: 156 kbps or more


## PROFIBUS card (OPC-F1-PDP)

With this interface card, you can do the following operations from the PROFIBUS-DP master: issuing the inverter operation command, issuing the frequency command, monitoring the operating status, and changing the settings in all the function codes of FRENIC-Eco.

- Transmission speed: 9.6 kbps to 12 Mbps
-Transmission distance: Max. 1200 m
-Connector: 6-pole terminal base


## LonWorks interface card (OPC-F1-LNW)

With use of this interface card, the peripheral devices (including a master) linked through LonWorks can be connected to FRENIC-Eco. This allows you to issue an operation command or a frequency setting command from the master.
$\bullet$ No. of network variables: 62

- No. of connectable devices: 24
-Transmission speed: 78kbps


## OMounting adapter for external cooling (PB-F1- $\square \square \square$ )

Use this adapter to shift the heat sink to the outside of the control panel. For 37 kW or larger inverters, the head sink can be extended, without using this adapter, by simply relocating the mounting base.

-Multi-function keypad (TP-G1,TP-G1-J1,TP-G1-C1)

-Extension cable for remote operation (CB- $\square$ S)
This straight cable is used to connect the inverter and the remote
keypad.



## -Panel-mount adapter (MA-F1- $\square \square \square$ )

Use this adapter when installing the FRENIC-Eco by using the mounting hole of the already installed inverter (FRENIC5000P11S, 5.5 to 37 kW ).


| Optional type | Applicable inverter type | Already instaled inverter type |
| :--- | :--- | :--- |
| MA-F1-5.5 | FRNO.75F1S-2A | FRN5.5P11S-2 |
|  | FRN1.5F1S-2A | FRN7.5P11S-2 |
|  | FRN2.2F1S-2A | FRN11P11S-2 |
|  | FRN3.7F1S-2A | FRN5.5P11S-4 |
|  | FRN5.5F1S-2A | FRN7.5P11S-4 |
|  | FRN0.75F1S-4A | FRN11P11S-4 |
|  | FRN1.5F1S-4A |  |
|  | FRN2.2F1S-4A |  |
|  | FRN3.7F1S-4A |  |
|  | FRN5.5F1S-4A |  |
| MA-F1-15 | FRN7.5F1S-2A | FRN15P11S-2 |
|  | FRN11F1S-2A | FRN18.5P11S-2 |
|  | FRN15F1S-2A | FRN22P11S-2 |
|  | FRN7.5F1S-4A | FRN15P11S-4 |
|  | FRN11F1S-4A | FRN18.5P11S-4 |
|  | FRN15F1S-4A | FRN22P11S-4 |
| MA-F1-30 | FRN18.5F1S-2A | FRN30P11S-2 |
|  | FRN22F1S-2A | FRN37P11S-2 |
|  | FRN30F1S-2A | FRN30P11S-4 |
|  | FRN18.5F1S-4A | FRN37P11S-4 |
|  | FRN22F1S-4A |  |
|  | FRN30F1S-4A |  |

Note: The * mark in the applicable inverter type stands for any of the following alphabets. * S (standard type), H (DCR built-in type), E (EMC filter built-in type)

## Options

## Wiring equipment



- The frame and series of the MCCB and ELCB models vary according to the transformer capacity and so on of the equipment. Choose the optimum ones according to the catalog and technical data of the circuit breaker and others.
- Choose the optimum rated sensitive current of the ELCB according to technical data, too. The rated currents of the MCCB and ELCB specified in this table indicate those of $\mathrm{SA} \square \mathrm{B} / \square$ and $\mathrm{SA} \square \mathrm{R} / \square$ models.
- Description in the above table may vary for different ambient temperatures, power supply voltages or other conditions.
*1: Use crimp terminals equipped with insulation sheath or those equipped with an insulation tube or the like.
The cable to be used is 600 V HIV insulated cable with an allowable temperature of $75^{\circ} \mathrm{C}$. The ambient temperature is assumed to be $50^{\circ} \mathrm{C}$.
*2: If $150 \mathrm{~mm}^{2}$ cables are used at the main power input terminals of FRN75F1 $\square$-2J, use ones complying with JEM1399 Low voltage crimp terminal CB150-10.
*3: Substitute " $\square$ " in the inverter model with an alphabetic letter.
- S (Standard type), E (EMC filter built-in type), or H (DC REACTOR built-in type), L or D (Waterproof type)
*4: Made by Aichi Electric Works Co., Ltd.


## Guideline for Suppressing Harmonics

## Application to "Guideline for Suppressing Harmonics by the Users Who Receive High Voltage or Special High Voltage"

Our FRENIC-Multi series are the products specified in the "Guideline for Suppressing Harmonics by Customers Receiving High Voltage or Special High Voltage." When you enter into a new contract with an electric power company or update a contract, you are requested by the electric power company to submit an accounting statement form.
(1) Scope of regulation

In principle, the guideline applies to the customers that meet the following two conditions: - The customer receives high voltage or special high voltage.

- The "equivalent capacity" of the converter load exceeds the standard value for the receiving voltage ( 50 kVA at a receiving voltage of 6.6 kV ).
(2) Regulation method

The level (calculated value) of the harmonic current that flows from the customer's receiving point out to the system is subjected to the regulation. The regulation value is proportional to the contract demand. The regulation values specified in the guideline are shown in Table 1.
Table 1 Upper limits of harmonic outflow current per kW of contract demand [mA/kW]

| Receiving volage | 5 th | 7 th | 11 th | 13 th | 17 th | 19 th | 23 th |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6.5 kV | 35 th |  |  |  |  |  |  |
| 22 kV | 1.8 | 2.5 | 1.6 | 1.3 | 1.0 | 0.90 | 0.76 |

## 1. Calculation of Equivalent Capacity (Pi)

Although the equivalent capacity ( Pi ) is calculated using the equation of (input rated capacity) $\times$ (conversion factor), catalog of conventional inverters do not contain input rated capacities. A description of the input rated capacity is shown below:
(1) "Inverter rated capacity" corresponding to "Pi"

- Calculate the input fundamental current 11 from the kW rating and efficiency of the load motor, as well as the efficiency of the inverter. Then, calculate the input rated capacity as shown below: Input rated capacity $=\sqrt{3} \times$ (power supply voltage) $\times 11 \times 1.0228 / 1000[\mathrm{kVA}]$ Where 1.0228 is the 6 -pulse converter's value obtained by (effective current) / (fundamental current).
-When a general-purpose motor or inverter motor is used, the appropriate value shown in Table 2 can be used. Select a value based on the kW rating of the motor used, irrespective of the inverter type.

Table 2 "Input rated capacities" of general-purpose inverters determined by the nominal applied motors

 \begin{tabular}{c|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline Pi \& 200 V \& 0.57 \& 0.97 \& 1.95 \& 2.81 \& 4.61 \& 6.77 \& 9.07 \& 13.1 \& 17.6 \& 21.8 \& 25.9 <br>
\cline { 2 - 10 } \& \& \& \&

 

\hline [kVA] \& 400 V \& 0.57 \& 0.97 \& 1.95 \& 2.81 \& 4.61 \& 6.77 \& 9.07 \& 13.1 \& 17.6 \& 21.8 \& 25.9 <br>
\hline

 

\hline Narinalapalidedmor Fav| \& 30 \& 37 \& 45 \& 55 \& 75 \& 90 \& 110 \& 132 \& 160 \& 200 \& 220 <br>
\hline

 

\hline Pi \& 200 V \& 34.7 \& 42.8 \& 52.1 \& 63.7 \& 87.2 \& 104 \& 127 \& \& \& \& <br>
[kVA] \& 400 V \& 34.7 \& 42.8 \& 52.1 \& 63.7 \& 87.2 \& 104 \& 127 \& 153 \& 183 \& 229 \& 252 <br>
\hline
\end{tabular}

 | $[$ [kVA] | 400 V | 286 | 319 | 359 | 405 | 456 | 512 | 570 | 604 | 638 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

(2) Values of "Ki (conversion factor)"

- Depending on whether an optional ACR (AC REACTOR) or DCR (DC REACTOR) is used, apply the appropriate
conversion factor specified in the appendix to the guideline. The values of the converter factor are shown in Table 3 .
Table 3 "Conversion factors Ki" for general-purpose inverters determined by reactors

| Circuitcategory | Circuit type |  | Conversion factor Ki | Main applications |
| :---: | :---: | :---: | :---: | :---: |
| 3 | Three-phase bridge 3 (capacitor smoothing) | Without a reactor | K $31=3.4$ | - General-purpose inverters <br> - Elevators <br> - Refrigerators, air conditioning systems <br> - Other general appliances |
|  |  | With a reactor (ACR) | K32=1.8 |  |
|  |  | With a reactor (DCR) | K33=1.8 |  |
|  |  | With reactors (ACR and DCR) | K34=1.4 |  |

## 2. Calculation of Harmonic Current

(1) Value of "input fundamental current"

- Apply the appropriate value shown in Table 4 based on the kW rating of the motor, irrespective of the inverter type or whether a reactor is used.
* If the input voltage is different, calculate the input fundamental current in inverse proportion to the voltage.

Table 4 "Input fundamental currents" of general-purpose inverters determined by the nominal applied motors

| Nominal applied moior [WW] |  | 0.4 | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 200 V | 1.62 | 2.74 | 5.50 | 7.92 | 13.0 | 19.1 | 25.6 | 36.9 | 49.8 | 61.4 | 73.1 |
| current [ $A$ ] | 400 V | 0.81 | 1.37 | 2.75 | 3.96 | 6.50 | 9.55 | 12.8 | 18.5 | 24.9 | 30.7 | 36.6 |
|  |  | 49 | 83 | 167 | 240 | 394 | 579 | 776 | 1121 | 1509 | 1860 | 2220 |
| Norinal applied moiv [WW\| |  | 30 | 37 | 45 | 55 | 75 | 90 | 110 | 132 | 160 | 200 | 220 |
| $\begin{array}{c\|} \hline \text { Input } \\ \text { fundamental } \\ \text { curent }[A] \end{array}$ | 200 V | 98.0 | 121 | 147 | 180 | 245 | 293 | 357 |  |  |  |  |
|  | 400 V | 49.0 | 60.4 | 73.5 | 89.9 | 123 | 147 | 179 | 216 | 258 | 323 | 355 |
| 6.6 W converted value $\mathrm{mN} /$ ] |  | 2970 | 3660 | 4450 | 5450 | 7450 | 8910 | 10850 | 13090 | 15640 | 19580 | 21500 |
| Nominal applied moior [WV\| |  | 250 | 280 | 315 | 355 | 400 | 450 | 500 | 530 | 560 | 630 |  |
| $\begin{gathered} \text { Input } \\ \text { fundamental } \\ \text { current }[A] \end{gathered}$ | 200 V |  |  |  |  |  |  |  |  |  |  |  |
|  | 400 V | 403 | 450 | 506 | 571 | 643 | 723 | 804 | 852 | 900 | 1013 |  |
| 6.6 W Converete value mak ] |  | 24400 | 27300 | 30700 | 34600 | 39000 | 43800 | 48700 | 51600 | 54500 | 61400 |  |

(2) Calculation of harmonic current

Table 5 Generated harmonic current [\%], 3-phase bridge (capacitor smoothing)

| Degree | 5 th | 7 th | 11 th | 13 th | 17 th | 19 th | 23 th | 25 th |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Without a reactor | 65 | 41 | 8.5 | 7.7 | 4.3 | 3.1 | 2.6 | 1.8 |
| With a reactor (ACR) | 38 | 14.5 | 7.4 | 3.4 | 3.2 | 1.9 | 1.7 | 1.3 |
| With a reactor (DCR) | 30 | 13 | 8.4 | 5.0 | 4.7 | 3.2 | 3.0 | 2.2 |
| With reactors (ACR and DCR) | 28 | 9.1 | 7.2 | 4.1 | 3.2 | 2.4 | 1.6 | 1.4 |

- ACR: $3 \%$
- DCR: Accumulated energy equal to 0.08 to 0.15 ms ( $100 \%$ load conversion)
- Smoothing capacitor: Accumulated energy equal to 15 to 30 ms ( $100 \%$ load conversion) -Load: 100\%
■ nth harmonic current $[\mathrm{A}]=$ Fundamental current $[\mathrm{A}] \times \frac{\text { Generated nth harmonic current [\%] }}{100}$ Calculate the harmonic current of each degree using the following equation:
(3) Maximum availability factor
- For a load for elevators, which provides intermittent operation, or a load with a sufficient designed motor rating, reduce the current by multiplying the equation by the "maximum availability factor" of the load.
- The "maximum availability factor of an appliance" means the ratio of the capacity of the harmonic generator in operation at which the avalability reaches the maximum, to its total capacity, and the capacity of the generator in operation is an average for 30 minutes.
- In general, the maximum availability factor is calculated according to this definition, but the standard values shown in Table 6 are recommended for inverters for building equipment.
Table 6 Availability factors of inverters, etc. for building equipment (standard values)

| Equipment type | Inverter capacity category | Single inverter availability factor |
| :---: | :---: | :---: |
| Air conditioning system | 200kW or less | 0.55 |
|  | Over 200 kW | 0.60 |
| Sanitary pump | - | 0.30 |
| Elevator | - | 0.25 |
| Refrigerator, freezer | 50 kW or less | 0.60 |
| UPS (6-pulse) | 200 kVA | 0.60 |

[Correction coefficient according to contract demand level]

- Since the total availability factor decreases with increase in the building scale, calculating reduced harmonics with the correction coefficient s defined in Table 7 below is permitted.

Table 7 Correction coefficient according to the building scale

| Contract demand $[\mathrm{kW}]$ | Correction coefficient $\beta$ |
| :---: | :--- | :--- |${ }^{*}$ If the contract demand is between two specified values



| 300 | 1.00 |
| :---: | :---: |
| 500 | 0.90 |
| 1000 | 0.85 |
| 2000 | 0.80 |

(4) Degree of harmonics to be calculated Calculate only the " 5 th and 7 th" harmonic currents

## 3. Others

"Guideline for Suppressing Harmonics in Home Electric and General-purpose Appliances" (established in September 1994 and revised in October 1999) issued by the Ministry of Economy, Trade and Industry was admonished on September 2004. Therefore, the "Guideline for Suppressing Harmonics by Customers Receiving High Voltage or Special High Voltage" will be applied in the future.
We, as before, recommend that you connect a reactor (for suppressing harmonics) to your inverter. As a reactor, select a "DC REACTOR" introduced in this catalog. For use of the other reactor, please inquire of us about detailed specifications.

# To all our customers who purchase Fuji Electric products included in this catalog: 

Please take the following items into consideration when placing your order.
When requesting an estimate and placing your orders for the products included in these materials, please be aware that any items such as specifications which are not specifically mentioned in the contract, catalog, specifications or other materials will be as mentioned below.
In addition, the products included in these materials are limited in the use they are put to and the place where they can be used, etc., and may require periodic inspection. Please confirm these points with your sales representative or directly with this company.
Furthermore, regarding purchased products and delivered products, we request that you take adequate consideration of the necessity of rapid receiving inspections and of product management and maintenance even before receiving your products.

## 1. Free of Charge Warranty Period and Warranty Range

## 1-1 Free of charge warranty period

(1) The product warranty period is "1 year from the date of purchase" or 24 months from the manufacturing date imprinted on the name place, whichever date is earlier.
(2) However, in cases where the use environment, conditions of use, use frequency and times used, etc., have an effect on product life, this warranty period may not apply.
(3) Furthermore, the warranty period for parts restored by Fuji Electric's Service Department is " 6 months from the date that repairs are completed."

## 1-2 Warranty range

(1) In the event that breakdown occurs during the product's warranty period which is the responsibility of Fuji Electric, Fuji Electric will replace or repair the part of the product that has broken down free of charge at the place where the product was purchased or where it was delivered. However, if the following cases are applicable, the terms of this warranty may not apply.

1) The breakdown was caused by inappropriate conditions, environment, handling or use methods, etc. which are not specified in the catalog, operation manual, specifications or other relevant documents.
2) The breakdown was caused by the product other than the purchased or delivered Fuji's product
3) The breakdown was caused by the product other than Fuji's product, such as the customer's equipment or software design, etc.
4) Concerning the Fuji's programmable products, the breakdown was caused by a program other than a program supplied by this company, or the results from using such a program.
5) The breakdown was caused by modifications or repairs affected by a party other than Fuji Electric
6) The breakdown was caused by improper maintenance or replacement using consumables, etc. specified in the operation manual or catalog, etc.
7) The breakdown was caused by a chemical or technical problem that was not foreseen when making practical application of the product at the time it was purchased or delivered.
8) The product was not used in the manner the product was originally intended to be used.
9) The breakdown was caused by a reason which is not this company's responsibility, such as lightning or other disaster.
(2) Furthermore, the warranty specified herein shall be limited to the purchased or delivered product alone
(3) The upper limit for the warranty range shall be as specified in item (1) above and any damages (damage to or loss of machinery or equipment, or lost profits from the same, etc.) consequent to or resulting from breakdown of the purchased or delivered product shall be excluded from coverage by this warranty.

## 1-3. Trouble diagnosis

As a rule, the customer is requested to carry out a preliminary trouble diagnosis. However, at the customer's request, this company or its service network can perform the trouble diagnosis on a chargeable basis. In this case, the customer is asked to assume the burden for charges levied in accordance with this company's fee schedule.
2. Exclusion of Liability for Loss of Opportunity, etc.

Regardless of whether a breakdown occurs during or after the free of charge warranty period, this company shall not be liable for any loss of opportunity, loss of profits, or damages arising from special circumstances, secondary damages, accident compensation to another company, or damages to products other than this company's products, whether foreseen or not by this company, which this company is not be responsible for causing.
3. Repair Period after Production Stop, Spare Parts Supply Period (Holding Period)

Concerning models (products) which have gone out of production, this company will perform repairs for a period of 7 years after production stop, counting from the month and year when the production stop occurs. In addition, we will continue to supply the spare parts required for repairs for a period of 7 years, counting from the month and year when the production stop occurs. However, if it is estimated that the life cycle of certain electronic and other parts is short and it will be difficult to procure or produce those parts, there may be cases where it is difficult to provide repairs or supply spare parts even within this 7 -year period. For details, please confirm at our company's business office or our service office.

## 4. Transfer Rights

In the case of standard products which do not include settings or adjustments in an application program, the products shall be transported to and transferred to the customer and this company shall not be responsible for local adjustments or trial operation.

## 5. Service Contents

The cost of purchased and delivered products does not include the cost of dispatching engineers or service costs
Depending on the request, these can be discussed separately.

## Variation

## The rich lineup of the active Fuji inverter family

| Applications | Series Name (Catalog No.) | Features |
| :---: | :---: | :---: |
| General Industrial equipment | FRENIC-MEGA (MEH642 for JE) (MEH655 for EN) | High-performance, multi-functional inverter <br> (Three-phase 400V: 0.4 to 630 kW , Three-phase 200V: 0.4 to 90 kW ) <br> - Loaded with vector control which is the peak of general purpose inverters. <br> - Prepared three types; the basic type, EMC filter built-in type. <br> - Maintainability is further improved with built-in USB port(option). <br> - The short-time acceleration and deceleration become enabled with achieving better rating of overload ratings at HD spec: $200 \%$ for 3 sec and $150 \%$ for 1 min and at LD spec: $120 \%$ for 1 min . |
|  | FRENIC5000G11S <br> (MEH403 for JE) <br> (MEH413 for EN) | High-performance, multi-functional inverter multi-functional Capacity range expanded (Three-phase 200V: 0.2 to 90 kW , Three-phase 400 V : 0.4 to 630 kW ) <br> - Fuji's original dynamic torque vector control system delivers a starting torque of $200 \%$ at 0.5 Hz . <br> - These inverters are packed with a full range of convenient functions, beginning with an auto tuning function. <br> - Compact, fully enclosed (22kW and below). |
|  | FRENIC5000P11S <br> (MEH403) | Fan, pump inverter <br> (Three-phase 200V: 5.5 to110kW, Three-phase 400V: 5.5 to 710 kW ) <br> - Suitable for fans and pumps. <br> - The built-in automatic energy-saving function makes energy saving operation easy. <br> - An interactive keypad is standard-equipped for ease of operation. |
|  | FRENIC-Multi (MEH652 for JE) (MEH653 for EN) | High performance, compact inverter <br> (Three-phase 200V: 0.1 to 15 kW , Single-phase 200 V : 0.1 to 2.2 kW , Three-phase 400 V : 0.4 to 15 kW ) <br> - The inverter featuring environment-friendly and long life design (10 years) complies with RoHS Directives (products manufactured beginning in the autumn of 2005). <br> - With expanded capacity range, abundant model variation, and simple and thorough maintenance, the Multi is usable for a wide range of applications. <br> - Equipped with the functions optimum for the operations specific to vertical and horizontal conveyance, such as hit-and-stop control, brake signal, torque limit, and current limit. |
|  | FRENIC-Eco <br> (MEH442) | Fan, pump inverter (for variable torque load) <br> (Three-phase 200V: 0.75 to 110 kW , Three-phase $400 \mathrm{~V}: 0.75$ to 560 kW ) <br> - Developed exclusively for controlling variable torque load like fans and pumps. <br> - Full of new functions such as auto energy saving, PID control, life warning, and switching sequence to the commercial power supply. <br> - Ideal for air conditioners, fans, pumps, etc. which were difficult to use with conventional general-purpose inverters because of cost or functions. |
|  | FRENIC-Mini (MEH441 for JE) (MEH451 for EN) | Compact inverter <br> (Three-phase 200V: 0.1 to 3.7 kW , Three-phase 400V: 0.4 to 3.7 kW , Single-phase 200V: 0.1 to 2.2 kW , Single-phase 100V: 0.1 to 0.75 kW ) <br> - A frequency setting device is standard-equipped, making operation simple. <br> - Loaded with auto torque boost, current limiting, and slip compensation functions, all of which are ideal for controlling traverse conveyors. <br> - Loaded with the functions for auto energy saving operation and PID control, which are ideal for controlling fans and pumps. |
|  | FRENIC5000VG7S <br> (MEH405) | High performance, vector control inverter Capacity range expanded <br> (Three-phase 200V: 0.75 to 90 kW , Three-phase $400 \mathrm{~V}: 3.7$ to 800 kW ) <br> - A high precision inverter with rapid control response and stable torque characteristics. <br> - Abundant functions and a full range of options make this inverter ideal for a broad range of general industrial systems. <br> The auto tuning function makes vector control operation possible even for general-purpose motors. |
| Safety Precautions | 1. Use the contents of this catalog only for selecting product types and models. When using a product, read the Instruction Manual beforehand to use the product correctly. <br> 2. Products introduced in this catalog have not been designed or manufactured for such applications in a system or equipment that will affect human bodies or lives. Customers, who want to use the products introduced in this catalog for special systems or devices such as for atomic-energy control, aerospace use, medical use, and traffic control, are requested to consult the Fuji's Sales Division. Customers are requested to prepare safety measures when they apply the products introduced in this catalog to such systems or facilities that will affect human lives or cause severe damage to property if the products become faulty. |  |



When running general-purpose motors

- Driving a 400V general-purpose motor When driving a 400 V general-purpose motor with an inverter using extremely long cables, damage to the insulation of the motor may occur. Use an output circuit filter (OFL) if necessary after checking with the motor manufacturer. Fuji's motors do not require the use of output circuit filters because of their reinforced insulation.
- Torque characteristics and temperature rise When the inverter is used to run a general-purpose motor, the temperature of the motor becomes higher than when it is operated using a commercial power supply. In the low-speed range, the cooling effect will be weakened, so decrease the output torque of the motor. If constant torque is required in the low-speed range, use a Fuji inverter motor or a motor equipped with an externally powered ventilating fan.


## - Vibration

When the motor is mounted to a machine resonance may be caused by the natural frequencies, including that of the machine Operation of a 2 -pole motor at 60 Hz or more may cause abnormal vibration.

* Study use of tier coupling or dampening rubber.
* It is also recommended to use the inverter jump frequency control to avoid resonance points.


## - Noise

When an inverter is used with a general-purpose motor, the motor noise level is higher than that with a commercial power supply. To reduce noise, raise carrier frequency of the inverter. High-speed operation at 60 Hz or more can also result in more noise.

## When running special motors

## - High-speed motors

When driving a high-speed motor while setting the frequency higher than 120 Hz , test the combination with another motor to confirm the safety of highspeed motors.

## Explosion-proof motors

When driving an explosion-proof motor with an inverter, use a combination of a motor and an inverter that has been approved in advance.

## - Submersible motors and pumps

These motors have a larger rated current than general-purpose motors. Select an inverter whose rated output current is greater than that of the motor.
These motors differ from general-purpose motors in thermal characteristics. Set a low value in the thermal time constant of the motor when setting the electronic thermal facility.

## - Brake motors

For motors equipped with parallel-connected brakes, their braking power must be supplied from the primary circuit (commercial power supply). If the brake power is connected to the inverter power output circuit (secondary circuit) by mistake, problems may occur.
Do not use inverters for driving motors equipped with series-connected brakes.

- Geared motors

If the power transmission mechanism uses an oil-
lubricated gearbox or speed changer/reducer, then continuous motor operation at low speed may cause poor lubrication. Avoid such operation.

## - Synchronous motors

It is necessary to use software suitable for this motor type. Contact Fuji for details.

## - Single-phase motors

Single-phase motors are not suitable for inverterdriven variable speed operation. Use three-phase motors.
*Even if a single-phase power supply is available, use a three-phase motor as the inverter provides three-phase output.

## Environmental conditions

- Installation location

Use the inverter in a location with an ambient temperature range of -10 to $50^{\circ} \mathrm{C}$.
The inverter and braking resistor surfaces become hot under certain operating conditions. Install the inverter on nonflammable material such as metal. Ensure that the installation location meets the environmental conditions specified in "Environment" in inverter specifications.

## Combination with peripheral devices

- Installing a molded case circuit breaker (MCCB)
Install a recommended molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) in the primary circuit of each inverter to protect the wiring. Ensure that the circuit breaker capacity is equivalent to or lower than the recommended capacity.
- Installing a magnetic contactor (MC) in the output (secondary) circuit
If a magnetic contactor (MC) is mounted in the inverter's secondary circuit for switching the motor to commercial power or for any other purpose, ensure that both the inverter and the motor are fully stopped before you turn the MC on or off. Remove the surge killer integrated with the MC.
- Installing a magnetic contactor (MC)
in the input (primary) circuit
Do not turn the magnetic contactor (MC) in the primary circuit on or off more than once an hour as an inverter fault may result. If frequent starts or stops are required during motor operation, use FWD/REV signals.


## - Protecting the motor

The electronic thermal facility of the inverter can protect the motor. The operation level and the motor type (general-purpose motor, inverter motor) should be set. For high-speed motors or water-cooled motors, set a small value for the thermal time constant to protect the motor.
If you connect the motor thermal relay to the motor with a long cable, a high-frequency current may flow into the wiring stray capacitance. This may cause the relay to trip at a current lower than the set value for the thermal relay. If this happens, lower the carrier frequency or use the output circuit filter (OFL).

- Discontinuance of power-factor correcting capacitor Do not mount power factor correcting capacitors in the inverter (primary) circuit. (Use the DC REACTOR to improve the inverter power factor.) Do
not use power factor correcting capacitors in the inverter output circuit (secondary). An overcurrent trip will occur, disabling motor operation
- Discontinuance of surge killer

Do not mount surge killers in the inverter output (secondary) circuit.

## - Reducing noise

Use of a filter and shielded wires are typical measures against noise to ensure that EMC Directives are met.

## - Measures against surge currents

If an overvoltage trip occurs while the inverter is stopped or operated under a light load, it is assumed that the surge current is generated by open/close of the phase-advancing capacitor in the power system.
We recommend connecting a DC REACTOR to the inverter.

## - Megger test

When checking the insulation resistance of the inverter, use a 500 V megger and follow the instructions contained in the Instruction Manual.

## Wiring

-Wiring distance of control circuit
When performing remote operation, use the twisted shield wire and limit the distance between the inverter and the control box to 20 m .

- Wiring length between inverter and motor If long wiring is used between the inverter and the motor, the inverter will overheat or trip as a result of overcurrent (high-frequency current flowing into the stray capacitance) in the wires connected to the phases. Ensure that the wiring is shorter than 50 m If this length must be exceeded, lower the carrier frequency or mount an output circuit filter (OFL).


## -Wiring size

Select cables with a sufficient capacity by referring to the current value or recommended wire size.

## -Wiring type

Do not use multicore cables that are normally used for connecting several inverters and motors.

## - Grounding

Securely ground the inverter using the grounding terminal.

## Selecting inverter capacity

- Driving general-purpose motor

Select an inverter according to the applicable motor ratings listed in the standard specifications table for the inverter. When high starting torque is required or quick acceleration or deceleration is required, select an inverter with a capacity one size greater than the standard.

- Driving special motors

Select an inverter that meets the following condition: Inverter rated current > Motor rated current.

## Transportation and storage

When transporting or storing inverters, follow the procedures and select locations that meet the environmental conditions that agree with the inverter specifications.

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# Designed for Fan and Pump Applications FRENIC-ECO 

## User's Manual

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The information contained herein is subject to change without prior notice for improvement.

## Preface

This manual provides all the information on the FRENIC-Eco series of inverters including its operating procedure, operation modes, and selection of peripheral equipment. Carefully read this manual for proper use. Incorrect handling of the inverter may prevent the inverter and/or related equipment from operating correctly, shorten their lives, or cause problems.

The table below lists the other materials related to the use of the FRENIC-Eco. Read them in conjunction with this manual as necessary.

| Name | Material No. | Description |
| :--- | :--- | :--- |
| Catalog | MEH442 | Product scope, features, specifications, external <br> drawings, and options of the product |
| Instruction Manual | INR-SI47-0882-E | Acceptance inspection, mounting \& wiring of the <br> inverter, operation using the keypad, running the motor <br> for a test, troubleshooting, and maintenance and <br> inspection |
| RS485 <br> Communication <br> User's Manual | MEH448 | Overview of functions implemented by using <br> FRENIC-Eco RS485 communications facility, its <br> communications specifications, Modbus RTU/Fuji <br> general-purpose inverter protocol and functions, and <br> related data formats |
| RS485 |  | Items on acceptance checking, and how to install the <br> card option <br> Communications <br> Card "OPC-F1-RS" <br> Installation Manual |
| INR-SI47-0872 |  | Items on acceptance checking, how to install the card <br> option, wiring and specifications |
| Relay Output Card <br> "OPC-F1-RY" <br> Instruction Manual | INR-SI47-0873 |  |
| Mounting Adapter for <br> External Cooling | INR-SI47-0880 | Items on acceptance checking, what to apply, and how <br> to install the adapter |
| "PB-F1" Installation |  |  |
| Manual |  |  |

The materials are subject to change without notice. Be sure to obtain the latest editions for use.
Documents related to Fuji inverters
Catalogs
FRENIC5000G11S/P11S MEH403/MEH413
FVR-E11S MEH404/MEH414
FRENIC-Mini MEH441/MEH451
User's Manuals and Technical Information
FRENIC5000G11S/P11S \& FVR-E11S Technical Information MEH406
FRENIC-Mini User's Manual
MEH446

## Guideline for Suppressing Harmonics in Home Electric and General-purpose Appliances

Our three-phase, 200 V series inverters of 3.7 kW or less (FRENIC-Eco series) were the products of which were restricted by the "Guideline for Suppressing Harmonics in Home Electric and General-purpose Appliances" (established in September 1994 and revised in October 1999) issued by the Ministry of Economy, Trade and Industry.
The above restriction, however, was lifted when the Guideline was revised in January 2004. Since then, the inverter makers have individually imposed voluntary restrictions on the harmonics of their products.
We, as before, recommend that you connect a reactor (for suppressing harmonics) to your inverter. As a reactor, select a "DC REACTOR" introduced in this manual. For use of the other reactor, please inquire of us about detailed specifications.

## Japanese Guideline for Suppressing Harmonics by Customers Receiving High Voltage or Special High Voltage

Refer to this manual, Appendix B for details on this guideline.

## Safety precautions

Read this manual and the FRENIC-Eco Instruction Manual (INR-SI47-0882-E) thoroughly before proceeding with installation, connections (wiring), operation, or maintenance and inspection. Ensure you have sound knowledge of the product and familiarize yourself with all safety information and precautions before proceeding to operate the inverter.
Safety precautions are classified into the following two categories in this manual.

| AWARNING | Failure to heed the information indicated by this symbol may lead to <br> dangerous conditions, possibly resulting in death or serious bodily injuries. |
| :--- | :--- |
| ACAUTION | Failure to heed the information indicated by this symbol may lead to <br> dangerous conditions, possibly resulting in minor or light bodily injuries <br> and/or substantial property damage. |

Failure to heed the information contained under the CAUTION title can also result in serious consequences. These safety precautions are of utmost importance and must be observed at all times.

## $\triangle$ CAUTION

This product is not designed for use in appliances and machinery on which lives depend. Consult your Fuji Electric representative before considering the FRENIC-Eco series of inverters for equipment and machinery related to nuclear power control, aerospace uses, medical uses or transportation. When the product is to be used with any machinery or equipment on which lives depend or with machinery or equipment which could cause serious loss or damage should this product malfunction or fail, ensure that appropriate safety devices and/or equipment are installed.

## Precautions for Use

| In running generalpurpose motors | Driving a 400V general-purpose motor | When driving a 400 V general-purpose motor with an inverter using extremely long wires, damage to the insulation of the motor may occur. Use an output circuit filter (OFL) if necessary after checking with the motor manufacturer. Fuji motors do not require the use of output circuit filters because of their reinforced insulation. |
| :---: | :---: | :---: |
|  | Torque characteristics and temperature rise | When the inverter is used to run a general-purpose motor, the temperature of the motor becomes higher than when it is operated using a commercial power supply. In the low-speed range, the cooling effect will be weakened, so decrease the output torque of the motor. |
|  | Vibration | When an inverter-driven motor is mounted to a machine, resonance may be caused by the natural frequencies of the machine system. <br> Note that operation of a 2-pole motor at 60 Hz or higher may cause abnormal vibration. <br> * The use of a rubber coupling or vibration dampening rubber is recommended. <br> * Use the inverter's jump frequency control feature to skip the resonance frequency zone(s). |
|  | Noise | When an inverter is used with a general-purpose motor, the motor noise level is higher than that with a commercial power supply. To reduce noise, raise carrier frequency of the inverter. Operation at 60 Hz or higher can also result in higher level of wind roaring sound. |
| In running special motors | Explosion-proof motors | When driving an explosion-proof motor with an inverter, use a combination of a motor and an inverter that has been approved in advance. |
|  | Submersible motors and pumps | These motors have a higher rated current than general-purpose motors. Select an inverter whose rated output current is higher than that of the motor. <br> These motors differ from general-purpose motors in thermal characteristics. Set a low value in the thermal time constant of the motor when setting the electronic thermal overcurrent protection (for motor). |
|  | Brake motors | For motors equipped with parallel-connected brakes, their braking power must be supplied from the inverter's primary circuit. If the brake power is connected to the inverter's output circuit by mistake, the brake will not work. <br> Do not use inverters for driving motors equipped with series-connected brakes. |
|  | Geared motors | If the power transmission mechanism uses an oil-lubricated gearbox or speed changer/reducer, then continuous motor operation at low speed may cause poor lubrication. Avoid such operation. |
|  | Synchronous motors | It is necessary to take special measures suitable for this motor type. Contact your Fuji Electric representative for details. |
|  | Single-phase motors | Single-phase motors are not suitable for inverter-driven variable speed operation. Use three-phase motors. |


| Environmental conditions | Installation location | Use the inverter within the ambient temperature range from -10 to $+50^{\circ} \mathrm{C}$. The heat sink and braking resistor of the inverter may become hot under certain operating conditions, so install the inverter on nonflammable material such as metal. <br> Ensure that the installation location meets the environmental conditions specified in Chapter 8, Section 8.5 "Operating Environment and Storage Environment." |
| :---: | :---: | :---: |
| Combination with peripheral devices | Installing an MCCB or RCD/ELCB | Install a recommended molded case circuit breaker (MCCB) or residual-current-operated protective device ( RCD )/earth leakage circuit breaker (ELCB) (with overcurrent protection) in the primary circuit of each inverter to protect the wiring. Ensure that the circuit breaker capacity is equivalent to or lower than the recommended capacity. |
|  | Installing an MC in the secondary circuit | If a magnetic contactor (MC) is installed in the inverter's output (secondary) circuit for switching the motor to commercial power or for any other purpose, ensure that both the inverter and the motor are completely stopped before you turn the MC on or off. <br> Remove a surge killer integrated with the magnet contactor in the inverter's output (secondary) circuit. |
|  | Installing an MC in the primary circuit | Do not turn the magnetic contactor (MC) in the primary circuit on or off more than once an hour as an inverter failure may result. <br> If frequent starts or stops are required during motor operation, use (FWD)/(REV) signals or the RUN/STOP key. |
|  | Protecting the motor | The electronic thermal feature of the inverter can protect the motor. The operation level and the motor type (general-purpose motor, inverter motor) should be set. For high-speed motors or water-cooled motors, set a small value for the thermal time constant. <br> If you connect the motor thermal relay to the motor with a long wire, a high-frequency current may flow into the wiring stray capacitance. This may cause the thermal relay to trip at a current lower than the set value. If this happens, lower the carrier frequency or use the output circuit filter (OFL). |
|  | Discontinuance of power-factor correcting capacitor | Do not connect power-factor correcting capacitors to the inverter's primary circuit. (Use the DC reactor to improve the inverter power factor.) Do not use power-factor correcting capacitors in the inverter's output (secondary) circuit. An overcurrent trip will occur, disabling motor operation. |
|  | Discontinuance of surge killer | Do not connect a surge killer to the inverter's output (secondary) circuit. |
|  | Reducing noise | Use of a filter and shielded wires is typically recommended to satisfy EMC Directives. <br> Refer to Appendices, App. A "Advantageous Use of Inverters (Notes on electrical noise)" for details. |
|  | Measures against surge currents | If an overvoltage trip occurs while the inverter is stopped or operated under light load, it is assumed that the surge current is generated by open/close of the phase-advancing capacitor in the power system. <br> * Connect a DC reactor to the inverter. |
|  | Megger test | When checking the insulation resistance of the inverter, use a 500 V megger and follow the instructions contained in the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 7, Section 7.5 "Insulation Test." |


|  | Control circuit <br> wiring length | When using remote control, limit the wiring length between the inverter and <br> operator box to 20 m or less and use twisted pair or shielded wire. |
| :--- | :--- | :--- |
|  | Wiring length <br> between inverter <br> and motor | If long wiring is used between the inverter and the motor, the inverter may <br> overheat or trip due to overcurrent because a higher harmonics current <br> flows into the stray capacitance between each phase wire. Ensure that the <br> wiring is shorter than 50 m. If this length must be exceeded, lower the <br> carrier frequency or install an output circuit filter (OFL). |
|  | Wire size | Select wires with a sufficient capacity by referring to the current value or <br> recommended wire size. |
|  | Wire type | Do not share one multi-core cable in order to connect several inverters with <br> motors. |
|  | Grounding | Securely ground the inverter using the grounding terminal. |
| Selecting <br> inverter <br> capacity | Driving <br> general-purpose <br> motor | Select an inverter according to the applicable motor ratings listed in the <br> standard specifications table for the inverter. <br> When high starting torque is required or quick acceleration or deceleration <br> is required, select an inverter with a capacity one size greater than the <br> standard. Refer to Chapter 7, Section 7.1 "Selecting Motors and Inverters" <br> for details. |
|  | Driving special <br> motors | Select an inverter that meets the following condition: <br> Inverter rated current > Motor rated current |
|  | When transporting <br> environmental conditions listed in the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), <br> Chapter 1, Section $1.3 ~ " T r a n s p o r t a t i o n " ~ a n d ~ S e c t i o n ~ 1.4 ~ " S t o r a g e ~ E n v i r o n m e n t . " ~$ |  |

## How this manual is organized

This manual contains Chapters 1 through 9, Appendices and Glossary.

Part 1 General Information

## Chapter 1 INTRODUCTION TO FRENIC-Eco

This chapter describes the features and control system of the FRENIC-Eco series, and the recommended configuration for the inverter and peripheral equipment.

## Chapter 2 PARTS NAMES AND FUNCTIONS

This chapter contains external views of the FRENIC-Eco series and an overview of terminal blocks, including a description of the LED display and keys on the keypad.

## Chapter 3 OPERATION USING THE KEYPAD

This chapter describes inverter operation using the keypad. The inverter features three operation modes (Running, Programming and Alarm modes) which enable you to run and stop the motor, monitor running status, set function code data, display running information required for maintenance, and display alarm data.

The keypad is available in two types: standard keypad and optional multi-function keypad. For the instructions on how to operate the multi-function keypad, refer to the "Multi-function Keypad Instruction Manual" (INR-SI47-0890-E).

Part 2 Driving the Motor

## Chapter 4 BLOCK DIAGRAMS FOR CONTROL LOGIC

This chapter describes the main block diagrams for the control logic of the FRENIC-Eco series of inverters.

## Chapter 5 RUNNING THROUGH RS485 COMMUNICATION

This chapter describes an overview of inverter operation through the RS485 communications facility. Refer to the RS485 Communication User's Manual (MEH448a) or RS485 Communications Card "OPC-F1-RS" Installation Manual (INR-SI47-0872) for details.

## Part 3 Peripheral Equipment and Options

## Chapter 6 SELECTING PERIPHERAL EQUIPMENT

This chapter describes how to use a range of peripheral equipment and options, FRENIC-Eco's configuration with them, and requirements and precautions for selecting wires and crimp terminals.

Part 4 Selecting Optimal Inverter Model

## Chapter 7 SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES

This chapter provides you with information about the inverter output torque characteristics, selection procedure, and equations for calculating capacities to help you select optimal motor and inverter models. It also helps you select braking resistors.

## Chapter 8 SPECIFICATIONS

This chapter describes specifications of the output ratings, control system, and terminal functions for the FRENIC-Eco series of inverters. It also provides descriptions of the operating and storage environment, external dimensions, examples of basic connection diagrams, and details of the protective functions.

## Chapter 9 FUNCTION CODES

This chapter contains overview lists of seven groups of function codes available for the FRENIC-Eco series of inverters and details of each function code.

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App. A Advantageous Use of Inverters (Notes on electrical noise)
App. B Japanese Guideline for Suppressing Harmonics by Customers Receiving High Voltage or Special High Voltage
App. C Effect on Insulation of General-purpose Motors Driven with 400 V Class Inverters
App. D Inverter Generating Loss
App. E Conversion from SI Units
App. F Allowable Current of Insulated Wires

## Icons

The following icons are used throughout this manual.
Noter
This icon indicates information which, if not heeded, can result in the inverter not operating to full efficiency, as well as information concerning incorrect operations and settings which can result in accidents.

Tip This icon indicates information that can prove handy when performing certain settings or operations.

This icon indicates a reference to more detailed information.

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## Part 1 General Information

Chapter 1 INTRODUCTION TO FRENIC-Eco
Chapter 2 PARTS NAMES AND FUNCTIONS
Chapter 3 OPERATION USING THE KEYPAD

## Chapter 1

## Introduction to FRENIC-Eco

This chapter describes the features and control system of the FRENIC-Eco series and the recommended configuration for the inverter and peripheral equipment.

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1.1 Features ..... 1-1
1.2 Control System ..... 1-19
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### 1.1 Features

## Default functions for fans and pumps

## Switching motor power between commercial lines and inverter outputs

The FRENIC-Eco series of inverters is equipped with built-in sequence control logic that supports starting of the motor via the commercial lines by using an external sequence and switches the motor power between commercial lines and inverter outputs. This feature simplifies the user's power control system configuration.
In addition to this Fuji's standard switching sequence, an auto-switching sequence is also available upon occurrence of an inverter alarm.
The schematic diagram below shows a typical sequence control circuit externally configured for an effective application of the sequence control logic.


Refer to function codes E01 to E05 in Section 9.2.2 "E codes" and J22 in Section 9.2.6 "J codes."

## Full PID control functions

The PID control has the "slow flowrate stop" and "deviation alarm/absolute value alarm output" functions. It also supports a variety of manual speed (frequency) commands to make a balance-less and bump-less switching available that automatically adjusts the output frequency against the frequency command.
Further, the PID control has an anti-reset wind-up function for prevention of overshooting, as well as supporting PID output limiter and integration hold/reset signals, facilitating the adjustment necessary for PID control.
Refer to the PID Frequency Command Generator in Section 4.9, function codes E01 to E05, E20 to E22, E24, and E27 in Section 9.2.2 "E codes," and J01 to J06, J10 to J13, and J15 to J19 in Section 9.2.6 "J codes."

## Slow flowrate stop function

A new function called slow flowrate stop is now added to the low limiter for securing the minimum operation speed of a fan and pump, etc., whereby the operation will stop if the flowrate drops and remains below the low limit for a certain length of time. This, combined with PID control, contributes to more energy-saving operation.


Refer to function codes E20 to E22, E24, and E27 in Section 9.2.2 "E codes" and J15, J16, and J17 in Section 9.2.6 "J codes."

## - Command loss detection

The analog frequency command is monitored and when an abnormal condition is detected, an alarm signal is output. Further, if in a critical system such as an air conditioner for an important facility, an abnormal condition is detected in the circuit handling the analog frequency command source, the system will be stopped or will continue its operation at the specified speed (at the specified percentage of the command just before the detection of the abnormal condition).


Dd Refer to function codes E20 to E22, E24, E27, and E65 in Section 9.2.2 "E codes."

## Low output torque detection

A low output torque detection signal is asserted in the event of sudden decrease in torque as a result of an abnormal condition such as the belt being broken between the motor and the load (e.g., a belt-driven fan). This signal, which indicates abnormal conditions occurring in the facility (load), can therefore be used as maintenance information.


Refer to function codes E20 to E22, E24, E27, E80 and E81 in Section 9.2.2 "E codes."

## - Continuous operation at momentary power failure

You can choose either tripping or automatic restart in the event of a momentary power failure. You can choose starting at the frequency at the momentary power failure occurrence or starting at 0 Hz , according to the requirement. Further, you can choose a control mode to prolong the running time utilizing the kinetic energy due to the load's moment of inertia during the momentary power failure.

(D) Refer to function code F14 in Section 9.2.1 "F codes."

## Switching between remote and local modes

You can choose a mode of inverter operation between remote (communications link or terminal commands) and local (keypad in any location such as built-in or on the power control enclosure) for both run commands and frequency commands, with combination sets of frequency command 1 and frequency command 2 , run command 1 and run command 2.


DD Refer to Running/stopping the motor in Section 3.2.3 and function codes F01 and F02 in Section 9.2.1 "F codes."

## Auto sync search with motor in idling state

The auto sync search feature helps the idling motor start smoothly, by setting a synchronizing frequency. When the motor is in idling state due to natural convection, momentary power failure or other similar situations, the inverter can automatically search for the current motor rotation speed and direction and start/restart the motor smoothly from the frequency that can be synchronized with the current motor speed and rotation, without stopping it. For restart after a recovery from the momentary power failure, you have a choice of two frequencies--the frequency saved at the power failure and the starting frequency.


Refer to function codes H 09 and H17 in Section 9.2.5 "H codes."

## ■ Choosing from a variety of frequency command sources

A variety of frequency command sources are provided to match your power system as listed below.

- Keypad (ヘ / © keys)

The keypad allows you to set a frequency command as an output frequency, motor rotation speed, load shaft speed, percentage to the maximum frequency, etc.

- Analog terminal inputs

You can set up analog inputs with the following signals, either individually or in combination of them. -4 to 20 mA DC [C1] or 0 to 10 VDC [12]

- Inverse of the above signals
- Voltage input terminal for analog setting [V2] (built-in)
- Multistep frequency (8 steps)
- UP/DOWN operation
- Switching between frequency commands 1 and 2
- Suitable manipulation (addition) of frequencies, available by using auxiliary frequency commands 1 and 2
- RS485 communications link facility supported as standard
- Switching between remote and local command sources


Refer to function code F01 in Section 9.2.1 "F codes," E01 to E05 and E61 to E63 in Section 9.2.2 "E codes," and H30 in Section 9.2.5 "H codes."

## Monitor for analog input

The inverter is equipped with input terminals for accepting analog signals from the outside equipment or the motor. By connecting the outputs of a flow meter, a pressure gauge, or any other sensor, you can display them on the LED monitor on the keypad that shows their physical values in easy-to-understand analog values (multiplied with a specified coefficient in some cases). It is also possible to build a host-controlled system by sending/receiving such information via the communications link to/from a host computer.

(D) Refer to function codes E43, E45, and E48 in Section 9.2.2 "E codes."

## Contribution to energy-saving

## Automatic energy-saving (standard feature)

A new, automatic energy-saving function is included as a standard feature, which controls the system to minimize the total loss (motor loss plus inverter loss), rather than just the motor loss as in the predecessor models. This feature thus contributes to further energy saving in applications with fans and pumps.


Figure 1.1 Example of Energy-Saving
Refer to the Drive Command Controller in Section 4.8 and function codes F09 and F37 in Section 9.2.1 "F codes."

## Monitoring electric power

In addition to electric power monitoring on the standard keypad (or optional multi-function keypad), online monitoring is available from the host equipment through the communications link.
This function monitors real-time power consumption, cumulative power consumption in watt-hours, and cumulative power consumption with a specified coefficient (such as an electricity charge).


Refer to Chapter 3 "OPERATION USING THE KEYPAD" and Chapter 5 "RUNNING THROUGH RS485 COMMUNICATION."

## PID control supported

PID control, which is a standard feature on the inverter, allows you to control temperature, pressure, and flowrate without using any external adjustment devices so that you can configure a temperature control system without an external thermal conditioner.
[1] Refer to the PID Frequency Command Generator in Section 4.9 and function codes J01 to J06 in Section 9.2.6 "J codes."

## ■ Cooling fan ON/OFF control

The inverter's cooling fan can be stopped whenever the inverter does not output power. This contributes to noise reduction, longer service life, and energy saving.

Refer to function codes E20 to E22, E24, and E27 in Section 9.2.2 "E codes" and H06 in Section 9.2.5 "H codes."

## Consideration for surrounding environment

## Reactor built-in type added to standard line-up

A DC reactor for power-factor correction is now integrated in the inverter (for the range of 0.75 to 55 kW ). In addition, a zero-phase reactor (ferrite ring) and a capacitive filter are integrated in the inverters of 22 kW or below. These features simplify the power-related wiring (no need for DC reactor and capacitive filter wiring). The new good-shortcut wiring feature also fully covers Standard Specifications for Public Building Construction set by the Japanese Ministry of Land, Infrastructure and Transport (Volume for Electric Facilities and Volume for Mechanical Facilities).


Refer to Chapter 6 "SELECTING PERIPHERAL EQUIPMENT."

## - Inrush current suppression circuit integrated in all models

An inrush current suppression circuit is integrated as standard in all models, therefore the cost of peripheral devices such as magnetic contactor (MC) can be reduced.

## EMC-filter built-in type added to semi-standard line-up

The product can be used to fully comply with the EMC Directives in EU. ( 15 kW or below)

## Standard installation of input terminals for auxiliary control power of all models

The auxiliary control input terminals provide a convenient shortcut for automatic input power source switching between commercial line and inverter as standard terminals.Refer to Section 8.4 "Terminal Specifications."

## Various functions for protection and easy maintenance

FRENIC-Eco series features the following facilities useful for maintenance.Refer to Chapter 3 "OPERATION USING THE KEYPAD" in this manual and the "FRENIC-Eco Instruction Manual" (INR-SI47-0882-E), Chapter 7 "MAINTENANCE AND INSPECTION."

## Lifetime estimation for DC link bus capacitors (reservoir capacitors)

This function shows the lifetime of the DC link bus capacitor as a ratio to its initial capacitance value, helping you determine the replacement timing of the capacitor. (Design life of DC link bus capacitors: 10 years under these conditions: load $=80 \%$ of inverter's rated current; ambient temperature $=40^{\circ} \mathrm{C}$ )

## Long-life fans

Use of a long-life fan reduces replacement work. (Design life of fans: 7 years for models of 5.5 kW or below; 4.5 years for models of $7.5-30 \mathrm{~kW} ; 3$ years for models of 37 kW or above, at ambient temperature of $40^{\circ} \mathrm{C}$ )

## Easy to replace cooling fans

On $5.5-30 \mathrm{~kW}$ models, you can easily replace the cooling fan in simple steps, since it is mounted on the upper part of the inverter. On models of 37 kW or above, you can replace it easily from the front side without detaching the inverter from your enclosure.

To replace the cooling fan, follow the procedures as shown below
$<$ FRN15F1S-2J $>$

$<$ FRN45F1S-2J>

(1)

Loosen the four screws at the four comers, slide the front cover in the direction of the arrow, and remove the front cover by pulling it toward you.

(3)

Disconnect the connector of the cable connecting the control circuit board to the keypad (shown in O above), tilt the keypad case to $90^{\circ}$ against the unit, slide it in the direction of the arrow while keeping this angle, and remove it by pulling it toward you.

(4)

Disconnect the connector for switching the fan's power supply and remove the four screws at the four comers (shown in O above).

(5)

Grab the fan-mounting board and pull the entire fan block toward you.

(6)

The fan block is now removed.
After replacing the cooling fan, follow this procedure in the reverse sequence.

## - Cumulative running hours of inverter, capacitor, cooling fan, and motor

FRENIC-Eco series accumulates running hours of the inverter itself, motor (mechanical system), cooling fan, and electrolytic capacitor on the printed circuit board for recording and displaying on the keypad.

These data can be transferred to host equipment via the communications link and used for monitoring and maintenance for mechanical system to increase the reliability of the facility or plant (load).


## - Outputting a lifetime early warning signal to the programmable transistor

When either one of the DC link bus capacitor (reservoir capacitor), the electrolytic capacitors on the printed circuit boards, and the cooling fans is nearing the end of its lifetime, a lifetime early warning signal is output.
(D) Refer to function codes E20 to E22, E24, and E27 in Section 9.2.2 "E codes."

## Record of the 4 latest alarm history available

You can view alarm codes and their related information up to four latest ones.

## DI) Refer to Section 3.3.7 "Reading alarm information."

## Protective function against phase loss in input/output

Protection against phase loss in input/output circuits is possible at start-up and during operation.
(D) Refer to the Protective Functions in Section 8.8 and function code H98 in Section 9.2.5 "H codes."

## - Protective function for grounding fault

Protection is provided for an overcurrent caused by a grounding fault.Refer to the Protective Functions in Section 8.8.

## Protection of motor with PTC thermistor

By connecting the Positive Temperature Coefficient (PTC) thermistor embedded in the motor to the terminal [V2], you can monitor the temperature of the motor, and stop the inverter output before the motor overheats, thereby protecting the motor. You can select the action in the event of an overheat hazard according to the PTC protection level: whether to stop the inverter (alarm stop) or to turn ON the alarm output signal on the programmed terminal.

(1) Refer to function codes F10 to F12 in Section 9.2.1 "F codes" and H26 and H27 in Section 9.2.5 "H codes."

## Simple operation and wiring

## Standard keypad capable of operating at a remote site

Using the optional extension cable easily allows local mode operation at a remote site such as on the power system enclosure wall or on hand.
The standard keypad has the function code data copying function that allows you to copy data to other inverters. A multi-function keypad (optional) is also available.


Refer to Chapter 2 "PARTS NAMES AND FUNCTIONS," Section 3.3.8 "Data copying information," Section 6.4.2 "Options for operation and communications," and Section 9.2 "Overview of Function Codes." Refer to function codes E43, E45 to E47 in Section 9.2.2 "E codes."

## - Quick setup function

Using an optional multi-function keypad can define a set of 19 function codes for quick setup. This feature thus allows you to combine only frequently used or important function codes into a customized set to shortcut operation and management.
(1) Refer to Section 3.3.1 "Setting up function codes quickly."

## - Menu mode accessible from the keypad

You can easily access the keypad menu mode including "Data setting," "Data checking," "Drive monitoring," "I/O checking," "Maintenance information," and "Alarm information."


Refer to Section 3.3 "Programming Mode."

## - Multi-function keypad (option)

- A backlit LCD makes it easy to view and note the displayed data.
- Interactive mode of operation simplifies the set-up procedures.
- The keypad can save function code data for up to three inverters.
- The key switches the mode between Remote and Local with a single touch on it (holding it down for three seconds).
- The keypad allows you to customize the defined set of 19 function codes for quick setup through addition and deletion into your own favorite function code set.
- The keypad allows you to measure the load factor around the clock.
- The keypad is equipped with a communications debug feature.


Refer to Section 6.4.2 "Options for operation and communications," Section 9.2 "Overview of Function Codes," and function codes E43, E45 to E47 in Section 9.2.2,"E codes."

## Easy-to-remove/mount front cover and terminal cover

The front cover and the terminal cover of the FRENIC-Eco are easy to remove and mount for setup, checkup and maintenance.

Refer to Section 2.1 "External View and Allocation of Terminal Blocks" in this manual and the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 2 "MOUNTING AND WIRING OF THE INVERTER."

## LED monitor on the keypad displaying all types of data

You can access and monitor all types of the inverter's operating status data including output frequency, reference frequency, load shaft speed, output current, output voltage, alarm history, and input power, using the keypad regardless the pattern of installation.

Refer to Chapter 3 "OPERATION USING THE KEYPAD."

## Global products

FRENIC-Eco series of inverters are designed for use in global market and to comply with the global standards listed below.

## All standard models comply with the EC Directive (CE marking), UL standards and Canadian standards (cUL certification).

All standard FRENIC-Eco inverters comply with European and North American/Canadian standards, enabling standardization of the specifications for machines and equipment used at home and abroad.

- If the model with built-in EMC filter is used, the model conforms to the European EMC Directive.



## Enhanced network support

With an optional card, the inverter extends its conformity with various world-standard of open bus protocols such as DeviceNet, PROFIBUS-DP, LonWorks network, Modbus Plus or CC-Link.
A standard RS485 communications port (compatible to Modbus RTU protocol, shared with a keypad) is a built-in feature. With an additional RS485 communications card (optional), up to two ports are available.
Networking allows you to control up to 31 inverters through host equipment such as a PC (personal computer) and PLC (programmable logic controller.)


Refer to Chapter 5 "RUNNING THROUGH RS485 COMMUNICATION," Section 6.4.2 "Options for operation and communications," and Section 9.4.7, "y codes."

## Space saving

## Side-by-side mounting is possible.

When multiple inverter units are installed next to each other inside a panel, the installation space can be minimized. This applies to inverters of 5.5 kW or below operating at ambient temperatures of $40^{\circ} \mathrm{C}$ or below.


Figure 1.2 Side-by-side Mounting (Example)

## The ideal functions to serve a multiplicity of needs

Compatible with a wide range of frequency command sources
You can select the optimum frequency command source that matches your machine or equipment via the keypad ( $\wedge$ keys), analog voltage input, analog current input, multistep frequency commands (steps 0 to 7 ), or the RS485 communications link.
(D) Refer to function codes E01 to E05 in Section 9.2.5 "H codes."

## Switchable sink/source signal input mode

The input mode (sink/source) of the digital input terminals can be switched by means of a slide switch inside the inverter. No engineering change is required in other control equipments including PLC.

DC] Refer to Section 8.4.1 "Terminal functions."

## Three transistor switch outputs and a relay output card option available

The three transistor switch outputs enable issuing of motor overload early warning, lifetime early warning and other information signals when the inverter is running. In addition, using the optional relay output card OPC-F1-RY can convert these outputs to three pairs of transfer relay contact outputs [Y1A/Y1B/Y1C], [Y2A/Y2B/Y2C] and [Y3A/Y3B/Y3C], which can be used in the same manner as the conventional relay contact output $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$.Refer to function codes E20 to E22, E24, and E27 in Section 9.2.2 "E codes" in this manual and the Relay Output Card "OPC-F1-RY" Instruction Manual (INR-SI47-0873).

## - Maximum frequency - up to 120 Hz

The inverter can be used with equipment that requires a high motor speed. For high-speed applications, you need to ensure beforehand that the inverter can operate normally with the motor.

DD Refer to function code F03 in Section 9.2.1 "F codes."

## - Two points can be set for a non-linear V/f pattern.

The addition of an extra point (total: 2 points) for the non-linear V/f pattern, which can be set as desired, improves the FRENIC-Eco's drive capability, because the V/f pattern can be adjusted to match a wider application area. (Maximum frequency: 120 Hz ; Base frequency range: 25 Hz and above)


Refer to Section 4.8 "Drive Command Controller" and function codes F04 and F05 in Section 9.2.1 "F codes."

## Flexible through options

## Function code data copying function

Because the optional multi-function keypad is provided with a built-in copy function, similar to that installed on the inverter as a standard feature, function code data can be easily copied to the second or more inverters without requiring setups individual to the inverter.

Refer to Section 9.2 "Overview of Function Codes" and Section 3.3.8 "Data copying."

## ■ Customized set of function code for simplified operation

By using an optional multi-function keypad, you can define your own set of function codes (in addition to those for quick setup) which you will use most frequently, so that you can modify and manage the data for those function codes in simple operation.
(1) Refer to the Multi-function Keypad Instruction Manual (INR-SI47-0890-E).

## - Inverter loader software (option)

FRENIC Loader is a support tool for FRENIC-Eco/Mini series of inverters to enable a Windows-based PC to remotely control the inverter. The Loader makes it significantly easier to perform data editing and management such as data management, data copying, and real-time tracing. (For connection via a USB port of your PC, an optional USB-RS485 interface converter is available.)


Refer to Chapter 5 "RUNNING THROUGH RS485 COMMUNICATION" in this manual and the FRENIC Loader Instruction Manual (INR-SI47-0903-E).

## - Mounting Adapter for External Cooling

A mounting adapter for external cooling (Option for 30 kW or below. Standard for 37 kW or above) cools the inverter outside the panel. It can be easily mounted on the enclosure.Refer to Section 6.4.3 "Extended installation kit options."

### 1.2 Control System

This section gives you a general overview of inverter control systems and features specific to the FRENIC-Eco series of inverters.
As shown in Figure 1.4, the converter section converts the input commercial power to DC power by means of a full-wave rectifier, which is then used to charge the DC link bus capacitor (reservoir capacitor). The inverter portion modulates the electric energy charged in the DC link bus capacitor by Pulse Width Modulation (PWM) and feeds the output to the motor. (The PWM switching frequency is called the "Carrier Frequency.") The voltage applied to the motor terminals has a waveform shown on the left-hand side ("PWM voltage waveform") of Figure 1.3, consisting of alternating cycles of positive pulse trains and negative pulse trains. The current running through the motor, on the other hand, has a fairly smooth alternating current (AC) waveform shown on the right-hand side ("Current waveform") of Figure 1.3, thanks to the inductance of the motor coil inductance. The control logic section controls the PWM so as to bring this current waveform as close to a sinusoidal waveform as possible.


PWM voltage waveform


Current waveform

Figure 1.3 Output Voltage and Current Waveform of the Inverter
For the frequency command given in the control logic, the accelerator/decelerator processor calculates the acceleration/deceleration rate required by run/stop control of the motor and transfers the calculated results to the 3-phase voltage processor directly or via the V/f pattern generator whose output drives the PWM block to switch the power gates.

Refer to Section 4.8 "Drive Command Controller" for details.
The FRENIC-Eco series features simplified magnetic flux estimation integrated in the V/f pattern generator section. This feature automatically adjusts the voltage applied to the motor according to the motor load so as to make the motor generate more stable and higher torque even during low speed operation.
The control logic section, which is the very brain of the inverter, allows you to customize the inverter's driving patterns throughout the function code data settings.

Refer to Section 4.8 "Drive Command Controller," function codes F04 and F05 in Section 9.2.1 "F codes," and H50 and H51 in Section 9.2.5 "H codes" for details.


Figure 1.4 Schematic Block Diagram of FRENIC-Eco

### 1.3 Recommended Configuration

To control a motor with an inverter correctly, you should consider the rated capacity of both the motor and the inverter and ensure that the combination matches the specifications of the machine or system to be used. Refer to Chapter 7 "SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES" for details.

After selecting the rated capacity, select appropriate peripheral equipment for the inverter, then connect them to the inverter.

Refer to Chapter 6 "SELECTING PERIPHERAL EQUIPMENT" and Section 8.7 "Connection Diagrams" for details on the selection and connection of peripheral equipment.

Figure 1.5 shows the recommended configuration for an inverter and peripheral equipment.


Figure 1.5 Recommended Configuration Diagram

## Chapter 2

## PARTS NAMES AND FUNCTIONS

This chapter contains external views of the FRENIC-Eco series and an overview of terminal blocks, including a description of the LED monitor, keys and LED indicators on the keypad.

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2.2 LED Monitor, Keys and LED Indicators on the Keypad ..... 2-4

### 2.1 External View and Allocation of Terminal Blocks

Figures 2.1 and 2.2 show the external views of the FRENIC-Eco.
(1) External views

(a) FRN15F1S-2J

(b) FRN37F1S-2J

Figure 2.1 External Views of Standard Type Inverters

- FRENIC-Eco with integrated DC reactor


Figure 2.2 External Views of FRENIC-Eco with Integrated DC Reactor (DCR)
(2) Terminal block location

(a) FRN15F1S-2J


Figure 2.3 Terminal Blocks and Keypad Enclosure Location


Figure 2.4 Enlarged View of the Terminal BlocksRefer to Chapter 8 "SPECIFICATIONS" for details on terminal functions, arrangement and connection and to Chapter 6, Section 6.2.1 "Recommended wires" when selecting wires.
For details on the keys and their functions, refer to Section 2.2 "LED Monitor, Keys and LED Indicators on the Keypad." For details on keying operation and function code setting, refer to Chapter 3 "OPERATION USING THE KEYPAD."

### 2.2 LED Monitor, Keys and LED Indicators on the Keypad

As shown at the right, the keypad consists of a four-digit LED monitor, six keys, and five LED indicators.

The keypad allows you to run and stop the motor, monitor running status, and switch to the menu mode. In the menu mode, you can set the function code data, monitor I/O signal states, maintenance information, and alarm information.

A multi-function keypad is optionally available.


Figure 2.5 Keypad

Table 2.1 Overview of Keypad Functions

| Item | LED Monitor, Keys, and LED Indicators | Functions |
| :---: | :---: | :---: |
| LED <br> Monitor | 6878 | Four-digit, 7-segment LED monitor which displays the followings according to the operation modes. <br> - In Running mode: Running status information (e.g., output frequency, current, and voltage) <br> - In Programming mode: Menus, function codes and their data <br> - In Alarm mode: Alarm code, which identifies the error factor if the protective function is activated. |
| Operation Keys | ( 5 Pas | Program/Reset key which switches the operation modes of the inverter. <br> - In Running mode: Pressing this key switches the inverter to Programming mode. <br> - In Programming mode: Pressing this key switches the inverter to Running mode. <br> - In Alarm mode: Pressing this key after removing the error factor will switch the inverter to Running mode. |
|  | encr | Function/Data key which switches the operation you want to do in each mode as follows: <br> In Running mode: <br> Pressing this key switches the information to be displayed concerning the status of the inverter (output frequency $(\mathrm{Hz})$, output current $(\mathrm{A})$, output voltage $(\mathrm{V})$, etc.). <br> In Programming mode: Pressing this key displays the function code and sets the data entered with @ and $\vee$ keys. <br> In Alarm mode: Pressing this key displays the details of the problem indicated by the alarm code that has come up on the LED monitor. |
|  | RuN | RUN key. Press this key to run the motor. |
|  |  | STOP key. Press this key to stop the motor. |
|  | (1) a | UP and DOWN keys. Press these keys to select the setting items and change the function code data displayed on the LED monitor. |
| LED <br> Indicators | RUN LED | Lights when the inverter is running by a run command from the eunl key, (FWD)/(REV) signal, or via the communications link. |
|  | KEYPAD <br> CONTROL LED | Lights when the keypad operation is selected ( $\mathrm{F} 02=0,2$ or 3). In Programming and Alarm modes, the keypad operation is disabled even if the indicator lights. |
|  | Unit and mode expression by the three LED indicators | The lower 3 LED indicators identify the unit of numeral displayed on the LED monitor in Running mode by combination of lit and unlit states of them. <br> Unit: $\mathrm{kW}, \mathrm{A}, \mathrm{Hz}, \mathrm{r} / \mathrm{min}$ and $\mathrm{m} / \mathrm{min}$ <br> Refer to Chapter 3, Section 3.2.1 "Monitoring the running status" for details. |
|  |  | While the inverter is in Programming mode, two LEDs at both ends of the lower indicators light. <br> In Programming mode: $\quad \mathrm{Hz} \quad \square \mathrm{A} \quad \mathrm{m}_{\mathrm{kW}}$ |

## LED monitor

In Running mode, the LED monitor displays running status information (output frequency, current or voltage); in Programming mode, it displays menus, function codes and their data; and in Alarm mode, it displays an alarm code which identifies the error factor if the protective function is activated.
If one of LED4 through LED1 is blinking, it means that the cursor is at this digit, allowing you to change it.

If the decimal point of LED1 is blinking, it means that the currently displayed data is a value of the PID process command, not the frequency data usually displayed.


Figure 2.6 7-Segment LED Monitor
Table 2.2 Alphanumeric Characters on the LED Monitor

| Character | 7 -segment | Character | 7-segment | Character | 7-segment | Character | 7-segment |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | ! 7 | 9 | 9 | i | , | r | - |
| 1 | ' | A | G | J | $\iota^{\prime}$ | S | 5 |
| 2 | $\square$ | b | $\square$ | K | -' | T | ! |
| 3 | 7 | C | $\stackrel{\square}{\square}$ | L | L | u | 4 |
| 4 | 4 | d | $\square$ | M | 17 | V | $\iota^{\prime}$ |
| 5 | 5 | E | $E$ | $n$ | 17 | w | 3 |
| 6 | ! | F | $\stackrel{ }{=}$ | o | $\square$ | X | $1-$ |
| 7 | 7 | G | $\stackrel{\square}{4}$ | P | P | y | $\square$ |
| 8 | G | H | H | q | 7 | Z | 2 |
| Special characters and symbols (numbers with decimal point, minus and underscore) |  |  |  |  |  |  |  |
| 0. - 9. | 为 - | - | - | - | - |  |  |

## - Simultaneous keying

Simultaneous keying means pressing two keys at the same time. The FRENIC-Eco supports simultaneous keying as listed below. The simultaneous keying operation is expressed by a " + " letter between the keys throughout this manual.
(For example, the expression "® + keys" stands for pressing the key while holding down the (rom key.)

Table 2.3 Simultaneous Keying

| Operation mode | Simultaneous keying | Used to: |
| :--- | :--- | :--- |
| Programming mode | keys | Change certain function code data. (Refer to codes F00, <br> H03, and H97 in Chapter 9 "FUNCTION CODES.") |
|  | keys | Switch to Programming mode without resetting alarms <br> currently occurred. |

## Chapter 3

## OPERATION USING THE KEYPAD

This chapter describes inverter operation using the keypad. The inverter features three operation modes (Running, Programming and Alarm modes) which enable you to run and stop the motor, monitor running status, set function code data, display running information required for maintenance, and display alarm data.

The keypad is available in two types: standard keypad and optional multi-function keypad. For the instructions on how to operate the multi-function keypad, refer to the "Multi-function Keypad Instruction Manual" (INR-SI47-0890-E).

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### 3.1 Overview of Operation Modes

FRENIC-Eco features the following three operation modes:
$\square$ Running mode : This mode allows you to enter run/stop commands in regular operation. You can also monitor the running status in real time.

- Programming mode: This mode allows you to set function code data and check a variety of information relating to the inverter status and maintenance.
$\square$ Alarm mode : If an alarm condition arises, the inverter automatically enters the Alarm mode. In this mode, you can view the corresponding alarm code* and its related information on the LED monitor.
* Alarm code: Indicates the cause of the alarm condition that has triggered a protective function. For details, refer to Chapter 8, Section 8.8 "Protective Functions."

Figure 3.1 shows the status transition of the inverter between these three operation modes.


Figure 3.1 Status Transition between Operation Modes
Figure 3.2 illustrates the transition of the LED monitor screen during Running mode, the transition between menu items in Programming mode, and the transition between alarm codes at different occurrences in Alarm mode.

*1 In speed monitor, you can have any of the following displayed according to the setting of function code E48: Output frequency (Hz), Motor speed (r/min), Load shaft speed (r/min), and Display speed (\%).
*2 Applicable only when PID control is active. ( $\mathrm{J} 01=1$ or 2 )
*3 Applicable only when the analog signal input monitor is assigned to any terminals [12], [C1], or [V2] by E61, E62 or E63 (= 20).
*4 Applicable only when the full-menu mode is active. ( $\mathrm{E} 52=2$ )
Figure 3.2 Transition between Basic Display Frames by Operation Mode

## 3．2 Running Mode

When the inverter is turned on，it automatically enters Running mode．In this mode，you can：
（1）Monitor the running status（e．g．，output frequency，output current），
（2）Set up the frequency command and others，and
（3）Run／stop the motor．

## 3．2．1 Monitoring the running status

In Running mode，the eleven items listed below can be monitored．Immediately after the inverter is turned on，the monitor item specified by function code E43 is displayed．Press the 圈 key to switch between monitor items．For details of switching the monitor item by using the 贯 key，refer to ＂Monitoring of Running Status＂in Figure 3．2 Transition between Basic Display Frames by Operation Mode．

Table 3．1 Monitoring Items

| Monitor Items | Display Sample on the LED monitor＊1 | LED indicator <br> $\square$ ：on，$\square$ ：off | Unit | Meaning of Displayed Value | Function Code E43 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Speed monitor | Function code E48 specifies what to be displayed on the LED monitor and LED indicators． |  |  |  | $\begin{gathered} 0 \\ (\mathrm{E} 48=0) \end{gathered}$ |
| Output frequency | 5イレイレイ | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | Hz | Frequency actually being output |  |
| Motor speed |  | ■ Hz ■A $\square \mathrm{kW}$ | $\mathrm{r} / \mathrm{min}$ | Output frequency（Hz）$\times \frac{120}{\mathrm{P} 01}$ | $(\mathrm{E} 48=3)$ |
| Load shaft speed | ジルバイハイ | ■ Hz ■A $\square \mathrm{kW}$ | $\mathrm{r} / \mathrm{min}$ | Output frequency（Hz）$\times$ E50 | $(E 48=4)$ |
| Speed（\％） | 5イ7\％ | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | \％ | $\frac{\text { Output frequency }}{\text { Maximum frequency }} \times 100$ | $(\mathrm{E} 48=7)$ |
| Output current | ルプジイ | $\square \mathrm{Hz} \mathrm{■a} \square \mathrm{~kW}$ | A | Current output from the inverter in RMS | 3 |
| Output voltage＊2 | ニ゙ルいでい！ | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | V | Voltage output from the inverter in RMS | 4 |
| Calculated output torque | 年 | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | \％ | Motor output torque in \％（Calculated value） | 8 |
| Input power | バインズイ | $\square \mathrm{Hz} \square \mathrm{A} \square_{\mathrm{kW}}$ | kW | Input power to the inverter | 9 |
| PID process command *3, *4 |  | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | － | PID process command／feedback value transformed to that of virtual physical value of the object to be controlled | 10 |
| PID feedback value $* 3, * 5$ | －7．141\％ | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | － | （e．g．temperature） <br> Refer to the function codes E40 and E41 for details． | 12 |
| PID output＊3，＊4 |  | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | \％ | PID output in \％as the maximum frequency（F03）being at $100 \%$ | 14 |
| Load factor＊6 | 5111 | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | \％ | Load factor of the motor in \％as the rated output being at $100 \%$ | 15 |
| Motor output＊7 | フ1ロイ゙ィ | $\square \mathrm{Hz} \square \mathrm{A} \square_{\mathrm{kW}}$ | kW | Motor output in kW | 16 |
| Analog input＊8 |  | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | － | Analog input signal to the inverter， transformed by E40 and E41 <br> Refer to the function codes E40 and E41 for details． | 17 |

*1 A value exceeding 9999 cannot be displayed on the 4-digit LED monitor screen, so " 5 ] ( 7 -segment letters) appear instead.
*2 For displaying an output voltage on the LED monitor, the 7 -segment letter $\AA \prime$ is used in the lowest digit as an alternative expression of the unit of the V (volt).
*3 These PID-related items appear only when the inverter PID-controls the motor according to a PID process command specified by the function code J 01 ( $=1$ or 2 ).
*4 When the LED monitor displays a PID process command or its output amount, the dot (decimal point) attached to the lowest digit of the 7 -segment letter blinks.
*5 When the LED monitor displays a PID feedback value, the dot (decimal point) attached to the lowest digit of the 7 -segment letter lights.
*6 For displaying a load factor on the LED monitor, the 7 -segment letter $\_$is used in the lowest digit as an alternative expression of the unit of $\%$.
*7 When the LED monitor displays the motor output, the unit LED indicator " kW " blinks.
*8 Analog input monitoring becomes active only when any data of the function codes E61, E62 and E63 is effective (= 20) to define a terminal function.

### 3.2.2 Setting up frequency and PID process commands

You can set up the desired frequency and PID process commands by using $\triangle$ and $\nabla$ keys on the keypad. It is also possible to set up the frequency command as load shaft speed, motor speed or speed (\%) by setting function code E48.

## ■ Setting up a frequency command

## Using $\ominus_{\text {and }} \ominus_{\text {keys (Factory default) }}$

(1) Set function code F01 to "0: Keypad operation." This can be done only when the inverter is in Running mode.
(2) Press the $\sigma / \nabla$ key to display the present reference frequency. The lowest digit will blink.
(3) If you need to change the frequency command, press the $\alpha$ / key again. The new setting will be automatically saved into the inverter's internal memory and retained even when the power is off. When the power is turned on next time, the setting will be used as an initial reference frequency.

- The frequency command can be saved either automatically as mentioned above or by pressing the 园 key. You can choose either way using function code E64.
- If you have set function code F01 to "0: Keypad operation ( $Q$ / key)" but have selected a frequency command source other than frequency command 1 (i.e., frequency command 2 , frequency command via communication, or multistep frequency command), then the $\sigma$ key is disabled to change the current frequency command even in Running mode. Pressing either of these keys just displays the present reference frequency.
- When you start specifying or changing the frequency command or any other parameter with the $/$ key, the lowest digit on the display blinks and starts changing. As you are holding down the key, blinking will gradually move to the upper digit places and the upper digits will be changeable.
- If you press the $Q / \triangle$ key once and then hold down the key for more than 1 second after the lowest digit starts blinking, blinking will move to the next upper digit place to allow you to change the value of that digit (cursor movement). This way you can easily change the values of the higher digits.
- By setting function code C30 to "0: Keypad operation ( $\triangle$ / key)" and selecting frequency command 2, you can also specify or change the frequency command in the same manner using the $Q$ / key

You can set up a frequency command not only with the frequency $(\mathrm{Hz})$ but also with other menu items (Motor speed, load shaft speed, and speed (\%)) depending on the setting of function code E48 (=3, 4, or 7) "Speed monitor items" as shown in Table 3.1.

## Make setting under PID control

To enable PID control, you need to set function code J01 to 1 or 2.
Under the PID control, the items that can be set or checked with $\triangle$ and $\boxtimes$ keys are different from those under regular frequency control, depending upon the current LED monitor setting. If the LED monitor is set to the speed monitor $(\mathrm{E} 43=0)$, you can access manual speed commands (Frequency command) with $\triangle$ and $\triangle$ keys; if it is set to any other, you can access the PID process command with those keys.

Refer to Chapter 4, Section 4.9, "PID Frequency Command Generator" for details on the PID control.

## Setting the PID process command with ${ }^{-}$and keys

(1) Set function code F01 to "0: Keypad operation."
(2) Set the LED monitor to something other than the speed monitor $(E 43=0)$ when the keypad is in Running mode. When the keypad is in Programming or Alarm mode, you cannot modify the PID process command with the $\triangle / \varnothing$ key. To enable the PID process command to be modified with the - key, first switch to Running mode.
(3) Press the $\triangle / \square$ key to have the PID process command displayed. The lowest digit will blink on the LED monitor.
(4) To change the PID process command, press the $\triangle$ / key again. The PID process command you have specified will be automatically saved into the inverter's internal memory. It is kept there even if you temporarily switch to another means of specifying the PID process command and then go back to the means of specifying the PID process command via the keypad. Also, it is kept there even while the inverter is powered off, and will be used as the initial PID process command next time the inverter is powered on.

- Even if multistep frequency is selected as the PID process command ((SS4) $=\mathrm{ON})$, you still can set the process command using the keypad.
- When function code J02 is set to any value other than 0 , pressing the $\triangle / \nabla$ key displays, on the 7-segment LED monitor, the PID command currently selected, while you cannot change the setting.
- On the 7 -segment LED monitor, the decimal point of the lowest digit is used to characterize what is displayed. The decimal point of the lowest digit blinks when a PID process command is displayed; the decimal point lights when a PID feedback value is displayed.


Table 3.2 PID Process Command Manually Set with $/$ Key and Requirements

| PID Control <br> (Selection) <br> J01 | PID Control <br> (Remote Process <br> Command) <br> J02 | LED Monitor <br> E43 | Multistep <br> Frequency <br> (SS4) | With the $\triangle / \varnothing$ key |
| :---: | :--- | :--- | :--- | :--- |

## Setting up the frequency command with and keys under PID control

When function code F01 is set to " 0 " (Enable $\sigma$ keys on keypad) and frequency command 1 is selected as a manual speed command (that is, disabling the frequency setting command via communications link and multistep frequency command), switching the LED monitor to the speed monitor in Running mode enables you to modify the frequency command with the $\sigma$ /keys.
In Programming or Alarm mode, the / keys are disabled to modify the frequency command. You need to switch to Running mode.
Table 3.3 lists the combinations of the commands and the figure illustrates how the manual speed command $(1)$ entered via the keypad is translated to the final frequency command 2 .
The setting procedure is the same as that for setting of a usual frequency command.

Table 3.3 Manual Speed (Frequency) Command Set with - Keys and Requirements

| PID <br> Control (Selection) J01 | LED <br> Monitor E43 | Frequency <br> Command 1 <br> F01 | Multistep <br> Frequency (SS2) | Multistep <br> Frequency (SS1) | Link <br> Operation Selection (LE) | Disable <br> PID <br> Control <br> (Hz/PID) | Pressing ©/D keys controls: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 or 2 | 0 | 0 | OFF | OFF | OFF | OFF <br> (PID <br> enabled) | PID output (as final frequency command) |
|  |  |  |  |  |  | ON <br> (PID <br> disabled) | Manual speed (frequency) command set by keypad |
|  |  | Other than the above |  |  |  | OFF <br> (PID <br> enabled) | PID output (as final frequency command) |
|  |  |  |  |  |  | ON <br> (PID <br> disabled) | Manual speed (frequency) command currently selected |



### 3.2.3 Running/stopping the motor

By factory default, pressing the key starts running the motor in the forward direction and pressing the key decelerates the motor to stop. The ent key is enabled only in Running mode.

The motor rotational direction can be selected by changing the setting of function code F02.

For the optional multi-function keypad, see page 3-10.


## Operational relationship between function code F02 (Run command) and ey key

Table 3.4 lists the relationship between function code F02 settings and the key, which determines the motor rotational direction.

Table 3.4 Motor Rotational Direction Specified by F02

| Data for F02 | Pressing the key runs the motor: |
| :---: | :--- |
| 0 | In the direction commanded by terminal <br> [FWD] or [REV] |
| 1 | ey key disabled <br> (The motor is driven by terminal command <br> $[$ FWD or [REV].) |
| 2 | In the forward direction |
| 3 | In the reverse direction |


(Note) The rotational direction of IEC-compliant motors is opposite to that of the motor shown here.

For the details on operations with function code F02, refer Chapter 9 "FUNCTION CODES."

When the keypad is in use for specifying the frequency settings or driving the motor, do not disconnect the keypad from the inverter when the motor is running. Doing so may stop the inverter.

## Remote and local modes

The inverter can be operated either in remote or local mode. In remote mode that applies to ordinary operation, the inverter is driven under the control of the data settings stored in the inverter, whereas in local mode that applies to maintenance operation, it is separated from the control system and is driven manually under the control of the keypad.

- Remote mode: The run and frequency commands are selected by source switching signals including function codes, run command $2 / 1$ signals, and communications link operation signal.
- Local mode: The command source is the keypad, regardless of the settings specified by function codes. The keypad takes precedence over the settings specified by run command $2 / 1$ signals or communications link operation signal.


## Run commands from the keypad in local mode

The table below shows the input procedures of run commands from the keypad in local mode.
Table 3.5 Run Commands from the Keypad in Local Mode

| When Data for F02 (Run command) is : | Input Procedures of Run Commands from Keypad |
| :---: | :---: |
| 0: Enable (20) / kisy keys on keypad (Motor rotational direction from digital terminals [FWD]/[REV]) | Pressing the key runs the motor in the direction specified by command (FWD) or (REV) assigned to terminal [FWD] or [REV], respectively. Pressing the key stops the motor. |
| 1: Enable terminal command (FWD)/(REV) | Pressing the key runs the motor in the forward direction only. Pressing the key stops the motor. |
| 2: Enable © / (Forward) keys on keypad (Forwa | No specification of the motor rotational direction is required. |
| 3: Enable (Reverse) | Pressing the key runs the motor in the reverse direction only. Pressing the key stops the motor. <br> No specification of the motor rotational direction is required. |

## Switching between remote and local modes

The remote and local modes can be switched by a digital input signal provided from the outside of the inverter.

To enable the switching, you need to assign (LOC) as a digital input signal to any of terminals [X1] to [X5] by setting " 35 " to any of E01 to E05, E98 and E99. By factory default, (LOC) is assigned to [X5].

Switching from remote to local mode automatically inherits the frequency settings used in remote mode. If the motor is running at the time of the switching from remote to local, the run command is automatically turned on so that all the necessary data settings will be carried over. If, however, there is a discrepancy between the settings used in remote mode and ones made on the keypad (e.g., switching from the reverse rotation in remote mode to the forward rotation only in local mode), the inverter automatically stops.

The transition paths between remote and local modes depend on the current mode and the value (on/off) of (LOC), as shown in the status transition diagram given below. Also, refer to Table 3.5 "Run Commands from the Keypad in Local Mode" for details.

For further details on how to specify run and frequency commands in remote and local modes, refer to Chapter 4, Section 4.3, "Drive Command Generator."


Transition between Remote and Local Modes by (LOC)

## Note <br> Switching between Remote and Local Modes on Optional Multi-function Keypad

The multi-function keypad has a remote/local toggle key least one second toggles between remote and local modes when the digital input signal (LOC) is off.
When the (LOC) is on, the key is disabled.
The figure below shows the switching by the key and (LOC).


## Run commands from the keypad in local mode

The multi-function keypad has the and keys instead of the key provided on the standard keypad.

The table below shows the input procedures of run commands from the multi-function keypad, which differ from those in Table 3.5.

Table 3.6 Run Commands from the Multi-Function Keypad in Local Mode

| When Data for F02 (Run command) is : | Input Procedures of Run Commands from Multi-Function Keypad |
| :---: | :---: |
| 0: Enable (ey) / keys on keypad (Motor rotational direction from digital terminals [FWD]/[REV]) | Pressing the / /moy key runs the motor in the forward or reverse direction, respectively. <br> Pressing the key stops the motor. |
| 1: Enable terminal command (FWD)/(REV) |  |
| 2: Enable (ext / Bey keys on keypad (Forward) | Pressing the (mol) / key on the keypad runs the motor in the forward direction or stops it, respectively. <br> Reverse rotation is not allowed. (The key is disabled.) |
| 3: Enable (20) / (109) keys on keypad (Reverse) | Pressing the / key on the keypad runs the motor in the reverse direction or stops it, respectively. <br> Forward rotation is not allowed. (The wey is disabled.) |

Tip
The multi-function keypad shows the current mode with the LED indicator indexes on the LCD monitor--REM for remote mode and LOC for local mode.

## 3．3 Programming Mode

The Programming mode provides you with these functions－－setting and checking function code data， monitoring maintenance information and checking input／output（I／O）signal status．The functions can be easily selected with the menu－driven system．Table 3.7 lists menus available in Programming mode． The leftmost digit（numerals）of each letter string on the LED monitor indicates the corresponding menu number and the remaining three digits indicate the menu contents．
When the inverter enters Programming mode from the second time on，the menu selected last in Programming mode will be displayed．

Table 3．7 Menus Available in Programming Mode

| Menu \＃ | Menu | LED monitor shows： | Main functions |  | Refer to： |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | ＂Quick Setup＂ |  | Displays only basic function codes to customize the inverter operation． |  | $\begin{gathered} \text { Section } \\ 3.3 .1 \end{gathered}$ |
| 1 | ＂Data Setting＂ | $1,1^{-}$ | F codes <br> （Fundamental functions） | Selecting each of these function codes enables its data to be displayed／changed． | $\begin{gathered} \text { Section } \\ 3.3 .2 \end{gathered}$ |
|  |  | $1,1^{-}$ | E codes （Extension terminal functions） |  |  |
|  |  | $1.11^{-}$ | C codes （Control functions of frequency） |  |  |
|  |  | $1,1^{1 / 2}$ | P codes <br> （Motor parameters） |  |  |
|  |  | ！， 1 ＇ו＇＿＿ | H codes <br> （High performance functions） |  |  |
|  |  | I，ı＇＿＿ | J codes <br> （Application functions） |  |  |
|  |  | ！！－̇＇－ | y codes（Link functions） |  |  |
|  |  | 1，1ロ－ | o code（Optional function） （Note） |  |  |
| 2 | ＂Data Checking＂ | ご，ーム゙ | Displays only function codes that have been changed from their factory defaults．You can refer to or change those function code data． |  | $\begin{gathered} \text { Section } \\ 3.3 .3 \end{gathered}$ |
| 3 | ＂Drive Monitoring＂ |  | Displays the running information required for maintenance or test running． |  | Section 3．3．4 |
| 4 | ＂I／O Checking＂ | いノーム | Displays external interface information． |  | $\begin{gathered} \hline \text { Section } \\ 3.3 .5 \end{gathered}$ |
| 5 | ＂Maintenance <br> Information＂ | 大．1－イ11－ | Displays maintenance information including cumulative run time． |  | $\begin{gathered} \hline \text { Section } \\ 3.3 .6 \end{gathered}$ |
| 6 | ＂Alarm Information＂ | E．，FIII | Displays the latest four alarm codes．You can refer to the running information at the time when the alarm occurred． |  | $\begin{gathered} \text { Section } \\ 3.3 .7 \end{gathered}$ |
| 7 | ＂Data Copying＂ | 「プイハイジ』 | Allows you to read or write function code data，as well as verifying it． |  | Section 3．3．8 |

（Note）An o code appears only when any option is mounted on the inverter．For details，refer to the instruction manual of the corresponding option．

Using the multi－function keypad（option）provides the＂Alarm Cause，＂＂Load Factor Measurement，＂＂User Setting，＂and＂Communication Debugging＂in addition to the menus listed above．
For details，refer to the＂Multi－function Keypad Instruction Manual＂（INR－SI47－0890－E）．

Figure 3.3 illustrates the menu-driven function code system in Programming mode.


Figure 3.3 Menu Transition in the Programming Mode

## Limiting menus to be displayed

The menu-driven system has a limiter function (specified by function code E52) that limits menus to be displayed for the purpose of simple operation. The factory default $(\mathrm{E} 52=0)$ is to display only three menus--Menu \#0 "Quick Setup," Menu \#1 "Data Setting" and Menu \#7 "Data Copying," allowing no switching to any other menu.

Table 3.8 Keypad Display Mode Selection - Function Code E52

| Data for E52 | Mode | Menus selectable |
| :---: | :--- | :--- |
| 0 | Function code data editing mode (factory default) | Menu \#0 "Quick Setup" <br> Menu \#1 "Data Setting" <br> Menu \#7 "Data Copying" |
| 1 | Function code data check mode | Menu \#2 "Data Checking" <br> Menu \#7 "Data Copying" |
| 2 | Full-menu mode | Menu \#0 through \#7 |

Pressing the $\sigma / V$ key will cycle through the menu. With the key, you can select the desired menu item. Once the entire menu has been cycled through, the display will return to the first menu item.

### 3.3.1 Setting up basic function codes quickly -- Menu \#0 "Quick Setup" --

Menu \#0 "Quick Setup" in Programming mode allows you to quickly display and set up a basic set of function codes specified in Chapter 9, Section 9.1, "Function Code Tables."

To use Menu \#0 "Quick Setup," you need to set function code E52 to "0" (Function code data editing mode) or "2" (Full-menu mode).

The predefined set of function codes that are subject to quick setup are held in the inverter.

Listed below are the function codes (including those not subject to quick setup) available on the FRENIC-Eco. A function code is displayed on the LED monitor on the keypad in the following format:


Table 3.9 Function Codes Available on FRENIC-Eco

| Function Code Group | Function Codes | Function | Description |
| :---: | :--- | :--- | :--- |
| F codes | F00 to F44 | Fundamental <br> functions | Functions concerning basic motor <br> running |
| E codes | E01 to E99 | Extension terminal <br> functions | Functions concerning the assignment <br> of control circuit terminals <br> Functions concerning the display of <br> the LED monitor |
| C codes | C01 to C53 | Control functions of <br> frequency | Functions associated with frequency <br> settings |
| P codes | P01 to P99 | Motor parameters | Functions for setting up <br> characteristics parameters (such as <br> capacity) of the motor |
| H codes | H03 to H98 | High performance <br> functions | Highly added-value functions <br> Functions for sophisticated control |
| J codes | J01 to J22 | Application functions | Functions for applications such as <br> PID control |
| y codes | y01 to y99 | Link functions | Functions for controlling <br> communication |
| o codes | o27 to o59 | Optional functions | Functions for options (Note) |

(Note) The o codes are displayed only when the corresponding option is mounted. For details of the o codes, refer to the Instruction Manual for the corresponding option.

For the list of function codes subject to quick setup and their descriptions, refer to Chapter 9, Section 9.1 "Function Code Tables."

## Function codes requiring simultaneous keying

To modify the data for function code F00 (data protection), H03 (data initialization), or H97 (clear alarm data), simultaneous keying is needed, involving the $+\infty$ keys or

## Changing, validating, and saving function code data when the inverter is running

Some function code data can be changed while the inverter is running, whereas others cannot. Further, depending on the function code, modifications may or may not validate immediately. For details, refer to the "Change when running" column in Chapter 9, Section 9.1 " Function Code Tables."

For details of function codes, refer to Chapter 9, Section 9.1 " Function Code Tables."

Figure 3.4 shows the menu transition in Menu \#1 "Quick Setup."


Figure 3.4 Menu Transition in Menu \#0 "Quick Setup"

Tip Through a multi-function keypad, you can add or delete function codes that are subject to Quick Setup. For details, refer to the "Multi-function Keypad Instruction Manual" (INR-SI47-0890-E).

Once you have added or deleted function codes for Quick Setup through a multi-function keypad, they will remain valid even after you switch to a standard keypad. To restore the function code settings subject to Quick Setup to their factory defaults, initialize the whole data using function code H 03 (data $=1$ ).

## Basic key operation

This section gives a description of the basic key operation，following the example of the function code data changing procedure shown in Figure 3．5．
This example shows you how to change function code F01 data from the factory default＂Enable $\nabla$ keys on keypad $(\mathrm{F} 01=0)$＂to＂Enable current input to terminal［C1］（4 to 20 mA DC$)(\mathrm{F} 01=2) . "$
（1）Turn the inverter on．It automatically enters Running mode．In that mode，press the key to switch to Programming mode．The function selection menu appears．（In this example， displayed．）
（2）If anything other than
（3）Press the key to proceed to a list of function codes．
（4）Use the $\widehat{\square}$ and keys to display the desired function code $\left(I^{\prime \prime} / \prime\right.$ in this example），then press the 图 key．
The data of this function code appears．（In this example，data 谷 of ！ו－Íappears．）
（5）Change the function code data using the and keys．（In this example，press the key two times to change data $\frac{1,1}{\prime \prime}$ to $\stackrel{\text { I．}}{2}$ ．）
（6）Press the 芫 key to establish the function code data．
The return to the function code list，then move to the next function code．（In this example， Pressing the key instead of the 图 key cancels the change made to the data．The data reverts to the previous value，the display returns to the function code list，and the original function code reappears．
（7）Press the key to return to the menu from the function code list．

## Cursor movement

You can move the cursor when changing function code data by holding down the key for 1 second or longer in the same way as with the frequency settings．This action is called ＂Cursor movement．＂


Figure 3．5 Example of Function Code Data Changing Procedure

### 3.3.2 Setting up function codes -- Menu \#1 "Data Setting" --

Menu \#1 "Data Setting" in Programming mode allows you to set up function codes for making the inverter functions match your needs.
To set function codes in this menu, it is necessary to set function code E52 to "0" (Function code data editing mode) or " 2 " (Full-menu mode).
Figure 3.6 shows the menu transition in Menu \#1 "Data Setting."


Figure 3.6 Menu Transition in Menu \#1 "Data Setting"

## Basic key operation

For details of the basic key operation, refer to Menu \#0 "Quick Setup" in Section 3.3.1.

### 3.3.3 Checking changed function codes -- Menu \#2 "Data Checking" --

Menu \#2 "Data Checking" in Programming mode allows you to check function codes that have been changed. Only the function codes whose data has been changed from the factory defaults are displayed on the LED monitor. You can refer to the function code data and change it again if necessary. Figure 3.7 shows the menu transition in Menu \#2 "Data Checking."


Figure 3.7 Menu Transition in Menu \#2 "Data Checking" (Changing F01, F05 and E52 data only)

## Basic key operation

For details of the basic key operation, refer to Menu \#1 "Quick Setup" in Section 3.3.1.
Tip To check function codes in Menu \#2 "Data Checking," it is necessary to set function code E52 to "1" (Function code data check mode) or "2" (Full-menu mode).

For details, refer to " Limiting menus to be displayed" on page 3-13.

## 3．3．4 Monitoring the running status－－Menu \＃3＂Drive Monitoring＂－－

Menu \＃3＂Drive Monitoring＂is used to monitor the running status during maintenance and trial running．The display items for＂Drive Monitoring＂are listed in Table 3．10．Figure 3.8 shows the menu transition in Menu \＃3＂Drive Monitoring．＂


Figure 3．8 Menu Transition in Menu \＃3＂Drive Monitoring＂

## Basic key operation

To monitor the running status on the drive monitor，set function code E52 to＂2＂（Full－menu mode） beforehand．
（1）Turn the inverter on．It automatically enters Running mode．In that mode，press the key to switch to Programming mode．The function selection menu appears．

（3）Press the 圈 key to proceed to a list of monitoring items（e．g．ジィに゙ルブ）
（4）Use the and $\triangle$ keys to display the desired monitoring item，then press the key． The running status information for the selected item appears．
（5）Press the key to return to a list of monitoring items．Press the key again to return to the menu．

Table 3.10 Drive Monitor Display Items

| LED <br> monitor <br> shows: | Item | Unit |  |
| :--- | :--- | :--- | :--- |
| Description |  |  |  |

## - Displaying running status

To display the running status in hexadecimal format, each state has been assigned to bits 0 to 15 as listed in Table 3.11. Table 3.12 shows the relationship between each of the status assignments and the LED monitor display. Table 3.13 gives the conversion table from 4-bit binary to hexadecimal.

Table 3.11 Running Status Bit Assignment

| Bit | Notation | Content | Bit | Notation | Content |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 15 | BUSY | 1 when function code data is being written. | 7 | VL | 1 under voltage limiting control. |
| 14 |  | Always 0 . | 6 | TL | Always 0 . |
| 13 | WR | Always 0. | 5 | NUV | 1 when the DC link bus voltage is higher than the undervoltage level. |
| 12 | RL | 1 when communication is enabled (when ready for run and frequency commands via communications link). | 4 | BRK | 1 during braking |
| 11 | ALM | 1 when an alarm has occurred. | 3 | INT | 1 when the inverter output is shut down. |
| 10 | DEC | 1 during deceleration. | 2 | EXT | 1 during DC braking. |
| 9 | ACC | 1 during acceleration. | 1 | REV | 1 during running in the reverse direction. |
| 8 | IL | 1 under current limiting control. | 0 | FWD | 1 during running in the forward direction. |

Table 3.12 Running Status Display


## - Hexadecimal expression

A 4-bit binary number can be expressed in hexadecimal format (1 hexadecimal digit). Table 3.13 shows the correspondence between the two notations. The hexadecimals are shown as they appear on the LED monitor.

Table 3.13 Binary and Hexadecimal Conversion

| Binary |  |  |  | Hexadecimal | Binary |  |  |  | Hexadecimal |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | 0 | 0 | 0 | ! 7 | 1 | 0 | 0 | 0 | $\square$ |
| 0 | 0 | 0 | 1 | ' | 1 | 0 | 0 | 1 | 9 |
| 0 | 0 | 1 | 0 | $\stackrel{\square}{\square}$ | 1 | 0 | 1 | 0 | 9 |
| 0 | 0 | 1 | 1 | $\exists$ | 1 | 0 | 1 | 1 | 名 |
| 0 | 1 | 0 | 0 | 4 | 1 | 1 | 0 | 0 | $L^{-}$ |
| 0 | 1 | 0 | 1 | 5 | 1 | 1 | 0 | 1 | $\square$ |
| 0 | 1 | 1 | 0 | $\square$ | 1 | 1 | 1 | 0 | $!$ |
| 0 | 1 | 1 | 1 | 7 | 1 | 1 | 1 | 1 | $\stackrel{ }{-}$ |

### 3.3.5 Checking I/O signal status -- Menu \#4 "//O Checking" --

Using Menu \#4 "I/O Checking" displays the I/O status of external signals including digital and analog I/O signals without using a measuring instrument. Table 3.14 lists check items available. The menu transition in Menu \#4 "I/O Checking" is shown in Figure 3.9.


Figure 3.9 Menu Transition in Menu \#4 "I/O Checking"

## Basic key operation

To check the status of the I／O signals，set function code E52 to＂2＂（Full－menu mode）beforehand．
（1）Turn the inverter on．It automatically enters Running mode．In that mode，press the key to switch to Programming mode．The function selection menu appears．
（2）Use the $\triangle$ and keys to display＂I／O Checking＂（ 1 ！וーロー）

（4）Use the and 8 keys to display the desired I／O check item，then press the key．
 keys switches the display method between the segment display（for external signal information in Table 3．15）and hexadecimal display（for I／O signal status in Table 3．16）．
（5）Press the key to return to a list of I／O check items．Press the key again to return to the menu．

Table 3.14 I／O Check Items

| LED monitor shows： | Item | Description |
| :---: | :---: | :---: |
|  | I／O signals on the control circuit terminals | Shows the ON／OFF state of the digital I／O terminals． Refer to <br> ＂■ Displaying control I／O signal terminals＂on the next page for details． |
| ヶィフ！ | I／O signals on the control circuit terminals under communication control | Shows the ON／OFF state for the digital I／O terminals that received a command via RS485 and optional communications．Refer to <br> ＂■ Displaying control I／O signal terminals＂and ＂Displaying control I／O signal terminals under communication control＂on the following pages for details． |
| ケィイバー | Input voltage on terminal［12］ | Shows the input voltage on terminal［12］in volts（V）． |
| トイパジ | Input current on terminal［C1］ | Shows the input current on terminal［C1］in milliamperes（mA）． |
| ーィイジーブ | Output voltage to analog meters［FMA］ | Shows the output voltage on terminal［FMA］in volts （V）． |
| ケィイ゙イ | Output voltage to digital meters［FMP］ | Shows the output voltage on terminal［FMP］in volts （V）． |
| ケィイレイ゙イ | Pulse rate of［FMP］ | Shows the output pulse rate on terminal［FMP］in p／s （pulses per second）． |
| ボイプ | Input voltage on terminal［V2］ | Shows the input voltage on terminal［V2］in volts（V）． |
|  | Output current to analog meters［FMA］ | Shows the output current on terminal［FMA］in mA． |

## ■ Displaying control I/O signal terminals

The status of control I/O signal terminal may be displayed with ON/OFF of the LED segment or in hexadecimal display.

- Display I/O signal status with ON/OFF of each LED segment

As shown in Table 3.15 and the figure below, each of segments " a " to " g " on LED1 lights when the corresponding digital input terminal circuit ([FWD], [REV], [X1], [X2], [X3], [X4] or [X5]) is closed; it goes off when it is open ${ }^{(* 1)}$. Segment "a to c" and "e" on LED3 lights when the circuit between output terminal [Y1], [Y2], or [Y3] and terminal [CMY], or [Y5A] and [Y5C] is closed; it goes off when the circuit is open. Segment "a" on LED4 is for terminals [30A/B/C]. Segment "a" on LED4 lights when the circuit between terminals [30C] and [30A] is closed; it goes off when it is open.

Tip If all terminal input signals are OFF (open), segment " g " on all of LED1 to LED4 will blink ("----").

Table 3.15 Segment Display for External Signal Information

|  | Segment | LED4 | LED3 | LED2 | LED1 |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | a | 30A/B/C | Y1-CMY | - | FWD (*1) |
|  | b | - | Y2-CMY | - | REV (*1) |
|  | c | - | Y3-CMY | - | X1 ${ }^{* 1}$ ) |
| $\bigcirc$ | d | - | - | - | X2 * $* 1)$ |
|  | e | - | Y5A-Y5C | - | X3 (*1) |
|  | f | - | - | (XF) ${ }^{(* 2)}$ | X4 (*1) |
| d dp | g | - | - | (XR) ${ }^{(* 2)}$ | X5 (*1) |
|  | dp | - | - | $(\mathrm{RST}){ }^{(* 2)}$ | - |

—: No corresponding control circuit terminal exists
(*1) For the open/close states of [FWD], [REV], [X1] through [X5] circuits, refer to the setting of the SINK/SOURCE slide switch in the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 2, Table 2.11 "Symbols, Names and Functions of the Control Circuit Terminals."
(*2) (XF), (XR), and (RST) are assigned for communication. Refer to "■ Displaying control I/O signal terminals under communication control" on the next page.

- Displaying I/O signal status in hexadecimal format

Each I/O terminal is assigned to bit 15 through bit 0 as shown in Table 3.16. An unassigned bit is interpreted as "0." Allocated bit data is displayed on the LED monitor in 4 hexadecimal digits (谷 to $I^{\prime}$ each).
With the FRENIC-Eco, digital input terminals [FWD] and [REV] are assigned to bit 0 and bit 1 , respectively. Terminals [X1] through [X5] are assigned to bits 2 through 6 . The bit is set to " 1 " when the corresponding input terminal is short-circuited (ON)*, and is set to " 0 " when it is open (OFF). For example, when [FWD] and [X1] are on (short-circuited) and all the others are off (open), displayed on LED4 to LED1.
(*) For the open/close states of [FWD], [REV], [X1] through [X5] circuits, refer to the setting of the SINK/SOURCE slide switch in the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 2, Table 2.11 "Symbols, Names and Functions of the Control Circuit Terminals."

Digital output terminal [Y1], [Y2] and [Y3] are assigned to bits 0 to 2 . Each bit is set to " 1 " when the terminal is short-circuited with [CMY], and to " 0 " when it is open. The status of the relay contact output terminal $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ is assigned to bit 8 . It is set to $" 1$ " when the circuit between output terminals [30A] and [30C] is closed and to " 0 " when the circuit between [30B] and [30C] is closed. The status of the relay contact output $[\mathrm{Y} 5 \mathrm{~A} / \mathrm{C}]$ is assigned to bit 4 . It is set " 1 " when the circuit between [Y5A] and [Y5C] is closed and to "0" when opened. For example, if [Y1] is on, [Y5A] is not connected to [Y5C], and [30A] is connected to [30C], then 谷 " Table 3.16 presents an example of bit assignment and corresponding hexadecimal display on the 7 -segment LED.

Table 3.16 Segment Display for I/O Signal Status in Hexadecimal Format

|  | LED No. | LED4 |  |  |  | LED3 |  |  |  | LED2 |  |  |  | LED1 |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| B |  | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|  | nput rminal | (RST)* | (XR)* | (XF)* | - | - | - | - | - | - | X5 | X4 | X3 | X2 | X1 | REV | FWD |
|  | Output <br> rminal | - | - | - | - | - | - | - | $\begin{array}{\|c\|} \hline 30 \\ \mathrm{~A} / \mathrm{B} / \mathrm{C} \end{array}$ | - | - | - | Y5A/C | - | Y3 | Y2 | Y1 |
|  | Binary | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
|  | Нехаdecimal on the LED monitor |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

* (XF), (XR), and (RST) are assigned for communication. Refer to "■ Displaying control I/O signal terminals under communication control" below.


## ■ Displaying control I/O signal terminals under communication control

During control via communication, input commands sent via RS485 communications can be displayed in two ways depending on setting of the function code S06: "Display with ON/OFF of the LED segment" or "In hexadecimal format." The content to be displayed is basically the same as that for the control I/O signal terminal status display; however, (XF), (XR), and (RST) are added as inputs. Note that under communications control, I/O display is in normal logic (using the original signals that are not inverted).Refer to the RS485 Communication User's Manual (MEH448a) for details on input commands sent through RS485 communications and the instruction manual of communication-related options as well.

### 3.3.6 Reading maintenance information <br> -- Menu \#5 "Maintenance Information" --

Menu \#5 "Maintenance Information" contains information necessary for performing maintenance on the inverter. Table 3.17 lists the maintenance information display items and Figure 3.10 shows the menu transition in Menu \#5 "Maintenance information."


Figure 3.10 Menu Transition in Menu \#5 "Maintenance Information"

## Basic key operation

To view the maintenance information, set function code E52 to "2" (Full-menu mode) beforehand.
(1) Turn the inverter on. It automatically enters Running mode. In that mode, press the key to switch to Programming mode. The function selection menu appears.


(4) Use the and $\triangle$ keys to display the desired maintenance item, then press the key. The data of the corresponding maintenance item appears.
(5) Press the key to return to a list of maintenance items. Press the key again to return to the menu.

Table 3．17 Display Items for Maintenance Information

| LED <br> Monitor shows： | Item | Description |
| :---: | :---: | :---: |
| 5－4， | Cumulative run time | Shows the content of the cumulative power－ON time counter of the inverter． <br> Unit：thousands of hours． <br> （Display range： 0.001 to $9.999,10.00$ to 65.53 ） <br> When the total ON－time is less than 10000 hours（display： 0.001 to 9．999），data is shown in units of one hour（0．001）．When the total time is 10000 hours or more（display： 10.00 to 65.53 ），it is shown in units of 10 hours $(0.01)$ ．When the total time exceeds 65535 hours，the counter will be reset to 0 and the count will start again． |
| 荗分i | DC link bus voltage | Shows the DC link bus voltage of the inverter main circuit． Unit：V（volts） |
| Sーロ゙心 | Max．temperature inside the inverter | Shows a maximum temperature inside the inverter for every hour． Unit：${ }^{\circ} \mathrm{C}$（Temperatures below $20^{\circ} \mathrm{C}$ are displayed as $20^{\circ} \mathrm{C}$ ．） |
| 5－173 | Max．temperature of heat sink | Shows the maximum temperature of the heat sink for every hour． Unit：${ }^{\circ} \mathrm{C}$（Temperatures below $20^{\circ} \mathrm{C}$ are displayed as $20^{\circ} \mathrm{C}$ ．） |
|  | Max．effective output current | Shows the maximum current in RMS for every hour． Unit：A（amperes） |
| 泴售 | Capacitance of the DC link bus capacitor | Shows the current capacitance of the DC link bus capacitor（reservoir capacitor）in \％，based on the capacitance when shipping as $100 \%$ ．Refer to the FRENIC－Eco Instruction Manual（INR－SI47－0882－E），Chapter 7 ＂MAINTENANCE AND INSPECTION＂for details． <br> Unit：\％ |
| 与－\％ | Cumulative run time of electrolytic capacitor on the printed circuit board | Shows the content of the cumulative run time counter of the electrolytic capacitor mounted on the printed circuit board． <br>  above． <br> However，when the total time exceeds 65535 hours，the count stops and the display remains at 65．53． |
| 567 | Cumulative run time of the cooling fan | Shows the content of the cumulative run time counter of the cooling fan． <br> This counter does not work when the cooling fan ON／OFF control （function code H06）is enabled but the fan does not run． <br>  above． <br> However，when the total time exceeds 65535 hours，the count stops and the display remains at 65．53． |
| 5－40 | Number of startups | Shows the content of the cumulative counter of times the inverter is started up（i．e．，the number of run commands issued）． <br> 1.000 indicates 1000 times．When any number from 0.001 to 9.999 is displayed，the counter increases by 0.001 per startup，and when any number from 10.00 to 65.53 is counted，the counter increases by 0.01 every 10 startups．When the counted number exceeds 65535 ，the counter will be reset to 0 and the count will start again． |
| 5－17 | Input watt－hour | Shows the input watt－hour of the inverter． <br> Unit： 100 kWh （Display range： 0.001 to 9999 ） <br> Depending on the value of integrated input watt－hour，the decimal point on the LED monitor shifts to show it within the LED monitors＇ resolution（e．g．the resolution varies between $0.001,0.01,0.1$ or 1 ）．To reset the integrated input watt－hour and its data，set function code E51 to ＂0．000．＂ <br> When the input watt－hour exceeds 1000000 kWh ，it returns to＂0．＂ |

Table 3．17 Continued

| LED Monitor shows： shows： | Item | Description |
| :---: | :---: | :---: |
| G－＂17 | Input watt－hour data | Shows the value expressed by＂input watt－hour $(\mathrm{kWh}) \times$ E51（whose data range is 0.000 to 9999）．＂ <br> Unit：None． <br> （Display range： 0.001 to 9999 ．The data cannot exceed 9999．（It will be fixed at 9999 once the calculated value exceeds 9999. ）） <br> Depending on the value of integrated input watt－hour data，the decimal point on the LED monitor shifts to show it within the LED monitors＇ resolution． <br> To reset the integrated input watt－hour data，set function code E51 to ＂0．000．＂ |
| S＿i | No．of RS485 errors（standard） | Shows the total number of errors that have occurred in standard RS485 communication（via the RJ－45 connector as standard）since the power is turned on． <br> Once the number of errors exceeds 9999 ，the count returns to 0 ． |
| 镸行 | Content of RS485 communications error（standard） | Shows the latest error that has occurred in standard RS485 communication in decimal format． <br> For error contents，refer to the RS485 Communication User＇s Manual （MEH448a）． |
| 5－17 | No．of option errors | Shows the total number of optional communications card errors since the power is turned on． <br> Once the number of errors exceeds 9999，the count returns to 0 ． |
| 今，バイ | Inverter＇s ROM version | Shows the inverter＇s ROM version as a 4 －digit code． |
| 高缺 | Keypad＇s ROM version | Shows the keypad＇s ROM version as a 4－digit code． |
| 517 | No．of RS485 errors（option） | Shows the total number of errors that have occurred in optional RS485 communication since the power is turned on． <br> Once the number of errors exceeds 9999 ，the count returns to 0 ． |
| 5 | Content of RS485 communications error（option） | Shows the latest error that has occurred in optional RS485 communication in decimal format． <br> For error contents，refer to the RS485 Communication User＇s Manual （MEH448a）． |
| 谷品 | Option＇s ROM version | Shows the option＇s ROM version as a 4 －digit code． |
|  | Cumulative motor run time | Shows the content of the cumulative power－ON time counter of the motor． <br> The display method is the same as for＂Cumulative run time（（今， above． |

### 3.3.7 Reading alarm information -- Menu \#6 "Alarm Information" --

Menu \#6 "Alarm Information" shows the causes of the past 4 alarms in alarm code. Further, it is also possible to display alarm information that indicates the status of the inverter when the alarm occurred. Figure 3.11 shows the menu transition in Menu \#6 "Alarm Information" and Table 3.18 lists the details of the alarm information.


Figure 3.11 "Alarm Information" Menu Transition

## Basic key operation

To view the alarm information，set function code E52 to＂2＂（Full－menu mode）beforehand．
（1）Turn the inverter on．It automatically enters Running mode．In that mode，press the key to switch to Programming mode．The function selection menu appears．

（3）Press the 芫 key to proceed to a list of alarm lists（e．g．I！III I＇）． In the list of alarm codes，the alarm information for the last 4 alarms is saved as an alarm history．
（4）Each time the or key is pressed，the last 4 alarms are displayed in order from the most recent one as $!, \bar{\prime}, \bar{\prime}$ and $\stackrel{\prime}{\prime}$ ．
（5）While the alarm code is displayed，press the 圈 key to have the corresponding alarm item number（e．g． approximately 1 second．You can also have the item number（e．g．言＿向 í）and data（e．g．Output current）for any other item displayed using the $\triangle$ and $\diamond$ keys．
（6）Press the key to return to a list of alarm codes．Press the key again to return to the menu．
Table 3．18 Alarm Information Displayed

| LED monitor <br> shows： <br> （item No．） | Item displayed |  |
| :--- | :--- | :--- |

Table 3.18 Continued

| LED monitor <br> shows: <br> (item No.) | Item displayed | Description |
| :--- | :--- | :--- |

When the same alarm occurs repeatedly in succession, the alarm information for the first and last occurrences will be preserved and the information for other occurrences inbetween will be discarded. Only the number of consecutive occurrences will be updated.

### 3.3.8 Data copying information -- Menu \#7 "Data Copying" --

Menu \#7 "Data Copying" is used to read function code data out of an inverter for which function codes are already set up and then to write such function code data altogether into another inverter, or to verify the function code data stored in the keypad with the one registered in the inverter.

## ■ If data copying does not work

Check whether
(1) If

- No data exists in the keypad memory. (No data read operation has been performed since shipment, or a data read operation has been aborted.)
- Data stored in the keypad memory contains any error.
- The models of copy source and destination inverters are different.
- A data write operation has been performed while the inverter is running.
- The copy destination inverter is data-protected. (function code F00=1)
- In the copy destination inverter, the "Enable write from keypad" command (WE-KP) is off.
(2) If
- The function codes stored in the keypad and ones registered in the inverter are not compatible with each other. (Either of the two may have been revised or upgraded in a non-standard or incompatible manner. Contact your Fuji Electric representative.)

Figure 3.12 shows the menu transition in Menu \#7 "Data Copying." Table 3.19 provides a detailed description of the Data Copying functions. The keypad can hold function codes for just one inverter.


Figure 3.12 Menu Transition in Menu \#7 "Data Copying"

## Basic keying operation

（1）Turn the inverter on．It automatically enters Running mode．In that mode，press the key to switch to Programming mode．The function selection menu appears．

（3）Press the 圏 key to proceed to a list of copying functions（e．g．ハールール゙ ）。
（4）Use the and $\triangle$ keys to select the desired function，then press the 圈 key to execute the selected function．（e．g．
（5）When the selected function has been executed，に！appears．Press the key to return to the data copying function list．Press the key again to return to the menu．

Table 3．19 List of Data Copying Functions

| Display on LED Monitor | Function | Description |
| :---: | :---: | :---: |
| －イイバニ゙ | Read data | Reads the function code data out of the inverter＇s memory and stores it into the keypad memory． <br> Pressing the immediately aborts the operation and displays <br> If this happens，the entire contents of the memory of the keypad will be completely cleared． |
| にルバー！－ | Write data | Writes data stored in the keypad memory into the inverter＇s memory． Pressing the immediately aborts the operation and displays <br> The contents（function code data，）of the inverter＇s memory remain partly old and partly updated．If this happens，do not operate the inverter；instead，perform initialization or rewrite the entire data． <br> If any incompatible code is about to be written， blinking． <br> If this function does not work，refer to＂$\square$ If data copying does not work＂on the previous page． |
| じ1しー， | Verify data | Verifies（collates）the data stored in the keypad memory with that in the inverter＇s memory． <br> If any mismatch is detected，the verify operation will be aborted，with the function code in disagreement displayed blinking．Pressing the key again causes the verification to continue from the next function code． <br> Pressing the immediately aborts the operation and displays <br> に－，appears blinking ${ }^{*}$ ）also when the keypad does not contain any valid data． |

[^37]
### 3.4 Alarm Mode

If an abnormal condition arises, the protective function is invoked to issue an alarm, and the inverter automatically enters Alarm mode. At the same time, an alarm code appears on the LED monitor.

### 3.4.1 Releasing the alarm and switching to Running mode

Remove the cause of the alarm and press the key to release the alarm and return to Running mode. The alarm can be removed using the key only when the alarm code is displayed.

### 3.4.2 Displaying the alarm history

It is possible to display the most recent 3 alarm codes in addition to the one currently displayed. Previous alarm codes can be displayed by pressing the $\sigma / \nabla$ key while the current alarm code is displayed.

### 3.4.3 Displaying the status of inverter at the time of alarm

When the alarm code is displayed, you may check various running status information (output frequency and output current, etc.) by pressing the key. The item number and data for each running information will be displayed alternately.

Further, you can view various pieces of information on the running status of the inverter using the / key. The information displayed is the same as for Menu \#6 "Alarm Information" in Programming mode. Refer to Table 3.18 in Section 3.3.7, "Reading alarm information."

Pressing the key while the running status information is displayed returns the display to the alarm codes.

When the running status information is displayed after removal of the alarm cause, pressing the key twice returns to the alarm code display and releases the inverter from the alarm state. This means that the motor starts running if a run command has been received by this time.

### 3.4.4 Switching to Programming mode

You can also switch to Programming mode by pressing + keys simultaneously with the alarm displayed, and modify the function code data.

Figure 3.13 summarizes the possible transitions between different menu items.


Figure 3.13 Menu Transition in Alarm Mode

## Part 2 Driving the Motor

Chapter 4 BLOCK DIAGRAMS FOR CONTROL LOGIC
Chapter 5 RUNNING THROUGH RS485 COMMUNICATION (OPTION)

## Chapter 4

## BLOCK DIAGRAMS FOR CONTROL LOGIC

This chapter describes the main block diagrams for the control logic of the FRENIC-Eco series of inverters.

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FRENIC-Eco series of inverters for variable (quadratic) torque loads increasing in proportion to the square of speed such as fans and pumps are equipped with a number of function codes to match a variety of motor operations required in your system. Refer to Chapter 9 "FUNCTION CODES" for details of the function codes.

The function codes have functional relationship each other. Several special function codes also work with execution priority each other depending on their functions or data settings.
This chapter explains the main block diagrams for control logic in the inverter. You are requested to fully understand the inverter's control logic together with the function codes in order to set the function code data correctly.
The block diagrams contained in this chapter show only function codes having mutual relationship. For the function codes that work independently and for detailed explanation of each function code, refer to Chapter 9 "FUNCTION CODES."

### 4.1 Symbols Used in Block Diagrams and their Meanings

Table 4.1 lists symbols commonly used in block diagrams and their meanings with some examples.
Table 4.1 Symbols and Meanings

| Symbol | Meaning |
| :---: | :---: |
| $\begin{aligned} & \text { [FWD], [Y1] } \\ & \text { etc. } \end{aligned}$ | Input/output signals to/from the inverter's control terminal block. |
| $\begin{aligned} & \text { (FWD), (REV) } \\ & \text { etc. } \end{aligned}$ | Control commands assigned to the control terminal block input signals. |
|  | Low-pass filter: Features appropriate characteristics by changing the time constant through the function code data. |
| Sen Frequincy | Internal control command for inverter logic. |
|  | High limiter: Limits the upper value by a constant or data set to a function code. |
| $\frac{T}{(F 15)}$ | Low limiter: Limits the lower value by a constant or data set to a function code. |
|  | Zero limiter: Prevents data from dropping to a negative value. |
|  | Gain multiplier for reference frequencies given by current and/or voltage input or for analog output signals. $\mathrm{C}=\mathrm{A} \times \mathrm{B}$ |
|  | Adder for 2 signals or values. $\mathrm{C}=\mathrm{A}+\mathrm{B}$ <br> If $B$ is negative then $C=A-$ $B$ (acting as a subtracter). |

$\left.\begin{array}{ll}\text { Function code. } \\ \text { Switch controlled by a } \\ \text { function code. Numbers } \\ \text { assigned to the terminals } \\ \text { express the function code } \\ \text { data. }\end{array}\right\}$

### 4.2 Drive Frequency Command Generator



Figure 4.1 Block Diagram of Drive Frequency Command Generator

Figure 4.1 shows the processes that generate the internal drive frequency command through the various frequency command and switching steps by means of function codes. If PID process control takes effect ( $\mathrm{J} 01=1$ or 2), the drive frequency command generator will differ from that shown in this diagram. (Refer to Section 4.9 "PID Frequency Command Generator.")

Additional and supplemental information is given below.

- Frequency command sources using the $Q / \square$ key on the keypad may take different formats such as motor speed in $\mathrm{r} / \mathrm{min}$, load shaft speed in $\mathrm{r} / \mathrm{min}$ or display speed in $\%$ by means of the data setup of function code E48. Refer to the function code E48 in Chapter 9 "FUNCTION CODES" for details.
- If the voltage input terminal [V2] is specified to the PTC thermistor input (i.e. setting the slide switch SW5 on the control printed circuit board to the PTC side and setup of function code H26 data at 1 or 2 ), then the frequency command input signal on the terminal [V2] will always be interpreted as "0."
- Case that data setup for both the gain and bias will take effect concurrently is only available for the frequency command source 1 (F01). For the frequency command source $2(\mathrm{C} 30)$ and auxiliary frequency command sources 1 and 2 (E61 to E63), only setup of the gain will take effect.
- Switching between normal and inverse operation is only effective for the reference frequency from the analog frequency command input signal (terminal [12], [C1] or [V2]). Note that the frequency command source set up by using the $\otimes / Q$ key is only valid for normal operation.
- Frequency commands by S01 and S05 for the communications link facility take different command formats as follows.
- S01: the setting range is -32768 to +32767 , where the maximum frequency is obtained at $\pm 20000$
- S05: the setting range is 0.00 to 655.35 Hz in increments of 0.01 Hz
- Basically, priority level for the command in S01 is higher than that in S05. If a value other than "0" is set in S01, the data set in S01 will take effect. If S01 is set at " 0 ", data in S05 will take effect.
- Refer to the RS485 Communication User's Manual (MEH448a) for details.
- The frequency limiter (Low) (F16) helps user select the inverter operation for either the output frequency is held at data of the frequency limiter (lower), or the inverter decelerates to stop the motor with reference frequency data of " 0 ", by specifying the lower limiter (select) (H63.)


### 4.3 Drive Command Generator



Figure 4.2 Block Diagram of Drive Command Generator

Figure 4.2 shows the processes that generate the final drive commands (FWD: Drive the motor in the forward direction and REV: Drive the motor in reverse direction) through the various run commands and switching steps by means of function codes.

Additional and supplemental information is given below.

- For the inverter operation given by the / mey on the standard keypad, the generator holds the run command ON upon depression of the key, decides the motor rotation direction according to the run forward command (FWD) or the run reverse command (REV), and releases the hold state upon depression of the (mey) key.
For the inverter operation given by the / the command ON upon depression of the / key, and releases the hold state upon depression of the ( $\times 2)$ key.
- The 3-wire operation terminal command (HLD) holds the run forward terminal command (FWD) and the run reverse terminal command (REV). This allows you to run the inverter in "3-Wire Operation." Refer to the function code E01 in Chapter 9 "FUNCTION CODES" for details.
If you do not assign the 3-wire operation command (HLD) to any digital input terminals, the " 2 -Wire Operation" using the commands (FWD) and (REV) will take effect. Note that the (HLD) function does not apply to the run forward 2 (FWD2) and run reverse 2 (REV2) commands.
- S06 (2-byte data of bit 15 through bit 0, programmable bitwise), the operation command via the communications link, includes:
- Bit 0: assigned to (FWD)
- Bit 1: assigned to (REV)
- Bit 13 (XF) and bit 14 (XR): Programmable bits equivalent to the terminal inputs [FWD] and [REV] In the block diagram, all of these are denoted as operation commands. The data setting for function code E98 to select the function of terminal [FWD] and E99 of [REV] determine which bit value should be selected as the run command. If bits 13 and 14 have the same setting to select the function of (FWD) or (REV), the output of bit 13-14 processor logic will follow the truth table listed in Figure 4.2.
If either one of bits 13 and 14 is ON (= 1 as a logic value), the OR logic output will make the enable communications link command (LE) turn on. This is the same as with bit 0 and 1.
- If run commands (FWD) and (REV) are concurrently turned on, then logic forcibly makes the internal run command <FWD> or <REV> turn off.
- If you set data, 1 or 3 , up to the function code H96 (STOP key priority/Start Check) to make the key priority effective, then depressing the key forcibly turns off the internal run commands <FWD> and <REV>. In this case, the generator automatically replaces deceleration characteristics of the inverter for that of the linear deceleration regardless of the setting of H 07 (Acceleration/deceleration pattern).
- If the reference frequency is lower than the starting frequency (F23) or the stop frequency (F25), then the internal run commands will be finally turned off according to the output of run decision logic, and the inverter decelerates to stop the motor. (Refer to the final stage of the block diagram.)
- If you have assigned the "enable to run" terminal command (RE), giving any RUN command cannot start the motor unless turning (RE) on in advance.
- Upon giving the "select local (keypad) mode" terminal command (LOC) to select the keypad for a command source, or holding down the key on the multi-function keypad, the generator disables the command sources such as:
- The run command source selected by the function code F02
- The "switch run command 2/run command 1 (FR2/FR1)" and
- The operation selection by the "enable communications link" command (LE)

The inverter operation is switched to the local run command issued by the key on the standard keypad or the ( $\operatorname{mog}$ / / key on the multi-function keypad. This command source switching operation also involves the frequency command source selected by the local keypad (E48). (Refer to Figure 4.1 "Block Diagram of Drive Frequency Command Generator.")

### 4.4 Digital Terminal Command Decoder

### 4.4.1 Terminals and related function codes

Table 4.2 shows a summery of relationship between digital control input terminals, those defined by a control string of the link command S06, and function codes to characterize them.

Table 4.2 Terminals and Related Function Codes

| Terminal <br> symbol | Bit assignment in the link <br> command S06 (Control string) | Function code to characterize a <br> digital input terminal |
| :---: | :---: | :---: |
| $[\mathrm{X} 1]$ | Bit 2 | E01 |
| $[\mathrm{X} 2]$ | Bit 3 | E02 |
| $[\mathrm{X} 3]$ | Bit 4 | E03 |
| $[\mathrm{X} 4]$ | Bit 5 | E04 |
| $[\mathrm{X} 5]$ | Bit 6 | E05 |
| $[\mathrm{FWD}]$ | Bit 13 | E98 |
| $[\mathrm{REV}]$ | Bit 14 | E99 |

Refer to the table on the next page for functions assigned to each terminal, and settings of function codes. Also refer to Chapter 9 "FUNCTION CODES" for details of function codes.

### 4.4.2 Functions assigned to digital control input terminals

Table 4.3 shows a summary of functions assigned to digital control input terminals. Refer to Chapter 9 "FUNCTION CODES" for details of the function code setting. Block diagrams shown on the succeeding pages differ with each other for every functional block.

Table 4.3 Functions Assigned to Digital Control Input Terminals

| Function code data |  | Command assignment to terminals | Symbol |
| :---: | :---: | :---: | :---: |
| Active ON | Active OFF |  |  |
| 0 | 1000 | Select multistep frequency | (SS1) |
| 1 | 1001 |  | (SS2) |
| 2 | 1002 |  | (SS4) |
| 6 | 1006 | Enable 3-wire operation | (HLD) |
| 7 | 1007 | Coast to a stop | (BX) |
| 8 | 1008 | Reset alarm | (RST) |
| 1009 | 9 | Enable external alarm trip | (THR) |
| 11 | 1011 | Switch reference frequency $2 / 1$ | (Hz2/Hz1) |
| 13 | - | DC injection brake | (DCBRK) |
| 15 | - | Switch to commercial power ( 50 Hz ) | (SW50) |
| 16 | - | Switch to commercial power ( 60 Hz ) | (SW60) |
| 17 | 1017 | UP (Increase output frequency) | (UP) |
| 18 | 1018 | DOWN (Decrease output frequency) | (DOWN) |
| 19 | 1019 | Enable write from keypad (Data changeable) | (WE-KP) |
| 20 | 1020 | Cancel PID control | (Hz/PID) |
| 21 | 1021 | Switch normal/inverse operation | (IVS) |
| 22 | 1022 | Interlock | (IL) |
| 24 | 1024 | Enable communications link via RS485 or field bus (option) | (LE) |
| 25 | 1025 | Universal DI | (U-DI) |
| 26 | 1026 | Select starting characteristic | (STM) |
| 1030 | 30 | Force to stop | (STOP) |
| 33 | 1033 | Reset PID integral and differential components | (PID-RST) |
| 34 | 1034 | Hold PID integral component | (PID-HLD) |
| 35 | 1035 | Select local (keypad) operation | (LOC) |
| 38 | 1038 | Enable to run | (RE) |
| 39 | - | Protect motor from dew condensation | (DWP) |
| 40 | - | Enable integrated sequence to switch to commercial power ( 50 Hz ) | (ISW50) |
| 41 | - | Enable integrated sequence to switch to commercial power ( 60 Hz ) | (ISW60) |
| 87 | 1087 | Switch run command $2 / 1$ | (FR2/FR1) |
| 88 | - | Run forward 2 | (FWD2) |
| 89 | - | Run reverse 2 | (REV2) |

### 4.4.3 Block diagrams for digital control input terminals

In the block diagrams for digital control input terminals, A [Terminal] should be replaced by [X1], [X2], [X3], [X4], [X5], [FWD] or [REV] depending on the function to be assigned.
Assign a function to a terminal by setting data of function codes E01 to E05, E98, and E99. Once a function is assigned to a terminal, "Select Input Terminal" shown in each block diagram is turned on. If one and the same function is assigned to more than one terminals, the decoder logic ORs them so that if any of the input signal is turned on, the function signal output is turned on.

## [ 1] Digital control input block (General)



Figure 4.3 (a) Block Diagram of Digital Control Input Block (General)

Figure 4.3 (a) Digital Control Input Block (General) is a block diagram indicating the functions that switch external control signals between the digital input terminals and the control string (bit information) in S06 from the communications link.

## [ 2 ] Digital control input block (Only for terminals)



Figure 4.3 (b) Block Diagram of Digital Control Input Block (Only for terminals)

Figure 4.3 (b) is a block diagram of the Digital Control Input Block (Only for terminals) that applies only to the digital terminal input functional block, which cannot use any control string from the communications link.
[ 3] Digital control input block (ORing the signals on terminals and the communications link)


Figure 4.3 (c) Block Diagram of Digital Control Input Block
(ORing the signals on terminals and communications link)

Figure 4.3 (c) is a block diagram of Digital Control Input Block (ORing the signals on terminals and communications link) that applies to the functional block of ORing (if any one signal being ON, the output turning ON ) the input signals on terminals and the communications link.

## [ 4] Digital control input block (Forced to turn off the signals on terminals during (LE) being turned on)



Figure 4.3 (d) Block Diagram of Digital Control Input Block (Forced to turn off the signals on terminals during (LE) being turned on)

Figure 4.3 (d) is a block diagram of the Digital Control Input Block (Forced to turn off the signals on terminals during the enable communications link command (LE) being turned on) that forces to turn off any signals on the digital input terminals during the communications link is activated ((LE) being turned on). Upon the "enable communications link" being disabled, the signals on the digital input terminals directly become the signal output for control.
[5] Assigning terminal functions via the communications link (Access to function code S06 exclusively reserved for the communications link)


Figure 4.3 (e) Block Diagram of Digital Control Input Block (Commanding via communications link)

Similar to the Drive Command Generator explained in the Section 4.3, the command from the communications link is also available for characterizing the terminal functions. Any inverter can communicate with host equipment such as a personal computer and PLC (programmable logic controller), via the standard communications port for the keypad or the RS485 card (option), using RS485 communications protocol. Inverters can also communicate with host equipment via the field bus (option) using the FA protocol like DeviceNet.
As shown in Figure 4.3 (e), the terminal function is assigned to each bit of 16-bit string in S06 bitwise. Bit 2 to bit 6 (functionally equivalent to E 01 to E05), bit 13 (equivalent to E 98 ) and bit 14 (equivalent to E99) are available for characterizing of terminal functions. To enable the communications link for host equipment, use the function codes H 30 and y 98 . For the field bus option, however, only use H 30 to activate the communications link because the bus option does not support y98.
For details of communications, refer to Chapter 5 "RUNNING THROUGH RS485 COMMUNICATION."

### 4.5 Digital Output Selector

### 4.5.1 Digital output components (Internal block)



Figure 4.4 (a) Block Diagram of Digital Output Components (Internal block)


Figure 4.4 (b) Block Diagram of Digital Output Components (Internal block)


Note: Numerals shown on tap-offs of switches of E20, E21, E22, E24 and E27 are the function code data expressed in the normal (active ON) logic system.

Figure 4.4 (c) Block Diagram of Digital Output Components (Final stage block)

The block diagrams shown in Figures 4.4 (a) to 4.4 (c) show you the processes to select the internal logic signals to generate five digital output signals at [Y1], [Y2], [Y3], [Y5A/C] and [30A/B/C]. Output terminals [Y1] to [Y3] (transistor outputs), [Y5A/C] and [30A/B/C] (mechanical relay contact outputs) are programmable terminals. You can assign various functions to these terminals using function codes E20 to E22, E24 and E27. Setting data of 1000s to the function code allows you to use these terminals for a negative logic system.

### 4.5.2 Universal DO (Access to the function code S07 exclusively reserved for the communications link)



Figure 4.4 (d) Block Diagram of Universal DO

The universal DO is a feature that receives a signal from the host equipment via the communications link and outputs commands in ON/OFF format to the equipment connected to the inverter via the inverter's output terminals. To enable the feature, assign data " 27 " to one of function codes E20 to E22, E24 and E27 (for a negative logic system, set "1027"). For the 16 -bit command string via the communications link, terminal and bit assignments are:

Bit 0 to bit 2 for output terminals [Y1] to [Y3] (transistor outputs) respectively
Bit 4 and bit 8 for output terminals [Y5A/C] and [30A/B/C] (relay contact outputs) respectively

### 4.6 Analog Output (FMA) Selector



Figure 4.5 Block Diagram of Analog Output (FMA) Selector

The block diagram Figure 4.5 shows the process for selecting and processing the internal signals to be output to the analog output terminal [FMA]. The data of function code F31 determines the signals to be output to [FMA]. Function code F30 is of adjusting the full-scale the output signal to a level suitable for the meter's indication to be connected to the [FMA] terminal. Function code F29 and the slide switch SW4 on the control circuit board allows you to select its output mode in voltage or in current.

Setting data at "10" in the function code F31 for enabling the universal AO (S12) allows you to output information from the host equipment via the communications link on the [FMA] terminal.

The voltage output range is 0 to +10 V DC and the maximum allowable load current is 2 mA . This is capable of driving up to two analog voltmeters with $10 \mathrm{~V}, 1 \mathrm{~mA}$ rating.

The current output range is +4 mA to +20 mA DC and the allowable load resistance is $500 \Omega$ or less.
The calibration analog output (14) makes an output of [FMA]'s full-scale voltage or current in order to adjust the scale of the connected meter.

### 4.7 Digital Output (FMP) Selector



Figure 4.6 Block Diagram of Digital Output (FMP) Selector

The block diagram Figure 4.6 shows the process for selecting and processing the internal signals to be output to the digital output terminal [FMP]. Data of the function code F35 determines the signal to output to [FMP]. Setting data at "10" in the function code F35 for enabling the universal AO (S12) allows you to output information from host equipment via the communications link on the [FMP] terminal.

Using the function codes F33 that determines [FMP] output pulse rate and F34 that determines [FMP] voltage adjust allows you to choose its output mode. The pulse output $(\mathrm{F} 34=0)$ is for a pulse counter, and changing the output pulse rate allows you to adjust digital display suitable for resolution of the counter. A 2 kbps pulse train output ( $\mathrm{F} 34 \neq 0$ ) is for driving an analog meter, and the "duty" ( $\mathrm{F} 34=1$ to $200 \%$, assuming that a half cycle of square wave is at $100 \%$ ) determines the output to be matched with the meter's indication range.

For details, refer to function code F34 in Chapter 9 "FUNCTION CODES."

### 4.8 Drive Command Controller



Figure 4.7 Block Diagram of Drive Command Controller and Related Part of the Inverter

Figure 4.7 is a schematic block diagram that explains the processes in which the inverter drives the motor according to the final run command <FWD> or <REV> and the <Drive Frequency Command> sent from the drive frequency command generator or the PID frequency command generator block.
Additional and supplemental information is given below.

- The logic shown in the upper left part of the block diagram processes the final reference frequency so that it is inverted $(\times(-1))$ for reverse rotation of the motor or is replaced with 0 (zero) for stopping the motor.
- The acceleration/deceleration processor determines the output frequency of the inverter by referring to data of related function codes. If the output frequency exceeds the upper limit given by the frequency limiter (High) (F15), the controller automatically limits the output frequency at the upper limit.
- If the overload prevention control is enabled, the logic automatically switches the output frequency to the enabled side of overload suppression control and controls the output frequency accordingly.
- If the current limiter is enabled ( $\mathrm{F} 43 \neq 0$ and $\mathrm{H} 12=1$ ), the logic automatically switches the output frequency to the enabled side of the current limiting.
- The voltage processor determines the output voltage of the inverter. The processor adjusts the output voltage to control the motor output torque.
- If the DC injection braking control is enabled, the logic switches the voltage and frequency control components to the ones determined by the DC injection braking block to feed the proper DC current to the motor for the DC injection braking.
- If regenerative energy redirection control is enabled, the logic automatically controls the output frequency at the higher level, consequently prolongs the deceleration time (automatic deceleration).


### 4.9 PID Frequency Command Generator



Figure 4.8 Block diagram of PID Frequency Command Generator

Figure 4.8 shows a block diagram of the PID frequency command generator when the PID control is enabled ( $\mathrm{J} 01=1$ or 2 ). The logic shown generates the <drive frequency command> according to the PID process command source and PID feedback source, PID conditioner, and the selected frequency command source for a manual speed command.

Additional and supplemental information is given below.

- Selection of the frequency command source $2(\mathrm{C} 30)$ and the auxiliary frequency command source 1 and 2 (E61 to E63) as a manual speed command are disabled under the PID control.
- The multistep frequency commands 1 and 2 are only applicable to the manual speed command.
- For selecting analog input (terminal [12], [C1], or [V2]) as the PID process command source, you need to set data up for function codes E61 to E62 and J02.
- The multistep frequency command 4 (C08) selected by (SS4) is only applicable to PID process command.
- To switch the operation between normal and inverse, the logic inverses the polarity of difference between the PID command and its feedback (turning the (INV) command on/ff, or setting data J01 at 1 or 2).
- Refer to Section 4.2 " Drive Frequency Command Generator" for explanations of common items.
- When the inverter has entered the process of stopping the motor due to slow flowrate under PID control, if any of conditions determined by function codes $\mathrm{J} 15, \mathrm{~J} 16$ and J 17 is taken, the slow flowrate stop control logic forces to switch the PID output (<drive frequency command>) to 0 Hz to stop the inverter output. For details, refer to function codes J15, J16 and J17 in Chapter 9, Section 9.2.6 "J codes (Application functions)."


## Chapter 5

## RUNNING THROUGH RS485 COMMUNICATION


#### Abstract

This chapter describes an overview of inverter operation through the RS485 communications facility. Refer to the RS485 Communication User's Manual (MEH448a) for details.


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### 5.1 Overview on RS485 Communication

Removing the built-in keypad from your FRENIC-Eco inverter and using the standard RJ-45 connector (modular jack) for it as an RS485 communications port brings about the following enhancements in functionality and operation:

## - Operation from a keypad at the remote location

You can use your built-in keypad or an optional multi-function keypad as a remote keypad by connecting it to the RJ-45 port by means of an extension cable. You may mount it on a panel of the conveniently located control enclosure for easy access. The maximum length of the extension cable is 20 m .

## - Operation by FRENIC Loader

The Windows-based PC can be connected to the standard RS485 communications port via a suitable converter. Through the RS485 communications facility, you may run FRENIC Loader on the PC to edit the function code data and monitor the running status information of the inverter.
■ Control via a host equipment
You can use a personal computer (PC) or a PLC as host (higher-level) equipment and through it control the inverter as its subordinate device.
Protocols for managing a network including inverters include the Modbus RTU protocol (compliant to the protocol established by Modicon Inc.) that is widely used in FA markets and the Fuji general-purpose inverter protocol that supports the FRENIC-Eco and conventional series of inverters.

When you use a remote keypad, the inverter automatically recognizes it and adopts the keypad protocol; there is no need to modify the function code setting.
When using FRENIC Loader, which requires a special protocol for handling Loader commands, you need to set up some communication function codes accordingly.
For details, refer to the FRENIC Loader Instruction Manual (INR-SI47-0903-E).

Further, you can add another RS485 communications port by installing an optional RS485 Communications Card onto the printed circuit board inside your FRENIC-Eco inverter. This additional communications link can be used only as the port for host equipment; you cannot use it as the communications port for a remote keypad or FRENIC Loader.

For details of RS485 communication, refer to the RS485 Communication User's Manual (MEH448a).

### 5.1.1 RS485 common specifications (standard and optional)

| Items | Specifications |  |  |
| :---: | :---: | :---: | :---: |
| Protocol | FGI-BUS | Modbus RTU | Loader commands (supported only on the standard version) |
| Compliance | Fuji general-purpose inverter protocol | Modicon Modbus RTU-compliant (only in RTU mode) | Dedicated protocol (Not disclosed) |
| No. of supporting stations | Host device: 1 <br> Inverters: Up to 31 |  |  |
| Electrical specifications | EIA RS485 |  |  |
| Connection to RS485 | 8-pin RJ-45 connector (standard) or terminal block (optional) |  |  |
| Synchronization | Asynchronous start-stop system |  |  |
| Transmission mode | Half-duplex |  |  |
| Transmission speed | 2400, 4800, 960019200 or 38400 bps |  |  |
| Max. transmission cable length | 500 m |  |  |
| No. of logical station addresses available | 1 to 31 | 1 to 247 | 1 to 255 |
| Message frame format | FGI-BUS | Modbus RTU | FRENIC loader |
| Frame synchronization | Detection SOH (Start Of Header) character | Detection of no-data transmission time for 3-byte period | Start code 96H detection |
| Frame length | Normal transmission: 16 bytes (fixed) <br> High-speed transmission: 8 or 12 bytes | Variable length | Variable length |
| Max. transfer data | Write: 1 word Read: 1 word | Write: 50 words <br> Read: 50 words | Write: 41 words <br> Read: 41 words |
| Messaging system | Polling/Selecting/Broadcast |  | Command message |
| Transmission character format | ASCII | Binary | Binary |
| Character length | 8 or 7 bits (selectable by the function code) | 8 bits (fixed) | 8 bits (fixed) |
| Parity | Even, Odd, or None (selectable by the function code) |  | Even (fixed) |
| Stop bit length | 1 or 2 bits (selectable by the function code) | No parity: 2 bits Even or Odd parity: <br> 1 bit | 1 bit (fixed) |
| Error checking | Sum-check | CRC-16 | Sum-check |

### 5.1.2 RJ-45 connector pin assignment for standard RS485 communications port

The port designed for a standard keypad uses an RJ-45 connector having the following pin assignment:

| Pin | Signal name | Function | Remarks |
| :--- | :--- | :--- | :--- |
| 1 and 8 | Vcc | Power source for the keypad | 5 V power lines |
| 2 and 7 | GND | Reference voltage level | Grounding pins |
| 3 and 6 | NC | Not used. | No connection |
| 4 | DX- | RS485 data $(-)$ | Built-in terminator: $112 \Omega$ <br> Open/close by SW3* |
| 5 | DX+ | RS485 data $(+)$ |  |

* For details about SW3, refer to "Setting up the slide switches" in Section 8.4.1 "Terminal functions."

Pins $1,2,7$, and 8 on the RJ- 45 connector are exclusively assigned to power supply and grounding for keypads. When connecting other devices to the RJ-45 connector, take care not to use those pins. Failure to do so may cause a short-circuit hazard.

### 5.1.3 Pin assignment for optional RS485 Communications Card

The RS485 Communications Card has two sets of pins for multi-drop connection as listed below.

| Terminal symbol |  | Terminal name | Function description |
| :--- | :--- | :--- | :--- |
| 1 (standard) | DX + | RS485 communications data <br> $(+)$ terminal | This is the $(+)$ terminal of RS485 <br> communications data. |
|  | DX- | RS485 communications data <br> $(-)$ terminal | This is the ( - ) terminal of RS485 <br> communications data. |
|  | SD | Communications cable shield <br> terminal | This is the terminal for relaying the shield of <br> the shielded cable, insulated from other <br> circuits. |
|  | DX+ | DX+ relay terminal | This is the relay terminal of RS485 <br> communications data ( + ). |
|  | DX- | DX- relay terminal | This is the relay terminal of RS485 <br> communications data ( - ). |
|  | SD | SD relay terminal | This is the terminal for relaying the shield of <br> the shielded cable, insulated from other <br> circuits. |

SW103 is provided on the RS485 Communications Card for connecting or disconnecting the terminating resistor (112 $)$. For the location of SW103, refer to the RS485 Communications Card "OPC-F1-RS" Installation Manual (INR-SI47-0872).


### 5.1.4 Cable for RS485 communications port

For connection with the RS485 communications port, be sure to use an appropriate cable and a converter that meet the applicable specifications.

DD For details, refer to the RS485 Communication User's Manual (MEH448a).

### 5.1.5 Communications support devices

This section provides information necessary for connection of the inverter to host equipment having no RS485 communications port such as a PC or for configuring a multi-drop connection.

## [ 1] Communications level converter

Most personal computers (PC) are not equipped with an RS485 communications port but RS232C and USB ports. To connect a FRENIC-Eco inverter to a PC, therefore, you need to use an RS232C-RS485 communications level converter or a USB-RS485 interface converter. For correct running of the communications facility to support FRENIC-Eco series of inverters, be sure to use one of the recommended converters listed below.

## Recommended converters

KS-485PTI (RS232C-RS485 communications level converter) USB-485I RJ45-T4P (USB-RS485 interface converter)
Supplied by SYSTEM SACOM Corporation.

## [ 2 ] Requirements for the cable

Use an off-the-shelf 10BASE-T/100BASE-TX LAN cable (ANSI/TIA/EIA-568A category 5 compliant, straight type).

Note
The RJ-45 connector has power source pins (pins 1, 27 and 8) exclusively assigned for keypads. When connecting other devices to the RJ-45 connector, take care not to use those pins. Failure to do so may cause a short-circuit hazard.

## [ 3 ] Multi-drop adapter

To connect a FRENIC-Eco inverter to a network in a multi-drop configuration with a LAN cable that has RJ-45 as the communications connector, use a multi-drop adapter for the RJ-45 connector.

Recommended multi-drop adapter
Model MS8-BA-JJJ made by SK KOHKI Co., Ltd.

## [ 4 ] RS485 Communications Card

To equip your inverter with another RS485 communications port in addition to the standard RS485 communications port, you need to install this optional card. Note that you cannot use FRENIC Loader through the optional RS485 communications port.

## RS485 Communications Card (option)

For details, refer to the RS485 Communications Card Option "OPC-F1-RS" Installation Manual (INR-SI47-0872).

For more details through Section 5.1.5, refer to the RS485 Communication User's Manual (MEH448a).

### 5.2 Overview of FRENIC Loader

FRENIC Loader is a software tool that supports the operation of the inverter via an RS485 communications link. It allows you to remotely run or stop the inverter, edit, set, or manage the function codes, monitor key parameters and values during operation, as well as monitor the running status (including alarm information) of the inverters on the RS485 communications network.

DD) For details, refer to the FRENIC Loader Instruction Manual (INR-SI47-0903-E).

### 5.2.1 Specifications

| Item |  | Specifications <br> (White on black indicates factory default) | Remarks |
| :---: | :---: | :---: | :---: |
| Name of software |  | FRENIC Loader Ver. 2.0.1.0 or later |  |
| Supported inverter |  | FRENIC-Eco series FRENIC-Mini series | (Note 1) |
| No. of supported inverters |  | Up to 31 |  |
| Recommended cable |  | 10BASE-T cable with RJ-45 connectors compliant with EIA568 |  |
| \#0000000000 | CPU | Intel Pentium 200 MHz with MMX or later | (Note 2) |
|  | OS | Microsoft Windows 98 <br> Microsoft Windows 2000 <br> Microsoft Windows XP |  |
|  | Memory | 32 MB or more RAM | 64 MB or more is recommended |
|  | Hard disk | 5 MB or more free space |  |
|  | COM port | RS-232C or USB | Conversion to RS485 communication required to connect inverters |
|  | Monitor resolution | XVGA (800 x 600) or higher | $1024 \times 768$, 16 -bit color or higher is recommended |
|  | COM port | COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8 | PC COM ports assigned to Loader |
|  | Transmission rate | 38400, 19200, 9600, 4800 and 2400 bps | 19200 bps or more is recommended. <br> (Note 3) |
|  | Character length | 8 bits | Prefixed |
|  | Stop bit length | 1 bit | Prefixed |
|  | Parity | Even | Prefixed |
|  | No. of retries | None or 1 to 10 | No. of retry times before detecting communications error |
|  | Timeout setting | $(100 \mathrm{~ms}, 300 \mathrm{~ms}, 500 \mathrm{~ms}),(1.0$ to 9.0 s ) or ( 10.0 to 60.0 s ) | This setting should be longer than the response interval time set by function code y09 of the inverter. |

(Note 1) FRENIC Loader cannot be used with inverters that do not support SX protocol (protocol for handling Loader commands).
With special order-made inverters, FRENIC Loader may not be able to display some function codes normally.
To use FRENIC Loader on FRENIC-Mini series of inverters, an RS485 Communications Card (Option: OPC-C1-RS) is required.
(Note 2) Use a PC with as high a performance as possible, since some slow PCs may not properly refresh the operation status monitor and Test-run windows.
(Note 3) To use FRENIC Loader on a network where a FRENIC-Mini inverter is also configured, choose 19200 bps or below.

### 5.2.2 Connection

By connecting a number of inverters to one PC , you can control one inverter at a time or a number of inverters simultaneously through multiple windows on the PC. You can also simultaneously monitor multiple inverters on a single screen.

For how to connect a PC to one or more inverters, refer to the RS485 Communication User's Manual (MEH448a).

### 5.2.3 Function overview

### 5.2.3.1 Setting of function code

You can set, edit, and checkout the setting of the inverter's function code data.

## List and Edit

In List and edit, you can list and edit function codes with function code No., name, set value, set range, and factory default.
You can also list function codes by any of the following groups according to your needs:

- Function code group
- Function codes that have been modified from their factory defaults
- Result of comparison with the settings of the inverter
- Result of search by function code name
- User-specified function code set



## Comparison

You can compare the function code data currently being edited with that saved in a file or stored in the inverter.

To perform a comparison and review the result displayed, click the Comparison tab and then click the Compared with inverter tab or click the Compared with file tab, and specify the file name.
The result of the comparison will be displayed also in the Comparison Result column of the list.

## File information

Clicking the File information tab displays the property and comments for identifying the function code editing file.
(1) Property

Shows file name, inverter model, inverter's capacity, date of readout, etc.
(2) Comments

Displays the comments you have entered. You can write any comments necessary for identifying the file.

### 5.2.3.2 Multi-monitor

This feature lists the status of all the inverters that are marked "connected" in the configuration table.

## Multi-monitor

Allows you to monitor the status of more than one inverter in a list format.


### 5.2.3.3 Running status monitor

The running status monitor offers four monitor functions: I/O monitor, System monitor, Alarm monitor, and Meter display. You can choose an appropriate monitoring format according to the purpose and situation.

## I/O monitor

Allows you to monitor the ON/OFF states of the digital input signals to the inverter and the transistor output signals.

## System monitor

Allows you to check the inverter's system information (version, model, maintenance information, etc.).


## Meter display

Displays analog readouts of the selected inverter (such as output frequency) on analog meters. The example on the right displays the reference frequency and the output frequency.

### 5.2.3.4 Test-running

The Test-running feature allows you to test-run the motor in "Run forward" or "Run reverse" while monitoring the running status of the selected inverter.

Select monitor item
Select what is to be displayed here from frequency command, current, etc.

Setting frequency command
Enter or select the set frequency command to write it into the inverter. Click Apply to make it effective.


* Refer to the table shown below for details of the operation buttons. The indented appearance of the FWD button as shown in the figure above indicates that it is active for running the motor forward, while that of the REV button is same for running reverse.

| Button | Description |
| :---: | :--- |
| STOP | Stops the motor. |
| FWD | Run the motor forward. |
| REV | Run the motor reverse. |
| RESET | Resets all alarm information saved in the selected inverter. |

### 5.2.3.5 Real-time trace—Displaying running status of an inverter in waveforms

This function allows you to monitor up to 4 analog readouts and up to 8 digital ON/OFF signals (a combined total of 8 channels), measured at fixed sampling intervals of 200 ms , which represent the running status of a selected inverter. These quantities are displayed in real-time waveforms on a time trace.
Waveform capturing capability: Max. 15,360 samples/channel


Note During the trace in progress you cannot:

- Change the RS485 station address,
- Change the advanced waveform settings, or
- Scroll the real-time trace screen or move the cursor.

Resizing the real-time trace window automatically changes the monitor window size.

# Part 3 Peripheral Equipment and Options 

Chapter 6 SELECTING PERIPHERAL EQUIPMENT

## CHAPTER 6

## SELECTING PERIPHERAL EQUIPMENT

This chapter describes how to use a range of peripheral equipment and options, FRENIC-Eco's configuration with them, and requirements and precautions for selecting wires and crimp terminals.

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### 6.1 Configuring the FRENIC-Eco

This section lists the names and features of peripheral equipment and options for the FRENIC-Eco series of inverters and includes a configuration example for reference. Refer to Figure 6.1 for a quick overview of available options.


Figure 6.1 Quick Overview of Options

### 6.2 Selecting Wires and Crimp Terminals

This section contains information needed to select wires for connecting the inverter to commercial power lines, motor or any of the optional/peripheral equipment. The level of electric noise issued from the inverter or received by the inverter from external sources may vary depending upon wiring and routing. To solve such noise-related problems, refer to Appendices App. A "Advantageous Use of Inverters (Notes on electrical noise)."

Select wires that satisfy the following requirements:

- Sufficient capacity to flow the rated current (allowable current capacity).
- Protective device coordination with an overcurrent circuit breaker such as an MCCB in the overcurrent zone for overcurrent protection.
- Voltage drop due to the wire length is within the allowable range.
- Suitable for the type and size of terminals of the inverter and optional equipment to be used.

Recommended wires are listed below. Use these wires unless otherwise specified.
600 V indoor PVC insulated wires (IV wires)
Use this class of wire for the indoor power circuits. This class of wire is hard to twist, so using it for the control signal circuits is not recommended. Maximum ambient temperature for this wire is $60^{\circ} \mathrm{C}$.
■ 600 V heat-resistant PVC insulated wires or 600 V polyethylene insulated wires (HIV wires)
As wires in this class are smaller in diameter and more flexible than IV wires and can be used at a higher ambient temperature $\left(75^{\circ} \mathrm{C}\right)$, they can be used for both of the main power and control signal circuits. To use this class of wire for the control circuits, you need to correctly twist the wires and keep the wiring length for equipment being connected as short as possible.
■ 600 V cross-link polyethylene-insulated wires (FSLC wires)
Use this class of wire mainly for power and grounding circuits. These wires are smaller in diameter and more flexible than those of the IV and HIV classes of wires, meaning that these wires can be used to save on space and on wiring cost of your power system, even in high temperature environments. The maximum allowable ambient temperature for this class of wires is $90^{\circ} \mathrm{C}$. The (Boardlex) wire range available from Furukawa Electric Co., Ltd. satisfies these requirements.

## - Shielded-twisted cables for internal wiring of electronic/electric equipment

Use this category of cables for the control circuits of the inverter so as to prevent the signal lines from being affected by radiation or induction noises from external sources, including the power input/output lines of the inverter themselves. Even if the signal lines are inside the power control enclosure, always use this category of cables when the length of wiring is longer than normal. Cables satisfying these requirements are the Furukawa's BEAMEX S shielded cables of the XEBV and XEWV ranges.

Currents flowing through components of the inverter
Table 6.1 summarizes average（effective）electric currents flowing across each component of the inverter for ease of reference when selecting peripheral equipment，options and electric wires for each inverter－－including supplied power voltage and applicable motor rating．

Table 6．1 Currents Flowing through Components of the Inverter

| Power supply voltage | Applicable <br> motor rating （kW） | Inverter type | $50 \mathrm{~Hz}, 200 \mathrm{~V} / 400 \mathrm{~V}$（380V） |  |  | $60 \mathrm{~Hz}, 220 \mathrm{~V}$（200V）／400V（440V） |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Input RMS current（A） |  | DC link circuit current <br> （A） | Input RMS current（A） |  |  |  | DC link bus current（A） |  |
|  |  |  | DC reactor（DCR） |  |  | DC reactor（DCR） |  |  |  |  |  |
|  |  |  | w／DCR | w／o DCR |  |  | CR | w／o | DCR |  |  |
| Three－ phase 200 V | 0.75 | FRN0．75F1■－2口 | 3.2 | 5.3 | 4.0 | 3.0 | （3．2） | 4.9 | （5．3） | 3.7 | （4．0） |
|  | 1.5 | FRN1．5F1■－2口 | 6.1 | 9.5 | 7.5 | 5.6 | （6．1） | 8.7 | （9．5） | 6.9 | （7．5） |
|  | 2.2 | FRN2．2F1■－2口 | 8.9 | 13.2 | 11.0 | 8.1 | （8．9） | 12.0 | （13．1） | 10.0 | （11．0） |
|  | 3.7 | FRN3．7F1臬－2口 | 15.0 | 22.2 | 18.4 | 13.6 | （14．9） | 20.0 | （22．0） | 16.7 | （18．3） |
|  | 5.5 | FRN5．5F1■－2口 | 21.1 | 31.5 | 25.9 | 19.0 | （20．9） | 28.4 | （31．2） | 23.3 | （25．6） |
|  | 7.5 | FRN7．5F1臬－2口 | 28.8 | 42.7 | 35.3 | 26.0 | （28．6） | 38.5 | （42．3） | 31.9 | （35．1） |
|  | 11 | FRN11F1泪－2口 | 42.2 | 60.7 | 51.7 | 38.0 | （41．8） | 54.7 | （60．1） | 46.6 | （51．2） |
|  | 15 | FRN15F1臬－2口 | 57.6 | 80.1 | 70.6 | 52.0 | （57．1） | 72.2 | （79．4） | 63.7 | （70．0） |
|  | 18.5 | FRN18．5F1■－2口 | 71.0 | 97.0 | 87.0 | 64.0 | （70．3） | 87.4 | （96．1） | 78.4 | （86．1） |
|  | 22 | FRN22F1臬－2口 | 84.4 | 112 | 103 | 76.0 | （83．6） | 101 | （111） | 93.1 | （102） |
|  | 30 | FRN30F1泪－2口 | 114 | 151 | 140 | 103 | 113 | 136 | 150 | 126 | （138） |
|  | 37 | FRN37F1■－2口 | 138 | 185 | 169 | 124 | 137 | 167 | 183 | 152 | （168） |
|  | 45 | FRN45F1臬－2口 | 167 | 225 | 205 | 150 | 165 | 203 | 223 | 184 | （203） |
|  | 55 | FRN55F1臬－2口 | 203 | 270 | 249 | 183 | 201 | 243 | 267 | 224 | （246） |
|  | 75 | FRN75F1臬－2口 | 282 | － | 345 | 254 | 279 |  |  | 311 | （342） |
| Three－ phase 400 V | 0.75 | FRN0．75F1■－4ロ | 1.6 （1．7） | 3.1 （3．3） | 2.0 （2．1） | 1.6 | （1．5） | 3.1 | （2．9） | 2.0 | （1．9） |
|  | 1.5 | FRN1．5F1■－4ロ | 3.0 （3．2） | 5.9 （6．3） | 3.7 （4．0） | 3.0 | （2．8） | 5.9 | （5．4） | 3.7 | （3．5） |
|  | 2.2 | FRN2．2F1■－4ロ | 4.5 （4．8） | 8.2 （8．7） | 5.6 （5．9） | 4.5 | （4．1） | 8.2 | （7．5） | 5.6 | （5．1） |
|  | 3.7 | FRN3．7F1■－4ロ | 7.5 （7．9） | 13 （13．7） | 9.2 （9．7） | 7.5 | （6．9） | 12.9 | （11．8） | 9.2 | （8．5） |
|  | 5.5 | FRN5．5F1■－4ロ | 10.6 （11．2） | 17.3 （18．3） | 13.0 （13．8） | 10.5 | （9．6） | 17.2 | （15．7） | 12.9 | （11．8） |
|  | 7.5 | FRN7．5F1■－4ロ | 14.4 （15．2） | 23.2 （24．5） | 17.7 （18．7） | 14.3 | （13．0） | 23.0 | （21．0） | 17.6 | （16．0） |
|  | 11 | FRN11F1■－4ロ | 21.1 （22．3） | $33.0 \quad(34.8)$ | 25.9 （27．4） | 20.9 | （19．0） | 32.7 | （29．8） | 25.6 | （23．3） |
|  | 15 | FRN15F1■－4口 | 28.8 （30．4） | 43.8 （46．2） | 35.3 （37．3） | 28.6 | （26．0） | 43.4 | （39．5） | 35.1 | （31．9） |
|  | 18.5 | FRN18．5F1■－4ロ | 35.5 （37．4） | 52.3 （55．1） | 43.5 （45．9） | 35.2 | （32．0） | 51.8 | （47．1） | 43.2 | （39．2） |
|  | 22 | FRN22F1■－4ロ | 42.2 （44．5） | $60.6 \quad(63.8)$ | 51.7 （54．6） | 41.8 | （38．0） | 60.0 | （54．6） | 51.2 | （46．6） |
|  | 30 | FRN30F1■－4ロ | 57.0 （60．0） | 77.9 （82．0） | 69.9 （73．5） | 56.5 | （51．4） | 77.2 | （70．2） | 69.2 | （63．0） |
|  | 37 | FRN37F1■－4口 | 68.5 （72．2） | 94.3 （99．3） | 83.9 （88．5） | 67.9 | （61．8） | 93.4 | （85．0） | 83.2 | （75．7） |
|  | 45 | FRN45F1■－4口 | 83.2 （87．6） | 114 （120） | 102 （107） | 82.4 | （75．0） | 113 | （103） | 101.0 | 92 |
|  | 55 | FRN55F1■－4ロ | 102 （107） | 140 （147） | 125 （132） | 101.0 | （92） | 139 | （126） | 124 | 113 |
|  | 75 | FRN75F1旦－4ロ | 138 （145） | － | 169 （178） | 137 | （124） |  |  | 168 | 152 |
|  | 90 | FRN90F1■－4ロ | 164 （173） | － | 201 （212） |  | （148） |  |  | 199 | 181 |
|  | 110 | FRN110F1■－4ロ | 201 （212） | － | 246 （259） | 199 | （181） |  |  | 244 | 222 |
|  | 132 | FRN132F1■－4ロ | 238 （251） | － | 292 （307） | 236 | （214） |  |  | 289 | 263 |
|  | 160 | FRN160F1■－4ロ | 286 （301） | － | 350 （369） | 283 | （258） |  |  | 347 | 315 |
|  | 200 |  | 357 （376） | － | 437 （460） | 354 | （321） |  |  | 433 | 394 |
|  | 220 | FRN220F1亩－4口 | 390 （411） | － | 478 （503） | 386 | （351） |  |  | 473 | 430 |

－Inverter efficiency is calculated using values suitable for each inverter model．The input route mean square（RMS）current is calculated under the following conditions：
Power supply capacity： 500 kVA ；power supply impedance： $5 \%$
－The RMS current listed in the above table will vary in inverse proportion to the power supply voltage，such as 230 VAC and 380 VAC．
Note 1）A box（■）in the above table replaces S（Standard type），E（EMC filter built－in type），or H（DCR built－in type）depending on the product specifications．
2） A box $(\square)$ in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$ ，or J depending on the shipping destination．

## 6．2．1 Recommended wires

Tables 6.2 and 6.3 list the recommended wires according to the internal temperature of your power control enclosure，for ease of reference to wiring of each inverter model．

■ If the internal temperature of your power control cabinet is $50^{\circ} \mathrm{C}$ or below

Table 6．2 Wire Size（for main circuit power input and inverter output）

| Power supply voltage | Appli－ cable <br> motor rating （kW） | Inverter type | Recommended wire size（ $\mathrm{mm}^{2}$ ） |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Main circuit power input［L1／R，L2／S ，L3／T］ |  |  |  |  |  |  |  | Inverter output［U，V，W］ |  |  |  |
|  |  |  | w／DC reactor（DCR） |  |  |  | w／o DC reactor（DCR） |  |  |  |  |  |  |  |
|  |  |  | Allowable temp．＊1 |  |  | Current （A） | Allowable temp．＊1 |  |  | Current （A） | Allowable temp．＊1 |  |  | Current （A） |
|  |  |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |  |
| Three－ phase 200 V | 0.75 | FRN0．75F1■－2口 | 2.0 | 2.0 | 2.0 | 3.2 | 2.0 | 2.0 | 2.0 | 5.3 | 2.0 | 2.0 | 2.0 | 4.2 |
|  | 1.5 | FRN1．5F1■－2口 | 2.0 | 2.0 | 2.0 | 6.1 | 2.0 | 2.0 | 2.0 | 9.5 | 2.0 | 2.0 | 2.0 | 7.0 |
|  | 2.2 |  | 2.0 | 2.0 | 2.0 | 8.9 | 2.0 | 2.0 | 2.0 | 13.2 | 2.0 | 2.0 | 2.0 | 10.6 |
|  | 3.7 |  | 2.0 | 2.0 | 2.0 | 15.0 | 5.5 | 2.0 | 2.0 | 22.2 | 3.5 | 2.0 | 2.0 | 16.7 |
|  | 5.5 |  | 5.5 | 2.0 | 2.0 | 21.1 | 8.0 | 3.5 | 3.5 | 31.5 | 5.5 | 2.0 | 2 | 22.5 |
|  | 7.5 |  | 8.0 | 3.5 | 2.0 | 28.8 | 14.0 | 5.5 | 5.5 | 42.7 | 8.0 | 3.5 | 2 | 29.0 |
|  | 11 | FRN11F1堲－2口 | 14.0 | 5.5 | 5.5 | 42.2 | 22.0 | 14.0 | 8.0 | 60.7 | 14.0 | 5.5 | 3.5 | 42.0 |
|  | 15 | FRN15F1臬－2口 | 22.0 | 14.0 | 8.0 | 57.6 | 38.0 | 22.0 | 14.0 | 80.1 | 22.0 | 8.0 | 5.5 | 55.0 |
|  | 18.5 | FRN18．5F1臬－2口 | 38.0 | 14.0 | 14.0 | 71.0 | 60.0 | 22.0 | 14.0 | 97.0 | 38.0 | 14.0 | 8.0 | 68.0 |
|  | 22 | FRN22F1堲－2口 | 38.0 | 22.0 | 14.0 | 84.4 | 60.0 | 38.0 | 22.0 | 112 | 38.0 | 14.0 | 14.0 | 80.0 |
|  | 30 | FRN30F1堲－2口 | 60.0 | 38.0 | 22.0 | 114 | 100 | 60.0 | 38.0 | 151 | 60.0 | 38.0 | 22.0 | 107 |
|  | 37 | FRN37F1■－2口 | 100 ＊2 | 38.0 | 38.0 | 138 | $60 \times 2$ | 60.0 | 38.0 | 185 | 100 ＊2 | 38.0 | 22.0 | 130 |
|  | 45 | FRN45F1堲－2口 | 100 | 60.0 | 38.0 | 167 | $100 \times 2$ | 100 | 60.0 | 225 | 100 | 60.0 | 38.0 | 156 |
|  | 55 | FRN55F1堲－2口 | $60 \times 2$ | 100 | 60.0 | 203 | $100 \times 2$ | 100 | 100 | 270 | $60 \times 2$ | 100 | 60.0 | 198 |
|  | 75 | FRN75F1■－2口 | 100×2 | 150 ＊3 | 100 | 282 | － | － | － | － | $100 \times 2$ | 100 | 100 | 270 |
| Three－ phase 400 V | 0.75 | FRN0．75F1■－4口 | 2.0 | 2.0 | 2.0 | 1.6 | 2.0 | 2.0 | 2.0 | 3.1 | 2.0 | 2.0 | 2.0 | 2.5 |
|  | 1.5 | FRN1．5F1■－4口 | 2.0 | 2.0 | 2.0 | 3.0 | 2.0 | 2.0 | 2.0 | 5.9 | 2.0 | 2.0 | 2.0 | 3.7 |
|  | 2.2 | FRN2．2F1■－4口 | 2.0 | 2.0 | 2.0 | 4.5 | 2.0 | 2.0 | 2.0 | 8.2 | 2.0 | 2.0 | 2.0 | 5.5 |
|  | 3.7 | FRN3．7F1的－4口 | 2.0 | 2.0 | 2.0 | 7.5 | 2.0 | 2.0 | 2.0 | 13.0 | 2.0 | 2.0 | 2.0 | 9.0 |
|  | 5.5 | FRN5．5F1■－4口 | 2.0 | 2.0 | 2.0 | 10.6 | 3.5 | 2.0 | 2.0 | 17.3 | 2.0 | 2.0 | 2.0 | 12.5 |
|  | 7.5 | FRN7．5F1的－4口 | 2.0 | 2.0 | 2.0 | 14.4 | 5.5 | 2.0 | 2.0 | 23.2 | 3.5 | 2.0 | 2.0 | 16.5 |
|  | 11 | FRN11F1堲－4ロ | 5.5 | 2.0 | 2.0 | 21.1 | 8.0 | 3.5 | 3.5 | 33.0 | 5.5 | 2.0 | 2.0 | 23.0 |
|  | 15 |  | 8.0 | 3.5 | 2.0 | 28.8 | 14.0 | 5.5 | 5.5 | 43.8 | 8.0 | 3.5 | 2.0 | 30.0 |
|  | 18.5 | FRN18．5F1■－4口 | 14.0 | 5.5 | 3.5 | 35.5 | 22.0 | 8.0 | 5.5 | 52.3 | 14.0 | 5.5 | 3.5 | 37.0 |
|  | 22 | FRN22F1■－4ロ | 14.0 | 5.5 | 5.5 | 42.2 | 22.0 | 14.0 | 8.0 | 60.6 | 14.0 | 5.5 | 5.5 | 44.0 |
|  | 30 | FRN30F1堲－4ロ | 22.0 | 14.0 | 8.0 | 57.0 | 38.0 | 14.0 | 14.0 | 77.9 | 22.0 | 14.0 | 8.0 | 58.0 |
|  | 37 | FRN37F1■－4ロ | 38.0 | 14.0 | 8.0 | 68.5 | 60.0 | 22.0 | 14.0 | 94.3 | 38.0 | 14.0 | 14.0 | 71.0 |
|  | 45 | FRN45F1■－4D | 38.0 | 22.0 | 14.0 | 83.2 | 60.0 | 38.0 | 22.0 | 114 | 38.0 | 22.0 | 14.0 | 84.0 |
|  | 55 | FRN55F1■－4ロ | 60.0 | 22.0 | 22.0 | 102 | 100 ＊2 | 38.0 | 38.0 | 140 | 60.0 | 22.0 | 22.0 | 102 |
|  | 75 | FRN75F1堲－4ロ | 100 ＊2 | 38.0 | 38.0 | 138 | － | － | － | － | 100 ＊2 | 38.0 | 38.0 | 139 |
|  | 90 | FRN90F1■－4D | 100 | 60.0 | 38.0 | 164 | － | － | － | － | 100 | 60.0 | 38.0 | 168 |
|  | 110 | FRN110F1■－4ロ | 60×2 | 100 | 60.0 | 201 | － | － | － | － | $60 \times 2$ | 100 | 60.0 | 203 |
|  | 132 | FRN132F1■－4ロ | $100 \times 2$ | 100 | 60.0 | 238 | － | － | － | － | $100 \times 2$ | 100 | 60.0 | 240 |
|  | 160 | FRN160F1■－4ロ | － | 150 | 100 | 286 | － | － | － | － | $100 \times 2$ | 150 | 100 | 290 |
|  | 200 | FRN200F1■－4ロ | － | 150 | 150 | 357 | － | － | － | － | － | 200 | 150 | 360 |
|  | 220 | FRN220F1■－4ロ | － | 200 | 150 | 390 | － | － | － | － | － | 200 | 150 | 415 |

＊1 Assuming the use of aerial wiring（without rack or duct）： 600 V indoor PVC insulated wires（IV wires）for up to $60^{\circ} \mathrm{C}, 600 \mathrm{~V}$ heat－resisting PVC insulated wires or 600 V class polyethylene insulated wires（HIV wires）for up to $75^{\circ} \mathrm{C}$ ，and 600 V cross－link polyethylene－insulated wires（FSLC wires）for up to $90^{\circ} \mathrm{C}$ ．
＊2 Use crimp terminals for low voltage devices，CB100－8（JEM 1399）compliant．
＊3 Use crimp terminals for low voltage devices，CB150－10（JEM 1399）compliant．
Note 1）A box（■）in the above table replaces S（Standard type），E（EMC filter built－in type），or H（DCR built－in type）depending on the product specifications．
2）A box（ $\square$ ）in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$ ，or J depending on the shipping destination．

If environmental requirements such as power supply voltage and ambient temperature differ from those recommendations listed above，select wires suitable for your system by referring to Table 6.1 and Appendices，App．F＂Allowable Current of Insulated Wires．＂

Table 6．2 Cont．（for DC reactor，control circuits，auxiliary power input（for the control circuit and fans）and inverter grounding）

| Power supply voltage | Appli－ <br> cable <br> motor <br> rating <br> （kW） | Inverter type | Recommended wire size（ $\mathrm{mm}^{2}$ ） |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | DC reactor$[\mathrm{P} 1, \mathrm{P}(+)]$ |  |  |  | Control circuit |  |  | Aux．power input （Ctrl．Cct．）［R0，T0］ |  |  | Aux．power input （Fans）［R1，T1］ |  |  | Inverter grounding ［ $\boldsymbol{B}^{-1} \mathrm{G}$ ］ |  |  |
|  |  |  | Allowable temp．＊1 |  |  | Current （A） | Allowable temp．＊1 |  |  | Allowable temp．＊1 |  |  | Allowable temp．＊1 |  |  | Allowable temp．＊1 |  |  |
|  |  |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |
|  | 0.75 | FRN0．75F1■－2口 | 2.0 | 2.0 | 2.0 | 4.0 | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | 2.0 | 2.0 | 2.0 | － | － | － | 2.0 |  |  |
|  | 1.5 | FRN1．5F1■－2口 | 2.0 | 2.0 | 2.0 | 7.5 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1■－2口 | 2.0 | 2.0 | 2.0 | 11.0 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3.7 | FRN3．7F1品－2口 | 3.5 | 2.0 | 2.0 | 18.4 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1品－2口 | 5.5 | 3.5 | 2.0 | 25.9 |  |  |  |  |  |  |  |  |  | 3.5 |  |  |
|  | 7.5 | FRN7．5F1■－2口 | 14.0 | 5.5 | 3.5 | 35.3 |  |  |  |  |  |  |  |  |  | 5.5 |  |  |
| Three－ | 11 | FRN11F1■－2口 | 22.0 | 8.0 | 5.5 | 51.7 |  |  |  |  |  |  |  |  |  |  |  |  |
| phase | 15 | FRN15F1■－2口 | 38.0 | 14.0 | 14.0 | 70.6 |  |  |  |  |  |  |  |  |  | 8.0 |  |  |
| 200 V | 18.5 | FRN18．5F1■－2口 | 38.0 | 22.0 | 14.0 | 87.0 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 22 | FRN22F1■－2口 | 60.0 | 22.0 | 22.0 | 103 |  |  |  |  |  |  |  |  |  | 14.0 |  |  |
|  | 30 | FRN30F1■－2口 | 100 | 38.0 | 38.0 | 140 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 37 | FRN37F1■－2口 | 100 ＊2 | 60.0 | 38.0 | 169 |  |  |  |  |  |  |  |  |  | 22.0 |  |  |
|  | 45 | FRN45F1■－2口 | － | 100 | 60.0 | 205 |  |  |  |  |  |  | 2.0 | 2.0 | 2.0 |  |  |  |
|  | 55 | FRN55F1■－2口 | － | 100 | 60.0 | 249 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 75 | FRN75F1■－2口 | － | 150 | 150 | 345 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 0.75 | FRN0．75F1■－4ロ | 2.0 | 2.0 | 2.0 | 2.1 | $\begin{aligned} & 0.75 \\ & \text { to } \\ & 1.25 \end{aligned}$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | 2.0 | 2.0 | 2.0 | － | － | － | 2.0 |  |  |
|  | 1.5 | FRN1．5F1■－4D | 2.0 | 2.0 | 2.0 | 4.0 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1■－4D | 2.0 | 2.0 | 2.0 | 5.9 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3.7 | FRN3．7F1■－4D | 2.0 | 2.0 | 2.0 | 9.7 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1■－4D | 2.0 | 2.0 | 2.0 | 13.8 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 7.5 | FRN7．5F1■－4口 | 3.5 | 2.0 | 2.0 | 18.7 |  |  |  |  |  |  |  |  |  | 3.5 |  |  |
|  | 11 | FRN11F1■－4ロ | 5.5 | 3.5 | 2.0 | 27.4 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 15 | FRN15F1■－4ロ | 14.0 | 5.5 | 3.5 | 37.3 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 18.5 | FRN18．5F1■－4ロ | 14.0 | 8.0 | 5.5 | 45.9 |  |  |  |  |  |  |  |  |  | 5.5 |  |  |
| Three－ | 22 | FRN22F1■－4ロ | 22.0 | 8.0 | 5.5 | 54.6 |  |  |  |  |  |  |  |  |  |  |  |  |
| phase | 30 | FRN30F1■－4ロ | 38.0 | 14.0 | 14.0 | 73.5 |  |  |  |  |  |  |  |  |  | 8.0 |  |  |
| 400 V | 37 | FRN37F1■－4ロ | 38.0 | 22.0 | 14.0 | 88.5 |  |  |  |  |  |  |  |  |  | 14.0 |  |  |
|  | 45 | FRN45F1■－4ロ | 60.0 | 38.0 | 22.0 | 107 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 55 | FRN55F1■－4ロ | 100 ＊2 | 38.0 | 22.0 | 132 |  |  |  |  |  |  | 2.0 | 2.0 | 2.0 |  |  |  |
|  | 75 | FRN75F1■－4ロ | $60 \times 2$ | 60.0 | 38.0 | 178 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 90 | FRN90F1■－4 $\square$ | － | 100 | 60.0 | 212 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 110 | FRN110F1■－4ロ | － | 100 | 100.0 | 259 |  |  |  |  |  |  |  |  |  | 22.0 |  |  |
|  | 132 | FRN132F1■－4ロ | － | 150 | 100 | 307 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 160 | FRN160F1■－4ロ | － | 200 | 150 | 369 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 200 | FRN200F1亩－4口 | － | 250 | 200 | 460 |  |  |  |  |  |  |  |  |  | 38.0 |  |  |
|  | 220 | FRN220F1■－4ロ | － | 250 | 200 | 503 |  |  |  |  |  |  |  |  |  |  |  |  |

＊1 Assuming the use of aerial wiring（without rack or duct）： 600 V indoor PVC insulated wires（IV wires）for up to $60^{\circ} \mathrm{C}, 600 \mathrm{~V}$ heat－resisting PVC insulated wires or 600 V class polyethylene insulated wires（HIV wires）for up to $75^{\circ} \mathrm{C}$ ，and 600 V cross－link polyethylene－insulated wires（FSLC wires）for up to $90^{\circ} \mathrm{C}$ ．
＊2 Use crimp terminals for low voltage devices，CB100－8（JEM 1399）compliant．
Note 1）A box（■）in the above table replaces S（Standard type），E（EMC filter built－in type），or H（DCR built－in type）depending on the product specifications．
2）A box（ $\square$ ）in the above table replaces $A, C, E$ ，or $J$ depending on the shipping destination．

If environmental requirements such as power supply voltage and ambient temperature differ from those recommendations listed above，select wires suitable for your system by referring to Table 6.1 and Appendices，App．F＂Allowable Current of Insulated Wires．＂
－If the internal temperature of your power control cabinet is $40^{\circ} \mathrm{C}$ or below

Table 6．3 Wire Size（for main circuit power input and inverter output）

| Power supply voltage | Appli－ <br> cable <br> motor <br> rating <br> （kW） | Inverter type | Recommended wire size（ $\mathrm{mm}^{2}$ ） |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Main circuit power input［L1／R，L2／S ，L3／T］ |  |  |  |  |  |  |  | Inverter output［U，V，W］ |  |  |  |
|  |  |  | w／DC reactor（DCR） |  |  |  | w／o DC reactor（DCR） |  |  |  |  |  |  |  |
|  |  |  | Allowable temp．＊1 |  |  | Current （A） | Allowable temp．＊1 |  |  | Current （A） | Allowable temp．＊1 |  |  | Current <br> （A） |
|  |  |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |  |
| Three－ phase 200 V | 0.75 | FRN0．75F1■－2口 | 2.0 | 2.0 | 2.0 | 3.2 | 2.0 | 2.0 | 2.0 | 5.3 | 2.0 | 2.0 | 2.0 | 4.2 |
|  | 1.5 | FRN1．5F1■－2口 | 2.0 | 2.0 | 2.0 | 6.1 | 2.0 | 2.0 | 2.0 | 9.5 | 2.0 | 2.0 | 2.0 | 7.0 |
|  | 2.2 | FRN2．2F1■－2口 | 2.0 | 2.0 | 2.0 | 8.9 | 2.0 | 2.0 | 2.0 | 13.2 | 2.0 | 2.0 | 2.0 | 10.6 |
|  | 3.7 | FRN3．7F1■－2口 | 2.0 | 2.0 | 2.0 | 15.0 | 3.5 | 2.0 | 2.0 | 22.2 | 2.0 | 2.0 | 2.0 | 16.7 |
|  | 5.5 | FRN5．5F1■－2口 | 2.0 | 2.0 | 2.0 | 21.1 | 5.5 | 3.5 | 2.0 | 31.5 | 3.5 | 2.0 | 2.0 | 22.5 |
|  | 7.5 | FRN7．5F1■－2口 | 3.5 | 2.0 | 2.0 | 28.8 | 8.0 | 5.5 | 3.5 | 42.7 | 3.5 | 2.0 | 2.0 | 29.0 |
|  | 11 |  | 8.0 | 5.5 | 3.5 | 42.2 | 14.0 | 8.0 | 5.5 | 60.7 | 8.0 | 5.5 | 3.5 | 42.0 |
|  | 15 | FRN15F1■－2口 | 14.0 | 8.0 | 5.5 | 57.6 | 22.0 | 14.0 | 14.0 | 80.1 | 14.0 | 8.0 | 5.5 | 55.0 |
|  | 18.5 | FRN18．5F1■－2口 | 14.0 | 14.0 | 8.0 | 71.0 | 38.0 | 22.0 | 14.0 | 97.0 | 14.0 | 14.0 | 8.0 | 68.0 |
|  | 22 | FRN22F1■－2口 | 22.0 | 14.0 | 14.0 | 84.4 | 38.0 | 22.0 | 14.0 | 112 | 22.0 | 14.0 | 14.0 | 80.0 |
|  | 30 | FRN30F1■－2口 | 38.0 | 22.0 | 22.0 | 114 | 60.0 | 38.0 | 38.0 | 151 | 38.0 | 22.0 | 14.0 | 107 |
|  | 37 | FRN37F1■－2口 | 60.0 | 38.0 | 22.0 | 138 | 100 ＊2 | 60.0 | 38.0 | 185 | 38.0 | 38.0 | 22.0 | 130 |
|  | 45 | FRN45F1既－2口 | 60.0 | 38.0 | 38.0 | 167 | 100 | 60.0 | 60.0 | 225 | 60.0 | 38.0 | 38.0 | 156 |
|  | 55 | FRN55F1堲－2口 | 100 | 60.0 | 38.0 | 203 | $60 \times 2$ | 100 | 60.0 | 270 | 100 | 60.0 | 38.0 | 198 |
|  | 75 | FRN75F1臬－2口 | $60 \times 2$ | 100 | 100 | 282 | － | － | － | － | 60×2 | 100 | 60.0 | 270 |
| Three－ phase 400 V | 0.75 | FRN0．75F1■－4口 | 2.0 | 2.0 | 2.0 | 1.6 | 2.0 | 2.0 | 2.0 | 3.1 | 2.0 | 2.0 | 2.0 | 2.5 |
|  | 1.5 | FRN1．5F1■－4口 | 2.0 | 2.0 | 2.0 | 3.0 | 2.0 | 2.0 | 2.0 | 5.9 | 2.0 | 2.0 | 2.0 | 3.7 |
|  | 2.2 | FRN2．2F1■－4口 | 2.0 | 2.0 | 2.0 | 4.5 | 2.0 | 2.0 | 2.0 | 8.2 | 2.0 | 2.0 | 2.0 | 5.5 |
|  | 3.7 | FRN3．7F1■－4口 | 2.0 | 2.0 | 2.0 | 7.5 | 2.0 | 2.0 | 2.0 | 13.0 | 2.0 | 2.0 | 2.0 | 9.0 |
|  | 5.5 | FRN5．5F1■－4口 | 2.0 | 2.0 | 2.0 | 10.6 | 2.0 | 2.0 | 2.0 | 17.3 | 2.0 | 2.0 | 2.0 | 12.5 |
|  | 7.5 | FRN7．5F1■－4ロ | 2.0 | 2.0 | 2.0 | 14.4 | 3.5 | 2.0 | 2.0 | 23.2 | 2.0 | 2.0 | 2.0 | 16.5 |
|  | 11 | FRN11F1■－4ロ | 2.0 | 2.0 | 2.0 | 21.1 | 5.5 | 3.5 | 2.0 | 33.0 | 3.5 | 2.0 | 2.0 | 23.0 |
|  | 15 | FRN15F1俉－4ロ | 3.5 | 2.0 | 2.0 | 28.8 | 8.0 | 5.5 | 3.5 | 43.8 | 3.5 | 3.5 | 2.0 | 30.0 |
|  | 18.5 | FRN18．5F1■－4口 | 5.5 | 3.5 | 3.5 | 35.5 | 14.0 | 8.0 | 5.5 | 52.3 | 5.5 | 3.5 | 3.5 | 37.0 |
|  | 22 | FRN22F1■－4ロ | 8.0 | 5.5 | 3.5 | 42.2 | 14.0 | 8.0 | 5.5 | 60.6 | 8.0 | 5.5 | 3.5 | 44.0 |
|  | 30 | FRN30F1■－4ロ | 14.0 | 8.0 | 5.5 | 57.0 | 22.0 | 14.0 | 8.0 | 77.9 | 14.0 | 8.0 | 5.5 | 58.0 |
|  | 37 | FRN37F1䂙－4ロ | 14.0 | 14.0 | 8.0 | 68.5 | 22.0 | 14.0 | 14.0 | 94.3 | 14.0 | 14.0 | 8.0 | 71.0 |
|  | 45 | FRN45F1■－4ロ | 22.0 | 14.0 | 14.0 | 83.2 | 38.0 | 22.0 | 14.0 | 114 | 22.0 | 14.0 | 14.0 | 84.0 |
|  | 55 | FRN55F1■－4ロ | 38.0 | 22.0 | 14.0 | 102 | 60.0 | 38.0 | 22.0 | 140 | 38.0 | 22.0 | 14.0 | 102 |
|  | 75 | FRN75F1■－4ロ | 60.0 | 38.0 | 22.0 | 138 | － | － | － | － | 60.0 | 38.0 | 22.0 | 139 |
|  | 90 | FRN90F1■－4ロ | 60 | 38.0 | 38 | 164 | － | － | － | － | 60 | 38.0 | 38.0 | 168 |
|  | 110 | FRN110F1■－4ロ | 100 | 60.0 | 38.0 | 201 | － | － | － | － | 100 | 60 | 38.0 | 203 |
|  | 132 | FRN132F1■－4ロ | 100 | 100 | 60.0 | 238 | － | － | － | － | 100 | 100 | 60.0 | 240 |
|  | 160 | FRN160F1■－4ロ | 60×2 | 100 | 100 | 286 | － | － | － | － | $60 \times 2$ | 100 | 100 | 290 |
|  | 200 | FRN200F1■－4ロ | $100 \times 2$ | 150 | 100 | 357 | － | － | － | － | $100 \times 2$ | 150 | 100 | 360 |
|  | 220 | FRN220F1■－4ロ | $100 \times 2$ | 150 | 150 | 390 | － | － | － | － | 100×2 | 150 | 150 | 415 |

＊1 Assuming the use of aerial wiring（without rack or duct）： 600 V indoor PVC insulated wires（IV wires）for up to $60^{\circ} \mathrm{C}, 600 \mathrm{~V}$ heat－resisting PVC insulated wires or 600 V class polyethylene insulated wires（HIV wires）for up to $75^{\circ} \mathrm{C}$ ，and 600 V cross－link polyethylene－insulated wires（FSLC wires）for up to $90^{\circ} \mathrm{C}$ ．
＊2 Use crimp terminals for low voltage devices，CB100－8（JEM 1399）compliant．
Note 1）A box（■）in the above table replaces S（Standard type），E（EMC filter built－in type），or H（DCR built－in type）depending on the product specifications．
2）A box（ $\square$ ）in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$ ，or J depending on the shipping destination．

（D）
If environmental requirements such as power supply voltage and ambient temperature differ from those recommendations listed above，select wires suitable for your system by referring to Table 6.1 and Appendices，App．F＂Allowable Current of Insulated Wires．＂

Table 6．3 Cont．（for DC reactor，control circuits，auxiliary power input（for the control circuit and fans）and inverter grounding）

| Power supply voltage | Appli－ <br> cable <br> motor <br> rating <br> （kW） | Inverter type | Recommended wire size（ $\mathrm{mm}^{2}$ ） |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | DC reactor ［P1，P（＋）］ |  |  |  | Control circuit |  |  | Aux．power input （Ctrl．Cct．）［R0，T0］ |  |  | Aux．power input （Fans）［R1，T1］ |  |  | Inverter grounding ［ ${ }^{-1} \mathrm{G}$ ］ |  |  |
|  |  |  | Allowable temp．＊1 |  |  | Current （A） | Allowable temp．＊1 |  |  | Allowable temp．＊1 |  |  | Allowable temp．＊1 |  |  | Allowable temp．＊1 |  |  |
|  |  |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |  | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ | $60^{\circ} \mathrm{C}$ | $75^{\circ} \mathrm{C}$ | $90^{\circ} \mathrm{C}$ |
|  | 0.75 | FRN0．75F1■－2口 | 2.0 | 2.0 | 2.0 | 4.0 | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | 2.0 | 2.0 | 2.0 | － | － | － | 2.0 |  |  |
|  | 1.5 | FRN1．5F1■－2口 | 2.0 | 2.0 | 2.0 | 7.5 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1■－2口 | 2.0 | 2.0 | 2.0 | 11.0 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3.7 | FRN3．7F1■－2口 | 2.0 | 2.0 | 2.0 | 18.4 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1■－2口 | 3.5 | 2.0 | 2.0 | 25.9 |  |  |  |  |  |  |  |  |  | 3.5 |  |  |
|  | 7.5 | FRN7．5F1■－2口 | 5.5 | 3.5 | 3.5 | 35.3 |  |  |  |  |  |  |  |  |  | 5.5 |  |  |
| Three－ | 11 | FRN11F1■－2口 | 14.0 | 5.5 | 5.5 | 51.7 |  |  |  |  |  |  |  |  |  |  |  |  |
| phase | 15 | FRN15F1■－2口 | 14.0 | 14.0 | 8.0 | 70.6 |  |  |  |  |  |  |  |  |  | 8.0 |  |  |
| 200 V | 18.5 | FRN18．5F1■－2口 | 22.0 | 14.0 | 14.0 | 87.0 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 22 | FRN22F1■－2口 | 38.0 | 22.0 | 14.0 | 103 |  |  |  |  |  |  |  |  |  | 14.0 |  |  |
|  | 30 | FRN30F1■－2口 | 60.0 | 38.0 | 22.0 | 140 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 37 | FRN37F1■－2口 | 60.0 | 38.0 | 38.0 | 169 |  |  |  |  |  |  |  |  |  | 22.0 |  |  |
|  | 45 | FRN45F1■－2口 | 100 | 60 | 38.0 | 205 |  |  |  |  |  |  | 2.0 | 2.0 | 2.0 |  |  |  |
|  | 55 | FRN55F1■－2口 | － | 100 | 60 | 249 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 75 | FRN75F1■－2口 | － | 150 | 100 | 345 |  |  |  |  |  |  |  |  |  |  |  |  |
| Three－ phase 400 V | 0.75 | FRN0．75F1■－4口 | 2.0 | 2.0 | 2.0 | 2.1 | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ | 2.0 | 2.0 | 2.0 | － | － | － | 2.0 |  |  |
|  | 1.5 | FRN1．5F1■－4D | 2.0 | 2.0 | 2.0 | 4.0 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1■－4口 | 2.0 | 2.0 | 2.0 | 5.9 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3.7 | FRN3．7F1■－4D | 2.0 | 2.0 | 2.0 | 9.7 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1■－4D | 2.0 | 2.0 | 2.0 | 13.8 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 7.5 | FRN7．5F1■－4口 | 2.0 | 2.0 | 2.0 | 18.7 |  |  |  |  |  |  |  |  |  | 3.5 |  |  |
|  | 11 | FRN11F1■－4ロ | 3.5 | 2.0 | 2.0 | 27.4 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 15 | FRN15F1■－4口 | 5.5 | 3.5 | 3.5 | 37.3 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 18.5 | FRN18．5F1■－4口 | 8.0 | 5.5 | 3.5 | 45.9 |  |  |  |  |  |  |  |  |  | 5.5 |  |  |
|  | 22 | FRN22F1■－4ロ | 14.0 | 8.0 | 5.5 | 54.6 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 30 | FRN30F1■－4ロ | 22.0 | 14.0 | 8.0 | 73.5 |  |  |  |  |  |  |  |  |  |  | 8.0 |  |
|  | 37 | FRN37F1■－4ロ | 22.0 | 14.0 | 14.0 | 88.5 |  |  |  |  |  |  |  |  |  | 14.0 |  |  |
|  | 45 | FRN45F1■－4ロ | 38.0 | 22.0 | 14.0 | 107 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 55 | FRN55F1■－4ロ | 38.0 | 38.0 | 22.0 | 132 |  |  |  |  |  |  | 2.0 | 2.0 | 2.0 |  |  |  |
|  | 75 | FRN75F1■－4口 | 60 | 60.0 | 38.0 | 178 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 90 | FRN90F1■－4口 | 100 | 60.0 | 60.0 | 212 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 110 | FRN110F1■－4ロ | － | 100 | 60.0 | 259 |  |  |  |  |  |  |  |  |  | 22.0 |  |  |
|  | 132 | FRN132F1■－4ロ | － | 100 | 100 | 307 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 160 | FRN160F1■－4ロ | $100 \times 2$ | 150 | 100 | 369 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 200 | FRN200F1■－4ロ | － | 200 | 150 | 460 |  |  |  |  |  |  |  |  |  | 38.0 |  |  |
|  | 220 | FRN220F1■－4ロ | － | 200 | 150 | 503 |  |  |  |  |  |  |  |  |  |  |  |  |

＊1 Assuming the use of aerial wiring（without rack or duct）： 600 V indoor PVC insulated wires（IV wires）for up to $60^{\circ} \mathrm{C}, 600 \mathrm{~V}$ heat－resisting PVC insulated wires or 600 V class polyethylene insulated wires（HIV wires）for up to $75^{\circ} \mathrm{C}$ ，and 600 V cross－link polyethylene－insulated wires（FSLC wires）for up to $90^{\circ} \mathrm{C}$ ．

Note 1）A box（■）in the above table replaces S（Standard type），E（EMC filter built－in type），or H（DCR built－in type）depending on the product specifications．
2）A box（ $\square$ ）in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$ ，or J depending on the shipping destination．

DD If environmental requirements such as power supply voltage and ambient temperature differ from those recommendations listed above，select wires suitable for your system by referring to Table 6.1 and Appendices，App．F＂Allowable Current of Insulated Wires．＂

### 6.3 Peripheral Equipment

## [ 1] Molded case circuit breaker (MCCB), earth leakage circuit breaker (ELCB) and magnetic contactor (MC)

## [ 1.1] Functional overview

■ MCCBs and ELCBs*
*With overcurrent protection
Molded Case Circuit Breakers (MCCBs) are designed to protect the power circuits between the power supply and inverter's main circuit terminals (L1/R, L2/S and L3/T) from overload or short-circuit, which in turn prevents secondary accidents caused by the inverter malfunctioning.

Earth Leakage Circuit Breakers (ELCBs) function in the same way as MCCBs.
Built-in overcurrent/overload protective functions protect the inverter itself from failures related to its input/output lines.

- MCs

An MC can be used at both the power input (primary) and output (secondary) sides of the inverter. At each side, the Magnetic Contactor (MC) works as described below. When inserted in the output circuit of inverter, the MC can also switch the motor drive power source between the inverter output and commercial power lines.

## At the power source (primary) side

Insert an MC in the power source side of the inverter in order to:
(1) Forcibly cut off the inverter from the power source with the protective function built into the inverter, or with the external signal input.
(2) Stop the inverter operation in an emergency when the inverter cannot interpret the stop command due to internal/external circuit failures.
(3) Cut off the inverter from the power supply if the MCCB on the power supply side cannot be turned OFF when maintenance or inspection of motor is required. For this purpose only, it is recommended that you use an MC that can be turned off manually.

When your system uses an MC to start or stop the inverter, keep the number of start/stop operations once or less per hour. Frequent such operations shorten not only the service life of the MC but also that of the inverter DC link bus capacitor(s) due to the thermal fatigue caused by the frequent flow of the charging current. Use terminal commands (FWD) and (REV) or the keypad as much as possible, to start or stop the inverter.

At the output (secondary) side
Insert an MC in the power output side of the inverter in order to:
(1) Prevent externally turned-around current from being applied to the inverter power output terminals (U, V, and W) unexpectedly. An MC should be used, for example, if a circuit that switches the motor driving power source between the inverter output and commercial power lines is connected to the inverter.

As application of the external power to the inverter's output side may break the Insulated Gate Bipolar Transistors (IGBTs), MCs should be used in the power control system circuits to switch the motor drive power source to the commercial power lines after the motor has come to a complete stop. Also ensure that voltage is never mistakenly applied to the inverter output terminals due to unexpected timer operation, or similar.
(2) Drive more than one motor selectively by a single inverter.
(3) Selectively cut off the motor whose thermal overload relay or equivalent devices have been activated.

Driving the motor using commercial power lines
MCs can also be used to run the motor driven by the inverter by a commercial power source.
Select the MC so as to satisfy the input RMS currents listed in Table 6.1, which are the most critical for using the inverter (Refer to Table 6.5).
Use an MC of class AC3 specified by IEC 60947-4-1 (JIS C8201-4-1) for the commercial power operation when you are making a switching operation of the motor between the inverter output and commercial power lines.

## [ 1.2 ] Applications and criteria for selection of contactors

Figure 6.2 shows external views and applications of MCCB/ELCB (with overcurrent protection) and MC in the inverter input circuit. Table 6.5 lists the rated current for the MCCB/ELCB and Fuji MC type. Table 6.6 lists the leakage current sensibility of the ELCB in conjunction with wiring length.

## $\triangle$ WARNING

Insert an MCCB or ELCB (with overcurrent protection) recommended for each inverter for its input circuits. Do not use an MCCB or ELCB of a higher rating than that recommended.
Doing so could result in a fire.


MCCB/
ELCB


Figure 6.2 External Views and Applications of MCCB/ELCB and MC

Table 6．5 Rated Current of MCCB／ELCB and MC（Note that values in the table below are valid in $50^{\circ} \mathrm{C}$ of ambient temperature．）

| Power supply voltage | Applicable motor rating （kW） | Inverter type | MCCB，ELCB Rated current（A） |  | MC type |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | MC1 （for input circuit） |  | MC2（for output circuit） |
|  |  |  | w／DCR | w／o DCR | w／DCR | w／o DCR |  |
| Three－ phase 200 V | 0.75 | FRN0．75F1■－2口 | 5 | 10 | SC－05 | SC－05 | SC－05 |
|  | 1.5 | FRN1．5F1■－2口 | 10 | 15 |  |  |  |
|  | 2.2 | FRN2．2F1■－2口 |  | 20 |  |  |  |
|  | 3.7 | FRN3．7F1■－2口 | 20 | 30 |  | SC－4－0 |  |
|  | 5.5 | FRN5．5F1■－2口 | 30 | 50 | SC－4－0 | SC－5－1 | SC－4－0 |
|  | 7.5 | FRN7．5F1■－2口 | 40 | 75 | SC－5－1 | SC－N1 | SC－5－1 |
|  | 11 | FRN11F1吅－2口 | 50 | 100 | SC－N1 | SC－N2S | SC－N1 |
|  | 15 | FRN15F1臬－2口 | 75 | 125 | SC－N2 | SC－N3 | SC－N2 |
|  | 18.5 | FRN18．5F1■－2口 | 100 | 150 | SC－N2S |  | SC－N2S |
|  | 22 | FRN22F1㑑－2口 |  | 175 | SC－N3 | SC－N4 |  |
|  | 30 | FRN30F1臬－2口 | 150 | 200 | SC－N4 | SC－N7 | SC－N4 |
|  | 37 | FRN37F1泪－2口 | 175 | 250 | SC－N5 |  |  |
|  | 45 | FRN45F1俉－2口 | 200 | 300 | SC－N7 | SC－N8 | SC－N7 |
|  | 55 | FRN55F1■－2口 | 250 | 350 | SC－N8 | SC－N11 |  |
|  | 75 | FRN75F1臬－2口 | 350 | － | SC－N11 | － | SC－N11 |
| Three－ phase 400 V | 0.75 |  | 5 | 5 | SC－05 | SC－05 | SC－05 |
|  | 1.5 | FRN1．5F1臬－4口 |  | 10 |  |  |  |
|  | 2.2 |  | 10 | 15 |  |  |  |
|  | 3.7 | FRN3．7F1臬－4ロ |  | 20 |  |  |  |
|  | 5.5 | FRN5．5F1臬－4ロ | 15 | 30 |  |  |  |
|  | 7.5 |  | 20 | 40 |  | SC－4－0 |  |
|  | 11 | FRN11F1臬－4］ | 30 | 50 | SC－4－0 | SC－N1 | SC－4－0 |
|  | 15 | FRN15F1堲－4］ | 40 | 60 | SC－5－1 |  | SC－5－1 |
|  | 18.5 | FRN18．5F1■－4ロ |  | 75 | SC－N1 | SC－N2 | SC－N1 |
|  | 22 | FRN22F1臬－4］ | 50 | 100 |  | SC－N2S |  |
|  | 30 | FRN30F1臬－4］ | 75 | 125 | SC－N2 |  | SC－N2 |
|  | 37 | FRN37F1■－4］ | 100 |  | SC－N2S | SC－N3 | SC－N2S |
|  | 45 | FRN45F1俉－4］ |  | 150 | SC－N3 | SC－N4 | SC－N3 |
|  | 55 | FRN55F1■－4］ | 125 | 200 | SC－N4 | SC－N5 | SC－N4 |
|  | 75 | FRN75F1俉－4］ | 175 | － | SC－N5 | － | SC－N5 |
|  | 90 | FRN90F1■－4］ | 200 |  | SC－N7 |  | SC－N7 |
|  | 110 |  | 250 |  | SC－N8 |  | SC－N8 |
|  | 132 | FRN132F1臬－4］ | 300 |  |  |  |  |
|  | 160 |  | 350 |  | SC－N11 |  | SC－N11 |
|  | 200 |  | 500 |  | SC－N12 |  | SC－N12 |
|  | 220 | FRN220F1■－4D |  |  | SC－N14 |  |  |

－The above table lists the rated current of MCCBs and ELCBs to be used in the power control enclosure with an internal temperature of lower than $50^{\circ} \mathrm{C}$ ．The rated current is factored by a correction coefficient of 0.85 as the MCCBs＇and ELCBs＇original rated current is specified when using them in an ambient temperature of $40^{\circ} \mathrm{C}$ or lower．Select an MCCB and／or ELCB suitable for the actual short－circuit breaking capacity needed for your power systems．
－For the selection of the MC type，it is assumed that the 600 V HIV（allowable ambient temperature： $75^{\circ} \mathbf{C}$ ）wires for the power input／output of the inverter are used．If an MC type for another class of wires is selected，the wire size suitable for the terminal size of both the inverter and the MC type should be taken into account．
－Use ELCBs with overcurrent protection．
－To protect your power systems from secondary accidents caused by the broken inverter，use an MCCB and／or ELCB with the rated current listed in the above table．Do not use an MCCB or ELCB with a rating higher than that listed．

[^38]Table 6.6 lists the relationship between the rated leakage current sensitivity of ELCBs (with overcurrent protection) and wiring length of the output (secondary) sides of the inverter. Note that the sensitivity levels listed in the table are estimated typical values based on the results obtained by the test setup in the Fuji laboratory where each inverter drives a single motor.

Table 6.6 Rated Current Sensitivity of ELCBs

| Power supply voltage | Applicable motor rating (kW) | Wiring length and current sensitivity |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 10 m | 30 m | 50 m | 100 m | 200 m | 300 m |
| Threephase 200 V | 0.75 |  |  |  |  |  |  |
|  | 1.5 |  |  |  |  |  |  |
|  | 2.2 |  | 30 mA |  |  |  |  |
|  | 3.7 |  |  |  |  |  |  |
|  | 5.5 |  |  |  |  |  |  |
|  | 7.5 |  |  |  | 100 mA |  |  |
|  | 11 |  |  |  |  |  |  |
|  | 15 |  |  |  |  |  |  |
|  | 18.5 |  |  |  |  | 200 mA |  |
|  | 22 |  |  |  |  |  |  |
|  | 30 |  |  |  |  |  |  |
|  | 37 |  |  |  |  |  |  |
|  | 45 |  |  |  |  |  |  |
|  | 55 |  |  |  |  |  |  |
|  | 75 |  |  |  |  |  | 500 mA |
|  | 90 |  |  |  |  |  |  |
|  | 110 |  |  |  |  |  |  |
| Threephase 400 V | 0.75 |  |  |  |  |  |  |
|  | 1.5 |  |  |  |  |  |  |
|  | 2.2 |  |  |  |  |  |  |
|  | 3.7 | 30 mA |  |  |  |  |  |
|  | 5.5 |  |  |  |  |  |  |
|  | 7.5 |  |  |  |  |  |  |
|  | 11 |  |  | 100 mA |  |  |  |
|  | 15 |  |  |  |  |  |  |
|  | 18.5 |  |  |  |  |  |  |
|  | 22 |  |  |  | 200 mA |  |  |
|  | 30 |  |  |  |  |  |  |
|  | 37 |  |  |  |  |  |  |
|  | 45 |  |  |  |  | 500 mA |  |
|  | 55 |  |  |  |  |  |  |
|  | 75 |  |  |  |  |  |  |
|  | 90 |  |  |  |  |  |  |
|  | 110 |  |  |  |  |  |  |
|  | 132 |  |  |  |  |  | 1000 mA |
|  | 160 |  |  |  |  |  | (Atypical |
|  | 200 |  |  |  |  |  | spec.) |
|  | 220 |  |  |  |  |  |  |
|  | 280 |  |  |  |  |  |  |
|  | 315 |  |  |  |  |  |  |
|  | 355 |  |  |  | 1000 mA |  | 3000 mA |
|  | 400 |  |  |  | (Atypical |  | (Atypical |
|  | 450 |  |  |  | spec.) |  | spec.) |
|  | 500 |  |  |  |  |  |  |

- Values listed above were obtained using Fuji ELCB EG or SG series applied to the test setup.
- The rated current of applicable motor rating indicates values for Fuji standard motor (4 poles, 50 Hz and 200 V 3-phase).
- The leakage current is calculated based on grounding of the single wire for $200 \mathrm{~V} \Delta$ connection and the neutral wire for 400 V Y connection.
- Values listed above are calculated based on the static capacitance to the earth when the 600 V IV wires are used in a metal conduit laid directly on the earth.
- Wiring length is the total length of wiring between the inverter and motor. If more than one motor is to be connected to a single inverter, the wiring length should be the total length of wiring between the inverter and motors.

For an EMC filter built-in type inverter, use an ELCB with higher rated leakage current sensitivity than specified one, or remove the built-in capacitive filter (grounding capacitor).

## [ 2 ] Surge killers

A surge killer eliminates surge currents induced by lightning and noise from the power supply lines. Use of a surge killer is effective in preventing the electronic equipment, including inverters, from damage or malfunctioning caused by such surges and/or noise.
The applicable model of surge killer is the FSL-323. Figure 6.3 shows its external dimensions and application example. Refer to the catalog "Fuji Noise Suppressors (SH310: Japanese edition only)" for details. These products are available from Fuji Electric Technica Co., Ltd.


Figure 6.3 Dimensions of Surge Killer and Application Example

## [ 3 ] Arresters

An arrester suppresses surge currents and noise invaded from the power supply lines. Use of an arrester is effective in preventing electronic equipment, including inverters, from damage or malfunctioning caused by such surges and/or noise.

Applicable arrester models are the CN23232 and CN2324E. Figure 6.4 shows their external dimensions and application examples. Refer to the catalog "Fuji Noise Suppressors (SH310: Japanese edition only)" for details. These products are available from Fuji Electric Technica Co., Ltd.


Figure 6.4 Arrester Dimensions and Application Examples

## [ 4 ] Surge absorbers

A surge absorber suppresses surge currents and noise from the power lines to ensure effective protection of your power system from the malfunctioning of the magnetic contactors, mini-control relays and timers.
Applicable surge absorber models are the S2-A-O and S1-B-O. Figure 6.5 shows their external dimensions. Refer to the catalog "Fuji Noise Suppressors (SH310: Japanese edition only)" for details. The surge absorbers are available from Fuji Electric Technica Co., Ltd.


Type: S1-B-O (for mini-control relay or timer)


Available from Fuji Electric Technica Co., Ltd.

Figure 6.5 Surge Absorber Dimensions

### 6.4 Selecting Options

### 6.4.1 Peripheral equipment options

## [1] DC reactors (DCRs)

A DCR is mainly used for power supply normalization and for input power-factor improvement (for suppressing harmonics).

## ■ For power supply normalization

- Use a DCR when the capacity of a power supply transformer exceeds 500 kVA and is 10 times or more the rated inverter capacity. In this case, the percentage-reactance of the power source decreases, and harmonic components and their peak levels increase. These factors may break rectifiers or capacitors in the converter section of inverter, or decrease the capacitance of the capacitor (which can shorten the inverter's service life).
- Also use a DCR when there are thyristor-driven loads or when phase-advancing capacitors are being turned on/off.
- Use a DCR when the interphase voltage unbalance ratio of the inverter power source exceeds $2 \%$.

$$
\text { Interphase voltage unbalance }(\%)=\frac{\text { Max. voltage }(\mathrm{V})-\text { Min. voltage }(\mathrm{V})}{3-\text { phase average voltage }(\mathrm{V})} \times 67
$$

## ■ For input power-factor improvement (for suppressing harmonics)

Generally a capacitor is used to correct the power factor of the load, however, it cannot be used in a system that includes an inverter. Using a DCR increases the reactance of inverter's power source so as to decrease harmonic components on the power source lines and correct the power factor of inverter. Using a DCR corrects the input power factor to approximately $95 \%$.

- At the time of shipping, a jumper bar is connected across terminals P 1 and $\mathrm{P}(+)$ on the terminal block. Remove the jumper bar when connecting a DCR.
- If a DCR is not going to be used, do not remove the jumper bar.


Figure 6.6 External View of a DCR and Application Example

Table 6．7 DCRs

| Power supply voltage | Applicable motor rating （kW） | Inverter type | DCR |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Type | Rated current <br> （A） | Inductance （ mH ） | $\begin{aligned} & \text { Coil resistance } \\ & \quad(\mathrm{m} \Omega) \end{aligned}$ | Generated loss （W） |
| Three－ phase 200 V | 0.75 | FRN0．75F1臬－2口 | DCR2－0．75 | 5.0 | 7.0 | 123 | 2.8 |
|  | 1.5 | FRN1．5F1■－2口 | DCR2－1．5 | 8.0 | 4.0 | 57.5 | 4.6 |
|  | 2.2 | FRN2．2F1泪－2口 | DCR2－2．2 | 11 | 3.0 | 43 | 6.7 |
|  | 3.7 | FRN3．7F1■－2口 | DCR2－3．7 | 18 | 1.7 | 21 | 8.8 |
|  | 5.5 | FRN5．5F1■－2口 | DCR2－5．5 | 25 | 1.2 | 16 | 14 |
|  | 7.5 | FRN7．5F1吅－2口 | DCR2－7．5 | 34 | 0.8 | 9.7 | 16 |
|  | 11 | FRN11F1吅－2口 | DCR2－11 | 50 | 0.6 | 7.0 | 27 |
|  | 15 | FRN15F1■－2口 | DCR2－15 | 67 | 0.4 | 4.3 | 27 |
|  | 18.5 | FRN18．5F1■－2口 | DCR2－18．5 | 81 | 0.35 | 3.1 | 29 |
|  | 22 | FRN22F1㖪－2口 | DCR2－22A | 98 | 0.3 | 2.7 | 38 |
|  | 30 |  | DCR2－30B | 136 | 0.23 | 1.1 | 37 |
|  | 37 | FRN37F1泪－2口 | DCR2－37B | 167 | 0.19 | 0.82 | 47 |
|  | 45 | FRN45F1泪－2口 | DCR2－45B | 203 | 0.16 | 0.62 | 52 |
|  | 55 |  | DCR2－55B | 244 | 0.13 | 0.79 | 55 |
|  | 75 | FRN75F1泪－2口 | DCR2－75B | 341 | 0.080 | 0.46 | 55 |
|  | 90 | FRN90F1臬－2口 | DCR2－90B | 410 | 0.067 | 0.28 | 57 |
|  | 110 | FRN110F1■－2口 | DCR2－110B | 526 | 0.055 | 0.22 | 67 |
| Three－ phase 400 V | 0.75 | FRN0．75F1■－4口 | DCR4－0．75 | 2.5 | 30 | 440 | 2.5 |
|  | 1.5 | FRN1．5F1■－4ロ | DCR4－1．5 | 4.0 | 16 | 235 | 4.8 |
|  | 2.2 | FRN2．2F1或－4口 | DCR4－2．2 | 5.5 | 12 | 172 | 6.8 |
|  | 3.7 | FRN3．7F1或－4ロ | DCR4－3．7 | 9.0 | 7.0 | 74.5 | 8.1 |
|  | 5.5 | FRN5．5F1■－4ロ | DCR4－5．5 | 13 | 4.0 | 43 | 10 |
|  | 7.5 | FRN7．5F1品－4口 | DCR4－7．5 | 18 | 3.5 | 35.5 | 15 |
|  | 11 | FRN11F1吅－4ロ | DCR4－11 | 25 | 2.2 | 23.2 | 21 |
|  | 15 | FRN15F1吅－4口 | DCR4－15 | 34 | 1.8 | 18.1 | 28 |
|  | 18.5 | FRN18．5F1■－4口 | DCR4－18．5 | 41 | 1.4 | 12.1 | 29 |
|  | 22 | FRN22F1吅－4 | DCR4－22A | 49 | 1.2 | 10.0 | 35 |
|  | 30 | FRN30F1吅－4 | DCR4－30B | 71 | 0.86 | 4.00 | 35 |
|  | 37 | FRN37F1■－4ロ | DCR4－37B | 88 | 0.70 | 2.80 | 40 |
|  | 45 | FRN45F1■－4D | DCR4－45B | 107 | 0.58 | 1.90 | 44 |
|  | 55 | FRN55F1吅－4口 | DCR4－55B | 131 | 0.47 | 1.70 | 55 |
|  | 75 | FRN75F1吅－4 | DCR4－75B | 178 | 0.335 | 1.40 | 58 |
|  | 90 | FRN90F1吅－4 | DCR4－90B | 214 | 0.29 | 1.20 | 64 |
|  | 110 | FRN110F1■－4口 | DCR4－110B | 261 | 0.24 | 0.91 | 73 |
|  | 132 | FRN132F1■－4口 | DCR4－132B | 313 | 0.215 | 0.64 | 84 |
|  | 160 | FRN160F1■－4ロ | DCR4－160B | 380 | 0.177 | 0.52 | 90 |
|  | 200 | FRN200F1■－4ロ | DCR4－200B | 475 | 0.142 | 0.52 | 126 |
|  | 220 | FRN220F1■－4口 | DCR4－220B | 524 | 0.126 | 0.41 | 131 |
|  | 280 | FRN280F1■－4口 | DCR4－280B | 649 | 0.100 | 0.32 | 150 |
|  | 315 | FRN315F1■－4口 | DCR4－315B | 739 | 0.089 | 0.33 | 190 |
|  | 355 | FRN355F1■－4口 | DCR4－355B | 833 | 0.079 | 0.28 | 205 |
|  | 400 | FRN400F1■－4口 | DCR4－400B | 938 | 0.070 | 0.23 | 215 |
|  | 450 | FRN450F1■－4D | DCR4－450B | 1056 | 0.063 | 0.23 | 272 |
|  | 500 | FRN500F1■－4口 | DCR4－500B | 1173 | 0.057 | 0.20 | 292 |

Note 1) Generated losses listed in the above table are approximate values that are calculated according to the following conditions

- The power source is 3-phase $200 \mathrm{~V} / 400 \mathrm{~V} 50 \mathrm{~Hz}$ with $0 \%$ interphase voltage unbalance ratio.
- The power source capacity uses the larger of either 500 kVA or 10 times the rated capacity of the inverter.
- The motor is a 4-pole standard model at full load (100\%).
- An AC reactor (ACR) is not connected.

2) A box (■) in the above table replaces $S$ (Standard type), E (EMC filter built-in type), or H (DCR built-in type) depending on the product specifications.
3) A box ( $\square$ ) in the above table replaces A, C, E, or J depending on the shipping destination.


Figure 6.7 Applying a DC Reactor (DCR)

## [ 2 ] AC reactors (ACRs)

Use an ACR when the converter part of the inverter should supply very stable DC power, for example, in DC link bus operation (shared PN operation). Generally, ACRs are used for correction of voltage waveform and power factor or for power supply normalization, but not for suppressing harmonic components in the power lines. For suppressing harmonic components, use a DCR.

An ACR should be also used when the power source is extremely unstable; for example, when the power source involves an extremely large interphase voltage unbalance.


Figure 6.8 External View of ACR and Application Example

Table 6．8 ACR

| Power supply voltage | Applicable <br> motor rating （kW） | Inverter type | ACR |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Type | Rated current <br> （A） | Reactance（mת／phase） |  | Coil resistance （ $\mathrm{m} \Omega$ ） | Generated loss （W） |
|  |  |  |  |  | 50 Hz | 60（Hz） |  |  |
| Three－ phase 200 V | 0.75 | FRN0．75F1臬－2口 | ACR2－0．75A | 5 | 493 | 592 | － | 12 |
|  | 1.5 | FRN1．5F1品－2口 | ACR2－1．5A | 8 | 295 | 354 |  | 14 |
|  | 2.2 |  | ACR2－2．2A | 11 | 213 | 256 |  | 16 |
|  | 3.7 | FRN3．7F1的－2口 | ACR2－3．7A | 17 | 218 | 153 |  | 23 |
|  | 5.5 | FRN5．5F1■－2口 | ACR2－5．5A | 25 | 87.7 | 105 |  | 27 |
|  | 7.5 | FRN7．5F1䀎－2口 | ACR2－7．5A | 33 | 65.0 | 78.0 |  | 30 |
|  | 11 | FRN11F1泪－2口 | ACR2－11A | 46 | 45.5 | 54.7 |  | 37 |
|  | 15 | FRN15F1泪－2口 | ACR2－15A | 59 | 34.8 | 41.8 |  | 43 |
|  | 18.5 | FRN18．5F1臬－2口 | ACR2－18．5A | 74 | 28.6 | 34.3 |  | 51 |
|  | 22 | FRN22F1俉－2口 | ACR2－22A | 87 | 24.0 | 28.8 |  | 57 |
|  | 30 | FRN30F1泪－2 | ACR2－37 | 200 | 10.8 | 13.0 | 0.5 | 28.6 |
|  | 37 | FRN37F1泪－2口 |  |  |  |  |  | 40.8 |
|  | 45 | FRN45F1泪－2口 | ACR2－55 | 270 | 7.50 | 9.00 | 0.375 | 47.1 |
|  | 55 | FRN55F1泪－2口 |  |  |  |  |  | 66.1 |
|  | 75 | FRN75F1㫜－2口 | ACR2－75 | 390 | 5.45 | 6.54 | 0.250 | 55.1 |
|  | 90 | FRN90F1泪－2口 | ACR2－90 | 450 | 4.73 | 5.67 | 0.198 | 61.5 |
|  | 110 |  | ACR2－110 | 500 | 4.25 | 5.10 | 0.180 | 83.4 |
| Three－ phase 400 V | 0.75 | FRN0．75F1■－4］ | ACR4－0．75A | 2.5 | 1920 | 2300 | － | 10 |
|  | 1.5 | FRN1．5F1的－4口 | ACR4－1．5A | 3.7 | 1160 | 1390 |  | 11 |
|  | 2.2 | FRN2．2F1的－4口 | ACR4－2．2A | 5.5 | 851 | 1020 |  | 14 |
|  | 3.7 | FRN3．7F1■－4ロ | ACR4－3．7A | 9 | 512 | 615 |  | 17 |
|  | 5.5 | FRN5．5F1的－4口 | ACR4－5．5A | 13 | 349 | 418 |  | 22 |
|  | 7.5 | FRN7．5F1■－4ロ | ACR4－7．5A | 18 | 256 | 307 |  | 27 |
|  | 11 | FRN11F1泪－4 | ACR4－11A | 24 | 183 | 219 |  | 40 |
|  | 15 | FRN15F1■－4ロ | ACR4－15A | 30 | 139 | 167 |  | 46 |
|  | 18.5 | FRN18．5F1■－4］ | ACR4－18．5A | 39 | 114 | 137 |  | 57 |
|  | 22 | FRN22F1俉－4 | ACR4－22A | 45 | 95.8 | 115 |  | 62 |
|  | 30 | FRN30F1吅－4ロ | ACR4－37 | 100 | 41.7 | 50 | 2.73 | 38.9 |
|  | 37 | FRN37F1泪－4 |  |  |  |  |  | 55.7 |
|  | 45 | FRN45F1泪－4ロ | ACR4－55 | 135 | 30.8 | 37 | 1.61 | 50.2 |
|  | 55 | FRN55F1泪－4ロ |  |  |  |  |  | 70.7 |
|  | 75 | FRN75F1畆－4ロ | ACR4－75＊ | 160 | 25.8 | 31 | 1.16 | 65.3 |
|  | 90 | FRN90F1吅－4D | ACR4－110 | 250 | 16.7 | 20 | 0.523 | 42.2 |
|  | 110 | FRN110F1恤－4口 |  |  |  |  |  | 60.3 |
|  | 132 | FRN132F1■－4ロ | ACR4－132 | 270 | 20.8 | 25 | 0.741 | 119 |
|  | 160 | FRN160F1■－4D | ACR4－220＊ | 561 | 10.0 | 12 | 0.236 | 56.4 |
|  | 200 |  |  |  |  |  |  | 90.4 |
|  | 220 | FRN220F1■－4D |  |  |  |  |  | 107 |
|  | 280 |  | ACR4－280 | 825 | 6.67 | 8 | 0.144 | 108 |
|  | 315 | FRN315F1■－4ロ | Consult your Fuji Electric representative case by case for these classes of inverters． |  |  |  |  |  |
|  | 355 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 400 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 450 | FRN450F1或－4］ |  |  |  |  |  |  |  |  |  |  |  |
|  | 500 |  |  |  |  |  |  |  |  |  |  |  |  |

＊Cool these reactors using a fan with $3 \mathrm{~m} / \mathrm{s}$ or more WV（Wind Velocity）．
Note 1）Generated losses listed in the above table are approximate values that are calculated according to the following conditions：
－The power source is 3－phase $200 \mathrm{~V} / 400 \mathrm{~V} 50 \mathrm{~Hz}$ with $0 \%$ interphase voltage unbalance ratio．
－The power source capacity uses the larger of either 500 kVA or 10 times the rated capacity of the inverter．
－The motor is a 4－pole standard model at full load（100\％）．
2）A box（ $\quad$ ）in the above table replaces $S$（Standard type），E（EMC filter built－in type），or H（DCR built－in type）depending on the product specifications．
3）A box（ $\square$ ）in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$ ，or J depending on the shipping destination．

## [ 3] Output circuit filters (OFLs)

Insert an OFL in the inverter power output circuit to:

- Suppress the voltage fluctuation at the motor power terminals

This protects the motor from insulation damage caused by the application of high voltage surge currents from the 400 V class of inverters.

- Suppress leakage current (due to higher harmonic components) from the inverter output lines This reduces the leakage current when the motor is connected by long power feed lines. Keep the length of the power feed line less than 400 m .
- Minimize radiation and/or induction noise issued from the inverter output lines

OFLs are effective noise suppression device for long wiring applications such as that used at plants.

Use an ACR within the allowable carrier frequency range specified by function code F26 (Motor sound (carrier frequency)). Otherwise, the filter will overheat.


Figure 6.9 External View of OFL and Application Example

Table 6．9 OFL（OFL－＊＊＊－2／4）

| Power supply voltage | Applicable motor rating （kW） | Inverter type | Filter type | Rated current （A） | Overload capability | Inverter power input voltage | Carrier frequency－ allowable range （kHz） | Maximur frequencs （ Hz ） |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { Three- } \\ & \text { phase } \\ & 200 \mathrm{~V} \end{aligned}$ | 0.75 | FRN0．75F1恤－2口 | OFL－1．5－2 | 8 | $150 \%$ for 1 min ．$\begin{aligned} & 200 \% \\ & \text { for } 0.5 \mathrm{sec} \end{aligned}$ | Three－phase 200 to 230 V $50 / 60 \mathrm{~Hz}$ | 8 to 15 | 400 |
|  | 1.5 | FRN1．5F1宜－2口 |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1恤－2口 | OFL－3．7－2 | 17 |  |  |  |  |
|  | 3.7 | FRN3．7F1昷－2口 |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1血－2口 | OFL－7．5－2 | 33 |  |  |  |  |
|  | 7.5 | FRN7．5F1畐－2口 |  |  |  |  |  |  |
|  | 11 | FRN11F1血－2口 | OFL－15－2 | 59 |  |  |  |  |
|  | 15 | FRN15F1晨－2口 |  |  |  |  |  |  |
|  | 18.5 | FRN18．5F1想－2口 | OFL－22－2 | 87 |  |  |  |  |
|  | 22 | FRN22F1退－2口 |  |  |  |  |  |  |
|  | 30 | FRN30F1厚－2口 | OFL－30－2 | 115 | $150 \%$ for 1 min ． |  | 6 or above | 120 |
|  | 37 | FRN37F1畐－2口 | OFL－37－2A | 145 |  |  |  |  |
|  | 45 | FRN45F1甼－2口 | OFL－45－2 | 180 |  |  |  |  |
|  | 55 | FRN55F1近－2口 | OFL－55－2 | 215 | $\begin{aligned} & 180 \% \\ & \text { for } 0.5 \mathrm{sec} \end{aligned}$ |  |  |  |
|  | 75 | FRN75F1畳－2口 | OFL－75－2 | 285 |  |  |  |  |
|  | 90 | FRN90F1恧－2口 | OFL－90－2 | Consult your Fuji Electric representative case by case for these classes of inverters． |  |  |  |  |
|  | 110 | FRN110F1宜－2口 | OFL－110－2 |  |  |  |  |  |  |  |  |  |
| Three－ phase 400 V | 0.75 | FRN0．75F1血－4］ | OFL－1．5－4 | 3.7 | $150 \%$ <br> for 1 min ． $\begin{aligned} & 200 \% \\ & \text { for } 0.5 \mathrm{sec} \end{aligned}$ | $\begin{gathered} \text { Three-phase } \\ 380 \text { to } 460 \mathrm{~V} \\ 50 / 60 \mathrm{~Hz} \end{gathered}$ | 8 to 15 | 400 |
|  | 1.5 | FRN1．5F1面－4D |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1厚－4D | OFL－3．7－4 | 9 |  |  |  |  |
|  | 3.7 | FRN3．7F1厚－4D |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1血－4D | OFL－7．5－4 | 18 |  |  |  |  |
|  | 7.5 | FRN7．5F1恧－4］ |  |  |  |  |  |  |
|  | 11 | FRN11F1近 | OFL－15－4 | 30 |  |  |  |  |
|  | 15 | FRN15F1㐌－4］ |  |  |  |  |  |  |
|  | 18.5 | FRN18．5F1厚－4］ | OFL－22－4 | 45 |  |  |  |  |
|  | 22 | FRN22F1㐌－4口 | OFL－22－4 | 45 |  |  |  |  |
|  | 30 | FRN30F1㐌－4D | OFL－30－4 | 60 | $\begin{aligned} & 150 \% \\ & \text { for } 1 \mathrm{~min} \text {. } \\ & 180 \% \\ & \text { for } 0.5 \mathrm{sec} \end{aligned}$ |  | 6 or above | 120 |
|  | 37 | FRN37F1䢕－40 | OFL－37－4 | 75 |  |  |  |  |
|  | 45 | FRN45F1㽞－4］ | OFL－45－4 | 91 |  |  |  |  |
|  | 55 | FRN55F1厚－4］ | OFL－55－4 | 112 |  |  |  |  |
|  | 75 | FRN75F1㽞－4］ | OFL－75－4 | 150 |  |  |  |  |
|  | 90 | FRN90F1㽞－4］ | OFL－90－4 | 176 |  |  |  |  |
|  | 110 | FRN110F1厚－4D | OFL－110－4 | 210 |  |  |  |  |
|  | 132 | FRN132F1厚－4D | OFL－132－4 | 253 |  |  |  |  |
|  | 160 | FRN160F1石－4］ | OFL－160－4 | 304 |  |  |  |  |
|  | 200 | FRN200F1最－4］ | OFL－200－4 | 377 |  |  |  |  |
|  | 220 | FRN220F1甼－4口 | OFL－220－4 | 415 |  |  |  |  |
|  | 280 | FRN280F1年40 | OFL－280－4 | Consult your Fuji Electric representative case by case for these classes of inverters． |  |  |  |  |
|  | 315 | FRN315F1近 | OFL－315－4 |  |  |  |  |  |  |  |  |  |
|  | 355 | FRN355F1近 | OFL－355－4 |  |  |  |  |  |  |  |  |  |
|  | 400 | FRN400F1㐌40 | OFL－400－4 |  |  |  |  |  |  |  |  |  |
|  | 450 | FRN450F1厚－40 | OFL－450－4 |  |  |  |  |  |  |  |  |  |
|  | 500 | FRN500F1ㅌ－4］ | OFL－500－4 |  |  |  |  |  |  |  |  |  |

Note 1）For inverter type of 30 kW （FRN30F1）or above，capacitor（s）of the OFL are to be installed separately．
2）A box（ $\boldsymbol{\square}$ ）in the above table replaces $S$（Standard type），E（EMC filter built－in type），or H （DCR built－in type）depending on the product specifications．
3）A box（ $\square$ ）in the above table replaces A，C，E，or J depending on the shipping destination．

Table 6．10 OFL（OFL－＊＊＊－4A）

| Power supply voltage | Applicable motor rating （kW） | Inverter type | Filter type | Rated current <br> （A） | Overload capability | Inverter power input voltage | Carrier frequency－ allowable （kHz） | Maximum frequency （Hz） |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Three－ phase 400 V | 0.75 |  | OFL－1．54A | 3.7 | $\begin{aligned} & 150 \% \\ & \text { for } 1 \mathrm{~min} . \\ & 200 \% \\ & \text { for } 0.5 \mathrm{sec} \end{aligned}$ | Three－phase 380 to 460 V $50 / 60 \mathrm{~Hz}$ | 0.75 to 15 | 400 |
|  | 1.5 | FRN1．5F1■－4D |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1■－4D | OFL－3．7－4A | 9 |  |  |  |  |
|  | 3.7 | FRN3．7F1■－4D |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1■－4D | OFL－7．5－4A | 18 |  |  |  |  |
|  | 7.5 | FRN7．5F1■－4D |  |  |  |  |  |  |
|  | 11 | FRN11F1■－4ロ | OFL－15－4A | 30 |  |  |  |  |
|  | 15 |  |  |  |  |  |  |  |
|  | 18.5 | FRN18．5F1■－4ロ | OFL－22－4A | 45 |  |  |  |  |
|  | 22 | FRN22F1臬－4ロ |  |  |  |  |  |  |
|  | 30 | FRN30F1俉－4D | OFL－30－4A | 60 | $\begin{aligned} & 150 \% \\ & \text { for } 1 \mathrm{~min} . \\ & 180 \% \\ & \text { for } 0.5 \mathrm{sec} \end{aligned}$ |  | 0.75 to 10 |  |
|  | 37 | FRN37F1■－4ロ | OFL－37－4A | 75 |  |  |  |  |
|  | 45 | FRN45F1■－4ロ | OFL－45－4A | 91 |  |  |  |  |
|  | 55 | FRN55F1■－4ロ | OFL－55－4A | 112 |  |  |  |  |
|  | 75 | FRN75F1■－4ロ | OFL－75－4A | 150 |  |  |  |  |
|  | 90 | FRN90F1臬－4口 | OFL－90－4A | 176 |  |  |  |  |
|  | 110 |  | OFL－110－4A | 210 |  |  |  |  |
|  | 132 | FRN132F1■－4］ | OFL－132－4A | 253 |  |  |  |  |
|  | 160 | FRN160F1近吅 | OFL－160－4A | 304 |  |  |  |  |
|  | 200 | FRN200F1■－4］ | OFL－200－4A | 377 |  |  |  |  |
|  | 220 |  | OFL－220－4A | 415 |  |  |  |  |
|  | 280 | FRN280F1迥 | OFL－280－4A | 520 |  |  |  |  |
|  | 315 | FRN315F1迥 | OFL－315－4A | Consult your Fuji Electric representative case by case for these classes of inverters． |  |  |  |  |
|  | 355 | FRN355F1年吅 | OFL－355－4A |  |  |  |  |  |  |  |  |  |
|  | 400 | FRN400F1㐌40 | OFL－400－4A |  |  |  |  |  |  |  |  |  |
|  | 450 |  | OFL－450－4A |  |  |  |  |  |  |  |  |  |
|  | 500 | FRN500F1边－4 | OFL－500－4A |  |  |  |  |  |  |  |  |  |

Note 1）For inverter type of 30 kW （FRN30F1）or above，capacitor（s）of the OFL are to be installed separately．
2）The OFL－＊＊＊－4A models have no restrictions on carrier frequency．
3）A box（ $\square$ ）in the above table replaces S （Standard type），E（EMC filter built－in type），or H （DCR built－in type）depending on the product specifications．
4）A box（ $\square$ ）in the above table replaces A，C，E，or J depending on the shipping destination．

## [ 4 ] Ferrite ring reactors for reducing radio noise (ACL)

An ACL is used to reduce radio frequency noise emitted by the inverter.
An ACL suppresses the outflow of high frequency harmonics caused by switching operation for the power supply lines inside the inverter. Pass the power source (primary) lines together through the ACL.
If wiring length between the inverter and motor is less than 20 m , insert an ACL to the power source (primary) lines; if it is more than 20 m , insert it to the power output (secondary) lines of the inverter.
Wire size is determined depending upon the ACL size (I.D.) and installation requirements.


Figure 6.10 Dimensions of ACL and Application Example

Table 6.11 ACL

| Ferrite ring type | Installation requirements for making 4 turns |  | Wire size$\left(\mathrm{mm}^{2}\right)$ |
| :---: | :---: | :---: | :---: |
|  | Number of rings | Number of turns |  |
| ACL-40B | 1 | 4 | 2.0 |
|  |  |  | 3.5 |
|  |  |  | 5.5 |
|  | 2 | 2 | 8 |
|  |  |  | 14 |
| ACL-74B | 1 | 4 | 8 |
|  |  |  | 14 |
|  | 2 | 2 | 22 |
|  |  |  | 38 |
|  |  |  | 60 |
|  | 4 | 1 | 100 |
|  |  |  | 150 |
|  |  |  | 200 |
|  |  |  | 250 |
|  |  |  | 325 |

The installation requirements and wire size listed above are determined for allowing three wires (3-phase input lines) to pass through the corresponding ferrite ring.

### 6.4.2 Options for operation and communications

## [ 1 ] External potentiometer for frequency setting

An external potentiometer may be used to set the frequency command. Connect the potentiometer to control signal terminals [11] to [13] of the inverter as shown in Figure 6.11.

Model: RJ-13 (BA-2 B-characteristics, $1 \mathrm{k} \Omega$ )


Dial plate type: YS549810-0
Knob type: MSS-2SB


Note: The dial plate and knob must be ordered as separate items. Available from Fuji Electric Technica Co., Ltd.

## Model: WAR3W (3W B-characteristics, $1 \mathrm{k} \Omega$ )



Knob


Note: The dial plate and knob are supplied together with the external potentiometer WAR3W. Available from Fuji Electric Technica Co., Ltd.


Figure 6.11 External Potentiometer Dimensions and Application Example

## [ 2 ] Multi-function keypad

By installing a TP-G1 multi-function keypad directly on a FRENIC-Eco series inverter as a built-in keypad or connecting those keypad using an optional remote operation extension cable (CB-5S, CB-3S, or CB-1S, depending on the distance), you can operate the inverter locally or remotely. In either mode, you can run and stop the motor, monitor the running status, and set up the function code data.
In addition, you can perform "Data copying": You can read function code data from the FRENIC-Eco, copy (write) it into another inverter, or verify it.


## [ 3] Extension cable for remote operation

The extension cable connects the inverter with the keypad (standard or multi-function) or USB-RS485 converter to enable remote operation of the inverter. The cable is a straight type with RJ-45 jacks and its length is selectable from 5,3 , and 1 m .

Note Do not use an off-the-shelf LAN cable for connection of the multi-function keypad.


Table 6.12 Extension Cable Length for Remote Operation

| Type | Length (m) |
| :---: | :---: |
| CB-5S | 5 |
| CB-3S | 3 |
| CB-1S | 1 |

You can use these cable to connect RS485 level converter to FRENIC-Eco inverters with some limitations described in "RS485 communications port," in Chapter 8, Section 8.4.1 "Terminal functions."

## [ 4] RS485 communications card

The RS485 communications card is exclusively designed for use with the FRENIC-Eco series of inverters and enables extended RS485 communication in addition to the standard RS485 communication (via the RJ-45 connector for connecting the keypad.)
The main functions include the following:

- Connecting the inverter to host equipment such as a PC or PLC, which enables the inverter to be controlled as a slave device.
- Operating the inverters by frequency command setting, forward/reverse running/stopping, coast-to-stop and resetting, etc.
- Monitoring the operation status of the inverter, e.g., output frequency, output current and alarm information, etc.
- Setting function code data.

Note that the card does not support any standard/multi-function keypad.

Table 6.13 Transmission Specifications

| Item | Specifications |  |  |
| :--- | :---: | :---: | :---: |
| Communication <br> protocol | SX protocol <br> (for exclusive use <br> with FRENIC <br> Loader) | Modbus RTU <br> (Conforming to Modicon's <br> Modbus RTU) | Fuji general-purpose <br> inverter protocol |
| Electrical <br> specifications | EIA RS-485 |  |  |
| Number of units <br> connected | Host: 1 unit, Inverter: 31 units |  |  |
| Transmission rate | 2400, 4800, 9600, 19200, and 38400 bps |  |  |
| Synchronization <br> system | Asynchronous start-stop system |  |  |
| Transmission <br> method | 500 (including tap-offs for multi-drop connection) |  |  |



## [5] Relay output card

The relay output card mounted on your FRENIC-Eco series of inverters converts transistor outputs at [Y1] to [Y3] on the inverter to relay outputs--three pairs of transfer contacts (SPDT).

When the relay output card is mounted, transistor output terminals [Y1] to [Y3] cannot be used.

## ■ Terminal assignment

The relay output terminals are assigned as shown below. Basically, the meaning of the relay outputs follows that of the transistor outputs [Y1] to [Y3], which is determined by their corresponding function codes.

Table 6.14 Terminal Assignment

| Terminal Symbol | Terminal Name | Description |
| :---: | :---: | :--- |
| $[\mathrm{Y} 1 \mathrm{~A} / \mathrm{Y} 1 \mathrm{~B} / \mathrm{Y} 1 \mathrm{C}]$ | Relay Output 1 | These are relay outputs directly linked to transistor outputs <br> [Y1] to [Y3]. Each relay is excited when its corresponding |
| $[\mathrm{Y} 2 \mathrm{~A} / \mathrm{Y} 2 \mathrm{~B} / \mathrm{Y} 2 \mathrm{C}]$ | Relay Output 2 | signal ([Y1], [Y2], or [Y3]) is ON. When excited, the relays <br> [Y1A]-[Y1C], [Y2A]-[Y2C], and [Y3A] -[Y3C] are closed, |
| and ones between [Y1B]-[Y1C], [Y2B]-[Y2C], and [Y3B]- |  |  |
| [Y3A/Y3B/Y3C] | Relay Output 3 | [Y3C] are opened. In this manner, the signals corresponding to <br> function codes E20 to E22 (such as inverter running, frequency <br> arrival, and motor overload early warning signals) can be <br> output as contact signals. |

## Noter

When the inverter's control power is OFF, all the $\mathrm{B}-\mathrm{C}$ contact pairs are short-circuited. If you are using negative logic to realize fail-safe operation, make sure that this does not cause any logic fault or confliction.

Electrical specifications
Table 6.15 Electrical Specifications

| Item | Specification |
| :---: | :---: |
| Contact capacity | $250 \mathrm{VAC}, 0.3 \mathrm{~A}(\cos \phi=0.3)$ or $48 \mathrm{VDC}, 0.5 \mathrm{~A}$ (resistive load) |
| Contact life | 200 thousand operations (with ON/OFF intervals of 1 second) |

If you anticipate frequent operations (ON/OFF switching) of relays (for example, if you deliberately use a signal for limiting the inverter's output to control the main current), be sure to use the transistor signals at terminals [Y1] through [Y3].

Wire properly, referring to the terminal allocation and symbol diagram, the internal block diagram, and the terminal and wiring specification table shown below.


Figure 6.12 Terminal Allocation and Symbol Diagram

| Table 6.16 |  <br> Recommended <br> Wire Gauge |
| :--- | :--- |
|  <br> Recommended Wire Gauge |  |
| Terminal Size | M3 |
| Tightening Torque | $0.7 \mathrm{~N} \cdot \mathrm{~m}$ |
| Recommended <br> Wire Gauge* | $0.75 \mathrm{~mm}^{2}$ |

* A 600 V HIV wire with allowable temperature of $75^{\circ} \mathrm{C}$ is recommended. An ambient temperature of $50^{\circ} \mathrm{C}$ is assumed.


Figure 6.13 Internal Block Diagram

[^39]
## [ 6 ] Inverter support loader software

FRENIC Loader is an inverter support software which enables the inverter to be operated via the standard RS485 communications port. The main functions include the following:

- Easy editing of function code data
- Monitoring the operation statuses of the inverter such as I/O monitor and multi-monitor
- Operation of inverters on a PC screen (Windows-based only)

DD Refer to Chapter 5 "RUNNING THOUGH RS485 COMMUNICATION" for details.


### 6.4.3 Extended installation kit options

## [1] Panel-mount Adapter

This adapter allows you to mount your FRENIC-Eco series of inverters using the mounting holes for an existing inverter (FRENIC 5000P11S $5.5 \mathrm{~kW} / 15 \mathrm{~kW} / 30 \mathrm{~kW}$ ).
(The FRENIC5000P11S $7.5 \mathrm{~kW} / 11 \mathrm{~kW} / 18.5 \mathrm{~kW} / 22 \mathrm{~kW}$ can be replaced with the FRENIC-Eco series without this adapter.)

Table 6.17 Panel-mount Adapter


Note A box ( $\square$ ) in the above table replaces A, C, E, or J depending on the shipping destination.

## ［ 2 ］Mounting Adapter for External Cooling

This adapter allows you to mount your FRENIC－Eco series of inverters（ 30 kW or less）on the panel in such a way that the heat sink assembly may be exposed to the outside．Using this adapter greatly reduces heat radiated or spread inside your enclosure．（For your inverter of 37 kW or above，remount its mounting base and mount it on the wall of your enclosure to realize the external cooling capability． Refer to FRENIC－Eco Instruction Manual（INR－S147－0882－E）Chapter 2 ＂MOUNTING AND WIRING OF THE INVERTER＂for details，）

Table 6．18 Mounting Adapter for External Cooling

| Model Name of Adapter and Accompanying Screws and Nuts |  |  |  | Applicable Inverter Models |
| :---: | :---: | :---: | :---: | :---: |
| PB－F1－5．5 |  |  |  | FRN5．5F1S－2口 |
|  |  | $4(\mathrm{M} 5 \times 8)$ | Cross recessed head tapping screws |  |
|  |  | $6(\mathrm{M} 6 \times 15)$ | Cross recessed pan head screws with captive washer | FRN5．5F1S－4■ |
|  |  | 6 （M6） | Hexagon nuts |  |
| PB－F1－15 |  | $6(\mathrm{M} 8 \times 25)$ | Cross recessed pan head | $\begin{aligned} & \text { FRN7.5F1S-2口 } \\ & \text { FRN11F1S-2口 } \\ & \text { FRN15F1S-2口 } \end{aligned}$ |
|  |  | $4 \text { (M8) }$ | washer <br> Hexagon nuts | FRN7．5F1S－4 <br> FRN11F1S－4 <br> FRN15F1S－4 |
| PB－F1－30 |  | $6(\mathrm{M} 8 \times 25)$ | Cross recessed pan head | $\begin{aligned} & \text { FRN18.5F1S-2■ } \\ & \text { FRN22F1S-2ם } \\ & \text { FRN30F1S-2 } \end{aligned}$ |
|  |  | $4 \text { (M8) }$ | washer <br> Hexagon nuts | FRN18．5F1S－4D FRN22F1S－4D FRN30F1S－4D |

Note A box（ $\square$ ）in the above table replaces A，C，E，or J depending on the shipping destination．

### 6.4.4 Meter options

## [ 1] Frequency meters

Connect a frequency meter to analog signal output terminals [FMA] (+) and [11] (-) of the inverter to measure the frequency component selected by function code F31. Figure 6.14 shows the dimensions of the frequency meter and application example.

## Model: TRM-45 (10 VDC, 1 mA )



Model: FM-60 (10 VDC, 1 mA )



Available from Fuji Electric Technica Co., Ltd.


Figure 6.14 Frequency Meter Dimensions and Application Example

## Part 4 Selecting Optimal Inverter Model

Chapter 7 SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES

## Chapter 7

## SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES

This chapter provides you with information about the inverter output torque characteristics, selection procedure, and equations for calculating capacities to help you select optimal motor and inverter models. This also helps you select braking resistors.

## Contents

7.1 Selecting Motors and Inverters ..... 7-1
7.1.1 Motor output torque characteristics ..... 7-1
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### 7.1 Selecting Motors and Inverters

When selecting a general-purpose inverter, first select a motor and then inverter as follows:
(1) Key point for selecting a motor: Determine what kind of load machine is to be used, calculate its moment of inertia, and then select the appropriate motor capacity
(2) Key point for selecting an inverter: Taking into account the operation requirements (e.g., acceleration time, deceleration time, and frequency in operation) of the load machine to be driven by the motor selected in (1) above, calculate the acceleration/deceleration/braking torque.

This section describes the selection procedure for (1) and (2) above. First, it explains the output torque obtained by using the motor driven by the inverter (FRENIC-Eco).

### 7.1.1 Motor output torque characteristics

Figures 7.1 and 7.2 graph the output torque characteristics of motors at the rated output frequency individually for 50 Hz and 60 Hz base. The horizontal and vertical axes show the output frequency and output torque (\%), respectively. Curves (a) through (d) depend on the running conditions.


Figure 7.1 Output Torque Characteristics (Base frequency: 50 Hz )


Figure 7.2 Output Torque Characteristics (Base frequency: 60 Hz )

## (1) Continuous allowable driving torque (Curve (a) in Figures 7.1 and 7.2)

Curve (a) shows the torque characteristic that can be obtained in the range of the inverter continuous rated current, where the motor cooling characteristic is taken into consideration. When the motor runs at the base frequency of $60 \mathrm{~Hz}, 100 \%$ output torque can be obtained; at 50 Hz , the output torque is somewhat lower than that in commercial power, and it further lowers at lower frequencies. The reduction of the output torque at 50 Hz is due to increased loss by inverter driving, and that at lower frequencies is mainly due to heat generation caused by the decreased ventilation performance of the motor cooling fan.

## (2) Maximum driving torque in a short time (Curves (b) and (c) in Figures 7.1 and 7.2)

Curve (b) shows the torque characteristic that can be obtained in the range of the inverter rated current in a short time (the output torque is $150 \%$ for one minute) when quick torque-vector control (the auto torque boost and slip compensation functions are activated) is enabled. At that time, the motor cooling characteristics have little effect on the output torque.

Curve (c) shows an example of the torque characteristic when one class higher capacity inverter is used to increase the short-time maximum torque. In this case, the short-time torque is 20 to $30 \%$ greater than that when the standard capacity inverter is used.

## (3) Starting torque (around the output frequency 0 Hz in Figures 7.1 and 7.2)

The maximum torque in a short time applies to the starting torque as it is.

## (4) Braking torque (Curve (d) in Figures 7.1 and 7.2)

In braking of the motor, kinetic energy is converted to electrical energy and regenerated to the reservoir capacitor on the DC link bus of the inverter. Only the motor and inverter consume this energy as their internal losses, so the braking torque is as shown in curve (d).
Note that the torque value in $\%$ varies according to the inverter capacity.

### 7.1.2 Selection procedure

Figure 7.3 shows the general selection procedure for optimal inverters. Items numbered (1) through (3) are described on the following pages.

You may easily select inverter capacity if there are no restrictions on acceleration and deceleration times. If "there are any restrictions on acceleration or deceleration time" or "acceleration and deceleration are frequent," then the selection procedure is more complex than that of the constant speed running.


Figure 7.3 Selection Procedure
(1) Calculating the load torque during constant speed running (For detailed calculation, refer to Section 7.1.3.1)
It is essential to calculate the load torque during constant speed running for all loads.
First calculate the load torque of the motor during constant speed running and then select a tentative capacity so that the continuous rated torque of the motor during constant speed running becomes higher than the load torque. To perform capacity selection efficiently, it is necessary to match the rated speeds (base speeds) of the motor and load. To do this, select an appropriate reduction-gear (mechanical transmission) ratio and the number of motor poles.
If the acceleration or deceleration time is not restricted, the tentative capacity can apply as a defined capacity.
(2) Calculating the acceleration time (For detailed calculation, refer to Section 7.1.3.2)

When there are some specified requirements for the acceleration time, calculate it according to the following procedure:

1) Calculate the total moment of inertia for the load and motor

Calculate the moment of inertia for the load, referring to Section 7.1.3.2, "Acceleration and deceleration time calculation." For the motor, refer to the related motor catalogs. Sum them up.
2) Calculate the required minimum acceleration torque (See Figure 7.4)

The acceleration torque is the difference between the motor short-time output torque (base frequency: 60 Hz ) explained in Section 7.1.1 (2), "Maximum driving torque in a short time" and the load torque ( $\tau_{\mathrm{L}} / \eta_{\mathrm{G}}$ ) during constant speed running calculated in the above (1). Calculate the required minimum acceleration torque over the whole range of speed.
3) Calculate the acceleration time

Assign the value calculated above to the equation (7.10) in Section 7.1.3.2, "Acceleration and deceleration time calculation" to calculate the acceleration time. If the calculated acceleration time is longer than the expected time, select the inverter and motor having one class higher capacity and calculate it again.


Figure 7.4 Example Study of Required Minimum Acceleration Torque

## (3) Deceleration time (For detailed calculation, refer to Section 7.1.3.2)

To calculate the deceleration time, check the motor deceleration torque characteristics for the whole range of speed in the same way as for the acceleration time.

1) Calculate the total moment of inertia for the load and motor Same as for the acceleration time.
2) Calculate the required minimum deceleration torque (See Figures 7.5 and 7.6.) Same as for the acceleration time.
3) Calculate the deceleration time

Assign the value calculated above to the equation (7.11) to calculate the deceleration time in the same way as for the acceleration time. If the calculated deceleration time is longer than the requested time, select the inverter and motor having one class higher capacity and calculate it again.


Figure 7.5 Example Study of Required Minimum Deceleration Torque (1)


Figure 7.6 Example Study of Required Minimum Deceleration Torque (2)

### 7.1.3 Equations for selections

### 7.1.3.1 Load torque during constant speed running

## [1] General equation

The frictional force acting on a horizontally moved load must be calculated. Calculation for driving a load along a straight line with the motor is shown below.

Where the force to move a load linearly at constant speed $v(\mathrm{~m} / \mathrm{s})$ is $F(N)$ and the motor speed for driving this is $\mathrm{N}_{M}(\mathrm{r} / \mathrm{min})$, the required motor output torque $\tau_{M}(\mathrm{~N} \cdot \mathrm{~m})$ is as follows:
$\tau_{\mathrm{M}}=\frac{60 \cdot \mathrm{v}}{2 \pi \cdot \mathrm{~N}_{\mathrm{M}}} \cdot \frac{\mathrm{F}}{\eta_{\mathrm{G}}}(\mathrm{N} \cdot \mathrm{m})$
where, $\eta_{\mathrm{G}}$ is Reduction-gear efficiency.
When the inverter brakes the motor, efficiency works inversely, so the required motor torque should be calculated as follows:

$$
\begin{equation*}
\tau_{\mathrm{M}}=\frac{60 \cdot \mathrm{v}}{2 \pi \cdot \mathrm{~N}_{\mathrm{M}}} \cdot \mathrm{~F} \cdot \eta_{\mathrm{G}} \quad(\mathrm{~N} \cdot \mathrm{~m}) \tag{7.2}
\end{equation*}
$$

$(60 \cdot v) /\left(2 \pi \cdot N_{M}\right)$ in the above equation is an equivalent turning radius corresponding to speed $v$ around the motor shaft.

The value $\mathrm{F}(\mathrm{N})$ in the above equations depends on the load type.

## [ 2 ] Obtaining the required force $F$

Moving a load horizontally
A simplified mechanical configuration model is assumed as shown in Figure 7.7. If the mass of the carrier table is $W_{0}(\mathrm{~kg})$, the load is $\mathrm{W} k g$, and the friction coefficient of the ball screw is $\mu$, then the friction force $\mathrm{F}(\mathrm{N})$ is expressed as follows, which is equal to a required force for driving the load:

$$
\begin{equation*}
\mathrm{F}=\left(\mathrm{W}_{0}+\mathrm{W}\right) \cdot \mathrm{g} \cdot \mu \quad(\mathrm{~N}) \tag{7.3}
\end{equation*}
$$

where, $g$ is the gravity acceleration $\left(\approx 9.8 \mathrm{~m} / \mathrm{s}^{2}\right)$.
Then, the required output torque around the motor shaft is expressed as follows:
$\tau_{M}=\frac{60 \cdot v}{2 \pi \cdot \mathrm{~N}_{\mathrm{M}}} \cdot \frac{\left(\mathrm{W}_{0}+\mathrm{W}\right) \cdot \mathrm{g} \cdot \mu}{\eta_{\mathrm{G}}} \quad(\mathrm{N} \cdot \mathrm{m})$


Figure 7.7 Moving a Load Horizontally

### 7.1.3.2 Acceleration and deceleration time calculation

When an object whose moment of inertia is $J\left(\mathrm{~kg} \cdot \mathrm{~m}^{2}\right)$ rotates at the speed $\mathrm{N}(\mathrm{r} / \mathrm{min})$, it has the following kinetic energy:

$$
\begin{equation*}
\mathrm{E}=\frac{\mathrm{J}}{2} \cdot\left(\frac{2 \pi \cdot \mathrm{~N}^{2}}{60}\right)^{2} \tag{J}
\end{equation*}
$$

To accelerate the above rotational object, the kinetic energy will be increased; to decelerate the object, the kinetic energy must be discharged. The torque required for acceleration and deceleration can be expressed as follows:

$$
\begin{equation*}
\tau=\mathrm{J} \cdot \frac{2 \pi}{60}\left(\frac{\mathrm{dN}}{\mathrm{dt}}\right)(\mathrm{N} \cdot \mathrm{~m}) \tag{7.6}
\end{equation*}
$$

This way, the mechanical moment of inertia is an important element in the acceleration and deceleration. First, calculation method of moment of inertia is described, then those for acceleration and deceleration time are explained.

## [ 1] Calculation of moment of inertia

For an object that rotates around the rotation axis, virtually divide the object into small segments and square the distance from the rotation axis to each segment. Then, sum the squares of the distances and the masses of the segments to calculate the moment of inertia.

$$
\begin{equation*}
\mathrm{J}=\sum\left(\mathrm{W}_{\mathrm{i}} \cdot \mathrm{r}_{\mathrm{i}}^{2}\right) \quad\left(\mathrm{kg} \cdot \mathrm{~m}^{2}\right) \tag{7.7}
\end{equation*}
$$

The following describes equations to calculate moment of inertia having different shaped loads or load systems.

## (1) Hollow cylinder and solid cylinder

The common shape of a rotating body is hollow cylinder. The moment of inertia around the hollow cylinder center axis can be calculated as follows, where the outer and inner diameters are $D_{1}$ and $D_{2}[m]$ and total mass is $\mathrm{W}(\mathrm{kg})$ in Figure 7.8.

$$
\begin{equation*}
\mathrm{J}=\frac{\mathrm{W} \cdot\left(\mathrm{D}_{1}{ }^{2}+\mathrm{D}_{2}^{2}\right)}{8}\left(\mathrm{~kg} \cdot \mathrm{~m}^{2}\right) \tag{7.8}
\end{equation*}
$$

For a similar shape, a solid cylinder, calculate the moment of inertia as $D_{2}$ is 0 .


Figure 7.8 Hollow Cylinder

## (2) For a general rotating body

Table 7.1 lists the calculation equations of moment of inertia of various rotating bodies including the above cylindrical rotating body.

Table 7.1 Moment of Inertia of Various Rotating Bodies

| Shape | Mass: W (kg) <br> Moment of inertia: $\mathrm{J}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)$ | Shape | Mass: W (kg) <br> Moment of inertia: $\mathrm{J}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)$ |
| :---: | :---: | :---: | :---: |
| Hollow cylinder <br> Sphere | $\begin{aligned} & \mathrm{W}=\frac{\pi}{4} \cdot\left(\mathrm{D}_{1}{ }^{2}-\mathrm{D}_{2}{ }^{2}\right) \cdot \mathrm{L} \cdot \mathrm{~F} \\ & \mathrm{~J}=\frac{1}{8} \cdot \mathrm{~W} \cdot\left(\mathrm{D}_{1}{ }^{2}+\mathrm{D}_{2}{ }^{2}\right) \\ & \mathrm{W}=\frac{\pi}{6} \cdot \mathrm{D}^{3} \cdot \rho \\ & \hdashline \mathrm{~J}=\frac{1}{10} \cdot \mathrm{~W} \cdot \mathrm{D}^{2} \end{aligned}$ |  | $\mathrm{W}=\mathrm{A} \cdot \mathrm{~B} \cdot \mathrm{~L} \cdot \rho$ $\begin{aligned} & \mathrm{J}_{\mathrm{a}}=\frac{1}{12} \cdot \mathrm{~W} \cdot\left(\mathrm{~L}^{2}+\mathrm{A}^{2}\right) \\ & \mathrm{J}_{\mathrm{b}}=\frac{1}{12} \cdot \mathrm{~W} \cdot\left(\mathrm{~L}^{2}+\frac{1}{4} \cdot \mathrm{~A}^{2}\right) \\ & \mathrm{J}_{\mathrm{c}} \approx \mathrm{~W} \cdot\left(\mathrm{~L}_{0}{ }^{2}+\mathrm{L}_{0} \cdot \mathrm{~L}+\frac{1}{3} \cdot \mathrm{~L}^{2}\right) \end{aligned}$ |
| Cone <br> Rectangular prism | $\begin{aligned} & \mathrm{W}=\frac{\pi}{12} \cdot \mathrm{D}^{2} \cdot \mathrm{~L} \cdot \mathrm{\rho} \\ & \mathrm{~J}=\frac{3}{40} \cdot \mathrm{~W} \cdot \mathrm{D}^{2} \\ & \mathrm{~W}=\mathrm{A} \cdot \mathrm{~B} \cdot \mathrm{~L} \cdot \mathrm{\rho} \\ & \mathrm{~J}=\frac{1}{12} \cdot \mathrm{~W} \cdot\left(\mathrm{~A}^{2}+\mathrm{B}^{2}\right) \end{aligned}$ |  | $\mathrm{W}=\frac{\pi}{4} \cdot \mathrm{D}^{2} \cdot \mathrm{~L} \cdot \rho$ $\begin{aligned} & \mathrm{J}_{\mathrm{a}}=\frac{1}{12} \cdot \mathrm{~W} \cdot\left(\mathrm{~L}^{2}+\frac{3}{4} \cdot \mathrm{D}^{2}\right) \\ & \mathrm{J}_{\mathrm{b}}=\frac{1}{3} \cdot \mathrm{~W} \cdot\left(\mathrm{~L}^{2}+\frac{3}{16} \cdot \mathrm{D}^{2}\right) \\ & \mathrm{J}_{\mathrm{c}} \approx \mathrm{~W} \cdot\left(\mathrm{~L}_{0}{ }^{2}+\mathrm{L}_{0} \cdot \mathrm{~L}+\frac{1}{3} \cdot \mathrm{~L}^{2}\right) \end{aligned}$ |
| Square cone (Pyramid, rectangular base) | $\mathrm{W}=\frac{1}{3} \cdot \mathrm{~A} \cdot \mathrm{~B} \cdot \mathrm{~L} \cdot \mathrm{\rho}$ $\mathrm{J}=\frac{1}{20} \cdot \mathrm{~W} \cdot\left(\mathrm{~A}^{2}+\mathrm{B}^{2}\right)$ |  | $\begin{aligned} & \mathrm{W}=\frac{1}{3} \cdot \mathrm{~A} \cdot \mathrm{~B} \cdot \mathrm{~L} \cdot \mathrm{\rho} \\ & \mathrm{~J}_{\mathrm{b}}=\frac{1}{10} \cdot \mathrm{~W} \cdot\left(\mathrm{~L}^{2}+\frac{1}{4} \cdot \mathrm{~A}^{2}\right) \\ & \mathrm{J}_{\mathrm{c}} \approx \mathrm{~W} \cdot\left(\mathrm{~L}_{0}{ }^{2}+\frac{3}{2} \cdot \mathrm{~L}_{0} \cdot \mathrm{~L}+\frac{3}{5} \cdot \mathrm{~L}^{2}\right) \end{aligned}$ |
| Triangular prism | $\begin{aligned} & \mathrm{W}=\frac{\sqrt{3}}{4} \cdot \mathrm{~A}^{2} \cdot \mathrm{~L} \cdot \mathrm{\rho} \\ & \mathrm{~J}=\frac{1}{3} \cdot \mathrm{~W} \cdot \mathrm{~A}^{2} \end{aligned}$ | caxis baxis | $\mathrm{W}=\frac{\pi}{12} \cdot \mathrm{D}^{2} \cdot \mathrm{~L} \cdot \rho$ |
| Tetrahedron with an equilateral triangular base | $\mathrm{W}=\frac{\sqrt{3}}{12} \cdot \mathrm{~A}^{2} \cdot \mathrm{~L} \cdot \mathrm{\rho}$ $\mathrm{J}=\frac{1}{5} \cdot \mathrm{~W} \cdot \mathrm{~A}^{2}$ |  | $\begin{aligned} & \mathrm{J}_{\mathrm{b}}=\frac{1}{10} \cdot \mathrm{~W} \cdot\left(\mathrm{~L}^{2}+\frac{3}{8} \cdot \mathrm{D}^{2}\right) \\ & \mathrm{J}_{\mathrm{c}} \approx \mathrm{~W} \cdot\left(\mathrm{~L}_{0}{ }^{2}+\frac{3}{2} \cdot \mathrm{~L}_{0} \cdot \mathrm{~L}+\frac{3}{5} \cdot \mathrm{~L}^{2}\right) \end{aligned}$ |
| Main metal density (at $20^{\circ} \mathrm{C}$ ) $\rho\left(\mathrm{kg} / \mathrm{m}^{3}\right.$ ) Iron: 7860, Copper: 8940 , Aluminum: 2700 |  |  |  |

## (3) For a load running horizontally

Assume a carrier table driven by a motor as shown in Figure 7.7. If the table speed is $v(\mathrm{~m} / \mathrm{s})$ when the motor speed is $N_{M}(r / m i n)$, then an equivalent distance from the rotation axis is equal to $60 \cdot v /\left(2 \pi \cdot N_{M}\right)$ m . The moment of inertia of the table and load to the rotation axis is calculated as follows:

$$
\begin{equation*}
\mathrm{J}=\left(\frac{60 \cdot \mathrm{v}}{2 \pi \cdot \mathrm{~N}_{\mathrm{M}}}\right)^{2} \cdot\left(\mathrm{~W}_{0}+\mathrm{W}\right) \quad\left(\mathrm{kg} \cdot \mathrm{~m}^{2}\right) \tag{7.9}
\end{equation*}
$$

## [2] Calculation of the acceleration time

Figure 7.9 shows a general load model. Assume that a motor drives a load via a reduction-gear with efficiency $\eta_{G}$. The time required to accelerate this load to a speed of $N_{M}(r / m i n)$ is calculated with the following equation:

$$
\begin{equation*}
\mathrm{t}_{\mathrm{ACC}}=\frac{\mathrm{J}_{1}+\mathrm{J}_{2} / \eta_{\mathrm{G}}}{\tau_{\mathrm{M}}-\tau_{\mathrm{L}} / \eta_{\mathrm{G}}} \cdot \frac{2 \pi \cdot\left(\mathrm{~N}_{\mathrm{M}}-0\right)}{60} \tag{7.10}
\end{equation*}
$$

where,
$\mathrm{J}_{1}$ : Motor shaft moment of inertia $\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)$
$\mathrm{J}_{2}$ : Load shaft moment of inertia converted to motor shaft $\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)$
$\tau_{\mathrm{M}}$ : Minimum motor output torque in driving mode ( $\mathrm{N} \cdot \mathrm{m}$ )
$\tau_{\mathrm{L}}$ : Maximum load torque converted to motor shaft ( $\mathrm{N} \cdot \mathrm{m}$ )
$\eta_{\mathrm{G}}$ : Reduction-gear efficiency.
As clarified in the above equation, the equivalent moment of inertia becomes $\left(\mathrm{J}_{1}+\mathrm{J}_{2} / \eta_{\mathrm{G}}\right)$ by considering the reduction-gear efficiency.


Figure 7.9 Load Model Including Reduction-gear

## [3] Calculation of the deceleration time

In a load system shown in Figure 7.9, the time needed to stop the motor rotating at a speed of $\mathrm{N}_{\mathrm{M}}$ $(\mathrm{r} / \mathrm{min})$ is calculated with the following equation:
$\mathrm{t}_{\mathrm{DEC}}=\frac{\mathrm{J}_{1}+\mathrm{J}_{2} \cdot \eta_{\mathrm{G}}}{\tau_{\mathrm{M}}-\tau_{\mathrm{L}} \cdot \eta_{\mathrm{G}}} \cdot \frac{2 \pi \cdot\left(0-\mathrm{N}_{\mathrm{M}}\right)}{60} \quad(\mathrm{~s})$
where,
$\mathrm{J}_{1}$ : Motor shaft moment of inertia $\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)$
$\mathrm{J}_{2}$ : Load shaft moment of inertia converted to motor shaft $\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)$
$\tau_{\mathrm{M}}$ : Minimum motor output torque in deceleration mode ( $\mathrm{N} \cdot \mathrm{m}$ )
$\tau_{\mathrm{L}}$ : Maximum load torque converted to motor shaft ( $\mathrm{N} \cdot \mathrm{m}$ )
$\eta_{\mathrm{G}}$ : Reduction-gear efficiency
In the above equation, generally output torque $\tau_{\mathrm{M}}$ is negative and load torque $\tau_{\mathrm{L}}$ is positive. So, deceleration time becomes shorter.

### 7.1.3.3 Heat energy calculation of braking resistor

If the inverter brakes the motor, the kinetic energy of mechanical load is converted to electric energy to be transmitted into the inverter circuit. This regenerative energy is often consumed in so-called braking resistors as heat. The following explains the braking resistor rating.

## [ 1 ] Calculation of regenerative energy

In the inverter operation, one of the regenerative energy sources is the kinetic energy that is generated at the time an object is moved by an inertial force.

Kinetic energy of a rotational object
When an object with moment of inertia $J\left(\mathrm{~kg} \cdot \mathrm{~m}^{2}\right)$ rotates at a speed $\mathrm{N}_{2}(\mathrm{r} / \mathrm{min})$, its kinetic energy is as follows:

$$
\begin{align*}
\mathrm{E} & =\frac{\mathrm{J}}{2} \cdot\left(\frac{2 \pi \cdot \mathrm{~N}_{2}}{60}\right)^{2}  \tag{7.12}\\
& \approx \frac{1}{182.4} \cdot \mathrm{~J} \cdot \mathrm{~N}_{2}^{2} \tag{J}
\end{align*}
$$

When this object is decelerated to a speed $\mathrm{N}_{1}(\mathrm{r} / \mathrm{min})$, the output energy is as follows:

$$
\begin{align*}
\mathrm{E} & =\frac{\mathrm{J}}{2} \cdot\left[\left(\frac{2 \pi \cdot \mathrm{~N}_{2}}{60}\right)^{2}-\left(\frac{2 \pi \cdot \mathrm{~N}_{1}}{60}\right)^{2}\right]  \tag{J}\\
& \approx \frac{1}{182.4} \cdot \mathrm{~J} \cdot\left(\mathrm{~N}_{2}^{2}-\mathrm{N}_{1}^{2}\right) \quad(\mathrm{J})
\end{align*}
$$

The energy regenerated to the inverter as shown in Figure 7.9 is calculated from the reduction-gear efficiency $\eta_{G}$ and motor efficiency $\tau_{\mathrm{M}}$ as follows:

$$
\begin{equation*}
E \approx \frac{1}{182.4} \cdot\left(\mathrm{~J}_{1}+\mathrm{J}_{2} \cdot \eta_{\mathrm{G}}\right) \cdot \eta_{\mathrm{M}} \cdot\left(\mathrm{~N}_{2}^{2}-\mathrm{N}_{1}^{2}\right) \tag{7.14}
\end{equation*}
$$

## [ 2 ] Calculation of energy able to regenerate per inverter

Energy able to regenerate per inverter is determined by the power source voltage and capacitance of the DC link bus capacitor(s).
$\mathrm{Ec}=\frac{1}{2} \cdot \mathrm{C} \cdot \mathrm{V}^{2} \quad(\mathrm{~J})$
If the value E obtained by the equation (7.14) does not exceed the value Ec obtained here, the inverter is able to decelerate its load.

## Part 5 Specifications

Chapter 8 SPECIFICATIONS
Chapter 9 FUNCTION CODES

## Chapter 8

## SPECIFICATIONS

This chapter describes specifications of the output ratings, control system, and terminal functions for the FRENIC-Eco series of inverters. It also provides descriptions of the operating and storage environment, external dimensions, examples of basic connection diagrams, and details of the protective functions.

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### 8.1 Standard Models

### 8.1.1 Three-phase 200 V series


*1) Fuil 4-pole standard motor
2) The rated capacity is calculated assuming the output rated voltage as 220 V for three-phase 200 V series.
*3) Output voltage cannot exceed the power supply voltage.
4) When setting the carrier frequency (F26) to 1 kHz or less, reduce the load to $80 \%$ of its rating.
${ }^{*} 5$ ) Use [R1, T1] terminals for driving AC cooling fans of an inverter powered by the DC link bus, such as by a high power factor PWM corverter. (In ordinary operation, the terminals are not used.)
6) Calculated under Fuji-specified conditions.
${ }^{*} 7$ ) Obtained when a DC reactor (DCR) is used.
*8) Average braking torque (Varies with the efficiency of the motor.)
99) Voltage unbalance $(\%)=\frac{\text { Max. voltage }(V)-\text { Min. voltage }(V)}{T} \times 67($ IEC61800-3 (5.2.3)) If this value is 2 to $3 \%$, use an $A C$ reactor (ACR)

Note A box ( $\square$ ) in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$, or J depending on the shipping destination.

### 8.1.2 Three-phase 400 V series

## - 0.75 to 55 kW


*1) Full 4-pole standard motor
*2) The rated capacity is calculated assuming the output rated voltage as 440 V for three-phase 400 V series.
${ }^{3}$ ) Output voltage cannot exceed the power supply voltage.
*4) When setting the carrier frequency (F26) to 1 kHz or less, reduce the load to $80 \%$ of its rating.
${ }^{*} 5$ ) Use [R1, T1] terminals for driving AC cooling fans of an inverter powered by the DC link bus, such as by a high power factor PWM converter (In ordinary operation, the terminals are not used.)
${ }^{*}$ 6) Calculated under Fuil-specified conditions.
${ }^{*} 7$ ) Obtained when a DC reactor (DCR) is used.
*8) Average braking torque (Varies with the efficiency of the motor.)
"9) Single-phase, 380 to $440 \mathrm{~V} / 50 \mathrm{~Hz}$ or Single-phase, 380 to $480 \mathrm{~V} / 60 \mathrm{~Hz}$
$\left.{ }^{*} 10\right)$ Voltage unbalance $(\%)=\frac{\text { Max. voltage }(V)-M i n . ~ v o l t a g e ~}{(V)}$ Three-phase average voltage $(V) \times 67$ (IEC61800-3 (5.2.3)) If this value is 2 to $3 \%$, use an $A C$ reactor (ACR).

Note A box (ロ) in the above table replaces A, C, E, or J depending on the shipping destination

- 75 to 500 kW

-1) Fuil 4 -pole standard motor

2) The rated capacity is calculated assuming the output rated voltage as 440 V for three-phase 400 V series.
${ }^{4}$ 3) Output voltage cannot exceed the power supply voltage.
*4) When setting the carrier frequency (F26) to 1 kHz or less, reduce the load to $80 \%$ of its rating-
${ }^{*} 5$ ) Use [R1, T1] terminals for driving AC cooling fans of an inverter powered by the DC link bus, such as by a high power factor PWM converter (In ordinary operation, the terminals are not used.)
*6) Calculated under Fujl-specified conditions.
${ }^{*} 7$ ) Obtained when a DC reactor (DCR) is used.
"B) Average braking torque (Varies with the efficiency of the motor.)
*9) Voltage unbalance $(\%)=\frac{\text { Max. voltage }(\mathrm{V})-\text { Min. voltage }(\mathrm{V})}{\text { Three-phase average voltage }(\mathrm{V})} \times 67$ (IEC61800-3 (5.2.3)) If this value is 2 to $3 \%$, use an $A C$ reactor (ACR).

Note A box (ロ) in the above table replaces A, C, E, or J depending on the shipping destination.

### 8.2 Models Available on Order

### 8.2.1 DCR built-in type

In the European version, the DCR built-in type is provided as a standard model. In other versions, it is available on order.

### 8.2.1.1 Three-phase 200 V series

| Item |  |  | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type (FRN__F1H-2口) |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 |
| Applicable motor rating *1) kW |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 |
|  | Rated capacity *2) KVA |  | 1.6 | 2.6 | 4.0 | 8.3 | 8.3 | 11 | 16 | 21 | 25 | 30 | 40 | 49 | 59 | 75 | 102 |
|  | Rated voltage *3) V |  | Three-phase $200 \mathrm{~V} / 50 \mathrm{~Hz}, 200 \mathrm{~V}, 220 \mathrm{~V}, 230 \mathrm{~V}, 240 \mathrm{~V} / 60 \mathrm{~Hz}$ (With AVR function) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current '4) A |  | 4.2 | 7.0 | 10.6 | 16.7 | 22.5 | 29 | 42 | 55 | 68 | 80 | 107 | 130 | 156 | 198 | 270 |
|  | Overioad capability |  | 120\% of rated current for 1 min |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases, voltage, frequency | Main power supply | Three-phase, 200 to $240 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Three-phase, 200 to $220 \mathrm{~V} / 50 \mathrm{~Hz}$ Three-phase, 200 to $230 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |
|  |  | Auxiliary control power input | Single-phase, 200 to $240 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Single-phase 20010220 VI 50 Hz Single-phase, 200 to 230 VIBOHz |  |  |  |
|  |  | Auxiliary fan power input "5) | - |  |  |  |  |  |  |  |  |  |  |  | Single-phase, 200 to $220 \mathrm{~V} / 50 \mathrm{~Hz}$ Single-phase, 200 to $230 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |
|  | Voltage/frequency variations |  | Voltage: +10 to -15\% (Voltage unbalance: $2 \%$ or less (*8)), Frequency: +5 to $-5 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current '6) A |  | 3.2 | 6.1 | 8.9 | 15.0 | 21.1 | 28.8 | 42.2 | 57.6 | 71.0 | 84.4 | 114 | 138 | 167 | 203 | 282 |
|  | Required power supply capacily kVA |  | 1.2 | 2.2 | 3.1 | 5.3 | 7.4 | 10 | 15 | 20 | 25 | 30 | 40 | 48 | 58 | 71 | 98 |
| $\begin{aligned} & \hline 9 \\ & \frac{5}{6} \\ & \hline \end{aligned}$ | Torque *7) \% |  |  |  |  |  |  |  |  |  |  |  | 10 to 15 |  |  |  |  |
|  | DC injection braking |  | Starting frequency: 0.0 to 60.0 Hz , Braking time: 0.0 to 30.0 s , Braking level: 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Reactor unit |  | DC reactor | Provided |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | Ferrite ring | Provided (for radio noise reduction) |  |  |  |  |  |  |  |  |  | Not provided |  |  |  |  |
|  |  | Capacitive fiter | Provided (removable) *9) |  |  |  |  |  |  |  |  |  | Not provided |  |  |  |  |
| Applicable safety standards |  |  | UL508C, C22.2No.14, EN50178:1997 (Approval pending) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure (IEC60529) |  |  | IP20, UL open type |  |  |  |  |  |  |  |  |  |  | IP20, UL type 1 (NEMA1) |  |  |  |
| Cooling method |  |  | Natural cooling |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |  |  |
| Mass kg |  |  | 5.9 | 6.2 | 6.6 | 6.7 | 6.9 | 12.7 | 13.6 | 15.3 | 18.7 | 19.5 | 23 | 39 | 52 | 55 | 63 |

1) Fuji 4 -pole standard motor
${ }^{\prime 2}$ ) The rated capacity is calculated assuming the output rated voltage as 220 V for three-phase 200 V series and 440 V for three-phase 400 V series.
2) Output voltage cannot exceed the power supply voltage.
*4) When setting the carrier frequency (F26) to 1 kHz or less, reduce the load to $80 \%$ of its rated value.
'5) It is used as an AC fan power supply input for applications combined with a high power-factor PWM converter with power regeneration function or the like (not used during ordinary operation).
*6) The value is calculated on assumption that the inverter is connected with a power supply capacity of 500 kVA (or 10 times the inverter capacity if the inverter capacity exceeds 50 kVA ) and $\% \mathrm{X}$ is $5 \%$.
${ }^{-7)}$ Average braking torque without optional braking resistor (Varies with the efficiency of the motor.)
*8) Voltage unbalance (\%) $=\frac{\text { Max. voltage }(\mathrm{V})-\mathrm{Min} \text {. voltage }(\mathrm{V})}{\text { Three-phase average voltage }(\mathrm{V})} \times 67$ (IEC61800-3(5.2.3)) If this value is 2 to $3 \%$, use an $A C$ reactor (ACR).
*9) Leakage current flown across the filter is approx. 7 mA for the input of $200 \mathrm{VAC}, 60 \mathrm{~Hz}$.
Note $A$ box ( $\square$ ) in the above table replaces $A, C, E$, or $J$ depending on the shipping destination

### 8.2.1.2 Three-phase 400 V series

|  |  |  | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type (FRN_ _ F1H-4[) |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 |
| Applicable motor rating *1) kW |  |  | 0.75 | 1.5 | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 |
| s6uper indino | Rated capacity *2) KVA |  | 1.9 | 2.8 | 4.1 | 6.8 | 9.5 | 12 | 17 | 22 | 28 | 33 | 44 | 54 | 64 | 77 | 105 |
|  | Rated voltage *3) V |  | Three-phase $380 \mathrm{~V}, 400 \mathrm{~V} / 50 \mathrm{~Hz}, 380 \mathrm{~V}, 400 \mathrm{~V}, 440 \mathrm{~V}, 460 \mathrm{~V} / 60 \mathrm{~Hz}$ (With AVR function) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated curr | ent *4) A | 2.5 | 3.7 | 6.5 | 9.0 | 12.5 | 16.5 | 23 | 30 | 37 | 44 | 58 | 71 | 84 | 102 | 139 |
|  | Overload capability |  | 120\% of rated current for 1 min |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency |  | $50,60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases, voltage. frequency | Main power supply | Three-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Three-phase, 380 to $440 \mathrm{~V} / 50 \mathrm{~Hz}$ Three-phase, 380 to $480 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |
|  |  | Auxiliary control power input | Single-phase, 380 to $480 \mathrm{~V}, 50 / 60 \mathrm{~Hz}$ |  |  |  |  |  |  |  |  |  |  | Single-phase. 380 to $440 \mathrm{~V} / 50 \mathrm{~Hz}$ Single-phase, 380 to $480 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |
|  |  | Auxiliary fan power input *5) |  Single-phase, <br> 380 to 440 V  <br> 150 Hz  <br>  Single-phase, <br> 380 to 480 V  <br>  160 Hz |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Voltage/frequency variations |  | Voltage: +10 to $-15 \%$ (Voltage unbalance: $2 \%$ or less (* 8 )), Frequency: +5 to $-5 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current '6) A |  | 1.6 | 3.0 | 4.5 | 7.5 | 10.6 | 14.4 | 21.1 | 28.8 | 35.5 | 42.2 | 57.0 | 68.5 | 83.2 | 102 | 138 |
|  | Required power supply capecily kVA |  | 1.2 | 2.2 | 3.1 | 5.3 | 7.4 | 10 | 15 | 20 | 25 | 30 | 40 | 48 | 58 | 71 | 96 |
| $\begin{array}{\|l\|} \hline 9 \\ \text { 喜 } \\ \hline 0 \\ \hline \end{array}$ | Torque ${ }^{\text {* }}$ 7) $\%$ |  | 20 10 to 15 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | DC injection braking |  | Starting frequency: 0.0 to 60.0 Hz , Braking time; 0.0 to 30.0 s , Braking level: 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Reactor unit |  | DC reactor | Provided |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | Ferrite ring | Provided (for radio noise reduction) |  |  |  |  |  |  |  |  |  | Not provided |  |  |  |  |
|  |  | Capacitive filter | Provided (removable) ${ }^{\text {a }} 9$ ) |  |  |  |  |  |  |  |  |  | Not provided |  |  |  |  |
| Applicable safely standards |  |  | UL508C, C22.2No.14, EN5017B:1997 (Approval pending) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure (IEC60529) |  |  | IP20, UL open type |  |  |  |  |  |  |  |  |  |  | IP20, UL type 1 (NEMA1) |  |  |  |
| Cooling method |  |  | Natural cooling |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |  |  |
| Mass kg |  |  | 5.9 | 6.2 | 6.4 | 6.8 | 6.8 | 13.5 | 13.5 | 15.0 | 19.4 | 20 | 23 | 39 | 41 | 54 | 67 |

1) Fuji 4 -pole standard motor
2) The rated capacity is calculated assuming the output rated voltage as 220 V for three-phase 200 V series and 440 V for three-phase 400 V series.
'3) Output voltage cannot exceed the power supply voltage.
3) When setting the carrier frequency (F26) to 1 kHz or less, reduce the load to $80 \%$ of its rated value.
"5) It is used as an AC fan power supply input for applications combined with a high power-factor PWM converter with power regeneration function or the like (not used during ordinary operation).
*) The value is calculated on assumption that the inverter is connected with a power supply capacity of 500 kVA (or 10 times the inverter capacity if the inverter capacity exceeds 50 kVA ) and $\% \mathrm{X}$ is $6 \%$.
${ }^{\text {7 }}$ ) Average braking torque without optional braking resistor (Varies with the efficiency of the motor.)
${ }^{-B)}$ Voltage unbalance $(\%)=\frac{\text { Max. voltage }(\mathrm{V})-\text { Min. voltage }(\mathrm{V})}{\text { Three-phase average voltage }(\mathrm{V})} \times 67$ (IEC61800-3(5.2.3)) If this value is 2 to $3 \%$, use an AC reactor (ACR).
-9) Leakage current flown across the filler is approx. 6 mA for the input $400 \mathrm{VAC}, 60 \mathrm{~Hz}$.
Note $A$ box $(\square)$ in the above table replaces $A, C, E$, or $J$ depending on the shipping destination.

### 8.3 Common Specifications

|  | Item | Explanation | Remarks | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | Maximum frequency | 25 to 120 Hz |  | F03 |
|  | Base frequency | 25 to 120 Hz |  | F04 |
|  | Starting frequency | 0.1 to 60.0 Hz |  | F23 |
|  |  | - 0.75 to $15 \mathrm{kHz}(200 \mathrm{~V} / 400 \mathrm{~V}: 0.75$ to 22 kW$)$ <br> - 0.75 to $10 \mathrm{kHz}(200 \mathrm{~V} / 400 \mathrm{~V}: 30$ to 75 kW$)$ <br> - 0.75 to $6 \mathrm{kHz}(200 \mathrm{~V} / 400 \mathrm{~V}: 90$ to 500 kW ) | The carrier frequency may drop automatically according to the ambient temperature or output current to protect the inverter. This protective operation can be canceled by function code H98. | $\begin{aligned} & \text { F26 } \\ & \text { F27 } \\ & \text { H98 } \end{aligned}$ |
|  | Accuracy (Stability) | - Analog setting: $\pm 0.2 \%$ of maximum frequency (at $25 \pm 10^{\circ} \mathrm{C}$ ) <br> - Keypad setting: $\pm 0.01 \%$ of maximum frequency (at -10 to $+50^{\circ} \mathrm{C}$ ) |  |  |
|  | Setting resolution | - Analog setting: $1 / 1000$ of maximum frequency (ex. 0.06 Hz at $60 \mathrm{~Hz}, 0.12 \mathrm{~Hz}$ at 120 Hz ) <br> - Keypad setting: 0.01 Hz ( 99.99 Hz or less), 0.1 Hz ( 100.0 Hz or more) <br> - Link setting: Selectable from 2 types- <br> -1/20000 of maximum frequency (ex. 0.003 Hz at $60 \mathrm{~Hz}, 0.006 \mathrm{~Hz}$ at 120 Hz ) <br> - 0.01 Hz (fixed) | Setting with $(\square) \text { keys. }$ |  |
| $\begin{aligned} & \overline{8} \\ & 0 \\ & 0 \\ & \hline 0 \end{aligned}$ | Control method | V/f control |  |  |
|  | Voltage/freq. characteristic <br> (Non-linear V/f setting) | Possible to set output voltage at base frequency and at maximum output frequency (common spec.). AVR control can be turned ON or OFF. | Three-phase 200 V : 80 to 240 V <br> Three-phase 400 V : 160 to 500 V <br> Three-phase 200 V : <br> 0 to $240 \mathrm{~V} / \mathrm{O}$ to 120 Hz <br> Three-phase 400 V : <br> 0 to $500 \mathrm{~V} / 0$ to 120 Hz | F03 to F05 H50, H51 |
|  | Torque boost | Torque boost can be set with the function code F09. | Set when 0, 1,3, or 4 is selected at F37. | F09, F37 |
|  | (Load selection) | Select application load type with the function code F37. <br> 0 : Variable torque load 1:Variable torque load (for high starting torque) 2: Auto-torque boost <br> 3: Auto-energy-saving operation (variable torque load in acceleration/deceleration) <br> 4: Auto-energy-saving operation (variable torque load (for high starting torque) for acceleration/deceleration) <br> 5: Auto-energy-saving operation (auto-torque boost in acceleration/deceleration) |  | F09, F37 |
|  | Starting torque | 50\% or over |  |  |
|  | Start/stop | Keypad operation Start (FWD/REV) and stop with (RUN) / (SIOP) keys | Keypad (standard) | F02 |
|  |  | Start and stop with (Fw) / (REV)/(STO) keys | Multifunction keypad (option) | F02 |
|  |  | External signals (7 digital inputs): Forward (reverse) rotation, stop command (capable of 3-wire operation), second operation command, coast-to-stop command, external alarm, alarm reset, etc. |  | E01 to E05 <br> E98, E99 |
|  |  | Link operation: Operation through RS485 communication and Field Bus communication (option) |  | H30, y98 |
|  |  | Operation command switch: Remote/local switch, link switch, second operation command switch |  |  |
|  | Frequency command source | Keypad operation: Can be set with ( $\triangle$ keys. |  | F01, C30 |
|  |  | External potentiometer ( 1 to $5 \mathrm{k} \Omega, 1 / 2 \mathrm{~W}$ ): Prepared by users | Connected to analog input terminals [13], [12], [11]. |  |
|  |  | Analog input Can be set with external voltage/current input. <br> 0 to $10 \mathrm{VDC}(0$ to $+5 \mathrm{VDC}) / 0$ to $100 \%$ (terminal [12], [V2]) <br> 4 to $20 \mathrm{~mA} \mathrm{DC} / 0$ to $100 \%$ (terminal [C1]) | E.g.: 0 to 5 VDC/1 to 5 VDC is applicable with bias/gain for analog input. | $\begin{aligned} & \mathrm{F} 18, \mathrm{C} 50, \mathrm{C} 32 \text { to } \\ & \mathrm{C} 34, \mathrm{C} 37 \text { to } \mathrm{C} 39, \\ & \mathrm{C} 42 \text { to } \mathrm{C} 44 \end{aligned}$ |
|  |  | Multistep frequency: Selectable from 8 steps (step 0 to 7 ) |  | C05 to C11 |
|  |  | UP/DOWN operation: The frequency rises or lowers while the digital input signal is turned on. |  | F01, C30 |
|  |  | Link operation: Can be set with RS485 communications and field bus communications (option). |  | H30, y98 |
|  |  | Frequency setting change: Two types of frequency settings can be switched with an external signal (digital input). Changeover between remote and local (keypad operation) or frequency setup through communication is also possible. |  | F01, C30 |
|  |  | Auxiliary frequency setting: Inputs at terminal [12], [C1] or [V2] can be added to the main setting as auxiliary frequency settings. |  | E61 to E63 |
|  |  | Inverse operation: The digital input signal and function code setting sets or switches between the normal and inverse operations. <br> - 10 to 0 VDC/0 to $100 \%$ (Terminal [12], [V2]) • 20 to $4 \mathrm{~mA} \mathrm{DC/0} \mathrm{to} 100 \%$ (Terminal [C1]) |  | C 53 |
|  | Acceleration/ deceleration time | $0.00 \text { to } 3600 \mathrm{~s}$ <br> - Acceleration and deceleration pattern can be selected from 4 types: Linear, S-curve (weak), S-curve (strong), Curve (constant output max. capacity). <br> - Shutoff of the operation command coasts the motor to decelerate and stop. |  | $\begin{aligned} & \text { F07, F08 } \\ & \text { H07 } \\ & \text { H11 } \end{aligned}$ |




### 8.4 Terminal Specifications

### 8.4.1 Terminal functions

Main circuit and analog input terminals

|  | Symbol | Name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | $\begin{array}{\|l} \mathrm{L} 1 / \mathrm{R}, \mathrm{~L} 2 / \mathrm{S}, \\ \mathrm{~L} 3 / \mathrm{T} \end{array}$ | Main circuit power inputs | Connect the three-phase input power lines. |  |
|  | U, V, W | Inverter outputs | Connect a three-phase motor. |  |
|  | R0, T0 | Auxiliary power input for the control circuit | For a backup of the control circuit power supply, connect AC power lines same as that of the main power input. |  |
|  | $\mathrm{P} 1, \mathrm{P}(+)$ | DC reactor connection | Connect a DC reactor (DCR) for improving power factor (an option for the inverter whose capacity is 55 kW or below). |  |
|  | $\mathrm{P}(+), \mathrm{N}(-)$ | DC link bus | Connect a DC link bus of other inverter(s). An optional regenerative converter is also connectable to these terminals. |  |
|  | R1, T1 | Auxiliary power input for the fans | Normally, no need to use these terminals. Use these terminals for an auxiliary power input of the fans in a power system using a power regenerative PWM converter (RHC series). |  |
|  | 블 | Grounding for inverter and motor | Grounding terminals for the inverter's chassis (or case) and motor. Earth one of the terminals and connect the grounding terminal of the motor. Inverters provide a pair of grounding terminals that function equivalently. |  |
|  | [13] | Potentiometer power supply | Power supply (+10 VDC) for frequency command potentiometer (Potentiometer: 1 to $5 \mathrm{k} \Omega$ ) Allowable maximum output current: 10 mA |  |
|  | [12] | Voltage input <br> (Normal operation) <br> (Inverse operation) | The frequency is commanded according to the external analog input voltage. <br> 0 to $+10 \mathrm{VDC} / 0$ to $100 \%$ <br> 0 to $+5 \mathrm{VDC} / 0$ to $100 \%$ or +1 to $+5 \mathrm{VDC} / 0$ to $100 \%$ can be selected by function code setting. <br> +10 to $0 \mathrm{VDC} / 0$ to $100 \%$ (switchable by digital input signal) | $\begin{aligned} & \text { F01, F18, } \\ & \text { C30, } \\ & \text { C32-C34, } \\ & \text { E61 } \end{aligned}$ <br> E01-E05, E98, E99 |
|  |  | (PID control) | Used for reference signal (PID process command) or PID feedback signal. |  |
|  |  | (Auxiliary frequency command source) | Used as additional auxiliary setting to various frequency command sources. |  |
|  |  | (Analog input monitor) | The peripheral analog signal can be displayed on the keypad. (Displaying coefficient: valid) |  |
|  |  | Electric characteristics of terminal [12] <br> - Input impedance: $22 \mathrm{k} \Omega$ <br> - Allowable maximum input voltage: +15 VDC <br> (If the input voltage is +10 VDC or over, the inverter assumes it to be +10 VDC.) |  |  |


|  | Symbol | Name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \tilde{\#} \\ & \stackrel{y}{\Xi} \\ & 00 \\ & \frac{0}{\tilde{c}} \end{aligned}$ | [C1] | Current input <br> (Normal operation) (Inverse operation) | The frequency is commanded according to the external analog input current. <br> 4 to $20 \mathrm{~mA} \mathrm{DC} / 0$ to $100 \%$ <br> 20 to $4 \mathrm{mADC} / 0$ to $100 \%$ (switchable by digital input signal) | $\begin{aligned} & \text { F01, F18, } \\ & \text { C30, } \\ & \text { C37-C39, } \\ & \text { E62, } \\ & \text { E01-E05, } \\ & \text { E98, E99 } \end{aligned}$ |
|  |  | (PID control) | Used for reference signal (PID process command) or PID feedback signal. |  |
|  |  | (Auxiliary frequency command) | Used as additional auxiliary setting to various frequency commands. |  |
|  |  | (Analog input monitor) | The peripheral analog signal can be displayed on the keypad. (Displaying coefficient: valid) |  |
|  |  | Electric characteristics of terminal [C1] <br> - Input impedance: $250 \Omega$ <br> - Allowable maximum input current: $+30 \mathrm{~mA} \mathrm{DC}$ (If the input current exceeds +20 mA DC, the inverter will limit it at +20 mA DC.) <br> Figure 8.1 A-D conversion |  |  |
|  |  |  |  |  |
|  | [V2] | Voltage input | The frequency is commanded according to the external analog input voltage. | $\begin{aligned} & \text { F01, F18, } \\ & \text { C30, } \\ & \text { C42-C44, } \\ & \text { E63 } \\ & \text { E01-E05, } \\ & \text { E98, E99 } \end{aligned}$ |
|  |  | (Normal operation) | $0 \text { to }+10 \mathrm{VDC} / 0 \text { to } 100 \%$ |  |
|  |  |  | 0 to $+5 \mathrm{VDC} / 0$ to $100 \%$ or +1 to $+5 \mathrm{VDC} / 0$ to $100 \%$ can be selected by function code setting. |  |
|  |  | (Inverse operation) | +10 to $0 \mathrm{VDC} / 0$ to $100 \%$ (switched by the terminal command (IVS)) |  |
|  |  | (PID control) | Used for a reference signal (PID process command) or PID feedback signal. |  |


|  | Symbol | Name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | [V2] | (For PTC thermistor) | Connects PTC (Positive Temperature Coefficient) thermistor for motor protection. Ensure that the slide switch SW5 on the control circuit PCB is turned to the PTC position (refer to "Setting up the slide switches" on page 8-26). <br> The figure shown below illustrates the internal circuit diagram where SW5 (switching the input of terminal [V2] between V2 and PTC) is turned to the PTC position. For details on SW5, refer to "Setting up the slide switches" on page 8-26. In this case, you must change data of the function code H26. <br> Figure 8.2 Internal Circuit Diagram (SW5 Selecting PTC) |  |
|  |  | (Auxiliary frequency command) | Used as additional auxiliary setting to various frequency commands. |  |
|  |  | (Analog input monitor) | The peripheral analog signal can be displayed on the keypad. (Displaying coefficient: valid) |  |
|  |  | Electric characteristics of terminal [V2] <br> - Input impedance: $22 \mathrm{k} \Omega$ <br> - Allowable maximum input voltage: +15 VDC <br> (If the input voltage is +10 VDC or over, the inverter assumes it to be +10 VDC.) |  |  |
|  | [11] | Analog common | Common for analog input signals ([13], [12], [C1], [V2], and [FMA]) <br> (Isolated from terminals [CM] and [CMY].) |  |



Digital Input Terminals



Figure 8.6 Circuit Configuration Using a Relay Contact
■ Using a programmable logic controller (PLC) to turn [X1], [X2], [X3], [X4], [X5], [FWD], or [REV] ON or OFF

Figure 8.7 shows two examples of a circuit that uses a programmable logic controller (PLC) to turn control signal input [X1], [X2], [X3], [X4], [X5], [FWD], or [REV] ON or OFF. In circuit (a), the switch SW1 has been turned to SINK, whereas in circuit (b) it has been turned to SOURCE.

In circuit (a) below, short-circuiting or opening the transistor's open collector circuit in the PLC using an external power source turns ON or OFF control signal [X1], [X2], [X3], [FWD], or [REV]. When using this type of circuit, observe the following:

- Connect the + node of the external power source (which should be isolated from the PLC's power) to terminal [PLC] of the inverter.
- Do not connect terminal [CM] of the inverter to the common terminal of the PLC.

(a) With the switch turned to SINK

(b) With the switch turned to SOURCE

Figure 8.7 Circuit Configuration Using a PLC
DD For details about the slide switch setting, refer to "Setting up the slide switches" on page 8-26.)

■ Commands assigned to digital input terminals


|  | Command | Command name |  | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | (SW50) | Switch to commercial power ( 50 Hz ) | (SW50) ON: | Starts at 50 Hz . | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=15) \end{aligned}$ |
|  | (SW60) | Switch to commercial power ( 60 Hz ) | (SW60) ON: | Starts at 60 Hz | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=16) \end{aligned}$ |
|  | (UP) | UP command | (UP) ON: | The output frequency rises while the circuit across (UP) and CM is connected. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=17) \\ & \text { F01, C30, } \\ & \text { J02 } \end{aligned}$ |
|  | (DOWN) | DOWN command | (DOWN) ON: | The output frequency drops while the circuit across (DOWN) and CM is connected. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=18) \\ & \begin{array}{l} \text { F01, C30, } \\ \text { J02 } \end{array} \end{aligned}$ |
|  | (WE-KP) | Enable editing of function code data from keypad | (WE-KP) ON: <br> (Data can be c allocated.) | The function code data can be changed from the keypad. nged when this function is not | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=19) \\ & \text { F00 } \end{aligned}$ |
|  | (Hz/PID) | Disable PID control | (Hz/PID) ON: <br> For detai "FUNCT | This signal cancels the PID control and switches to the operation using the frequency determined by a multistep frequency command, keypad input, or analog input. <br> about J01 to J06 data, refer to Chapter 9, N CODES. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=20) \\ & \text { J01-J06 } \\ & \text { J10-J19 } \\ & \text { F01 }=0-4 \\ & \text { C30 }=0-4 \end{aligned}$ |
|  | (IVS) | Switch between normal/inverse operation | (IVS) ON: | This signal switches the operation determined by frequency settings or PID control, between normal and inverse. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=21) \\ & \text { C53, J01 } \end{aligned}$ |
|  | (IL) | Interlock command | (IL) ON: | This signal interlocks the inverter upon occurrence of a momentary power failure in order to thoroughly detect the power failure if an MC is inserted between the inverter and motor so that its auxiliary B contact is driven by commercial/factory power sources. <br> Accordingly, this signal helps the inverter restart smoothly after a recovery from the power failure. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=22) \\ & \text { F14 } \end{aligned}$ |


|  | Command | Command name |  | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | (LE) | Enable communications link | (LE) ON: | While the circuit across (LE) and (CM) is short-circuited, the inverter runs according to commands sent via the standard or optional RS485 or field bus (option) communications port. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=24) \\ & \text { H30 }=3 \\ & \text { y99 } \end{aligned}$ |
|  | (U-DI) | Universal DI | (U-DI) ON: | An arbitrary digital input signal is transmitted to the host equipment. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=25) \end{aligned}$ |
|  | (STM) | Select idling motor sync mode | (STM) ON: | Starting at the pick-up frequency becomes valid. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=26) \\ & \text { H17, H09 } \end{aligned}$ |
|  | (STOP) | Forced stop command | (STOP) ON: | The inverter is forcibly stopped in the specified deceleration time. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=30) \\ & \text { H56 } \end{aligned}$ |
|  | (PID-RST) | Reset PID integral and derivative components | (PID-RST) ON: | PID integration and differentiation are reset. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=33) \\ & \text { J01-J06 } \\ & \text { J10-J19 } \end{aligned}$ |
|  | (PID-HLD) | Hold PID integral component | (PID-HLD) ON: | PID integration is temporarily stopped. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & \text { (= 34) } \\ & \text { J01-J06 } \\ & \text { J10-J19 } \end{aligned}$ |
|  | (LOC) | Select local (keypad) operation | (LOC) ON: | The run commands and frequency commands given at the keypad become valid. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=35) \end{aligned}$ |
|  | (RE) | Enable to run command | (RE) ON: | After a run command is input, operation starts upon activation of (RE). | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=38) \end{aligned}$ |
|  | (DWP) | Protect the motor from a dew condensation | (DWP) ON: | A current flows through the motor to avoid motor temperature drop during inverter stoppage so that dew condensation will not occur. | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=39) \\ & \text { J21, F21, } \\ & \text { F22 } \end{aligned}$ |


| $\left.\begin{array}{\|l\|l\|} \hline \frac{1}{4} & = \\ ⿹ 勹 匕 匕 \end{array} \right\rvert\,$ | Command | Command name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | （ISW50） | Enable the integrated sequence to switch motor drive source to commercial power （ 50 Hz ） | （ISW50）ON：Line operation starts according to the switching sequence built in the inverter．（For 50 Hz commercial line） | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=40) \\ & \text { J22 } \end{aligned}$ |
|  | （ISW60） | Enable the integrated sequence to switch motor drive source to commercial power （ 60 Hz ） | （ISW60）ON：Line operation starts according to the switching sequence built in the inverter．（For 60 Hz commercial line） | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=41) \\ & \text { J22 } \end{aligned}$ |
|  | （FR2／FR1） | Switch the run command source 2／1 | （FR2／FR1）ON：The run command source switches to（FWD2）or（REV2）side． | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=87) \\ & \text { F02 } \end{aligned}$ |
|  | （FWD2） | Run forward command 2 | （FWD2）ON：The motor runs forward． <br> （FWD2）OFF：The motor decelerates and stops． <br> When（FWD2）and（REV2）are simultaneously ON， the inverter immediately decelerates and stops the motor． | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=88) \end{aligned}$ |
|  | （REV2） | Run reverse command 2 | （REV2）ON：The motor runs reverse． <br> （REV2）OFF：The motor decelerates and stops． <br> When（FWD2）and（REV2）are simultaneously ON， the inverter immediately decelerates and stops the motor． | $\begin{aligned} & \text { E01-E05, } \\ & \text { E98, E99 } \\ & (=89) \end{aligned}$ |

Analog output, pulse output, transistor output, and relay output terminals

|  | Symbol | Name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | [FMA] | Analog monitor | The monitor signal for analog DC voltage ( 0 to +10 V ) or analog DC current ( +4 to +20 mA ) is output You can select either one of the output switching the slide switch SW4 on the control PCB (Refer to "Setting up the slide switches" on page $8-26$.), and changing data of the function code F29. You can also select the signal functions following with function code F31. <br> - Output frequency <br> - Output voltage <br> - Load factor <br> - PID feedback value <br> - Universal AO <br> - Analog output test <br> - PID output <br> * Input impedance of external device: Min. $5 \mathrm{k} \Omega$ ( 0 to 10 VDC output) <br> Input impedance of external device: Max. $500 \Omega$ (4 to 20 mA DC output) <br> * While the terminal is outputting 0 to 10 VDC , an output less than 0.3 V may become 0.0 V . <br> * While the terminal is outputting 0 to 10 VDC , it is capable to drive up to two meters with $10 \mathrm{k} \Omega$ impedance. While outputting the current, to drive a meter with $500 \Omega$ impedance max. (Adjustable range of the gain: 0 to $200 \%$ ) | F29-F31 |
|  | [11] | Analog common | Two common terminals for analog input and output signal terminals <br> These terminals are electrically isolated from terminals [CM]s and [CMY]. |  |
|  | [FMP] | Pulse monitor | You can also select the signal functions following with function code F35. <br> - Output frequency - Output current <br> - Output voltage - Output torque <br> - Load factor <br> - Input power <br> - PID feedback value - DC link bus voltage <br> - Universal AO - Motor output <br> - Analog output test • PID command <br> - PID output <br> * Input impedance of the external device: Min. $5 \mathrm{k} \Omega$ <br> * This output is capable to drive up to two meters with $10 \mathrm{k} \Omega$ impedance. (Driven by the average DC voltage of the output pulse train.) <br> (Adjustable range of the gain: 0 to 200\%) | F33-F35 |
|  | [CM] | Digital common | Two common terminals for digital input signal terminals and an output terminal [FMP] <br> These terminals are electrically isolated from other common terminals, [11]s and [CMY]. <br> These are the shared terminals with the common terminal [CM]s of the digital inputs. |  |



|  | Symbol | Name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |
|  | [Y5A/C] | General purpose relay output | (1) A general-purpose relay contact output usable as well as the function of the transistor output terminal [Y1], [Y2] or [Y3]. <br> Contact rating: <br> 250 VAC $0.3 \mathrm{~A}, \cos \phi=0.3$, $48 \mathrm{VDC}, 0.5 \mathrm{~A}$ <br> (2) Switching of the normal/negative logic output is applicable to the following two contact output modes: "Active ON" (Terminals [Y5A] and [ Y 5 C$]$ are closed (excited) if the signal is active.) and "Active OFF" (Terminals [Y5A] and [Y5C] are opened (non-excited) if the signal is active while they are normally closed.). | E24 |
|  | [30A/B/C] | Alarm relay output (for any error) | (1) Outputs a contact signal (SPDT) when a protective function has been activated to stop the motor. <br> Contact rating: $250 \mathrm{VAC}, 0.3 \mathrm{~A}, \cos \phi=0.3,48 \mathrm{VDC}, 0.5 \mathrm{~A}$ <br> (2) Any one of output signals assigned to terminals [Y1] to [Y3] can also be assigned to this relay contact to use it for signal output. <br> (3) Switching of the normal/negative logic output is applicable to the following two contact output modes: "Terminals [30A] and [30C] are closed (excited) for ON signal output (Active ON)" or "Terminals [30B] and [30C] are closed (non-excited) for ON signal output (Active OFF)." | E27 |

Signals assigned to transistor output terminals

|  | Signal | Signal name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | (RUN) | Inverter running | Comes ON when the output frequency is higher than the starting frequency. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=0) \end{aligned}$ |
|  | (RUN2) | Inverter output on | Comes ON when the inverter runs at the frequency lower than the starting frequency or when DC braking is in action. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=35) \end{aligned}$ |
|  | (FAR) | Frequency arrival | Comes ON when the output frequency arrives the reference frequency. <br> (Hysteresis band (fixed): 2.5 Hz ) | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=1) \end{aligned}$ |
|  | (FDT) | Frequency detection | Comes ON when the output frequency exceeds the preset detection level. <br> This signal goes off when the output frequency drops below the preset detection level. <br> (Hysteresis band (fixed): 1.0 Hz ) | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=2) \end{aligned}$ <br> E31 |
|  | (LU) | undervoltage detection (inverter stopped) | Comes ON when the inverter stops its output because of undervoltage while the run command is ON. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=3) \end{aligned}$ |
|  | (IOL) | Inverter output limiting (under current limiting) | Comes ON when the inverter is limiting the current or is under the anti-regenerative control. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=5) \\ & \text { F43, F44 } \\ & \text { H12, H69 } \end{aligned}$ |
|  | (IPF) | Auto-restart after a recovery from momentary power failure | Comes ON during auto-restarting operation (after a recovery from momentary power failure and until completion of restart). | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=6) \\ & \text { F14 } \end{aligned}$ |
|  | (OL) | Motor overload early warning | Comes ON when the calculated value of the electronic thermal simulator is higher than the preset alarm level. | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=7) \\ & \mathrm{F} 10-\mathrm{F} 12 \end{aligned}$ |
|  | (RDY) | Inverter ready-to-run signal | Comes ON when the inverter becomes ready to run. | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=10) \end{aligned}$ |
|  | (SW88) | Commercial power/inverter switching | Controls the magnetic contactor located at the commercial power line side, for switching the motor drive source between the commercial power lines and the inverter outputs. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=11) \end{aligned}$ |


|  | Signal | Signal name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | (SW52-2) | Commercial power/inverter switching | Controls the magnetic contactor located at the inverter output side (secondary side), for switching the motor drive source between the commercial power line and the inverter. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=12) \end{aligned}$ |
|  | (SW52-1) | Commercial power/inverter switching | Controls the magnetic contactor located at the inverter input side (primary side), for switching the motor drive source between the commercial power line and the inverter. | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=13) \end{aligned}$ |
|  | (AX) | AX terminal function | Controls the magnetic contactor located at the inverter input side (primary side). | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=15) \end{aligned}$ |
|  | (FAN) | Cooling fan on/off control | Comes ON when the cooling fan is running. | $\begin{array}{\|l} \mathrm{E} 20-\mathrm{E} 22, \\ \mathrm{E} 24, \mathrm{E} 27 \\ (=25) \\ \mathrm{H} 06 \end{array}$ |
|  | (TRY) | Retry in operation | Comes ON when the retry function is activated ( H 04 $\neq 0$ ). | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=26) \\ & \text { H04, H05 } \end{aligned}$ |
|  | (U-DO) | Universal DO | Comes ON to command a peripheral apparatus according to signals sent from the host equipment. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=27) \end{aligned}$ |
|  | (OH) | Heat sink overheat early warning | Comes ON as a forecast warning before the inverter trips due to a heat sink overheated. <br> This signal also comes ON if the internal air circulation DC fan (used in 200 V series inverters of 45 kW or above or 400 V series inverters of 55 kW or above) locks. | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=28) \end{aligned}$ |
|  | (LIFE) | Service lifetime alarm | Outputs alarm signals according to the preset lifetime level. <br> This signal also comes ON if the internal air circulation DC fan (used in 200 V series inverters of 45 kW or above or 400 V series inverters of 55 kW or above) locks. | $\begin{aligned} & \begin{array}{l} \text { E20-E22, } \\ \text { E24, E27 } \\ (=30) \end{array} \\ & \begin{array}{l} \text { H42, H43, } \\ \text { H98 } \end{array} \end{aligned}$ |
|  | (REF OFF) | Command loss detected | Comes ON when a frequency command missing condition is detected. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=33) \end{aligned}$ <br> E65 |
|  | (OLP) | Overload prevention control | Comes ON during inverter control for avoiding overload. | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=36) \\ & \mathrm{H} 70 \end{aligned}$ |


|  | Signal | Signal name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | (ID) | Current detection | Comes ON when a current larger than the preset value has been detected for the preset timer count. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=37) \\ & \text { E34, E35 } \end{aligned}$ |
|  | (PID-ALM) | PID alarm detected | Signals an absolute-value alarm ( $\mathrm{J} 11=0$ to 3 ) or deviation-value alarm (J11 = 4 to 7 ) under PID control. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=42) \\ & \text { J11 to J13 } \end{aligned}$ |
|  | (PID-CTL) | PID control in operation | Comes ON when the PID control is active. | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=43) \end{aligned}$ |
|  | (PID-STP) | Motor stopped at slow flowrate | Comes ON if operation is stopped due to slow water flowrate under PID control. (The inverter is stopped even if the operation command is issued.) | $\begin{aligned} & \begin{array}{l} \text { E20-E22, } \\ \text { E24, E27 } \\ (=44) \\ \text { J15 to J17 } \end{array} \end{aligned}$ |
|  | (U-TL) | Low output torque detected | Comes ON if the torque value has been below the preset level for the time elapsed longer than the specified timer count. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=45) \\ & \text { E80 to } \\ & \text { E81 } \end{aligned}$ |
|  | (RMT) | Inverter in remote operation | Comes ON when the inverter is in Remote mode. | $\begin{aligned} & \mathrm{E} 20-\mathrm{E} 22, \\ & \mathrm{E} 24, \mathrm{E} 27 \\ & (=54) \end{aligned}$ |
|  | (AX2) | Run command activated | Comes ON when the inverter receives a run command and becomes ready to run. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=55) \end{aligned}$ |
|  | (THM) | Overheat alarm detected by PTC | Comes ON when a temperature alarm condition is detected by a PTC thermistor in the motor but the inverter is running the motor instead of issuing | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=56) \\ & \text { H26, H27 } \end{aligned}$ |
|  | (ALM) | Alarm relay output (for any fault) | Comes ON as a transistor output signal. | $\begin{aligned} & \text { E20-E22, } \\ & \text { E24, E27 } \\ & (=99) \end{aligned}$ |

RS485 communications port

|  | Connector | Name | Functions | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
|  | RJ-45 <br> connector <br> for the <br> keypad | Standard RJ-45 connector | (1) Used to connect the inverter with PC or PLC using RS485 port. The inverter supplies the power to the keypad through the pins specified below. The extension cable for remote operation also uses wires connected to these pins for supplying the keypad power. <br> (2) Remove the keypad from the standard RJ-45 connector, and connect the RS485 communications cable to control the inverter through the PC or PLC (Programmable Logic Controller). Refer to "Setting up the slide switches" on page $8-26$ for setting of the terminating resistor. | $\begin{aligned} & \text { H30, } \\ & \text { y01-y10, } \\ & \text { y98, y99 } \end{aligned}$ |
|  |  | Figure <br> * Do not use pin equipment sinc | 10 RJ-45 Connector and its Pin Assignment* <br> $1,2,7$, and 8 for using this connector to connect other these pins are assigned to power lines for the keypad. |  |

- Route the wiring of the control terminals as far from the wiring of the main circuit as possible. Otherwise electric noise may cause malfunctions.
- Fix the control circuit wires inside the inverter to keep them away from the live parts of the main circuit (such as the terminal block of the main circuit).


## Setting up the slide switches

Switching the slide switches located on the PCB allows you to customize the operation mode of the analog output terminals, digital I/O terminals, and communications ports. The locations of those switches are shown in Figure 8.11.
To access the slide switches, remove the front and terminal block covers so that you can watch the control PCB. For models of 37 kW or above, open also the keypad enclosure.
Close the control circuit terminal symbol plate since the plate being opened interferes with switching of some switches. (Refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 2, Section 2.3.8, "Setting up slide switches and handling control circuit terminal symbol plate."

DD For details on how to remove the front cover, terminal block cover, and keypad enclosure, refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 2, Section 2.3.1, "Removing and mounting the terminal block (TB) cover and the front cover" and Chapter 1, Section 1.2, "External View and Terminal Blocks," Figure 1.4.

Table 8.1 lists the function of each slide switch.
Table 8.1 Function of Each Slide Switch

| Slide Switch | Function |  |  |
| :---: | :---: | :---: | :---: |
| (1) SW1 | Switches the service mode of the digital input terminals between SINK and SOURCE. <br> - To make the digital input terminal [X1] to [X5], [FWD] or [REV] serve as a current sink, turn SW1 to the SINK position. <br> - To make them serve as a current source, turn SW1 to the SOURCE position. |  |  |
| (2. SW3 | Switches the terminating resistor of RS485 communications port on the inverter on and off. <br> - To connect a keypad to the inverter, turn SW3 to OFF. (Factory default) <br> - If the inverter is connected to the RS485 communications network as a terminating device, turn SW3 to ON. |  |  |
| (3. SW4 | Switches the output mode of the analog output terminal [FMA] between voltage and current. <br> When changing this switch setting, also change the data of function code F29. |  |  |
|  |  | SW4 | Set data of F29 to: |
|  | Voltage output (Factory default) | VO | 0 |
|  | Current output | IO | 1 |
| (4. SW5 | Switches property of the analog input terminal [V2] for V2 or PTC. <br> When changing this switch setting, also change the data of function code H26. |  |  |
|  |  | SW5 | Set data of H26 to: |
|  | Analog frequency setting in voltage (Factory default) | V2 | 0 |
|  | PTC thermistor input | PTC | 1 or 2 |

Figure 8.11 shows the location of slide switches for the input/output terminal configuration.


Figure 8.11 Location of the Slide Switches

## 8．4．2 Terminal arrangement diagram and screw specifications

## 8．4．2．1 Main circuit terminals

The table below shows the main circuit screw sizes，tightening torque and terminal arrangements． Note that the terminal arrangements differ according to the inverter types．Two terminals designed for grounding shown as the symbol，in Figures A to I make no distinction between a power supply source（a primary circuit）and a motor（a secondary circuit）．

Table 8．2 Main Circuit Terminal Properties

| Power supply voltage | Applicable motor rating （kW） | Inverter type | Terminal screw size | Tightening torque （ $\mathrm{N} \cdot \mathrm{m}$ ） | Grounding screw size | Tightening torque （ $\mathrm{N} \cdot \mathrm{m}$ ） | Refer to： |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Three－ phase 200 V | 0.75 | FRN0．75F1■－2口 | M4 | 1.8 | M4 | 1.8 | Figure A |
|  | 1.5 | FRN1．5F1■－2口 |  |  |  |  |  |
|  | 2.2 | FRN2．2F1■－2口 |  |  |  |  |  |
|  | 3.7 | FRN3．7F1■－2口 |  |  |  |  |  |
|  | 5.5 | FRN5．5F1■－2口 |  |  |  |  |  |
|  | 7.5 | FRN7．5F1■－2口 | M5 | 3.8 | M5 | 3.8 | Figure B |
|  | 11 | FRN11F1■－2口 |  |  |  |  |  |
|  | 15 | FRN15F1■－2口 | M6 | 5.8 | M6 | 5.8 |  |
|  | 18.5 | FRN18．5F1■－2口 |  |  |  |  | Figure C |
|  | 22 | FRN22F1■－2口 |  |  |  |  |  |
|  | 30 | FRN30F1■－2口 | M8 | 13.5 | M8 | 13.5 | Figure D |
|  | 37 | FRN37F1■－2口 |  |  |  |  | Figure E |
|  | 45 | FRN45F1■－2口 | M10 | 27 |  |  |  |
|  | 55 | FRN55F1■－2口 |  |  |  |  | Figure G |
|  | 75 | FRN75F1■－2口 |  |  |  |  |  |
| Three－ phase 400 V | 0.75 | FRN0．75F1■－4ロ | M4 | 1.8 | M4 | 1.8 | Figure A |
|  | 1.5 | FRN1．5F1■－4D |  |  |  |  |  |
|  | 2.2 | FRN2．2F1■－4口 |  |  |  |  |  |
|  | 3.7 | FRN3．7F1■－4口 |  |  |  |  |  |
|  | 5.5 | FRN5．5F1■－4口 |  |  |  |  |  |
|  | 7.5 | FRN7．5F1■－4■ | M5 | 3.8 | M5 | 3.8 | Figure B |
|  | 11 | FRN11F1■－4ロ |  |  |  |  |  |
|  | 15 | FRN15F1■－4■ | M6 | 5.8 | M6 | 5.8 |  |
|  | 18.5 | FRN18．5F1■－4■ |  |  |  |  | Figure C |
|  | 22 | FRN22F1■－4■ |  |  |  |  |  |
|  | 30 | FRN30F1■－4■ | M8 | 13.5 | M8 | 13.5 | Figure D |
|  | 37 | FRN37F1■－4■ |  |  |  |  | Figure E |
|  | 45 | FRN45F1■－4■ |  |  |  |  | Figure E |
|  | 55 | FRN55F1■－4ロ |  |  |  |  |  |
|  | 75 | FRN75F1■－4■ |  |  |  |  | Figure F |
|  | 90 | FRN90F1■－4■ | M10 | 27 |  |  | Figure G |
|  | 110 | FRN110F1■－4ロ |  |  |  |  |  |
|  | 132 | FRN132F1吅4 |  |  |  |  | Figure H |
|  | 160 | FRN160F1吅－4■ | M12 | 48 | M10 | 27 | Figure I |
|  | 200 | FRN200F1■－4■ |  |  |  |  |  |
|  | 220 | FRN220F1■－4■ |  |  |  |  |  |

Terminal R0，T0（Common to all types）：Screw size M3．5，Tightening torque $1.2(\mathrm{~N} \cdot \mathrm{~m})$
Terminal R1，T1：Screw size M3．5，Tightening torque $0.9(\mathrm{~N} \cdot \mathrm{~m})$（for the models of 200 V series 45 kW or above，for 400 V series 55 kW or above

Note 1）A box（ $\Phi$ ）in the above table replaces S （Standard type），E（EMC filter built－in type），or H （DCR built－in type）depending on the product specifications．
2）A box（ $\square$ ）in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$ ，or J depending on the shipping destination．

## Figure A

Figure F
恩 ${ }^{(9)}$

$\stackrel{0}{0}$
Figure G


Figure $\mathbf{H}$

| $\mathbf{P}$ | $\mathbf{\Phi}$ |
| :--- | :--- |
| $\mathbf{R 0} 0$ |  |


| $\mathbf{4}$ | $\boldsymbol{\oplus}$ | $\mathbf{9}$ |
| :--- | :--- | :--- |
| $\mathbf{R 1 1}$ |  |  |



Figure I


Figure D


Figure E


### 8.4.2.2 Control circuit terminals

The control circuit terminal arrangement, screw sizes, and tightening torque are shown below. They are the same in all FRENIC-Eco series of inverters.


Screw size: M3, Tightening torque: $0.7 \mathrm{~N} \cdot \mathrm{~m}$ Recommended wire size: 0.75 to $1.25 \mathrm{~mm}^{2}$

### 8.5 Operating Environment and Storage Environment

### 8.5.1 Operating environment

Install the inverter in an environment that satisfies the requirements listed in Table 8.3.
Table 8.3 Environmental Requirements

| Item | Specifications |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Site location | Indoors |  |  |  |
| Ambient temperature | -10 to $+50^{\circ} \mathrm{C}$ (Note 1) |  |  |  |
| Relative humidity | 5 to 95\% (No condensation) |  |  |  |
| Atmosphere | The inverter must not be exposed to dust, direct sunlight, corrosive gases, flammable gas, oil mist, vapor or water drops. <br> Pollution level 2 (IEC60664-1) (Note 2) <br> The atmosphere can contain a small amount of salt. <br> ( $0.01 \mathrm{mg} / \mathrm{cm}^{2}$ or less per year) <br> The inverter must not be subjected to sudden changes in temperature that will cause condensation to form. |  |  |  |
| Altitude | 1,000 m max. (Note 3) |  |  |  |
| Atmospheric pressure | 86 to 106 kPa |  |  |  |
| Vibration | For models of 75 kW or below |  | For models of 90 kW or above |  |
|  | $\begin{aligned} & 3 \mathrm{~mm} \\ & \text { (Max. amplitude) } \end{aligned}$ | 2 to less than 9 Hz | $\begin{aligned} & 3 \mathrm{~mm} \\ & \text { (Max. amplitude) } \end{aligned}$ | 2 to less than 9 Hz |
|  | $9.8 \mathrm{~m} / \mathrm{s}^{2}$ | 9 to less than 20 Hz | $2 \mathrm{~m} / \mathrm{s}^{2}$ | 9 to less than 55 Hz |
|  | $2 \mathrm{~m} / \mathrm{s}^{2}$ | 20 to less than 55 Hz | $1 \mathrm{~m} / \mathrm{s}^{2}$ | 55 to less than 200 Hz |
|  | $1 \mathrm{~m} / \mathrm{s}^{2}$ | 55 to less than 200 Hz |  |  |

(Note 1) When inverters are mounted side-by-side without any gap between them ( 5.5 kW or less), the ambient temperature should be within the range from -10 to $+40^{\circ} \mathrm{C}$.
(Note 2) Do not install the inverter in an environment where it may be exposed to cotton waste or moist dust or dirt which will clog the heat sink in the inverter. If the inverter is to be used in such an environment, install it in the enclosure of your system or other dustproof containers.
(Note 3) If you use the inverter in an altitude above 1000 m , you should apply an output current derating factor as listed in Table 8.4.

Table 8.4 Output Current Derating Factor in Relation to Altitude

| Altitude | Output current derating factor |
| :---: | :---: |
| 1000 m or lower | 1.00 |
| 1000 to 1500 m | 0.97 |
| 1500 to 2000 m | 0.95 |
| 2000 to 2500 m | 0.91 (Note 4) |
| 2500 to 3000 m | 0.88 (Note 4$)$ |

(Note 4) For the location with altitude of 2000 m or higher, insulate interface circuits/lines of the inverter from the main power source/lines for complying with Low Voltage Directive.

### 8.5.2 Storage environment

### 8.5.2.1 Temporary storage

Store the inverter in an environment that satisfies the requirements listed below.
Table 8.5 Storage and Transport Environments

| Item | Specifications |  |
| :--- | :--- | :--- |
| Storage <br> temperature <br> ${ }_{1}$ | -25 to $+65^{\circ} \mathrm{C}$ | Places not subjected to abrupt temperature changes or <br> condensation or freezing |
| Relative <br> humidity | 5 to $95 \%^{* 2}$ |  |
| The inverter must not be exposed to dust, direct sunlight, corrosive or flammable gases, <br> oil mist, vapor, water drops or vibration. The atmosphere must contain only a low level of <br> salt. ( $0.01 \mathrm{mg} / \mathrm{cm}^{2}$ or less per year) |  |  |
| Atmospheric <br> pressure | 86 to 106 kPa (during storage) |  |

*1 Assuming a comparatively short time storage, e.g., during transportation or the like.
*2 Even if the humidity is within the specified requirements, avoid such places where the inverter will be subjected to sudden changes in temperature that will cause condensation to form.

Precautions for temporary storage
(1) Do not leave the inverter directly on the floor.
(2) If the environment does not satisfy the specified requirements listed above, wrap the inverter in an airtight vinyl sheet or the like for storage.
(3) If the inverter is to be stored in a high-humidity environment, put a drying agent (such as silica gel) in the airtight package described in item (2).

### 8.5.2.2 Long-term storage

The long-term storage method of the inverter varies largely according to the environment of the storage site. General storage methods are described below.
(1) The storage site must satisfy the requirements specified for temporary storage.

However, for storage exceeding three months, the ambient temperature range should be within the range from -10 to $30^{\circ} \mathrm{C}$. This is to prevent electrolytic capacitors in the inverter from deterioration.
(2) The package must be airtight to protect the inverter from moisture. Add a drying agent inside the package to maintain the relative humidity inside the package within $70 \%$.
(3) If the inverter has been installed to the equipment or control board at construction sites where it may be subjected to humidity, dust or dirt, then temporarily remove the inverter and store it in the environment specified in Table 8.5.

## Precautions for storage over 1 year

If the inverter has not been powered on for a long time, the property of the electrolytic capacitors may deteriorate. Power the inverters on once a year and keep the inverters powering on for 30 to 60 minutes. Do not connect the inverters to the load circuit (secondary side) or run the inverter.

### 8.6 External Dimensions

### 8.6.1 Standard models

The diagrams below show external dimensions of the FRENIC-Eco series of inverters according to the type.


Note A box ( $\square$ ) in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$, or J depending on the shipping destination.


| Power supply voltage | Type | Dimensions（mm） |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | W3 | W4 | H | H1 | D | D1 | D2 | D3 | D4 | $\phi \mathrm{A}$ | $\phi \mathrm{B}$ |
| Three－ phase 200 V | $\begin{array}{\|l\|} \hline \text { FRN7.5F1S-2 } \square \\ \hline \text { FRN11F1S-2 } \square \\ \hline \end{array}$ | 220 | 196 | 63.5 | 46.5 | 46.5 | 260 | 238 | 215 | 118.5 | 96.5 | 141.7 | 16 | 27 | 34 |
|  | FRN15F1S－2口 |  |  |  |  |  |  |  |  |  |  | 136.7 | 21 | 34 | 42 |
|  | FRN18．5F1S－2口 | 250 | 226 | 67 | 58 | 58 | 400 | 378 |  | 85 | 130 | 166.2 | 2 |  |  |
|  | FRN22F1S－2 $\square$ |  |  |  |  |  |  |  |  |  |  | 166.2 | 2 |  |  |
|  | FRN30F1S－2口 |  |  | － | － | － |  |  |  |  |  | － | － | － | － |
| Three－ phase 400 V | FRN7．5F1S－4 $\square$ | 220 | 196 | 63.5 | 46.5 | 46.5 | 260 | 238 | 215 | 118.5 | 96.5 | 141.7 | 16 | 27 | 34 |
|  | FRN11F1S－4D |  |  |  |  |  |  |  |  |  |  | 141.7 | 16 | 27 | 34 |
|  | FRN15F1S－4D |  |  |  |  |  |  |  |  |  |  | 136.7 | 21 | 34 | 42 |
|  | FRN18．5F1S－4口 | 250 | 226 | 67 | 58 | 58 | 400 | 378 |  | 85 | 130 | 166.2 | 2 |  |  |
|  | FRN22F1S－4 $\square$ |  |  |  |  |  |  |  |  |  |  | 166.2 |  |  |  |
|  | FRN30F1S－4D |  |  | － | － | － |  |  |  |  |  | － | － | － | － |

Note A box（ $\square$ ）in the above table replaces A，C，E，or J depending on the shipping destination．


| Power supply voltage | Type | Dimensions（mm） |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | W3 | W4 | W5 | H | H1 | H2 | D | D1 | D2 | D3 | D4 | $\phi \mathrm{A}$ |
| Three－ phase <br> 200 V | FRN37F1S－2口 | 320 | 240 | 304 | 310.2 | 8 | 10 | 550 | 530 | 12 | 255 | 115 | 140 | 4 | 4.5 | 10 |
|  | FRN45F1S－2口 | 355 | 275 | 339 | 345.2 |  |  | 615 | 595 |  | 270 |  | 155 |  |  |  |
|  | FRN55F1S－2口 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN75F1S－2口 |  |  |  |  |  |  | 740 | 720 |  |  |  |  |  |  |  |
| Three－ phase 400 V | FRN37F1S－4D | 320 | 240 | 304 | 310.2 | 8 | 10 | 550 | 530 | 12 | 255 | 115 | 140 | 4 | 4.5 | 10 |
|  | FRN45F1S－4口 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN55F1S－4］ | 355 | 275 | 339 | 345.2 |  |  |  |  |  | 270 |  | 155 |  |  |  |
|  | FRN75F1S－4D |  |  |  |  |  |  | 615 | 595 |  | 270 |  |  |  |  |  |
|  | FRN90F1S－4D |  |  |  |  |  |  | 740 | 720 |  | 300 | 145 |  |  | 6 |  |
|  | FRN110F1S－4口 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN132F1S－4口 | 530 | 430 | 503 | 509.2 | 13.5 | 15 |  | 710 | 15.5 | 315 | 135 | 180 |  |  | 15 |
|  | FRN160F1S－4口 |  |  |  |  |  |  |  |  |  | 360 | 180 |  |  |  |  |
|  | FRN200F1S－4D |  |  |  |  |  |  | 1000 | 970 |  |  |  |  |  |  |  |

Note A box（ $\square$ ）in the above table replaces A，C，E，or J depending on the shipping destination．

## 8．6．2 DC reactor

Unit：mm


Figure A

| Power supply voltage | Inverter type | $\begin{aligned} & \text { DC reactor } \\ & \text { type } \end{aligned}$ | Refer to： | Dimensions（mm） |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | A | B | C | D | E | F | G | Female mounting thread size | Female terminal thread size |
| Three－ <br> phase <br> 200 V | FRN37F1S－2口 | DCR2－37C | Figure A | $210 \pm 10$ | 125 | $101 \pm 2$ | 185 | $81 \pm 1$ | $50.5 \pm 1$ | 125 | M6 | M10 |
|  | FRN45F1S－2口 | DCR2－45C | Figure A | $210 \pm 10$ | 125 | $106 \pm 2$ | 185 | $86 \pm 1$ | $53 \pm 1$ | 135 | M6 | M12 |
|  | FRN55F1S－2口 | DCR2－55C | Figure A | $255 \pm 10$ | 145 | $96 \pm 2$ | 225 | $76 \pm 1$ | $48 \pm 1$ | 140 | M6 | M12 |
|  | FRN75F1S－2口 | DCR2－75C | Figure A | $255 \pm 10$ | 145 | $106 \pm 2$ | 225 | $86 \pm 1$ | $53 \pm 1$ | 145 | M6 | M12 |
| Three－ phase 400 V | FRN37F1S－4D | DCR4－37C | Figure B | $210 \pm 10$ | 125 | $101 \pm 2$ | 185 | $81 \pm 1$ | $50.5 \pm 1$ | 105 | M6 | M8 |
|  | FRN45F1S－4D | DCR4－45C | Figure A | $210 \pm 10$ | 125 | $106 \pm 2$ | 185 | $86 \pm 1$ | $53 \pm 1$ | 120 | M6 | M8 |
|  | FRN55F1S－4D | DCR4－55C | Figure A | $255 \pm 10$ | 145 | $96 \pm 2$ | 225 | $76 \pm 1$ | $48 \pm 1$ | 120 | M6 | M10 |
|  | FRN75F1S－4口 | DCR4－75C | Figure A | $255 \pm 10$ | 145 | $106 \pm 2$ | 225 | $86 \pm 1$ | $53 \pm 1$ | 125 | M6 | M10 |
|  | FRN90F1S－4D | DCR4－90C | Figure A | $255 \pm 10$ | 145 | $116 \pm 2$ | 225 | $96 \pm 1$ | $58 \pm 1$ | 140 | M6 | M12 |
|  | FRN110F1S－4■ | DCR4－110C | Figure A | $300 \pm 10$ | 155 | $116 \pm 2$ | 265 | $90 \pm 2$ | $58 \pm 1$ | 175 | M8 | M12 |
|  | FRN132F1S－4］ | DCR4－132C | Figure A | $300 \pm 10$ | 160 | $126 \pm 4$ | 265 | $100 \pm 2$ | $63 \pm 2$ | 180 | M8 | M12 |
|  | FRN160F1S－4］ | DCR4－160C | Figure A | $350 \pm 10$ | 190 | $131 \pm 4$ | 310 | $103 \pm 2$ | $65.5 \pm 2$ | 180 | M10 | M12 |
|  | FRN200F1S－4口 | DCR4－200C | Figure A | $350 \pm 10$ | 190 | $141 \pm 4$ | 310 | $113 \pm 2$ | $70.5 \pm 2$ | 185 | M10 | M12 |
|  | FRN220F1S－4口 | DCR4－220C | Figure A | $350 \pm 10$ | 190 | $146 \pm 4$ | 310 | $118 \pm 2$ | $73 \pm 2$ | 200 | M10 | M12 |

Note 1）A DCR is standard for inverters of 75 kW or above，but optional for ones below 75 kW ．
2）A box（ $\square$ ）in the above table replaces $A, C, E$ ，or $J$ depending on the shipping destination．

### 8.6.3 Models available on order

### 8.6.3.1 DCR built-in type



| Power supply voltage | Inverter type |
| :--- | :---: |
| Three-phase 200 V | FRN5.5F1H-2 $\square$ |
| Three-phase 400 V | FRN5.5F1H-4 $\square$ |



| Power supply voltage | Inverter type | Dimensions（mm） |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W3 | W4 | W5 | H | H1 | D | D1 | D2 | ¢A | ¢B |
| Three－ phase 200 V | FRN7．5F1H－2口 | 220 | 160 | 63.5 | 46.5 | 46.5 | 440 | 415 | 260 | 205.5 | 16 | 27 | 34 |
|  | FRN11F1H－2口 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1H－2口 |  |  |  |  |  |  |  |  | 200.5 | 21 | 34 | 42 |
|  | FRN18．5F1H－2口 | 250 | 190 | 66 | 59 | 59 | 600 | 575 |  | 202 | 7 |  |  |
|  | FRN22F1H－2口 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN30F1H－2口 |  |  |  |  |  |  |  |  |  |  |  | 48 |
| Three－ phase 400 V | FRN7．5F1H－4口 | 220 | 160 | 63.5 | 46.5 | 46.5 | 440 | 415 | 260 | 205.5 | 16 | 27 | 34 |
|  | FRN11F1H－4ロ |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1H－4ロ |  |  |  |  |  |  |  |  | 200.5 | 21 | 34 | 42 |
|  | FRN18．5F1H－4口 | 250 | 190 | 66 | 59 | 59 | 600 | 575 |  | 202 | 7 |  |  |
|  | FRN22F1H－4ロ |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN30F1H－4ロ |  |  |  |  |  |  |  |  |  |  |  | 48 |

[^40]Unit：mm


| Power supply voltage | Inverter type | Dimensions（mm） |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | W3 | W4 | W5 | H | H1 | H2 | H3 | D | D1 | D2 | $\phi \mathrm{A}$ | $\phi$ B |
| Three－ phase 200 V | FRN37F1H－2口 | 355.8 | 336.8 | 240 | 82.9 | 75 | 100 | 770 | 750 | 220 | 477 | 255.4 | 219.1 | 4 | 48 | 48 |
|  | FRN45F1H－2口 FRN55F1H－2口 | 390.8 | 371.8 | 275 | 76.4 | 78 | 120 | 850 | 830 | 235 | 542 | 270.4 | 231.1 | 7 |  | 64 |
|  | FRN75F1H－2口 |  |  |  |  |  |  | 1000 | 980 | 260 | 667 |  |  |  |  |  |
| Three－ <br> phase <br> 400 V | FRN37F1H－4口 | 355.8 | 336.8 | 240 | 82.9 | 75 | 100 | 770 | 750 | 220 | 477 | 255.4 | 219.1 | 4 | 48 | 48 |
|  | FRN45F1H－4口 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN55F1H－4口 | 390.8 | 371.8 | 275 | 76.4 | 78 | 120 |  |  |  |  | 270.4 | 231.1 | 7 |  | 64 |
|  | FRN75F1H－4口 |  |  |  |  |  |  | 850 | 830 | 235 | 542 |  |  |  |  |  |

[^41]
### 8.6.4 Standard keypad



### 8.7 Connection Diagrams

### 8.7.1 Running the inverter with keypad

The diagram below shows a basic connection example for running the inverter with the keypad.

(Note 1) When connecting a DC reactor ( DCR ), first remove the short bar between terminals [ P 1$]$ and $[\mathrm{P}+]$. A DCR is standard for inverters of 75 kW or above, but optional for ones below 75 kW . For inverters of 75 kW or above, be sure to connect a DCR.
(Note 2) To protect wiring, insert a molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) (with overcurrent protection) of the type recommended for the inverter between the commercial power supply and the inverter. Do not use a circuit breaker with a capacity exceeding the recommended capacity.
(Note 3) In addition to an MCCB or ELCB, insert, if necessary, a magnetic contactor (MC) of the type recommended for the inverter to cut off the commercial power supply to the inverter. Furthermore, if the coil of the MC or solenoid comes into close contact with the inverter, install a surge absorber in parallel.
(Note 4) Connect this pair of wires to terminals [R0] and [T0] if you want the inverter to stay in standby state, with only its control circuit being active, when the main circuit power supply is open (cut off). Without this pair of wires connected to these terminals, you can still run the inverter as long as the main wires of the commercial power supply to the main circuit are properly connected.
(Note 5) Normally no need to be connected. Use these terminals when the inverter is equipped with a high power factor PWM converter with a regenerative facility.
(Note 6) It is recommended that a 3-phase, 4-wire cable be used for wiring to the motor for reduction of electric noises. Connect the motor's grounding wire to the inverter's grounding terminal $\boldsymbol{\theta}_{\mathrm{G}} \mathrm{G}$.

### 8.7.2 Running the inverter by terminal commands

The diagram below shows a basic connection example for running the inverter with terminal commands.

(Note 1) When connecting a DC reactor (DCR), first remove the short bar between terminals [P1] and [P+]. A DCR is standard for inverters of 75 kW or above, but optional for those below 75 kW . For inverters of 75 kW or above, be sure to connect a DCR.
(Note 2) To protect wiring, insert a molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) (with overcurrent protection) of the type recommended for the inverter between the commercial power supply and the inverter. Do not use a circuit breaker with a capacity exceeding the recommended capacity.
(Note 3) In addition to an MCCB or ELCB, insert, if necessary, a magnetic contactor (MC) of the type recommended for the inverter to cut off the commercial power supply to the inverter. Furthermore, if the coil of the MC or solenoid comes into close contact with the inverter, install a surge absorber in parallel.
(Note 4) Connect this pair of wires to terminals [R0] and [T0] if you want the inverter to stay in standby state, with only its control circuit being active, when the main circuit power supply is open (cut off). Without this pair of wires connected to these terminals, you can still run the inverter as long as the main wires of the commercial power supply to the main circuit are properly connected.
(Note 5) Normally no need to be connected. Use these terminals when the inverter is equipped with a high power factor PWM converter with a regenerative facility.
(Note 6) It is recommended that a 3-phase, 4-wire cable be used for wiring to the motor for reduction of electric noises. Connect the motor's grounding wire to the inverter's grounding terminal $\boldsymbol{B}$.
(Note 7) You can set the frequency command source either electronically by supplying a DC voltage signal (within the range of 0 to $10 \mathrm{~V}, 0$ to 5 V , or 1 to 5 V , depending on the model) between terminals [12] and [11], or manually by connecting a frequency command potentiometer to terminals [13], [12], and [11].
(Note 8) For the wiring of the control circuit, use shielded or twisted wires. When using shielded wires, connect the shields to earth. To prevent malfunction due to noise, keep the control circuit wires as far away as possible from the main circuit wires (recommended distance: 10 cm or longer), and never put them in the same wire duct. Where a control circuit wire needs to cross a main circuit wire, route them so that they meet at right angles.

### 8.7.3 Running the DCR built-in type with terminal commands

The diagram below shows a basic connection example for running the DC reactor (DCR) built-in type with terminal commands.

(Note 1) To protect wiring, insert a molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) (with overcurrent protection) of the type recommended for the inverter between the commercial power supply and the inverter. Do not use a circuit breaker with a capacity exceeding the recommended capacity.
(Note 2) In addition to an MCCB or ELCB, insert, if necessary, a magnetic contactor (MC) of the type recommended for the inverter to cut off the commercial power supply to the inverter. Furthermore, if the coil of the MC or solenoid comes into close contact with the inverter, install a surge absorber in parallel.
(Note 3) Connect this pair of wires to terminals [R0] and [T0] if you want the inverter to stay in standby state, with only its control circuit being active, when the main circuit power supply is open (cut off). Without this pair of wires connected to these terminals, you can still run the inverter as long as the main wires of the commercial power supply to the main circuit are properly connected.
(Note 4) Normally no need to be connected. Use these terminals when the inverter is equipped with a high power factor PWM converter with a regenerative facility.
(Note 5) It is recommended that a 3-phase, 4-wire cable be used for wiring to the motor for reduction of electric noises. Connect the motor's grounding wire to the inverter's grounding terminal $\boldsymbol{B}^{\mathrm{G}} \mathrm{G}$.
(Note 6) You can set the frequency command source either electronically by supplying a DC voltage signal (within the range of 0 to $10 \mathrm{~V}, 0$ to 5 V , or 1 to 5 V , depending on the model) between terminals [12] and [11], or manually by connecting a frequency command potentiometer to terminals [13], [12], and [11].
(Note 7) For the wiring of the control circuit, use shielded or twisted wires. When using shielded wires, connect the shields to earth. To prevent malfunction due to noise, keep the control circuit wires as far away as possible from the main circuit wires (recommended distance: 10 cm or longer), and never put them in the same wire duct. Where a control circuit wire needs to cross a main circuit wire, route them so that they meet at right angles.

### 8.8 Protective Functions

The table below lists the name of the protective functions, description, alarm codes on the LED monitor, presence of alarm output at terminals $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$, and related function codes. If an alarm code appears on the LED monitor, remove the cause of activation of the alarm function referring to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 6, "TROUBLESHOOTING."


| Name | Description | LED monitor displays | $\begin{gathered} \text { Alarm } \\ \text { output } \\ {[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]} \end{gathered}$ | Related function codes |
| :---: | :---: | :---: | :---: | :---: |
| Input phase loss protection | Detects input phase loss，stopping the inverter output． This function prevents the inverter from undergoing heavy stress that may be caused by input phase loss or inter－phase voltage unbalance and may damage the inverter． <br> If connected load is light or a DC reactor is connected to the inverter，this function will not detect input phase loss if any． | L | Yes | H98 |
| Output phase loss protection | Detects breaks in inverter output wiring at the start of running and during running，stopping the inverter output． |  | Yes |  |
| Overheat protection | －Stops the inverter output upon detecting excess heat sink temperature in case of cooling fan failure or overload． <br> －Detects a failure of the internal air circulation DC fan and alarm－stops the inverter （For models of 45 kW or above in 200 V series， 55 kW or above in 400 V series） |  | Yes | H43 |
|  | Stops the inverter output upon detecting an excessively high ambient temperature inside the inverter caused by a failure or an overload condition of the cooling fan． |  | Yes |  |
| Overload protection | Stops the inverter output if the Insulated Gate Bipolar Transistor（IGBT）internal temperature calculated from the output current and temperature of inside the inverter is over the preset value． | ！でじし！ | Yes | － |
| External alarm input | Places the inverter in alarm－stop state upon receiving digital input signal（THR）． |  | Yes | $\begin{aligned} & \text { E01-E05 } \\ & \text { E98, E99 } \end{aligned}$ |
| Blown fuse | Upon detection of a fuse blown in the inverter＇s main circuit，this function stops the inverter output． （Applicable to 90 kW or above（for both 3－phase 200 V and 3－phase 400 V ）） |  | Yes | － |
| Abnormal condition in charger circuit | Upon detection of an abnormal condition in the charger circuit inside the inverter，this function stops the inverter output．（Applicable to 45 kW or above（3－phase 200 V ） or 55 kW or above（3－phase 400 V ）） |  | Yes | － |
|  Electronic <br> thermal <br> onern  <br> overheat  <br> simulator  | In the following cases，the inverter stops running the motor to protect the motor in accordance with the electronic thermal overheat simulator setting． | ！ill ！ | Yes | F10F11，F12 |
|  | －Protects general－purpose motors over the entire frequency range（ $\mathrm{F} 10=1$ ．） <br> －Protects inverter motors over the entire frequency range（ $\mathrm{F} 0=2$ ．） <br> ＊The operation level and thermal time constant can be set by F11 and F12． |  |  |  |


| Name | LED <br> monitor <br> displays | Alarm <br> output <br> $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ | Related <br> function <br> codes |
| :--- | :--- | :---: | :---: | :---: |


| Name |  | Description | LED monitor displays | $\begin{gathered} \text { Alarm } \\ \text { output } \\ {[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]} \end{gathered}$ | Related function codes |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Operation error detection | Start check function | The inverter prohibits any run operations and displays に，に on the 7 －segment LED monitor if any run command is present when： <br> －Powering up <br> －An alarm is released（the key is turned ON or an alarm reset（RST）is input．） <br> －＂Enable communications link（LE）＂has been activated and the run command is active in the linked source． | Eー心 | Yes | H96 |
| Tuning error detection | During t or has detected output． | ing of motor parameters，the tuning has failed orted，or an abnormal condition has been in the tuning result，the inverter stops its | E－7 | Yes | P04 |
| RS485 communications error detection | When the network keypad， inverter | inverter is connected to a communications the RS485 port designed for the standard tecting a communications error stops the put and displays an error code 底底。 | にー！ | Yes | － |
| Data save error during under－ voltage | If the dat undervo the alarm | could not be saved during activation of the age protection function，the inverter displays code． | にールー | Yes | － |
| RS485 <br> communications error detection （optional） | When the network detecting output an | inverter is connected to a communications via an optional RS485 communications card， a communications error stops the inverter d displays an error code | Eーバ | Yes | － |
| LSI error detection （Power PCB） | When an circuit （Applicab series 55 | error occurred in the LSI on the power printed oard，this function stops the inverter． le to： 200 V series 45 kW or above，and 400 V kW or above） | Eール゙ーツ | Yes | － |
| Retry | When the function and resta the latency | inverter has stopped because of a trip，this allows the inverter to automatically reset itself t．（You can specify the number of retries and y between stop and reset．） | － | － | H04，H05 |
| Surge protection |  | he inverter against surge voltages which might tween one of the power lines for the main dhe ground． | － | － | － |
| Command loss detected | Upon det of a brok continues frequency before the | cting a loss of a frequency command（because n wire，etc．），this function issues an alarm and the inverter operation at the preset reference （specified as a ratio to the frequency just detection）． | － | － | E65 |
| Protection against instantaneous power failure | Upon detecting an instantaneous power failure lasting more than 15 msec ，this function stops the inverter output． |  | －－ | － | F14H13-H16 |
|  | If restart this funct been rest | after instantaneous power failure is selected， ion invokes a restart process when power has red within a predetermined period． |  |  |  |
| Overload prevention control | In the overload output fre inverter | ent of overheating of the heat sink or an condition（alarm code：！！III！！or ！i゙l！！），the quency of the inverter is reduced to keep the rom tripping． | － | － | H70 |

## Chapter 9

## FUNCTION CODES

This chapter contains overview lists of seven groups of function codes available for the FRENIC-Eco series of inverters and details of each function code.

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### 9.1 Function Code Tables

Function codes enable the FRENIC-Eco series of inverters to be set up to match your system requirements.
Each function code consists of a 3-letter alphanumeric string. The first letter is an alphabet that identifies its group and the following two letters are numerals that identify each individual code in the group. The function codes are classified into eight groups: Fundamental Functions ( F codes), Extension Terminal Functions ( E codes), Control Functions of Frequency ( C codes), Motor Parameters (P codes), High Performance Functions (H codes), Application Functions (J codes), Link Function (y codes) and. Option Function (o codes) To determine the property of each function code, set data to the function code.

This manual does not contain the descriptions of Option Function (o codes). For Option Function (o codes), refer to the instruction manual for each option.
The following descriptions supplement those given in the function code tables on page 9-3 and subsequent pages.

## - Changing, validating, and saving function code data when the inverter is running

Function codes are indicated by the following based on whether they can be changed or not when the inverter is running:

| Notation | Change when running | Validating and saving function code data |
| :---: | :---: | :---: |
| Y* | Possible | If the data of the codes marked with $\mathrm{Y}^{*}$ is changed with $\widehat{ }$ and keys, the change will immediately take effect; however, the change is not saved into the inverter's memory. To save the change, press the key. If you press the key without pressing the key to exit the current state, then the changed data will be discarded and the previous data will take effect for the inverter operation. |
| Y | Possible | Even if the data of the codes marked with Y is changed with and keys, the change will not take effect. Pressing the key will make the change take effect and save it into the inverter's memory. |
| N | Impossible | - |

## Copying data

A standard keypad is capable of copying of the function code data stored in the inverter's memory into the keypad's memory (refer to Menu \#7 "Data copying" in Programming mode). With this feature, you can easily transfer the data saved in a source inverter to other destination inverters.
If the specifications of the source and destination inverters differ, some code data may not be copied to ensure safe operation of your power system. Therefore, you need to set up the uncopied code data individually as necessary. Whether data will be copied or not is detailed with the following symbols in the "Data copying" column of the function code tables given below.
Y: Will be copied unconditionally.
Y1: Will not be copied if the rated capacity differs from the source inverter.
Y2: Will not be copied if the rated input voltage differs from the source inverter.
N : Will not be copied. (The function code marked with " N " is not subject to the Verify operation, either.)
It is recommended that you set up those function codes which are not subject to the Copy operation individually using Menu \#1 "Data setting" as necessary.

For details of how to set up or edit function codes, refer to Chapter 3 "OPERATION USING THE KEYPAD."

If you are using the multi-function keypad (option), refer to the Multi-function Keypad Instruction Manual (INR-SI47-0890-E) for details.

## - Using negative logic for programmable I/O terminals

The negative logic signaling system can be used for the digital input and output terminals by setting the function code data specifying the properties for those terminals. Negative logic refers to inverted ON/OFF (logical value 1 (true)/0 (false)) state of input or output signal. An ON-active signal (the function takes effect if the terminal is short-circuited.) in the normal logic system is functionally equivalent to OFF-active signal (the function takes effect if the terminal is opened.) in the negative logic system. An ON-active signal can be switched to OFF-active signal, and vice verse, with the function code data setting.

To set the negative logic system for an I/O signal terminal, enter data of 1000s (by adding 1000 to the data for the normal logic) in the corresponding function code and then press the key.
For example, if a coast-to-stop command ( BX : data $=7$ ) is assigned to any one of digital input terminals [X1] to [X5] by setting any of function codes E01 through E05, then turning (BX) on will make the motor coast to a stop. Similarly, if the coast-to-stop command $(B X$ : data $=1007)$ is assigned, turning (BX) off will make the motor coast to a stop.

The following tables list the function codes available for the FRENIC-Eco series of inverters
F codes: Fundamental Functions

| Code | Name | Data setting range | Increment | Unit | Change when running | $\left\|\begin{array}{c} \text { Data } \\ \text { copying } \end{array}\right\|$ | Default setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| F00 | Data Protection | 0 : Disable data protection <br> (Function code data can be edited.) <br> 1: Enable data protection | - | - | $Y$ | $Y$ | 0 | 9-19 |
| F01 | Frequency Command 1 | 0: Enable $\bigcirc \mathrm{r}$ ) keys on keypad <br> 1: Enable voltage input to terminal [12] ( 0 to 10 VDC ) <br> 2: Enable current input to terminal [C1] ( 4 to 20 mA DC ) <br> 3: Enable sum of voltage and current inputs to terminals [12] and (C1] <br> 5: Enable voltage input to terminal [V2] ( 0 to 10 VDC ) <br> 7: Enable terminal signal command (UP) $/$ (DOWN) control | - | - | N | $Y$ | 0 | $\begin{aligned} & 9-19 \\ & 9-89 \end{aligned}$ |
| F02 | Run Command | 0: Enable (3) keys on keypad <br> (Motor rotational direction from digital terminals (FWD] / [REV)] <br> 1: Enable terminal command (FWD) or (REV) <br> 2: Enable (9) 10 keys on keypad (forward) <br> 3: Enable (9) 1 ©) keys on keypad (reverse) | - | - | N | $Y$ | 2 | 9-20 |
| F03 | Maximum Frequency | 25.0 to 120.0 | 0.1 | Hz | N | $Y$ | 60.0 | 9-21 |
| F04 | Base Frequency | 25.0 to 120.0 | 0.1 | Hz | N | $Y$ | Depends on the shipping destination. | $\begin{array}{\|c} 9-22 \\ 9-112 \end{array}$ |
| F05 | Rated Voltage at Base Frequency | 0. Output a voltage in proportion to input voltage <br> 80 to 240: Output a voltage AVR-controlled (for 200 V series) <br> 160 to 500: Output a voitage AVR-controlled (for 400 V series) | 1 | V | N | Y2 | Depends on the shipping destination. |  |
| F07 | Acceleration Time 1 | $0.00 \text { to } 3600$ <br> Note: Acceleration time is ignored at 0.00 . (External soft-start) | 0.01 | 8 | $Y$ | $Y$ | 20.0 | 9-25 |
| F08 | Deceleration Time 1 | 0.00 to 3600 <br> Note: Deceleration time is ignored at 0,00 . (External sof-stop) | 0.01 | s | $Y$ | $Y$ | 20.0 |  |
| F09 | Torque Boost | 0.0 to 20.0 <br> (The set voltage at base frequency for F05 is 100\%) <br> Note: This setting is effective for auto torque boost/auto energy saving operations specified by function code F37 $(=0,1,3$, or 4$)$. | 0.1 | \% | $Y$ | $Y$ | Depends on the inverter capacity. | $\begin{aligned} & 9-25 \\ & 9-46 \end{aligned}$ |

The $\square$ shaded function codes are applicable to the quick setup.
( F code continued)

| Code | Name | Data setting range | Increment | Unit | Change when running | $\begin{gathered} \text { Data } \\ \text { copying } \end{gathered}$ | Default setting | $\begin{aligned} & \text { Refer } \\ & \text { to } \\ & \text { page: } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| F10 | Electronic Thermal Overload Protection for Motor <br> (Select motor characteristics) <br> (Overload detection level) | 1: For general-purpose motors with built-in sell-cooling fan <br> 2: For inverter-driven motors or high-speed motors with forced-ventilation fan | - | - | $Y$ | $Y$ | 1 | 9-28 |
| F11 |  | 0.00 (Disable) <br> 1 to 135\% of the rated current (allowable continuous drive current) of the motor | 0.01 | A | $Y$ | $\begin{aligned} & Y 1 \\ & Y 2 \end{aligned}$ | $100 \%$ of the motor rated current |  |
| F12 | (Thermal time constant) | $0.5 \text { to } 75.0$ | 0.1 | min | Y | Y | $5(22 \mathrm{~kW}$ or below) $10(30 \mathrm{~kW}$ or above) |  |
| F14 | Restart Mode after Momentary Power Failure (Mode selection) | 0: Disable (Trip immediately without restart) <br> 1: Enable (Trip after a recovery from power failure, without restart) <br> 3: Enable (Continuous running for heavy inertia or general loads) <br> 4: Enable (Restart at the frequency at which power failure occurred, for general loads) <br> 5: Enable (Restart at the start frequency, for low-inertia load) | - | - | $Y$ | Y | 1 | $\begin{aligned} & 9-31 \\ & 9-108 \\ & 9-114 \end{aligned}$ |
| F15 | Frequency Limiter $\begin{array}{rr} \\ & \text { (High) } \\ & \text { (Low) }\end{array}$ | 0.0 to 120.0 | 0.1 | Hz | $Y$ | $Y$ | 70.0 | 9-38 |
| F16 |  | 0.0 to 120.0 | 0.1 | Hz | $Y$ | $Y$ | 0.0 | $\begin{gathered} 9-38 \\ 9-112 \end{gathered}$ |
| F18 | Bias (Frequency command 1) | -100.00 to $100.00 \cdot 1$ | 0.01 | \% | $\gamma *$ | Y | 0.00 | $\begin{aligned} & 9-39 \\ & 9-89 \\ & 9-90 \end{aligned}$ |
| F20 | DC Injection Braking (Starting frequency) <br> (Operation level) <br> (Braking time) | 0.0 to 60.0 | 0.1 | Hz | $Y$ | $Y$ | 0.0 | $\begin{array}{\|c} 9-40 \\ 9-114 \end{array}$ |
| F21 |  | 0 to 60 (Rated output current of the inverter interpreted as $100 \%$ ) | 1 | \% | $Y$ | $Y$ | 0 | 9-40 |
| F22 |  | 0.00: (Disable) <br> 0.01 to 30.00 | 0.01 | 5 | Y | $Y$ | 0.00 |  |
| F23 | Starting Frequency | 0.1 to 60.0 | 0.1 | Hz | $Y$ | $Y$ | 0.5 | 9-42 |
| F25 | Stop Frequency | 0.1 to 60.0 | 0.1 | Hz | $Y$ | $Y$ | 0.2 |  |
| F26 | Motor Operation Sound (Carrier frequency) | 0.75 to $15\left(22 \mathrm{~kW}\right.$ or below) ${ }^{* 2}$ <br> 0.75 to 10 ( 30 to 75 kW ) <br> 0.75 to 6 ( 90 kW or above) | 1 | kHz | $Y$ | Y | 2 |  |
| F27 | (Tone) | $\begin{array}{ll} \text { 0: } & \text { Level } 0 \text { (Inactive) } \\ \text { 1: } & \text { Level } 1 \\ \text { 2: } & \text { Level } 2 \\ \text { 3: } & \text { Level } 3 \end{array}$ | - | - | $Y$ | Y | 0 |  |
| F29 | Terminal [FMA] (Analeg output) <br> (Mode selection) <br> (Voltage adjust) | 0 : Output in voltage ( 0 to 10 VDC ) <br> 1: Output in current ( 4 to 20 mA DC ) | - | - | $Y$ | $Y$ | 0 | 9-43 |
| F30 |  | 0 to 200 | 1 | \% | $Y^{*}$ | $Y$ | 100 |  |

The $\square$ shaded function codes are applicable to the quick setup.
${ }^{11}$ When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is:
" 1 " for -200 to -100 , " 0.1 " for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .
*2 If the carrier frequency is set at 1 kHz or below, estimate the maximum motor output torque at $80 \%$ or less of the rated motor torque.
( F code continued)


## E codes: Extension Terminal Functions

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E01 |  | Select data to specify the function of terminals [X1] to [X5] as follows. To assign a negative logic input to a terminal, set the value of 1000 s shown in () in the table below to the function code. | - | - | N | Y | 6 | $\begin{aligned} & 9-48 \\ & 9-86 \end{aligned}$ |
| E02 |  |  | - | - | N | Y | 7 |  |
| E03 |  | Negative logic is not available for the terminal commands with no (1000s) data. | - | - | N | Y | 8 |  |
| E04 |  | 0 (1000): <br> (SS1) | - | - | N | Y | 11 |  |
| E05 |  | 1 (1001): $\}$ Select multistep frequency (SS2) | - | - | $N$ | Y | 35 |  |
|  |  | 6 (1006): Enable 3-wire operation <br> (HLD) |  |  |  |  |  |  |
|  |  | 7 (1007): Coast to a stop (BX) |  |  |  |  |  |  |
|  |  | 8 (1008): Reset alarm (RST) |  |  |  |  |  |  |
|  |  | 9 (1009): Enable external alarm trip (THR) |  |  |  |  |  |  |
|  |  | 11 (1011): Switch reference frequency $2 / 1 \quad(\mathrm{Hz2} / \mathrm{Hz} 1)$ |  |  |  |  |  |  |
|  |  | 13: DC injection brake (DCBRK) |  |  |  |  |  |  |
|  |  | 15: Switch to commercial power ( 50 Hz ) <br> (SW50) |  |  |  |  |  |  |
|  |  | 16: Switch to commercial power (60 Hz) |  |  |  |  |  |  |
|  |  | (SW60) <br> 17(1017): UP (Increase output frequency) <br> (UP) |  |  |  |  |  |  |
|  |  | 18(1018): DOWN (Decrease output <br> frequency) <br> (DOWN) |  |  |  |  |  |  |
|  |  | 19(1019): Enable write from keypad (Data changeable) <br> (WE-KP) |  |  |  |  |  |  |
|  |  | 20 (1020): Cancel PID control (Hz/PID) |  |  |  |  |  |  |
|  |  | 21 (1021): Switch normal/inverse operation (IVS) |  |  |  |  |  |  |
|  |  | 22 (1022): Interlock |  |  |  |  |  |  |
|  |  | 24(1024): Enable communications link via RS485 or field bus (option) |  |  |  |  |  |  |
|  |  | 25 (1025): Universal DI (U-DI) |  |  |  |  |  |  |
|  |  | 26 (1026): Select starting characteristics (STM) |  |  |  |  |  |  |
|  |  | $30(1030):$ Force to stop (STOP) |  |  |  |  |  |  |
|  |  | 33 (1033): Reset PID integral and differential |  |  |  |  |  |  |
|  |  | 34(1034): Hold PID integral component (PID-HLD) |  |  |  |  |  |  |
|  |  | 35 (1035): Select local (keypad) operation (LOC) |  |  |  |  |  |  |
|  |  | 38 (1038): Enable to run (RE) |  |  |  |  |  |  |
|  |  | 39: Protect motor from dew condensation <br> (DWP) |  |  |  |  |  |  |
|  |  | 40: Enable integrated sequence to switch <br> to commercial power ( 50 Hz ) <br> (ISW50) |  |  |  |  |  |  |
|  |  | 41: Enable integrated sequence to switch to commercial power $(60 \mathrm{~Hz})$ <br> (ISW60) |  |  |  |  |  |  |
|  |  | 87 (1087): Switch run command 2/1 (FR2/FR1) |  |  |  |  |  |  |
|  |  | 88: Run forward 2 (FWD2) |  |  |  |  |  |  |
|  |  | 89: Run reverse 2 (REV2) |  |  |  |  |  |  |
|  |  | Note: For (THR) and (STOP), data (1009) and (1030) are assigned for normal logic, and " 9 " and " 30 " are for negative logic, respectively. |  |  |  |  |  |  |

(E code continued)

| Code | Name | Data setting range | Increment | Unit | Change when running | $\begin{gathered} \text { Data } \\ \text { copying } \end{gathered}$ | Default setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E20 | Status Signal Assignment to: <br> (Transistor signal) <br> [Y1] | Select data to specify the function of terminals [Y1] to [Y3]. [Y5A/C], and [30A/B/C] as follows. To assign a negative logic output to a terminal, set the value of 1000s shown in () on the table below to the function code. (Function is active when terminal is open.) | - | - | N | $Y$ | 0 | 9.70 |
| E21 |  |  | - | - | N | $Y$ | 1 |  |
| E22 |  | Negative logic is not available for the status signals with no (1000s) data. | - | - | N | $Y$ | 2 |  |
| E24 | (Relay contact signal) [Y5A/C] [30A/B/C] | no (1000s) data. <br> 0 (1000): Inverter running <br> (RUN) | - | - | N | $Y$ | 15 |  |
| E27 |  |  | - | - | N | Y | 99 |  |
|  |  | 1 (1001): Frequency arrival signal (FAR) |  |  |  |  |  |  |
|  |  | 2 (1002): Frequency detected (FDT) |  |  |  |  |  |  |
|  |  | 3 (1003): Undervoltage detected (Inverter stopped) |  |  |  |  |  |  |
|  |  | 5 (1005): Inverter output limiting (Current limiting) |  |  |  |  |  |  |
|  |  | 6 (1006): Auto-restarting after momentary power failure |  |  |  |  |  |  |
|  |  | 7 (1007): Motor overioad early warning (OL) |  |  |  |  |  |  |
|  |  | 10(1010): Inverter ready to run (RDY) |  |  |  |  |  |  |
|  |  | 11: Switch motor drive source between commercial power and inverter output (For MC on commercial line) <br> (SW88) |  |  |  |  |  |  |
|  |  | 12: Switch motor drive source between commercial power and inverter output (For primary side) <br> (SW52-2) |  |  |  |  |  |  |
|  |  | 13: Switch motor drive source between commercial power and inverter output (For secondary side) <br> (SW52-1) |  |  |  |  |  |  |
|  |  | 15(1015): Select AX terminal function (For MC on primary side) $(A X)$ |  |  |  |  |  |  |
|  |  | 25 (1025): Cooling fan in operation (FAN) |  |  |  |  |  |  |
|  |  | 26(1026): Auto-resetting (TRY) |  |  |  |  |  |  |
|  |  | 27 (1027): Universal DO enabled (U-DO) |  |  |  |  |  |  |
|  |  | 28(1028): Heat sink overheat early warning (OH) |  |  |  |  |  |  |
|  |  | 30 (1030): Service life alarm (LIFE) |  |  |  |  |  |  |
|  |  | 33(1033): Command loss detected (REF OFF) |  |  |  |  |  |  |
|  |  | 35(1035): Inverter output on (RUN2) |  |  |  |  |  |  |
|  |  | 36(1036): Overioad prevention control (OLP) |  |  |  |  |  |  |
|  |  | 37 (1037): Current detected (ID) |  |  |  |  |  |  |
|  |  | 42(1042): PID alarm output (PID-ALM) |  |  |  |  |  |  |
|  |  | 43 (1043): Under PID control (PID-CTL) |  |  |  |  |  |  |
|  |  | 44(1044): Motor stopping due to slow flowrate under PID control <br> (PID-STP) |  |  |  |  |  |  |
|  |  | 45 (1045): Low output torque detected (U-TL) |  |  |  |  |  |  |
|  |  | 54 (1054): Inverter in remote operation (RMT) |  |  |  |  |  |  |
|  |  | 55(1055): Run command presence (AX2) |  |  |  |  |  |  |
|  |  | 56 (1056): Motor overheat detection (PTC) (THM) |  |  |  |  |  |  |
|  |  | 99 (1099): Alarm relay output (for any alarm) (ALM) |  |  |  |  |  |  |

( E code continued)

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default setting | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E31 | Frequency Detection <br> (FDT) (Operation level) | 0.0 to 120.0 | 0.1 | Hz | $Y$ | $Y$ | 60.0 | 9.77 |
| E34 | Overload Early Warning /Current Detection <br> (Level) <br> (Timer) | 0 : (Disable) Current value of 1 to $150 \%$ of the inverter rated current | 0.01 | A | $Y$ | $\begin{aligned} & Y 1 \\ & Y 2 \end{aligned}$ | $100 \%$ of the motor rated current |  |
| E35 |  | 0.01 to $600,00 * 1$ | 0.01 | s | $Y$ | Y | 10.00 |  |
| E40 | PID Display Coefficient A PID Display Coefficient B | -999 to 0.00 to $999 * 1$ | 0.01 | - | $Y$ | $Y$ | 100 | 9-78 |
| E41 |  | -999 to 0.00 to $999 * 1$ | 0.01 | - | Y | $Y$ | 0.00 |  |
| E43 | LED Monitor (Mode selection) | 0: Speed monitor (Select by E48.) <br> 3: Output current <br> 4: Output voltage <br> 8: Calculated torque <br> 9. Input power <br> 10: PID process command <br> 12: PID feedback value <br> 14: PID output <br> 15: Load factor <br> 16: Motor output <br> 17: Analog input monitor | - | - | $Y$ | $Y$ | 0 | $\begin{aligned} & 9-80 \\ & 9-82 \end{aligned}$ |
| E45 | LCD Monitor*3 <br> (Mode selection) | 0: Display running status, rotational direction and operation guide <br> 1: Display bar charts for output frequency, current and calculated torque | - | - | $Y$ | Y | 0 | 9.81 |
| E46 | (Language selection) | 0: Japanese <br> 1: English <br> 2. German <br> 3: French <br> 4: Spanish <br> 5: Italian | - | - | $Y$ | Y | * 4 | $9-82$ |
| E47 | (Contrast control) | 0 (dull) to 10 (sharp) | 1 | - | $Y$ | $Y$ | 5 |  |
| E48 | LED Manitor <br> (Speed monitor item) | 0: Output frequency <br> 3: Motor speed in rimin <br> 4: Load shaft speed in rimin <br> 7: Display speed in \% | - | - | $Y$ | $Y$ | 0 | $\begin{aligned} & 9-80 \\ & 9-82 \end{aligned}$ |
| E50 | Coefficient for Speed Indication | 0.01 to $200.00 * 1$ | 0.01 | - | $Y$ | $Y$ | 30.00 | 9-82 |
| E51 | Display Coefficient for Input Watt-hour Dats | 0.000: (Cancelireset) 0.001 to 9999 | 0.001 | - | $Y$ | $Y$ | 0.010 |  |
| E52 | Keypad <br> (Menu display mode) | 0 : Function code data setting mode (Menu \#0, \#1 and *7) <br> Function code data check mode (Menu \#2 and \#7) <br> 2. Full-menu mode | - | - | $Y$ | Y | 0 | $9-83$ |

The $\square$ shaded function codes are applicable to the quick setup.
${ }^{* 1}$ When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from - 200.00 to 200.00 , the incremental unit is:
"1" for -200 to -100 , " 0.1 " for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .
${ }^{* 3}$ LCD monitor settings are applicable only to the inverter equipped with a multi-function keypad.
${ }^{* 4}$ Factory default setting varies depending on the shipping destination, that is, " 1 " for Asian countries and " 0 " for Japan.
( E code continued)

| Code | Name | Data setting range | Increment | Unit | Change when running | $\begin{gathered} \text { Data } \\ \text { copying } \end{gathered}$ | Default setting | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E61 | Analog Input for (Extension function selection) | Select a signal to specify the terminal function from the followings. <br> 0: None <br> 1: Auxiliary frequency command 1 <br> 2: Auxiliary frequency command 2 <br> 3: PID process command 1 <br> 5: PID feedback value <br> 20: Analog signal input monitor | - | - | N | $Y$ | 0 | 9-84 |
| E62 |  |  | - | - | N | $Y$ | 0 |  |
| E63 |  |  | - | - | N | $Y$ | 0 |  |
| E64 | Saving Digital Reference Frequency | 0: Auto saving (upon main power turned off) <br> 1: Saving by pressing the key | - | - | $Y$ | $Y$ | 0 |  |
| E65 | Command Loss Detection (Level) | 0: Decelerate to stop <br> 20 to 120 <br> 999. Disabled | 1 | \% | $Y$ | $Y$ | 999 | 9-85 |
| E80 | Detect Low Torque (Detection level) | 0 to 150 | 1 | \% | $Y$ | $Y$ | 20 | 9-86 |
| E81 | (Timer) | 0.01 to $600.00 * 1$ | 0.01 | $s$ | $Y$ | $Y$ | 20.00 |  |

${ }^{* 1}$ When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is:
" 1 " for -200 to $-100, ~ " 0.1$ " for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .
(E code continued)

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E98 | Command Assignment to: <br> [FWD] <br> [REV] | Select data to specify the terminal function as follows. To assign a negative logic input to a terminal, set the value of 1000 s shown in () in the table below to the function code. | - | - | N | $Y$ | 98 | $\begin{aligned} & 9-48 \\ & 9-86 \end{aligned}$ |
| E99 |  |  | - | - | $N$ | $Y$ | 99 |  |
|  |  | Negative logic is not available for the terminal |  |  |  |  |  |  |
|  |  | 0 (1000): <br> (SS1) |  |  |  |  |  |  |
|  |  | 1 (1001): $\}$ Select multistep frequency (SS2) |  |  |  |  |  |  |
|  |  | 2 (1002): (SS4) |  |  |  |  |  |  |
|  |  | 6 (1006): Enable 3-wire operation (HLD) |  |  |  |  |  |  |
|  |  | 7 (1007): Coast to a stop (BX) |  |  |  |  |  |  |
|  |  | 8 (1008): Reset alarm (RST) |  |  |  |  |  |  |
|  |  | 9 (1009): Enable external alarm trip (THR) |  |  |  |  |  |  |
|  |  | 11 (1011): Switch reference frequency $2 / 1 \quad$ (Hz2/Hz1) |  |  |  |  |  |  |
|  |  | 13: DC injection brake (DCBRK) |  |  |  |  |  |  |
|  |  | 15: Switch to commercial power ( 50 Hz ) |  |  |  |  |  |  |
|  |  | (SW50) |  |  |  |  |  |  |
|  |  | 16: Switch to commercial power ( 60 Hz ) |  |  |  |  |  |  |
|  |  | (SW60) |  |  |  |  |  |  |
|  |  | 17(1017): UP (Increase output frequency) (UP) |  |  |  |  |  |  |
|  |  | 18(1018): DOWN (Decrease output frequency) <br> (DOWN) |  |  |  |  |  |  |
|  |  | 19(1019): Enable write from keypad (Data changeable) |  |  |  |  |  |  |
|  |  | 20(1020): Cancel PID control (Hz/PID) |  |  |  |  |  |  |
|  |  | 21 (1021): Switch normalinverse operation (IVS) |  |  |  |  |  |  |
|  |  | 22(1022): Interlock (IL) |  |  |  |  |  |  |
|  |  | 24 (1024): Enable communications link via RS485 or field bus (option) |  |  |  |  |  |  |
|  |  | 25(1025): Universal DI (U-DI) |  |  |  |  |  |  |
|  |  | 26(1026): Select starting characteristics (STM) |  |  |  |  |  |  |
|  |  | 30 (1030): Force to stop ${ }^{\text {(STOP) }}$ |  |  |  |  |  |  |
|  |  | 33 (1033): Reset PID integral and differential components <br> (PID-RST) |  |  |  |  |  |  |
|  |  | 34 (1034): Hold PID integral component (PID-HLD) |  |  |  |  |  |  |
|  |  | 35 (1035): Select local (keypad) operation (LOC) |  |  |  |  |  |  |
|  |  | 38(1038): Enable to run (RE) |  |  |  |  |  |  |
|  |  | 39: Protect motor from dew condensation <br> (DWP) |  |  |  |  |  |  |
|  |  | 40. Enable integrated sequence to switch to commercial power ( 50 Hz ) <br> (ISW50) |  |  |  |  |  |  |
|  |  | 41: Enable integrated sequence to switch <br> to commercial power ( 60 Hz ) <br> (ISW60) |  |  |  |  |  |  |
|  |  | 87 (1087): Switch run command $2 / 1$ (FR2/FR1) |  |  |  |  |  |  |
|  |  | 88: Run fonward 2 (FWD2) |  |  |  |  |  |  |
|  |  | 89: Run reverse 2 (REV2) |  |  |  |  |  |  |
|  |  | 98: Run fonward (FWD) |  |  |  |  |  |  |
|  |  | 99: Run reverse (REV) |  |  |  |  |  |  |
|  |  | Note: For (THR) and (STOP), data (1009) and (1030) are assigned for normal logic, and "9" and "30" are for negative logic, respectively. |  |  |  |  |  |  |

## C codes: Control Functions of Frequency

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default setting | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C01 | Jump Frequency | 0.0 to 120.0 | 0.1 | Hz | Y | Y | 0.0 | 9-87 |
| C02 |  |  |  |  | Y | Y | 0.0 |  |
| C03 |  |  |  |  | Y | Y | 0.0 |  |
| C04 |  | 0.0 to 30.0 | 0.1 | Hz | $Y$ | Y | 0.0 |  |
| C05 | Multistep Frequency <br> 1 <br> 2 <br> 3 <br> 4 <br> 5 <br> 6 <br> 7 | 0.00 to $120.00 * 1$ | 0.01 | Hz | $Y$ | Y | 0.00 | 9-88 |
| C 06 |  |  |  |  | Y | Y | 0.00 |  |
| $\mathrm{C07}$ |  |  |  |  | Y | $Y$ | 0.00 |  |
| C08 |  |  |  |  | Y | $Y$ | 0.00 |  |
| C09 |  |  |  |  | $Y$ | Y | 0.00 |  |
| C10 |  |  |  |  | Y | Y | 0.00 |  |
| C11 |  |  |  |  | Y | Y | 0.00 |  |
| C30 | Frequency Command 2 | 0: Enable $\qquad$ keys on keypad <br> 1: Enable voltage input to terminal [12] ( 0 to 10 VDC) <br> 2: Enable current input to terminal [C1] ( 4 to 20 mADC ) <br> 3: Enable sum of voltage and current inputs to terminals [12] and [C1] <br> 5. Enable voltage input to terminal [V2] ( 0 to 10 VDC ) <br> 7: Enable terminal command (UP) / (DOWN) control | - | - | N | Y | 2 | $\begin{aligned} & 9-19 \\ & 9-89 \end{aligned}$ |
| C32 | Analog Input Adjustment for Terminal [12] (Gain) | 0.00 to 200.00 * 1 | 0.01 | \% | $Y^{*}$ | Y | 100.0 | $\begin{aligned} & 9-39 \\ & 9-89 \end{aligned}$ |
| C33 | Filter time constant) | 0.00 to 5.00 | 0.01 | s | Y | Y | 0.05 | 9-90 |
| C34 | (Gain reference point) | 0.00 to 100.00 * 1 | 0.01 | \% | $Y^{*}$ | Y | 100.0 | 9-39 |
| C37 | Analog Input Adjustment for Terminal [C1] (Gain) | 0.00 to $200.00 * 1$ | 0.01 | \% | $Y^{*}$ | Y | 100.0 |  |
| C38 | (Filter time constant) | 0.00 to 5.00 | 0.01 | s | $Y$ | $Y$ | 0.05 | 9-90 |
| C39 | (Gain reference point) | 0.00 to 100.00 * 1 | 0.01 | \% | $Y^{*}$ | Y | 100.0 | 9-39 |
| C42 | Analog Input Adjustment for Terminal [V2] (Gain) | 0.00 to 200.00 * 1 | 0.01 | \% | $Y^{*}$ | Y | 100.0 | 9-89 |
| C43 | (Filter time constant) | 0.00 to 5.00 | 0.01 | s | Y | Y | 0.05 | 9-90 |
| C44 |  | 0.00 to $100.00 * 1$ | 0.01 | \% | $Y^{*}$ | Y | 100.0 | $\begin{aligned} & 9-39 \\ & 9-89 \end{aligned}$ |
| C50 | Bias Reference Point (Frequency command 1) | 0.00 to 100.0 * 1 | 0.01 | \% | $Y^{*}$ | Y | 0.00 | $\begin{aligned} & 9-39 \\ & 9-90 \end{aligned}$ |
| C51 | Bias for PID command 1 <br> (Bias value) | -100.0 to $100.00 * 1$ | 0.01 | \% | $Y^{*}$ | Y | 0.00 | 9-90 |
| C52 | (Bias reference point) | 0.00 to $100.00 * 1$ | 0.01 | \% | $Y^{*}$ | Y | 0.00 |  |
| C53 | Selection of Normal/Inverse Operation (Frequency command 1) | 0 : Normal operation <br> 1: Inverse operation | - | - | Y | Y | 0 |  |

${ }^{1}$ When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is:
" 1 " for -200 to $-100, ~ " 0.1$ " for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .

P codes: Motor Parameters

| Code |  | Name | Data setting range | Increment | Unit | Change when running | $\begin{gathered} \text { Data } \\ \text { copying } \end{gathered}$ | Default setting | $\begin{aligned} & \text { Refer } \\ & \text { to } \\ & \text { page: } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| P01 | Motor | (No. of poles) | 2 to 22 | 2 | Pole | N | $\begin{aligned} & \mathrm{Y} 1 \\ & \mathrm{Y} 2 \end{aligned}$ | 4 | 9-91 |
| P02 |  | (Capacity) | 0.01 to 1000 (where, the data of function code P99 is 0 , 3, or 4.) <br> 0.01 to 1000 (where, the data of function code P99 is 1.) | $\begin{aligned} & 0.01 \\ & 0.01 \end{aligned}$ | kW <br> HP | N | $\begin{aligned} & Y 1 \\ & Y 2 \end{aligned}$ | Rated capacity of motor |  |
| P03 |  | (Rated current) | 0.00 to 2000 | 0.01 | A | N | $\begin{aligned} & Y 1 \\ & Y 2 \end{aligned}$ | Rated current of Full standard motor |  |
| P04 |  | (Auto-tuning) | 0: Disable <br> 1: Enable (Tune \%R1 and $\% \mathrm{X}$ while the motor is stopped.) <br> 2: Enable (Tune \%R1 and $\% \mathrm{X}$ while the motor is stopped, and no-load current while running.) | - | - | N | N | 0 |  |
| P06 |  | No-load current) | 0.00 to 2000 | 0.01 | A | N | $\begin{aligned} & Y_{1} \\ & Y_{2} \end{aligned}$ | Rated value of Fuil standard motor | 9-92 |
| P 07 |  | (\%R1) | 0.00 to 50.00 | 0.01 | \% | Y | $\begin{aligned} & \mathrm{Y} 1 \\ & \mathrm{Y} 2 \end{aligned}$ | Rated value of Fuif standard motor |  |
| P08 | (\%X) |  | 0.00 to 50.00 | 0.01 | \% | $Y$ | $\begin{aligned} & Y 1 \\ & Y 2 \end{aligned}$ | Rated value of Full standard motor |  |
| P99 | Motor | election | 0. Characteristics of motor 0 <br> (Fupi standard motors, 8-series) <br> Characteristics of motor 1 (HP-labeled motors) <br> Characteristics of motor 3 <br> (Fuli standard motors, 6-series) <br> Other motors | - | - | N | $\begin{aligned} & \mathrm{Y}_{1} \end{aligned}$ | 0 | 9-93 |

The $\square$ shaded function codes are applicable to the quick setup.

## H codes: High Performance Functions

| Code | Name | Data setting range | Increment | Unit | Change when running | $\left\|\begin{array}{c} \text { Data } \\ \text { copying } \end{array}\right\|$ | Default setting | $\begin{aligned} & \text { Refer } \\ & \text { to } \\ & \text { page: } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| H03 | Data Initializing | 0: Disable initialization (All function code data already set remains.) <br> 1: Initialize all function code data to the factory defaults <br> 2: Initialize motor parameters | - | - | N | N | 0 | 9-94 |
| H04 | Auto-resetting <br> (Times) | $\begin{aligned} & \text { 0: Disable } \\ & \text { ito } 10 \end{aligned}$ | 1 | Times | $Y$ | $Y$ | 0 | 9-101 |
| H05 | (Reset interval) | 0.5 to 20.0 | 0.1 | s | $Y$ | $Y$ | 5.0 |  |
| H06 | Cooling Fan ON/OFF Control | 0: Disable (Always in operation) <br> 1: Enable (ON/OFF controllable) | - | - | $Y$ | $Y$ | 0 | 9-102 |
| H07 | Acceleration/Deceleration Pattern | 0: Disable Linear <br> 1: S-curve (Weak) <br> 2: S-curve (Strong) <br> 3: Curvilinear | - | - | $Y$ | $Y$ | 0 | 9-103 |
| H09 | Select Starting Characteristics (Auto sync search mode) | 0: Disable <br> 3: Enable (Following the Run command, the inverter synchronizes the motor rotation either forward or reverse.) <br> 4: Enable (Following the Run command, the imverter synchronizes the motor rotation both forward and reverse.) <br> 5: Enable (Following the Run command, the inverter synchronizes the motor rotation inversely both forward and reverse.) | - | - | N | $Y$ | 0 | 9-105 |
| H11 | Deceleration Mode | 0: Normal deceleration <br> 1: Coast-to-stop | - | - | Y | $Y$ | 0 | 9-107 |
| H12 | Instantaneous Overcurrent Limiting | 0: Disable <br> 1: Enable | - | - | $Y$ | $Y$ | 1 |  |
| H13 | Restart Mode after Momentary Power Failure (Restart time) | 0.1 to 10.0 | 0.1 | $s$ | Y | $\begin{aligned} & \mathrm{Y} 1 \\ & \mathrm{Y} 2 \end{aligned}$ | Depending on the inverter capacity | $\begin{gathered} 9-31 \\ 9-108 \end{gathered}$ |
| H14 | (Frequency fall rate) | 0.00: Set deceleration time <br> 0.01 to 100.00 <br> 999: Follow the current limit command | 0.01 | Hz/s | Y | $Y$ | 999 |  |
| H15 | (Holding DC voltage) | 200 V series: 200 to 300 <br> 400 V series: 400 to 600 | 1 | V | $Y$ | Y2 | $\begin{aligned} & 235 \\ & 470 \end{aligned}$ |  |
| H16 | (Allowable momentary power failure time) | 0.0 to 30.0 <br> 999: The longest time automatically determined by the inverter | 0.1 | s | Y | $Y$ | 999 |  |
| H17 | Select Starting <br> Characteristics <br> (Synchronizing frequency) | 0.0 to 120.0 <br> 999: Synchronize at the maximum frequency | 0.1 | Hz | $Y$ | $Y$ | 999 | $\begin{gathered} 9-25 \\ 9-108 \end{gathered}$ |
| H26 | PTC Thermistor <br> (Mode selection) | Disable <br> 1: Enable (Upon detection (PTC), the inverter Immediately trips and stops with $O M 4$ displayed on the LED monitor.) <br> 2: Enable (Upon detection (PTC), the inverter continues running while outputting a alarm signal (THM).) | - | - | $Y$ | $Y$ | 0 | 9-108 |
| H27 | (Leval) | 0.00 to 5.00 | 0.01 | V | $Y$ | $Y$ | 1.60 |  |

(H code continued)

| Code | Name | Data setting range |  | Incre- | Unit | Change when | Data | Default | Refer to |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| H30 | Communications Link Function <br> (Function selection) | Frequency command <br> 0: F01/C30 <br> 1: RS485 link <br> 2: F01/C30 <br> 3: RS485 link <br> 4: RS485 link (Option) <br> 5: RS485 link (Option) <br> 6: F01/C30 <br> 7: RS485 link <br> 8: RS485 link (Option) | Run command <br> F02 <br> F02 <br> RS485 link <br> RS485 link <br> F02 <br> RS485 link <br> RS485 link (Option) <br> RS485 link (Option) <br> RS485 link (Option) | - | - | $Y$ | $Y$ | 0 | $\begin{array}{\|l\|l\|} 9-110 \\ 9-133 \end{array}$ |
| H42 | Capacitance of DC Link Bus Capacitor | Indication for replacing DC link bus capacitor (0000 to FFFF: Hexadecimal) |  | 1 | - | Y | N | - | 9-111 |
| H43 | Cumulative Run Time of Cooling Fan | Indication of cumulative run time of cooling fan for replacement |  | - | - | $Y$ | N | - |  |
| H47 | Initial Capacitance of DC Link Bus Capacitor | Indication for replacing DC link bus capacitor ( 0000 to FFFF: Hexadecimal) |  | - | - | $Y$ | N | Set at factory shipping |  |
| H48 | Cumulative Run Time of Capacitors on the PCB | Indication for replacing capacitors on PC board (0000 to FFFF: Hexadecimal). Resettable. |  | - | - | $Y$ | N | - |  |
| H49 | Idling Motor Sync Start Mode <br> (Sync start time) | 0.0 to 10.0 |  | 0.1 | \$ | $Y$ | $Y$ | 0.0 | 9-112 |
| H50 | Non-linear V/f Pattern (Frequency) <br> (Voltage) | $\begin{aligned} & 0.0 \text { : (Cancel) } \\ & 0.1 \text { to } 120.0 \end{aligned}$ |  | 0.1 | Hz | $N$ | $Y$ | $0.0(22$ kW or below) $5.0(30$ kW or above) | $\begin{gathered} 9-22 \\ 9-112 \end{gathered}$ |
| H51 |  | 0 to 240: Output voltage AVR-controlled (for 200 V series) <br> 0 to 500: Output voltage AVR-controlled (for 400 V series) |  | 1 | V | N | Y2 | $0(22 \mathrm{~kW}$ <br> or below) <br> $20(30$ <br> kW or <br> above for 200V series) <br> 40 (30 <br> kW or <br> above for 400 V series) |  |
| H56 | Deceleration Time for Forced to Stop | 0.00 to 3600 |  | 0.01 | \$ | $Y$ | $Y$ | 20.0 | 9.112 |
| H63 | Low Limiter <br> (Mode selection) | 0: Limit by F16 (Frequency Limiter: Low) and continue to run <br> 1: If the output frequency lowers less than the one limited by F16 (Frequency Limiter: Low), decelerates to stop the motor. |  | - | - | $Y$ | $Y$ | 0 | $\begin{array}{\|c} 9-38 \\ 9-112 \end{array}$ |
| H64 | (Specify low limiting frequ ency) | 0.0 (Depends on F16 (Frequency Limiter: Low)).$0.1 \text { to } 60.0$ |  | 0.1 | Hz | $Y$ | $Y$ | 2.0 | 9-112 |
| H69 | Automatic Deceleration | 0: Disable <br> 3: Enable (Control DC link bus voltage at a constant.) |  | - | - | $Y$ | $Y$ | 0 |  |
| H70 | Overload Prevention Control | 0.00 (Equivalent to deceleration time applied). $0.01 \text { to } 100.00 \text {, }$ <br> 999 (Disable) |  | 0.01 | Hz/s | $Y$ | $Y$ | 999 | 9-113 |
| H71 | Deceleration Characteristics | 0 : Disable <br> 1: Enable |  | - | - | Y | Y | 0 |  |

(H code continued)

| Code | Name | Data setting range |  |  | Incre- <br> ment | Unit | Change when running | Data copying | Default setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| H80 | Gain for Suppression of Output Current Fluctuation for Motor | 0.00 to 0.40 |  |  | 0.01 | - | Y | $Y$ | Depending on the inverter capacity *3 | 9-113 |
| H86 | Reserved. *2 | 0 to 2 |  |  | 1 | - | $Y$ | $\begin{aligned} & \mathrm{Y} 1 \\ & \mathrm{Y} 2 \end{aligned}$ | Depending on the inverter capacity. 4 | - |
| H87 | Reserved. *2 | 25.0 to 120.0 |  |  | 0.1 | Hz | $Y$ | $Y$ | 25.0 |  |
| H88 | Reserved. *2 | 0 to 3.999 |  |  | 1 | - | $Y$ | N | 0 |  |
| H89 | Reserved. *2 | 0,1 |  |  | - | - | $Y$ | $Y$ | 0 |  |
| H90 | Reserved. *2 | 0,1 |  |  | - | - | $Y$ | $Y$ | 0 |  |
| H91 | Reserved. ${ }^{\text {2 }}$ | 0,1 |  |  | - | - | Y | $Y$ | 0 |  |
| H92 | Continue to Run (P-component: gain) | 0.000 to 10.000. $999 * 1$ |  |  | 0.001 | Times | $Y$ | $\begin{aligned} & Y_{1} \\ & Y_{2} \end{aligned}$ | 999 | $\begin{array}{\|c} 9-31 \\ 9-114 \end{array}$ |
| H93 | (1-component: time) | 0.010 to 10.000.999*1 |  |  | 0.001 | $s$ | $Y$ | $\begin{aligned} & Y_{1} \\ & Y_{2} \end{aligned}$ | 999 | $\begin{array}{\|c} 9-38 \\ 9-114 \end{array}$ |
| H94 | Cumulative Run Time of Motor | Change or reset the cumulative data |  |  | - | - | N | N | - | 9-114 |
| H95 | DC Injection Braking (Braking response mode) | $\begin{aligned} & \text { 0: Slow } \\ & \text { 1: Quick } \end{aligned}$ |  |  | - | - | $Y$ | $Y$ | 1 | $\begin{array}{\|c} 9-40 \\ 9-114 \end{array}$ |
| H96 | STOP Key Priontyl Start Check Function | Data | STOP key priority | Start | - | - | Y | $Y$ | 0 | $9-114$ |
|  |  | 0 : | Disable |  |  |  |  |  |  |  |
|  |  | 1: | Enable |  |  |  |  |  |  |  |
|  |  | 2. | Disable |  |  |  |  |  |  |  |
|  |  | 3: | Enable |  |  |  |  |  |  |  |
| H97 | Clear Alarm Data | If H91 $=1$ its data returns to zero after clearing alarm data). |  |  | - | - | $Y$ | N | 0 | 9-115 |
| H98 | Protection/ <br> Maintenance Function | 0 to 63: (Displays data on the LED of keypad in decimal format. In each bit, " 0 " for disabled, " 1 " for enabled <br> Bit 0: Automatic lowering function of carrier frequency <br> Bit 1: Protection against input phase loss <br> Bit 2: Protection against output phase loss <br> Bit 3: Selection of life judgment criteria of DC link bus capacitors <br> Bit 4: Judgment on the life of DC link bus capacitors <br> Bit 5: Detection of DC fan lock |  |  | - | - | $Y$ | $Y$ | $\begin{gathered} 19 \\ \text { (Bits 4, } 1 . \\ 0=1 \\ \text { Bits 5, 3. } \\ 2=0) \end{gathered}$ | $\begin{gathered} 9-42 \\ 9-115 \end{gathered}$ |

${ }^{* 1}$ When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is:
" 1 " for -200 to -100 , " 0.1 " for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .
${ }^{2}$ The H86 through H91 are displayed, but they are reserved for particular manufacturers. Unless otherwise specified, do not access these function codes.
${ }^{3}$ Select 0.10 for models of 45 kW or above ( 200 V series) and 55 kW or above ( 400 V series), 0.20 for models of 37 kW or below ( 200 V series) and 45 kW or below ( 400 V series).
${ }^{* 4}$ Select 2 for models of 45 kW or above ( 200 V series) and 55 kW or above ( 400 V series), 0 for models of 37 kW or below ( 200 V series) and 45 kW or below ( 400 V series).

## J codes: Application Functions


${ }^{11}$ When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is:
" 1 " for -200 to -100 , " 0.1 " for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .

## y codes: Link Functions

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| y01 | RS485 Communication (Standard) <br> (Station address) <br> (Communications error processing) | 1 to 255 | 1 | - | N | Y | 1 | 9-131 |
| y02 |  | 0: Immediately trip and alarm <br> 1: Trip and alarm the timer set by y03 <br> 2: Retry during the period specified by the timer (y03). If retry fails, trip and alarm $\mathbb{E}-1$ If it succeeds, continue to run. <br> 3: Continue to run | - | - | Y | Y | 0 |  |
| y03 | (Error processing timer) <br> (Transmission speed) | 0.0 to 60.0 | 0.1 | s | Y | Y | 2.0 |  |
| y04 |  | 0 : 2400 bps <br> 1: 4800 bps <br> 2: 9600 bps <br> 3: 19200 bps <br> 4: 38400 bps | - | - | Y | Y | 3 |  |
| y05 | (Data length) | 0 : 8 bits <br> 1: 7 bits | - | - | Y | Y | 0 |  |
| y06 | (Parity check) | 0: None <br> 1: Even parity <br> 2: Odd parity | - | - | Y | Y | 0 |  |
| y07 | (Stop bits) | 0: 2 bits <br> 1: 1 bit | - | - | Y | Y | 0 |  |
| y08 | (No-response error detection time) | 0 (No detection), 1 to 60 | 1 | s | Y | Y | 0 |  |
| y09 | (Response latency time) | 0.00 to 1.00 | 0.01 | s | Y | Y | 0.01 |  |
| y10 | (Protocol selection) | 0: Modbus RTU protocol <br> 1: SX protocol (Loader protocal) <br> 2: Fuji general-purpose inverter protocol | - | - | Y | Y | 1 |  |

(y code continued)


### 9.2 Overview of Function Codes

This section provides a detailed description of the function codes available for the FRENIC-Eco series of inverters. In each code group, its function codes are arranged in an ascending order of the identifying numbers for ease of access. Note that function codes closely related each other for the implementation of an inverter's operation are detailed in the description of the function code having the youngest identifying number. Those related function codes are indicated in the title bar as shown below.

| F01 | Frequency Command 1 |
| :--- | :--- |
| Refer to C30. |  |

### 9.2.1 $\quad$ F codes (Fundamental functions)

F00 specifies whether function code data is to be protected from being accidentally changed by keypad operation.

| Data for F00 | Function |
| :---: | :--- |
| 0 | Disable the data protection function, allowing you to change all function code <br> data. |
| 1 | Enable the data protection function, allowing you to change only the data for <br> function code F00. You cannot change any other function code data. |

If data protection is enabled ( $\mathrm{F} 00=1$ ), the $\widehat{\text { ® key operation to change data is disabled so }}$ that no function code data except F00 data can be changed from the keypad. To change F00 data, simultaneous keying of

Tip Even when $\mathrm{F} 00=1$, function code data can be changed via the communications link.
For similar purposes, (WE-KP), a signal enabling editing of function code data from the keypad is provided as a terminal command for digital input terminals. For details, refer to function codes E01 to E05, E98 and E99.

F01 selects the source of the reference frequency 1 (F01) or reference frequency $2(\mathrm{C} 30)$ for specifying the output frequency of the inverter (motor's rotation speed).

| Data for <br> F01, C30 | Function |
| :---: | :--- |
| 0 | Enable / / keys on the standard or multi-function keypad. (Refer to <br> Chapter 3 "OPERATION USING THE KEYPAD.") |
| 1 | Enable the voltage input to terminal [12] (0 to 10 VDC, maximum frequency <br> obtained at 10 VDC). |
| 2 | Enable the current input to terminal [C1] (4 to 20 mA DC, maximum <br> frequency obtained at 20 mA DC). |
| 3 | Enable the sum of voltage and current inputs to terminals [12] and [C1]. See <br> the two items listed above for the setting range and the value required for <br> maximum frequencies. |
| Note: If the sum exceeds the maximum frequency (F03), the maximum <br> frequency will apply. |  |
| 5 | Enable the voltage input to terminal [V2] (0 to 10 VDC, maximum frequency <br> obtained at 10 VDC). |
| 7 | Enable (UP) and (DOWN) commands assigned to the digital input terminals. <br> Assign (UP) command (data = 17) and (DOWN) command (data = 18) to the <br> digital input terminals [X1] to [X5]. |

Certain source settings (e.g., communications link and multistep frequency) have priority over the one specified by F01. For details, refer to the block diagram in Chapter 4, Section 4.2 "Drive Frequency Command Generator."

- You can modify the reference frequency anywhere you choose using the gain and bias settings, to these analog inputs (voltages entered via terminals [12] and [V2]; the current entered via terminal [C1]). For details, refer to function code F18.
- You can enable the noise reduction filter that applies to the analog input (voltages entered via terminals [12] and [V2]; the current entered via terminal [C1]). For details, refer to function codes C33, C38 and C43 (Terminal [12], [C1] and [V2] (Analog input) (Filter time constant)).
- Using the terminal command ( $\mathrm{Hz} 2 / \mathrm{Hz} 1)$ assigned to one of the digital input terminals switches between frequency commands 1 and 2. For details, refer to function codes E01 to E05, E98 and E99.
- You can modify the reference frequency specified by frequency command 1 (F01) by using the selection (C53) and switching (IVS) of normal/inverse operation. For details, refer to the description of "Switch Normal/Inverse Operation (IVS)" in function codes E01 to E05.


## Run Command

F02 selects the source issuing a run command for running the motor.

| Data for F02 | Run Command | Description |
| :---: | :---: | :---: |
| 0 | Keypad | On standard keypad <br> Enables the ( Nof / keys on the keypad to start and stop the motor. The direction of rotation is determined by the commands given at terminals [FWD] and [REV]. <br> On multi-function keypad <br> Enables FOC / ®ev, / noef keys to run (forward and reverse) and stop the motor. <br> (There is no need to specify a rotation direction command.) |
| 1 | External signal | Enables the external signals given at terminals [FWD] and [REV] to run the motor. |
| 2 | Keypad <br> (Forward rotation) | Enables only forward rotation. You cannot run the motor in the reverse direction. There is no need to specify the direction of rotation. <br> On standard keypad <br> Enables ( Nof / keys to run and stop the motor. <br> On multi-function keypad <br> Enables ( mof keys to run and stop the motor. <br> Disables the Rey, key. |
| 3 | Keypad <br> (Reverse rotation) | Enables only reverse rotation. You cannot run the motor in the forward direction. There is no need to specify the direction of rotation. <br> On standard keypad <br> Enables ( wof / nef keys to run and stop the motor. <br> On multi-function keypad <br> Enables बey / Ime keys to run and stop the motor. Disables the mo key. |

When function code $\mathrm{F} 02=0$ or 1 , the run forward command (FWD) and the run reverse command (REV) must be assigned to terminals [FWD] and [REV], respectively.

In addition to the run command (F02) described, there are several other sources available with priority over F02: Remote/Local switching, Communications link, Run forward command 2 (FWD2), and Run reverse command 2 (REV2). For details, refer to the block diagram in Chapter 4, Section 4.3 "Drive Command Generator."
The table below shows relationship between the keying and run commands in running per standard keypad ( $\mathrm{F} 02=0$, rotation direction is defined by the digital inputs).

| Keying on the Keypad |  | Digital inputs |  | Results <br> (Final command) |
| :---: | :---: | :---: | :---: | :---: |
| ๗ny key | OPy | (FWD) | (REV) |  |
| - | ON | - | - | Stop |
| ON | OFF | OFF | OFF | Run forward |
| ON | OFF | ON | OFF | Run reverse |
| ON | OFF | OFF | ON | Stop |
| ON | OFF | ON | ON | St |

## Note

- Digital input commands (FWD) and (REV) are valid for specifying the motor rotation direction, and the commands (FWD2) and (REV2) are invalid.
- If you have assigned the (FWD) or (REV) function to the [FWD] or [REV] terminal, you cannot change the setting of function code F02 while the terminals [FWD] and [CM]* or the terminals [REV] and [CM]* are short-circuited.
- If you have specified the external signal $(\mathrm{F} 02=1)$ as the run command and have assigned commands other than the (FWD) or (REV) command to the [FWD] or [REV] terminal, caution should be exercised in changing the settings. Because, if under this condition you assign the (FWD) or (REV) function to the [FWD] or [REV] terminal while the terminals [FWD] and [CM]* or the terminals [REV] and $[\mathrm{CM}]^{*}$ are short-circuited, the motor would start running.
*[CM] replaces with [PLC] for SOURCE mode.

When "Local" is selected in Remote/Local switching, the operation of the keypad concerning run commands varies with the setting of F02. The operation also varies between the standard keypad and the multi-function keypad. For details, refer to "■ Remote and local modes" in Chapter 3, Section 3.2.3.

## Maximum Frequency

F03 specifies the maximum frequency at which the motor can run. Specifying the frequency out of the range rated for the equipment driven by the inverter may cause damage or a dangerous situation. Set a maximum frequency appropriate for the equipment.

- Data setting range: 25.0 to $120.0(\mathrm{~Hz})$


## $\triangle$ CAUTION

The inverter can easily accept high-speed operation. When changing the speed setting, carefully check the specifications of motors or equipment beforehand.
Otherwise injuries could occur.
Modifying F03 data to apply a higher output frequency requires also changing F15 data specifying frequency limiter (high).

These function codes specify the base frequency and the voltage at the base frequency essentially required for running the motor properly. If combined with the related function codes H 50 and H 51 , these function codes may profile the non-linear V/f pattern by specifying increase or decrease in voltage at any point on the V/f pattern.
The following description includes setups required for the non-linear V/f pattern.
At high frequencies, the motor impedance may increase, resulting in an insufficient output voltage and a decrease in output torque. This feature is used to increase the voltage at high frequencies to prevent this problem from happening. Note, however, that you cannot increase the output voltage beyond the voltage of the inverter's input power.

## ■ Base Frequency (F04)

Set the rated frequency printed on the nameplate labeled on the motor.

- Data setting range: 25.0 to $120.0(\mathrm{~Hz})$
- Rated Voltage at Base Frequency (F05)

Set 0 or the rated voltage printed on the nameplate labeled on the motor.

| Data for F05 | Function |
| :---: | :--- |
| 0 | Output a voltage in proportion to input voltage. (The AVR is disabled. AVR: <br> Automatic Voltage Regulator) |
| 80 to $240(\mathrm{~V})$ | Output a voltage AVR-controlled for 200 V series |
| 160 to $500(\mathrm{~V})$ | Output a voltage AVR-controlled for 400 V series |

- If 0 is set, the rated voltage at base frequency is determined by the power source of the inverter. The output voltage will vary in line with any variance in input voltage.
- If the data is set to anything other than 0 , the inverter automatically keeps the output voltage constant in line with the setting. When any of the automatic torque boost settings, automatic energy saving or slip compensation is active, the voltage settings should be equal to the rated voltage of the motor.


## ■ Non-linear V/f Pattern for Frequency (H50)

Set the frequency component at an arbitrary point of the non-linear V/f pattern.

- Data setting range: 0.0 to 120.0 Hz
(Setting 0.0 to H50 disables the non-linear V/f pattern operation.)


## ■ Non-linear V/f Pattern for Voltage (H51)

Sets the voltage component at an arbitrary point of the non-linear V/f pattern.

| Data for H51 | Function |
| :---: | :--- |
| 0 to $240(\mathrm{~V})$ | Output the voltage AVR-controlled for 200 V series |
| 0 to $500(\mathrm{~V})$ | Output the voltage AVR-controlled for 400 V series |

If the rated voltage at base frequency (F05) is set to 0 , settings of function codes H 50 and H 51 will be ignored.
If the auto torque boost (F37) is enabled, H50 and H51 will be ignored.
Factory settings:
For models of 22 kW or below the non-linear $\mathrm{V} / \mathrm{f}$ is disabled $(\mathrm{H} 50=0, \mathrm{H} 51=0$.)
For models of 30 kW or above it is enabled, that is, ( $\mathrm{H} 50=5 \mathrm{~Hz}, \mathrm{H} 51=20 \mathrm{~V}$ ), for the 200 V series, $(\mathrm{H} 50=5 \mathrm{~Hz}, \mathrm{H} 51=40 \mathrm{~V})$ for 400 V series.

The factory default varies depending on the inverter's rated capacity and rated input voltage.
See the table below.

| Function code | Name | $\begin{array}{c}\text { Rated capacity } \\ (\mathrm{kW})\end{array}$ | Rated input voltage* |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | 400 V series |  |
| F04 | Base Frequency | 5.5 to 75 | 50.0 Hz | 50.0 Hz |
| F05 | $\begin{array}{c}\text { Rated Voltage } \\ \text { (at base frequency) }\end{array}$ | 5.5 to 75 | 200 V | 400 V |
| H 50 | $\begin{array}{c}\text { Non-linear V/f Pattern } \\ \text { (Frequency) }\end{array}$ | 30 or below | 0 Hz | 0 Hz |
|  |  | 37 or above | 5.0 Hz | 5.0 Hz |
| H 51 | Non-linear V/f Pattern |  |  |  |
| (Voltage) |  |  |  |  |$)$

*For Japanese models

## Example:

■ Normal (linear) V/f pattern


■ V/f Pattern with Non-linear Point below the Base Frequency


■ V/f Pattern with Non-linear Point above the Base Frequency


## Acceleration Time 1

## Deceleration Time 1

F07 specifies the acceleration time, the length of time the frequency increases from 0 Hz to the maximum frequency. F08 specifies the deceleration time, the length of time the frequency decreases from the maximum frequency down to 0 Hz .

- Data setting range: 0.00 to 3600 (sec.)

- If you choose S-curve acceleration/deceleration or curvilinear acceleration/ deceleration in Acceleration/Deceleration Pattern (H07), the actual acceleration/deceleration times are longer than the specified times. Refer to the descriptions of H07 for details.
- If you specify an improperly long acceleration/deceleration time, the current limiting function or the automatic deceleration function (regenerative bypass function) may be activated, resulting in an actual acceleration/deceleration time longer than the specified one.

F37 specifies V/f pattern, torque boost type, and auto energy saving operation for optimizing the operation in accordance with the characteristics of the load. F09 specifies the type of torque boost in order to provide sufficient starting torque.

| Data for F37 | V/f pattern | Torque boost | Auto-energy saving | Applicable load |
| :---: | :---: | :---: | :---: | :---: |
| 0 | For non-linear torque load | Torque boost specified by F09 | Disabled | General purpose fans and pumps |
| 1 | For linear torque load |  |  | Pumps require high starting torque* ${ }^{1}$ |
| 2 |  | Auto-torque boost |  | Pumps require high start torque (A motor may be over-excited at no load.) |
| 3 | For non-linear torque load | Torque boost specified by F09 | Enabled | General-purpose fans and pumps |
| 4 | For linear torque load |  |  | Pumps require high start torque*1 |
| 5 |  | Auto torque boost |  | Pumps require high start torque (A motor may be over-excited at no load.) |

[^42]Factory default setting varies depending on the inverter's rated capacity. See Table below.

| Rated capacity (kW) | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 or above |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Factory default | 3.4 | 2.7 | 2.1 | 1.6 | 1.3 | 1.1 | 0 |

FRENIC-Eco is a series of inverters exclusively designed for fans and pumps whose torque loads are characterized by a term of variable torque load that is a torque load increasing proportional to square of the load speed. FRENIC-Eco cannot drive any constant torque load even if you select a linear V/f pattern. If you attempt to drive a constant-torque load with a FRENIC-Eco inverter, the inverter's current limit function may be activated or an insufficient torque situation may result, and you would need to reduce the inverter output. For details, contact your Fuji Electric representative.
■ V/f characteristics
The FRENIC-Eco series of inverters offers a variety of V/f patterns and torque boosts, which include V/f patterns suitable for non-linear torque load such as general fans and pumps or for special pump load requiring high start torque. Two types of torque boost are available: manual and automatic.

Non-linear torque characteristics (F37 = 0)
Output voltage (V)
Torque
boost

Linear torque characteristics (F37 =1


When the non-linear torque load characteristics is selected in function code F37 (=
Tip 0 or 3), the output voltage may be low and insufficient voltage output may result in less output torque of the motor at a low frequency zone, depending on some motor itself and load characteristics. In such a case, it is recommended to increase the output voltage at the low frequency zone using the non-linear V/f pattern.
Recommended value: $\mathrm{H} 50=1 / 10$ of the base frequency
$\mathrm{H} 51=1 / 10$ of the voltage at base frequency


- Torque boost
- Manual torque boost (F09)

In torque boost using F09, constant voltage is added to the basic V/f pattern, regardless of the load, to give the output voltage. To secure a sufficient start torque, manually adjust the output voltage to optimally match the motor and its load by using F09. Select an appropriate level that guarantees smooth start-up and yet does not cause over-excitation with no or light load.
Torque boost per F09 ensures high driving stability since the output voltage remains constant regardless of the load fluctuation.
Specify the data for function code F09 in percentage to the Rated Voltage at Base Frequency (F05). At factory shipment, F09 is preset to a level that ensures some $50 \%$ of start torque.

Specifying a high torque boost level will generate a high torque, but may cause overcurrent due to over-excitation at no load. If you continue to drive the motor, it may overheat. To avoid such a situation, adjust torque boost to an appropriate level. When the non-linear V/f pattern and the torque boost are used together, the torque boost takes effect below the frequency on the non-linear V/f pattern's point.


## ■ Automatic torque boost

This function automatically optimizes the output voltage to fit the motor with its load. Under light load, automatic torque boost decreases the output voltage to prevent the motor from over-excitation. Under heavy load, it increases the output voltage to increase output torque of the motor.

- Since this function relies also on the characteristics of the motor, set the base frequency (F04), the rated voltage at base frequency (F05), and other pertinent motor parameters (P01 though P03 and P06 though P99) in line with the motor capacity and characteristics, or else perform auto tuning per P04.
- When a special motor is driven or the load does not have sufficient rigidity, the maximum torque might decrease or the motor operation might become unstable. In such cases, do not use automatic torque boost but choose manual torque boost per F09 (F37 = 0 or 1).


## ■ Auto energy saving operation

This feature automatically controls the supply voltage to the motor to minimize the total power consumption of motor and inverter. (Note that this feature may not be effective depending upon the motor or load characteristics. Check the advantage of energy saving before actually apply this feature to your power system.).

The inverter enables this feature only upon constant speed operation. During acceleration and deceleration, the inverter will run with manual torque boost (F09) or automatic torque boost, depending on data of the function code F37. If auto energy saving operation is enabled, the response to a change in motor speed may be slow. Do not use this feature for a system that requires quick acceleration and deceleration.

Note

- Use auto energy saving only where the base frequency is 60 Hz or lower. If the base frequency is set at 60 Hz or higher, you may get little or no energy saving advantage. The auto energy saving operation is designed for use with the frequency lower than the base frequency. If the frequency becomes higher than the base frequency, the auto energy saving operation will be invalid.
- Since this function relies also on the characteristics of the motor, set the base frequency (F04), the rated voltage at base frequency (F05), and other pertinent motor parameters (P01 through P03 and P06 through P99) in line with the motor capacity and characteristics, or else perform auto tuning per P04.


## Electronic Thermal Overload Protection for Motor (Overload detection level)

## Electronic Thermal Overload Protection for Motor (Thermal time constant)

F10 through F12 specify the thermal characteristics of the motor for its electronic thermal overload protection that is used to detect overload conditions of the motor inside the inverter.

F10 selects the motor cooling mechanism to specify its characteristics, F11 specifies the overload detection current, and F12 specifies the thermal time constant.

Thermal characteristics of the motor specified by F10 and F12 are also used for the overload early warning. Even if you need only the overload early warning, set these characteristics data to these function codes. To disable the electronic thermal motor overload protection, set data of F11 to "0.00."

## Select motor characteristics (F10)

F10 selects the cooling mechanism of the motor--built-in cooling fan or externally powered forced-ventilation fan.

| Data for F10 | Function |
| :---: | :--- |
| 1 | For general-purpose motors with built-in self-cooling fan <br> (The cooling effect will decrease in low frequency operation.) |
| 2 | For inverter-driven motors or high-speed motors with forced-ventilation fan <br> (The cooling effect will be kept constant regardless of the output frequency.) |

The figure below shows operating characteristics of the electronic thermal overload protection when $\mathrm{F} 10=1$. The characteristic factors $\alpha 1$ through $\alpha 3$ as well as their corresponding switching frequencies $f 2$ and $f 3$ vary with the characteristics of the motor. The tables below lists the factors of the motor selected by P99 (Motor Selection).


Cooling characteristics of motor equipped with a self-cooling fan
Applicable motor rating and characteristic factors when P99 (Motor selection) $=0$ or 4

| Applicable motor rating (kW) | Thermal time constant $\tau$ (Factory default) | Output current for setting the thermal time constant (Imax) | Switching frequency for motor characteristic factor |  | Characteristic factor (\%) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | f2 | f3 | $\alpha 1$ | $\alpha 2$ | 人3 |
| 0.4, 0.75 | 5 min | Rated current $\times 150 \%$ | 5 Hz | 7 Hz | 75 | 85 | 100 |
| 1.5 to 3.7 |  |  |  |  | 85 | 85 | 100 |
| 5.5 to 11 |  |  |  | 6 Hz | 90 | 95 | 100 |
| 15 |  |  |  | 7 Hz | 85 | 85 | 100 |
| 18.5, 22 |  |  |  | 5 Hz | 92 | 100 | 100 |
| 30 to 45 | 10 min |  | Base frequency $\times 33 \%$ | Base frequency $\times 83 \%$ | 54 | 85 | 95 |
| 55 to 90 |  |  |  |  | 51 | 95 | 95 |
| 110 or above |  |  |  |  | 53 | 85 | 90 |

Applicable motor rating and characteristic factors when P99 (Motor selection) $=1$ or 3

| Applicable motor rating (kW) | Thermal time constant $\tau$ (Factory default) | Output current for setting the thermal time constant (Imax) | Switching frequency for motor characteristic factor |  | Characteristic factor (\%) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | f2 | f3 | $\alpha 1$ | $\alpha 2$ | $\alpha 3$ |
| 0.2 to 22 | 5 min | $\begin{aligned} & \text { Rated current } \\ & \times 150 \% \end{aligned}$ | Base frequency $\times 33 \%$ | $\begin{gathered} \text { Base } \\ \text { frequency } \\ \times 33 \% \end{gathered}$ | 69 | 90 | 90 |
| 30 to 45 | 10 min |  |  | Base frequency $\times 83 \%$ | 54 | 85 | 95 |
| 55 to 90 |  |  |  |  | 51 | 95 | 95 |
| 110 or above |  |  |  |  | 53 | 85 | 90 |

■ Overload detection level (F11)
F11 specifies the level at which an overload condition is to be recognized by the electronic thermal overload protection.

- Data setting range: 1 to $135 \%$ of the rated current (allowable continuous drive current) of the inverter
In general, set F11 to the rated current of motor when driven at the base frequency (i.e. 1.0 to 1.1 multiple of the rated current of motor (P03)). To disable the electronic thermal overload protection, set F11 to 0.00 (Disable).


## ■ Thermal time constant (F12)

F12 specifies the thermal time constant of the motor. The time constant is the time until the electronic thermal overload protection detects the motor overload while the current of $150 \%$ of the overload detection level set up by F11 has flown. The thermal constants of most general-purpose motors including Fuji motors are set at about 5 minutes for capacities of 22 kW or below or about 10 minutes for capacities of 30 kW or above as default setting at factory shipment.

- Data setting range: 0.5 to 75.0 (minutes), (in increments of 0.1 minute)
(Example) When function code F12 is set at "5.0" ( 5 minutes)
As shown below, the electronic thermal overload protection is activated to detect an alarm condition (alarm code $\stackrel{L}{L \prime \prime}_{\prime \prime \prime}^{\prime}$ ) when the output current of $150 \%$ of the rated current flows for 5 minutes; $120 \%$ of the operating level for about 12.5 minutes.
The actual operating time when the motor overload alarm is issued tends to be shorter than the specified value as the time period from when the output current starts exceeding the rated current ( $100 \%$ ) until the current reaches the $150 \%$ of the operating level.

Example of Operating Characteristics


## Restart Mode after Momentary Power Failure (Mode selection)

Refer to H13, H14, H15, H16, H92 and H93.
F14 specifies the action to be taken by the inverter such as trip and restart in the event of a momentary power failure.

- Restart after a momentary power failure (Mode selection) (F14)

| Data for F14 | Mode | Description |
| :---: | :---: | :---: |
| 1 | No restart after a power failure (Trip immediately) | As soon as the DC link bus voltage drops below the undervoltage detection level upon a momentary power failure, the output of the inverter is shut down, with undervoltage alarm $L \prime \prime \prime$ issued, and the motor enters a coast-to-stop state. |
| 2 | No restart after a momentary power failure (Trip after recovery of power) | As soon as the DC link bus voltage drops below the undervoltage detection level upon a momentary power failure, the output of the inverter is shut down, the motor enters a coast-to-stop state, but no undervoltage alarm $\iota^{\prime} \iota^{\prime} \prime$ issued. <br> When power is restored, an undervoltage alarm L $_{6} \\|^{\prime}$ is issued, while the motor remains in coast-to-stop state. |
| 3 | Restart after a momentary power failure (Continuous running) | When the DC link bus voltage drops below the continuous running level upon a momentary power failure, continuous running control is invoked. Continuous running control regenerates kinetic energy from the load's moment of inertia, slowing down the motor and prolongs the running time. When an undervoltage condition is detected due to a lack of energy to be regenerated, the output frequency at that time is saved, the output of the inverter is shut down, and the motor enters a coast-to-stop state. <br> When power is restored, if a run command has been input, restart begins at the reference frequency saved during the power failure processing. This setting is ideal for fan applications with a large moment of inertia. |
| 4 | Restart after a momentary power failure (Restart at the frequency at which the power failure occurred) | As soon as the voltage of the DC link bus drops below the undervoltage detection level upon a momentary power failure, the output frequency at the time is saved, the output of the inverter is shut down, and the motor enters a coast-to-stop state. <br> When power is restored, if a run command has been input restart begins at the reference frequency saved during the power failure processing. This setting is ideal for applications with a moment of inertia large enough not to slow down the motor quickly, such as fans, even after the motor enters a coast-to-stop state upon occurrence of a momentary power failure. |
| 5 | Restart after a momentary power failure (restart at the starting frequency) | After a momentary power failure, when power is restored and then a run command is input, restart will begin at the starting frequency commanded by function code F23. <br> This setting is ideal for heavy load applications such as pumps, having a small moment of inertia, in which the motor speed quickly goes down to zero as soon as it enters a coast-to-stop state upon occurrence of a momentary power failure. |

## - Restart after a recovery from momentary power failure (Basic operation)

The inverter recognizes a momentary power failure upon detecting the condition that DC link bus voltage goes below the undervoltage level, while the inverter in running. If the load of the motor is light and the duration of the momentary power failure is extremely short, the voltage drop may not be great enough for a momentary power failure to be recognized, and the motor may continue to run uninterrupted.

Upon recognizing a momentary power failure, the inverter enters the restart mode (after a recovery from momentary power failure) and prepares for restart. When power is recovered, the inverter goes through an initial charging stage and enters the ready-to-run state. When a momentary power failure occurs, the power supply voltage for external circuits such as relay sequence circuits may also drop, the run command may be turned off. In consideration of such a situation, the inverter waits 2 seconds for input of a run command after the inverter enters ready-to-run state. If a run command is received within 2 seconds, the inverter begins the restart processing in accordance with the data of F14 (Mode selection). If no run command has been received within 2 -second wait period, the restart mode (after a recovery from momentary power failure) will be canceled, and the inverter needs to be started again from the ordinary starting frequency. Therefore, ensure that a run command is entered within 2 seconds after a recovery of power, or install a mechanical latch relay.

In case the run commands are entered via a standard keypad, the above operation is also necessary for the mode $(\mathrm{F} 02=0)$ in which the direction of rotation is determined by the terminal command, (FWD) or (REV). In the modes where the direction of rotation is fixed ( $\mathrm{F} 02=2$ or 3 ), the direction of rotation is retained inside the inverter, and the restart will begin as soon as the inverter enters the ready-to-run state.


When the power is recovered, the inverter will wait 2 seconds for input of a run command. However, if the allowable momentary power failure time (H16) elapses after the power failure was recognized, even within the 2 seconds, the waiting time for a run command is canceled. The inverter will start operation in the normal stating sequence.
If a coast-to-stop command (BX) is entered during the power failure, the inverter gets out of the restart mode and enters the normal running mode. If a run command is entered with power supply applied, the inverter will start from the normal starting frequency.
The inverter recognizes a momentary power failure by detecting an undervoltage condition whereby the voltage of the DC link bus goes below the lower limit. In a configuration where a magnetic contactor is installed on the output side of the inverter, the inverter may fail to recognize a momentary power failure because the momentary power failure shuts down the operating power of the magnetic contactor, causing the contactor circuit to open. When the contactor circuit is open, the inverter is cut off from the motor and load, and the voltage drop in the DC link bus is not great enough to be recognized as a power failure. In such an event, restart after a recovery from momentary power failure does not work properly as designed. To solve this, connect the interlock command (IL) line to the auxiliary contact of the magnetic contactor, so that a momentary power failure can sure be detected.

During a momentary power failure the motor slows down. After power has been recovered, the inverter is restarted at the frequency just before the momentary power failure. Then, the current limiting function works and the output frequency of the inverter automatically decreases. When synchronization is established between the output frequency and the rotation of the motor, the motor accelerates up to the original frequency. Refer to the figure below. In this case, to make the motor synchronize, the instantaneous overcurrent limiting must be enabled (H12 = 1).


## - Restart mode after momentary power failure

(Allowable momentary power failure time) (H16)
Specifies the maximum allowable duration ( 0.0 to 30.0 seconds) from a momentary power failure (undervoltage) occurrence until the inverter is to be restarted. Specify the maximum length of time that can be tolerated in terms of the machine system and facility during which the motor can coast to stop. Restart will take place if power is recovered within the specified duration. When the power is not recovered within the duration, the inverter recognizes the power has been shut down so that the inverter will make a start upon power recovery (normal starting).


If you set the allowable momentary power failure time (H16) to "999," restart will take place until the DC link bus voltage drops down to the allowable voltage for restart after a momentary power failure as shown below. If the DC link bus voltage goes below the allowable voltage for restart after momentary power failure, the inverter recognizes the power has been shut down so that the inverter will make a start upon power recovery (normal starting).

Allowable voltage for restart after momentary power failure

| Power supply | Allowable voltage for restart after momentary power failure |
| :---: | :---: |
| 200 V series | 50 V |
| 400 V series | 100 V |

The time required from when the DC link bus voltage drops from the threshold of undervoltage until the voltage reaches the allowable voltage for restart after momentary power failure, greatly varies depending on inverter capacity, the presence of options, and other factors.

■ Auto-restart after a recovery from momentary power failure (waiting time) (H13)
This function specifies the time period from momentary power failure occurrence until the inverter reacts for restarting process.
If the inverter starts the motor while motor's residual electricity is still in a high level, an overvoltage alarm may be recognized due to a high rush current or temporary regeneration occurrence. For safety, therefore, it is advisable to set H 13 to a certain level so that restart will take place only after the residual electricity has dropped to a low level. Note that even when power is recovered, restart will not take place until the waiting time (H13) has elapsed.


## - Factory default:

By factory default, H13 is set at one of the values shown below according to the inverter capacity. Basically, you do not need to change data of H13. However, if the long waiting time causes the flow rate of the pump to overly decrease or causes any other problem, you might as well reduce the setting to about a half of the default value. In such a case, make sure that no alarm occurs.

| Inverter capacity <br> (kW) | H13: Factory default (unit: s) of waiting time for restarting after a <br> recovery from momentary power failure |
| :---: | :---: |
| 0.1 to 7.5 | 0.5 |
| 11 to 37 | 1.0 |
| 45 to 110 | 1.5 |
| 132 to 160 | 2.0 |
| 200 to 280 | 2.5 |
| 315 to 355 | 4.0 |
| 400 to 500 | 5.0 |

Function code H13 (Restart mode after a momentary power failure -- waiting time) also applies to the switching operation between line and inverter (refer to E01 through E05; terminals [X1] through [X5]).

## - Restart after a momentary power failure (Frequency fall rate) (H14)

If, during restart after a momentary power failure, synchronization cannot be established between the output frequency of the inverter and the rotation of the motor, an overcurrent will flow and the overcurrent limiting is activated. If an overcurrent is detected, reduce the output frequency to match the rotation of the motor so that synchronization may be established. Function code H14 specifies the rate of reducing the output frequency (Frequency fall rate: $\mathrm{Hz} / \mathrm{s}$ ).

| Data for H14 | Inverter's action on the frequency fall rate |
| :---: | :--- |
| 0.00 | Follow the deceleration time (F08). |
| 0.01 to $100.00 \mathrm{~Hz} / \mathrm{s}$ | Follow data specified by H14. |
| 999 | Follow setting of the PI controller in current limiter (PI constant is <br> prefixed inside the inverter). |

If the frequency fall rate is too high, regeneration may take place at the moment the rotation of the motor comes into synchronization with the output frequency of the inverter, causing an overvoltage trip. If the frequency fall rate is too low, the time to establish synchronization (duration of current limiting action) may be prolonged, causing the inverter overload prevention control to be triggered.

## ■ Restart after a momentary power failure (Holding DC voltage) (H15)

■ Continue to run (P, I) (H92, H93)
If you have set F14 to "3"(Continuous running), a momentary power failure occurs while the inverter is running, at the time when the DC link bus voltage drops below the continuous running level (H15), the continuous running control will be activated DC link bus. H15 adjusts the continuous running level (voltage) for the continuous running control to be evoked.
During the continuous running control, deceleration is controlled by PI regulator. Specify the P (proportional) and I (integral) components with H92 and H93, respectively. For normal operation of the inverter, you do not have to modify H15, H92 or H93.


| Power Supply | $\alpha$ |  |
| :---: | :---: | :---: |
|  | 22 kW or below | 30 kW or above |
| 200 V | 5 V | 10 V |
| 400 V | 10 V | 20 V |

Even if you select the continuous running control, the inverter may not be able to continue operation when the load's inertia is small or the load is heavy, due to undervoltage caused by a control delay. Even in such a case, however, the output frequency when the undervoltage alarm occurred is saved and the inverter will restart at the saved frequency upon recovery from momentary power failure.

When the input power voltage for the inverter is high, setting the continuous running level high makes the control more stable even if the load's inertia is relatively small. Raising the continuous running level too high, however, might cause the continuous running control activated even during normal operation.

When the input power voltage for the inverter is extremely low, continuous running control might be activated even during normal operation, at the beginning of acceleration or at an abrupt change in load. To avoid this, lower the continuous running level. Lowering the continuous running level too low, however, might cause undervoltage that results from voltage drop due to a control delay. Even in such a case, however, the output frequency when the undervoltage alarm occurred is saved and the inverter will restart at the saved frequency upon recovery from momentary power failure.

Before you change the continuous running level, make sure that the continuous running control will be performed properly, by considering the fluctuations of the load and the input voltage.

## Frequency Limiter (High)

## Frequency Limiter (Low)

Frequency limiter (Upper) F15 specifies the upper limit of the output frequency, while frequency limiter (Lower) F16 specifies the lower limit.
Low limiter H63 allows you to select the operation when the reference frequency drops below the frequency limiter (Lower) F16 as follows:

- If H63 $=0$, the output frequency will be held at the frequency limiter (Lower).
- If $\mathrm{H} 63=1$, the inverter decelerates to stop the motor.
- Data setting range: 0.0 to 120.0 Hz


- When you change the frequency limiter (High) (F15) in order to raise the running frequency, be sure to change the maximum frequency (F03) accordingly.
- Maintain the following relationship among the data for frequency control:

$$
\begin{aligned}
& \mathrm{F} 15>\mathrm{F} 16, \mathrm{~F} 15>\mathrm{F} 23 \text { and } \mathrm{F} 15>\mathrm{F} 25 \\
& \mathrm{~F} 03>\mathrm{F} 16
\end{aligned}
$$

where, F23 is of the starting frequency and F25 is of the stop frequency.
If you specify any wrong data for these function codes, the inverter may not run the motor at the desired speed, or cannot start it normally.

Bias (Frequency command 1)
Refer to C50, C32, C34, C37, C39, C42 and C44.

If you select any analog input for the frequency command 1 (F01), you can define the relationship between the analog input and the frequency command arbitrarily by multiplying the gain and adding the bias.

| Function code | Function | Data setting range (\%) |
| :---: | :--- | :---: |
| F18 | Bias | -100.00 to 100.00 |
| C50 | Bias reference point | 0.00 to 100.00 |
| C32 | Gain for terminal [12] | 0.00 to 200.00 |
| C34 | Gain reference point for terminal [12] | 0.00 to 100.00 |
| C37 | Gain for terminal [C1] | 0.00 to 200.00 |
| C39 | Gain reference point for terminal [C1] | 0.00 to 100.00 |
| C42 | Gain for terminal [V2] | 0.00 to 200.00 |
| C44 | Gain reference point for terminal [V2] | 0.00 to 100.00 |

As shown below, the relationship between the analog input and the reference frequency selected by frequency command 1 is a frequency shown by the points "A" and "B." The bias function code (F18) and its reference point (C50) define a point "A." The gain function code (C32, C37, or C42) and its reference point (C34, C39, or C44) in conjunction with each analog input define a point "B." A pair of C32 and C34 will apply to terminal [12], that of C37 and C39 for terminal [C1], and that of C42 and C44 to [V2].
Configure the bias (F18) and gain (C32, C37, C42), assuming the maximum frequency as $100 \%$, and the bias reference point (C50) and gain reference point (C34, C39, C44), assuming the full scale ( 10 VDC or 20 mA DC ) of analog input as $100 \%$.

- The analog input less than the bias reference point (C50) is limited by the bias value (F18).
- If you specified data that the data of the bias reference point (C50) is equal to or greater than that of each gain reference point (C34, C39, C44), the inverter will interpret the setting as an invalid one, and set the reference frequency to 0 Hz .


Example: Setting the bias, gain and its reference points when the reference frequency 0 to $100 \%$ follows the analog input of 1 to 5 VDC to terminal [12] (in frequency command 1).

(Point A)
If you want to make 0 Hz as the reference frequency at when the analog input is at 1 V , then set the bias at $0 \%(\mathrm{~F} 18=0)$. As 1 V is the bias reference point and 1 V is equal to $10 \%$ of 10 V , then set the bias reference point at $10 \%(\mathrm{C} 50=10)$.
(Point B)
If you want to make the maximum frequency as the reference frequency at when an analog input is at 5 V , then set the gain at $100 \%(\mathrm{C} 32=100 \mathrm{As} 5 \mathrm{~V}$ is the gain reference point and 5 V is equal to $50 \%$ of 10 V , set the gain reference point at $50 \%(\mathrm{C} 34=50)$.

The setting procedure for specifying a gain or bias alone without changing any reference points is the same as that of Fuji conventional inverters of FRENIC5000G11S/P11S series, FVR-E11S series, etc.

DC Injection Braking (Operation level)
DC Injection Braking (Braking time)
If it is necessary to prevent the motor from running by inertia during deceleration-to-stop operation, enable the DC injection braking.
When the motor is in deceleration-to-stop operation by turning off the run command or by decreasing the reference frequency, stop frequency makes the DC injection braking activate at the time when the output frequency has reached the DC injection braking starting frequency. Specify the function codes such as the DC injection braking starting frequency (F20), the braking level (F21), and the braking time (F22). In addition, H95 specifies the response of the DC injection braking current.
Setting function code F22 (Braking time) to "0.0" (second) means that DC injection braking is disabled.

## - Starting frequency (F20)

Specify the frequency at which the DC injection braking starts its operation during motor deceleration-to-stop state.

- Data setting range: 0.0 to $60.0(\mathrm{~Hz})$

■ Braking level (F21)
Specify the output current level to be applied when the DC injection braking is activated. The function code data should be set, assuming the rated output current of the inverter as $100 \%$ in increments of $1 \%$.

- Data setting range: 0 to 60 (\%)


## ■ Braking time (F22)

Specify the braking period that activates DC injection braking.

- Data setting range: 0.01 to 30.00 (sec.)
(Note that setting 0.00 disables DC injection braking.)


■ DC injection braking response (H95)
Specifies the DC injection braking response mode.

| Data for H95 | Characteristics | Note |
| :---: | :--- | :---: |
| 0 | Slow response. Slows the rising edge <br> of the current, thereby preventing <br> reverse rotation at the start of DC <br> injection braking. | Insufficient braking torque may result <br> at the start of DC injection braking. |
| 1 | Quick response. Quickens the rising <br> edge of the current, thereby <br> accelerating the build-up of the <br> braking torque. | Reverse rotation may result <br> depending on the moment of inertia <br> of the mechanical load and the <br> coupling mechanism. |

Tip It is also possible to use an external digital input signal as DC injection braking command (DCBRK).
When a DC injection braking command (DCBRK) is turned on, DC injection braking takes place as long as (DCBRK) is on, regardless of the setting of the braking time F22. Also, even while the inverter is in stopped state, DC injection braking takes place when (DCBRK) is turned on. This allows the motor to be excited before starting, resulting in smoother acceleration (quicker build-up of acceleration torque).

In general, specify data of the function code F20 at a value close to the rated slip frequency of motor. If you set it at an extremely high value, control may become unstable and an overvoltage alarm may result in some cases.

## $\triangle$ CAUTION

The DC injection brake function of the inverter does not provide any holding mechanism. Injuries could occur.

## Starting Frequency

## Stop Frequency

At the startup of an inverter, the initial output frequency is equal to the starting frequency. The inverter stops its output at the stop frequency.
Set the starting frequency to a level that will enable the motor to generate enough torque for startup. Generally, set the motor's rated slip frequency at the starting frequency F23.

- Data setting range: 0.0 to $60.0(\mathrm{~Hz})$ (for both starting and stop frequencies)

If the starting frequency is lower than the stop frequency, the inverter will not output any power as long as the frequency command does not exceed the stop frequency.


## Motor Operation Sound (Carrier frequency)

 Refer to H 98.
## Motor Operation Sound (Tone)

- Motor operation sound (Carrier frequency) (F26)

F26 controls the carrier frequency so as to reduce a sound noise generated by the motor or inverter itself, and to decrease a leakage current from the main output (secondary) wirings.

| Carrier frequency <br> should be between: | Inverter rated capacity: 0.75 to 22 kW | 0.75 kHz and 15 kHz |
| :--- | :--- | :--- |
|  | Inverter rated capacity: 30 to 75 kW | 0.75 kHz and 10 kHz |
|  | Inverter rated capacity: 90 to 500 kW | 0.75 kHz and 6 kHz |
| Motor sound noise emission | The higher the less. |  |
| Motor temperature (due to harmonics components) | The higher the less. |  |
| Output current waveform | The higher the better. |  |
| Leakage current | The lower the less. |  |
| Electromagnetic noise emission | The lower the less. |  |
| Inverter loss | The lower the less. |  |

If you specify the carrier frequency too low, the output current waveform tends to have a large amount of ripples (many harmonics components). As a result, the motor loss increases, causing the motor temperature to rise. Furthermore, the large amount of ripples tends to cause a current limiting alarm. Therefore, if you have set the carrier frequency below 1 kHz , reduce the load so that the inverter output current is $80 \%$ or less of the rated current.
If you specify the carrier frequency too high, when the temperature of inverter increases by ambient temperature rise or an increase of the load, a function that automatically decreases the carrier frequency, and prevents inverter overheat alarm
 automatically reduce the carrier frequency in consideration of the motor noise, you can disable automatic reduction of carrier frequency. Refer to function code H98.

## ■ Motor operation sound (Tone) (F27)

Changes the motor running sound tone. This setting is effective when the carrier frequency set to function code F26 is 7 kHz or lower. Changing the tone level may reduce the high and harsh running noise from the motor.

| Data for F27 | Function |
| :---: | :---: |
| 0 | Disable (Tone level 0) |
| 1 | Enable (Tone level 1) |
| 2 | Enable (Tone level 2) |
| 3 | Enable (Tone level 3) |

If the sound level is set too high, the output current may become unstable, or mechanical vibration and noise may increase. Also, these function codes may not be very effective for certain types of motor.

Terminal [FMA] (Analog output) (Selection)
Terminal [FMA] (Analog output) (Voltage adjust)

## Terminal [FMA] (Analog output) (Function)

These function codes allow you to output to terminal [FMA] monitored data such as the output frequency and the output current in the form of an analog DC voltage or current. The magnitude of such analog voltage or current is adjustable.

■ Terminal [FMA] (Analog output) (F29)
Specifies the property of the output to terminal [FMA]. You need to set the switch SW4 on the control printed circuit board (PCB) again accordingly, referring to the table below.

| Data for F29 | Output form | Positioning slide switch (SW4) mounted on the <br> control PCB |
| :---: | :---: | :--- |
| 0 | Voltage (0 to 10 VDC) | VO |
| 1 | Current (4 to 20 mADC$)$ | IO |

The current output is not isolated from the analog input and does not have its own independent power source. Therefore, this output must not be connected in cascade to outside instrument and gauges if some difference in potential is there between the inverter and peripheral equipment regarding connection of analog input etc. Avoid needlessly long wiring.

## ■ Voltage adjust (F30)

Allows you to adjust the output voltage or current representing the monitored data selected by function code F31 within the range of 0 to $200 \%$.

- Data setting range: 0 to 200 (\%)


Function (F31)
This function specifies what is output to the analog output terminal [FMA].

| $\begin{aligned} & \text { Data for } \\ & \text { F31 } \end{aligned}$ | [FMA] output | Function (Monitor the following) | Monitoring amount (Full scale at 100\%) |
| :---: | :---: | :---: | :---: |
| 0 | Output frequency | Output frequency of the inverter | Maximum frequency (F03) |
| 2 | Output current | Output current (RMS) of the inverter | Twice the inverter rated current |
| 3 | Output voltage | Output voltage (RMS) of the inverter | 250 V for 200 V series, 500 V for 400 V series |
| 4 | Output torque | Motor shaft torque | Twice the rated motor torque |
| 5 | Load factor | Load factor (Equivalent to the indication of the load meter) | Twice the rated motor load, or <br> - Rated output torque of the motor at the base frequency or below <br> - Rated motor output (kW) at the base frequency or above |
| 6 | Input power | Input power of the inverter | Twice the rated output of the inverter |
| 7 | PID feedback value (PV) | Feedback value under PID control | 100\% of the feedback value |
| 9 | DC link bus voltage | DC link bus voltage of the inverter | 500 V for 200 V series, 1000 V for 400 V series |
| 10 | Universal AO | Command via communications link (Refer to the RS485 Communications User's Manual (MEH448a)) | 20,000 as $100 \%$ |
| 13 | Motor output | Motor output (kW) | Twice the rated motor output |
| 14 | Calibration analog output (+) | Full scale output of the meter calibration | 10 VDC or 20 mA DC |
| 15 | PID process command (SV) | Process command under PID control | 100\% of the feedback value |
| 16 | PID process output (MV) | Output level of the PID controller under PID control (Frequency command) | Maximum frequency (F03) |

## Terminal [FMP] (Pulse output) (Duty)

## Terminal [FMP] (Pulse output) (Function)

These function codes allow you to output to terminal [FMP] monitored data such as the output frequency and the output current in the form of a variable rate pulse train or a fixed rate pulse train. The fixed rate ( 2 kpps ) pulse train whose pulse duty control produces variance of an average output voltage of the train can be used to drive an analog meter.
You can set the specification of the output pulse for each item of the monitored data (object).
To use this terminal as a pulse output, set function code F33 to an appropriate value and set F34 to "0".
To use this terminal as the fixed rate pulse train output, set F34 within the range of 1 to $200 \%$. The setting of F33 will be ignored.

## - Pulse rate (F33)

Specifies the number of pulses at which the output of the set monitored item reaches $100 \%$, in accordance with the specifications of the counter to be connected.

- Data setting range: 25 to 6000 (pps)

■ Duty (F34)

| Data for F34 | [FMP] output | Pulse duty | Pulse rate | Connected equipment <br> (Example) |
| :---: | :--- | :--- | :--- | :--- |
| 0 | Pulse train | Around $50 \%$ | Variable | Pulse counter |
| 1 to $200 \%$ | Fixed rate pulse train | Variable | 2000 pps | Analog meter |

F34 allows you to scale the average voltage corresponding to full scale of the monitored item selected by function code F35 within the range of 1 to $200(\%)$ where $100 \%$ stands on a half cycle of a square wave pulse in the train.


- Pulse train output waveform

- FMP output circuit


LD. For the voltage specifications of the pulse output, refer to Chapter 8 "SPECIFICATIONS."

- Function (F35)

Select the item (object) to monitor and to output to the [FMP] terminal. Those contents, and amounts (Definition of $100 \%$ ) are the same as those for function code F31. Refer to the table in function code F31.

Refer to the descriptions of function codes F09.

When the output current of the inverter exceeds the level specified by the current limiter (F44), the inverter automatically manages its output frequency to prevent a stall and to limit the output current.
If F43 $=1$, the current limiter is enabled only during constant speed operation. If F43 $=2$, the current limiter is enabled during both of acceleration and constant speed operation. Choose F43 $=1$ if you need to run the inverter at full capability during acceleration and to limit the output current during constant speed operation.

■ Operation selection (F43)
Selects the motor running state in which the current limiter will be active.

| Data for F43 | Function |
| :---: | :--- |
| 0 | Disable (No current limiter is active.) |
| 1 | Enable the current limiter during constant speed operation |
| 2 | Enable the current limiter during acceleration and constant speed operation |

## ■ Operation level (F44)

Selects the operation level at which the current limiter will be active.

- Data setting range: 20 to 120 (\%) (Percentage ratio to rated current of the inverter)
- Since the current limit operation with F43 and F44 is performed by software, it may cause a delay in control. If you need a quick response, specify a current limit operation by hardware $(\mathrm{H} 12=1)$ at the same time.
- If an excessive load is applied when the current limiter operation level is set extremely low, the inverter will immediately lower its output frequency. This may cause an overvoltage trip or dangerous turnover of the motor rotation due to undershooting.


### 9.2.2 E codes (Extension terminal functions)

Function codes E01 to E05, E98 and E99 allow you to assign commands to terminals [X1] to [X5], [FWD], and [REV] which are general-purpose programmable input terminals.
These function codes may also switch the logic system between normal and negative to define how the inverter logic interprets either ON or OFF status of each terminal. The default setting is normal logic system "Active ON." So, explanations that follow are given in normal logic system "Active ON."

## $\triangle C A U T I O N$

In the case of digital input, you can assign commands to the switching means for the run command and its operation, the reference frequency and the motor drive power (e.g., (SS1), (SS2), (SS4), (Hz2/Hz1), (SW50), (SW60), (Hz/PID), (IVS), (LE), (LOC), and (FR2/FR1)). Be aware of that switching of any of such signals may cause a sudden start (running) or an abrupt change in speed

An accident or physical injury may result.

| Function code data |  | Assigned terminal command | Symbol |
| :---: | :---: | :---: | :---: |
| Active ON | Active OFF |  |  |
| 0 | 1000 | Select multistep frequency | (SS1) |
| 1 | 1001 |  | (SS2) |
| 2 | 1002 |  | (SS4) |
| 6 | 1006 | Enable 3-wire operation | (HLD) |
| 7 | 1007 | Coast to a stop | (BX) |
| 8 | 1008 | Reset alarm | (RST) |
| 1009 | 9 | Enable external alarm trip | (THR) |
| 11 | 1011 | Switch reference frequency $2 / 1$ | (Hz2/Hz1) |
| 13 | - | DC injection brake | (DCBRK) |
| 15 | - | Switch to commercial power ( 50 Hz ) | (SW50) |
| 16 | - | Switch to commercial power ( 60 Hz ) | (SW60) |
| 17 | 1017 | UP (Increase output frequency) | (UP) |
| 18 | 1018 | DOWN (Decrease output frequency) | (DOWN) |
| 19 | 1019 | Enable write from keypad (Data changeable) | (WE-KP) |
| 20 | 1020 | Cancel PID control | (Hz/PID) |
| 21 | 1021 | Switch normal/inverse operation | (IVS) |
| 22 | 1022 | Interlock | (IL) |
| 24 | 1024 | Enable communications link via RS485 or field bus (option) | (LE) |
| 25 | 1025 | Universal DI | (U-DI) |
| 26 | 1026 | Select auto sync search mode | (STM) |
| 1030 | 30 | Force to stop | (STOP) |
| 33 | 1033 | Reset PID integral and differential components | (PID-RST) |
| 34 | 1034 | Hold PID integral component | (PID-HLD) |
| 35 | 1035 | Select local (keypad) operation | (LOC) |
| 38 | 1038 | Enable to run | (RE) |
| 39 | - | Protect motor from dew condensation | (DWP) |
| 40 | - | Enable integrated sequence to switch to commercial power ( 50 Hz ) | (ISW50) |
| 41 | - | Enable integrated sequence to switch to commercial power ( 60 Hz ) | (ISW60) |
| 87 | 1087 | Switch run command 2/1 | (FR2/FR1) |
| 88 | - | Run forward 2 | (FWD2) |
| 89 | - | Run reverse 2 | (REV2) |
| 98 | - | Run forward (Exclusively assigned to [FWD] and [REV] terminals by E98 and E99) | (FWD) |
| 99 | - | Run reverse (Exclusively assigned to [FWD] and [REV] terminals by E98 and E99) | (REV) |

For the functions having " - " under the Data: Active OFF column, you cannot specify any negative logic (Active off) command.
For "External alarm" and "Forced to stop," fail-safe settings are selected by default. For example, in External alarm, when data = "9," "Active OFF" (alarm is triggered when OFF); when data $=1009$, "Active ON" (alarm is triggered when ON).

## Terminal function assignment and data setting

■ Assignment of multistep frequency (1 to 7 steps) - (SS1), (SS2), and (SS4)
(Function code data $=0,1$, and 2)
Combination of turning digital input signals (SS1), (SS2), and (SS4) on and off selects one of eight different frequency commands defined beforehand by seven function codes C05 to C11 (Multistep frequency 1 to 7 ). With this, the inverter can drive the motor at 8 different preset speeds.
The table below lists the frequencies that can be obtained by the combination of switching (SS1), (SS2), and (SS4). In the "Selected frequency" column, "Other than multistep frequency" represents the reference frequency commanded by the frequency command 1 (F01), frequency command $2(\mathrm{C} 30)$, or others. For details, refer to the block diagram in Chapter 4, Section 4.2 "Drive Frequency Command Generator."

| Terminal [X3] <br> (Function code E03) | Terminal [X2] <br> (Function code E02) | Terminal [X1] <br> (Function code E01) | Selected frequency |
| :---: | :---: | :---: | :---: |
| 2 (SS4) | 1 (SS2) | 0 (SS1) |  |
| OFF | OFF | OFF | Other than multistep <br> frequency |
| OFF | OFF | ON | C05 (Multistep frequency 1) |
| OFF | ON | OFF | C06 (Multistep frequency 2) |
| OFF | ON | ON | C07 (Multistep frequency 3) |
| ON | OFF | OFF | C08 (Multistep frequency 4) |
| ON | OFF | ON | C09 (Multistep frequency 5) |
| ON | ON | OFF | C10 (Multistep frequency 6) |
| ON | ON | ON | C11 (Multistep frequency 7) |

■ Assignment of 3-wire operation command -- (HLD)
(Function code data $=6$ )
The (HLD) terminal command self-holds the forward (FWD) or reverse (REV) run command issued with it, to enable 3-wire inverter operation.
Short-circuiting the terminals between the (HLD)-assigned and [CM] (i.e., when (HLD) is on) will self-hold the first (FWD) or (REV) command at its leading edge. Turning (HLD) off will release the self-holding.

When (HLD) is not assigned, 2-wire operation involving only (FWD) and (REV) takes effect.


■ Assignment of coast-to-stop command -- (BX)
(Function code data $=7$ )
Short-circuiting the terminals between the (BX)-assigned and [CM] will immediately shutdown the inverter output so that the motor will enter the coast-to-stop operation without issuing any alarms.

Assignment of reset alarm -- (RST) (Function code data $=8$ )
Turning (RST) on clears the (ALM) state - alarm output (for any fault). Turning it off thereafter erases the alarm display and clears the alarm hold state.
When you turn on the (RST) command, keep it on for 10 ms or more. The (RST) command should be kept off for the normal inverter operation.


■ Assignment of trip command from external equipment -- (THR)
(Function code data $=9$ )
Turning (THR) OFF causes the inverter output to be immediately shut down (the motor will
 be output. This signal is self-held, and is reset when the alarm reset takes place.

Tip
Trip command from external equipment is used when you have to immediately shut down the inverter output in the event of an abnormal situation in a peripheral equipment.

- Assignment of switch the reference frequency $2 / 1$-- (Hz2/Hz1)
(Function code data $=11$ )
Turning the digital input signal $(\mathrm{Hz2} / \mathrm{Hz1})$ on and off switches the source of the reference frequency between the frequency command 1 (Hz1: F01) and frequency command 2 (Hz2: C30).
Turning the $(\mathrm{Hz} 2 / \mathrm{Hz1})$ command on allows you to run the inverter with the reference frequency 2 from the frequency command 2.
If you have not made an assignment of code data 11, the frequency specified by F01 becomes effective by default.

| Frequency command <br> $(\mathrm{Hz2} / \mathrm{Hz1})$ | Frequency command source |
| :---: | :---: |
| OFF | Follow F01: Frequency command 1 |
| ON | Follow C30: Frequency command 2 |

For details of the relationship with other frequency command sources, refer to Chapter 4, Section 4.2 "Drive Frequency Command Generator."

## - Assignment of DC injection braking command -- (DCBRK)

(Function code data $=13$ )
A digital input signal supplied from outside becomes the DC injection braking command (DCBRK). When (DCBRK) is turned ON, DC injection braking takes place as long as (DCBRK) is ON, regardless of the setting of the DC injection braking time. Furthermore, when (DCBRK) is turned ON while the inverter is in stopped state, DC injection braking takes place. This allows the motor to be excited before startup, resulting in smoother acceleration (quicker build-up of acceleration torque).

You also need to set, using F20 to F22 and H95, parameters for DC injection braking (starting frequency, braking level, braking time, and braking response mode) properly.

- Assignment of switch to commercial power command for 50 Hz (SW50) or 60 Hz (SW60)
(Function code data $=15,16$ )
When an external sequence switches the motor drive power from the commercial lines to the inverter according to the operation scheme shown on the next page, the terminal command (SW50) or (SW60) enables the FRENIC-Eco inverter to start running the motor with the current commercial power frequency, regardless settings of the reference/output frequency in the inverter. A running motor driven by commercial power is carried on into inverter operation. This command helps you smoothly switch the motor drive power source from the commercial power to the inverter power. For details, refer to the table below, the operation scheme and an example of an external sequence and its operation time scheme on the next following pages.

| Assignment | The inverter: | Description |
| :---: | :---: | :---: |
| (SW50) | Starts at 50 Hz. | Do not concurrently assign both <br> (SW50) and (SW60). |
| (SW60) | Starts at 60 Hz. |  |

<Operation scheme>

- When the motor speed remains almost the same during coast-to-stop:

- When the motor speed decreases significantly during coast-to-stop:

- Secure more than 0.1 second before turning ON the Run command after turning on the Switch to commercial power frequency command.
- Secure more than 0.2 second of overlapping between the Switch to commercial power frequency command being ON and the Run command being ON.
- If an alarm has been issued or $(\mathrm{BX})$ has been ON when the motor drive source is switched from the commercial power to the inverter, the inverter will not be started at the commercial power frequency and will remain OFF. After the alarm has been reset or (BX) turned OFF, operation at the frequency of the commercial power will not be continued, and the inverter will be started at the ordinary starting frequency.
If you wish to switch the motor drive source from the commercial line to the inverter, be sure to turn (BX) OFF before the Switch to commercial line command is turned OFF.
- If you wish to switch the motor drive source from the inverter to commercial power, adjust the inverter's reference frequency at or slightly higher than that of the commercial power frequency beforehand, taking into consideration the motor speed down during coast-to-stop period during the switching.
- Note that when the motor drive source is switched from the inverter to the commercial power, a large rush current will be generated, because the phase of the commercial power usually does not match the motor speed at the switching. Make sure that the power supply and all the peripheral equipment are capable of withstanding this rush current.
- If you have already selected auto-restart after a recovery from momentary power failure ( $\mathrm{F} 14=3,4$, or 5), keep (BX) ON during operation by commercial power, to prevent the inverter from entering the auto-restart after momentary power failure mode.
<Example of sequence circuit>


## Main power supply



Note 1) Emergency switch

- Manual switch provided for the event that the motor drive source cannot be switched normally to the commercial power due to a serious problem of the inverter.
Note 2) When any alarm has occurred inside the inverter, the motor drive source will automatically be switched to the commercial power.
<Example of operation time scheme>


Alternatively, you may use the integrated sequence by which some of the actions above are automatically performed by the inverter itself. For details, refer to the description of (ISW50) and (ISW60).

■ Assignment of UP command (UP) and DOWN command (DOWN)
(Function code data $=17,18$ )

- Frequency setting

When UP/DOWN control is selected for a frequency command source and the Run command is ON, turning (UP) or (DOWN) on causes the output frequency to increase or decrease within the range of 0 Hz to the maximum frequency as shown below.

| Data $=17$ | Data $=18$ | Function |
| :---: | :---: | :--- |
| (UP) | (DOWN) |  |
| OFF | OFF | Keep the current output frequency. |
| ON | OFF | Increase the output frequency over the acceleration time <br> specified by function code F07. |
| OFF | ON | Decrease the output frequency over the deceleration time <br> specified by function code F08. |
| ON | ON | Keep the current output frequency. |

In UP/DOWN control, the inverter saves the output frequency in its internal memory. Thus, the inverter will start control at the frequency that has been saved in the last operation when operation is resumed (including restart by power on). Refer to the timing scheme diagram shown below and table on the next page, for details of this operation.

Note
If you issue an (UP) or (DOWN) command before the internal frequency arrives up to the current reference frequency previously commanded, during the restart cycle, then the inverter saves the output frequency at the time of the (UP) or (DOWN) command issued in its internal memory, and starts UP/DOWN control with reference to this new frequency. This means that the previous frequency originally saved is overwritten and is lost.


Initial settings of UP/DOWN control when the source of the frequency command is switched:
When the frequency command source is switched to UP/DOWN control from other sources, the initial frequency of UP/DOWN control are as follows:

| Frequency command <br> source | Switching command | Initial frequency of UP/DOWN <br> control |
| :--- | :--- | :--- |
| Other than UP/DOWN <br> (F01, C30) | Reference frequency <br> 2/Reference frequency 1 <br> (Hz 2/Hz 1) | Reference frequency given by the <br> frequency command source just <br> before switching |
| Local (keypad) | Local (Select the keypad) <br> (LOC) | Digital frequency command given by <br> keypad |
| PID conditioner | Cancel PID control <br> (Hz/PID) | Reference frequency given by PID <br> control (PID processor output) |
| Multistep frequency | Multistep frequency <br> command (SS1) to (SS4) | Reference frequency at the time of <br> previous UP/DOWN control |
| Communications link | Enable communications <br> link (LE) |  |

To enable the UP command (UP) and the DOWN command (DOWN), you need to select Frequency command source 1 (F01) or Frequency command 2 (C30) at " 7 " beforehand.

- PID process command

While UP/DOWN control is selected as the PID process command, turning (UP) or (DOWN) ON when the Run command is ON causes the process command to change within the range of 0 to $100 \%$.

The setting is enabled in units of the process amount according to the PID display coefficients.

| $(\mathrm{UP})$ | $(\mathrm{DOWN})$ | Function |
| :---: | :---: | :--- |
| Data $=17$ | Data $=18$ |  |
| OFF | OFF | Retain the current process command |
| ON | OFF | Increase the process command at a rate between $0.1 \% / 0.1 \mathrm{~s}$ <br> and $1 \% / 0.1 \mathrm{~s}$. |
| OFF | ON | Decrease the process command at a rate between $0.1 \% / 0.1$ <br> s and $1 \% / 0.1 \mathrm{~s}$. |
| ON | ON | Retain the current process command |

The process command specified by UP/DOWN control is internally retained. At the time of restart (including power on), the operation resumes with the previous process command.

To enable the UP command (UP) and the DOWN command (DOWN), you need to set the Remote Process command $(\mathrm{J} 02=4)$ beforehand.

For details of PID control, refer to Chapter 4, Section 4.9, "PID Frequency Command Generator" and Section 9.2.6, "J Codes."

For details of displaying the PID process command, refer to the descriptions of function codes E40 and E41: PID Display Coefficients A and B.

- Assignment of Enable Editing of Function Code Data from the Keypad -- (WE-KP) (Function code data $=19$ )
Turning off the (WE-KP) command disables changing of function code data from the keypad.
Only when the (WE-KP) command is ON, you can change function code data from the keypad according to the setting of function code F00 as listed below.

| (WE-KP) | F00 | Function |
| :---: | :---: | :--- |
| OFF | Disable | Disable editing of all function code data except that of F00. |
| ON | 0 | Enable editing of all function code data |
|  | 1 | Inhibit editing of all function code data except that of F00 |

If the (WE-KP) command is not assigned to any terminal, the inverter will interpret (WE-KP) to be always ON by default.

If you mistakenly assign (WE-KP) command to a terminal, you cannot edit or modify function code data anymore. In such a case, temporarily short-circuit (turn ON ) the (WE-KP)-assigned terminal to the terminal [CM], and then reassign the (WE-KP) command to a correct terminal.

■ Assignment of Cancel PID control -- (Hz/PID)
(Function code data $=20$ )
Turning the (Hz/PID) command ON disables the PID control.
If the PID control is disabled with the (Hz/PID) being ON, the inverter runs the motor with the reference frequency manually set by any of the multistep, keypad, analog input, etc.

| $(\mathrm{Hz} / \mathrm{PID})$ | Function |
| :---: | :---: |
| OFF | Enable PID control |
| ON | Disable PID control/Enable manual settings |

For details of PID control, refer to Chapter 4, Section 4.9, "PID Frequency Command Generator" and Section 9.2.6, "J Codes."

■ Assignment of Switch Normal/Inverse Frequency Command -- (IVS)
(Function code data $=21$ )
Turning the (IVS) command on/off switches the output frequency control between normal (proportional to the input value) and inverse in PID process control and manual frequency command. To select the inverse operation, turn the (IVS) command ON.


Switching between normal and inverse control of the output frequency is useful particularly for air-conditioners that are switched between cooling and heating. In cooling, the speed of the fan motor (output frequency of the inverter) is increased to lower the temperature. In heating, the speed of the fan motor (output frequency of the inverter) is reduced to lower the temperature. This switching is realized by the switch normal/inverse frequency command.

- When the inverter is driven by an external analog frequency command sources (terminals [12], [C1], and [V2])
The switching normal/inverse frequency command can apply only to the analog frequency command sources (terminals [12], [C1], and [V2]) in Frequency command 1 (F01) and does not affect Frequency command 2 (C30) or UP/DOWN control. The table below summarizes the combination of the setting of Selection of normal/inverse operation for the frequency command 1 (C53) and the Switch normal/inverse frequency command (IVS).

Selection of normal/inverse operation (Frequency command 1) (C53)

| Data for C53 | Rotation defined by C53 | (IVS) | Final rotation command |
| :---: | :---: | :---: | :---: |
| 0 | Normal | OFF | Normal |
|  |  | ON | Inverse |
| 1 | Inverse | OFF | Inverse |
|  |  | ON | Normal |

- In case process control is performed under the PID control facility integrated in the inverter:
During the mode in which process control is performed under the PID control function integrated in the inverter, the PID cancel command (Hz/PID) enables PID control (process is to be controlled by the PID processor) or disables PID control (process is to be controlled by the manually set frequency). For both cases, you can select normal or inverse operation by the combination of the Switch normal/inverse frequency command (IVS) and the Normal/inverse operation selection (Frequency command 1) (C53), or PID Control selection (J01). The normal or inverse operation can be determined as shown below.
- When PID control is enabled:

Normal/inverse operation selection for the PID processor output (reference frequency) follows.

| Mode selected for PID control (J01) | (IVS) | Rotation direction |
| :--- | :---: | :---: |
| 1: Enable PID process control (normal <br> operation) | OFF | Normal |
|  | ON | Inverse |
| 2: Enable PID process control (inverse <br> operation) | OFF | Inverse |
|  | ON | Normal |

- When PID control is disabled:

Normal/inverse operation selection for the manual reference frequency follows.

| Normal/inverse operation selection <br> (Frequency command 1) (C53) | (IVS) | Rotation direction |
| :---: | :---: | :---: |
| 0: Normal operation | - | Normal |
| 1: Inverse operation | - | Inverse |

In case process control is performed under the PID control facility integrated in the inverter, the Switch normal/inverse frequency command (IVS) is used to switch the output (frequency setting) of the PID processor between normal and inverse mode, and has no effect on any normal/inverse operation selection of the manual frequency setting.

For details of PID control, refer to Chapter 4, Section 4.9 "PID Frequency Command Generator" and Section 9.2.6 "J Codes."

■ Assignment of Interlock Command -- (IL)
(Function code data $=22$ )
In a configuration where a magnetic contactor is installed in the power output (secondary) circuit of the inverter, the detection feature of momentary power failure provided inside the inverter alone may not be able to accurately detect a momentary power failure. In such a configuration, you can ensure accurate detection of a momentary power failure by inputting a digital signal using the interlock command (IL).

| Interlock <br> command (IL) | Status |
| :---: | :--- |
| OFF | No momentary power failure has occurred. |
| ON | A momentary power failure has occurred <br> (Restart after a recovery from momentary power failure enabled) |

For details of operation after a recovery from momentary power failure, refer to the description of function code F14.

The inverter recognizes a momentary power failure by detecting an undervoltage condition whereby the voltage of the DC link bus goes below the lower limit. In a configuration where a magnetic contactor (MC) is installed on the secondary side of the inverter, however, the inverter may fail to recognize a momentary power failure because the momentary power failure may shutdown the exciter power for the magnetic contactor, which causes the contactor to open. When the contactor circuit is open, the inverter is cut off from the motor, and the voltage drop in the DC link bus is not high enough to be recognized as a power failure. In this case, the function of restart after a recovery from momentary power failure does not work properly as designed. To solve this problem, connect the interlock command (IL) line to the auxiliary contact of the magnetic contactor, so that a momentary power failure can sure be detected.


Assignment of Enable Communications Link -- (LE)
(Function code data $=24$ )
When (LE) is ON, the frequency command or the run command received via the RS485 communications link or the field bus (option) specified by the Communications link operation (Function selection) (H30) or the Bus link function for supporting data input (Function selection) (y98), takes precedence.
When (LE) is not assigned, the operation is the same as when (LE) is ON by default.
For details of switching, refer to H30 Communications Link Operation (Function selection) and y98 Bus Link Function for Supporting Data Input (Function selection).

■ Assignment of Universal DI -- (U-DI)
(Function code data $=25$ )
You can monitor digital signals of peripheral equipments of the inverter via an RS485 communications link or a field bus (option) by feeding them into the digital input terminals of the inverter. The signal assigned to the universal DI does not take part in the operation of the inverter, but it is simply monitored.

For an access to Universal DI via the RS485 or field bus communications link, refer to their respective Instruction Manuals.

## ■ Select Starting Characteristics -- (STM)

(Function code data $=26$ )
At the start, you can determine whether an idling motor is to be synchronized (an idling motor to be synchronized without stopping it) or not, using this terminal command.

DD
For details of synchronization of an idling motor, refer to H 09 (Start mode) and H17 Start mode (Synchronizing frequency).

Assignment of Forced to Stop -- (STOP) (Function code data $=30$ )
Turning the terminal command "STOP" OFF causes the motor to decelerate to stop over the time specified by H56 (Deceleration time for forced to stop). After the motor stops, the inverter enters the alarm state with alarm

■ Assignment of Reset PID differential/integral operation -- (PID-RST)
(Function code data $=33$ )
Turning (PID-RST) ON causes the delivative and integral components of the PID processor to be reset.

For details of PID control, refer to Chapter 4, Section 4.9 "PID Frequency Command Generator" and Section 9.2.6 "J Codes."

Assignment of Hold PID integral component -- (PID-HLD)
(Function code data $=34$ )
Turning (PID-HLD) ON holds the integral components of the PID processor.For details of PID control, refer to Chapter 4, Section 4.9 "PID Frequency Command Generator" and Section 9.2.6 "J Codes."

## ■ Assignment of Select the Local (Keypad) Operation -- (LOC)

(Function code data $=35$ )
This command helps you switch the source of the run command and frequency command between remote and local by an external digital input signal.

For details of the local mode, refer to " $\square$ Switching between remote and local modes" in Chapter 3, Section 3.2.3.

■ Assignment of Run Enable -- (RE)
(Function code data $=38$ )
If you assign the Run enable command (RE) to a digital input terminal, the inverter will not start operation unless receiving a Run command. When the inverter gets ready for operation after receiving the Run command, the inverter will output the digital signal (AX2) notifying the presence of a Run command. The inverter will be started once the Run command has been issued and the Run Enable command (RE) is turned ON.

| Input |  | Output | Inverter's operation |
| :---: | :---: | :---: | :---: |
| Run command <br> e.g., (FWD) | Run enable <br> command "RE" | "AX2" <br> (Run command <br> present) |  |
| OFF | OFF | OFF | Stopped |
| OFF | ON | OFF | Stopped |
| ON | OFF | ON | Running |
| ON | ON | ON |  |

<Usage example>
Listed below is a typical example of starting sequence:
(1) Run command "FWD" is issued to the inverter.
(2) Upon getting ready after receiving the Run command, the inverter issues the digital signal "AX2", notifying that a Run command is present.
(3) Upon receiving "AX2", the host equipment starts preparation of the peripheral devices such as opening the mechanical damper/brake.
(4) When the preparation of the peripheral devices is complete, the host equipment (controller or sequencer) issues the Run Enable command "RE" to the inverter.
(5) Upon receiving "RE", the inverter starts operation.

■ Assignment of Protect the motor from Dew Condensation -- (DWP) (Function code data $=39$ )
When "DWP" is turned ON, a DC current is fed to the motor while it is in stopped state, so that the heat generated by the current prevents dew condensation.

For details of dew condensation protection, refer to function code J21 (Dew Condensation Protection (Duty)).

■ Assignment of Enable integrated commercial power switching sequence ( 50 Hz ) -(ISW50),
integrated commercial power switching sequence ( 60 Hz ) -- (ISW60)
(Function code data $=40,41$ )
Assigning the terminal command (ISW50) or (ISW60) allows the magnetic contactor for switching the motor drive source between the commercial power and the inverter to be controlled by the integrated sequence.
This control is effective only when (ISW50) or (ISW60) is already assigned, and (SW88) and (SW52-2) used for switching from the commercial power to the inverter are also assigned to the digital output terminals.
The selection between (ISW50) and (ISW60) is determined by the frequency of the commercial power, that is, (ISW50) for 50 Hz , (ISW60) for 60 Hz .
For details of these commands, proceed to referring to the circuit diagrams and timing schemes on the following pages.

| Assignment | Operation (when switched from <br> commercial power to inverter) |
| :--- | :---: |
| Enable integrated commercial power switching sequence <br> $(50 \mathrm{~Hz})$ (ISW50) | Starts at 50 Hz. |
| Enable integrated commercial power switching sequence <br> $(60 \mathrm{~Hz})$ (ISW60) | Starts at 60 Hz. |

Do not assign both (ISW50) and (ISW60) at the same time. If you do, the result cannot be guaranteed.
<Circuit diagram and Configuration>



Configuration of control circuit

Summary of operation

| Input |  | Command status and inverter operation |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| (ISW50) or (ISW60) | Run command | (SW52-1) | (SW52-2) | (SW88) | Inverter operation |
| OFF <br> (Commercial power) | ON | OFF | OFF | ON | OFF |
|  | OFF |  |  | OFF |  |
| ON <br> (Inverter) | ON | ON | ON | OFF | ON |
|  | OFF |  |  |  | OFF |

$<$ Timing scheme>
Switching from inverter operation to commercial-power operation ((ISW50)/(ISW60): ON $\rightarrow$ OFF)
(1) The inverter output is shut off immediately (Power gate IGBT OFF)
(2) The inverter primary circuit (SW52-1) and the inverter secondary side (SW52-2) are turned off immediately.
(3) If a Run command is present after a lapse of t1 (time specified by function code $\mathrm{H} 13+$ 0.2 sec ), the commercial power circuit (SW88) is turned on .

Switching from commercial-power operation to inverter operation ((ISW50)/(SW60): OFF $\rightarrow \mathrm{ON}$ )
(1) The inverter primary circuit (SW52-1) is turned on immediately.
(2) The commercial power circuit (SW88) is immediately shut off,
(3) After a lapse of t2 (time required for the main circuit to get ready +0.2 sec ) after (SW52-1) is turned on, the inverter secondary circuit (SW52-2) is turned on.
(4) After a lapse of t 3 (time specified by function code H13 +0.2 sec ) after (SW52-2) is turned on, the inverter leads in the motor from the commercial-power operation, afterwards the motor returns to the operation by the inverter operation.

$\mathrm{t} 1: 0.2 \mathrm{sec}+$ time specified by H13 (Auto-restart wait time after a recovery from momentary power failure)
t2: time required for inverter to get ready +0.2 sec
t3: $0.2 \mathrm{sec}+$ time specified by H13 (Auto-restart wait time after a recovery from momentary power failure)
<Selection of the integrated commercial power switching sequence>
Function code J22 allows you to specify whether operation should automatically switched to commercial-power operation when an inverter alarm occurs.

| Data for J22 | Sequence (for occurrence of an alarm) |
| :---: | :--- |
| 0 | Stay with inverter-operation. (Inverter is stopped with an alarm.) |
| 1 | Automatically switch to commercial-power operation. |

- The sequence operates normally also even when (SW52-1) is not used and the main power of the inverter is supplied at all times.
- If you choose to use (SW52-1), be sure to connect the input terminals [R0] and [T0] for an auxiliary control power. Otherwise, when (SW52-1) is turned off, the control power is also lost.
- In general, the sequence circuit operates normally even if an alarm occurs in the inverter. If the inverter is broken, however, the sequence may not operate normally. Therefore, for a critical facility, be sure to install an emergency switching circuit outside the inverter.
- If you would turn on both the commercial-power-side contactor (SW88) and the contactor for the inverter output (secondary) side (SW52-2) simultaneously, you would be mistakenly supplying main power from the output (secondary) side of the inverter, which might cause damage to the inverter. Be sure to set up interlocking logic outside the inverter.
<Examples of sequence circuits>

1) Standard sequence

2) Sequence with an emergency switching function

3) Sequence with an emergency switching function --Part 2 (Automatic switching by the alarm output issued by the inverter)


■ Assignment of Switch the Run Command 2/Run command 1 -- (FR2/FR1),
Run forward command 2 (FWD2), and Run reverse command 2 (REV2)
(Function code data $=87,88$ or 89 )
Allow you to switch the source of the run command. This is particularly useful when run commands come either from the communications link or from the local keypad.

Refer to Chapter 4, Section 4.3 "Drive Command Generator" for details.

| Terminal command <br> "FR2/FR1" | Run command source |  |
| :---: | :--- | :--- |
|  | Communications link disabled <br> (Normal operation) | Communications link enabled |
| OFF | Follow the data of F02. | Follow <br> S06: FWD/REV |
| ON | (FWD2) or (REV2) | Follow <br> S06: FWD2/REV2 |

An inverter runs the motor forward if (FWD2) is turned on and decelerates-to-stop the motor if (FWD2) off.
An inverter runs the motor in reverse if (REV2) is turned on and decelerates-to-stop the motor if (REV2) off.

■ Assignment of Run Forward Command -- (FWD) (Function code data $=98$ )
If the (FWD) command is turned on, the inverter runs the motor forward and decelerates-to-stop the motor if (FWD) off.

The Run forward command (FWD) is only assigned by E98 or E99.

- Assignment of Run Reverse Command -- (REV)
(Function code data $=99$ )
If the (REV) is turned on, the inverter runs the motor in reverse; if off, it decelerates-to-stop the motor.


The Run reverse command (REV) is only assigned by E98 or E99.

## E20 to E22

Status Signal Assignment to Terminal [Y1] to [Y3]
(Transistor signal)
E24, E27
Status Signal Assignment to Terminal [Y5A/C] and [30A/B/C] (Relay contact signal)

Terminals [Y1], [Y2], [Y3], [Y5A/C], and [30A/B/C] are programmable, general-purpose output terminals to which you can assign functions using function codes E20, E21, E22, E24, and E27. By the selection of negative logic, you can also specify which of the ON and OFF states are to be regarded as active.
The factory default settings for these functions are "Active ON." Terminals [Y1], [Y2], and [Y3] are transistor outputs, whereas terminals [Y5A/C] and [30A/B/C] are relay contact outputs. In general, in normal logic, when the relay is energized upon alarm occurrence, terminals 30 A and 30 C are closed and terminals 30 B and 30 C are opened. In negative logic, when the relay is de-energized upon alarm occurrence, terminals 30 A and 30 C are opened and terminals 30 B and 30 C closed. Therefore, this negative logic is easily applied for a fail-safe purpose.

- When negative logic is employed, all signals become active (e.g. an alarm would be recognized) while the inverter is powered OFF. Therefore, it is recommendable to arrange for some interlocking outside the inverter as necessary, for example using the POWER ON signal. Furthermore, the validity of output signals is not guaranteed for approximately 2 seconds after power-on, and it is also recommendable to introduce a mechanism such that they will be ignored (masked) during this transient period.
- Relay outputs (terminals [Y5A/C] and [30A/B/C]) are mechanical outputs and cannot tolerate frequent ON/OFF switching. In case frequent switching (ON/OFF) is anticipated (for example, limiting a current by using signals subject to limit control in the inverter), use transistor outputs [Y1] through [Y3] instead. The life of a relay contact is approximately 200,000 times if it is switched on and off every second. For the signals that are turned on and off very frequently, use the transistor outputs.

The table below lists functions assigned to the terminals [Y1], [Y2], [Y3], [Y5A/C], and [30A/B/C].
To make the explanations simpler, the examples shown below are all written for the normal logic (Active ON.)

| Function code data |  | Function (command) assigned to the terminal | Symbol |
| :---: | :---: | :---: | :---: |
| Active ON | Active OFF |  |  |
| 0 | 1000 | Inverter running | (RUN) |
| 1 | 1001 | Frequency arrival signal | (FAR) |
| 2 | 1002 | Frequency detected | (FDT) |
| 3 | 1003 | Undervoltage detected (Inverter stopped) | (LU) |
| 5 | 1005 | Inverter output limiting (Current limiting) | (IOL) |
| 6 | 1006 | Auto-restarting after a recovery from momentary power failure | (IPF) |
| 7 | 1007 | Motor overload early warning | (OL) |
| 10 | 1010 | Inverter ready to run | (RDY) |
| 11 | - | Switch the motor drive source between commercial power and inverter output (For MC on the commercial line) | (SW88) |
| 12 | - | Switch the motor drive source between commercial power and inverter output (For the primary side) | (SW52-2) |
| 13 | - | Switch the motor drive source between commercial line and inverter output (For the secondary side) | (SW52-1) |
| 15 | 1015 | Select the AX terminal function (For MC on the primary side) | (AX) |
| 25 | 1025 | Cooling fan in operation | (FAN) |
| 26 | 1026 | Auto-resetting | (TRY) |
| 27 | 1027 | Universal DO enabled | (U-DO) |
| 28 | 1028 | Heat sink overheat early warning | (OH) |
| 30 | 1030 | Service life alarm | (LIFE) |
| 33 | 1033 | Command missing detected | (REF OFF) |
| 35 | 1035 | Inverter output on | (RUN2) |
| 36 | 1036 | Overload prevention control | (OLP) |
| 37 | 1037 | Current detected | (ID) |
| 42 | 1042 | PID alarm output | (PID-ALM) |
| 43 | 1043 | Under PID control | (PID-CTL) |
| 44 | 1044 | Motor stopping due to slow flowrate under PID control | (PID-STP) |
| 45 | 1045 | Low output torque detected | (U-TL) |
| 54 | 1054 | Inverter in remote operation | (RMT) |
| 55 | 1055 | Run command presence | (AX2) |
| 56 | 1056 | Motor overheat detection (PTC) | (THM) |
| 99 | 1099 | Alarm relay output (for any fault) | (ALM) |

A mark "-" in the Active OFF column means that you cannot apply a negative logic for the terminal function.

■ Assignment of Inverter Running (Presence of Speed) -- (RUN)
(Function code data $=0$ )
This output signal is used to notify the external equipment that the inverter is running at a starting frequency or higher. Its output is turned on when the inverter output frequency exceeds the starting frequency and turned off when the output frequency is less the stop frequency. The output is also turned off while the DC injection braking is activated. If this signal is assigned as "Active OFF," it can be used as a signal indicating "inverter in stopped state."

- Assignment of Frequency Arrival Signal -- (FAR) (Function code data = 1)
This signal is turned on when the difference between the inverter output frequency and the reference frequency comes into the allowable error zone. (prefixed to 2.5 Hz ).

■ Assignment of Frequency Detection -- (FDT) (Function code data $=2$ )
This signal is turned on when the inverter output frequency comes into the frequency detection level specified by function code E31 and turned off when the output frequency drops lower than the detection level minus 1 Hz (hysteresis band of the frequency comparator: prefixed at 1 Hz ).

■ Assignment of Undervoltage Detection -- (LU)
(Function code data $=3$ )
This signal is turned on when the DC link bus voltage of the inverter drops below the specified undervoltage. Even if a running command is given during undervoltage detection, the inverter cannot be operated. This signal is turned off if the DC link bus voltage exceeds the specified undervoltage level. When the undervoltage protective function is activated and the motor is in an abnormal stop sate (e.g.: tripped state), this signal is turned on.

■ Assignment of Inverter Output Limiting -- (IOL) (Function code data $=5$ )
This signal is turned on when the inverter is exerting control on the output frequency by taking one of the following actions (minimum width of the output signal: 100 ms ):

- Current limiting by software (F43: Current limiter (operation selection); F44: Current limiter (Operation level))
- Current limiting by hardware $(\mathrm{H} 12=1)$
- Automatic deceleration $(\mathrm{H} 69=3)$

Note that when the "inverter output limiting (current limiting)" signal (IOL) is ON, the output frequency may have deviated from (or dropped below) the frequency specified by the frequency command because of this limiting function.

## ■ Assignment of Auto-restart from Momentary Power Failure -- (IPF) (Function code data $=6$ )

This signal is turned on either while continuous running control is invoked after power failure, or during the period from when the inverter has detected an undervoltage condition and has shut down the output until restart has been complete (the output has reached the reference frequency). To enable the auto-restart after a recovery of momentary power failure (IPF), set F14 (Restart after momentary power failure) at 3 (Continuous running), 4 (Restart mode from power failure), or 5 (Restart at the starting frequency) beforehand.

- Assignment of Motor Overload Early Warning -- (OL) (Function code data $=7$ )
This signal is used to issue a motor overload early warning for enabling you to take corrective action before the inverter detects a motor overload alarm $i_{1 \prime \prime}^{\prime \prime \prime}$ 'and stops its output. Motor overload early warning is turned on when the current exceeds the level specified by E34 (Overload early warning). In general, set E34 for $80-90 \%$ of the level specified by F11 (Electronic thermal motor overload protection). Also specify the thermal characteristics of the motor with F10 (Select the motor property) and F12 (Thermal time constant).

Function code E34 is effective for not only the motor overload early warning (OL), but also for the operation level of the current detection (ID).

■ Assignment of Inverter Ready to Run -- (RDY)
(Function code data $=10$ )
This signal is turned on when hardware preparation such as initial charging up of DC link bus capacitor/s (reservoir capacitor/s) and initialization of the control circuit has been complete and no protective function activated so that the inverter has got ready to run.

■ Assignment of Switch Commercial Power/Inverter Operation -- (SW88), (SW52-2), and (SW52-1)
(Function code data $=11,12,13$ )
Upon receiving the terminal commands (ISW50) or (ISW60), the inverter controls the magnetic contactor for switching the motor drive source between the commercial power and the inverter output by means of the integrated sequence, using commands (WS52-2), (SW52-1) and (SW88) assigned to the transistor output terminals [Y3], [Y2] and [Y1] respectively e.g. For details, refer to the description and diagrams in the section of assignment of (ISW50) $(50 \mathrm{~Hz})$ and (ISW60) $(60 \mathrm{~Hz})$ to any terminals [X1] through [X5], [FWD] and [REV].

- Assignment of Select the AX Terminal Function -- (AX)
(Function code data $=15$ )
This signal controls the magnetic contactor on the commercial power supply side, in response to a run command, (FWD).
The signal turns on when the inverter receives a run command, and off after the motor has coasted-to-stop upon receiving a stop command. It turns off immediately when a coast-to-stop command is received or when an alarm occurs.

- Assignment of Cooling fan in operation -- (FAN)
(Function code data $=25$ )
When Cooling Fan ON/OFF control is enabled ( $\mathrm{H} 06=1$ ), this signal is turned on while the cooling fan is running and is off while it is stopped. This signal can be used to make the cooling system of peripheral equipment interlocked for an ON/OFF control.
■ Assignment of Auto-resetting -- (TRY) (Function code data $=26$ )
This signal is turned on while the retry function is in operation. The retry function is specified by H04 (Number of retries or resetting times) and H05 (Latency time or Reset interval). Refer to function codes H 04 and H 05 for details of the number of retries and output timing.

■ Assignment of Universal DO Enabled -- (U-DO)
(Function code data $=27$ )
Connect an inverter output terminal that Universal DO signal has been assigned to, to a digital input terminal of peripheral equipment via RS485 communications link or field bus. Consequently, you can allow the inverter to give commands to the peripheral equipment. Universal DO can be used as an output signal independent of the operation of the inverter.
DD] For the procedure for establishing access to Universal DO via the RS485 communications link or the field bus, refer to the respective Instruction Manual.

- Assignment of Heat Sink Overheat Early Warning--(OH)
(Function code data $=28$ )
This signal is turned on when the temperature of the heat sink of the inverter exceeds the threshold of the overheat trip ( $\stackrel{\prime \prime \prime \prime \prime \prime}{\prime \prime \prime}!$ temperature minus $5^{\circ} \mathrm{C}$ ) and is turned off when it drops
 can take necessary action before an overheat trip actually happens.
This signal is also turned on when the internal air circulation DC fan has locked for models of 45 kW or above ( 200 V series) or 55 kW or above ( 400 V series).

■ Assignment of Service Life Alarm -- (LIFE)
$($ Function code data $=30)$
This signal is turned on when it is judged that any of capacitors such as DC link bus capacitor/s (reservoir capacitor/s) and electrolytic capacitor/s on the printed circuit board and cooling fan has exceeded the service life judgment criteria.
This signal is also turned on when the internal air circulation DC fan has locked for models of 45 kW or above ( 200 V series) or 55 kW or above ( 400 V series).
This function provides tentative information for service life of the parts. If this signal is issued, check the service life of these parts in your inverter according to the normal maintenance procedure to determine whether the parts should be replaced or not. To maintain stable and reliable operation and avoid unexpected failures, daily and periodic maintenance must be performed.

For details, refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 7, Section 7.3, Table 7.3 "Criteria for Issuing a Lifetime Alarm."

■ Assignment of Command Loss Detected -- (REF OFF)
(Function code data $=33$ )
This signal is turned on when an analog input used as the frequency command source is in command loss state under some condition due to a broken wire or a weak connection, this signal is turned on upon detecting the state. The condition is defined by E65 (Command Loss detection (Level). This signal is turned off when the operation under the analog input used as the frequency command source is resumed.

For details of the command loss detection, refer to the descriptions of function code E65.

■ Assignment of Inverter Output On -- (RUN2)
(Function code data $=35$ )
This signal is turned on when the inverter is running at the starting frequency or below, or the DC injection braking is in operation.

■ Assignment of Overload Prevention Control -- (OLP) (Function code data $=36$ )
This signal is turned ON when the overload prevention control is activated. The minimum ON-duration is 100 ms .For details of the overload prevention control, refer to the descriptions of function code H70.

■ Assignment of Current Detection -- (ID)
(Function code data $=37$ )
This signal is turned on when the output current of the inverter has exceeded the level specified by E34 (Current Detection (Level)) longer than the period specified by E35 (Current Detection (Timer)), and is turned off when the output current drops below $90 \%$ of the rated operation level. (Minimum width (ON-duration) of the output signal: 100 ms )

Function code E34 is effective for not only the motor overload early warning (OL), but also for the operation level of the current detection (ID).
For details of current detection, refer to the descriptions of function code E34 and E35.
Assignment of PID Alarm output -- (PID-ALM)
(Function code data $=42$ )
Two types of alarm output concerning PID control are provided: absolute-value alarm and deviation alarm.

For details of PID alarm, refer to the descriptions of function codes J11 through J13.

- Assignment of PID Control Enabled -- (PID-CTL)
(Function code data $=43$ )
This signal is turned on when PID control is enabled (PID cancel command ( $\mathrm{Hz} / \mathrm{PID}$ ) $=\mathrm{OFF}$ ) and a Run command is ON.

The inverter may stop upon activation of slow flowrate stopping function or due to other reasons, even if PID control is enabled. Even in such cases, (PID-CTL) remains ON. As long as (PID-CTL) is ON, PID control is taking effect. Note that the inverter may abruptly resume its operation, depending on the feedback value in PID control.

## $\triangle$ WARNING

When PID control is enabled, the inverter may stop its output during operation because of sensor signals or for some other reasons. In such cases, operation will resume automatically.
Design your machinery so that safety is ensured even in such cases.

## Otherwise, an accident could occur.

For details of PID control, refer to the description of function codes J01 or later.

- Assignment of Motor Stopping due to Slow Flowrate under PID Control -- (PID-STP) $($ Function code data $=44)$
This signal is turned ON when the inverter is in stopped state due to slow flowrate during PID control.

■ Assignment of Low Output Torque Detected -- (LU-TL)
(Function code data $=45$ )
This signal is turned ON when the torque value calculated by the inverter has been below the level specified by E80 (Detect low torque (Detection level)) longer than the period specified by E81 (Detect low torque (Timer)). (Minimum width of the output signal: 100 ms )


For details of low output torque detection, refer to the description of function codes E80 and E81.

■ Assignment of Inverter in Remote Operation -- (RMT)
(Function code data $=54$ )
In Remote/Local switching, this signal is ON while the inverter is in the remote mode.


For details about switching between Remote and Local, refer to Chapter 3, Section 3.2.3 " Switching between remote and local modes."

■ Assignment of Run Command Presence -- (AX2) (Function code data $=55$ )
When the Run enable (RE) is assigned to a digital input terminal, the inverter cannot be started with a Run command alone. (AX2) should be turned on to indicate the presence of a Run command to notify the inverter is ready to run upon receipt of a Run command, for external control equipment. Once (RE) is issued in such a state, the inverter is started.


For details of the Run Enable (RE) and the Run command presence (AX2), refer to the description of $(\mathrm{RE})($ data $=38)$ for function codes E01 through E05.

■ Assignment of Motor Overheat Detection (PTC) -- (THM) (Function code data $=56$ )
This signal indicates that a temperature alarm condition has been detected by a PTC thermistor on the motor. You may have the option of continuing operation while detecting an



For details of the PTC thermistor, refer to the description of function codes H26 and H27.

- Assignment of Alarm Relay Contact Output (for any fault) -- (ALM) (Function code data $=99$ )
This signal is turned on if any of the protective functions is activated and the inverter enters Alarm mode.


## Frequency Detection (FDT) (Operation level)

■ Frequency Detection - (FDT)
When the output frequency has exceeded the frequency detection level specified by E31, the FDT signal goes on; when it has dropped below "the frequency detection level minus hysteresis (fixed at 1 Hz )," it goes off.
You need to assign (FDT) (Frequency detection: data $=2$ ) to one of digital output terminals.

- Data setting range: 0.0 to $120.0(\mathrm{~Hz})$



## Overload Early Warning/Current Detection (Level)

## Overload Early Warning/Current Detection (Timer)

These function codes specify, in conjunction with output terminal signals, (OL) and (ID), the level and duration of overload and current beyond which an early warning or an alarm will be issued.

## ■ Overload Early Warning

The warning signal (OL) is used to detect a symptom of an overload condition (alarm code I'III $_{\prime \prime \prime}^{\prime}$ ) of the motor so that the user can take an appropriate action before the alarm actually happens. The signal turns on when the current level specified by E34 (Overload early warning) is exceeded. In typical cases, set E34 to 80-90\% against data of F11 (Electronic thermal motor overload protection (Operation level)). Specify also the thermal characteristics of the motor with F10 (Electronic thermal motor overload protection (Select the motor property)) and F12 (Electronic thermal motor overload protection (Thermal time constant)). To utilize this feature, you need to assign (OL) (Motor overload early warning) (data =7) to any of the digital output terminals.

## ■ Current Detection

The signal (ID) turns on when the output current of the inverter has exceeded the level specified by E34 (Current detection (Level)) and the output current continues longer than the period specified by E35 (Current detection (Timer)). The signal turns off when the output current drops below $90 \%$ of the rated operation level. (Minimum width of the output signal: 100 ms )

To utilize this feature, you need to assign (ID) (Current detection) (data $=37$ ) to any of digital output terminals.


- Data setting range (E34): Current value of 1 to $150 \%$ of the rated inverter current in units of amperes. (0: disable)
- Data setting range (E35): 0.01 to 600.00 (sec.)


## PID Display Coefficient A

## PID Display Coefficient B

These function codes provide display coefficients to convert the PID process command, PID feedback value, or analog input monitor in easy-to-understand mnemonic physical quantities to display.

- Data setting range: -999 to 0.00 to 9990 for the display coefficients A and B.

■ Display Coefficients of PID Process Command and PID Feedback Value
The PID display coefficients A and B convert the PID process command and the PID feedback value into mnemonic quantities before they are displayed. E40 specifies the PID display coefficient A (display of the value at $100 \%$ of the PID process command or PID feedback value); and E41 specifies the PID display coefficient B (display of the value at $0 \%$ of the PID process command or PID feedback value).
The value displayed is determined as follows:
Value displayed $=(\mathrm{PID}$ process command or PID feedback value $(\%)) / 100 \times($ display coefficient A - B) + B


## - Example

You wish to maintain the pressure around 16 kPa (sensor voltage 3.13 V ) while the pressure sensor can detect $0-30 \mathrm{kPa}$ over the output voltage range of $1-5 \mathrm{~V}$.
Select the terminal [12] as the feedback terminal and set the gain to $200 \%$ so that 5 V corresponds to $100 \%$.
By setting:
"Display at $100 \%$ of PID process command \& PID feedback value $=$ Display coefficient E40 $=30.0 "$ and
"Display at $0 \%$ of PID process command \& PID feedback value $=$ Display coefficient E41 $=$ -7.5,"
you can have the monitor and the setting on the keypad of the value of the PID process command and PID feedback value recognized as the pressure.
If you wish to control the pressure at 16 kPa on the keypad, you set the value to 16.0 .


DD) For details of PID control, refer to the description of function codes J01 and later.
Dd For the method to display the PID process command and PID feedback value, refer to the description of function code E43.

## ■ Analog input monitor

By inputting analog signals from various sensors such as temperature sensors in air conditioners to the inverter, you can monitor the state of peripheral devices via the communications link. By using an appropriate display coefficient, you can also have various values converted into physical values such as temperature and pressure before being displayed.


To set up the analog input monitor, use function codes E61 through E63. Use E43 to choose the item to be displayed.

E43 specifies the monitoring item to be displayed on the LED monitor.

| Data for E43 | The LED monitor <br> displays: | Description |
| :---: | :--- | :--- |
| 0 | Speed monitor | Selected by the sub item of function code E48 |
| 3 | Output current | Inverter output current expressed in RMS (A) |
| 4 | Output voltage | Inverter output voltage expressed in RMS (V) |
| 8 | Calculated torque | Output torque of the motor (\%) |
| 9 | Input power | Inverter's input power (kW) |
| 10 | PID process command <br> value (frequency) * | Refer to function codes E40 and E41. |
| 12 | PID feedback value * | Refer to function codes E40 and E41. |
| 14 | PID output value * | $100 \%$ at Maximum frequency |
| 15 | Load factor | Inverter's load factor (\%) |
| 16 | Motor output | Motor output (kW) |
| 17 | Analog input (Monitor) | Refer to function codes E40 and E41 |

* If 0 (Disable) is set for function code J01, "- - - -" appears on the LED monitor.

Selecting the speed monitor in E43 allows you to select a speed-monitoring format determined by E48 (: LED Monitor (Speed Monitor Item)) to display a speed.
Define the speed-monitoring format on the LED monitor as shown in the table below.

| Data for E48 | Display format of the sub item: |  |
| :---: | :--- | :--- |
| 0 | Output frequency | Expressed in Hz |
| 3 | Motor speed in $\mathrm{r} / \mathrm{min}$ | $120 \div$ Number of poles $(\mathrm{P} 01) \times$ frequency $(\mathrm{Hz})$ |
| 4 | Load shaft speed in <br> $\mathrm{r} / \mathrm{min}$ | Coefficient for speed display $(\mathrm{E} 50) \times$ Frequency $(\mathrm{Hz})$ |
| 7 | Display speed in \% | $100 \%$ at Maximum output frequency $(\mathrm{F03})$ |

## LCD Monitor (Item selection)

E45 specifies the mode of the LCD display during Running mode using the multi-function keypad.

| Data for E45 | What is displayed: |
| :---: | :--- |
| 0 | Running status, direction of rotation, operation guide |
| 1 | Output frequency, output current, calculated torque in bar graphs |

Example of display for $\mathrm{E} 45=0$ (during running)


Full-scale values on bar charts

| Item displayed | Full scale |
| :---: | :--- |
| Output frequency | Maximum frequency (F03) |
| Output current | Inverter's rated current $\times 200 \%$ |
| Calculated torque | Motor's rated torque $\times 200 \%$ |

        LCD Monitor (Language selection)
    E46 specifies the language of display on the multi-function keypad as follows:

| Data for E46 | Language |
| :---: | :--- |
| 0 | Japanese |
| 1 | English |
| 2 | German |
| 3 | French |
| 4 | Spanish |
| 5 | Italian |

## LCD Monitor (Contrast control)

Adjusts the contrast of the LCD monitor on the multi-function keypad as follows:

| Data for E47 | $0,1,2,3,4,5,6,7,8,9,10$ |  |
| :---: | :--- | :--- |
| Contrast | Less $\longleftrightarrow$ High |  |

## LED Monitor (Speed monitor item)

Refer to E43.
For how to set E48: LED Monitor (Speed monitor item), refer to the description of function code E43.

## Coefficient for Speed Indication

Use this coefficient for displaying the load shaft speed on the LED monitor (refer to function code E43).

- Load shaft speed

The load shaft speed is displayed as E50 (Coefficient for speed indication) $\times$ frequency $(\mathrm{Hz})$.

## Display Coefficient for Input Watt-hour Data

Use this coefficient (multiplication factor) for displaying the input watt-hour data ( $\left(\begin{array}{c}\prime \\ \hline\end{array}\right.$ a part of maintenance information on the keypad.

The input watt-hour data will be displayed as follows:
E51 (Coefficient for input watt-hour data) $\times$ input watt-hour $(\mathrm{kWh})$

Setting E51 $=0.000$ clears the input watt-hour and its data to " 0 ." If the setting E51 $=0.000$ remains, accumulators cannot start counting. After clearing them, restore the setting of E51 for the previous display coefficient.

For the procedure for viewing maintenance information, refer to Chapter 3 "OPERATION USING THE KEYPAD."

## Keypad（Menu display mode）

E52 specifies the menu display mode on the standard keypad as shown in the table below．

| Menu \＃ | Menu | $\begin{gathered} \text { LED } \\ \text { monitor } \\ \text { shows: } \end{gathered}$ | Main functions |  |
| :---: | :---: | :---: | :---: | :---: |
| 0 | ＂Quick Setup＂ |  | Displays only basic function codes to customize the inverter operation． |  |
| 1 | ＂Data Setting＂ | $11_{-}$ | F codes <br> （Fundamental functions） | Selecting each of these function codes enables its data to be displayed／changed． |
|  |  | ILE－ | E codes <br> （Extension terminal functions） |  |
|  |  | IL＇－ | C codes <br> （Control functions of frequency） |  |
|  |  | $11_{1}$ | P codes <br> （Motor parameters） |  |
|  |  | I．1－1＿ | $\begin{aligned} & \text { H codes } \\ & \text { (High performance } \\ & \text { functions) } \end{aligned}$ |  |
|  |  | ＇，＇1＇－ | J codes （Application functions） |  |
|  |  | $!⿳ 亠 口 冋$ | y codes（Link functions） |  |
|  |  | ！ロ1－－ | o code（Optional function） （Note） |  |
| 2 | ＂Data Checking＂ | E，－－M | Displays only function codes that have been changed from their factory defaults．You can refer to or change those function code data． |  |
| 3 | ＂Drive Monitoring＂ | F7， | Displays the running information required for maintenance or test running． |  |
| 4 | ＂I／O Checking＂ | ケ！ィーロ | Displays external interface information． |  |
| 5 | ＂Maintenance Information＂ | S．1ヶH1发 | Displays maintenance information including accumulated run time． |  |
| 6 | ＂Alarm <br> Information＂ | S．1＇1／ | Displays the latest four alarm codes．You can refer to the running information at the time when the alarm occurred． |  |
| 7 | ＂Data Copying＂ | イ1，イトローシ | Allows you to read or write function code data，as well as verifying it． |  |

（Note）An o code appears only when any option is mounted on the inverter．For details，refer to the instruction manual of the corresponding option．
（D）For details of each menu item，refer to Chapter 3，＂OPERATION USING THE KEYPAD．＂

The setting of function code E52 determines the menu to be displayed as follows：

| Data for E52 | Mode | Menu to be displayed |
| :---: | :--- | :--- |
| 0 | Function code data editing mode | Menu \＃0，Menu \＃1，and Menu \＃7 |
| 1 | Function code data check mode | Menu \＃2 and Menu \＃7 |
| 2 | Full－menu mode | Menu \＃0 through \＃7 |

The multi－function keypad always displays all the menu items regardless of the setting of this function．Additional menu items are included on the multi－function keypad．

## Analog Input for Terminal [12] (Extension function selection)

## Analog Input for Terminal [C1] (Extension function selection)

## Analog Input for Terminal [V2] (Extension function selection)

E61, E62, and E63 define the function of the terminals [12], [C1], and [V2], respectively. There is no need to set up these terminals if they are to be used for frequency command sources.

| Data for E61, E62, or E63 | Input assigned to [12], [C1] and [V2]: | Description |
| :---: | :---: | :---: |
| 0 | None | -- |
| 1 | Auxiliary frequency command 1* | Auxiliary frequency input to be added to the reference frequency given by Frequency command 1 (F01). Will not be added to any other reference frequency given by such as Frequency command 2 and Multistep frequency commands. |
| 2 | Auxiliary frequency command 2* | Auxiliary frequency to be added to all reference frequencies given by Frequency command 1, Frequency command 2, Multistep frequency commands, etc. |
| 3 | PID process command 1 | Inputs process command sources such as temperature and pressure under PID control. You also need to set function code J02. |
| 5 | PID feedback value | Inputs feedback values such as temperature and pressure under PID control. |
| 20 | Analog signal input monitor | By inputting analog signals from various sensors such as the temperature sensors in air conditioners to the inverter, you can monitor the state of external devices via the communications link. By using an appropriate display coefficient, you can also have various values to be converted into physical values such as temperature and pressure before being displayed. |

* For details, refer to Chapter 4, Section 4.2 "Drive Frequency Command Generator."

If these terminals have been set up to have the same data, the operation priority is

## Note

 given in the following order:E61 > E62 > E63

## Saving Digital Reference Frequency

E64 specifies how to save the reference frequency specified in digital formats by the © keys on the keypad as shown in the table below.

| Data for E64 | How to save the reference frequency: |
| :---: | :--- |
| 0 | The reference frequency will be automatically saved when the main power is <br> turned off. At the next power-on, the inverter will start at the reference <br> frequency at the time of the previous power-off of the main power supply. |
| 1 | The reference frequency is to be saved by pressing the key. If the control <br> power is turned off before you press the <br> next power-on, the inverter will start at the reference frequency saved when <br> you pressed the the the last. |

## Command Loss Detection (Level)

When the analog frequency command (by frequency setting through terminals [12], [C1], and [V2]) has dropped below $10 \%$ of the expected frequency command within 400 ms , the inverter presumes that the analog frequency command wire has been broken and continues its operation at the frequency determined by the ratio specified by E65 to the reference frequency. When the frequency command level (in voltage or current) returns to a level higher than that specified by E65, the inverter presumes that the broken wire has been fixed and continues to run following the frequency command.


In the diagram above, fl is the level of the analog frequency command sampled at any given time. The sampling is repeated at regular intervals to continually monitor the wiring connection of the analog frequency command.

[^43]
## Detect Low Torque (Detection level)

## Detect Low Torque (Timer)

The signal (U-TL) turns on when the torque calculated by the inverter with reference to its output current has dropped below the level specified by E80 (Detect low torque (Detection level)) for the time longer than the period specified by E81 (Detect low torque (Timer)). The signal turns off when the calculated torque exceeds the level specified by E80 $+5 \%$. (Minimum width of output signal: 100 ms )
You need to assign (U-TL) (Low output torque detection) (data $=45$ ) to the general-purpose output terminals.


The operation level is set so that $100 \%$ corresponds to the rated torque of the motor.
In the inverter's low frequency operation, as substantial error in torque calculation occurs, low torque cannot be detected. (In this case, the result of recognition before entering this operation range is retained.)
The low torque detection signal (U-TL) turns off when the inverter is stopped..
Since the motor parameters are used in the calculation of torque, it is recommended that you perform auto-tuning using by function code P04 to achieve higher accuracy.

## Command Assignment to Terminal [REV]

(Refer to E01 to E05.)
For details of the command assignment to terminals [FWD] and [REV], refer to the descriptions for function codes E01 to E05.

### 9.2.3 C codes (Control functions of frequency)

## C01 to C03

## Jump Frequency 1, 2 and 3

## Jump Frequency Band

These function codes enable the inverter to jump over three different points on the output frequency in order to skip resonance caused by the motor running frequency and natural frequency of the driven machinery.

- While you are increasing the reference frequency, the moment the reference frequency reaches the bottom of the jump frequency band, the inverter keeps the output at that bottom frequency. When the reference frequency exceeds the upper limit of the jump frequency band, the internal reference frequency takes on the value of the reference frequency. When you are decreasing the reference frequency, the situation will be reversed.
- When the more than two jump frequency bands overlap, the inverter actually takes the lowest frequency within the overlapped bands as the bottom frequency and the highest as the upper limit. Refer to the figure on the lower right.

- Jump frequencies 1, 2 and 3 (C01, C02 and C03)

Specify the center of the jump frequency band.

- Data setting range: 0.0 to $120.0(\mathrm{~Hz})$ (Setting at 0.0 results in no jump band)
- Jump frequency band (C04)

Specify the jump frequency band.

- Data setting range: 0.0 to $30.0(\mathrm{~Hz})$ (Setting to 0.0 results in no jump band)


## C05 to C11

## Multistep Frequency 1 to 7

These function codes specify 7 frequencies required for driving the motor at frequencies 1 to 7 .
Turning terminal commands (SS1), (SS2) and (SS4) ON/OFF selectively switches the reference frequency of the inverter in 7 steps. For details of the terminal function assignment, refer to the descriptions for function codes E01 to E05 " Terminal Command Assignment to [X1] to [X5]."

- Data setting range: 0.00 to $120.00(\mathrm{~Hz})$

The combination of (SS1), (SS2), and (SS3) and the selected frequencies are as follows.

| (SS4) | (SS2) | (SS1) | Selected frequency command |
| :---: | :---: | :---: | :---: |
| OFF | OFF | OFF | Other than multistep frequency * |
| OFF | OFF | ON | C05 (multistep frequency 1) |
| OFF | ON | OFF | C06 (multistep frequency 2) |
| OFF | ON | ON | C07 (multistep frequency 3) |
| ON | OFF | OFF | C08 (multistep frequency 4) |
| ON | OFF | ON | C09 (multistep frequency 5) |
| ON | ON | OFF | C10 (multistep frequency 6) |
| ON | ON | ON | C11 (multistep frequency 7) |

* "Other than multistep frequency" means any other frequency command sources than multistep frequency command sourced by the frequency command 1 (F01) and frequency command 2 (C30).

To use these features, you need to assign multistep frequency selections (SS1), (SS2), and (SS4) (data $=0,1,2)$ to the digital input terminals.

For the relationship between multistep frequency operation and other frequency commands, refer to Chapter 4, Section 4.2 "Drive Frequency Command Generator."

■ To enable PID control ( $\mathrm{J} 01=1$ or 2 ):
You can set the process command in PID control as the preset value (multistep frequency 1). You can also use multistep frequency (multistep frequency 3) for manual speed command during disabling of PID control $((\mathrm{Hz} / \mathrm{PID})=\mathrm{ON})$.

- Process Command

| (SS4) | (SS2) | (SS1) | Frequency Command |
| :---: | :---: | :---: | :---: |
| OFF | - | - | Process command by J02 |
| ON | - | - | Multistep frequency by C08 |

You can set C 08 in increments of 1 Hz . The following formula can be used to convert a value of the process command to the C08 data and vice versa:
C08 data $=$ Process command (\%) $\times$ Maximum frequency $($ F03 $) \div 100$

- Manual speed command

| $(\mathrm{SS} 4)$ | $(\mathrm{SS} 2)$ | (SS1) | Selected frequency |
| :---: | :---: | :---: | :---: |
| - | OFF | OFF | Other than multistep frequency |
| - | OFF | ON | C05 (multistep frequency 1) |
| - | ON | OFF | C06 (multistep frequency 2) |
| - | ON | ON | C07 (multistep frequency 3) |

For PID process commands, refer to the block diagram in Chapter 4, Section 4.9, "PID Frequency Command Generator."

Frequency Command 2
(Refer to F01.)
For details of the frequency command 2, refer to the description for function code F01.


For details of the analog input commands, refer to the description for function code F18.

## Analog Input Adjustment for Terminal [C1] (Filter time constant)

## Analog Input Adjustment for Terminal [V2] (Filter time constant)

These function codes provide the filter time constants for the voltage and current of the analog input at terminals [12], [C1], and [V2]. Choose appropriate values for the time constants considering the response speed of the mechanical system as large time constants slow down the response. In case the input voltage fluctuates because of noise, specify large time constants.

- Data setting range: 0.00 to 5.00 (sec.)

Bias Reference Point (Frequency command 1)
(Refer to F18.)
For details of setting the bias reference point for the frequency command 1 , refer to the descriptions of function code F18.

## Bias (PID command 1)

Bias reference point (PID command 1)
These function codes specify the bias and bias reference point of the analog PID process command 1 to enable defining arbitrary relationship between the analog input and PID process commands.

The actual setting is the same as that of function code F18. For details, refer to the description of function code F18.

Note that function codes C32, C34, C37, C39, C42, and C44 are shared by the frequency commands.

- Bias (C51)
- Data setting range: - 100.00 to 100.00 (\%)
- Bias reference point (C52)
- Data setting range: 0.00 to 100.00 (\%)

Selection of Normal/Inverse Operation (Frequency command souce1)
C53 switches the reference frequency given by Frequency command 1 (F01) or the manual frequency command source under PID control between normal and inverse.
DD) For details, refer to the description of Switch normal/inverse command (IVS) (data = 21) for function codes E01 through E05.

### 9.2.4 P codes (Motor parameters)

P01 specifies the number of poles of the motor. Enter the value shown on the nameplate of the motor. This setting is used to display the motor speed on the LED monitor (refer to function code E43). The following formula is used for the conversion:

$$
\text { Motor speed }(\mathrm{r} / \mathrm{min})=\frac{120}{\text { No. of poles }} \times \text { Frequency }(\mathrm{Hz})
$$

## Motor (Capacity)

P02 specifies the rated capacity of the motor. Enter the rated value shown on the nameplate of the motor.

| Data for P02 | Unit | Dependency on function code P99 |
| :--- | :--- | :--- |
| 0.01 to 1000 | kW | $\mathrm{P} 99=0,3$ or 4 |
|  | HP | $\mathrm{P} 99=1$ |

## P03

## Motor (Rated current)

P03 specifies the rated current of the motor. Enter the rated value shown on the nameplate of the motor.

- Data setting range: 0.00 to 2000 (A)

Motor (Auto-tuning)
This function automatically detects the motor parameters and saves them in the inverter's internal memory. Basically, you do not need to perform tuning if you use a Fuji standard motor with a standard connection with the inverter.

In any of the following cases, you may not obtain the best performance under auto torque boost, torque calculation monitoring, or auto energy saving operation, by default settings, since the motor parameters are different from that of Fuji standard motors. In such a case, perform auto tuning.

- The motor to be driven is made by other manufacturer or is a non-standard motor.
- Cabling between the motor and the inverter is long.
- A reactor is inserted between the motor and the inverter.

For details of auto tuning, refer to the FRENIC-Eco Instruction Manual
(INR-SI47-0882-E), Chapter 4, Section 4.1.3 "Preparation before running the motor for a test-Setting function code data."

## Motor (No-load current)

Motor (\%R1)
Motor (\%X)
These function codes specify no load current, $\%$ R1, and $\% \mathrm{X}$. Obtain the appropriate values from the test report of the motor or by calling the manufacturer of the motor. If you perform auto tuning, these parameters are automatically set as well.

- No load current: Enter the value obtained from motor manufacturer.
- \%R1: Enter the value calculated by the following formula:

$$
\% \mathrm{R} 1=\frac{\mathrm{R} 1+\text { Cable } \mathrm{R} 1}{\mathrm{~V} /(\sqrt{3} \times \mathrm{I})} \times 100(\%)
$$

where,
R1: primary resistance of the motor $(\Omega)$
Cable R1: resistance of the output cable ( $\Omega$ )
V : rated voltage of the motor $(\mathrm{V})$
I: rated current of the motor (A)

- $\% \mathrm{X}$ : Enter the value calculated by the following formula:
$\% \mathrm{X}=\frac{\mathrm{X} 1+\mathrm{X} 2 \times \mathrm{XM} /(\mathrm{X} 2+\mathrm{XM})+\text { Cable } \mathrm{X}}{\mathrm{V} /(\sqrt{3} \times \mathrm{I})} \times 100(\%)$
where,
X1: primary leakage reactance of the motor $(\Omega)$
X2: secondary leakage reactance of the motor (converted to primary) ( $\Omega$ )
XM: exciting reactance of the motor $(\Omega)$
Cable X: reactance of the output cable $(\Omega)$
V : rated voltage of the motor $(\mathrm{V})$
I: rated current of the motor (A)

[^44]Motor Selection
P99 specifies the motor to be used.

| Data for P99 |  |
| :---: | :--- |
| 0 | Fuji standard motors (8-series) |
| 1 | GE motors |
| 3 | Fuji standard motors (6-series) |
| 4 | Other motors |

Automatic control such as auto-torque boost and auto-energy saving or motor overload protection (electronic thermal motor overload protection) uses the motor parameters and characteristics. To match the property of a control system with that of the motor, select characteristics of the motor, and set H03 Data initializing at " 2 " to initialize the old motor parameters stored in the inverter. When initialization is complete, data of $\mathrm{P} 03, \mathrm{P} 06, \mathrm{P} 07$, and P08 and the old related internal data is automatically updated.

For P99, enter the following data according to the motor type.

- Fuji standard 8-series motors (Current standard): P99 $=0$ (Characteristics 1)
- Fuji standard 6-series motors (Conventional standard): P99 = 3 (Characteristics 2)
- Other manufacturer's or unknown motors: P99 $=4$ (Others)
- If you choose P99 = 4 (Others), the inverter runs following the motor characteristics of Fuji standard 8 -series.
- The inverter also supports motors rated by HP (horse power: typical in North America, P99 = 1).


### 9.2.5 H codes (High performance functions)

## Data Initializing

H03 initializes the current function code settings to the factory defaults or initializes the motor parameters.

To change the H 03 data, it is necessary to press and $\widehat{\odot}$ keys or and simultaneously.

| Data for H03 | Function |
| :---: | :--- |
| 0 | Disable initialization <br> (Settings manually made by the user will be retained.) |
| 1 | Initialize all function code data to the factory defaults |
| 2 | Initialize the motor parameters in accordance with P02 (rated capacity) and <br> P99 (motor selection). <br> Function codes subject to initialization: P01, P03, P06, P07, and P08, <br> including the internal control constants <br> These function codes will be initialized to the values listed in tables on the <br> following pages. |

- To initialize the motor parameters, set the related function codes as follows.

1) P02 Motor (Rated capacity):
2) P99 Motor Selection:
3) H03 Data Initializing:
4) P03 Motor (Rated current): data differs from the rated current printed on the nameplate of the motor.

- Upon completion of the initialization, the data of function code H 03 is reset to " 0 " (default setting).
- If a capacity other than that of applicable motor rating is set at P 02 , the capacity will be internally converted to the applicable motor rating (see the table on the following pages).

■ When Fuji standard 8-series motors $(P 99=0)$ or other motors $(P 99=4)$ are selected, the motor parameters for P02 through P08 are as listed in following tables.

200 V series motors shipped for Japan

| Applicable motor rating ( kW ) | Motor capacity (kW) P02 | $\begin{gathered} \text { Rated } \\ \text { current (A) } \\ \text { P03 } \end{gathered}$ | No-load current (A) P06 | $\begin{aligned} & \text { \%R } \\ & \text { (\%) } \\ & \text { P07 } \end{aligned}$ | $\begin{aligned} & \text { \%X } \\ & \text { (\%) } \\ & \text { P08 } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0.01 to 0.09 | 0.06 | 0.44 | 0.40 | 13.79 | 11.75 |
| 0.10 to 0.19 | 0.1 | 0.68 | 0.55 | 12.96 | 12.67 |
| 0.20 to 0.39 | 0.2 | 1.30 | 1.06 | 12.95 | 12.92 |
| 0.40 to 0.74 | 0.4 | 2.30 | 1.66 | 10.20 | 13.66 |
| 0.75 to 1.49 | 0.75 | 3.60 | 2.30 | 8.67 | 10.76 |
| 1.50 to 2.19 | 1.5 | 6.10 | 3.01 | 6.55 | 11.21 |
| 2.20 to 3.69 | 2.2 | 9.20 | 4.85 | 6.48 | 10.97 |
| 3.70 to 5.49 | 3.7 | 15.0 | 7.67 | 5.79 | 11.25 |
| 5.50 to 7.49 | 5.5 | 22.5 | 11.0 | 5.28 | 14.31 |
| 7.50 to 10.99 | 7.5 | 29.0 | 12.5 | 4.50 | 14.68 |
| 11.00 to 14.99 | 11 | 42.0 | 17.7 | 3.78 | 15.09 |
| 15.00 to 18.49 | 15 | 55.0 | 20.0 | 3.25 | 16.37 |
| 18.50 to 21.99 | 18.5 | 67.0 | 21.4 | 2.92 | 16.58 |
| 22.00 to 29.99 | 22 | 78.0 | 25.1 | 2.70 | 16.00 |
| 30.00 to 36.99 | 30 | 107 | 38.9 | 2.64 | 14.96 |
| 37.00 to 44.99 | 37 | 130 | 41.5 | 2.76 | 16.41 |
| 45.00 to 54.99 | 45 | 156 | 47.5 | 2.53 | 16.16 |
| 55.00 to 74.99 | 55 | 190 | 58.6 | 2.35 | 16.20 |
| 75.00 to 89.99 | 75 | 260 | 83.2 | 1.98 | 16.89 |
| 90.00 to 109.99 | 90 | 310 | 99.2 | 1.73 | 16.03 |
| 110.00 or above | 110 | 376 | 91.2 | 1.99 | 20.86 |

400 V series motors shipped for Japan

| Applicable motor rating ( kW ) | Motor capacity (kW) P02 | $\begin{gathered} \text { Rated } \\ \text { current (A) } \\ \text { P03 } \end{gathered}$ | No-load current (A) P06 | $\begin{aligned} & \text { \%R } \\ & \text { (\%) } \\ & \text { P07 } \end{aligned}$ | $\begin{aligned} & \text { \%X } \\ & \text { (\%) } \\ & \text { P08 } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0.01 to 0.09 | 0.06 | 0.22 | 0.20 | 13.79 | 11.75 |
| 0.10 to 0.19 | 0.10 | 0.35 | 0.27 | 12.96 | 12.67 |
| 0.20 to 0.39 | 0.20 | 0.65 | 0.53 | 12.95 | 12.92 |
| 0.40 to 0.74 | 0.4 | 1.15 | 0.83 | 10.20 | 13.66 |
| 0.75 to 1.49 | 0.75 | 1.80 | 1.15 | 8.67 | 10.76 |
| 1.50 to 2.19 | 1.5 | 3.10 | 1.51 | 6.55 | 11.21 |
| 2.20 to 3.69 | 2.2 | 4.60 | 2.43 | 6.48 | 10.97 |
| 3.70 to 5.49 | 3.7 | 7.50 | 3.84 | 5.79 | 11.25 |
| 5.50 to 7.49 | 5.5 | 11.5 | 5.50 | 5.28 | 14.31 |
| 7.50 to 10.99 | 7.5 | 14.5 | 6.25 | 4.50 | 14.68 |
| 11.00 to 14.99 | 11 | 21.0 | 8.85 | 3.78 | 15.09 |
| 15.00 to 18.49 | 15 | 27.5 | 10.0 | 3.25 | 16.37 |
| 18.50 to 21.99 | 18.5 | 34.0 | 10.7 | 2.92 | 16.58 |
| 22.00 to 29.99 | 22 | 39.0 | 12.6 | 2.70 | 16.00 |
| 30.00 to 36.99 | 30 | 54.0 | 19.5 | 2.64 | 14.96 |
| 37.00 to 44.99 | 37 | 65.0 | 20.8 | 2.76 | 16.41 |
| 45.00 to 54.99 | 45 | 78.0 | 23.8 | 2.53 | 16.16 |
| 55.00 to 74.99 | 55 | 95.0 | 29.3 | 2.35 | 16.20 |
| 75.00 to 89.99 | 75 | 130 | 41.6 | 1.98 | 16.89 |
| 90.00 to 109.99 | 90 | 155 | 49.6 | 1.73 | 16.03 |
| 110.00 to 131.99 | 110 | 188 | 45.6 | 1.99 | 20.86 |
| 132.00 to 159.99 | 132 | 224 | 57.6 | 1.75 | 18.90 |
| 160.00 to 199.99 | 160 | 272 | 64.5 | 1.68 | 19.73 |
| 200.00 to 219.99 | 200 | 335 | 71.5 | 1.57 | 20.02 |
| 220.00 to 249.99 | 220 | 365 | 71.8 | 1.60 | 20.90 |
| 250.00 to 279.99 | 250 | 415 | 87.9 | 1.39 | 18.88 |
| 280.00 to 314.99 | 280 | 462 | 93.7 | 1.36 | 19.18 |
| 315.00 to 354.99 | 315 | 520 | 120 | 0.84 | 16.68 |
| 355.00 to 399.99 | 355 | 580 | 132 | 0.83 | 16.40 |
| 400.00 to 449.99 | 400 | 670 | 200 | 0.62 | 15.67 |
| 450.00 to 529.99 | 450 | 770 | 270 | 0.48 | 13.03 |
| 530.00 or above | 530 | 880 | 270 | 0.53 | 13.05 |

■ When Fuji standard 6-series motors $(\mathrm{P99}=3)$ is selected, the motor parameters for P02 through P08 are as listed in following tables.

Note
The values below in the "Rated current" column are exclusively applicable to the four-pole Fuji standard motors rated for 200 V and 400 V at 50 Hz . Even if you use Fuji standard motors, when those base frequency, rated voltage, and the number of poles differ from the above mentioned, change the P03 data to the rated current shown on the motor's nameplate.
If you use non-standard or other manufacturer's motors, change the P03 data to the rated current printed on the motor's nameplate.

200 V series motors shipped for Japan

| Applicable motor rating ( kW ) | Motor capacity (kW) P02 | $\begin{gathered} \text { Rated } \\ \text { current (A) } \\ \text { P03 } \end{gathered}$ | No-load current <br> (A) <br> P06 | $\begin{aligned} & \% R \\ & (\%) \\ & \text { P07 } \end{aligned}$ | $\begin{aligned} & \text { \%X } \\ & \text { (\%) } \\ & \text { P08 } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0.01 to 0.09 | 0.06 | 0.44 | 0.40 | 13.79 | 11.75 |
| 0.10 to 0.19 | 0.1 | 0.68 | 0.55 | 12.96 | 12.67 |
| 0.20 to 0.39 | 0.2 | 1.30 | 1.00 | 12.61 | 13.63 |
| 0.40 to 0.74 | 0.4 | 2.30 | 1.56 | 10.20 | 14.91 |
| 0.75 to 1.49 | 0.75 | 3.60 | 2.35 | 8.67 | 10.66 |
| 1.50 to 2.19 | 1.5 | 6.10 | 3.00 | 6.55 | 11.26 |
| 2.20 to 3.69 | 2.2 | 9.20 | 4.85 | 6.48 | 10.97 |
| 3.70 to 5.49 | 3.7 | 15.0 | 7.70 | 5.79 | 11.22 |
| 5.50 to 7.49 | 5.5 | 22.0 | 10.7 | 5.09 | 13.66 |
| 7.50 to 10.99 | 7.5 | 29.0 | 12.5 | 4.50 | 14.70 |
| 11.00 to 14.99 | 11 | 42.0 | 17.6 | 3.78 | 15.12 |
| 15.00 to 18.49 | 15 | 55.0 | 20.0 | 3.24 | 16.37 |
| 18.50 to 21.99 | 18.5 | 67.0 | 21.9 | 2.90 | 17.00 |
| 22.00 to 29.99 | 22 | 78.0 | 25.1 | 2.70 | 16.05 |
| 30.00 to 36.99 | 30 | 107 | 38.9 | 2.69 | 15.00 |
| 37.00 to 44.99 | 37 | 130 | 41.5 | 2.76 | 16.42 |
| 45.00 to 54.99 | 45 | 156 | 47.5 | 2.53 | 16.16 |
| 55.00 to 74.99 | 55 | 190 | 58.6 | 2.35 | 16.20 |
| 75.00 to 89.99 | 75 | 260 | 83.2 | 1.98 | 16.89 |
| 90.00 to 109.99 | 90 | 310 | 99.2 | 1.73 | 16.03 |
| 110.00 or above | 110 | 376 | 91.2 | 1.99 | 20.86 |

400 V series motors destined for Japan

| Applicable motor rating ( kW ) | Motor capacity (kW) P02 | $\begin{gathered} \text { Rated } \\ \text { current (A) } \\ \text { P03 } \end{gathered}$ | No-load current (A) P06 | $\begin{aligned} & \% R \\ & (\%) \\ & \text { P07 } \end{aligned}$ | $\begin{aligned} & \text { \%X } \\ & \text { (\%) } \\ & \text { P08 } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0.01 to 0.09 | 0.06 | 0.22 | 0.20 | 13.79 | 11.75 |
| 0.10 to 0.19 | 0.10 | 0.35 | 0.27 | 12.96 | 12.67 |
| 0.20 to 0.39 | 0.20 | 0.65 | 0.50 | 12.61 | 13.63 |
| 0.40 to 0.74 | 0.4 | 1.20 | 0.78 | 10.20 | 14.91 |
| 0.75 to 1.49 | 0.75 | 1.80 | 1.18 | 8.67 | 10.66 |
| 1.50 to 2.19 | 1.5 | 3.10 | 1.50 | 6.55 | 11.26 |
| 2.20 to 3.69 | 2.2 | 4.60 | 2.43 | 6.48 | 10.97 |
| 3.70 to 5.49 | 3.7 | 7.50 | 3.85 | 5.79 | 11.22 |
| 5.50 to 7.49 | 5.5 | 11.0 | 5.35 | 5.09 | 13.66 |
| 7.50 to 10.99 | 7.5 | 14.5 | 6.25 | 4.50 | 14.70 |
| 11.00 to 14.99 | 11 | 21.0 | 8.80 | 3.78 | 15.12 |
| 15.00 to 18.49 | 15 | 27.5 | 10.0 | 3.24 | 16.37 |
| 18.50 to 21.99 | 18.5 | 34.0 | 11.0 | 2.90 | 17.00 |
| 22.00 to 29.99 | 22 | 39.0 | 12.6 | 2.70 | 16.05 |
| 30.00 to 36.99 | 30 | 54.0 | 19.5 | 2.69 | 15.00 |
| 37.00 to 44.99 | 37 | 65.0 | 20.8 | 2.76 | 16.42 |
| 45.00 to 54.99 | 45 | 78.0 | 23.8 | 2.53 | 16.16 |
| 55.00 to 74.99 | 55 | 95.0 | 29.3 | 2.35 | 16.20 |
| 75.00 to 89.99 | 75 | 130 | 41.6 | 1.98 | 16.89 |
| 90.00 to 109.99 | 90 | 155 | 49.6 | 1.73 | 16.03 |
| 110.00 to 131.99 | 110 | 188 | 45.6 | 1.99 | 20.86 |
| 132.00 to 159.99 | 132 | 224 | 57.6 | 1.75 | 18.90 |
| 160.00 to 199.99 | 160 | 272 | 64.5 | 1.68 | 19.73 |
| 200.00 to 219.99 | 200 | 335 | 71.5 | 1.57 | 20.02 |
| 220.00 to 249.99 | 220 | 365 | 71.8 | 1.60 | 20.90 |
| 250.00 to 279.99 | 250 | 415 | 87.9 | 1.39 | 18.88 |
| 280.00 to 314.99 | 280 | 462 | 93.7 | 1.36 | 19.18 |
| 315.00 to 354.99 | 315 | 520 | 120 | 0.84 | 16.68 |
| 355.00 to 399.99 | 355 | 580 | 132 | 0.83 | 16.40 |
| 400.00 to 449.99 | 400 | 670 | 200 | 0.62 | 15.67 |
| 450.00 to 529.99 | 450 | 770 | 270 | 0.48 | 13.03 |
| 530.00 or above | 530 | 880 | 270 | 0.53 | 13.05 |

■ When HP motors (P99 = 1) is selected, the motor parameters for P02 through P08 are as listed in following tables.

The values below in the "Rated current" column are exclusively applicable to the four-pole Fuji standard motors rated for 200 V and 400 V at 50 Hz . If you use any of other voltage series, poles other than 4, non-standard or other manufacturer's motors, change the P03 data to its rated current printed on the motor's nameplate.

For 200 V series motors shipped for Japan

| Applicable motor rating (HP) | Motor capacity (HP) P02 | $\begin{gathered} \text { Rated } \\ \text { current (A) } \\ \text { P03 } \end{gathered}$ | No-load current <br> (A) <br> P06 | \%R <br> (\%) <br> P07 | $\begin{aligned} & \text { \%X } \\ & \text { (\%) } \\ & \text { P08 } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0.01 to 0.11 | 0.1 | 0.44 | 0.40 | 13.79 | 11.75 |
| 0.12 to 0.24 | 0.12 | 0.68 | 0.55 | 12.96 | 12.67 |
| 0.25 to 0.49 | 0.25 | 1.40 | 1.12 | 11.02 | 13.84 |
| 0.50 to 0.99 | 0.5 | 2.00 | 1.22 | 6.15 | 8.80 |
| 1.00 to 1.99 | 1 | 3.00 | 1.54 | 3.96 | 8.86 |
| 2.00 to 2.99 | 2 | 5.80 | 2.80 | 4.29 | 7.74 |
| 3.00 to 4.99 | 3 | 7.90 | 3.57 | 3.15 | 20.81 |
| 5.00 to 7.49 | 5 | 12.60 | 4.78 | 3.34 | 23.57 |
| 7.50 to 9.99 | 7.5 | 18.60 | 6.23 | 2.65 | 28.91 |
| 10.00 to 14.99 | 10 | 25.30 | 8.75 | 2.43 | 30.78 |
| 15.00 to 19.99 | 15 | 37.30 | 12.70 | 2.07 | 29.13 |
| 20.00 to 24.99 | 20 | 49.10 | 9.20 | 2.09 | 29.53 |
| 25.00 to 29.99 | 25 | 60.00 | 16.70 | 1.75 | 31.49 |
| 30.00 to 39.99 | 30 | 72.40 | 19.80 | 1.90 | 32.55 |
| 40.00 to 49.99 | 40 | 91.00 | 13.60 | 1.82 | 25.32 |
| 50.00 to 59.99 | 50 | 115.00 | 18.70 | 1.92 | 24.87 |
| 60.00 to 74.99 | 60 | 137.00 | 20.80 | 1.29 | 26.99 |
| 75.00 to 99.99 | 75 | 174.00 | 28.60 | 1.37 | 27.09 |
| 100.00 to 124.99 | 100 | 226.00 | 37.40 | 1.08 | 23.80 |
| 125.00 to 149.99 | 125 | 268.00 | 29.80 | 1.05 | 22.90 |
| 150.00 or above | 150 | 337.00 | 90.40 | 0.96 | 21.61 |

For 400 V series motors shipped for Japan

| Applicable motor <br> rating (HP) | Motor <br> capacity <br> (HP) <br> P02 | Rated <br> current (A) <br> P03 | No-load <br> current <br> (A) <br> P06 | \%R <br> $(\%)$ <br> P07 | \%X <br> (\%) <br> P08 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0.01 to 0.11 | 0.1 | 0.22 | 0.20 | 13.79 | 11.75 |
| 0.12 to 0.24 | 0.12 | 0.34 | 0.27 | 12.96 | 12.67 |
| 0.25 to 0.49 | 0.25 | 0.70 | 0.56 | 11.02 | 13.84 |
| 0.50 to 0.99 | 0.5 | 1.00 | 0.61 | 6.15 | 8.80 |
| 1.00 to 1.99 | 1 | 1.50 | 0.77 | 3.96 | 8.86 |
| 2.00 to 2.99 | 2 | 2.90 | 1.40 | 4.29 | 7.74 |
| 3.00 to 4.99 | 3 | 4.00 | 1.79 | 3.15 | 20.81 |
| 5.00 to 7.49 | 5 | 6.30 | 2.39 | 3.34 | 23.57 |
| 7.50 to 9.99 | 7.5 | 9.30 | 3.12 | 2.65 | 28.91 |
| 10.00 to 14.99 | 10 | 12.70 | 4.37 | 2.43 | 30.78 |
| 15.00 to 19.99 | 15 | 18.70 | 6.36 | 2.07 | 29.13 |
| 20.00 to 24.99 | 20 | 24.60 | 4.60 | 2.09 | 29.53 |
| 25.00 to 29.99 | 25 | 30.00 | 8.33 | 1.75 | 31.49 |
| 30.00 to 39.99 | 30 | 36.20 | 9.88 | 1.90 | 32.55 |
| 40.00 to 49.99 | 40 | 45.50 | 6.80 | 1.82 | 25.32 |
| 50.00 to 59.99 | 50 | 57.50 | 9.33 | 1.92 | 24.87 |
| 60.00 to 74.99 | 60 | 68.70 | 10.40 | 1.29 | 26.99 |
| 75.00 to 99.99 | 75 | 86.90 | 14.30 | 1.37 | 27.09 |
| 100.00 to 124.99 | 100 | 113.00 | 18.70 | 1.08 | 23.80 |
| 125.00 to 149.99 | 125 | 134.00 | 14.90 | 1.05 | 22.90 |
| 400.00 to 449.99 | 400 | 429.00 | 80.70 | 1.11 | 18.92 |
| 450.00 to 499.99 | 450 | 481.00 | 85.50 | 0.95 | 19.01 |
| 300.00 to 599.99 | 500 | 534.00 | 99.20 | 1.05 | 18.39 |
| 300.00 to 324.99 | 300 | 323.00 | 45.10 | 0.53 | 18.44 |
| 250.00 to 349.99 | 325 | 600 | 323.00 | 45.10 | 0.53 |

Auto－resetting（Times）

## Auto－resetting（Reset Interval）

While the auto－resetting feature is specified，even if protective functions subject to retry is activated and the inverter enters the forced to stop state（tripped state），the inverter will automatically attempt to reset the tripped state and restart without issuing an alarm（for any faults）．Once the inverter enters the alarm mode in excess of the times specified by the auto－resetting times H04，it will issue an alarm（for any faults）and not attempt to auto－reset the tripped state．

Listed below are the recoverable alarm statuses of the inverter．

| Alarm status | LED monitor displays： | Alarm status | LED monitor displays： |
| :---: | :---: | :---: | :---: |
| Instantaneous overcurrent protection |  | Motor overheated |  |
| Overvoltage protection |  | Motor overloaded | ill íl |
| Heat sink overheated | －111）！ | Inverter overloaded |  |
| Inverter overheated | －111イジ̇ |  |  |

## ■ Number of Resetting Times（H04）

Sets the number of auto－resetting＂retry＂times for automatic escaping the alarm mode．If the protective function is activated more than the specified resetting（retry）times，inverter enters the alarm mode，issues an alarm（for any faults）and not attempt to escape the alarm mode．
－Data setting range： 1 to 10 （times）（If＂ 0 ＂is set，the＂retry＂operation will not be activated．）

$$
\triangle \text { WARNING }
$$

If the＂retry＂function has been specified，the inverter may automatically restart and run the
motor stopped due to a trip fault，depending on the cause of the tripping．
Design the machinery so that human body and peripheral equipment safety is ensured even
when the auto－resetting succeeds．

## Otherwise an accident could occur．

## ■ Reset Interval (H05)

- Data setting range: 0.5 to 20.0 (sec.)

Sets the interval time to attempt performing auto-resetting the alarm mode (tripped state). Refer to the timing scheme diagram below.
<Operation timing scheme>

<Timing scheme for failed retry (No. of retry times: three)>


- The retry operation state can be monitored by external equipment via the inverter's output terminal [Y1] through [Y3], [Y5A/C], or [30A/B/C]. Set the data "26" of terminal function (TRY) in function codes E20 through E22, E24 and E27 to one of these terminals.


## Cooling Fan ON/OFF Control

To prolong the life of the cooling fan and to reduce fan noise during running, the cooling fan is stopped when the temperature inside the inverter drops below a certain level while the inverter is stopped. However, since frequent switching of the cooling fan shortens its life, it is kept running for 10 minutes once it is started.
This function code (H06: Cooling fan control) allows you to specify whether the cooling fan is to be kept running all the time or to be controlled ON/OFF.

| Data for H06 | Cooling fan ON/OFF: |
| :---: | :--- |
| 0 | Disable (Fan is always in operation) |
| 1 | Enable (ON/OFF controllable) |

## Acceleration/Deceleration Pattern

H07 specifies the acceleration and deceleration patterns (Patterns to control output frequency).

| Data for H07 | Accl./Decel. pattern |
| :---: | :--- |
| 0 | Default: Linear |
| 1 | S-curve (weak) |
| 2 | S-curve (strong) |
| 3 | Curvilinear |

## Linear acceleration/deceleration

The inverter runs the motor with the constant acceleration and deceleration.

## S-curve acceleration/deceleration

To reduce the impact on the inverter-driven motor and/or its mechanical load during acceleration/deceleration, the inverter gradually accelerates/decelerates the motor in both the acceleration/deceleration starting and ending zones. Two types of S-curve acceleration/deceleration are available; $5 \%$ (weak) and $10 \%$ (strong) of the maximum frequency, which are shared by the four inflection points. The acceleration/deceleration time command determines the duration of acceleration/deceleration in the linear period; hence, the actual acceleration/deceleration time is longer than the reference acceleration/deceleration time.


Acceleration/deceleration time
$<$ S-curve acceleration/deceleration (weak): when the frequency change is more than $10 \%$ of the maximum frequency>
Acceleration/deceleration time (s): $(2 \times 5 / 100+90 / 100+2 \times 5 / 100) \times($ reference acceleration or deceleration time) $=1.1 \times$ (reference acceleration or deceleration time)
$<$ S-curve acceleration/deceleration (strong): when the frequency change is more than $20 \%$ of the maximum frequency>
Acceleration/deceleration time (s): $(2 \times 10 / 100+80 / 100+2 \times 10 / 100) \times($ reference acceleration/deceleration time)
$=1.2 \times($ reference acceleration/deceleration time $)$

Curvilinear acceleration/deceleration
Acceleration/deceleration is linear below the base frequency (constant torque) but slows down above the base frequency to maintain a certain level of load factor (constant output).

This acceleration/deceleration pattern allows the motor to accelerate or decelerate with the maximum performance of the motor.


The figures at left show the acceleration characteristics. Similar characteristics apply to the deceleration.

Choose an appropriate acceleration/deceleration time considering the machinery's load torque.
For details, refer to Chapter 7 "SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES."

H 09 and H 17 specify the auto synch search start mode and its starting frequency respectively to synchronize and run the idling motor without stopping it.
The start mode can be also enabled by assigning the terminal command (STM) (Select start mode) to one of digital input terminals (E01 to E05: function code data $=26$ ). If no (STM) is assigned, the inverter interprets it as (STM) being on by default.

## Synchronizing an idling motor

When a run command is turned ON while (STM) is ON, the inverter starts the auto sync search operation at the starting frequency (H17) to synchronize and run the idling motor without stopping it. If there is a large difference between the motor speed and the synchronizing frequency, the current limiting control may be triggered. The inverter automatically reduces its output frequency to homologize with the idling motor speed for synchronizing them each other. Upon completion of the synchronization, the inverter releases the current limiting control and accelerates the motor to the reference frequency in accordance with the preset acceleration time.


■ Select start mode (STM) (Digital input signal)
This digital input signal specifies whether or not to perform auto sync search operation when the inverter starts.

| Data for H09 | Auto synch <br> search start <br> mode | Select start <br> mode (STM) | Function |
| :---: | :---: | :---: | :--- |
| 0 | Disable | - | Start at the starting frequency |
| 3,4 , or 5 | Enable | ON | Start at the auto sync search starting <br> frequency (H17) |
|  |  | OFF | Start at the starting frequency |

## Starting frequency (H17)

H17 specifies the starting frequency for the auto sync search operation for an idling motor. Be sure to set a value higher than the speed of the idling motor. Otherwise, an overvoltage trip may occur. If the current motor speed is unknown, specify "999" that uses the maximum frequency at the start of auto sync search operation.

## ■ Auto sync search start mode (H09)

H09 specifies the starting rotational direction of run command, auto sync search (forward/reverse), and the starting pattern (pattern 1 to 4). If the motor is idling in reverse direction that is against the specified direction because of natural convection, it is necessary to start it in the direction opposite to the rotational direction of original reference frequency.
For the case when the rotational direction of the idling motor is unknown, two starting patterns are provided as listed below, which start search from forward rotation and, if not succeeded from reverse rotation (e.g. $\mathrm{H} 09=5$, pattern 3), starts search from reverse rotation (e.g. $\mathrm{H} 09=5$, pattern 4 ).

| Data for H09 | Run command | Rotational direction <br> at the start of auto <br> sync search | Starting pattern |
| :---: | :---: | :---: | :---: |
| 3 | Run forward | Forward | Pattern 1 |
|  | Run reverse | Reverse | Pattern 2 |
| 4 | Run forward | Forward | Pattern 3 |
|  | Run reverse | Reverse | Pattern 4 |
| 5 | Run forward | Reverse | Pattern 4 |
|  | Run reverse | Forward | Pattern 3 |

## Starting patterns

The inverter makes its frequency shift in accordance with the starting patterns shown below to search the speed and rotation direction of the idling motor. When synchronization is complete between the motor speed (including its rotation direction) and the inverter output frequency, the frequency shift by auto sync search operation is terminated.


* Only when the auto sync search has not succeeded at the first trial, the starting from the opposite direction is attempted.


## Starting Patterns

Auto sync search operation is attempted using one of the patterns shown above. If not succeeded, it will be tried again. If seven consecutive retries failed, the inverter will issue $\stackrel{\text { III }}{\prime \prime \prime}-\underset{\prime}{\prime}$ alarm and stop.

## Deceleration Mode

H11 specifies the mode of deceleration when the run command is turned OFF.

| Data for H11 | Function |
| :---: | :--- |
| 0 | The inverter decelerates and stops the motor according to normal deceleration <br> commands (H07: Deceleration pattern and F08: Deceleration time). |
| 1 | Coast-to-stop (The inverter immediately shuts down its output. The motor will <br> stop according to the inertia of motor and load machinery, and their kinetic <br> energy losses. |

Even if you have chosen "coast-to-stop" $(\mathrm{H} 11=1)$, deceleration takes place in accordance with the setting of deceleration time when the reference frequency is low.

Instantaneous Overcurrent Limiting
H12 specifies whether the inverter invokes the current limit processing or enters the overcurrent trip when its output current exceeds the instantaneous overcurrent limiting level. Under the current limit processing, the inverter immediately turns off its output gate to suppress the further current increase and continues to control the output frequency.

| Data for H12 | Function |
| :---: | :--- |
| 0 | Overcurrent trip at the instantaneous overcurrent limiting level is ineffective. |
| 1 | Current limiting processing is effective. |

In case any problem occurs when the motor torque temporarily drops during current limiting processing, you need to enable overcurrent trip $(\mathrm{H} 12=0)$ and actuate a mechanical brake at the same time.

The function codes F43 and F44 have current limit functions similar to that of function code H12. Because the current limit functions of F43 and F44 implement the current control by software, an operation delay occurs. When you have enabled the current limit by function codes F43 and F44, enable the current limit processing by function code H 12 as well, to obtain a quick response current limiting.
Depending on the load, extremely short acceleration time may activate the current limiting to suppress the increase of the inverter output frequency, causing the system oscillation (hunting) or activating the inverter overvoltage trip ( ( $\prime^{\prime \prime \prime \prime \prime}$ 'alarm). When setting the acceleration time, therefore, you need to take into account machinery characteristics and moment of inertia of the load.


## Restart Mode after Recovery from Momentary Power Failure (Restart time) <br> (Refer to F14.)

Restart Mode after Recovery from Momentary Power Failure (Frequency fall rate)
(Refer to F14.)

| Restart Mode after Recovery from Momentary Power Failure <br> voltage) |
| :--- |
| Restart Molding DC <br> (Refer to F14.) <br> momentary power failure time) |

For how to set these function codes (sub-functions for F14: Restart after a recovery from momentary power failure, such as restart time (waiting time), frequency fall rate, holding DC link bus voltage (continuous running voltage level of the DC link bus), and allowable time of momentary power failure), refer to function code F14.

Auto Sync Search (Starting frequency)
(Refer to F09.)
For how to set the starting frequency for the auto sync search operation, refer to function code H09.

## PTC Thermistor (Selection)

## PTC Thermistor (Level)

These function codes protect the motor from overheating or to output an alarm signal using the PTC (Positive Temperature Coefficient) thermistor embedded in the motor.

- PTC thermistor (Selection) (H26)

Selects the function operation mode (protection or alarm) for the PTC thermistor as shown below.

| Data for H26 | Action |
| :---: | :--- |
| 0 | Disable |
| 1 | Enable: When the voltage sensed by PTC thermistor exceeds the detection <br> level, motor protective function (alarm intil-4') is triggered, causing the inverter <br> to enter an alarm stop state. |
| 2 | Enable: When the voltage sensed by the PTC thermistor exceeds the detection <br> level, a motor alarm signal is output but the inverter continues running. <br> You need to assign the motor overheat protection (THM) to one of the digital <br> output terminals beforehand, by which a temperature alarm condition can been <br> detected by the thermistor (PTC) (function code data $=56$ ). |

- PTC thermistor (Level) (H27)

Specifies the detection level for the temperature (expressed in voltage) sensed by PTC thermistor.

- Data setting range: 0.00 to $5.00(\mathrm{~V})$

The temperature at which the overheating protection is to be activated depends on the characteristics of the PTC thermistor. The internal resistance of the thermistor will significantly change at the alarm temperature. The detection level (voltage) is specified based on the change of internal resistance.


Suppose that the resistance of PTC thermistor at alarm temperature Rp, the detection (voltage) level $\mathrm{V}_{\mathrm{v} 2}$ is calculated by the equation below. Set the result $\mathrm{V}_{\mathrm{v} 2}$ to function code H27.

Substitute the internal resistance of the PTC thermistor at the alarm temperature with Rp to obtain $\mathrm{V}_{\mathrm{v} 2}$ :

$$
\mathrm{V}_{\mathrm{V} 2}=\frac{\frac{237 \times \mathrm{R}_{\mathrm{p}}}{237+\mathrm{R}_{\mathrm{p}}}}{1000+\frac{237 \times \mathrm{R}_{\mathrm{p}}}{237+\mathrm{R}_{\mathrm{p}}}} \times 10(\mathrm{~V})
$$

Connect the PTC thermistor as shown below. The voltage that is obtained by dividing the input voltage to the terminal [V2] with a set of internal resistors is compared with the preset detection level voltage (function code H 27 ).


## Communications Link Function (Function selection)

The FRENIC-Eco series offers external interfaces with personal computers and PLCs via RS485 communications link and field bus (option), which allow you to monitor the operation state of the inverter and the code data, to set frequency command contents and to issue a run command from a remote location. These function codes allow you to specify the means of setting frequencies and issuing run commands. H30 is for the RS485 communications link; y98 is for the field bus.


Command source and description

| Command source | Description |
| :---: | :--- |
| Inverter | Means except RS485 communications and field bus <br> Frequency command: Set by F01 and C30, or multistep <br> frequency command <br> Run command: Keypad and digital input terminals |
| RS485 communications <br> (Standard) | Via the standard RJ-45 port used for connecting keypad |
| RS48 communications card <br> (Option) | Via RS485 communications card (option) |
| Field bus (Option) | Via field bus (option) using FA protocol such as DeviceNet or <br> PROFIBUS-DP |

Command source defined by H30 (Communications link function code)

| Data for H30 | Frequency command source | Run command source |
| :---: | :--- | :--- |
| 0 | Inside inverter | Inside inverter |
| 1 | Standard RS485 communications | Inside inverter |
| 2 | Inside inverter | Standard RS485 communications |
| 3 | Standard RS485 communications | Standard RS485 communications |
| 4 | Optional RS485 communications | Inside inverter |
| 5 | Optional RS485 communications | Standard RS485 communications |
| 6 | Inside inverter | Optional RS485 communications |
| 7 | Standard RS485 communications | Optional RS485 communications |
| 8 | Optional RS485 communications | Optional RS485 communications |

Command source defined by y98 bus function

| Data for y98 | Frequency command source | Run command source |
| :---: | :--- | :--- |
| 0 | Follow setting of H30 | Follow setting of H30 |
| 1 | Follow setting via field bus (Option) | Follow setting of H30 |
| 2 | Follow setting of H30 | Follow setting via field bus (Option) |
| 3 | Follow setting via field bus (Option) | Follow setting via field bus (Option) |

Command source definition matrix

|  |  | Frequency command source |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Inside inverter | Standard RS485 communications | Optional RS485 communications | Field bus (Option) |
|  | Inside inverter | $\begin{aligned} \mathrm{H} 30 & =0 \\ \mathrm{y} 98 & =0 \end{aligned}$ | $\begin{aligned} \mathrm{H} 30 & =1 \\ \mathrm{y} 98 & =0 \end{aligned}$ | $\begin{aligned} \mathrm{H} 30 & =4 \\ \mathrm{y} 98 & =0 \end{aligned}$ | $\begin{gathered} \mathrm{H} 30=0(1,4) \\ \mathrm{y} 98=1 \end{gathered}$ |
|  | Standard RS485 communications | $\begin{aligned} \mathrm{H} 30 & =2 \\ \mathrm{y} 98 & =0 \end{aligned}$ | $\begin{aligned} \mathrm{H} 30 & =3 \\ \mathrm{y} 98 & =0 \end{aligned}$ | $\begin{array}{r} \mathrm{H} 30=5 \\ \mathrm{y} 98=0 \end{array}$ | $\begin{gathered} \mathrm{H} 30=2(3,5) \\ \mathrm{y} 98=1 \end{gathered}$ |
|  | Optional RS485 communications | $\begin{aligned} \mathrm{H} 30 & =6 \\ \mathrm{y} 98 & =0 \end{aligned}$ | $\begin{aligned} \mathrm{H} 30 & =7 \\ \mathrm{y} 98 & =0 \end{aligned}$ | $\begin{aligned} \mathrm{H} 30 & =8 \\ \mathrm{y} 98 & =0 \end{aligned}$ | $\begin{gathered} \mathrm{H} 30=6(7,8) \\ \mathrm{y} 98=1 \end{gathered}$ |
|  | Field bus (Option) | $\begin{aligned} & \mathrm{H} 30=0(2 \text { or } 6) \\ & \mathrm{y} 98=2 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=1(3 \text { or } 7) \\ & \mathrm{y} 98=2 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=4(5 \text { or } 8) \\ & \mathrm{y} 98=2 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=0(1 \text { to } 8) \\ & \mathrm{y} 98=3 \end{aligned}$ |

DD For details, refer to Chapter 4 "BLOCK DIAGRAMS FOR CONTROL LOGIC" and the RS485 communication User's Manual (MEH448a) or the Field Bus Option Instruction Manual.

- If you assign the (LE) terminal command to a digital input terminals, the settings of function codes H 30 and y98 become effective when the assigned input terminal and the terminal [CM] are short-circuited, and become ineffective when they are open. ("Ineffective" means that for both frequency and run commands, the inverter takes control.)

H42 displays the measured capacitance of the DC link bus capacitor (reservoir capacitor).

## Cumulative Run Time of Cooling Fan

H43 displays the cumulative run time of the cooling fan.

H47 displays the initial value of the capacitance of the DC link bus capacitor (reservoir capacitor).

Cumulative Run Time of Capacitors on the PCB
H48 displays the cumulative run time of the capacitors mounted on the printed circuit board.

H49 specifies the synchronizing time.

- Data setting range: 0.0 to 10.0 (sec.)

| H50 | Non-linear V/f Pattern (Frequency) | (Refer to F04.) |
| :---: | :---: | :---: |
| H51 | Non-linear V/f Pattern (Voltage) | (Refer to F05.) |

For details of setting the non-linear V/f pattern, refer to the descriptions of function code F04 and F05.

## Deceleration Time for Forced to stop

When (STOP) is turned on while the forced to stop signal (STOP) is assigned to the digital input terminal (function code data $=30$ ), the inverter output decelerates to stop in accordance with the setting of H56 (Deceleration time for forced to stop). When the inverter output has stopped after deceleration, it enters an alarm stop state, with the 镸 alarm displayed.

For how to set up this function code data, refer to function codes F15 and F16.

Lower Limiter (Specify the lower limiting frequency)
When the output current limiter and/or overload prevention control is activated, this function specifies the lower limit of the frequency that may vary with the limit control.

- Data setting range: 0.0 to $60.0(\mathrm{~Hz})$


## Automatic Deceleration

H69 specifies whether automatic deceleration control is to be enabled or disabled. During deceleration of the motor, if regenerative energy exceeds the level that can be handled by the inverter, overvoltage trip may happen. With automatic deceleration enabled, when the DC link

| Data for H69 | Function |
| :---: | :---: |
| 0 | Disable |
| 1 | Enable | bus voltage exceeds the level (internally fixed) for starting automatic deceleration, the output frequency is controlled to prevent the DC link bus voltage from rising further; thus regenerative energy is suppressed .

[^45]
## Overload Prevention Control

H70 specifies the rate of decreasing the output frequency to prevent an overload condition. Under this control, an overload trip is prevented by decreasing the output frequency of the inverter before the inverter trips because of the overheating of the cooling fan or the
 for facilities such as pumps where a decrease in the output frequency leads to a decrease in the load and it is necessary to keep the motor running even when the output frequency goes low.

| Data for H70 | Function |
| :---: | :--- |
| 0.00 | Decelerate the motor by the deceleration time $1(\mathrm{~F} 08)$ |
| 0.01 to 100.0 | Decelerate the motor by deceleration rate 0.01 to $100.0(\mathrm{~Hz} / \mathrm{s})$ |
| 999 | Disable overload prevention control |

In applications where a decrease in the output frequency does not lead to a decrease Note in the load, this function is of no use and should not be enabled.

Setting this function code to "1" (ON) enables forced brake control. If the regenerative energy produced during the deceleration of the motor exceeds the inverter's regenerative braking capacity,
 an overvoltage trip will occur. Forced brake control increases the loss of the motor and the deceleration torque during deceleration.

This function is aimed at controlling the torque during deceleration; it has no effect if there is braking load.

The inverter output current driving the motor may fluctuate due to the motor characteristics and/or backlash in the mechanical load. Modify the data in function code H80 to adjust the controls in order to suppress such fluctuation. However, as incorrect setting of this gain may cause larger current fluctuation, do not modify the default setting unless it is necessary.

- Data setting range: 0.00 to 0.40

For how to set continuous running $(\mathrm{P}, \mathrm{I})$, refer to function code F14.

## Cumulative Run Time of Motor

You can view the cumulative run time of the motor on the keypad. This feature is useful for management and maintenance of the mechanical system. With this function code (H94), you can set the cumulative run time of the motor to any value you choose. For example, by specifying " 0, " you can clear the cumulative run time of the motor.

Note
The data for H 94 is in hexadecimal notation. Check the cumulative run time of the motor on the keypad.

For how to set DC injection braking, refer to function codes F20 through F22.

## STOP Key Priority/Start Check Function

The inverter can be operated using a functional combination of "Priority on Key" and "Start Check."

| Data for H96 | Priority on key | Start check function |
| :---: | :---: | :---: |
| 0 | Disable | Disable |
| 1 | Enable | Disable |
| 2 | Disable | Enable |
| 3 | Enable | Enable |

## STOP key priority

Even when the run commands are received from the digital input terminals or via RS485 communications link (link operation), pressing the key forces the inverter to decelerate and stop the motor. "危" is displayed on the LED monitor after stopping.

## - Start check function

For safety, this function checks whether any run command has been turned ON or not. If a run command has been turned ON, an alarm code "镸" without the inverter being started up. This applies to the following situations:

- When any run command has been ON when the power to the inverter is turned ON.
- A run command is already input when the key is pressed to release the alarm status or when the reset alarm command (RST) (digital input) is input.
- When the run command source has been switched by the enable link operation (LE) (digital input) or the run command $2 /$ run command 1 (FR2/FR1), a run command is already turned ON at the new source.


## Clear Alarm Data

H97 deletes the information such as alarm history and data at the time of alarm occurrence, including alarms that have occurred during the check-up or adjustment of the machinery. Data is then brought back to a normal state without an alarm.
Deleting the alarm information requires simultaneous keying of and © keys.

| Data for H97 | Function |
| :---: | :--- |
| 0 | Disable |
| 1 | Clear all. (Setting data at "1" clears all alarm data stored and H97 returns to <br> "0". |

H98 specifies whether to enable or disable (a) automatic lowering of the carrier frequency, (b) protection against input phase loss, (c) protection against output phase loss, and (d) judgment on the DC link bus capacitor life, and the change of judgment criteria on the DC link bus capacitor life and the selection of handling on DC fan lock detection, in a style of combination.

## Automatic lowering function of carrier frequency

You have to prevent an important machinery from stopping as much as possible. Even if the inverter is in heat sink overheating or overload state because of excessive load, abnormal ambient temperature, or a trouble in the cooling system, with this function enabled, the
 feature is enabled the motor noise increases.

## Protection against input phase loss ( $\left.\begin{array}{l}1 \\ L \\ \text { וーו }\end{array}\right)$

Upon detecting an excessive stress inflicted on the apparatus connected to the main circuit because of phase loss or inter-phase imbalance in the 3-phase power supplied to the inverter, this feature stops the inverter and displays an alarm $\stackrel{L}{L}$

In configurations where only a light load is driven or a DC reactor is connected, a phase loss or an inter-phase imbalance may not be detected because of the relatively small stress on the apparatus connected to the main circuit.

Upon detecting a phase loss in the output while the inverter is running, this feature stops the inverter and displays an alarm output circuit, if the magnetic contactor goes OFF during operation, all the phases will be lost. In such a case, this protection feature does not work.

## Selection of life judgment criteria of the DC link bus capacitors

Allows you to select the criteria for judging the life of the DC link bus capacitor/s (reservoir capacitor/s) between factory default setting and your own choice.

Before specifying the criteria of your own choice, measure and confirm the reference level in advance. For details, refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 7 "MAINTENANCE AND INSPECTION."

Judgment on the life of DC link bus capacitors
Whether the DC link bus capacitor (reservoir capacitor) has reached its life is determined by measuring the length of time for discharging after power off. The discharging time is determined by the capacitance of the DC link bus capacitor and the load inside the inverter. Therefore, if the load inside the inverter fluctuates significantly, the discharging time cannot be accurately measured, and as a result, it may be mistakenly determined that the life has been reached. To avoid such an error, you can disable the judgment on the life of the DC link bus capacitor.
Load may vary significantly in the following cases. Disable the judgment on the life during operation, and either conduct the measurement with the judgment enabled under appropriate conditions during periodical maintenance or conduct the measurement under the actual use conditions.

- Auxiliary input for control power is used
- An option card or multi-function keypad is used
- Another inverter or equipment such as a PWM converter is connected to the terminals of the DC link bus.

For details, refer to the FRENIC-Eco Instruction Manual (INR-SI47-0882-E), Chapter 7 "MAINTENANCE AND INSPECTION."

Detection of DC fan lock ( 200 V series: 45 kW or above, 400 V series: 55 kW or above)
An inverter of 45 kW or above ( 200 V series), or of 55 kW or above ( 400 V series) is equipped with the internal air circulation DC fan. When the inverter detects that the DC fan is locked by a failure or other cause, you can select either continuing the inverter operation or entering into alarm state.

Continuing operation: The inverter does not enter the alarm mode, and continues operation of the motor.

Note that, however, the inverter turns on (OH) and (LIFE) signals on the transistor output terminals whenever the DC fan lock is detected regardless your selection.

If ON/OFF control of the cooling fan is enabled ( $\mathrm{H} 06=1$ ), the cooling fan may stop depending on operating condition of the inverter. In this case, the DC fan lock detection feature is considered normal (e.g.; the cooling fan is normally stopped by the stop fan command.) so that the inverter may turn off the (LIFE) or (OH) signal output, or enable to cancel the $\stackrel{\text { Kinlíl }}{-1 / \text { alarm, even if the internal air circulation DC }}$ fan is locked due to a failure etc. (When you start the inverter in this state, it automatically issues the run fan command, then the inverter detects the DC fan lock


Note that, operating the inverter under the condition that the DC fan is locked for long time may shorten the life of electrolytic capacitors on the printed circuit board due to local high temperature inside the inverter. Be sure to check with the (LIFE) signal etc., and replace the broken fan as soon as possible.
To set data of the function code H98, assign functions to each bit (total 6 bits) and set it in decimal format. The table below lists functions assigned to each bit.

| Bit | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Function | Detect DC <br> fan lock | Judge life of <br> the DC link <br> bus capacitor/s | Select the life <br> judgment <br> criteria of the <br> DC link bus <br> capacitor/s | Detect <br> output <br> phase loss | Detect <br> input phase <br> loss | Auto <br> lowering of <br> the carrier <br> frequency |
| Data $=0$ | Enter into <br> the alarm <br> state | Disable | Use the <br> factory <br> default | Disable | Disable | Disable |
| Data =1 | Continue <br> the <br> operation | Enable | Use the user <br> setting | Enable | Enable | Enable |
| Example <br> of decimal <br> expression <br> $(19)$ | Enter into <br> the alarm <br> state (0) | Enable (1) | Use the <br> factory <br> default (0) | Disable <br> $(0)$ | Enable (1) | Enable (1) |

Conversion table (Decimal to/from binary)

| Decimal | Binary |  |  |  |  |  | Decimal | Binary |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |  | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 33 | 1 | 0 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 0 | 0 | 1 | 0 | 34 | 1 | 0 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 0 | 0 | 1 | 1 | 35 | 1 | 0 | 0 | 0 | 1 | 1 |
| 4 | 0 | 0 | 0 | 1 | 0 | 0 | 36 | 1 | 0 | 0 | 1 | 0 | 0 |
| 5 | 0 | 0 | 0 | 1 | 0 | 1 | 37 | 1 | 0 | 0 | 1 | 0 | 1 |
| 6 | 0 | 0 | 0 | 1 | 1 | 0 | 38 | 1 | 0 | 0 | 1 | 1 | 0 |
| 7 | 0 | 0 | 0 | 1 | 1 | 1 | 39 | 1 | 0 | 0 | 1 | 1 | 1 |
| 8 | 0 | 0 | 1 | 0 | 0 | 0 | 40 | 1 | 0 | 1 | 0 | 0 | 0 |
| 9 | 0 | 0 | 1 | 0 | 0 | 1 | 41 | 1 | 0 | 1 | 0 | 0 | 1 |
| 10 | 0 | 0 | 1 | 0 | 1 | 0 | 42 | 1 | 0 | 1 | 0 | 1 | 0 |
| 11 | 0 | 0 | 1 | 0 | 1 | 1 | 43 | 1 | 0 | 1 | 0 | 1 | 1 |
| 12 | 0 | 0 | 1 | 1 | 0 | 0 | 44 | 1 | 0 | 1 | 1 | 0 | 0 |
| 13 | 0 | 0 | 1 | 1 | 0 | 1 | 45 | 1 | 0 | 1 | 1 | 0 | 1 |
| 14 | 0 | 0 | 1 | 1 | 1 | 0 | 46 | 1 | 0 | 1 | 1 | 1 | 0 |
| 15 | 0 | 0 | 1 | 1 | 1 | 1 | 47 | 1 | 0 | 1 | 1 | 1 | 1 |
| 16 | 0 | 1 | 0 | 0 | 0 | 0 | 48 | 1 | 1 | 0 | 0 | 0 | 0 |
| 17 | 0 | 1 | 0 | 0 | 0 | 1 | 49 | 1 | 1 | 0 | 0 | 0 | 1 |
| 18 | 0 | 1 | 0 | 0 | 1 | 0 | 50 | 1 | 1 | 0 | 0 | 1 | 0 |
| 19 | 0 | 1 | 0 | 0 | 1 | 1 | 51 | 1 | 1 | 0 | 0 | 1 | 1 |
| 20 | 0 | 1 | 0 | 1 | 0 | 0 | 52 | 1 | 1 | 0 | 1 | 0 | 0 |
| 21 | 0 | 1 | 0 | 1 | 0 | 1 | 53 | 1 | 1 | 0 | 1 | 0 | 1 |
| 22 | 0 | 1 | 0 | 1 | 1 | 0 | 54 | 1 | 1 | 0 | 1 | 1 | 0 |
| 23 | 0 | 1 | 0 | 1 | 1 | 1 | 55 | 1 | 1 | 0 | 1 | 1 | 1 |
| 24 | 0 | 1 | 1 | 0 | 0 | 0 | 56 | 1 | 1 | 1 | 0 | 0 | 0 |
| 25 | 0 | 1 | 1 | 0 | 0 | 1 | 57 | 1 | 1 | 1 | 0 | 0 | 1 |
| 26 | 0 | 1 | 1 | 0 | 1 | 0 | 58 | 1 | 1 | 1 | 0 | 1 | 0 |
| 27 | 0 | 1 | 1 | 0 | 1 | 1 | 59 | 1 | 1 | 1 | 0 | 1 | 1 |
| 28 | 0 | 1 | 1 | 1 | 0 | 0 | 60 | 1 | 1 | 1 | 1 | 0 | 0 |
| 29 | 0 | 1 | 1 | 1 | 0 | 1 | 61 | 1 | 1 | 1 | 1 | 0 | 1 |
| 30 | 0 | 1 | 1 | 1 | 1 | 0 | 62 | 1 | 1 | 1 | 1 | 1 | 0 |
| 31 | 0 | 1 | 1 | 1 | 1 | 1 | 63 | 1 | 1 | 1 | 1 | 1 | 1 |

### 9.2.6 J codes (Application functions)

## J01

PID Control (Selection)

PID Control (Remote process command)

## PID Control (Gain)

## PID Control (Integral time)

## PID Control (Differentiation time)

## PID Control (Feedback filter)

In PID control, the state of control object is detected by a sensor or similar device and is compared with the commanded value (e.g. temperature control command). If there is any deviation between them, the PID control operates so as to minimize it. Namely, it is a closed loop feedback system that matches controlled variable (feedback value). The PID control applies to a process control such as flowrate control, pressure control, and temperature control as shown in the schematic block diagram below.
If PID control is enabled ( $\mathrm{J} 01=1$ or 2 ), frequency control of the inverter is switched from the drive frequency command generator block to the PID frequency command generator block.

Refer to Chapter 4, Section 4.9 "PID Frequency Command Generator" for details.


- PID Control Selection (J01)

Selects PID control function.

| Data for J01 | Function |
| :---: | :--- |
| 0 | Disable PID control |
| 1 | Enable PID control <br> (normal operation) |
| 2 | Enable PID control <br> (inverse operation) |

- As normal operation or inverse operation against the output of PID control can be selected, you can fine-control the motor speed and rotation direction against the difference between commanded value and feedback value. Thus, FRENIC-Eco inverters can apply to many kinds of applications such as air conditioners. The operation mode can also be switched between normal and inverse by using the terminal command (IVS).

Refer to function codes E01 to E05 for details of assignment of the switching normal/inverse command (IVS).

## Selection of Feedback Terminals

For feedback control, determine the connection terminal according to the type of the sensor output.

- If the sensor is current output type: Use the current input terminal [C1] of the inverter.
- If the sensor is voltage output type: Use the voltage input terminal [12] or [V2] of the inverter.

For details, refer to function codes E61 through E63.

The operating range for PID control is internally controlled as $0 \%$ through $100 \%$. For the given feedback input, determine the range of control by means of gain adjustment.
For example, if the sensor output is in the range of $1-5 \mathrm{~V}$ :

- Use terminal [12] since this is a voltage input.
- Example of gain adjustment

Set Gain adjustment (C32) at $200 \%$, so that the maximum value ( 5 V ) of the external sensor's output corresponds to $100 \%$. Note that the input specification for terminal [12] is 0 -10 V corresponding to $0-100 \%$; thus, a gain factor of $200 \%(=10 \mathrm{~V} \div 5 \times 100)$ should be specified. Note also that any bias setting must not apply to feedback control.


## ■ Remote process command (J02)

Selects the source to set the command value (SV) under PID control.

| Data for J02 | Function |
| :---: | :--- |
| 0 | Keypad <br> Using the / / key on the keypad in conjunction with display coefficients <br> E40 and E41, you can specify the PID process command in 0 to 100\% of the <br> easy-to-understand converted command format, such as in temperature and <br> pressure. For details of operation, refer to Chapter 3 "OPERATION USING <br> THE KEYPAD." |
| 1 | PID Process command 1 (Terminals [12], [C1], [V2]) <br> In addition to J02, various analog settings (function codes E61, E62, and E63) <br> also need to select PID process command 1. For details, refer to function codes <br> E61, E62, and E63. |
| 3 | UP/DOWN command <br> Using the UP (UP) or DOWN (DOWN) command in conjunction with display <br> coefficients E40 and E41, you can specify the PID process command in 0 to <br> 100\% of the easy-to-understand converted command format. In addition to <br> setting J02 at "3," you also need to assign the function selection for the E01 <br> through E05 terminals ([X1] to [X5]) to the UP (UP) and DOWN (DOWN) <br> commands (function code data = 17, 18). For details of (UP)/(DOWN) <br> operation, refer to the assignment of the UP (UP) and DOWN (DOWN) <br> command. |
| 4 | Command via communications link <br> Use the function code (S13) for communications-linked PID process <br> command: the transmission data of 20000 (decimal) is equal to 100\% (max. <br> frequency) of the process command. For details of the communications format |
| etc., refer to the RS485 communication User's Manual (MEH448a). |  |

Other than the process command selection by function code J 02 , the multistep frequency $(\mathrm{C} 08=4)$ specified by the terminal command $(\mathrm{SS} 4)$ can also be selected as a preset value for the PID process command.
Calculate the setting data of the process command using the equation below.
Process command data $(\%)=$ (preset multistep frequency) $\div$ (maximum frequency) $\times 100$

Setting range for PID process command (for analog input only)
The operating range for PID control is internally controlled at $0 \%$ through $100 \%$. Therefore, if you use an analog input as a PID process command, you need to set the range of the PID process command beforehand. As with frequency setting, you can arbitrary map relationship between the process command and the analog input value by adjusting the gain and bias.For details, refer to function codes C32, C34, C37, C39, C42, C44, C51, and C52.
Example) Mapping the range of 1 through 5 V at the terminal [12] to 0 through $100 \%$


## PID Display Coefficient and monitoring

To monitor the PID process command and its feedback value, set the display coefficient to convert the displayed value into easy-to-understand numerals of the process control value such as temperature.

Refer to function codes E40 and E41 for details on display coefficients, and to E43 for details on monitoring.

## - Gain (J03)

Sets the gain for the PID processor.

- Data setting range: 0.000 to 30.000 (multiple)


## P (Proportional) control

An operation that an MV (manipulated value: output frequency) is proportional to the deviation is called P control, which outputs a manipulated value in proportion to deviation. However, the manipulated variable alone cannot eliminate deviation.
Gain is data that determines the system response level against the deviation in the P control. An increase in gain speeds up response, an excessive gain may cause vibration, and a decrease in gain delays response.


- Integration time (J04)

Sets the integration time for the PID processor.

- Data setting range: 0.0 to 3600.0 (sec.)
0.0 means that the integral component is ineffective.


## I (Integral) control

An operation that the change rate of an MV (manipulated value: output frequency) is proportional to the integral value of deviation is called I control that outputs the manipulated value that integrates the deviation. Therefore, I control is effective in bringing the feedback value close to the commanded value. For the system whose deviation rapidly changes, however, this control cannot make it react quickly.
The effectiveness of I control is expressed by integration time as parameter, that is J4 data. The longer the integration time, the slower the response. The reaction to the external turbulence also becomes slow. The shorter the integration time, the faster the response. Setting too short integration time, however, makes the inverter output tend to oscillate against the external turbulence.


## ■ Differentiation time (J05)

Sets the differentiation time for the PID processor.

- Data setting range: 0.00 to 600.00 (sec.)
0.0 means that the differential component is ineffective.


## D (Differential) control

An operation that the MV (manipulated value: output frequency) is proportional to the differential value of the deviation is called D control that outputs the manipulated value that differentiates the deviation. D control makes the inverter quickly react to a rapid change of deviation.

The effectiveness of D control is expressed by differentiation time as parameter, that is J05 data. Setting a long differentiation time will quickly suppress oscillation caused by P action when a deviation occurs. Too long differentiation time makes the inverter output oscillation more. Setting short differentiation time will weakens the suppression effect when the deviation occurs.


Descriptions of a combined use of $P$, I, and D control are shown below.
(1) PI control

PI control, which is a combination of P and I control, is generally used to minimize the remaining deviation caused by P control. PI control acts to always minimize the deviation even if a commanded value changes or external disturbance steadily occurs. However, the longer the integration time, the slower the system response to quick-changed control.
$P$ control can be used alone for loads with very large part of integral components.
(2) PD control

In PD control, the moment that a deviation occurs, the control rapidly generates much manipulative value than that generated by D control alone, to suppress the deviation increase. When the deviation becomes small, the behavior of P control becomes small.
A load including the integral component in the controlled system may oscillate due to the action of the integral component if P control alone is applied. In such a case, use PD control to reduce the oscillation caused by P control, for keeping the system stable. That is, PD control is applied to a system that does not contain any braking actions in its process.
(3) PID control

PID control is implemented by combining $P$ control with the deviation suppression of $I$ control and the oscillation suppression of D control. PID control features minimal control deviation, high precision and high stability.
In particular, PID control is effective to a system that has a long response time to the occurrence of deviation.

Follow the procedure below to set data to PID control function codes.
It is highly recommended that you adjust the PID control value while monitoring the system response waveform with an oscilloscope or equivalent. Repeat the following procedure to determine the optimal solution for each system.

- Increase the data of function code J03 PID control (P (gain)) in the range where the feedback signal does not oscillate.
- Decrease the data of function code J04 PID control (I (Integration time)) in the range where the feedback signal does not oscillate.
- Increase the data of function code J05 PID control (D (Differentiation time)) in the range where the feedback signal does not oscillate.
Refining the system response waveforms is shown below.

1) Suppressing overshoot

Increase the data of function code J04 (Integration time) and decrease that of code J05
(Differentiation time)

2) Quick stabilizing (moderate overshoot allowable)

Decrease the data of function code J03 (Gain) and increase that of code J05 (Differentiation time)

3) Suppressing oscillation longer than the integration time specified by function code J04 Increase the data of function code J04 (Integration time)

4) Suppressing oscillation of approximately same period as the time set for function code J05 (Differentiation time)
Decrease the data of function code J 05 (Differentiation time).
Decrease the data of function code J 03 (Gain), when the oscillation cannot be suppressed even if the differentiation time is set at 0 sec.


## ■ Feedback filter (J06)

Sets the time constant of the filter for feedback signals in PID control.

- Data setting range: 0.0 to 900.0 (sec.)
- This setting is used to stabilize the PID control loop. Setting too long a time constant makes the system response slow.


## PID Control (Anti reset windup)

J10 suppresses overshoot in control with PID processor. As long as the deviation between the feedback value and the PID process command is beyond the preset range, the integrator holds its value and does not perform integration operation.

- Data setting range: 0.0 to 200.0 (\%)



## PID Control (Select alarm output)

## PID Control (Upper limit alarm (AH))

## PID Control (Lower limit alarm (AL))

Two types of alarm signals are can be output associated with PID control: absolute-value alarm and deviation alarm. You need to assign the PID alarm output (PID-ALM) to one of the digital output terminals (function code data $=42$ ).

■ PID Control (Select alarm output) (J11)
Specifies the alarm type. The table below lists all the alarms available in the system.

| Data for J11 | Alarm | Description |
| :---: | :---: | :---: |
| 0 | Absolute-value alarm | While $\mathrm{PV}<\mathrm{AL}$ or $\mathrm{AH}<\mathrm{PV}$, (PID-ALM) is ON. |
| 1 | Absolute-value alarm (with hold) | Same as above (with hold) |
| 2 | Absolute-value alarm (with latch) | Same as above (with latch) |
| 3 | Absolute-value alarm (with hold and latch) | Same as above (with hold and latch) |
| 4 | Deviation alarm | While PV $<\mathrm{SV}-\mathrm{AL}$ or $\mathrm{SV}+\mathrm{AH}<\mathrm{PV}$, (PID-ALM) is ON . |
| 5 | Deviation alarm (with hold) | Same as above (with hold) |
| 6 | Deviation alarm (with latch) | Same as above (with latch) |
| 7 | Deviation alarm (with hold and latch) | Same as above (with hold and latch) |

Hold: During the power-on sequence, the alarm output is kept OFF (disabled) even when the monitored quantity is within the alarm range. Once it goes out of the alarm range, and comes into the alarm range again, the alarm is enabled.
Latch: Once the monitored quantity comes into the alarm range and the alarm is turned ON, the alarm will remain ON even if it goes out of the alarm range. To release the latch, perform a reset by using the key or turning ON the terminal command (RST), etc. Resetting can be done by the same way as resetting an alarm.

PID Control (High limit alarm (AH)) (J12)
Specifies the upper limit of the alarm (AH) in percentage (\%) of the process value.

- PID Control (Low limit alarm) (AL)) (J13)

Specifies the lower limit of the alarm (AL) in percentage (\%) of the process value.
The value displayed (\%) is the ratio of the upper/lower limit to the full scale ( 10 V or 20 mA ) of the feedback value (in the case of a gain of $100 \%$ ).
High limit alarm AH and Low limit alarm AL also apply to the following alarms.

| Alarm | Description | How to handle the alarm: |  |
| :---: | :---: | :---: | :---: |
|  |  | Select alarm output (J11) | Parameter setting |
| High limit (absolute) | ON when $\mathrm{AH}<\mathrm{PV}$ | Absolute-value alarm | $\mathrm{J} 13=0$ |
| Low limit (absolute) | ON when $\mathrm{PV}<\mathrm{AL}$ |  | $\mathrm{J} 12=100 \%$ |
| High limit (deviation) | ON when $\mathrm{SV}+\mathrm{AH}<\mathrm{PV}$ | Deviation alarm | $\mathrm{J} 13=100 \%$ |
| Low limit (deviation) | ON when $\mathrm{PV}<\mathrm{SV}-\mathrm{AL}$ |  | $\mathrm{J} 12=100 \%$ |
| High/low limit (deviation) | ON when $\|\mathrm{SV}-\mathrm{PV}\|>\mathrm{AL}$ |  | $\mathrm{J} 13=\mathrm{J} 12$ |
| Range high/low limit (deviation) * | $\begin{aligned} & \mathrm{ON} \text { when } \mathrm{SV}-\mathrm{AL}<\mathrm{PV}< \\ & \mathrm{SV}+\mathrm{AL} \end{aligned}$ | Deviation alarm | (DO) inversed |
| Range high/low limit (absolute) * | ON when $\mathrm{AL}<\mathrm{PV}<\mathrm{AH}$ | Absolute-value alarm | (DO) inversed |
| Range high/low limit (deviation) * | ON when $\mathrm{SV}-\mathrm{AL}<\mathrm{PV}<$ $\mathrm{SV}+\mathrm{AH}$ | Deviation alarm | (DO) inversed |

*Alarm limit is given via the communications line.
PID Control (Stop frequency for slow flowrate)
PID Control (Slow flowrate level stop latency)
PID Control (Starting frequency)
These function codes specify the data for the slow flowrate stop in pump control, a feature that stops the inverter when, the discharge pressure rises, causing the volume of water to decrease.

## ■ Slow flowrate stop feature

When the discharge pressure has increased, decreasing the reference frequency (output of the PID processor) below the stop frequency for slow flowrate level (J15) for more than the elapsed stopping time on slow flowrate level stop latency (J16), the inverter decelerates to stop, while PID control itself continues to operate. When the discharge pressure decreases, increasing the reference frequency (output of the PID processor) above the starting frequency (J17), the inverter resumes operation.
If you wish to have a signal indicating the state in which the inverter is stopped due to the slow flowrate stop feature, you need to assign (PID-STP) (Inverter stopping due to slow flowrate under PID control ) to one of the general-purpose output terminal (function code data $=44$ ).

## ■ PID Control (Stop frequency for slow flowrate) (J15)

Specifies the frequency which triggers slow flowrate stop of inverter.

- PID Control (Slow flowrate level stop latency) (J16)

Specifies the elapsed time from when the inverter stops operation due to slow flowrate level condition.

■ PID Control (Starting frequency) (J17)
Specifies the starting frequency. Select a frequency higher than the slow flowrate level stop frequency. If the specified starting frequency is lower than the slow flowrate level stop frequency, the latter stop frequency is ignored; the slow flowrate level stop is triggered when the output of the PID processor drops below the specified starting frequency.


PID Control (Upper limit of PID process output)

## PID Control (Lower limit of PID process output)

The upper and lower limiter can be specified to the PID output, exclusively used for PID control. The settings are ignored when PID cancel is enabled and the inverter is operated at the reference frequency previously specified.

■ PID Control (Upper limit of PID process output) (J18)
Specifies the upper limit of the PID processor output limiter in increments of 1 Hz . If you specify "999," the setting of the frequency limiter (Upper) (F15) will serve as the upper limit.

■ PID Control (Lower limit of PID process output) (J19)
Specifies the lower limit of the PID processor output limiter in increments of 1 Hz . If you specify "999," the setting of the frequency limiter (Lower) (F16) will serve as the lower limit.

## Dew Condensation Prevention (Duty)

When the inverter is stopped, dew condensation on the motor can be prevented, by feeding DC power to the motor at regular intervals to keep the temperature of the motor above a certain level.

To utilize this feature, you need to assign a terminal command (DWP) (dew condensation prevention) to one of general-purpose digital input terminals (function code data $=39$ ).

## ■ Enabling Dew Condensation Prevention

To enable dew condensation prevention, turn ON the condensation prevention command (DWP) while the inverter is stopped. Then, this feature starts.

■ Dew Condensation Prevention (Duty) (J21)
The magnitude of the DC power applied to the motor is the same as the setting of F21 (DC injection braking: Braking level) and its duration inside each interval is the same as the setting of F22 (DC injection braking: Braking time). The interval T is determined so that the ratio of the duration of the DC power to T is the value (Duty) set for J 21 .

Duty for condensation prevention $(J 21)=\frac{F 22}{T} \times 100(\%)$


Condensation Prevention Cycle

For how to set the commercial power switching sequence, refer to function codes E01 through E05.

### 9.2.7 y codes (Link functions)

Up to two ports of RS485 communications link are available, including the terminal block option as shown below.

| Port | Route | Function code | Applicable equipment |
| :---: | :--- | :---: | :--- |
| Port 1 | Standard RS485 (for <br> Communications <br> connection with keypad) via <br> RJ-45 port | y01 through y10 | Standard keypad <br> Multi-function keypad |
| PC running FRENIC |  |  |  |
| Port 2 | Optional RS485 <br> communications card via the <br> terminal port on the card | y11 through y20 | Loader <br> Host equipment |
| Host equipment <br> No FRENIC Loader <br> supported |  |  |  |

To connect any of the applicable devices, follow the procedures shown below.
(1) Standard keypad; Multi-function keypad (optional)

Both the standard keypad and the multi-function keypad (optional) allow you to run and monitor the inverter.

There is no need to set the y codes.
(2) FRENIC Loader

Using your PC running FRENIC Loader, you can monitor the inverter's running status information, edit function codes, and test-run the inverters.

Setting data of the y codes, refers to function codes y01 to y10. For details, refer to the FRENIC Loader Instruction Manual (INR-SI47-0903-E).
(3) Host equipment

The inverter can be managed and monitored by connecting host equipment such as a PC and PLC to the inverter. Modbus RTU* and Fuji general-purpose inverter protocol are available for communications protocols.

> *Modbus RTU is a protocol established by Modicon, Inc.
(D)

For details, refer to the RS485 communication User's Manual (MEH448a).

## RS485 Communication (Standard and option)

■ Station Address (y01 for standard port and y11 for option port)
These function codes specify the station address for the RS485 communications link. The table below lists the protocols and the station address setting ranges.

| Protocol | Station address | Broadcast address |
| :--- | :---: | :---: |
| Modbus RTU | 1 to 247 | 0 |
| FRENIC Loader | 1 to 255 | None |
| FUJI general-purpose inverter | 1 to 31 | 99 |

- If any wrong address beyond the above range is specified, no response is returned since the inverter will be unable to receive any enquiries except the broadcast message.
- When FRENIC Loader is used, set the station address in line with that of the connected PC.
- Communications error processing (y02 for standard port and y12 for option port)

Set the operation performed when an RS485 communications error has occurred.
RS485 communications errors contain logical errors such as address error, parity error, framing error, and transmission protocol error, and physical errors such as communications disconnection error set by y08 and y18. In each case, these are judged as an error only when the inverter is running while the operation command or frequency command has been set to the configuration specified through RS485 communications. When neither the operation command nor frequency command are issued through RS485 communications, or the inverter is not running, error occurrence is not recognized.

| Data for y02 <br> and y12 | Function |
| :---: | :--- |
| 0 | Indicate an RS485 communications error ( <br> and stop operation immediately. (The inverter stops with alarm issue.) |
| 1 | Run during the time set on the error processing timer (y03, y13), display an <br> RS485 communications error ( <br> operation. (The inverter stops with alarm issue.) |
| 2 | Retry transmission during the time set on the error processing timer (y03, <br> y13). If communications link is recovered, continue operation. Otherwise, <br> display an RS485 communications error <br> stop operation. (The inverter stops with alarm issue.) |
| 3 | Continue operation even when a communications error occurs. |

For details, refer to the RS485 communication User's Manual (MEH448a).

## ■ Error processing timer (y03 and y13)

Set an error processing timer.
When the set timer count has elapsed because of no response on other end etc., if a response request was issued, the inverter interprets that an error occurs. See the section of "No-response error detection time (y08, y18)."

- Data setting range: 0.0 to 60.0 (sec.)

■ Transmission speed (y04 and y14)
Select the transmission speed for RS485 communications.

- Setting for FRENIC Loader: Set the same transmission speed as that specified by the connected PC.

| Data for y04 <br> and y14 | Transmission speed (bps) |
| :---: | :---: |
| 0 | 2400 |
| 1 | 4800 |
| 2 | 9600 |
| 3 | 19200 |
| 4 | 38400 |

## ■ Character length (y05 and y15)

Select the character length for transmission.

- Setting for FRENIC Loader: Loader sets the length in 8 bits automatically. (The same applies to the Modbus RTU protocol.)

| Data for y05 <br> and y15 | Character length |
| :---: | :---: |
| 0 | 8 bits |
| 1 | 7 bits |

## ■ Parity check (y06 and y16)

Select the property of the parity bit.

- Setting for FRENIC Loader: Loader sets it to the even parity automatically.

| Data for y06 <br> and y16 | Parity |
| :---: | :--- |
| 0 | No parity bit |
| 1 | Even parity |
| 2 | Odd parity |

## ■ Stop bits (y07 and y17)

Select the number of stop bits.

- Setting for FRENIC Loader: Loader sets it to 1 bit automatically.
For the Modbus RTU protocol, the stop bits are automatically determined associated with the property of parity bits. So no setting is required.

| Data for y07 <br> and y17 | Stop bit(s) |
| :---: | :---: |
| 0 | 2 bits |
| 1 | 1 bit |

■ No-response error detection time (y08 and y18)
Set the time interval from the inverter detecting no access until it enters communications error alarm mode due to network failure and processes the communications error. This applies to a mechanical system that always accesses its station within a predetermined interval during communications using the RS485 communications link.

For the processing of communications errors, refer to y02 and y12.

| Data for y08 <br> and y18 | Function |
| :---: | :--- |
| 0 | Disable |
| 1 to 60 | 1 to 60 sec. |

## ■ Response latency time (y09 and y19)

Sets the latency time after the end of receiving a query sent from the host equipment (such as a PC or PLC) to the start of sending the response. This function allows using equipment whose response time is slow while a network requires quick response, enabling the equipment to send a response timely by the latency time setting.

- Data setting range: 0.00 to 1.00 (sec.)

$\mathrm{T} 1=$ Latency time $+\alpha$
where $\alpha$ is the processing time inside the inverter. This time may vary depending on the processing status and the command processed in the inverter.
DD For details, refer to the RS485 communication User's Manual (MEH448a).

Note
When setting the inverter with FRENIC Loader, pay sufficient attention to the performance and/or configuration of the PC and protocol converter such as RS485-RS232C communications level converter. Note that some protocol converters monitor the communications status and switch the send/receive of transmission data by a timer.

## - Protocol selection (y10)

Select the communications protocol for the standard RS485 port.

- Specifying FRENIC loader to connect to the inverter can only be made by y10. Select FRENIC Loader ( $\mathrm{y} 10=1$ ).

| Data for y10 | Protocol |
| :---: | :--- |
| 0 | Modbus RTU |
| 1 | FRENIC Loader |
| 2 | FUJI general-purpose <br> inverter |

## - Protocol selection (y20)

Select the communications protocol for the optional communications port.

| Data for y20 | Protocol |
| :---: | :--- |
| 0 | Modbus RTU |
| 2 | FUJI general-purpose <br> inverter |

For how to set y98 bus link function (function selection), refer to function code H30.

## Loader Link Function (Function selection)

This is a link switching function for FRENIC Loader. Rewriting the data of this function code y99 (=3) to enable RS485 communications from Loader helps Loader send the inverter the frequency and run commands. Since the data in the function code of the inverter is automatically set by Loader, no keypad operation is required. While Loader is selected as the source of the run command, if the PC runs out of control and cannot be stopped by a stop command sent from Loader, disconnect the RS485 communications cable from the standard port (Keypad), connect a keypad instead, and reset the y99 to " 0 ." This setting " 0 " in y99 means that the run and frequency command source specified by function code H30 takes place.

Note that the inverter cannot save the setting of $y 99$. When power is turned off, the data in y99 is lost (y99 is reset to "0").

| Data for y99 | Function |  |
| :---: | :--- | :--- |
|  | Frequency command | Run command |
| 0 | Follow the setting of H30 | Follow the setting of H30 |
| 1 | Enable commands from RS485 <br> communications link (S01 and S05) | Follow the setting of H30 |
| 2 | Follow the setting of H30 | Enable commands from RS485 <br> communications link (S06) |
| 3 | Enable commands from RS485 <br> communications link (S01 and S05) | Enable commands from RS485 <br> communications link (S06) |

## Appendices

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# App.A Advantageous Use of Inverters (Notes on electrical noise) 

- Disclaimer: This document provides you with a summary of the Technical Document of the Japan Electrical Manufacturers' Association (JEMA) (April 1994). It is intended to apply to the domestic market only. It is only for reference for the foreign market. -


## A. 1 Effect of inverters on other devices

Inverters have been and are rapidly expanding its application fields. This paper describes the effect that inverters have on electronic devices already installed or on devices installed in the same system as inverters, as well as introducing noise prevention measures. (Refer to Section A. 3 [3], "Noise prevention examples" for details.)

## [1] Effect on AM radios

| Phenomenon | If an inverter operates, an AM radio set near the inverter may pick up noise <br> radiated from the inverter. (An inverter has almost no effect on an FM radio or <br> television set.) |
| :--- | :--- |
| Probable cause $\quad$Radios may receive noise radiated from the inverter. <br> Measures$\quad$Inserting a noise filter on the power source (primary) side of the inverter is <br> effective. |  |

## [2] Effect on telephones


#### Abstract

Phenomenon If an inverter operates, nearby telephones may pick up noise radiated from the inverter in conversation so that it may be difficult to hear. Probable cause A high-frequency leakage current radiated from the inverter and motors enters shielded telephone cables, causing noise. Measures $\quad$ It is effective to commonly connect the grounding terminals of the motors and return the common grounding line to the grounding terminal of the inverter.


## [3] Effect on proximity switches


#### Abstract

Phenomenon If an inverter operates, proximity switches (capacitance-type) may malfunction. Probable cause The capacitance-type proximity switches may provide inferior noise immunity. Measures It is effective to connect a filter to the input terminals of the inverter or change the power supply treatment of the proximity switches. These switches can be replaced with superior noise immunity types such as magnetic type ones.


## [4] Effect on pressure sensors

| Phenomenon | If an inverter operates, pressure sensors may malfunction. |
| :--- | :--- |
| Probable cause | Noise may penetrate through a grounding wire into the signal line. |
| Measures |  |$\quad$| It is effective to install a noise filter on the power source (primary) side of the |
| :--- |
| inverter or to change the wiring. |

## [5] Effect on position detectors (pulse generators PGs or pulse encoders)

Phenomenon If an inverter operates, pulse encoders may produce erroneous pulses that shift the stop position of a machine.
Probable cause Erroneous pulses are liable to occur when the signal lines of the PG and power lines are bundled together.
Measure The influence of induction noise and radiation noise can be reduced by separating the PG signal lines and power lines. Providing noise filters at the input and output terminals will be also an effective measure.

## A. 2 Noise

This section gives a summary of noises generated in inverters and their effects on devices subject to noise.

## [ 1] Inverter noise

Figure A. 1 shows an outline of the inverter configuration. The inverter converts AC to DC (rectification) in a converter unit, and converts DC to AC (inversion) with 3-phase variable voltage and variable frequency. The conversion (inversion) is performed by PWM implemented by switching six transistors (IGBT: Insulated Gate Bipolar Transistor, etc), and is used for variable speed motor control.

Switching noise is generated by high-speed on/off switching of the six transistors. Noise current (i) is emitted and at each high-speed on/off switching, the noise current flows through stray capacitance (C) of the inverter, cable and motor to the ground. The amount of the noise current is expressed as follows:

$$
\mathrm{i}=\mathrm{C} \cdot \mathrm{dv} / \mathrm{dt}
$$

It is related to the stray capacitance (C) and dv/dt (switching speed of the transistors). Further, this noise current is related to the carrier frequency since the noise current flows each time the transistors are switched on or off.

In addition to the main inverter part, the DC-to-DC switching power regulator (DC-DC converter), which is the power source for the control electronics of the inverter, may be a noise source in the same principles as stated above. Refer to Figure A. 1 below.

The frequency band of this noise is less than approximately 30 to 40 MHz . Therefore, the noise will affect devices such as AM radio sets using low frequency band, but will not virtually affect FM radio sets and television sets using higher frequency than this frequency band.


Figure A. 1 Outline of Inverter Configuration

## [2] Types of noise

Noise generated in an inverter is propagated through the main circuit wiring to the power source (primary) and output (secondary) sides so as to affect a wide range of applications from the power supply transformer to the motor. The various propagation routes are shown in Figure A.2. According to those routes, noises are roughly classified into three types--conduction noise, induction noise, and radiation noise.


Figure A. 2 Noise Propagation Routes

## (1) Conduction noise

Noise generated in an inverter may propagate through the conductor and power supply so as to affect peripheral devices of the inverter (Figure A.3). This noise is called "conduction noise." Some conduction noises will propagate through the main circuit $(\mathbb{1}$. If the ground wires are connected to a common ground, conduction noise will propagate through route $\sqrt{\mathbf{2}}$. As shown in route (3), some conduction noises will propagate through signal lines or shielded wires.


Figure A. 3 Conduction Noise

## (2) Induction noise

When wires or signal lines of peripheral devices are brought close to the wires on the input and output sides of the inverter through which noise current is flowing, noise will be induced into those wires and signal lines of the devices by electromagnetic induction (Figure A.4) or electrostatic induction (Figure A.5). This is called "induction noise" ( (4).


Figure A. 4 Electromagnetic Noise


Figure A. 5 Electrostatic Induction Noise

## (3) Radiation noise

Noise generated in an inverter may be radiated through the air from wires (that act as antennas) at the power source (primary) and output (secondary) sides of the inverter. This noise is called "radiation noise" (5) as shown below. Not only wires but motor frames or power control enclosures containing inverters may also act as antennas.


Figure A. 6 Radiation Noise

## A. 3 Noise prevention

The more noise prevention is strengthened, the more effective. However, with the use of appropriate measures, noise problems may be resolved easily. It is necessary to implement economical noise prevention according to the noise level and the equipment conditions.

## [ 1] Noise prevention prior to installation

Before inserting an inverter in your power control enclosure or installing an inverter enclosure, you need to consider noise prevention. Once noise problems occur, it will cost additional materials and time for solving them.

Noise prevention prior to installation includes:

1) Separating the wiring of main circuits and control circuits
2) Putting main circuit wiring into a metal pipe (conduit pipe)
3) Using shielded wires or twist shielded wires for control circuits.
4) Implementing appropriate grounding work and grounding wiring.

These noise prevention measures can avoid most noise problems.

## [2] Implementation of noise prevention measures

There are two types of noise prevention measures--one for noise propagation routes and the other for noise receiving sides (that are affected by noise).

The basic measures for lessening the effect of noise at the receiving side include:
Separating the main circuit wiring from the control circuit wiring, avoiding noise effect.
The basic measures for lessening the effect of noise at the generating side include:

1) Inserting a noise filter that reduces the noise level.
2) Applying a metal conduit pipe or metal enclosure that will confine noise, and
3) Applying an insulated transformer for the power supply that cuts off the noise propagation route.

Table A. 1 lists the noise prevention measures, their goals, and propagation routes.
Table A. 1 Noise Prevention Measures

| Noise prevention method |  | Goal of noise prevention measures |  |  |  | Conduction route |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Make it more difficult to receive noise | Cutoff noise conduction | Confine noise | $\begin{aligned} & \text { Reduce } \\ & \text { noise } \\ & \text { level } \end{aligned}$ | Conduction noise | Induction noise | Radia- tion noise |
| Wiring and installation | Separate main circuit from control circuit | Y |  |  |  |  | Y |  |
|  | Minimize wiring distance | Y |  |  | Y |  | Y | Y |
|  | Avoid parallel and bundled wiring | Y |  |  |  |  | Y |  |
|  | Use appropriate grounding | Y |  |  | Y | Y | Y |  |
|  | Use shielded wire and twisted shielded wire | Y |  |  |  |  | Y | Y |
|  | Use shielded cable in main circuit |  |  | Y |  |  | Y | Y |
|  | Use metal conduit pipe |  |  | Y |  |  | Y | Y |
| Power control enclosure | Appropriate arrangement of devices in the enclosure | Y |  |  |  |  | Y | Y |
|  | Metal enclosure |  |  | Y |  |  | Y | Y |
| Anti-noise device | Line filter | Y |  |  | Y | Y |  | Y |
|  | Insulation transformer |  | Y |  |  | Y |  | Y |
| Measures at noise receiving sides | Use a passive capacitor for control circuit | Y |  |  |  |  | Y | Y |
|  | Use ferrite core for control circuit | Y |  |  | Y |  | Y | Y |
|  | Line filter | Y |  | Y |  | Y |  |  |
| Others | Separate power supply systems |  | Y |  |  | Y |  |  |
|  | Lower the carrier frequency |  |  |  | Y* | Y | Y | Y |

Y: Effective, Y*: Effective conditionally, Blank: Not effective

What follows is noise prevention measures for the inverter drive configuration.

## (1) Wiring and grounding

As shown in Figure A.7, separate the main circuit wiring from control circuit wiring as far as possible regardless of being located inside or outside the system enclosure containing an inverter. Use shielded wires and twisted shielded wires that will block out extraneous noises, and minimize the wiring distance. Also avoid bundled wiring of the main circuit and control circuit or parallel wiring.


Figure A. 7 Separate Wiring

For the main circuit wiring, use a metal conduit pipe and connect its wires to the ground to prevent noise propagation (refer to Figure A.8).
The shield (braided wire) of a shielded wire should be securely connected to the base (common) side of the signal line at only one point to avoid the loop formation resulting from a multi-point connection (refer to Figure A.9).
The grounding is effective not only to reduce the risk of electrical shocks due to leakage current, but also to block noise penetration and radiation. Corresponding to the main circuit voltage, the grounding work should be Class D grounding work ( 300 VAC or less, grounding resistance of $100 \Omega$ or less) and Class C grounding work ( 300 to 600 VAC , grounding resistance of $10 \Omega$ or less). Each ground wire is to be provided with its own ground or separately wired to a grounding point.


Figure A. 8 Grounding of Metal Conduit Pipe


Figure A. 9 Treatment of Braided Wire of Shielded Wire

## (2) Power control enclosure

A power control enclosure containing an inverter is generally made of metal, which can shield noise radiated from the inverter itself.

When installing other electronic devices such as a programmable logic controller in the same enclosure, be careful with the layout of each device. If necessary, arrange shield plates between the inverter and peripheral devices.

## (3) Anti-noise devices

To reduce the noise propagated through the electrical circuits and the noise radiated from the main circuit wiring to the air, a line filter and power supply transformer should be used (refer to Figure A.10).

Line filters are available in these types--the simplified type such as a capacitive filter to be connected in parallel to the power supply line and an inductive filter to be connected in series to the power supply line and the orthodox type such as an LC filter to meet radio noise regulations. Use them according to the targeted effect for reducing noise.
Power supply transformers include popular isolation transformers, shielded transformers, and noise-cutting transformers. These transformers have different effectiveness in blocking noise propagation.


Figure A. 10 Various Filters and their Connection

## (4) Noise prevention measures at the receiving side

It is important to strengthen the noise immunity of those electronic devices installed in the same enclosure as the inverter or located near an inverter. Line filters and shielded or twisted shielded wires are used to block the penetration of noise in the signal lines of these devices. The following treatments are also implemented.

1) Lower the circuit impedance by connecting capacitors or resistors to the input and output terminals of the signal circuit in parallel.
2) Increase the circuit impedance for noise by inserting choke coils in series in the signal circuit or passing signal lines through ferrite core beads. It is also effective to widen the signal base lines ( 0 V line) or grounding lines.

## (5) Other

The level of generating/propagating noise will change with the carrier frequency of the inverter. The higher the carrier frequency, the higher the noise level.
In an inverter that can change the carrier frequency, lowering the carrier frequency can reduce the generation of electrical noise and result in a good balance with the audible noise of the running motor.

## [3] Noise prevention examples

Table A. 2 lists examples of the measures to prevent noise generated by a running inverter.
Table A. 2 Examples of Noise Prevention Measures

| No. | Target device | Phenomena | Noise prevention measures | Notes |
| :---: | :---: | :---: | :---: | :---: |
| 1 | $\begin{aligned} & \text { AM } \\ & \text { radio } \\ & \text { set } \end{aligned}$ | When operating an inverter, noise enters into an AM radio broadcast band (500 to 1500 kHz ). <br> <Possible cause> The AM radio set may receive noise radiated from wires at the power source (primary) and output (secondary) sides of the inverter. | 1) Install an LC filter at the power source side of the inverter. (In some cases, a capacitive filter may be used as a simple method.) <br> 2) Install a metal conduit wiring between the motor and inverter. Or use shielded wiring. <br> Note: Minimize the distance between the LC filter and inverter as much as possible (within 1 m ). | 1) The radiation noise of the wiring can be reduced. <br> 2) The conduction noise to the power source side can be reduced. <br> Note: Sufficient improvement may not be expected in narrow regions such as between mountains. |
| 2 | $\begin{array}{\|l\|} \hline \text { AM } \\ \text { radio } \\ \text { set } \end{array}$ | When operating an inverter, noise enters into an AM radio broadcast band ( 500 to 1500 kHz ). <br> <Possible cause> The AM radio set may receive noise radiated from the power line at the power source (primary) side of the inverter. | 1) Install inductive filters at the power source (primary) and output (secondary) sides of the inverter. <br> The number of turns of the zero-phase reactor (or ferrite ring) should be as large as possible. In addition, wiring between the inverter and the zero-phase reactor (or ferrite ring) should be as short as possible. (within 1m) <br> 2) When further improvement is necessary, install LC filters. | 1) The radiation noise of the wiring can be reduced. |

Table A. 2 Continued

| No. | Target device | Phenomena | Noise prevention measures | Notes |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |
| 3 | Tele- <br> phone <br> (in a <br> common <br> private <br> residence <br> at a <br> distance <br> of 40 m ) | When driving a ventilation fan with an inverter, noise enters a private telephone in a residence at a distance of 40 m. <br> <Possible cause> A high-frequency leakage current emitted from the inverter or motor onto the commercial power lines interferes with a public telephone network service hub near the pole transformer, through the transformer's grounding line. In this case, the leakage current flowing on the grounding line may crosstalk in the hub through its grounding line and will be propagated to the telephone by electrostatic induction. | 1) Connect the ground terminals of the motors in a common connection with the inverter to return the high frequency components to the inverter enclosure, and insert a $1 \mu \mathrm{~F}$ capacitor between the input terminal of the inverter and ground. Refer to the note at right for details. | 1) The effect of the inductive filter and LC filter may not be expected because of its incapability of eliminating audio frequency. <br> 2) In the case of a V-connection power supply transformer in a 200 V system, it is necessary to connect capacitors as shown in the following figure, because of different potentials to ground. |
| 4 | Photoelectric relay | A photoelectric relay malfunctioned when the inverter runs the motor. [The inverter and motor are installed in the same place (such as for overhead hoist gear)] <br> <Possible cause> <br> It is considered that induction noise entered the photoelectric relay since the inverter's input power supply line and the photoelectric relay's wiring are routed in parallel each other within 25 mm clearance over a distance of 30 to 40 m or longer. Due to restrictions of the installation, these lines cannot be more separated. | 1) As a temporary measure, connect a $0.1 \mu \mathrm{~F}$ capacitor between the 0 V terminal of the power supply circuit in the photoelectric relay of the overhead gear and a frame of its enclosure. <br> 2) As a permanent measure, move the 24 V power supply from the floor to the overhead gear enclosure, and transfer the photoelectric relay signal to the equipment on the floor with relay contacts in the overhead gear. | 1) The wiring is separated by more than 30 cm . <br> 2) When separation is impossible, signals can be received and sent with dry contacts etc. <br> 3) Never wire weak-current signal lines and power lines closely each other in parallel. |

Table A. 2 Continued

| No. | Target device | Phenomena | Noise prevention measures | Notes |
| :---: | :---: | :---: | :---: | :---: |
| 5 | Photoelectric relay | A photoelectric relay malfunctioned when the inverter was operated. <br> <Possible cause> <br> Although the inverter and photoelectric relay are separated by a sufficient distance but the power supplies share a common connection, it is considered that conduction noise entered through the power supply line into the photoelectric relay. | 1) Insert a $0.1 \mu \mathrm{~F}$ capacitor between the output common terminal of the amplifier of the photoelectric relay and the frame. | 1) Taking a weak-current signal circuit malfunctioning into account may help you easily find simple and economical countermeasure. |
| 6 | Proximity switch (electrostatic type) | A proximity switch malfunctioned. <br> <Possible cause> It is considered that the capacitance type proximity switch is susceptible to conduction and radiation noise because of its low noise immunity. | 1) Install an LC filter at the output (secondary) side of the inverter. <br> 2) Install a capacitive filter at the power source (primary) side of the inverter. <br> 3) Ground the 0 V (common) line of the DC power supply of the proximity switch through a capacitor to the enclosure of the machine. | 1) Noise generated in the inverter can be reduced. <br> 2) The switch is superseded by a proximity switch of superior noise immunity (such as a magnetic type). |

Table A. 2 Continued

| No. | Target device | Phenomena | Noise prevention measures | Notes |
| :---: | :---: | :---: | :---: | :---: |
| 7 | Pressure sensor | A pressure sensor malfunctioned. <br> <Possible cause> The pressure sensor may malfunction due to noise that came from the enclosure through the shielded wire. | 1) Install an LC filter on the power source (primary) side of the inverter. <br> 2) Connect the shield of the wire of the pressure sensor to the 0 V line (common) of the pressure sensor, changing the old connection. | 1) The shield sheath of the wire for sensor signal is connected to a common point in the system. <br> 2) Conduction noise from the inverter can be reduced. |
| 8 | Position detector (pulse generator : PG) | Erroneous-pulse outputs from a pulse converter caused a shift in the stop position of a crane. <br> $<$ Possible cause> Erroneous pulses may be outputted by induction noise since the power line of the motor and the signal line of the PG are bundled together. | 1) Install an LC filter and a capacitive filter at the power source (primary) side of the inverter. <br> 2) Install an LC filter at the output (secondary) side of the inverter. | 1) This is an example of a measure where the power line and signal line cannot be separated. <br> 2) Induction noise and radiation noise at the output side of the inverter can be reduced. |
| 9 | Program mable logic controller (PLC) | The PLC program sometimes malfunctions. <br> $<$ Possible cause> Since the power supply system is the same for the PLC and inverter, it is considered that noise enters the PLC through the power supply. | 1) Install a capacitive filter and an LC filter on the power source (primary) side of the inverter. <br> 2) Install an LC filter on the output (secondary) side of the inverter. <br> 3) Lower the carrier frequency of the inverter. | 1) Total conduction noise and induction noise in the electric line can be reduced. |

# App.B Japanese Guideline for Suppressing Harmonics by Customers Receiving High Voltage or Special High Voltage 

- Disclaimer: This document provides you with a translated summary of the Guideline of the Ministry of International Trade and Industry (September 1994). It is intended to apply to the domestic market only. It is only for reference for the foreign market. -

Agency of Natural Resource and Energy of Japan published the following two guidelines for suppressing harmonic noise in September 1994.
(1) Guideline for suppressing harmonics in home electric and general-purpose appliances
(2) Guideline for suppressing harmonics by customers receiving high voltage or special high voltage

Assuming that electronic devices generating high harmonics will be increasing, these guidelines are to establish regulations for preventing high frequency noise interference on devices sharing the power source. These guidelines should be applied to all devices that are used on the commercial power lines and generate harmonic current. This section gives a description limited to general-purpose inverters.

## B. 1 Application to general-purpose inverters

## [1] Guideline for suppressing harmonics in home electric and general-purpose appliances

Our three-phase, 200 V series inverters of 3.7 kW or less (FRENIC-Eco series) were the products of which were restricted by the "Guideline for Suppressing Harmonics in Home Electric and General-purpose Appliances" (established in September 1994 and revised in October 1999) issued by the Ministry of Economy, Trade and Industry.
The above restriction, however, was lifted when the Guideline was revised in January 2004. Since then, the inverter makers have individually imposed voluntary restrictions on the harmonics of their products.
We, as before, recommend that you connect a reactor (for suppressing harmonics) to your inverter.
[2] Guideline for suppressing harmonics by customers receiving high voltage or special high voltage

Unlike other guidelines, this guideline is not applied to the equipment itself such as a general-purpose inverter, but is applied to each large-scale electric power consumer for total amount of harmonics. The consumer should calculate the harmonics generated from each piece of equipment currently used on the power source transformed and fed from the high or special high voltage source.

## (1) Scope of regulation

In principle, the guideline applies to the customers that meet the following two conditions:

- The customer receives high voltage or special high voltage.
- The "equivalent capacity" of the converter load exceeds the standard value for the receiving voltage ( 50 kVA at a receiving voltage of 6.6 kV ).

Appendix B. 2 [1] "Calculation of equivalent capacity ( Pi )" gives you some supplemental information with regard to estimation for the equivalent capacity of an inverter according to the guideline.

## (2) Regulation

The level (calculated value) of the harmonic current that flows from the customer's receiving point out to the system is subjected to the regulation. The regulation value is proportional to the contract demand. The regulation values specified in the guideline are shown in Table B.1.

Appendix B. 2 gives you some supplemental information with regard to estimation for the equivalent capacity of the inverter for compliance to "Japanese guideline for suppressing harmonics by customers receiving high voltage or special high voltage."

Table B. 1 Upper Limits of Harmonic Outflow Current per kW of Contract Demand (mA/kW)

| Receiving <br> voltage | 5th | 7th | 11th | 13th | 17 th | 19 th | 23rd | Over <br> 25th |
| ---: | ---: | ---: | :---: | ---: | ---: | ---: | ---: | ---: |
| 6.6 kV | 3.5 | 2.5 | 1.6 | 1.3 | 1.0 | 0.90 | 0.76 | 0.70 |
| 22 kV | 1.8 | 1.3 | 0.82 | 0.69 | 0.53 | 0.47 | 0.39 | 0.36 |

## (3) When the regulation applied

The guideline has been applied. As the application, the estimation for "Voltage waveform distortion rate" required as the indispensable conditions when entering into the consumer's contract of electric power is already expired.

## B. 2 Compliance to the harmonic suppression for customers receiving high voltage or special high voltage

When calculating the required matters related to inverters according to the guideline, follow the terms listed below. The following descriptions are based on "Technical document for suppressing harmonics" (JEAG 9702-1995) published by the Japan Electric Association (JEA).

## [1] Calculation of equivalent capacity ( Pi )

The equivalent capacity ( Pi ) may be calculated using the equation of (input rated capacity) x (conversion factor). However, catalogs of conventional inverters do not contain input rated capacities, so a description of the input rated capacity is shown below:

## (1) "Inverter rated capacity" corresponding to "Pi"

- In the guideline, the conversion factor of a 6-pulse converter is used as reference conversion factor 1. It is, therefore, necessary to express the rated input capacity of inverters in a value including harmonic component current equivalent to conversion factor 1.
- Calculate the input fundamental current $\mathrm{I}_{1}$ from the kW rating and efficiency of the load motor, as well as the efficiency of the inverter. Then, calculate the input rated capacity as shown below:

$$
\text { Input rated capacity }=\sqrt{3} \times(\text { power supply voltage }) \times \mathrm{I}_{1} \times 1.0228 / 1000(\mathrm{kVA})
$$

where 1.0228 is the 6-pulse converter's value of (effective current)/(fundamental current).

- When a general-purpose motor or inverter motor is used, the appropriate value shown in Table B. 2 can be used. Select a value based on the kW rating of the motor used, irrespective of the inverter type.

The input rated capacity shown above is for the dedicated use in the equation to calculate capacity of the inverters, following the guideline. Note that the capacity cannot be applied to the reference for selection of the equipment or wires to be used in the power source (primary) side.

For selection of capacity for the peripheral equipment, refer to the catalogs or technical documents issued from their manufacturers.

Table B. 2 "Input Rated Capacities" of General-purpose Inverters Determined by the Applicable Motor Ratings

| Applicable <br> motor rating <br> $(\mathrm{kW})$ |  | 0.4 | 0.75 | 1.5 | 2.2 | 3.7 <br> 4.0 | 5.5 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Pi <br> $(\mathrm{kVA})$ | 200 V | 0.57 | 0.97 | 1.95 | 2.81 | 4.61 | 6.77 |
|  | 400 V | 0.57 | 0.97 | 1.95 | 2.81 | 4.61 | 6.77 |

(2) Values of "Ki (conversion factor)"

Depending on whether an optional ACR (AC reactor) or DCR (DC reactor) is used, apply the appropriate conversion factor specified in the appendix to the guideline. The values of the conversion factor are listed in Table B.3.

Table B. 3 "Conversion Factors Ki" for General-purpose Inverters Determined by Reactors

| Circuit category | Circuit type |  | Conversion factor Ki | Main applications |
| :---: | :---: | :---: | :---: | :---: |
| 3 | 3-phase bridge (w/ reservoir capacitor) | w/o reactor | $\mathrm{K} 31=3.4$ | - General-purpose inverters <br> - Elevators <br> - Refrigerators, air conditioning systems <br> - Other general appliances |
|  |  | w/ reactor (ACR) | $\mathrm{K} 32=1.8$ |  |
|  |  | w/ reactor ( DCR ) | $\mathrm{K} 33=1.8$ |  |
|  |  | w/ reactors (ACR and DCR) | $\mathrm{K} 34=1.4$ |  |

Note Some models are equipped with a reactor as a built-in standard accessory.

## [2] Calculation of harmonic current

(1) Value of "input fundamental current"

- When you calculate the amount of harmonics according to Table 2 in Appendix of the Guideline, you have to previously know the input fundamental current.
- Apply the appropriate value shown in Table B. 4 based on the kW rating of the motor, irrespective of the inverter type or whether a reactor is used.

Note
If the input voltage is different, calculate the input fundamental current in inverse proportion to the voltage.

Table B. 4 "Input Fundamental Currents" of General-purpose Inverters Determined by the Applicable Motor Ratings

| Applicable motor rating <br> $(\mathrm{kW})$ | 0.4 | 0.75 | 1.5 | 2.2 | 3.7 <br> 4.0 | 5.5 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Input <br> fundamental <br> current (A) | 200 V | 1.62 | 2.74 | 5.50 | 7.92 | 13.0 | 19.1 |
|  | 400 V | 0.81 | 1.37 | 2.75 | 3.96 | 6.50 | 9.55 |
| 6.6 kV converted value <br> $(\mathrm{mA})$ | 49 | 83 | 167 | 240 | 394 | 579 |  |

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## (2) Calculation of harmonic current

Usually, calculate the harmonic current according to the Sub-table 3 "Three phase bridge rectifier with the reservoir capacitor" in Table 2 of the Guideline's Appendix. Table B. 5 lists the contents of the sub-table 3.

Table B. 5 Generated Harmonic Current (\%), 3-phase Bridge Rectifier (w/ reservoir capacitor)

| Higher harmonics order | 5th | 7th | 11 th | 13th | 17th | 19th | 23rd | 25th |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| w/o a reactor | 65 | 41 | 8.5 | 7.7 | 4.3 | 3.1 | 2.6 | 1.8 |
| w/ a reactor (ACR) | 38 | 14.5 | 7.4 | 3.4 | 3.2 | 1.9 | 1.7 | 1.3 |
| w/ a reactor (DCR) | 30 | 13 | 8.4 | 5.0 | 4.7 | 3.2 | 3.0 | 2.2 |
| w/ reactors (ACR and DCR) | 28 | 9.1 | 7.2 | 4.1 | 3.2 | 2.4 | 1.6 | 1.4 |

- ACR:
$\begin{array}{lll}\text { - } & \text { DCR: } & \text { Accumulated energy equal to } 0.08 \text { to } 0.15 \mathrm{~ms}(100 \% \text { load conversion }) \\ \text { - } & \text { Reservoir capacitor: } & \text { Accumulated energy equal to } 15 \text { to } 30 \mathrm{~ms} \mathrm{(100} \mathrm{\%} \mathrm{load} \mathrm{conversion)}\end{array}$
- Reservoir capacitor: Accumulated energy equal to 15 to 30 ms ( $100 \%$ load conversion)
- Load: 100\%

Calculate the harmonic current of each order using the following equation:

$$
\text { nth harmonic current }(\mathrm{A})=\text { Fundamental current }(\mathrm{A}) \times \frac{\text { Generated nth harmonic current }(\%)}{100}
$$

## (3) Maximum availability factor

- For a load for elevators, which provides intermittent operation, or a load with a sufficient designed motor rating, reduce the current by multiplying the equation by the "maximum availability factor" of the load.
- The "maximum availability factor of an appliance" means the ratio of the capacity of the harmonic generating source in operation at which the availability reaches the maximum, to its total capacity, and the capacity of the generating source in operation is an average for 30 minutes.
- In general, the maximum availability factor is calculated according to this definition, but the standard values shown in Table B. 6 are recommended for inverters for building equipment.

Table B. 6 Availability Factors of Inverters, etc. for Building Equipment (Standard Values)

| Equipment <br> type | Inverter capacity <br> category | Single inverter <br> availability |
| :--- | :--- | :---: |
| Air <br> conditioning <br> system | 200 kW or less | 0.55 |
| Sanitary pump | Over 200 kW | 0.60 |
| Elevator | - | 0.30 |
| Refrigerator, <br> freezer | 50 kW or less | 0.60 |
| UPS (6-pulse) | 200 kVA | 0.60 |

Correction coefficient according to contract demand level
Since the total availability factor decreases if the scale of a building increases, calculating reduced harmonics with the correction coefficient $\beta$ defined in Table B. 7 is permitted.

Table B. 7 Correction Coefficient according to the Building Scale

| Contract demand <br> $(\mathrm{kW})$ | Correction <br> coefficient $\beta$ |
| :---: | :---: |
| 300 | 1.00 |
| 500 | 0.90 |
| 1000 | 0.85 |
| 2000 | 0.80 |

Note: If the contract demand is between two specified values listed in Table B.7, calculate the value by interpolation.
Note: The correction coefficient $\beta$ is to be determined as a matter of consultation between the customer and electric power supplier for the customers receiving the electric power over 2000 kW or from the special high voltage lines.

## (4) Order of harmonics to be calculated

The higher the order of harmonics, the lower the current flows. This is the property of harmonics generated by inverters so that the inverters are covered by "The case without any special hazard" of the term (3) in the Guideline's Appendix 3.

Therefore, "It is sufficient that the 5th and 7th harmonic currents should be calculated."

## [3] Examples of calculation

## (1) Equivalent capacity

| Example of loads | Input capacity and <br> No. of inverters | Conversion factor | Equivalent capacity |
| :--- | :--- | :--- | :--- |
| [Example 1] $400 \mathrm{~V}, 3.7 \mathrm{~kW}, 10$ units <br> w/ AC reactor and DC reactor | $4.61 \mathrm{kVA} \times 10$ units | $\mathrm{K} 34=1.4$ | $4.61 \times 10 \times 1.4$ <br> $=64.54 \mathrm{kVA}$ |
| [Example 2] $400 \mathrm{~V}, 1.5 \mathrm{~kW}, 15$ units <br> w/ DC reactor | $1.95 \mathrm{kVA} \times 15$ units | $\mathrm{K} 33=1.8$ | $1.95 \times 15 \times 1.8$ <br> $=52.65 \mathrm{kVA}$ |
|  | Refer to Table B.2. | Refer to Table B.3. |  |

## (2) Harmonic current every orders

[Example 1] 400V, 3.7 kW 10 units, $\mathrm{w} / \mathrm{AC}$ reactor and DC reactor, and maximum availability: 0.55

| Fundamental current onto 6.6 kV lines (mA) | Harmonic current onto 6.6 kV lines (mA) |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $394 \times 10=3940$ | $\begin{gathered} 5 \text { th } \\ (28 \%) \end{gathered}$ | $\begin{gathered} 7 \text { th } \\ (9.1 \%) \end{gathered}$ | $\begin{gathered} 11 \text { th } \\ (7.2 \%) \end{gathered}$ | $\begin{gathered} \text { 13th } \\ (4.1 \%) \end{gathered}$ | $\begin{gathered} 17 \mathrm{th} \\ (3.2 \%) \end{gathered}$ | $\begin{aligned} & \text { 19th } \\ & (2.4 \%) \end{aligned}$ | $\begin{gathered} 23 \mathrm{rd} \\ (1.6 \%) \end{gathered}$ | $\begin{gathered} 25 \mathrm{th} \\ (1.4 \%) \end{gathered}$ |
|  | 606.8 | 197.2 |  |  |  |  |  |  |
| Refer to Tables B. 4 and B.6. | Refer to Table B.5. |  |  |  |  |  |  |  |

[Example 2] $400 \mathrm{~V}, 1.5 \mathrm{~kW}, 15$ units, w/ DC reactor, and maximum availability: 0.55

| Fundamental current onto 6.6 kV lines (mA) | Harmonic current onto 6.6 kV lines (mA) |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $167 \times 15=2505$ | $\begin{gathered} 5 \text { th } \\ (30 \%) \end{gathered}$ | $\begin{gathered} 7 \text { th } \\ (13 \%) \end{gathered}$ | $\begin{gathered} 11 \text { th } \\ (8.4 \%) \end{gathered}$ | $\begin{gathered} \text { 13th } \\ (5.0 \%) \end{gathered}$ | $\begin{gathered} 17 \mathrm{th} \\ (4.7 \%) \end{gathered}$ | $\begin{gathered} \text { 19th } \\ (3.2 \%) \end{gathered}$ | $\begin{gathered} 23 \mathrm{rd} \\ (3.0 \%) \end{gathered}$ | $\begin{gathered} 25 \mathrm{th} \\ (2.2 \%) \end{gathered}$ |
| $2505 \times 0$ | 413.4 | 179.2 |  |  |  |  |  |  |
| Refer to Tables B. 4 and B.6. | Refer to Table B.5. |  |  |  |  |  |  |  |

# App.C Effect on Insulation of General-purpose Motors Driven with 400 V Class Inverters 


#### Abstract

- Disclaimer: This document provides you with a summary of the Technical Document of the Japan Electrical Association (JEA) (March, 1995). It is intended to apply to the domestic market only. It is only for reference for the foreign market. -


## Preface

When an inverter drives a motor, surge voltages generated by switching the inverter elements are superimposed on the inverter output voltage and applied to the motor terminals. If the surge voltages are too high they may have an effect on the motor insulation and some cases have resulted in damage.

For preventing such cases this document describes the generating mechanism of the surge voltages and countermeasures against them.
DD) Refer to A. 2 [1] "Inverter noise" for details of the principle of inverter operation.

## C. 1 Generating mechanism of surge voltages

As the inverter rectifies a commercial power source voltage and smoothes into a DC voltage, the magnitude E of the DC voltage becomes about $\sqrt{2}$ times that of the source voltage (about 620 V in case of an input voltage of 440 VAC ). The peak value of the output voltage is usually close to this DC voltage value.

But, as there exists inductance (L) and stray capacitance (C) in wiring between the inverter and the motor, the voltage variation due to switching the inverter elements causes a surge voltage originating in LC resonance and results in the addition of high voltage to the motor terminals. (Refer to Figure C.1)

This voltage sometimes reaches up to about twice that of the inverter DC voltage ( $620 \mathrm{~V} \times 2=$ approximately $1,200 \mathrm{~V}$ ) depending on a switching speed of the inverter elements and wiring conditions.


Figure C. 1 Voltage Wave Shapes of Individual Portions

A measured example in Figure C. 2 illustrates the relation of a peak value of the motor terminal voltage with a wiring length between the inverter and the motor.

From this it can be confirmed that the peak value of the motor terminal voltage ascends as the wiring length increases and becomes saturated at about twice the inverter DC voltage.

The shorter a pulse rise time becomes, the higher the motor terminal voltage rises even in the case of a short wiring length.


Excerpt from [J. IEE Japan, Vol. 107, No. 7, 1987]
Figure C. 2 Measured Example of Wiring Length and Peak Value of Motor Terminal Voltage

## C. 2 Effect of surge voltages

The surge voltages originating in LC resonance of wiring may be applied to the motor input terminals and depending on their magnitude sometimes cause damage to the motor insulation.

When the motor is driven with a 200 V class inverter, the dielectric strength of the motor insulation has no problem even if the peak value of the motor terminal voltage increases twice at most due to the surge voltages since the DC link bus voltage is only approx. 300 V .

But in case of a 400 V class inverter the DC voltage to be switched is approximately 600 V and depending on the wiring length, the surge voltages may greatly increase (nearly at $1,200 \mathrm{~V}$ ) and sometimes result in damage to the motor insulation.

## C. 3 Countermeasures against surge voltages

The following methods are countermeasures against damage to the motor insulation by the surge voltages and using a motor driven with a 400 V class inverter.

## [ 1] Method using motors with enhanced insulation

Enhanced insulation of a motor winding allows its surge proof strength to be improved.

## [2] Method to suppress surge voltages

There are two methods for suppressing the surge voltages, one is to reduce the voltage rise time and another is to reduce the voltage peak value.

## (1) Output reactor

If wiring length is relatively short the surge voltages can be suppressed by reducing the voltage rise time (dv/dt) with the installation of an AC reactor on the output (secondary) side of the inverter. (Refer to Figure C. 3 (1).)

However, if the wiring length becomes long, suppressing the peak voltage due to surges may be difficult for this countermeasure.

## (2) Output filter

Installing a filter on the output side of the inverter allows a peak value of the motor terminal voltage to be reduced. (Refer to Figure C. 3 (2).)


Figure C. 3 Method to Suppress Surge Voltage

## C. 4 Regarding existing equipment

## [ 1] In case of a motor being driven with 400 V class inverter

A survey over the several years on motor insulation damage due to the surge voltages originating from switching of inverter elements shows that the damage incidence is $0.013 \%$ under the surge voltage condition of over $1,100 \mathrm{~V}$ and most of the damage occurs several months after commissioning the inverter. Therefore there seems to be little probability of occurrence of motor insulation damage after a lapse of several months of commissioning.
[2] In case of an existing motor driven using a newly installed 400 V class inverter We recommend suppressing the surge voltages with the method of Section C.3.

## App．D Inverter Generating Loss

The table below lists the inverter generating loss．

| Power supply voltage | Applicable motor rating（ kW ） | Inverter type | Generating loss（W） |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | Low carrier frequency ${ }^{* 1}$ | High carrier frequency ${ }^{* 2}$ |
| $\begin{aligned} & \text { Three- } \\ & \text { phase } \\ & 200 \mathrm{~V} \end{aligned}$ | 0.75 | FRN0．75F1■－2口 | 50 | 60 |
|  | 1.5 | FRN1．5F1■－2口 | 79 | 110 |
|  | 2.2 | FRN2．2F1■－2口 | 110 | 140 |
|  | 3.7 | FRN3．7F1■－2■ | 167 | 210 |
|  | 5.5 | FRN5．5F1■－2口 | 210 | 280 |
|  | 7.5 | FRN7．5F1■－2口 | 320 | 410 |
|  | 11 | FRN11F1■－2口 | 410 | 520 |
|  | 15 | FRN15F1■－2口 | 550 | 660 |
|  | 18.5 | FRN18．5F1■－2口 | 670 | 800 |
|  | 22 | FRN22F1■－2口 | 810 | 970 |
|  | 30 | FRN30F1■－2口 | 1070 | $1190{ }^{* 3}$ |
|  | 37 | FRN37F1■－2口 | 1700 | $1800{ }^{* 3}$ |
|  | 45 | FRN45F1■－2口 | 1500 | 1650 ＊3 |
|  | 55 | FRN55F1■－2口 | 1900 | $2150{ }^{* 3}$ |
|  | 75 | FRN75F1■－2口 | 2400 | $2700^{* 3}$ |
| Three－ phase 400 V | 0.75 | FRN0．75F1■－4ロ | 45 | 82 |
|  | 1.5 | FRN1．5F1■－4■ | 60 | 110 |
|  | 2.2 | FRN2．2F1■－4■ | 80 | 150 |
|  | 3.7 | FRN3．7F1■－4■ | 130 | 230 |
|  | 5.5 | FRN5．5F1■－4■ | 160 | 280 |
|  | 7.5 | FRN7．5F1■－4■ | 220 | 370 |
|  | 11 | FRN11F1■－4口 | 340 | 530 |
|  | 15 | FRN15F1■－4口 | 450 | 700 |
|  | 18.5 | FRN18．5F1■－4■ | 460 | 790 |
|  | 22 | FRN22F1■－4ロ | 570 | 970 |
|  | 30 | FRN30F1■－4口 | 950 | $1200{ }^{* 3}$ |
|  | 37 | FRN37F1■－4口 | 1150 | $1450{ }^{* 3}$ |
|  | 45 | FRN45F1■－4口 | 1300 | $1600^{* 3}$ |
|  | 55 | FRN55F1■－4口 | 1350 | $1700{ }^{* 3}$ |
|  | 75 | FRN75F1■－4口 | 1550 | 2050 ＊3 |
|  | 90 | FRN90F1■－4ロ | 1850 | $2100{ }^{* 4}$ |
|  | 110 | FRN110F1■－4口 | 2200 | $2500{ }^{* 4}$ |
|  | 132 | FRN132F1■－4口 | 2550 | $2900{ }^{* 4}$ |
|  | 160 | FRN160F1■－4D | 3150 | $3550{ }^{* 4}$ |
|  | 200 | FRN200F1■－4口 | 3800 | $4350{ }^{* 4}$ |
|  | 220 | FRN220F1■－4口 | 4350 | $4950{ }^{* 4}$ |

[^46]
## App.E Conversion from SI Units

All expressions given in Chapter 7, "SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES" are based on SI units (International System of Units). This section explains how to convert expressions to other units.

## [1] Conversion of units

(1) Force

- $1(\mathrm{kgf}) \approx 9.8(\mathrm{~N})$
- $1(\mathrm{~N}) \approx 0.102$ (kgf)
(2) Torque
- 1 (kgf $\cdot \mathrm{m}) \approx 9.8(\mathrm{~N} \cdot \mathrm{~m})$
- $1(\mathrm{~N} \cdot \mathrm{~m}) \approx 0.102$ (kgf$\cdot \mathrm{m})$
(3) Work and Energy
- $1(\mathrm{kgf} \cdot \mathrm{m}) \approx 9.8(\mathrm{~N} \cdot \mathrm{~m})=9.8(\mathrm{~J})=$ 9.8 (W•s)
(4) Power
- $1(\mathrm{kgf} \cdot \mathrm{m} / \mathrm{s}) \approx 9.8(\mathrm{~N} \cdot \mathrm{~m} / \mathrm{s})=9.8(\mathrm{~J} / \mathrm{s})$ $=9.8(\mathrm{~W})$
- $1(\mathrm{~N} \cdot \mathrm{~m} / \mathrm{s}) \approx 1(\mathrm{~J} / \mathrm{s})=1(\mathrm{~W})$ $\approx 0.102(\mathrm{kgf} \cdot \mathrm{m} / \mathrm{s})$
(5) Rotation speed
- $1(\mathrm{r} / \mathrm{min})=\frac{2 \pi}{60}(\mathrm{rad} / \mathrm{s}) \approx 0.1047(\mathrm{rad} / \mathrm{s})$
- $1(\mathrm{rad} / \mathrm{s})=\frac{60}{2 \pi}(\mathrm{r} / \mathrm{min}) \approx 9.549(\mathrm{r} / \mathrm{min})$
(6) Inertia constant

| $\mathrm{J}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)$ | :moment of inertia |
| :--- | :--- |
| $\mathrm{GD}^{2}\left(\mathrm{~kg} \cdot \mathrm{~m}^{2}\right)$ | :flywheel effect |

- $\mathrm{GD}^{2}=4 \mathrm{~J}$
- $\mathrm{J}=\frac{\mathrm{GD}^{2}}{4}$
(7) Pressure and stress
- $1(\mathrm{mmAq}) \approx 9.8(\mathrm{~Pa}) \approx 9.8\left(\mathrm{~N} / \mathrm{m}^{2}\right)$
- $1(\mathrm{~Pa}) \approx 1\left(\mathrm{~N} / \mathrm{m}^{2}\right) \approx 0.102(\mathrm{mmAq})$
- $1(\mathrm{bar}) \approx 100000(\mathrm{~Pa}) \approx 1.02\left(\mathrm{~kg} \cdot \mathrm{~cm}^{2}\right)$
- $1\left(\mathrm{~kg} \cdot \mathrm{~cm}^{2}\right) \approx 98000(\mathrm{~Pa}) \approx 980(\mathrm{mbar})$
- 1 atmospheric pressure $=1013$ (mbar)
$=760(\mathrm{mmHg})=101300(\mathrm{~Pa})$
$\approx 1.033\left(\mathrm{~kg} / \mathrm{cm}^{2}\right)$


## [2] Calculation formula

(1) Torque, power, and rotation speed

- $\mathrm{P}(\mathrm{W}) \approx \frac{2 \pi}{60} \cdot \mathrm{~N}(\mathrm{r} / \mathrm{min}) \cdot \tau(\mathrm{N} \cdot \mathrm{m})$
- $\mathrm{P}(\mathrm{W}) \approx 1.026 \cdot \mathrm{~N}(\mathrm{r} / \mathrm{min}) \cdot \mathrm{T}(\mathrm{kgf} \cdot \mathrm{m})$
- $\tau(\mathrm{N} \cdot \mathrm{m}) \approx 9.55 \cdot \frac{\mathrm{P}(\mathrm{W})}{\mathrm{N}(\mathrm{r} / \mathrm{min})}$
- $\mathrm{T}(\mathrm{kgf} \cdot \mathrm{m}) \approx 0.974 \cdot \frac{\mathrm{P}(\mathrm{W})}{\mathrm{N}(\mathrm{r} / \mathrm{min})}$
(2) Kinetic energy
- $\mathrm{E}(\mathrm{J}) \approx \frac{1}{182.4} \cdot \mathrm{~J}\left(\mathrm{~kg} \cdot \mathrm{~m}^{2}\right) \cdot \mathrm{N}^{2}\left[(\mathrm{r} / \mathrm{min})^{2}\right]$
- $\mathrm{E}(\mathrm{J}) \approx \frac{1}{730} \cdot \mathrm{GD}^{2}\left(\mathrm{~kg} \cdot \mathrm{~m}^{2}\right) \cdot \mathrm{N}^{2}\left[(\mathrm{r} / \mathrm{min})^{2}\right]$
(3) Torque of linear moving load

Driving mode

- $\tau(\mathrm{N} \cdot \mathrm{m}) \approx 0.159 \cdot \frac{\mathrm{~V}(\mathrm{~m} / \mathrm{min})}{\mathrm{N}_{\mathrm{M}}(\mathrm{r} / \mathrm{min}) \cdot \eta_{\mathrm{G}}} \cdot \mathrm{F}(\mathrm{N})$
- $\mathrm{T}(\mathrm{kgf} \cdot \mathrm{m}) \approx 0.159 \cdot \frac{\mathrm{~V}(\mathrm{~m} / \mathrm{min})}{\mathrm{N}_{\mathrm{M}}(\mathrm{r} / \mathrm{min}) \cdot \eta_{\mathrm{G}}} \cdot \mathrm{F}(\mathrm{kgf})$


## Braking mode

- $\tau(\mathrm{N} \cdot \mathrm{m}) \approx 0.159 \cdot \frac{\mathrm{~V}(\mathrm{~m} / \mathrm{min})}{\mathrm{N}_{\mathrm{M}}(\mathrm{r} / \mathrm{min}) / \eta_{\mathrm{G}}} \cdot \mathrm{F}(\mathrm{N})$
- $\mathrm{T}(\mathrm{kgf} \cdot \mathrm{m}) \approx 0.159 \cdot \frac{\mathrm{~V}(\mathrm{~m} / \mathrm{min})}{\mathrm{N}_{\mathrm{M}}(\mathrm{r} / \mathrm{min}) / \eta_{\mathrm{G}}} \cdot \mathrm{F}(\mathrm{kgf})$
(4) Acceleration torque

Driving mode

- $\tau(\mathrm{N} \cdot \mathrm{m}) \approx \frac{\mathrm{J}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)}{9.55} \cdot \frac{\Delta \mathrm{~N}(\mathrm{r} / \mathrm{min})}{\Delta \mathrm{t}(\mathrm{s}) \cdot \eta_{\mathrm{G}}}$
- $\mathrm{T}(\mathrm{kgf} \cdot \mathrm{m}) \approx \frac{\mathrm{GD}^{2}\left(\mathrm{~kg} \cdot \mathrm{~m}^{2}\right)}{375} \cdot \frac{\Delta \mathrm{~N}(\mathrm{r} / \mathrm{min})}{\Delta \mathrm{t}(\mathrm{s}) \cdot \eta_{\mathrm{G}}}$

Braking mode

- $\tau(\mathrm{N} \cdot \mathrm{m}) \approx \frac{\mathrm{J}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)}{9.55} \cdot \frac{\Delta \mathrm{~N}(\mathrm{r} / \mathrm{min}) \cdot \eta_{\mathrm{G}}}{\Delta \mathrm{t}(\mathrm{s})}$
- $\mathrm{T}(\mathrm{kgf} \cdot \mathrm{m}) \approx \frac{\mathrm{GD}^{2}\left(\mathrm{~kg} \cdot \mathrm{~m}^{2}\right)}{375} \cdot \frac{\Delta \mathrm{~N}(\mathrm{r} / \mathrm{min}) \cdot \eta_{\mathrm{G}}}{\Delta \mathrm{t}(\mathrm{s})}$
(5) Acceleration time
- $\mathrm{t}_{\mathrm{ACC}}(\mathrm{s}) \approx \frac{\mathrm{J}_{1}+\mathrm{J}_{2} / \eta_{\mathrm{G}}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)}{\tau_{\mathrm{M}}-\tau_{\mathrm{L}} / \eta_{\mathrm{G}}(\mathrm{N} \cdot \mathrm{m})} \cdot \frac{\Delta \mathrm{N}(\mathrm{r} / \mathrm{min})}{9.55}$
- $\mathrm{t}_{\mathrm{ACC}}(\mathrm{s}) \approx \frac{\mathrm{GD}_{1}{ }^{2}+\mathrm{GD}_{2}{ }^{2} / \eta_{\mathrm{G}}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)}{\mathrm{T}_{\mathrm{M}}-\mathrm{T}_{\mathrm{L}} / \eta_{\mathrm{G}}(\mathrm{kgf} \cdot \mathrm{m})} \cdot \frac{\Delta \mathrm{N}(\mathrm{r} / \mathrm{min})}{375}$
(6) Deceleration time
- $\mathrm{t}_{\mathrm{DEC}}(\mathrm{s}) \approx \frac{\mathrm{J}_{1}+\mathrm{J}_{2} \cdot \eta_{\mathrm{G}}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)}{\tau_{\mathrm{M}}-\tau_{\mathrm{L}} \cdot \eta_{\mathrm{G}}(\mathrm{N} \cdot \mathrm{m})} \cdot \frac{\Delta \mathrm{N}(\mathrm{r} / \mathrm{min})}{9.55}$
$\cdot \mathrm{t}_{\mathrm{DEC}}(\mathrm{s}) \approx \frac{\mathrm{GD}_{1}{ }^{2}+\mathrm{GD}_{2}{ }^{2} \cdot \eta_{\mathrm{G}}\left(\mathrm{kg} \cdot \mathrm{m}^{2}\right)}{\mathrm{T}_{\mathrm{M}}-\mathrm{T}_{\mathrm{L}} \cdot \eta_{\mathrm{G}}(\mathrm{kgf} \cdot \mathrm{m})} \cdot \frac{\Delta \mathrm{N}(\mathrm{r} / \mathrm{min})}{375}$


## App.F Allowable Current of Insulated Wires

The tables below list the allowable current of IV wires, HIV wires, and 600 V class of cross-linked polyethylene-insulated wires.
■IV wires (Maximum allowable temperature: $60^{\circ} \mathrm{C}$ )
Table F. 1 (a) Allowable Current of Insulated Wires

| Wire size ( $\mathrm{mm}^{2}$ ) | Allowable current | Wiring outside duct |  |  |  |  | Wiring in the duct (Max. 3 wires in one duct) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{array}{\|c\|} \hline \text { reference value } \\ \text { (up to } 30^{\circ} \mathrm{C} \text { ) } \\ \text { lo }(\mathrm{A}) \\ \hline \end{array}$ | $\begin{gathered} 35^{\circ} \mathrm{C} \\ (10 \times 0.91) \end{gathered}$ <br> (A) |  | $\begin{gathered} 45^{\circ} \mathrm{C} \\ (\operatorname{lo} \times 0.71) \end{gathered}$ <br> (A) | $\begin{gathered} 50^{\circ} \mathrm{C} \\ (10 \times 0.58) \end{gathered}$ <br> (A) | $\begin{gathered} 55^{\circ} \mathrm{C} \\ (10 \times 0.40) \end{gathered}$ (A) | $\begin{gathered} 35^{\circ} \mathrm{C} \\ (10 \times 0.63) \end{gathered}$ (A) | $\begin{gathered} 40^{\circ} \mathrm{C} \\ (10 \times 0.57) \end{gathered}$ (A) |  | $\begin{gathered} 50^{\circ} \mathrm{C} \\ (10 \times 0.40) \end{gathered}$ <br> (A) |
| 2.0 | 27 | 24 | 22 | 19 | 15 | 11 | 17 | 15 | 13 | 10 |
| 3.5 | 37 | 33 | 30 | 26 | 21 | 15 | 23 | 21 | 18 | 14 |
| 5.5 | 49 | 44 | 40 | 34 | 28 | 20 | 30 | 27 | 24 | 19 |
| 8.0 | 61 | 55 | 50 | 43 | 35 | 25 | 38 | 34 | 29 | 24 |
| 14 | 88 | 80 | 72 | 62 | 51 | 36 | 55 | 50 | 43 | 35 |
| 22 | 115 | 104 | 94 | 81 | 66 | 47 | 72 | 65 | 56 | 46 |
| 38 | 162 | 147 | 132 | 115 | 93 | 66 | 102 | 92 | 79 | 64 |
| 60 | 217 | 197 | 177 | 154 | 125 | 88 | 136 | 123 | 106 | 86 |
| 100 | 298 | 271 | 244 | 211 | 172 | 122 | 187 | 169 | 146 | 119 |
| 150 | 395 | 359 | 323 | 280 | 229 | 161 | 248 | 225 | 193 | 158 |
| 200 | 469 | 426 | 384 | 332 | 272 | 192 | 295 | 267 | 229 | 187 |
| 250 | 556 | 505 | 455 | 394 | 322 | 227 | 350 | 316 | 272 | 222 |
| 325 | 650 | 591 | 533 | 461 | 377 | 266 | 409 | 370 | 318 | 260 |
| 400 | 745 | 677 | 610 | 528 | 432 | 305 | 469 | 424 | 365 | 298 |
| 500 | 842 | 766 | 690 | 597 | 488 | 345 | 530 | 479 | 412 | 336 |
| $2 \times 100$ | 497 | 452 | 407 | 352 | 288 | 203 | 313 | 283 | 243 | 198 |
| $2 \times 150$ | 658 | 598 | 539 | 467 | 381 | 269 | 414 | 375 | 322 | 263 |
| $2 \times 200$ | 782 | 711 | 641 | 555 | 453 | 320 | 492 | 445 | 383 | 312 |
| $2 \times 250$ | 927 | 843 | 760 | 658 | 537 | 380 | 584 | 528 | 454 | 370 |
| $2 \times 325$ | 1083 | 985 | 888 | 768 | 628 | 444 | 682 | 617 | 530 | 433 |
| $2 \times 400$ | 1242 | 1130 | 1018 | 881 | 720 | 509 | 782 | 707 | 608 | 496 |
| $2 \times 500$ | 1403 | 1276 | 1150 | 996 | 813 | 575 | 883 | 799 | 687 | 561 |

- HIV wires (Maximum allowable temperature: $75^{\circ} \mathrm{C}$ )

Table F. 1 (b) Allowable Current of Insulated Wires

| Wire size ( $\mathrm{mm}^{2}$ ) | Allowable current reference value (up to $30^{\circ} \mathrm{C}$ ) lo (A) | Wiring outside duct |  |  |  |  | Wiring in the duct (Max. 3 wires in one duct) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{gathered} 35^{\circ} \mathrm{C} \\ (10 \times 0.91) \end{gathered}$ <br> (A) |  |  | $\begin{gathered} 50^{\circ} \mathrm{C} \\ (10 \times 0.58) \end{gathered}$ <br> (A) | $\begin{gathered} 55^{\circ} \mathrm{C} \\ (10 \times 0.40) \end{gathered}$ <br> (A) | $\begin{gathered} 35^{\circ} \mathrm{C} \\ (10 \times 0.63) \end{gathered}$ <br> (A) | $\begin{gathered} 40^{\circ} \mathrm{C} \\ (10 \times 0.57) \\ (\mathrm{A}) \\ \hline \end{gathered}$ |  |  |
| 2.0 | 32 | 31 | 29 | 27 | 24 | 22 | 21 | 20 | 18 | 17 |
| 3.5 | 45 | 42 | 39 | 37 | 33 | 30 | 29 | 27 | 25 | 23 |
| 5.5 | 59 | 56 | 52 | 49 | 44 | 40 | 39 | 36 | 34 | 30 |
| 8.0 | 74 | 70 | 65 | 61 | 55 | 50 | 48 | 45 | 42 | 38 |
| 14 | 107 | 101 | 95 | 88 | 80 | 72 | 70 | 66 | 61 | 55 |
| 22 | 140 | 132 | 124 | 115 | 104 | 94 | 92 | 86 | 80 | 72 |
| 38 | 197 | 186 | 174 | 162 | 147 | 132 | 129 | 121 | 113 | 102 |
| 60 | 264 | 249 | 234 | 217 | 197 | 177 | 173 | 162 | 151 | 136 |
| 100 | 363 | 342 | 321 | 298 | 271 | 244 | 238 | 223 | 208 | 187 |
| 150 | 481 | 454 | 426 | 395 | 359 | 323 | 316 | 296 | 276 | 248 |
| 200 | 572 | 539 | 506 | 469 | 426 | 384 | 375 | 351 | 328 | 295 |
| 250 | 678 | 639 | 600 | 556 | 505 | 455 | 444 | 417 | 389 | 350 |
| 325 | 793 | 747 | 702 | 650 | 591 | 533 | 520 | 487 | 455 | 409 |
| 400 | 908 | 856 | 804 | 745 | 677 | 610 | 596 | 558 | 521 | 469 |
| 500 | 1027 | 968 | 909 | 842 | 766 | 690 | 673 | 631 | 589 | 530 |
| $2 \times 100$ | 606 | 571 | 536 | 497 | 452 | 407 | 397 | 372 | 347 | 313 |
| $2 \times 150$ | 802 | 756 | 710 | 658 | 598 | 539 | 526 | 493 | 460 | 414 |
| $2 \times 200$ | 954 | 899 | 844 | 782 | 711 | 641 | 625 | 586 | 547 | 492 |
| $2 \times 250$ | 1130 | 1066 | 1001 | 927 | 843 | 760 | 741 | 695 | 648 | 584 |
| $2 \times 325$ | 1321 | 1245 | 1169 | 1083 | 985 | 888 | 866 | 812 | 758 | 682 |
| $2 \times 400$ | 1515 | 1428 | 1341 | 1242 | 1130 | 1018 | 993 | 931 | 869 | 782 |
| $2 \times 500$ | 1711 | 1613 | 1515 | 1403 | 1276 | 1150 | 1122 | 1052 | 982 | 883 |

600 V class of Cross-linked Polyethylene-insulated wires (Maximum allowable temperature: $90^{\circ} \mathrm{C}$ )

Table F. 1 (c) Allowable Current of Insulated Wires

| Wire size$\left(\mathrm{mm}^{2}\right)$ | Allowable current reference value (up to $30^{\circ} \mathrm{C}$ ) lo (A) | Wiring outside duct |  |  |  |  | Wiring in the duct (Max. 3 wires in one duct) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{gathered} 35^{\circ} \mathrm{C} \\ (10 \times 0.91) \end{gathered}$ <br> (A) | $\begin{gathered} 40^{\circ} \mathrm{C} \\ (10 \times 0.82) \end{gathered}$ <br> (A) | $\begin{gathered} 45^{\circ} \mathrm{C} \\ (10 \times 0.71) \end{gathered}$ <br> (A) | $\begin{gathered} 50^{\circ} \mathrm{C} \\ (\mathrm{l} \times \times 0.58) \end{gathered}$ <br> (A) | $\begin{gathered} 55^{\circ} \mathrm{C} \\ (10 \times 0.40) \end{gathered}$ <br> (A) | $\begin{gathered} 35^{\circ} \mathrm{C} \\ (10 \times 0.63) \end{gathered}$ <br> (A) | $\begin{gathered} 40^{\circ} \mathrm{C} \\ (\mathrm{lo} \times 0.57) \end{gathered}$ <br> (A) | $\begin{gathered} 45^{\circ} \mathrm{C} \\ (10 \times 0.49) \end{gathered}$ <br> (A) | $\begin{gathered} 50^{\circ} \mathrm{C} \\ (\mathrm{lo} \times 0.40) \end{gathered}$ <br> (A) |
| 2.0 | 38 | 36 | 34 | 32 | 31 | 29 | 25 | 24 | 22 | 21 |
| 3.5 | 52 | 49 | 47 | 45 | 42 | 39 | 34 | 33 | 31 | 29 |
| 5.5 | 69 | 66 | 63 | 59 | 56 | 52 | 46 | 44 | 41 | 39 |
| 8.0 | 86 | 82 | 78 | 74 | 70 | 65 | 57 | 54 | 51 | 48 |
| 14 | 124 | 118 | 113 | 107 | 101 | 95 | 82 | 79 | 74 | 70 |
| 22 | 162 | 155 | 148 | 140 | 132 | 124 | 108 | 103 | 97 | 92 |
| 38 | 228 | 218 | 208 | 197 | 186 | 174 | 152 | 145 | 137 | 129 |
| 60 | 305 | 292 | 279 | 264 | 249 | 234 | 203 | 195 | 184 | 173 |
| 100 | 420 | 402 | 384 | 363 | 342 | 321 | 280 | 268 | 253 | 238 |
| 150 | 556 | 533 | 509 | 481 | 454 | 426 | 371 | 355 | 335 | 316 |
| 200 | 661 | 633 | 605 | 572 | 539 | 506 | 440 | 422 | 398 | 375 |
| 250 | 783 | 750 | 717 | 678 | 639 | 600 | 522 | 500 | 472 | 444 |
| 325 | 916 | 877 | 838 | 793 | 747 | 702 | 611 | 585 | 552 | 520 |
| 400 | 1050 | 1005 | 961 | 908 | 856 | 804 | 700 | 670 | 633 | 596 |
| 500 | 1187 | 1136 | 1086 | 1027 | 968 | 909 | 791 | 757 | 715 | 673 |
| $2 \times 100$ | 700 | 670 | 641 | 606 | 571 | 536 | 467 | 447 | 422 | 397 |
| $2 \times 150$ | 927 | 888 | 848 | 802 | 756 | 710 | 618 | 592 | 559 | 526 |
| $2 \times 200$ | 1102 | 1055 | 1008 | 954 | 899 | 844 | 735 | 703 | 664 | 625 |
| $2 \times 250$ | 1307 | 1251 | 1195 | 1130 | 1066 | 1001 | 871 | 834 | 787 | 741 |
| $2 \times 325$ | 1527 | 1462 | 1397 | 1321 | 1245 | 1169 | 1018 | 974 | 920 | 866 |
| $2 \times 400$ | 1751 | 1676 | 1602 | 1515 | 1428 | 1341 | 1167 | 1117 | 1055 | 993 |
| $2 \times 500$ | 1978 | 1894 | 1809 | 1711 | 1613 | 1515 | 1318 | 1262 | 1192 | 1122 |

## Glossary

This glossary explains the technical terms that are frequently used in this manual.

## Acceleration time

Period required when an inverter accelerates its output from 0 Hz to the output frequency.
Related function codes: F03, F07, E10, and H54

## Alarm mode

One of the three operation modes supported by the inverter. If the inverter detects any malfunction, error, or fault in its operation, it immediately shuts down or trips the output to the motor and enters this mode in which corresponding alarm codes are displayed on the LED monitor.

## Alarm output (for any faults)

A mechanical contact output signal that is generated when the inverter is halted by an alarm, by short-circuiting between terminals [30A] and [30C].
Related function code: E27
See Alarm mode.

## Analog input

An external voltage or current input signal to give the inverter the frequency command. The analog voltage is applied on the terminal [11] or [V2], the current on the [C1]. These terminals are also used to input the signal from the external potentiometer, PTC and PID feedback signals depending on the function code definition.
Related function codes: F01, C30, E60 to E62 and J02

## Analog output

An analog DC output signal of the monitored data such as the output frequency, the current and voltage inside an inverter. The signal drive an analog meter installed outside the inverter for indicating the current inverter running status.
Refer to Chapter 8, Section 8.4.1 "Terminal functions."

## Applicable motor rating

Rated output (in kW ) of a general-purpose motor that is used as a standard motor listed in tables in Chapter 6, "SELECTING PERIPHERAL EQUIPMENT" and Chapter 8, "SPECIFICATIONS."

## Automatic deceleration

A control mode in which deceleration time is automatically extended up to 3 times of the commanded time to prevent the inverter from tripping due to an overvoltage caused by regenerative power even if a braking resistor is used.
Related function code: H69

## Automatic energy saving operation

Energy saving operation that automatically drives the motor with lower output voltage when the motor load has been light, for minimizing the product of voltage and current (electric power).
Related function code: F37

## AVR (Automatic Voltage Regulator) control

A control that keeps an output voltage constant regardless to variations of the input source voltage or load.


The minimum frequency at which an inverter delivers a constant voltage in the output V/f pattern. Related function code: F04

## Bias

A value to be added to an analog input frequency to modify and produce the output frequency.
Related function codes: F18, C50 to C52

## Braking torque

Torque that acts in a direction that will stop a rotating motor (or the force required to stop a running motor).


During accelerating or running at constant speed


During decelerating

If a deceleration time is shorter than the natural stopping time (coast-to-stop) determined by a moment of inertia for a load machine, then the motor works as a generator when it decelerates, causing the kinetic energy of the load to be converted to electrical energy that is returned to the inverter from the motor. If this power (regenerative power) is consumed or accumulated by the inverter, the motor generates a braking force called "braking torque."

## Carrier frequency

Frequency used to modulate a modulated frequency to establish the modulation period of a pulse width under the PWM control system. The higher the carrier frequency, the closer the inverter output current approaches a sinusoidal waveform and the quieter the motor becomes.
Related function code: F26

## Coast-to-stop

If the inverter stops its output when the motor is running, the motor will coast to a stop due to inertial force.

## Communications link function

A feature to control an inverter from external equipment serially linked to the inverter such as a PC or PLC.
Related function code: H30

## Constant feeding rate time

Time required for an object to move in a constant distance previously defined. The faster speed, the shorter time and vise versa. This facility may be applied to a chemical process that determines a processing time of materials as the speed such as heating, cooling, drying, or doping in some constant-speed machinery.
Related function codes: E50.

## Constant output load

A constant output load is characterized by:

1) The required torque is in inverse proportion to the load $\mathrm{r} / \mathrm{min}$
2) An essentially constant power requirement Related function code: F37
Applications: Machine tool spindles


## Constant torque load

A constant torque load is characterized by:

1) A requirement for an essentially constant torque, regardless of the $\mathrm{r} / \mathrm{min}$
2) A power requirement that decreases in proportion to the $\mathrm{r} / \mathrm{min}$
Related function code: F37
Applications: Conveyors, elevators, and transport machines


## Control circuit terminals

Terminals on the inverter, which are used for input/output of signals to control or manage the inverter/external equipment directly or indirectly

## Current limiter

A device that keeps an inverter output frequency within the specified current limit.

## Cursor

Marker blinking on the four-digit, 7-segment LED monitor which shows that data in the blinking digit can be changed/modified by keying operation.

## Curvilinear V/f pattern

A generic name for the inverter output patterns with curvilinear relation between the frequency and voltage.
Refer to function code H07 in Chapter 9, Section 9.2.5 "H codes."

## DC braking (DC injection braking)

DC current braking that an inverter injects into the motor to brake and stop it against the moment of inertia of the motor or its load. The inertial energy generated is consumed as heat in the motor.
If a motor having the load with large moment of inertia is going to stop abruptly, the moment of inertia may force to rotate the motor after the inverter output frequency has been reduced to 0 Hz . Use DC injection braking to stop the motor completely.
Related function codes: F20 and F21

## DC link bus voltage

Voltage at the DC link bus that is the end stage of the converter part of inverters. The part rectifies the input AC power to charge the DC link bus capacitor/s as the DC power to be inverted to AC power.

## Deceleration time

Period during which an inverter slows its output frequency down from the maximum to 0 Hz . Related function codes: F03, F08, E11, and H54

## Digital input

Input signals given to the programmable input terminals or the programmable input terminals themselves. A command assigned to the digital input is called the terminal command to control the inverter externally.
Refer to Chapter 8, Section 8.4.1 "Terminal functions."

## Electronic thermal overload protection

Electronic thermal overload protection to issue an early warning of the motor overheating to safeguard a motor.
An inverter calculates the motor overheat condition based on the internal data (given by function code P99 about the properties of the motor) and the driving conditions such as the drive current, voltage and frequency.

## External potentiometer

A potentiometer (optional) that is used to set frequencies as well as built-in one.

## Fan stop operation

A mode of control in which the cooling fan is shut down if the internal temperature in the inverter is low and when no operation command is issued. Related function code: H06

## Frequency accuracy (stability)

The percentage of variations in output frequency to a predefined maximum frequency.

## Frequency limiter

Frequency limiter used inside the inverter to control the internal drive frequency in order to keep the motor speed within the specified level between the high and low frequency.
Related function codes: F15, F16, and H64

## Frequency resolution

The minimum step, or increment, in which output frequency is varied, rather than continuously.

## Function code

Code to customize the inverter. Setting function codes realizes the potential capability of the inverter to meet it for the individual power system applications.

## Gain (for frequency command)

A frequency command gain enables varying the slope the reference frequency set with an analog input signal.
Related function codes: C32, C34, C37, and C39

## IGBT (Insulated Gate Bipolar Transistor)

Stands for Insulated Gate Bipolar Transistor that enables the inverter section to switch high voltage/current DC power in very high speed and to output pulse train.

## Interphase unbalance

A condition of an AC input voltage (supply voltage) that states the voltage balance of each phase in an expression as:

$$
\begin{aligned}
& \text { Interphase voltage unbalance }(\%) \\
& =\frac{\text { Max.voltage }(\mathrm{V})-\text { Min.voltage }(\mathrm{V})}{3 \text { - phase average voltage }(\mathrm{V})} \times 67
\end{aligned}
$$

## Inverse mode operation

A mode of operation in which the output frequency lowers as the analog input signal level rises.

## Jogging operation

A special operation mode of inverters, in which a motor jogs forward or reverse for a short time at a slower speed than usual operating modes.
Related function codes: F03, C20, and H54

## Jump frequencies

Frequencies that have a certain output with no change in the output frequency within the specified frequency band in order to skip the resonance frequency band of a machine.
Related function codes: C 01 to C 04

## Keypad operation

To use a keypad to run an inverter.

## Line speed

Running speed of an object (e.g., conveyor) driven by the motor. The unit is meter per minute, $\mathrm{m} / \mathrm{min}$.

## Load shaft speed

Number of revolutions per minute ( $\mathrm{r} / \mathrm{min}$ ) of a rotating load driven by the motor, such as a fan.

## Main circuit terminals

Power input/output terminals of an inverter, which includes terminals to connect the power source, motor, DC rector, braking resistor, and other power components.

## Maximum frequency

The output frequency commanded by the input of the maximum value of a reference frequency setup signal (for example, 10 V for a voltage input range of 0 to 10 V or 20 mA for a current input range of 4 to 20 mA ).
Related function code: F03

## Modbus RTU

Communication protocol used in global FA network market, which is developed by Modicon, Inc. USA.

## Momentary voltage dip capability

The minimum voltage ( V ) and time ( ms ) that permit continued rotation of the motor after a momentary voltage drop (instantaneous power failure).

## Multistep frequency selection

To preset frequencies (up to 7 stages), then select them at some later time using external signals.
Related function codes: E01 to E03, C05 to C11

## Overload capability

The overload current that an inverter can tolerate, expressed as a percentage of the rated output current and also as a permissible energization time.

## PID control

The scheme of control that brings controlled objects to a desired value quickly and accurately, and which consists of three categories of action: proportional, integral and derivative.
Proportional action minimizes errors from a set point. Integral action resets errors from a desired value to 0 . Derivative action applies a control value in proportion to a differential component of the difference between the PID reference and feedback values. (See Chapter 4, Figure 4.7.)
Related function codes: E01 to E03, E40, E41, E43, E60 to E62, C51, C52, J01 to J06

## Programming mode

One of the three operation modes supported by the inverter. This mode uses the menu-driven system and allows the user to set function codes or check the inverter status/maintenance information.

## PTC (Positive Temperature Coefficient) thermistor

Type of thermistor with a positive temperature coefficient. Used to safeguard a motor.
Related function codes: H26 and H27

## Rated capacity

The rating of an inverter output capacity (at the secondary side), or the apparent power that is represented by the rated output voltage times the rated output current, which is calculated by solving the following equation and is stated in kVA :

$$
\begin{aligned}
& \text { Rated capacity }(\mathrm{kVA}) \\
& =\sqrt{3} \times \text { Rated output voltage }(\mathrm{V}) \\
& \times \text { Rated output current }(\mathrm{A}) \times 10^{-3}
\end{aligned}
$$

The rated output voltage is assumed to be 220 V for 200 V class equipment and 440 V for 400 V class equipment.

## Rated output current

A total RMS equivalent to the current that flows through the output terminal under the rated input and output conditions (the output voltage, current, frequency, and load factor meet their rated conditions). Essentially, equipment rated at 200 V covers the current of a $200 \mathrm{~V}, 50 \mathrm{~Hz} 6$-pole motor and equipment rated at 400 V covers the current of a $380 \mathrm{~V}, 50 \mathrm{~Hz} 4$-pole motor.

## Rated output voltage

A fundamental wave RMS equivalent to the voltage that is generated across the output terminal when the AC input voltage (supply voltage) and frequency meet their rated conditions and the output frequency of the inverter equals the base frequency.

## Required power supply capacity

The capacity required of a power supply for an inverter. This is calculated by solving either of the following equations and is stated in kVA :

$$
\begin{aligned}
& \text { Required power supply capacity }(\mathrm{kVA}) \\
& =\sqrt{3} \times 200 \times \text { Input RMS current }(200 \mathrm{~V}, 50 \mathrm{~Hz}) \\
& \text { or } \\
& =\sqrt{3} \times 220 \times \text { Input RMS current }(220 \mathrm{~V}, 60 \mathrm{~Hz}) \\
& \text { Required power supply capacity }(\mathrm{kVA}) \\
& =\sqrt{3} \times 400 \times \text { Input RMS current }(400 \mathrm{~V}, 50 \mathrm{~Hz}) \\
& \text { or } \\
& =\sqrt{3} \times 440 \times \text { Input RMS current }(40 \mathrm{~V}, 60 \mathrm{~Hz})
\end{aligned}
$$

## Running mode

One of the three operation modes supported by the inverter. If the inverter is turned ON , it automatically enters this mode which you may: run/stop the motor, set up the reference frequency, monitor the running status, and jog the motor.

## S-curve acceleration/deceleration (weak/strong)

To reduce the impact on the inverter driven machine during acceleration/deceleration, the inverter gradually accelerates/decelerates the motor at the both ends of the acceleration/deceleration zones like a figure of $S$ letter.
Related function code: H07

## Slip compensation control

A mode of control in which the output frequency of an inverter plus an amount of slip compensation is used as an actual output frequency to compensate for motor slippage.
Related function code: P09

## Stall

A behavior of a motor when it loses speed by tripping of the inverter due to overcurrent detection or other malfunctions of the inverter.

## Starting frequency

The minimum frequency at which an inverter starts its output (not the frequency at which a motor starts rotating).
Related function code: F23

## Starting torque

Torque that a motor produces when it starts rotating (or the drive torque with which the motor can run a load).

## Simultaneous keying

To simultaneously press the 2 keys on the keypad. This presents the special function of inverters.

## Stop frequency

The output frequency at which an inverter stops its output.
Related function code: F25

## Thermal time constant

The time needed to activate the electronic thermal overload protection after the preset operation level (current) continuously flows. This is an adjustable function code data to meet the property of a motor that is not manufactured by Fuji Electric.
Related function code: F12

## Torque boost

If a general-purpose motor is run with an inverter, voltage drops will have a pronounced effect in a low-frequency region, reducing the motor output torque. In a low-frequency range, therefore, to increase the motor output torque, it is necessary to augment the output voltage. This process of voltage compensation is called torque boost. Related function code: F09


## Transistor output

A control signal that generates predefined data from within an inverter via a transistor (open collector).

## Trip

In response to an overvoltage, overcurrent, or any other unusual condition, actuation of an inverter's protective circuit to stop the inverter output.

## V/f characteristic

A characteristic expression of the variations in output voltage $\mathrm{V}(\mathrm{V})$, and relative to variations in output frequency $\mathrm{f}(\mathrm{Hz})$. To achieve efficient motor operation, an appropriate V/f (voltage/frequency) characteristic helps a motor produce its output torque matching the torque characteristics of a load.

## V/f control

The rotating speed $\mathrm{N}(\mathrm{r} / \mathrm{min})$ of a motor can be stated in an expression as

$$
\mathrm{N}=\frac{120 \times \mathrm{f}}{\mathrm{p}} \times(1-\mathrm{s})
$$

where,
f: Output frequency
p: Number of poles
s: Slippage
On the basis of this expression, varying the output frequency varies the speed of the motor. However, simply varying the output frequency $\mathrm{f}(\mathrm{Hz})$ would result in an overheated motor or would not allow the motor to demonstrate its optimum utility if the output voltage $\mathrm{V}(\mathrm{V})$ remains constant. For this reason, the output voltage V must be varied with the output frequency f by using an inverter. This scheme of control is called V/f control.

## Variable torque load

A squared torque load is characterized by:

1) A change in the required torque in proportion to the square of the number of revolutions per minute. 2) $A$ power requirement that decreases in proportion to the cube of the decrease in the number of revolutions per minute.

Required power $(\mathrm{kW})$
$=\frac{\text { Rotating speed }(\mathrm{r} / \mathrm{min}) \times \text { Torque }(\mathrm{N} \cdot \mathrm{m})}{9.55}$
Related function code: F37
Applications: Fans and pumps


## Voltage and frequency variations

Variations in the input voltage or frequency within permissible limits. Variations outside these limits might cause an inverter or motor to fail.

## Designed For Fan and Pump Applications

## FRENIC-ECO

## User's Manual

First Edition, March 2005

Fuji Electric FA Components \& Systems Co., Ltd.

The purpose of this manual is to provide accurate information in the handling, setting up and operating of the FRENIC-Eco series of inverters. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

In no event will Fuji Electric FA Components \& Systems Co., Ltd. be liable for any direct or indirect damages resulting from the application of the information in this manual.

# Designed for Fan and Pump Applications FRENIC-Eco Pump Control 

## $\triangle$ CAUTION

Thank you for purchasing our FRENIC-Eco series of inverters.

- This product is designed to drive a three-phase induction motor. Read through this instruction manual and be familiar with the handling procedure for correct use.
- Improper handling might result in incorrect operation, a short life, or even a failure of this product as well as the motor.
- Deliver this manual to the end user of this product. Keep this manual in a safe place until this product is discarded.
- For how to use an optional device, refer to the installation and instruction manuals for that optional device.

The FRENIC-Eco series of inverters for fan and pump applications (for variable torque load) is capable of dynamically driving more than one pump.

This manual describes the pump drive and lists points that should be noted during operation.
Read through this manual in conjunction with the FRENIC-Eco Instruction Manual.

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## Chapter 1 Overview

"Pump control" refers to controlling more than one pump motor by a single inverter. The inverter selectively drives one of pump motors in a liquid dispatch system, while switching power sources of other pump motors to commercial power lines as required.

In the pump control, the PID controller integrated in the inverter processes the PID command such as flowrate or pressure.

When the inverter-driven motor is no longer sustain the discharge flowrate required, the inverter issues an output signal that dynamically switches the power source for individual motors between the inverter output and commercial lines or mounts a commercial power-driven motor(s).

If the discharge flowrate is low, for example, the inverter drives one of the motors; if higher, it mounts more motors driven by commercial power in order to ensure the total discharge flowrate required. This pump control system further works to even the historical operation conditions of motors such as the cumulative run time.

The pump control system is available in two configurations: one with a fixed inverter-driven motor and the other with a floating inverter-driven motor. The details are described later in this manual.

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| Item | Dynamic rotation of pumps |  | Remarks |
| :---: | :---: | :---: | :---: |
|  | With a fixed inverter-driven motor | With a floating inverter-driven motor |  |
| Maximum number of pumps to drive | Inverter-driven: 1 <br> Commercial power-driven: $4$ | Inverter- and commercial power-driven: 3 | Optional relay output card (OPC-F1S-RY) required |
| Applicable motor rating | All pump motors managed by the inverter shall be of the same rating. |  |  |
| Control | PID control integrated in the inverter |  |  |
| Motor mount/unmount order | The inverter automatically mounts or unmounts a motor(s) to even the cumulative run time of all motors. |  | Selectable by function code data |
| Periodic motor switching | The inverter switches motors at the specified intervals even if the number of motors in operation does not change. |  | Selectable by function code data |
| Motor stop mode | Choice of the following two: To stop all motors or only the inverter-driven one with a Stop command issued to the inverter |  | Selectable by function code data |
| Forced stop | Using function code data or digital input enables or disables a forced stop for individual motors. |  | Selectable by function code data |
| Cumulative run time | The cumulative run time can be monitored for individual motors. |  |  |
| Cumulative number of relay ON times | The cumulative number of ON/OFF switching times can be monitored for each relay. |  |  |
| Clear periodic switching time | The interval for periodic switching can be reset to zero by terminal command (MCLR) from the external equipment. |  |  |
| Motor mount/unmount command | (M1_L): Mount motor 1, commercial-powerdriven | (M1_I): Mount motor 1, inverter-driven | These signals can be assigned to transistor output [Y1] to [Y3], relay contact output [Y5A/C], [30A/B/C], or relay output card's [Y1A/B/C] to [Y3A/B/C]. |
|  | (M2_L): Mount motor 2, commercial-powerdriven | (M1_L): Mount motor 1, commercial-power-d riven |  |
|  | (M3_L): Mount motor 3, commercial-powerdriven | (M2_I): Mount motor 2 inverter-driven |  |
|  | (M4_L): Mount motor 4, commercial-powerdriven | (M2_L): Mount motor 2 commercial-power-d riven |  |
|  |  | (M3_I): Mount motor 3 inverter-driven |  |
|  |  | (M3_L): Mount motor 3 commercial-power-d riven |  |
| Periodic switching early warning signal | This signal gives the external equipment an early warning of the periodic switching. |  |  |
| Pump control limit signal | The inverter issues this signal when it detects such a condition that requires further mounting a motor(s) even after all pump motors are in operation. |  |  |

### 2.1 Dynamic Rotation of Pump Motors

### 2.1.1 With a fixed inverter-driven motor

This configuration consists of a motor driven by the inverter (M0) and motors driven by commercial power (M1 to M4). The inverter-driven motor is fixed at M0 and is controlled for variable speed. When the inverter-driven motor M0 alone cannot sustain the desired discharge flowrate, the inverter mounts one or more motors driven by commercial power as necessary.


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### 2.1.2 With a floating inverter-driven motor

In this configuration, all the motors can be driven by the inverter or commercial power. At the start of operation, each motor is driven by the inverter and is controlled for varying speed. When the first motor alone cannot sustain the desired discharge flowrate, it is switched to commercial-power operation, and the inverter drives the second motor.


### 2.1.3 Assignment to output terminals

In the pump control, contactors (relay outputs) are used to change the configuration of several pump motors or to run/stop them.

The following number of contactor control signal lines is required for motor control:
Configuration with a fixed inverter-driven motor: Max. 4 output signal lines ( 4 motors $\times 1$ line/motor)
Configuration with a floating inverter-driven motor: Max. 6 output signal lines ( 3 motors $\times 2$ lines/motor)
The inverter has five output terminals ( $\mathrm{Y} 1, \mathrm{Y} 2, \mathrm{Y} 3, \mathrm{Y} 5 \mathrm{~A} / \mathrm{C}$, and $30 \mathrm{~A} / \mathrm{B} / \mathrm{C}$ ) as standard. If more are needed, use output terminals ( $\mathrm{Y} 1 \mathrm{~A} / \mathrm{B} / \mathrm{C}, \mathrm{Y} 2 \mathrm{~A} / \mathrm{B} / \mathrm{CRY}$, and $\mathrm{Y} 3 \mathrm{~A} / \mathrm{B} / \mathrm{CRY}$ ) of an optional relay output card.
Using the relay output card for pump control requires setting up its contact functions for $\mathrm{Y} 1, \mathrm{Y} 2$, and Y 3 on the inverter with function codes J 45 to J 47 . When the card is used for the original purpose, that is, for converting Y 1 , Y 2 , and Y 3 signals to relay contact ones, no special setup is required.

## Chapter 3 Function Codes

### 3.1 List of Function Codes

The table below lists the function codes associated with pump control. For the details of PID and other controls, refer to the Instruction Manual and the User's Manual of the inverter.

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E01 | Command Assignment to [X1] | Refer to the instruction manual of the inverter for data other than listed below. | - | - | N | Y | 6 | 9 |
| E02 | [X2] |  | - | - | N | Y | 7 |  |
| E03 | [X3] | 50 (1050): Clear periodic switching time (MCLR) | - | - | N | Y | 8 |  |
| E04 | [X4] | 51 (1051): Enable pump drive (motor 1) (MEN1) | - | - | N | Y | 11 |  |
| E05 | [X5] | 52 (1052): Enable pump drive (motor 2) (MEN2) | - | - | N | Y | 35 |  |
| E98 | [FWD] | 53 (1053): Enable pump drive (motor 3) (MEN3) |  |  |  |  |  |  |
| E99 | [REV] | 54 (1054): Enable pump drive (motor 4) (MEN4) |  |  |  |  |  |  |
| E20 | Signal Assignment to: (Transistor signal) | Refer to the instruction manual of the inverter for data other than listed below. | - | - | N | Y | 0 | 9 |
| E21 | [Y1] | 60 (1060): Mount motor 1 driven by inverter (M1_I) | - | - | N | Y | 1 |  |
| E22 | [Y2] | 61 (1061): Mount motor 1 driven by commercial power <br> (M1_L) | - | - | N | Y | 2 |  |
| E24 | [Y3] | 62 (1062): Mount motor 2 driven by inverter (M2_I) | - | - | N | Y | 15 |  |
| E27 | (Relay contact signal) <br> [Y5A/C] <br> [30A/B/C] | 63 (1063): Mount motor 2 driven by commercial power <br> (M2_L) 64 (1064): Mount motor 3 driven by inverter <br> 65 (1065): Mount motor 3 driven by commercial power <br> (M3_L) <br> 67 (1067): Mount motor 4 driven by commercial power <br> (M4_L) <br> 68 (1068): Periodic switching early warning <br> (MCHG) <br> 69 (1069): Pump control limit signal <br> (MLIM) | - | - | N | Y | 99 |  |
| J25 | Pump Control (Mode selection) | 0: Disable 1: Enable (Fixed inverter-driven motor) 2: Enable (Floating inverter-driven motor) | 1 | - | N | Y | 0 | 10 |
| J26 | Motor 1 Mode | 0: Disable (Always OFF) | 1 | - | Y | Y | 0 | 10 |
| J27 | Motor 2 Mode | 1: Enable | 1 | - | Y | Y | 0 |  |
| J28 | Motor 3 Mode | 2: Force to run by commercial power | 1 | - | Y | Y | 0 |  |
| J29 | Motor 4 Mode |  | 1 | - | Y | Y | 0 |  |
| J30 | Motor Switching Order | 0: Fixed 1: Automatically (Constant run time) | 1 | - | Y | Y | 0 | 11 |
| J31 | Motor Stop Mode | 0: Stop all motors (inverter- and commercial power-driven) <br> 1: Stop inverter-driven motors only (excl. alarm state) <br> 2: Stop inverter-driven motors only (incl. alarm state) | 1 | - | Y | Y | 0 | 12 |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI
Code table continued.

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default <br> setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| J32 | Periodic Switching Time for Motor Drive | 0.0: Disable switching 0.1 to 720.0 h : Switching time range 999: Fix to 3 minutes | 1 | - | Y | Y | 0 | 13 |
| J33 | Periodic Switching Signaling Period | 0.00 to 600.00 | 0.01 | s | Y | Y | 0.1 | 14 |
| J34 | Mount of Commercial Power-driven Motor (Frequency) | 0 to 120 <br> 999: Depends on setting of J18 <br> (This code is used to judge whether or not to mount a commercial power-driven motor by checking the output frequency of the inverter-driven motor.) | 1 | Hz | Y | Y | 999 | 15 |
| J35 | (Duration) | 0.00 to 3600 | Variable | s | Y | Y | 0 |  |
| J36 | Unmount of Commercial Power-driven Motor (Frequency) | $0 \text { to } 120$ <br> 999: Depends on setting of J19 <br> (This code is used to judge whether or not to unmount a commercial power-driven motor by checking the output frequency of the inverter-driven motor.) | 1 | Hz | Y | Y | 999 |  |
| J37 | (Duration) | 0.00 to 3600 | Variable | s | Y | Y | 0 |  |
| J38 | Contactor Delay Time | 0.01 to 2.00 | 0.01 | s | Y | Y | 0.1 | 17 |
| J39 | Switching Time for Motor Mount <br> (Deceleration time) | 0.00: Depends on the setting of F08, 0.01 to 3600 | Variable | s | Y | Y | 0 | 15 |
| J40 | Switching Time for Motor Unmount <br> (Acceleration time) | 0.00 : Depends on the setting of F07, 0.01 to 3600 | Variable | s | Y | Y | 0 |  |
| J41 | Motor Mount/Unmount Switching Level | 0 to 100 | 1 | \% | Y | Y | 0\% | 15 |
| J42 | Switching Motor Mount/Unmount (Dead band) | 0.0: Disable 0.1 to 50.0 | 0.1 | \% | Y | Y | 0.00\% | 17 |
| J43 | PID Control Startup Frequency | $\begin{aligned} & \text { 0: Disable } \\ & 1 \text { to } 120 \\ & \text { 999: Depends on the setting of J36 } \end{aligned}$ | 1 | Hz | Y | Y | 999 | 17 |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O
Code table continued.


### 3.2 Details of Function Codes

This section describes the function codes that are used for pump control. For the description of function codes not found here, refer to the Instruction Manual and the User's Manual of the inverter.

## E01 to E05, E98, E99: Command Assignment to Terminals [X1] to [X5], [FWD], and [REV]

Function codes E01 to E05, E98 and E99 allow you to assign commands to general-purpose, programmable input terminals [X1] to [X5], [FWD], and [REV].
For the programmable input functions other than pump control, refer to the Instruction Manual of the inverter.
< Pump Control Functions >
■ Assignment of "Clear periodic switching time" command (MCLR) (E01 to E05, E98, E99 = 50)
■ Assignment of "Enable pump drive" commands (MEN1) to (MEN4) (E01 to E05, E98, E99 = 51, 52, 53, 54)
For details, refer to the description of each function code in this manual. (J32: Periodic switching time for motor drive, J26 to J29: Motor 1 mode to Motor 4 mode.)

## E20 to E22, E24, E27, J45 to J47: <br> Signal Assignment to Terminals [Y1] to [Y3], [Y5A/C], [30A/B/C], and [Y1A/B/C] to [Y3A/B/C]

Function codes E20 to E22, E24 and E27 allow you to assign output signals to general-purpose, programmable output terminals $[Y 1]$ to $[Y 3]$, $[Y 5 A / C]$, and $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$. If more terminals are needed, terminals $[\mathrm{Y} 1 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$, $[Y 2 A / B / C]$, and $[Y 3 A / B / C]$ on the optional relay output card can be used as general-purpose programmable output terminals (for pump functions only).
For the programmable output functions other than pump control, refer to the Instruction Manual for the inverter.
Note: If J 45 to $\mathrm{J} 47=100$, terminals $[\mathrm{Y} 1 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ to $[\mathrm{Y} 3 \mathrm{~A} / \mathrm{B} / \mathrm{C}$ ] provide the same output signals as terminals [Y1] to [Y3]. Further, you cannot assign any functions other than those associated with pump control.

## < Pump Control Functions >

■ Assignment of "Mount pump motor" command signals (M1_I) to (M3_I) and (M1_L) to (M4_L) (E20 to E22, E24, E27, J45 to J47 = 60 to 67)
Specify "Mount pump motor" command signals according to the configuration and the number of pump motors, as listed below.

| Item | Configuration with a fixed inverter-driven motor | Configuration with a floating inverter-driven motor |
| :---: | :---: | :---: |
| "Mount pump motor" command signals | (M1_L): Mount pump motor 1, commercial-power-driven | (M1_I): Mount pump motor 1, inverter-driven |
|  | (M2_L): Mount pump motor 2, commercial-power-driven | (M1_L): $\begin{aligned} & \text { Mount pump motor 1, } \\ & \text { commercial-power-driven }\end{aligned}$ |
|  | (M3_L): Mount pump motor 3, commercial-power-driven | (M2_I):Mount pump motor 2, <br> inverter-driven |
|  | (M4_L): Mount pump motor 4, commercial-power-driven | (M2_L): Mount pump motor 2, commercial-power-driven |
|  |  | (M3_I): Mount pump motor 3, inverter-driven |
|  |  | (M3_L): $\begin{aligned} & \text { Mount pump motor 3, } \\ & \text { commercial-power-driven }\end{aligned}$ |

■ Assignment of "Periodic switching early warning" signal (MCHG) (E20 to E22, E24, E27, J45 to J47 = 68)
For details, refer to the description of the related function code. (J33: Periodic switching signaling period)

Assignment of "Pump control limit signal" (MLIM) (E20 to E22, E24, E27, J45 to J47 = 69)
This signal turns on when the inverter detects such a condition that requires further mounting a motor(s) by J34 and J35 even after all pump motors are in operation. This signal can thus detect a situation where the output flowrate (pressure) does not increase because of a pipe crack or other reasons.

## J25: Pump Control (Mode selection)

Pump control is effective only when $\mathrm{J} 25=1$ or 2 and the PID control integrated in the inverter is enabled (J01 $\neq$ $0)$.
J25 specifies the configuration of dynamic motor rotation with a fixed inverter-driven motor or with a floating inverter-driven motor.

## J26 to J29: Motor 1 Mode to Motor 4 Mode

J26 to J29 allow you to specify the number of pump motors to be controlled and unmount a pump motor(s) from the control system.

The combination of J26 to J29 and "Enable pump drive" commands (MEN1) to (MEN4) assigned to the digital input terminals makes it also possible to enable or disable pump control.

■ Assignment of "Enable pump drive" commands (MEN1) to (MEN4) (E01 to E05, E98, E99 = 51, 52, 53, 54)
The operation of each pump motor is determined by the combination of J26 to J29 and "Enable pump drive" commands (MEN1) to (MEN4) as listed below.

| Motor 1 Mode <br> to <br> Motor 4 Mode <br> (J26 to J29) | "Enable pump drive" <br> (MEN1) to (MEN4) |  | Operation |
| :---: | :---: | :--- | :--- |
| 0 | - | Disable: | Disable both inverter- and commercial <br> power-driven motors. |
| 1 | ON | Enable: | Under pump control |
| 2 | OFF | Disable: | Disable both inverter- and commercial <br> power-driven motors. |
|  | ON | Force to run <br> (Forced ON): | Forcibly switch from "Driven by inverter" to <br> "Driven by commercial power," regardless of <br> Run commands. |
|  | OFF | Disable: | Disable both inverter- and commercial <br> power-driven motors. |

Note: When the inverter is driving a forced-ON motor, changing data of J26 to J29 from "2" (Force to run) to "1" (Enable) continues to run the motor by commercial power under PID control.
When the inverter is stopped, changing data of J26 to J29 from "2" (Force to run) to "1" (Enable) determines the operation of the motor specified for "Force to run" depending upon the data of J 31 (Motor stop mode). If $\mathrm{J} 31=0$, the motor will stop. If $\mathrm{J} 31=1$ or 2 , it will continue to run by commercial power.

In pump control, the inverter manages the number of motors to be driven. J30 specifies the mount/unmount motor sequence.

| Data | Operation |
| :---: | :--- |
| 0 | The inverter mounts motors in ascending order of their numbers, i.e., Motor $1 \rightarrow$ Motor $2 \rightarrow$ <br> Motor $3 \rightarrow$ Motor 4 and unmounts them in descending order. <br> When restarting the motors after coast-to-stop, the inverter mounts Motor 1 first. |
| 1 | To even the cumulative run time among the motors, the inverter mounts the motor whose <br> cumulative run time is shortest first and unmounts the one whose cumulative run time is <br> longest first. |

J31 specifies how to stop the pump motors when a Run command (FWD or REV) is turned OFF under pump control.

| Data | Operation |
| :---: | :--- |
| 0 | The inverter-driven motor decelerates to the stop frequency (F25) during the deceleration time <br> (F08) to stop. <br> As soon as the output of the inverter is shut down, the relays for the inverter-driven motor are <br> turned OFF. <br> The relays for all the motors driven by commercial power are turned OFF when the inverter has <br> come to a stop. <br> Also in an alarm state, all the motors are brought to a stop: the output to the inverter-driven <br> motor is turned OFF and the relays for the commercial-power-driven motors are turned OFF. |
| 1 | The inverter-driven motor decelerates to the stop frequency (F25) during the deceleration time <br> (F08) to stop. <br> As soon as the output of the inverter is shut down, the relays for the inverter-driven motor are <br> turned OFF. Note that other relays remain ON so that the commercial-power-driven motors <br> continue to run. <br> In an alarm state, all the motors are brought to a stop: the output to the inverter-driven motor is <br> turned OFF and the relays for the commercial-power-driven motors are turned OFF. |
| 2 | The inverter-driven motor decelerates to the stop frequency (F25) during the deceleration time <br> (F08) to stop. <br> As soon as the output of the inverter is shut down, the relays for the inverter-driven motor are <br> turned OFF. Note that other relays remain ON so that the commercial-power-driven motors <br> continue to run. <br> In an alarm state, only the output to the inverter-driven motor is turned OFF but the relays for <br> the commercial-power-driven motors remain ON. The commercial-power-driven motors <br> continue to run. |

Note: To stop commercial-power-driven motors when J31 is set at " 1 " or "2," take one of the following actions:-

- To stop pump motors individually, specify "Disable" for them using J26 to J29.
- To stop pump motors individually, turn OFF their corresponding "Enable pump drive" commands (MEN1) to (MEN4) assigned to the input terminals.
- To stop all the commercial-power-driven motors, disable pump control ( $\mathrm{J} 25=0$ or $\mathrm{J} 01=0$ ).
- To stop all the commercial-power-driven motors, input the "Coast-to-stop" command (BX).

The periodic switching time for motor drive is designed to balance the cumulative run time among multiple motors for extending the life of the pump motors and preventing rust. When the number of motors in operation does not change for the specified period, the inverter dynamically swaps the motors in operation.


Note: Periodic switching is not applicable to motors specified for "Force to run by commercial power" by J26 to J29 (data = 2).

- Assignment of "Clear periodic switching time" command (MCLR) (E01 to E05, E98, E99=50)

As long as (MCLR) is ON, the periodic switching timer is reset to " 0 ." To restart the timer, turn OFF (MCLR).

## J33: Periodic Switching Signaling Period

J33 specifies the output timing of the periodic switching early warning signal (MCHG).
■ Assignment of "Periodic switching early warning signal (MCHG) (E20 to E 22, E24, E27, J45 to J47 = 68)
When the periodic switching conditions are met, the inverter outputs a periodic switching early warning for the period specified by J33 and then enters actual switching operation. This signal, therefore, can be used as an early warning of periodic switching.


J34 to J37: Mount of Commercial Power-driven Motor (Threshold frequency and duration)
J39, J40:

## Switching Time for Motor Mount (Deceleration time), Switching Time for Motor Unmount (Acceleration time)

## J41: Motor Mount/Unmount Switching Level

< Mounting motor(s) >
When the PID output (which is fed to the inverter-driven motor) has exceeded the threshold frequency (specified by J34) longer than the duration specified by J35, the inverter mounts a pump motor(s).

When a decision is made to mount a motor, the inverter-driven motor decelerates to the threshold frequency (J36) for the motor mount switching time (deceleration time specified by J39) and then restarts PID control.

The motor to be mounted starts being driven by commercial power when the inverter-driven motor has reached the motor mount/unmount switching level (J41) during deceleration.

The motor mount/unmount switching level (J41) serves as an adjuster for ensuring smooth transition (switch-over) and operates at the timing indicated by the following formula:

Switching frequency $(\mathrm{Hz})=(\mathrm{J} 41 / 100 \%) \times(\mathrm{J} 18-\mathrm{J} 19)+\mathrm{J} 19$,
where J18 = PID upper limiter and J19 = PID lower limiter.


When the PID output (which is fed to the inverter-driven motor) has been dropped below the threshold frequency (specified by J36) longer than the duration specified by J37, the inverter unmounts a pump motor(s).
When a decision is made to unmount a motor, the inverter-driven motor accelerates to the threshold frequency (J34) for the motor unmount switching time (acceleration time specified by J40) and then restarts PID control.
Commercial power to the motor to be unmounted is cut OFF when the inverter-driven motor has reached the motor mount/unmount switching level (J41) during acceleration.
The motor mount/unmount switching level (J41) serves as an adjuster for ensuring smooth transition (switch-over) and operates at the timing indicated by the following formula:
Switching frequency $(\mathrm{Hz})=(\mathrm{J} 41 / 100 \%) \times(\mathrm{J} 18-\mathrm{J} 19)+\mathrm{J} 19$,
where $\mathrm{J} 18=$ PID upper limiter and $\mathrm{J} 19=$ PID lower limiter.


Tip
It is recommended that the PID upper and lower limiters $(\mathrm{J} 18, \mathrm{~J} 19)$ be specified wider than the band specified by the threshold frequencies (J34, J36). In this way, the monitoring of the frequency going above or below the frequencies starts before it reaches the PID upper or lower limiter (J18, J19). This results in a shorter duration of the flowrate being limited, thereby minimizing the fluctuation of pressure when the number of motors is mounted or unmounted.


Upper limit of PID process output (J18)
$=$ Threshold frequency for mounting of a commercial-power-driven pump motor (J34)

J38 specifies the contactor delay time or latency (delay in relay or contactor activation) to be incorporated when the motor power source is switched from the inverter to commercial power when a motor is mounted.

## J42: Switching Motor Mount/Unmount (Dead band)

J42 suppresses the mount/unmount of a pump motor when the difference between the PID process command value and the feedback value is smaller than its setting value band. This feature is provided to prevent frequent actions of mounting or unmounting motors just around the threshold frequencies (J34, J36).

## J43: PID Control Startup Frequency

When turning ON a Run command starts a pump motor, the inverter accelerates the motor up to the frequency specified by J 43 for the acceleration time specified by F07 and then starts PID control.

## J48 to J52: Cumulative Run Time of Motor

J 48 to J 52 allow you to monitor the cumulative run time of each motor as reference data useful for maintenance.
The cumulative run time can be displayed in units of 1 hour in decimal format on the multi-function keypad or in hexadecimal format on the remote keypad.
The cumulative run time can be modified only through a keypad and cleared by setting "Oh."
Reset the cumulative run time whenever you replace a pump or as required during maintenance.

## J53 to J55: Maximum Cumulative Number of Relay ON Times

During pump control, external relays and relays on the relay output card are frequently turned ON or OFF by transistor outputs Y1 to Y3. J53 to J55 allow you to monitor the number of ON times by relay group, which serves an indicator of relay life. The maximum cumulative number of relay ON times is displayed in units of 1,000 (A display of 1.000 means 1,000 ON times).
The cumulative number goes back to zero (0) when the number of actual ON times overruns $1,000,000$.
You can reset the cumulative number of relay ON times to "0" only through a keypad.
Reset it whenever you replace a relay.

| Output | Life | Contact Capacity |
| :--- | :--- | :---: |
| Transistor output (Y1, Y2, Y3) | (Determined by specifications of external <br> relay) | - |
| Y5A/C, 30A/B/C (control board in inverter) | 200,000 times (when turned ON every <br> second) | 250 VAC 0.3 A <br> 48 VDC 0.5 A |
| Relay output card <br> (Y1A/B/C, Y2A/B/C, Y3A/B/C) | 200,000 times (when turned ON every <br> second) | 250 VAC 0.3 A <br> 48 |

a) The electronic thermal overload protection (F10), PTC thermistor (H26) or cumulative motor run time (Menu 5_23) cannot be used since they are not compatible with inverter operation of the dynamic pump motor rotation.
b) While pump control is in effect, the restart mode after momentary power failure (Mode selection) works differently as shown below.

| Data of F14 | Restart mode when pump control is not in effect | Restart mode when pump control is in effect |
| :---: | :---: | :---: |
| 0 | Disable restart (Trip immediately) | Disable restart (Trip immediately) (same as F14 = 0) |
| 1 | Disable restart (Trip after a recovery from power failure) |  |
| 3 | Enable restart (Continue to run, for heavy inertia or general loads) | Enable restart (Restart at the starting frequency, for low-inertia load) (same as F14 = 5) |
| 4 | Enable restart (Restart at the frequency at which the power failure occurred, for general loads) |  |
| 5 | Enable restart (Restart at the starting frequency, for low-inertia load) |  |

c) No commercial-power-switching terminal commands (SW50), (SW60), (ISW50) and (ISW60) can be used.
d) The slow flowrate stop function of PID control can be used.
e) When pump control is in effect, the "Coast-to-stop" terminal command (BX) is used to stop (shut down) all pump motors, regardless of being driven by the inverter or by commercial power. For a configuration allowing commercial-power-driven motors to continue running even after a Run command is turned OFF, it is recommended that the $(B X)$ input be provided.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI Indication Diagrams for Dynamic Rotation of Pump Motors
(1) With a fixed inverter-driven motor


End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (2) With a floating inverter-driven motor


## Designed For Fan and Pump Applications

# FRENIC-Eco Pump control 

## Instruction Manual

First Edition, May 2005
Fuji Electric FA Components \& Systems Co., Ltd.

[^47]
## Fuji Electric FA Components \& Systems Co., Ltd.

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# FRENIC-ECO 

## $\triangle C A U T I O N$

Thank you for purchasing our FRENIC-Eco series of inverters.

- This product is designed to drive a three-phase induction motor. Read through this instruction manual and be familiar with the handling procedure for correct use.
- Improper handling might result in incorrect operation, a short life, or even a failure of this product as well as the motor.
- Deliver this manual to the end user of this product. Keep this manual in a safe place until this product is discarded.
- For how to use an optional device, refer to the installation and instruction manuals for that optional device.

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The information contained herein is subject to change without prior notice for improvement.

Thank you for purchasing our FRENIC-Eco series of inverters.
This product is designed to drive a three-phase induction motor for fan and pump applications. Read through this instruction manual and be familiar with proper handling and operation of this product.
Improper handling might result in incorrect operation, a short life, or even a failure of this product as well as the motor.
Have this manual delivered to the end user of this product. Keep this manual in a safe place until this product is discarded.
Listed below are the other materials related to the use of the FRENIC-Eco. Read them in conjunction with this manual as necessary.

- FRENIC-Eco User's Manual
- RS485 Communication User's Manual
- Catalog
- RS485 Communications Card "OPC-F1-RS" Installation Manual
- Relay Output Card "OPC-F1-RY" Instruction Manual
- Mounting Adapter for External Cooling "PB-F1" Installation Manual (INR-SI47-0880)
- Panel-mount Adapter "MA-F1" Installation Manual
- Multi-function Keypad "TP-G1" Instruction Manual
- FRENIC Loader Instruction Manual
(MEH456)
(MEH448)
(MEH442)
(INR-SI47-0872)
(INR-SI47-0873)
(INR-SI47-0881)
(INR-SI47-0890-E)
(INR-SI47-0903-E)

The materials are subject to change without notice. Be sure to obtain the latest editions for use.

## ■ Safety precautions

Read this manual thoroughly before proceeding with installation, connections (wiring), operation, or maintenance and inspection. Ensure you have sound knowledge of the device and familiarize yourself with all safety information and precautions before proceeding to operate the inverter.
Safety precautions are classified into the following two categories in this manual.

| Failure to heed the information indicated by this symbol may lead to |
| :--- | :--- |
| dangerous conditions, possibly resulting in death or serious bodily injuries. |

Failure to heed the information contained under the CAUTION title can also result in serious consequences. These safety precautions are of utmost importance and must be observed at all times.

## $\triangle$ WARNING

- FRENIC-Eco is designed to drive a three-phase induction motor. Do not use it for single-phase motors or for other purposes.
Fire or an accident could occur.
- FRENIC-Eco may not be used for a life-support system or other purposes directly related to the human safety.
- Though FRENIC-Eco is manufactured under strict quality control, install safety devices for applications where serious accidents or material losses are foreseen in relation to the failure of it.
An accident could occur.


## Installation

## $\triangle$ WARNING

- Install the inverter on a nonflammable material such as metal.

Otherwise fire could occur.

- Do not place flammable matter nearby.

Doing so could cause fire.

## $\triangle$ CAUTION

- Do not support the inverter by its terminal block cover during transportation. Doing so could cause a drop of the inverter and injuries.
- Prevent lint, paper fibers, sawdust, dust, metallic chips, or other foreign materials from getting into the inverter or from accumulating on the heat sink.
Otherwise, a fire or an accident might result.
- Do not install or operate an inverter that is damaged or lacking parts.


## Doing so could cause fire, an accident or injuries.

- Do not get on a shipping box.
- Do not stack shipping boxes higher than the indicated information printed on those boxes. Doing so could cause injuries. Wiring


## $\triangle$ WARNING

- When wiring the inverter to the power source, insert a recommended molded case circuit breaker (MCCB) or residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) (with overcurrent protection) in the path of power lines. Use the devices within the recommended current range.
- Use wires in the specified size.

Otherwise, fire could occur.

- Do not use one multicore cable in order to connect several inverters with motors.
- Do not connect a surge killer to the inverter's output (secondary) circuit.

Doing so could cause fire.

- Ground the inverter in compliance with the national or local electric code.

Otherwise, electric shock could occur.

- Qualified electricians should carry out wiring.
- Be sure to perform wiring after turning the power OFF.

Otherwise, electric shock could occur.

- Be sure to perform wiring after installing the inverter body. Otherwise, electric shock or injuries could occur.
- Ensure that the number of input phases and the rated voltage of the product match the number of phases and the voltage of the AC power supply to which the product is to be connected.
Otherwise fire or an accident could occur.
- Do not connect the power source wires to output terminals ( $\mathrm{U}, \mathrm{V}$, and W ).

Doing so could cause fire or an accident.

- Generally, control signal wires are not enforced- insulated. If they accidentally touch any of live parts in the main circuit, their insulation coat may break for any reasons. In such a case, an extremely high voltage may be applied to the signal lines. Make a complete remedy to protect the signal line from contacting any hot high voltage lines.
Otherwise, an accident or electric shock could occur.


## $\triangle$ CAUTION

- Wire the three-phase motor to terminals $\mathrm{U}, \mathrm{V}$, and W of the inverter, aligning phases each other. Otherwise injuries could occur.
- The inverter, motor and wiring generate electric noise. Take care of malfunction of the nearby sensors and devices. To prevent the motor from malfunctioning, implement noise control measures.
Otherwise an accident could occur.


## $\triangle$ WARNING

- Be sure to install the terminal block cover and the front cover before turning the power ON. Do not remove the covers while power is applied.


## Otherwise electric shock could occur.

- Do not operate switches with wet hands.

Doing so could cause electric shock.

- If the retry function has been selected, the inverter may automatically restart and drive the motor depending on the cause of tripping.
(Design the machinery or equipment so that human safety is ensured after restarting.)
- If the stall prevention function (current limiter), automatic deceleration, and overload prevention control have been selected, the inverter may operate at an acceleration/deceleration time or frequency different from the commanded ones. Design the machine so that safety is ensured even in such cases.
Otherwise an accident could occur.
- The key on the keypad is effective only when the keypad operation is enabled with function code F02 ( $=0,2$ or 3). When the keypad operation is disabled, prepare an emergency stop switch separately for safe operations.
Switching the run command source from keypad (local) to external equipment (remote) by turning ON the "Enable communications link" command (LE) or "Switch run command 2/1" command (FR2/FR1), disables the key. To enable the key for an emergency stop, select the STOP key priority with function code H 96 ( $=1$ or 3).
- If an alarm reset is made with the Run command signal turned ON, a sudden start will occur. Ensure that the Run command signal is turned OFF in advance.


## Otherwise an accident could occur.

- If you enable the "Restart mode after momentary power failure" (Function code F14 =3, 4, or 5), then the inverter automatically restarts running the motor when the power is recovered.
(Design the machinery or equipment so that human safety is ensured after restarting.)
- If you set the function codes wrongly or without completely understanding this instruction manual and the FRENIC-Eco User's Manual (MEH456), the motor may rotate with a torque or at a speed not permitted for the machine.
An accident or injuries could occur.
- Do not touch the inverter terminals while the power is applied to the inverter even if the inverter stops. Doing so could cause electric shock.
- Do not turn the main circuit power (circuit breaker) ON or OFF in order to start or stop inverter operation. Doing so could cause failure.
- Do not touch the heat sink because they become very hot.

Doing so could cause burns.

- Setting the inverter to high speeds is easy. Before changing the frequency (speed) setting, check the specifications of the motor and machinery.
- The brake function of the inverter does not provide mechanical holding means. Injuries could occur.


## Setting control switches


#### Abstract

ADVNARNING - Before setting up any internal control switches, turn OFF the power and wait more than five minutes for models of 30 kW or below, or ten minutes for models of 37 kW or above. Make sure that the LED monitor and charging lamp (on models of 37 kW or above) are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC link bus voltage between the terminals $\mathrm{P}(+)$ and $\mathrm{N}(-)$ has dropped below the safe voltage (+25 VDC). Otherwise electric shock could occur.


## Maintenance and inspection, and parts replacement

## $\triangle$ WARNING

- Turn the power OFF and wait for at least five minutes for models of 30 kW or below, or ten minutes for models of 37 kW or above, before starting inspection. Further, check that the LED monitor and charging lamp (on models of 37 kW or above) are unlit and that the DC link bus voltage between the $\mathrm{P}(+)$ and N (-) terminals is lower than 25 VDC.
Otherwise, electric shock could occur.
- Maintenance, inspection, and parts replacement should be made only by qualified persons.
- Take off the watch, rings and other metallic objects before starting work.
- Use insulated tools.

Otherwise, electric shock or injuries could occur.

## Disposal

## $\triangle$ CAUTION

- Treat the inverter as an industrial waste when disposing of it. Otherwise injuries could occur.


## Others

## $\triangle$ WARNING

- Never attempt to modify the inverter.

Doing so could cause electric shock or injuries.

| GENERAL PRECAUTIONS |
| :--- |
| Drawings in this manual may be illustrated without covers or safety shields for explanation of detail parts. |
| Restore the covers and shields in the original state and observe the description in the manual before |
| starting operation. |

If installed according to the guidelines given below, inverters marked with CE can be considered to be compliant with the Low Voltage Directive $73 / 23 /$ EEC.

## $\triangle C A U T I O N$

1. Be sure to earth the grounding terminal ${ }^{-1}$ G. Use an earth wire sized more than that of the power wires used in the power dispatch system. Do not use a residual-current-operated protective device (RCD)* or an earth leakage circuit breaker (ELCB)* as a sole mechanism of electric shock protection. *With overcurrent protection.
2. Use an MCCB, RCD/ELCB or MC in conformity with EN or IEC standards.
3. When an RCD/ELCB is used for protection of electric shock caused by a direct or indirect contact to the live parts, insert a type B RCD/ELCB in input lines (primary) of the inverter for the 3-phase 200 V or 400 $\checkmark$ power source.
4. Use inverters in an environment that does not exceed pollution degree 2. If inverters are to be used in an environment with pollution degree 3 or 4, place them in an enclosure of IP54 or above.
5. To protect human body from an electric shock caused by a contact to live parts, install inverters, AC reactor and input /output filter in the enclosure of IP2X. In the case where human body easily contacts to live parts, a top panel of the enclosure should be IP4X or higher.
6. Do not directly connect a copper wire to the grounding terminal. Use a crimp terminal with tin or equivalent plating to connect the earth wire.
7. When using inverters at an altitude of more than 2000 m , note that the basic insulation applies to the insulation degree of the control circuitry. At an altitude of more than 3000 m , inverters cannot be used.

7 End of Avon St Leichhardt SPS－i．Power Solutions－Ipswich Ref J7985－01－SP22 O＇Keefe St SPS－OI Conformity with Low Voltage Directive in the EU（continued）

## $\triangle$ CAUTION

8．Use the wires listed in EN60204 Appendix C．

|  |  | Inverter type | MCCB or RCD／ELCB＊1 Rated current （A） |  | Recommended wire size（ $\mathrm{mm}^{2}$ ） |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | Main power input＊ ［L1／R，L2／S，L3／T］ Inverter＇s grounding［ ${ }^{-1} \mathrm{G}$ ］ |  |  |  | Contro <br> $\begin{array}{c}\text { Screw } \\ \text { terminal }\end{array}$ | ｜circuit |  |  |
|  |  |  | $\begin{gathered} \hline \text { W/ } \\ \text { DCR } \end{gathered}$ | $\begin{aligned} & \hline \text { W/o } \\ & \text { DCR } \end{aligned}$ | $\begin{gathered} \hline \text { W/ } \\ \text { DCR } \end{gathered}$ | W／o DCR |  |  | base | $\begin{array}{\|l\|l\|} \hline \text { terminal } \\ \text { block } \end{array}$ |  |  |
|  | 0.75 | FRN0．75F1S－2口 | 5 | 10 | 2.5 | 2.5 | 2.5 | 2.5 | $\begin{gathered} 0.25 \\ \text { to } \\ 0.75 \end{gathered}$ | $\begin{gathered} 0.25 \\ \text { to } \\ 0.75 \end{gathered}$ | 2.5 |  |
|  | 1.5 | FRN1．5F1S－2口 | 10 | 15 |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1S－2口 |  | 20 |  |  |  |  |  |  |  |  |
|  | 3.7 | FRN3．7F1S－2口 | 20 | 30 |  | 4.0 |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1S－2口 | 30 | 50 | 4.0 | 6.0 | 4.0 | 4.0 |  |  |  |  |
|  | 7.5 | FRN7．5F1S－2口 | 40 | 75 | 6.0 | 10 | 6.0 | 6.0 |  |  |  |  |
|  | 11 | FRN11F1S－2口 | 50 | 100 | 10 | 16 | 10 | 16 |  |  |  |  |
|  | 15 | FRN15F1S－2口 | 75 | 125 | 16 | 25 | 16 | 25 |  |  |  |  |
|  | 18.5 | FRN18．5F1S－2口 | 100 | 150 | 25 | 35 | 25 | 35 |  |  |  |  |
|  | 22 | FRN22F1S－2口 |  | 175 | 35 | 50 | 35 | 35 |  |  |  |  |
|  | 30 | FRN30F1S－2口 | 150 | 200 | 50 | 70 | 50 | 70 |  |  |  |  |
|  | 37 | FRN37F1S－2口 | 175 | 250 | 25x2 | 50x2 | 25x2 | 25x2 |  |  |  |  |
|  | 45 | FRN45F1S－2口 | 200 | 300 | 95 | 70x2 | 95 | 120 |  |  |  | 2.5 |
|  | 55 | FRN55F1S－2口 | 250 | 350 | 50x2 | 95x2 | 70x2 | 150 |  |  |  |  |
|  | 75 | FRN75F1S－2口 | 350 | － | 95x2 | － | 95x2 | 95x2 |  |  |  |  |
|  | 0.75 | FRN0．75F1S－4ロ | 5 | 5 | 2.5 | 2.5 | 2.5 | 2.5 | $\begin{gathered} 0.25 \\ \text { to } \\ 0.75 \end{gathered}$ | $\begin{gathered} 0.25 \\ \text { to } \\ 0.75 \end{gathered}$ | 2.5 | － |
|  | 1.5 | FRN1．5F1S－4口 |  | 10 |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2．2F1S－4口 |  | 15 |  |  |  |  |  |  |  |  |
|  | $\begin{aligned} & \hline 3.7 \\ & (4.0)^{\star 3} \\ & \hline \end{aligned}$ | FRN3．7F1S－4口 FRN4．0F1S－4E | 10 | 20 |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5．5F1S－4D | 15 | 30 |  |  |  |  |  |  |  |  |
|  | 7.5 | FRN7．5F1S－4ロ | 20 | 40 |  | 4.0 |  |  |  |  |  |  |
|  | 11 | FRN11F1S－4ロ | 30 | 50 | 4.0 | 6.0 | 4.0 | 4.0 |  |  |  |  |
|  | 15 | FRN15F1S－4D | 40 | 60 | 6.0 | 10 | 6.0 | 6.0 |  |  |  |  |
| ¢ | 18.5 | FRN18．5F1S－4D |  | 75 |  | 16 | 10 | 10 |  |  |  |  |
| $\stackrel{\otimes}{*}$ | 22 | FRN22F1S－4D | 50 | 100 | 10 |  |  | 16 |  |  |  |  |
| $\stackrel{\square}{0}$ | 30 | FRN30F1S－4D | 75 | 125 | 16 | 25 | 16 | 25 |  |  |  |  |
| $\dot{\text { ® }}$ | 37 | FRN37F1S－4D | 100 |  | 25 | 35 | 25 |  |  |  |  |  |
| $\stackrel{\text { ¢ }}{ }$ | 45 | FRN45F1S－4D |  | 150 |  | 50 | 35 | 35 |  |  |  |  |
|  | 55 | FRN55F1S－4D | 125 | 200 | 35 | 25x2 | 50 | $16 \times 2$ |  |  |  | 2.5 |
|  | 75 | FRN75F1S－4］ | 175 | － | 25x2 | － | 25x2 | 25x2 |  |  |  |  |
|  | 90 | FRN90F1S－4D | 200 |  | 95 |  | 95 | 120 |  |  |  |  |
|  | 110 | FRN110F1S－4D | 250 |  | 50x2 |  | 50x2 | 150 |  |  |  |  |
|  | 132 | FRN132F1S－4ロ | 300 |  |  |  | 70x2 | 70x2 |  |  |  |  |
|  | 160 | FRN160F1S－4D | 350 |  | 185 |  | 240 | 300 |  |  |  |  |
|  | 200 | FRN200F1S－4D | 500 |  | 300 |  | 300 | 185x2 |  |  |  |  |
|  | 220 | FRN220F1S－4ロ |  |  |  |  | 120x2 |  |  |  |  |  |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．
＊1 The frame size and model of the MCCB or RCD／ELCB（with overcurrent protection）will vary，depending on the power transformer capacity．Refer to the related technical documentation for details．
＊2 $^{2}$ The recommended wire size for main circuits is for the $70^{\circ} \mathrm{C} 600 \mathrm{~V} \mathrm{PVC}$ wires used at an ambient temperature of $40^{\circ} \mathrm{C}$ ．
＊3 The applicable motor rating of FRN4．0F1S－4E to be shipped for EU is 4.0 kW ．

UL/cUL-listed inverters are subject to the regulations set forth by the UL standards and CSA standards (cUL-listed for Canada) by installation within precautions listed below.

## $\triangle$ CAUTION

1. Solid state motor overload protection (motor protection by electronic thermal overload relay) is provided in each model.
Adjust function codes F10 to F12 to decide the protection level.
2. Suitable for use on a circuit capable of delivering not more than $100,000 \mathrm{rms}$ three-phase symmetrical amperes, 240 Volts maximum for 200 V class input 30 kW or less, 230 Volts maximum for 200 V class input 37 kW or above or 480 Volts maximum for 400 V class input.
3. Use $60^{\circ} \mathrm{C} / 75^{\circ} \mathrm{C} \mathrm{Cu}$ wire only.
4. Use Class 1 wire only.
5. Field wiring connections must be made by a UL Listed and CSA Certified closed-loop terminal connector sized for the wire gauge involved. Connector must be fixed using the crimp tool specified by the connector manufacturer.
6. All circuits with terminals L1/R, L2/S, L3/T, R0, T0, R1, T1 must have a common disconnect and be connected to the same pole of the disconnect if the terminals are connected to the power supply.


## End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI

Conformity with UL standards and CSA standards (cUL-listed for Canada) (continued)
$\triangle$ CAUTION
7. Install UL-listed fuses or circuit breaker between the power supply and the inverter, referring to the table below.


Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.
${ }^{* 1}$ Select the rated current of a fuse or a circuit breaker which is suitable to the connecting wire size.
*2 The applicable motor rating of FRN4.0F1S-4E to be shipped for EU is 4.0 kW .

| In running generalpurpose motors | Driving a 400 V general-purpose motor | When driving a 400 V general-purpose motor with an inverter using extremely long wires, damage to the insulation of the motor may occur. Use an output circuit filter (OFL) if necessary after checking with the motor manufacturer. Fuji motors do not require the use of output circuit filters because of their reinforced insulation. |
| :---: | :---: | :---: |
|  | Torque characteristics and temperature rise | When the inverter is used to run a general-purpose motor, the temperature of the motor becomes higher than when it is operated using a commercial power supply. In the low-speed range, the cooling effect will be weakened, so decrease the output torque of the motor. |
|  | Vibration | When an inverter-driven motor is mounted to a machine, resonance may be caused by the natural frequencies of the machine system. <br> Note that operation of a 2 -pole motor at 60 Hz or higher may cause abnormal vibration. <br> * The use of a rubber coupling or vibration dampening rubber is recommended. <br> * Use the inverter's jump frequency control feature to skip the resonance frequency zone(s). |
|  | Noise | When an inverter is used with a general-purpose motor, the motor noise level is higher than that with a commercial power supply. To reduce noise, raise carrier frequency of the inverter. Operation at 60 Hz or higher can also result in higher noise level. |
| In running special motors | Explosion-proof motors | When driving an explosion-proof motor with an inverter, use a combination of a motor and an inverter that has been approved in advance. |
|  | Submersible motors and pumps | These motors have a larger rated current than general-purpose motors. Select an inverter whose rated output current is greater than that of the motor. <br> These motors differ from general-purpose motors in thermal characteristics. Set a low value in the thermal time constant of the motor when setting the electronic thermal function. |
|  | Brake motors | For motors equipped with parallel-connected brakes, their braking power must be supplied from the primary circuit. If the brake power is connected to the inverter's output circuit by mistake, the brake will not work. <br> Do not use inverters for driving motors equipped with series-connected brakes. |
|  | Geared motors | If the power transmission mechanism uses an oil-lubricated gearbox or speed changer/reducer, then continuous motor operation at low speed may cause poor lubrication. Avoid such operation. |
|  | Synchronous motors | It is necessary to take special measures suitable for this motor type. Contact your Fuji Electric representative for details. |
|  | Single-phase motors | Single-phase motors are not suitable for inverter-driven variable speed operation. Use three-phase motors. |
| Environmental conditions | Installation location | Use the inverter within the ambient temperature range from -10 to $+50^{\circ} \mathrm{C}$. The heat sink of the inverter may become hot under certain operating conditions, so install the inverter on nonflammable material such as metal. <br> Ensure that the installation location meets the environmental conditions specified in Chapter 2, Section 2.1 "Operating Environment." |


| Combination with peripheral devices | Installing an MCCB or RCD/ELCB | Install a recommended molded case circuit breaker (MCCB) or resid-ual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) (with overcurrent protection) in the primary circuit of the inverter to protect the wiring. Ensure that the circuit breaker rated current is equivalent to or lower than the recommended rated current. |
| :---: | :---: | :---: |
|  | Installing an MC in the secondary circuit | If a magnetic contactor (MC) is mounted in the inverter's output (secondary) circuit for switching the motor to commercial power or for any other purpose, ensure that both the inverter and the motor are completely stopped before you turn the MC ON or OFF. <br> Remove the magnet contactor ( MC ) already installed and built-in surge killer from the inverter's output (secondary) circuit before installing the MC to switch the motor power. |
|  | Installing an MC in the primary circuit | Do not turn the magnetic contactor (MC) in the primary circuit ON or OFF more than once an hour as an inverter failure may result. <br> If frequent starts or stops are required during motor operation, use (FWD)/(REV) signals or the RUN/STOP key. |
|  | Protecting the motor | The electronic thermal function of the inverter can protect the motor. The operation level and the motor type (general-purpose motor, inverter motor) should be set. For high-speed motors or water-cooled motors, set a small value for the thermal time constant and protect the motor. <br> If you connect the motor thermal relay to the motor with a long wire, a high-frequency current may flow into the wiring stray capacitance. This may cause the relay to trip at a current lower than the set value for the thermal relay. If this happens, lower the carrier frequency or use the output circuit filter (OFL). |
|  | Discontinuance of power-factor correcting capacitor | Do not mount power-factor correcting capacitors in the inverter's primary circuit. (Use the DC reactor to improve the inverter power factor.) Do not use power-factor correcting capacitors in the inverter's output (secondary) circuit. An overcurrent trip will occur, disabling motor operation. |
|  | Discontinuance of surge killer | Do not connect a surge killer to the inverter's output (secondary) circuit. |
|  | Reducing noise | Use of a filter and shielded wires is typically recommended to satisfy EMC Directives. |
|  | Measures against surge currents | If an overvoltage trip occurs while the inverter is stopped or operated under a light load, it is assumed that the surge current is generated by open/close of the power-factor correcting capacitor in the power system. <br> * Connect a DC reactor to the inverter. |
|  | Megger test | When checking the insulation resistance of the inverter, use a 500 V megger and follow the instructions contained in Chapter 7, Section 7.5 "Insulation Test." |
| Wiring | Control circuit wiring length | When using remote control, limit the wiring length between the inverter and operator box to 20 m or less and use twisted pair or shielded wire. |
|  | Wiring length between inverter and motor | If long wiring is used between the inverter and the motor, the inverter will overheat or trip as a result of overcurrent (high-frequency current flowing into the stray capacitance) in the wires connected to the phases. Ensure that the wiring is shorter than 50 m . If this length must be exceeded, lower the carrier frequency or mount an output circuit filter (OFL). |
|  | Wiring size | Select wires with a sufficient capacity by referring to the current value or recommended wire size. |
|  | Wiring type | When several inverters drive motors, do not use one multicore cable in order to connect several inverters with motors. |
|  | Grounding | Securely ground the inverter using the grounding terminal. |


|  | Driving gen- <br> eral-purpose <br> motor <br> Selecting <br> inverter <br> capacity | Select an inverter according to the applicable motor ratings listed in the <br> standard specifications table for the inverter. <br> When high starting torque is required or quick acceleration or deceleration <br> is required, select an inverter with a capacity one size greater than the <br> standard. |
| :--- | :--- | :--- |
|  | Driving special <br> motors | Select an inverter that meets the following condition: <br> Inverter rated current > Motor rated current |
| Transpor- <br> tation and <br> storage | When transporting or storing inverters, follow the procedures and select locations that meet the <br> environmental conditions listed in Chapter 1, Section 1.3 "Transportation" and Section 1.4 <br> "Storage Environment." |  |

This manual is made up of chapters 1 through 10 .

## Chapter 1 BEFORE USING THE INVERTER

This chapter describes acceptance inspection and precautions for transportation and storage of the inverter.

## Chapter 2 MOUNTING AND WIRING OF THE INVERTER

This chapter provides operating environment, precautions for installing the inverter, wiring instructions for the motor and inverter.

## Chapter 3 OPERATION USING THE KEYPAD

This chapter describes inverter operation using the keypad. The inverter features three operation modes (Running, Programming and Alarm modes) which enable you to run and stop the motor, monitor running status, set function code data, display running information required for maintenance, and display alarm data.

## Chapter 4 OPERATION

This chapter describes preparation to be made before running the motor for a test and practical operation.

## Chapter 5 FUNCTION CODES

This chapter provides a list of the function codes. Function codes to be used often and irregular ones are described individually.

## Chapter 6 TROUBLESHOOTING

This chapter describes troubleshooting procedures to be followed when the inverter malfunctions or detects an alarm condition. In this chapter, first check whether any alarm code is displayed or not, and then proceed to the troubleshooting items.

## Chapter 7 MAINTENANCE AND INSPECTION

This chapter describes inspection, measurement and insulation test which are required for safe inverter operation. It also provides information about periodical replacement parts and guarantee of the product.

## Chapter 8 SPECIFICATIONS

This chapter lists specifications including output ratings, control system, external dimensions and protective functions.

## Chapter 9 LIST OF PERIPHERAL EQUIPMENT AND OPTIONS

This chapter describes main peripheral equipment and options which can be connected to the FRENIC-Eco series of inverters.

## Chapter 10 CONFORMITY WITH STANDARDS

This chapter describes standards with which the FRENIC-Eco series of inverters comply.

## Icons

The following icons are used throughout this manual.
Note This icon indicates information which, if not heeded, can result in the inverter not operating to full efficiency, as well as information concerning incorrect operations and settings which can result in accidents.
Tip This icon indicates information that can prove handy when performing certain settings or operations.
[1] This icon indicates a reference to more detailed information.

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## Chapter 1 BEFORE USING THE INVERTER

### 1.1 Acceptance Inspection

Unpack the package and check the following:
(1) An inverter and accessories below are contained in the package.

- Cooling fan fixing screws (for inverters of 7.5 to 30 kW )
- Keypad fixing screws (for inverters of 0.75 to 30 kW )
- Bush rubbers for cable guide plate (for inverters of 0.75 to 22 kW )
- Instruction manual (this manual)
(2) The inverter has not been damaged during transportation-there should be no dents or parts missing.
(3) The inverter is the model you ordered. You can check the model name and specifications on the main nameplate. (Main and sub nameplates are attached to the inverter and are located as shown on the following page.) For the inverter whose capacity is 37 kW or above, its mass is printed on the nameplate.

| Fe |  |  |
| :---: | :---: | :---: |
| Tipl | $\frac{\text { FRNS.5F } 15-2 \mathrm{Sa}}{}$ |  |
| SOURCE |  |  |
| OUTPIT | $\begin{aligned} & \text { 3PH 8.3kVA } 200-240 \mathrm{~V} \text { 0.1-120Hz } 23.8 \mathrm{~A} \\ & 120 \% 1 \mathrm{~min} \end{aligned}$ |  |
| SERNo. | 3Z3710K1208 | 321 |
|  | Fuji Electric FA | Mase in Japan |

(a) Main Nameplate

TYPE FRN5.5F1S-2A
SER.No. 3Z3710K1208

TYPE: Type of inverter


SOURCE: Number of input phases (three-phase: 3PH), input voltage, input frequency, input current
OUTPUT: Number of output phases, rated output capacity, rated output voltage, output frequency range, rated output current, overload capacity
MASS: Mass of the inverter in kilogram ( 37 kW or above)
SER. No.: Product number


If you suspect the product is not working properly or if you have any questions about your product, contact your Fuji Electric representative.

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1.2 External View and Terminal Blocks
(1) Outside and inside views

(a) FRN15F1S-2

(b) FRN37F1S-2

(c) FRN220F1S-4 $\square$

Note: A box ( $\square$ ) in the above model names replaces A, K, or E depending on the shipping destination.
Figure 1.2 Outside and Inside Views of Inverters
（2）Warning plates and label

## FRENIC－ECO

| A WARN／NG |
| :---: |
| －RISK OF INJURY OR ELECTFIC SHOCK <br> －Refer to the instruction manual before installation and operation． <br> －Do nol rerlove anty cover while applying povier and al least 5min．atter disco：heciri＇g power． <br> －Serurely ground（earth）the equipment． |
| 婁佼険 |
|  <br>  を娔んでもの誢示に行うこと。 <br> 面力八ーを開けないこと。 <br> －確実所接地を发こなうこと。 |
| Only type B of RCD is allowed． See manual for details． |

## $F$



Warning Label
（b）FRN37F1S－2 $\square$

## A WARNING

－RISK OF I NJURY OR ELECTRIC SHOCK
－Refer ta the instruction manual befo＇e
installation and operation．
－RISK OF ELECTRIC SHOCK
－Din ron remove this cover whila applying porver
－Ihis cover can be removed atter at least 10 min of power off and after the＂CHARGE＂lamp turris aff．
－Do nat insert fingers or anything else into
the inverter．
－Secureiv ground learthit the inverter．


き打指示に样ここを。
－䲱刑わおそれあり









Warning Plate

Warning Plate
（a）FRN15F1S－2 $\square$

Note：A box（ $\square$ ）in the above model names replaces A，K，or E depending on the shipping destination．
Figure 1．3 Warning Plates and Label
（3）Terminal block location

（c）FRN220F1S－4 $\square$
Note：A box（ $\square$ ）in the above model names replaces $\mathrm{A}, \mathrm{K}$ ，or E depending on the shipping destination．

Figure 1．4 Terminal Blocks and Keypad Enclosure Location

### 1.3 Transportation

- When carrying an inverter, always support its bottom at the front and rear sides with both hands. Do not hold covers or individual parts only. You may drop the inverter or break it.
- When hoisting an inverter with hoisting holes, hook or rope the 4 holes evenly.


### 1.4 Storage Environment

### 1.4.1 Temporary storage

Store the inverter in an environment that satisfies the requirements listed in Table 1.1.
Table 1.1 Environmental Requirements for Storage and Transportation

| Item | Requirements |  |
| :--- | :--- | :--- |
| Storage temperature ${ }^{* 1}$ | -25 to $+70^{\circ} \mathrm{C}$ | A location where the inverter is not subject to abrupt changes in <br> temperature that would result in the formation of condensation or ice. |
| Relative humidity | 5 to $95 \%{ }^{* 2}$ | The inverter must not be exposed to dust, direct sunlight, corrosive or flammable gases, <br> oil mist, vapor, water drops or vibration. The atmosphere must contain only a low level of <br> salt. $\left(0.01 \mathrm{mg} / \mathrm{cm}^{2}\right.$ or less per year) |
| Atmosphere | 86 to 106 kPa (in storage) |  |
|  | 70 to 106 kPa (during transportation) |  |
| Atmospheric pressure |  |  |

*1 Assuming a comparatively short storage period (e.g., during transportation or the like).
*2 Even if the humidity is within the specified requirements, avoid such places where the inverter will be subjected to sudden changes in temperature that will cause condensation to form.

## Precautions for temporary storage

(1) Do not leave the inverter directly on the floor.
(2) If the environment does not satisfy the specified requirements, wrap the inverter in an airtight vinyl sheet or the like for storage.
(3) If the inverter is to be stored in an environment with a high level of humidity, put a drying agent (such as silica gel) in the airtight package described in item (2).

### 1.4.2 Long-term storage

The long-term storage methods for the inverter vary largely according to the environment of the storage site. General storage methods are described below.
(1) The storage site must satisfy the requirements specified for temporary storage.

However, for storage exceeding three months, the ambient temperature should be within the range from -10 to $+30^{\circ} \mathrm{C}$. This is to prevent the electrolytic capacitors in the inverter from deteriorating.
(2) The inverter must be stored in a package that is airtight to protect it from moisture. Include a drying agent inside the package to maintain the relative humidity inside the package to within $70 \%$.
(3) If the inverter has been installed in the equipment or control board at a construction site where it may be subjected to humidity, dust or dirt, then remove the inverter and store it in a suitable environment specified in Table 1.1.

## Precautions for storage over 1 year

If the inverter will not be powered on for a long time, the property of the electrolytic capacitors may deteriorate. Power the inverters on once a year and keep them on for 30 to 60 minutes. Do not connect the inverters to motors or run the motor.

Chapter 2 MOUNTING AND WIRING OF THE INVERTER

### 2.1 Operating Environment

Install the inverter in an environment that satisfies the requirements listed in Table 2.1.

Table 2.1 Environmental Requirements

| Item | Specifications |
| :--- | :--- |
| Site location | Indoors |
| Ambient <br> temperature | -10 to $+50^{\circ} \mathrm{C}$ (Note 1) |
| Relative <br> humidity | 5 to $95 \%$ (No condensation) |
| Atmosphere | The inverter must not be exposed to dust, direct <br> sunlight, corrosive gases, flammable gas, oil mist, <br> vapor or water drops. <br> Pollution degree 2 (IEC60664-1) (Note 2) |

The atmosphere can contain a small amount of salt. ( $0.01 \mathrm{mg} / \mathrm{cm}^{2}$ or less per year)
The inverter must not be subjected to sudden changes in temperature that will cause condensation to form.

| Altitude | $1,000 \mathrm{~m}$ max. (Note 3) |
| :--- | :--- |
| Atmospheric <br> pressure | 86 to 106 kPa |

Vibration
For inverters of 75 kW or below 3 mm (Max. amplitude) 2 to less than 9 Hz
$9.8 \mathrm{~m} / \mathrm{s}^{2}$
9 to less than 20 Hz
$2 \mathrm{~m} / \mathrm{s}^{2}$
20 to less than 55 Hz
$1 \mathrm{~m} / \mathrm{s}^{2}$
55 to less than 200 Hz
For inverters of 90 kW or above
$3 \mathrm{~m} / \mathrm{s}^{2}$ (Max. amplitude) 2 to less than 9 Hz
$2 \mathrm{~m} / \mathrm{s}^{2} \quad 9$ to less than 55 Hz
$1 \mathrm{~m} / \mathrm{s}^{2} \quad 55$ to less than 200 Hz

### 2.2 Installing the Inverter

## (1) Mounting base

The temperature of the heat sink will rise up to approx. $90^{\circ} \mathrm{C}$ during operation of the inverter, so the inverter should be mounted on a base made of material that can withstand temperatures of this level.


Install the inverter on a base constructed from metal or other non-flammable material.
A fire may result with other material.

## (2) Clearances

Ensure that the minimum clearances indicated in Figure 2.1 are maintained at all times. When installing the inverter in the enclosure of your system, take extra care with ventilation inside the enclosure as the temperature around the inverter will tend to increase. Do not install the inverter in a small enclosure with poor ventilation.

Table 2.2 Output Current Derating Factor in

| Relation to Altitude |  |
| :---: | :---: |
| Altitude | Output current <br> derating factor |
| 1000 m or lower | 1.00 |
| 1000 to 1500 m | 0.97 |
| 1500 to 2000 m | 0.95 |
| 2000 to 2500 m | 0.91 |
| 2500 to 3000 m | 0.88 |

(Note 1) When inverters are mounted side-by-side without any gap between them ( 5.5 kW or less), the ambient temperature should be within the range from -10 to $+40^{\circ} \mathrm{C}$.
(Note 2) Do not install the inverter in an environment where it may be exposed to cotton waste or moist dust or dirt which will clog the heat sink in the inverter. If the inverter is to be used in such an environment, install it in the enclosure of your system or other dustproof containers.
(Note 3) If you use the inverter in an altitude above 1000 m , you should apply an output current derating factor as listed in Table 2.2.


Figure 2.1 Mounting Direction and Required Clearances
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$\square$ When mounting two or more inverters
Horizontal layout is recommended when two or more inverters are to be installed in the same unit or enclosure. If it is necessary to mount the inverters vertically, install a partition plate or the like between the inverters so that any heat radiating from an inverter will not affect the one/s above. As long as the ambient temperature is $40^{\circ} \mathrm{C}$ or lower, inverters can be mounted side-by-side without any gap between them (only for inverters with a capacity of 5.5 kW or below).

## - When employing external cooling

At the shipment time, the inverter is set up for mount inside your equipment or enclosure so that cooling is done all internally.
To improve cooling efficiently, you can take the heat sink out of the equipment or the enclosure (as shown on the right) so that cooling is done both internally and externally (this is called "external cooling").
In external cooling, the heat sink, which dissipates about $70 \%$ of the total heat (total loss) generated into air, is situated outside the equipment or the enclosure. As a result, much less heat is radiated inside the equipment or the enclosure.
To take advantage of external cooling, you need to use the external cooling attachment option for inverters with a capacity of 30 kW or below, or simply re-position the mounting bases for the cooling unit for inverters with a capacity of 37 kW or above.
In an environment with high humidity or a lot of fibrous dust, however, do not use external cooling in an environment with high humidity or a lot of fibrous dust, which tends to clog the heat sink.

For details, refer to the Mounting Adapter for External Cooling "PB-F1" Installation Manual (INR-SI47-0880) and FRENIC-Eco User's Manual (MEH456).


Figure 2.2 External Cooling

## $\triangle$ CAUTION

Prevent lint, paper fibers, sawdust, dust, metallic chips, or other foreign materials from getting into the inverter or from accumulating on the heat sink.
This may result in a fire or accident.

To utilize external cooling for inverters with a capacity of 37 kW or above, change the position of the top and bottom mounting bases from the edge to the center of the inverter as illustrated in Figure 2.3.
Screws differ in size, length and count for each inverter. Be sure to refer to the table below.
Table 2.3 Screw Count and Tightening Torque

| Power supply voltage | Inverter type | Base fixing screw (Count) | Case fixing screw (Count) | Tightening torque (N.m) | Refer to: |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 3-phase 200 V | FRN37F1S-2 $\square$ to FRN75F1S-2 | M6 $\times 20$ (3 pcs each for upper and lower sides) | $\begin{aligned} & \text { M6 } \times 12 \\ & (3 \text { pcs for upper side }) \end{aligned}$ | 5.8 | Figure A |
| 3-phase 400 V | $\begin{aligned} & \text { FRN37F1S-4 } \square \text { to } \\ & \text { FRN110F1S-4 } \end{aligned}$ | M6 $\times 20$ <br> (3 pcs each for upper and lower sides) | $\mathrm{M} 6 \times 12$ <br> (3 pcs for upper side) | 5.8 |  |
|  | FRN132F1S-4 $\square$ to FRN220F1S-4 $\square$ | M6 $\times 20$ <br> (2 pcs each for upper and lower sides) <br> M5 $\times 16$ <br> (4 pcs each for upper and lower sides) | M6 $\times 20$ <br> (2 pcs each for upper and lower sides) <br> M5 $\times 12$ <br> (4 pcs each for upper and lower sides) | $\begin{aligned} & 5.8 \\ & 3.5 \end{aligned}$ | Figure B |

Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.
(1. For models shown in Figure A

1) Remove all of the base fixing screws from the top and bottom of the inverter. Also remove the case fixing screws from the top. (The case fixing screws are not necessary in external cooling. Store them for future use. On the bottom are no case fixing screws.)
2) Secure the top mounting base to the center of the inverter with the base fixing screws, using case fixing screw holes.
3) Secure the bottom mounting base to the center of the inverter with the base fixing screws.
(2. For models shown in Figure $B$
4) Remove all of the base fixing screws from the top and bottom of the inverter. Also remove the case fixing screws.
5) Secure the top mounting base to the center of the inverter with the base fixing screws, using case fixing screw holes. Set the removed case fixing screws to the screw holes where the top mounting bases were secured.
6) In the same way, secure the bottom mounting base to the center of the inverter.


Figure A


Figure B
Figure 2.3 Relocating the Top and Bottom Mounting Bases

## $\triangle$ CAUTION

When moving the top and bottom mounting bases, use only the specified screws.
A fire or an accident may be caused.

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(3) Mounting direction

Mount the inverter vertically to the mounting surface and fix it securely with four screws or bolts so that the logo "FRENIC-Eco" can be seen from the front.

## Note

Do not mount the inverter upside down or horizontally. Doing so will reduce the heat dissipation efficiency of the inverter and cause the overheat protection function to operate, so the inverter will not run.

## (4) Solving abnormal vibration after installation

If any vibration in the surroundings reaches the inverter and causes abnormal vibration to the cooling fan(s) or the keypad, fix them firmly using the fixing screws provided as accessories.

- Fixing the cooling fan(s)

Table 2.4 Fixing Screws

| Power supply voltage | Nominal applied motor (kW) | Inverter type | Screw size (accessory) | Tightening torque ( $\mathrm{N} \cdot \mathrm{m}$ ) | Refer to: |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Threephase 200 V | 7.5 | FRN7.5F1S-2 $\square$ | M4x35 (4 pcs) | 0.8 | Figure A |
|  | 11 | FRN11F1S-2 $\square$ |  |  |  |
|  | 15 | FRN15F1S-2 $\square$ |  |  |  |
|  | 18.5 | FRN18.5F1S-2 $\square$ | M4x50 (2 pcs) | 0.5 | Figure B |
|  | 22 | FRN22F1S-2 $\square$ |  |  |  |
|  | 30 | FRN30F1S-2 $\square$ |  |  |  |
| Threephase 400 V | 7.5 | FRN7.5F1S-4 $\square$ | M4x35 (4 pcs) | 0.8 | Figure A |
|  | 11 | FRN11F1S-4 $\square$ |  |  |  |
|  | 15 | FRN15F1S-4 $\square$ |  |  |  |
|  | 18.5 | FRN18.5F1S-4 $\square$ | M4x50 (2 pcs) | 0.5 | Figure B |
|  | 22 | FRN22F1S-4 $\square$ |  |  |  |
|  | 30 | FRN30F1S-4 $\square$ |  |  |  |

Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.


Figure 2.4 Fixing the Cooling Fan(s)
(1) Remove the terminal block (TB) cover and the front cover. (For the procedure, refer to 2.3.1 "Removing and mounting the terminal block (TB) cover and the front cover.")
(2. To fix the front cover and keypad, hold the front cover and the keypad together and tighten the two attached screws (provided as accessories) from the back of the keypad.


Tightening torque: $0.7 \mathrm{~N} \cdot \mathrm{~m}$
Figure 2.5 Fixing the Keypad

### 2.3 Wiring

Follow the procedure below. (In the following description, the inverter has already been installed.)

### 2.3.1 Removing and mounting the terminal block (TB) cover and the front cover

## (1) For inverters with a capacity of 30 kW or below

- Removing the covers
(1. To remove the terminal block (TB) cover, first loosen the TB cover fastening screw on it, and put your finger in the dimple of the terminal block (TB) cover (labeled "PULL"), and then pull it up toward you.
(2. To remove the front cover, hold it with both hands, slide it downward to unlatch. Tilt the front cover toward you, and pull it upward.


Figure 2.6 Removing the Covers (FRN15F1S-2 $\square$ )*

* A box ( $\square$ ) replaces A, K, or E depending on the shipping destination.
- Mounting the covers
(1. Put the front cover to the inverter case while fitting the edge of the front cover between the both hinges provided on the inverter case. Slide it upward until the front cover latches.
(2. Fit the latches on the terminal block (TB) cover in the holes provided to the front cover and push it towards the inverter case.
(3. Tighten the TB cover fastening screw on the terminal block (TB) cover (Tightening torque: $1.8 \mathrm{~N} \cdot \mathrm{~m}$ ).


Hinge


Figure 2.7 Mounting the Covers (FRN15F1S-2口)*

* A box ( $\square$ ) replaces $\mathrm{A}, \mathrm{K}$, or E depending on the shipping destination.
(2) For inverters with a capacity of 37 kW to 160 kW
- Removing and mounting the covers
(1. To remove the front cover, loosen the four fastening screws on it, hold it with both hands, and slide it upward. (Refer to Figure 2.8.)
(2. Put the front cover back in reverse order of the (1. Make sure to properly match the position of the screw holes on both of the front cover and inverter case.

Table 2.5 Screw count and tightening torque

| Power supply voltage | Inverter type | Front cover screw | Tightening torque <br> $(\mathrm{N} \cdot \mathrm{m})$ |
| :---: | :---: | :---: | :---: |
| Three-phase 200 V | FRN37F1S-2 $\square$ to FRN75F1S-2 $\square$ | $\mathrm{M} 4 \times 8(4 \mathrm{pcs})$ | 1.8 |
| Three-phase 400 V | FRN37F1S-4 $\square$ to FRN110F1S-4 $\square$ | $\mathrm{M} 4 \times 8(4 \mathrm{pcs})$ | 1.8 |
|  | FRN132F1S-4 $\square$ to FRN160F1S-4 $\square$ | $\mathrm{M} 4 \times 8(4 \mathrm{pcs})$ | 3.5 |

Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.


Figure 2.8 Removing the Front Cover (FRN37F1S-2 $\square$ )*

* A box ( $\square$ ) replaces $\mathrm{A}, \mathrm{K}$, or E depending on the shipping destination.
(3) For inverters with a capacity of 200 kW to 220 kW
- Removing and mounting the covers
(1. To remove the lower front cover, loosen the five fastening screws on it, and hold it with both hands, and then slide it upward.

Note You can do wiring works just removing the lower front cover.
(2. To remove the upper front cover, loosen the five screws on it while supporting it with a hand. Pull and remove it with both hands. (Refer to Figure 2.9.)
(3. Put back the upper and lower front covers in reverse order of (1) and (2. Make sure to properly match the position of the screw holes on the upper and lower front covers and inverter case.


Wire toffrom the inverter after removing the lower front cover.


The upper front cover is removable as well as shown above.
Tightening torque: $3.5 \mathrm{~N} \cdot \mathrm{~m}$
Figure 2.9 Removing the Front Covers (FRN220F1S-4 $\square$ )*

* A box ( $\square$ ) replaces A, K, or E depending on the shipping destination.


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### 2.3.2 Removing and mounting the cable guide plate (for models of 0.75 kW to $\mathbf{2 2} \mathbf{~ k W ) ~}$

For inverters of 22 kW or below use the cable guide plate to secure IP20 protective structure. Follow the steps to work on it.

## - Removing the cable guide plate

Before to proceed, remove the terminal block cover in advance.
Remove the cable guide plate fastening screw, and pull the cable guide plate.


Figure 2.10 Removing the Cable Guide Plate (FRN15F1S-2 $\square$ )*

* A box ( $\square$ ) replaces A, K, or E depending on the shipping destination.

■ Opening half-punched holes and mounting rubber bushes
(1. Tap the three half-punched holes of the cable guide plate by using a screwdriver grip end or the like and punch them out.

Note Be careful not to injure yourself by sharp cutting edges of parts.
(2) Set the three attached rubber bushes in the punched holes. Make cut-outs on the rubber bushes before wiring.


Figure 2.11 Punching out the Holes and Mounting the Rubber Bushes

## $\triangle$ WARNING

Be sure to use the rubber bushes. If not, a sharp cutting edge of the cable guide plate hole may damage the cable sheath. This may induce a short-circuit fault or ground fault.
A fire or an accident may be caused.

Mounting the cable guide plate
Mount the cable guide plate following the steps illustrated in Figure 2.10 in reverse. (Tightening torque: $1.8 \mathrm{~N} \cdot \mathrm{~m}$ )

### 2.3.3 Terminal arrangement diagram and screw specifications

The table below shows the main circuit screw sizes, tightening torque and terminal arrangements. Note that the terminal arrangements differ according to the inverter types. Two terminals designed for grounding shown as the symbol, $\mathbf{e}$ in Figures A to J make no distinction between a power supply source (a primary circuit) and a motor (a secondary circuit).
(1) Arrangement of the main circuit terminals

Table 2.6 Main Circuit Terminal Properties

| Power supply voltage | Nominal applied motor (kW) | Inverter type | Terminal screw size | Tightening torque ( $\mathrm{N} \cdot \mathrm{m}$ ) | Grounding screw size | Tightening torque (N•m) | Refer to: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Threephase 200 V | 0.75 | FRN0.75F1S-2 $\square$ | M4 | 1.8 | M4 | 1.8 | Figure A |
|  | 1.5 | FRN1.5F1S-2 $\square$ |  |  |  |  |  |
|  | 2.2 | FRN2.2F1S-2 $\square$ |  |  |  |  |  |
|  | 3.7 | FRN3.7F1S-2 $\square$ |  |  |  |  |  |
|  | 5.5 | FRN5.5F1S-2 $\square$ |  |  |  |  |  |
|  | 7.5 | FRN7.5F1S-2 $\square$ | M5 | 3.8 | M5 | 3.8 | Figure B |
|  | 11 | FRN11F1S-2 $\square$ |  |  |  |  |  |
|  | 15 | FRN15F1S-2 $\square$ | M6 | 5.8 | M6 | 5.8 |  |
|  | 18.5 | FRN18.5F1S-2 $\square$ |  |  |  |  | Figure C |
|  | 22 | FRN22F1S-2 $\square$ |  |  |  |  |  |
|  | 30 | FRN30F1S-2 $\square$ | M8 | 13.5 | M8 | 13.5 | Figure D |
|  | 37 | FRN37F1S-2 $\square$ |  |  |  |  | Figure E |
|  | 45 | FRN45F1S-2 $\square$ | M10 | 27 |  |  | Figure G |
|  | 55 | FRN55F1S-2 $\square$ |  |  |  |  |  |
|  | 75 | FRN75F1S-2 $\square$ |  |  |  |  |  |
| Threephase 400 V | 0.75 | FRN0.75F1S-4 $\square$ | M4 | 1.8 | M4 | 1.8 | Figure A |
|  | 1.5 | FRN1.5F1S-4 $\square$ |  |  |  |  |  |
|  | 2.2 | FRN2.2F1S-4 $\square$ |  |  |  |  |  |
|  | $\begin{gathered} 3.7 \\ (4.0)^{\star} \end{gathered}$ | $\begin{aligned} & \text { FRN3.7F1S-4 } \\ & \text { FRN4.0F1S-4E } \end{aligned}$ |  |  |  |  |  |
|  | 5.5 | FRN5.5F1S-4 $\square$ |  |  |  |  |  |
|  | 7.5 | FRN7.5F1S-4 $\square$ | M5 | 3.8 | M5 | 3.8 | Figure B |
|  | 11 | FRN11F1S-4 $\square$ |  |  |  |  |  |
|  | 15 | FRN15F1S-4 $\square$ | M6 | 5.8 | M6 | 5.8 |  |
|  | 18.5 | FRN18.5F1S-4 $\square$ |  |  |  |  | Figure C |
|  | 22 | FRN22F1S-4 $\square$ |  |  |  |  |  |
|  | 30 | FRN30F1S-4 $\square$ | M8 | 13.5 | M8 | 13.5 | Figure D |
|  | 37 | FRN37F1S-4 $\square$ |  |  |  |  |  |
|  | 45 | FRN45F1S-4D |  |  |  |  | gure E |
|  | 55 | FRN55F1S-4 $\square$ |  |  |  |  | Figure F |
|  | 75 | FRN75F1S-4 $\square$ |  |  |  |  | Figure |
|  | 90 | FRN90F1S-4 $\square$ | M10 | 27 |  |  |  |
|  | 110 | FRN110F1S-4 $\square$ |  |  |  |  | Figure G |
|  | 132 | FRN132F1S-4 $\square$ |  |  | M10 | 27 | Figure H |
|  | 160 | FRN160F1S-4 $\square$ | M12 | 48 |  |  | Figure I |
|  | 200 | FRN200F1S-4 $\square$ |  |  |  |  | Figure J |
|  | 220 | FRN220F1S-4 $\square$ |  |  |  |  |  |

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Figure $A$
Figure F


| $\boldsymbol{P}$ | $\boldsymbol{\Phi}$ |
| :--- | :--- |
| RO | TO |





Figure D


Figure E
"O" Charging Lamp

(2) The control circuit terminals (common to all models)

- For the screw terminal base


Screw size: M3 Tightening torque: $0.7(\mathrm{~N} \cdot \mathrm{~m})$

- For the Europe type terminal block


Screw size: M3 Tightening torque: 0.5 to $0.6(\mathrm{~N} \cdot \mathrm{~m})$

Table 2.7 Control Circuit Terminals

| Screwdriver to be used (Head style) | Allowable wire size | Bared wire length $\qquad$ Tmmar <br> $\xrightarrow{l}$ | Dimension of openings in the control circuit terminals for Europe type terminals* |
| :---: | :---: | :---: | :---: |
| Flat head ( $0.6 \times 3.5 \mathrm{~mm}$ ) | AWG26 to AWG16 ( 0.14 to $1.5 \mathrm{~mm}^{2}$ ) | 7 mm | 2.75 (W) x 2.86 (H) mm |

* Manufacturer of Europe type terminals: Phoenix Contact Inc. Refer to Table 2.8.

Table 2.8 Recommended Europe Type Terminals

| Screw size | Type |  |
| :--- | :---: | :---: |
|  | With insulated collar | Without insulated collar |
| AWG24 $\left(0.25 \mathrm{~mm}^{2}\right)$ | Al0.25-6BU | - |
| AWG22 $\left(0.34 \mathrm{~mm}^{2}\right)$ | Al0.34-6TQ | A0.34-7 |
| AWG20 $\left(0.5 \mathrm{~mm}^{2}\right)$ | Al0.5-6WH | A0.5-6 |
| AWG18 $\left(0.75 \mathrm{~mm}^{2}\right)$ | Al0.75-6GY | A0.75-6 |
| AWG16 $\left(1.25 \mathrm{~mm}^{2}\right)$ | Al1.5-6BK | A1.5-7 |



Head thickness: 0.6 mm Screwdriver head style

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### 2.3.4 Recommended wire sizes

Table 2.9 lists the recommended wire sizes. Those for main circuits are examples for using a single wire (for $60 / 70^{\circ} \mathrm{C}$ ) at an ambient temperature of $50^{\circ} \mathrm{C}$.

Table 2.9 Recommended Wire Sizes

|  | Nominal applied motor (kW) | Inverter type | Recommended wire size ( $\mathrm{mm}^{2}$ ) *1 |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Main circuits |  |  |  |  |  |  |  |
|  |  |  | Main circuit power input <br> (L1/R, L2/S, L3/T) |  | Grounding [ F G] | Inverter output [U, V, W] | Auxiliary Power Input (Ctrl. cct.) [R0, T0] | Auxiliary <br> Power Input (Fans) [R1, T1] | $\begin{gathered} \mathrm{DCR} \\ {[\mathrm{P} 1, \mathrm{P}(+)]} \end{gathered}$ |  |
|  |  |  | w/ DCR | w/o DCR |  |  |  |  |  |  |
|  | 0.75 | FRN0.75F1S-2口 | 2 | 2 | 2 | 2 | 2 | - | 2 | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ |
|  | 1.5 | FRN1.5F1S-2 $\square$ |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2.2F1S-2 $\square$ |  |  |  |  |  |  |  |  |
|  | 3.7 | FRN3.7F1S-2 $\square$ |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5.5F1S-2 $\square$ |  | 3.5 | 3.5 | 3.5 |  |  | 3.5 |  |
|  | 7.5 | FRN7.5F1S-2 $\square$ | 3.5 | 5.5 | 5.5 |  |  |  | 5.5 |  |
|  | 11 | FRN11F1S-2 $\square$ | 5.5 | 14 |  | 8 |  |  | 8 |  |
|  | 15 | FRN15F1S-2 $\square$ | 14 | 22 | 8 | 14 |  |  | 14 |  |
|  | 18.5 | FRN18.5F1S-2 $\square$ |  |  |  |  |  |  | 22 |  |
|  | 22 | FRN22F1S-2 $\square$ | 22 | 38 | 14 | 22 |  |  |  |  |
|  | 30 | FRN30F1S-2 $\square$ | 38 | 60 |  | 38 |  |  | 38 |  |
|  | 37 | FRN37F1S-2 $\square$ |  |  | 22 |  |  |  | 60 |  |
|  | 45 | FRN45F1S-2 $\square$ | 60 | 100 |  | 60 |  | 2 | 100 |  |
|  | 55 | FRN55F1S-2 $\square$ | 100 |  |  | 100 |  |  |  |  |
|  | 75 | FRN75F1S-2 $\square$ | $\begin{gathered} 60 \times 2 \\ \text { or } \\ 150 \text { *2 } \end{gathered}$ | - |  |  |  |  | 150 |  |
|  | 0.75 | FRN0.75F1S-4 $\square$ | 2 | 2 | 2 | 2 | 2 | - | 2 | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ |
|  | 1.5 | FRN1.5F1S-4 $\square$ |  |  |  |  |  |  |  |  |
|  | 2.2 | FRN2.2F1S-4 $\square$ |  |  |  |  |  |  |  |  |
|  | $\begin{aligned} & \hline 3.7 \\ & (4.0)^{*} 3 \\ & \hline \end{aligned}$ | FRN3.7F1S-4 $\square$ FRN4.0F1S-4E |  |  |  |  |  |  |  |  |
|  | 5.5 | FRN5.5F1S-4 $\square$ |  |  |  |  |  |  |  |  |
|  | 7.5 | FRN7.5F1S-4 $\square$ |  |  | 3.5 |  |  |  |  |  |
|  | 11 | FRN11F1S-4 $\square$ |  | 3.5 |  |  |  |  | 3.5 |  |
|  | 15 | FRN15F1S-4 $\square$ | 3.5 | 5.5 |  | 3.5 |  |  |  |  |
|  | 18.5 | FRN18.5F1S-4 $\square$ | 5.5 | 8 | 5.5 | 5.5 |  |  | 5.5 |  |
|  | 22 | FRN22F1S-4 $\square$ |  |  |  |  |  |  | 8 |  |
|  | 30 | FRN30F1S-4 $\square$ | 14 |  | 8 | 14 |  |  | 14 |  |
|  | 37 | FRN37F1S-4 $\square$ |  | 22 |  |  |  |  |  |  |
|  | 45 | FRN45F1S-4 $\square$ | 22 | 38 |  | 22 |  |  | 22 |  |
|  | 55 | FRN55F1S-4 $\square$ |  |  | 14 | 38 |  | 2 | 38 |  |
|  | 75 | FRN75F1S-4 $\square$ | 38 | - |  |  |  |  | 60 |  |
|  | 90 | FRN90F1S-4 $\square$ | 60 |  |  | 60 |  |  | 100 |  |
|  | 110 | FRN110F1S-4D | 100 |  | 22 | 100 |  |  |  |  |
|  | 132 | FRN132F1S-4 $\square$ |  |  |  |  |  |  | 150 |  |
|  | 160 | FRN160F1S-4 $\square$ | 150 |  |  | 150 |  |  | 150 |  |
|  | 200 | FRN200F1S-4D |  |  | 38 | 200 |  |  | 250 |  |
|  | 220 | FRN220F1S-4D | 200 |  |  |  |  |  |  |  |

DCR: DC reactor
*1 Use the terminal crimp with an insulation sheath or with processing by the insulation tube.
Use the insulated wire with allowable heat resistance to 60 or $70^{\circ} \mathrm{C}$. This selection assumes the inverter is used in ambient temperature at $50^{\circ} \mathrm{C}$.
*2 When using the $150 \mathrm{~mm}^{2}$ wire in size, apply the CB150-10 crimp terminal for low voltage appliance in compliance with JEM1399 or its equivalent.
*3 The applicable motor rating of FRN4.0F1S-4E to be shipped for EU is 4.0 kW .
Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.

### 2.3.5 Wiring precautions

Follow the rules below when performing wiring for the inverter.
(1) Make sure that the source voltage is within the rated voltage range specified on the nameplate.
(2) Be sure to connect the three-phase power wires to the main circuit power input terminals L1/R, L2/S and $\mathrm{L} 3 / \mathrm{T}$ of the inverter. If the power wires are connected to other terminals, the inverter will be damaged when the power is turned on.
(3) Always connect the grounding terminal to prevent electric shock, fire or other disasters and to reduce electric noise.
(4) Use crimp terminals covered with insulated sleeves for the main circuit terminal wiring to ensure a reliable connection.
(5) Keep the power supply wiring (primary circuit) and motor wiring (secondary circuit) of the main circuit, and control circuit wiring as far away as possible from each other.

## $\triangle$ WARNING

- When wiring the inverter to the power source, insert a recommended molded case circuit breaker (MCCB) or earth leakage circuit breaker (ELCB) (with overcurrent protection) in the path of each pair of power lines to inverters. Use the devices recommended ones within the related current range.
- Use wires in the specified size.
- Tighten terminals with specified torque.

Otherwise, fire could occur.

- Do not connect a surge killer to the inverter's output circuit.
- Do not use one multicore cable in order to connect several inverters with motors.

Doing so could cause fire.

- Ground the inverter in compliance with the national or local electric code. Otherwise, electric shock or fire could occur.
- Qualified electricians should carry out wiring.
- Be sure to perform wiring after turning the power off.

Otherwise, electric shock could occur.

- Be sure to perform wiring after installing the inverter.

Otherwise, electric shock or injuries could occur.

- Ensure that the number of input phases and the rated voltage of the product match the number of phases and the voltage of the AC power supply to which the product is to be connected.
- Do not connect the power source wires to output terminals ( $\mathrm{U}, \mathrm{V}$, and W ).

Doing so could cause fire or an accident.

### 2.3.6 Wiring for main circuit terminals and grounding terminals

Table 2.10 shows the main circuit power terminals and grounding terminals.
Table 2.10 Symbols, Names and Functions of the Main Circuit Power Terminals

| Symbol | Name | Functions |
| :---: | :---: | :---: |
| L1/R, L2/S, L3/T | Main circuit power inputs | Connect the 3-phase input power lines. |
| U, v, w | Inverter outputs | Connect a 3-phase motor. |
| R0, T0 | Auxiliary power input for the control circuit | For a backup of the control circuit power supply, connect AC power lines same as that of the main power input. |
| P1, P(+) | DC reactor connection | Connect a DC reactor (DCR) for improving power factor (an option for the inverter whose capacity is 55 kW or below). |
| $\mathrm{P}(+), \mathrm{N}(-)$ | DC link bus | Connect a DC link bus of other inverter(s). An optional regenerative converter is also connectable to these terminals. |
| R1, T1 | Auxiliary power input for the fans | Normally, no need to use these terminals. Use these terminals for an auxiliary power input of the fans in a power system using a power regenerative PWM converter (RHC series). |
|  | Grounding for inverter and motor | Grounding terminals for the inverter's chassis (or case) and motor. Earth one of the terminals and connect the grounding terminal of the motor. Inverters provide a pair of grounding terminals that function equivalently. |

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O Follow the procedure below for wiring and configuration of the inverter. Figure 2.12 illustrates the wiring procedure with peripheral equipment.

## Wiring procedure

(1.) Grounding terminals (
2. Inverter output terminals (U, V, W, and 올G)

DC reactor connection terminals ( P 1 and $\mathrm{P}(+))^{*}$
(4. Switching connectors* (For the models of 200 V series 45 kW or above, for 400 V series 55 kW or above. Refer to page 2-18.)
5. DC link bus terminals $(P(+) \text { and } N(-))^{*}$
6. Main circuit power input terminals (L1/R, L2/S and L3/T)

Auxiliary power input terminals for the control circuit (R0 and T0)*
(8. Auxiliary power input terminals for the fans ( R 1 and T 1 )* (For models of 200 V series 45 KW or above, for 400 V series 55 kW or above. Refer to page 2-22.)

* Perform wiring as necessary


Note: A box ( $\square$ ) in the above figure replaces $A, K$, or $E$ depending on the shipping destination.
Figure 2.12 Wiring Procedure for Peripheral Equipment
(1) Grounding terminals (올G)

Be sure to ground either of the two grounding terminals for safety and noise reduction. The inverter is designed to use with a safety grounding to avoid electric shock, fire and other disasters.
Grounding terminals should be grounded as follows:

1) Ground the inverter in compliance with the national or local electric code.
2) Use a thick grounding wire with a large surface area and keep the wiring length as short as possible.

## 

Inverter's output terminals should be connected as follows:

1) Connect the three wires of the 3-phase motor to terminals $\mathrm{U}, \mathrm{V}$, and W , aligning phases each other.
2) Connect the secondary grounding wire to the grounding terminal (


- The wiring length between the inverter and motor should not exceed 50 m , when they are connected directly. If the wiring length exceeds 50 m , an output circuit filter (option) should be inserted. (E.g. total power cable length is 400 m as shown in the figure below.)
- Do not use one multicore cable to connect several inverters with motors even if some possible combinations of inverters and motors are considered.

| No Output Circuit Filter installed |  | Output Circuit Filter installed |
| :--- | :--- | :--- |
| Power |  |  |
| Input |  |  |

Note - Do not connect a power factor correcting capacitor or surge absorber to the inverter's output lines (secondary circuit).

- If the wiring length is long, the stray capacitance between the wires will increase, resulting in an outflow of the leakage current. It will activate the overcurrent protection, increase the leakage current, or will not assure the accuracy of the current display. In the worst case, the inverter could be damaged.
- If more than one motor is to be connected to a single inverter, the wiring length should be the sum of the length of the wires to the motors.
- If an output circuit filter is installed in the inverter or the wires between the motor and the inverter are too long, the actual voltage applied to the motor would drop measurably because of the voltage drop over the filter or the wires. As a result, the output current may fluctuate because of an insufficient voltage.
In such installations, set the voltage on the higher side, by setting the function code F37 (Load Selection/Auto torque Boost/Auto energy Saving Operation) to "1: Variable torque load increasing in proportion to square of speed" (Higher start-up torque required), or selecting a non-linear V/f pattern (using the function codes H 50 and H51 (Non-linear V/f pattern (Frequency and Voltage)).
- Use an output circuit (secondary) filter of OFL-ㅁㅁㅁ-पA.
- If a thermal relay is installed in the path between the inverter and the motor to protect the motor from overheating, the thermal relay may malfunction even with a wiring length shorter than 50 m . In this situation, add an output circuit filter (option) or lower the carrier frequency (Function code F26).
- If the motor is driven by a PWM-type inverter, surge voltage that is generated by switching the inverter component may be superimposed on the output voltage and may be applied to the motor terminals. Particularly if the wiring length is long, the surge voltage may deteriorate the insulation resistance of the motor. Consider any of the following measures.
- Use a motor with insulation that withstands the surge voltage. (All Fuji standard motors feature insulation that withstands the surge voltage.)
- Connect an output circuit filter (option) to the output terminals (secondary circuits) of the inverter.
- Minimize the wiring length between the inverter and motor (10 to 20 m or less).


## (3. DC reactor terminals, P1 and P (+)

1) Remove the jumper bar from terminals P 1 and $\mathrm{P}(+)$.
2) Connect a DC reactor (option) to terminals P 1 and $\mathrm{P}(+)$.

Note - The wiring length should be 10 m or below.

- Do not remove the jumper bar if a DC reactor is not going to be used.
- An inverter with a capacity of 75 kW or above is equipped with a DC reactor as standard. Be sure to connect the DC reactor except when an optional converter is connected to the inverter.


## (4. Switching connectors

- Power switching connectors (CN UX) (for the models of 400 V series 55 kW or above)

An inverter of 400 V series 55 kW or above is equipped with a set of switching connectors CU UX (male) which should be configured with a jumper according to the power source voltage and frequency. Set the jumper to U1 or U 2 depending upon the power source voltage applied to the main power inputs (L1/R, L2/S, L3/T) or auxiliary power input terminals (R1, T1) for fans, as shown in Figure 2.16.

- Fan power supply switching connectors (CN R) and (CN W) (for models of 45 kW or above ( 200 V series) or 55 kW or above ( 400 V series))

The standard FRENIC-Eco series of inverters also accept DC-linked power input in combination with a power regenerative PWM converter (RHC series). Even when you drive the inverter with a DC-linked power, however, you also need to supply AC power for models of 45 kW or above ( 200 V series) or 55 kW or above ( 400 V series), since it contains components such as AC fans that are driven by AC power. In this case, reinstall the connectors (CN R) and (CN W) to the NC and FAN positions respectively and supply the power to the auxiliary power input terminals (R1, T1).

For the actual procedure, refer to Figures 2.14 to 2.16 below.
Note On the fan power supply switching connectors (CN R) and (CN W), the jumpers are installed at FAN and NC positions respectively by factory default. Do not relocate the jumper unless you drive the inverter with a DC-linked power supply.
If there is a mistake in the installation of the jumpers for the switching connectors, the cooling fan will



Figure 2.13 Switching Fan Power Source

These switching connectors are located on the power printed circuit board (power PCB) mounted at the right hand side of the control printed circuit board (control PCB) as shown below.

Switching Connectors for


Figure 2.14 Location of Switching Connectors and Auxiliary Power Input Terminals


Figure 2.15 Inserting/Removing the Jumpers

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Figure 2.16 shown below illustrates how the configuration jumpers of the connectors (CN UX), (CN R) and (CN W) are setup by factory defaults, and to change their settings for a new power configuration.

- Setting up the power switching connector (CN UX)
(for the models of 400 V series 55 kW or above)


- Setting up the fan power supply switching connectors (CN R) and (CN W)
(for the models of 200 V series 45 kW or above ; 400 V series 55 kW or above)


Figure 2.16 Reconfiguration of the (CN UX), (CN R) and (CN W) Connectors

These are provided for the DC link bus powered system. Connect these terminals with terminals $\mathrm{P}(+)$ and $\mathrm{N}(-)$ of other inverters.

Note Consult your Fuji Electric representative if these terminals are to be used.

Main circuit power input terminals, L1/R, L2/S, and L3/T (three-phase input)

1) For safety, make sure that the molded case circuit breaker (MCCB) or magnetic contactor (MC) is turned off before wiring the main circuit power input terminals.
2) Connect the main circuit power supply wires ( $\mathrm{L} 1 / \mathrm{R}, \mathrm{L} 2 / \mathrm{S}$ and $\mathrm{L} 3 / \mathrm{T}$ ) to the input terminals of the inverter via an MCCB or residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB)*, and MC if necessary.
It is not necessary to align phases of the power supply wires and the input terminals of the inverter with each other.

* With overcurrent protection

Tip It is recommended that a magnetic contactor be inserted that can be manually activated. This is to allow you to disconnect the inverter from the power supply in an emergency (e.g., when the protective function is activated) so as to prevent a failure or accident from causing the secondary problems.

## (7. Auxiliary power input terminals R0 and T0 for the control circuit

In general, the inverter will run normally without power supplied to the auxiliary power input for the control circuit. However, if you share the input power for the control circuit with that for the main circuit, you would be lost when, in the event of an error or alarm, you turn OFF the magnetic contactor between the inverter and the commercial power supply. If the magnetic contactor is turned OFF, the input power to the control circuit is shut OFF, causing the alarm signals $(30 \mathrm{~A} / \mathrm{B} / \mathrm{C})$ to be lost and the display on the keypad to disappear. To secure input power to the control circuit at all times, supply the power from the primary side of the magnetic contactor to control power auxiliary input terminals RO and TO.

## (8. Auxiliary power input terminals R1 and T1 for the fan

Inverters, 200 V series 45 kW or above and 400 V series 55 kW or above are equipped with these terminals R1 and T1. Only if the inerter works with the DC linked power input whose source is a power regenerative PWM converter (e.g. RHC series), these terminals are used to feed power to the fans while they are not used in any power system of ordinary configuration. The fan power is:
Single phase 200 to $220 \mathrm{VAC} / 50 \mathrm{~Hz}$, 200 to $230 \mathrm{VAC} / 60 \mathrm{~Hz}$ for 200 V series 45 kW or above
Single phase 380 to $440 \mathrm{VAC} / 50 \mathrm{~Hz}$. 380 to $480 \mathrm{VAC} / 60 \mathrm{~Hz}$ for 400 V series 55 kW or above

### 2.3.7 Wiring for control circuit terminals

## $\triangle$ WARNING

In general, sheaths and covers of the control signal cables and wires are not specifically designed to withstand a high electric field (i.e., reinforced insulation is not applied). Therefore, if a control signal cable or wire comes into direct contact with a live conductor of the main circuit, the insulation of the sheath or the cover might break down, which would expose the signal wire to a high voltage of the main circuit. Make sure that the control signal cables and wires will not come into contact with live conductors of the main circuit.
Failure to observe these precautions could cause electric shock and/or an accident.

## $\triangle$ CAUTION

Noise may be emitted from the inverter, motor and wires.
Take appropriate measure to prevent the nearby sensors and devices from malfunctioning due to such noise.
An accident could occur.

Table 2.11 lists the symbols, names and functions of the control circuit terminals. The wiring to the control circuit terminals differs depending upon the setting of the function codes, which reflects the use of the inverter. Route wires properly to reduce the influence of noise, referring to the notes on the following pages.

Table 2.11 Symbols, Names and Functions of the Control Circuit Terminals

|  | Symbol | Name | Functions |
| :---: | :---: | :---: | :---: |
|  | [13] | Potentiometer power supply | Power supply ( +10 VDC ) for the potentiometer that gives the frequency command (Potentiometer: 1 to $5 \mathrm{k} \Omega$ ) <br> Allowable output current: 10 mA |
|  | [12] | Voltage input | (1) The frequency is commanded according to the external analog input voltage. 0 to $10 \mathrm{VDC} / 0$ to 100 (\%) (Normal mode operation) 10 to 0 VDC/0 to 100 (\%) (Inverse mode operation) <br> (2) Used for PID process command signal or its feedback. <br> (3) Used as an additional auxiliary frequency command to be added to one of various main frequency commands. <br> * Input impedance: $22 \mathrm{k} \Omega$ <br> * The allowable maximum input voltage is +15 VDC . If the input voltage is +10 VDC or more, the inverter will interpret it as +10 VDC. |
|  | [C1] | Current input | (1) The frequency is commanded according to the external analog input current. <br> 4 to $20 \mathrm{mADC} / 0$ to 100 (\%) (Normal mode operation) <br> 20 to $4 \mathrm{mADC} / 0$ to 100 (\%) (Inverse mode operation) <br> (2) Used for PID process command signal or its feedback. <br> (3) Used as an additional auxiliary frequency command to be added to one of various main frequency commands. <br> * Input impedance: $250 \Omega$ <br> * The allowable input current is +30 mADC . If the input current exceeds +20 mA DC , the inverter will interpret it as +20 mADC . |
|  | [V2] | Voltage input | (1) The frequency is commanded according to the external analog input voltage. 0 to 10 VDC/0 to 100 (\%) (Normal mode operation) 10 to 0 VDC/0 to 100 (\%) (Inverse mode operation) <br> (2) Used for PID process command signal or its feedback. <br> (3) Used as an additional auxiliary frequency command to be added to one of various main frequency commands. <br> * Input impedance: $22 \mathrm{k} \Omega$ <br> * The allowable input voltage is +15 VDC . If the input voltage exceeds +10 VDC , however, the inverter will interpret it as +10 VDC. |
|  |  |  | (4) Connects PTC (Positive Temperature Coefficient) thermistor for motor protection. Ensure that the slide switch SW5 on the control PCB is turned to the PTC position (refer to Section 2.3.8 "Setting up slide switches and handling control circuit terminal symbol plate." <br> The figure shown at the right illustrates the internal circuit diagram where SW5 (switching the input of terminal [V2] between V2 and PTC) is turned to the PTC position. For details on SW5, refer to Section 2.3.8 "Setting up slide switches and handling control circuit terminal symbol plate." In this case, you must change data of the function code H26. <br> Figure 2.17 Internal Circuit Diagram (SW5 Selecting PTC) |
|  | [11] | Analog common | Two common terminals for analog input and output signal terminals [13], [12], [C1], [V2] and [FMA]. <br> These terminal are electrically isolated from terminals [CM]s and [CMY]. |



Figure 2.18 Connection of Shielded Wire
Figure 2.19 Example of Electric Noise Reduction

Table 2.11 Continued

| \% | Symbol | Name | Functions |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | [X1] | Digital input 1 | (1) The various signals such as coast-to-stop, alarm from external equipment, and multistep frequency commands can be assigned to terminals [X1] to [X5], [FWD] and [REV] by setting function codes E01 to E05, E98, and E99. For details, refer to Chapter 5, Section 5.2 "Overview of Function Codes." <br> (2) Input mode, i.e. Sink/Source, is changeable by using the internal slide switch. <br> (3) Switches the logic value ( $1 / 0$ ) for ON/OFF of the terminals between [X1] to [X5], [FWD] or [REV], and [CM]. If the logic value for ON between [X1] and [CM] is 1 in the normal logic system, for example, OFF is 1 in the negative logic system and vice versa. <br> (4) The negative logic system never applies to the terminals assigned for (FWD) and (REV). |  |  |  |  |
|  | [X2] | Digital input 2 |  |  |  |  |  |
|  | [X3] | Digital input 3 |  |  |  |  |  |
|  | [X4] | Digital input 4 |  |  |  |  |  |
|  | [X5] | Digital input 5 | (Digital input circuit specifications) |  |  |  |  |
|  | [FWD] | Run |  | Iter |  | Min. | Max. |
|  |  | command | <Control Circuit> | Operation | ON level | 0 V | 2 V |
|  |  |  | ○ | (SINK) | OFF level | 22 V | 27 V |
|  |  |  | SINE | Operation | ON level | 22 V | 27 V |
|  | [REV] | Run reverse command |  | (SOURCE) | OFF level | 0 V | 2 V |
|  |  |  | source: | Operation current at ON (Input voltage is at OV) |  | 2.5 mA | 5 mA |
|  |  |  |  | Allowable leakage current at OFF |  |  | 0.5 mA |
|  |  |  | Figure 2.20 Digital Input Circuit |  |  |  |  |
|  | [PLC] | PLC signal power | Connects to PLC output signal power supply. <br> (Rated voltage: +24 VDC: Allowable range: +22 to +27 VDC) <br> This terminal also supplies a power to the circuitry connected to the transistor output terminals [Y1] to [Y3]. Refer to "Transistor output" described later in this table for more. |  |  |  |  |
|  | [CM] | Digital common | Two common terminals for digital input signal terminals and output terminal [FMP] These terminals are electrically isolated from the terminals, [11]s and [CMY]. |  |  |  |  |



Figure 2.21 Circuit Configuration Using a Relay Contact

## Using a programmable logic controller (PLC) to turn [X1], [X2], [X3], [X4], [X5], [FWD], or [REV] ON or OFF

Figure 2.22 shows two examples of a circuit that uses a programmable logic controller (PLC) to turn control signal input [X1], [X2], [X3], [X4], [X5], [FWD], or [REV] ON or OFF. In circuit (a), the switch SW1 has been turned to SINK, whereas in circuit (b) it has been turned to SOURCE.

In circuit (a) below, short-circuiting or opening the transistor's open collector circuit in the PLC using an external power source turns ON or OFF control signal [X1], [X2], [X3], [FWD], or [REV]. When using this type of circuit, observe the following:

- Connect the + node of the external power source (which should be isolated from the PLC's power) to terminal [PLC] of the inverter.
- Do not connect terminal [CM] of the inverter to the common terminal of the PLC.

(a) With the switch turned to SINK

(b) With the switch turned to SOURCE

Figure 2.22 Circuit Configuration Using a PLC
(D) For details about the slide switch setting, refer to Section 2.3.8 "Setting up slide switches and handling control circuit terminal symbol plate."

| - | Symbol | Name | Functions |
| :---: | :---: | :---: | :---: |
|  | [FMA] | Analog monitor | The monitor signal for analog DC voltage ( 0 to +10 V ) or analog DC current ( +4 to +20 mA ) is output. You can select either one of the output switching the slide switch SW4 on the control PCB (Refer to Section 2.3.8.), and changing data of the function code F29. You can select one of the following signal functions with function code F31. <br> - Output frequency <br> - Output torque <br> - PID feedback value <br> - Motor output <br> - PID output <br> * Input impedance of the external device: Min. $5 \mathrm{k} \Omega$ ( 0 to 10 VDC output) Input impedance of the external device: Max. $500 \Omega$ (4 to 20 mA DC output) <br> * While the terminal is outputting 0 to 10 VDC , an output less than 0.3 V may become 0.0 V. <br> * While the terminal is outputting 0 to 10 VDC, it is capable of driving up to two meters with $10 \mathrm{k} \Omega$ impedance. While outputting the current, to drive a meter with $500 \Omega$ impedance max. (Adjustable range of the gain: 0 to 200\%) |
|  | [FMI]* | Analog monitor | The monitor signal for analog DC current ( +4 to +20 mA ) is output. You can select one of the following signal functions with function code F35. <br> - Output frequency <br> - Output torque <br> - PID feedback value <br> - Motor output <br> - PID output <br> * Input impedance of the external device: Max. $500 \Omega$ <br> * It is capable of driving a meter with a maximum of $500 \Omega$ impedance. <br> (Adjustable gain range: 0 to 200\%) |
|  | [11] | Analog common | Two common terminals for analog input and output signal terminals These terminals are electrically isolated from terminals [CM]s and [CMY]. |
|  | [FMP]* | Pulse monitor | You can select one of the following signal functions with function code F35. <br> - Output frequency <br> - Output current <br> - Output voltage <br> - Output torque . Load factor . Input power <br> - PID feedback value . DC link bus voltage . Universal AO <br> - Motor output • Analog output test • PID command <br> - PID output <br> * Input impedance of the external device: Min. $5 \mathrm{k} \Omega$ <br> * This output is capable of driving up to two meters with $10 \mathrm{k} \Omega$ impedance. (Driven by the average DC voltage of the output pulse train.) (Adjustable range of the gain: 0 to $200 \%$ ) |
|  | [CM] | Digital common | Two common terminals for digital input signal terminals and an output terminal [FMP] These terminals are electrically isolated from other common terminals, [11]s and [CMY]. These are the shared terminals with the common terminal [CM]s of the digital inputs. |

* The control PCB is equipped with either a screw terminal base or Europe type terminal block, supporting [FMP] or [FMI], respectively. Note that terminals [FMP] and [FMI] cannot coexist in an inverter so that the function code, F35 shares the identical function selection for these terminals.


Figure 2.24 Connecting PLC to Control Circuit

|  | Symbol | Name | Functions |
| :---: | :---: | :---: | :---: |
| $\begin{aligned} & \stackrel{\rightharpoonup}{3} \\ & \text { 를 } \\ & \stackrel{\rightharpoonup}{0} \end{aligned}$ | [Y5A/C] | General purpose relay output | (1) A general-purpose relay contact output usable as well as the function of the transistor output terminal [Y1], [Y2] or [Y3]. <br> Contact rating: 250 VAC $0.3 \mathrm{~A}, \cos \phi=0.3,48 \mathrm{VDC}, 0.5 \mathrm{~A}$ <br> (2) Switching of the normal/negative logic output is applicable to the following two contact output modes: "Active ON" (Terminals [Y5A] and [Y5C] are closed (excited) if the signal is active.) and "Active OFF" (Terminals [Y5A] and [Y5C] are opened (non-excited) if the signal is active while they are normally closed.). |
|  | [30A/B/C] | Alarm relay output (for any error) | (1) Outputs a contact signal (SPDT) when a protective function has been activated to stop the motor. <br> Contact rating: 250 VAC, $0.3 \mathrm{~A}, \cos \phi=0.3$, 48 VDC, 0.5 A <br> (2) Any one of output signals assigned to terminals [Y1] to [Y3] can also be assigned to this relay contact to use it for signal output. <br> (3) Switching of the normal/negative logic output is applicable to the following two contact output modes: "Terminals [30A] and [30C] are closed (excited) for ON signal output (Active ON)" or "Terminals [30B] and [30C] are closed (non-excited) for ON signal output (Active OFF)." |
|  | RJ-45 connector for the keypad | Standard RJ-45 connector | (1) Used to connect the inverter with PC or PLC using RS485 port. The inverter supplies the power to the keypad through the pins specified below. The extension cable for remote operation also uses wires connected to these pins for supplying the keypad power. <br> (2) Remove the keypad from the standard RJ-45 connector, and connect the RS485 communications cable to control the inverter through the PC or PLC (Programmable Logic Controller). Refer to Section 2.3.8 "Setting up slide switches and handling control circuit terminal symbol plate" for setting of the terminating resistor. |

Figure 2.25 RJ-45 Connector and its Pin Assignment*

* Pins 1, 2, 7, and 8 are exclusively assigned to power lines for the keypad, so do not use those pins for any other equipment.
- For models of FRN132F1S-4 $\square$ to FRN220F1S-4 ${ }^{*}$
* $A$ box ( $\square$ ) replaces $A, K$, or $E$ depending on the shipping destination.
(1. Route the control circuit cable in keeping with the left side panel of the inverter as shown in Figure 2.26.
(2. Fasten the control circuit cable to the cable tie support with a cable tie (insulation lock) as shown in Figure 2.26.

The hole in the cable tie support is $3.8 \mathrm{~mm} \times 1.5 \mathrm{~mm}$ in size. To pass the cable tie through the hole, it should be 3.8 mm or less in width and 1.5 mm or less in thickness.


Figure 2.26 Routing and Fastening the Control Circuit Cable

[^49]- Fix the control circuit wires inside the inverter to keep them away from the live parts of the main circuit (such as the terminal block of the main circuit).


### 2.3.8 Setting up slide switches and handling control circuit terminal symbol plate

## $\triangle$ WARNING

Before changing the switches or touching the control circuit terminal symbol plate, turn OFF the power and wait more than five minutes for models of 30 kW or below, or ten minutes for models of 37 kW or above. Make sure that the LED monitor and charging lamp (on models of 37 kW or above) are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC link bus voltage between the terminals $P$ $(+)$ and $\mathrm{N}(-)$ has dropped below the safe voltage (+25 VDC).
An electric shock may result if this warning is not heeded as there may be some residual electric charge in the DC bus capacitor even after the power has been turned off.

- Setting up the slide switches

Switching the slide switches located on the control PCB allows you to customize the operation mode of the analog output terminals, digital I/O terminals, and communications ports. The locations of those switches are shown in Figure 2.29.

To access the slide switches, remove the front and terminal block covers so that you can watch the control PCB. For models of 37 kW or above, open also the keypad enclosure.
For a screw terminal base, close the control circuit terminal symbol plate since the plate being opened interferes with switching of some switches. See Figures 2.27 and 2.28.
[a] For details on how to remove the front cover, terminal block cover, and keypad enclosure, refer to Section 2.3.1, "Removing and mounting the terminal block (TB) cover and the front cover" and Chapter 1, Section 1.2, "External View and Terminal Blocks," Figure 1.4.

Table 2.12 lists function of each slide switch.
Table 2.12 Function of Each Slide Switch

| Switch | Function |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| (1) SW1 | Switches the service mode of the digital input terminals between SINK and SOURCE. <br> - To make the digital input terminal [X1] to [X5], [FWD] or [REV] serve as a current sink, turn SW1 to the SINK position. <br> - To make them serve as a current source, turn SW1 to the SOURCE position. |  |  |  |
|  |  | Asia | Taiwan/Korea | EU |
|  | Factory default | SINK | SINK | SOURCE |
| (2. SW3 | Switches the terminating resistor of RS485 communications port on the inverter on and off. <br> - To connect a keypad to the inverter, turn SW3 to OFF. (Factory default) <br> - If the inverter is connected to the RS485 communications network as a terminating device, turn SW3 to ON. |  |  |  |
| (3. SW4 | Switches the output mode of the analog output terminal [FMA] between voltage and current. When changing this switch setting, also change the data of function code F29. |  |  |  |
|  |  |  | sw4 | Set data of F29 to: |
|  | Voltage output (F | default) | vo | 0 |
|  | Current output |  | 10 | 1 |
| (4.) SW5 | Switches property of the analog input terminal [V2] for V2 or PTC. When changing this switch setting, also change the data of function code H26. |  |  |  |
|  |  |  | SW5 | Set data of H26 to: |
|  | Analog frequenc voltage <br> (Factory default) | nand in | V2 | 0 |
|  | PTC thermistor in |  | PTC | 1 or 2 |
| Q-Pulse Id TMS1380 | Actixese $04 / 08 / 2015$ |  |  | Page 1206 of 20 |

The symbolic names of the control circuit terminals are marked on the control circuit terminal symbol plate provided on the top of the terminal block. The plate can be opened or closed as necessary. Follow the procedures illustrated below to open or close the plate.

- Opening the plate


Figure 2.27 Opening the Control Circuit Terminal Symbol Plate

- Closing the plate


Figure 2.28 Closing the Control Circuit Terminal Symbol Plate

Figure 2.29 shows the location of slide switches for the input/output terminal configuration.

Switching example
SW1

| SINK | SOURCE |
| :---: | :---: |
|  |  |

SW3


Figure 2.29 Location of the Slide Switches

### 2.4 Mounting and Connecting a Keypad

### 2.4.1 Mounting style and parts needed for connection

(1) Mounting style

You can mount a keypad in any style described below.

- Mounting a keypad on the enclosure wall (Refer to Figure 2.30.)
- Installing a keypad at a remote site (e.g. for operation on hand) (Refer to Figure 2.31.)


Figure 2.30 Mounting Keypad on the Enclosure Wall


Figure 2.31 Installing Keypad at a Remote Site (e.g. for Operation on Hand)

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(2) Parts needed for connection

To mount/install a keypad on a place other than an inverter, parts listed below are needed.

| Parts name |  | Model |
| :--- | :--- | :--- |
| Extension cable (Note 1) | CB-5S, CB-3S and CB-1S | Remarks |
| Fastening screw | M3 $\times \square \quad$ (Note 2) | Two screws needed. Purchase off-the-shelf ones <br> separately. |

(Note 1) When using an off-the-shelf LAN cable, use a 10BASE-T/100BASE-TX straight type cable compliant to US ANSI TIA/EIA-568A Category 5. (Less than 20m)
Recommended LAN cable
Manufacturer: SANWA Supply Co., LTD.
Model: KB-10T5-01K (1m)
KB-STP-01K: (1m) (Shielded LAN cable compliant to EMC Directive)
(Note 2) When mounting on an enclosure wall, use the screws fitted to the thickness of the wall. (Refer to Figure 2.34.)

### 2.4.2 Mounting/installing steps

## - Mounting a keypad on the enclosure wall

(1. Pull the keypad toward you while holding down the hook (pointed to by the arrow in Figure 2.32)


Figure 2.32 Removing a Keypad
(2. Separate the keypad from the dummy cover by sliding them in the arrowed directions as shown in Figure 2.33 below.


Figure 2.33 Separation of the Dummy Cover
(3. Make a cut-out on the enclosure wall. For details, refer to Chapter 8, Section 8.5.3 "Keypad."
(4) To mount the keypad on the enclosure wall, fix it firmly using a pair of M3 screws put through the taps shown below. (Figure 2.34.)
(Tightening torque: $0.7 \mathrm{~N} \cdot \mathrm{~m}$ )


Figure 2.34 Mounting a Keypad on the Enclosure Wall
5. Connect an extension cable (CB-5S, CB-3S or CB-1S) or off-the-shelf straight LAN cable to RJ-45 connectors (Modular jacks) on the keypad and inverter (standard RS485 port.) (Refer to Figure 2.35)


Figure 2.35 Connecting a Keypad and an Inverter's Standard RS485 port

- Installing a keypad at a remote site (e.g. for operation on hand

Follow the step (5) in $\square$ Mounting it on the enclosure wall.

## - Retracting the keypad into the inverter

Put the keypad in the original slot while engaging its bottom latches with the holes (as shown below), and push it onto the case of the inverter (arrow (2) while holding it downward (against the terminal block cover) (arrow (1).


Figure 2.36 Retracting the Keypad

### 2.5 Cautions Relating to Harmonic Component, Noise, and Leakage Current

## (1) Harmonic component

Input current to an inverter includes a harmonic component, which may affect other loads and power factor correcting capacitors that are connected to the same power source as the inverter. If the harmonic component causes any problems, connect a DC reactor (option) to the inverter. It may also be necessary to connect an AC reactor to the power factor correcting capacitors.

## (2) Noise

If noise generated from the inverter affects other devices, or that generated from peripheral equipment causes the inverter to malfunction, follow the basic measures outlined below.

1) If noise generated from the inverter affects the other devices through power wires or grounding wires:

- Isolate the grounded metal frames of the inverter from those of the other devices.
- Connect a noise filter to the inverter power wires.
- Isolate the power system of the other devises from that of the inverter with an insulated transformer.

2) If induction or radio noise generated from the inverter affects other devices through power wires or grounding wires:

- Isolate the main circuit wires from the control circuit wires and other device wires.
- Put the main circuit wires through a metal conduit and connect the pipe to the ground near the inverter.
- Install the inverter onto the metal switchboard and connect the whole board to the ground.
- Connect a noise filter to the inverter power wires.

3) When implementing measures against noise generated from peripheral equipment:

- For the control signal wires, use twisted or shielded-twisted wires. When using shielded-twisted wires, connect the shield of the shielded wires to the common terminals of the control circuit or ground.
- Connect a surge absorber in parallel with a coil or solenoid of the magnetic contactor.


## (3) Leakage current

Harmonic component current generated by insulated gate bipolar transistors (IGBTs) switching on/off inside the inverter becomes leakage current through stray capacitors of inverter input and output wires or a motor. If any of the problems listed below occur, take an appropriate measure against them.

Table 2.13 Leakage Current Countermeasures

| Problem | Measures |
| :--- | :--- |
| An earth leakage circuit 1) Decrease the carrier frequency. <br> breaker* that is connected to  <br> the input (primary) has tripped.  <br> * With overcurrent protection 2) Make the wires between the inverter and motor shorter. <br>  3) Use an earth leakage circuit breaker that has a longer sensitive current than <br> one currently being used. <br> Use an earth leakage circuit breaker that features measures against <br> harmonic component (Fuji SG and EG series).  |  |
| An external thermal relay was  <br> activated. 1) Decrease the carrier frequency. <br> 2) Increase the settling current of the thermal relay. <br>  3) Use the electronic thermal relay built in the inverter, instead of an external <br> thermal relay. |  |

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### 3.1 LED Monitor, Keys and LED Indicators on the Keypad

As shown at the right, the keypad consists of a four-digit LED monitor, six keys, and five LED indicators.

The keypad allows you to run and stop the motor, monitor running status, and switch to the menu mode. In the menu mode, you can set the function code data, monitor I/O signal states, maintenance information, and alarm information.


Table 3.1 Overview of Keypad Functions

| Item | LED Monitor, Keys, and LED Indicators | Functions |
| :---: | :---: | :---: |
| LED <br> Monitor | $56 \pi 6$ | Four-digit, 7-segment LED monitor which displays the following according to the operation modes. <br> - In Running mode: Running status information (e.g., output frequency, current, and voltage) <br> - In Programming mode: Menus, function codes and their data <br> - In Alarm mode: Alarm code, which identifies the error factor if the protective function is activated. |
| Operation Keys | (3ive | Program/Reset key which switches the operation modes of the inverter. <br> ■ In Running mode: Pressing this key switches the inverter to Programming mode. <br> ■ In Programming mode: Pressing this key switches the inverter to Running mode. <br> - In Alarm mode: Pressing this key after removing the error factor will switch the inverter to Running mode. |
|  | $x$ | Function/Data key which switches the operation you want to do in each mode as follows: <br> ■ In Running mode: Pressing this key switches the information to be displayed concerning the status of the inverter (output frequency $(\mathrm{Hz})$, output current $(\mathrm{A})$, output voltage $(\mathrm{V})$, etc.). <br> - In Programming mode: Pressing this key displays the function code and sets the data entered with the $\square$ key. <br> - In Alarm mode: <br> Pressing this key displays the details of the problem indicated by the alarm code that has come up on the LED monitor. |
|  | nue | RUN key. Press this key to run the motor. |
|  | nof | STOP key. Press this key to stop the motor. |
|  | $\cdots$ | UP and DOWN keys. Press these keys to select the setting items and change the function code data displayed on the LED monitor. |
| LED Indicators | RUN LED | Lights when any run command to the inverter is active. |
|  | KEYPAD <br> CONTROL LED | Lights when the inverter is ready to run with a run command entered by the key. In Programming and Alarm modes, you cannot run the inverter even if the indicator lights. |
|  | Unit and mode expression by the three LED indicators | The lower 3 LED indicators identify the unit of numeral displayed on the LED monitor in Running mode by combination of lit and unlit states of them. <br> Unit: $\mathrm{kW}, \mathrm{A}, \mathrm{Hz}, \mathrm{r} / \mathrm{min}$ and $\mathrm{m} / \mathrm{min}$ <br> Refer to Chapter 3, Section 3.3.1 "Monitoring the running status" for details. |
|  |  | While the inverter is in Programming mode, the LEDs at both ends of the lower indicators light. <br> In Programming mode: $\quad$ Hz $\square$ A $\quad$ kW |

## Simultaneous keying

Simultaneous keying means pressing two keys at the same time. The FRENIC-Eco supports simultaneous keying as listed below. The simultaneous keying operation is expressed by a " + " letter between the keys throughout this manual.
(For example, the expression "
Table 3.2 Simultaneous Keying

| Operation mode | Simultaneous keying | Used to: |
| :--- | :--- | :--- |
| Programming <br> mode | Change certain function code data. <br> (Refer to codes F00, H03, and H97 in Chapter 5 "FUNCTION <br> CODES.") |  |
| Alarm mode | Switch to Programming mode without resetting alarms currently <br> occurred. |  |

### 3.2 Overview of Operation Modes

FRENIC-Eco features the following three operation modes:
■ Running mode : This mode allows you to enter run/stop commands in regular operation. You can also monitor the running status in real time.

- Programming mode: This mode allows you to set function code data and check a variety of information relating to the inverter status and maintenance.
- Alarm mode : If an alarm condition arises, the inverter automatically enters the Alarm mode. In this mode, you can view the corresponding alarm code* and its related information on the LED monitor.
*Alarm code: Indicates the cause of the alarm condition that has triggered a protective function. For details, refer to Chapter 8, Section 8.6 "Protective Functions."
Figure 3.1 shows the status transition of the inverter between these three operation modes.


Figure 3.1 Status Transition between Operation Modes
Figure 3.2 illustrates the transition of the LED monitor screen during Running mode, the transition between menu items in Programming mode, and the transition between alarm codes at different occurrences in Alarm mode.

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(*1) In speed monitor, you can have any of the following displayed according to the setting of function code E48: Output frequency (Hz), Motor speed (r/min), Load shaft speed ( $\mathrm{r} / \mathrm{min}$ ), and Speed (\%).
(*2) Applicable only when PID control is active. (J01 = 1 or 2 )
(*3) Applicable only when the analog signal input monitor is assigned to any terminals [12], [C1], or [V2] by E61, E62 or E63 (= 20).
(*4) Applicable only when the full-menu mode is active. (E52 = 2)
Figure 3.2 Transition between Basic Display Frames by Operation Mode

## 3．3 Running Mode

When the inverter is turned on，it automatically enters Running mode．In this mode，you can：
（1）Monitor the running status（e．g．，output frequency，output current），
（2）Set up the frequency command and others，and
（3）Run／stop the motor．

## 3．3．1 Monitoring the running status

In Running mode，the eleven items listed below can be monitored．Immediately after the inverter is turned on，the monitor item specified by function code E43 is displayed．Press the key to switch between monitor items．For details of switching the monitor item by using the key，refer to＂Monitoring of Running Status＂in Figure 3.2 Transition between Basic Display Frames by Operation Mode．

Table 3．3 Monitoring Items

| Monitor Items | Display Sample on the LED monitor＊1 | LED indicator <br> ■：on，ㅁ：off | Unit | Meaning of Displayed Value | Function Code E43 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Speed monitor | Function code E48 specifies what to be displayed on the LED monitor and LED indicators． |  |  |  | 0 |
| Output frequency | 5イレイル゙イ | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | Hz | Frequency actually being output | （E48＝0） |
| Motor speed | ハイル゙イ゙ | ■Hz ■A $\square \mathrm{kW}$ | r／min | Output frequency $\times \frac{120}{\mathrm{P} 01}$ | $(\mathrm{E} 48=3)$ |
| Load shaft speed | ジイ1110， | ■ Hz ■A $\square \mathrm{kW}$ | r／min | Output frequency（Hz）x E50 | （E48＝4） |
| Speed（\％） | 517， | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | \％ | $\frac{\text { Output frequency }}{\text { Maximum frequency }} \times 100$ | $(\mathrm{E} 48=7)$ |
| Output current | ハニ゙ゴイ゙ィ | $\square \mathrm{Hz} \mathrm{■A} \square \mathrm{~kW}$ | A | Current output from the inverter in RMS | 3 |
| Output voltage＊2 |  | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | V | Voltage output from the inverter in RMS | 4 |
| Calculated output torque | 51 | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | \％ | Motor output torque in \％（Calculated value） | 8 |
| Input power | バインニ゙イ | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{mW}$ | kW | Input power to the inverter | 9 |
| PID process command ${ }_{*} 3,{ }^{*} 4$ |  | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | － | PID process command／feedback value transformed to that of virtual physical value | 10 |
| PID feedback value *3, *5 | －1， $11 / 17$ | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | － | perature） <br> Refer to the function codes E40 and E41 for details． | 12 |
| PID output＊3，＊4 |  | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | \％ | PID output in \％as the maximum frequency （F03）being at 100\％ | 14 |
| Load factor＊6 | Sイル | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | \％ | Load factor of the motor in \％as the rated output being at $100 \%$ | 15 |
| Motor output＊7 | タイロ゙心 | $\square \mathrm{Hz} \square \mathrm{A}$ ■kW | kW | Motor output in kW | 16 |
| Analog input＊8 | ロイン， | $\square \mathrm{Hz} \square \mathrm{A} \square \mathrm{kW}$ | － | Analog input signal to the inverter，trans－ formed by E40 and E41 <br> Refer to the function codes E40 and E41 for details． | 17 |

＊1 A value exceeding 9999 cannot be displayed on the 4－digit LED monitor screen，so＂［ J］（7－segment letters）appear instead．
＊2 For displaying an output voltage on the LED monitor，the 7－segment letter $L^{\prime}$＇is used in the lowest digit as an alternative expression of the unit of the V （volt）．
＊3 These PID－related items appear only when the inverter PID－controls the motor according to a PID process command specified by the function code J 01 （＝ 1 or 2）．
＊4 When the LED monitor displays a PID process command or its output amount，the dot（decimal point）attached to the lowest digit of the 7 －segment letter blinks．
＊5 When the LED monitor displays a PID feedback value，the dot（decimal point）attached to the lowest digit of the 7－segment letter lights．
＊6 For displaying a load factor on the LED monitor，the 7 －segment letter $L$ is used in the lowest digit as an alternative expression of the unit of \％．
＊7 When the LED monitor displays the motor output，the unit LED indicator＂kW＂blinks．
＊8 Analog input monitoring becomes active only when any data of the function codes E61，E62 and E63 is effective（＝20） to define a terminal function．

### 3.3.2 Setting up frequency and PID process commands

You can set up the desired frequency and PID process commands by using the ब and keys on the keypad. It is also possible to set up the frequency command as load shaft speed, motor speed or speed (\%) by setting function code E48.

## - Setting up a frequency command

## Using the and keys (Factory default)

(1) Set function code F01 to "0: Enable ब / © keys on keypad." This can be done only when the inverter is in Running mode.
(2) Press the ( / key to display the current reference frequency. The lowest digit will blink.
(3) If you need to change the frequency command, press the © / key again. The new setting will be automatically saved into the inverter's internal memory and retained even when the power is off. When the power is turned on next time, the setting will be used as an initial reference frequency.

Tip - The frequency command can be saved either automatically as mentioned above or by pressing the ( key. You can choose either way using function code E64.

- If you have set function code F01 to "0: Enable © / 『keys on keypad" but have selected a frequency command other than frequency command 1 (i.e., frequency command 2 , frequency command via communication, or multistep frequency command), then the ब / keys are disabled to change the current frequency command even in Running mode. Pressing either of these keys just displays the current reference frequency.
- When you start specifying or changing the frequency command or any other parameter with the ब/ Q key, the lowest digit on the display blinks and starts changing. As you are holding down the key, blinking will gradually move to the upper digit places and the upper digits will be changeable.
- If you press the ब / 『key once and then hold down the key for more than 1 second after the lowest digit starts blinking, blinking will move to the next upper digit place to allow you to change the value of that digit (cursor movement). This way you can easily change the values of the higher digits.
- By setting function code C 30 to "0: Enable ब / $\quad$ keys on keypad" and selecting frequency command 2 , you can also specify or change the frequency command in the same manner using the ${ }^{\text {/// }}$ $\otimes$ key.

You can set up a frequency command not only with the frequency ( Hz ) but also with other menu items (Motor speed, load shaft speed, and speed (\%)) depending on the setting of function code E48 (=3, 4, or 7) "Speed monitor items" as shown in Table 3.3.

■ Make setting under PID control
To enable PID control, you need to set function code J01 to 1 or 2.
Under the PID control, the items that can be set or checked with the ब and $\triangle$ keys are different from those under regular frequency control, depending upon the current LED monitor setting. If the LED monitor is set to the speed monitor ( $\mathrm{E} 43=0$ ), you can access manual speed commands (Frequency command) with the $\widehat{\sigma}$ and $\Omega$ keys; if it is set to any other, you can access the PID process command with those keys.
[1] Refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4, Section 4.9, "PID Frequency Command Generator" for details on the PID control.

## Setting the PID process command with the and ${ }^{\text {and }}$

(1) Set function code J02 to "0: Enable © / 『 keys on keypad."
(2) Set the LED monitor to something other than the speed monitor (E43 = 0) when the inverter is in Running mode. When the keypad is in Programming or Alarm mode, you cannot modify the PID process command with the © / key. To enable the PID process command to be modified with the © / 『key, first switch to Running mode.
(3) Press the © / key to have the PID process command displayed. The lowest digit will blink on the LED monitor.
(4) To change the PID process command, press the ब/ key again. The PID process command you have specified will be automatically saved into the inverter's internal memory. It is kept there even if you temporarily switch to another means of specifying the PID process command and then go back to the means of specifying the PID process command via the keypad. Also, it is kept there even while the inverter is powered off, and will be used as the initial PID process command next time the inverter is powered on.

Tip - Even if multistep frequency is selected as the PID process command ((SS4) $=\mathrm{ON})$, you still can set the process command using the keypad.

- When function code J02 is set to any value other than 0 , pressing the ब / key displays, on the 7 -segment LED monitor, the PID command currently selected, while you cannot change the setting.
- On the 7 -segment LED monitor, the decimal point of the lowest digit is used to characterize what is displayed. The decimal point of the lowest digit blinks when a PID process command is displayed; the decimal point lights when a PID feedback value is displayed.


Table 3.4 PID Process Command Manually Set with the / Key and Requirements

| PID Control (Selection) J01 | PID Control (Remote Process Command) J02 | LED Monitor E43 | Multistep <br> Frequency <br> (SS4) | With the ©/® key |
| :---: | :---: | :---: | :---: | :---: |
| 1 or 2 | 0 | Other than 0 | ON or OFF | PID process command by keypad |
|  | Other than 0 |  |  | PID process command currently selected |

## Setting up the frequency command with the and ${ }^{\top}$ keys under PID control

When function code F01 is set to "0: Enable ब"/ keys on keypad" and frequency command 1 is selected as a manual speed command (that is, disabling the frequency setting command via communications link and multistep frequency command), switching the LED monitor to the speed monitor in Running mode enables you to modify the frequency command with the ब / ® keys.
In Programming or Alarm mode, the ब/ / keys are disabled to modify the frequency command. You need to switch to Running mode.
Table 3.5 lists the combinations of the commands and the figure illustrates how the manual speed command (1) entered via the keypad is translated to the final frequency command (2).
The setting procedure is the same as that for setting of a usual frequency command.
Table 3.5 Manual Speed (Frequency) Command Set with the $/ \triangle$ Keys and Requirements

| PID Control (Selection) J01 | LED <br> Monitor E43 | Frequency Command 1 F01 | Multistep <br> Frequency (SS2) | Multistep <br> Frequency (SS1) | Link Operation Selection (LE) | Disable PID <br> Control <br> (Hz/PID) | Pressing the keys controls: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 or 2 | 0 | 0 | OFF | OFF | OFF | OFF <br> (PID enabled) | PID output (as final frequency command) |
|  |  |  |  |  |  | ON <br> (PID disabled) | Manual speed (frequency) command set by keypad |
|  |  | Other than the above |  |  |  | OFF <br> (PID enabled) | PID output (as final frequency command) |
|  |  |  |  |  |  | ON <br> (PID disabled) | Manual speed (frequency) command currently selected |



### 3.3.3 Running/stopping the motor

By factory default, pressing the eigey starts running the motor in the forward direction and pressing the key decelerates the motor to stop. The key is enabled only in Running mode.
The motor rotational direction can be selected by changing the setting of function code F02.


## ■ Operational relationship between function code F02 (Run command) and (og) key

Table 3.6 lists the relationship between function code F02 settings and the wey, which determines the motor rotational direction.

Table 3.6 Motor Rotational Direction Specified by F02

| Data for F02 | Pressing the Fei key runs the motor: |
| :---: | :--- |
| 0 | In the direction commanded by the terminal <br> [FWD] or [REV] |
| 1 | Fel key disabled <br> (The motor is driven by terminal command <br> [FWD] or [REV].) |
| 2 | In the forward direction |
| 3 | In the reverse direction |


(Note) The rotational direction of IEC-compliant motors is opposite to that of the motor shown here.

For the details on operations with function code F02, refer to Chapter 5 "FUNCTION CODES."
Note When the keypad is in use for specifying the frequency settings or driving the motor, do not disconnect the keypad from the inverter when the motor is running. Doing so may stop the inverter.

## $\square$ Remote and local modes

The inverter can be operated either in remote or local mode. In remote mode that applies to ordinary operation, the inverter is driven under the control of the data settings stored in the inverter, whereas in local mode that applies to maintenance operation, it is separated from the control system and is driven manually under the control of the keypad.

- Remote mode: The run and frequency commands are selected by source switching signals including function codes, run command $2 / 1$ signals,, and communications link operation signal.
- Local mode: The command source is the keypad, regardless of the settings specified by function codes. The keypad takes precedence over the settings specified by run command $2 / 1$ signals or communications link operation signal.


## Run commands from the keypad in local mode

The table below shows the input procedures of run commands from the keypad in local mode.
Table 3.7 Run Commands from the Keypad in Local Mode

| When Data for Fo2 <br> (Run command) is : | Input Procedures of Run Commands from Keypad |
| :--- | :--- |

## Switching between remote and local modes

The remote and local modes can be switched by a digital input signal provided from the outside of the inverter.
To enable the switching, you need to assign (LOC) as a digital input signal to any of terminals [X1] to [X5] by setting " 35 " to any of E01 to E05, E98 and E99. By factory default, (LOC) is assigned to [X5].

Switching from remote to local mode automatically inherits the frequency settings used in remote mode. If the motor is running at the time of the switching from remote to local, the run command is automatically turned on so that all the necessary data settings will be carried over. If, however, there is a discrepancy between the settings used in remote mode and ones made on the keypad (e.g., switching from the reverse rotation in remote mode to the forward rotation only in local mode), the inverter automatically stops.
The transition paths between remote and local modes depend on the current mode and the value (on/off) of (LOC), as shown in the status transition diagram given below. Also, refer to Table 3.7 " Run Commands from the Keypad in Local Mode" for details.

For further details on how to specify run and frequency commands in remote and local modes, refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4, Section 4.3, "Drive Command Generator."


Transition between Remote and Local Modes by (LOC)

### 3.4 Programming Mode

The Programming mode provides you with these functions--setting and checking function code data, monitoring maintenance information and checking input/output (I/O) signal status. The functions can be easily selected with the menu-driven system. Table 3.8 lists menus available in Programming mode. The leftmost digit (numerals) of each letter string on the LED monitor indicates the corresponding menu number and the remaining three digits indicate the menu contents.
When the inverter enters Programming mode from the second time on, the menu selected last in Programming mode will be displayed.

Table 3.8 Menus Available in Programming Mode

(Note) An o code appears only when any option is mounted on the inverter. For details, refer to the instruction manual of the corresponding option.

Figure 3.3 illustrates the menu-driven function code system in Programming mode.


Figure 3.3 Menu Transition in the Programming Mode

## Limiting menus to be displayed

The menu-driven system has a limiter function (specified by function code E52) that limits menus to be displayed for the purpose of simple operation. The factory default (E52 = 0) is to display only three menus--Menu \#0 "Quick Setup," Menu \#1 "Data Setting" and Menu \#7 "Data Copying," allowing no switching to any other menu.

Table 3.9 Keypad Display Mode Selection - Function Code E52

| Data for E52 | Mode | Menus selectable |
| :---: | :--- | :--- |
| 0 | Function code data editing mode <br> (factory default) | Menu \#0 "Quick Setup" <br> Menu \#1 "Data Setting" <br> Menu \#7 "Data Copying" |
| 1 | Function code data check mode | Menu \#2 "Data Checking" <br> Menu \#7 "Data Copying" |
| 2 | Full-menu mode | Menu \#0 through \#7 |

Tip Pressing the $\triangle$ key will cycle through the menu. With the key, you can select the desired menu item. Once the entire menu has been cycled through, the display will return to the first menu item.

### 3.4.1 Setting up basic function codes quickly - Menu \#0 "Quick Setup"

Menu \#0 "Quick Setup" in Programming mode allows you to quickly display and set up a basic set of function codes specified in Chapter 5, Section 5.1, "Function Code Tables."
To use Menu \#0 "Quick Setup," you need to set function code E52 to "0: Function code data editing mode" or "2: Full-menu mode."

The predefined set of function codes that are subject to quick setup are held in the inverter.
Listed below are the function codes (including those not subject to quick setup) available on the FRENIC-Eco. A function code is displayed on the LED monitor on the keypad in the following format:


Table 3.10 Function Codes Available on FRENIC-Eco

| Function Code Group | Function <br> Codes | Function | Description |
| :---: | :--- | :--- | :--- |
| F codes | F00 to F44 | Fundamental <br> functions | Functions concerning basic motor running |
| E codes | E01 to E99 | Extension <br> terminal func- <br> tions | Functions concerning the assignment of <br> control circuit terminals <br> Functions concerning the display of the LED <br> monitor |
| C codes | C01 to C53 | Control func- <br> tions of fre- <br> quency | Functions associated with frequency set- <br> tings |
| P codes | P01 to P99 | Motor <br> parameters | Functions for setting up characteristics pa- <br> rameters (such as capacity) of the motor |
| H codes | H03 to H98 | High perform- <br> ance functions | Highly added-value functions <br> Functions for sophisticated control |
| J codes | J01 to J22 | Application <br> functions | Functions for applications such as PID <br> Control |
| y codes | y01 to y99 | Link <br> functions | Functions for controlling communication |
| o codes | o27 to o59 | Optional <br> functions | Functions for options (Note) |

(Note) The o codes are displayed only when the corresponding option is mounted.
For details of the o codes, refer to the Instruction Manual for the corresponding option.
(1] For the list of function codes subject to quick setup and their descriptions, refer to Chapter 5, Section 5.1 "Function Code Tables."

## - Function codes requiring simultaneous keying

To modify the data for function code F00 (Data protection), H03 (Data initialization), or H97 (Clear alarm data), simultaneous keying is needed, involving the

## - Changing, validating, and saving function code data when the inverter is running

Some function code data can be changed while the inverter is running, whereas others cannot. Further, depending on the function code, modifications may or may not validate immediately. For details, refer to the "Change when running" column in Chapter 5, Section 5.1 " Function Code Tables."
(LD) For details of function codes, refer to Chapter 5, Section 5.1" Function Code Tables."

Figure 3.4 shows the menu transition in Menu \#1 "Quick Setup."


Figure 3.4 Menu Transition in Menu \#0 "Quick Setup"

Tip Through a multi-function keypad, you can add or delete function codes that are subject to Quick Setup. For details, refer to the "Multi-function Keypad Instruction Manual" (INR-SI47-0890-E).

Once you have added or deleted function codes for Quick Setup through a multi-function keypad, they will remain valid even after you switch to a standard keypad. To restore the function code settings subject to Quick Setup to their factory defaults, initialize the whole data using function code H 03 (data = 1).

## Basic key operation

This section gives a description of the basic key operation, following the example of the function code data changing procedure shown in Figure 3.5.
This example shows you how to change function code F01 data from the factory default "0: Enable ब/ / keys on keypad" to "2: Enable current input to terminal [C1] (4 to 20 mA DC )."
(1) Turn the inverter on. It automatically enters Running mode. In that mode, press the key to switch to Programming mode. The function selection menu appears. (In this example, $17.1, I_{1 / 2}$ is displayed.)
(2) If anything other than
(3) Press the key to proceed to a list of function codes.
(4) Use the © and $\triangle$ keys to display the desired function code ( $1 / 7 \prime$ in this example), then press the 原 key. The data of this function code appears. (In this example, data $\overline{\prime \prime}$ of, $\bar{\prime} /$ appears.)
(5) Change the function code data using the ब and ( keys. (In this example, press the ब key two times to change data $\frac{17}{17}$ to $\zeta_{\text {? }}^{7}$.)
(6) Press the key to establish the function code data. The function code list, then move to the next function code. (In this example, 1 ,
Pressing the key instead of the key cancels the change made to the data. The data reverts to the previous value, the display returns to the function code list, and the original function code reappears.
(7) Press the key to return to the menu from the function code list.

## Tip Cursor movement

You can move the cursor when changing function code data by holding down the key for 1 second or longer in the same way as with the frequency settings. This action is called "Cursor movement."


Figure 3.5 Example of Function Code Data Changing Procedure

### 3.4.2 Setting up function codes - Menu \#1 "Data Setting"

Menu \#1 "Data Setting" in Programming mode allows you to set up function codes for making the inverter functions match your needs.
To set function codes in this menu, it is necessary to set function code E52 to " 0 : Function code data editing mode" or "2: Full-menu mode."

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O Figure 3.6 shows the menu transition in Menu \#1 "Data Setting."


Figure 3.6 Menu Transition in Menu \#1 "Data Setting"

## Basic key operation

For details of the basic key operation, refer to Menu \#0 "Quick Setup" in Section 3.4.1.

### 3.4.3 Checking changed function codes - Menu \#2 "Data Checking"

Menu \#2 "Data Checking" in Programming mode allows you to check function codes that have been changed. Only the function codes whose data has been changed from the factory defaults are displayed on the LED monitor. You can refer to the function code data and change it again if necessary. Figure 3.7 shows the menu transition in Menu \#2 "Data Checking."


Figure 3.7 Menu Transition in Menu \#2 "Data Checking" (Changing F01, F05 and E52 data only)

## Basic key operation

For details of the basic key operation, refer to Menu \#1 "Quick Setup" in Section 3.4.1.
Tip To check function codes in Menu \#2 "Data Checking," it is necessary to set function code E52 to "1: Function code data check mode" or "2: Full-menu mode."

For details, refer to "旦 Limiting menus to be displayed" on page 3-11.

### 3.4.4 Monitoring the running status - Menu \#3 "Drive Monitoring"

Menu \#3 "Drive Monitoring" is used to monitor the running status during maintenance and trial running. The display items for "Drive Monitoring" are listed in Table 3.11. Figure 3.8 shows the menu transition in Menu \#3 "Drive Monitoring."


Figure 3.8 Menu Transition in Menu \#3 "Drive Monitoring"

## Basic key operation

To monitor the running status on the drive monitor, set function code E52 to "2: Full-menu mode" beforehand.
(1) Turn the inverter on. It automatically enters Running mode. In that mode, press the key to switch to Programming mode. The function selection menu appears.

(3) Press the key to proceed to a list of monitoring items (e.g.
(4) Use the © and $\boxtimes$ keys to display the desired monitoring item, then press the key. The running status information for the selected item appears.
(5) Press the key to return to a list of monitoring items. Press the key again to return to the menu.

Table 3.11 Drive Monitor Display Items

| LED <br> monitor <br> shows: | Item | Unit |  |
| :--- | :--- | :--- | :--- |
| Ont | Description |  |  |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI

## - Displaying running status

To display the running status in hexadecimal format, each state has been assigned to bits 0 to 15 as listed in Table 3.12. Table 3.13 shows the relationship between each of the status assignments and the LED monitor display. Table 3.14 gives the conversion table from 4-bit binary to hexadecimal.

Table 3.12 Running Status Bit Assignment

| Bit | Notation | Content | Bit | Notation | Content |
| :---: | :--- | :--- | :--- | :--- | :--- |
| 15 | BUSY | 1 when function code data is being writ- <br> ten. | 7 | VL | 1 under voltage limiting control. |
| 14 | 13 | WR | Always 0. | 6 | TL |
|  |  | 5 | NUV | 1 when the DC link bus voltage is higher <br> than the undervoltage level. |  |
| 12 | RL | 1 when communication is enabled (when <br> ready for run and frequency commands <br> via communications link). | 4 | BRK | 1 during braking |
| 11 | ALM | 1 when an alarm has occurred. | 3 | INT | 1 when the inverter output is shut down. |
| 10 | DEC | 1 during deceleration. | 2 | EXT | 1 during DC braking. |
| 9 | ACC | 1 during acceleration. | 1 | REV | 1 during running in the reverse direction. |
| 8 | IL | 1 under current limiting control. | 0 | FWD | 1 during running in the forward direction. |

Table 3.13 Running Status Display

|  | ED No. | LED4 |  |  |  | LED3 |  |  |  | LED2 |  |  |  | LED1 |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Bit |  | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|  | tation | BUSY | WR |  | RL | ALM | DEC | ACC | IL | VL | TL | NUV | BRK | INT | EXT | REV | FWD |
|  | Binary | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
|  | Hexadecimal on the LED monitor |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

## - Hexadecimal expression

A 4-bit binary number can be expressed in hexadecimal format (1 hexadecimal digit). Table 3.14 shows the correspondence between the two notations. The hexadecimals are shown as they appear on the LED monitor.

Table 3.14 Binary and Hexadecimal Conversion

| Binary |  |  |  | Hexadecimal | Binary |  |  |  | Hexadecimal |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | 0 | 0 | 0 | \% 7 | 1 | 0 | 0 | 0 | 名 |
| 0 | 0 | 0 | 1 | ' | 1 | 0 | 0 | 1 | 9 |
| 0 | 0 | 1 | 0 | $\stackrel{\square}{\square}$ | 1 | 0 | 1 | 0 | 9 |
| 0 | 0 | 1 | 1 | 7 | 1 | 0 | 1 | 1 | L |
| 0 | 1 | 0 | 0 | 4 | 1 | 1 | 0 | 0 | $L^{-}$ |
| 0 | 1 | 0 | 1 | 5 | 1 | 1 | 0 | 1 | $\square$ |
| 0 | 1 | 1 | 0 | E | 1 | 1 | 1 | 0 | E |
| 0 | 1 | 1 | 1 | 7 | 1 | 1 | 1 | 1 | $\stackrel{\square}{\square}$ |

### 3.4.5 Checking I/O signal status - Menu \#4 "I/O Checking"

Using Menu \#4 "I/O Checking" displays the I/O status of external signals including digital and analog I/O signals without using a measuring instrument. Table 3.15 lists check items available. The menu transition in Menu \#4 "I/O Checking" is shown in Figure 3.9.


Figure 3.9 Menu Transition in Menu \#4 "I/O Checking"

## Basic key operation

To check the status of the I／O signals，set function code E52 to＂ 2 ：Full－menu mode＂beforehand．
（1）Turn the inverter on．It automatically enters Running mode．In that mode，press the key to switch to Programming mode．The function selection menu appears．


（4）Use the $\triangle$ and $\boxtimes$ keys to display the desired I／O check item，then press the key．
 the display method between the segment display（for external signal information in Table 3．16）and hexa－ decimal display（for I／O signal status in Table 3．17）．
（5）Press the key to return to a list of I／O check items．Press the key again to return to the menu．

Table 3.15 I／O Check Items

| LED monitor shows： | Item | Description |
| :---: | :---: | :---: |
| サーイ゙イ゙ | I／O signals on the control circuit terminals | Shows the ON／OFF state of the digital I／O terminals．Refer to ＂■ Displaying control I／O signal terminals＂on the next page for details． |
| ープ！ | I／O signals on the control circuit terminals under communication control | Shows the ON／OFF state for the digital I／O terminals that received a command via RS485 and optional communications．Refer to ＂Displaying control I／O signal terminals＂and＂■ Displaying control I／O signal terminals under communications control＂on the following pages for details． |
| サーイ゙1゙ | Input voltage on terminal［12］ | Shows the input voltage on terminal［12］in volts（V）． |
| ケーイジ | Input current on terminal［C1］ | Shows the input current on terminal［C1］in milliamperes（mA）． |
| ゲイヅす | Output voltage to analog meters［FMA］ | Shows the output voltage on terminal［FMA］in volts（V）． |
| サーイ゙ー＊ | Output voltage to digital me－ ters［FMP］ | Shows the output voltage on terminal［FMP］in volts（V）． |
| サーイ゙イフ＊ | Pulse rate of［FMP］ | Shows the output pulse rate on terminal［FMP］in p／s（pulses per second）． |
| サイプフ | Input voltage on terminal［V2］ | Shows the input voltage on terminal［V2］in volts（V）． |
| ケインバイ | Output current to analog meters［FMA］ | Shows the output current on terminal［FMA］in mA． |
| サーイブプ＊ | Output current to analog meters［FMI］ | Shows the output current on terminal［FMI］in mA． |

＊The inverter has either［FMP］or［FMI］depending on the type of the control printed circuit board（control PCB）．



## ■ Displaying control I/O signal terminals

The status of control I/O signal terminal may be displayed with ON/OFF of the LED segment or in hexadecimal display.

## - Display I/O signal status with ON/OFF of each LED segment

As shown in Table 3.16 and the figure below, each of segments " $a$ " to " $g$ " on LED1 lights when the corresponding digital input terminal circuit ([FWD], [REV], [X1], [X2], [X3], [X4] or [X5]) is closed; it goes off when it is open (*1). Segment "a to c" and "e" on LED3 lights when the circuit between output terminal [Y1], [Y2], or [Y3] and terminal [CMY], or [Y5A] and [Y5C] is closed, and does not light when the circuit is open. Segment "a" and "e to g" on LED4 is for terminals $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$, and terminals $[\mathrm{Y} 1 \mathrm{~A}],[\mathrm{Y} 2 \mathrm{~A}]$ and $[\mathrm{Y} 3 \mathrm{~A}]$ on the relay output option card. Segment "a" or "e to g " on LED4 lights when the circuit between terminals [30C] and [30A] or the relay terminal circuit of [Y1A], [Y2A] or $[Y 3 A]$ is short-circuited (ON) respectively and does not light when it is open.

Tip If all terminal input signals are OFF (open), segments " g " on all of LED1 to LED4 will blink ("----").

Table 3.16 Segment Display for External Signal Information

| LED4 LED3 LED2 LED1 | Segment | LED4 | LED3 | LED2 | LED1 |
| :---: | :---: | :---: | :---: | :---: | :---: |

-: No corresponding control circuit terminal exists.
(*1) For the open/close states of [FWD], [REV], [X1] through [X5] circuits, refer to the setting of the SINK/SOURCE slide switch in Chapter 2, Table 2.11 "Symbols, Names and Functions of the Control Circuit Terminals."
(*2) (XF), (XR), and (RST) are assigned for communication. Refer to "■ Displaying control I/O signal terminals under communications control" on the next page.

- Displaying I/O signal status in hexadecimal format

Each I/O terminal is assigned to bit 15 through bit 0 as shown in Table 3.17. An unassigned bit is interpreted as "0." Allocated bit data is displayed on the LED monitor in 4 hexadecimal digits ( $\square_{1}$ to $I^{-}$each).
With the FRENIC-Eco, digital input terminals [FWD] and [REV] are assigned to bit 0 and bit 1 , respectively. Terminals [X1] through [ X 5 ] are assigned to bits 2 through 6 . The bit is set to " 1 " when the corresponding input terminal is short-circuited $(\mathrm{ON})^{*}$, and is set to " 0 " when it is open (OFF). For example, when [FWD] and [X1] are on (short-circuited) and all the others are off (open),

* For the open/close states of [FWD], [REV], [X1] through [X5] circuits, refer to the setting of the SINK/SOURCE slide switch in Chapter 2, Table 2.11 "Symbols, Names and Functions of the Control Circuit Terminals."
Digital output terminal [Y1] to [Y3] are assigned to bits 0 to 2 . Each bit is set to "1" when the terminal is short-circuited with [CMY], and " 0 " when it is open. The status of the relay contact output [Y5A/C] is assigned to bit 4 and it is set to " 1 " when the circuit between [ Y 5 A ] and [ Y 5 C ] is closed.
The status of the relay contact output terminal $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ is assigned to bit 8 . It is set to " 1 " when the circuit between output terminals [30A] and [30C] is closed, and " 0 " when the circuit between [30B] and [30C] is closed.
The status of the relay contact output terminals $[\mathrm{Y} 1 \mathrm{~A}]$ to $[\mathrm{Y} 3 \mathrm{~A}]$ is assigned to bits 12 to 14 . Each bit is set to "1" when the terminal circuits of $[\mathrm{Y} 1 \mathrm{~A}]$ to $[\mathrm{Y} 1 \mathrm{C}]$ are closed, and " 0 " when they are open.
For example, if $[Y 1]$ is on, the circuit between $[\mathrm{Y} 5 \mathrm{~A}]$ and $[\mathrm{Y} 5 \mathrm{C}]$ is open, the circuit between $[30 \mathrm{~A}]$ and $[30 \mathrm{C}]$ is closed, and all $[\mathrm{Y} 1 \mathrm{~A}]$ to $[\mathrm{Y} 3 \mathrm{~A}]$ are open, then "
Table 3.17 presents an example of bit assignment and corresponding hexadecimal display on the 7 -segment LED.
Table 3.17 Segment Display for I/O Signal Status in Hexadecimal Format

- No corresponding control terminal exists.
* (XF), (XR), and (RST) are assigned for communication. Refer to " Displaying control I/O signal terminals under communications control" below.


## Displaying control I/O signal terminals under communications control

Under communications control, input commands (function code S06) sent via RS485 or other optional communications can be displayed in two ways: "with ON/OFF of each LED segment" and "in hexadecimal format." The content to be displayed is basically the same as that for the control I/O signal terminal status display; however, (XF), (XR), and (RST) are added as inputs. Note that under communications control, the I/O display is in normal logic (using the original signals not inverted).
(1) Refer to the RS485 Communication User's Manual (MEH448a) for details on input commands sent through RS485 communications and the instruction manual of communication-related options as well.

### 3.4.6 Reading maintenance information - Menu \#5 "Maintenance Information"

Menu \#5 "Maintenance Information" contains information necessary for performing maintenance on the inverter. Table 3.18 lists the maintenance information display items and Figure 3.10 shows the menu transition in Menu \#5 "Maintenance information."


Figure 3.10 Menu Transition in Menu \#5 "Maintenance Information"

## Basic key operation

To view the maintenance information, set function code E52 to "2: Full-menu mode" beforehand.
(1) Turn the inverter on. It automatically enters Running mode. In that mode, press the key to switch to Programming mode. The function selection menu appears.
(2) Use the ล and $\triangle$ keys to display "Maintenance Information" (
(3) Press the key to proceed to a list of maintenance item codes (e.g. 5ı,
(4) Use the $\widehat{\Omega}$ and keys to display the desired maintenance item, then press the key. The data of the corresponding maintenance item appears.
(5) Press the key to return to a list of maintenance items. Press the key again to return to the menu.

Table 3．18 Display Items for Maintenance Information

| LED Monitor shows： | Item | Description |
| :---: | :---: | :---: |
| 5ーロ゙イ | Cumulative run time | Shows the content of the cumulative power－ON time counter of the inverter． <br> Unit：thousands of hours． <br> （Display range： 0.001 to $9.999,10.00$ to 65.53 ） <br> When the total ON－time is less than 10000 hours（display： 0.001 to 9.999 ），data is shown in units of one hour（0．001）．When the total time is 10000 hours or more （display： 10.00 to 65.53 ），it is shown in units of 10 hours（ 0.01 ）．When the total time exceeds 65535 hours，the counter will be reset to 0 and the count will start again． |
|  | DC link bus voltage | Shows the DC link bus voltage of the inverter main circuit． Unit：V（volts） |
| Sーロ゙心 | Max．tempera－ ture inside the inverter | Shows a maximum temperature inside the inverter for every hour． Unit：${ }^{\circ} \mathrm{C}$（Temperatures below $20^{\circ} \mathrm{C}$ are displayed as $20^{\circ} \mathrm{C}$ ．） |
| 5109 | Max．temperature of heat sink | Shows the maximum temperature of the heat sink for every hour． Unit：${ }^{\circ} \mathrm{C}$（Temperatures below $20^{\circ} \mathrm{C}$ are displayed as $20^{\circ} \mathrm{C}$ ．） |
| Sイジ | Max．effective output current | Shows the maximum current in RMS for every hour． Unit：A（amperes） |
| 516 | Capacitance of the DC link bus capacitor | Shows the current capacitance of the DC link bus capacitor（reservoir capacitor） in \％，based on the capacitance when shipping as $100 \%$ ．Refer to Chapter 7 ＂MAINTENANCE AND INSPECTION＂for details． <br> Unit：\％ |
| 5 | Cumulative run time of electrolytic capacitor on the printed circuit board | Shows the content of the cumulative run time counter of the electrolytic capacitor mounted on the printed circuit board． <br> The display method is the same as for＂Cumulative run time（ $G_{-}$ However，when the total time exceeds 65535 hours，the count stops and the display remains at 65．53． |
| 5197 | Cumulative run time of the cooling fan | Shows the content of the cumulative run time counter of the cooling fan． <br> This counter does not work when the cooling fan ON／OFF control（function code H06）is enabled but the fan does not run． <br> The display method is the same as for＂Cumulative run time（5－ However，when the total time exceeds 65535 hours，the count stops and the display remains at 65．53． |
| 518 | Number of startups | Shows the content of the cumulative counter of times the inverter is started up（i．e．， the number of run commands issued）． <br> 1.000 indicates 1000 times．When any number from 0.001 to 9.999 is displayed，the counter increases by 0.001 per startup，and when any number from 10.00 to 65.53 is counted，the counter increases by 0.01 every 10 startups．When the counted number exceeds 65535，the counter will be reset to 0 and the count will start again． |
| 5－69 | Input watt－hour | Shows the input watt－hour of the inverter． <br> Unit： 100 kWh （Display range： 0.001 to 9999 ） <br> Depending on the value of integrated input watt－hour，the decimal point on the LED monitor shifts to show it within the LED monitors＇resolution（e．g．the resolution varies between $0.001,0.01,0.1$ or 1 ）．To reset the integrated input watt－hour and its data，set function code E51 to＂0．000．＂ <br> When the input watt－hour exceeds 1000000 kWh ，it returns to＂ 0 ．＂ |
| S－ | Input watt－hour data | Shows the value expressed by＂input watt－hour $(\mathrm{kWh}) \times \mathrm{E} 51$（whose data range is 0.000 to 9999）．＂ <br> Unit：None． <br> （Display range： 0.001 to 9999 ．The data cannot exceed 9999．（It will be fixed at 9999 once the calculated value exceeds 9999．）） <br> Depending on the value of integrated input watt－hour data，the decimal point on the LED monitor shifts to show it within the LED monitors＇resolution． <br> To reset the integrated input watt－hour data，set function code E51 to＂0．000．＂ |

Table 3．18 Continued

| LED Monitor shows： | Item | Description |
| :---: | :---: | :---: |
| S＿ii | No．of RS485 errors（stan－ dard） | Shows the total number of errors that have occurred in standard RS485 commu－ nication（via the RJ－45 connector as standard）since the power is turned on． Once the number of errors exceeds 9999 ，the count returns to 0 ． |
| S．Iz | Content of RS485 commu－ nications error （standard） | Shows the latest error that has occurred in standard RS485 communication in decimal format． <br> For error contents，refer to the RS485 Communication User＇s Manual（MEH448a）． |
| 5－17 | No．of option errors | Shows the total number of optional communications card errors since the power is turned on． <br> Once the number of errors exceeds 9999，the count returns to 0 ． |
| G＿ | Inverter＇s ROM version | Shows the inverter＇s ROM version as a 4－digit code． |
| 5－117 | Keypad＇s ROM version | Shows the keypad＇s ROM version as a 4－digit code． |
| 5－17 | No．of RS485 errors（option） | Shows the total number of errors that have occurred in optional RS485 commu－ nication since the power is turned on． <br> Once the number of errors exceeds 9999，the count returns to 0 ． |
| 57 | Content of RS485 commu－ nications error （option） | Shows the latest error that has occurred in optional RS485 communication in decimal format． <br> For error contents，refer to the RS485 Communication User＇s Manual（MEH448a）． |
| 5－9 | Option＇s ROM version | Shows the option＇s ROM version as a 4－digit code． |
| 5ーゴ | Cumulative motor run time | Shows the content of the cumulative power－ON time counter of the motor． <br> The display method is the same as for＂Cumulative run time（ 5 ， $1 / \cdots 7)$ above． |

Menu \#6 "Alarm Information" shows the causes of the past 4 alarms in alarm code. Further, it is also possible to display alarm information that indicates the status of the inverter when the alarm occurred. Figure 3.11 shows the menu transition in Menu \#6 "Alarm Information" and Table 3.19 lists the details of the alarm information.


Figure 3.11 "Alarm Information" Menu Transition

## Basic key operation

To view the alarm information，set function code E52 to＂2：Full－menu mode＂beforehand．
（1）Turn the inverter on．It automatically enters Running mode．In that mode，press the key to switch to Programming mode．The function selection menu appears．

（3）Press the key to proceed to a list of alarm codes（e．g． In the list of alarm codes，the alarm information for the last 4 alarms is saved as an alarm history．
（4）Each time the ब or $\vee$ key is pressed，the last 4 alarms are displayed in order from the most recent one as i， $\square, 7$ and 4 ．
（5）While the alarm code is displayed，press the key to have the corresponding alarm item number（e．g．
 can also have the item number（e．g． $\bar{\sigma}_{-} \bar{\prime} i^{\prime}$ ）and data（e．g．Output current）for any other item displayed using the ब and $\Omega$ keys．
（6）Press the key to return to a list of alarm codes．Press the key again to return to the menu．
Table 3．19 Alarm Information Displayed

| LED monitor shows： （item No．） | Item displayed | Description |
| :---: | :---: | :---: |
|  | Output frequency | Output frequency |
| 吕㕣i | Output current | Output current |
| 呂促 | Output voltage | Output voltage |
| ローロフ | Calculated torque | Calculated motor output torque |
|  | Reference frequency | Frequency specified by frequency command |
| 回年 | Rotational direction | This shows the rotational direction being output． ，－：forward；，－：reverse；－－－－：stop |
|  | Running status | This shows the running status in hexadecimal．Refer to ＂■ Displaying running status＂in Section 3．4．4． |
| G67 | Cumulative run time | Shows the content of the cumulative power－ON time counter of the in－ verter． <br> Unit：thousands of hours． <br> （Display range： 0.001 to $9.999,10.00$ to 65.53 ） <br> When the total ON－time is less than 10000 hours（display： 0.001 to $9.999)$ ，data is shown in units of one hour（0．001）．When the total time is 10000 hours or more（display： 10.00 to 65.53 ），it is shown in units of 10 hours（ 0.01 ）．When the total time exceeds 65535 hours，the counter will be reset to 0 and the count will start again． |
| 回代 | No．of startups | Shows the content of the cumulative counter of times the inverter is started up（i．e．，the number of run commands issued）． <br> 1.000 indicates 1000 times．When any number from 0.001 to 9.999 is displayed，the counter increases by 0.001 per startup，and when any number from 10.00 to 65.53 is counted，the counter increases by 0.01 every 10 startups．When the counted number exceeds 65535 ，the counter will be reset to 0 and the count will start again． |
| 回哭 | DC link bus voltage | Shows the DC link bus voltage of the inverter main circuit． Unit：V（volts） |
| 高＂ | Temperature inside the inverter | Shows the temperature inside the inverter when an alarm occurs． Unit：${ }^{\circ} \mathrm{C}$ |
| G－i＇ | Max．temperature of heat sink | Shows the temperature of the heat sink． Unit：${ }^{\circ} \mathrm{C}$ |


| LED monitor shows： （item No．） | Item displayed | Description |
| :---: | :---: | :---: |
| E．に＇ | Terminal I／O signal status （displayed with the ON／OFF of LED seg－ ments） | Shows the ON／OFF status of the digital I／O terminals．Refer to <br> ＂Displaying control I／O signal terminals＂in Section 3．4．5＂Checking I／O signal status＂for details． |
| 年， | Terminal input signal status（in hexadecimal format） |  |
| E＿ו＇゙ | Terminal output signal status（in hexa－ decimal format） |  |
| 镸品 | No．of consecutive oc－ currences | This is the number of times the same alarm occurs consecutively． |
|  | Overlapping alarm 1 | Simultaneously occurring alarm codes（1） （＂－－－－＂is displayed if no alarms have occurred．） |
| E－17 | Overlapping alarm 2 | Simultaneously occurring alarm codes（2） （＂－－－－＂is displayed if no alarms have occurred．） |
|  | Terminal I／O signal status under communication con－ trol （displayed with the ON／OFF of LED segments） | Shows the ON／OFF status of the digital I／O terminals under RS485 communications control．Refer to＂■ Displaying control I／O signal terminals under communications control＂in Section 3．4．5＂Checking I／O signal status＂for details． |
| 谷 | Terminal input signal status under communication con－ trol （in hexadecimal format） |  |
|  | Terminal output signal status under communica－ tion control （in hexadecimal format） |  |
| 可ご | Error sub code | Secondary error code for the alarm． |

Note
When the same alarm occurs repeatedly in succession，the alarm information for the first and last occurrences will be preserved and the information for other occurrences inbetween will be discarded． Only the number of consecutive occurrences will be updated．

## 3．4．8 Data copying information－Menu \＃7＂Data Copying＂

Menu \＃7＂Data Copying＂is used to read function code data out of an inverter for which function codes are already set up and then to write such function code data altogether into another inverter，or to verify the function code data stored in the keypad with the one registered in the inverter．
This subsection introduces restrictions and special notes concerning＂Data Copying．＂
■ If data copying does not work
Check whether
（1）If
－No data exists in the keypad memory．（No data read operation has been performed since shipment，or a data read operation has been aborted．）
－Data stored in the keypad memory contains any error．
－The models of copy source and destination inverters are different．
－A data write operation has been performed while the inverter is running．
－The copy destination inverter is data－protected．（function code $\mathrm{F} 00=1$ ）
－In the copy destination inverter，the＂Enable write from keypad＂command（WE－KP）is off．
－A Read data operation has been performed for the inverter whose data protection was enabled．
(2) If

- The function codes stored in the keypad and ones registered in the inverter are not compatible with each other. (Either of the two may have been revised or upgraded in a non-standard or incompatible manner. Contact your Fuji Electric representative.)

Figure 3.12 shows the menu transition in Menu \#7 "Data Copying." The keypad can hold function codes for just one inverter.


Figure 3.12 Menu Transition in Menu \#7 "Data Copying"

## Basic keying operation

(1) Turn the inverter on. It automatically enters Running mode. In that mode, press the key to switch to Programming mode. The function selection menu appears.

(3) Press the key to proceed to a list of copying functions (e.g.
(4) Use the ब and $\triangle$ keys to select the desired function, then press the key to execute the selected function. (e.g. ィ-EMGI will blink.)
(5) When the selected function has been executed, E-G appears. Press the to return to the data copying function list. Press the key again to return to the menu.

You can protect data saved in the keypad from unexpected modifications. Enabling the data protection that was
 the inverter.

To enable or disable the data protection, follow the next steps.
(1) Select the data copy "T1,1,
(2) Holding the key down for 5 seconds or more alternates data protection status between enabled or disabled.

- Disabling the enabled Data protection


While running the Data copying ( after appearing "AF-=,-1"" temporarily to complete disabling the Data protection.

- Enabling the disabled Data protection

 after appearing ",-וֹ/" temporarily to complete disabling the Data protection.

Table 3.20 below lists details of the Data copying function.

Table 3．20 List of Data Copying Functions

| Display on LED Monitor | Function | Description |
| :---: | :---: | :---: |
| ールーヅ | Read data | Reads the function code data out of the inverter＇s memory and stores it into the keypad memory． <br>  the operation and displays <br> If this happens，the entire contents of the memory of the keypad will be completely cleared． |
| くロバロ | Write data | Writes data stored in the keypad memory into the inverter＇s memory． <br>  operation that is under way will be aborted and＂I，－，－＂will appear blinking（＊）． The contents（function code data，）of the inverter＇s memory remain partly old and partly updated．If this happens，do not operate the inverter；instead，perform ini－ tialization or rewrite the entire data． <br> If any incompatible code is about to be written， <br> If this function does not work，refer to＂■ If data copying does not work＂on page 3－29． |
| じに，－ | Verify data | Verifies（collates）the data stored in the keypad memory with that in the inverter＇s memory． <br> If any mismatch is detected，the verify operation will be aborted，with the function code in disagreement displayed blinking．Pressing the key again causes the verification to continue from the next function code． <br> Pressing the key during a verify operation（iNT，，blinking）immediately aborts the operation and displays <br> I－，－appears blinking ${ }^{(*)}$ also when the keypad does not contain any valid data． |
| ハーイーツ | Enable Data protection | Enables the Data protection of data stored in the inverter＇s memory． <br> In this state，you cannot read any data stored in the inverter＇s memory，but write data into the memory and verify data in the memory． <br> Upon pressing the <br> key the inverter immediately displays＂Eん－，－．＂ |



## 3．5 Alarm Mode

If an abnormal condition arises，the protective function is invoked to issue an alarm，and the inverter automatically enters Alarm mode．At the same time，an alarm code appears on the LED monitor．

## －Releasing the alarm and switching to Running mode

Remove the cause of the alarm and press the key to release the alarm and return to Running mode．The alarm can be removed using the key only when the alarm code is displayed．

## －Displaying the alarm history

It is possible to display the most recent 3 alarm codes in addition to the one currently displayed．Previous alarm codes can be displayed by pressing the ब／

- Displaying the status of inverter at the time of alarm

When the alarm code is displayed, you may check various running status information (output frequency and output current, etc.) by pressing the key. The item number and data for each running information will be displayed alternately.
Further, you can view various pieces of information on the running status of the inverter using the ब/ $\triangle$ key. The information displayed is the same as for Menu \#6 "Alarm Information" in Programming mode. Refer to Table 3.19 in Section 3.4.7, "Reading alarm information."
Pressing the key while the running status information is displayed returns the display to the alarm codes.
Note When the running status information is displayed after removal of the alarm cause, pressing the key twice returns to the alarm code display and releases the inverter from the alarm state. This means that the motor starts running if a run command has been received by this time.

## ■ Switching to Programming mode

You can also switch to Programming mode by pressing + keys simultaneously with the alarm displayed, and modify the function code data.

Figure 3.13 summarizes the possible transitions between different menu items.


Figure 3.13 Menu Transition in Alarm Mode

### 4.1 Running the Motor for a Test

### 4.1.1 Inspection and preparation prior to powering on

Check the following prior to starting powering on.
(1) Check if connection is correct.

Especially check if the power wires are connected to the inverter input terminals L1/R, L2/S and L3/T, and output terminals $\mathrm{U}, \mathrm{V}$ and W respectively and that the grounding wires are connected to the ground electrodes correctly. Note that FRENIC-Eco series inverter is designed for three phase input and driving three phase motors.

## $\triangle$ WARNING

- Do not connect power supply wires to the inverter output terminals $\mathrm{U}, \mathrm{V}$, and W . Otherwise, the inverter may be broken if you turn the power ON.
- Be sure to connect the grounding wires of the inverter and the motor to the ground electrodes. Otherwise, electric shock may occur.
(2) Check for short circuits between terminals and exposed live parts and ground faults.
(3) Check for loose terminals, connectors and screws.
(4) Check if the motor is separated from mechanical equipment.
(5) Turn the switches OFF so that the inverter does not start or operate erroneously at power-on.
(6) Check if safety measures are taken against runaway of the system, e.g., a defense to protect people from unexpectedly approaching your power system.


Figure 4.1 Connection of Main Circuit Terminals

### 4.1.2 Turning ON power and checking

## $\triangle$ WARNING

- Be sure to install the covers for both the main circuit terminal block, control circuit terminal block and the front cover if any before turning the power ON.
Do not remove any cover while powering on.
- Do not operate switches with wet hands.

Otherwise electric shock could occur.
Turn the power ON and check the following points. This is a case when no function code data is changed from the factory setting.
(1) Check if the LED monitor displays ${ }^{\circ}$ frequency command is 0 Hz ) that is blinking. (See Figure 4.2.) If the LED monitor displays numbers except入 1 , keys to set
(2) Check if a built-in cooling fan rotates.
(When only the auxiliary power is fed while the main power is turned OFF, the cooling fan does not rotate. For the inverter of 1.5 kW or below no cooling fan is mounted.)


Figure 4.2 Display of the LED Monitor after Power-on

### 4.1.3 Preparation before running the motor for a test--Setting function code data

Before starting running the motor, set function code data specified in Table 4.1 to the motor ratings and your system design values. For the motor, check the rated values printed on the nameplate of the motor. For your system design values, ask system designers about them.
[D] For details about how to change function code data, refer to Chapter 3, Section 3.4.1 "Setting up function codes quickly." Refer to the function code H03 in Chapter 5 "FUNCTION CODES" for the factory default setting of motor parameters. If any of them is different from the default setting, change the function code data.

End of Avon St Leichhardt SPS－i．Power Solutions－Ipswich Ref J7985－01－SP22 O＇Keefe St SPS－OI
Table 4．1 Settings of Function Code Data before Driving the Motor for a Test

| Function code | Name | Function code data | Factory setting |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Asia（A） | Taiwan and Korea（K） | EU（E） |
| ハージィ | Base frequency | Motor ratings（printed on the nameplate of the motor） | 60.0 （Hz） | 50.0 （Hz） | 50.0 （Hz） |
| に－ | Rated voltage |  | 220 （V） | 200 （V） |  |
|  | （at base frequency） |  | 380 （V） | 400 （V） | 400 （V） |
| ロイプ | Motor parameter （Rated capacity） |  | Applicable motor rated capacity |  |  |
| ローイシ | Motor parameter （Rated current） |  | Rated current of applicable motor |  |  |
| ロダロ | Motor Selection |  | 0 ：Characteristic of motor， 0 （Fuji standard 8－series motors） |  |  |
| ハイブ | Maximum frequency | System design values <br> For a test－driving of the motor， increase values so that they are longer than your system design values．If the set time is short，the inverter may not start running the motor． | 60.0 （Hz） | 60.0 （Hz） | 50.0 （Hz） |
| に，\％7 | Acceleration time $1^{*}$ |  | 20.0 （s） |  |  |
|  | Deceleration time ${ }^{\text {＊}}$ |  | 20.0 （s） |  |  |

Tip In any of the following cases，the default settings may not produce the best results for auto torque boost， torque calculation monitoring，or auto energy saving，since the standard settings of motor parameters for Fuji motors are not applicable．Tune the motor parameters according to the procedure set forth below．
－The motor to be driven is not a Fuji product or is a non－standard product．
－The cabling between the motor and the inverter is long．
－A reactor is inserted between the motor and the inverter．
＜Tuning procedure＞

## 1）Preparation

Referring to the rating plate on the motor，set the following function codes to their nominal ratings：
－F04：Base frequency
－F05：Rated voltage（at Base frequency）
－P02：Rated capacity
－P03：Rated current
2）Selection of Tuning Process
Check the situation of the machine system and choose between＂Tuning while the motor is stopped（P04 $=1)$＂and＂Tuning while the motor is running（ $\mathrm{P} 04=2$ ）．＂In the case of＂Tuning while the motor is running （P04＝2），＂also adjust the acceleration and deceleration times（F07 and F08）and set the rotation direction properly so that it matches the actual rotation direction of the machine system．

| Data for <br> P04 | Motor parameters <br> subject to Tuning： | Action | Choose the process when： |
| :---: | :--- | :--- | :--- |
| 1 | Primary resistance（\％R1） <br> Leakage reactance（\％X） | Measure \％R1 and \％X while <br> the motor is stopped． | The motor cannot be rotated，or <br> more than 50\％of the rated load <br> would be applied on the motor if <br> rotated． |
| 2 | Primary resistance（\％R1） <br> Leakage reactance（\％X） <br> No－load current | Measure \％R1 and \％X while <br> the motor is stopped，and <br> later no－load current while <br> the motor is running．（At <br> $50 \%$ of the Base frequency）． | Even if the motor is rotated，it is <br> safe and the load applied on the <br> motor would be no more than 50\％ <br> of the rating．（If you do the tuning <br> with no load，you will get the <br> highest precision．） |

Upon completion of the tuning，the primary resistance \％R1 will be automatically saved into P07，the leakage reactance \％X into P08，and the no－load current into P06．
3) Preparation of Machine System

Perform appropriate preparations on the motor and its load, such as disengaging the coupling and deactivating the safety device.
4) Perform tuning
(1. Set function code P04 to "1" or "2" and press the key. (The blinking of ion or the LED monitor will slow down.)
(2. Enter a Run command for the rotation direction you have chosen. The factory default setting is "forward rotation upon pressing the wey on the keypad." To switch to reverse rotation, change the setting of function code F02.
(3. The display of is or $I^{7}$ stays lit, and tuning takes place while the motor is stopped. (Maximum tuning time: approximately 40 (s).)
(4. If the function code P04 $=2$, the motor is accelerated to approximately $50 \%$ of the base frequency and then tuning takes place. Upon completion of measurements, the motor will coast-to-stop. (Estimated tuning time: Acceleration time +10 (s) + Deceleration time)
5. If the terminal signal (FWD) or (REV) is selected as the Run command (F02 $=1$ ), Erno' will appear upon completion of the measurements.
6. The Run command is turned OFF and the tuning completes, with the next function code displayed on the keypad (the Run command given through the keypad or the communications link is automatically turned OFF).

■ Errors during tuning
Improper tuning would negatively affect the operation performance and, in the worst case, could even cause hunting or deteriorate precision. Therefore, if the inverter finds any abnormality in the results of the tuning or any error in the process of the tuning, it will display $\bar{I}$ and discard the tuning data.
Listed below are the abnormal or error conditions that can be recognized during tuning.

| Abnormal/error condition | Description |
| :--- | :--- |
| Abnormal result of tuning | An inter-phase imbalance has been detected; <br> Tuning has resulted in an abnormally high or low value of a parameter. |
| Abnormal output current | An abnormally high current has been caused during tuning. |
| Sequence error | During tuning, the Run command has been turned OFF, or forced STOP, <br> coast-to-stop command (BX), dew condensation protection (DWP), or a <br> similar abnormal command has been received. |
| Limitation exceeded | During tuning, a certain limitation has been reached or exceeded; <br> The maximum output frequency or the peak limiter for output frequency has <br> been reached or exceeded. |
| Other alarm condition | An undervoltage or an alarm has been occurred. |

If any of these conditions has occurred, either eliminate the abnormal or error factor(s) and perform tuning again, or contact your Fuji Electric representative.

Note:
If a filter other than Fuji optional output filter ( $\mathrm{OFL}-\square \square \square-4 \mathrm{~A}$ ) is connected to the inverter's output (secondary) circuit, the result of tuning can be unpredictable. When you replace an inverter, take note of the old inverter's settings for the primary resistance \%R1, the leakage reactance $\% \mathrm{X}$, and the no-load current, and set those values to the new inverter's function codes.

### 4.1.4 Test run

## $\triangle$ WARNING

If the user set the function codes wrongly or without completely understanding this Instruction Manual and the FRENIC-Eco User's Manual (MEH456), the motor may rotate with a torque or at a speed not permitted for the machine.
Accident or injury may result.

Follow the descriptions of the previous Section 4.1.1, "Inspection and preparation prior to powering on" to Section 4.1.3, "Preparation before running the motor for a test," and begin test-driving of the motor.

## $\triangle$ CAUTION

If any abnormality is found to the inverter or motor, immediately stop operation and determine the cause referring to Chapter 6, "TROUBLESHOOTING."

## Procedure for Test Run

(1) Turn the power ON and check that the LED monitor blinks while indicating the ${ }^{[7, L i n}, \mathrm{Hz}$ frequency.
(2) Set the frequency to a low frequency such as 5 Hz , using / keys. (Check that frequency command blinks on the LED monitor.)
(3) Press the key to start running the motor in the forward direction. (Check that the frequency command is displayed on the LED monitor correctly.)
(4) To stop the motor, press the key.
<Check the following points>

- Check if the direction of rotation is forward.
- Check for smooth rotation without motor humming or excessive vibration.
- Check for smooth acceleration and deceleration.

When no abnormality is found, press the key again to start driving the motor, and increase the frequency command using ©/ keys. Check the above points for the test-driving of the motor.

### 4.2 Operation

After confirming ordinary operation by performing a test run, make mechanical connections (connections of the machine system) and electrical connections (wiring and cabling), and set the necessary parameters properly before starting a production run.

Note
Depending on the conditions of the production run, further adjustments can be required, such as adjustments of torque boost (F09), acceleration time (F07), and deceleration time (F08). Make sure to set relevant function codes properly.

## Chapter 5 FUNCTION CODES

### 5.1 Function Code Tables

Function codes enable the FRENIC-Eco series of inverters to be set up to match your system requirements.
Each function code consists of a 3-letter alphanumeric string. The first letter is an alphabet that identifies its group and the following two letters are numerals that identify each individual code in the group. The function codes are classified into eight groups: Fundamental Functions (F codes), Extension Terminal Functions (E codes), Control Functions of Frequency (C codes), Motor Parameters (P codes), High Performance Functions (H codes), Application Functions (J codes), Link Function (y codes) and Option Function (o codes). To determine the property of each function code, set data to the function code.

This manual does not contain the descriptions of Option Function (o codes). For Option Function (o codes), refer to the instruction manual for each option.

The following descriptions supplement those given in the function code tables on page 5-3 and subsequent pages.

## - Changing, validating, and saving function code data when the inverter is running

Function codes are indicated by the following based on whether they can be changed or not when the inverter is running:

| Notation | Change when running | Validating and saving function code data |
| :---: | :---: | :--- |
| $\mathrm{Y}^{*}$ | Possible | If the data of the codes marked with $\mathrm{Y}^{*}$ is changed with <br> the change will immediately take effect; however, the change is not saved <br> into the inverter's memory. To save the change, press the key. If you <br> press the key without pressing the key to exit the current state, <br> then the changed data will be discarded and the previous data will take <br> effect for the inverter operation. |
| Y | Possible | Even if the data of the codes marked with Y is changed with <br> keys, the change will not take effect. Pressing the <br> change take effect and save it into the inverter's memory. |
| N | Impossible make the | - |

## - Copying data

The keypad is capable of copying of the function code data stored in the inverter's memory into the keypad's memory (refer to Menu \#7 "Data copying" in Programming mode). With this feature, you can easily transfer the data saved in a source inverter to other destination inverters.

If the specifications of the source and destination inverters differ, some code data may not be copied to ensure safe operation of your power system. Whether data will be copied or not is detailed with the following symbols in the "Data copying" column of the function code tables given below.
Y: Will be copied unconditionally.
Y1:Will not be copied if the rated capacity differs from the source inverter.
Y2:Will not be copied if the rated input voltage differs from the source inverter.
N : Will not be copied. (The function code marked with " N " is not subject to the Verify operation, either.) If necessary, set up uncopied code data manually and individually.

For details of how to set up or edit function codes, refer to Chapter 3 "OPERATION USING THE KEYPAD."
[]] If you are using the multi-function keypad (option), refer to the Multi-function Keypad Instruction Manual (INR-SI47-0890-E) for details.

The negative logic signaling system can be used for the digital input and output terminals by setting the function code data specifying the properties for those terminals. Negative logic refers to the inverted ON/OFF (logical value 1 (true)/0 (false)) state of input or output signal. An ON-active signal (the function takes effect if the terminal is short-circuited.) in the normal logic system is functionally equivalent to OFF-active signal (the function takes effect if the terminal is opened.) in the negative logic system. An ON-active signal can be switched to OFF-active signal, and vice verse, with the function code data setting.

To set the negative logic system for an I/O signal terminal, enter data of 1000s (by adding 1000 to the data for the normal logic) in the corresponding function code and then press the key.

The table below shows that the coast-to-stop command $(\mathrm{BX})$ is assigned to the terminal [X1] using the function code E01.

| Function code data |  |
| :---: | :---: |
| 7 | If $(B X)$ is ON, the inverter coast-to-stops the motor. |
| 1007 | If $(B X)$ is OFF, the inverter coast-to-stops the motor |

The following tables list the function codes available for the FRENIC-Eco series of inverters
[1] If you find any [-] (not available here) mark in the related page column of the function code tables, refer to FRENIC-Eco User's Manual (MEH456) for details.

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI F codes: Fundamental Functions

| Cose | Name | Dass texing range | Increment | Unit | Change nhen runting | Data oopying | Defaul setting | $\begin{gathered} \text { Poloe } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| F00 | Dasa Protection | 0. Disable daca prosection (Function code data can be edited.) <br> 1. Enable data protection | - | - | $Y$ | $Y$ | 0 | $5-22$ |
| FOt | Frequency Command 1 | 0. Enable $(\mathrm{O})$ (O) kays on keypad <br> 1. Enable voltage input to terminal [12] $(01010 \mathrm{VDC})$ <br> 2. Enable curent ingut to leminal [C1] ( 4 to 20 mA DC) <br> 1. Enable sum of vollage and curneel ingela to tominals [12) and \|C1] <br> 5. Enable voltage input to leminal (V2] (0 to 10 VDC ) <br> 7: Enable terminal command (UP) $f$ (DOWN) contrel | - | - | N | $\gamma$ | 0 |  |
| $F 12$ | Run Command | 0. Enable (o) $l$ (o) keys an keypad (Motor rotational direction from digital terminals [FWD// [REVD] <br> 1. Enable torminal command (FWC) or (REV) <br> 2. Enable (o) 1 E) kers on keypad (forward) <br> 3: Cnatie (ay) f fig keys on keypad (reverse) | - | - | N | $\gamma$ | 2 | 5.23 |
| F03 | Maximum Frequency | 25.0 vo 120.0 | 0.1 | Her | N | Y | Ruter to tablo betove. | 5-24 |
| F0t | Base Frequency | 25.050120 .0 | 0.1 | Hz | N | $Y$ | Refer to table below. |  |
| F05 | Rased Voltagn as: Base Frequency | 0. Outcut a votage in proportion to input votage 80 10 240. Output a voltage AVR-cootroled (for 200 V series) <br> 160 so 500. Output a voltage AVR-controlled (for 400 V series) | 1 | V | $N$ | Y2 | Refor to table below: |  |
| foy | Acceleration Time 1 | 0.00 ss 3600 <br> Note: Ensering 0.00 cancols the accolerasion time. requiring external sot-stan. | 0.01 | 5 | $Y$ | $Y$ | 20.9 | $5-27$ |
| F00 | Deceleration Time 1 | $0.00 \text { to } 3600$ <br> Note: Entering 0.00 cancels the deceleration time. requiring excenal wot-start. | 0.01 | $s$ | $Y$ | $Y$ | 20.0 |  |

The shaded function codes ( $\square$ ) are applicable to the quick setup.
■ Factory defaults (F03, F04 and F05)

| Function code | Factory defaults |  |  |
| :---: | :---: | :---: | :---: |
|  | Asia (A) | Taiwan and Korea (K) | EU (E) |
| F03 | 60 Hz | 60 Hz | 50 Hz |
| F04 | 60 Hz | 50 Hz | 50 Hz |
| F05 | 220 V | 200 V | -. |
|  | 380 V | 400 V | 400 V |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (F code continued)

| Cose | Name | Data selting ranga | increment | Unit | Change when Nunning | Dess ospying | Opfaut setting | $\begin{aligned} & \text { Refer } \\ & \text { to } \\ & \text { page: } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Fob | Torque Boost | 0.0 to 20.0 <br> (Percentage of the rated voltage at base trequency (F05)) <br> Note. This seding is eflective when F37 = 0, 1, 3, or 4. | 0.1 | \% | Y | Y | Refer to table below | 5-27 |
| F10 | Electronic Themal Overioad Protection for Motor (Select motor charnctoriaties) <br> (Overload detection level) | 1: For goneras -purpose motors wth buitin seif-cooling fan <br> 2. For inverter-driven motors or high-speed motors with forced/ventilation fan | - | - | $Y$ | $Y$ | 1 | 5-30 |
| F11 |  | Q.00. Disable <br> Ito $135 \%$ of the rated current (ellowatio continuous dive current) of the motor | 0.01 | A | $Y$ | $\begin{aligned} & \mathrm{Y} 1 \\ & \mathrm{Y} 2 \end{aligned}$ | $100 \%$ of the molor rated ourent |  |
| F12 | (Thermal time constant) | 0.5 to 75.0 | 0.1 | $\min$ | $Y$ | $Y$ | $5(22 \mathrm{~kW}$ or below) $10(30 \mathrm{~kW}$ or above) |  |
| F14 | Aestant Mode atter Momentary Power Failure (Mode selection) | Q. Disable restart (Trip immediately) <br> 1: Disable restart (Trip after a recovery from power faluro) <br> 3. Enable restart (Continue to run, for heavy inveria or geowral loads) <br> 4. Enable resiat (Aestart at the frequency at which the power fallure cocurred, for general loads) <br> 5: Enable restart (Restart at the starting frequency, for low-inerta lowd) | - | - | Y | $Y$ | 1 (0) ${ }^{2} 2$ | 5-33 |
| F15 | Frequency Limier (Migh) | 0.0 to 120.0 | 0.1 | Hz | $Y$ | $Y$ | 70.0 | 5-38 |
| F16 |  | 0.0 to 120.0 | 0.1 | Hz | $Y$ | $Y$ | 0.0 |  |
| F18 | Bias <br> (Frequency commiand 1) | -100.00 to 100.00*1 | 0.01 | \% | $\mathrm{Y}^{*}$ | $\boldsymbol{Y}$ | D.00 | 5-39 |
| F20 | DC Braking <br> (Brabing stat frequency) | 0.01060 .0 | 0.1 | Hz | $Y$ | $Y$ | 0.0 | 5-40 |
| F21 | (Eraking level) | Oto 69 (Rated oulput curfent of the inverter innerpreted as 100\%) | 1 | \% | $Y$ | $Y$ | 0 |  |
| F22 | (Braking fime) | 0.00 - Disabie <br> 0.01 to 30,00 | 0.01 | 5 | $Y$ | $Y$ | 0.00 |  |
| F23 | Starting Frequency | 0.11000 .0 | 0.1 | Hz | $Y$ | $r$ | 0.5 | 5-41 |
| F25 | Siop Frequency | 0.1 to 60.0 | 0.1 | Hz | $Y$ | $Y$ | 0.2 |  |

The shaded function codes $\qquad$ ) are applicable to the quick setup.
*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is:
"1" for -200 to -100, "0.1" for -99.9 to -10.0 and for 100.0 to 200.0, and "0.01" for -9.99 to -0.01 and for 0.00 to 99.99 .
*2 Values in parentheses () in the above table denote default settings for the EU version.

- Torque boost per motor capacity by factory defaults (F09)

| Motor rating (kW) | Torque boost (\%) | Motor rating (kW) | Torque boost (\%) |
| :---: | :---: | :---: | :---: |
| 0.1 | 8.4 | 5.5 | 3.4 |
| 0.2 | 8.4 | 7.5 | 2.7 |
| 0.4 | 7.1 | 11 | 2.1 |
| 0.75 | 6.5 | 15 | 1.6 |
| 1.5 | 4.9 | 18.5 | 1.3 |
| 2.2 | 4.5 | 22 | 1.1 |
| 3.7 | 4.1 | 30 to 220 | 0.0 |

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (F code continued)

| Code | Name | Duta setting range | Increment | Unit | Change whon running | Data oopying | Detault setting | $\begin{array}{\|c} \text { Refer } \\ \text { to } \\ \text { page: } \\ \hline \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| F20 | Motor Sound <br> (Carrier trequency) <br> (Tone) | 0.75 to 15 (22 kW or below) *9 <br> 0.75 to 10 (30 to 75 kW$)$ <br> 0.75 lo 6 ( 90 kW or above) | 1 | kele | $Y$ | $Y$ | $\begin{gathered} 2 \\ (15100)^{*} \end{gathered}$ | $5-41$ |
| 127 |  | 0. Level 0 (Inactiva) <br> 1: Leval 1 <br> 2. Level 2 <br> 2. Level 1 | - | - | $Y$ | $r$ | 0 |  |
| F29 | Analog Oulpul [FMA] <br> (Mode seleclion) <br> (Criput adjustment) | 0. Output in voltage (0 to 10 VDC) <br> 1. Output in corrent (4 to 20 mA DC) | - | - | $Y$ | $Y$ | 0 | 5-42 |
| F30 |  | 0 to 200 | 1 | \% | $Y^{*}$ | $Y$ | 100 |  |
| F31 | Analog Outoul [FMA] (Function) | Select a function to be monitored from the followings. <br> 0. Output freculncy <br> 2. Output ourrens <br> 3: Output votage <br> 4. Oulpul torque <br> D: Load factor <br> 6. Input power <br> 7. PiD feedback value (PV) <br> 9. DC link bus voltage <br> 10: Universal AO <br> 13: Moner output <br> 14: Test analog output <br> 15: P1O proseses sommand (5V) <br> 16: PIO process ontput (MV) | - | - | $Y$ | $Y$ | 0 |  |
| F33 | Pulse Output [FMPI*3 (Pulee rate) <br> (Duty) | 25 to 6000 (Pulse rate at $100 \%$ output) | 1 | p/s | $y^{*}$ | $Y$ | 1440 | 5-44 |
| F34 |  | 0. Output pulse rase (Fixed at sosis duty) <br> I to 200. Volage output adjustinest (Pulse rate is fored at $2000 \mathrm{p} / \mathrm{s}$. Adjust the mavirnum pulse duty.) | 1 | $\%$ | $\mathrm{V}^{*}$ | $Y$ | 0 |  |
| F35 | (Function) | Select a function to be montored from the followings. <br> 0. Output frequency <br> 2. Output current <br> 3: Output woitage <br> 4: Output torgue <br> 5. Load factor <br> 6. Inpell power <br> 7. PID feedback value (PV) <br> 2. DC link bas voliage <br> 10. Universal AO <br> 13: Motor output <br> 14: Test analog output <br> 15. Pro process command (SV) <br> 16: P1O process cutput (MV) | - | - | $Y$ | $Y$ | 0 |  |

The shaded function codes $\qquad$ are applicable to the quick setup.
*1 If the carrier frequency is set at 1 kHz or below, estimate the maximum motor output torque at $80 \%$ or less of the rated motor torque.
*2 Values in parentheses () in the above table denote default settings for the EU version.
*3 The control printed circuit board (the control PCB) is equipped with either a screw terminal base or Europe type terminal block, supporting [FMP] or [FMI], respectively. The [FMP] enables F33 to F35, but the [FMI] enables only F34 and F35 so that F33 will not appear.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (F code continued)

| Code | Name | Data selting range | Incre- ment | Unit | Change when runring | Data copying | Detaut setting | Reber to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| F34 | Tomminal [FM] ${ }^{+1}$ | 010 200: Voltage eutot asjustment | 1 | * | Y* | $Y$ | 100 | 5-44 |
| F35 |  | Select a function to be monitored from the followings. <br> 0: Ouput frequency <br> 2. Ouput curtent <br> 3. Ouput votage <br> 4: Output torque <br> 5: Load factor <br> 6. Inpul power <br> 7. PID feedbeck value (PV) <br> 9. DC link bus voltage <br> 10:. Universal AO <br> 13: Molor output <br> 14: Test analog output <br> 15: PID process command (SV) <br> 15: PID process output (MM) | - | - | V | $Y$ | 0 |  |
| F37 | Losd Selaction Aufo Torque Boost ! Asfo Energy Saving Operation | 0. Varabie sorque iosd increasing in proportion to square of speed <br> 1: Vanable forque load increasing in proportion to square of tepeed (Higher startup torgoe required) <br> 2. Auto-forque boonl <br> 3. Auto-energy saving operation (Varable torque load increasing in proportion to square of speed) <br> 4: Auto-nengy saving operation (Varable torque load increasing in proportion to square of tpeed (Migher startup torque required)) Note: Apply this setting to a load with short acoeleration time. <br> 5. Auto-energy saving operation (Aiso torque boose) Nobe: Apply this setting to a load with loceg abceleration time. | - | - | N | $Y$ | 1 | $5-27$ |
| F43 | Current Limiter <br> (Mode selection) | 0: Disable (No current limiter works.) <br> 1. Enable at constant speed <br> (Disabled during acopleration and deceleration) <br> 2. Enable during aconleration and at constant speed | - | - | $Y$ | $Y$ | 0 | - |
| F44 | (Level) | 20 to 120 (The data is interpeeted as the rated oulpot cument of the iwverter for $100 \%$.) | 1 | \% | $Y$ | $\gamma$ | 110 |  |

*1 The control PCB is equipped with either a screw terminal base or Europe type terminal block, supporting [FMP] or [FMI], respectively. The [FMP] enables F33 to F35, but the [FMI] enables only F34 and F35 so that F33 will not appear.

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI
E codes: Extension Terminal Functions

| Code | Name | Data setting range | linctement | Unit | Change when nurning | $\begin{gathered} \text { Duta } \\ \text { booying } \end{gathered}$ | Detaut setting | Refer to page |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E01 | Comvand Assigrment tor$[\mathrm{X} 1]$$[\times 2]$$[\times 3]$$[\times 4]$$[\times 5]$ | Selocling Aunction oode data assigns tlap corresponding IUnetion to terminals [X1] to [X5] as listed below. | - | - | N | $Y$ | 6 | 5-45 |
| E02 |  | Setling the value of 1000 s in parentheses () shown below assigns a negative logic input to a teminal. | - | - | N | $Y$ | 7 |  |
| E03 |  | \} Select mutistep frecuency $\quad$ (S\$1) | - | - | N | $Y$ | 5 |  |
| E04 |  | $\left.\begin{array}{l}1(1001) \\ 2(1002)\end{array}\right\}$ Select mutistep frequency $\quad$ (SS2) | - | - | N | $r$ | 11 |  |
| E06 |  | 6 (1006): Enable 3-wire oceration 0.0) | - | - | N | $Y$ | 35 |  |
|  |  | 7 (1007) Coast to a stop (8X) |  |  |  |  |  |  |
|  |  | 8 (1005) Reset alarm (RST) |  |  |  |  |  |  |
|  |  | $9(1009)$ Enable external alarm trip (TiR) |  |  |  |  |  |  |
|  |  | 11(1011). Swich fregancy command 211 (Hz2HE1) |  |  |  |  |  |  |
|  |  | 13: Enable DC brake (DCBRK) |  |  |  |  |  |  |
|  |  | 15: Swith to conmmercisl power ( 50 Hz ) (SW50) |  |  |  |  |  |  |
|  |  | 16: Switch to conmmercial power ( 60 Hz ) (SWb0) |  |  |  |  |  |  |
|  |  | 17 (1017): UP (increase oulput frequency) (UP) |  |  |  |  |  |  |
|  |  | 15 (1016): DOWN (Decreose output frequency) |  |  |  |  |  |  |
|  |  | (DCWN) |  |  |  |  |  |  |
|  |  | 13 (1019): Enable write from keypad (Oata changeabie) (WE-KP) |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  | 21 (1021). Swich normal/nverse operation (VV) |  |  |  |  |  |  |
|  |  | 22 (1022) Intoriock (4) |  |  |  |  |  |  |
|  |  | 24 (1024): Enabie communications ink via RS485 or field bus (option) |  |  |  |  |  |  |
|  |  | 25 (1025) Univertai OL (U-DO) |  |  |  |  |  |  |
|  |  | 25 (1026): Select starting characteristics |  |  |  |  |  |  |
|  |  | 30 (1030): Force is stop (STOP) |  |  |  |  |  |  |
|  |  | 33 (1030): Reset PID integral and diflerential componetts |  |  |  |  |  |  |
|  |  | 34 (1034) Hoid PID integrat component (PID-RLD) |  |  |  |  |  |  |
|  |  | 35 (1035) Select local (keypad) operation |  |  |  |  |  |  |
|  |  | 30 (1030): Enable to run $\quad$ (RE) |  |  |  |  |  |  |
|  |  | 32: Protect motor from dew condensation |  |  |  |  |  |  |
|  |  | 49. Enable integrited teguence to swith (DWP) |  |  |  |  |  |  |
|  |  | 45. Enable integrated sequence to switch <br> to commencial power ( 50 Hz ) <br> (ISW50) |  |  |  |  |  |  |
|  |  | 41. Enable integrated sequence to swith |  |  |  |  |  |  |
|  |  | 10 commencial power ( 60 Hz ) (ISW00) |  |  |  |  |  |  |
|  |  | 60 (1050): Clear periodic switching time |  |  |  |  |  |  |
|  |  | 51 (1051) Enable pump drve (motor 1) |  |  |  |  |  |  |
|  |  | 52 (1052): Einable pump drive (motor 2) (MEN2) |  |  |  |  |  |  |
|  |  | 53 (1053): Enable pump drive (motor 3) (MEN3) |  |  |  |  |  |  |
|  |  | 54 (1054): Chable pump drve (motor 4) |  |  |  |  |  |  |
|  |  | 67 (1057): Swich run command 2/4 (FRQFR1) |  |  |  |  |  |  |
|  |  | 88: Runforward2 ${ }^{\text {2 }}$ (FWD2) |  |  |  |  |  |  |
|  |  | 89: Run reverse 2 (REV2) |  |  |  |  |  |  |
|  |  | Nople: In tev cave of (THR) and (5TOP), data (1006) and (60S6) are for normal logic, and "'g' and '30r are for (regrtive iodic, respectively. |  |  |  |  |  |  |

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (E code continued)


[^50]7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (E code continued)

| Code | Name | Dala selting range | increment | Und | Change when running | $\begin{gathered} \text { Dasa } \\ \text { ocopyon } \end{gathered}$ | Dotavt selting | $\begin{array}{\|c\|} \text { Refor } \\ \text { to } \\ \text { page: } \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E31 | Frequency Detection (FDT) (Detection level) | 00 \$0 12000 | 0.1 | He | $Y$ | $Y$ | $\begin{array}{l\|l\|} \hline 60.0 \\ (50.0)^{-2} \end{array}$ | - |
| ES4 | Ovorload Early Warning CGument Detection <br> (Level) <br> (Timer) | 0. (Disable) <br> Current valye of 1 to $150 \%$ of the inverter rated curment | 0.01 | A | $Y$ | $\begin{aligned} & Y_{1} \\ & n \end{aligned}$ | $000 \%$ of $\mathrm{e}=$ moloor ratioc coment | 5-58 |
| E35 |  | $0.0110600 .00-4$ | 0.01 | 5 | $Y$ | $Y$ | 10.00 |  |
| E40 | PID Display Coefficiest A | -999 to 0.00 to 099* | 0.01 | - | $\gamma$ | $Y$ | 100 | - |
| E41 | PID Display Coeflicioet 8 | -999 to 0.00 15 509 -1 | 0.01 | - | $\gamma$ | $Y$ | 0.00 |  |
| E43 | LED Montor (fitem setioction) | 0. Speed monitor (Select by E48.) <br> 3: Output current <br> 4. Output votige <br> 8. Caloulated lorque <br> 9. Input poreer <br> 10: PID process command (Final) <br> 12. PID feedbsck value <br> 14: PID output <br> 15: Losd factor <br> 16: Motor output <br> 17: Analicg input | - | - | $\boldsymbol{r}$ | $Y$ | 0 |  |
| E45 | LCO Monitsery (trom selection) | 0. Purning status. robasonal dirsction and operation guide <br> 1: Bar chars for culput froquency. Current and calculated torque | - | - | $Y$ | $Y$ | 0 |  |
| E4S | (amguage melection) | 0. Japaneve <br> 1: Englinh <br> 2. Ceman <br> 3. French <br> 4. Spanish <br> 5. Malan | - | - | $\gamma$ | $\checkmark$ | 1 |  |
| E47 | (Contrast contro) | 0 (Low) to 10 06igh) | 1 | - | $Y$ | $Y$ | 5 |  |
| e4s | LEO Monitor <br> (Speed monitor hiem) | 0. Oubut frequency <br> 3: Motor speed in rimin <br> 4; Lood shat speed in rimin <br> 7: Display speed in \% | - | - | $Y$ | $Y$ | 0 |  |
| E50 | Coufficiest for Speed indication | $0.0100200 .00 \% 9$ | 0.01 | - | $\gamma$ | $Y$ | 30.00 |  |
| E51 | Display Coefficient for Input Wan-hour Data | 0.000: (Cancelireset) <br> 0.001 to 9999 | 0.001 | - | $Y$ | $Y$ | 0.010 | 5-50 |
| ES2 | Keypad (Menu dispiay mode) | 0. Function code deta editing mode (Menus 10,81 and m) <br> 1: Function code casa check mode (Menus $\mathrm{F}_{2}$ and m 7 ) <br> 2: Fuls-menu mose (Menses me though m) | - | - | $\gamma$ | $Y$ | 0 | - |

The shaded function codes ( $\square$ ) are applicable to the quick setup.
*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00 , the incremental unit is:
"1" for -200 to -100, "0.1" for -99.9 to -10.0 and for 100.0 to 200.0, and "0.01" for -9.99 to -0.01 and for 0.00 to 99.99 .
*2 Values in parentheses () in the above table denote default settings for the EU version.
*3 LCD monitor settings are applicable only to the inverter equipped with a multi-function keypad.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (E code continued)

| Code | Name | Dara sotting range | Increment | Unit |  | Data | Default setting | Reler 10 page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\pm 61$ $\pm 62$ | Analog inpu: tor <br> (Extensian furiction selestion) <br> [12] <br> [C1] <br> [V2] | Selecting function code data assigns the conresponding furnclion to terninials [12], [C1] and [V2] es listed below. <br> 0. None <br> 1. Auxiliary ltequency cominamid 1 <br> 2: Auxiliary frequency commaned 2 <br> 3 PID process nammand 1 <br> 5. PID leedjack value <br> 20: Analog input monitnt |  |  | N <br> N | $Y$ <br> $Y$ | 0 0 | - |
| $\pm 63$ |  |  | - | - | N | $Y$ | 0 |  |
| 564 | Saving Digital Reference Frequency | 0. Auto sav rg (at the time of main power turned off) <br> 1. Saving jy pressing key | - | - | $Y$ | $Y$ | 0 |  |
| E65 | Command Lass Detection (Level) | 0. Decelerate to stop 20 :0 120 999: Disabele | 1 | $\%$ | $Y$ | $Y$ | 900 | 5-59 |
| $\pm 80$ | Detect Low Torque (Detection level) | $0 \% 150$ | 1 | $\%$ | $Y$ | $Y$ | 20 | $5-60$ |
| E81 | (Timer) | 0.01 to $600.60 \% 1$ | 0.01 | 5 | $Y$ | $Y$ | 20.00 |  |

*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is:
"1" for -200 to $-100, ~ " 0.1 "$ for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .

| Code | Name | Data setting range | Increment | Unit | Change when rurning | Data copying | Default setting | Refer ta nage: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\pm 98$ | Command Assignment to: <br> [FMD] <br> [REV] | Selecting function code data assigns the corresponding function to terminals [FWD] and [REV] as listed below. <br> Setting the value of 10008 in parentheses () shown below assigns a negative logic input to a terminal. <br> Note: In the case of (THR) and (STOF). data (1009) and (1030) are for norma logic. and "G" arc' "39" are for negative logic, respectively. | - | - | N | $Y$ | 98 | 5-45 |
| $\pm 99$ |  |  | - | - | N | $Y$ | 99 |  |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI C codes: Control Functions of Frequency

| Code | Name | Data setting range | ncrement | Unit | Change when rustring | Dopata | Default setting | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Co1 | Jump Frequency 1 | 0.0 to 120.0 | 0.1 | Hz | $Y$ | $Y$ | 0.0 |  |
| C02 |  |  |  |  | $r$ | $\gamma$ | 0.0 |  |
| C03 |  |  |  |  | $Y$ | $Y$ | 0.0 |  |
| 004 |  | 0.0 to 30.0 | 0.1 | Hz | $Y$ | $\gamma$ | 0.0 |  |
| cos | Multistep Frequency 1 | 0.00 to $120.00{ }^{1}$ | 0.01 | Hz | $Y$ | $\gamma$ | 0.00 |  |
| cos |  |  |  |  | Y | $Y$ | 0.00 |  |
| c07 |  |  |  |  | $Y$ | $Y$ | 0.00 |  |
| C0s |  |  |  |  | $Y$ | $Y$ | 0.00 |  |
| 009 |  |  |  |  | $Y$ | $\gamma$ | 0.00 |  |
| C10 |  |  |  |  | $Y$ | $\gamma$ | 0.00 |  |
| 0.11 |  |  |  |  | $Y$ | $\gamma$ | 0.00 |  |
| 030 | Frecuency Command 2 | a: Enable (a) <br> 1: Enable voltage inout to teminal [12] <br> (0 to 10 VDC ) <br> 2: Enable current input to lerminal [C1] <br> ( 4 to $20 \mathrm{~m} \Omega \mathrm{DC}$ ) <br> 3: Enable sum of voltage and rurrent inpults to terminals [12] and [C 1] <br> 5: Enable voltage in out to terminal \|VZ| ( 0 to 10 VDC ) <br> 7. Enable te:minal command (UP) '( (OOWN) centrol | - | - | $N$ | $\nabla$ | 2 | $5-22$ |
| C 32 | Analog Input Adjustment for [12] <br> (Gain) <br> (Filter time constent) <br> (Gain reference point) | 0.00 to $200.00 \cdot 1$ | 0.01 | \% | $\gamma$ | $\gamma$ | 100.0 | 5 -39 |
| 633 |  | 0.00 to 5.00 | 0.01 | 5 | $Y$ | $Y$ | 0.05 | 5-60 |
| C34 |  | 000 to $100.00 * 1$ | 0.01 | $\%$ | $\mathrm{Y}^{*}$ | $Y$ | 1000 | 5-39 |
| C.37 | Analog Input Adjustment for [61] <br> (Gain) <br> (Filler tirrie constant) <br> (Gain reference point) | 0.00 to $200.00 * 1$ | 0.01 | \% | $Y^{*}$ | $Y$ | 100.0 |  |
| C38 |  | 0.00105 .00 | 0.01 | $s$ | $Y$ | $Y$ | 0.05 | 5-60 |
| C39 |  | 0.00 to $100.00 * 1$ | 0.01 | $\%$ | ${ }^{*}$ | $\gamma$ | 100.0 | 5-39 |
| 042 | Analug Input Adjustment for [V2] <br> (Garn) <br> (Filter time constant) <br> (Gain reference point) | 0.00 to $200.00 * 1$ | 0.01 | \% | $Y^{*}$ | Y | 100.0 |  |
| C43 |  | 0.00 to 5.00 | 0.01 | 5 | $Y$ | Y | 0.05 | $5-60$ |
| C44 |  | 0.00 to $100.00 * 1$ | 0.01 | \% | $\gamma^{*}$ | $Y$ | 100.0 | 5-39 |
| 050 | Eias Refererce Poin: (Friquency command 1) | 0.00 to $100.0 \%$ | 0.01 | \% | Y* | $Y$ | 0.00 |  |
| 051 | Bias for PID carmmand 1 <br> (Bias value)$\|$ | -100.0 to $100.00 * 1$ | 0.01 | \% | $Y$ | $Y$ | 0.00 | - |
| 052 |  | 0.00 to $100.00 * 1$ | 0.01 | \% | $\psi^{*}$ | $\gamma$ | 0.00 |  |
| C53 | Selemtion of Normal Inverse Operation (Frequency command 1) | 0: Normal operation <br> 1: Inverse operation | - | - | $Y$ | $\gamma$ | 0 |  |

*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00, the incremental unit is:
"1" for -200 to $-100, ~ " 0.1$ " for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O P codes: Motor Parameters


The shaded function codes $\qquad$ ) are applicable to the quick setup.

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O H codes: High Performance Functions

| Code | Name | Data setting range | fincrembent | Unit | Change when nunnige | Data copping | Detint setting | Refer to poge |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| H03 | Ora Initidication | a. Pisablo initiplization <br> 1. Initislize al function code satas so the factory defaits <br> 2 Initialte motor parameters | - | - | N | N | 0 | $5-82$ |
| H04 | Auto-reseming <br> (Times) <br> (Reset intnrval) | $\begin{aligned} & \text { o: Disuatile } \\ & \text { ito } 10 \end{aligned}$ | 1 | Tines | Y | $Y$ | 0 | 5.67 |
| HOS |  | 0.5 to 20.0 | 0.1 | $\stackrel{1}{*}$ | $r$ | $Y$ | 5.0 |  |
| H06 | Cooling Fan ONVOFF Control | Q. Disabie (Always in operation) <br> 1. Enable (ONOFF controlable) | - | - | $r$ | $r$ | 0 | $5-68$ |
| H0\% | Accoleration/Deceleration Pastern | 0. Unear <br> 1: S-rurve (Week) <br> 2. S-ourve (Strong) <br> 3. Curvinear | - | - | $Y$ | $Y$ | 0 |  |
| H09 | Select Starting Characteristics <br> (A)to seauch for iding motor SOENO) | 0 . Disation <br> 3. Enable (Follow Run command, either foward or reverse.) <br> 4: Enable (Follow Run command, beh lowasd and reverso.) <br> 8. Enable (Follow Run sommand, itversaly both forward and reverse.) | - | - | $N$ | $Y$ | 0 | $5-69$ |
| HH | Deceleration Mode | 0. Nomal deceleration <br> f: Copstho-stop | - | - | $Y$ | $Y$ | 0 | 8.71 |
| H12 | Inslantaneous Overcurrent Limiting | O. Disatlie <br> 1. Erable | - | - | $\gamma$ | $Y$ | 1 | 572 |
| H13 | Restart Mode afier Momeclacy Power Fallure (Restart time) <br> (Frequency fall rabe) | 0.11010 .0 | 0.1 | 5 | Y | $\begin{aligned} & \mathrm{Y} 1 \\ & \mathrm{Y} 2 \end{aligned}$ | Depending on the inverter capacity | 5.33 |
| H 14 |  | ```0.00: Set deceleration time 0.01 to 100.00 90%: Follow the current limit commmed``` | 0.01 | Hzas | $Y$ | $Y$ | 999 |  |
| H+5 | (Continuous runring level) | 200 V series: 200 to 300 400 V series: 400 to 600 | 1 | V | $\gamma$ | Y2 | $\begin{aligned} & 235 \\ & 470 \end{aligned}$ | - |
| H 16 | (Aliowatile mornentary power fallyre (Ime) | 0.0 to 30.0 <br> 999 The longest time automatically determined by the irverter | 0.1 | * | Y | $\gamma$ | 099 | 5-39 |
| H17 | Select Starting Characteristios (Frequency for iding motor speed) | 0.0 to 120.0 <br> 999. Harmionlze at the maximum frequency | 0.1 | Hz | Y | V | 999 | 5.69 |
| H26 | PTC Thermistor (Mode selection) | a. Disatle <br> 1. Einable (Upon detection of (PTC), the imverter inmediably bips and stops with OWV displsyed.) <br> 2 Enpble (Upon detection of (PTC), Eve irverter continues running while outpulting alarm sigral (TPMO) | - | - | $\mathbf{Y}$ | V | 0 | - |
| H27 | (Level) | 0.00 to 5.00 | 0.01 | v | Y | $Y$ | 1.60 |  |

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (H code continued)

| Code | Name | Data setting ramge | increment | Unit | Change when runnigg | Data copying | Detanit setting | $\begin{gathered} \text { Reler } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| H39 | Communications Link Function <br> (Mose seiection) |  | - | - | $Y$ | $Y$ | 0 | $5-72$ |
| H42 | Capwoltance of OC Link Bus Cigaciter | Indication for replagieg DC, link bus capacitor (0000 to FFFF: Hexadecimal) | 1 | - | Y | N | - | - |
| H43 | Cumalative Run Time of Cooling Fan | Indicabion of eumulative run time of cooling fan for replacement | - | - | $Y$ | N | - |  |
| 1447 | Intial Capocilance of DC Link Rus Capaclor | Indication for replacing DC link bus capaotor (0000 to FFFF: Hexadecimal) | - | - | $Y$ | N | Set at factory shipping |  |
| H48 | Cumulative Run Time of Capacitors on the Printed Circull Board | Indication for replacing capscilors on printed ciecull board (0000 fo FFFF: Hexadocimal). Resetiablo. | - | - | $\gamma$ | N | - |  |
| $\mathrm{H49}$ | Select Starting <br> Chwacteristics <br> (Auto search time for idiling motor speed) | 0.01010 .0 | 0.1 | 5 | $r$ | $Y$ | 0.0 |  |
| HSO | Nonlinear V/I Patlem (Frequency) <br> (Vicage) | 00 Cancel 0.1 to 120.0 | 0.1 | Hz | N | $Y$ | $\left\|\begin{array}{c} 0.0(22 \mathrm{~kW} \\ \text { or below }) \\ 5.0(30 \mathrm{~kW} \\ \text { or above) } \end{array}\right\|$ | 5-24 |
| HS1 |  | 0 so 240 : Output a voleges AVR-coctrolled (for 200 V series) <br> 0 so 500: Output a volage AVR-controled (for 400 V series) | 1 | V | N | Y2 | $0(22 \mathrm{~kW}$ or below $)$ $20(30 \mathrm{~kW}$ or above for 200 V series) 40 ( 30 kWW of above for 400 V series) |  |
| HS6 | Deceleration Time for Forced Stop | 0.00 10 3600 | 0.01 | $s$ | $\gamma$ | $r$ | 20.0 | - |
| H69 | Low Limiter <br> (Mose selection) | 0: Limit by F16 (Frequency Limaec: Low) and consnue to fun <br> 1. If the colput frequency lowers less than the one Imiled by F18 (Fresuency Limber: Loed decelerates fo stop the motor. | - | - | $Y$ | $\gamma$ | 0 |  |
| H64 | (Lower limiting frequency) | 0.0 (Depends on F 16 (Frequency Limiter: Low)) 0.1 to 60.0 | 0.1 | Hz | $Y$ | $Y$ | 2.0 |  |
| Hes | Automatic Deceleration | 0. Disabie <br> 3: Enable (Control DC link but voltage at a conatant) | - | - | $\mathbf{Y}$ | Y | 0 | 5-74 |
| H70 | Ovelload Prevestion Contral | 0.00. Follow decelaration time specified by F08 0.01 to 100.00 <br> pop: Disable | 0.01 | $\mathrm{Hz} / \mathrm{s}$ | $\boldsymbol{\gamma}$ | $\gamma$ | 999 |  |
| W71 | Deseleration Chatacteriasics | 0. Disabie <br> t: Snable | - | - | $Y$ | $Y$ | 0 | - |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (H code continued)

| Code | Name | Data setting range |  |  | Increment | Unit | Change when running | Data copying | Default setting | $\begin{gathered} \text { Refer } \\ \text { to } \\ \text { page: } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| H80 | Gain for Suppression of Output Current Fluctuation for Motor | 0.00 to 0.40 |  |  | 0.01 | - | Y | Y | Depending on the inverter capacily | - |
| H86 | Reserved. *2 | 0 to 2 |  |  | 1 | - | $Y$ | $\begin{aligned} & Y 1 \\ & Y 2 \end{aligned}$ | $* 4$ <br> Depending on the inverter capacity |  |
| H87 | Reserved. *2 | 25.0 to 120.0 |  |  | 0.1 | Hz | $Y$ | $Y$ | 25.0 |  |
| H88 | Reserved. *2 | 0 to 3, 999 |  |  | 1 | - | $Y$ | N | 0 |  |
| H89 | Reserved. *2 | 0, 1 |  |  | - | - | $Y$ | $Y$ | 0 |  |
| H90 | Reserved. *2 | 0.1 |  |  | - | - | Y | $Y$ | 0 |  |
| H91 | Reserved. *2 | 0.1 |  |  | - | - | Y | Y | 0 |  |
| H92 | Continue to Run <br> (P-component: gain) | 0.000 to $10.000 .999 * 1$ |  |  | 0.001 | Times | Y | $\begin{aligned} & Y 1 \\ & Y 2 \end{aligned}$ | 999 |  |
| H93 | (I-component; time) | 0.010 to $10.000,999 * 1$ |  |  | 0.001 | s | Y | $\begin{aligned} & Y 1 \\ & Y 2 \end{aligned}$ | 999 |  |
| H94 | Cumulative Run Time of Motor | Change or reset the cumulative data |  |  | - | - | N | N | - | 5-74 |
| H95 | DC Braking (Braking response mode) | 0: Slow <br> 1: Quick |  |  | - | - | $Y$ | Y | 1 | 5-40 |
| H96 | STOP Key Priority/ Start Check Function | Data | STOP key priority | Start check function | - | - | $Y$ | $Y$ | 0 | - |
|  |  | 0 : | Disable | Disable |  |  |  |  |  |  |
|  |  | 1. | Enable | Disable |  |  |  |  |  |  |
|  |  | 2. | Disable | Enable |  |  |  |  |  |  |
|  |  | $3:$ | Enable | Enable |  |  |  |  |  |  |
| H97 | Clear Alarm Data | Setting H97 data to "1" clears alarm data and then returns to zero. |  |  | - | - | Y | N | 0 | 5-75 |
| H98 | Protection/ <br> Maintenance Function | 0 to 63: Display data on the keypad's LED monitor in decimal format (In each bit, "0" for disabled, "1" for enabled.) <br> Bit 0: Lower the carrier frequency automatically <br> Bit 1: Detect input phase loss <br> Bit 2: Detect output phase loss <br> Bit 3: Select life judgment criteria of DC link bus capacitor <br> Bit 4: Judge the life of DC link bus capacitor <br> Bit 5: Detect DC fan lock |  |  | - | - | Y | Y | $\begin{gathered} 19 \\ (\text { Bits } 4,1, \\ 0=1 \\ \text { Bits } 5,3, \\ 2=0) \end{gathered}$ |  |

*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00 , the incremental unit is:
"1" for -200 to -100, "0.1" for -99.9 to -10.0 and for 100.0 to 200.0, and "0.01" for -9.99 to -0.01 and for 0.00 to 99.99 .
*2 The H86 through H91 are displayed, but they are reserved for particular manufacturers. Unless otherwise specified, do not access these function codes.
*3 Select 0.10 for models of 45 kW or above ( 200 V series) and 55 kW or above ( 400 V series), 0.20 for models of 37 kW or below ( 200 V series) and 45 kW or below ( 400 V series).
*4 Select 2 for models of 45 kW or above ( 200 V series) and 55 kW or above ( 400 V series), 0 for models of 37 kW or below ( 200 V series) and 45 kW or below ( 400 V series).

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI $J$ codes: Application Functions

| Code | Name | Data setring range | Increevent | Unit | Change whan numing | Data oopying | Defaut seming | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 301 | FID Control <br> (Mode selection) <br> (Remete process command) | $\begin{aligned} & \text { 0: Disable } \\ & \text { 1: Enatie (nomal operation) } \\ & \text { 2: Enable (inverse operation) } \end{aligned}$ | - | - | N | $Y$ | 0 | - |
| 302 |  | 0. Enatio kays on keypad <br> 1: PID procets command 1 <br> 3. Enable ferminal command (UP) /(DCWN) control <br> 4: Command via communicators link | - | - | N | Y | 0 |  |
| 303 |  | 0.000 to $30.000 * 1$ | 0.001 | Tines | $Y$ | $Y$ | 0.100 |  |
| 304 |  | 0.0 to $3600.0{ }^{*} 1$ | 0.1 | $\stackrel{1}{ }$ | $\checkmark$ | $Y$ | 0.0 |  |
| . 05 |  | 0.00 to $000.00 \% 1$ | 0.01 | 3 | $\gamma$ | $Y$ | 0.00 |  |
| 306 |  | 0.0 to 9000 | Q. 1 | $s$ | $\gamma$ | $Y$ | 0.5 |  |
| d10 |  | O to 200 | 1 | \% | $Y$ | $Y$ | 200 |  |
| 111 |  | 0: Abecivio-value alam <br> 1: Absolute-value alarm ( $\mathbf{m} / \mathrm{h}$ Hold) <br> 2. Absolute-value alainn (with Latch) <br> 3. Absolute-value atarm (with Hold and Latch) <br> 4. Devation alarm <br> 5. Deviation alarm (with Hold) <br> 6. Deviation alarm (with Latch) <br> 7. Deviation alarm (with Hold and Latch) | - | - | $Y$ | $Y$ | 0 |  |
| J12 | (Upper limit alarm (AH)) <br> (Lower lint alam (AL)) <br> (Stop froquency for slow fowrase) | Olo 100 | 1 | \% | $Y$ | $Y$ | 100 |  |
| 313 |  | 010900 | 1 | \% | $Y$ | $Y$ | 0 |  |
| 315 |  | $\begin{aligned} & \text { 0: Disabio } \\ & \text { ito } 120 \end{aligned}$ | 1 | Hz | $Y$ | $Y$ | 0 |  |
| 316 | (Slow flowrate levat stop latency) | 1 to 60 | 1 | 3 | $Y$ | $Y$ | 30 |  |
| 317 | (Upper limit of PID process oulpua <br> (Lower limit of PID process outpul) | $\begin{aligned} & \text { 0: Disable } \\ & \text { ito } 120 \end{aligned}$ | 1 | Hz | Y | $Y$ | 0 |  |
| 218 |  | 1 to 120 <br> 909 . Depends on setting of F15 | 1 | Hz | $\checkmark$ | $Y$ | 999 |  |
| 119 |  | $\begin{aligned} & 1 \text { to } 120 \\ & \text { 905: Depends on setting of F16 } \end{aligned}$ | 1 | Hz | Y | $Y$ | 980 |  |
| 121 | Dew Condensation <br> Prevertion <br> (DMD) | 1 to 50 | 1 | \% | $\boldsymbol{Y}$ | $Y$ | 1 | $5-79$ |
| 122 | Commercial Power Siwliching Sequence | Q. Keep invefler operation (Silop due fo alam) <br> 1. Automatically swifch lo commercial-power operation | - | - | N | $Y$ | 0 | - |

*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00 , the incremental unit is:
"1" for -200 to $-100, ~ " 0.1 "$ for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .

End of Avon St Leichhardt SPS－i．Power Solutions－Ipswich Ref J7985－01－SP22 O＇Keefe St SPS－O （ J code continued）

| Code | Name | Data seting range | Ircre－ ment | Unil |  | Data | Default setting | Refer to户的采 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| J25 | Pump Contral <br> （Mode selection） | 0：Disable <br> 1：Enable（Fixed，inverter－driven） <br> 2：Enable（Floaling，inverter－driven） | － | － | $N$ | $Y$ | 0 | － |
| J26 | Metor 1 Made | 0：Disable（Alwoys QFF） <br> 1：Enable <br> 2：Force in r．un by commersial power <br> 0：Fixed <br> 1．Automatically（Constant run time） | － | － | $Y$ | $Y$ | 0 |  |
| 127 | Mator 2 Made |  | － | － | $Y$ | $Y$ | 0 |  |
| J28 | Metor 3 Made |  | － | － | Y | $Y$ | 0 |  |
| J29 | Motor 4 Made |  | － | － | Y | $Y$ | 0 |  |
| J30 | Metor Switching Order |  | － | － | N | $Y$ | $\square$ |  |
| 131 | Mator Stop Mande | 0：Stop all motors（inverter－and commercial power－d：iven） <br> 1：Stop inverter－driven motor only（excl alarm state） <br> 2：Stop inverter－driven motor only（incl alarm state） | － | － | N | $Y$ | 0 |  |
| J32 | Periodic Switching Time for Motar Drive | 0．0：Disable switching 0.1 to 720.0 ：Switching time range 999：Fix to 3 minutes | 0.1 | $\dagger$ | $N$ | $Y$ | 0.0 |  |
| 133 | Periodic Swilching Signaling Period | 0.00 to 600.00 | 0.01 | $\stackrel{ }{ }$ | $Y$ | $Y$ | 0.1 |  |
| J34 | Mount of Commercial Power－driven Metor （Fiequency） | 0 to 120 <br> 999：Depends on setting of J 18 <br> （This cocie is used to judge whether or not to mount a commercial power－driven motor by checking the output frequency of the inverter－driven motor．） | 1 | 112 | $\gamma$ | $Y$ | 999 |  |
| J35 | （Curation） | 0.00 to 3600 | Variable | 5 | $\gamma$ | $Y$ | 0 |  |
| J36 | Unmount of Commercial Power－driven Motor （Frequency） | 0 to 120 <br> 999：Depends on setting of J19 <br> （This cade is used to judge whether or not to ummount a commercial power－driven motor by oherking the output frequency of the inverter－driven motor．） | 1 | Hz | $Y$ | $Y$ | 989 |  |
| 137 | （Duration） | 0.00 to 3600 | Variable | 5 | $Y$ | $Y$ | 0 |  |
| J38 | Contactor Delay Time | 0.01 to 2.00 | 0.01 | $s$ | $Y$ | $Y$ | 0.01 |  |
| J39 | Smilching Time for Motor Mnount <br> （Decl．tlme） | O．On：Deperds on the serting of F08， 0.01 to 3 fill | Variable | \％ | Y | $Y$ | 0.00 |  |
| 140 | Switching Time for Molor Unmaunt（Accel time） | 0．00：Deperds on the setting of F07， 0.01 to 3600 | Variable | 5 | Y | $Y$ | 0.00 |  |
| J41 | Motor Monnt／Unmount Swilthing Level | 0 to 100 | 1 | $\%$ | Y | $Y$ | 0 |  |
| J4＇2 | Switching Motor Mount Unmount（Dead band） | 0．0：Disable 0.1 to 50.0 | 0.1 | $\%$ | $Y$ | $Y$ | 0.0 |  |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O (J code continued)

| Cade | Name | Data setfing range | Increment | Unit |  | Data copying | Default setting | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 143 | PID Contral Startup Frecuency | $\begin{aligned} & \text { 0: Disable } \\ & \text { 1 to } 120 \\ & \text { g99: Deperds on the setting of J } 396 \end{aligned}$ | 1 | Hz | $Y$ | $Y$ | 999 | - |
| J4E | Signal Assignment to: <br> (For relay output card) <br> [ $\mathrm{Y} 1 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ <br> [ $\mathrm{Y} 2 \mathrm{~A} / \mathrm{B} / \mathrm{C}$ ] <br> [Y3AB/C] | Selecting function code data assigns the corresponding function to terminals [ $Y 1 / A / B / C]$. $[Y 2 A / B / C]$, and [ $\mathrm{Y} 3 \mathrm{~A} / \mathrm{B} / \mathrm{C}$ ]. | - | - | $N$ | $Y$ | 100 |  |
| J46 |  | 100: Depends on the setting of $\Xi 20$ to E22 <br> 60 (1060): Whount molar 1. inverler-driven (W1_) | - | - | $N$ | $Y$ | 100 |  |
| 147 |  |  | - | - | N | $Y$ | 100 |  |
| 148 | Currulative Run Tirte of Mistor <br> (Motor O) | Indication of curnulative run lime of molor for replacement | 1 | ヶ | $Y$ | $Y$ | - |  |
| 149 | (Moter 1) |  | 1 | h | $Y$ | $Y$ |  |  |
| J50 | (Motor 2) |  | 1 | h | $Y$ | Y | - |  |
| $J 51$ | (Moter 3) |  | 1 | h | $Y$ | $Y$ | - |  |
| $\sqrt{52}$ | (Mater 4) |  | 1 | h | $Y$ | $Y$ | - |  |
| J53 | Maximum Cumulative Number of Relay ON Times [ $\mathrm{Y} 1 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ to $[\mathrm{Y} 3 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ | Indication of the maximium number of OR' times of relay contacts on the relay output card or those built in inverles <br> Display of 1.000 means 1000 times. | 1 | Times | $Y$ | $Y$ | - |  |
| J54 | $\begin{gathered} {[Y 1],[Y 2],[Y 3]} \\ {[Y 5 A],[3 Q A / B / C]} \end{gathered}$ |  | 1 | Times | $Y$ | $Y$ | - |  |
| J55 |  | For built-in mecharnical contacts | 1 | Tlomes | $Y$ | $Y$ | - |  |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI y codes: Link Functions

| Cabe | Name | Data setting range | increment | Unil | $\begin{aligned} & \text { Clange } \\ & \text { when } \\ & \text { nunning } \end{aligned}$ | $\left\lvert\, \begin{array}{c\|} \text { Dasa } \\ \text { copying } \end{array}\right.$ | Defait seting | $\begin{gathered} \text { Refor } \\ 10 \\ \text { pagec } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| y01 | RS485 Communication (Standart) <br> (Slation address) <br> (Conmurications error processing) | 16255 | 1 | - | N | $\gamma$ | 1 | - |
| 802 |  | 0. Immedialely trip and alam $\varepsilon_{-}-\beta$ <br> 1: Trip and alame Er-Bater ruaning for the peosod specified by timer y03 <br> 2. Refy during the peniod sopocited by timer yo3. It retry tails, trip and alam $\varepsilon-8$. If a succeeds, continue to run. <br> 1. Continue to run | - | - | $Y$ | $\checkmark$ | 0 |  |
| 003 | (Enor processing timer) <br> (Tranamission speed) | 0.0 \$0 000 | 0.1 | 3 | $Y$ | $\checkmark$ | 20 |  |
| 504 |  | O. 2400 bps <br> 1: 4000 bps <br> 2: 9600 bos <br> 3. 19200 bps <br> 4: 38400 bps | - | - | $Y$ | $Y$ | 3 |  |
| 005 | (Data length) | $\begin{array}{ll} \text { o. } & 8 \text { bits } \\ \text { i: } & 7 \text { bits } \end{array}$ | - | - | $Y$ | $\gamma$ | 0 |  |
| y06 | (Panty check) | 0. None <br> 1: Even pwity <br> 2. Odd pariky | - | - | $Y$ | $Y$ | 0 |  |
| 907 | (Siog bis) | $\begin{array}{ll} 0 & 2 \mathrm{bits} \\ 1: & 1 \mathrm{bt} \end{array}$ | - | - | $Y$ | Y | 0 |  |
| 908 | ONo-response arror detection time) (Responte latency Lime ) (Protocol telection) | 0 (No detection), 1 to 60 | 1 | s | $Y$ | $Y$ | 0 |  |
| 909 |  | 0.00101 .00 | 0.01 | $\pm$ | $\gamma$ | $\boldsymbol{Y}$ | 0.01 |  |
| y10 |  | a. Moatbus RTU protocol <br> 1. FRENIC Loader prolocel (SX probscol) <br> 2. Ful peneral-purpose imverter protocol <br> 3. Metasys-N2 (Avalioble only for products shicped for Asia (A) and EU (E)) | - | - | $\boldsymbol{\gamma}$ | Y | 1 |  |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI (y code continued)

| Code | Name |  | Data satting | range | Increment | Unit | Change when funning | $\begin{gathered} \text { Data } \\ \text { copying } \end{gathered}$ | Defaut setting | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $7^{11}$ | M8485 Communicabion (Option) <br> (Sation asdress) <br> (Communications emor processing) | 1 to 255 |  |  | 1 | - | N | $Y$ | 1 | - |
| 912 |  | a. Immediately tip and alarm $E_{r}, O$ <br> 1: Trip and alarm Er-Paher funning for the period speoifed by timer y13. <br> 2: Retry duining the period specijed by timer y13. If retry fals, trip and alamn Er-P, if it subceeds, continue to nn. <br> 3: Continue to nuin. |  |  | - | - | $\mathbf{Y}$ | $Y$ | 0 |  |
| 413 | (Enor processing timer) <br> (Transmission speed) | 0.0 to 60.0 |  |  | 0.1 | $s$ | $\boldsymbol{\gamma}$ | $\gamma$ | 2.0 |  |
| y14 |  | 0. 2400 bps <br> 1: 4600 bps <br> 2. 9000 bps <br> 3. 19200 bps <br> 4. 38400 bps |  |  | - | - | Y | $Y$ | 3 |  |
| y15 | (Data length) | O. 1 bla <br> 1: 7 bis |  |  | - | - | $\gamma$ | $Y$ | 0 |  |
| y 16 | (No-resconve error detection time) <br> (Response latency time) <br> (Protocol selection) | 0. None <br> 1: Even panity <br> 2. Odd parky |  |  | - | - | $Y$ | $Y$ | 6 |  |
| 917 |  | $\begin{array}{ll} 0 & 2 \mathrm{bis} \\ 1: & 1 \mathrm{bi} \end{array}$ |  |  | - | - | $Y$ | $Y$ | 0 |  |
| 918 |  | 0. (No detection)$11060$ |  |  | 1 | 3 | $Y$ | $Y$ | 0 |  |
| $y 19$ |  | 0.00101 .90 |  |  | 0.01 | 8 | $Y$ | $Y$ | 0.01 |  |
| $y 20$ |  | 6. Modbus RTU protocol <br> 2. Fup general-purpose inverter protocet <br> 3. Melasys-N2 (Avalable only for products shipped for Asia (A) and EU (E]) |  |  | - | - | $\gamma$ | $Y$ | 0 |  |
| y98 | Bus Link Function <br> (Mode selection) |  | Frequency command | Run coenmend | - | - | $Y$ | $\gamma$ | 0 | 5-72 |
|  |  | 0. | Follow H90 dala | Follow H30 data |  |  |  |  |  |  |
|  |  | 1 1. | Va field bus option | Follow H30 data |  |  |  |  |  |  |
|  |  | 2. | Follow H39 data | Va field bus option |  |  |  |  |  |  |
|  |  | 3: | Ya feld bus opton | Va feld bus optign |  |  |  |  |  |  |
| y99 | Loader Link Function (Mode selection) |  | Frequency command | Ruin command | - | - | $\mathbf{Y}$ | N | 0 | - |
|  |  | 0. | Follow H30 and y98 data | Follow H89 and y98 data |  |  |  |  |  |  |
|  |  | 1 1: | Va RStes lirk (Loaser) | Follow H80 and you data |  |  |  |  |  |  |
|  |  | 2 | Follow H30 and y98 data | Via RS465 link (Lasden) |  |  |  |  |  |  |
|  |  | 3 : | Via RS485 link (loader) | Via RS485 link (Losder) |  |  |  |  |  |  |

### 5.2 Overview of Function Codes

This section provides an overview of the function codes frequently used for the FRENIC-Eco series of inverter.
[1] For details of the function codes given below and other function codes not given below, refer to the FRENIC-Eco User's Manual (MEH456), Chapter 9 "FUNCTION CODES."

| F00 | Data Protection |
| :--- | :--- |
|  | Specifies whether function code data is to be protected from being accidentally changed by |
| keypad operation. If data protection is enabled (F00 $=1$ ), the |  |
| data is disabled so that no function code data except F00 data can be changed from to che keypad. |  |
| To change F00 data, simultaneous keying of |  |
| is required. |  |

Even when $\mathrm{F} 00=1$, function code data can be changed via the communications link.
For similar purposes, (WE-KP), a signal enabling editing of function code data from the keypad is provided as a terminal command for digital input terminals. For details, refer to function codes E01 to E05, E98 and E99.

| F01 | Frequency Command 1 |
| :--- | :--- |
| C30 | Frequency Command 2 |

F01 selects the source of reference frequency 1 (F01) or reference frequency 2 (C30) for specifying the output frequency of the inverter (motor speed).

| Data for <br> F01, C30 | Function |
| :---: | :--- |
| 0 | Enable / keys on the keypad. (Refer to Chapter 3 "OPERATION <br> USING THE KEYPAD.") |
| 1 | Enable the voltage input to terminal [12] (0 to 10 VDC, maximum frequency ob- <br> tained at 10 VDC). |
| 2 | Enable the current input to terminal [C1] (4 to 20 mA DC, maximum frequency <br> obtained at 20 mA DC). |
| 3 | Enable the sum of voltage and current inputs to terminals [12] and [C1]. See the <br> two items listed above for the setting range and the value required for maximum <br> frequencies. <br> Note: If the sum exceeds the maximum frequency (F03), the maximum <br> frequency will apply. |
| 5 | Enable the voltage input to terminal [V2] (0 to 10 VDC, maximum frequency ob- <br> tained at 10 VDC). |
| 7 | Enable (UP) and (DOWN) commands assigned to the digital input terminals. <br> Assign (UP) command (data = 17) and (DOWN) command (data = 18) to the digital <br> input terminals [X1] to [X5]. |

Certain source settings (e.g., communications link and multistep frequency) have priority over the one specified by F01. For details, refer to the block diagram in the FRENIC-Eco User's Manual (MEH456), Chapter 4, Section 4.2 "Drive Frequency Command Generator."

Tip - You can modify the reference frequency anywhere you choose using the gain and bias settings, to these analog inputs (voltages entered via terminals [12] and [V2]; the current entered via terminal [C1]). For details, refer to function code F18.

- You can enable the noise reduction filter that applies to the analog input (voltages entered via terminals [12] and [V2]; the current entered via terminal [C1]). For details, refer to function codes C33, C38 and C43 (Terminal [12], [C1] and [V2] (Analog input) (Filter time constant)).
- Using the terminal command ( $\mathrm{Hz} 2 / \mathrm{Hz} 1$ ) assigned to one of the digital input terminals switches between frequency commands 1 and 2 . For details, refer to function codes E01 to E05, E98 and E99.
- You can modify the reference frequency specified by frequency command 1 (F01) by using the selection (C53) and switching (IVS) of normal/inverse operation. For details, refer to the description of "Switch Normal/Inverse Operation (IVS)" in function codes E01 to E05.
F02 Run Command

F02 selects the source issuing a run command for running the motor.

| Data for F02 | Run Command | Description |
| :---: | :---: | :---: |
| 0 | Keypad | Enables the (exid / keys to start and stop the motor. The direction of rotation is determined by the commands given at terminals [FWD] and [REV]. |
| 1 | External signal | Enables the external signals given at terminals [FWD] and [REV] to run the motor. |
| 2 | Keypad <br> (Forward rotation) | Enables (xa) / keys to run and stop the motor. <br> Enables only forward rotation. You cannot run the motor in the reverse direction. There is no need to specify the direction of rotation. |
| 3 | Keypad <br> (Reverse rotation) | Enables (y) / Firk keys to run and stop the motor. <br> Enables only reverse rotation. You cannot run the motor in the forward direction. There is no need to specify the direction of rotation. |

When function code F02 $=0$ or 1 , the run forward (FWD) and run reverse (REV) commands must be assigned to terminals [FWD] and [REV], respectively.

In addition to the run command (F02) described, there are several other sources available with priority over F02: Remote/Local switching, Communications link, Run forward command 2 (FWD2), and Run reverse command 2 (REV2). For details, refer to the block diagram in the FRENIC-Eco User's Manual (MEH456), Chapter 4, Section 4.3 "Drive Command Generator." The table below shows relationship between keying and run commands in running per a keypad ( $F 02=0$, rotation direction is defined by the digital inputs).

| Keying on the keypad |  | Digital inputs |  | Results <br> (Final command) |
| :---: | :---: | :---: | :---: | :---: |
| (wa) key | sor key | (FWD) | (REV) |  |
| - | ON | - | - | Stop |
| ON | OFF | OFF | OFF | Stop |
| ON | OFF | ON | OFF | Run forward |
| ON | OFF | OFF | ON | Run reverse |
| ON | OFF | ON | ON | Stop |

- Digital input commands (FWD) and (REV) are valid for specifying the motor rotation direction, and the commands (FWD2) and (REV2) are invalid.
- If you have assigned the (FWD) or (REV) function to the [FWD] or [REV] terminal, you cannot change the setting of function code F02 while the terminals [FWD] and/or [REV] are on.
- Make sure that terminals [FWD] and [REV] are off before changing the (FWD) or (REV) function from the function other than the (FWD) and (REV) functions to (FWD) or (REV) function. Because, if under this condition you assign the (FWD) or (REV) function to the [FWD] or [REV] terminal while the terminals [FWD] and/or [REV] are on, the motor would start running.

When "Local" is selected in Remote/Local switching, the operation of the keypad concerning run commands varies with the setting of F02. For details, refer to "■ Remote and local modes" in Chapter 3, Section 3.3.3.

| F03 | Maximum Frequency |
| :--- | :--- |
| F03 specifies the maximum frequency at which the motor can run. Specifying the frequency out of <br> the range rated for the equipment driven by the inverter may cause damage or a dangerous <br> situation. Set a maximum frequency appropriate for the equipment. |  |

## $\triangle$ CAUTION

The inverter can easily accept high-speed operation. When changing the speed setting, carefully check the specifications of motors or equipment beforehand.
Otherwise injuries could occur.
Note
Modifying F03 data to apply a higher output frequency requires also changing F15 data specifying a frequency limiter (high).

| F04 | Base Frequency |
| :--- | :--- |
| F05 | Rated Voltage at Base Frequency |
| H50 | Non-linear V/f Pattern (Frequency) |
| H51 | Non-linear V/f Pattern (Voltage) |

These function codes specify the base frequency and the voltage at the base frequency essentially required for running the motor properly. If combined with the related function codes H 50 and H 51 , these function codes may profile the non-linear V/f pattern by specifying increase or decrease in voltage at any point on the V/f pattern.
The following description includes setups required for the non-linear V/f pattern.
At high frequencies, the motor impedance may increase, resulting in an insufficient output voltage and a decrease in output torque. This feature is used to increase the voltage at high frequencies to prevent this problem from happening. Note, however, that you cannot increase the output voltage beyond the voltage of the inverter's input power.

Set the rated frequency printed on the nameplate labeled on the motor.

- Rated Voltage at Base Frequency (F05)

Set 0 or the rated voltage printed on the nameplate labeled on the motor.

- If 0 is set, the rated voltage at base frequency is determined by the power source of the inverter. The output voltage will vary in line with any variance in input voltage.
- If the data is set to anything other than 0 , the inverter automatically keeps the output voltage constant in line with the setting. When any of the automatic torque boost settings, automatic energy saving or slip compensation is active, the voltage settings should be equal to the rated voltage of the motor.
- Non-linear V/f Pattern for Frequency (H50)

Set the frequency component at an arbitrary point of the non-linear V/f pattern.
(Setting 0.0 to H 50 disables the non-linear V/f pattern operation.)

■ Non-linear V/f Pattern for Voltage (H51)
Sets the voltage component at an arbitrary point of the non-linear V/f pattern.
Note If the rated voltage at base frequency (F05) is set to 0 , settings of function codes H 50 and H 51 will be ignored.
If the auto torque boost (F37) is enabled, H 50 and H 51 will be ignored.
Factory settings:
For models of 22 kW or below the non-linear V/f is disabled ( $\mathrm{H} 50=0, \mathrm{H} 51=0$.)
For models of 30 kW or above it is enabled, that is, ( $\mathrm{H} 50=5 \mathrm{~Hz}, \mathrm{H} 51=20 \mathrm{~V}$ ), for the 200 V series, ( $\mathrm{H} 50=5 \mathrm{~Hz}, \mathrm{H} 51=40 \mathrm{~V}$ ) for 400 V series.

| Function code | Name | Rated capacity (kW) | Rated input voltage* |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | 200 V series | 400 V series |
| F04 | Base Frequency | 5.5 to 75 | 50.0 Hz | 50.0 Hz |
| F05 | Rated Voltage at Base Frequency | 5.5 to 75 | 200 V | 400 V |
| H50 | Non-linear V/f Pattern (Frequency) | 30 or below | 0 Hz | 0 Hz |
|  |  | 37 or above | 5.0 Hz | 5.0 Hz |
| H51 | Non-linear V/f Pattern (Voltage) | 30 or below | 0 Hz | 0 Hz |
|  |  | 37 or above | 20 V | 40 V |

■ Normal (linear) V/f pattern


- V/f Pattern with Non-linear Point below the Base Frequency

- V/f Pattern with Non-linear Point above the Base Frequency

Output voltage (V)


F07 Acceleration Time 1
F08 Deceleration Time 1
F07 specifies the acceleration time, the length of time the frequency increases from 0 Hz to the maximum frequency. F08 specifies the deceleration time, the length of time the frequency decreases from the maximum frequency down to 0 Hz .


- If you choose S-curve acceleration/deceleration or curvilinear acceleration/ deceleration in Acceleration/Deceleration Pattern (H07), the actual acceleration/deceleration times are longer than the specified times. Refer to the descriptions of H 07 for details.
- If you specify an improperly long acceleration/deceleration time, the current limiting function or the automatic deceleration function (regenerative bypass function) may be activated, resulting in an actual acceleration/deceleration time longer than the specified one.

| F09 | Torque Boost |
| :--- | :--- |
| F37 | Load Selection/Auto Torque Boost/Auto Energy Saving Operation |

F37 specifies V/f pattern, torque boost type, and auto energy saving operation for optimizing the operation in accordance with the characteristics of the load. F09 specifies the type of torque boost in order to provide sufficient starting torque.

| Data for F37 | V/f pattern | Torque boost | Auto-energy saving | Applicable load |
| :---: | :---: | :---: | :---: | :---: |
| 0 | Variable torque load | Torque boost specified by F09 | Disabled | General purpose fans and pumps |
| 1 | Constant torque load |  |  | Pumps require high starting torque* |
| 2 |  | Auto-torque boost |  | Pumps require high start torque (A motor may be over-excited at no load.) |
| 3 | Variable torque load | Torque boost specified by F09 | Enabled | General-purpose fans and pumps |
| 4 | Constant torque load |  |  | Pumps require high start torque* |
| 5 |  | Auto torque boost |  | Pumps require high start torque (A motor may be over-excited at no load.) |

[^51]FRENIC-Eco is a series of inverters exclusively designed for fans and pumps whose torque loads are characterized by a term of variable torque load that is a torque load increasing proportional to square of the load speed. FRENIC-Eco cannot drive any linear torque load even if you select a linear V/f pattern. If you attempt to drive a linear torque load with a FRENIC-Eco inverter, the inverter's current limit function may be activated or an insufficient torque situation may result, and you would need to reduce the inverter output. For details, contact your Fuji Electric representative.

- V/f characteristics

The FRENIC-Eco series of inverters offers a variety of V/f patterns and torque boosts, which include V/f patterns suitable for variable torque load such as general fans and pumps or for special pump load requiring high start torque. Two types of torque boost are available: manual and automatic.


Tip When the variable torque load characteristics is selected in function code F37 ( $=0$ or 3), the output voltage may be low and insufficient voltage output may result in less output torque of the motor at a low frequency zone, depending on some motor itself and load characteristics. In such a case, it is recommended to increase the output voltage at the low frequency zone using the non-linear V/f pattern.
Recommended value: $H 50=1 / 10$ of the base frequency
$H 51=1 / 10$ of the voltage at base frequency


- Torque boost
- Manual torque boost (F09)

In torque boost using F09, constant voltage is added to the basic V/f pattern, regardless of the load, to give the output voltage. To secure a sufficient start torque, manually adjust the output voltage to optimally match the motor and its load by using F09. Select an appropriate level that guarantees smooth start-up and yet does not cause over-excitation with no or light load.
Torque boost per F09 ensures high driving stability since the output voltage remains constant regardless of the load fluctuation.
Specify the data for F09 in percentage to the rated voltage at base frequency (F05). At factory shipment, F09 is preset to a level that provides approx. $50 \%$ of starting torque.

Specifying a high torque boost level will generate a high torque, but may cause overcurrent due to over-excitation at no load. If you continue to drive the motor, it may overheat. To avoid such a situation, adjust torque boost to an appropriate level.
When the non-linear V/f pattern and the torque boost are used together, the torque boost takes effect below the frequency on the non-linear V/f pattern's point.


## ■ Automatic torque boost

This function automatically optimizes the output voltage to fit the motor with its load. Under light load, automatic torque boost decreases the output voltage to prevent the motor from over-excitation. Under heavy load, it increases the output voltage to increase output torque of the motor.

- Since this function relies also on the characteristics of the motor, set the base frequency (F04), the rated voltage at base frequency (F05), and other pertinent motor parameters (P01 though P03 and P06 though P99) in line with the motor capacity and characteristics, or else perform auto tuning per P04.
- When a special motor is driven or the load does not have sufficient rigidity, the maximum torque might decrease or the motor operation might become unstable. In such cases, do not use automatic torque boost but choose manual torque boost per F09 (F37 = 0 or 1).
- Auto energy saving operation

This feature automatically controls the supply voltage to the motor to minimize the total power consumption of motor and inverter. (Note that this feature may not be effective depending upon the motor or load characteristics. Check the advantage of energy saving before actually apply this feature to your power system.)
The inverter enables this feature only upon constant speed operation. During acceleration and deceleration, the inverter will run with manual torque boost (F09) or automatic torque boost, depending on data of the function code F37. If auto energy saving operation is enabled, the response to a change in motor speed may be slow. Do not use this feature for a system that requires quick acceleration and deceleration.

- Use auto energy saving only where the base frequency is 60 Hz or lower. If the base frequency is set at 60 Hz or higher, you may get little or no energy saving advantage. The auto energy saving operation is designed for use with the frequency lower than the base frequency. If the frequency becomes higher than the base frequency, the auto energy saving operation will be invalid.
- Since this function relies also on the characteristics of the motor, set the base frequency (F04), the rated voltage at base frequency (F05), and other pertinent motor parameters (P01 through P03 and P06 through P99) in line with the motor capacity and characteristics, or else perform auto tuning per P04.

Electronic Thermal Overload Protection for Motor
(Select motor characteristics, Overload detection level, and Thermal time constant)
F10 through F12 specify the thermal characteristics of the motor for its electronic thermal overload protection that is used to detect overload conditions of the motor inside the inverter.

F10 selects the motor cooling mechanism to specify its characteristics, F11 specifies the overload detection current, and F12 specifies the thermal time constant.

Note
Thermal characteristics of the motor specified by F10 and F12 are also used for the overload early warning. Even if you need only the overload early warning, set these characteristics data to these function codes. To disable the electronic thermal motor overload protection, set function code F11 to "0.00."

Select motor characteristics (F10)
F10 selects the cooling mechanism of the motor--built-in cooling fan or externally powered forced-ventilation fan.

| Data for F10 | Function |
| :---: | :--- |
| 1 | For general-purpose motors with built-in self-cooling fan <br> (The cooling effect will decrease in low frequency operation.) |
| 2 | For inverter-driven motors or high-speed motors with forced-ventilation fan <br> (The cooling effect will be kept constant regardless of the output frequency.) |

The figure below shows operating characteristics of the electronic thermal overload protection when $\mathrm{F} 10=1$. The characteristic factors $\alpha 1$ through $\alpha 3$ as well as their corresponding switching frequencies $f 2$ and $f 3$ vary with the characteristics of the motor. The tables below lists the factors of the motor selected by P99 (Motor Selection).
$\frac{\text { Actual Output Current (Continuous) }}{\text { Overload Detection Level (F11) }} \quad(\%)$
Cooling Characteristics of Motor Equipped with a Self-cooling Fan

Applicable Motor Rating and Characteristic Factors when P99 (Motor selection) $=0$ or 4

| Applicable motor rating (kW) | Thermal time constant $\tau$ <br> (Factory default) | Output current for setting the thermal time constant (Imax) | Switching frequency for motor characteristic factor |  | Characteristic factor (\%) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | f2 | f3 | $\alpha 1$ | $\alpha 2$ | 人3 |
| 0.4, 0.75 | 5 min | Rated current$\times 150 \%$ | 5 Hz | 7 Hz | 75 | 85 | 100 |
| 1.5 to 3.7 |  |  |  |  | 85 | 85 | 100 |
| 5.5 to 11 |  |  |  | 6 Hz | 90 | 95 | 100 |
| 15 |  |  |  | 7 Hz | 85 | 85 | 100 |
| 18.5, 22 |  |  |  | 5 Hz | 92 | 100 | 100 |
| 30 to 45 | 10 min |  | Base frequency $\times 33 \%$ | Base frequency $\times 83 \%$ | 54 | 85 | 95 |
| 55 to 90 |  |  |  |  | 51 | 95 | 95 |
| 110 or above |  |  |  |  | 53 | 85 | 90 |

Applicable Motor Rating and Characteristic Factors when P99 (Motor selection) $=1$ or 3

| Applicable motor rating (kW) | Thermal time constant $\tau$ (Factory default) | Output current for setting the thermal time constant (Imax) | Switching frequency for motor characteristic factor |  | Characteristic factor (\%) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | f2 | f3 | $\alpha 1$ | $\alpha 2$ | 人3 |
| 0.2 to 22 | 5 min | Rated current$\times 150 \%$ | Base frequency $\times 33 \%$ | Base frequency $\times 33 \%$ | 69 | 90 | 90 |
| 30 to 45 | 10 min |  |  | Base | 54 | 85 | 95 |
| 55 to 90 |  |  |  | $\begin{aligned} & \text { x } 83 \% \end{aligned}$ | 51 | 95 | 95 |
| 110 or above |  |  |  |  | 53 | 85 | 90 |

## - Overload detection level (F11)

F11 specifies the level at which the electronic thermal overload protection becomes activated. In general, set F11 to the rated current of motor when driven at the base frequency (i.e. 1.0 to 1.1 multiple of the rated current of motor (P03)). To disable the electronic thermal overload protection, set F11 to "0.00: Disable."

- Thermal time constant (F12)

F12 specifies the thermal time constant of the motor. The time constant is the time until the electronic thermal overload protection detects the motor overload while the current of $150 \%$ of the overload detection level specified by F11 has flown. The thermal constants of most gen-eral-purpose motors including Fuji motors are set at about 5 minutes for capacities of 22 kW or below or about 10 minutes for capacities of 30 kW or above by factory default.
(Example) When function code F 12 is set at " 5.0 " ( 5 minutes)
As shown below, the electronic thermal overload protection is activated to detect an alarm condition (alarm code int ) when the output current of $150 \%$ of the overload detection level (specified by F11) flows for 5 minutes, and $120 \%$ for approx. 12.5 minutes.
The actual driving time required for issuing a motor overload alarm tends to be shorter than the value specified as the time period from when the output current exceeds the rated current ( $100 \%$ ) until it reaches $150 \%$ of the overload detection level.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O Example of Operating Characteristics


Restart Mode after Momentary Power Failure
Restart after Momentary Power Failure
H13
(Mode selection)
(Restart time) (Frequency fall rate)
(Allowable momentary power failure time)

F14 specifies the action to be taken by the inverter such as trip and restart in the event of a momentary power failure.

- Restart mode after momentary power failure (Mode selection) (F14)

| Data for F14 | Mode | Description |
| :---: | :---: | :---: |
| 0 | Disable restart <br> (Trip immediately) | As soon as the DC link bus voltage drops below the undervoltage detection level upon a momentary power failure, the output of the inverter is shut down, with undervoltage alarm $\iota^{\prime} \iota^{\prime}$ issued, and the motor enters a coast-to-stop state. |
| 1 | Disable restart <br> (Trip after a recovery from power failure) | As soon as the DC link bus voltage drops below the undervoltage detection level upon a momentary power failure, the output of the inverter is shut down, the motor enters a coast-to-stop state, but no undervoltage alarm $i, L_{\prime}^{\prime}$ issued. <br> When power is restored, an undervoltage alarm $L^{\prime} L^{\prime}$ is issued, while the motor remains in a coast-to-stop state. |
| 3 | Enable restart <br> (Continue to run, for heavy inertia or general loads) | When the DC link bus voltage drops below the continuous running level upon a momentary power failure, continuous running control is invoked. Continuous running control regenerates kinetic energy from the load's moment of inertia, slowing down the motor and prolongs the running time. When an undervoltage condition is detected due to a lack of energy to be regenerated, the output frequency at that time is saved, the output of the inverter is shut down, and the motor enters a coast-to-stop state. <br> When power is restored, if a run command has been input, restart begins at the reference frequency saved during the power failure processing. This setting is ideal for fan applications with a large moment of inertia. |
| 4 | Enable restart <br> (Restart at the frequency at which the power failure occurred, for general loads) | As soon as the voltage of the DC link bus drops below the undervoltage detection level upon a momentary power failure, the output frequency at the time is saved, the output of the inverter is shut down, and the motor enters a coast-to-stop state. <br> When power is restored, if a run command has been input restart begins at the reference frequency saved during the power failure processing. This setting is ideal for applications with a moment of inertia large enough not to slow down the motor quickly, such as fans, even after the motor enters a coast-to-stop state upon occurrence of a momentary power failure. |
| 5 | Enable: <br> Restart at the starting frequency, for low-inertia load | After a momentary power failure, when power is restored and then a run command is input, restart will begin at the starting frequency commanded by function code F23. <br> This setting is ideal for heavy load applications such as pumps, having a small moment of inertia, in which the motor speed quickly goes down to zero as soon as it enters a coast-to-stop state upon occurrence of a momentary power failure. |

## $\triangle$ WARNING

If you enable the "Restart mode after momentary power failure" (Function code F14 = 3, 4, or 5), the inverter automatically restarts the motor running when the power is recovered. Design the machinery or equipment so that human safety is ensured after restarting.
Otherwise an accident could occur.

Restart mode after momentary power failure (Basic operation)
The inverter recognizes a momentary power failure upon detecting the condition that DC link bus voltage goes below the undervoltage level, while the inverter in running. If the load of the motor is light and the duration of the momentary power failure is extremely short, the voltage drop may not be great enough for a momentary power failure to be recognized, and the motor may continue to run uninterrupted.

Upon recognizing a momentary power failure, the inverter enters the restart mode (after a recovery from momentary power failure) and prepares for restart. When power is recovered, the inverter goes through an initial charging stage and enters the ready-to-run state. When a momentary power failure occurs, the power supply voltage for external circuits such as relay sequence circuits may also drop, the run command may be turned off. In consideration of such a situation, the inverter waits 2 seconds for input of a run command after the inverter enters ready-to-run state. If a run command is received within 2 seconds, the inverter begins the restart processing in accordance with the data of F14 (Mode selection). If no run command has been received within 2 -second wait period, the restart mode (after a recovery from momentary power failure) will be canceled, and the inverter needs to be started again from the ordinary starting frequency. Therefore, ensure that a run command is entered within 2 seconds after a recovery of power, or install a mechanical latch relay.

In case the run commands are entered via the keypad, the above operation is also necessary for the mode ( $\mathrm{FO} 2=0$ ) in which the direction of rotation is determined by the terminal command, (FWD) or (REV). In the modes where the direction of rotation is fixed (FO2 = 2 or 3 ), the direction of rotation is retained inside the inverter, and the restart will begin as soon as the inverter enters the ready-to-run state.


Note
When the power is recovered, the inverter will wait 2 seconds for input of a run command. However, if the allowable momentary power failure time (H16) elapses after the power failure was recognized, even within the 2 seconds, the waiting time for a run command is canceled. The inverter will start operation in the normal stating sequence.

If a coast-to-stop command $(\mathrm{BX})$ is entered during the power failure, the inverter gets out of the restart mode and enters the normal running mode. If a run command is entered with power supply applied, the inverter will start from the normal starting frequency.
The inverter recognizes a momentary power failure by detecting an undervoltage condition whereby the voltage of the DC link bus goes below the lower limit. In a configuration where a magnetic contactor is installed on the output side of the inverter, the inverter may fail to recognize a momentary power failure because the momentary power failure shuts down the operating power of the magnetic contactor, causing the contactor circuit to open. When the contactor circuit is open, the inverter is cut off from the motor and load, and the voltage drop in the DC link bus is not great enough to be recognized as a power failure. In such an event, restart after a recovery from momentary power failure does not work properly as designed. To solve this, connect the interlock command (IL) line to the auxiliary contact of the magnetic contactor, so that a momentary power failure can sure be detected.

During a momentary power failure the motor slows down. After power has been recovered, the inverter is restarted at the frequency just before the momentary power failure. Then, the current limiting function works and the output frequency of the inverter automatically decreases. When the output frequency matches the motor speed, the motor accelerates up to the original frequency. See the figure below. In this case, the instantaneous overcurrent limiting must be enabled ( $\mathrm{H} 12=1$ ).


- Restart mode after momentary power failure (Allowable momentary power failure time) (H16)

H16 specifies the maximum allowable duration ( 0.0 to 30.0 seconds) from an occurrence of a momentary power failure (undervoltage) until the inverter is to be restarted. Specify the coast-to-stop time during which the machine system and facility can be tolerated.

If the power is recovered within the specified duration, the inverter restarts in the restart mode specified by F14. If the power is recovered after the specified duration, the inverter recognizes that the power has been shut down so that it does not restart but starts (normal starting).


If you set the allowable momentary power failure time (H16) to "999," restart will take place until the DC link bus voltage drops down to the allowable voltage for restart after a momentary power failure as shown below. If the DC link bus voltage drops below the allowable voltage for restart after momentary power failure, the inverter recognizes that the power has been shut down so that it does not restart but starts (normal starting).

Allowable voltage for restart after momentary power failure

| Power supply | Allowable voltage for restart after momentary power failure |
| :---: | :---: |
| 200 V series | 50 V |
| 400 V series | 100 V |

The time required from when the DC link bus voltage drops from the threshold of undervoltage until it reaches the allowable voltage for restart after momentary power failure, greatly varies depending on the inverter capacity, the presence of options, and other factors.

■ Auto-restart after a recovery from momentary power failure (waiting time) (H13)
This function specifies the time period from momentary power failure occurrence until the inverter reacts for restarting process.

If the inverter starts the motor while motor's residual voltage is still in a high level, a large inrush current may flow or an overvoltage alarm may occur due to an occurrence of temporary regeneration. For safety, therefore, it is advisable to set H 13 to a certain level so that restart will take place only after the residual voltage has dropped to a low level. Note that even when power is recovered, restart will not take place until the waiting time (H13) has elapsed.


## - Factory default

By factory default, H 13 is set at one of the values shown below according to the inverter capacity. Basically, you do not need to change H13 data. However, if the long waiting time causes the flow rate of the pump to overly decrease or causes any other problem, you might as well reduce the setting to about a half of the default value. In such a case, make sure that no alarm occurs.

| Inverter capacity <br> (kW) | Factory default of H13 (Restart time in seconds) |
| :---: | :---: |
| 0.1 to 7.5 | 0.5 |
| 11 to 37 | 1.0 |
| 45 to 110 | 1.5 |
| 132 to 160 | 2.0 |
| 200 to 280 | 2.5 |
| 315 to 355 | 4.0 |
| 400 to 500 | 5.0 |

Function code H13 (Restart mode after momentary power failure -- Restart time) also applies to the switching operation between line and inverter (refer to E01 through E05; terminals [X1] through [X5]).

- Restart after momentary power failure (Frequency fall rate) (H14)

During restart after a momentary power failure, if the inverter output frequency and the motor rotation cannot be harmonized with each other, an overcurrent will flow, activating the overcurrent limiter. If it happens, the inverter reduces the output frequency to match the motor rotation according to the reduction rate (Frequency fall rate: Hz/s) specified by H14.

| Data for H 14 | Inverter's action on the frequency fall rate |
| :---: | :--- |
| 0.00 | Follow the deceleration time specified by F08 |
| 0.01 to $100.00 \mathrm{~Hz} / \mathrm{s}$ | Follow data specified by H14 |
| 999 | Follow the setting of the PI controller in current limiter <br> (The PI constant is prefixed inside the inverter.) |

## Note

If the frequency fall rate is too high, regeneration may take place at the moment the motor rotation matches the inverter output frequency, causing an overvoltage trip. On the contrary, if the frequency fall rate is too low, the time required for the output frequency to match the motor speed (duration of current limiting action) may be prolonged, triggering the inverter overload prevention control.

| F15 | Frequency Limiter (High) <br> F16 |
| :--- | :--- |

F15 and F16 specify the upper and lower limits of the output frequency, respectively.


- When you change the frequency limiter (High) (F15) in order to raise the running frequency, be sure to change the maximum frequency (F03) accordingly.
- Maintain the following relationship among the data for frequency control:
F15 > F16, F15 > F23, and F15 > F25
F03 > F16
where, F23 is of the starting frequency and F25 is of the stop frequency.
If you specify any wrong data for these function codes, the inverter may not run the motor at the desired speed, or cannot start it normally.

C32, C34 Analog Input Adjustment for [12]

Analog Input Adjustment for [C1] Analog Input Adjustment for [V2]
(Gain, Gain reference point)
(Gain, Gain reference point)
(Gain, Gain reference point)

When any analog input for frequency command 1 (F01) is used, it is possible to define the relationship between the analog input and the reference frequency by multiplying the gain and adding the bias specified by F18.

As shown in the graph below, the relationship between the analog input and the reference frequency specified by frequency command 1 is determined by points "A" and "B." Point "A" is defined by the combination of the bias (F18) and its reference point (C50); Point B, by the combination of the gain (C32, C37 or C42) and its reference point (C34, C39 or C44).

The combination of C32 and C34 applies to terminal [12], that of C37 and C39, to [C1], and that of C42 and C44, to [V2].

Configure the bias (F18) and gain (C32, C37 or C42), assuming the maximum frequency as $100 \%$, and the bias reference point (C50) and gain reference point (C34, C39 or C44), assuming the full scale ( 10 VDC or 20 mA DC ) of analog input as $100 \%$.

Note

- The analog input less than the bias reference point (C50) is limited by the bias value (F18)
- Specifying that the data of the bias reference point (C50) is equal to or greater than that of each gain reference point (C34, C39 or C44) will be interpreted as invalid, so the inverter will reset the reference frequency to 0 Hz .


Example: Setting the bias, gain and its reference points when the reference frequency 0 to $100 \%$ follows the analog input of 1 to 5 VDC to terminal [12] (in frequency command 1).


To set the reference frequency to 0 Hz for an analog input being at 1 V , set the bias to $0 \%$ (F18 = 0). Since 1 V is the bias reference point and it is equal to $10 \%$ of 10 V , set the bias reference point to $10 \%(C 50=10)$.
(Point B)
To make the maximum frequency equal to the reference frequency for an analog input being at 5 V , set the gain to $100 \%(C 32=100)$. Since 5 V is the gain reference point and it is equal to $50 \%$ of 10 V , set the gain reference point to $50 \%(\mathrm{C} 34=50)$.

The setting procedure for specifying a gain or bias alone without changing any reference points is the same as that of Fuji conventional inverters of FRENIC5000G11S/P11S series, FVR-E11S series, etc.

F20 to F22 DC Braking (Braking start frequency, Braking level, and Braking time)
H95 DC Braking (Braking response mode)
F20 through F22 specify the DC braking that prevents the motor from running by inertia during deceleration-to-stop operation
If the motor enters a deceleration-to-stop operation by turning off the run command or by decreasing the reference frequency below the stop frequency, the inverter activates the DC braking by flowing a current at the braking level (F21) during the braking time (F22) when the output frequency reaches the DC braking start frequency (F20).
Setting the braking time to "0.0" (F22 = 0) disables the DC braking.


Tip It is also possible to use an external digital input signal as a DC braking command (DCBRK).
As long as the (DCBRK) command is ON, the inverter performs DC braking, regardless of the braking time specified by F22.
Turning the (DCBRK) command ON even when the inverter is in a stopped state activates DC braking. This feature allows the motor to be excited before starting, resulting in smoother acceleration (quicker build-up of acceleration torque).
In general, specify data of the function code F20 at a value close to the rated slip frequency of motor. If you set it at an extremely high value, control may become unstable and an overvoltage alarm may result in some cases.

| $\triangle \mathrm{CAUTION}$ |
| :--- |
| The DC brake function of the inverter does not provide any holding mechanism. <br> Injuries could occur. |

At the startup of an inverter, the initial output frequency is equal to the starting frequency. The inverter stops its output at the stop frequency.
Set the starting frequency to a level that will enable the motor to generate enough torque for startup. Generally, set the motor's rated slip frequency at the starting frequency F23.

Note If the starting frequency is lower than the stop frequency, the inverter will not output any power as long as the frequency command does not exceed the stop frequency.


| F26 | Motor Sound (Carrier frequency) <br> F27 |
| :--- | :--- |
|  | Motor Sound (Tone) |

F26 controls the carrier frequency so as to reduce an audible noise generated by the motor or inverter itself, and to decrease a leakage current from the main output (secondary) wirings.

| Carrier frequency | Inverter rated capacity: 0.75 to 22 kW | 0.75 to 15 kHz |
| :--- | :--- | :--- |
|  | Inverter rated capacity: 30 to 75 kW | 0.75 to 10 kHz |
|  | Inverter rated capacity: 90 to 500 kW | 0.75 to 6 kHz |
| Motor sound noise emission | High $\leftrightarrow$ Low |  |
| Motor temperature (due to harmonics components) | High $\leftrightarrow$ Low |  |
| Ripples in output current waveform | Large $\leftrightarrow$ Small |  |
| Leakage current | Low $\leftrightarrow$ High |  |
| Electromagnetic noise emission | Low $\leftrightarrow$ High |  |
| Inverter loss | Low $\leftrightarrow$ High |  |

Note
Specifying a too low carrier frequency will cause the output current waveform to have a large amount of ripples (many harmonics components). As a result, the motor loss increases, causing the motor temperature to rise. Furthermore, the large amount of ripples tends to cause a current limiting alarm. When the carrier frequency is set to 1 kHz or below, therefore, reduce the load so that the inverter output current comes to be $80 \%$ or less of the rated current.
When a high carrier frequency is specified, the temperature of the inverter may rise due to an ambient temperature rise or an increase of the load. If it happens, the inverter automatically decreases the carrier frequency to prevent the inverter overheat alarm : matic reduction of carrier frequency can be disabled (see function code H98).

Motor sound (Tone) (F27)
F12 changes the motor running sound tone. This setting is effective when the carrier frequency set to function code F26 is 7 kHz or lower. Changing the tone level may reduce the high and harsh running noise from the motor.

| Data for F27 | Function |
| :---: | :---: |
| 0 | Disable (Tone level 0) |
| 1 | Enable (Tone level 1) |
| 2 | Enable (Tone level 2) |
| 3 | Enable (Tone level 3) |

If the sound level is set too high, the output current may become unstable, or mechanical vibration and noise may increase. Also, these function codes may not be very effective for certain types of motor.

| F29 | Analog Output [FMA] |
| :--- | :--- |
| F30 | (Mode selection) <br> (Output adjustment) <br> F31 |
| (Function) |  |

These function codes allow you to output to terminal [FMA] monitored data such as the output frequency and the output current in the form of an analog DC voltage or current. The magnitude of such analog voltage or current is adjustable.

- Mode selection (F29)

F29 specifies the property of the output to terminal [FMA]. You need to set switch SW4 on the control PCB accordingly, referring to the table below.

| Data for F29 | Output form | Positioning slide switch (SW4) <br> mounted on the control PCB |
| :---: | :---: | :---: |
| 0 | Voltage (0 to $+10 \mathrm{VDC})$ | VO |
| 1 | Current (+4 to $+20 \mathrm{mADC})$ | 10 |

The current output is not isolated from the analog input and does not have its own independent power source. Therefore, this output must not be connected in cascade to outside instrument and gauges if some difference in potential is there between the inverter and peripheral equipment regarding connection of analog input etc. Avoid needlessly long wiring.

F30 allows you to adjust the output voltage or current representing the monitored data selected by function code F31 within the range of 0 to $200 \%$.


- Function (F31)

F31 specifies what is output to the analog output terminal [FMA].

| Data for F31 | [FMA] output | Function (Monitor the following) | Meter scale <br> (Full scale at 100\%) |
| :---: | :---: | :---: | :---: |
| 0 | Output frequency | Output frequency of the inverter | Maximum frequency (F03) |
| 2 | Output current | Output current (RMS) of the inverter | Twice the inverter rated current |
| 3 | Output voltage | Output voltage (RMS) of the inverter | 250 V for 200 V series, 500 V for 400 V series |
| 4 | Output torque | Motor shaft torque | Twice the rated motor torque |
| 5 | Load factor | Load factor (Equivalent to the indication of the load meter) | Twice the rated motor load, or <br> - Rated output torque of the motor at the base frequency or below <br> - Rated motor output (kW) at the base frequency or above |
| 6 | Input power | Input power of the inverter | Twice the rated output of the inverter |
| 7 | PID feedback value (PV) | Feedback value under PID control | 100\% of the feedback value |
| 9 | DC link bus voltage | DC link bus voltage of the inverter | 500 V for 200 V series, 1000 V for 400 V series |
| 10 | Universal AO | Command via communications link (Refer to the RS485 Communications User's Manual (MEH448a)) | 20,000 as 100\% |
| 13 | Motor output | Motor output (kW) | Twice the rated motor output |
| 14 | Calibration analog output (+) | Full scale output of the meter calibration | 10 VDC or 20 mA DC |
| 15 | PID process command (SV) | Process command under PID control | 100\% of the feedback value |
| 16 | PID process output (MV) | Output level of the PID controller under PID control (Frequency command) | Maximum frequency (F03) |


| F33 | Pulse Output [FMP] |
| :--- | :--- |
| F34 | (Pulse rate) <br> (Duty) <br> F35 |

The control PCB is equipped with either a screw terminal base or Europe type terminal block, supporting [FMP] or [FMI], respectively. The [FMP] enables F33 to F35, but the [FMI] enables only F34 and F35 so that F33 will not appear.

## For [FMP]

These function codes allow you to output to terminal [FMP] monitored data such as the output frequency and the output current in the form of a variable rate pulse train or a These function codes allow you to output monitored data (such as the output frequency and the output current) to terminal [FMP] in the form of a variable rate pulse train or a fixed rate pulse train. The fixed rate pulse train (whose pulse duty control produces a variance of an average output voltage of the train) can be used to drive an analog meter.
The output pulse can be specified for each of monitored data items.
To use this terminal for pulse output, set F33 to an appropriate value and set F34 to "0."
To use this terminal for fixed rate pulse train output, set F34 within the range from 1 to $200 \%$. This setting causes the setting of F33 to be ignored.

- Pulse rate (F33)

F33 specifies the number of pulses at which the output of the set monitored item reaches $100 \%$, in accordance with the specifications of the counter to be connected.

Duty (F34)

| Data for F34 | [FMP] output | Pulse duty | Pulse rate | Connected equipment <br> (Example) |
| :---: | :--- | :--- | :--- | :--- |
| 0 | Pulse train | Around $50 \%$ | Variable | Pulse counter |
| 1 to $200 \%$ | Fixed rate pulse <br> train | Variable | $2000 \mathrm{p} / \mathrm{s}$ | Analog meter |

F34 allows you to scale the average voltage corresponding to full scale of the monitored item selected by function code F35 within the range of 1 to 200 (\%) where $100 \%$ stands on a half cycle of a square wave pulse in the train.


Average Voltage $\left.\begin{array}{l}\text { Pulse train output waveform } \\ \text { of Pulse Train Output }\end{array}\right]=-1 \mathrm{~V}^{\max }$


For the voltage specifications of the pulse output, refer to Chapter 2 "MOUNTING AND WIRING OF THE INVERTER."

F35 selects the item (object) to monitor and to output to the [FMP] terminal. Those contents, and amounts (Definition of $100 \%$ ) are the same as those for function code F31. Refer to the table in function code F31.

## For [FMI]

The inverter outputs monitoring data including output frequency and output current via terminal [FMI] in analog current level.

- Voltage adjust (F34)

Setting this function code adjusts the output current level of the selected monitor item within 0 to $200 \%$ as well as the function code F30.

- Function (F35)

Setting this function code selects a monitor item to be output to terminal [FMI] as well as the function code F31.

E01 to E05
Command Assignment to [X1] to [X5]
E98, E99
Command Assignment to [FWD] and [REV]
Function codes E01 to E05, E98 and E99 allow you to assign commands to terminals [X1] to [X5], [FWD], and [REV] which are general-purpose, programmable input terminals.

These function codes may also switch the logic system between normal and negative to define how the inverter logic interprets either ON or OFF status of each terminal. The default setting is normal logic system "Active ON." So, explanations that follow are given in normal logic system "Active ON."

## $\triangle$ CAUTION

In the case of digital input, you can assign commands to the switching means for the run command and its operation, the reference frequency and the motor drive power (e.g., (SS1), (SS2), (SS4), (Hz2/Hz1), (SW50), (SW60), (Hz/PID), (IVS), (LE), (LOC), and (FR2/FR1)). Be aware of that switching of any of such signals may cause a sudden start (running) or an abrupt change in speed.
An accident or physical injury may result.

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| Function code data |  | Terminal commands assigned | Symbol |
| :---: | :---: | :---: | :---: |
| Active ON | Active OFF |  |  |
| 0 | 1000 | Select multistep frequency | (SS1) |
| 1 | 1001 |  | (SS2) |
| 2 | 1002 |  | (SS4) |
| 6 | 1006 | Enable 3-wire operation | (HLD) |
| 7 | 1007 | Coast to a stop | (BX) |
| 8 | 1008 | Reset alarm | (RST) |
| 1009 | 9 | Enable external alarm trip | (THR) |
| 11 | 1011 | Switch frequency command 2/1 | (Hz2/Hz1) |
| 13 | - | Enable DC brake | (DCBRK) |
| 15 | - | Switch to commercial power ( 50 Hz ) | (SW50) |
| 16 | - | Switch to commercial power ( 60 Hz ) | (SW60) |
| 17 | 1017 | UP (Increase output frequency) | (UP) |
| 18 | 1018 | DOWN (Decrease output frequency) | (DOWN) |
| 19 | 1019 | Enable write from keypad (Data changeable) | (WE-KP) |
| 20 | 1020 | Cancel PID control | (Hz/PID) |
| 21 | 1021 | Switch normal/inverse operation | (IVS) |
| 22 | 1022 | Interlock | (IL) |
| 24 | 1024 | Enable communications link via RS485 or field bus (op- | (LE) |
| 25 | 1025 | Universal DI | (U-DI) |
| 26 | 1026 | Select starting characteristics | (STM) |
| 1030 | 30 | Force to stop | (STOP) |
| 33 | 1033 | Reset PID integral and differential components | (PID-RST) |
| 34 | 1034 | Hold PID integral component | (PID-HLD) |
| 35 | 1035 | Select local (keypad) operation | (LOC) |
| 38 | 1038 | Enable to run | (RE) |
| 39 | - | Protect motor from dew condensation | (DWP) |
| 40 | - | Enable integrated sequence to switch to commercial power ( 50 Hz ) | (ISW50) |
| 41 | - | Enable integrated sequence to switch to commercial power ( 60 Hz ) | (ISW60) |
| 50 | 1050 | Clear periodic switching time | (MCLR) |
| 51 | 1051 | Enable Pump Drive (Motor 1 to 4) | (MEN1) |
| 52 | 1052 |  | (MEN2) |
| 53 | 1053 |  | (MEN3) |
| 54 | 1054 |  | (MEN4) |
| 87 | 1087 | Switch run command 2/1 | (FR2/FR1) |
| 88 | - | Run forward 2 | (FWD2) |
| 89 | - | Run reverse 2 | (REV2) |
| 98 | - | Run forward (Exclusively assigned to [FWD] and [REV] | (FWD) |
| 99 | - | Run reverse (Exclusively assigned to [FWD] and [REV] | (REV) |

Any negative logic (Active off) command cannot be assigned to the functions marked with "-" in the "Active OFF" column.
The "Enable external alarm trip" and "Force to stop" are fail-safe terminal commands. For example, when data $=$ " 9 " in "Enable external alarm trip," Active OFF (alarm is triggered when OFF); when data $=1009$, "Active ON" (alarm is triggered when ON).

- Select multistep frequency (1 to 7 steps) - (SS1), (SS2), and (SS4)
(Function code data $=0,1$, and 2)
The combination of ON/OFF states of digital input signals (SS1), (SS2) and (SS4) selects one of eight different frequency commands defined beforehand by seven function codes C05 to C11 (Multistep frequency 1 to 7 ). With this, the inverter can drive the motor at 8 different preset speeds.
The table below lists the frequencies that can be obtained by the combination of switching (SS1), (SS2), and (SS4). In the "Selected frequency" column, "Other than multistep frequency" represents the reference frequency commanded by frequency command 1 (F01), frequency command 2 (C30), or others.

| Terminal [X3] <br> (Function code E03) | Terminal [X2] <br> (Function code E02) | Terminal [X1] <br> (Function code E01) | Selected frequency |
| :---: | :---: | :---: | :---: |
| 2 (SS4) | 1 (SS2) | 0 (SS1) |  |
| OFF | OFF | OFF | Other than multistep frequency |
| OFF | OFF | ON | C05 (Multistep frequency 1) |
| OFF | ON | OFF | C06 (Multistep frequency 2) |
| OFF | ON | ON | C07 (Multistep frequency 3) |
| ON | OFF | OFF | C08 (Multistep frequency 4) |
| ON | OFF | ON | C09 (Multistep frequency 5) |
| ON | ON | OFF | C10 (Multistep frequency 6) |
| ON | ON | ON | C11 (Multistep frequency 7) |

- Enable 3-wire operation -- (HLD)
(Function code data $=6$ )
Turning this terminal command ON self-holds the forward (FWD) or reverse (REV) run command issued with it, to enable 3-wire operation.
Turning (HLD) ON self-holds the first (FWD) or (REV) command at its leading edge. Turning (HLD) OFF releases the self-holding.
When (HLD) is not assigned, 2-wire operation involving only (FWD) and (REV) takes effect.

- Coast to a stop -- (BX)
(Function code data $=7$ )
Turning (BX) ON will immediately stop and the motor will enter the coast to a stop operation without issuing any alarms.

■ Reset alarm -- (RST)
(Function code data $=8$ )
Turning this terminal command ON clears the (ALM) state--alarm output (for any fault). Turning it OFF erases the alarm display and clears the alarm hold state.

When you turn the (RST) command ON, keep it ON for 10 ms or more. This command should be kept OFF for the normal inverter operation.


■ Enable external alarm trip -- (THR)
(Function code data = 9)
Turning this terminal command OFF immediately shuts down the inverter output (so that the motor coasts to stop), displays the alarm The (THR) is self-held, and is reset when an alarm reset takes place.

Tip Use a trip command from external equipment when you have to immediately shut down the inverter output in the event of an abnormal situation in peripheral equipment.

Switch frequency command $2 / 1$-- (Hz2/Hz1)
(Function code data = 11)
Turning this digital input signal ON and OFF switches the frequency command source between frequency command 1 (Hz1: F01) and frequency command 2 (Hz2: C30).
If nothing is assigned to this terminal command, the frequency specified by F01 takes effect by default.

| Frequency command <br> $(\mathrm{Hz2} 2 / \mathrm{Hz} 1)$ | Frequency command source |
| :---: | :---: |
| OFF | Follow F01 (Frequency command 1) |
| ON | Follow C30 (Frequency command 2) |

- Enable DC brake -- (DCBRK)
(Function code data = 13)
Turing this terminal command ON activates the DC braking. As long as this command remains ON, the DC braking is working regardless of the braking time specified by F22. Furthermore, turning this command ON even when the inverter is in a stopped state activates DC braking. This feature allows the motor to be excited before starting, resulting in smoother acceleration (quicker build-up of acceleration torque).

Note For details, refer to the description of F20 to F22.

- Enable write from keypad -- (WE-KP)
(Function code data = 19)
Turning this terminal command OFF disables changing of function code data from the keypad.
Only when this command is ON , you can change function code data from the keypad according to the setting of function code F00 as listed below.

| (WE-KP) | F00 | Function |
| :---: | :---: | :--- |
| OFF | Disable | Disable editing of all function code data except that of F00. |
| ON | 0 | Enable editing of all function code data |
|  | 1 | Inhibit editing of all function code data except that of F00 |

If the (WE-KP) command is not assigned to any terminal, the inverter will interpret (WE-KP) to be always ON by default.

If you mistakenly assign a (WE-KP) command to a terminal, you cannot edit or modify function code data anymore. In such a case, temporarily turn on the (WE-KP)-assigned terminal and then reassign the (WE-KP) command to a correct terminal.

- Switch normal/inverse operation -- (IVS)
(Function code data $=21$ )
This terminal command switches the output frequency control between normal (proportional to the input value) and inverse in PID process control and manual frequency command. To select the inverse operation, turn the (IVS) command ON.


Tip
The normal/inverse switching operation is useful for air-conditioners that require switching between cooling and heating. In cooling, the speed of the fan motor (output frequency of the inverter) is increased to lower the temperature. In heating, it is reduced to lower the temperature. This switching is realized by the "Switch normal/inverse operation" command.
[1] For details of PID control, refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4, Section 4.9 "PID Frequency Command Generator" and Chapter 9, Section 9.2.6 "J codes."

- When the inverter is driven by an external analog frequency command sources (terminals [12], [C1], and [V2]):
The "Switch normal/inverse operation" command (IVS) can apply only to the analog frequency command sources (terminals [12], [C1] and [V2]) in frequency command 1 (F01) and does not affect frequency command 2 (C30) or UP/DOWN control.

As listed below, the combination of the "Selection of normal/inverse operation for frequency command 1" (C53) and "Switch normal/inverse operation" (IVS) determines the final operation.

Combination of C53 and (IVS)

| Data for C53 | (IVS) | Final operation |
| :---: | :---: | :---: |
| 0: Normal operation | OFF | Normal |
|  | ON | Inverse |
| 1: Inverse operation | OFF | Inverse |
|  | ON | Normal |

- Interlock -- (IL)
(Function code data = 22)
In a configuration where a magnetic contactor (MC) is installed in the power output (secondary) circuit of the inverter, the momentary power failure detection feature provided inside the inverter may not be able to accurately detect a momentary power failure by itself. Using a digital signal input with the interlock command (IL) assures the accurate detection

| (IL) | Meaning |
| :---: | :--- |
| OFF | No momentary power failure has occurred. |
| ON | A momentary power failure has occurred. <br> (Restart after a momentary power failure enabled) |

[1] For details of operation after a recovery from momentary power failure, refer to the description of function code F14.

■ Enable communications link via RS485 or field bus (option) -- (LE)
(Function code data = 24)
Turning this terminal command ON assigns priorities to frequency commands or run commands received via the RS485 communications link (H30) or the field bus option (y98).
No (LE) assignment is functionally equivalent to the (LE) being ON.
[1] For details of switching, refer to H30 (Communications link function) and y98 (Bus link function.

■ Universal DI -- (U-DI)
(Function code data $=25$ )
Using (U-DI) enables the inverter to monitor digital signals sent from the peripheral equipment via an RS485 communications link or a field bus option by feeding those signals to the digital input terminals. Signals assigned to the universal DI are simply monitored and do not operate the inverter.
(1) For an access to universal DI via the RS485 or field bus communications link, refer to their respective Instruction Manuals.

- Select starting characteristics -- (STM)
(Function code data $=26$ )
This digital terminal command determines, at the start of operation, whether or not to search for idling motor speed and follow it.
[1] For details of auto search for idling motor speed, refer to H 09 and H 17 (Select starting characteristics).
- Force to stop -- (STOP)
(Function code data $=30$ )
Turning this terminal command OFF causes the motor to decelerate to a stop during the time specified by H56 (Deceleration time for forced stop). After the motor stops, the inverter enters the alarm state with alarm Apply this command to a failsafe facility.
- Select local (keypad) operation -- (LOC)
(Function code data = 35)
This terminal command switches the source of the run command and frequency command between remote and local by an external digital input signal.
[】] For details of the local mode, refer to "Switching between remote and local modes" in Chapter 3, Section 3.3.3.
- Protect motor from dew condensation -- (DWP)
(Function code data $=39$ )
Turning this terminal command ON supplies a DC current to the motor that is on halt in order to generate heat, preventing dew condensation.
[1] For details of dew condensation protection, refer to function code J21 (Dew condensation prevention (Duty)).
- Switch run command 2/1-- (FR2/FR1)

Run forward 2 and Run reverse 2 -- (FWD2) and (REV2)
(Function code data $=87,88$ or 89)
These terminal commands switch the run command source. They are useful to switch the source between the digital input and the local keypad when the "Enable communications link" command (LE) and "Select local (keypad) operation" command (LOC) are turned OFF.
[】] Refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4, Section 4.3 "Drive Command Generator" for details.

| (FR2/FR1) | Run command source |  |
| :---: | :--- | :--- |
|  | Communications link disabled <br> (Normal operation) | Communications link enabled |
| OFF | Follow the data of F02 | Follow the data of S06 (FWD/REV) |
| ON | (FWD2) or (REV2) | Follow the data of S06 (FWD2/REV2) |

Turning the (FWD2) command ON runs the motor forward, and turning the (REV2) command, reverse. Turning either of them OFF decelerates the motor to stop.

- Run forward -- (FWD)
(Function code data $=98$ )
Turning this terminal command ON runs the motor in the forward direction; turning it OFF decelerates it to stop.
[1] This terminal command can be assigned only by E98 or E99.
- Run reverse -- (REV)
(Function code data = 99)
Turning this terminal command ON runs the motor in the reverse direction; turning it OFF decelerates it to stop.
[1] This terminal command can be assigned only by E98 or E99.

E20 to E22, E24, and E27 assign output signals (listed on the next page) to general-purpose, programmable output terminals [Y1], [Y2], [Y3], [Y5A/C], and [30A/B/C]. These function codes can also switch the logic system between normal and negative to define the property of those output terminals so that the inverter logic can interpret either the ON or OFF status of each terminal as active. The factory default settings are "Active ON."
Terminals [Y1], [Y2], and [Y3] are transistor outputs and terminals [ $\mathrm{Y} 5 \mathrm{~A} / \mathrm{C}$ ] and [30A/B/C] are relay contact outputs. In normal logic, if an alarm occurs, the relay will be energized so that [30A] and $[30 \mathrm{C}]$ will be closed, and $[30 \mathrm{~B}]$ and $[30 \mathrm{C}]$ opened. In negative logic, the relay will be deenergized so that $[30 \mathrm{~A}]$ and $[30 \mathrm{C}]$ will be opened, and $[30 \mathrm{~B}]$ and $[30 \mathrm{C}]$ closed. This may be useful for the implementation of failsafe power systems.

Note

- When a negative logic is employed, all output signals are active (e.g. an alarm would be recognized) while the inverter is powered OFF. To avoid causing system malfunctions by this, interlock these signals to keep them ON using an external power source. Furthermore, the validity of these output signals is not guaranteed for approximately 3 seconds after power-on, so introduce such a mechanism that masks them during the transient period.
- Terminals $[\mathrm{Y} 5 \mathrm{~A} / \mathrm{C}]$ and $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ ) use mechanical contacts that cannot stand frequent ON/OFF switching. Where a frequent ON/OFF switching is anticipated (for example, limiting a current by using signals subjected to inverter output limit control such as switching to commercial power line), use transistor outputs [Y1] through [Y3] instead. The service life of a relay is approximately 200,000 times if it is switched on and off at one-second intervals.

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The table below lists functions that can be assigned to terminals [Y1], [Y2], [Y3], [Y5A/C], and [30A/B/C].
To make the explanations simpler, the examples shown below are all written for the normal logic (Active ON.)

| Function code data |  | Functions assigned | Symbol |
| :---: | :---: | :---: | :---: |
| Active ON | Active OFF |  |  |
| 0 | 1000 | Inverter running | (RUN) |
| 1 | 1001 | Frequency arrival signal | (FAR) |
| 2 | 1002 | Frequency detected | (FDT) |
| 3 | 1003 | Undervoltage detected (Inverter stopped) | (LU) |
| 5 | 1005 | Inverter output limiting | (IOL) |
| 6 | 1006 | Auto-restarting after momentary power failure | (IPF) |
| 7 | 1007 | Motor overload early warning | (OL) |
| 10 | 1010 | Inverter ready to run | (RDY) |
| 11 | - | Switch motor drive source between commercial power and inverter output (For MC on commercial line) | (SW88) |
| 12 | - | Switch motor drive source between commercial power and inverter output (For primary side) | (SW52-2) |
| 13 | - | Switch motor drive source between commercial power and inverter output (For secondary side) | (SW52-1) |
| 15 | 1015 | Select AX terminal function (For MC on primary side) | (AX) |
| 25 | 1025 | Cooling fan in operation | (FAN) |
| 26 | 1026 | Auto-resetting | (TRY) |
| 27 | 1027 | Universal DO | (U-DO) |
| 28 | 1028 | Heat sink overheat early warning | $(\mathrm{OH})$ |
| 30 | 1030 | Service life alarm | (LIFE) |
| 33 | 1033 | Command loss detected | (REF OFF) |
| 35 | 1035 | Inverter output on | (RUN2) |
| 36 | 1036 | Overload prevention control | (OLP) |
| 37 | 1037 | Current detected | (ID) |
| 42 | 1042 | PID alarm | (PID-ALM) |
| 43 | 1043 | Under PID control | (PID-CTL) |
| 44 | 1044 | Motor stopping due to slow flowrate under PID control | (PID-STP) |
| 45 | 1045 | Low output torque detected | (U-TL) |
| 54 | 1054 | Inverter in remote operation | (RMT) |
| 55 | 1055 | Run command activated | (AX2) |
| 56 | 1056 | Motor overheat detected (PTC) | (THM) |
| 60 | 1060 | Mount motor 1, inverter-driven | (M1_I) |
| 61 | 1061 | Mount motor 1, commercial-power-driven | (M1_L) |
| 62 | 1062 | Mount motor 2, inverter-driven | (M2_I) |
| 63 | 1063 | Mount motor 2, commercial-power-driven | (M2_L) |
| 64 | 1064 | Mount motor 3, inverter-driven | (M3_I) |
| 65 | 1065 | Mount motor 3, commercial-power-driven | (M3_L) |
| 67 | 1067 | Mount motor 4, commercial-power-driven | (M4_L) |
| 68 | 1068 | Periodic switching early warning | (MCHG) |
| 69 | 1069 | Pump control limit signal | (MLIM) |
| 99 | 1099 | Alarm output (for any alarm) | (ALM) |

A mark "-" in the Active OFF column means that a negative logic cannot be applied to the terminal function.
(Function code data $=0$ )
This output signal is used to tell the external equipment that the inverter is running at a starting frequency or higher. It comes ON when the output frequency exceeds the starting frequency, and it goes OFF when it is less than the stop frequency. It is also OFF when the DC braking is in operation.
If this signal is assigned in negative logic (Active OFF), it can be used as a signal indicating "inverter being stopped."

- Frequency arrival signal -- (FAR)
(Function code data $=1$ )
This output signal comes ON when the difference between the output frequency and reference frequency comes within the allowable error zone. (prefixed to 2.5 Hz ).
- Frequency detected -- (FDT)
(Function code data $=2$ )
This output signal comes ON when the output frequency exceeds the frequency detection level specified by function code E31, and it goes OFF when the output frequency drops below the "Detection level - 1 Hz (hysteresis band of frequency comparator: prefixed at 1 Hz )."
- Undervoltage detected -- (LU)
(Function code data $=3$ )
This output signal comes ON when the DC link bus voltage of the inverter drops below the specified undervoltage level, and it goes OFF when the voltage exceeds the level.
This signal is ON also when the undervoltage protective function is activated so that the motor is in an abnormal stop state (e.g., tripped).
When this signal is ON , a run command is disabled if given.
- Inverter output limiting -- (IOL)
(Function code data $=5$ )
This output signal comes ON when the inverter is limiting the output frequency by activating any of the following actions (minimum width of the output signal: 100 ms ).
- Current limiting by software (F43 and F44: Current limiter (Mode selection) and (Level))
- Instantaneous overcurrent limiting by hardware $(\mathrm{H} 12=1)$
- Automatic deceleration $(\mathrm{H} 69=3)$ )

Note When the (IOL) signal is ON, it may mean that the output frequency may have deviated from (or dropped below) the frequency specified by the frequency command because of this limiting function.

- Auto-restarting after momentary power failure -- (IPF)
(Function code data $=6$ )
This output signal is ON either during continuous running after a momentary power failure or during the period from when the inverter has detected an undervoltage condition and shut down the output until restart has been completed (the output has reached the reference frequency).
To enable this (IPF) signal, set F14 (Restart mode after momentary power failure) to "3: Enable restart (Continue to run)," "4: Enable restart (Restart at the frequency at which the power failure occurred)," or "5: Enable restart (Restart at the starting frequency)" beforehand.

■ Motor overload early warning -- (OL)
(Function code data $=7$ )
This output signal is used to issue a motor overload early warning that enables you to take an corrective action before the inverter detects a motor overload alarm ili' $\dot{\prime}$ and shuts down its output.
This signal comes ON when the current exceeds the level specified by E34 (Overload early warning).

Note Function code E34 is effective for not only the (OL) signal, but also for the "Current detected" signal (ID).

■ Inverter ready to run -- (RDY)
(Function code data $=10$ )
This output signal comes ON when the inverter becomes ready to run by completing hardware preparation (such as initial charging of DC link bus capacitors and initialization of the control circuit) and no protective functions are activated.

- Select AX terminal function -- (AX)
(Function code data $=15$ )
In response to a run command (FWD), this output signal controls the magnetic contactor on the commercial-power supply side. It comes ON when the inverter receives a run command and it goes OFF after the motor decelerates to stop because of a stop command received.
This signal immediately goes OFF upon receipt of a coast-to-stop command or when an alarm occurs.

- Cooling fan in operation -- (FAN)
(Function code data $=25$ )
Under the cooling fan ON/OFF control enabled ( $\mathrm{H} 06=1$ ), this output signal is ON when the cooling fan is in operation, and OFF when it is stopped. This signal can be used to make the cooling system of peripheral equipment interlocked for an ON/OFF control.

■ Auto-resetting -- (TRY)
(Function code data = 26)
This output signal comes ON when auto resetting is in progress. The auto-resetting is specified by H 04 and H 05 (Auto-resetting). Refer to function codes H 04 and H 05 for details about the number of resetting times and reset interval.

■ Universal DO -- (U-DO)
(Function code data = 27)
Assigning this output signal to an inverter's output terminal and connecting the terminal to a digital input terminal of peripheral equipment via the RS485 communications link or the field bus, allows the inverter to send commands to the peripheral equipment.

The universal DO can be used as an output signal independent of the inverter operation.
[1] For the procedure for access to Universal DO via the RS485 communications link or field bus, refer to the respective instruction manual.

■ Heat sink overheat early warning -- ( OH )
(Function code data $=28$ )
This output signal is used to issue a heat sink overheat early warning that enables you to take a corrective action before an overheat trip Lilliti' $^{\prime}$ actually happens.
 temperature minus $5^{\circ} \mathrm{C}$," and it goes OFF when it drops down to the "overheat trip 'nilit $^{\prime}$ temperature minus $8^{\circ} \mathrm{C}$."
This signal comes ON also when the internal air circulation DC fan ( 45 kW or above for 200 V series or 55 kW or above for 400 V series) has locked.

■ Service life alarm -- (LIFE)
(Function code data = 30)
This output signal comes ON when it is judged that the service life of any one of electrolytic capacitors on the PCBs, DC link bus capacitor and cooling fan has expired.
This signal comes ON also when the internal air circulation DC fan ( 45 kW or above for 200 V series or 55 kW or above for 400 V series) has locked.
This signal should be used as a guide for replacement of the capacitors and cooling fan. If this signal comes ON, use the specified maintenance procedure to check the service life of these parts and determine whether the parts should be replaced or not.
[1] For details, refer to Section 7.3, Table 7.3 "Criteria for Issuing a Lifetime Alarm."

- Command loss detected -- (REF OFF)
(Function code data = 33)
This output signal comes ON when an analog input used as a frequency command source is in a command loss state (as specified by E65) due to a wire break or a weak connection. This signal goes OFF when the operation under the analog input is resumed.
[1] For details of the command loss detection, refer to the descriptions of function code E65.

This output signal comes ON when the inverter is running at the starting frequency or below or the DC braking is in operation.

■ Overload prevention control -- (OLP)
(Function code data = 36)
This output signal comes ON when the overload prevention control is activated. The minimum ON-duration is 100 ms .
LD] For details of the overload prevention control, refer to the descriptions of function code H 70 .

- Current detected -- (ID)
(Function code data = 37)
This output signal comes ON when the output current of the inverter exceeds the level specified by E34 (Current detection (Level)) for the time longer than the one specified by E35 (Current detection (Timer)). The minimum ON-duration is 100 ms .
This signal goes OFF when the output current drops below $90 \%$ of the rated operation level.
Note
Function code E34 is effective for not only the motor overload early warning (OL), but also for the operation level of the current detection (ID).
Lal For details of the current detection, refer to the descriptions of function codes E34 and E35.

■ Low output torque detected -- (U-TL)
(Function code data $=45$ )
This output signal comes ON when the torque value calculated by the inverter decreases below the level specified by E80 (Detect low torque (Detection level)) for the time longer than the one specified by E81 (Detect low torque (Timer)). The minimum ON-duration is 100 ms .
[1] For details of the low output torque detection, refer to the description of function codes E80 and E81.

■ Inverter in remote operation -- (RMT)
(Function code data $=54$ )
This output signal comes ON when the inverter switches from local to remote mode.
[1] For details about the remote and local modes, refer to Chapter 3, Section 3.3.3 "Switching between remote and local modes."

■ Alarm output (for any alarm) -- (ALM) (Function code data = 99)
This output signal comes ON if any of the protective functions is activated and the inverter enters Alarm mode.

E34 and E35 specify, in conjunction with output terminal signals (OL) and (ID), the level and duration of overload and current beyond which an early warning will be issued.

## ■ Overload Early Warning

The warning signal (OL) is used to detect a symptom of an overload condition (alarm code $i_{\text {IIN }}^{\prime \prime \prime}$ i) of the motor so that the user can take an appropriate action before the alarm actually happens. The signal turns on when the current level specified by E34 (Overload early warning) is exceeded. In typical cases, set E34 to 80-90\% against data of F11 (Electronic thermal overload protection for motor (Overload detection level)). Specify also the thermal characteristics of the motor with F10 (Electronic thermal overload protection for motor (Select motor characteristics)) and F12 (Electronic thermal overload protection for motor (Thermal time constant)). To utilize this feature, you need to assign $(\mathrm{OL})$ (Motor overload early warning) $($ data $=7$ ) to any of the digital output terminals

## ■ Current Detection

The signal (ID) turns on when the output current of the inverter has exceeded the level specified by E34 (Current detection (Level)) and the output current continues longer than the period specified by E35 (Current detection (Timer)). The signal turns off when the output current drops below $90 \%$ of the rated operation level. (Minimum width of the output signal: 100 ms )
To utilize this feature, you need to assign (ID) (Current detection) (data $=37$ ) to any of digital output terminals.


| E51 | Display Coefficient for Input Watt-hour Data |
| :---: | :---: |
|  | Use this coefficient (multiplication factor) for displaying the input watt-hour data ( $5_{-}^{\prime \prime \prime} 7$ ) in a part of maintenance information on the keypad. |
|  | The input watt-hour data will be displayed as follows: |
|  | E51 (Coefficient for input watt-hour data) $\times$ Input watt-hour (kWh) |
|  | Note <br> Setting E51 data to 0.000 clears the input watt-hour and its data to "0." After clearing, be sure to restore E51 data to the previous display coefficient; otherwise, input watt-hour data will not be accumulated. |
|  | [1] For the procedure for viewing maintenance information, refer to Chapter 3 "OPERATION USING THE KEYPAD." |

When the analog frequency command (by frequency setting through terminals [12], [C1], and [V2]) has dropped below $10 \%$ of the expected frequency command within 400 ms , the inverter presumes that the analog frequency command wire has been broken and continues its operation at the frequency determined by the ratio specified by E 65 to the reference frequency. When the frequency command level (in voltage or current) returns to a level higher than that specified by E65, the inverter presumes that the broken wire has been fixed and continues to run following the frequency command.


In the diagram above, f 1 is the level of the analog frequency command sampled at any given time. The sampling is repeated at regular intervals to continually monitor the wiring connection of the analog frequency command.

## Note

Avoid abrupt voltage or current change for the analog frequency command. Otherwise, a broken wire condition may be recognized.
When E65 is set at 999 (Disabled), though the command loss detection signal (REF OFF) is issued, the reference frequency remains unchanged (the inverter runs at the analog frequency command as specified).
When E65 is set at "0" or 999, the reference frequency level that the broken wire has been recognized as fixed is " $\mathrm{f} 1 \times 0.2$."
When E65 is set at $100 \%$ or higher, the reference frequency level of the broken wire fixing is "f1 $\times 1$."
The command loss detection is not affected by the setting of Analog input adjustment (filter time constants: C33, C38, and C43).

| E80 | Detect Low Torque (Detection level) |
| :--- | :--- |
| E81 | Detect Low Torque (Timer) |

The signal ( $\mathrm{U}-\mathrm{TL}$ ) turns on when the torque calculated by the inverter with reference to its output current has dropped below the level specified by E80 for the time longer than the one specified by E81. The signal turns off when the calculated torque exceeds the level specified by $\mathrm{E} 80+5 \%$. The minimum width of output signal is 100 ms .
You need to assign the "Low output torque detected" signal $(U-T L)(d a t a=45)$ to the gen-eral-purpose output terminals.


The detection level is set so that $100 \%$ corresponds to the rated torque of the motor.
In the inverter's low frequency operation, as a substantial error in torque calculation occurs, no low torque can be detected within the operation range at less than $20 \%$ of the base frequency (F04). (In this case, the result of recognition before entering this operation range is retained.)
The (U-TL) signal goes off when the inverter is stopped.
Since the motor parameters are used in the calculation of torque, it is recommended that auto-tuning be applied by function code P04 to achieve higher accuracy.

| C33 | Analog Input Adjustment for [12] (Filter time constant) |
| :--- | :--- |
| C38 | Analog Input Adjustment for [[1] (Fitter time constant) |
| C43 | Analog Input Adjustment for [V2] (Filter time constant) |

P01 Motor (No. of poles)

P01 specifies the number of poles of the motor. Enter the value shown on the nameplate of the motor. This setting is used to display the motor speed on the LED monitor (refer to function code E43). The following formula is used for the conversion.

$$
\text { Motor speed }(\mathrm{r} / \mathrm{min})=\frac{120}{\text { No. of poles }} \times \text { Frequency }(\mathrm{Hz})
$$

P02 \begin{tabular}{l}
Motor (Rated capacity) <br>
\hline <br>
P02 specifies the rated capacity of the motor. Enter the rated value shown on the nameplate of <br>
the motor. <br>

| Data for P02 | Unit | Dependency on function code P99 |
| :---: | :---: | :--- |
| 0.01 to 1000 | kW | P99 $=0,3$ or 4 |
|  | HP | P99 $=1$ |

\end{tabular}

| P03 | Motor (Rated current) |
| :--- | :--- |
| P03 specifies the rated current of the motor. Enter the rated value shown on the nameplate of the <br> motor |  |

P04 Motor (Auto-tuning)

This function automatically detects the motor parameters and saves them in the inverter's internal memory. Basically, you do not need to perform tuning if you use a Fuji standard motor with a standard connection with the inverter.
In any of the following cases, you may not obtain the best performance under auto torque boost, torque calculation monitoring, or auto energy saving operation, by default settings, since the motor parameters are different from that of Fuji standard motors. In such a case, perform auto tuning.

- The motor to be driven is made by other manufacturer or is a non-standard motor.
- Cabling between the motor and the inverter is long.
- A reactor is inserted between the motor and the inverter.

Lal For details of auto tuning, refer to Chapter 4, Section 4.1.3 "Preparation before running the motor for a test -- Setting function code data."

| P06 | Motor (No-load current) |
| :--- | :--- |
| P07 | Motor (\%R1) |
| P08 | Motor (\%X) |

These function codes specify no load current, \%R1, and \%X. Obtain the appropriate values from the test report of the motor or by calling the manufacturer of the motor. If you perform auto tuning, these parameters are automatically set as well.

- No load current: Enter the value obtained from motor manufacturer.
- \%R1: Enter the value calculated by the following formula.
$\% \mathrm{R} 1=\frac{\mathrm{R} 1+\text { Cable R1 }}{\mathrm{V} /(\sqrt{3} \times \mathrm{I})} \times 100$ (\%)
where,
R1: Primary resistance of the motor ( $\Omega$ )
Cable R1: Resistance of the output cable ( $\Omega$ )
V : $\quad$ Rated voltage of the motor (V)
I: Rated current of the motor (A)
- \%X: Enter the value calculated by the following formula:
$\% \mathrm{X}=\frac{\mathrm{X} 1+\mathrm{X} 2 \times \mathrm{XM} /(\mathrm{X} 2+\mathrm{XM})+\text { Cable } \mathrm{X}}{\mathrm{V} /(\sqrt{3} \times 1)} \times 100(\%)$
where,
X1: Primary leakage reactance of the motor ( $\Omega$ )
X2: Secondary leakage reactance of the motor (converted to primary) ( $\Omega$ )
XM: Exciting reactance of the motor ( $\Omega$ )
Cable X: Reactance of the output cable ( $\Omega$ )
V : $\quad$ Rated voltage of the motor (V)
I: Rated current of the motor (A)
Note For reactance, choose the value at the base frequency (F04).

Automatic control (such as auto-torque boost and auto-energy saving) or electronic thermal motor overload protection uses the motor parameters and characteristics. To match the property of a control system with that of the motor, select characteristics of the motor and set H03 (Data Initialization) to "2" to initialize the old motor parameters stored in the inverter. When initialization is complete, data of P03, P06, P07, and P08 and the old related internal data are automatically updated.
For P99, enter the following data according to the motor type.

- $\mathrm{P} 99=0$ : Fuji standard 8 -series motors (Current standard)
- $\mathrm{P} 99=3:$ Fuji standard 6 -series motors (Conventional standard)
- $\mathrm{P} 99=4$ Other manufacturer's or unknown motors

Note
If P99 $=4$ (Other motors), the inverter runs following the motor characteristics of Fuji standard 8 -series.

H03 Data Initialization
H03 initializes the current function code settings to the factory defaults or initializes the motor parameters.
To change the H03 data, it is necessary to press and keys or and keys simultaneously.

| Data for H03 | Function |
| :---: | :--- |
| 0 | Disable initialization <br> (Settings manually made by the user will be retained.) |
| 1 | Initialize all function code data to the factory defaults |
| 2 | Initialize motor parameters in accordance with P02 (rated capacity) and P99 <br> (motor selection) |
| Function codes subject to initialization: P01, P03, P06, P07, and P08, in- <br> cluding the internal control constants <br> (These function codes will be initialized to the values listed in tables on the <br> following pages.) |  |

- To initialize the motor parameters, set the related function codes as follows.

1) P02 Motor (Rated capacity)
2) P99 Motor Selection
3) H03 Data Initializing
4) PO3 Motor (Rated current)

Set the rated capacity of the motor to be used in kW.

Select the characteristics of the motor. (Refer to the descriptions given for P99.)
Initialize the motor parameters. ( $\mathrm{H} 03=2$ )
Set the rated current on the nameplate if the already set data differs from the rated current printed on the nameplate of the motor.

- Upon completion of the initialization, the data of function code H 03 is reset to " 0 " (default setting).
- If a capacity other than that of applicable motor rating is set at P02, the capacity will be internally converted to the applicable motor rating (see the table on the following pages).

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- When Fuji standard 8 -series motors $(\mathrm{P99}=0)$ or other motors ( $\mathrm{P99}=4$ ) are selected, the motor parameters for P02 through P08 are as listed in following tables.

200 V series motors shipped for Taiwan and Korea (K)

| Motor capacity (kW) | Applicable motor rating (kW) | Rated current <br> (A) | No-load current <br> (A) | $\begin{aligned} & \% R \\ & (\%) \end{aligned}$ | $\begin{aligned} & \% X \\ & (\%) \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| P02 |  | P03 | P06 | P07 | P08 |
| 0.01 to 0.09 | 0.06 | 0.44 | 0.40 | 13.79 | 11.75 |
| 0.10 to 0.19 | 0.1 | 0.68 | 0.55 | 12.96 | 12.67 |
| 0.20 to 0.39 | 0.2 | 1.30 | 1.06 | 12.95 | 12.92 |
| 0.40 to 0.74 | 0.4 | 2.30 | 1.66 | 10.20 | 13.66 |
| 0.75 to 1.49 | 0.75 | 3.60 | 2.30 | 8.67 | 10.76 |
| 1.50 to 2.19 | 1.5 | 6.10 | 3.01 | 6.55 | 11.21 |
| 2.20 to 3.69 | 2.2 | 9.20 | 4.85 | 6.48 | 10.97 |
| 3.70 to 5.49 | 3.7 | 15.0 | 7.67 | 5.79 | 11.25 |
| 5.50 to 7.49 | 5.5 | 22.5 | 11.0 | 5.28 | 14.31 |
| 7.50 to 10.99 | 7.5 | 29.0 | 12.5 | 4.50 | 14.68 |
| 11.00 to 14.99 | 11 | 42.0 | 17.7 | 3.78 | 15.09 |
| 15.00 to 18.49 | 15 | 55.0 | 20.0 | 3.25 | 16.37 |
| 18.50 to 21.99 | 18.5 | 67.0 | 21.4 | 2.92 | 16.58 |
| 22.00 to 29.99 | 22 | 78.0 | 25.1 | 2.70 | 16.00 |
| 30.00 to 36.99 | 30 | 107 | 38.9 | 2.64 | 14.96 |
| 37.00 to 44.99 | 37 | 130 | 41.5 | 2.76 | 16.41 |
| 45.00 to 54.99 | 45 | 156 | 47.5 | 2.53 | 16.16 |
| 55.00 to 74.99 | 55 | 190 | 58.6 | 2.35 | 16.20 |
| 75.00 to 89.99 | 75 | 260 | 83.2 | 1.98 | 16.89 |
| 90.00 to 109.99 | 90 | 310 | 99.2 | 1.73 | 16.03 |
| 110.00 or above | 110 | 376 | 91.2 | 1.99 | 20.86 |

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| Motor capacity (kW) | Applicable motor rating (kW) | Rated current <br> (A) | No-load current <br> (A) | $\begin{aligned} & \text { \%R } \\ & (\%) \end{aligned}$ | $\begin{aligned} & \text { \%X } \\ & \text { (\%) } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| P02 |  | P03 | P06 | P07 | P08 |
| 0.01 to 0.09 | 0.06 | 0.22 | 0.20 | 13.79 | 11.75 |
| 0.10 to 0.19 | 0.10 | 0.35 | 0.27 | 12.96 | 12.67 |
| 0.20 to 0.39 | 0.20 | 0.65 | 0.53 | 12.95 | 12.92 |
| 0.40 to 0.74 | 0.4 | 1.15 | 0.83 | 10.20 | 13.66 |
| 0.75 to 1.49 | 0.75 | 1.80 | 1.15 | 8.67 | 10.76 |
| 1.50 to 2.19 | 1.5 | 3.10 | 1.51 | 6.55 | 11.21 |
| 2.20 to 3.69 | 2.2 | 4.60 | 2.43 | 6.48 | 10.97 |
| 3.70 to 5.49 | 3.7 | 7.50 | 3.84 | 5.79 | 11.25 |
| 5.50 to 7.49 | 5.5 | 11.5 | 5.50 | 5.28 | 14.31 |
| 7.50 to 10.99 | 7.5 | 14.5 | 6.25 | 4.50 | 14.68 |
| 11.00 to 14.99 | 11 | 21.0 | 8.85 | 3.78 | 15.09 |
| 15.00 to 18.49 | 15 | 27.5 | 10.0 | 3.25 | 16.37 |
| 18.50 to 21.99 | 18.5 | 34.0 | 10.7 | 2.92 | 16.58 |
| 22.00 to 29.99 | 22 | 39.0 | 12.6 | 2.70 | 16.00 |
| 30.00 to 36.99 | 30 | 54.0 | 19.5 | 2.64 | 14.96 |
| 37.00 to 44.99 | 37 | 65.0 | 20.8 | 2.76 | 16.41 |
| 45.00 to 54.99 | 45 | 78.0 | 23.8 | 2.53 | 16.16 |
| 55.00 to 74.99 | 55 | 95.0 | 29.3 | 2.35 | 16.20 |
| 75.00 to 89.99 | 75 | 130 | 41.6 | 1.98 | 16.89 |
| 90.00 to 109.99 | 90 | 155 | 49.6 | 1.73 | 16.03 |
| 110.00 to 131.99 | 110 | 188 | 45.6 | 1.99 | 20.86 |
| 132.00 to 159.99 | 132 | 224 | 57.6 | 1.75 | 18.90 |
| 160.00 to 199.99 | 160 | 272 | 64.5 | 1.68 | 19.73 |
| 200.00 to 219.99 | 200 | 335 | 71.5 | 1.57 | 20.02 |
| 220.00 to 249.99 | 220 | 365 | 71.8 | 1.60 | 20.90 |
| 250.00 to 279.99 | 250 | 415 | 87.9 | 1.39 | 18.88 |
| 280.00 to 314.99 | 280 | 462 | 93.7 | 1.36 | 19.18 |
| 315.00 to 354.99 | 315 | 520 | 120 | 0.84 | 16.68 |
| 355.00 to 399.99 | 355 | 580 | 132 | 0.83 | 16.40 |
| 400.00 to 449.99 | 400 | 670 | 200 | 0.62 | 15.67 |
| 450.00 to 529.99 | 450 | 770 | 270 | 0.48 | 13.03 |
| 530.00 or above | 530 | 880 | 270 | 0.53 | 13.05 |

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200 V series motors shipped for Asia (A)

| Motor capacity (kW) | Applicable motor rating (kW) | Rated current <br> (A) | No-load current <br> (A) | $\begin{aligned} & \% R \\ & (\%) \end{aligned}$ | $\begin{aligned} & \text { \%X } \\ & (\%) \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| P02 |  | P03 | P06 | P07 | P08 |
| 0.01 to 0.09 | 0.06 | 0.40 | 0.37 | 11.40 | 9.71 |
| 0.10 to 0.19 | 0.1 | 0.62 | 0.50 | 10.74 | 10.50 |
| 0.20 to 0.39 | 0.2 | 1.18 | 0.97 | 10.69 | 10.66 |
| 0.40 to 0.74 | 0.4 | 2.10 | 1.52 | 8.47 | 11.34 |
| 0.75 to 1.49 | 0.75 | 3.29 | 2.11 | 7.20 | 8.94 |
| 1.50 to 2.19 | 1.5 | 5.56 | 2.76 | 5.43 | 9.29 |
| 2.20 to 3.69 | 2.2 | 8.39 | 4.45 | 5.37 | 9.09 |
| 3.70 to 5.49 | 3.7 | 13.67 | 7.03 | 4.80 | 9.32 |
| 5.50 to 7.49 | 5.5 | 20.50 | 10.08 | 4.37 | 11.85 |
| 7.50 to 10.99 | 7.5 | 26.41 | 11.46 | 3.73 | 12.15 |
| 11.00 to 14.99 | 11 | 38.24 | 16.23 | 3.13 | 12.49 |
| 15.00 to 18.49 | 15 | 50.05 | 18.33 | 2.69 | 13.54 |
| 18.50 to 21.99 | 18.5 | 60.96 | 19.62 | 2.42 | 13.71 |
| 22.00 to 29.99 | 22 | 70.97 | 23.01 | 2.23 | 13.24 |
| 30.00 to 36.99 | 30 | 97.38 | 35.66 | 2.18 | 12.38 |
| 37.00 to 44.99 | 37 | 118.2 | 38.04 | 2.28 | 13.56 |
| 45.00 to 54.99 | 45 | 141.9 | 43.54 | 2.09 | 13.36 |
| 55.00 to 74.99 | 55 | 172.8 | 53.72 | 1.94 | 13.39 |
| 75.00 to 89.99 | 75 | 236.5 | 76.27 | 1.64 | 13.97 |
| 90.00 to 109.99 | 90 | 282.0 | 90.93 | 1.43 | 13.26 |
| 110.00 or above | 110 | 342.0 | 83.60 | 1.65 | 17.25 |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI 400 V series motors shipped for Asia (A)

| Motor capacity (kW) | Applicable motor rating | Rated current <br> (A) | No-load current <br> (A) | $\begin{aligned} & \text { \%R } \\ & (\%) \end{aligned}$ | $\begin{aligned} & \text { \%X } \\ & \text { (\%) } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| P02 |  | P03 | P06 | P07 | P08 |
| 0.01 to 0.09 | 0.06 | 0.19 | 0.16 | 12.54 | 10.68 |
| 0.10 to 0.19 | 0.1 | 0.31 | 0.21 | 12.08 | 11.81 |
| 0.20 to 0.39 | 0.2 | 0.58 | 0.42 | 12.16 | 12.14 |
| 0.40 to 0.74 | 0.4 | 1.07 | 0.66 | 9.99 | 13.38 |
| 0.75 to 1.49 | 0.75 | 1.72 | 0.91 | 8.72 | 10.82 |
| 1.50 to 2.19 | 1.5 | 3.10 | 1.20 | 6.89 | 11.80 |
| 2.20 to 3.69 | 2.2 | 4.54 | 1.92 | 6.73 | 11.40 |
| 3.70 to 5.49 | 3.7 | 7.43 | 3.04 | 6.04 | 11.73 |
| 5.50 to 7.49 | 5.5 | 11.49 | 4.35 | 5.55 | 15.05 |
| 7.50 to 10.99 | 7.5 | 14.63 | 4.95 | 4.78 | 15.59 |
| 11.00 to 14.99 | 11 | 21.23 | 7.01 | 4.02 | 16.06 |
| 15.00 to 18.49 | 15 | 28.11 | 7.92 | 3.50 | 17.61 |
| 18.50 to 21.99 | 18.5 | 35.01 | 8.47 | 3.16 | 17.97 |
| 22.00 to 29.99 | 22 | 40.11 | 9.98 | 2.92 | 17.32 |
| 30.00 to 36.99 | 30 | 55.21 | 15.44 | 2.84 | 16.10 |
| 37.00 to 44.99 | 37 | 66.88 | 16.47 | 2.99 | 17.77 |
| 45.00 to 54.99 | 45 | 80.43 | 18.84 | 2.75 | 17.54 |
| 55.00 to 74.99 | 55 | 97.91 | 23.20 | 2.55 | 17.58 |
| 75.00 to 89.99 | 75 | 133.8 | 32.93 | 2.15 | 18.30 |
| 90.00 to 109.99 | 90 | 159.4 | 39.27 | 1.87 | 17.35 |
| 110.00 to 131.99 | 110 | 195.3 | 36.10 | 2.18 | 22.81 |
| 132.00 to 159.99 | 132 | 232.4 | 45.60 | 1.91 | 20.64 |
| 160.00 to 199.99 | 160 | 282.7 | 51.06 | 1.84 | 21.58 |
| 200.00 to 219.99 | 200 | 349.1 | 56.60 | 1.72 | 21.96 |
| 220.00 to 249.99 | 220 | 381.0 | 56.84 | 1.76 | 22.96 |
| 250.00 to 279.99 | 250 | 432.5 | 69.59 | 1.52 | 20.71 |
| 280.00 to 314.99 | 280 | 481.9 | 74.18 | 1.49 | 21.06 |
| 315.00 to 354.99 | 315 | 541.0 | 95.00 | 0.92 | 18.27 |
| 355.00 to 399.99 | 355 | 603.6 | 104.5 | 0.91 | 17.96 |
| 400.00 to 449.99 | 400 | 691.5 | 158.3 | 0.67 | 17.02 |
| 450.00 to 529.99 | 450 | 788.5 | 213.7 | 0.52 | 14.05 |
| 530.00 or above | 530 | 907.2 | 213.7 | 0.58 | 14.16 |

H04 Auto－resetting（Times）
H05 Auto－resetting（Reset interval）
While the auto－resetting feature is specified，even if the protective function subject to retry is ac－ tivated and the inverter enters the forced－to－stop state（tripped state），the inverter will auto－ matically attempt to reset the tripped state and restart without issuing an alarm（for any faults）．If the protection function works in excess of the times specified by H04，the inverter will issue an alarm（for any faults）and not attempt to auto－reset the tripped state．
Listed below are the recoverable alarm statuses to be retried．

| Alarm status | LED monitor dis－ plays： | Alarm status | LED monitor dis－ plays： |
| :---: | :---: | :---: | :---: |
| Instantaneous overcurrent protection | ぐİ | Motor overheated |  |
| Overvoltage protection |  | Motor overloaded | 保 ！ |
| Heat sink overheated | －1117！ | Inverter overloaded | 兄じ |
| Inverter overheated | ハイレイン |  |  |

Number of resetting times（H04）
H04 specifies the number of auto－resetting＂retry＂times for automatically escaping the tripped state．If the protective function is activated more than the specified resetting（retry）times，the inverter issues an alarm（for any faults）and does not attempt to escape the tripped state．

## $\triangle$ WARNING

If the＂retry＂function has been specified，the inverter may automatically restart and run the motor stopped due to a trip fault，depending on the cause of the tripping．
Design the machinery so that human body and peripheral equipment safety is ensured even when the auto－resetting succeeds．
Otherwise an accident could occur．
－Reset interval（H05）
H05 specifies the interval time to attempt performing auto－resetting the tripped state．Refer to the timing scheme diagram below．
＜Operation timing scheme＞


To prolong the life of the cooling fan and to reduce fan noise during running, the cooling fan is stopped when the temperature inside the inverter drops below a certain level while the inverter is stopped. However, since frequent switching of the cooling fan shortens its life, it is kept running for 10 minutes once it is started.
This function code (H06: Cooling fan ON/OFF control) allows you to specify whether the cooling fan is to be kept running all the time or to be controlled ON/OFF.

| Data for H06 | Cooling fan ON/OFF |
| :---: | :--- |
| 0 | Disable (Always in operation) |
| 1 | Enable (ON/OFF controllable) |

## Acceleration/Deceleration Pattern

H07 specifies the acceleration and deceleration patterns (Patterns to control output frequency).

## Linear acceleration/deceleration

The inverter runs the motor with the constant acceleration and deceleration.

## S-curve acceleration/deceleration

To reduce the impact on the inverter-driven motor and/or its mechanical load during acceleration/deceleration, the inverter gradually accelerates/decelerates the motor in both the acceleration/deceleration starting and ending zones. Two types of S-curve acceleration/deceleration are available; $5 \%$ (weak) and $10 \%$ (strong) of the maximum frequency, which are shared by the four inflection points. The acceleration/deceleration time command determines the duration of acceleration/deceleration in the linear period; hence, the actual acceleration/deceleration time is longer than the reference acceleration/deceleration time.


## Acceleration/deceleration time

<S-curve acceleration/deceleration (weak): when the frequency change is more than $10 \%$ of the maximum frequency>
Acceleration/deceleration time (s): $\quad(2 \times 5 / 100+90 / 100+2 \times 5 / 100) \times$ (reference acceleration or deceleration time)
$=1.1 \times$ (reference acceleration or deceleration time)
<S-curve acceleration/deceleration (strong): when the frequency change is more than $20 \%$ of the maximum frequency>
Acceleration/deceleration time (s): $\quad(2 \times 10 / 100+80 / 100+2 \times 10 / 100) \times$ (reference acceleration/deceleration time)
$=1.2 \times$ (reference acceleration/deceleration time)

Acceleration/deceleration is linear below the base frequency (linear torque) but slows down above the base frequency to maintain a certain level of load factor (constant output).
This acceleration/deceleration pattern allows the motor to accelerate or decelerate with the maximum performance of the motor.


Note
Choose an appropriate acceleration/deceleration time considering the machinery's load torque.

Select Starting Characteristics (Auto search for idling motor speed)
H17 Select Starting Characteristics (Frequency for idling motor speed)
H09 and H17 specify the auto search mode for idling motor speed and its frequency, respectively, to run the idling motor without stopping it.
The auto search mode can be switched by assigning the (STM) terminal command to one of digital input terminals (E01 to E05, function code data $=26$ ). If no $(S T M)$ is assigned, the inverter interprets it as (STM) being ON by default.

## Searching for idling motor speed

When a run command is turned ON with the (STM) being ON, the inverter starts the auto search operation at the auto search frequency specified by H 17 to run the idling motor without stopping it. If there is a large difference between the motor speed and the auto search frequency, the current limiting control may be triggered. The inverter automatically reduces its output frequency to harmonize the idling motor speed. Upon completion of the harmonization, the inverter releases the current limiting control and accelerates the motor up to the reference frequency according to the preset acceleration time.


Searching for idling motor speed to follow

The frequency drop caused by the current limiting control during auto search for idling motor speed is determined by the frequency fall rate specified by H 14.
To use the auto search, be sure to enable the instantaneous overcurrent limiting ( $\mathrm{H} 12=1$ ).

Select starting characteristic (STM) (Digital input signal)
The (STM) terminal command specifies whether or not to perform auto search operation for idling motor speed at the start of running.

| Data for H09 | Auto search for <br> idling motor speed | "Select starting <br> characteristics" <br> terminal command <br> (STM) |  |
| :---: | :---: | :---: | :--- |
| 0 | Disable | - | Function |
| $3,4,5$ | Enable | ON | Start at the auto search frequency <br> specified by H17 |
|  |  | OFF | Start at the starting frequency |

- Frequency for idling motor speed (H17)

H 17 specifies the auto search frequency for idling motor speed. Be sure to set a value higher than the idling motor speed. Otherwise, an overvoltage trip may occur. If the current motor speed is unknown, specify "999" that uses the maximum frequency at the start of auto search operation.

- Auto search for idling motor speed (H09)

H09 specifies the starting rotational direction (forward/reverse) of the auto search and the starting pattern (patterns 1 to 4). If the motor is idling in the reverse direction that is against the specified direction because of natural convection, it is necessary to start it in the direction opposite to the rotational direction of the original reference frequency.

When the rotational direction of the idling motor is unknown, two starting patterns are provided as listed below, which start search from the forward rotation and, if not succeeded from the reverse rotation (e.g. H09 =5, pattern 3), start search from the reverse rotation (e.g. $\mathrm{H} 09=5$, pattern 4).

| Data for H09 | Run command | Rotational direction <br> at the start of auto search | Starting pattern |
| :---: | :--- | :--- | :--- |
| 3 | Run forward | Forward | Pattern 1 |
|  | Run reverse | Reverse | Pattern 2 |
| 4 | Run forward | Forward | Pattern 3 |
|  | Run reverse | Reverse | Pattern 4 |
| 5 | Run forward | Reverse | Pattern 4 |
|  | Run reverse | Forward | Pattern 3 |

The inverter makes its frequency shift in accordance with the starting patterns shown below to search the speed and rotation direction of the idling motor. When harmonization is complete between the motor speed (including its rotation direction) and the inverter output frequency, the frequency shift by auto search operation is terminated.


* Only when the auto search has not succeeded at the first trial, the starting from the opposite direction is attempted.


## Starting Patterns

## Note

Auto search operation is attempted using one of the patterns shown above. If not succeeded, it will be tried again. If seven consecutive retries failed, the inverter will issue

## Deceleration Mode

H11 specifies the mode of deceleration when a run command is turned OFF.

| Data for H11 | Function |
| :---: | :--- |
| 0 | Normal deceleration <br> The inverter decelerates and stops the motor according to deceleration com- <br> mands specified by H07 (Acceleration/deceleration pattern) and F08 (Decelera- <br> tion time 1). |
| 1 | Coast-to-stop <br> The inverter immediately shuts down its output. The motor stops according to the <br> inertia of motor and load machinery and their kinetic energy losses. |

Note
When the reference frequency is low, the inverter decelerates the motor according to the deceleration commands even if $\mathrm{H} 11=1$ (Coast-to-stop).

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H12 Instantaneous Overcurrent Limiting

H 12 specifies whether the inverter invokes the current limit processing or enters the overcurrent trip when its output current exceeds the instantaneous overcurrent limiting level. Under the current limit processing, the inverter immediately turns off its output gate to suppress the further current increase and continues to control the output frequency.

| Data for H12 | Function |
| :---: | :--- |
| 0 | Disable <br> An overcurrent trip occurs at the instantaneous overcurrent limiting level. |
| 1 | Enable <br> The current limiting operation is effective. |

If any problem occurs when the motor torque temporarily drops during current limiting processing, it is necessary to cause an overcurrent trip $(\mathrm{H} 12=0)$ and actuate a mechanical brake at the same time.

Note
Function codes F43 and F44 have current limit functions similar to that of function code H12. Since the current limit functions of F43 and F44 implement the current control by software, an operation delay occurs. When you have enabled the current limit by F43 and F44, enable the current limit operation by H 12 as well, to obtain a quick response current limiting.
Depending on the load, extremely short acceleration time may activate the current limiting to suppress the increase of the inverter output frequency, causing the system oscillation (hunting) or activating the inverter overvoltage trip ('ili' ${ }^{\prime}$ 'alarm). When setting the acceleration time, therefore, you need to take into account machinery characteristics and moment of inertia of the load.

| H30 | Communications Link Function (Mode selection) <br> y98 |
| :--- | :--- |
|  | H3s Link Function (Function selection) |
|  | "computers or PLCs via the RS485 communications link (standard or option) or field bus (op- |
| tion)." H30 is for the RS485 communications link, and y98 for the field bus. |  |
|  | Using the communications link function allows you to monitor the operation information of the <br> inverter and the function code data, set frequency commands, and issue run commands from a <br> remote location. |


(Option)
Command sources selectable

| Command sources | Description |
| :--- | :--- |
| Inverter itself | Sources except RS485 communications link and field bus <br> Frequency command source: Specified by F01 and C30, or <br> multistep frequency command <br> Run command source: Via the keypad or digital input terminals |
| Via RS485 communications link <br> (standard) | Via the standard RJ-45 port used for connecting keypad |
| Via RS485 communications link <br> (option card) | Via RS485 communications link (option card) |
| Via field bus (option) | Via field bus (option) using FA protocol such as DeviceNet or <br> PROFIBUS-DP |
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Command sources specified by H30

| Data for H30 | Frequency command | Run command |
| :---: | :--- | :--- |
| 0 | Inverter itself (F01/C30) | Inverter itself (F02) |
| 1 | Via RS485 communications link <br> (standard) | Inverter itself (F02) |
| 2 | Inverter itself (F01/C30) | Via RS485 communications link <br> (standard) |
| 3 | Via RS485 communications link <br> (standard) | Via RS485 communications link <br> (standard) |
| 4 | Via RS485 communications link <br> (option card) | Inverter itself (F02) |
| 5 | Via RS485 communications link <br> (option card) | Via RS485 communications link (stan- <br> dard) |
| 7 | Inverter itself (F01/C30) | Via RS485 communications link <br> (option card) |
| 8 | Via RS485 communications link <br> (standard) | Via RS485 communications link <br> (option card) |
| Via RS485 communications link (op- <br> tion card) | Via RS485 communications link <br> (option card) |  |

Command sources specified by y98

| Data for y98 | Frequency command | Run command |
| :---: | :--- | :--- |
| 0 | Follow H30 data | Follow H30 data |
| 1 | Via field bus (option) | Follow H30 data |
| 2 | Follow H30 data | Via field bus (option) |
| 3 | Via field bus (option) | Via field bus (option) |

Combination of command source

|  |  | Frequency command |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Inverter itself | Via RS485 communications link (standard) | Via RS485 communications link (option card) | Via field bus (option) |
|  | Inverter itself | $\begin{aligned} & \mathrm{H} 30=0 \\ & \mathrm{y} 98=0 \end{aligned}$ | $\begin{aligned} & H 30=1 \\ & y 98=0 \end{aligned}$ | $\begin{aligned} & H 30=4 \\ & y 98=0 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=0(1 \text { or } 4) \\ & \mathrm{y} 98=1 \end{aligned}$ |
|  | Via RS485 communications link (standard) | $\begin{aligned} & H 30=2 \\ & y 98=0 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=3 \\ & \mathrm{y} 98=0 \end{aligned}$ | $\begin{aligned} & H 30=5 \\ & y 98=0 \end{aligned}$ | $\begin{aligned} & H 30=2(3 \text { or } 5) \\ & y 98=1 \end{aligned}$ |
|  | Via RS485 communications link (option card) | $\begin{aligned} & \mathrm{H} 30=6 \\ & \mathrm{y} 98=0 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=7 \\ & \mathrm{y} 98=0 \end{aligned}$ | $\begin{aligned} & H 30=8 \\ & y 98=0 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=6(7 \text { or } 8) \\ & \mathrm{y} 98=1 \end{aligned}$ |
|  | Via field bus (option) | $\begin{aligned} & \mathrm{H} 30=0(2 \text { or } 6) \\ & \mathrm{y} 98=2 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=1(3 \text { or } 7) \\ & y 98=2 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=4(5 \text { or } 8) \\ & \text { y98 }=2 \end{aligned}$ | $\begin{aligned} & \mathrm{H} 30=0(1 \text { to } 8) \\ & \mathrm{y} 98=3 \end{aligned}$ |

[1] For details, refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4 "BLOCK DIAGRAMS FOR CONTROL LOGIC" and the RS485 communication User's Manual (MEH448a) or the Field Bus Option Instruction Manual.

- When the (LE) terminal command is assigned to a digital input terminal and the terminal is ON, the settings of function code H30 and y98 are effective. When the terminal is OFF, the settings of those function codes are ineffective, and both frequency commands and run commands specified from the inverter itself take control.

H69 specifies whether automatic deceleration control is to be enabled or disabled. During deceleration of the motor, if regenerative energy exceeds the level that can be handled by the inverter, overvoltage trip may happen. With automatic deceleration enabled, when the DC link bus voltage exceeds the level (internally fixed) for starting automatic deceleration, the output frequency is controlled to prevent the DC link bus voltage from rising further; thus regenerative energy is suppressed.

If automatic deceleration is enabled, deceleration may take a longer time. This is designed to limit the torque during deceleration, and is therefore of no use where there is a braking load.

Disable the automatic deceleration when a braking unit is connected. The automatic deceleration control may be activated at the same time when a braking unit starts operation, which may make the acceleration time fluctuate. In case the set deceleration time is so short, the DC link bus voltage of the inverter rises quickly, and consequently, the automatic deceleration may not follow the voltage rise. In such a case, prolong the deceleration time.

Even if the time period of 3 times of the deceleration time 1 (F08) has elapsed after the inverter entered automatic deceleration, there may be a case that the motor does not stop or the frequency dose not decrease. In this case, cancel the automatic deceleration forcibly for safety and decelerate the motor according to the set deceleration time. Prolong the deceleration time also.

| H70 | Overload Prevention Control |
| :--- | :--- |
| H70 specifies the rate of decreasing the output frequency to prevent an overload condition. <br> Under this control, an overload trip is prevented by decreasing the output frequency of the in- <br> verter before the inverter trips because of the overheating of the cooling fan or the overloading of <br> the inverter (with an alarm indication of <br> pumps where a decrease in the output frequency leads to a decrease in the load and it is nec- <br> essary to keep the motor running even when the output frequency goes low. |  |
| Data for H70  <br> 0.00 Decelerate the motor by deceleration time 1 specified by F08 <br> 0.01 to 100.0 Decelerate the motor by deceleration rate 0.01 to $100.0(\mathrm{~Hz} / \mathrm{s})$ <br> 999 Disable overload prevention control |  |

In applications where a decrease in the output frequency does not lead to a decrease in the load, this function is of no use and should not be enabled.
H94 Cumulative Run Time of Motor

You can view the cumulative run time of the motor on the keypad. This feature is useful for management and maintenance of the mechanical system. With this function code (H94), you can set the cumulative run time of the motor to any value you choose. For example, by specifying " 0, ," you can clear the cumulative run time of the motor.

Note
The data for H 94 is in hexadecimal notation. Check the cumulative run time of the motor on the keypad.

H97 deletes the information such as alarm history and data at the time of alarm occurrence, including alarms that have occurred during the check-up or adjustment of the machinery. Data is then brought back to a normal state without an alarm.
Deleting the alarm information requires simultaneous keying of and $\circlearrowright$ keys.

| Data for H97 | Function |
| :---: | :--- |
| 0 | Disable |
| 1 | Clear all <br> (This data clears all alarm data stored and returns to "0.") |

H98 Protection/Maintenance Function
H98 specifies whether to enable or disable (a) automatic lowering of the carrier frequency, (b) protection against input phase loss, (c) protection against output phase loss, and (d) judgment on the DC link bus capacitor life, and the change of judgment criteria on the DC link bus capacitor life and the selection of handling on DC fan lock detection, in a style of combination.

## Automatic lowering function of carrier frequency

You have to prevent important machinery from stopping as much as possible. Even if the inverter is in heat sink overheating or overload state because of excessive load, abnormal ambient temperature, or a trouble in the cooling system, with this function enabled, the inverter lowers the carrier frequency to avoid tripping ( motor noise increases.

## Protection against input phase loss ( 1,17 )

Upon detecting an excessive stress inflicted on the apparatus connected to the main circuit because of phase loss or inter-phase imbalance in the 3-phase power supplied to the inverter, this feature stops the inverter and displays an alarm $i$

In configurations where only a light load is driven or a DC reactor is connected, a phase loss or an inter-phase imbalance may not be detected because of the relatively small stress on the apparatus connected to the main circuit.

## Protection against output phase loss (

Upon detecting a phase loss in the output while the inverter is running, this feature stops the inverter and displays an alarm circuit, if the magnetic contactor goes OFF during operation, all the phases will be lost. In such a case, this protection feature does not work.

## Selection of life judgment criteria of the DC link bus capacitors

Allows you to select the criteria for judging the life of the DC link bus capacitor/s (reservoir capacitor/s) between factory default setting and your own choice.

Before specifying the criteria of your own choice, measure and confirm the reference level in advance. For details, refer to Chapter 7 "MAINTENANCE AND INSPECTION."

Whether the DC link bus capacitor (reservoir capacitor) has reached its life is determined by measuring the length of time for discharging after power off. The discharging time is determined by the capacitance of the DC link bus capacitor and the load inside the inverter. Therefore, if the load inside the inverter fluctuates significantly, the discharging time cannot be accurately measured, and as a result, it may be mistakenly determined that the life has been reached. To avoid such an error, you can disable the judgment on the life of the DC link bus capacitor.

Load may vary significantly in the following cases. Disable the judgment on the life during operation, and either conduct the measurement with the judgment enabled under appropriate conditions during periodical maintenance or conduct the measurement under the actual use conditions.

- Auxiliary input for control power is used
- An option card or multi-function keypad is used
- Another inverter or equipment such as a PWM converter is connected to the terminals of the DC link bus.

For details, refer to Chapter 7 "MAINTENANCE AND INSPECTION."

Detection of DC fan lock ( 200 V series: 45 kW or above, 400 V series: 55 kW or above)
An inverter of 45 kW or above ( 200 V series), or of 55 kW or above ( 400 V series) is equipped with the internal air circulation DC fan. When the inverter detects that the DC fan is locked by a failure or other cause, you can select either continuing the inverter operation or entering into alarm state.

Continuing operation: The inverter does not enter the alarm mode, and continues operation of the motor.

Note that, however, the inverter turns on (OH) and (LIFE) signals on the transistor output terminals whenever the DC fan lock is detected regardless your selection.

If ON/OFF control of the cooling fan is enabled ( $\mathrm{H} 06=1$ ), the cooling fan may stop depending on operating condition of the inverter. In this case, the DC fan lock detection feature is considered normal (e.g.; the cooling fan is normally stopped by the stop fan command.) so that the inverter may turn off the (LIFE) or (OH) signal output, or enable to cancel the $\quad$ : $1 / 1 / \prime$ ' 'alarm, even if the internal air circulation DC fan is locked due to a failure etc. (When you start the inverter in this state, it automatically issues the run fan command, then the inverter detects the DC fan lock state, and turn on the (LIFE) or (OH) output or enters the ITlil' $^{\prime}$ ' 'alarm state.)
Note that, operating the inverter under the condition that the DC fan is locked for long time may shorten the life of electrolytic capacitors on the control PCB due to local high temperature inside the inverter. Be sure to check with the (LIFE) signal etc., and replace the broken fan as soon as possible.
To set data of the function code H98, assign functions to each bit (total 6 bits) and set it in decimal format. The table below lists functions assigned to each bit.

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| Bit | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Function | Detect DC <br> fan lock | Judge the <br> life of DC <br> link bus <br> capacitor | Select life <br> judgment <br> criteria of <br> DC link bus <br> capacitor | Detect out- <br> put phase <br> loss | Detect input <br> phase loss | Lower the <br> carrier fre- <br> quency <br> automatically |
| Data $=0$ | Enter into <br> the alarm <br> state | Disable | Use the <br> factory <br> default | Disable | Disable | Disable |
| Data = 1 | Continue <br> the opera- <br> tion | Enable | Use the user <br> setting | Enable | Enable | Enable |
| Example of <br> decimal <br> expression <br> (19) | Enter into <br> the alarm <br> state (0) | Enable (1) | Use the <br> factory <br> default (0) | Disable (0) | Enable (1) | Enable (1) |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI Conversion table (Decimal to/from binary)

| Decimal | Binary |  |  |  |  |  | Decimal | Binary |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |  | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 33 | 1 | 0 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 0 | 0 | 1 | 0 | 34 | 1 | 0 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 0 | 0 | 1 | 1 | 35 | 1 | 0 | 0 | 0 | 1 | 1 |
| 4 | 0 | 0 | 0 | 1 | 0 | 0 | 36 | 1 | 0 | 0 | 1 | 0 | 0 |
| 5 | 0 | 0 | 0 | 1 | 0 | 1 | 37 | 1 | 0 | 0 | 1 | 0 | 1 |
| 6 | 0 | 0 | 0 | 1 | 1 | 0 | 38 | 1 | 0 | 0 | 1 | 1 | 0 |
| 7 | 0 | 0 | 0 | 1 | 1 | 1 | 39 | 1 | 0 | 0 | 1 | 1 | 1 |
| 8 | 0 | 0 | 1 | 0 | 0 | 0 | 40 | 1 | 0 | 1 | 0 | 0 | 0 |
| 9 | 0 | 0 | 1 | 0 | 0 | 1 | 41 | 1 | 0 | 1 | 0 | 0 | 1 |
| 10 | 0 | 0 | 1 | 0 | 1 | 0 | 42 | 1 | 0 | 1 | 0 | 1 | 0 |
| 11 | 0 | 0 | 1 | 0 | 1 | 1 | 43 | 1 | 0 | 1 | 0 | 1 | 1 |
| 12 | 0 | 0 | 1 | 1 | 0 | 0 | 44 | 1 | 0 | 1 | 1 | 0 | 0 |
| 13 | 0 | 0 | 1 | 1 | 0 | 1 | 45 | 1 | 0 | 1 | 1 | 0 | 1 |
| 14 | 0 | 0 | 1 | 1 | 1 | 0 | 46 | 1 | 0 | 1 | 1 | 1 | 0 |
| 15 | 0 | 0 | 1 | 1 | 1 | 1 | 47 | 1 | 0 | 1 | 1 | 1 | 1 |
| 16 | 0 | 1 | 0 | 0 | 0 | 0 | 48 | 1 | 1 | 0 | 0 | 0 | 0 |
| 17 | 0 | 1 | 0 | 0 | 0 | 1 | 49 | 1 | 1 | 0 | 0 | 0 | 1 |
| 18 | 0 | 1 | 0 | 0 | 1 | 0 | 50 | 1 | 1 | 0 | 0 | 1 | 0 |
| 19 | 0 | 1 | 0 | 0 | 1 | 1 | 51 | 1 | 1 | 0 | 0 | 1 | 1 |
| 20 | 0 | 1 | 0 | 1 | 0 | 0 | 52 | 1 | 1 | 0 | 1 | 0 | 0 |
| 21 | 0 | 1 | 0 | 1 | 0 | 1 | 53 | 1 | 1 | 0 | 1 | 0 | 1 |
| 22 | 0 | 1 | 0 | 1 | 1 | 0 | 54 | 1 | 1 | 0 | 1 | 1 | 0 |
| 23 | 0 | 1 | 0 | 1 | 1 | 1 | 55 | 1 | 1 | 0 | 1 | 1 | 1 |
| 24 | 0 | 1 | 1 | 0 | 0 | 0 | 56 | 1 | 1 | 1 | 0 | 0 | 0 |
| 25 | 0 | 1 | 1 | 0 | 0 | 1 | 57 | 1 | 1 | 1 | 0 | 0 | 1 |
| 26 | 0 | 1 | 1 | 0 | 1 | 0 | 58 | 1 | 1 | 1 | 0 | 1 | 0 |
| 27 | 0 | 1 | 1 | 0 | 1 | 1 | 59 | 1 | 1 | 1 | 0 | 1 | 1 |
| 28 | 0 | 1 | 1 | 1 | 0 | 0 | 60 | 1 | 1 | 1 | 1 | 0 | 0 |
| 29 | 0 | 1 | 1 | 1 | 0 | 1 | 61 | 1 | 1 | 1 | 1 | 0 | 1 |
| 30 | 0 | 1 | 1 | 1 | 1 | 0 | 62 | 1 | 1 | 1 | 1 | 1 | 0 |
| 31 | 0 | 1 | 1 | 1 | 1 | 1 | 63 | 1 | 1 | 1 | 1 | 1 | 1 |

J21 Dew Condensation Prevention (Duty)
When the inverter is stopped, dew condensation on the motor can be prevented, by feeding DC power to the motor at regular intervals to keep the temperature of the motor above a certain level.
To utilize this feature, you need to assign a terminal command (DWP) (dew condensation prevention) to one of general-purpose digital input terminals (function code data $=39$ ).

- Enabling Dew Condensation Prevention

To enable dew condensation prevention, turn ON the condensation prevention command (DWP) while the inverter is stopped. Then, this feature starts.

## ■ Dew Condensation Prevention (Duty) (J21)

The magnitude of the DC power applied to the motor is the same as the setting of F21 (DC Braking, Braking level) and its duration inside each interval is the same as the setting of F22 (DC Braking, Braking time). The interval T is determined so that the ratio of the duration of the DC power to T is the value (Duty) set for J 21 .

Duty for condensation prevention (J21) $=\frac{\mathrm{F} 22}{\mathrm{~T}} \times 100$ (\%)


Chapter 6 TROUBLESHOOTING

### 6.1 Before Proceeding with Troubleshooting

## $\triangle$ WARNING

If any of the protective functions have been activated, first remove the cause. Then, after checking that the all run commands are set to off, reset the alarm. Note that if the alarm is reset while any run commands are set to on, the inverter may supply the power to the motor which may cause the motor to rotate.
Injury may occur.

- Even though the inverter has interrupted power to the motor, if the voltage is applied to the main circuit power input terminals L1/R, L2/S and L3/T, voltage may be output to inverter output terminals $\mathrm{U}, \mathrm{V}$, and W .
- Turn OFF the power and wait more than five minutes for models of 30 kW or below, or ten minutes for models of 37 kW or above. Make sure that the LED monitor and charging lamp (on models of 37 kW or above) are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC link bus voltage between the terminals $\mathrm{P}(+)$ and $\mathrm{N}(-)$ has dropped below the safe voltage (+25 VDC).
Electric shock may occur.

Follow the procedure below to solve problems.
(1) First, check that the inverter is correctly wired, referring to Chapter 2 Section 2.3.6 "Wiring for main circuit terminals and grounding terminals."
(2) Check whether an alarm code is displayed on the LED monitor.

- No alarm code appears on the LED monitor

Abnormal motor aperation
Go to Section 6.2.1
[1] The motor does not rotate.
[2] The motor rotates, but the speed does not increase.
[3] The motor runs in the opposite direction to the command.
[4] If the speed variation and current vibration (such as hunting) occur at the constant speed
[5] If grating sound can be heard
[6] The motor does not accelerate and decelerate at the set time
[7] Even if the power recovers after an instantaneous power failure, the motor does not restart.
Problems with inverter settings
Go to Section 6.2 .2
[1] Nothing appears on the LED monitor.
[2] The desired menu is not displayed.
[3] Data of function codes cannot be changed

- If an alarm code appears on the LED monitor
$\longrightarrow$ Go to Section 6.3
- If an abnormal pattern appears on the LED monitor


Go to Section 6.4 while no alarm code is displayed

If any problems persist after the above recovery procedure, contact your Fuji Electric representative.

### 6.2 If No Alarm Code Appears on the LED Monitor

### 6.2.1 Motor is running abnormally

## [1] The motor does not rotate.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |

(1) No power supplied to the inverter.
(2) No forward/reverse operation command was inputted, or both the commands were inputted simultaneously (external signal operation).

Check the input voltage, output voltage and interphase voltage unbalance.
$\rightarrow$ Turn ON a molded case circuit breaker, an earth leakage circuit breaker (with overcurrent protection) or a magnetic contactor.
$\rightarrow$ Check for voltage drop, phase loss, poor connections, or poor contacts, and fix them if necessary.
$\rightarrow$ If only auxiliary control power is supplied, turn ON the main power.
Check the input status of the forward/reverse command with Menu \#4 "I/O Checking" using the keypad.
$\rightarrow$ Input a run command.
$\rightarrow$ Set either the forward or reverse operation command to off if both commands are being inputted.
$\rightarrow$ Correct the assignment of commands (FWD) and (REV) to function codes E98 and E99.
$\rightarrow$ Connect the external circuit wires to control circuit terminals [FWD] and [REV] correctly.
$\rightarrow$ Make sure that the sink/source slide switch on the printed circuit board is properly configured.
(3) No indication of rotation direction (keypad

Check the input status of the forward/reverse rotation direction command with Menu \#4 "I/O Checking" using the keypad.
operation).
$\rightarrow$ Input the rotation direction ( $\mathrm{FO2}=0$ ), or select the keypad operation with which the rotation direction is fixed ( $\mathrm{F} 02=2$ or 3 ).

Check which operation mode the inverter is in, using the keypad.
$\rightarrow$ Shift the operation mode to Running mode and enter a run command.
(4) The inverter could not accept any run commands from the keypad since it was in Programming mode.
(5) A run command with higher priority than the one attempted was active, and the run command was stopped.
(6) The frequency command was set below the starting or stop frequency.

While referring to the block diagram of the drive command generator*, check the higher priority run command with Menu \#2 "Data Checking" and Menu \#4 "I/O Checking" using the keypad.
*Refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4.
$\rightarrow$ Correct any incorrect function code data settings (in H30, y98, etc.) or cancel the higher priority run command.
Check that a frequency command has been entered, with Menu \#4 "I/O Checking" using the keypad.
$\rightarrow$ Set the value of the frequency command to the same or higher than that of the starting or stop frequency (F23 or F25).
$\rightarrow$ Reconsider the starting and stop frequencies (F23 and F25), and if necessary, change them to lower values.
$\rightarrow$ Inspect the frequency command, signal converters, switches, or relay contacts. Replace any ones that are faulty.
$\rightarrow$ Connect the external circuit wires correctly to terminals [13], [12], [11], [C1], and [V2].
(7) A frequency command with higher priority than the one attempted was active.

Check the higher priority run command with Menu \#2 "Data Checking" and Menu \#4 "I/O Checking" using the keypad, referring to the block diagram of the drive command generator*.
*Refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4.
$\rightarrow$ Correct any incorrect function code data settings (e.g. cancel the higher priority run command).
(8) The upper and lower frequencies for the frequency limiters were set incorrectly.

Check the data of function codes F15 (Frequency limiter (high)) and F16 (Frequency limiter (low)).

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| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (9) The coast-to-stop <br> command was effective. | Check the data of function codes E01, E02, E03, E04, E05, E98 and E99 <br> and the input signal status with Menu \#4 I/O Checking using the keypad. <br> $\rightarrow$ Release the coast-to-stop command setting. |
| (10) Broken wire, incorrect <br> connection or poor contact <br> with the motor. | Check the cabling and wiring (Measure the output current). <br> $\rightarrow$ Repair the wires to the motor, or replace them. |
| (11) Overload | Measure the output current. <br> $\rightarrow$ Lighten the load (In winter, the load tends to increase.) |
|  | Check that a mechanical brake is in effect. <br> $\rightarrow$ Release the mechanical brake, if any. |
| (12) Torque generated by the |  |
| motor was insufficient. | Check that the motor starts running if the value of torque boost (F09) is <br> increased. <br> $\rightarrow$ Increase the value of torque boost (F09) and try to run the motor. |
|  | Check the data of function codes F04, F05, H50, and H51. <br> $\rightarrow$ Change the V/f pattern to match the motor's characteristics. |

## [ 2 ] The motor rotates, but the speed does not increase.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)The maximum frequency <br> currently specified was too <br> low. | Check the data of function code F03 (Maximum frequency). <br> $\rightarrow$ Readjust the data of F03. |
| (2)The data of frequency <br> limiter currently specified <br> was too low. | Check the data of function code F15 (Frequency limiter (high)). <br> $\rightarrow$ Readjust the data of F15. |
| (3)The reference frequency <br> currently specified was too <br> low. | Check the signals for the frequency command from the control circuit <br> terminals with Menu \#4 "I/O Checking" on the keypad. <br> $\rightarrow$ Increase frequency of the command. |
|  | If an external potentiometer for frequency command, signal converter, <br> switches, or relay contacts are malfunctioning, replace them. <br> $\rightarrow$ Connect the external circuit wires to terminals [13], [12], [11], [C1], and <br> [V2] correctly. |
| (4)A frequency command (e.g., <br> multistep frequency or via <br> communications) with higher <br> priority than the one <br> expected was active and its <br> reference frequency was too <br> low. | Check the data of the relevant function codes and what frequency <br> commands are being received, through Menu \#1 "Data Setting," Menu \#2 <br> "Data Checking" and Menu \#4 "I/O Checking," on the keypad by referring to <br> the block diagram of the frequency command*. <br> *Refer to the FRENIC-Eco User's Manual (MEH456), Chapter 4. <br> $\rightarrow$ Correct any incorrect data of function code (e.g. The higher priority run <br> command is mistakenly canceled, etc.). |
| (5)The acceleration time was <br> too long. | Check the data of function code F07 (Acceleration time 1) <br> $\rightarrow$ Change the acceleration/deceleration time to match the load. |

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| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (6) Overload | Measure the output current. <br> $\rightarrow$ Lighten the load. |
|  | Check if mechanical brake is working. <br> $\rightarrow$ Release the mechanical brake (Adjust the dumper of the fan or the valve <br> of the pump). (In winter, the load tends to increase.) |
| (7) Mismatch with the <br> characteristics of the <br> motor | In case auto-torque boost or auto-energy saving operation is under way, <br> check whether P02, P03, P06, P07, and P08 agree with the parameters of <br> the motor. <br> $\rightarrow$ Set P02, P03, and P06 properly and perform auto-tuning in accordance <br> with P04. |
| (8) The current limiting |  |
| operation did not increase |  |
| the output frequency. |  |$\quad$| Make sure that F43 (Current limiter (mode selection)) is set to "2" and check |
| :--- |
| the setting of F44 (Current limiter (level)). |
| $\rightarrow$ If the current limiting operation is not needed, set F43 to "0" (disabled). |

## [3] The motor runs in the opposite direction to the command.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) Wiring has been |  |
| connected to the motor |  |
| incorrectly. |  |$\quad$| Check the wiring to the motor. |
| :--- |
| $\rightarrow$ Connect terminals U, V, and W of the inverter to the respective U, V, and |
| W terminals of the motor. |

## [4] If the speed variation and current vibration (such as hunting) occur at the constant speed

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) The frequency command |  |
| fluctuated. | Check the signals for the frequency command with Menu \#4 "I/O Checking" <br> using the keypad. <br> $\rightarrow$ Increase the filter constants (C33, C38, and C43) for the frequency <br> command. |

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\(\left.$$
\begin{array}{l|l}\hline \text { Possible Causes } & \begin{array}{l}\text { What to Check and Suggested Measures }\end{array} \\
\hline \text { (2) The external frequency } \\
\text { command source device } \\
\text { was used. }\end{array}
$$ \quad \begin{array}{l}Check that there is no noise in the control signal wires from external sources. <br>
\rightarrow Isolate the control signal wires from the main circuit wires as far as <br>
possible. <br>

\rightarrow Use shielded or twisted wires for the control signal.\end{array}\right]\)|  | Check whether the frequency command source has not failed because of <br> noise from the inverter. <br> $\rightarrow$ Connect a capacitor to the output terminal of the frequency command <br> source or insert a ferrite core in the signal wire. (Refer to Chapter 2 <br> Section 2.3.7 "Wiring for control circuit terminals.") |
| :--- | :--- |

## [5] If grating sound can be heard from motor

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) The carrier frequency was |  |
| set too low. |  | | Check the data of function codes F26 (Motor sound (carrier frequency)) and |
| :--- |
| F27 (Motor sound (tone)). |
| $\rightarrow$ Increase the carrier frequency (F26). |
| $\rightarrow$ Readjust the setting of F27 to appropriate value. |

[ 6 ] The motor does not accelerate and decelerate at the set time.

| Possible Causes | What to Check and Suggested Measures |
| :---: | :---: |
| (1) The inverter ran the motor by S-curve or curvilinear pattern. | Check the data of function code H 07 (Acceleration/deceleration pattern). <br> $\rightarrow$ Select the linear pattern ( $\mathrm{H} 07=0$ ). <br> $\rightarrow$ Shorten the acceleration/deceleration time (F07, F08). |
| (2) The current limiting prevented the output frequency from increasing (during acceleration). | Make sure that F43 (Current limiter (mode selection)) is set to "2: Enable during acceleration and at constant speed," then check that the setting of F44 (Current limiter (level)) is reasonable. <br> $\rightarrow$ Readjust the setting of F 44 to appropriate value, or disable the function of current limiter in F43. <br> Increase the acceleration/deceleration time (F07/F08). |
| (3) The automatic regenerative braking was active. | Check the data of function code H 69 (Automatic deceleration). <br> $\rightarrow$ Increase the deceleration time (F08). |
| (4) Overload | Measure the output current. <br> $\rightarrow$ Lighten the load (In the case of a fan or a pump load, lower the setting data of the F15 (Frequency limiter (high)). (In winter, the load tends to increase.). |
| (5) Torque generated by the motor was insufficient. | Check that the motor starts running if the value of the torque boost (F09) is increased. <br> $\rightarrow$ Increase the value of the torque boost (F09). |
| (6) An external frequency command is being used. | Check that there is no noise in the external signal wires. <br> $\rightarrow$ Isolate the control signal wires from the main circuit wires as far as possible. <br> $\rightarrow$ Use shielded wire or twisted wire for the control signal wires. <br> $\rightarrow$ Connect a capacitor to the output terminal of the frequency command or insert a ferrite core in the signal wire. (Refer to Chapter 2 Section 2.3.7 "Wiring for control circuit terminals.") |
| (7) The V2/PTC switch was turned to PTC (when V2 was being used). | Check whether control terminal [V2] is not set to the PTC thermistor input mode. <br> $\rightarrow$ Turn the V2/PTC switch on the printed circuit board to V2. |

## [7] Even if the power recovers after a momentary power failure, the motor does not restart.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)The data of function code <br> F14 is either 0 or 1. | Check if an undervoltage trip occurs. <br> T Change the data of function code F14 (Restart mode after momentary <br> power failure (mode selection)) to 3, 4 or 5. |
| (2) The run command stayed |  |
| off even after power has |  |
| been restored. |  | | Check the input signal with Menu \#4 "I/O Checking" using the keypad. |
| :--- |
| $\rightarrow$ Check the power recovery sequence with an external circuit. If necessary, |
| consider the use of a relay that can keep the run command on. |

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### 6.2.2 Problems with inverter settings

## [1] Nothing appears on the LED monitor.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)No power supplied to the <br> inverter (main circuit <br> power, auxiliary power for <br> control circuit). | Check the input voltage, output voltage and interphase voltage unbalance. <br> $\rightarrow$ Connect a molded case circuit breaker, an earth leakage circuit breaker <br> (with overcurrent protection) or a magnetic contactor. <br> $\rightarrow$ Check for voltage drop, phase loss, poor connections, or poor contacts, <br> and fix them if necessary. |
| (2) The power for the control |  |
| circuit did not reach a high |  |
| enough level. |  |$\quad$| Check if the short bar has been removed between terminals P1 and P (+) or |
| :--- |
| if there is poor contact between the short bar and the terminals. |
| $\rightarrow$ Connect the short bar or DC reactor between terminals P1 and P (+) or |
| retighten the screws. |

## [ 2] The desired menu is not displayed.

| Causes | Check and Measures |
| :--- | :--- |
| (1) The limiting menus |  |
| function was not selected <br> appropriately. | Check the data of function code E52 (Keypad (menu display mode)). <br> $\rightarrow$ Change the data of function code E52 so that the desired menu can be <br> displayed. |

## [3] Data of function codes cannot be changed

| Possible Causes |  | What to Check and Suggested Measures |
| :---: | :---: | :---: |
| (1) | An attempt was made to change function code data that cannot be changed when the inverter is running. | Check if the inverter is running with Menu \#3 "Drive Monitoring" using the keypad and then confirm whether the data of the function codes can be changed when the motor is running by referring to the function code tables. <br> Stop the motor then change the data of the function codes. |
| (2) | The data of the function codes is protected. | Check the data of function code F00 (Data protection). <br> $\rightarrow$ Change the setting of F00 from "1" to "0." |
| (3) | The WE-KP command ("Enable editing of function code data from keypad") is not input though it has been assigned to a digital input terminal. | Check the data of function codes E01, E02, E03, E04, E05, E98 and E99 and the input signals with Menu \#4 "I/O Checking" using the keypad. <br> $\rightarrow$ Change the setting of F00 from "1" to " 0, " or input a WE-KP command through a digital input terminal. |
| (4) | The key was not pressed. | Check whether you have pressed the key after changing the function code data. <br> $\rightarrow$ Press the key after changing the function code data. |
| (5) | The setting data of function code F02 could not be changed. | The inputs to the terminals of (FWD) and (REV) commands are concurrently turned ON. <br> $\rightarrow$ Turn OFF both (FWD) and (REV). |
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## 6．3 If an Alarm Code Appears on the LED Monitor

－Quick reference table of alarm codes

| Alarm code | Name | Refer to | Alarm code | Name | Refer to |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Instantaneous overcurrent | 6－8 | だい゙す | Fuse blown | 6－13 |
| バープ |  |  | バイル | Charger circuit fault | 6－13 |
| バ11－ |  |  | İII）！ | Electronic thermal overload relay | 6－14 |
| E！ | Ground fault | 6－9 | バル！！ | Overload | 6－14 |
| ！¢711！ | Overvoltage | 6－9 | E－！ | Memory error | 6－15 |
| －7゙バ1 |  |  | にーに | Keypad communications error | 6－15 |
| パフ！ |  |  | シース | CPU error | 6－15 |
| ட́＇＇ | Undervoltage | 6－10 | ミーム | Option card communications error | 6－16 |
| L＂17 | Input phase loss | 6－10 | ミーム | Option card error | 6－16 |
|  | Output phase loss | 6－11 | 旨灾 | Incorrect operation error | 6－16 |
| －1117！ | Heat sink overheat | 6－11 | フ | Tuning error | 6－17 |
|  | Alarm issued by an external device | 6－12 |  | RS485 communications error | 6－17 |
| バ11イプ | Inside of the inverter overheat | 6－12 | に，－ | Data saving error during undervoltage | 6－18 |
| バ11イブーブ | Motor protection（PTC thermistor） | 6－12 | ミーロー | RS485 communications error （Option card） | 6－18 |
|  |  |  | ミール゙ | LSI error（Power PCB） | 6－19 |

## ［1］$\sim \sim n$ Instantaneous overcurrent

Problem The inverter momentary output current exceeded the overcurrent level．
，Overcurrent occurred during acceleration．
Overcurrent occurred during deceleration．
Overcurrent occurred when running at a constant speed．


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| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (4) The value set for torque |  |
| boost (F09) was too large. |  |
| (F37 = 0, 1, 3, or 4) |  |$\quad$| Check that the output current decreases and the motor does not come to |
| :--- |
| stall if you set a lower value than the current one for F09. |
| $\rightarrow$ Lower the value for torque boost (F09) if the motor is not going to stall. |

## [2] $E F$ Ground fault ( 90 kW or above)

Problem A ground fault current flew from the output terminal of the inverter.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)The output terminal of <br> the inverter is <br> short-circuited to the <br> ground (ground fault, or <br> earthed). | Disconnect the wires from the output terminals ([U], $[\mathrm{V}]$, and $[\mathrm{W}]$ ) and perform <br> a megger test. <br> $\rightarrow$ Remove the earthed path (including the replacement of the wires, the <br> terminals, or the motor as necessary). |

## [3] ILin Overvoltage

Problem The DC link bus voltage was over the detection level of overvoltage.
[ili,' ; Overvoltage occurs during the acceleration.
[illil Overvoltage occurs during the deceleration.
[17) Overvoltage occurs during running at constant speed.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) The power supply voltage <br> was over the range of the <br> inverter's specifications. | Measure the input voltage. <br> $\rightarrow$ Decrease the voltage to within that of the specifications. |
| (2) A surge current entered <br> the input power source. | If within the same power source a phase-advancing capacitor is turned ON <br> or OFF or a thyristor converter is activated, a surge (temporary precipitous <br> rise in voltage or current) may be caused in the input power. <br> $\rightarrow$ Install a DC reactor. |
| The deceleration time was <br> too short for the moment <br> of inertia for load. | Recalculate the deceleration torque from the moment of inertia for load and <br> the deceleration time. <br> $\rightarrow$ Increase the deceleration time (F08). <br> $\rightarrow$ Enable the regenerative braking (H69 = 3), or automatic deceleration <br> (H71 = 1). |
| $\rightarrow$ Set the rated voltage (at base frequency) (F05) to "0" to improve braking |  |
| ability. |  |

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| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (5) Braking load was tooheavy. | Compare the braking torque of the load with that of the inverter. <br> $\rightarrow$ Set the rated voltage (at base frequency) (F05) to 0 to improve braking <br> ability. |
| (6) Malfunction caused by |  |
| noise. |  | | Check if the DC link bus voltage was below the protective level when the |
| :--- |
| alarm occurred. |
| $\rightarrow$ Improve noise control. For details, refer to "Appendix A" of the |
| FRENIC-Eco User's Manual (MEH456). |
| $\rightarrow$ Enable the auto-resetting (H04). |
| $\rightarrow$ Connect a surge absorber to the coil or solenoid of the magnetic contactor |
| causing the noise. |

## [4] L'U'Undervoltage

Problem DC link bus voltage was below the undervoltage detection level.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)A momentary power <br> failure occurred. | $\rightarrow$ Reset the alarm. <br> $\rightarrow$ If you want to restart running the motor by not treating this condition as an <br> alarm, set F14 to "3," "4" or "5," depending on the load. |
| (2)The power to the inverter <br> was switched back on too <br> soon (with F14 = 1). | Check if the power to the inverter was switched back on although its control <br> circuit was still operating. <br> $\rightarrow$ Switch ON the power again after the display on the keypad has <br> disappeared. |
| (3)The power supply voltage <br> did not reach the range of <br> the inverter's <br> specifications. | Measure the input voltage. <br> $\rightarrow$ Increase the voltage to within that of the specifications. |
| (4)Peripheral equipment for <br> the power circuit <br> malfunctioned, or the <br> connection was incorrect. | Measure the input voltage to find where the peripheral equipment <br> malfunctioned or which connection is incorrect. <br> $\rightarrow$ Replace any faulty peripheral equipment, or correct any incorrect <br> connections. |
| (5)Other loads were <br> connected to the same <br> power source and <br> required a large current to <br> start running to the extent <br> that it caused a temporary <br> voltage drop on the supply <br> side. | Measure the input voltage and check the voltage variation. <br> $\rightarrow$ Reconsider the power system configuration. |
| (6)Inverter's inrush current <br> caused the power voltage <br> drop because power <br> transformer capacity was <br> insufficient. | Check if the alarm occurs when you switch on a molded case circuit breaker, <br> an earth leakage circuit breaker (with overcurrent protection) or a magnetic <br> contactor. <br> $\rightarrow$ Reconsider the capacity of the power source transformer. |

## [5] L ר Input phase loss

Problem Input phase loss occurred, or interphase voltage unbalance rate was large.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) Main circuit power input |  |
| wires broken. |  | | Measure the input voltage. |
| :--- |
| $\rightarrow$ Repair or replace the wires. |

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| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (3) Interphase unbalance rate <br> of three-phase voltage <br> was too large. | Measure the input voltage. <br> $\rightarrow$ Connect an AC reactor (ACR) to lower the voltage unbalance between <br> input phases. <br> $\rightarrow$ Raise the inverter capacity. |
| (4) Overload cyclicallyoccurred. | Measure ripple wave of DC link bus voltage. <br> $\rightarrow$ If the ripple is large, raise the inverter capacity |
| (5)Single-phase voltage was <br> input to the inverter <br> instead of three-phase <br> voltage input. | Check the inverter type. <br> $\rightarrow$ Apply three-phase power. FRENIC-Eco cannot be driven by single-phase <br> power source. |

Note You can disable input phase loss protection using the function code H98.

## [6] $\mathrm{Il}^{\circ} \mathrm{Cl}$ Output phase loss

Problem Output phase loss occurred.

$\left.$| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) Inverter output wires are |  |
| broken. |  |$\quad$| Measure the output current. |
| :--- |
| $\rightarrow$ Replace the output wires. | \right\rvert\, | (2) Wires for motor winding |
| :--- | :--- |
| are broken. |$\quad$| Measure the output current. |
| :--- |
| $\rightarrow$ Replace the motor. |

## [7] $7 H^{\prime \prime}$; Heat sink overheat

Problem Temperature around heat sink rose.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) |  |
| Temperature around the <br> inverter exceeded that of <br> inverter specifications. | Measure the temperature around the inverter. <br> $\rightarrow$ Lower the temperature around the inverter (e.g., ventilate the enclosure <br> well). |
| (2) Air vent is blocked. | Check if there is sufficient clearance around the inverter. <br> $\rightarrow$ Increase the clearance. |
|  | Check if the heat sink is not clogged. <br> $\rightarrow$ Clean the heat sink. |
| (3) Accumulated running time <br> of the cooling fan <br> exceeded the standard <br> period for replacement, or <br> the cooling fan <br> malfunctioned. | Check the cumulative running time of the cooling fan. Refer to Chapter 3, <br> Section 3.4.6 "Reading maintenance information - "Maintenance <br> Information"." <br> $\rightarrow$ Replace the cooling fan. |
|  | Visually check whether the cooling fan rotates abnormally. <br> $\rightarrow$ Replace the cooling fan. |
| (4) Load was too heavy. | Measure the output current. <br> $\rightarrow$ Lighten the load (e.g. lighten the load before the overload protection <br> occurs using the overload early warning (E34). (In winter, the load tends <br> to increase.) |
| $\rightarrow$ Decease the motor sound (carrier frequency) (F26). |  |
| $\rightarrow$ Enable the overload protection control (H70). |  | The 200 V series inverters with a capacity of 45 kW or above and the 400 V series inverters with a capacity of 55 kW or above each have a cooling fan/fans for heat sinks and a DC fan for internal air circulation (dispersing the heat generated inside the inverter). For their locations, refer to Chapter 1, Section 1.2 "External View and Terminal Blocks."

## [8] 8 ?

Problem External alarm was inputted (THR).
(in case external alarm (THR) is assigned to one of digital input terminals [X1] through [X5], [FWD], or [REV])

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) An alarm function of the <br> external equipment was <br> activated. | Inspect external equipment operation. <br> $\rightarrow$ Remove the cause of the alarm that occurred. |
| (2) Connection has been <br> performed incorrectly. | Check if the wire for the external alarm signal is correctly connected to the <br> terminal to which the "Alarm from external equipment" has been assigned <br> (Any of E01, E02, E03, E04, E05, E98, and E99 is set to "9."). <br> $\rightarrow$ Connect the wire for the alarm signal correctly. |
| (3) Incorrect settings. | Check if the "Alarm from external equipment" has not been assigned to an <br> unassigned terminal assigned (E01, E02, E03, E04, E05, E98, or E99). <br> $\rightarrow$ Correct the assignment. |
|  | Check whether the assignment (normal/negative logic) of the external signal <br> agrees with that of thermal command (THR) set by E01, E02, E03, E04, E05, <br> E98, and E99. <br> $\rightarrow$ Ensure that the polarity matches. |

## [9] 3 Inside of the inverter overheat

Problem The temperature inside the inverter exceeded the allowable limit.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) The ambient temperature | Measure the ambient temperature. |
| exceeded the allowable <br> limit specified for the <br> inverter. | $\rightarrow$ Lower the ambient temperature by improving the ventilation. |

## 

Problem Temperature of the motor rose abnormally.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) Temperature around the <br> motor exceeded that of <br> motor specifications. | Measure the temperature around the motor. <br> $\rightarrow$ Lower the temperature. |
| (2) Cooling system for the |  |
| motor malfunctioned. | Check if the cooling system of the motor is operating normally. <br> $\rightarrow$ Repair or replace the cooling system of the motor. |
| (3) Load was too heavy. | Measure the output current. <br> $\rightarrow$ Lighten the load (e.g., lighten the load before overload occurs using the <br> overload early warning (E34) function) (In winter, the load tends to <br> increase.). <br> $\rightarrow$ Lower the temperature around the motor. <br> $\rightarrow$ Increase the motor sound (carrier frequency) (F26). |

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| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (4)The set activation level <br> (H27) of the PTC <br> thermistor for motor <br> overheat protection was <br> inadequate. | Check the thermistor specifications and recalculate the detection voltage. <br> $\rightarrow$ Reconsider the data of function code H27. |
| (5) A PTC thermistor and |  |
| pull-up resistor were <br> connected incorrectly or <br> the resistance was <br> inadequate. | Check the connection and the resistance of the pull-up resistor. <br> $\rightarrow$ Correct the connections and replace the resistor with one with an <br> appropriate resistance. |
| (6)The value set for the <br> torque boost (F09) was <br> too high. | Check the data of function code F09 and readjust the data so that the motor <br> does not stall even if you set the data to a lower value. <br> $\rightarrow$ Readjust the data of the function code F09. |
| (7)The V/f pattern did not <br> match the motor. | Check if the base frequency (F04) and rated voltage at base frequency (F05) <br> match the values on the nameplate on the motor. <br> $\rightarrow$ Match the function code data to the values on the nameplate of the motor. |
| (8) Wrong settings | Although no PTC thermistor is used, the V2/PTC switch is turned to PTC, <br> which means that the thermistor input is active on the PTC (H26). <br> $\rightarrow$ Set H26 (PTC thermistor Input) to "0" (inactive). |

## [ 11 ]

Problem The fuse inside the inverter blew.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) The fuse blew because of | Check whether there has been any excess surge or noise coming from |
| a short-circuiting inside <br> the inverter. | outside. |
|  | $\rightarrow$ Take measures against surges and noise. |
|  | $\rightarrow$ Have the inverter repaired. |

## [ 12 ]

( 45 kW or above ( 200 V Series), 55 kW or above ( 400 V Series))
Problem The magnetic contactor for short-circuiting the resistor for charging failed to work.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) Control power was not <br> supplied to the magnetic <br> contactor intended for <br> short-circuiting the <br> charging resistor. | Check whether, in normal connection of the main circuit (not connection via <br> the DC link bus), the connector (CN) on the power supply printed circuit <br> board is not inserted to NC. |
|  | $\rightarrow$ Insert the connector to FAN. |

Problem Electronic thermal function for motor overload detection was activated.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) The characteristics of |  |
| electronic thermal did not |  |
| math those of the motor |  |
| overload. |  |$\quad$| Check the motor characteristics. |
| :--- |
| $\rightarrow$ Reconsider the data of function codes P99, F10 and F12. |
| $\rightarrow$ Use an external thermal relay. |

## [14] 次 L' Overload

Problem Temperature inside inverter rose abnormally.

| Possible Causes | What to Check and Suggested Measures |
| :---: | :---: |
| (1) Temperature around the inverter exceeded that of inverter specifications. | Measure the temperature around the inverter. <br> $\rightarrow$ Lower the temperature (e.g., ventilate the enclosure well). |
| (2) The torque boost setting (F09) was too high. | Check the setting of F 09 (torque boost) and make sure that lowering it would not cause the motor to stall. <br> $\rightarrow$ Adjust the setting of F09. |
| (3) The acceleration/ deceleration time was too short. | Recalculate the required acceleration/deceleration torque and time from the moment of inertia for the load and the deceleration time. <br> $\rightarrow$ Increase the acceleration/deceleration time (F07 and F08). |
| (4) Load was too heavy. | Measure the output current. <br> $\rightarrow$ Lighten the load (e.g., lighten the load before overload occurs using the overload early warning (E34)). (In winter, the load tends to increase.) <br> $\rightarrow$ Decrease the motor sound (carrier frequency) (F26). <br> $\rightarrow$ Enable overload protection control (H70). |
| (5) Air vent is blocked. | Check if there is sufficient clearance around the inverter. <br> $\rightarrow$ Increase the clearance. |
|  | Check if the heat sink is not clogged. <br> Clean the heat sink. |
| (6) The service life of the cooling fan has expired or the cooling fan malfunctioned. | Check the cumulative running time of cooling fan. Refer to Chapter 3, Section 3.4.6 " Reading maintenance information - "Maintenance Information"." <br> Replace the cooling fan. |
|  | Visually check that the cooling fan rotates normally. <br> $\rightarrow$ Replace the cooling fan. |
| (7) The wires to the motor are too long and caused a large amount of current to leak from them. | Measure the leakage current. <br> $\rightarrow$ Insert an output circuit filter (OFL). |

Problem Error occurred in writing the data to the memory in the inverter.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) While the inverter was |  |
| writing data (especially |  |
| initializing data or copying |  |
| data), power supply was |  |
| turned OFF and the |  |
| voltage for the control |  |
| circuit dropped. |  |$\quad$| Check if pressing the 共 key resets the alarm after the function code data |
| :--- |
| are initialized by setting the data of H03 to 1. |
| $\rightarrow$ Return the initialized function code data to their previous settings, then |
| restart the operation. |

## [16] $\varepsilon_{r}$ C Keypad communications error

Problem A communications error occurred between the remote keypad and the inverter.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) Break in the |  |
| communications cable or |  |
| poor contact. |  |$\quad$| Check continuity of the cable, contacts and connections. |
| :--- |
| $\rightarrow$ Re-insert the connector firmly. |
| $\rightarrow$ Replace the cable. |

## [ 17 ] $E_{r} 3$ CPU error

Problem A CPU error (e.g. erratic CPU operation) occurred.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) A high intensity noise was |  |
| given to the inverter. |  | | Check if appropriate noise control measures have been implemented (e.g. |
| :--- |
| correct grounding and routing of control and main circuit wires and |
| communications cable). |
| $\rightarrow$ Improve noise control. |

[ 18 ] $E_{r}-4$ Option card communications error
Problem A communications error occurred between the option card and the inverter.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) There was a problem with <br> the connection between <br> the bus option card and <br> the inverter. | Check whether the connector on the bus option card is properly mating with <br> the connector of the inverter. <br> $\rightarrow$ Reload the bus option card into the inverter. |
| (2)There was a high intensity <br> noise from outside. | Check whether appropriate noise control measures have been implemented <br> (e.g. correct grounding and routing of control and main circuit wires and <br> communications cable). <br> $\rightarrow$ Reinforce noise control measures. |

## [19] Er-S Option card error

An error detected by the option card. Refer to the instruction manual of the option card for details.

## [20] $\varepsilon_{r}-S$ Incorrect operation error

Problem You incorrectly operated the inverter.

| Possible Causes | What to Check and Suggested Measures |
| :---: | :---: |
| (1) The key was pressed when H96 = 1 or 3 . | Although a Run command had been inputted from the input terminal or through the communications port, the inverter was forced to decelerate to stop. <br> If this was not intended, check the setting of H96. |
| (2) The start check function was activated when H96 = 2 or 3. | With a Run command being inputted, any of the following operations has been performed: <br> - Turning the power ON <br> - Releasing the alarm <br> - Switching the enable communications link (LE) operation <br> $\rightarrow$ Review the running sequence to avoid input of a Run command when this error occurs. <br> If this was not intended, check the setting of H96. <br> (To reset the alarm, turn the Run command OFF.) |
| (3) The forced stop digital input (STOP) was turned ON. | Turning ON the forced stop digital input (STOP) decelerated the inverter to stop according to the specified deceleration period (H96). <br> $\rightarrow$ If this was not intended, check the settings of E01 through E05 on terminals X1 through X5. | [21] $\varepsilon_{r}-7$ Tuning error

Problem Auto-tuning failed.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)A phase was missing <br> (There was a phase loss) <br> in the connection between <br> the inverter and the motor. | $\rightarrow$ Properly connect the motor to the inverter. |
| (2)V/f or the rated current of <br> the motor was not properly <br> set. | Check whether the data of function codes F04, F05, H50, H51, P02, and P03 <br> agrees with the specifications of the motor. |
| (3)The connection between <br> the inverter and the motor <br> was too long. | Check whether the connection length between the inverter and the motor is <br> not exceeding 50m. <br> $\rightarrow$ Review, and if necessary, change the layout of the inverter and the motor <br> to shorten the connection wire. Alternatively, minimize the connection <br> wire length without changing the layout. <br> $\rightarrow$ Disable both auto-tuning and auto-torque (set F37 to "1"). |
| (4)The rated capacity of the <br> motor was significantly <br> different from that of the <br> inverter. | Check whether the rated capacity of the motor is smaller than that of the <br> inverter by three or more orders of class or larger by two or more orders of <br> class. <br> $\rightarrow$ Check whether it is possible to replace the inverter with one with an <br> appropriate capacity. |
| $\rightarrow$Manually specify the values for the motor parameters P06, P07, and P08. <br> $\rightarrow$ Disable both auto-tuning and auto-torque boost (set F37 to "1"). |  |
| (5)The motor was a special <br> type such as a high-speed <br> motor. | $\rightarrow$ Disable both auto-tuning and auto-torque boost (set F37 to "1"). |

Flal For details of tuning errors, refer to "Errors during Tuning" in Chapter 4, Section 4.1.3 "Preparation before running the motor for a test - Setting function code data."

## [ 22] $\varepsilon_{1}-B$ RS485 communications error

Problem A communications error occurred during RS485 communications.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)Conditions for <br> communications differ <br> between the inverter and <br> host equipment. | Compare the settings of the y codes (y01 to y10) with those of the host <br> equipment. <br> $\rightarrow$ Correct any settings that differ. |
| (2)Even though no response <br> error detection time (y08) <br> has been set, <br> communications is not <br> performed within the <br> specified cycle. | Check the host equipment. <br> $\rightarrow$ Change the settings of host equipment software, or make the no <br> response error detection time be ignored (y08=0). |
| (3)Host equipment (e.g., <br> PLCs and personal <br> computers) did not <br> operate due to incorrect <br> setting and/or defective <br> software/hardware. | Check the host equipment. <br> $\rightarrow$ Remove the cause of the equipment error. |
| (4)Relay converters (e.g., <br> RS485 relay converter) <br> did not operate due to <br> incorrect connections and <br> settings, or defective <br> hardware. | Check the RS485 relay converter (e.g., check for poor contact). <br> $\rightarrow$ Change the various RS485 converter settings, reconnect the wires, or <br> replace hardware (such as recommended devices) as appropriate. |
| (5)Broken communications <br> cable or poor contact. | Check continuity of the cable, contacts and connections. <br> $\rightarrow$ Replace the cable. |

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| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (6) A high intensity noise was |  |
| given to the inverter. | Check if appropriate noise control measures have been implemented (e.g., <br> correct grounding and routing of control and main circuit wires). <br> $\rightarrow$ Improve noise control. <br> $\rightarrow$ Improve noise reduction measures on the host side. <br> $\rightarrow$ Replace the RS485 relay converter with a recommended insulated <br> converter. |

## [ 23] $\varepsilon_{1}-\digamma$ Data saving error during undervoltage

Problem The inverter was unable to save data such as the frequency commands and PID process command set through the keypad when the power was switched off.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) The control circuit voltage |  |
| drepped suddenly while |  |
| data was being saved |  |
| when the power was |  |
| turned OFF, because the |  |
| DC link bus was rapidly |  |
| discharged. |  | | Check how long it takes for the DC link bus voltage to drop to the preset |
| :--- |
| voltage when power is turned OFF. |
| $\rightarrow$ Remove whatever is causing the rapid discharge of the DC link bus |
| electricity. After pressing the (ers key and releasing the alarm, set, using a |
| remote keypad, the data of the relevant function codes (such as the |
| frequency commands and PID process command) back to the original |
| values and then restart the operation. |

## [ 24] $E_{1}-P$ RS485 communications error (Option card)

Problem A communications error occurred during RS485 communications (Option card).

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)Conditions for <br> communications differ <br> between the inverter and <br> host equipment. | Compare the settings of the y codes (y01 to y10) with those of the host <br> equipment. <br> $\rightarrow$ Correct any settings that differ. |
| (2)Even though no response <br> error detection time (y18) <br> has been set, <br> communications did not <br> occur cyclically. | Check the host equipment. <br> $\rightarrow$ Change the settings of host equipment software, or make the no <br> response error detection time invalid (y18=0). |
| (3)Host equipment (e.g., <br> PLCs and personal <br> computers) did not <br> operate due to incorrect <br> settings and/or defective <br> software/hardware.$\quad$Check the host equipment. <br> (4) Remove the cause of the equipment error. |  |
| Relay converters (e.g., <br> RS485 relay converter) <br> did not operate due to <br> incorrect connections and <br> settings, and defective <br> hardware. | Check the RS485 relay converter (e.g., check for poor contact). <br> $\rightarrow$ Change the various RS485 converter settings, reconnect the wires, or <br> replace hardware (such as recommended devices) as appropriate. |

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\(\left.$$
\begin{array}{l|l}\hline \text { Possible Causes } & \text { What to Check and Suggested Measures } \\
\hline \text { (5) Broken communications } \\
\text { cable or poor contact. }\end{array}
$$ \quad \begin{array}{l}Check continuity of the cable, contacts and connections. <br>

\rightarrow Replace the cable.\end{array}\right]\)| (6) A high intensity noise was |
| :--- | :--- |
| given to the inverter. |$\quad$| Check if appropriate noise control measures have been implemented (e.g., |
| :--- |
| correct grounding and routing of control and main circuit wires). |
| $\rightarrow$ Improve noise control. |
| $\rightarrow$ Improve noise reduction measures on the host side. |
| $\rightarrow$ Replace the RS485 relay converter with a recommended insulated |
| converter. |

[ 25 ] $\varepsilon_{-}-H$ LSI error (Power PCB) ( 45 kW or above ( 200 V series); 55 kW or above ( 400 V series))
Problem An error occurred in the LSI on the power printed circuit board (power PCB).

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1) The capacity is not set |  |
| properly on the control |  |
| printed circuit board. |  |$\quad$| The inverter capacity needs to be modified again. |
| :--- |
| $\rightarrow$ Contact your Fuji Electric representative. |

### 6.4 If an Abnormal Pattern Appears on the LED Monitor while No Alarm Code is Displayed

## [1] --- - (center bar) appears

Problem A center bar (----) has appeared on the LCD monitor.

| Possible Causes | What to Check and Suggested Measures |
| :---: | :---: |
| (1) When PID control had been disabled ( $\mathrm{J} 01=0$ ), you changed E43 (display selection) to 10 or 12. <br> You disabled PID control ( $\mathrm{J} 01=0$ ) when the LED monitor had been set to display the PID final command value or PID feedback value by pressing the 출 key. | Make sure that when you wish to view other monitor items, E43 is not set to <br> "10: PID process command (final)" or "12: PID feedback value." <br> $\rightarrow$ Set E43 to a value other than "10" or "12." <br> Make sure that when you wish to view a PID process command or a PID feedback value, PID control is still in effect or J01 is not set to 0 . <br> $\rightarrow$ Set J01 to "1: Enable (normal operation)" or "2: Enable (inverse operation)." |
| (2) Connection to the keypad was in poor connection. | Prior to proceed, check that pressing the key does not take effect for the LED display. <br> Check connectivity of the extension cable for the keypad used in remote operation. <br> $\rightarrow$ Replace the cable. |

Problem An under bar (___) appeared on the LED monitor when you pressed the key or entered a run forward command (FWD) or a run reverse command (REV). The motor did not start.

| Possible Causes | What to Check and Suggested Measures |
| :---: | :---: |
| (1) The voltage of the DC link bus was low. | Select 今_i7 i under Menu \#5 "Maintenance Information" in Programming mode on the keypad, and check the voltage of the DC link bus, which should be: 200 VDC or below for 3-phase 200V, and 400 VDC or below for 3-phase 400 V . <br> $\rightarrow$ Connect the inverter to a power supply that meets its input specifications. |
| (2) The main power is not ON, while the auxiliary input power to the control circuit is supplied | Check that the main power is turned ON. <br> $\rightarrow$ If it is not ON, turn it ON. |

## [3] [ ]appears

Problem Parentheses ( $\left[\begin{array}{l}{[ } \\ ]\end{array}\right)$ has appeared on the screen while the keypad displaying the Drive Monitor.

| Possible Causes | What to Check and Suggested Measures |
| :--- | :--- |
| (1)The data to be displayed <br> could not fit the LED <br> monitor (e.g. overflown). | Check that the product of the output frequency and the display coefficient <br> (E50) does not exceed 9999. <br> $\rightarrow$ Adjust the setting of E50. |

## Chapter 7 MAINTENANCE AND INSPECTION

Perform daily and periodic inspection to avoid trouble and keep reliable operation for a long time. Take care of the following items during work.

## $\triangle$ WARNING

- Before proceeding to the maintenance/inspection jobs, turn OFF the power and wait more than five minutes for models of 30 kW or below, or ten minutes for models of 37 kW or above. Make sure that the LED monitor and charging lamp (on models of 37 kW or above) are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC link bus voltage between the terminals $\mathrm{P}(+)$ and $\mathrm{N}(-)$ has dropped below the safe voltage (+25 VDC).
Electric shock may occur.
- Maintenance, inspection, and parts replacement should be made only by authorized persons.
- Take off the watch, rings and other metallic matter before starting work.
- Use insulated tools.
- Never modify the inverter.

Electric shock or injuries could occur.

### 7.1 Daily Inspection

Visually inspect errors in the state of operation from the outside without removing the covers while the inverter operates or while it is turned ON.

- Check if the expected performance (satisfying the standard specification) is obtained.
- Check if the surrounding environment satisfies Chapter 2, Section 2.1 "Operating Environment."
- Check that the LED monitor displays normally.
- Check for abnormal noise, odor, or excessive vibration.
- Check for traces of overheat, discoloration and other defects.


### 7.2 Periodic Inspection

Perform periodic inspection by following the items of the list of periodic inspection in Table 7.1. Before performing periodic inspection, be sure to stop the motor, turn OFF the inverter, and shut down power supply. Then remove the covers of the control and main circuit terminal blocks.

Table 7.1 List of Periodic Inspections

| Check part | Check item | How to inspect | Evaluation criteria |
| :---: | :---: | :---: | :---: |
| Environment | 1) Check the ambient temperature, humidity, vibration and atmosphere (dust, gas, oil mist, or water drops). <br> 2) Check if tools or other foreign matter or dangerous objects are left around the equipment. | 1) Check visually or measure using apparatus. <br> 2) Visual inspection | 1) The standard specification must be satisfied. <br> 2) No foreign or dangerous objects are left. |
| Voltage | Check if the voltages of the main and control circuit are correct. | Measure the voltages using a multimeter or the like. | The standard specification must be satisfied. |
| Keypad | 1) Check if the display is clear. <br> 2) Check if there is missing parts in the characters. | 1), 2) <br> Visual inspection | 1), 2) <br> The display can be read and there is no fault. |

Table 7.1 Continued

| Check part |  | Check item | How to inspect | Evaluation criteria |
| :---: | :---: | :---: | :---: | :---: |
| Structure such as frame and cover |  | 1) Abnormal noise and excessive vibration <br> 2) Loosen bolts (tightened parts) <br> 3) Deformation and breakage <br> 4) Discoloration and deformation caused by overheat <br> 5) Check for foulness and dust. | 1) Visual or hearing inspection <br> 2) Retighten. <br> 3), 4), 5) <br> Visual inspection | $\begin{aligned} & \text { 1), 2), 3), 4), 5) } \\ & \text { No abnormalities } \end{aligned}$ |
|  | Common | 1) Check if bolts and screws are tight and not missing. <br> 2) Check the devices and insulators for deformation, cracks, breakage and discoloration caused by overheat and deterioration. <br> 3) Check for foulness and dust. | 1) Retighten. <br> 2), 3) <br> Visual inspection | 1), 2), 3) <br> No abnormalities |
|  | Conductor and wire | 1) Check the conductor for discoloration and distortion caused by overheat. <br> 2) Check the sheath of the cable for cracks and discoloration. | 1), 2) <br> Visual inspection | 1), 2) <br> No abnormalities |
|  | Terminal block | Check that the terminals are not damaged. | Visual inspection | No abnormalities |
|  | Filtering capacitor | 1) Check for electrolyte leakage, discoloration, cracks and swelling of the case. <br> 2) Check if the safety valve does not protrude remarkably. <br> 3) Measure the capacitance if necessary. | 1), 2) <br> Visual inspection <br> 3) Measure discharge time with capacitance probe. | 1), 2) <br> No abnormalities <br> 3) The discharge time is not shorter than time specified by the replacement manual |
|  | Transformer and reactor | Check for abnormal roaring noise and odor. | Hearing, visual and smelling inspection | No abnormalities |
|  | Magnetic contactor and relay | 1) Check for chatters during operation. <br> 2) Check for rough contacts. | 1) Hearing inspection <br> 2) Visual inspection | 1), 2) <br> No abnormalities |
| 응 은 응 | Printed circuit board | 1) Check for loose screws and connectors. <br> 2) Check for odor and discoloration. <br> 3) Check for cracks, breakage, deformation and remarkable rust. <br> 4) Check the capacitors for electrolyte leaks and deformation. | 1) Retighten. <br> 2) Smelling and visual inspection <br> 3), 4) <br> Visual inspection | $\begin{aligned} & \text { 1), 2), 3), 4) } \\ & \text { No abnormalities } \end{aligned}$ |
|  | Cooling fan | 1) Check for abnormal noise and excessive vibration. <br> 2) Check for loose bolts. <br> 3) Check for discoloration caused by overheat. | 1) Hearing and visual inspection, or turn manually (be sure to turn the power OFF). <br> 2) Retighten. <br> 3) Visual inspection | 1) Smooth rotation <br> 2), 3) <br> No abnormalities |
|  | Ventilation path | Check the heat sink, intake and exhaust ports for clogging and foreign matter. | Visual inspection | No abnormalities |

If the inverter is stained, wipe it off with a chemically neutral cloth to remove dust and use a vacuum cleaner.

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### 7.3 List of Periodical Replacement Parts

Each part of the product has its own service life that will vary according to the environmental and operating conditions. It is recommended that the following parts be replaced as specified below.
When the replacement is necessary, contact your Fuji Electric representative.
Table 7.2 Replacement Parts

| Part name | Standard replacement intervals |
| :--- | :--- |
| DC link bus capacitor | 7 years |
| Electrolytic capacitor on the printed circuit board | 7 years |
|  | 7 years $(5.5 \mathrm{~kW}$ or below $)$ |
| Cooling fan | 4.5 years $(7.5$ to 30 kW$)$ |
|  | 3 years $\quad(37 \mathrm{~kW}$ or above $)$ |
| Fuse | 10 years $\quad(90 \mathrm{~kW}$ or above $)$ |

(Note) These replacement intervals are based on the estimated service life of the inverter at an ambient temperature of $40^{\circ} \mathrm{C}$ under $80 \%$ of full load. In environments with an ambient temperature above $40^{\circ} \mathrm{C}$ or a large amount of dust or dirt, the replacement intervals may need to be reduced.

### 7.3.1 Judgment on service life

## (1) Viewing data necessary for judging service life; Measurement procedures

Through Menu \#5 "Maintenance Information" in Programming mode, you can view on the keypad various data (as a guideline) necessary for judging whether key components such as the DC link bus capacitor, the electrolytic capacitor on the printed circuit board, and the cooling fan are approaching their service life.
(1) - 1 Measuring the capacitance of the DC link bus capacitor (in comparison with that at factory shipment)

Measure the capacitance of the DC link bus capacitor according to the procedure given below. The result will be displayed on the keypad as a ratio (\%) to the initial capacitance at the time of factory shipment.

## Procedure for measuring capacitance

1) To ensure validity in the comparative measurement, put the condition of the inverter back to the state at factory shipment.

- Remove the option card (if already in use) from the inverter.
- In case another inverter is connected via the DC link bus to the $\mathrm{P}(+)$ and $\mathrm{N}(-)$ terminals of the main circuit, disconnect the wires. (You do not need to disconnect a DC reactor (optional), if any.)
- Disconnect power wires for the auxiliary input to the control circuit (R0, T0).
- In case the standard keypad has been replaced with a multi-function keypad after the purchase, put back the original standard keypad.
- Turn OFF all the digital input signals fed to terminals [FWD], [REV], and [X1] through [X5] of the control circuit.
- If a potentiometer is connected to terminal [13], disconnect it.
- If an external apparatus is attached to terminal [PLC], disconnect it.
- Ensure that transistor output signals ([Y1] - [Y3]) and relay output signals ([Y5A/C] and [30A/B/C]) will not be turned ON.
Note If negative logic is specified for the transistor output and relay output signals, they are considered ON when the inverter is not running. Specify positive logic for them.
- Keep the ambient temperature within $25 \pm 10^{\circ} \mathrm{C}$.

2) Switch $O N$ the main circuit power.
3) Confirm that the cooling fan is rotating and the inverter is in stopped state.
4) Switch OFF the main circuit power.
5) Start the measurement of the capacitance of the DC link bus capacitor. Make sure that " . . . " appears on the LED monitor.
Note If " . . . " does not appear on the LED monitor, the measurement will not start. Check the conditions listed in 1).
6) Once " . . . ." has disappeared from the LED monitor, switch ON the main circuit power again.
7) Select Menu \#5 "Maintenance Information" in Programming mode and note the reading (relative capacitance (\%) of the DC link bus capacitor).
(1) - 2 Measuring the capacitance of the DC link bus capacitor (during power-off time under ordinary operating condition)
In general, the discharging condition of the DC link bus capacitor during a power-off time under the ordinary operating condition at the end user's installation is different from that under which the initial measurement is conducted at the time of factory shipment. As a result, the measured data for the DC link bus capacitor may not be updated. A method is provided, therefore, that allows you to measure the capacitance of the DC link bus capacitor during an ordinary power-off time by taking on (assuming) its discharging condition during a power-off time under the ordinary operation condition at the end user's installation.

Presented below is the procedure for taking on the discharging condition during a power-off time under the ordinary operating condition at the end user's installation.

## Procedure for setting up measurement condition

1) Set function code H98 (Protection/maintenance function) to enable the user to specify the judgment criteria for the service life of the DC link bus capacitor (Bit 3 ) (refer to function code H98).
2) Place the inverter in stopped state.
3) Place the inverter in the state of power-off under ordinary operating conditions.
4) Set both function codes H42 (Capacitance of DC link bus capacitor) and H47 (Initial capacitance of DC link bus capacitor) to "0000."
5) Switch OFF the inverter.

Measure the discharging time of the DC link bus capacitor and save the result in function code H 47 (Initial capacitance of DC link bus capacitor).
The condition under which the measurement has been conducted will be automatically collected and saved. During the measurement, " . . . " will appear on the LED monitor.
6) Switch ON the inverter again. Confirm that H42 (Capacitance of DC link bus capacitor) and H47 (Initial capacitance of DC link bus capacitor) hold right values. Move to Menu \#5 "Maintenance Information" and confirm that the relative capacitance (ratio to full capacitance) is $100 \%$.

Note If the measurement has failed, "0001" is entered into both H 42 and H47. Check whether there has been any mistake in operation and conduct the measurement again.

To change the settings back to the state at the time of factory shipment, set H 47 (Initial capacitance of DC link bus capacitor) to "0002"; the original values will be restored.
Hereafter, each time the inverter is switched OFF, the discharging time of the DC link bus capacitor is automatically measured if the above condition is met.

Note
The condition given above produces a rather large measurement error. If this mode gives you a lifetime alarm, set H98 (Maintenance operation) back to the default setting (Bit 3 (Specify service life criteria for replacing the $D C$ link bus capacitor) $=0$ ) and conduct the measurement under the condition at the time of factory shipment.

## Electrolytic capacitor on the printed circuit board

Move to Menu \#5 "Maintenance Information" in Programming mode and check the accumulated run time of the electrolytic capacitor on the printed circuit board. This value is calculated from the cumulative total number of hours a voltage has been applied on the electrolytic capacitor, adjusted with ambient temperature, and is used as the basis for judging whether it has reached its service life. The value is displayed on the LED monitor in units of 1000 hours.

## (3. Cooling fan

Select Menu \#5 "Maintenance Information" and check the accumulated run time of the cooling fan. The inverter accumulates hours for which the cooling fan has run. The display is in units of 1000 hours. The accumulated time should be used just a guide since the actual service life will be significantly affected by the temperature and operation environment.
(2) Early warning of lifetime alarm

For the components listed in Table 7.3, you can get an early warning of lifetime alarm at one of the transistor output terminals ([Y1] to [Y3]) and the relay contact terminals ([Y5A] - [Y5C], and [30A/B/C]) as soon as any of the conditions listed under the "Judgment level" column has been exceeded.
The early warning signal is also turned ON when a lock condition on the internal air circulation DC fan (on 200V series inverters with a capacity of 45 kW or above; on 400 V series inverters with a capacity of 55 kW or above) has been detected.

Table 7.3 Criteria for Issuing a Lifetime Alarm

| Parts to be replaced | Judgment level |
| :--- | :--- |
| DC link bus capacitor | $85 \%$ or lower of the capacitance than that of the factory setting |
| Electrolytic capacitor on the printed circuit board | 61000 hours or longer as accumulated run time |
| Cooling fan | Accumulated run time $\geq 61000$ hours $(5.5 \mathrm{~kW}$ or below) <br>  <br>  <br>  <br>  <br>  <br>  <br>  <br>  <br>  <br>  <br>  <br> Accumulated run time $\geq 40000$ hours $(7.5$ to 30 kW$)$ <br> (estimated service life at the inverter's ambient temperature of $\geq 25000$ hours ( 37 kW or above) <br> $40^{\circ} \mathrm{C}$ under $80 \%$ of full load) |

### 7.4 Measurement of Electrical Amounts in Main Circuit

Because the voltage and current of the power supply (input, primary circuit) of the main circuit of the inverter and those of the motor (output, secondary circuit) include harmonic components, the readings may vary with the type of the meter. Use meters indicated in Table 7.4 when measuring with meters for commercial frequencies.
The power factor cannot be measured by a commercially available power-factor meter that measures the phase difference between the voltage and current. To obtain the power factor, measure the power, voltage and current on each of the input and output sides and calculate in the following formula.

- Three-phase input

Power factor $=\frac{\text { Electric power }(\mathrm{W})}{\sqrt{3} \times \text { Voltage }(\mathrm{V}) \times \text { Current }(\mathrm{A})} \times 100 \%$
Table 7.4 Meters for Measurement of Main Circuit

| $\stackrel{\text { 테̇ }}{\text { ¢ }}$ | Input (primary) side |  |  | Output (secondary) side |  |  | DC link bus voltage ( $\mathrm{P}(+)-\mathrm{N}(-))$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & E \\ & \end{aligned}$ |  <br> Current |  |  |  |  |  |  |
|  | Ammeter Ar, As, At | Voltmeter <br> Vr, Vs, VT | Wattmeter $W_{R}, W_{T}$ | Ammeter $A u, A v, A w$ | Voltmeter Vu, Vv, Vw | Wattmeter Wu, Ww | $\underset{\mathrm{V}}{\mathrm{DC} \text { voltmeter }}$ |
|  | Moving iron type | Rectifier or moving iron type | Digital AC power meter | Digital AC power meter | Digital AC power meter | Digital AC power meter | Moving coil type |
|  | $\mathbb{K}$ | $H \underset{K}{*}$ | - | - | - | - | (-) |

Note
It is not recommended that meters other than a digital AC power meter be used for measuring the output voltage or output current since they may cause larger measurement errors or, in the worst case, they may be damaged.


Figure 7.1 Connection of Meters

### 7.5 Insulation Test

Because an insulation test is made in the factory before shipment, avoid a Megger test.
If a Megger test is unavoidable, follow the procedure below. Because a wrong test procedure will cause breakage of the inverter, take sufficient care.
A dielectric strength test will cause breakage of the inverter similarly to the Megger test if the test procedure is wrong. When the dielectric strength test is necessary, contact your Fuji Electric representative.

## (1) Megger test of main circuit

1) Use a 500 VDC Megger and shut off the main power supply without fail during measurement.
2) If the test voltage leaks to the control circuit due to the wiring, disconnect all the control wiring.
3) Connect the main circuit terminals with a common cable as shown in Figure 7.2.
4) The Megger test must be limited to across the common line of the main circuit and the ground terminal ( ( $\boldsymbol{\tau}_{\mathrm{V}}$ ))
5) $5 \mathrm{M} \Omega(1 \mathrm{M} \Omega$ for the EMC filter built-in type of inverters) or a larger value displayed at the Megger indicates a correct state. (The value is for a discrete inverter.)


Figure 7.2 Megger Test

## (2) Dielectric strength test of control circuit

Do not perform a Megger test or dielectric strength test for the control circuit. Prepare a high resistance range tester for the control circuit.

1) Disconnect all the external wiring from the control circuit terminals.
2) Perform a continuity test to the ground. $1 \mathrm{M} \Omega$ or a larger measurement indicates a correct state.
(3) Dielectric strength test of external main circuit and sequence control circuit

Disconnect all the inverter terminals so that the test voltage is not applied.

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7.6 Inquiries about Product and Guarantee
(1) When making an inquiry

Upon breakage of the product, uncertainties, failure or inquiries, report the following information to your Fuji Electric representative.

1) Inverter type (Refer to Chapter 1, Section 1.1.)
2) SER No. (serial number of equipment) (Refer to Chapter 1, Section 1.1.)
3) Function codes and their data that you changed (Refer to Chapter 3, Section 3.4.3.)
4) ROM version (Refer to Chapter 3, Section 3.4.6.)
5) Date of purchase
6) Inquiries (for example, point and extent of breakage, uncertainties, failure phenomena, and other circumstances)

## (2) Product warranty

The term of product warranty is one year after the purchase or 24 months from the month and year of production specified on the nameplate, whichever comes first. However, the product will not be repaired free of charge in the following cases, even if the warranty term has not expired.

1) The cause includes incorrect usage or inappropriate repair or modification.
2) The product is used outside the standard specified range.
3) The failure is caused by dropping, damage or breakage during transportation after the purchase.
4) The cause is earthquake, fire, storm or flood, lightening, excessive voltage, or other types of disaster or secondary disasters. Chapter 8 SPECIFICATIONS

### 8.1 Standard Models

### 8.1.1 Three-phase 200 V series

|  |  | Itam | Specifications |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type (FRN_ _ F1S-2 $\square$ ) |  |  | 0.75 | : 5 | 2.2 | 3.7 | 5.5 | 7.5 | 11. | \% 5 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 | 110 |
| Nominal applied motor ${ }_{4}(\mathrm{WW}){ }^{*} 1$ |  |  | 0.75 | $\therefore 5$ | 2.2 | 3.7 | 5.5 | 7.5 | 11. | : 5 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 | 1111 |
|  | Rated sapacity (kVA) $\quad 2$ |  | 1.6 | 2.6 | 4.0 | 6.3 | 9.0 | 12 | 17 | 22 | 27 | 32 | 43 | 53 | 64 | 80 | 105 | 122 | 148 |
|  | Rated voitage (V) |  | Three-phase, $200 \mathrm{~V} / 50 \mathrm{~Hz}, 20 \mathrm{C}, 22 \mathrm{C}, 23 \mathrm{C}, 24 \mathrm{C} \mathrm{V} / 6 \mathrm{CHz}$ (W:th AVR function) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current (A) |  |  |  |  |  | $\begin{aligned} & 23.8 \\ & (22.5) \end{aligned}$ | $\begin{aligned} & 31.8 \\ & (29) \end{aligned}$ | $\begin{gathered} 45 \\ (42) \end{gathered}$ | $\begin{gathered} 58 \\ (55) \end{gathered}$ | $\begin{gathered} 73 \\ (68) \end{gathered}$ | $\begin{gathered} 85 \\ (80) \end{gathered}$ | $\binom{114}{(107)}$ | $\binom{140}{(130)}$ | $\left\|\begin{array}{c} 170 \\ (156) \end{array}\right\|$ | $\left\lvert\, \begin{aligned} & 211 \\ & (198) \end{aligned}\right.$ | $\left.\begin{array}{\|c\|} \hline 276 \\ (270) \end{array} \right\rvert\,$ | $\begin{aligned} & 322 \\ & 1320) \end{aligned}$ | $\begin{array}{\|c} 390 \\ (384) \end{array}$ |
|  | Over'oad capaiility |  | 120\% of rated current for ${ }^{\text {a min }}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated frequency |  | 50, 60 Hz |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Phases, voltege, freque.cy | Main power supry | Three-phase, 200 to $240 \mathrm{~W}, 50 / 60 \mathrm{Fz}$ |  |  |  |  |  |  |  |  |  |  | Three-phase, 200 to $220 \mathrm{~W} / 50 \mathrm{~Hz}$ Three-phase, 200 to $230 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |  |  |
|  |  | Auxiliary ecntrel power input <br> Auxiilary fa. power :nput | Sing e-phase, 200 to $24 \mathrm{CV}, 50 \mathrm{bc} \mathrm{Hz}$ for the terminals |  |  |  |  |  |  |  |  |  |  | Single-phase, 200 ta $220 \mathrm{~V} / 50 \mathrm{~Hz}$ Single-phase, 200 ta $230 \mathrm{~V} / 60 \mathrm{~Hz}$ |  |  |  |  |  |
|  | Veltageffequency variations |  | Voltage: +10 to $-15 \%$ (Voltage unbalance: $2 \%$ or less) ${ }^{+10}$, Frequency +5 to $-5 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Faterd ${ }^{\text {(witi DCR }}$ ) |  |  | 6.1 | 8.9 | 15.0 | 21.1 | 28.8 | 42.2 | 57.6 | 71.0 | 84.4 | 114 | 138 | 167 | 203 | 282 | 334 | 410 |
|  | curfent (A) <br> Required po supply capa |  |  |  | $\begin{aligned} & 13.2 \\ & 3.1 \end{aligned}$ | $\begin{aligned} & 22.2 \\ & 5.3 \end{aligned}$ | $\begin{aligned} & 31.5 \\ & 7.4 \end{aligned}$ | $\begin{aligned} & 42.7 \\ & 10 \end{aligned}$ | $\begin{aligned} & 60.7 \\ & 15 \end{aligned}$ |  | 97.0 25 | $\begin{aligned} & 112 \\ & 30 \end{aligned}$ | $\begin{aligned} & 151 \\ & 40 \end{aligned}$ | $\begin{aligned} & 185 \\ & 48 \end{aligned}$ | $\begin{aligned} & 225 \\ & 58 \end{aligned}$ | $\begin{aligned} & 270 \\ & 71 \end{aligned}$ | $\begin{gathered} - \\ 98 \end{gathered}$ | $\begin{array}{r} - \\ 116 \end{array}$ | - 142 |
| 므줄 | Torque (\%) |  | 20 |  |  |  |  |  |  |  |  |  | 10 to 15 |  |  |  |  |  |  |
| 年 | DC braking feactor (DCR) |  | Sta.ting frequency: 0.0 to 60.0 F .2, Braking time: 0.0 to 30.0 s , Eraking level: 0 to $60 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| App"icable safety standards <br> Enclosture (IEC60529) |  |  | ```UL508C, 622.2 NG 4, ER50:78:497 (Apply:Mg) IP20, UL opex type ``` |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cooling method Mass (kg) |  |  | Natura cooling |  | Fan cooling |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 3.1 |  | 33 | 3.4 | 3.4 | 5.8 | 6.0 | 6.9 | 9.5 | 9.7 | 11.5 | 23 | 33 | 34 | 41 |  |  |

*1 Furi 4-pole standard motor
*2 Rated cafacity is calcilated jy assoming tae output tated woltage as 220 w for three-phase 200 w series.
*3 Output wotage cannot exceed the power suppy weltage.
*4 An excessively low setting of the carfer frequency may tesult in tan highen notor temperature or tripping of the inverter by its overcurrent imiter setting. Lower the contioupse oad o: maximur: load instead. (When setting the carrier frequency (F26) to ikHz, reduce the load to $80 \%$ of its rating.)
*5 When an inverter is continuousy ranning with tine carrier frequency of 3 kHz or rore in the ambient terrperature of 40 ºt or higher, manage its load current to be within tie rated ones denoted in parentheses ()
*G Use $\left[\mathrm{R}^{\prime} ., \mathrm{T}^{*}\right]$ terminals for driving AC cooling fans of an i:verter powered by the DC link bus, such as by a hish power factor PWM converter. (Ir ordinary operation, the terrinals are not used.)
*7 Calculated under Fuï-specified conditions.
*8 Optained when a DC reactor (DCR) is used.

* Average jraking torque (Varies with the efficiency of the rootor.)
* 10 Votage uabaiance (\%) $=\frac{\text { Max. woltage (W)-Min. voitage (V) }}{\text { Three-phase average voltage (V) }} \times 67$ (IEC61800-3 (5.2.3)

If this value is 2 to $3 \%$, use an $A C$ reactor ( ACR ).

Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.

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### 8.1.2 Three-phase 400 V series

$\square 0.75$ to 55 kW


* 1 -

2 Rated capacity is calculated by assuming the output rated voltage as 440 V for three-phase 40 V series-

* Qutput valdage cannot exceed the power supply voltage.
* An excessively low setuing of the carrier frequency may result in the higher motor temperature or tripping of the inverter by its overcurrent limiter setting. Lower the continubus load or maximum load instead. (When setifing the tarrier frequenty (F26) to 1 kJz , roduce the load to $80 \%$ of its rating.)
*5 Jise [R1, T1" serminals for driving AC cooling fans of an inwerter powered by the DC link bus, such as by a high power factor PWM converser. (In ordinary operation, the terminals are not wised.)
*is Calculated under Fuji-specified conditions.
- Obtained when a DC reactor (DCR) is used.
* Average braking torque (Varies with the efficiency of the motor,)
* The nominal applied motor of =RN4,0F1S-4E to be shipped for EU is 4.0 kW .
*it Single-phase, 380 :o 440 W 50 Hz or Single-phase, 380 to 480 W 60 Hz

15 this value is 2 to $3 \%$, use an $A C$ reactor ( $A C$ ? ).
Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.

*: Fuji 4-pole standard motor
*2 Rated capacily is calculated by assuming the output rated voltage as 440 V for three-phese 400 V series.
*3 Output voltage cannot cxccod fhe power supply voltage.
*4 An excessively low setting of the carrier frequency may result in the higher motor temperature or tripping of the inverter by its overcurrent limiter setting. Lower the continuous load or maximum load instead. When setting the carrier frequency (F26) to 1 kHz , feduce the load to $80 \%$ of its rating.)
*5 Use [R1, T1] terminals for driving $A C$ cooling fans of an inverter powered by the $D C$ link bus, such as by a high power factor FwiM converter (In ordinary operalion, the termirals are not used.)
${ }^{+6}$ Calculated under Fuji-specilied conditions.
${ }^{7}$ Obtained when a DC reactor ( $D C R$ ) is used.
* Average braking torque (varies with the efficiency of the motar.)
$* 9$ voltage unbalance $(\%)=\frac{\text { Max. voltage (V) - Min. voltage (V) }}{\text { Three-phase average voltage (V) }} \times 67$ (IEC61800-3 (5.2.3) If this value is 2 to $3 \%$, use an $A C$ reactor (ACR).

Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.

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### 8.2 Specifications of Keypad Related

### 8.2.1 General specifications of keypad

Table 8.1 General Specifications

| Items | Specification | Remarks |
| :---: | :---: | :---: |
| Protective structure | Front side: IP40, Back (mounting) side: IP20 |  |
| Site to be installed | In door |  |
| Ambient temperature | -10 to $50^{\circ} \mathrm{C}$ |  |
| Ambient humidity | 5 to $95 \%$ RH, no condensation allowed |  |
| Ambient air | No corrosive gas, no inflammable gas, no dust, and no direct sunlight allowed |  |
| Altitude | 1000 m or less | (Note) |
| Air pressure | 86 to 106 kPa |  |
| Vibration | 3 mm (maximum amplitude): Within 2 to 9 Hz <br> $9.8 \mathrm{~m} / \mathrm{s}^{2}:$ Within 9 to 20 Hz <br> $2 \mathrm{~m} / \mathrm{s}^{2}:$ Within 20 to 55 Hz <br> $1 \mathrm{~m} / \mathrm{s}^{2}:$ Within 55 to 200 Hz |  |
| Storage ambient temperature | -25 to $70^{\circ} \mathrm{C}$ |  |
| Storage ambient humidity | 5 to $95 \%$ RH (no condensation allowed) |  |
| External dimension | Refer to Section 8.5.3 "Keypad" |  |
| Mass | 55 grams |  |

(Note) When using an inverter in a place of an altitude within 1000 m to 3000 m , you need to lower the output current of the inverter. For details, refer to Chapter 2, Section 2.1 "Operating Environment."

### 8.2.2 Communications specifications of keypad

Table 8.2 Hardware specifications

| Items | Specification | Remarks |
| :--- | :--- | :--- |
| No. of linkable unit | One-to-one connection with an inverter | For a remote site <br> operation. |
| Link cable | US ANSI TIA/EIA-568A category 5 compliant straight type cable <br> (10BASE-T/100BASE-TX straight type) | Extension cable for <br> the remote site <br> operation (CB-5S, CB- <br> 3S, CB-1S and etc.) |
| Maximum cable <br> length | 20 m |  |
| Connector | Standard RJ-45 connector/jack | Refer to Table 8.3 |

Table 8.3 Pin Assignment of RJ-45 Connector

| Pin number | Signal | Description | Remarks |
| :--- | :--- | :--- | :--- |
| 1 and 8 | Vcc | Power supply lines for keypad | 5 VDC |
| 2 and 7 | GND | Grounding lines | 0 V to the ground |
| 3 and 6 | NC | Reserved |  |
| 4 | DX- | RS485 communications data line $(-)$ |  |
| 5 | DX + | RS485 communications data line $(+)$ |  |

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Table 8.4 Data Transmission Specification

| Items | Specification | Remarks |
| :--- | :--- | :--- |
| Station address | No need to specify. | To use any keypad, no setup <br> is needed for RS485 <br> communications related <br> function codes y01 to y10 <br> because their data is ignored. |
| Communications protocol | Modbus-RTU |  |
| Synchronization system | Asynchronous start-stop system |  |
| Communications system | Half-duplex | 19,200 bps |
| Transmission speed | Even |  |
| Parity | 1 bit | CRC-16 |

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|  | Item | Explanation | Remarks |
| :---: | :---: | :---: | :---: |
|  | Trip error code | Displays the cause of trip by codes. <br> - B1- ; (Overcurrent during acceleration) <br> RIG (Overcurent during deceleration) <br> - IL 7 I Overcuren: durirg nonning at constart speed:- <br> EF (Grounding fault) <br> - 1 in [Input phase lpss) <br> - LU (Undervoltage) <br> - Di, (Output phase lass) <br> - LTS (Overvoltage duting atcelemation) <br> - DLIC (Overvotage during ceceleration) <br> - BU 3 tovervoltage duing nun no at constant sseed) <br> - MA ; (Oveneatireg of the heat sink) <br> - RHC (External alarmi) <br> - DH 3 (lnverter overheat) <br> - 17 H (Motor protection (PTC thermistor)) <br> - Ti. ( (Motor overload) <br> - El U (Inverter overload) <br> - FIS, (Blown fuse) <br> * Gi= (Charging circuit fault) <br> - Ei I (Memory error) <br> - Er (keypad communication error) <br> - Er (CPU emor) <br> - Er 4 (Optional communication error) <br> - Er 5 (Option emor) <br> - Er Er (Operation action error) <br> , Er ? (Tuning emar) <br> - Er - (RS485 communication error) <br>  <br> - Er H (LS eror) |  |
|  | Trip history | Saves annd displays the leas: 4 trip ermr contes and their delailed destiption. |  |
|  | Refer to Section 8.6 "Protective Functions." |  |  |
|  | Refer to Chapter | n 1.4 "Sterage Envinomment" and Chapter 2. Seclion 2.1 "Operating Envirenment. |  |

### 8.4 Terminal Specifications

### 8.4.1 Terminal functions

For details about the main and control circuit terminals, refer to Chapter 2, Section 2.3.6 and Section 2.3.7 (Table 2.11), respectively.

### 8.4.2 Running the inverter with keypad


(Note 1) When connecting a DC reactor (DCR), first remove the short bar between terminals [P1] and [P+]. A DCR is optional for inverters below 75 kW but standard for inverters of 75 kW or above. For inverters of 75 kW or above, be sure to connect a DCR.
(Note 2) To protect wiring, insert a molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) (with overcurrent protection) of the type recommended for the inverter between the commercial power supply and the inverter. Do not use a circuit breaker with a capacity exceeding the recommended capacity.
(Note 3) In addition to an MCCB or ELCB, insert, if necessary, a magnetic contactor (MC) of the type recommended for the inverter to cut off the commercial power supply to the inverter. Furthermore, if the coil of the MC or solenoid comes into close contact with the inverter, install a surge absorber in parallel.
(Note 4) To put the inverter on standby by making the control circuit only active with the main circuit power supply being opened, connect this pair of wires to terminals [R0] and [T0]. Without connecting this pair of wires to these terminals, you can still run the inverter as long as the main wires of the commercial power supply to the main circuit are properly connected.
(Note 5) Normally no need to be connected. Use these terminals when the inverter is equipped with a high power factor PWM converter with a regenerative facility.
(Note 6) The inverter has either [FMP] or [FMI] depending on the type of the control printed circuit board (control PCB).

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### 8.4.3 Running the inverter by terminal commands


(Note 1) When connecting a DC reactor (DCR), first remove the short bar between terminals $[\mathrm{P} 1]$ and $[\mathrm{P}+]$. A DCR is optional for inverters below 75 kW but standard for inverters of 75 kW or above. For inverters of 75 kW or above, be sure to connect a DCR.
(Note 2) To protect wiring, insert a molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) (with overcurrent protection) of the type recommended for the inverter between the commercial power supply and the inverter. Do not use a circuit breaker with a capacity exceeding the recommended capacity.
(Note 3) In addition to an MCCB or ELCB, insert, if necessary, a magnetic contactor (MC) of the type recommended for the inverter to cut off the commercial power supply to the inverter. Furthermore, if the coil of the MC or solenoid comes into close contact with the inverter, install a surge absorber in parallel.
(Note 4) To put the inverter on standby by making the control circuit only active with the main circuit power supply being opened, connect this pair of wires to terminals [R0] and [T0]. Without connecting this pair of wires to these terminals, you can still run the inverter as long as the main wires of the commercial power supply to the main circuit are properly connected.
(Note 5) Normally no need to be connected. Use these terminals when the inverter is equipped with a high power factor PWM converter with a regenerative facility.
(Note 6) You can select the frequency command source either electronically by supplying a DC voltage signal (within the range of 0 to 10 V , 0 to 5 V , or 1 to 5 V ) between terminals [12] and [11], or manually by connecting a frequency command potentiometer to terminals [13], [12], and [11].
(Note 7) The inverter has either [FMP] or [FMI] depending on the type of the control printed circuit board (control PCB).
(Note 8) For the wiring of the control circuit, use shielded or twisted wires. When using shielded wires, connect the shields to earth. To prevent malfunction due to noise, keep the control circuit wires as far away as possible from the main circuit wires (recommended distance: 10 cm or longer), and never put them in the same wire duct. Where a control circuit wire needs to cross a main circuit wire, route them so that they meet at right angles.

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## 8．5 External Dimensions

## 8．5．1 Standard models



| Power supply voltage | Type |
| :---: | :---: |
| Three－ phase 200 V | FRN0．75F1S－2口 |
|  | FRN1．5F1S－2口 |
|  | FRN2．2F1S－2口 |
|  | FRN3．7F1S－2口 |
|  | FRN5．5F1S－2口 |
| Three－ phase 400 V | FRN0．75F1S－4口 |
|  | FRN1．5F1S－4D |
|  | FRN2．2F1S－4］ |
|  | FRN3．7F1S－4］ |
|  | FRN4．0F1S－4E＊ |
|  | FRN5．5F1S－4口 |

Unit：mm
＊The applicable motor rating of FRN4．0F1S－4E to be shipped for EU is 4.0 kW ．

Note：A box（口）in the above table replaces $A$ ，K，or $E$ depending on the shipping destination．


| $\begin{aligned} & \hline \text { Power } \\ & \text { supply } \\ & \text { voltage } \\ & \hline \end{aligned}$ | Type | Dimensions（mm） |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | W3 | W4 | H | H1 | D | D1 | D2 | D3 | D4 | ¢ ${ }^{\text {a }}$ | ¢B |
| Three－ phase 200 V | FRN7．5F1S－2口 <br> FRN11F1S－2口 | 220 | 196 | 63.5 | 46.5 | 46.5 | 260 | 238 | 215 | 118.5 | 96.5 | 141.7 | 16 | 27 | 34 |
|  | FRN15F1S－2口 |  |  |  |  |  |  |  |  |  |  | 136.7 | 21 | 34 | 42 |
|  | FRN18．5F1S－2口 | 250 | 226 | 67 | 58 | 58 | 400 | 378 |  | 85 | 130 | 166.2 | 2 |  |  |
|  | FRN32F1S－2口 |  |  | － | － | － |  |  |  |  |  | － | － | － | － |
| Three－ phase 400 V | FRN7．5F1S－4］ | 220 | 196 | 63.5 | 46.5 | 46.5 | 260 | 238 | 215 | 118.5 | 96.5 | 141.7 | 16 | 27 | 34 |
|  | FRN11F1S－4口 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN15F1S－4D |  |  |  |  |  |  |  |  |  |  | 136.7 | 21 | 34 | 42 |
|  | FRN18．5F1S－4ロ | 250 | 226 | 67 | 58 | 58 | 400 | 378 |  | 85 | 130 | 166.2 | 2 |  |  |
|  | FRN30F1S－4口 |  |  | － | － | － |  |  |  |  |  | － | － | － | － |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．


| Power supply voltage | Type | Dimensions（mm） |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | W3 | W4 | W5 | H | H1 | H2 | D | D1 | D2 | D3 | D4 | фA |
| Three－ phase 200 V | FRN37F1S－2口 | 320 | 240 | 304 | 310.2 | 8 | 10 | 550 | 530 | 12 | 255 | 115 | 140 | 4 | 4.5 | 10 |
|  | ｜${ }^{\text {FRN45F1S－2口 }}$ | 355 | 275 | 339 | 345.2 |  |  | 615 | 595 |  | 270 |  | 155 |  |  |  |
|  | FRN75F1S－2口 |  |  |  |  |  |  | 740 | 720 |  |  |  |  |  |  |  |
| Three－ phase 400 V | FRN37F1S－4D | 320 | 240 | 304 | 310.2 | 8 | 10 | 550 | 530 | 12 | 255 | 115 | 140 | 4 | 4.5 | 10 |
|  | FRN45F1S－4D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN55F1S－4口 | 355 | 275 | 339 | 345.2 |  |  |  |  |  | 270 |  | 155 |  |  |  |
|  | FRN75F1S－4口 |  |  |  |  |  |  | 615 | 595 |  |  |  |  |  |  |  |
|  | ｜FRN110F1S－4口 |  |  |  |  |  |  | 740 | 720 |  | 300 | 145 |  |  | 6 |  |
|  | FRN132F1S－4D | 530 | 430 | 503 | 509.2 | 13.5 | 15 |  | 710 | 15.5 | 315 | 135 | 180 |  |  | 15 |
|  | FRN160F1S－4］ |  |  |  |  |  |  |  |  |  | 360 | 180 |  |  |  |  |
|  | FRN200F1S－4D <br> FRN220F1S－4D |  |  |  |  |  |  | 1000 | 970 |  |  |  |  |  |  |  |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．

### 8.5.2 DC reactor



Note 1) For inverters of 75 kW or above types (FRN75F1S-2ם, FRN75F1S-4ロ or above), a DC reactor is attached as standard.
2) $A$ box ( $\square$ ) in the above table replaces $A, K$, or $E$ depending on the shipping destination.

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Unit : mm


## 8．6 Protective Functions

| Name | Description |  | LED monitor displays | $\begin{gathered} \text { Alarm } \\ \text { output } \\ {[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]} \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: |
| Overcurrent protection | Stops the inverter output to protect the inverter from an overcurrent resulting from overload． | During acceleration | ！III ！ | Yes |
| Short－circuit protection | Stops the inverter output to protect the inverter from overcurrent due to a short－circuiting in the output circuit． |  |  |  |
|  |  | During deceleration | バ1－－ |  |
| Ground fault protection | Stops the inverter output to protect the inverter from overcurrent due to a ground fault in the output circuit．This protection is effective only during startup of the inverter．If you turn ON the inverter without removing the ground fault，this protection may not work．（Applicable to inverters of 75 kW or below（3－phase 200 V ）or 220 kW or below（3－phase 400 V ）） | During running at constant speed | －111－7 |  |
|  | Upon detection of zero－phase current in the output power，this function stops the inverter output to protect the inverter from overcurrent due to a ground fault in the output circuit． （Applicable to inverters of 90 kW or above（3－phase 200 V ）or 280 kW or above（3－phase 400 V ）） |  | に， | Yes |
| Overvoltage protection | The inverter stops the inverter output upon detection of an overvoltage condition（400 VDC for 3－phase 200V， 800 VDC for 3－phase 400V series）in the DC link bus． <br> This protection is not assured if extremely large AC line voltage is applied inadvertently． | During acceleration | ！でい！ | Yes |
|  |  | During deceleration | バ1112 |  |
|  |  | During running at constant speed （Stopped） | イーインプ |  |
| Undervoltage protection | Stops the inverter output when the DC link bus voltage drops below the undervoltage level（ 200 VDC for 3－phase 200V， 400 VDC for 3－phase 400 V series）． <br> However，if data＂3，4，or 5＂is selected for F14，no alarm is output even if the DC link bus voltage drops． |  | Ĺ＇ | Yes＊1 |
| Input phase loss protection | Detects input phase loss，stopping the inverter output．This function prevents the inverter from undergoing heavy stress that may be caused by input phase loss or inter－phase voltage unbalance and may damage the inverter． <br> If connected load is light or a DC reactor is connected to the inverter，this function will not detect input phase loss if any． |  | ＇ı1 | Yes |
| Output phase loss protection | Detects breaks in inverter output wiring at the start of running and during running， stopping the inverter output． |  |  | Yes |
| Overheat protection | －Stops the inverter output upon detecting excess heat sink temperature in case of cooling fan failure or overload． <br> Detects a failure of the internal air circulation DC fan and alarm－stops the inverter <br> （For models of 45 kW or above in 200 V series， 55 kW or above in 400 V series） |  | ハイ1イー！ | Yes |
|  | Stops the inverter output upon detecting an excessively high ambient temperature inside the inverter caused by a failure or an overload condition of the cooling fan． |  |  | Yes |
| Overload protection | Stops the inverter output if the Insulated Gate Bipolar Transistor（IGBT）internal temperature calculated from the output current and temperature of inside the inverter is over the preset value． |  | ！でイ！ | Yes |
| External alarm input | Places the inverter in alarm－stop state upon receiving digital input signal（THR）． |  |  | Yes |

＊1 This alarm on［30A／B／C］should be ignored depending upon the function code setting．

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|  | Name |  | Description | LED monitor displays | $\begin{gathered} \text { Alarm } \\ \text { output } \\ {[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]} \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Blown fuse |  | Upon detection of a fuse blown in the inverter＇s main circuit，this function stops the inverter output．（Applicable to 90 kW or above（for both 3－phase 200 V and 3－ phase 400 V ）） |  | イール゙イ | Yes |
| Abnormal condition in charger circuit |  | Upon detection of an abnormal condition in the charger circuit inside the inverter， this function stops the inverter output．（Applicable to 45 kW or above（3－phase 200 V ）or 55 kW or above（3－phase 400 V ）） |  | バミルー | Yes |
|  | Electronic thermal | In the following cases，the inverter stops running the motor to protect the motor in accordance with the electronic thermal overload protection setting． |  | ！III ！ | Yes |
|  |  | －Protects general－purpose motors over the entire frequency range（F10＝1．） <br> －Protects inverter motors over the entire frequency range（ $\mathrm{F0} 0=2$ ．） <br> ＊The operation level and thermal time constant can be set by F11 and F12． |  |  |  |
|  | PTC | A PTC thermistor input stops the inverter output for motor protection． |  | イン11イン！ | Yes |
|  |  | Connect a PTC thermistor between terminals［V2］and［11］and set the function codes and slide switch on the control PCB accordingly． |  |  |  |
|  | Overload early warning | Outputs a preliminary alarm at a preset level before the motor is stopped by the electronic thermal overload protection for the motor． |  | － | － |
| Stall prevention |  | Operates when instantaneous overcurrent limiting is active． |  | － | － |
|  |  | －Instantaneous overcurrent limiting： <br> Operates if the inverter＇s output current exceeds the instantaneous overcurrent limit level，avoiding tripping of the inverter（during constant speed operation or during acceleration）． |  |  |  |
|  | rm relay <br> put any fault） | －The inverter outputs a relay contact signal when the inverter issues an alarm and stops the inverter output． <br> ＜Alarm reset＞ <br> The alarm stop state is reset by pressing the key or by the digital input signal（RST）． <br> ＜Saving the alarm history and detailed data＞ <br> The information on the previous 4 alarms can be saved and displayed． |  | － | Yes |
|  | mory error ection | The inverter checks memory data after power－on and when the data is written．If a memory error is detected，the inverter stops． |  | に－！ | Yes |
|  | ypad <br> mmuni－ <br> ions error ection | The inverter stops by detecting a communications error between the inverter and the keypad during operation using the standard keypad or the multi－function keypad（optional）． |  | に，ご | Yes |
|  | U error ection | If the inverter detects a CPU error or LSI error caused by noise or some other factors，this function stops the inverter |  | ミーシ | Yes |
|  | tion mmuni－ ions error ection | Upon detection of an error in the communication between the inverter and an optional card，stops the inverter output． |  | Eーム゙ | － |
|  | tion error ection | When an option card has detected an error，this function stops the inverter output． |  | に， | － |
| Operation error detection |  | STOP <br> key priority | Pressing the key on the keypad forces the inverter to decelerate and stop the motor even if the inverter is running by any run command given via the terminals or communications link．After the motor stops，the inverter issues alarm | に，心 | Yes |

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| Name | Description |  | LED monitor displays | Alarm output $[30 \mathrm{~A} / \mathrm{B} / \mathrm{C}]$ |
| :---: | :---: | :---: | :---: | :---: |
| Operation error detection | Start check function | The inverter prohibits any run operations and displays 7 －segment LED monitor if any run command is present when： <br> －Powering up <br> －An alarm is released（the key is turned ON or an alarm reset （RST）is input．） <br> －＂Enable communications link（LE）＂has been activated and the run command is active in the linked source． | Eーに | Yes |
| Tuning error detection | During tuning of motor parameters，the tuning has failed or has aborted，or an abnormal condition has been detected in the tuning result，the inverter stops its output． |  | E－7 | Yes |
| RS485 communi－ cations error detection | When the inverter is connected to a communications network via the RS485 port designed for the keypad，detecting a communications error stops the inverter output and displays an error code $E--\bar{B}$ ． |  | にーロ | Yes |
| Data save error during undervoltage | If the data could not be saved during activation of the undervoltage protection function，the inverter displays the alarm code． |  | Er－İ | Yes |
| RS485 communi－ cations error detection （optional） | When the inverter is connected to a communications network via an optional RS485 communications card，detecting a communications error stops the inverter output and displays an error code |  | E－IC | Yes |
| LSI error detection （Power PCB） | When an error occurred in the LSI on the power printed circuit board（power PCB），this function stops the inverter．（Applicable to： 200 V series 45 kW or above，and 400 V series 55 kW or above） |  | Eール | Yes |
| Retry | When the inverter has stopped because of a trip，this function allows the inverter to automatically reset itself and restart．（You can specify the number of retries and the latency between stop and reset．） |  | － | － |
| Surge protection | Protects the inverter against a surge voltage which might appear between one of the power lines for the main circuit and the ground． |  | － | － |
| Command loss detected | Upon detecting a loss of a frequency command（because of a broken wire，etc．）， this function issues an alarm and continues the inverter operation at the preset reference frequency（specified as a ratio to the frequency just before the detection）． |  | － | － |
| Protection against momentary power failure | Upon detecting a momentary power failure lasting more than 15 ms ，this function stops the inverter output． |  | － | － |
|  | If restart after momentary power failure is selected，this function invokes a restart process when power has been restored within a predetermined period． |  |  |  |
| Overload prevention control | In the event of overheating of the heat sink or an overload condition（alarm code：＇Lin＇＇or＇IM $L^{\prime} L^{\prime}$ ），the output frequency of the inverter is reduced to keep the inverter from tripping． |  | － | － |

＂－＂：Not applicable．

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI Chapter 9 LIST OF PERIPHERAL EQUIPMENT AND OPTIONS

The table below lists the main peripheral equipment and options that are connected to the FRENIC-Eco. Use them in accordance with your system requirements.
[D] For details, refer to the FRENIC-Eco User's Manual (MEH456), Chapter 6 "SELECTING PERIPHERAL EQUIPMENT."

|  | Name of peripheral equipment | Function and application |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Molded case circuit breaker (MCCB) <br> Residual-currentoperated protective device (RCD) <br> /Earth leakage circuit breaker (ELCB) ${ }^{*}$ <br> * with overcurrent protection | MCCBs are designed to protect the power circuits between the power control board and inverter's main terminals (L1/R, L2/S and L3/T) from overload or short-circuit which in turn prevents secondary disasters caused by the inverter malfunctioning. <br> RCDs/ELCBs function in the same way as MCCBs. Use the MCCBs and RCDs/ELCBs that satisfy the recommended rated current listed below. |  |  |  |  |
|  |  | Input power source (3-phase) | Applicable motor rating (kW) | Inverter type | Rated current of MCCB and ELCB (A) |  |
|  |  |  |  |  | w/ DCR | w/o DCR |
|  |  | 200 V | 0.75 | FRN0.75F1S-2 $\square$ | 5 | 10 |
|  |  |  | 1.5 | FRN1.5F1S-2 $\square$ | 10 | 15 |
|  |  |  | 2.2 | FRN2.2F1S-2 $\square$ |  | 20 |
|  |  |  | 3.7 | FRN3.7F1S-2 $\square$ | 20 | 30 |
|  |  |  | 5.5 | FRN5.5F1S-2 $\square$ | 30 | 50 |
|  |  |  | 7.5 | FRN7.5F1S-2 $\square$ | 40 | 75 |
|  |  |  | 11 | FRN11F1S-2 $\square$ | 50 | 100 |
|  |  |  | 15 | FRN15F1S-2口 | 75 | 125 |
|  |  |  | 18.5 | FRN18.5F1S-2 $\square$ | 100 | 150 |
|  |  |  | 22 | FRN22F1S-2 $\square$ | 100 | 175 |
|  |  |  | 30 | FRN30F1S-2 $\square$ | 150 | 200 |
|  |  |  | 37 | FRN37F1S-2 $\square$ | 175 | 250 |
|  |  |  | 45 | FRN45F1S-2 $\square$ | 200 | 300 |
|  |  |  | 55 | FRN55F1S-2 $\square$ | 250 | 350 |
|  |  |  | 75 | FRN75F1S-2 $\square$ | 350 | - |
|  |  | 400 V | 0.75 | FRN0.75F1S-4 $\square$ | 510 | 5 |
|  |  |  | 1.5 | FRN1.5F1S-4 $\square$ |  | 10 |
|  |  |  | 2.2 | FRN2.2F1S-4 $\square$ |  | 15 |
|  |  |  | $\begin{gathered} 3.7 \\ (4.0)^{\star} \end{gathered}$ | $\begin{aligned} & \text { FRN3.7F1S-4] } \\ & \text { FRN4.0F1S-4E } \end{aligned}$ |  | 20 |
|  |  |  | 5.5 | FRN5.5F1S-4 $\square$ | 15 | 30 |
|  |  |  | 7.5 | FRN7.5F1S-4 $\square$ | 20 | 40 |
|  |  |  | 11 | FRN11F1S-4D | 30 | 50 |
|  |  |  | 15 | FRN15F1S-4 $\square$ | 40 | 60 |
|  |  |  | 18.5 | FRN18.5F1S-4 $\square$ | 40 | 75 |
|  |  |  | 22 | FRN22F1S-4 $\square$ | 50 | 100 |
|  |  |  | 30 | FRN30F1S-4 $\square$ | 75 | 125 |
|  |  |  | 37 | FRN37F1S-4口 | 100 | 125 |
|  |  |  | 45 | FRN45F1S-4 $\square$ | 100 | 150 |
|  |  |  | 55 | FRN55F1S-4D | 125 | 200 |
|  |  |  | 75 | FRN75F1S-4 $\square$ | 175 | - |
|  |  |  | 90 | FRN90F1S-4 $\square$ | 200 | - |
|  |  |  | 110 | FRN110F1S-4 $\square$ | 250 | - |
|  |  |  | 132 | FRN132F1S-4] | 300 | - |
|  |  |  | 160 | FRN160F1S-4D | 350 | - |
|  |  |  | 200 | FRN200F1S-4D | 500 | - |
|  |  |  | 220 | FRN220F1S-4 $\square$ |  | - |

* The applicable motor rating of FRN4.0F1S-4E to be shipped for EU is 4.0 kW .

Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.
Select the MCCB or RCD/ELCB with appropriate breaking capacity according to the power supply capacity.

| Name of <br> peripheral <br> equipment | Molded case <br> circuit breaker <br> Earth leakage <br> circuit breaker* <br> *ith overcurrent <br> protection | When connecting the inverter to the power supply, add a recommended molded case <br> circuit breaker and earth leakage circuit breaker* in the path of power supply. Do not use <br> the devices with the rated current out of the recommenced range. <br> *With overcurrent protection |
| :--- | :--- | :--- |
| Fire could occur. |  |  |


|  | Name of option | Function and application |
| :---: | :---: | :---: |
|  | DC reactors (DCRs) | A DCR is mainly used for power supply normalization and for supplied power-factor reformation (for reducing harmonic components). <br> 1) For power supply normalization <br> - Use a DCR when the capacity of a power supply transformer exceeds 500 kVA and is 10 times or more than the rated inverter capacity. In this case, the percentage-reactance of the power source decreases, and harmonic components and their peak levels increase. These factors may break rectifiers or capacitors in the converter section of inverter, or decrease the capacitance of the capacitor (which can shorten the inverter's service life). <br> - Also use a DCR when there are thyristor-driven loads or when phase-advancing capacitors are being turned ON/OFF. <br> 2) For supplied power-factor reformation (harmonic component reduction) <br> Generally a capacitor is used to reform the power factor of the load, however, it cannot be used in a system that includes an inverter. Using a DCR increases the reactance of inverter's power source so as to decrease harmonic components on the power source lines and reform the power factor of inverter. Using a DCR reforms the input power factor to approximately 86 to $90 \%$. <br> Note: At the time of shipping, a short bar is connected across the terminals P1 and $\mathrm{P}(+)$ on the terminal block. Remove the short bar when connecting a DCR. |
|  | Output circuit filters <br> (OFLs) | Include an OFL in the inverter power output (secondary) circuit to: <br> 1) Suppress the voltage fluctuation at the motor input terminals <br> This protects the motor from insulation damage caused by the application of high voltage surge currents by the 400 V class of inverters. <br> 2) Suppress leakage current from the power output lines (due to harmonic components) This reduces the leakage current when the motor is hooked by long power feed lines. It is recommended that the length of the power feed line be kept to less than 400 m . <br> 3) Minimize emission and/or induction noise issued from the power output lines OFLs are effective in reducing noise from long power feed lines, such as those used in plants, etc. <br> Note: Use an OFL within the allowable carrier frequency range specified by function code F26 (Motor sound (Carrier frequency)). Otherwise, the filter will overheat. |
|  | Ferrite ring reactors for reducing radio frequency noise (ACL) | An ACL is used to reduce radio noise emitted by the inverter. <br> An ACL suppresses the outflow of high frequency harmonics caused by switching operation for the power supply (primary) lines inside the inverter. Pass the power supply lines together through the ACL for 4 turns (coiled 3 times). <br> If wiring length between the inverter and motor is less than 20 m , insert an ACL to the power supply (primary) lines; if it is more than 20 m , insert it to the power output (secondary) lines of the inverter. |
|  | EMC-compliant filter | A special filter for making the inverter in conformity with Europe's EMC directives. |
|  | AC Reactor (ACR) | - This optional feature must be connected to the primary side (commercial power supply side) of the inverter, when the inter-phase unbalance factor of the commercial power supply is $2 \%$ to $3 \%$. $\text { Voltage unbalance }(\%)=\frac{\text { Max. voltage }(\mathrm{V})-\text { Min. voltage }(\mathrm{V})}{3-\text { phase average voltage }(\mathrm{V})} \times 67$ <br> In case the inter-phase unbalance factor of the commercial power supply exceeds $3 \%$, you would need to take other measures such as increasing the capacity of the inverter. Contact your Fuji Electric representative. <br> - In a DC link bus system (using terminals $[P(+)]$ and $[N(-)])$, the $A C$ reactor protects the inverter against damage caused by unbalance in current. |


|  | Name of option | Function and application |
| :---: | :---: | :---: |
|  | External potentiometer for frequency commands | An external potentiometer may be used to set the drive frequency. Connect the potentiometer to control signal terminals 11 to 13 of the inverter. |
|  | Multi-function keypad | Allows you to monitor the status of the inverter including voltage, current, and input power, as well as to set various parameters in a conversational mode. Equipped with a liquid crystal display (LCD). <br> Also allows you to copy function code data from one FRENIC-Eco inverter to another. |
|  | Extension cable for remote keypad operation | The extension cable connects the RS485 communications port (standard) with a keypad or an RS485-USB converter. <br> Three lengths are available: $5 \mathrm{~m}, 3 \mathrm{~m}$ and 1 m |
|  | RS485 <br> Communications Card | This makes communication to a PLC or personal computer system easy. (Option) |
|  | RS485-USB converter | A converter that allows connection of an RS485 communications port to a USB port on a PC. |
|  | Inverter support loader software | Inverter support loader software, Windows GUI (Graphics User Interface) based, that makes setting of function codes easy. |
|  | Surge absorbers | A surge absorber suppresses surge currents and noise from the power lines to ensure effective protection of your power system from the malfunctioning of the magnetic contactors, mini-relays and timers. |
|  | Surge killers | A surge killer eliminates surge currents induced by lightening and noise from the power supply lines. Use of a surge killer is effective in preventing the electronic equipment, including inverters, from damage or malfunctioning caused by such surges and/or noise. |
|  | Arresters | An arrester suppresses surge currents and noise invaded from the power supply lines. Use of an arrester is effective in preventing electronic equipment, including inverters, from damage or malfunctioning caused by such surges and/or noise. |
|  | Frequency meter | Displays the frequency in accordance with signal output from the inverter. |
|  | Mounting adapters | FRENIC-Eco series of inverters can be installed to your system enclosure or equipment using mounting adapters which utilize the mounting holes used for conventional inverters of FRENIC5000P11S ( $5.5 \mathrm{~kW}, 15 \mathrm{~kW}$ or 30 kW ) series. <br> FRENIC5000P11S $7.5 \mathrm{~kW}, 11 \mathrm{~kW}, 18.5 \mathrm{~kW}$ and 22 kW models do not need this adapter. |
|  | Attachment for external cooling | This adapter allows you to mount your FRENIC-Eco series of inverters on the panel in such a way that the heat sink assembly may be exposed to the outside. Using this adapter greatly reduces heat radiated or spread inside your enclosure. <br> Applicable only to inverters with a capacity of 30 kW or below. <br> (On inverters with a capacity of 37 kW or above, you only need to re-position the mounting bases.) |

### 10.1 Conformity with UL Standards and Canadian Standards (cUL-listed for Canada)

### 10.1.1 General

The UL standards, originally established by Underwriters Laboratories, Inc. of U.S., are now a set of standards authorized in the U.S. for preventing fire and accidents, thereby protecting operators, service personnel, and ordinary citizens.
"cUL-listed for Canada" means that the products have been evaluated to the CSA Standards by the UL. Therefore, cUL-listed products are equivalent to those in conformity with CSA Standards.
10.1.2 Considerations when using FRENIC-Eco as a product certified by UL or cUL

If you want to use the FRENIC-Eco series of inverters as a part of UL Standards or CSA Standards (cUL-listed for Canada) certified product, refer to the related guidelines described on pages viii and ix.

### 10.2 Conformity with EU Directives

The CE Marking on Fuji products indicates that they comply with the essential requirements of the Electromagnetic Compatibility (EMC) Directive 89/336/EEC issued by the Council of the European Communities and the Low Voltage Directive 73/23/EEC.

EMC-filter built-in inverters that bear a CE Marking are in conformity with EMC Directives. Inverters having no EMC filter can be in conformity with EMC Directives if an optional EMC-compliant filter is mounted to them.

Inverters that bear a CE Marking are compliant with the Low Voltage Directive.

■The FRENIC-Eco series of inverters is in conformity with the following standards:
Low Voltage Directive EN50178: 1997
EMC Directive EN61800-3: $1996+$ A11: 2000
EN55011: $1998+\mathrm{A} 1: 1999$

## CAUTION

The FRENIC-Eco series of inverters is categorized as a "restricted sales distribution class" according to the EN61800-3. When you use these products in a domestic environment, you may need to take appropriate countermeasures to reduce or eliminate any noise emitted from these products.

### 10.3 Conformity with Low Voltage Directive

### 10.3.1 General

General-purpose inverters are subject to the regulations set forth by the Low Voltage Directive in the EU. Fuji Electric declares the inverters bearing a CE marking are compliant with the Low Voltage Directive.
10.3.2 Considerations when using FRENIC-Eco as a product in conformity with Low Voltage Directive If you wish to use the FRENIC-Eco series of inverters as a product in conformity with the Low Voltage Directive, refer to the related guidelines described on pages vi and vii.

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### 10.4 Harmonic Component Regulation in the EU

### 10.4.1 General

When a general-purpose industrial inverter is to be used in the EU, the harmonics emitted from the inverter to power lines are strictly regulated as stated below.
When an inverter whose rated input is 1 kW or below is connected to a public low-voltage power supply, it is subject to the harmonics emission regulations (users $A$ and $B$ below), except when the inverter is connected to an industrial low-voltage power supply (user C below). See Figure 10.1 for details.


Figure 10.1 Connection to Power Line

### 10.4.2 Conformity with the harmonics regulation

A general-purpose industrial inverter is not a product in conformity with EN61000-3-2 (+A14). When you connect it to a low-voltage commercial power supply, you must obtain permission of the local power supplier (See the case of User A or B in Figure 10.1 above.) If you need harmonic current data of the inverter, consult your Fuji Electric representative.
10.5 Conformity with the EMC Directive in the EU

### 10.5.1 General

The CE Marking on inverters does not ensure that the entire equipment including CE-marked products is compliant with the EMC Directive. Therefore, it is the responsibility of the equipment manufacturer to ensure that the equipment including the product (inverter) or connected with it actually complies with the standard and to put a CE Marking as the equipment.
In general, the user's equipment comprises a variety of products supplied from a number of manufacturers in addition to Fuji inverters. Therefore, the manufacturer of the final equipment needs to take responsibility for conformity.
In addition, to satisfy the requirements noted above, it is necessary to use a Fuji inverter in connection with an EMC-compliant filter (option) and install it in accordance with the instructions contained in this instruction manual. Install the Fuji inverter in a metal enclosure.

Tip To use Fuji EMC-filter built-in inverters, refer to the FRENIC-Eco Instruction Manual Supplement for EMC-Filter Built-in Type, Chapter 10, "CONFORMITY WITH STANDARDS."

### 10.5.2 EMC-compliant filter (Option)

There are two installation styles of an optional EMC-compliant filter--Footmount and split styles. As listed on the next page, the footmount style applies to inverters with 3-phase $400 \mathrm{~V}, 0.75$ to 22 kW , and the split style, to inverters with 3-phase 200 V and 3-phase 400 V 30 to 220 kW .
For how to install the EMC-compliant filter, see Section 10.5.3 "Recommended installation of EMC-compliant filter."

Note The use of an EMC-compliant filter increases leakage current as shown on the next page.

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Table 10．1 EMC－compliant Filters and Leakage Current

| Power supply voltage | Inverter type | EMC－compliant filter model | Leakage current（mA）＊1＊2 |  | Installation style |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Normal condition | Worst condition |  |
| 3－phase 200 V | FRN0．75F1S－2口 | EFL－4．0E11－2 | 2.96 | 2.96 | Split style <br> See Figure 10.2 （B）． |
|  | FRN1．5F1S－2 $\square$ |  |  |  |  |
|  | FRN2．2F1S－2口 |  |  |  |  |
|  | FRN3．7F1S－2 $\square$ |  |  |  |  |
|  | FRN5．5F1S－2 $\square$ | EFL－7．5E11－2 | 10.6 | 10.6 |  |
|  | FRN7．5F1S－2 $\square$ |  |  |  |  |
|  | FRN11F1S－2 $\square$ | EFL－15SP－2 | 20.0 | 23.0 |  |
|  | FRN15F1S－2 $\square$ |  |  |  |  |
|  | FRN18．5F1S－2口 | EFL－22SP－2 | 20.0 | 23.0 |  |
|  | FRN22F1S－2口 |  |  |  |  |
|  | FRN30F1S－2 $\square$ | FS5536－180－40 | 37.0 | 211.0 |  |
|  | FRN37F1S－2 $\square$ | FS5536－250－28 | 78.0 | 424.0 |  |
|  | FRN45F1S－2口 |  |  |  |  |
|  | FRN55F1S－2 $\square$ | FS5536－400－99 | 89.0 | 484.0 |  |
|  | FRN75F1S－2口 |  |  |  |  |
| 3－phase 400 V | FRN0．75F1S－4D | EFL－4．0G11－4 | 3.0 | 105.0 | Footmount style See Figure $10.2(A)$ ． |
|  | FRN1．5F1S－4 $\square$ |  |  |  |  |
|  | FRN2．2F1S－4 $\square$ |  |  |  |  |
|  | FRN3．7F1S－4 $\square$ FRN4．0F1S－4E＊3 |  |  |  |  |
|  | FRN5．5F1S－4口＊4 | EFL－7．5G11－4 | 3.0 | 105.0 |  |
|  | FRN7．5F1S－4 $\square$ |  |  |  |  |
|  | FRN11F1S－4 $\square$ |  |  |  |  |
|  | FRN15F1S－4 $\square$＊ | EFL－15G11－4 | 6.0 | 158.0 |  |
|  | FRN18．5F1S－4 | EFL－22G11－4 | 3.0 | 105.0 |  |
|  | FRN22F1S－4 $\square$ |  |  |  |  |
|  | FRN30F1S－4 $\square$ | FS5536－100－35 | 24.4 | 143.0 | Split style <br> See Figure 10.2 （B）． |
|  | FRN37F1S－4 $\square$ |  |  |  |  |
|  | FRN45F1S－4 $\square$ | FS5536－180－40 | 37.0 | 211.0 |  |
|  | FRN55F1S－4 $\square$ |  |  |  |  |
|  | FRN75F1S－4 $\square$ |  |  |  |  |
|  | FRN90F1S－4 $\square$ |  |  |  |  |
|  | FRN110F1S－4 $\square$ | FS5536－250－28 | 78.0 | 424.0 |  |
|  | FRN132F1S－4 $\square$ |  |  |  |  |
|  | FRN160F1S－4 $\square$ | FS5536－400－99－1 |  |  |  |
|  | FRN200F1S－4D |  |  |  |  |
|  | FRN220F1S－4■ |  |  |  |  |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．
＊1 The values are calculated assuming the power supply frequency of 50 Hz for both 3 －phase 240 V and 3 －phase 400 V ．
＊2 The worst condition includes a phase loss in the supply line．
＊3 The applicable motor rating of FRN4．0F1S－4E to be shipped for EU is 4.0 kW ．
＊4 Requires a panel－mount adapter（option）．

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - OI 10.5.3 Recommended installation of EMC-compliant filter

This section shows how to install an EMC-compliant filter. In the footmount style, mount the inverter on the EMC-compliant filter. In the split style, mount the filter beside or under the inverter.

Note For the footmount style, inverters with ratings of 400 V 5.5 kW and 15 kW require a panel-mount adapter (option) as listed below.

Table 10.2 EMC-compliant Filter and Panel-mount Adapter (option)

| 3-phase 400 V | Inverter type | EMC filter model <br> [Bundled screws to fix the filter onto <br> panel-mount adapter] | Panel-mount adapter model <br> [Bundled screws to fix the adapter <br> onto inverter] |
| :--- | :--- | :---: | :---: |
| 5.5 kW | FRN5.5F1S-4 $\square$ | EFL-7.5G11-4 <br> [Four M8 $\times 20$ screws] | MA-F1-5.5 <br> [Four M5 $\times 15$ screws] |
| 15 kW | FRN15F1S-4 $\square$ | EFL-15G11-4 <br> [Four M8 $\times 20$ screws] | MA-F1-15 <br> [Four M8 $\times 25$ screws] |

Note: A box ( $\bar{\square}$ ) in the above table replaces $\mathrm{A}, \mathrm{K}$, or E depending on the shipping destination.


Figure 10.2 Installing Inverter and EMC-compliant Filter

The EMC-compliant filter and the inverter should be connected with each other according to the procedure given below. The wiring on the inverter and motor should be performed by an authorized electrical engineer. In order to ensure compliance with the EMC Directive, this procedure should be followed as closely as possible.

## ■ Basic connection procedure

1) Install the inverter and the EMC-compliant filter on a grounded metal plate. Use a shielded cable also for connection to the motor and make it as short as possible. Connect the shield layer of the cable firmly to the metal plate. Also, at the motor side, connect the shield layer electrically to the grounding terminal of the motor.
2) Use a shielded cable for connection of control circuit lines of the inverter and also for connection of the signal cable of an RS485 communications card. As with the motor, clamp the shield layer of the cable firmly to a grounded plate.
3) If noise radiated from the inverter exceeds the level prescribed in the EMC Directive, enclose the inverter and its peripherals (EMC-compliant filter) inside a metal enclosure as shown in Figure 10.3.


Figure 10.3 Installation of EMC-Compliant Filter (Option)

### 10.5.4 EMC-compliant environment and class

The table below lists the capacity and power supply voltage of the FRENIC-Eco and the EMC-compliant environment.

| Power supply voltage | Standards | Inverter capacity |  |
| :---: | :---: | :---: | :---: |
|  |  | 0.75 to 90 kW | 110 to 220 kW |
| 3-phase 200 V | Immunity | EN61800-3 Second environment (Industrial environment) |  |
|  | Emission | EN61800-3 Second environment (Industrial environment) |  |
| 3-phase 400 V | Immunity | EN61800-3 Second environment (Industrial environment) |  |
|  | Emission | EN55011 <br> Group 1 Class A | EN61800-3 Second environment (Industrial environment) Note 1 |

## Note 1: Wiring change for compliance

Changing the internal wiring makes EMC-compliant level (emission) be in conformity with Group 1 Class A. Refer to the wiring procedures given on the following pages.

## $\triangle$ WARNING

Before changing any internal wiring, turn OFF the power and wait more than five minutes for models of 30 kW or below, or ten minutes for models of 37 kW or above. Make sure that the LED monitor and charging lamp (on models of 37 kW or above) are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the $D C$ link bus voltage between the terminals $P(+)$ and $N(-)$ has dropped below the safe voltage ( +25 VDC).
Otherwise electric shock could occur.

1) Remove the front cover. (Refer to Chapter 2, Section 2.3 "Wiring.")
2) Change wiring at points $A$ and $B$ shown in the internal location diagram below.


Figure 10.4 Internal Location Diagram (FRN110F1S-4 $\square$ )

Point A As shown below, remove the screw (M4) to release the wire end terminal and secure the terminal to the support with the screw removed. (Tightening torque: $1.8 \mathrm{~N} \cdot \mathrm{~m}$ )


Figure 10.5 Point A

Point B As shown below, cut the cable tie (insulation lock) with a nipper to remove the protective cap. Remove the screw (M5) and secure the wire end terminal with the screw removed. (Tightening torque: 3.5 $\mathrm{N} \cdot \mathrm{m}$ )


Figure 10.6 Pont B

1) Remove the front cover. Refer to Chapter 2, Section 2.3 "Wiring."
2) Change wiring at points $A$ and $B$ shown in the internal location diagram below.


Figure 10.7 Internal Location Diagram (FRN132F1S-4D, FRN160F1S-4D)
Point A As shown below, remove the screw (M4) to release the wire end terminal and secure the terminal to the support with the screw removed. (Tightening torque: $1.8 \mathrm{~N} \cdot \mathrm{~m}$ )


Figure 10.8 Point A
Point B As shown below, cut the cable tie (insulation lock) with a nipper to remove the protective cap. Remove the screw (M5) and secure the wire end terminal with the screw removed. (Tightening torque: 3.5 $N \cdot m$ )


Figure 10.9 Point B

1) Remove the front cover. Refer to Chapter 2, Section 2.3 "Wiring."
2) Change wiring at points $A$ and $B$ shown in the internal location diagram below.


Figure 10.10 Internal Location Diagram (FRN200F1S-4 $\square$, FRN220F1S-4 $\square$ )
Point A As shown below, remove the screw (M4) to release the wire end terminal and secure the terminal to the support with the screw removed. (Tightening torque: $1.8 \mathrm{~N} \cdot \mathrm{~m}$ )


Figure 10.11 Point A

Point B As shown below, cut the cable tie (insulation lock) with a nipper to remove the protective cap. Remove the screw (M5) and secure the wire end terminal with the screw removed. (Tightening torque: 3.5 $N \cdot m$ )


Figure 10.12 Point B

Note The wiring change in Note 1 can improve the EMC-compliant level of the inverter for an environment or class; however, it increases the leakage currents listed in Table 10.1 to the ones listed below. Make sure that these leakage currents are allowable for your system requirements beforehand.

| Power supply voltage | Inverter type | EMC-compliant filter model | Leakage current (mA) |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | Normal condition | Worst condition |
| 3-phase 400 V | FRN110F1S-4 $\square$ | FS5536-250-28 | 108.0 | 464.0 |
|  | FRN132F1S-4 $\square$ |  |  |  |
|  | FRN160F1S-4 $\square$ | FS5536-400-99-1 |  |  |
|  | FRN200F1S-4 $\square$ |  |  |  |
|  | FRN220F1S-4 $\square$ |  |  |  |

For improvement in EMC compliance for 3-phase 200 V types of inverters, consult your Fuji Electric representative for improving EMC-compliant level.

7 End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O
MEMO

Designed For Fan and Pump Applications
FRENIC-ECO

## Instruction Manual

First Edition, May 2005
Fuji Electric FA Components \& Systems Co., Ltd.

[^52]
## Fuji Electric FA Components \& Systems Co., Ltd.

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# FRENIC-ECO 

200 V class series<br>90 kW : FRN90F1S-2口 110 kW: FRN110F1S-2口

400 V class series 280 kW: FRN280F1S-4■<br>to 560 kW: FRN560F1S-4■

## $\triangle$ CAUTION

Thank you for purchasing our FRENIC-Eco series of inverters.

- This product is designed to drive a three-phase induction motor. Read through this supplement in conjunction with the instruction manual (INR-SI47-1059-E) and be familiar with the handling procedure for correct use.
- Improper handling might result in incorrect operation, a short life, or even a failure of this product as well as the motor.
- Deliver this supplement to the end user of this product. Keep this supplement in a safe place until this product is discarded.
- For how to use an optional device, refer to the installation and instruction manuals for that optional device.

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The information contained herein is subject to change without prior notice for improvement.

This manual, a supplement to the FRENIC-Eco Instruction Manual (INR-SI47-1059 $\square$-E), contains pages that apply exclusively to high-capacity inverters. Substitute them for the corresponding pages in the original manual. Chapters 2 and 10, however, are complete in themselves, so there is no need to refer back.

## - Safety precautions

Read this manual thoroughly before proceeding with installation, connections (wiring), operation, or maintenance and inspection. Ensure you have sound knowledge of the device and familiarize yourself with all safety information and precautions before proceeding to operate the inverter.
Safety precautions are classified into the following two categories in this manual.

| AWARNING | Failure to heed the information indicated by this symbol may lead to <br> dangerous conditions, possibly resulting in death or serious bodily injuries. |
| :---: | :--- |
| ANANTON | Failure to heed the information indicated by this symbol may lead to <br> dangerous conditions, possibly resulting in minor or light bodily injuries <br> and/or substantial property damage. |

Failure to heed the information contained under the CAUTION title can also result in serious consequences. These safety precautions are of utmost importance and must be observed at all times.

## How this manual is organized

This manual is made up of the following chapters.

## Chapter 2 MOUNTING AND WIRING OF THE INVERTER

This chapter provides operating environment, precautions for installing the inverter, wiring instructions for the motor and inverter.

## Chapter 3 OPERATION USING THE KEYPAD

This chapter describes inverter operation using the keypad. The inverter features three operation modes (Running, Programming and Alarm modes) which enable you to run and stop the motor, monitor running status, set function code data, display running information required for maintenance, and display alarm data.

## Chapter 5 FUNCTION CODES

This chapter provides a list of the function codes. Function codes to be used often and irregular ones are described individually.

## Chapter 7 MAINTENANCE AND INSPECTION

This chapter describes inspection, measurement and insulation test which are required for safe inverter operation. It also provides information about periodical replacement parts and guarantee of the product.

## Chapter 8 SPECIFICATIONS

This chapter lists specifications including output ratings, control system, external dimensions and protective functions.

## Chapter 10 CONFORMITY WITH STANDARDS

This chapter describes standards with which the FRENIC-Eco series of inverters comply.

## Icons

The following icons are used throughout this manual.
Noter
This icon indicates information which, if not heeded, can result in the inverter not operating to full efficiency, as well as information concerning incorrect operations and settings which can result in accidents.

Tip This icon indicates information that can prove handy when performing certain settings or operations.
[1] This icon indicates a reference to more detailed information.

End of Avon St Leichhardt SPS－i．Power Solutions－Ipswich Ref J7985－01－SP22 O＇Keefe St SPS－Ol Conformity with Low Voltage Directive in the EU
If installed according to the guidelines given below，inverters marked with CE can be considered to be compliant with the Low Voltage Directive $73 / 23 /$ EEC．
$\triangle$ CAUTION
1．Be sure to earth the grounding terminal ${ }^{-1}$ G．Use an earth wire sized more than that of the power wires used in the power dispatch system．Do not use a residual－current－operated protective device（RCD）＊or an earth leakage circuit breaker（ELCB）＊as a sole mechanism of electric shock protection． ＊With overcurrent protection．
2．Use an MCCB，RCD／ELCB or MC in conformity with EN or IEC standards．
3．When an RCD／ELCB is used for protection of electric shock caused by a direct or indirect contact to the live parts，insert a type B RCD／ELCB in input lines（primary）of the inverter for the 3－phase 200 V or 400 $\checkmark$ power source．
4．Use inverters in an environment that does not exceed pollution degree 2 ．If inverters are to be used in an environment with pollution degree 3 or 4，place them in an enclosure of IP54 or above．
5．To protect human body from an electric shock caused by a contact to live parts，install inverters，AC reactor and input／output filter in the enclosure of IP2X．In the case where human body easily contacts to live parts，a top panel of the enclosure should be IP4X or higher．
6．Do not directly connect a copper wire to the grounding terminal．Use a crimp terminal with tin or equivalent plating to connect the earth wire．
7．When using inverters at an altitude of more than 2000 m ，note that the basic insulation applies to the insulation degree of the control circuitry．At an altitude of more than 3000 m ，inverters cannot be used．
8．Use the wires listed in EN60204 Appendix C．

|  |  | Inverter type | MCCB or RCD／ELCB＊1 Rated current <br> （A） |  | Recommended wire size（ $\mathrm{mm}^{2}$ ） |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | Main power input＊2 ［L1／R，L2／S，L3／T］ Inverter＇s grounding［ ${ }^{-1} \mathrm{G}$ ］ |  |  |  | Control circuit |  |  |  |
|  |  |  |  |  | Screw | Europe type |  |  |  |  |
|  |  |  | $\begin{gathered} \mathrm{W} / \\ \mathrm{DCR} \end{gathered}$ | W／o DCR |  |  | $\begin{gathered} \text { W/ } \\ \text { DCR } \end{gathered}$ |  | W／o DCR | base |  |  | block |
| － | 90 | FRN90F1S－2口 | 400 | －－ | 185 | －－ |  | 240 | 120x2 | $\begin{gathered} 0.25 \\ \text { to } \\ 0.75 \end{gathered}$ | $\begin{gathered} 0.25 \\ \text { to } \\ 0.75 \end{gathered}$ | 2.5 | 2.5 |
| $\left\|\begin{array}{c} \dot{\Phi} \\ \stackrel{\text { ¢ }}{2} \end{array}\right\|$ | 110 | FRN110F1S－2口 | 500 |  | 150x2 |  | 300 | 150x2 |  |  |  |  |
| $>$ | 280 | FRN280F1S－4ロ | 600 |  | 185x2 |  | 185x2 | 185x2 |  |  |  |  |
| ¢ | 315 | FRN315F1S－4D | 700 |  |  |  | 240x2 | $240 \times 2$ |  |  |  |  |
| \％ | 355 | FRN355F1S－4D | 800 |  | 240x2 |  | 150x3 |  |  |  |  |  |
| \％ | 400 | FRN400F1S－4D | 1000 |  | 185x3 |  | 185x3 | 240x3 |  |  |  |  |
| 웅 | 450 | FRN450F1S－4D |  |  | 240x3 |  | 240x3 | 300x3 |  |  |  |  |
| ¢ | 500 | FRN500F1S－4口 | 1200 |  |  |  | 300x3 |  |  |  |  |  |
| $\stackrel{ }{ }$ | 560 | FRN560F1S－4D |  |  | 300x3 |  |  | 300x4 |  |  |  |  |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．
＊1 The frame size and model of the MCCB or RCD／ELCB（with overcurrent protection）will vary，depending on the power transformer capacity．Refer to the related technical documentation for details．
＊2 The recommended wire size for main circuits is for the $70^{\circ} \mathrm{C} 600 \mathrm{~V}$ PVC wires used at an ambient temperature of $40^{\circ} \mathrm{C}$ ．

UL/cUL-listed inverters are subject to the regulations set forth by the UL standards and CSA standards (cUL-listed for Canada) by installation within precautions listed below.

## $\triangle$ CAUTION

1. Solid state motor overload protection (motor protection by electronic thermal overload relay) is provided in each model.
Adjust function codes F10 to F12 to decide the protection level.
2. Suitable for use on a circuit capable of delivering not more than $100,000 \mathrm{rms}$ three-phase symmetrical amperes, 240 Volts maximum for 200 V class input 30 kW or less, 230 Volts maximum for 200 V class input 37 kW or above or 480 Volts maximum for 400 V class input.
3. Use $75^{\circ} \mathrm{C}$ Cu wire only.
4. Use Class 1 wire only.
5. Field wiring connections must be made by a UL Listed and CSA Certified closed-loop terminal connector sized for the wire gauge involved. Connector must be fixed using the crimp tool specified by the connector manufacturer.
6. All circuits with terminals L1/R, L2/S, L3/T, R0, T0, R1, T1 must have a common disconnect and be connected to the same pole of the disconnect if the terminals are connected to the power supply.


End of Avon St Leichhardt SPS－i．Power Solutions－Ipswich Ref J7985－01－SP22 O＇Keefe St SPS－Ol Conformity with UL standards and CSA standards（cUL－listed for Canada）（continued）

| $\triangle \mathrm{ACOT} O N$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1．Required torque |  |  |  |  |  |  |
|  | Inverter type | Main terminal | Required torque lb－in（N•m） |  |  |  |
|  |  |  |  | Aux．control | Control | circuit |
|  |  |  |  | R0，T0 | Screw terminal base | Europe type terminal block |
|  | FRN90F1S－2口 FRN110F1S－2口 | $\begin{gathered} 424.7 \\ (48) \end{gathered}$ | $\begin{gathered} 238.9 \\ (27) \end{gathered}$ | $\begin{aligned} & 10.6 \\ & (1.2) \end{aligned}$ | $\begin{gathered} 6.1 \\ (0.7) \end{gathered}$ | $\begin{gathered} 4.4 \\ (0.5) \end{gathered}$ |
|  | FRN280F1S－4ロ | $\begin{gathered} 424.7 \\ (48) \end{gathered}$ | $\begin{gathered} 238.9 \\ (27) \end{gathered}$ | $\begin{aligned} & 10.6 \\ & (1.2) \end{aligned}$ | $\begin{gathered} 6.1 \\ (0.7) \end{gathered}$ | $\begin{gathered} 4.4 \\ (0.5) \end{gathered}$ |
|  | FRN315F1S－4ロ |  |  |  |  |  |
|  | FRN355F1S－4口 |  |  |  |  |  |
|  | FRN400F1S－4口 |  |  |  |  |  |
|  | FRN450F1S－4口 |  |  |  |  |  |
|  | FRN500F1S－4］ |  |  |  |  |  |
|  | FRN560F1S－4口 |  |  |  |  |  |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．
Note：The unit of values in parentheses（）is $N \cdot m$ ．

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - O Conformity with UL standards and CSA standards (cUL-listed for Canada) (continued)


Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.
Note: The unit of values in parentheses () is $\mathrm{mm}^{2}$.
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## Chapter 2 MOUNTING AND WIRING OF THE INVERTER

### 2.1 Operating Environment

Install the inverter in an environment that satisfies the requirements listed in Table 2.1.

Table 2.1 Environmental Requirements

| Item | Specifications |
| :---: | :---: |
| Site location | Indoors |
| Ambient temperature | -10 to $+50^{\circ} \mathrm{C}$ |
| Relative humidity | 5 to 95\% (No condensation) |
| Atmosphere | The inverter must not be exposed to dust, direct sunlight, corrosive gases, flammable gas, oil mist, vapor or water drops. <br> Pollution degree 2 (IEC60664-1) (Note 1) <br> The atmosphere can contain a small amount of salt. ( $0.01 \mathrm{mg} / \mathrm{cm}^{2}$ or less per year) <br> The inverter must not be subjected to sudden changes in temperature that will cause condensation to form. |
| Altitude | 1,000 m max. (Note 2) |
| Atmospheric pressure | 86 to 106 kPa |
| Vibration | 3 mm (Max. amplitude) 2 to less than 9 Hz <br> $2 \mathrm{~m} / \mathrm{s}^{2}$ 9 to less than 55 Hz <br> $1 \mathrm{~m} / \mathrm{s}^{2}$ 55 to less than 200 Hz |

Table 2.2 Output Current Derating Factor in

Relation to Altitude

| Relation to Altitude |  |
| :---: | :---: |
| Altitude | Output current <br> derating factor |
| 1000 m or lower | 1.00 |
| 1000 to 1500 m | 0.97 |
| 1500 to 2000 m | 0.95 |
| 2000 to 2500 m | 0.91 |
| 2500 to 3000 m | 0.88 |

(Note 1) Do not install the inverter in an environment where it may be exposed to cotton waste or moist dust or dirt which will clog the heat sink in the inverter. If the inverter is to be used in such an environment, install it in the enclosure of your system or other dustproof containers.
(Note 2) If you use the inverter in an altitude above 1000 m , you should apply an output current derating factor as listed in Table 2.2.

### 2.2 Installing the Inverter

## (1) Mounting base

The temperature of the heat sink will rise up to approx. $90^{\circ} \mathrm{C}$ during operation of the inverter, so the inverter should be mounted on a base made of material that can withstand temperatures of this level.

## $\triangle$ WARNING

Install the inverter on a base constructed from metal or other non-flammable material.
A fire may result with other material.

## (2) Clearances

Ensure that the minimum clearances indicated in Figure 2.1 are maintained at all times. When installing the inverter in the enclosure of your system, take extra care with ventilation inside the enclosure as the temperature around the inverter will tend to increase. Do not install the inverter in a small enclosure with poor ventilation.

## ■ When mounting two or more inverters

Horizontal layout is recommended when two or more inverters are to be installed in the same unit or enclosure. If it is necessary to mount the inverters vertically, install a partition plate or the like between the inverters so that any heat radiating from an inverter will not affect the one/s above.

## ■ When employing external cooling

At the shipment time，the inverter is set up for mount inside your equipment or enclosure so that cooling is done all internally．
To improve cooling efficiently，you can take the heat sink out of the equipment or the enclosure（as shown on the right）so that cooling is done both internally and externally（this is called ＂external cooling＂）．
In external cooling，the heat sink，which dissipates about $70 \%$ of the total heat（total loss）generated into air，is situated outside the equipment or the enclosure．As a result，much less heat is radiated inside the equipment or enclosure．
Note that external cooling should not be used in an environment with high humidity or a lot of fibrous dust，which easily clogs the heat sink．


Figure 2．2 External Cooling

## $\triangle C A U T I O N$

Prevent lint，paper fibers，sawdust，dust，metallic chips，or other foreign materials from getting into the inverter or from accumulating on the heat sink．
This may result in a fire or accident．

To utilize external cooling for inverters，change the position of the top and bottom mounting bases from the edge to the center of the inverter as shown in Figure 2.3 on the next page．

Screws differ in size，length and count for each inverter．Be sure to refer to the table below．
Table 2．3 Screw Count and Tightening Torque

| Power supply voltage | Inverter type | Base fixing screw （Count） | Case fixing screw （Count） | Tightening torque （ $\mathrm{N} \bullet \mathrm{m}$ ） | Refer to： |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 3－phase$200 \text { V }$ | FRN90F1S－2口 | M6 $\times 20$ <br> （7 pcs each for upper and lower sides） | M5 x 20 <br> （5 pcs each for upper and lower sides） | $\begin{aligned} & \text { M6: } 5.8 \\ & \text { M5: } 3.5 \end{aligned}$ | Figure 2.3 |
|  | FRN110F1S－2口 | $\text { M6 × } 20$ <br> （ 6 pcs each for upper and lower sides） | M5 x 20 <br> （ 6 pcs each for upper and lower sides） | $\begin{aligned} & \text { M6: } 5.8 \\ & \text { M5: } 3.5 \end{aligned}$ |  |
| $\begin{aligned} & \text { 3-phase } \\ & 400 \mathrm{~V} \end{aligned}$ | FRN280F1S－4 to FRN315F1S－4 | $\text { M6 } \times 20$ <br> （2 pcs each for upper and lower sides） $\text { M5 x } 16$ <br> （ 6 pcs each for upper and lower sides） | M6 x 20 <br> （2 pcs each for upper and lower sides） $\text { M5 x } 16$ <br> （ 6 pcs each for upper and lower sides） | $\begin{aligned} & \text { M6: } 5.8 \\ & \text { M5: } 3.5 \end{aligned}$ |  |
|  | $\begin{aligned} & \text { FRN355F1S-4ロ to } \\ & \text { FRN560F1S-4J } \end{aligned}$ | M6 x 20 <br> （ 6 pcs each for upper and lower sides） $\text { M5 x } 16$ <br> （2 pcs each for upper and lower sides） | M6 x 20 <br> （ 6 pcs each for upper and lower sides） $\text { M5 x } 16$ <br> （2 pcs each for upper and lower sides） | $\begin{aligned} & \text { M6: } 5.8 \\ & \text { M5: } 3.5 \end{aligned}$ |  |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．

1) Remove all of the base fixing screws from the top and bottom of the inverter. Also remove the case fixing screws from the top. (The case fixing screws are not necessary in external cooling. Store them for future use. On the bottom are no case fixing screws.)
2) Secure the top mounting base to the center of the inverter with the base fixing screws, using case fixing screw holes.
3) In the same way, secure the bottom mounting base to the center of the inverter.


Figure 2.3 Relocating the Top and Bottom Mounting Bases

## $\triangle$ CAUTION

When moving the top and bottom mounting bases, use only the specified screws.
A fire or an accident may be caused.

## (3) Mounting direction

Mount the inverter vertically to the mounting surface and fix it securely with bolts so that the logo "FRENIC-Eco" can be seen from the front.

Note
Do not mount the inverter upside down or horizontally. Doing so will reduce the heat dissipation efficiency of the inverter and cause the overheat protection function to operate, so the inverter will not run.

Follow the procedure below. (In the following description, the inverter has already been installed.)

### 2.3.1 Removing and mounting the terminal block (TB) cover and the front cover

## (1) For inverters with a capacity of 90 kW or 110 kW

(1. To remove the front cover, loosen the fastening screws on it, hold it with both hands, and slide it upwards and towards you. (See Figure 2.4.)
(2. Put the front cover back in the reverse order of removal. Make sure to properly match the position of the screw holes on both of the front cover and inverter case.


Tightening torque: $3.5 \mathrm{~N} \cdot \mathrm{~m}$

Figure 2.4 Removing the Front Cover
(2) For inverters with a capacity of 280 kW to 560 kW
(1) To remove the lower front cover, loosen the fastening screws on it, hold it with both hands, and pull it upwards and towards you.
Note After removing the lower front cover, you can perform wiring works.
(2. To remove the upper front cover, remove the fastening screws on it while supporting it with one hand and then remove it with both hands. (See Figure 2.5.)
Inverters with a capacity of 355 to 560 kW : Loosen the fastening screws on the upper front cover, hold it with both hands, and pull it upwards and towards you.
(3. Put back the upper and lower front covers in the reverse order of removal. Make sure to properly match the position of the screw holes on the upper and lower front covers and inverter case.


The lower front cover should be removed for wiring.


The upper front cover can also be removed as shown above.

Figure 2.5 Removing the Front Covers

End of Avon St Leichhardt SPS－i．Power Solutions－Ipswich Ref J7985－01－SP22 O＇Keefe St SPS－O

## 2．3．2 Terminal arrangement diagram and screw specifications

The table and figures given below show the terminal screw sizes，tightening torque and terminal arrangements． Note that the terminal arrangements differ depending upon the inverter types．In each of the figures，two grounding terminals（县）are not exclusive to the power supply wiring（primary circuit）or motor wiring （secondary circuit）．
（1）Arrangement of main circuit terminals
Table 2．4 Main Circuit Terminals

| Power supply voltage | Nominal applied motor （kW） | Inverter type | Terminal screw size | Tightening torque（N•m） | Grounding screw size | Tightening torque（ $\mathrm{N} \cdot \mathrm{m}$ ） |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Three－ phase 200 V | 90 | FRN90F1S－2口 | M12 | 48 | M10 | 27 |
|  | 110 | FRN110F1S－2口 |  |  |  |  |
| Three－ phase 400 V | 280 | FRN280F1S－4 |  |  |  |  |
|  | 315 | FRN315F1S－4 $\square$ |  |  |  |  |
|  | 355 | FRN355F1S－4ロ |  |  |  |  |
|  | 400 | FRN400F1S－4口 |  |  |  |  |
|  | 450 | FRN450F1S－4D |  |  |  |  |
|  | 500 | FRN500F1S－4 $\square$ |  |  |  |  |
|  | 560 | FRN560F1S－4 $\square$ |  |  |  |  |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．
Terminal R0，T0：Screw size M3．5，Tightening torque $1.2 \mathrm{~N} \cdot \mathrm{~m}$
Terminal R1，T1：Screw size M3．5，Tightening torque $0.9 \mathrm{~N} \cdot \mathrm{~m}$

FRN90F1S－2


FRN110F1S－2


FRN280F1S－4 and FRN315F1S－4


FRN355F1S－4 and FRN400F1S－4


FRN450F1S－4 to FRN560F1S－4



Screw size：M3 Tightening torque： $0.7 \mathrm{~N} \cdot \mathrm{~m}$

## 2．3．3 Recommended wire sizes

Table 2.5 lists the recommended wire sizes．Those for the main circuits are examples of using single HIV wires （for $75^{\circ} \mathrm{C}$ ）at an ambient temperature of $50^{\circ} \mathrm{C}$ ．

Table 2．5 Recommended Wire Sizes

| Power supply voltage | Nominal applied motor （kW） | Inverter type | Recommended wire size（ $\mathrm{mm}^{2}$ ）＊1 |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Main circuits |  |  |  |  |  | Control circuit |
|  |  |  | Main circuit power input （L1／R，L2／S， L3／T） | Grounding ［ | Inverter output ［U，V，W］ | Auxiliary power input （Ctrl．cct．） ［R0，T0］ | Auxiliary power input （Fans） ［R1，T1］ | $\begin{gathered} \mathrm{DCR} \\ {[\mathrm{P} 1, \mathrm{P}(+)]} \end{gathered}$ |  |
|  |  |  | w／DCR |  |  |  |  |  |  |
| Three－ phase 200 V | 90 | FRN90F1S－2口 | 150 | 38 | 150 | 2 | 2 | 200 | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ |
|  | 110 | FRN110F1S－2口 | 200 |  | 200 |  |  | 250 |  |
| Three－ phase 400 V | 280 | FRN280F1S－4］ | 250 | 38 | 325 | 2 | 2 | $200 \times 2$ | $\begin{gathered} 0.75 \\ \text { to } \\ 1.25 \end{gathered}$ |
|  | 315 | FRN315F1S－4D | 325 | 60 | 325 |  |  | $200 \times 2$ |  |
|  | 355 | FRN355F1S－4口 | $200 \times 2$ |  | $200 \times 2$ |  |  | $250 \times 2$ |  |
|  | 400 | FRN400F1S－4口 | $200 \times 2$ |  | $250 \times 2$ |  |  | $250 \times 2$ |  |
|  | 450 | FRN450F1S－4］ | $250 \times 2$ |  | $250 \times 2$ |  |  | $325 \times 2$ |  |
|  | 500 | FRN500F1S－4■ | $325 \times 2$ | 100 | $325 \times 2$ |  |  | $325 \times 2$ |  |
|  | 560 | FRN560F1S－4］ | $250 \times 3$ |  | $250 \times 3$ |  |  | $325 \times 3$ |  |

＊1 Use a crimp terminal with an insulation sheath or the one processed with an insulation tube．
Use a 600 V ，HIV wire with the allowable heat resistance $75^{\circ} \mathrm{C}$ ．This selection assumes the inverter is used in an ambient temperature of $50^{\circ} \mathrm{C}$ ．

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．

### 2.3.4 Wiring precautions

Follow the rules below when performing wiring for the inverter.
(1) Make sure that the source voltage is within the rated voltage range specified on the nameplate.
(2) Be sure to connect the three-phase power wires to the main circuit power input terminals $\mathrm{L} 1 / \mathrm{R}, \mathrm{L} 2 / \mathrm{S}$ and $L 3 / T$ of the inverter. If the power wires are connected to other terminals, the inverter will be damaged when the power is turned on.
(3) Always connect the grounding terminal to prevent electric shock, fire or other disasters and to reduce electric noise.
(4) Use crimp terminals covered with insulated sleeves for the main circuit terminal wiring to ensure a reliable connection.
(5) Keep the power supply wiring (primary circuit) and motor wiring (secondary circuit) of the main circuit, and control circuit wiring as far away as possible from each other.


- When wiring the inverter to the power source, insert a recommended molded case circuit breaker (MCCB) or earth leakage circuit breaker (ELCB) (with overcurrent protection) in the path of each pair of power lines to inverters. Use the devices recommended ones within the related current range.
- Use wires in the specified size.
- Tighten terminals with specified torque.

Otherwise, fire could occur.

- Do not connect a surge killer to the inverter's output circuit.
- Do not use one multicore cable in order to connect several inverters with motors.

Doing so could cause fire.

- Ground the inverter in compliance with the national or local electric code.

Otherwise, electric shock or fire could occur.

- Qualified electricians should carry out wiring.
- Be sure to perform wiring after turning the power off.

Otherwise, electric shock could occur.

- Be sure to perform wiring after installing the inverter. Otherwise, electric shock or injuries could occur.
- Ensure that the number of input phases and the rated voltage of the product match the number of phases and the voltage of the AC power supply to which the product is to be connected.
- Do not connect the power source wires to output terminals ( $\mathrm{U}, \mathrm{V}$, and W ).

Doing so could cause fire or an accident.

### 2.3.5 Wiring for main circuit terminals and grounding terminals

Table 2.6 shows the main circuit terminals and grounding terminals.
Table 2.6 Symbols, Names and Functions of the Main Circuit Terminals

| Symbol | Name | Functions |
| :---: | :---: | :---: |
| L1/R, L2/S, L3/T | Main circuit power inputs | Connect the 3-phase input power lines. |
| U, v, w | Inverter outputs | Connect a 3-phase motor. |
| Ro, T0 | Auxiliary power input for the control circuit | For a backup of the control circuit power supply, connect AC power lines same as that of the main power input. |
| P1, P(+) | DC reactor connection | Connect a DC reactor (DCR) for improving power factor. |
| $\mathrm{P}(+), \mathrm{N}(-)$ | DC link bus | Connect a DC link bus of other inverter(s). An optional regenerative converter is also connectable to these terminals. |
| R1, T1 | Auxiliary power input for the fans | Normally, no need to use these terminals. Use these terminals for an auxiliary power input of the fans in a power system using a power regenerative PWM converter (RHC series). |
| EG | Grounding for inverter and motor | Grounding terminals for the inverter's chassis (or case) and motor. Earth one of the terminals and connect the grounding terminal of the motor. Inverters provide a pair of grounding terminals that function equivalently. |

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - Ol Follow the procedure below for wiring and configuration of the inverter. Figure 2.6 illustrates the wiring procedure with peripheral equipment.

## Wiring procedure

(1) Grounding terminals (
2. Inverter output terminals (U, V, W) and motor grounding terminal (

DC reactor connection terminals ( P 1 and $\mathrm{P}(+))^{\star}$
(4. Switching connectors* (See page 2-11.)
(5.) DC link bus terminals $(\mathrm{P}(+) \text { and } \mathrm{N}(-))^{*}$
(6.) Main circuit power input terminals (L1/R, L2/S and L3/T)
(7. Auxiliary power input terminals for the control circuit (R0 and TO)*
(8) Auxiliary power input terminals for the fans (R1 and T1)* (See page 2-14.)

* Perform wiring as necessary


Note: A box ( $\square$ ) in the above figure replaces A, K , or E depending on the shipping destination.

Figure 2.6 Wiring Procedure for Peripheral Equipment

Be sure to ground either of the two grounding terminals for safety and noise reduction．The inverter is designed to use with a safety grounding to avoid electric shock，fire and other disasters．
Grounding terminals should be grounded as follows：
1）Ground the inverter in compliance with the national or local electric code．
2）Use a thick grounding wire with a large surface area and keep the wiring length as short as possible．

## Inverter output terminals，U，V，W and grounding terminals（

Inverter＇s output terminals should be connected as follows：
1）Connect the three wires of the 3 －phase motor to terminals $\mathrm{U}, \mathrm{V}$ ，and W ，aligning phases each other．
2）Connect the secondary grounding wire to the grounding terminal（
－The wiring length between the inverter and motor should not exceed 50 m ，when they are connected directly．If the wiring length exceeds 50 m ，an output circuit filter（option）should be inserted．（E．g．total power cable length is 400 m as shown in the figure below．）
－Do not use one multicore cable to connect several inverters with motors even if some possible combinations of inverters and motors are considered．

| No Output Circuit Filter installed |
| :--- |

－Do not connect a power factor correcting capacitor or surge absorber to the inverter＇s output lines （secondary circuit）．
－If the wiring length is long，the stray capacitance between the wires will increase，resulting in an outflow of the leakage current．It will activate the overcurrent protection，increase the leakage current，or will not assure the accuracy of the current display．In the worst case，the inverter could be damaged．
－If more than one motor is to be connected to a single inverter，the wiring length should be the sum of the length of the wires to the motors．
－If an output circuit filter is installed in the inverter or the wires between the motor and the inverter are too long，the actual voltage applied to the motor would drop measurably because of the voltage drop over the filter or the wires．As a result，the output current may fluctuate because of an insufficient voltage．
In such installations，set the voltage on the higher side，by setting the function code F37（Load Selection／Auto torque Boost／Auto energy Saving Operation）to＂1：Variable torque load increasing in proportion to square of speed＂（Higher start－up torque required），or selecting a non－linear V／f pattern（using the function codes H50 and H51（Non－linear V／f pattern（Frequency and Voltage））．
－Use an output circuit（secondary）filter of OFL－ロロローロA．

## Note Driving 400 V series motor

- If a thermal relay is installed in the path between the inverter and the motor to protect the motor from overheating, the thermal relay may malfunction even with a wiring length shorter than 50 m . In this situation, add an output circuit filter (option) or lower the carrier frequency (Function code F26).
- If the motor is driven by a PWM-type inverter, surge voltage that is generated by switching the inverter component may be superimposed on the output voltage and may be applied to the motor terminals. Particularly if the wiring length is long, the surge voltage may deteriorate the insulation resistance of the motor. Consider any of the following measures.
- Use a motor with insulation that withstands the surge voltage. (All Fuji standard motors feature insulation that withstands the surge voltage.)
- Connect an output circuit filter (option) to the output terminals (secondary circuits) of the inverter.
- Minimize the wiring length between the inverter and motor (10 to 20 m or less).


## DC reactor terminals, P1 and P (+)

Connect a DC reactor to terminals P 1 and $\mathrm{P}(+)$.
Note - The wiring length should be 10 m or below.

- A DC reactor is provided as standard. Be sure to connect the DC reactor except when an optional converter is connected to the inverter.


## (4. Switching connectors <br> - Power switching connectors (CN UX)

The inverter is equipped with a set of switching connectors CU UX (male) which should be configured with a jumper according to the power source voltage and frequency. Set the jumper to U1 or U2 depending upon the power source voltage applied to the main power inputs (L1/R, L2/S, L3/T) or auxiliary power input terminals (R1, T1) for fans, as shown in Figures 2.8 to 2.10.

- Fan power supply switching connectors (CN R) and (CN W)

The standard FRENIC-Eco series of inverters also accept DC-linked power input in combination with a power regenerative PWM converter (RHC series). Even when driving the inverter with a DC-linked power, you also need to supply AC power to AC fans and other AC power driven components contained inside. In this case, set up the CN R and CN W on the NC and FAN positions respectively and supply AC power to the auxiliary power input terminals (R1, T1).

For the actual procedure, see Figures 2.8 to 2.10 below.
Note The fan power supply switching connectors CN R and CN W are set up on the FAN and NC positions respectively by factory default. Do not change the connection unless you drive the inverter with a DC-linked power supply.
Wrong connection cannot run the cooling fan, resulting in a heat sink overheating alarm " "Lilit i" or a



Figure 2.7 Switching Fan Power Source

- Setting up the jumpers for the connectors CN UX, CN R and CN W

These switching connectors are located on the power printed circuit board (power PCB) mounted at the right hand side of the control printed circuit board (control PCB) as shown below.


Figure 2.8 Location of Switching Connectors and Auxiliary Power Input Terminals


To remove the jumper, pinch its upper side between your fingers, unlock its fastener and pull it up. To insert it, push it down as firmly as it locks with the connector until you will have heard a click sound.

Figure 2.9 Inserting/Removing the Jumpers

Figure 2.10 shows how the configuration jumpers of the connectors (CN UX), (CN R) and (CN W) are set up by factory defaults, and how to change their settings for a new power configuration.

- Setting up the power switching connector (CN UX)

| Connector configuration |  |  |
| :---: | :---: | :---: |
| Power source voltage | $\begin{aligned} & 398 \text { to } 440 \mathrm{~V} / 50 \mathrm{~Hz} \\ & 430 \text { to } 480 \mathrm{~V} / 60 \mathrm{~Hz} \end{aligned}$ <br> (Factory default for Taiwan/Korea/EU) <br> Note: Allowable power input voltage range should be within $-15 \%$ to $+10 \%$ of power source voltage. | $\begin{gathered} 380 \text { to } 398 \mathrm{~V} / 50 \mathrm{~Hz} \\ 380 \text { to } 430 \mathrm{~V} / 60 \mathrm{~Hz} \\ \text { (Factory default for Asia) } \end{gathered}$ <br> Note: Allowable power input voltage range should be within $-15 \%$ to $+10 \%$ of power source voltage. |

- Setting up the fan power supply switching connectors (CN R) and (CN W)


Figure 2.10 Reconfiguration of the (CN UX), (CN R) and (CN W) Connectors

## (5. DC link bus terminals, $\mathrm{P}(+)$ and $\mathrm{N}(-)$

These are provided for the DC link bus powered system. Connect these terminals with terminals $P(+)$ and $N(-)$ of other inverters.

Note Consult your Fuji Electric representative if these terminals are to be used.
(6.: Main circuit power input terminals, L1/R, L2/S, and L3/T (three-phase input)

1) For safety, make sure that the molded case circuit breaker (MCCB) or magnetic contactor (MC) is turned off before wiring the main circuit power input terminals.
2) Connect the main circuit power supply wires ( $\mathrm{L} 1 / \mathrm{R}, \mathrm{L} 2 / \mathrm{S}$ and $\mathrm{L} 3 / \mathrm{T}$ ) to the input terminals of the inverter via an MCCB or residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB)*, and MC if necessary.
It is not necessary to align phases of the power supply wires and the input terminals of the inverter with each other.

* With overcurrent protection

Tip It is recommended that a magnetic contactor be inserted that can be manually activated. This is to allow you to disconnect the inverter from the power supply in an emergency (e.g., when the protective function is activated) so as to prevent a failure or accident from causing the secondary problems.
(7. Auxiliary power input terminals R0 and T0 for the control circuit

In general, the inverter runs normally without power supplied to terminals R0 and T0. If the control circuit shares the power supply with the main circuit, however, activating the protective circuit and turning off the magnetic contactor (MC) in the inverter primary circuit cuts off power to the control circuit, causing alarm signals ( $30 \mathrm{~A} / \mathrm{B} / \mathrm{C}$ ) to be lost and the display on the keypad to disappear. To secure input power to the control circuit at all times, supply power to terminals R0 and T0 from the primary circuit of the MC.

## (8. Auxiliary power input terminals R1 and T1 for fans

The inverter is equipped with terminals R1 and T1. Only if the inverter works with the DC-linked power input whose source is a power regenerative PWM converter (e.g. RHC series), these terminals are used to feed power to the fans while they are not used in any power system of ordinary configuration. The fan power is:
Single phase 200 to $220 \mathrm{VAC} / 50 \mathrm{~Hz}$, 200 to $230 \mathrm{VAC} / 60 \mathrm{~Hz}$ for 200 V series 45 kW or above
Single phase 380 to $440 \mathrm{VAC} / 50 \mathrm{~Hz}$. 380 to $480 \mathrm{VAC} / 60 \mathrm{~Hz}$ for 400 V series 55 kW or above

### 2.3.6 Wiring for control circuit terminals

## $\triangle$ WARNING

In general, sheaths and covers of the control signal cables and wires are not specifically designed to withstand a high electric field (i.e., reinforced insulation is not applied). Therefore, if a control signal cable or wire comes into direct contact with a live conductor of the main circuit, the insulation of the sheath or the cover might break down, which would expose the signal wire to a high voltage of the main circuit. Make sure that the control signal cables and wires will not come into contact with live conductors of the main circuit.
Failure to observe these precautions could cause electric shock and/or an accident.

## $\triangle$ CAUTION

Noise may be emitted from the inverter, motor and wires.
Take appropriate measure to prevent the nearby sensors and devices from malfunctioning due to such noise.
An accident could occur.

Table 2.7 lists the symbols, names and functions of the control circuit terminals. The wiring to the control circuit terminals differs depending upon the setting of the function codes, which reflects the use of the inverter. Route wires properly to reduce the influence of noise, referring to the notes on the following pages.

Table 2.7 Symbols, Names and Functions of the Control Circuit Terminals

| (1) | Symbol | Name | Functions |
| :---: | :---: | :---: | :---: |
|  | [13] | Potentiometer power supply | Power supply (+10 VDC) for the potentiometer that gives the frequency command (Potentiometer: 1 to $5 \mathrm{k} \Omega$ ) <br> Allowable output current: 10 mA |
|  | [12] | Voltage input | (1) The frequency is commanded according to the external analog input voltage. <br> 0 to 10 VDC/0 to 100 (\%) (Normal mode operation) <br> 10 to 0 VDC/0 to 100 (\%) (Inverse mode operation) <br> (2) Used for PID process command signal or its feedback. <br> (3) Used as an additional auxiliary frequency command to be added to one of various main frequency commands. <br> * Input impedance: $22 \mathrm{k} \Omega$ <br> * The allowable maximum input voltage is +15 VDC . If the input voltage is +10 VDC or more, the inverter will interpret it as +10 VDC. |
|  | [C1] | Current input | (1) The frequency is commanded according to the external analog input current. <br> 4 to $20 \mathrm{~mA} \mathrm{DC/0}$ to 100 (\%) (Normal mode operation) <br> 20 to $4 \mathrm{mADC} / 0$ to 100 (\%) (Inverse mode operation) <br> (2) Used for PID process command signal or its feedback. <br> (3) Used as an additional auxiliary frequency command to be added to one of various main frequency commands. <br> * Input impedance: $250 \Omega$ <br> * The allowable maximum input current is +30 mA DC. If the input current exceeds +20 mA DC , the inverter will interpret it as +20 mADC . |
|  | [V2] | Voltage input | (1) The frequency is commanded according to the external analog input voltage. <br> 0 to 10 VDC/0 to 100 (\%) (Normal mode operation) <br> 10 to 0 VDC/0 to 100 (\%) (Inverse mode operation) <br> (2) Used for PID process command signal or its feedback. <br> (3) Used as an additional auxiliary frequency command to be added to one of various main frequency commands. <br> * Input impedance: $22 \mathrm{k} \Omega$ <br> * The allowable maximum input voltage is +15 VDC . If the input voltage exceeds +10 VDC, however, the inverter will interpret it as +10 VDC. |
|  |  |  | (4) Connects PTC (Positive Temperature Coefficient) thermistor for motor protection. Ensure that the slide switch SW5 on the control PCB is turned to the PTC position (refer to Section 2.3.7 "Setting up slide switches and handling control circuit terminal symbol plate." <br> The figure shown at the right illustrates the internal circuit diagram where SW5 (switching the input of terminal [V2] between V2 and PTC) is turned to the PTC position. For details on SW5, refer to Section 2.3.7 "Setting up slide switches and handling control circuit terminal symbol plate." In this case, you must change data of the function code H26. <br> Figure 2.11 Internal Circuit Diagram (SW5 Selecting PTC) |
|  | [11] | Analog common | Two common terminals for analog input and output signal terminals [13], [12], [C1], [V2] and [FMA]. <br> These terminal are electrically isolated from terminals [CM]s and [CMY]. |



Table 2.7 Continued



Figure 2.15 Circuit Configuration Using a Relay Contact

## ■ Using a programmable logic controller (PLC) to turn [X1], [X2], [X3], [X4], [X5], [FWD], or [REV] ON or OFF

Figure 2.16 shows two examples of a circuit that uses a programmable logic controller (PLC) to turn control signal input [X1], [X2], [X3], [X4], [X5], [FWD], or [REV] ON or OFF. In circuit (a), the switch SW1 has been turned to SINK, whereas in circuit (b) it has been turned to SOURCE.

In circuit (a) below, short-circuiting or opening the transistor's open collector circuit in the PLC using an external power source turns ON or OFF control signal [X1], [X2], [X3], [FWD], or [REV]. When using this type of circuit, observe the following:

- Connect the + node of the external power source (which should be isolated from the PLC's power) to terminal [PLC] of the inverter.
- Do not connect terminal [CM] of the inverter to the common terminal of the PLC.

(a) With the switch turned to SINK

(b) With the switch turned to SOURCE

Figure 2.16 Circuit Configuration Using a PLC
ID) For details about the slide switch setting, refer to Section 2.3.7 "Setting up slide switches and handling control circuit terminal symbol plate."

Table 2.7 Continued

|  | Symbol | Name | Functions |
| :---: | :---: | :---: | :---: |
|  | [FMA] | Analog monitor | The monitor signal for analog DC voltage ( 0 to +10 V ) or analog DC current ( +4 to +20 mA ) is output. You can select either one of the output switching the slide switch SW4 on the control PCB (Refer to Section 2.3.7.), and changing data of the function code F29. You can select one of the following signal functions with function code F31. <br> - Output frequency <br> - Output torque <br> - PID feedback value <br> - Motor output <br> - PID output <br> * Input impedance of the external device: Min. $5 \mathrm{k} \Omega$ ( 0 to 10 VDC output) Input impedance of the external device: Max. $500 \Omega$ ( 4 to 20 mA DC output) <br> * While the terminal is outputting 0 to 10 VDC , an output less than 0.3 V may become 0.0 V. <br> * While the terminal is outputting 0 to 10 VDC, it is capable of driving up to two meters with $10 \mathrm{k} \Omega$ impedance. While outputting the current, to drive a meter with $500 \Omega$ impedance max. (Adjustable range of the gain: 0 to 200\%) |
|  | [FMI]* | Analog monitor | The monitor signal for analog DC current ( +4 to +20 mA ) is output. You can select one of the following signal functions with function code F35. <br> - Output frequency - Output current - Output voltage <br> - Output torque • Load factor • Input power <br> - PID feedback value . DC link bus voltage . Universal AO <br> - Motor output . Analog output test . PID command <br> - PID output <br> * Input impedance of the external device: Max. $500 \Omega$ <br> * It is capable of driving a meter with a maximum of $500 \Omega$ impedance. (Adjustable gain range: 0 to 200\%) |
|  | [11] | Analog common | Two common terminals for analog input and output signal terminals These terminals are electrically isolated from terminals [CM]s and [CMY]. |
|  | [FMP]* | Pulse monitor | You can select one of the following signal functions with function code F35. <br> - Output frequency • Output current - Output voltage <br> - Output torque • Load factor • Input power <br> - PID feedback value - DC link bus voltage - Universal AO <br> - Motor output - Analog output test . PID command <br> - PID output <br> * Input impedance of the external device: Min. $5 \mathrm{k} \Omega$ <br> * This output is capable of driving up to two meters with $10 \mathrm{k} \Omega$ impedance. (Driven by the average DC voltage of the output pulse train.) (Adjustable range of the gain: 0 to $200 \%$ ) |
|  | [CM] | Digital common | Two common terminals for digital input signal terminals and an output terminal [FMP] These terminals are electrically isolated from other common terminals, [11]s and [CMY]. These are the shared terminals with the common terminal [CM]s of the digital inputs. |

[^53]

Figure 2.18 Connecting PLC to Control Circuit


Figure 2.19 RJ-45 Connector and its Pin Assignment*

* Pins 1, 2, 7, and 8 are exclusively assigned to power lines for the keypad, so do not use those pins for any other equipment.
(T. Route the control circuit cable in keeping with the left side panel of the inverter as shown in Figure 2.20.
(2. Fasten the control circuit cable to the cable tie support with a cable tie (insulation lock) as shown in Figure 2.20.

The hole in the cable tie support is $3.8 \mathrm{~mm} \times 1.5 \mathrm{~mm}$ in size. To pass the cable tie through the hole, it should be 3.8 mm or less in width and 1.5 mm or less in thickness.


Figure 2.20 Routing and Fastening the Control Circuit Cable

## Note

- Route the wiring of the control terminals as far from the wiring of the main circuit as possible. Otherwise electric noise may cause malfunctions.
- Fix the control circuit wires inside the inverter to keep them away from the live parts of the main circuit (such as the terminal block of the main circuit).


### 2.3.7 Setting up slide switches and handling control circuit terminal symbol plate

## $\triangle$ WARNING

Before changing the switches, turn OFF the power and wait at least 10 minutes. Make sure that the LED monitor and charging lamp are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC link bus voltage between the terminals $\mathrm{P}(+)$ and $\mathrm{N}(-)$ has dropped below the safe voltage (+25 VDC).
An electric shock may result if this warning is not heeded as there may be some residual electric charge in the DC bus capacitor even after the power has been turned off.

## - Setting up the slide switches

Switching the slide switches located on the control PCB allows you to customize the operation mode of the analog output terminals, digital I/O terminals, and communications ports. The locations of those switches are shown in Figure 2.23.
To access the slide switches, remove the front and terminal block covers and open the keypad enclosure so that you can watch the control PCB.
For a screw terminal base, close the control circuit terminal symbol plate since the plate being opened interferes with switching of some switches. See Figures 2.21 and 2.22.

For details on how to remove the front cover, terminal block cover, and keypad enclosure, refer to Section 2.3.1 "Removing and mounting the terminal block (TB) cover and the front cover" and Chapter 1, Section 1.2 "External View and Terminal Blocks," Figure 1.4.

Table 2.8 lists function of each slide switch.
Table 2.8 Function of Each Slide Switch

| Switch | Function |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| (1. SW1 | Switches the service mode of the digital input terminals between SINK and SOURCE. <br> - To make the digital input terminal [X1] to [X5], [FWD] or [REV] serve as a current sink, turn SW1 to the SINK position. <br> - To make them serve as a current source, turn SW1 to the SOURCE position. |  |  |  |
|  |  | Asia | Taiwan/Korea | EU |
|  | Factory default | SINK | SINK | SOURCE |
| (2) SW3 | Switches the terminating resistor of RS485 communications port on the inverter on and off. <br> - To connect a keypad to the inverter, turn SW3 to OFF. (Factory default) <br> - If the inverter is connected to the RS485 communications network as a terminating device, turn SW3 to ON. |  |  |  |
| (3) SW4 | Switches the output mode of the analog output terminal [FMA] between voltage and current. When changing this switch setting, also change the data of function code F29. |  |  |  |
|  |  |  | SW4 | Set data of F29 to: |
|  | Voltage output (F | default) | vo | 0 |
|  | Current output |  | 10 | 1 |
| (4. SW5 | Switches property of the analog input terminal [V2] for V2 or PTC. When changing this switch setting, also change the data of function code H26. |  |  |  |
|  |  |  | SW5 | Set data of H26 to: |
|  | Analog frequenc voltage <br> (Factory default) | mand in | V2 | 0 |
|  | PTC thermistor in |  | PTC | 1 or 2 |

The symbolic names of the control circuit terminals are marked on the control circuit terminal symbol plate provided on the top of the terminal block. The plate can be opened or closed as necessary. Follow the procedures illustrated below to open or close the plate.

- Opening the plate


Figure 2.21 Opening the Control Circuit Terminal Symbol Plate

- Closing the plate


Figure 2.22 Closing the Control Circuit Terminal Symbol Plate

Figure 2.23 shows the location of slide switches for the input/output terminal configuration.


Switching example
SW1


SW3


Note

Figure 2.23 Location of the Slide Switches

### 2.4 Mounting and Connecting a Keypad

### 2.4.1 Mounting style and parts needed for connection

## (1) Mounting style

You can mount a keypad in any style described below.

- Mounting a keypad on the enclosure wall (See Figure 2.24.)
- Installing a keypad at a remote site (e.g. for operation on hand) (See Figure 2.25.)


Figure 2.24 Mounting Keypad on the Enclosure Wall


Figure 2.25 Using Keypad at a Remote Site (e.g. for Operation on Hand)
(2) Parts needed for connection

To mount/install a keypad on a place other than an inverter, parts listed below are needed.

| Parts name |  | Model |
| :--- | :--- | :--- |
| Extension cable (Note 1) | CB-5S, CB-3S and CB-1S | Remarks |
| Fastening screw | M3 $\times \square \quad$ (Note 2) | Two screws needed. Purchase off-the-shelf ones <br> separately. |

(Note 1) When using an off-the-shelf LAN cable, use a 10BASE-T/100BASE-TX straight type cable compliant to US ANSI/TIA/EIA-568A Category 5. (Less than 20m)
Recommended LAN cable
Manufacturer: SANWA Supply Co., LTD.
Model: $\quad$ KB-10T5-01K (1m)
KB-STP-01K: (1 m) (Shielded LAN cable to be compliant to EMC Directive)
(Note 2) When mounting on an enclosure wall, use the screws fitted to the thickness of the wall.
(Refer to Figure 2.28.)

### 2.4.2 Mounting/installing steps

## - Mounting a keypad on the enclosure wall

(1. Pull the keypad toward you while holding down the hook (pointed to by the arrow in Figure 2.26)


Figure 2.26 Removing a Keypad
(2) Separate the keypad from the dummy cover by sliding them in the arrowed directions as shown below.


Figure 2.27 Separation of the Dummy Cover
(3. Make a cut-out on the enclosure wall. For details, refer to Chapter 8, Section 8.5.3 "Keypad."
(4. To mount the keypad on the enclosure wall, fix it firmly using a pair of M3 screws put through the taps shown below. (Figure 2.28.)
(Tightening torque: $0.7 \mathrm{~N} \cdot \mathrm{~m}$ )


Figure 2.28 Mounting a Keypad on the Enclosure Wall
(5. Connect an extension cable (CB-5S, CB-3S or CB-1S) or off-the-shelf straight LAN cable to RJ-45 connectors (Modular jacks) on the keypad and inverter (standard RS485 port.) (Refer to Figure 2.29.)


Figure 2.29 Connecting a Keypad and an Inverter's Standard RS485 port

## ■ Installing a keypad at a remote site (e.g. for operation on hand)

Follow step (5.' in Mounting a keypad on the enclosure wall.

## - Putting the keypad back into place

Align the bottom of the keypad with the latches (shown below). While holding down the keypad against the terminal block cover (arrow (1) , push it onto the inverter case (arrow (Z).


Figure 2.30 Putting the Keypad Back Into Place

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### 2.5 Cautions Relating to Harmonic Component, Noise, and Leakage Current

## (1) Harmonic component

Input current to an inverter includes a harmonic component, which may affect other loads and power factor correcting capacitors that are connected to the same power source as the inverter. If the harmonic component causes any problems, connect a DC reactor (option) to the inverter. It may also be necessary to connect an AC reactor to the power factor correcting capacitors.

## (2) Noise

If noise generated from the inverter affects other devices, or that generated from peripheral equipment causes the inverter to malfunction, follow the basic measures outlined below.

1) If noise generated from the inverter affects the other devices through power wires or grounding wires:

- Isolate the grounded metal frames of the inverter from those of the other devices.
- Connect a noise filter to the inverter power wires.
- Isolate the power system of the other devises from that of the inverter with an insulated transformer.

2) If induction or radio noise generated from the inverter affects other devices through power wires or grounding wires:

- Isolate the main circuit wires from the control circuit wires and other device wires.
- Put the main circuit wires through a metal conduit and connect the pipe to the ground near the inverter.
- Install the inverter onto the metal switchboard and connect the whole board to the ground.
- Connect a noise filter to the inverter power wires.

3) When implementing measures against noise generated from peripheral equipment:

- For the control signal wires, use twisted or shielded-twisted wires. When using shielded-twisted wires, connect the shield of the shielded wires to the common terminals of the control circuit or ground.
- Connect a surge absorber in parallel with a coil or solenoid of the magnetic contactor.


## (3) Leakage current

Harmonic component current generated by insulated gate bipolar transistors (IGBTs) switching on/off inside the inverter becomes leakage current through stray capacitors of inverter input and output wires or a motor. If any of the problems listed below occur, take an appropriate measure against them.

Table 2.9 Leakage Current Countermeasures

| Problem | Measures |
| :--- | :--- |
| An earth leakage circuit | 1) Decrease the carrier frequency. |
| breaker* that is connected to |  |
| the input (primary) side has | 2) Make the wires between the inverter and motor shorter. |
| tripped. | 3) Use an earth leakage circuit breaker that has a longer sensitive current than |
| * With overcurrent protection | 4)Use an earth leakage circuit breaker that features measures against <br> harmonic component (Fuji SG and EG series). <br> An external thermal relay was <br> activated.1)Decrease the carrier frequency. <br> Increase the settling current of the thermal relay.3) Use the electronic thermal relay built in the inverter, instead of an external <br> thermal relay. |

Chapter 3 OPERATION USING THE KEYPAD

## 3．4 Programming Mode

## 3．4．6 Reading maintenance information－Menu \＃5＂Maintenance Information＂

Table 3．18 Display Items for Maintenance Information

| LED Monitor shows： | Item | Description |
| :---: | :---: | :---: |
|  | Cumulative run time | Shows the content of the cumulative power－ON time counter of the inverter． <br> Unit：thousands of hours． <br> （Display range： 0.001 to $9.999,10.00$ to 65.53 ） <br> When the total ON－time is less than 10000 hours（display： 0.001 to 9.999 ），data is shown in units of one hour（0．001）．When the total time is 10000 hours or more （display： 10.00 to 65.53 ），it is shown in units of 10 hours（ 0.01 ）．When the total time exceeds 65535 hours，the counter will be reset to 0 and the count will start again． |
| 今分！ | DC link bus voltage | Shows the DC link bus voltage of the inverter main circuit． Unit：V（volts） |
| 今ーイ゙İ | Max．tempera－ ture inside the inverter | Shows a maximum temperature inside the inverter for every hour． Unit：${ }^{\circ} \mathrm{C}$（Temperatures below $20^{\circ} \mathrm{C}$ are displayed as $20^{\circ} \mathrm{C}$ ．） |
| ヒーイブ | Max．temperature of heat sink | Shows the maximum temperature of the heat sink for every hour． Unit：${ }^{\circ} \mathrm{C}$（Temperatures below $20^{\circ} \mathrm{C}$ are displayed as $20^{\circ} \mathrm{C}$ ．） |
| 今ーバーブ | Max．effective output current | Shows the maximum current in RMS for every hour． Unit：A（amperes） |
| ヒーイ゙ィ | Capacitance of the DC link bus capacitor | Shows the current capacitance of the DC link bus capacitor（reservoir capacitor） in \％，based on the capacitance when shipping as $100 \%$ ．Refer to Chapter 7 ＂MAINTENANCE AND INSPECTION＂for details． <br> Unit：\％ |
| ラーイ゙イフ | Cumulative run time of electro－ lytic capacitors on printed circuit boards | Shows the content of the cumulative run time counter of the electrolytic capacitors mounted on the printed circuit boards after multiplying the content by the coefficient of the ambient temperature． <br> Unit：thousands of hours． <br> （Display range： 0.001 to $9.999,10.00$ to 99.99 ）＊ <br> When the total ON－time is less than 10000 hours（display： 0.001 to 9.999 ），data is shown in units of one hour（0．001）．When the total time is 10000 hours or more （display： 10.00 to 99.99 ），it is shown in units of 10 hours（ 0.01 ）． <br> However，when the total time exceeds 99990 hours，the count stops and the display remains at 99．99． |
| 今ィヲ7 | Cumulative run time of the cooling fan | Shows the content of the cumulative run time counter of the cooling fan． <br> This counter does not work when the cooling fan ON／OFF control（function code H06）is enabled but the fan is stopped． <br> The display method is the same as for＂Cumulative run time of electrolytic capacitors on printed circuit boards（ $\left.5, A_{1}\right)$ above．＊ <br> When the total time exceeds 99990 hours，the count stops and the display remains at 99．99． |
| 5 ミイ゙ | Number of startups | Shows the content of the cumulative counter of times the inverter is started up（i．e．， the number of run commands issued）． <br> 1.000 indicates 1000 times．When any number from 0.001 to 9.999 is displayed，the counter increases by 0.001 per startup，and when any number from 10.00 to 65.53 is counted，the counter increases by 0.01 every 10 startups．When the counted number exceeds 65535 ，the counter will be reset to 0 and the count will start again． |

＊For inverters with the ROM version 1400 or later：The count range of the cumulative run time counters listed above has increased to 99.99 （ 99990 hours）．The early warning of lifetime alarm has changed as listed in Table 7.3 in Chapter 7，Section 7．3．1．

Tip The inverter＇s ROM version can be checked on Menu \＃5＂Maintenance Information＂（5＿14）．

Table 3．18 Display Items for Maintenance Information（Continued）

| LED Monitor shows： | Item | Description |
| :---: | :---: | :---: |
| 519 | Input watt－hour | Shows the input watt－hour of the inverter． <br> Unit： 100 kWh（Display range： 0.001 to 9999） <br> Depending on the value of integrated input watt－hour，the decimal point on the LED monitor shifts to show it within the LED monitors＇resolution（e．g．the resolution varies between $0.001,0.01,0.1$ or 1 ）．To reset the integrated input watt－hour and its data，set function code E51 to＂0．000．＂ <br> When the input watt－hour exceeds 1000000 kWh ，it returns to＂ 0 ．＂ |
| $5 \square^{\prime \prime}$ | Input watt－hour data | Shows the value expressed by＂input watt－hour（kWh）$\times$ E51（whose data range is 0.000 to 9999）．＂ <br> Unit：None． <br> （Display range： 0.001 to 9999 ．The data cannot exceed 9999 ．（It will be fixed at 9999 once the calculated value exceeds 9999．）） <br> Depending on the value of integrated input watt－hour data，the decimal point on the LED monitor shifts to show it within the LED monitors＇resolution． <br> To reset the integrated input watt－hour data，set function code E51 to＂0．000．＂ |
| 5－1i | No．of RS485 errors（stan－ dard） | Shows the total number of errors that have occurred in standard RS485 commu－ nication（via the RJ－45 connector as standard）since the power is turned on． Once the number of errors exceeds 9999 ，the count returns to 0 ． |
| S\％ | Content of RS485 commu－ nications error （standard） | Shows the latest error that has occurred in standard RS485 communication in decimal format． <br> For error contents，refer to the RS485 Communication User＇s Manual（MEH448a）． |
| 519 | No．of option errors | Shows the total number of optional communications card errors since the power is turned on． <br> Once the number of errors exceeds 9999，the count returns to 0 ． |
| S． | Inverter＇s ROM version | Shows the inverter＇s ROM version as a 4－digit code． |
| 5 | Keypad＇s ROM version | Shows the keypad＇s ROM version as a 4－digit code． |
| 5817 | No．of RS485 errors（option） | Shows the total number of errors that have occurred in optional RS485 commu－ nication since the power is turned on． <br> Once the number of errors exceeds 9999 ，the count returns to 0 ． |
| 5－119 | Content of RS485 commu－ nications error （option） | Shows the latest error that has occurred in optional RS485 communication in decimal format． <br> For error contents，refer to the RS485 Communication User＇s Manual（MEH448a）． |
| 519 | Option＇s ROM version | Shows the option＇s ROM version as a 4－digit code． |
| 5 5ーゴ | Cumulative motor run time | Shows the content of the cumulative power－ON time counter of the motor． <br> The display method is the same as for＂Cumulative run time（ $5_{-}$ |

Chapter 5 FUNCTION CODES

### 5.1 Function Code Tables



[^54]End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - Ol

| Code | Name | Data setting range | Increment | Unit | Change when running | Data copying | Default setting | Refer to page: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| E31 | Frequency Detection (FDT) (Detection level) | 0.0 to 120.0 | 0.1 | Hz | Y | Y | $\begin{aligned} & 60.0 \\ & (50.0) * 2 \end{aligned}$ | 5-57-1 |
| E32 | (Hysteresis width) | 0.0 to 120.0 | 0.1 | Hz | Y | Y | 1.0 | 5-57-1 |
| E34 | Overload Early Warning /Current Detection <br> (Level) | 0 : (Disable) <br> Current value of 1 to $150 \%$ of the inverter rated current | 0.01 | A | Y | $\begin{aligned} & \text { Y1 } \\ & \text { Y2 } \end{aligned}$ | $100 \%$ of the motor rated current | 5-58 |
| E35 | (Timer) | 0.01 to 600.00 *1 | 0.01 | S | Y | Y | 10.00 |  |
| E40 | PID Display Coefficient A | -999 to 0.00 to 999 *1 | 0.01 | - | Y | Y | 100 | - |
| E41 | PID Display Coefficient B | -999 to 0.00 to 999 *1 | 0.01 | - | Y | Y | 0.00 |  |
| E43 | LED Monitor (Item selection) | 0: Speed monitor (Select by E48.) <br> 3: Output current <br> 4: Output voltage <br> 8: Calculated torque <br> 9: Input power <br> 10: PID process command (Final) <br> 12: PID feedback value <br> 14: PID output <br> 15: Load factor <br> 16: Motor output <br> 17: Analog input | - | - | Y | Y | 0 |  |
| E45 | LCD Monitor *3 (Item selection) | 0: Running status, rotational direction and operation guide <br> 1: Bar charts for output frequency, current and calculated torque | - | - | Y | Y | 0 |  |
| E46 | (Language selection) | 0: Japanese <br> 1: English <br> 2: German <br> 3: French <br> 4: Spanish <br> 5: Italian | - | - | Y | Y | 1 |  |
| E47 | (Contrast control) | 0 (Low) to 10 (High) | 1 | - | Y | Y | 5 |  |
| E48 | LED Monitor (Speed monitor item) | 0: Output frequency <br> 3: Motor speed in $\mathrm{r} / \mathrm{min}$ <br> 4: Load shaft speed in $\mathrm{r} / \mathrm{min}$ <br> 7: Display speed in \% | - | - | Y | Y | 0 |  |
| E50 | Coefficient for Speed Indication | 0.01 to 200.00 *1 | 0.01 | - | Y | Y | 30.00 |  |
| E51 | Display Coefficient for Input Watt-hour Data | 0.000: (Cancel/reset) <br> 0.001 to 9999 | 0.001 | - | Y | Y | 0.010 | 5-58 |
| E52 | Keypad <br> (Menu display mode) | 0: Function code data editing mode (Menus \#0, \#1 and \#7) <br> 1: Function code data check mode (Menus \#2 and \#7) <br> 2: Full-menu mode (Menus \#0 through \#7) | - | - | Y | Y | 0 | - |

The shaded function codes ) are applicable to the quick setup.
*1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
(Example) If the setting range is from -200.00 to 200.00 , the incremental unit is:
"1" for -200 to -100 , " 0.1 " for -99.9 to -10.0 and for 100.0 to 200.0 , and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .
*2 Values in parentheses () in the above table denote default settings for the EU version.
*3 LCD monitor settings are applicable only to the inverter equipped with a multi-function keypad.

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[^55]End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - Ol
The table below lists functions that can be assigned to terminals [Y1], [Y2], [Y3], [Y5A/C], and [30A/B/C].
To make the explanations simpler, the examples shown below are all written for the normal logic (Active ON.)

| Function code data |  | Functions assigned | Symbol |
| :---: | :---: | :---: | :---: |
| Active ON | Active OFF |  |  |
| 0 | 1000 | Inverter running | (RUN) |
| 1 | 1001 | Frequency arrival signal | (FAR) |
| 2 | 1002 | Frequency detected | (FDT) |
| 3 | 1003 | Undervoltage detected (Inverter stopped) | (LU) |
| 5 | 1005 | Inverter output limiting | (IOL) |
| 6 | 1006 | Auto-restarting after momentary power failure | (IPF) |
| 7 | 1007 | Motor overload early warning | (OL) |
| 10 | 1010 | Inverter ready to run | (RDY) |
| 11 | - | Switch motor drive source between commercial power and inverter output (For MC on commercial line) | (SW88) |
| 12 | - | Switch motor drive source between commercial power and inverter output (For secondary side) | (SW52-2) |
| 13 | - | Switch motor drive source between commercial power and inverter output (For primary side) | (SW52-1) |
| 15 | 1015 | Select AX terminal function (For MC on primary side) | (AX) |
| 25 | 1025 | Cooling fan in operation | (FAN) |
| 26 | 1026 | Auto-resetting | (TRY) |
| 27 | 1027 | Universal DO | (U-DO) |
| 28 | 1028 | Heat sink overheat early warning | $(\mathrm{OH})$ |
| 30 | 1030 | Service life alarm | (LIFE) |
| 33 | 1033 | Command loss detected | (REF OFF) |
| 35 | 1035 | Inverter output on | (RUN2) |
| 36 | 1036 | Overload prevention control | (OLP) |
| 37 | 1037 | Current detected | (ID) |
| 42 | 1042 | PID alarm | (PID-ALM) |
| 43 | 1043 | Under PID control | (PID-CTL) |
| 44 | 1044 | Motor stopping due to slow flowrate under PID control | (PID-STP) |
| 45 | 1045 | Low output torque detected | (U-TL) |
| 54 | 1054 | Inverter in remote operation | (RMT) |
| 55 | 1055 | Run command activated | (AX2) |
| 56 | 1056 | Motor overheat detected (PTC) | (THM) |
| 59 | 1059 | Terminal [C1] wire break | (C1OFF) |
| 60 | 1060 | Mount motor 1, inverter-driven | (M1_I) |
| 61 | 1061 | Mount motor 1, commercial-power-driven | (M1_L) |
| 62 | 1062 | Mount motor 2, inverter-driven | (M2_I) |
| 63 | 1063 | Mount motor 2, commercial-power-driven | (M2_L) |
| 64 | 1064 | Mount motor 3, inverter-driven | (M3_I) |
| 65 | 1065 | Mount motor 3, commercial-power-driven | (M3_L) |
| 67 | 1067 | Mount motor 4, commercial-power-driven | (M4_L) |
| 68 | 1068 | Periodic switching early warning | (MCHG) |
| 69 | 1069 | Pump control limit signal | (MLIM) |
| 99 | 1099 | Alarm output (for any alarm) | (ALM) |

A mark "-" in the Active OFF column means that a negative logic cannot be applied to the terminal function.

This output signal is used to tell the external equipment that the inverter is running at a starting frequency or higher. It comes ON when the output frequency exceeds the starting frequency, and it goes OFF when it is less than the stop frequency. It is also OFF when the DC braking is in operation.
If this signal is assigned in negative logic (Active OFF), it can be used as a signal indicating "inverter being stopped."

■ Frequency arrival signal -- (FAR)
(Function code data = 1)
This output signal comes ON when the difference between the output frequency and reference frequency comes within the allowable error zone. (prefixed to 2.5 Hz ).

- Frequency detected -- (FDT)
(Function code data = 2)
This output signal comes ON when the output frequency exceeds the frequency detection level specified by function code E31, and it goes OFF when the output frequency drops below the "Detection level (E31) - Hysteresis width (E32)."

■ Undervoltage detected -- (LU)
(Function code data = 3)
This output signal comes ON when the DC link bus voltage of the inverter drops below the specified undervoltage level, and it goes OFF when the voltage exceeds the level.
This signal is ON also when the undervoltage protective function is activated so that the motor is in an abnormal stop state (e.g., tripped).
When this signal is ON , a run command is disabled if given.
■ Inverter output limiting -- (IOL)
(Function code data $=5$ )
This output signal comes ON when the inverter is limiting the output frequency by activating any of the following actions (minimum width of the output signal: 100 ms ).

- Current limiting by software (F43 and F44: Current limiter (Mode selection) and (Level))
- Instantaneous overcurrent limiting by hardware (H12 = 1)
- Automatic deceleration ( $\mathrm{H} 69=3$ ))

Note When the (IOL) signal is ON, it may mean that the output frequency may have deviated from (or dropped below) the frequency specified by the frequency command because of this limiting function.

■ Auto-restarting after momentary power failure -- (IPF)
(Function code data $=6$ )
This output signal is ON either during continuous running after a momentary power failure or during the period from when the inverter has detected an undervoltage condition and shut down the output until restart has been completed (the output has reached the reference frequency).
To enable this (IPF) signal, set F14 (Restart mode after momentary power failure) to "3: Enable restart (Continue to run)," "4: Enable restart (Restart at the frequency at which the power failure occurred)," or "5: Enable restart (Restart at the starting frequency)" beforehand.

- Inverter output on -- (RUN2)
(Function code data $=35$ )
This output signal comes ON when the inverter is running at the starting frequency or below or the DC braking is in operation.

■ Overload prevention control -- (OLP)
(Function code data = 36)
This output signal comes ON when the overload prevention control is activated. The minimum ON -duration is 100 ms .
[1] For details of the overload prevention control, refer to the descriptions of function code H 70 .

- Current detected -- (ID)
(Function code data = 37)
This output signal comes ON when the output current of the inverter exceeds the level specified by E34 (Current detection (Level)) for the time longer than the one specified by E35 (Current detection (Timer)). The minimum ON-duration is 100 ms .
This signal goes OFF when the output current drops below $90 \%$ of the rated operation level.
Note Function code E34 is effective for not only the motor overload early warning (OL), but also for the operation level of the current detection (ID).
[1] For details of the current detection, refer to the descriptions of function codes E34 and E35.

■ Low output torque detected -- (U-TL)
(Function code data $=45$ )
This output signal comes ON when the torque value calculated by the inverter decreases below the level specified by E80 (Detect low torque (Detection level)) for the time longer than the one specified by E81 (Detect low torque (Timer)). The minimum ON-duration is 100 ms .
[1] For details of the low output torque detection, refer to the description of function codes E80 and E81.

- Inverter in remote operation -- (RMT)
(Function code data = 54)
This output signal comes ON when the inverter switches from local to remote mode.
[1] For details about the remote and local modes, refer to Chapter 3, Section 3.3.3 "Switching between remote and local modes."

■ Terminal [C1] wire break -- (C1OFF)
(Function code data = 59)
This output signal comes ON when the inverter detects that the input current (after filtered with C38) on analog input terminal [C1] drops below 2 mA , interpreting it as a terminal [C1] wire broken.

- Alarm output (for any alarm) -- (ALM)
(Function code data = 99)
This output signal comes ON if any of the protective functions is activated and the inverter enters Alarm mode.

E31, E32 Frequency Detection (Detection level and Hysteresis width)
If the output frequency exceeds the frequency detection level specified by E31, the FDT signal comes ON; if it drops below the "Frequency detection level (E31) minus hysteresis width (E32)," it goes OFF.
It is necessary to assign the signal (FDT) to one of the output terminals Y 1 to $\mathrm{Y} 3, \mathrm{Y} 5 \mathrm{~A} / \mathrm{C}$, and $30 \mathrm{~A} / \mathrm{B} / \mathrm{C}$ using any of E20 to E22, E24, and E27 (data = 2).

- Data setting range: 0.0 to $120.0(\mathrm{~Hz})$


H69 specifies whether automatic deceleration control is to be enabled or disabled. During deceleration of the motor, if regenerative energy exceeds the level that can be handled by the inverter, overvoltage trip may happen. With automatic deceleration enabled, when the DC link bus voltage exceeds the level (internally fixed) for starting automatic deceleration, the output frequency is controlled to prevent the DC link bus voltage from rising further; thus regenerative energy is suppressed.

Note
If automatic deceleration is enabled, deceleration may take a longer time. This is designed to limit the torque during deceleration, and is therefore of no use where there is a braking load.

Disable the automatic deceleration when a braking unit is connected. The automatic deceleration control may be activated at the same time when a braking unit starts operation, which may make the acceleration time fluctuate. In case the set deceleration time is so short, the DC link bus voltage of the inverter rises quickly, and consequently, the automatic deceleration may not follow the voltage rise. In such a case, prolong the deceleration time.

Even if the time period of 3 times of the deceleration time 1 (F08) has elapsed after the inverter entered automatic deceleration, there may be a case that the motor does not stop or the frequency dose not decrease. In this case, cancel the automatic deceleration forcibly for safety and decelerate the motor according to the set deceleration time. Prolong the deceleration time also.
H70 Overload Prevention Control

H70 specifies the rate of decreasing the output frequency to prevent an overload condition. Under this control, an overload trip is prevented by decreasing the output frequency of the inverter before the inverter trips because of the overheating of the cooling fan or the overloading of the inverter (with an alarm indication of $\mathcal{I N H}^{\prime \prime} I^{\prime}$ 'or $L^{\prime \prime \prime} L^{\prime \prime} L^{\prime}$ ). This control is useful for facilities such as pumps where a decrease in the output frequency leads to a decrease in the load and it is necessary to keep the motor running even when the output frequency goes low.

| Data for H 70 | Function |
| :---: | :--- |
| 0.00 | Decelerate the motor by deceleration time 1 specified by F08 |
| 0.01 to 100.0 | Decelerate the motor by deceleration rate 0.01 to $100.0(\mathrm{~Hz} / \mathrm{s})$ |
| 999 | Disable overload prevention control |

Note
In applications where a decrease in the output frequency does not lead to a decrease in the load, this function is of no use and should not be enabled.

Using the analog input terminal［C1］（current input）for feedback signals under PID control（E62＝ 5）enables wire break detection and alarm $\left(L^{-}-1 I^{-}\right)$issuance．H91 specifies whether to enable the wire break detection or the duration of less than 2 mA on the terminal［C1］＊．
If the inverter detects that the input current on［C1］is less than 2 mA （after filtered with C38）for the duration specified by H91，it interprets the state as a terminal［C1］wire break and issues an alarm（にば）
－Data setting range： 0.0 （Disable alarm detection）
0.1 to 60.0 s （If the current level is less than 2 mA for this duration， detect wire break and issue
＊It is also possible to assign the signal（C1OFF）to one of the output terminals Y 1 to $\mathrm{Y} 3, \mathrm{Y} 5 \mathrm{~A} / \mathrm{C}$ ， and $30 \mathrm{~A} / \mathrm{B} / \mathrm{C}$ using any of E20 to E22，E24，and E27（data＝59）．The C1OFF goes ON if the input current level（after filtered with C38）on［C1］drops below 2 mA ，and it goes OFF if the current level rises to 2 mA or above．

You can view the cumulative run time of the motor on the keypad．This feature is useful for management and maintenance of the mechanical system．With this function code（H94），you can set the cumulative run time of the motor to any value you choose．For example，by specifying＂ 0, ，＂ you can clear the cumulative run time of the motor．

Note
The data for H 94 is in hexadecimal notation．Check the cumulative run time of the motor on the keypad．

## Chapter 7 MAINTENANCE AND INSPECTION

### 7.3 List of Periodical Replacement Parts

Each part of the product has its own service life that will vary according to the environmental and operating conditions. It is recommended that the following parts be replaced as specified below.
When the replacement is necessary, contact your Fuji Electric representative.
Table 7.2 Replacement Parts

| Part name | Standard replacement intervals |  |
| :---: | :---: | :---: |
|  | Old specifications | New specifications |
| DC link bus capacitor | 7 years | 10 years |
| Electrolytic capacitors on printed circuit boards | 7 years | 10 years |
| Cooling fan | 7 years $(5.5 \mathrm{~kW}$ or below) <br> 4.5 years $(7.5 \mathrm{to} 30 \mathrm{~kW})$ <br> 3 years $(37 \mathrm{~kW}$ or above $)$ | 10 years $(5.5 \mathrm{~kW}$ or below) <br> 10 years $(7.5 \mathrm{to} 30 \mathrm{~kW})$ <br> 7 years $(37 \mathrm{~kW}$ or above) |
| Fuse | 10 years ( 90 kW or above) | 10 years ( 90 kW or above) |

(Note) These replacement intervals are based on the estimated service life of the inverter at an ambient temperature of $40^{\circ} \mathrm{C}$ under $80 \%$ of full load. In environments with an ambient temperature above $40^{\circ} \mathrm{C}$ or a large amount of dust or dirt, the replacement intervals may need to be reduced.

### 7.3.1 Judgment on service life

## (1) Viewing data necessary for judging service life; Measurement procedures

Through Menu \#5 "Maintenance Information" in Programming mode, you can view on the keypad various data (as a guideline) necessary for judging whether key components such as the DC link bus capacitor, the electrolytic capacitors on the printed circuit boards, and the cooling fan are approaching their service life.
(T) - 1 Measuring the capacitance of the DC link bus capacitor (in comparison with that at factory shipment) Measure the capacitance of the DC link bus capacitor according to the procedure given below. The result will be displayed on the keypad as a ratio (\%) to the initial capacitance at the time of factory shipment.

## Procedure for measuring capacitance

$\qquad$

1) To ensure validity in the comparative measurement, put the condition of the inverter back to the state at factory shipment.

- Remove the option card (if already in use) from the inverter.
- In case another inverter is connected via the DC link bus to the $P(+)$ and $N(-)$ terminals of the main circuit, disconnect the wires. (You do not need to disconnect a DC reactor (optional), if any.)
- Disconnect power wires for the auxiliary input to the control circuit (R0, T0).
- In case the standard keypad has been replaced with a multi-function keypad after the purchase, put back the original standard keypad.
- Turn OFF all the digital input signals fed to terminals [FWD], [REV], and [X1] through [X5] of the control circuit.
- If a potentiometer is connected to terminal [13], disconnect it.
- If an external apparatus is attached to terminal [PLC], disconnect it.
- Ensure that transistor output signals ([Y1] - [Y3]) and relay output signals ([Y5A/C] and [30A/B/C]) will not be turned ON.

Notel If negative logic is specified for the transistor output and relay output signals, they are considered ON when the inverter is not running. Specify positive logic for them.

- Keep the ambient temperature within $25 \pm 10^{\circ} \mathrm{C}$.

2) Switch ON the main circuit power.
3) Confirm that the cooling fan is rotating and the inverter is in stopped state.
4) Switch OFF the main circuit power.
5) Start the measurement of the capacitance of the DC link bus capacitor. Make sure that " . . . " appears on the LED monitor.

> Note If " . . . " does not appear on the LED monitor, the measurement will not start. Check the conditions listed in 1 ).
6) Once " . . . " " has disappeared from the LED monitor, switch ON the main circuit power again.
7) Select Menu \#5 "Maintenance Information" in Programming mode and note the reading (relative capacitance (\%) of the DC link bus capacitor).
(2) Early warning of lifetime alarm

For the components listed in Table 7.3, you can get an early warning of lifetime alarm at one of the transistor output terminals ([Y1] to [Y3]) and the relay contact terminals ([Y5A] - [Y5C], and [30A/B/C]) as soon as any of the conditions listed under the "Judgment level" column has been exceeded.
Note that the judgment level differs depending upon the inverter's ROM version.
The early warning signal is also turned ON when a lock condition on the internal air circulation DC fan (on 200V series inverters with a capacity of 45 kW or above; on 400 V series inverters with a capacity of 55 kW or above) has been detected.

Table 7.3 Criteria for Issuing a Lifetime Alarm

| Inverter's ROM version | 1399 or earlier | 1400 or later | Remarks |
| :--- | :--- | :--- | :--- |
| Parts to be replaced | Judgment level |  |  |
| DC link bus capacitor | $85 \%$ or lower of the capacitance than that of the factory setting |  |  |
| Electrolytic capacitors <br> on printed circuit boards | 61000 hours or longer as <br> accumulated run time | 87000 hours or longer as <br> accumulated run time | 5.5 kW or below |
| Cooling fan | Accumulated run time $\geq 61000$ <br> hours | Accumulated run time $\geq 87000$ <br> hours | 7.5 to 30 kW |
|  | Accumulated run time $\geq 40000$ <br> hours | Accumulated run time $\geq 87000$ <br> hours | Accumulated run time $\geq 61000$ <br> hours |
|  | Accumulated run time $\geq 25000$ <br> hours | or above <br>  <br> (Estimated service life at the inverter's ambient temperature of $40^{\circ} \mathrm{C}$ under $80 \%$ of full <br> load) |  |

## Tip

The inverter's ROM version can be checked on Menu \#5 "Maintenance Information" (5_14).

### 7.4 Measurement of Electrical Amounts in Main Circuit

Because the voltage and current of the power supply (input, primary circuit) of the main circuit of the inverter and those of the motor (output, secondary circuit) include harmonic components, the readings may vary with the type of the meter. Use meters indicated in Table 7.4 when measuring with meters for commercial frequencies.
The power factor cannot be measured by a commercially available power-factor meter that measures the phase difference between the voltage and current. To obtain the power factor, measure the power, voltage and current on each of the input and output sides and calculate in the following formula.

- Three-phase input

Power factor $=\frac{\text { Electric power }(\mathrm{W})}{\sqrt{3} \times \text { Voltage }(\mathrm{V}) \times \text { Current }(\mathrm{A})} \times 100 \%$
Table 7.4 Meters for Measurement of Main Circuit

| $\stackrel{\text { E }}{ \pm}$ | Input (primary) side |  |  | Output (secondary) side |  |  | DC link bus voltage ( $\mathrm{P}(+)-\mathrm{N}(-))$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |
|  | Ammeter Ar, As, At | Voltmeter <br> $\mathrm{V}_{\mathrm{R}, \mathrm{Vs}, \mathrm{V}}$ | Wattmeter Wr, WT | Ammeter $A u, A v, A w$ | Voltmeter <br> Vu, Vv, Vw | Wattmeter Wu, Ww | $\underset{V}{\text { DC voltmeter }}$ |
|  | Moving iron type | Rectifier or moving iron type | Digital AC power meter | Digital AC power meter | Digital AC power meter | Digital AC power meter | Moving coil type |
|  | $\underset{K}{K}$ | H $\frac{8}{*}$ | - | - | - | - | (n) |

Noter
It is not recommended that meters other than a digital AC power meter be used for measuring the output voltage or output current since they may cause larger measurement errors or, in the worst case, they may be damaged.

## Chapter 8 SPECIFICATIONS

### 8.1 Standard Models

### 8.1.1 Three-phase 200 V series


*1 Fuji 4-pole standard motor

* Reted capacity is calculated by assuming the output rated woltage as 220 V for three-phase 200 V series.
*3 Output voltage cannot exceed the power supply voltage
* An excessively low setting of the carrier frequency may result in the higher motor temperature ar tripping of the inverter by its overcurrent limiter setting. Lower the continuous load or maximum load instead. (When setting the carrier frequency (F26) to 1 kHz , reduce the load to $80 \%$ of its rating.)
45 When an inverter is continuously rumning with the carrier frequency of 3 kHz or more in the ambient temperature of $40^{\circ} \mathrm{C}$ or higher, manage its load current to be within the rated anes denoted in parentheses if.
46 Use $[\mathrm{R} 1, \mathrm{~T} 1]$ terminals tor driving $A C$ cooling fans of an inverter powered by the DC link bus, such as by a high power factor PWiM converter (In ordinary operation, the terminals are not used.)
* Calculated under Fuji-specified conditions.
* Obtained when a OC reactor (DCR) is used
* Average braking torque (varies with the efficiency of the motor.)
*it Voltage unbalance (\%) $=\frac{\text { Max. voltage (V) }- \text { Min. voltage }(\mathrm{V})}{\text { Three-phase average voltage }(\mathrm{V})} \times 67$ (IEC61800-3 (5.2.3))
If this value is 2 lo $3 \%$, wse an $A C$ teaclor (ACR),

Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.

### 8.1.2 Three-phase 400 V series

$\square 0.75$ to 55 kW


* 1 -

2 Rated capacity is calculated by assuming the oufpu; rated voltage as 440 V for three-phase 40 V series.

* Qutput volisge cannot exteded the power stuply veltage.
*4 An excessively low sewing of the carrier frequency may result in the higher motor temperature ar tripping of the inverter by its overcurrent
 $80 \%$ of its rating.)
" 5 Jse [R1, T1" terminals for driving AC cooling fans of an inverter powered by the $D C$ link bus, such as by a high power factor PWM converser. (In ordinary operation, the terminals are not used.)
'f Calculated under Fuji-specified conditions.
-7 Obtained when a DC reactor (DCR) is used.
* Average braking torque (varies with the eficientry of the motor,
*G The nominal applied motor of =RN4.0F1S-4E to be shipped for EU is 4.0 kW .
*10 Single-phase, 380 s $0440 \mathrm{Wi50} \mathrm{~Hz}$ or Single-phase, 380 to 480 V 6 PHz

If this value is 2 to $3 \%$, use an $A C$ reactor ( $A C R$ ).
Note: A box ( $\square$ ) in the above table replaces $\mathrm{A}, \mathrm{K}$, or E depending on the shipping destination.

End of Avon St Leichhardt SPS - i.Power Solutions - Ipswich Ref J7985-01 - SP22 O'Keefe St SPS - Ol

- 75 to 560 kW

| Tiem |  |  |  |  | Speoflovitins |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type (FRM_. F13-4]) |  |  |  |  | 75 | 90 | 110 | 132 | 160 | 200 | 220 | 200 | 315. | 305 | 400 | 450 | 500 | 500 |
| Nismical locied nolor (kW) --1 |  |  |  |  | 75 | 90 | 170 | 132 | 160 | 200 | 220 | 260 | 315 | 355 | 400 | 450. | 500 | 580 |
|  | Ratnd capacity (QVO) - - |  |  |  | 105 | 128 | 154 | 162 | 221 | 274 | 316: | 396 | 445 | 405 | 563 | 1840 | 731 | 792 |
|  | Raled voiesge (V) |  |  |  | Tree-ghase. $350.400 \mathrm{VIS0} \mathrm{~Hz} 300.400 .440 .400$ vie0 le iwith AvP function) |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated current (A) |  |  |  | 139 | 188 | 203 | 240 | 290 | \$80 | 415. | 520 | 585 | 650 | 740 | 846 | 565 | 1040 |
|  | Ovpiroud capibity |  |  |  | 120s\% of chled curvent for 1 mus |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated feequincy |  |  |  | 50.6016 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| $\frac{\frac{8}{3}}{\frac{8}{3}}$ | Prasers. voltage, bigquency | Man | pas |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | Apciliny coetres power irgut |  |  | Singre-bhase. 360 N0 400 V. 60.60 He |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | Auxdiary fan power rout |  |  | Singe-phase. 360 No $440 \mathrm{~V} / 50 \mathrm{NE}$ Singer-phase. 380 no 430 Vivo 14 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Veltageftrequency wariatens |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Rated carrent (A) |  |  |  | 738 | 194 | 201 | 230 | 205 | 357 | 390 | 500 | 5 Se | $62 \%$ | 705 | 76e | 501 | 1900 |
|  |  | - |  |  | - | - | - | - | - | - | - | - | - | - | $\square$ | - | - | - |
|  | Redured power supply insecity $(\mathrm{aVH}$ ) |  |  | * | 56 | 114 | 140 | 165 | 198 | 248 | 271 | 367 | 338 | 435 | 488 | 547 | 811 | 598 |
| $\frac{8}{3}$ | Tongae (1) |  |  |  | ( 10 to |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | DC braking |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DC rewestor (DCRa |  |  |  |  | Stansard |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Applicable salety standieds |  |  |  |  | ULS0BC, C72 2 Na 14, ENSO178-1297 (Applying) |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclovure (EC60529) |  |  |  |  | IP00. UL epen type |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cooling method |  |  |  |  | Fant coning |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mass (ka) |  |  |  |  | 34 | 42 | 45 | 63 | 67 | 96 | 50 | 162 | 165 | 240 | 240 | 365 | 360 | 360 |

${ }^{4}$ Fugi 4 -polh standand molor
"2 Reved cepacity as caindated by assuming the auput natigd voltppe as 440 V for throe-phase 400 V serves
0 Outpia voitage cannot exceed the pewer supply voityge

 soll of its naing.
 In aedieary specation men tormanals are not innd)

- Calolinted under Fu-spopifeg conskiont.
\&) Obtaned when a DC. reyckor (DCA) as used
"I Averagy brating tomper (Varies with the alfoiency of the motec)



Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.

|  | Item | Explanation | Remarks |
| :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { 듬 } \\ & \text { 苞 } \\ & \text { 를 } \end{aligned}$ | Trip error code | Displays the cause of trip by codes. <br> - B1- ; (Overcurrent during acceleration) <br> RIC (Overcurent during deceleration) <br> - IL a a overcumen: durirg running at constert speed; <br> EF (Grounding fault) <br> - 1 in [Input phase loss) <br> - LU (Undervoltage) <br> - Di, [Output phase lass) <br> - LT: (Overvoltage duting atcelemation) <br> - Dide (Overvatage during cleceleration) <br> - R15 3 'Overvoltage duing nun nat at constant soeed) <br> - BN ; (Oveneating of the heat sink) <br> - RHC (External alarm) <br> - 17 J (lnverter overheat) <br> - 744 (Mator protection (PTC thermistor)) <br> - Bi, ( Motor overload) <br> - El U (Invertar overload) <br> - FIS (Blown fuse) <br> * Gr, (Charging circuit fault) <br> - Es I (Memory error) <br> - Er (keypad communication error) <br> - E. $\bar{I}$ (CPU mor) <br> - Er- 4 (Optióng comimunication ermor) <br> - Er 5 (Option emor) <br> - Er Er (Operation action error) <br> , Er 7 (Tuning emar) <br> - Er - (RS485 communication error) <br>  <br> - Er H' (LSl eror) |  |
|  | Trip history | Saves annd displays the less' 4 triph ermr contes and their thelailed destription. |  |
|  | Refer to Section 8.6 "Protective Functions." |  |  |
|  | Refer to Chapter | ח 1.4 "Storage Envimonment" and Chapter 2. Section 2.1 "Operating Environment." |  |

### 8.4 Terminal Specifications

### 8.4.1 Terminal functions

For details about the main and control circuit terminals, refer to Chapter 2, Section 2.3.5 and Section 2.3.6 (Table 2.7), respectively.

### 8.4.2 Running the inverter with keypad


(Note 1) When connecting a DC reactor (DCR), first remove the short bar between terminals [ P 1 ] and $[\mathrm{P}+]$. A DCR is optional for inverters below 75 kW but standard for inverters of 75 kW or above. For inverters of 75 kW or above, be sure to connect a DCR.
(Note 2) To protect wiring, insert a molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) (with overcurrent protection) of the type recommended for the inverter between the commercial power supply and the inverter. Do not use a circuit breaker with a capacity exceeding the recommended capacity.
(Note 3) In addition to an MCCB or ELCB, insert, if necessary, a magnetic contactor (MC) of the type recommended for the inverter to cut off the commercial power supply to the inverter. Furthermore, if the coil of the MC or solenoid comes into close contact with the inverter, install a surge absorber in parallel.
(Note 4) To put the inverter on standby by making the control circuit only active with the main circuit power supply being opened, connect this pair of wires to terminals [R0] and [TO]. Without connecting this pair of wires to these terminals, you can still run the inverter as long as the main wires of the commercial power supply to the main circuit are properly connected.
(Note 5) Normally no need to be connected. Use these terminals when the inverter is equipped with a high power factor PWM converter with a regenerative facility.
(Note 6) The inverter has either [FMP] or [FMI] depending on the type of the control printed circuit board (control PCB).

End of Avon St Leichhardt SPS－i．Power Solutions－Ipswich Ref J7985－01－SP22 O＇Keefe St SPS－Ol

## 8．5 External Dimensions

## 8．5．1 Standard models



| Power supply voltage | Inverter type | Dimensions（mm） |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | W | W1 | W2 | H | H1 | H2 | D | D1 | D2 | D3 | ФА |
| Three－phase 200 V | FRN90F1S－2口 | 530 | 430 | 15 | 750 | 720 | 15.5 | 380 | 240 | 140 | 4 | 2×15 |
|  | FRN110F1S－2口 | 680 | 290 |  | 880 | 850 | 15.5 | 395 | 255 | 140 | 4 | 3x15 |
| Three－phase 400 V | FRN280F1S－4口 | 680 | 290 |  |  |  | 15.5 |  |  |  | 6.4 | $3 \times 15$ |
|  | FRN315F1S－4D |  |  |  | 1000 | 970 |  | 380 | 200 | 180 |  |  |
|  | FRN355F1S－4］ |  |  |  | 1400 | 1370 |  | 440 | 260 | 180 |  |  |
|  | FRN400F1S－4口 |  |  |  |  |  |  |  |  |  |  |  |
|  | FRN450F1S－4］ | 880 | 260 |  |  |  |  |  |  |  |  |  |
|  | FRN500F1S－4］ |  |  |  |  |  |  |  |  |  |  | $4 \times 15$ |
|  | FRN560F1S－4］ |  |  |  |  |  |  |  |  |  |  |  |

Note：A box（ $\square$ ）in the above table replaces A，K，or E depending on the shipping destination．

End of Avon St Leichhardt SPS－i．Power Solutions－Ipswich Ref J7985－01－SP22 O＇Keefe St SPS－Ol

## 8．5．2 DC reactor

Figure $A$


Figure B


Figure C


| Power supply voltage | Inverter type | Reactor | See： | Dimensions（mm） |  |  |  |  |  |  |  |  | $\begin{aligned} & \text { Mass } \\ & (\mathrm{kg}) \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | W | W1 | D | D1 | D2 | D3 | H | Mounting through－ hole for： | Termina through hole for |  |
| Three－ phase 200 V | FRN90F1S－2口 | DCR2－90C | Fig．A | $255 \pm 10$ | 225 | $116 \pm 2$ | 96 | 155 | $58 \pm 1$ | 145 | M6 | M12 | 14 |
|  | FRN110F1S－2口 | DCR2－110C |  | $300 \pm 10$ | 265 | $116 \pm 4$ | 90 | 185 | $58 \pm 1$ | 160 | M8 | M12 | 17 |
| Three－ phase 400 V | FRN280F1S－4D | DCR4－280C | Fig．B | $350 \pm 10$ | 310 | $161 \pm 4$ | 133 | 210 | $80.5 \pm 2$ | 190 | M10 | M16 | 36 |
|  | FRN315F1S－4D | DCR4－315C |  | $400 \pm 10$ | 345 | $146 \pm 4$ | 118 | 200 | $73 \pm 1$ | 225 |  |  | 40 |
|  | FRN355F1S－4口 | DCR4－355C |  |  |  | $156 \pm 4$ | 128 |  | $78 \pm 1$ |  |  | Ф15 | 47 |
|  | FRN400F1S－4D | DCR4－400C |  | $455 \pm 10$ | 385 | $145 \pm 4$ | 117 | 213 | $72.5 \pm 1$ | 245 |  |  | 52 |
|  | FRN450F1S－4D | DCR4－450C |  | $440 \pm 10$ | 385 | $150 \pm 4$ | 122 | 215 | $75 \pm 2$ | 5 |  |  | 60 |
|  | FRN500F1S－4］ | DCR4－500C |  | $445 \pm 10$ | 390 | $165 \pm 4$ | 137 | 220 | $82.5 \pm 2$ | 245 |  |  | 70 |
|  | FRN560F1S－4D | DCR4－560C | Fig．C | $270 \pm 10$ | 145 | $208 \pm 4$ | 170 | 200 | $104 \pm 2$ | 480 | M12 |  |  |

Note 1：For inverters with a capacity of 75 kW or above，a DC reactor（DCR）is provided as standard．
Note 2：$A$ box（ $\square$ ）in the above table replaces $A, K$ ，or $E$ depending on the shipping destination．

Chapter 10 CONFORMITY WITH STANDARDS

### 10.1 Conformity with UL Standards and Canadian Standards (cUL-listed for Canada)

### 10.1.1 General

The UL standards, originally established by Underwriters Laboratories, Inc. of U.S., are now a set of standards authorized in the U.S. for preventing fire and accidents, thereby protecting operators, service personnel, and ordinary citizens.
"cUL-listed for Canada" means that the products have been evaluated to the CSA Standards by UL. Therefore, cUL-listed products are equivalent to those in conformity with CSA Standards.
10.1.2 Considerations when using FRENIC-Eco as a product certified by UL or cUL

If you want to use the FRENIC-Eco series of inverters as a part of UL Standards or CSA Standards (cUL-listed for Canada) certified product, refer to the related guidelines described on pages viii, ix, and ix-1.

### 10.2 Conformity with EU Directives

The CE Marking on Fuji products indicates that they comply with the essential requirements of the Electromagnetic Compatibility (EMC) Directive 89/336/EEC issued by the Council of the European Communities and the Low Voltage Directive 73/23/EEC.
Inverters bearing a CE Marking are in conformity with EMC Directives if an optional EMC-compliant filter is mounted to them.
Inverters that bear a CE Marking are compliant with the Low Voltage Directive.
$\square$ The FRENIC-Eco series of inverters is in conformity with the following standards:
Low Voltage Directive EN50178: 1997
EMC Directive $\quad$ EN61800-3: $1996+$ A11: 2000
EN55011: $1998+\mathrm{A} 1: 1999$

## CAUTION

The FRENIC-Eco series of inverters is categorized as a "restricted sales distribution class" according to the EN61800-3. When you use these products in a domestic environment, you may need to take appropriate countermeasures to reduce or eliminate any noise emitted from these products.

### 10.3 Conformity with Low Voltage Directive

### 10.3.1 General

General-purpose inverters are subject to the regulations set forth by the Low Voltage Directive in the EU. Fuji Electric declares the inverters bearing a CE marking are compliant with the Low Voltage Directive.
10.3.2 Considerations when using FRENIC-Eco as a product in conformity with Low Voltage Directive If you wish to use the FRENIC-Eco series of inverters as a product in conformity with the Low Voltage Directive, refer to the related guidelines described on pages vi/vii.
10.4 Conformity with the EMC Directive in the EU

### 10.4.1 General

The CE Marking on inverters does not ensure that the entire equipment including CE-marked products is compliant with the EMC Directive. Therefore, it is the responsibility of the equipment manufacturer to ensure that the equipment including the product (inverter) or connected with it actually complies with the standard and to put a CE Marking as the equipment.
In general, the user's equipment comprises a variety of products supplied from a number of manufacturers in addition to Fuji inverters. Therefore, the manufacturer of the final equipment needs to take responsibility for conformity.
In addition, to satisfy the requirements noted above, it is necessary to use a Fuji inverter in connection with an EMC-compliant filter (option) and install it in accordance with the instructions contained in this instruction manual. Install the Fuji inverter in a metal enclosure.

### 10.4.2 EMC-compliant filter (Option)

There are two installation styles of an optional EMC-compliant filter--Footmount and split styles. As listed below, the split style applies to 3 -phase, 400 V inverters with a capacity of 30 to 560 kW .
For how to install the EMC-compliant filter, see Section 10.4.3 "Recommended installation of EMC-compliant filter."

Note The use of an EMC-compliant filter increases leakage current as shown below.
Table 10.1 EMC-compliant Filters and Leakage Current

| Power supply voltage | Inverter type | EMC-compliant filter model | Leakage current (mA) *1*2 |  | Installation style |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Normal condition | Worst condition |  |
| 3-phase 400 V | FRN280F1S-4■ | FN3359-600-99 | 36.0 | 210.0 | Split style |
|  | FRN315F1S-4■ |  |  |  |  |
|  | FRN355F1S-4口 | FN3359-800-99 |  |  |  |
|  | FRN400F1S-4■ |  |  |  |  |
|  | FRN450F1S-4■ |  |  |  |  |
|  | FRN500F1S-4口 | FN3359-1000-99 | 37.0 | 216.0 |  |
|  | FRN560F1S-4] | FN3359-1000-99 | 37.0 | 216.0 |  |

Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.
$* 1$ The values are calculated assuming the power supply frequency of 50 Hz for 3 -phase 400 V .
*2 The worst condition includes a phase loss in the supply line.

The EMC-compliant filter and the inverter should be connected with each other according to the procedure given below. The wiring on the inverter and motor should be performed by an authorized electrical engineer. In order to ensure compliance with the EMC Directive, this procedure should be followed as closely as possible.

## $\square$ Basic connection procedure

1) Install the inverter and the EMC-compliant filter on a grounded metal plate. Use a shielded cable also for connection to the motor and make it as short as possible. Connect the shield layer of the cable firmly to the metal plate. Also, at the motor side, connect the shield layer electrically to the grounding terminal of the motor.
2) Use a shielded cable for connection of control circuit lines of the inverter and also for connection of the signal cable of an RS485 communications card. As with the motor, clamp the shield layer of the cable firmly to a grounded plate.
3) If noise radiated from the inverter exceeds the level prescribed in the EMC Directive, enclose the inverter and its peripherals (EMC-compliant filter) inside a metal enclosure as shown in Figure 10.3.


Figure 10.3 Installation of EMC-Compliant Filter (Option)

### 10.4.4 EMC-compliant environment and class

The table below lists the capacity and power supply voltage of the FRENIC-Eco and the EMC-compliant environment.

| Power <br> supply <br> voltage | Standards | Inverter capacity |
| :---: | :---: | :---: |
|  |  | Emission |

(Note 1) The FRN90F1S-2 $\square$ and FRN110F1S-2 $\square$ are not EMC-compliant.

| Power supply voltage | Standards | Inverter capacity |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 0.75 to 90 kW | 110 to 220 kW | 280 to 560 kW |
| 3-phase$400 \mathrm{~V}$ | Immunity | EN61800-3 Second environment (Industrial environment) |  |  |
|  | Emission | EN55011 <br> Group 1 Class A | EN61800-3 <br> Category C3 (Note 2) | EN61800-3 <br> Category C3 |

(Note 2) Wiring change for compliance
Changing the internal wiring makes EMC-compliant level (emission) be in conformity with EN55011 Group 1 Class A. Refer to the wiring procedures given in the Instruction Manual (INR-SI47-1059-E).

Designed For Fan and Pump Applications
FRENIC-ECO

## Instruction Manual <br> Supplement for High-Capacity Inverters

First Edition, June 2006
Third Edition, July 2009
Fuji Electric Systems Co., Ltd.

The purpose of this instruction manual is to provide accurate information in handling, setting up and operating of the FRENIC-Eco series of inverters. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

In no event will Fuji Electric Systems Co., Ltd be liable for any direct or indirect damages resulting from the application of the information in this manual.

## Fuji Electric Systems Co., Ltd.

## Altivar ${ }^{\circledR} 61$ / 71

User Manual 30072-452-35
Retain for future use

EtherNet/IP Card
VW3A3316


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## 1. Important Information

## NOTICE

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instruction are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

## DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, will result in death, serious injury, or equipment damage.

## A WARNING

Warning indicates a potentially hazardous situation, which, if not avoided, can result in death, serious injury, or equipment damage.

## A CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, can result in injury or equipment damage.

## TERMINOLOGY NOTE:

As used in this manual, the terms fault and error are defined as follows:
Fault: An abnormal condition that may cause a functional unit to loose its capability to perform a required function.
Error: A discrepancy between a computed, observed, or measured value or condition and the true, specified, or theoretically correct value or condition.

## PLEASE NOTE:

Electrical equipment should be serviced only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained persons. © 2007 Schneider Electric. All Rights Reserved.

## 2. Before you begin

Read and understand these instructions before performing any procedure with this drive controller.

## DANGER

## HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Read and understand this manual before installing or operating the Altivar 61 (ATV61) or Altivar 71 (ATV71) drive controller. Installation, adjustment, repair, and maintenance must be performed by qualified personnel.
- The user is responsible for compliance with all international and national electrical code requirements with respect to grounding of all equipment.
- Many parts of this drive controller, including the printed circuit boards, operate at the line voltage. DO NOT TOUCH. Use only electrically insulated tools.
- DO NOT touch unshielded components or terminal strip screw connections with voltage present.
- DO NOT short across terminals PA/+ and PC/- or across the DC bus capacitors.
- Before servicing the drive controller
- Disconnect all power, including external control power that may be present.
- Place a "DO NOT TURN ON" label on all power disconnects.
- Lock all power disconnects in the open position.
- WAIT 15 MINUTES to allow the DC bus capacitors to discharge. Then follow the DC bus voltage measurement procedure given in the Installation Manual to verify that the DC voltage is less than 45 V . The drive LED is not an indicator of the absence of DC bus voltage.
- Install and close all covers before applying power or starting and stopping the drive controller

Failure to follow these instructions will result in death or serious injury.

## A WARNING <br> DAMAGED DRIVE CONTROLLER OR DRIVE ACCESSORY—UNINTENDED EQUIPMENT OPERATION

Do not install or operate any drive controller or drive accessory that appears damaged.The relays, inputs, or outputs of a damaged drive controller may not operate in a normal manner, leading to unintended equipment operation.

Failure to follow this instruction can result in death, serious injury, or equipment damage.

## A WARNING

## LOSS OF CONTROL

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical control functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop and overtravel stop.
- Separate or redundant control paths must be provided for critical control functions.
- System control paths may include communication links. Consideration must be given to the implications of unanticipated transmission delays or failures of the link.*
- Each implementation of an Altivar 71 Modbus TCP/IP EtherNet/IP card must be individually and thoroughly tested for proper operation before being placed into service.

Failure to follow this instruction can result in death, serious injury, or equipment damage.

* For additional information, refer to NEMA ICS 1.1 (latest edition), "Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control" and to NEMA ICS 7.1 (latest edition), "Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems."


## 3. Documentation

The following Altivar 61 and Altivar 71 technical documents are available on the Web site www.us.Telemecanique.com and on the CD ROM delivered with each drive controller.

## - Installation Manual

This manual describes:

- How to assemble the drive controller
- How to connect the drive controller


## - Programming Manual

This manual describes:

- The drive controller functions
- The drive controller parameters
- How to use the drive display terminal (integrated display terminal and graphic display terminal)


## Installation and Programming Manuals

| Drive <br> Family | Range <br> (hp) | Installation Manual <br> Module No. | Programming Manual <br> Module No. |
| :--- | :--- | :--- | :--- |
| ATV61 | $0.5-100$ | 1760643 <br> (atv61s_installation_manual) | 1760649 <br> (atv61_programming_manual) |
| $75-800$ | 1760655 <br> (atv61e_installation_manual) |  |  |
| ATV71 | $0.5-100$ | 1755843 <br> (atv71s_installation_manual) | 1755855 <br> (atv71_programming_manual) |
|  | 75-700 | 1755849 <br> (atv71e_installation_manual) |  |

## 4. Introduction

## 4. 1. Presentation

The EtherNet/IP card (catalog number VW3A3316) is used to connect an Altivar 71 (ATV71) or an Altivar 61 (ATV61) drive controller to an Ethernet network using EtherNet/IP protocol.

IMPORTANT: This communication option card is supported by Altivar 61 firmware version V1.5 IE 13 and higher, and is only supported by Altivar 71 firmware version V1.6 IE 19 and above. Specific versions of the Altivar 71 firmware are not supported.

The VW3A3316 card is equipped with two shielded RJ45 EtherNet/IP connectors.
Accessories for connecting the drive controller to the EtherNet/IP network must be ordered separately
The data exchanges permit the following drive controller functionality:

- Configuration
- Adjustment
- Control
- Monitoring
- Diagnostics

The standard web server (English only) provides access to the following pages:

- Altivar Viewer
- Data Viewer
- EtherNet/IP
- Security

The graphic display terminal or the integrated display terminal can be used to access numerous functions for communication diagnostics.

## 4. 2. Notation

The following notation is used in this manual:

## Drive terminal displays

The graphic display terminal menus are shown in square brackets.
Example: [1.9 COMMUNICATION].
The integrated 7-segment display terminal menus are shown in round brackets.
Example: ([ प П-).
The parameter names displayed on the graphic display terminal are shown in square brackets.
Example: [Fallback speed].
The parameter codes displayed on the integrated 7-segment display terminal are shown in round brackets. Example: ( $L$ FF).

## Formats

Hexadecimal values are written as follows: 16\#
Binary values are written as follows: 2\#

## 5. Hardware setup

## 5. 1. Receipt

Upon receipt of the card:

- Ensure that the card catalog number marked on the label is the same as that on the packing list and the corresponding purchase order.
- Remove the option card from its packaging and check that it has not been damaged in transit.


## AcAution

## STATIC SENSITIVE COMPONENTS

The EtherNet/IP card can be damaged by static electricity. Observe electrostatic precautions when handling and installing the card.
Failure to follow this instruction can result in equipment damage.
Observe the following precautions for handling static-sensitive components:

- Keep static-producing material such as plastic, upholstery, and carpeting out of the immediate work area.
- Store the EtherNet/IP card in its protective packaging when it is not installed in the drive controller.
- When handling the EtherNet/IP card, wear a conductive wrist strap connected to the card through a minimum of 1 megohm resistance.
- Avoid touching exposed conductors and component leads with skin or clothing.


## 5. 2. Hardware description



## 5. 3. Installing the card in the drive controller

## 6. Connecting to the EtherNet/IP network

## 6. 1. Card RJ45 connector pinout

The EtherNet/IP card is equipped with two shielded RJ45 connectors. The shielding is connected to the drive controller ground. Use a shielded twisted pair (STP) EtherNet/IP cable.


| Pin | Signal |
| :---: | :---: |
| 1 | TD+ |
| 2 | TD- |
| 3 | RD+ |
| 4 |  |
| 5 |  |
| 6 | RD- |
| 7 |  |
| 8 |  |



The transmission speed is detected automatically by the card (10 Mbps or 100 Mbps ).
The card can operate in half duplex or full duplex mode, whether connected to a hub or a switch, and regardless of the transmission speed.

## 6. 2. Example of connection to an EtherNet/IP network



## 7. Using the HMI with the EtherNet/IP card

## 7. 1. Access to EtherNet/IP menu via graphic display terminal

The [EtherNet/IP] submenu is used to configure and display the EtherNet/IP card parameters and can be accessed via the [1.9-COMMUNICATION] menu.

This menu is only accessible in standard, advanced, and expert mode. In the [2 ACCESS LEVEL] ( $L$ A [ - ) menu, set the level to [expert] ( $E$ Pr).


## 7. 2. Access to EtherNet/IP menu via the integrated display terminal

The ( $E$ 上H-) submenu is used to configure and display the EtherNet/IP card parameters. It can be accessed via the ( $[\square \Pi-)$ menu.


## 7．Using the HMI with the EtherNet／IP card

## 7．3．Ethernet／IP configuration with the HMI

The following table shows the parameters available on the Ethernet／IP configuration menu．These parameters can also be set from the web server or with the PowerSuite software．In the table，parameters which are not followed by their parameter code（between parenthesis）are not displayed on the 7 segment display of the drive controller．
［1．9－COMMUNICATION］$\left([\square \sqcap-) \rightarrow\right.$ menu［ETHIP］$\left(E t h_{1}\right)$

| Parameter | Possible value | Terminal display |
| :---: | :---: | :---: |
| ［DEVICE NAME］ <br> The device name is required if the card uses DHCP to obtain its IP Address． | 16 characters | ［ABC．．．］ |
| ［Rate Setting］（ $\operatorname{rd}$ ） <br> Use this parameter to set the transmission speed and the transmission mode of the card． | 0：Autodetect（default） <br> 1： 10 Mbps Full <br> 2： 10 Mbps Half <br> 3： 100 Mbps Full <br> 4： 100 Mbps Half（do not use） |  |
| ［Actual Rate］（ $\mathrm{A} \stackrel{\mathrm{r}}{\mathrm{d}}$ ） <br> This field displays the baud rate and the transmission mode currently used by the communication card．（Display only） | 0 ：Autodetect <br> 1： 10 Mbps Full <br> 2： 10 Mbps Half <br> 3： 100 Mbps Full <br> 4： 100 Mbps Half |  |
| ［IP mode］（IP 1 ） <br> Use this parameter to select the IP address assignment method． | $\begin{aligned} & \text { 0: Manual } \\ & \text { 1: BOOTP } \\ & \text { 2: DHCP } \end{aligned}$ | $\begin{aligned} & {[\mathrm{fixed}](\text { П月пU) }} \\ & {[\mathrm{BOOTP}](\vdash \square \square E)} \\ & {[\mathrm{DHCP}](\square H[P)} \end{aligned}$ |
| $\begin{aligned} & {[\text { IP card] }(\text { IP }-)} \\ & (\mid P[\mid)(\mid P[\Xi) \\ & (\mid P[\exists)(\mid P[4) \\ & \text { IP address of the card } \end{aligned}$ | These fields can be edited when the IP mode is set to Fixed address． | $\begin{aligned} & {[139.160 .069 .241]} \\ & (\text { (ヨコ) (1 } 1 \text { ロ) (ロロコ) (コ4 ) } \end{aligned}$ |
| Subnet mask | These fields can be edited when the IP mode is set to Fixed address． | $\begin{aligned} & {[255.255 .254 .0]} \\ & (\text { こ5 5) }(\text { こ } 55)(\text { こ5 } 4)(\square) \end{aligned}$ |
|  | These fields can be edited when the IP mode is set to Fixed address． | $\begin{aligned} & {[0.0 .0 .0]} \\ & (\square)(\square)(\square)(\square) \end{aligned}$ |
| －If the address has been given by a BOOTP <br> －After dynamic addressing by a BOOTP or D | or a DHCP server，these fields are read only． DHCP server，the new address value is displayed． |  |
| ［Services］（ $E \quad E$ ） <br> Enables web server and e－mail functions． <br> This parameter can only be configured from the web server or PowerSuite software． <br> This parameter is significant at the bit level． Bit 0 and bit 1 are used to set the values shown in this table．The other bits are reserved． | 0 ：Web Server and Email functions disabled <br> 1：Web Server activated <br> 2：Email function activated <br> 3：Web server and Email functions activated | $\begin{aligned} & 0 \\ & 1 \\ & 2 \\ & 3 \end{aligned}$ |
| ［MAC＠］ <br> MAC address display | ［00－80－F4－XX－XX－XX］ | ［00－80－F4－XX－XX－XX］ |

## 7. Using the HMI with the EtherNet/IP card

## 7. 4. Detail of the configured parameters <br> ■ IP address

Assigning IP addresses
The drive controller needs 3 IP addresses:

- The drive IP address
- The subnet mask
- The gateway IP address (not always required)

According to the setting of the IP Mode parameter (see the table below), the IP addresses can be provided by:

- A BOOTP server (correspondence between the MAC address and the IP addresses).
- Or a DHCP server (correspondence between Device Name [DEVICE NAME] and the IP addresses).

| IP Mode value | Comments |
| :--- | :--- |
| IP mode $=0$ | The card uses the address defined in <br> IPC1, IPC2, IPC3, IPC4 |
| IP mode $=1$ | The card receives its address from a BOOTP server |
| IP mode $=2$ |  |
| And Device name contains a valid name. | The card receives its address from a DHCP server |

IMPORTANT: The IP Mode parameter may be modified according to the configuration control attribute of the TCP/IP interface object (CIP standard). See page $5 \underline{50}$.

## 7. 5. Assemblies and scanner configuration

The assemblies are chosen at the master controller level. See chapter 12, Integration in RSlogix, beginning on page 34.
For the 4 ODVA set of assemblies ( $20,21,22,23,70,71,72,73$ ), no further configuration is required at the communication scanner level.
For the Telemecanique assemblies $(100,101)$ and Allen-Bradley ${ }^{\circledR}$ assemblies $(103,104)$ you must:

- Configure the size of the assembly at the drive controller level, and
- Define the mapping of the additional parameters.


## 8. Configuration of the assemblies

## 8. 1. Configuration of the assemblies: overview

## VW3A3316 EtherNet/IP communication card

 Features overview

## 8. Configuration of the assemblies

## 8. 2. Configuration of assemblies 100-101, Telemecanique native profile

The size of the assembly is fixed and is equal to 8 words.
The variables exchanged by assemblies 100 and 101 are mapped with the communication scanner. See page 16.
The addresses are defined with NCAx and NMAx can be configured with the graphic keypad:
For assembly 100, go to the [1.9- COMMUNICATION] ( $[\square \Pi-)$ menu, [COM.SCANNER OUTPUT] ( $\square[5-$ ) submenu
For assembly 101, go to the [1.9- COMMUNICATION] ( $[\square \Pi-$ ) menu, [COM.SCANNER INPUT] ( $/[5-$ ) submenu.
See menu [1.2 MONITORING] > COMMUNICATION MAP for monitoring the communication scanner.
See also "Configuring the communication scanner" on page 16.


The following is an example of the configuration of assemblies 100-101 from RSLogix software:


## 8. Configuration of the assemblies

## 8. 3. Configuration of assemblies 103-104, Allen-Bradley® profile

The size of the assembly is selectable from 2 to 10 words.
The first two words of the input assembly are fixed as Control word and Speed setpoint.
The first four words of the output assembly are two-pad words and fixed as Status word and Actual speed.
IMPORTANT: NCA1 and NCA2 are already configured by the default settings of the drive controller. It is important when configuring this assembly to manually remove the default assignment of NCA1 and NCA2 by setting NCA1 and NCA2 to a null address or by configuring these two addresses to other required parameters of the drive controller.

This will avoid a conflict between NCA1 and the control word of the profile (located in the first word of assembly 103).
The configuration of the addresses defined with NCAx and NMAx can be made with the graphic keypad:
For assembly 103, go to the [1.9- COMMUNICATION] ( $[\square \sqcap-)$ menu, [COM.SCANNER OUTPUT] ( $\square[5-$ ) submenu
For assembly 104, go to the [1.9- COMMUNICATION] ( $[\square \Pi-)$ menu, [COM.SCANNER INPUT] ( $1[5-$ ) submenu.
See menu [1.2 MONITORING] > COMMUNICATION MAP for monitoring the communication scanner.
See also "Configuring the communication scanner" on page 16
The mapping of the other parameters is made with the EtherNet/IP scanner:


The following is an example of the configuration of assemblies 103-104 from RSLogix software:

The sizes indicated must be adjusted according to the settings defined with the EtherNet/IP scanner setup (via the web server or PowerSuite software).

## Note:

- The size of the assembly cannot be modified dynamically; such a change requires cycling the power.
- Given that assembly 103-104 uses NCAx and NMAx, the configuration edited with the web server or PowerSuite software is also applied to the drive controller communication scanner of the drive controller (like assemblies 100-101).



## 8．Configuration of the assemblies

## 8．4．Configuring the communication scanner

You need to read this chapter only if you use assemblies 100 or 101 ．
The variables exchanged by output assembly 100 and input assembly 101 are selected by configuring the communication scanner．
The 8 output variables of assembly 100 are assigned by means of the 8 parameters at［Scan．Oute address］（ $n$［ 月 $\bullet$ ）．They are configured using the graphic display terminal via the［1．9－COMMUNICATION］（ $[\square \square-)$ menu，［COM．SCANNER OUTPUT］（ $\square[5-$ ）submenu．

The 8 input variables of assembly 101 are assigned by means of the 8 parameters at［Scan．In address］（ $n$ П月 $\bullet$ ）．They are configured using the graphic display terminal via the［1．9－COMMUNICATION］（ $[\square \Pi-$ ）menu，［COM．SCANNER INPUT］（ $/[5-$ ）submenu．

Enter the logic address of the parameter（see the Communication parameters manual）．
If a parameter［Scan．Out address］（ $n[A \bullet$ ）or［Scan．In $\bullet$ address］（ $n \Pi 月 \bullet$ ）is equal to zero，the corresponding period variable is not used by the drive controller．

The 8 assignment parameters are described in the tables below：

| Parameter name | Output assembly 100 | Default assignment |
| :---: | :---: | :---: |
| ［Scan．Out1 address］（ $n$［ 月 I） |  | NCA1＝ 8501 （Control word） |
| ［Scan．Out2 address］（n［ 月 ） |  | NCA2＝ 8602 （Speed reference in rpm） |
| ［Scan．Out3 address］（ $n$［ 月 ヨ） |  | NCA3＝not used |
| ［Scan．Out4 address］（ $n$［ 月 4 ） |  | NCA4＝not used |
| ［Scan．Out5 address］（ $n$［ 月 5 ） |  | NCA5＝not used |
| ［Scan．Out6 address］（ $n$［ A E） |  | NCA6＝not used |
| ［Scan．Out7 address］（ $n$［ A 7） |  | NCA7＝not used |
| ［Scan．Out8 address］（ $n$［ 月 日） |  | NCA8＝not used |


| Parameter name | Input assembly 101 | Default assignment |
| :---: | :---: | :---: |
| ［Scan． $\ln 1$ address］（ $п 17$ 月 ） |  | NMA1＝ 3201 （Status） |
| ［Scan．In2 address］（п 1 月 こ ） |  | NMA2＝ 8604 （Output speed in rpm） |
| ［Scan．In3 address］（ п П 月 コ） |  | NMA3＝not used |
| ［Scan． $\ln 4$ address］（пПП4） |  | NMA4＝not used |
| ［Scan．In5 address］（п П ¢ 5） |  | NMA5＝not used |
| ［Scan．In6 address］（пППБ） |  | NMA6＝not used |
| ［Scan． $\ln 7$ address］（ п П 7 7） |  | NMA7＝not used |
| ［Scan．In8 address］（ 1 П 7 日 ${ }^{\text {a }}$ |  | NMA8＝not used |

The following is an example of configuration via the graphic display terminal：


## Note：

Modifications to parameters［Scan．Out address］（ $n[H \bullet$ ）or［Scan．In $\bullet$ address］（ $n \Pi 月 \bullet$ ）must be made with the motor stopped．The master PLC program must be updated to take account of this modification．

## 8. Configuration of the assemblies

## 8. 5. Configuring the control

## ■ Principle

By configuring the control, it is possible to select the channel from which the drive controller receives its commands and setpoint, either permanently or by a switching command.

Numerous configurations are possible. For more information, refer to the Programming Manual and Communication Parameters Manual. The following are some of the possible configurations.

## - Control with communication scanner

If the default assemblies $(100,101)$ are selected, the modes and profiles of the Altivar 71 drive controller are unrestricted.
It is possible to use the following profiles and modes of the drive controller:

- I/O profile
- Drivecom profiles with separate or non separate modes

I/O profile allows simple operation of the drive controller. Bit 0 of cmd word is the run command. The other bits can be configured in the same way as the drive's logic inputs.

Drivecom requires that specific steps be followed to operate the drive controller. See the Communications Parameters and Programming guides for additional details.

By configuring the communication scanner, it is possible to assign any relevant parameter of the drive controller to the 4 input and 4 output variables of the assemblies.

The input / output interface with the PLC can be customized depending on the application.
Use the communication scanner to interface with a Controller Inside card.

## - Control according to ODVA AC drive profile

The ODVA AC drive profile is activated when one of the following assemblies is selected:

- 20: Basic speed control output
- 21: Extended speed control output
- 22: Speed and torque control output
- 23: Extended speed and torque control output
- 70: Basic speed control input
- 71: Extended speed control input
- 72: Speed and torque control input
- 73: Extended speed and torque control input

The advantage of using the ODVA drive profile standard is the interchangeability with other brands.
The drive controller must be configured in the Drivecom profile with separate mode.
The EtherNet/IP card translates the commands, behavior, and monitoring information from the ODVA profile (on the network) to the Drivecom profile (in the drive controller).

## Control according to Allen-Bradley ${ }^{\circledR}$ drive profile

The Allen-Bradley drive profile is activated when one of the following assemblies is selected:

- 103: Allen-Bradley drive output
- 104: Allen-Bradley drive input

If you need to replace Allen-Bradley drive controllers in an existing application, using this profile is a good way to minimize modification.
The drive controller must be configured in the Drivecom profile with Separate mode.
The EtherNet/IP card translates the commands, behavior, and monitoring information from the Allen-Bradley drive profile (on the network) to the Drivecom profile (in the drive controller).

## 8．Configuration of the assemblies

## －Available configurations

If you use the communication scanner：
－100：Communication scanner output
－101：Communication scanner input．There are no restrictions in the configuration of the control．
The examples beginning on page 19 are only possible if you use the communication scanner．
$\square$ If you use the ODVA AC drive profile or the Allen－Bradley ${ }^{\circledR}$ drive profile，the assemblies are defined as follows：
－20：Basic speed control output
－21：Extended speed control output
－22：Speed and torque control output
－23：Extended speed and torque control output
－70：Basic speed control input
－71：Extended speed control input
－72：Speed and torque control input
－73：Extended speed and torque control input
－103：Allen－Bradley drive output
－104：Allen－Bradley drive input

| Parameter | Permitted value | Comment |
| :--- | :--- | :--- |
| Profile | Drivecom profile separate | The run commands are in Drivecom profile， <br> the command and the reference can come from different channels． |
| Setpoint 1 configuration | Network card | Setpoint 1 comes from EtherNet／IP． |
| Setpoint 1B configuration | Terminals | Setpoint 2 comes from terminals（AI1 or AI2）． |
| Setpoint 2 configuration | Terminals | Setpoint 2 comes from terminals（AI1 or AI2）． |
| Command 1 configuration | Network card | Command 1 comes from EtherNet／IP． |
| Command 2 configuration | Terminals | Command 2 comes from terminals． |
| Setpoint switching | Network card bit 12 | Bit 12 of the control word switches the setpoint（1 $\leftrightarrow 1 \mathrm{~B}$ or 1 $\leftrightarrow 2)$. |
| Command switching | Network card bit 13 | Bit 13 of the control word switches the command． |

Configuration via the graphic display terminal or the integrated display terminal：
Case 1：Setpoint 1B is connected to the functions（Summing，PID，etc．）which remain active even after switching．

| Menu | Parameter | Permitted value |
| :---: | :---: | :---: |
| ［1．6－COMMAND］（［EL－） | ［Profile］（LH［F） | ［Separate］（ $5: P$ ） |
|  | ［Ref． 1 channel］（ $F_{\text {r }}$ I） | ［Com．card］（ $n E t$ ） |
|  | ［Ref．1B channel］（ $F_{\text {r l }}$ Iロ） |  |
|  | ［Cmd channel 1］（［GI） | ［Com．card］（ $n E t$ ） |
|  | ［Cmd channel 2］（［d己） | ［Terminals］（ E ¢ ） |
|  | ［Cmd switching］（［［ 5） | ［C312］（［ コ／コ） |
| $\begin{aligned} & \text { [1.7 APPLICATION FUNCT.] }\left(F \\| n^{-}\right) \\ & \text {[REFERENCE SWITCH.] } \end{aligned}$ | ［Ref 1B switching］（ $\quad$［ $)^{\text {）}}$ | ［C313］（［ ヨ｜ヨ ） |

Case 2：Setpoint 2 is directly connected to the drive controller＇s reference limit．If switching is performed，the functions that affect the reference（summing，PID，etc．）are inhibited．

| Menu | Parameter | Permitted value |
| :---: | :---: | :---: |
| $\begin{aligned} & \text { [1.6 - COMMAND] }([L L-) \\ & \text { [1.7 APPLICATION FUNCT.] }\left(F \\|_{n}-\right) \\ & \text { [REFERENCE SWITCH.] } \end{aligned}$ | ［Profile］（L H［ F ） | ［Separate］（ $5: P$ ） |
|  | ［Ref． 1 channel］（ $F_{\text {r }}$ I） | ［Com．card］（ $n E t$ ） |
|  | ［Ref．2 channel］（Fr ${ }^{\text {P }}$ ） |  |
|  | ［Cmd channel 1］（［d） | ［Com．card］（ $n E t$ ） |
|  | ［Cmd channel 2］（［ d $)$ | ［Terminals］（ $1 E_{r}$ ） |
|  | ［Cmd switching］（［［ 5） | ［C312］（－コ こ ） |
|  | ［Ref． 2 switching］（ $\_$F［） | ［C313］（ $¢ \exists 1 \exists$ ） |

Note：It is not possible to configure the display terminal as a channel．
To switch to the display terminal，use the force local function and assign parameter［Forced local Ref．］to［HMI］（L［［ ）．

## 8. Configuration of the assemblies

## ■ Control via EtherNet/IP in I/O profile

Note: This configuration can only be used if the communication scanner assemblies (100 and 101) are selected.
The command and the setpoint come from EtherNet/IP.
Control is from the I/O profile.
Configure the following parameters:

| Parameter | Value | Comment |
| :--- | :--- | :--- |
| Profile | I/O profile | The run command comes from bit 0 of the command word. |
| Setpoint 1 configuration | Network card | The setpoint comes from EtherNet/IP. |
| Command 1 configuration | Network card | The command comes from EtherNet/IP. |

Configuration via the graphic display terminal or the integrated display terminal:

| Menu | Parameter | Value |
| :---: | :---: | :---: |
| [1.6-COMMAND] ( $\left[E L^{-}\right.$) | [Profile] (LH[F) | [//O profile] ( $1 \square$ ) |
|  | [Ref. 1 channel] ( $F_{\text {r }}$ I) | [Com. card] ( $n E \in$ ) |
|  | [Cmd channel 1] ([al) | [Com. opt card] ( $n E t$ ) |

## Control via EtherNet/IP or via the terminals in I/O profile

Note: This configuration can only be used if the communication scanner assemblies (100 and 101) are selected.
The command and the setpoint both come from EtherNet/IP or the terminals. Input LI5 at the terminals is used to switch between EtherNet/IP and the terminals.
Control is from the I/O profile.
Configure the following parameters:

| Parameter | Value | Comment |
| :--- | :--- | :--- |
| Profile | I/O profile | The run command comes from bit 0 of the control word. |
| Setpoint 1 configuration | Network card | Setpoint 1 comes from EtherNet/IP. |
| Setpoint 1B configuration | Analog input 1 on the terminals | Setpoint 1B comes from input AI1 on the terminals. |
| Setpoint switching | Input LI5 | Input LI5 switches the setpoint (1 $\leftrightarrow 1 \mathrm{~B})$. |
| Command 1 configuration | Network card | Command 1 comes from EtherNet/IP. |
| Command 2 configuration | Terminals | Command 2 comes from the terminals. |
| Command switching | Input LI5 | Input LI5 switches the command. |

Note: Setpoint 1 B is connected to the functions (Summing, PID, etc.) which remain active even after switching.
Configuration via the graphic display terminal or the integrated display terminal:

| Menu | Parameter | Value |
| :---: | :---: | :---: |
| [1.6-COMMAND] ([LL - ) | [Profile] (LH[F) | [//O profile] ( $1 \square$ ) |
|  | [Ref. 1 chan] ( $F_{r}$ I) | [Com. card] ( $n E E$ ) |
|  | [Cmd channel 1] ([ $[1$ ) | [Com. card] ( $n E E$ ) |
|  | [Cmd channel 2] ( [ ¢ ) | [Terminals] ( $E_{E_{r} \text { ) }}$ |
|  | [Cmd switching] ([ [ 5) | [LI5] (L 15) |
| [1.7 APPLICATION FUNCT.] (FUn-) [REFERENCE SWITCH.] | [Ref.1B chan] ( $r_{\text {r Ib) }}$ | [Al1 ref.] ( $\mathrm{A}_{1} 1$ ) |
|  | [Ref 1B switching] (r [ b) | [LI5] (L 15) |

## 8. Configuration of the assemblies

## ■ Control via EtherNet/IP in Drivecom profile

Note: This configuration can only be used if the communication scanner assemblies (100 and 101) are selected.
The command and the setpoint come from EtherNet/IP.
Configure the following parameters:

| Parameter | Value | Comment |
| :--- | :--- | :--- |
| Profile | Separate Drivecom profile | The run commands are from the Drivecom profile. The command and the <br> setpoint can come from different channels. |
| Setpoint 1 configuration | Network card | The setpoint comes from EtherNet/IP. |
| Command 1 configuration | Network card | Command 1 comes from EtherNet/IP. |

Configuration via the graphic display terminal or the integrated display terminal:

| Menu | Parameter | Value |
| :---: | :---: | :---: |
| [1.6-COMMAND] ([EL - ) | [Profile] ( $/$ H [ F ) | [Separate] ( $5: P$ ) |
|  | [Ref. 1 chan] ( $F_{r}$ I) | [Com. card] ( $n E t$ ) |
|  | [Cmd channel 1] ([d) | [Com. card] ( $n E t$ ) |

## ■ Control via EtherNet/IP or the terminals in Drivecom profile

Note: This configuration can only be used if the communication scanner assemblies (100 and 101) are selected.
The command and the setpoint both come from EtherNet/IP or the terminals. Input LI5 is used to switch between EtherNet/IP and the terminals.

Configure the following parameters:

| Parameter | Value | Comment |
| :--- | :--- | :--- |
| Profile | Separate Drivecom profile | The run commands come from the Drivecom profile. The command and <br> the setpoint can come from different channels. |
| Setpoint 1 configuration | Network card | Setpoint 1 comes from EtherNet/IP. |
| Setpoint 2 configuration | Analog input 1 on the terminals | Setpoint 2 comes from input AI1 on the terminals. |
| Setpoint switching | Input LI5 | Input LI5 switches the setpoint (1 $\leftrightarrow 2)$ and the command. |
| Command 1 configuration | Network card | Command 1 comes from EtherNet/IP. |
| Command 2 configuration | Terminals | Command 2 comes from the terminals. |
| Command switching | Input LI5 | Input LI5 switches the command. |

Note: Setpoint 2 is directly connected to the drive controller reference limit. If switching is performed, the functions that affect the reference (summing, PID, etc.) are inhibited.

Configuration via the graphic display terminal or the integrated display terminal:

| Menu | Parameter | Value |
| :---: | :---: | :---: |
| [1.6-COMMAND] ( $\left[\right.$ - $L^{-}$) | [Profile] (L H [ F ) | [Separate] ( 5 E P) |
|  | [Ref. 1 chan] ( $F_{r}$ ) 1 ) | [Com. card] ( $n E t$ ) |
|  | [Ref. 2 chan] ( $F_{\text {r }}$ ) ) | [Al1 ref.] ( ${ }^{\text {l }}$ I ) |
|  | [Ref. 2 switching] ( $-F$ [ ) | [LI5] (L 15) |
|  | [Cmd channel 1] ([ d I) | [Com. card] ( $n E t$ ) |
|  | [Cmd channel 2] ([dこ) | [Terminals] ( $E_{\text {r r }}$ ) |
|  | [Cmd switching] ([ [5) | [LI5] (L 15) |

## 8. Configuration of the assemblies

## ■ Control in Drivecom profile via EtherNet/IP and setpoint switching at the terminals

Note: This configuration can only be used if the communication scanner assemblies (100 and 101) are selected.
The command comes from EtherNet/IP.
The setpoint comes either from EtherNet/IP or from the terminals. Input LI5 at the terminals is used to switch the setpoint between EtherNet/IP and the terminals.
Control comes from the Drivecom profile.

Configure the following parameters:

| Parameter | Value | Comment |
| :--- | :--- | :--- |
| Profile | Separate Drivecom profile | The run commands come from the Drivecom profile. The command and <br> the setpoint can come from different channels. |
| Setpoint 1 configuration | Network card | Setpoint 1 comes from EtherNet/IP. |
| Setpoint 1B configuration | Analog input 1 on the terminals | Setpoint 1B comes from input AI1 on the terminals. |
| Setpoint switching | Input LI5 | Input LI5 switches the setpoint (1 $\leftrightarrow 1 \mathrm{~B})$. |
| Command 1 configuration | Network card | Command 1 comes from EtherNet/IP. |
| Command switching | Channel 1 | Channel 1 is the command channel. |

Note: Setpoint 1 B is connected to the functions (summing, PID, etc.) which remain active even after switching.
Configuration via the graphic display terminal or the integrated display terminal:

| Menu | Parameter | Value |
| :---: | :---: | :---: |
| [1.6-COMMAND] ([LL - ) | [Profile] ( L H [ F ) | [Separate] ( $5 E P$ ) |
|  | [Ref. 1 chan] ( $F_{r}$ I) | [Com. card] ( $n E E$ ) |
|  | [Cmd channel 1] ([d) | [Com. card] ( $n E E$ ) |
|  | [Cmd switching] ([ [ 5) | [ch1 active] ([ \\| I) |
| [1.7 APPLICATION FUNCT.] (F Un - ) [REFERENCE SWITCH.] | [Ref.1B chan] ( $r_{\text {r Ib) }}$ | [Al1 ref.] ( $\mathrm{A} \mathrm{I} \mathrm{I}^{\text {) }}$ |
|  | [Ref 1B switching] (r [ 口 ) | [LI5] (L 15) |

## 9. Fault management

## 9. 1. Fault management

An EtherNet/IP time out is triggered if the card does not receive any cyclic messages within a predefined time period.
This time period is managed by the EtherNet/IP controller (not by the drive controller), and is configured in the Module Properties window. The duration of the time out is defined by the RPI (request packet intervals). See the figure below.

If the card is controlled by explicit messages (without periodic exchanges), there is no control of the communication time-out.


The response of the drive controller to a time out can be configured as shown below.

Configuration can be performed using the graphic display terminal or the integrated display terminal using the [Network fault mgt] ( $[L L$ ) parameter in the [1.8 FAULT MANAGEMENT] ( $F L E-$ ) menu, [COM. FAULT MANAGEMENT] ([LL-) submenu.

| RDY | NET | $+0.00 \mathrm{~Hz}$ |  |
| :---: | :---: | :---: | :---: |
| COM. FAULT MANAGEMENT | $\square$ |  |  |
| Network fault mgt | $:$ | Freewheel |  |
| CANopen fault mgt | $:$ |  | Freewheel |
| Modbus fault mgt | $:$ |  | Freewheel |
|  | $:$ |  |  |
|  | $:$ |  |  |
| Code |  |  | Quick |

The values of the [Network fault mgt] ( $[L L$ ) parameter which trigger a [COM. network] ( $[\square F$ ) fault to the drive are:

| Value | Meaning |
| :---: | :---: |
| [Freewheel] ( リE 5) | Freewheel stop (factory setting) |
|  | Stop on ramp |
| [Fast stop] (F5t) | Fast stop |
| [DC injection] ( $\\|_{\text {[ }}$ [ $\quad$ ) | DC injection stop |

The values of the [Network fault mgt] ( $[L L$ ) parameter which do not trigger a [COM. network] ( $[n F$ ) fault to the drive are:

| Value | Meaning |
| :--- | :--- |
| $[$ lgnore $](\curvearrowleft \square)$ | Fault ignored |
| $[$ Per STT $](5 t E)$ | Stop according to configuration of [Type of stop] (5t ) |
| $[$ Fallback spd $](L F F)$ | Switch to fallback speed, maintained as long as the fault is present and the run command is <br> not disabled. |
| $[$ Spd maint. $](r L 5)$ | The drive controller maintains the speed at the time the fault occurred, as the fault persists <br> and the run command has not been removed. |

The fallback speed can be configured via the [Fallback spd] ( $L F F$ ) parameter in the [1.8 FAULT MANAGEMENT] ( $F L E-$ ) menu.

## 9. Fault management

## 9. 2. Status of the LEDs

The VW3A3316 Ethernet/IP card features 5 LEDs, which are visible through the Altivar 61/71 drive controller cover.
1.1
1.2
1.3
1.4
1.5
2.1 Port 1 activity
2.2 Port 2 activity
2.3 Link status
2.4 NS "Network status"
2.5 MS "Module status"

The first two LEDS indicate the status of the two Ethernet ports.
The third LED indicates the IP link status.
The last two LEDs indicate EtherNet/IP and CIP communication status.
The following table defines the LED indications.

| LED | Color/ state | Description |
| :---: | :---: | :---: |
| 2.1 | Off | No link |
|  | Flashing Green/yellow | Power up testing |
|  | Green ON | Link at 100 Mbps |
|  | Yellow ON | Link at 10 Mbps |
|  | Green BLINK | Activity at 100 Mbps |
|  | Yellow BLINK | Activity at 10 Mbps |
|  |  |  |
| 2.2 | Off | No link |
|  | Flashing Green/yellow | Power up testing |
|  | Green ON | Link at 100 Mbps |
|  | Yellow ON | Link at 10 Mbps |
|  | Green BLINK | Activity at 100 Mbps |
|  | Yellow BLINK | Activity at 10 Mbps |
|  |  |  |
| 2.3 | Off | Physical connections unplugged. No IP address obtained. |
|  | Flashing Green/red | Power up testing |
|  | Green On | At least one port is connected and an IP address has been obtained. |
|  | Green flashing 3 times | Ports are unplugged, but the card has an IP address. |
|  | Green flashing 4 times | Error: Duplicated IP address (1) |
|  | Green flashing 5 times | The card is performing a BOOTP or DHCP sequence. |
|  |  |  |
| $\begin{aligned} & 2.4 \\ & \text { "NS" } \end{aligned}$ | Off | The device does not have an IP address or the power is off. |
|  | Flashing Green/red | Power up testing |
|  | Green On | The device has at least one established connection (even to the Message Router). |
|  | Green flashing | The device has not established connections, but has obtained an IP address. |
|  | Red flashing | One or more of the connections in which this device is the target has timed out. This indication stops only if the time out connections are reestablished or the device is reset. |
|  | Red On | The device has detected that its IP address is already in use (1). |
|  |  |  |
| 2.5 <br> "MS" | Off | No power is supplied to the device |
|  | Flashing Green/red | Power Up testing |
|  | Green On | The device is operating correctly. |
|  | Green flashing | The device has not been configured. |
|  | Red flashing | The device has detected a recoverable minor fault. |
|  | Red On | The device has detected a non-recoverable major fault (1). |

(1) If duplicate IP addresses are detected, LED 2.3 flashes green 4 times, and LEDs 2.4 and 2.5 are on red.

## 10. Configuration of monitored parameters

It is possible to select up to 4 parameters for display on the [1.2-MONITORING] menu of the graphic display terminal.
The selection is made via the [6-MONITORING CONFIG.] menu, [6.3-COM. MAP CONFIG.] submenu.
Each parameter in the range [Address 1 select.] to [Address 4 select.] is used to select the parameter logic address. Select an address of zero to disable the function.

In the example given here, the monitored words are:

- Parameter 1 = Motor current (LCR): logic address 3204; signed decimal format.
- Parameter 2 = Motor torque (OTR): logic address 3205; signed decimal format.
- Parameter 3 = Last fault occurred (LFT): logic address 7121; hexadecimal format.
- Disabled parameter: address 0; default format: hexadecimal format.

| RDY NET | $+0.00 \mathrm{~Hz}$ | 0A |
| :---: | :---: | :---: |
| 6.3 COM. MAP CONFIG. |  |  |
| Word 1 add. select. |  | 3204 |
| Format word 1 |  | Signed |
| Word 2 add. select. |  | 3205 |
| Format word 2 |  | Signed |
| Word 3 add. select. |  | 7121 |
| Code | Quick | k $\checkmark$ |


| Word 4 add. select. | $:$ | 0 |
| :--- | :--- | ---: |
| Format word 4 | $:$ | $H e x$ |

One of the three display formats shown below can be assigned to each monitored word:

| Format | Range | Terminal display |
| :--- | :--- | :--- |
| Hexadecimal | 0000 to FFFF | [Hex] |
| Signed decimal | $-32,767$ to 32,767 | [Signed] |
| Unsigned decimal | 0 to 65,535 | [Unsigned] |

## 11. Web server

This chapter describes the function of the EtherNet/IP card's integrated web server. See page 11. The [SERVICES] parameter must be set to " 1 " to access the web server.

## 11. 1. Opening the Altivar home page

From your web browser, log in with the default http password. The passwords are USER for monitor and setup security level, and ADMIN for administrator level.


From the Altivar home page, you can access 4 main menus:

- Drive
- Network setup
- Network diagnostic
- Email


## 11. 2. Web pages structure

Each web page has the same structure. The main menus (Drive, Network setup, and Network diagnostic) have their own sub menus, which are displayed on the left side of web page.


The toggle button shows or hides the left side menus.

## 11. Web server

## 11. 3. Drive



## ■ Drive monitor



## 11. Web server

## Drive parameters



The left column is used to select a mod/imd group of parameters. The right side of the window displays the parameters, their Modbus addresses, and their current values

## Saving parameters

To avoid numerous writes to the flash memory, when drive controller parameters are modified from the web server, they are not saved into drive memory. However, it is possible to backup the parameters from the web server by writing 2 to the CMI parameter. This operation saves the drive controller parameters to flash memory.

## 11. Web server

## ■ Drive recorder



The Drive recorder plots two preselected parameters as a graph to display trends.
RUN/STOP: Starts or stops the trend recording.
Reset: Erases the recorded trend.
Min/Max: defines the lowest and highest values displayed on the Drive recorder window.
Per(s): Periodicity: Minimal value.

## 11. Web server

## 11. 4. Network setup



- Monitor security


The Monitor security password provides basic level access to the drive controller through the web server. It allows access to the various web pages, but does not authorize write access. The monitor security user name and password can be changed in this window.

## 11. Web server

## ■ Setup security



HTTP: data write.
Data write level password.

## Administrator security



## 11. Web server

## ■ EtherNet/IP setup



## ■ EtherNet/IP scanner setup



See page 15. The default assignment of NCA1 and NCA2 must be removed when using the assembly 103 and 104 profile.

## 11. Web server

## ■ Email management



The Email management window allows you to send an email under one of four selectable conditions. You can also specify:

- The email IP server address
- The email recipient's address
- The email sender's address


## 11. 5. Diagnostics



## 11. Web server

## ■ Ethernet statistics



## Message statistics



NOTE: The EtherNet/IP option card uses internal MODBUS TCP for the web-server. The MODBUS TCP port is not accessible.

## 12. Integration in RSLogix

## 12. 1. Principle

An Altivar 61/71 drive controller equipped with an EtherNet/IP card can be configured as a generic ethernet module in the same way as the EtherNet/IP adapter of the Powerflex 70 drives as show in section 12.2, or an EDS file can be used as shown in section 12.3 beginning on page 41.

## 12. 2. Procedure

## $■$ Create a new project (project name is RSX for this example)



## 12. Integration in RSLogix

■ Add a EtherNet/IP scanner to the I/O configuration


## 12. Integration in RSLogix

| Select Module |  | X |
| :---: | :---: | :---: |
| Module | Description | Vendor |
| -1756-CNBR/D | 1756 ControlNet Bridge, Redundant Media | Allen-Bradley A |
| - 1756-CNBR ${ }^{\text {E }}$ | 1756 ControlNet Bridge, Redundant Media | Allen-Bradey |
| -1756-DHRIO/B | 1756 DH+ Bridge/RIO Scanner | Allen-Bradley |
| -1756-DHRIO/C | 1756 DH+ Bridge/RIO Scanner | Allen-Bradley |
| -1756-DHRIO/D | 1756 DH+ Bridge/RIO Scanner | Allen-Bradley |
| -1756-DNB | 1756 DeviceNet Scanner | Allen-Bradley |
| -1756-EN2T/A | $175610 / 100 \mathrm{Mbps}$ Ethernet Bridge, Twisted-Pair Media | Allen-Bradley |
| 1756-ENBT/A | 1756101100 Mbps Ethernet Eridge, Twisted-Pair Media | Allen-Bradley |
| -1756-ENET/A | 1756 Ethernet Communication Interface | Allen-Bradley |
| -1756-ENET/B | 1756 Ethernet Communication Interface | Allen-Bradley |
| - 1756-EWEB/A | 1756 10/100 Mbps Ethernet Bridge w/Enhanced Web Serv., | Allen-Bradley |
| -1756-5YNCH/A | SynchLink Interface | Allen-Bradley |
|  |  | $\checkmark$ |
|  |  | 1 |



## 12. Integration in RSLogix

## ■ Configure the EtherNet/IP scanner



■ Add a EtherNet/IP ATV61/71 drive controller to the I/O configuration


## 12．Integration in RSLogix



| Controler Tags Controler Fauk Hander Power－Up Hander $\square$ © MainProgran Unschediled Prograns／Phases Motion Groups <br> EI Ungrouped Axes Trends <br> －Ct Stings <br> （4）Predefined <br> Cis Module－Defined <br> a．A1／O Configuration E1756 Bockplane，1756－A10 <br>  <br> E．［1］ 1756 －ENBT／A EtherthetP，Scarner PLC01告古 Ethernet |
| :---: |
| Descration Elierfietp sconner of PLCDI <br> Status Ortine <br> Modia Fast  |



## 12. Integration in RSLogix



■ Configure the ATV61/71 EtherNet/IP card
In the following example, the Allen-Bradley Drive profile is selected.


## 12. Integration in RSLogix

In the following example, the CIP extended speed control profile is selected.


In the following example, the CIP extended speed and torque control profile is selected.


## 12. Integration in RSLogix

In the following example, the RSX profile is selected.


## 12. 3. Registering the EDS file in RSlogix

An EDS file is provided on the CD that ships with the drive controller.
There is 1 EDS file for the ATV71 and 1 EDS file for the ATV61.
This section describes how to import these files in your project:
In RSnetWorx, start the EDS Wizard.


## 12. Integration in RSLogix

Click Next (Suivant) to continue.


Choose "Register an EDS file(s)" to import a new EDS file. If you want to update an EDS file, you must unregister device first.


## 12. Integration in RSLogix

## Select the required file, then click Open (Ouvrir):



The dialog box displays the result of the import operation.


## 13. CIP objects

## 13. 1. Supported object classes

Three categories of object classes can be defined:

- 1: CIP device on EtherNet/IP
- 2: AC/DC drive controller
- 3: VSD specific

The following table describes these objects.

| Object class | Class ID | Cat. | Number of instances | Effect on behavior Interface |
| :---: | :---: | :---: | :---: | :---: |
| Identity object (13.2.) page 44 | 16\#01 | 1 | 1 | Supports the reset service |
| Message router object (13.3.) page 45 | 16\#02 | 1 | 1 | Explicit message connection |
| Ethernet Link object (13.4.) page 47 | 16\#F6 | 1 | 1 | Counter and status information |
| TCP/IP Interface object (13.5.) page 50 | 16\#F5 | 1 | 1 | TCP/IP configuration |
| Connection object manager (13.6.) page 52 | 16\#05 | 1 | 1 |  |
| Motor data object (13.7.) page 53 | 16\#28 | 2 | 1 | Defines data for the motor connected to the device |
|  | 16\#29 | 2 | 1 | Manages drive functions, operational states and control |
| AC/DC Drive Object (13.9.) page 56 | 16\#2A | 2 | 1 | Provides drive configuration |
| Assembly object (13.10.) page 57 | 16\#04 | 2 | 12 | Defines I/O data format |
| Application objects (13.11.) page 58 |  | 3 | 1 | Vendor specific - drive controller's parameters |

## 13. 2. Identity object

The Identity object provides identification and status information about the drive controller.

## Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \# 01$ | 1 |

## Class attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Optional | UINT | 1 | - |
| 2 | Get | Max Instances | Optional | UINT | 1 | 1 defined instance |

## 13. CIP objects

## Instance attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Vendor ID | Required | UINT | 243 | Schneider Automation, Inc. [243] |
| 2 | Get | Device type | Required | UINT | $16 \# 02$ | AC/DC drive profile |
| 3 | Get | Product code | Required | UINT | 5 or 7 | 5: ATV71 <br> 7: ATV61 |
| 4 | Get | Revision | Required | Structure <br> of: <br> USINT <br> USINT | - | Product revision of the drive controller (1) |
| 5 | Get | Status | Required | WORD | - | See definition in the table below |
| 6 | Get | Serial number | Required | UDINT | - | Serial number of the drive controller |
| 7 | Get | Product name | Required | Structure <br> of: <br> USINT <br> STRING | - | 11 (product name length) <br> "ATV71 Drive" |
| 8 | Get | State | Optional | USINT | - | 0: Non existent <br> 1: Device self-testing <br> 2: Standby <br> 3: Operational <br> 4: Major recoverable fault <br> 5: Major unrecoverable fault |
| 10 | Get/Set | Heartbeat interval <br> (2) | Optional | USINT | 0-255 | Interval in seconds between two heartbeat messages. <br> 0: No message. |

(1) Mapped in a word: MSB minor revision (second USINT), LSB major revision (first USINT).

Example: $517=16 \# 0205$ means revision V5.2.
(2)The heartbeat message broadcasts the current state of the device.

## 13. 3. Message router object

The Message router object directs explicit messages to their target objects.

## Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \# 02$ | 2 |

## Class attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Optional | UINT | 1 | - |
| 2 | Get | Max instances | Optional | UINT | 1 | 1 Defined instance |

## 13. CIP objects

## Instance attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Object list: <br> Number classes | Optional | Structure <br> of: <br> UINT <br> UINT [ ] | 20 <br> (codes) | List of supported objects; the first UINT is the number of <br> supported classes; the remaining UINTs are the codes <br> of these classes. |
| 2 | Get | Number available | Optional | UINT | 1 | Maximum number of simultaneous connections |
| 3 | Get | Number active | Optional | UINT | 1 | Number of active connections |
| 4 | Get | Active connections | Optional | UINT [] | 1 | List of active connections (referred to with their <br> respective Connection instance ID) |

## Class service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |

## Instance service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |

## 13. CIP objects

## 13. 4. Ethernet Link object

This object provides the mechanism to configure a device's TCP/IP network interface.

## ■ Class code

| Hexadecimal | decimal |
| :--- | :--- |
| $16 \# F 5$ | 245 |

## ■ Class attributes

Class attributes for this object are optional.

## ■ Instance attributes

| Attribute ID | Access | Name | Need | Data type | Value |  | Details |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Get | Status | Required | DWORD | Bit level | 0 | The interface configuration attribute has not been configured. |
|  |  |  |  |  |  | 1 | The interface configuration contains a valid configuration. |
|  |  |  |  |  |  | 2-15 | Reserved for future use. |
| 2 | Get | Configuration capability | Required | DWORD | Bit level | 0 | BOOTP Client |
|  |  |  |  |  |  | 1 | DNS Client |
|  |  |  |  |  |  | 2 | DHCP Client |
|  |  |  |  |  |  | 3 | DHCP-DNS capable |
|  |  |  |  |  |  | 4 | Interface configuration settable |
|  |  |  |  |  |  | The o | ther bits are reserved and are set to 0 . |
| 3 | Get <br> Set | Configuration control | Required | DWORD | Bit level | 0 | The interface configuration is valid. |
|  |  |  |  |  |  | 1 | The interface configuration must be obtained with BOOTP. |
|  |  |  |  |  |  | 2 | The interface configuration must be obtained with DHCP. |
|  |  |  |  |  |  | 3 | Reserved |
| NOTE: This attribute interacts with the Altivar 71 parameter [IP mode] (see chapter 8.). |  |  |  |  |  | 4 | DNS Enable |
|  |  |  |  |  | The other bits are reserved and are set to 0 . |
| 4 | Get | Physical link | Required | STRUCT \{ <br> UINT path size Padded EPATH path \} |  | Path size: The number of 16 bit words in the element path. <br> Path: Logical segments identifying the physical link object. The path is restricted to one logical class segment and one logical instance segment. The maximum size is 12 bytes. |  |

## 13. CIP objects

| Attribute ID | Access | Name | Need | Data type Value | Details |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 5 | Get Set | Interface configuration | Required | STRUCT \{ <br> UDINT IP Address <br> UDINT Network Mask <br> UDINT Gateway address <br> UDINT Primary Name server <br> UDINT Secondary name server <br> STRING Default Domain name \} | IP Address: Value of 0 indicates that no IP address has been configured. Otherwise, the IP address must be set to a valid Class A, B, or C address and must not be set to the loopback address (127.0.0.1). <br> Network Mask: Value of 0 indicates that no network mask address has been configured. <br> Gateway Address: Value of 0 indicates that no IP address has been configured. Otherwise, the IP address must be set to a valid Class A, B, or C address and must not be set to the loopback address (127.0.0.1). <br> Primary name: Value of 0 indicates that no name server address has been configured. Otherwise, the name server address must be set to a valid Class A, $B$, or $C$ address. <br> Secondary Name: Value of 0 indicates that no secondary name server address has been configured. Otherwise, the name server address must be set to a valid Class A, B, or C address. <br> Default domain name: ASCII characters. Maximum length is 48 characters, padded to an even number of characters (pad not included in length). A length of 0 indicates that no Domain Name is configured. |
| 6 | Get Set | Host Name | Required | STRING | ASCII characters. Maximum length is 64 characters, padded to an even number of characters (pad not included in length). A length of 0 indicates that no Host Name is configured. |

## - Class service

| Service Code | Service Name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 01$ | Get_Attribute_All | Optional | Returns a predefined listing of this object's <br> attributes. |
| $16 \# 0 \mathrm{E}$ | Get_Attribute_Single | Optional | Returns the contents of the specified attribute. |

■ Instance service

| Service Code | Service Name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 01$ | Get_Attribute_All | Optional | Returns a predefined listing of this objects <br> attributes. |
| $16 \# 0 \mathrm{E}$ | Get_Attribute_Single | Required | Returns the contents of the specified attribute. |
| $16 \# 02$ | Set_Attribute_All | optional | Modifies all settable attributes. |
| $16 \# 10$ | Set_Attribute_Single | Required | Modifies a single attribute. |

## 13. CIP objects

## Behavior

The following diagram illustrates configuration of the TCP/IP network interface.


## 13. CIP objects

## 13. 5. TCP/IP Interface object

This object maintains link specific counters and status information for an Ethernet 802.3 communications interface.

## $\square$ Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \#$ F6 | 246 |

## ■ Class attributes

| Attribute ID | Access | Name | Need | Data type | Value |
| :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Required | UINT | 2 |
| 2 through 7 |  |  | Optional |  |  |

■ Instance attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Interface Speed | Required | UDINT | $0,10,100$ <br> $1000, ~ e t c . ~$ | Speed in Mbps. |

## 13. CIP objects

| Attribute ID | Access | Name | Need | Data type Value | Details |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 5 | Get | Media Counters | Conditional | STRUCT \{ |  |
|  |  |  |  | UDINT Alignment errors | Frames received that are not an integral number of octets in length |
|  |  |  |  | UDINT FCS Errors | Frames received that do not pass the FCS check |
|  |  |  |  | UDINT Single collisions | Successfully transmitted frames experienced one collision |
|  |  |  |  | UDINT Multiple Collisions | Successfully transmitted frames experienced more than one collision |
|  |  |  |  | UDINT SQE Test Errors | Number of times SQE test error message is generated |
|  |  |  |  | UDINT Deferred Transmissions | Frames for which first transmission attempt is delayed because the medium is busy |
|  |  |  |  | UDINT Late Collisions | Number of times a collision is detected later than 512 bittimes into the transmission of a packet |
|  |  |  |  | UDINT Excessive Collisions | Frames for which transmission is unsuccessful due to excessive collision |
|  |  |  |  | UDINT MAC Transmit errors | Frames for which transmission is unsuccessful due to an internal MAC sublayer transmit error |
|  |  |  |  | UDINT Carrier sense Errors | Times that the carrier sense condition was lost or never asserted when attempting to transmit a frame |
|  |  |  |  | UDINT Frame too long | Frames received that exceed the maximum permitted frame size |
|  |  |  |  | UDINT MAC Receive Errors | Frames for which reception on an interface is unsuccessful due to an internal MAC sublayer receive error |
|  |  |  |  | \} |  |
| 6 | Set | Interface control | Optional | STRUCT \{ |  |
|  |  |  |  | WORD Control Bits | Interface control bits |
|  |  |  |  | UINT Force interface Speed | Speed at which the interface is forced to operate. |
|  |  |  |  | \} |  |

## 13. CIP objects

## ■ Class service

| Service Code | Service Name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 01$ | Get_Attribute_All | Optional | Returns a predefined listing of this object's attributes. |
| $16 \# 0 E$ | Get_Attribute_Single | Optional | Returns the contents of the specified attribute. |
| $16 \# 10$ | Get_and_clear | Conditional | Modifies a single attribute |

## ■ Instance service

| Service Code | Service Name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 01$ | Get_Atribute_All | Optional | Returns a predefined listing of this object's attributes. |
| $16 \# 0 \mathrm{E}$ | Get_Atribute_Single | Required | Returns the contents of the specified attribute. |
| $16 \# 10$ | Set_Attribute_Single | Required | Modifies a single attribute. |

## 13. 6. Connection object manager

## Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \# 05$ | 5 |

## Class attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Optional | UINT | 1 | - |
| 2 | Get | Max instances | Optional | UINT | 4 | 3 defined instances (1) |

(1)Only instances 1 (explicit message), 2 (polled I/O message), and 4 (change of state/cyclic message) are supported. Instance 3 (bit strobe) is not supported.

## Attributes of instance 1—Explicit message instance

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Get | State | Req. | USINT | - | 0: Non-existent <br> 3: Established <br> 5: Deferred delete |
| 2 | Get | Instance_type | Req. | USINT | 0 | Explicit message |
| 3 | Get | TransportClass_trigger | Req. | BYTE | 16\#83 | Class 3 server |
| 4 | Get | Produced_connection_id | Req. | UINT | 10xxxxxx011 | xxxxxx $=$ Node address |
| 5 | Get | Consumed_connection_id | Req. | UINT | 10xxxxxx100 | xxxxxx = Node address |
| 6 | Get | Initial_comm_characteristics | Req. | BYTE | 16\#21 | Explicit messaging via Group 2 |
| 7 | Get | Produced_connection_size | Req. | UINT | 36 | Produced data maximum size (in bytes) |
| 8 | Get | Consumed_connection_size | Req. | UINT | 36 | Consumed data maximum size (in bytes) |
| 9 | Get/Set | Expected_packet_rate | Req. | UINT | 2500 | 2.5 sec. (Time-out) |
| 12 | Get/Set | Watchdog_timeout_action | Req. | USINT | 1 or 3 | 1: Auto-delete <br> 3: Deferred delete (default) |
| 13 | Get | Produced connection path length | Req. | UINT | 0 | Length of attribute 14 data |
| 14 | Get | Produced connection path | Req. | Array of UINT | Null | Empty |
| 15 | Get | Consumed connection path length | Req. | UINT | 0 | Length of attribute 16 data |
| 16 | Get | Consumed connection path | Req. | Array of UINT | Null | Empty |

Refer to the EtherNet/IP specification for more information.

## 13. CIP objects

## 13. 7. Motor data object

The Motor data object acts as a motor parameter database.

## Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \# 28$ | 40 |

## Object 28hex (Motor Data)

| Path | CIP name | CIP configuration parameter name |
| :--- | :--- | :--- |
| $16 \# 28 / 01 / 06=40 / 1 / 6$ | RatedCurrent | Motor Rated Cur |
| $16 \# 28 / 01 / 07=40 / 1 / 7$ | RatedVoltage | Motor Rated Volt |
| $16 \# 28 / 01 / 09=40 / 1 / 9$ | RatedFreq | Motor Rated Freq |
| $16 \# 28 / 01 / 0 F=40 / 1 / 15$ | BaseSpeed | Motor Base Speed |

## Telemecanique adaptation:

| Path | Code | Altivar name | Logic address |
| :--- | :--- | :--- | :--- |
| $16 \# 28 / 01 / 06=40 / 1 / 6$ | NCR | Rated mot. current | $16 \# 2583=9603$ |
| $16 \# 28 / 01 / 07=40 / 1 / 7$ | UNS | Rated motor volt. | $16 \# 2581=9601$ |
| $16 \# 28 / 01 / 09=40 / 1 / 9$ | FRS | Rated motor freq. | $16 \# 2582=9602$ |
| $16 \# 28 / 01 / 0 F=40 / 1 / 15$ | NSP | Rated motor speed | $16 \# 2584=9604$ |

Class attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Opt. | UINT | 2 | - |
| 2 | Get | Max instance | Opt. | UINT | 1 |  |
| 6 | Get | Max ID number of class attribute | Opt. | UINT | - |  |
| 7 | Get | Max ID number of instance attribute | Opt. | UINT | 15 | - |

Instance attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | Get/Set | MotorType | Req. | USINT | 7 | $6=$ Wound rotor induction motor <br> 7 = Squirrel cage induction motor |
| 6 | Get/Set | RatedCurrent | Req. | UINT | Determined by the drive controller rating | [Rated mot. current] ( $n[r$ ) |
| 7 | Get/Set | RatedVoltage | Req. | UINT | Determined by the drive controller rating | [Rated mot. volt.] ( $\downarrow$ п 5 ) |
| 9 | Get/Set | RatedFreq | Opt. | UINT | 50/60 | [Rated motor freq.] (Fr 5) |
| 15 | Get/Set | BaseSpeed | Opt. | UINT | Determined by the drive controller rating | [Nom motor speed] ( $n 5$ P) |

## Class service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Req. | Read an attribute |

## Instance service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Req. | Read an attribute |
| $16 \# 10$ | Set_Attribute_Single | Opt. | Write an attribute |

## 13. CIP objects

## 13. 8. Control supervisor object

The Control supervisor object models the functions for managing devices within the hierarchy of motor control devices.
Object 29hex (Control Supervisor)

| Path | CIP name | CIP configuration parameter name |
| :--- | :--- | :--- |
| $16 \# 29 / 01 / 0 D=41 / 1 / 13$ | FaultCode | Fault Code |

## Telemecanique adaptation:

| Path | Code | Altivar name | Logic address |
| :--- | :--- | :--- | :--- |
| $16 \# 29 / 01 / 0 \mathrm{D}=41 / 1 / 13$ | ERRD | CiA402 fault code | $16 \# 219 \mathrm{E}=8606$ |

## Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \# 29$ | 41 |

## Class attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Optional | UINT | 2 | - |
| 2 | Get | Max instance | Optional | UINT | 1 | - |
| 6 | Get | Max ID number of class attribute | Optional | UINT | 7 | - |
| 7 | Get | Max ID number of instance attribute | Optional | UINT | 17 | - |

Instance attributes

| Attribute ID | Access | Name | Need | Data type | Details |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | Get/Set | Run Fwd | Required | BOOL | On an edge ( $0 \rightarrow 1$ ) |
| 4 | Get/Set | Run Rev | Optional | BOOL | On an edge ( $0 \rightarrow 1$ ) |
| 5 | Get/Set | NetCtrl | Optional | BOOL | 0: Local Control (Channel 1) <br> 1: Network Control (default) |
| 6 | Get | State | Optional | USINT | $\begin{aligned} & 0=\text { Vendor Specific, } \\ & 1=\text { Startup, } 2=\text { Not_Ready, } 3=\text { Ready }, \\ & 4=\text { Enabled, } 5=\text { Stopping, } \\ & 6=\text { Fault_Stop, } 7=\text { Drive detected fault } \end{aligned}$ |
| 7 | Get | Running Fwd | Required | BOOL |  |
| 8 | Get | Running Rev | Optional | BOOL |  |
| 9 | Get | Ready | Optional | BOOL |  |
| 10 | Get | Faulted | Required | BOOL |  |
| 12 | Get/Set | FaultRst | Required | BOOL | Clear detected fault ( $0 \rightarrow 1$ ) |
| 13 | Get | FaultCode | Optional | UINT | Refer to the Communication parameters manual: DSP402 fault code (Errd) |
| 15 | Get | CtrIFromNet | Optional | BOOL | 0 = Local Control; 1 = Network Control |

## 13. CIP objects

Class service

| Service Code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |

## Instance service

| Service Code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |
| $16 \# 10$ | Set_Attribute_Single | Required | Write an attribute |
| $16 \# 05$ | Reset | Required | Drive reset |

Control supervisor state transition diagram


## 13. CIP objects

## 13. 9. AC/DC Drive Object

The AC/DC Drive object models the drive controller functions such as torque control and speed ramp.
Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \# 2 \mathrm{~A}$ | 42 |

## Class attributes

| Attribute ID | Access | Name | Need | Data Type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Optional | UINT | 1 | - |
| 2 | Get | Max instance | Optional | UINT | 1 | - |
| 6 | Get | Max ID number of class attribute | Optional | UINT | 7 | - |
| 7 | Get | Max ID number of instance attribute | Optional | UINT | 21 | - |

## Instance attributes

| Attribute ID | Access | Name | Need | Data type | Details |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | Get | AtReference | Optional | BOOL |  |
| 4 | Get/Set | NetRef (1) | Required | BOOL | 0: Local speed setpoint (Al1 or AI2) <br> 1: Speed setpoint via the network |
| 5 | Get/Set | NetProc | Optional | BOOL | Not handled |
| 6 | Get/Set | Drive mode | Required | USINT | 1: Open loop <br> 2: Closed loop (FVC) |
| 7 | Get | SpeedActual | Required | INT | Output speed (rFrd) |
| 8 | Get/Set | SpeedRef | Required | INT | Speed setpoint (LFrd) |
| 9 | Get | CurrentActual | Optional | INT | Motor current (LCr) |
| 10 | Get/Set | CurrentLimit | Optional | INT | [Mot. therm. current] (ItH) |
| 11 | Get | TorqueActual | Optional | INT | Output torque (Otrn) |
| 12 | Get/Set | TorqueRef | Optional | INT | Torque setpoint (LtCr) |
| 18 | Get/Set | AccelTime | Optional | UINT | Acceleration time (ACCd) |
| 19 | Get/Set | DecelTime | Optional | UINT | Deceleration time (dECd) |
| 20 | Get/Set | LowSpdLimit | Optional | UINT | Parameter [Low speed] (LSP) converted in RPM |
| 21 | Get/Set | HighSpdLimit | Optional | UINT | Parameter [High speed] (HSP) converted in RPM |

## Class service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |

## Instance service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |
| $16 \# 10$ | Set_Attribute_Single | Optional | Write an attribute |

## 13. CIP objects

## 13. 10. Assembly object

The Assembly object binds together the attributes of multiple objects so that information to or from each object can be communicated over a single connection.

Assembly objects are static.
The assemblies in use can be modified through the network configuration tool (RSNetWorx) parameter access.
Power to the drive controller must be cycled for the new assembly assignments to be effective.
Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \# 04$ | 4 |

Class attribute

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Optional | UINT | 2 | - |
| 2 | Get | Max instance | Optional | UINT | 105 | 13 defined instances |

Instances supported

| Instance | Name | Data size |
| :--- | :--- | :--- |
| 20 | ODVA Basic speed control output | 4 bytes |
| 21 | ODVA Extended speed control output | 4 bytes |
| 22 | ODVA Speed and torque control output | 6 bytes |
| 23 | ODVA Extended speed and torque control output | 6 bytes |
| 100 | Native drive output | 16 bytes |
| 103 | Allen-Bradley ${ }^{\circledR}$ drive output | 20 bytes |
| 70 | ODVA Basic speed control input | 4 bytes |
| 71 | ODVA Extended speed control input | 4 bytes |
| 72 | ODVA Speed and torque control input | 6 bytes |
| 73 | ODVA Extended speed and torque control input | 6 bytes |
| 101 | Native drive input | 16 bytes |
| 104 | Allen-Bradley ${ }^{\circledR}$ drive input | 20 bytes |

The description of each instance is detailed in chapter 15. Device profiles

## Instance attributes

| Attribute ID | Access | Name | Need | Data type | Value | Details |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 3 | Get/Set (1) | Data | Required |  |  |  |

(1)Set access is restricted to output instances only (instances 20, 21, 22, 23, 100 and 103).

Class service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |

## Instance service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |
| $16 \# 10$ | Set_Attribute_Single | Optional | Write an attribute |

## 13. CIP objects

## 13. 11. Application objects

## Class code

| Hexadecimal | Decimal |
| :--- | :--- |
| $16 \# 70$ to 16\#A8 | 112 to 424 |

## Altivar parameters path

The Altivar parameters are grouped in classes.
Each application class has only 1 instance.
Each instance groups 200 parameters.
Each attribute in an instance relates to a parameter.
The first parameter registered in the first application class (class code: $16 \# 70=112$ ) has the logical address 3000.
Examples:

| Logical address | Path Hexadecimal | Path decimal |
| ---: | :--- | :--- |
| 3000 | $16 \# 70 / 01 / 01$ | $112 / 1 / 1$ |
| 3100 | $16 \# 70 / 01 / 65$ | $112 / 1 / 101$ |
| 3200 | $16 \# 71 / 01 / 01$ | $113 / 1 / 1$ |
| 64318 | $16 \#$ A2 / / /77 | $418 / 1 / 119$ |

Refer to the Communication parameters manual.

## Class attributes

| Attribute ID | Access | Name | Need | Data type | Value |
| :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Get | Revision | Optional | UINT | 1 |
| 2 | Get | Max instance | Optional | UINT | 1 |
| 6 | Get | Max ID number of class attribute | Optional | UINT | 7 |
| 7 | Get | Max ID number of instance attribute | Optional | UINT | X |

## Instance attributes

| Attribute ID | Access | Name | Data type | Value |
| :--- | :--- | :--- | :--- | :--- |
| 1 | Get/Set | First parameter of the class | UINT / USINT | Value returned by the drive controller |
| $\ldots$ | $\ldots$ | $\ldots$ | $\ldots$ | $\ldots$ |
| $X$ | Get/Set | Last parameter of the class | UINT / USINT | Value returned by the drive controller |

Note: Certain parameters do not have write access. Refer to the Communication parameters manual for more information.

## Class service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |

## Instances service

| Service code | Service name | Need | Description |
| :--- | :--- | :--- | :--- |
| $16 \# 0 E$ | Get_Attribute_Single | Required | Read an attribute |
| $116 \# 0$ | Set_Attribute_Single | Optional | Write an attribute |

## 13. CIP objects

## ■ Object 2Ahex (AC/DC Drive)

| Path | CIP name | CIP configuration parameter name |
| :--- | :--- | :--- |
| $16 \# 2 A / 01 / 07=42 / 1 / 7$ | SpeedActual | Speed Actual |
| $16 \# 2 A / 01 / 08=42 / 1 / 8$ | SpeedRef | Speed Reference |
| $16 \# 2 A / 01 / 09=42 / 1 / 9$ | CurrentActual | Current Actual |
| $16 \# 2 A / 01 / 0 A=42 / 1 / 10$ | CurrentLimit | Current Limit |
| $16 \# 2 A / 01 / 0 B=42 / 1 / 11$ | TorqueActual | Torque Actual |
| $16 \# 2 A / 01 / 0 \mathrm{C}=42 / 1 / 12$ | TorqueRef | Torque Reference |
| $16 \# 2 A / 01 / 12=42 / 1 / 18$ | AccelTime | Accel Time |
| $16 \# 2 A / 01 / 13=42 / 1 / 19$ | DeceITime | Decel Time |
| $16 \# 2 A / 01 / 14=42 / 1 / 20$ | LowSpdLimit | Low Speed Limit |
| $16 \# 2 A / 01 / 15=42 / 1 / 21$ | HighSpdLimit | High Speed Limit |

Telemecanique adaptation:

| Path | Code | Altivar name | Logic address | Unit Id |
| :--- | :--- | :--- | :--- | :--- |
| $16 \# 2 A / 01 / 07=42 / 1 / 7$ | RFRD | Output velocity | $16 \# 219 C=8604$ |  |
| $16 \# 2 A / 01 / 08=42 / 1 / 8$ | LFRD | Speed setpoint | $16 \# 219 A=8602$ |  |
| $16 \# 2 A / 01 / 09=42 / 1 / 9$ | LCR | Motor current | $16 \# 0 C 84=3204$ |  |
| $16 \# 2 A / 01 / 0 A=42 / 1 / 10$ | ITH | Mot. therm. current | $16 \# 2596=9622$ |  |
| $16 \# 2 A / 01 / 0 B=42 / 1 / 11$ | Otrn | Output torque $(\mathrm{Nm})$ | $16 \# 2 A 0 B=10763$ | 251 |
| $16 \# 2 A / 01 / 0 C=42 / 1 / 12$ | n.a. | Torque setpoint $($ Nm $)$ | $16 \# 2 A 0 C=10764$ | 251 |
| $16 \# 2 A / 01 / 12=42 / 1 / 18$ | ACCD | CIP acceleration time | $16 \# 2 A 12=10770$ | 251 |
| $16 \# 2 A / 01 / 13=42 / 1 / 19$ | DECD | CIP deceleration time | $16 \# 2 A 13=10771$ | 251 |
| $16 \# 2 A / 01 / 14=42 / 1 / 20$ | LSPD | CIP Low speed limit | $16 \# 2 A 14=10772$ | 251 |
| $16 \# 2 A / 01 / 15=42 / 1 / 21$ | HSPD | CIP High speed limit | $16 \# 2 A 15=10773$ | 251 |

## 14. Explicit Messaging

The following figure shows an example of explicit messaging: The value of the ACC parameter (Modbus @ = 9001 / CIP address $16 \# 2 A: 1: 16 \# 12$ ) is modified when the variable "bit01" is toggled On.


The following figure shows the Message Configuration window in detail.


## 15. Device profiles

The EtherNet/IP card provides several profiles:

- CIP AC drive profile ( $0 \times 02$ ) (default setting)
- Allen-Bradley ${ }^{\circledR}$ drive profile
- Telemecanique: CiA 402 and I/O

The profile is chosen by selecting the appropriate input and output assemblies.
"Integration in RSLogix," beginning on page 35 of this manual, describes how to select the assemblies.

## ■ List of assemblies

## Output assemblies

| Assembly name | Number | Size |
| :--- | :---: | :--- |
| CIP basic speed control output | 20 | 2 words (4 bytes) |
| CIP extended speed control output | 21 | 2 words (4 bytes) |
| CIP speed and torque control output | 22 | 3 words (6 bytes) |
| CIP extended speed and torque control output | 23 | 3 words (6 bytes) |
| Native drive output | 100 | 2 to 10 words (4 to 20 bytes) |
| Allen-Bradley ${ }^{\circledR( }$ drive output | 103 | 2 to 10 words (4 to 20 bytes) |

Input assemblies

| Assembly name | Number | Size |
| :--- | :---: | :--- |
| CIP basic speed control input | 70 | 2 words (4 bytes) |
| CIP extended speed control input | 71 | 2 words (4 bytes) |
| CIP speed and torque control input | 72 | 3 words (6 bytes) |
| CIP extended speed and torque control input | 73 | 3 words (6 bytes) |
| Native drive input | 101 | 2 to 10 words (4 to 20 bytes) |
| Allen-Bradley ${ }^{\circledR}$ drive input | 104 | 2 to 10 words ( 4 to 20 bytes) |

## IMPORTANT REMARK:

For the assemblies 20 and 22, the default settings define that the speed setpoint comes from the terminals. To fully control the drive controller from the network, object 2A/1/4 (netref) must be changed from 0 to 1 (byte). This assignment can be accomplished:

- By a program, with an MSG() instruction block, or
- With the Class Instance Editor



## 15. Device profiles

## ■ Assembly 20: CIP basic speed control output

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | CIP basic command word |
| 1 | Speed setpoint (rpm) |

## CIP basic command word

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Not used | Not used | Not used | Not used | Not used | Fault clear (1) | Not used | Run Forward (2) |
| $0=$ Stop |  |  |  |  |  |  |  |
| $1=$ Run command |  |  |  |  |  |  |  |

(1)Active on rising edge.
(2)Active on level.

| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Not used | Not used | Not used | Not used | Not used | Not used | Not used | Not used |

■ Assembly 70: CIP basic speed control input
Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | CIP basic status word |
| 1 | Actual speed (rpm) |

CIP basic status word

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Not used | Not used | Not used | Not used | Not used | Running | Not used | Fault status |
|  |  |  |  |  | $\begin{aligned} & 0=\text { Stopped } \\ & 1=\text { Running } \end{aligned}$ |  | $\begin{aligned} & 0=\text { No fault } \\ & 1=\text { Fault } \end{aligned}$ |


| Bit 15 | Bit 14 | Bit | Bit | Bit 11 | Bit 10 | Bit 9 | Bit 8 |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Not used | Not used | Not used | Not used | Not used | Not used | Not used | Not used |

## - Assembly 21: CIP extended speed control output

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | CIP extended command word |
| 1 | Speed setpoint (rpm) |

## CIP extended command word

| Bit 7 | Bit 6 | Bit 5 |  | Bit 4 | Bit 3 | Bit 2 |  | Bit 1 Bit 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Not used | Network setpoint $\begin{aligned} & 0=\text { Setpoint by terminals } \\ & 1=\text { Setpoint by network } \end{aligned}$ | Network command$\begin{aligned} & 0=\text { Command by terminals } \\ & 1=\text { Command by network } \end{aligned}$ |  | Not used | Not used | Fault clear (1) <br> $0=$ No command <br> 1 = Fault clear |  | Run forward / reverse <br> $00=$ Quick stop <br> 01 = Run forward <br> $10=$ Run reverse <br> 11 = Freewheel stop |
| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 |  | Bit 9 | Bit 8 |
| Not used | Not used | Not used | Not used | Not used | Not used |  | Not used | Not used |

(1)Active on rising edge.

## 15. Device profiles

## Assembly 71: CIP extended speed control input

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | CIP extended status word |
| 1 | Actual speed (rpm) |

## CIP extended status word

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| At reference 0 = Reference not reached 1 = Reference reached | Setpoint from network $0=$ Setpoint from terminals 1 = Setpoint from network | Command from network $0=$ Command from terminals 1 = Command from network | $\begin{aligned} & \text { Ready } \\ & 0=\text { Not ready } \\ & 1=\text { Ready } \end{aligned}$ | Running forward / reverse <br> $00=$ Stopped <br> 01 = Running forward <br> $10=$ Running reverse <br> 11 = Not used |  | Alert signal $0=$ No alert signal 1 = Alert signal | Not used |
| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 |
| Not used | Not used | Not used | Not used | Not used | Bit 8 to bit 10 are used for the drive controller state $000=$ Not used <br> 001 = Startup <br> $010=$ Not ready <br> 011 = Ready <br> 100 = Enabled <br> 101 = Stopping <br> 110 = Fault stop <br> 111 = Drive detected fault |  |  |

## ■ Assembly 22: CIP speed and torque control output

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | CIP basic command word (1) |
| 1 | Speed setpoint (rpm) |
| 2 | Torque setpoint (Nm) |

(1) Refer to assembly 20.

## ■ Assembly 72: CIP speed and torque control input

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | CIP basic status word (1) |
| 1 | Actual speed (rpm) |
| 2 | Actual torque (Nm) |

(1) Refer to assembly 70.

## ■ Assembly 23: CIP extended speed and torque control output

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | CIP extended command word (1) |
| 1 | Speed setpoint (rpm) |
| 2 | Torque setpoint (Nm) |

(1) Refer to assembly 21.

## 15. Device profiles

## ■ Assembly 73: CIP extended speed and torque control input

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | CIP extended status word (1) |
| 1 | Actual speed (rpm) |
| 2 | Actual torque (Nm) |

(1) Refer to assembly 71.

## - Assembly 100: Native drive output

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | Control word |
| 1 | Velocity setpoint |
| 2 | Scanner write word 1 |
| 3 | Scanner write word 2 |
| 4 | Scanner write word 3 |
| 5 | Scanner write word 4 |
| 6 | Scanner write word 5 |
| 7 | Scanner write word 6 |

## Altivar 71/61 assignment

| Word number | Code | Name | Logic address |
| :---: | :--- | :--- | ---: |
| 0 | NC1 | Communication scanner, value of write word 1 <br> (default value:CMD, Control word) | $16 \# 31 D 9=12761$ |
| 1 | NC2 | Communication scanner, value of write word 2 <br> (default value: LFRD, velocity setpoint) | $16 \# 31 \mathrm{DA}=12762$ |
| 2 | NC3 | Communication scanner, value of write word 3 | $16 \# 31 \mathrm{DB}=12763$ |
| 3 | NC4 | Communication scanner, value of write word 4 | $16 \# 31 \mathrm{DC}=12764$ |
| 4 | NC5 | Communication scanner, value of write word 5 | $16 \# 31 \mathrm{DD}=12765$ |
| 5 | NC6 | Communication scanner, value of write word 6 | $16 \# 31 \mathrm{DE}=12766$ |
| 6 | NC7 | Communication scanner, value of write word 7 | $16 \# 31 \mathrm{DF}=12767$ |
| 7 | NC8 | Communication scanner, value of write word 8 | $16 \# 31 \mathrm{E} 0=12768$ |

Note: The default assignment of NC1 and NC2 must be changed to "Not assigned".

## 15. Device profiles

## ■ Assembly 101: Native drive input

## Assembly mapping

| Word number |  |
| :---: | :--- |
| 0 | Scanner read word 1 |
| 1 | Scanner read word 2 |
| 2 | Scanner read word 3 |
| 3 | Scanner read word 4 |
| 4 | Scanner read word 5 |
| 5 | Scanner read word 6 |
| 6 | Scanner read word 7 |
| 7 | Scanner read word 8 |

## Altivar 71/61 assignment

| Word number | Code | Name | Logic address |
| :---: | :--- | :--- | ---: |
| 0 | NM1 | Communication scanner, value of read word 1 <br> (default value: Status word, ETA) | $16 \# 31 C 5=12741$ |
| 1 | NM2 | Communication scanner, value of read word 2 <br> (default value: Velocity actual value, RFRD) | $16 \# 31 C 6=12742$ |
| 2 | NM3 | Communication scanner, value of read word 3 | $16 \# 31 C 7=12743$ |
| 3 | NM4 | Communication scanner, value of read word 4 | $16 \# 31 C 8=12744$ |
| 4 | NM5 | Communication scanner, value of read word 5 | $16 \# 31 C 9=12745$ |
| 5 | NM6 | Communication scanner, value of read word 6 | $16 \# 31 C A=12746$ |
| 6 | NM7 | Communication scanner, value of read word 7 | $16 \# 31 C B=12747$ |
| 7 | NM8 | Communication scanner, value of read word 8 | $16 \# 31 C C=12748$ |

## 15. Device profiles

## ■ Assembly 103: Allen-Bradley ${ }^{\circledR}$ drive output

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | Allen-Bradley ${ }^{\circledR \text { ® drive logic command }}$ |
| 1 | Standardized speed setpoint (reference) |
| 2 | Scanner write word 1 |
| 3 | Scanner write word 2 |
| 4 | Scanner write word 3 |
| 5 | Scanner write word 4 |
| 6 | Scanner write word 5 |
| 7 | Scanner write word 6 |
| 8 | Scanner write word 7 |
| 9 | Scanner write word 8 |

## Altivar 71/61 assignment

| Word number | Code | Name | Logic address |
| :---: | :--- | :--- | :--- |
| 0 | n.a. | Allen-Bradley® drive logic command | n.a. |
| 1 | LFR | Frequency setpoint | $16 \# 2136=8502$ |
| 2 | NC1 | Communication scanner, value of write word 1 | $16 \# 31 D 9=12761$ |
| 3 | NC2 | Communication scanner, value of write word 2 | $16 \# 31 D A=12762$ |
| 4 | NC3 | Communication scanner, value of write word 3 | $16 \# 31 D B=12763$ |
| 5 | NC4 | Communication scanner, value of write word 4 | $16 \# 31 D C=12764$ |
| 6 | NC5 | Communication scanner, value of write word 5 | $16 \# 31 D D=12765$ |
| 7 | NC6 | Communication scanner, value of write word 6 | $16 \# 31 D E=12766$ |
| 8 | NC7 | Communication scanner, value of write word 7 | $16 \# 31 D F=12767$ |
| 9 | NC8 | Communication scanner, value of write word 8 | $16 \# 31 E 0=12768$ |

Note: The default assignment of NC1 and NC2 must be changed to another value or to not assigned.

## 15. Device profiles

## ■ Allen-Bradley ${ }^{\circledR}$ drive logic command

The logic command is a 16 -bit control word produced by the scanner and consumed by the EtherNet/IP card.
If enabled, the logic command word is word 0 in the output image.

| Bit 7 | Bit 6 | Bit 5 Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| MOP Increment <br> $0=$ Not Increment <br> 1 = Increment | Local control $\begin{aligned} & 0=\text { No local } \\ & 1=\text { control } \\ & 1=\text { Local control } \end{aligned}$ | Direction <br> $00=$ No command (4) <br> 01 = Forward command <br> 10 = Reverse command <br> 11 = Hold direction control | $\begin{aligned} & \text { Clear faults (3) } \\ & 0=\text { Not clear faults } \\ & 1=\text { Clear faults } \end{aligned}$ | $\begin{aligned} & \text { Jog } \\ & 0=\text { Not jog } \\ & 1=\text { Jog } \end{aligned}$ | $\begin{aligned} & \text { Start (2) } \\ & 0=\text { Not start } \\ & 1=\text { Start } \end{aligned}$ | $\begin{aligned} & \text { Stop (1) } \\ & 0=\text { Not stop } \\ & 1=\text { Stop } \end{aligned}$ |


| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 Bit 10 | Bit 9 Bit 8 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| MOP Decrement $\begin{aligned} & 0=\text { Not decrement } \\ & 1=\text { Decrement } \end{aligned}$ | $\begin{aligned} & \text { Reference select } \\ & 000=\text { No command (7) } \\ & 001=\text { Setpoint } 1 \text { channel (Fr1) } \\ & 010=\text { Setpoint } 2 \text { channel (Fr2) } \\ & 011=\text { Ref. } 3 \text { (Preset 3) } \\ & 100=\text { Ref. } 4 \text { (Preset 4) } \\ & 101=\text { Ref. } 5 \text { (Preset 5) } \\ & 110=\text { Ref. } 6 \text { (Preset 6) } \\ & 111=\text { Ref. } 7 \text { (Preset } 7) \end{aligned}$ |  |  | Decel rate <br> $00=$ No command (6) <br> 01 = Decel rate 1 command <br> $10=$ Decel rate 2 command <br> 11 = Hold decel rate | ```Accel rate \(00=\) No command (5) \(01=\) Accel rate 1 command \(10=\) Accel rate 2 command 11 = Hold accel rate``` |

(1)Stop: Active at level.
(2) Start: Active on rising edge. A Not Stop condition (logic $0=0$ ) must first be present before a Start condition (logic $1=1$ ) will start the drive controller.
(3) Clear faults: Active on rising edge. To perform this command, the value must switch from " 0 " to " 1 ."
(4) Direction \No command: If a direction is selected, acts like Hold direction control.
(5) Accel rate $\backslash$ No command: If a rate is selected, acts like Hold accel rate.
(6) Decel rate $\backslash$ No command: If a rate is selected, acts like Hold decel rate.
(7)Reference select $\backslash$ No command: If a rate is selected, acts like Hold command.

## ■ Altivar 71/61 assignment

| Bit 7 | Bit 6 |  | Bit 5 Bit 4 |  |  | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Not used | Not used |  | $\begin{aligned} & \hline \text { Direction } \\ & 00=\text { No command (4) } \\ & 01 \text { = Forward command } \\ & 10=\text { Reverse command } \\ & 11 \text { = Hold direction control } \end{aligned}$ |  |  | Clear faults (3) $0=\text { Not clear faults }$ $1 \text { = Clear faults }$ | Not used | Start (2) $\begin{aligned} & 0=\text { Not start } \\ & 1=\text { Start } \end{aligned}$ | $\begin{aligned} & \text { Stop (1) } \\ & 0=\text { Not stop } \\ & 1=\text { Stop } \end{aligned}$ |
| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 |  |  |  |
| Not used | $\begin{aligned} & \text { Setpoint select } \\ & 000=\text { No command } \\ & 001=\text { Terminals } \\ & 010=\text { Control by network } \\ & 011=\text { Preset } 3 \\ & 100=\text { Preset } 4 \\ & 101=\text { Preset } 5 \\ & 110=\text { Preset } 6 \\ & 111=\text { Preset } 7 \end{aligned}$ |  |  | Not used | Not used | Not used |  | Not used |  |

(1)Stop: Active at level.
(2) Start: Active on rising edge. A Not Stop condition (logic $0=0$ ) must first be present before a Start condition (logic $1=1$ ) will start the drive controller.
(3)Clear faults: Active on rising edge. To perform this command, the value must switch from " 0 " to " 1 ."
(4) Direction \No command: If a direction is selected, acts like Hold direction control.

## 15. Device profiles

## Standardized setpoint

The setpoint (16 bits only) is produced by the controller and consumed by the EtherNet/IP card.
If enabled, the setpoint is word 1 in the output image.
The setpoint value is a standardized (scaled) value; it is not an engineering value.

## Telemecanique adaptation

[Frequency setpoint] ( $L F_{r}$ ) is configured in high resolution: standardized value on 16 signed bits at maximum frequency. The value 32767 corresponds to the parameter [Max frequency] $\left(E_{F_{r}}\right)$. The default value of the parameter [Max frequency] ( $t_{r} F_{r}$ ) is 60 Hz , and the resolution is approximately 0.0018 Hz .

## Note:

The commanded maximum speed can never exceed the value of parameter [High speed] (HSP).
The table below shows example setpoints and their results on an Altivar drive controller that has its parameter [Max frequency] ( $t F_{r}$ ) set to 130 Hz and its parameter [High speed] (H5F) set to 60 Hz .

| Setpoint value | Scale |  | Output speed | Feedback value |
| :--- | :--- | :--- | :--- | :--- |
|  | Percent | Value |  |  |
| $32767(1)$ | $100 \%$ | 130 Hz | $60 \mathrm{~Hz}(2)$ | $15123(3)$ |
| 16384 | $50 \%$ | 65 Hz | $60 \mathrm{~Hz}(2)$ | 8192 |
| 8192 | $25 \%$ | 32.5 Hz | 32.5 Hz | 0 |
| 0 | $0 \%$ | 0 Hz | 0 Hz |  |

(1)A value of 32767 is equivalent to the parameter [Max frequency] ( $L F_{r}$ ) frequency value. Values greater than 32767 reverse speed.
(2) The drive controller runs at 60 Hz instead of 130 Hz or 65 Hz because the parameter [High speed] (H 5 P) sets 60 Hz as the maximum speed.
(3) The feedback value is also scaled based on the value of the parameter [Max frequency] ( $E F_{r}$ ), for example, $60 / 130=0.46$ so $32767 \times 0.46=15123$.

## ■ Assembly 104: Allen-Bradley ${ }^{\circledR}$ drive input

## Assembly mapping

| Word number | Definition |
| :---: | :--- |
| 0 | Allen-Bradley $^{\circledR 3}$ drive logic status |
| 1 | Speed feedback (actual value) |
| 2 | Scanner read word 1 |
| 3 | Scanner read word 2 |
| 4 | Scanner read word 3 |
| 5 | Scanner read word 4 |
| 6 | Scanner read word 5 |
| 7 | Scanner read word 6 |
| 8 | Scanner read word 7 |
| 9 | Scanner read word 8 |


| Word number | Code | Name | Logic address |
| :---: | :--- | :--- | :--- |
| 0 | n.a. | Allen-Bradley ${ }^{\circledR}$ drive logic status | n.a. |
| 1 | RFR | Output frequency | $16 \# 0 C 82=3202$ |
| 2 | NM1 | Communication scanner, value of read word 1 | $16 \# 31$ C5 = 12741 |
| 3 | NM2 | Communication scanner, value of read word 2 | $16 \# 31 \mathrm{C} 6=12742$ |
| 4 | NM3 | Communication scanner, value of read word 3 | $16 \# 31 C 7=12743$ |
| 5 | NM4 | Communication scanner, value of read word 4 | $16 \# 31 C 8=12744$ |
| 6 | NM5 | Communication scanner, value of read word 5 | $16 \# 31 C 9=12745$ |
| 7 | NM6 | Communication scanner, value of read word 6 | $16 \# 31 C A=12746$ |
| 8 | NM7 | Communication scanner, value of read word 7 | $16 \# 31 C B=12747$ |
| 9 | NM8 | Communication scanner, value of read word 8 | $16 \# 31 C C=12748$ |

Note: The default assignment of NM1 and NM2 must be changed to "Not assigned."

## 15. Device profiles

## - Allen-Bradley ${ }^{(8)}$ drive logic status

Logic Status is a 16-bit status word produced by the EtherNet/IP card and consumed by the scanner. If enabled, Logic Status is word 2 in the input image.

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Fault | Alarm | Decelerating | Accelerating | Actual direction | Command direction | Active |  |
| $0=$ No fault | $0=$ No alarm |  |  |  |  |  |  |
| $1=$ Fault | $1=$ Alarm | Not decelerating <br> $1=$ Decelerating | $0=$ Not accelerating <br> $1=$ Accelerating | $0=$ Reverse <br> $1=$ Forward | $0=$ Reverse <br> $1=$ Forward | $0=$ Not active <br> $1=$ Active | $0=$ Not ready <br> $1=$ Ready |


| Bit 15 Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reference <br> $0000=$ Ref $A$ auto <br> $0001=$ Ref $B$ auto <br> $0010=$ Preset 2 auto <br> $0011=$ Preset 3 auto <br> $0100=$ Preset 4 auto <br> $0101=$ Preset 5 auto <br> $0110=$ Preset 6 auto <br> $0111=$ Preset 7 auto <br> $1000=$ Term blk manual <br> 1001 = DPI 1 manual <br> $1010=$ DPI 2 manual <br> 1011 = DPI 3 manual <br> $1100=$ DPI 4 manual <br> $1101=$ DPI 5 manual <br> 1110 = DPI 6 manual <br> 1111 = Jog reference |  |  | Local con <br> $000=$ Por <br> 001 = Por <br> 010 = Por <br> 011 = Por <br> $100=$ Por <br> 101 = Por <br> $110=$ Por <br> 111 = No |  |  | At speed <br> $0=$ Not at reference <br> 1 = At reference |

## Telemecanique adaptation



Note: When the value of Setpoint source (bits 12, 13, 14, and 15) is Preset speed $x$, it means that the corresponding command is given by assembly 103 via Setpoint select (bits 12, 13, and 14) and not by the terminals.

## 16. Configuring an ATV71/61 drive to replace a Powerflex ${ }^{\circledR}$ drive

This chapter illustrates how to exchange a Powerflex ${ }^{\circledR}$ drive with an ATV71 drive controller. There are three ways to configure a drive controller equipped with an EtherNet/IP card. This example uses RSlogix ${ }^{\circledR}$ software.

## IMPORTANT NOTE:

The ATV71/61 drive controller provides several assembly sets. Assemblies 103 and 104 emulate Powerflex drive assemblies 1 and 2. For compatibility, these assemblies are interchangeable. This means that in the ATV71/61:

- output assemblies 103 and 2 are identical and
- input assemblies 104 and 1 are identical.

In the following example assumes a network consisting of a single Powerflex drive. It describe how to replace the Powerflex drive with an ATV71 drive controller.


## 16. Configuring an ATV71/61 drive to replace a Powerflex® drive

Place the RSlogix environment Offline as shown below.


Then edit the module properties of the ethernet module Powerflex by double-clicking in the navigation tree.


## 16. Configuring an ATV71/61 drive to replace a Powerflex® drive

Notice that only the Module Name is changed.


Confirm the modification by clicking OK, save the project, and download it to the PLC.

## 16. Configuring an ATV71/61 drive to replace a Powerflex® drive

Now, switch to RSnetworx, The old configuration is displayed:


Browse the whole network:


## 16. Configuring an ATV71/61 drive to replace a Powerflex® drive

Once the network has been scanned, you should obtain this:


This last screen is the ATV71 drive controller data screen.


30072-452-35

# Altivar ${ }^{\circledR}$ 61/71 EtherNet/IP Card VW3A3316 Reference Sheet 

Retain for future use.

## Please Note

Table 1: Installation and Programming Manuals

| $\begin{array}{l}\text { Drive } \\ \text { Family }\end{array}$ | $\begin{array}{l}\text { Range } \\ \text { (hp) }\end{array}$ | $\begin{array}{l}\text { Installation } \\ \text { Manual } \\ \text { Module No. }\end{array}$ | $\begin{array}{l}\text { Programming } \\ \text { Manual } \\ \text { Module No. }\end{array}$ |
| :--- | :--- | :--- | :--- |
| ATV61 | $0.5-100$ | $\begin{array}{l}\text { 1760643 } \\ \text { (atv61s_installation__ } \\ \text { manual) }\end{array}$ | $\begin{array}{l}1760649 \\ \text { (atv61_programming_ } \\ \text { manual) }\end{array}$ |
|  | $75-800$ | $\begin{array}{l}\text { 1760655 } \\ \text { (atv61e_installation_ } \\ \text { manual) }\end{array}$ | $\begin{array}{l}\text { 1755843 } \\ \text { (atv71s_installation_- } \\ \text { manual) }\end{array}$ | \(\left.\begin{array}{l}1755855 <br>

(atv71_programming_ <br>
manual)\end{array}\right\}\)

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www.us.Telemecanique.com

Before installing or operating the Altivar ${ }^{\circledR}$ 61/71 EtherNet/IP Card:

1. For complete installation and operation instructions, refer to the installation and programming manual provided with your drive controller. See Table 1.
2. Read and understand the instructions in bulletin 30072-452-35, Altivar ${ }^{\circledR}$ 61/71 EtherNet/IP Card VW3A3316, and the following instructions before performing any procedure on the drive controller.

You can download these documents from the Technical Library at www.us.Telemecanique.com.

## A DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Read and understand this document before installing or operating the Altivar 61/71 EtherNet IP Card VW3A3316. Installation, adjustment, repair, and maintenance must be performed by qualified personnel.
- The user is responsible for compliance with all international and national electrical code requirements with respect to grounding of all equipment.
- Many parts of this drive controller, including the printed circuit boards, operate at the line voltage. DO NOT TOUCH. Use only electrically insulated tools.
- DO NOT touch unshielded components or terminal strip screw connections with voltage present.
- DO NOT short across terminals PA/+ and PC/- or across the DC bus capacitors.
- Before servicing the drive controller:
- Disconnect all power, including external control power that may be present.
- Place a "DO NOT TURN ON" label on all power disconnects.
- Lock all power disconnects in the open position.
- WAIT 15 MINUTES to allow the DC bus capacitors to discharge. Then follow the DC Bus Voltage Measurement Procedure in the installation manual for your drive controller (see Table 1) to verify that the DC voltage is less than 45 V . The drive LED is not an indicator of the absence of DC bus voltage.
- Install and close all covers before applying power or starting and stopping the drive controller.

Failure to follow these instructions will result in death or serious injury.

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.
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## 13. Kingfisher

K I N G F I S HER RTUs

## toolbox

Kingfisher Series II RTU Configuration Software


| Document Control |  |
| :---: | :---: |
| Document Title | Toolbox - Kingfisher Series II RTU Configuration Software |
| Master File Name | ToolboxManual.doc |
| Master Location | RAD\Release\Manuals\Toolbox |
| Copyright | Copyright © RTUnet (Australia) Pty Ltd. ABN 35006805910 Info@rtunet.com, www.rtunet.com |
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| Revision History |  |  |
| :---: | :---: | :---: |
| Rev. | Date | Summary |
| 1.23a | 22/01/1996 | Release 1. (Version number matches Toolbox software version.) |
| 1.31b | 09/04/1998 | Release 2. |
| 1.35b | 20/07/2000 | Release 3. |
| 1.41c | 18/10/2001 | Release 4. |
| 1.41j | 17/10/2002 | Release 5. |
| $1.41 \mathrm{j}-2$ | 31/10/2002 | Release 6. |
| 1.43 d | 30/07/2004 | Release 7. |
| 1.44a | 06/01/2005 | Release 8. |
| 1.44d | 17/11/2005 | Release 9. |
| 1.45a | 10/8/2006 | Release 10. Added all the new information from the online help. Added an initialisation string option for dialling up a paging service. Added socket information for ethernet ports. Added a new command for setting up CDMA modems. Modbus driver can now support 6 digit (extended) addressing. Post TX delay descriptions updated for RS485. Updated the topic Configuration - Spread Spectrum Radio. New establish ethernet connection bit \#YLSTrrr.11. Added appendix - Communicating With A Kingfisher G3. The Redundant Communications topic now shows how to change a comms path as well as a port. Moved topic Example - Primary / Secondary RTUs to Redundancy appendix D. Added port information for Trio M Series radios. |

## FOREWORD

To get a basic RTU configuration loaded fast, please see the Quick Start section (you can even skip this foreword!)

For a more detailed overview of Kingfisher RTUs and their functionality, simply review chapters 1 and 2 (introductory information and explanations) and then step through each section of chapter 3 (which details the options of the Toolbox Configuration menu). An RTU is configured by setting up some of the options in the Configuration menu and then adding intelligence to the RTU by using ladder logic. Examples of ladder logic are detailed in Chapter 5 with each type of ladder block being described in chapter 4. You may choose to review sections of Appendix K - RTU Data if you would like to know how to access various types of RTU data (eg. time information).

As new versions of Toolbox, Toolbox Help, RTU firmware and documentation become available, these are released on the RTUnet web site: www.rtunet.com/support

We hope this manual will answer most of your questions but if you need more help, please do not hesitate to contact your local Kingfisher representative or our technical support staff at RTUnet and we will do our best to help you.

Thankyou for choosing the RTU that is reliably serving people around the world.
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## QUICK START

Don't want to read this lovely thick manual? Then this section will help you bypass all the detail and get a basic RTU configuration loaded fast! Just follow the steps below.

- All Kingfisher Series II (pronounced '2') RTUs (remote terminal units) are configured using Toolbox software (for installation tips, please see the topic Getting Started, Installing Toolbox). All Toolbox menu commands below are shown in italics.
- If you have an LP-1 RTU, you are reading the wrong manual! Please see the LP-1 Product Manual available from the RTUnet website www.rtunet.com.
- Power up the RTU. If you are not sure how, please see the RTU Layout section of the Installation Manual available from the RTUnet website www.rtunet.com. A basic guide is shown below.

- Connect the Toolbox cable to port 1 of the RTU as shown below. Note: if you only have USB ports on your PC (and no DB9 serial COM ports), you will need a USB to 9-pin RS-232 serial converter cable.

- Start Toolbox. Ensure Toolbox is using the correct PC communications port (usually COM1). The COM port can be changed from the Toolbox menu - Configuration, PC Setup. You can then automatically detect the address and baudrate of the RTU using View, Auto Detect. If you are using the correct COM port and it is working correctly, you will see the 'Rx' LED on the processor module flash during the Auto Detect.
- If you have any IO (input / output) modules (that allow inputs and outputs to be wired up), the state of all the inputs and outputs can be viewed from View, Hardware Overview. By clicking on the Slot button, the details for each module can be viewed.
- A new RTU configuration file is created by selecting File, New. The new configuration file can be saved using an appropriate name by selecting File, Save As and specifying a different name or the default name (NEW.SDB) can be used.
- The following items are all configured from the Configuration menu. The default settings that need to be changed are detailed below.
Address and Description - Set Site Address to a number in the range of 1 to 249 eg. 1. System Parameters - Set RTU/CPU Type to match the RTU processor you are using eg. CP10/11.
Memory - Set Image Buffer to at least 32K if using image capture.
Port List - Click button '2' you have a port 2 option board installed. The default settings are for an RS232 serial option port (labelled SER-I or SER-S). Click OK if using RS232 or change Type to match the option port. For more information on the various port settings please see the topic Configuration, Port List. Note: if you have more communication ports, these will also need to be configured. Usually each port is assigned the next available port number as illustrated below.
Network List - Only used if communicating with other RTUs. Please see the topic Configuration, Network List for more information.

- Save the configuration by selecting File, Save.
- Extra functionality is added to the RTU using firmware drivers. If you would like to use a communications driver (eg. Modbus), perform SMS paging or use a special feature, you will need to download a firmware driver. A driver listing is available from the RTUnet website. Standard drivers are available from the website and can be downloaded using Toolbox by selecting Utilities, Advance, Download Firmware Driver.
- Download the configuration file (Filename.SDB) into the processor module from Configuration, Download RTU Configuration. When asked "Download Ladder Logic now?", select No (there isn't any ladder logic yet!)
- Ladder logic is used to add more intelligence to the RTU. Basic RTU configurations that have ladder logic are available from the RTUnet website. Explanations about ladder logic and how to create it are contained in the Ladder Logic chapter. Sample ladder logic code is contained in the Ladder Logic Examples chapter.
- Ladder logic must be compiled before it is downloaded. First select Ladder (or Logic), Compile and then select Ladder (or Logic), Download To RTU.
- The RTU is now configured and ready for operation! You can check that everything is OK by selecting View, RTU Status. Check that I/O Processing and Logic Processing both say 'Enabled' and that the RTU time is updating.


## CHAPTER 1 INTRODUCTION

### 1.1 What Is A Remote Terminal Unit (RTU)?

Telemetry is electronic equipment that is like a small computer. Unlike a small computer, telemetry can be wired to a whole range of devices like switches, relays and transducers (for measuring flowrates, levels etc). Each telemetry unit can monitor and control the things it is wired to. Many telemetry systems are used to monitor and control equipment in distant or remote places. This has led to the common term - Remote Terminal Unit or 'RTU' for short.

There are two types of devices that a telemetry unit can be wired to - digital and analog. A digital signal is an ON or OFF state of a switch or relay. An analog signal is a variable measurement like flowrate, tank level or valve position etc.

Because an RTU contains a small computer, it can make its own decisions about when to set its outputs on and how long to keep them on for. An RTU can also decide when it's got something new to tell another RTU and can then initiate communications. A data radio, a private line or a PSTN modem is commonly used for the communication path.

A Kingfisher Series II RTU is comprised of up to 64 modules that plug onto 1 or more backplanes.


### 1.2 Master And Outstation RTUs

When there are two or more RTUs, one RTU is usually set up as the 'Master' RTU so that it is able to talk to all the other RTUs. These other RTUs are referred to as 'Outstation' RTUs. RTUs can directly communicate with each other or they can indirectly communicate via 'store and forward' RTUs. A store and forward RTU is an RTU that has been setup to store and then forward messages that are not for itself. In figure 1.2, RTU1 is the master RTU. RTUs 2,3 and 4 are outstation RTUs and RTU3 is also a store and forward RTU between RTU1 and RTU4.

The task of the master RTU is to get a copy of all the relevant information from the outstation RTUs. This information may include the outstation RTU's inputs, outputs and local registers (local registers are used for things like counting and keeping totals).


Figure 1.2: Example RTU Network

Every RTU has three places for storing data: Hardware Registers (hardware inputs and outputs), Local Registers and Network Registers. When data is sent from one RTU to another, the data is always stored as network registers in the destination RTU. Network registers are simply a copy of the hardware and local registers that are received from the sending RTU.

Figure 1.2 illustrates how local data in RTUs 2,3 and 4 is stored as network data in RTU1. For example, if local register 5 (\#R5) is sent from RTU2 to RTU1, it will be stored as RTU2 network register 5 in RTU1 (\#NR2.5).

### 1.3 Polling And Exception Reports

There are two ways that a copy of all the system data can be accumulated in the Master RTU. These are:

- Polling

The master RTU regularly calls each outstation RTU and gets its data whether it has changed or not. In a system that only uses polling it takes approximately 0.1 to 10 seconds to poll each site in turn depending on baud rates and network configuration.

## - Exception Reporting

Each outstation RTU monitors its analog and digital input signals and when a digital changes state or an analog changes significantly, the outstation RTU sends all its relevant data to the master RTU (an RTU can also be configured to exception report on almost any other condition).

If only polling is used, it will take up to the poll time before the master RTU knows about new data. Eg. if the master polls its outstation RTUs every 2 minutes, it will take up to 2 minutes before the master receives any new data.

If only exception reporting is used then there is a chance that the master RTU will never know that an outstation RTU has failed. If the master RTU does not hear from an outstation RTU for a long time this could mean that either there is no new data or that the outstation RTU has failed.

The best method is to use both polling and exception reports. This means that if an outstation RTU fails, the master RTU will find out about the fail when it performs the next poll. And as soon as a data value changes, the master RTU will be told about it by an exception report.

### 1.4 RTU Communications

An RTU network communicates between all its RTUs using a serial data stream. This means that a series of logical 1's and 0's are sent over the communications channel and then decoded by the receiving RTU. For every message that is sent, a 16-bit Cyclic Redundancy Check (CRC) is also sent. The CRC is used for error checking and allows the RTU to determine if the message has been corrupted. By using a CRC of this length it is virtually impossible for an erroneous message to be accepted by the receiving RTU. If a message is detected with an error, the sending RTU simply retransmits the message until it is received accurately or until the sending RTU stops trying.

### 1.5 Toolbox Software

Toolbox is a software program that allows users to configure and view information from Kingfisher Series II RTUs.

Toolbox allows off-line configuration which means that an RTU configuration can be created without the PC being connected to an RTU. The configuration can then be downloaded to the RTU at another time.

In the following sections, the Toolbox menu to use to perform the particular function is shown in Italics eg. View, Auto Detect.

## CHAPTER 2 GETTING STARTED

### 2.1 Building An RTU

Every RTU must have a power supply and a processor (CPU) module. Most RTUs also have some inputs and outputs as well. The two main types of power supplies are a PSU-3 and a PS$11 / 21$. The two main types of processors are a PC-1 and a CP-11/21. A PSU-3 is used with a PC-1 and a PS-11/21 is used with a CP-11/21 as shown below. A wide variety of input and output modules are available and these can be used in any combination.

Both types of RTUs are configured the same way with the same Toolbox software. However, the PC-1 RTU was designed to be a simpler RTU and does not have the same speed, memory and functionality of a CP-11/21 RTU.

A PC-1 module can only be used on a 4-slot backplane (a BA-4) and is installed in the left-most slot. A CP-11/21 can be used on a 4, 6 or 12 slot backplane (a BA-40, BA-6 or BA-12 respectively) and can be placed in any slot. Usually the CP-11/21 is installed in slot 2 (the second slot from the left) and the PS-11/21 power supply is installed in slot 1 . Typical RTU layouts are shown below.


Figure 2.1a: Example RTU Layouts
A number of backplanes can also be linked together to allow one processor module to control up to 6310 modules.

### 2.2 Installing Toolbox

To Install Toolbox, Run SETUP.EXE. By following the prompts, Toolbox will be installed on your hard disk and a Windows program group will be created.

Latest Versions: A number of Toolbox files are available from the RTUnet web site (www.rtunet.com/support) which are used to upgrade a full install of Toolbox. The latest Toolbox help file is also available.

### 2.3 Communicating With An RTU

Caution! After assembling your Series II RTU by plugging all the modules into the backplane and then powering up the power supply, it is recommended that modules are not removed or installed while the RTU is powered up. Changing modules while the RTU is powered up will usually cause a warm start to occur which may affect the state of outputs.

## Establishing Communications

Connect the Toolbox cable to port 1 of the RTU as shown below. Note: if you only have USB ports on your PC (and no DB9 serial COM ports), you will need a USB to 9-pin RS-232 serial converter cable.


COM port 1 and a baud rate of 9600 are commonly used between the PC and RTU. If COM1 is being used by another device, you can use COM2 to COM16 or ethernet for RTU communications but you will need to change the port setting in Toolbox using the menu Configuration, PC Setup. You can then automatically detect the address of the RTU by using View, Auto Detect.

Note: if two or more programs (eg. Toolbox and Citect) are polling the RTU, each program should have a unique address. This is because the RTU treats each program like another RTU and may get confused about which port each program is connected to. The address for Toolbox is configured from the menu Configuration, PC Setup. Both Toolbox and Citect use address 255 by default and may clash. For more information, please see the topic Configuration - PC Setup.

Assuming that you are using the correct COM port (as specified in the PC Setup), Auto Detect will first try to talk to the local RTU at the baud rate configured in the PC Setup. If the baud rate is correct, Auto Detect will return the address of the RTU. If the baud rate is incorrect, an option will appear asking if you would like Toolbox to automatically search at the other baud rates. Note: you can tell if the RTU receives a message if the RX LED on the port flashes. If the RX LED does not flash at all, then a message has not been sent to the RTU and there is something wrong with the COM port setup or with the PC.

## RTU Status

You can view the current state of the RTU using the menu - View, RTU Status. An example RTU Status window is shown in View - RTU Status.

The time field will keep updating every time Toolbox polls the RTU. The Comms Repeat Rate of the PC Setup (Configuration, PC Setup) determines the polling rate.

### 2.4 Reading And Writing Module Data

The types of RTU modules that are present are automatically detected by Toolbox. There can be up to 4 racks of 16 modules, which can be of almost any mix and position on the rack. The module types and their slot positions can be viewed using - View - Hardware Overview.

| RTU Hardware Overview |  |  |  |  |  |  |  | x |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Slot | Module | Slot | Mod | Slot | Mod | Slot | Module |  |
| $\square$ | $\begin{aligned} & \text { PC-1 } \\ & 10-4 \end{aligned}$ | 17 |  | 33 |  | 49 |  |  |
| 2 |  | 18 |  | 34 |  | 50 |  |  |
| 3 |  | 19 |  | 35 |  | 51 |  |  |
| 4 |  | 20 |  | 36 |  | 52 |  |  |
| 5 |  | 21 |  | 37 |  | 53 |  |  |
| 6 |  | 22 |  | 38 |  | 54 |  |  |
| 7 |  | 23 |  | 39 |  | 55 |  |  |
| 8 |  | 24 |  | 40 |  | 56 |  |  |
| 9 |  | 25 |  | 41 |  | 57 |  |  |
| 10 |  | 26 |  | 42 |  | 58 |  |  |
| 11 |  | 27 |  | 43 |  | 59 |  |  |
| 12 |  | 28 |  | 44 |  | 60 |  |  |
| 13 |  | 29 |  | 45 |  | 61 |  |  |
| 14 |  | 30 |  | 46 |  | 62 |  |  |
| 15 |  | 31 |  | 47 |  | 63 |  |  |
| 16 |  | 32 |  | 48 |  | 64 |  |  |
|  |  |  | OK | Help |  |  |  |  |

By clicking the button next to any of the modules that appear, the module input and output (IO) details are displayed on the screen. You can then view inputs and set outputs using Toolbox (the outputs can only be changed if they are not being controlled by ladder logic).

## CHAPTER 3 CREATING A NEW CONFIGURATION

### 3.1 Configuration - New Project

A project is used to group all the RTU Configurations in a telemetry system. To create a new project select File, Open new or existing Project... The window below will then be displayed.


First double-click on the yellow Folders to select where you would like to store the new project.
Then enter the file name and click OK. The file name can be quite long and may contain spaces. It cannot contain any of the following characters: $\backslash /:$ *? " < > |

You will then be prompted with the window below:
Open a New or Existing Project X


After clicking Yes, the window below will be displayed.


Finally, select File, Save to create the project file (Filename.PRJ).

### 3.2 Configuration - New Site

After you have created or opened a project, you can now create an RTU site. An RTU site (Filename.SDB) is a text file that contains all the communication settings for the RTU. To create a new site, select File (or Project), Add a Site or Logic File. The window shown below will then be displayed.


Please enter a file name with no file name extension eg. Pump Station (as shown above) and then click OK. The file name can be quite long and may contain spaces. It cannot contain any of the following characters: \/ : * ? " < > |

You will then be prompted with the window below:


After clicking Yes, you will be prompted for some more information. An example window with the information filled in is shown below:


The above information should be filled in according to the next section - Configuration - Address and Description.

After clicking OK, the new site will now appear in the project window as shown below.

| W. Water Project.PRJ |  |  | - - |
| :---: | :---: | :---: | :---: |
| Site gsi: Pump Sta Pump Station Master RTUM: |  |  |  |
|  |  |  |  |

When a Project file is open (ie. it is the active window), RTU sites can be added or removed from the project by using the menu Project, Add A Site Or Logic File or Project, Remove Site.

By double clicking on 'Site 001: etc' in the project window, the Pump Station.SDB file will appear. You will then be able to configure the rest of the RTU options from the Configuration menu as shown below.

| Address \& Description |  |
| :--- | :--- |
| System Parameters |  |
| Memory |  |
| Port List |  |
| Network List |  |
| I/O Modules List |  |
| Fhone Directory |  |
| TMR Directory |  |
| Pager Configuration |  |
| PC Setup | F8 |
| Download RTU Config |  |

Figure 3.2a: Configuration Menu
An RTU is configured by stepping through each of the above configuration options and filling in the appropriate information as detailed in the following sections.

### 3.3 Configuration - Address \& Description

Each RTU in the telemetry system should have a unique address. This allows the RTUs to communicate with each other one at a time and avoids communication fails.


Figure 3.3a: Address And Description window (displayed if a project is being used)
Site Address: (0-249) Address 250 is reserved for paging parameters and addresses 251 to 255 are reserved for Toolbox (configured in Configuration, PC Setup) as a PC running Toolbox is treated like an RTU. Address 0 should not be used for an RTU in a network as address 0 is the global address. Every RTU (no matter what its address is) will respond to messages for RTU 0 . Address 1 is commonly used for the master RTU.

Site Name: (Only visible when a project is open) 8-character site description. By default, the first 8 characters of 'Filename.SDB' are used.

Site Description: (Optional) A 32-character comment used to describe the RTU site.

### 3.4 Configuration - System Parameters

System parameters are the parameters that affect the general communications of the entire RTU. Please ensure 'RTU/CPU Type' is set to the type of RTU you are using. The default values for the other parameters can be used in most cases and are detailed below.


Figure 3.4a: Example System Parameters For A Master RTU


Figure 3.4b: Example System Parameters For An Outstation RTU

RTU Type: The type of processor used by the RTU: CP-1, PC-1, CP-10/11, CP-21, SBX, ERS Micro, LP-1, SB-1, Micro-4 or Other. This setting allows Toolbox to compile ladder logic in the correct format (for each microprocessor type).

I/O Scan Interval: The period (in milliseconds) at which the RTU scans all its IO modules and processes ladder. By increasing the period at which the RTU scans its IO modules and processes its ladder, more time is left over for responding to incoming messages on the RTU's communication ports. This setting is particularly useful for a master RTU that has two or more RS232 communication ports that are constantly in use. The I/O Scan Interval can be set to 100 milliseconds for a master RTU and 0 for an outstation RTU. Note: a zero I/O Scan Interval will cause a 'Scan Overrun' system flag to appear in the RTU Status. Scan Overrun means that the RTU cannot process all the IO and ladder at the configured interval. A zero setting will cause the RTU to scan as fast as possible.

System ID: The communications sync character used to screen incoming messages. An RTU will only 'hear' and respond to messages that have the same sync character as this System ID. It is recommended that the AE default be used except when configuring a store-and-forward RTU as detailed in the section 'Configuration - Network List, System ID'.

RTU Status Register: Blank or a local register (\#R). If a local register is entered, the RTU system status register ( \#YSTAT) will be continuously copied into this register even if ladder logic is disabled. This option makes it possible to monitor the RTU status and alarm if the IO Processing and/or Logic Processing is disabled or corrupted.

DNP Base Register: (\#R) A local register defining the beginning of a block of 64 registers (RTUnet uses \#R129 by default). All the DNP3 parameters are defined in these registers by using ladder logic. The definition of each register in the 32-register block is available from RTUnet by request.

Comms Priority: ( 0,1 or 2 ) Comms Priority defines how often the RTU tries sending messages after a communications failure. A Comms Priority of 0 is used by default. The 'Message Retries' parameter mentioned below is configured for each RTU in Configuration - Network List.

- Priority 0: Each message will have up to 'Message Retries' or until it is successful. The Global Retries field is ignored.
- Priority 1: Each Message will have up to 'Message Retries' or the amount specified in the 'Global Retries' field (whichever is less). Once communications to an RTU have failed more than the 'Global Retries' setting, the next messages will only be sent once until a successful message is received from that RTU.
- Priority 2: Each Message will have up to 'Message Retries' or the amount specified in the 'Global Retries' field (whichever is less). Once communications to an RTU have failed more than the 'Global Retries' setting, no more messages will be sent to that RTU until a successful message is received from that RTU.

Global Retries: This is the total number of allowable consecutive communication attempt failures for any RTU site before action is taken. This field is only used when a Comms Priority of 1 or 2 is configured (please see above).

Eg. After 10 communication fails in a row to RTU2, RTU1 will then only have one attempt at each new message to RTU2. RTU2 will continue to have up to 3 retries at each new message to RTU1. The global retries setting for each RTU will be:

| Master RTU1 | Outstation RTU2 |
| :--- | :--- |
| Priority=1  <br> Global Retries=10 Comms Link | Priority=0 <br> Global Retries=0 |
| Network List <br> RTU2 Message Retries=3 |  |
|  |  |

Global Timeout: This parameter is used with the 'Timeout' setting of the Network List for each network RTU. An RTU will wait for 'Timeout' milliseconds for a reply to its first message attempt. If more attempts are required, the RTU will wait a combination of 'Timeout' and 'Global Timeout' milliseconds before initiating the next attempt or recording a message failure as detailed in the 'Timeout' section of the Network List.

Quiet Time before TX: The minimum amount of quiet time that an RTU will wait before sending a message. Used to implement priority in a radio system to prevent message clashes. Quiet Time Before TX is usually set to 0 in the master RTU. When used in store-and-forward RTUs, messages are delayed by this time before being forwarded and so a Quiet Time of 1000ms is often used in store-and-forward RTUs.

Update Register Blocks and Update Hardware Blocks: (ALL, NONE, 16\#0000 to 16\#FFFF) The local register blocks and hardware register blocks that will be checked and polled (if they have changed) when an 'Rx Update' message is received from another RTU. A hexadecimal constant (please see the appendix - Hexadecimal Numbers) can be entered corresponding to the blocks to update. Alternatively, you can enter 'ALL' (all blocks are updated) or 'NONE' (none of the blocks are updated). When 'ALL' is selected (or 16\#FFFF hex) for Update Register Blocks, all 2048 local registers are updated. Note: a maximum of 16 register and hardware blocks can be checked and updated for each RTU. Ie. If 'ALL' is specified for Update Register Blocks, then 'NONE' must be specified for Update Hardware Blocks and vice versa.

| Local Reg. Block 1 | \#R1 to \#R64 | Ch1 | 0001 He |
| :---: | :---: | :---: | :---: |
| Local Reg. Block 2 | \#R65 to \#R128 | Ch2 | 0002 Hex |
| Local Reg. Block 3 | \#R129 to \#R192 | Ch3 | 0004 He |
| Local Reg. Block 4 | \#R193 to \#R256 | Ch4 | 0008 Hex |
| Local Reg. Block 5 | \#R257 to \#R320 | Ch5 | 0010 He |
| Local Reg. Block 6 | \#R321 to \#R384 | Ch6 | 0020 Hex |
| Local Reg. Block 7 | \#R385 to \#R448 | Ch7 | 0040 He |
| Local Reg. Block 8 | \#R449 to \#R512 | Ch8 | 0080 He |
| Local Reg. Block 9 | \#R513 to \#R576 | Ch9 | 0100 He |
| Local Reg. Block 10 | \#R577 to \#R640 | Ch10 | 0200 He |
| Local Reg. Block 11 | \#R641 to \#R704 | Ch11 | 0400 H |
| Local Reg. Block 12 | \#R705 to \#R768 | Ch12 | 0800 He |
| Local Reg. Block 13 | \#R769 to \#R832 | Ch13 | 1000 He |
| Local Reg. Block 14 | \#R833 to \#R896 | Ch14 | 2000 He |
| Local Reg. Block 15 | \#R897 to \#R960 | Ch15 | 4000 He |
| Local Reg. Block 16 | \#R961 to \#R1024 | Ch16 | 8000 |

Hexadecimal constants for Update Hardware Blocks

| Analog Modules 1-8 | \#A1.1 to \#A8.8 | Ch1 | 0001 Hex |  |
| :--- | :--- | :--- | :--- | :---: |
| Analog Modules 9-16 | \#A9.1 to \#A16.8 | Ch2 | 0002 Hex |  |
| Analog Modules 15-24 | \#A17.1 to \#A24.8 | Ch3 | 0004 Hex |  |
| Analog Modules 25-32 | \#25.1 to \#A32.8 | Ch4 | 0008 Hex |  |
| Analog Modules 39-40 | \#A33.1 to \#A40.8 | Ch5 | 0010 Hex |  |
| Analog Modules 41-48 | \#A41.1 to \#A48.8 | Ch6 | 0020 Hex |  |
| Analog Modules 49-56 | \#A49.1 to \#A56.8 | Ch7 | 0040 Hex |  |
| Analog Modules 57-64 | \#557.1 to \#A64.8 | Ch8 | 0000 Hex |  |
| Digital Modules 1-64 | \#D1.1 to \#D64.16 | Ch9 | 0100 Hex |  |
|  |  | Ch10- N/A |  |  |
|  |  | Ch16 |  |  |

## 1/O Power Saving Control

Configures the RTU to switch on and off various output supply voltages. This enables the RTU to reduce power consumption by switching off external devices. The voltages that can be controlled are:

- 24 V output voltage from IO modules (eg. Al-1, IO-3, IO-4)
- 24 V auxiliary supply from a PSU-1, PS-1, PS-xx or PC-1
- 12 V Vr from a PC-1, PS-1 or PS-xx (note: the 12V output supply from an LM-2 or from a PC-1/MC-1 radio board is not switched off)

For example, an RTU can be configured to switch its output voltages on after 5 minutes, wait two seconds, scan all the IO modules for 10 seconds and then switch off its output voltages. The time intervals used in this process are configured using the following parameters:

- Interval: The period of time (in seconds) that the output voltages are switched off for. To disable Power Saving Control, set Interval to zero.
- Warmup Time: The period of time after the output voltages are switched on that is waited before scanning the IO modules.
- Sample Time: The period of time that the IO modules are scanned for after the Warmup Time has expired.

The Power Saving Control cycle is then repeated 'Interval' seconds after the 'Sample Time' has expired. Note: the LP-1 does not use these parameters.

### 3.5 Configuration - Memory

Each RTU has battery backed RAM (SRAM) that is used to store information about that RTU. Some memory is reserved by the RTU for storing module data, local registers, configuration parameters and other information used by the operating system. The remaining memory is configurable and is used to store event logs, ladder logic, network data, phone numbers, images and firmware drivers. The memory available for user configuration can be checked by clicking the 'Check memory usage' button or by referring to the table below.

| CPU | Reserved | User | Total |
| :--- | :--- | :--- | :--- |
| PC-1* $/$ CP-1 | 64 K | 192 K | 256 K |
| CP-10/11 | 576 K | 448 K | 1024 K |
| CP-21 | 680 K | 1344 K | 2048 K |
| LP-1 | 128 K | 384 K | 512 K |

* Early revision PC-1 modules had a total of 128K SRAM.

Memory space is automatically allocated for telephone numbers (if configured) and the ladder source file (if stored in the RTU) when the RTU configuration is downloaded. The default Memory configuration window is shown below.


Store ladder logic source files[.LL) in RTU


Figure 3.5a: Default RTU Memory Configuration Window
Event Logs: Each event log is stored as 12 bytes. The maximum number of logs that the RTU can store at any one time is then automatically calculated. For example, if 32 K is allocated, the maximum number of logs is: 32 K ( 32768 Bytes) / $12=2730$ logs. (Note: If firmware prior to V1.30A is used, memory for 255 log definitions ( 4590 bytes) is automatically reserved).

Compiled Logic: Before Toolbox downloads the compiled ladder logic it checks if enough memory has been allocated. To determine the amount of memory required, simply check the size of the compiled ladder file (FILENAME.LLO). 32K is enough memory for most applications.

Network Reg. Blocks: If an RTU is used to store data from another RTU then it must have some memory allocated for network register blocks. 1K per outstation RTU is usually enough. If the network data is overflowed, a 'Netblocks Overrun' error (please see \#YFLAGS.9) will be triggered and displayed in the RTU Status - View, RTU Status. When the RTU is cold-started, all the network blocks are cleared.

## Calculating the Network Register Blocks Required

Analog, digital and local register information is all stored in separate network register blocks. For analog data (\#AI or \#AO), 8 registers are used to store each module's inputs or outputs while for digital data (\#DI or \#DO) a single register is used for each module's inputs or outputs. Each network block contains 64 registers ( 128 bytes). This means that one network block can store the data for 8 consecutive analog modules or for 64 digital modules or for 64 consecutive local registers. The first network block contains registers 1 to 64, the second network block contains registers 65 to 128 and so on. This means that in order to store \#R64 and \#R65, two network blocks would be required as the first block is used to store \#R64 and the second block is used to store \#R65. Similarly, with analog registers, the first network block contains the data for analog modules 1 to 8, the second network block contains the data for analog modules 9 to 16 and so on. Example:

Data To Be Stored
\#DI1, \#DI4, \#DO5
Network Blocks Required
\#AI1.4, \#Al3.1 to \#Al3.8, \#AI9.1
1
\#R1, \#R2, \#R1002 2

Optimize For Speed: (For CP-xx only) When ticked, the RTU optimizes the network register access speed by using a lookup table. This will allow the scan rate of IO modules and ladder logic to be vastly improved (up to twice as quick) if ladder logic uses a lot of network registers. Note: when using this option, ensure at least 17K of memory is allocated for 'Network Reg. Blocks' as 16K of this memory is used for the lookup table. The remaining memory is used for storing network registers.

Image Buffer: (For image capture option boards only). A medium quality image uses 10 kB of memory. It is recommended that at least 100 kB be allocated for image storage to allow buffering before the images are uploaded. When the buffer is filled, the oldest image is overwritten by the newest image. When using an MC-xx for image capture, 256kB of memory is automatically allocated for image storage in the MC-xx and the Image Buffer setting can be set to OkB .

Firmware Drivers: If there is not enough room in flash memory, drivers can also be downloaded to Static RAM (SRAM). Firmware drivers stored in SRAM are erased after a cold start (drivers are not affected by a cold start when stored in flash memory). The RTU requires CP-1/PC-1 firmware V1.35d or CP-xx firmware V1.36b and newer to make use of SRAM drivers. LP-1 RTUs can only store drivers in SRAM.

LP1 Exp. Memory: An LP-1 has 384K of SRAM available for user configuration (128K of the 512 K total SRAM is reserved for RTU use). For extra capacity, the LP-1 can be fitted with an additional 4 MB of flash memory. This flash memory can then be used for storing event logs or images by ticking the 'LP1 Exp. Memory' box. When the box is ticked, ALL event logs and/or images are stored in flash memory (SRAM is not used).

Store ladder logic (.LL) files in RTU: When ticked, every time ladder logic is downloaded to the RTU, the compiled logic and the ladder source file will both be downloaded. This ensures the latest copy of the ladder source file is always stored in the RTU. Future changes can be made by uploading the ladder source file from the RTU using Toolbox, performing the changes, compiling the ladder logic and then downloading the compiled logic and the ladder source file again. Memory space is automatically allocated for the ladder source file by Toolbox. (To determine the amount of memory that will be allocated, simply view the size of the ladder source file (FILENAME.LL) on your PC using Windows Explorer).

Check Memory Usage: Provides details about the memory usage of the RTU configuration file. Will also attempt to communicate with the RTU and display the available memory in the RTU.


Figure 3.5b: Example RTU Memory Usage details

### 3.6 Configuration - Port List

The port list defines the communications parameters for each of the 16 possible ports on an RTU. A port list showing some of the types of RTU communications for each port is shown below.


Figure 3.6a: Example Port List Window
The settings for each port can be configured by clicking on the port button (1 to 16). This will display the window shown below.


Figure 3.6b: Example Module Port Configuration Window

Module: The module type and its port number that is to be configured. CP-1 and PC-1 modules have 2 ports which are configured as port 1 and port 2. A CP-xx module has 3 ports that are configured as ports 1 to 3 . The available 'Module' options are:

- NONE: Clears existing port configuration
- CP-x P1: Central Processing Module, Port 1 (RS232)
- CP-x P2: Central Processing Module, Port 2 (CP-1: RS232, RS485 or Option Board)
- CP-x P3: Central Processing Module, Port 3 (Option Board)
- PC-1 P1: Power and Processor Module, Port 1 (RS232)
- PC-1 P2: Power and Processor Module, Port 2 (Option Board)
- MC-x P1: Communications Module, Port 1 (RS232)
- MC-x P2: Communications Module, Port 2 (MC-1: RS232 or Option Board)
- MC-x P3: Communications Module, Port 3 (Option Board)
- RD-1: Radio Module with one radio port (future release)
- LM-1: PSTN Modem Module (future release)
- LM-2 P1: Line Modem Module, Port 1 (FSK)
- LM-2 P2: Line Modem Module, Port 2 (FSK)

Slot: The slot address in which the module is positioned (1 to 64). It is not necessary to specify a slot address for a CP-xx or a PC-1 module.

Type: The type of the port as labelled on the RTU module. Option boards installed on CP-xx modules are displayed from the Hardware Overview as 'None' (no option board installed), 'UART Detected' (SER-S, SER-I, V34-D, Line-2, Fibre or HART option board), 'PSTN Modem' (V22-d option board) 'Ethernet' (E'NET-E or E'NET option board), 'Line Modem / Radio' (LINE-L option board) or 'Image' (IMAGE-J option board). The Type setting should match the option board type as detailed below:

- RS232: RS232 serial communications with RTS-CTS control. This setting is also used for fibre optic ports and for spread spectrum radio ports if the radio does not need to be configured with an initialisation string. A fibre optic port is configured the same way as an RTU serial port.
- RS485: RS485 serial communications (used for multiple RTUs connected to a two-wire highway up to 600 metres long). Please see the topic Example - RS485 Communications.
- RS422: RS422 serial communications (used for multiple RTUs connected to a four-wire highway).
- RADIO: Original radio connection. To use the radio setting, the module must have a Radio option board (PC-1/MC-1) or an older-style CP-10/MC-10 Line option board (labelled 'LINEL') or an LM-2 must be used. Note: LM-2, CP-xx and MC-xx ports operate at 1200 baud while PC-1 and MC-1 ports can operate at 300 or 1200 baud. The newer line option boards (labelled 'LINE-2') are configured as Line-2 (please see below) instead of RADIO. The output power of a radio port can be configured by clicking the Configure button as shown in Configuration - RADIO/PLINE.
- PLINE: Original private line connection. To use the private line setting, the module must have a Private Line option board (PC-1/MC-1) or an older-style CP-10/MC-10 Line Option Board (labelled LINE-L) or an LM-2 must be used. Note: LM-2, CP-xx and MC-xx ports operate at 1200 baud while PC-1 and MC-1 ports can operate at 300 or 1200 baud. The newer line option boards (labelled LINE-2) are configured as Line-2 (please see below) instead of PLINE. The output power of a private line port can be configured by clicking the Configure button as shown in Configuration - RADIO/PLINE.
- PSTN: For external dial-up modems and Dial option boards used on telephone lines. PSTN can be used on any RS232 port and has a number of configurable parameters that are configured by clicking the Configure button as shown in Configuration - PSTN.
- TMR: Trunk Mobile Radio communications. Uses RS232 serial communications and a special form of message encoding. To be able to use the TMR protocol a special version of RTU firmware is required. TMR has a couple of configurable parameters that can be configured by clicking the Configure button as shown in Configuration-TMR.
- RADIO HOT: (For PC-1/MC-1 only) For use with FSK radios that constantly transmit or receive a carrier signal. When this option is selected, the receiving RTU does not wait for the carrier to drop before replying. The receiving RTU ignores the 'Quiet Time Before TX' System Parameter and replies immediately. Please see Line-2 HOT for Line-2 option boards.
- Mobitex: For Mobitex radio communications on one of the RTU's serial ports. A firmware driver is required in order to use the Mobitex protocol.
- Ethernet: The ethernet port settings can be configured by clicking the Configure button as shown in Configuration - Ethernet.
- Image Capture: Image capture option board. When this option is selected, settings for Baudrate, Pre TX, Post TX and Protocol are ignored. Please see the topic Example Kingfisher Images.
- RS232 RADIO: For radios with an RS232 interface and RF Carrier Detect signal. Carrier detect is used to prevent messages being sent when the radio network is busy.
- LP-1 FFSK P3: (formerly called 'MicroX Radio') For LP-1 port 3 integrated radio. The integrated radio has a number of configurable parameters that can be configured by clicking the Configure button as shown in Configuration - LP-1 Integrated Radio.
- LP-1 FSK P3: For LP-1 FSK port 3 Trio radio (ie. TC-xxxSR).
- GPS Internal: GPS option board for CP-21. Please see the topic Driver - GPS.
- GPS External: External GPS device.
- Line-2: Private Line or radio connection for later revision 'Line-2' option boards.
- Line-2 HOT: Same functionality as 'RADIO HOT' except applies to Line-2 option boards.
- GPRS: General Packet Radio Services. Allows connection to a GPRS modem when using the GPRS firmware driver. Please see the topic Example - Using GPRS Modems.
- SS Radio: Spread spectrum radio module. Allows an initialisation string to be set to the radio by clicking the Configure button as shown in the topic Configuration - Spread Spectrum Radio. To obtain radio data or for other port settings please see the topic Driver Spread Spectrum Radio. Note: RS232 can be used for the port type if the radio does not need to be configured.

Baud rate: (300 to 115200) The speed at which the RTU will send or receive messages. Note: Radio and Private Line ports have a maximum baud rate of 1200. When using a PSTN modem to dial a paging service, set the Baud rate to 9600 (or 2400 if experiencing problems connecting reliably). An LP-1 has a maximum baudrate of 38400 on ports 1 and 2.

Pre TX: For radio and private line ports, this parameter defines how long the carrier and RTS are transmitted for before data is sent. Radios commonly require a Pre TX of 300ms while 50 to 100 ms is used for private lines. 10 ms is used for RS485 and RS422. Note: for PSTN ports, the RTU will wait a minimum of 3 seconds after a carrier is detected before setting the online bit. Pre TX can be used to set the amount of extra time the RTU will wait after a carrier is detected before setting the online bit and allowing messages to be initiated. A setting of 0 is used for most PSTN modems or set to $20,000 \mathrm{~ms}$ for a Motorola 9522 satellite phone.

Post TX: For radio and private line ports, this parameter defines how long the carrier and RTS are transmitted for after the data has been sent. Radios commonly require a Post TX of 100ms while 10 to 50 ms is used for private lines. CP-xx line option boards require 50 ms Post TX when used with private lines. RS485 and RS422 sometimes require very short Post TX delays. The following values can be used:
$0=0-5 \mathrm{~ms}$ ( 5 ms resolution)
$1=0-1 \mathrm{~ms}$ ( 1 ms resolution. This is the shortest Post TX setting)
$2=1-2 \mathrm{~ms}$ ( 1 ms resolution)
$3=2-3 \mathrm{~ms}$ ( 1 ms resolution)
$4=3-4 \mathrm{~ms}$ ( 1 ms resolution)
$5=4-5 \mathrm{~ms}$ ( 1 ms resolution)
All other settings ie 6-65535 have a 5 ms resolution
Note: for PSTN ports, Post TX is the maximum delay before the RTU decides the message being received has finished. Set to 0 for most PSTN modems or set to 1100 ms for CDMA modems. Post TX is used to allow for breaks in the message received (as occurs with the CDMA network). If Post TX is set below 350 ms , the RTU will use a minimum value of 350 ms .

Protocol: The protocol that the RTU is able to use on the port. Protocols require a firmware driver* to be loaded in the RTU and cannot be used with other protocols on the same port (with the exception of Modbus and Kingfisher). The available protocols are:

- Series 2: Kingfisher Series 2 protocol. This is the default Protocol setting.
- ADS Data Logger: Device protocol.
- Allen Bradley: Allen Bradley PLC.
- ALERT: Radio reporting gauge.
- Alstrom Relay: Device protocol.
- ASCII No Parity: Device protocol.
- ASCII Even Parity: Device protocol. Same as above but with even parity.
- BCL ARC Device: Device protocol.
- Cooper: Device protocol.
- DATAC: DATAC RTU.
- Datataker: Device protocol.
- Datran DT300: Device protocol.
- DNP-3: Please see the driver documentation from RTUnet.
- DV1000: Device protocol.
- Form 4C: Form 4C Reclosure.
- FUJI Micrex-F: Fuji Micrex-F PLC.
- FUJI NJ Series: Device protocol.
- GE CCM: Device protocol.
- GE SNP-X: Device protocol.
- GE T60 Relay: Device protocol.
- Genisys: Genisys train controller.
- GPS: Device protocol.
- GPS NMEA: Device protocol.
- Hart: Device protocol.
- IDEC PLC: Device protocol.
- INLINE, INLINE2: Inline flow computer. Please see the topic Driver - Inline Flow Computer.
- INTRAC: Motorola INTRAC RTU.
- JZA Train Control: Device protocol.
- MAC-800: MAC 800 RTU.
- Mercury: Mercury flow computer.
- Microtran: Email Microtran RTU.
- Mier Transposer: Device protocol.
- Minitran: Email Minitran RTU.
- G\&F Minitran: Gas and Fuel Minitran RTU.
- MTran Host: Minitran Host, South East Water.
- Mbus ASCII Init \#: Modbus protocol for an MC-xx port only. Identical to 'Mbus init, S2' but uses ASCII data format instead of Modbus RTU format.
- Mbus init, S2 \#: Modbus and Series 2 protocols. Allows the RTU to initiate Modbus messages from ladder (TX_MBUS and RX_MBUS ladder blocks) and to relay output messages in Modbus format.
- Mbus init\&resp, S2 \#: For CPU ports only. Modbus and Series 2 protocols. Allows the RTU to initiate its own Modbus messages from ladder (TX_MBUS and RX_MBUS ladder blocks) and respond to Modbus messages from other devices. This option should only be selected if two devices are connected using the Modbus protocol and both sides will initiate messages.
- Mbus SCADA, S2 \#: (Was Mbus master, S2) Modbus master and Series 2 protocols. The RTU will respond to Modbus messages that are for itself and for any other RTU. This option is used for the master RTU which stores copies of the outstation RTU data. If data is requested from an outstation RTU, the RTU will respond with its own network data corresponding to that RTU. The local RTU will also relay Modbus output messages in either Series 1, Series 2 or Modbus format. Modbus messages are relayed in Series 1 format to outstations that have a system ID of AC or in Series 2 format to outstations that have a system ID of AE. Modbus messages are relayed in Modbus format if the port that the RTU relays the message out of is configured as a Modbus initiating port.
- Mbus slave, S2 \#: Modbus and Series 2 protocols. The RTU will respond to Modbus messages that are for itself only.
- Mbus init\&parity \#: Identical to 'Mbus init, S2' but uses an even parity port setting and will not respond to Series 2 messages.
- Mbus init\&resp\&par \#: For CPU ports only. Identical to 'Mbus init\&resp, S2' but uses an even parity port setting and will not respond to Series 2 messages.
- Mbus SCADA\&parity \#: Identical to 'Mbus SCADA, S2' but uses an even parity port setting and will not respond to Series 2 messages.
- Mbus slave\&parity \#: Identical to 'Mbus slave, S2' but uses an even parity port setting and will not respond to Series 2 messages.
- Modem Sw Unit: Email Modem Switch Unit.
- Monitor WeatherStn: GLX data logger.
- Multitrode 2PC: Multitrode pump controller.
- NEC DCU: NEC PLC.
- OMRON: Omron PLC.
- PEEK: PEEK traffic light controller.
- Remote Data Logger: Protocol for Sagasco.
- S1 Ctrl, Mbus, S2 \#: Series 1 Controller, Modbus and Series 2 protocols. This will do the same as the 'Mbus SCADA, S2' setting and will also respond as a Series 1 master RTU. Will also relay series 1 messages to RTUs that are in the Network List.
- S1 Outstn, S2: Series 1 Outstation and Series 2 protocols. Will not relay series 1 messages for other RTUs.
- S1 Ctrl, no CRC, S2: Original Series 1 Controller (for use with CPU1 modules) and Series 2 protocols. Will relay series 1 messages to RTUs that are in the Network List.
- S1 Out, no CRC, S2: Original Series 1 Outstation (for use with CPU1 modules) and Series 2 protocols. Will not relay series 1 messages for other RTUs.
- SER_SSPA: Device protocol.
- Shaft Encoder: Hohner Shaft Encoder.
- Simatic TI: Siemens Simatic 500 series PLCs.
- SM6615: Device protocol.
- STIC Gauge: Enraf STIC receiver.
- Tandberg: Digital receiver and decoder.
- Traffic Light Controller: Device protocol.
- TRIO Eseries: Trio E series radio interface.
- TS5000: TS5000 RTU.
- User-Defined: User defined protocol configured in ladder logic. When 'User-Defined' is selected, another configuration box will appear. The number of data bits (7 or 8), the parity (none, even or odd) and the number of stop bits (1 or 2 ) can then be specified.
- YSI Logger: Device protocol.

Port Security: (Level 0 to 5) The security access level of each port. Port security is enabled by loading the Security driver and configuring the port with a non-zero security level. Please see the appendix - RTU Security for more information.

* All protocols except 'Series 2' require a special version of firmware or a firmware driver. Special versions of firmware and firmware drivers are available from RTUnet. Standard firmware drivers are available from the RTUnet web site: www.rtunet.com. Some protocols will operate on both CPU and MC ports while other protocols operate on CPU ports only or MC ports only as detailed in the document 'protocols.pdf' available from the web site.
\# Note 1: When using the Modbus port protocols, some addresses cannot be used for external Modbus devices. These addresses correspond to the SYNC characters used for the Series 2 and Series 1 protocols. Since Modbus messages begin with the Modbus device address, these messages can be confused with Series 2 and Series 1 messages which begin with sync characters AE (Series 2), AC (Series 1 CPU3) or A5 (Series 1 CPU1). Each Modbus protocol port setting will also respond to Series 2 messages and so Modbus device address 174 (AE Hex) cannot be used. If the Series 1 CPU3 port protocol is used, then Modbus device address 172 (AC) cannot be used. If the Series 1 CPU1 port protocol is used, then Modbus device address 165 (A5) cannot be used.
Note 2: When a Modbus port setting is used on an ethernet port, the Series 2 protocol is not supported.


## Configuration - PSTN

If the port type is set to PTSN, clicking the 'Configure' button will display the following window. Note: the first 4 parameters also apply to GPRS modems.


Figure 3.6c: Default PSTN Configuration Window showing Initialisation String for an External Modem or GSM.

Dial Retries: The number of times that the RTU will attempt to re-dial the target RTU. The time waited before performing the next dialing attempt changes according to the dialing attempt number. After the first dialing attempt, the RTU will wait 30 seconds and then dial again. The RTU then increments the wait time by 1 minute between subsequent dialing attempts.

```
After RTU Waits:
1st Dial }30\mathrm{ seconds
2nd Dial }1\mathrm{ minute }30\mathrm{ seconds
3rd Dial }2\mathrm{ minutes }30\mathrm{ seconds
4th Dial }3\mathrm{ minutes }30\mathrm{ seconds etc
```

Dial Timeout (seconds): The time from when dialing begins that is waited to get carrier detect (carrier detect occurs a short time after the receiving modem has answered). When dialing a GSM, the Dial Timeout should be set to at least 45 seconds.

Automatically Hanging Up
An RTU can be configured to automatically hang up after a certain amount of time has elapsed from sending the last message or from receiving the last message. There are two parameters used to specify these times and the parameter that is used is dependent on whether the last message was transmitted or received. If the last message was transmitted, the RTU will wait for 'Hang Up After' seconds and then hang up. If the last message was received, the RTU will wait for 'On Line Inactivity' seconds and then hang up.

On Line Inactivity (seconds): (0-32767) The RTU will hang up after this amount of time has elapsed since the last message received. A value of 0 disables the function.

Hang Up After (seconds): (0-32767) The RTU will hang up after this amount of time has elapsed after connection or after sending the last message. A value of 0 disables this function.

## Remaining Online

To remain online after connection, set 'On Line Inactivity' to 0 and 'Hang Up After' to 0 in both RTUs in the PSTN link. If the line is disconnected, the RTU will reconnect when the next TX or $R X$ message is initiated from ladder logic.

Init String: (0-29 characters) These characters are sent to the modem to initialise it after startup, after disconnection and if a dial attempt fails. The default initialisation strings for each type of modem can be obtained by clicking the appropriate button below the Initialisation String field and are listed below.

| Modem | Default Initialisation String |
| :---: | :---: |
| External Modem or GSM (eg. Banksia modem or Wavecom GSM) ${ }^{\#}$ | AT\&FTEOVOSO=2\&W |
| V34-D Option Board ${ }^{\text {\# }}$ | AT\&FTEOVOS0=2\&W <br> Note: for original dial option boards (that were labeled 'S2DOB REV 1.0' on the circuit board) X0 can be added to the above string to ignore dial tone if required. Alternative strings that configure the timing parameters for recognising dial tone are: <br> AT\&FTEOVOSO $=2 *$ NC40\&W (Australia) <br> AT\&FTEOVOSO $=2^{*}$ NC22\&W (USA) <br> AT\&FTEOVOSO=2*NC16\&W (UK) <br> AT\&FTEOVOSO $=2^{*}$ NC43\&W (Japan) |
| V22-D Option Board | AT\&FTEOVOSO=2\&C1\&W '\&C1' = track DCD from remote. <br> For this option board, the port baud rate should be set to 2400 bps (or lower). |
| LP-1 Falcom GSM * | AT@\|+CICB=0|+CBST=7|+DS=0|\&W <br> For an LP-1 with 1.40 E or newer firmware, the above string is interpreted by the LP-1 as a number of separate AT commands as shown below: <br> ATE0\%C0 $\mathrm{NOSO}=2 \& \mathrm{D} 2$ <Enter> <br> AT+CICB=0 <Enter> <br> AT+CBST=7 <Enter> <br> AT+DS=0 <Enter> <br> AT\&W <br> The '@' character is replaced by 'E0\%COINOSO=2\&D2' by the LP-1 (this keeps the initialisation string below the 29character limit). '\&D2' allows the RTU to hang up the GSM using DTR. '+CICB=0\|+CBST=7|+DS=0' sets the GSM to 9600 baud data mode. The '|' character is replaced by a carriage return and 'AT' by the LP-1. |

* For LP-1 firmware prior to 1.40E (which allows multiple '+C' commands to be configured on the one AT command line), the Falcom GSM required a number of setup parameters to ensure correct operation. If the GSM is reset to factory defaults (ie. AT\&F), these setup parameters will be lost. If this occurs, configure the GSM with the following AT commands using the Toolbox Comms Terminal program (on RTU Remote Port 3):
AT+CBST=7 <enter> Set 9600 baud
AT+DS=0 <enter> Set data mode
AT\&W <enter> Write to memory buffer
Initialisation String for $<1.40 \mathrm{E}$ firmware: $\mathrm{AT} \% \mathrm{CO} N \mathrm{NSO}=2 \& \mathrm{D} 2 \& \mathrm{~W}+\mathrm{CICB}=0$
\# Dialing A Paging Service: If using the modem to dial a paging service, error correction may need to be disabled by including 'NO' ie. AT\&FEOVOSO=2WNO\&W. If experiencing problems connecting to a paging service when using an MC module and a Dial option board, the baudrate may need to be limited to 9600 by including F8 in the initialisation string ie. AT\&FE0V0S0=2F8\&W.


## Configuration - TMR

If the port type is set to TMR, clicking the 'Configure' button will display the following window.


Figure 3.6d: TMR Configuration Window
On Line Inactivity: (0-32767) The RTU will hang up after this amount of time has elapsed since the last message received. A value of 0 disables the function.

Hang Up After: (0-32767) The RTU will hang up after this amount of time has elapsed after connection or after sending the last message. A value of 0 disables this function.

## Configuration - RADIO / PLINE

If the port type is set to RADIO or PLINE, clicking the 'Configure' button will display the following window. Attenuation Level only applies to the original 'LINE-L' option boards.


Figure 3.6e: RADIO / PLINE Configuration Window

Attenuation Level: (0-15) The TX Audio output level is reduced in power by this amount. The default setting ' 0 ' maintains the maximum output power ( -6 dBm ).

| Attenuation <br> Level | Output <br> dBm | Signal level <br> mV RMS <br> (into 2 x 600 Ohm) |
| :---: | :---: | :---: |
| 0 | -6 | 400 |
| 1 | -7 | 350 |
| 2 | -8 | 310 |
| 3 | -9 | 276 |
| 4 | -10 | 251 |
| 5 | -11 | 223 |
| 6 | -12 | 195 |
| 7 | -13 | 173 |
| 8 | -14 | 158 |
| 9 | -15 | 141 |
| 10 | -16 | 123 |
| 11 | -17 | 110 |
| 12 | -18 | 100 |
| 13 | -19 | 89 |
| 14 | -20 | 78 |
| 15 | -21 | 69 |

## Configuration - LP-1 Integrated Radio

If the port type is set to 'LP-1 FFSK P3', clicking the 'Configure' button will display the following window.


Figure 3.6f: LP-1 Integrated Radio Configuration Window

Rx Frequency: ( $0-512,000,000 \mathrm{~Hz}$ ) The frequency of incoming messages.
Tx Frequency: (0-512,000,000 Hz) The frequency of outgoing messages.
Min Rx Detection Level: (90-120 dB) The weakest detectable signal strength. Note: radio noise is received up from -120 to -108 dB . A setting of '90' (ie. -90 dB ) is recommended. The larger the number, the weaker the signal that can be detected by the radio.

Bandwidth: (12.5, 20 or 25 kHz ) Bandwidth of the radio. Standard setting is 25 kHz (Wideband).
Radio Mode: (Async Mode, Sync Mode (20bpp), Sync Mode (253bpp)) Standard setting is Sync Mode 20bpp.

## Configuration - Ethernet

If the port type is set to Ethernet, clicking the 'Configure' button will display the following window.


Figure 3.6 g : Ethernet Configuration Window
IP Address: A local area network may be used to communicate with an RTU that has an ethernet option board. A valid IP (internet protocol) address may be obtained from your network administrator. Each number in the IP address can have values in the range of 0-255. The IP address can then be used by Toolbox to communicate with the RTU via ethernet.

Gateway IP Addr: The IP address that allows access to the outside world for communications to an RTU on another local area network. Each number in the Gateway IP address can have values in the range of 0-255.

Subnet Mask: Allows for detailed configuration of devices on a LAN. The default setting of 255.255.255.0 is used in most cases. Each number in the Subnet Mask can have values in the range of 0-255.

Type: (TCP/IP or UDPIP) Ethernet protocol type to use.

## Port Address

The ethernet port address varies according to the protocol being used.

| Protocol | Ethernet Port Address |
| :--- | :---: |
| Kingfisher Series 2 | 473 |
| Modbus | 502 |
| DNP3 | 20,000 |
| Allen Bradley | 2,222 |

## Ethernet Sockets

The RTU opens a socket when initiating a message. To respond to a message, the RTU uses the socket that has already been opened for the incoming message. There is no socket dedicated for incoming messages except when using DNP3. A socket is then reserved for the Series II protocol. If all sockets are being used and the RTU needs to initiate a new message, it will disconnect the socket with the greatest inactivity and reuse that socket. If all sockets are being used and another device tries to establish an ethernet connection with the RTU, the socket will not be able to be opened and the request will be rejected.

A CP-10/11 socket is automatically closed after 60 seconds of inactivity. A CP-10/11 can reserve up to 3 of its 4 sockets for incoming messages (eg from SCADA software) by setting the port Pre TX delay. Pre TX settings of 1-3 reserve 1-3 sockets respectively for incoming messages. The remaining sockets can be used for outgoing connections.

A CP-21 can have up to 24 socket connections at the same time.

## Configuration - Spread Spectrum Radio

If the port type is set to 'SS_RADIO', clicking the 'Configure' button will display the following window.


Figure 3.6h: Spread Spectrum Radio Configuration Window
The spread spectrum radio uses extended AT commands to set or read various parameters.
Default String: The beginning of the initialisation string sent to the radio. When configured (ie the Default String is not blank), the RTU automatically adds the Vendor ID, Destination Address and Hopping Pattern commands to the end of the string and then sends the complete string to the radio in the format:
[Default String],[Vendor ID],[Destination Address],[Hopping Pattern],WR
Default String options:

| Radio Defaults |  |
| :--- | :--- |
| AUS/US (Point to Point): |  |
| AUlank - no string sent to radio> |  |
| AUS/US (Point to Multi-point): |  |
| International Radio | ATBRO,MT0 |
|  |  |

BR0: Data is transmitted between the radios at 9600 bps. Note: if a higher baud rate is used, the transmission range may be reduced.
MT: Multi-Transmit mode (Australia / US only. Not required for the International radio). MT0 [default] = point to point mode, MT2 = point to multi-point mode.

Vendor ID: (16-32767, default=0) Sets the ID number of the Spread Spectrum radio. All radios on the same network need to have the same Vendor ID in order to communicate with each other. It is recommended that Vendor ID is changed to avoid interference with other radio networks.

Destination Address: (0-4095, default=0) Sets the Destination address of the Spread Spectrum radio. All radios on the same network need to have the same Destination Address in order to communicate with each other. It is recommended that Destination Address is changed to avoid interference with other radio networks.

Hopping Channel: (0-6, default=0) Each pair of spread spectrum radios must be set to the same hopping channel number to enable them to communicate. To minimise interference from another RTU using a spread spectrum radio, a hopping channel number that is different to the offending radio should be used.

## Advanced Radio Configuration

A spread spectrum radio can be initialised using the Toolbox Comms Terminal. Eg. for RTU1 with an SS radio on port 2, the following Comms Terminal settings would be used:


Once Comms Terminal has started, the radio may first need to be put into command mode by sending +++ <wait for a couple of seconds until OK appears>. Commands can then be sent to the radio. Command examples:

| ATRE | Reset to factory defaults |
| :--- | :--- |
| ATPL2 | Set Transmit power level to 100mW [default is 1W] |
| ATDTxxxx | Sets the Destination Address to xxxx hexadecimal |
| ATWR | Save settings to radio memory |

For a comprehensive list of AT commands, a product manual (for the 9Xtend 900 MHz OEM RF Module) is available from the supplier - www.maxstream.net/products/xtend/module/9xtend.php.

## RTU Port / Network Settings

Please see the topic Driver - Spread Spectrum Radios for port and network link settings. The topic also describes the diagnostic data that is available from the spread spectrum radio itself.

## Communicating With A G3

Please see the appendix - Communicating With A G3.

### 3.7 Configuration - Network List

The Network List tells the local RTU how to communicate with remote RTUs in the RTU network.

By default, an RTU will automatically create or update links in its network list if a message is received that is different to the link in the network list. Eg. if an RTU has a network link to RTU2 using port 3 and a message is received from RTU2 on port 4, the network link will be updated to port 4. This feature can be disabled using ladder logic (by setting \#YMODE.2=1).

An RTU network with direct and indirect communications is shown below. Master RTU1 can talk directly with RTU2 and indirectly with RTU3.


Figure 3.7a: Example RTU Network

The Network List for each RTU is shown below.


Figure 3.7b: Network List For RTU1 In Figure 3.7a


Figure 3.7c: Network List For RTU2 In Figure 3.7a.


Figure 3.7d: Network List For RTU3 In Figure 3.7a.
A network link can be added by moving to a new row and clicking on the button. After clicking on a button, the window shown below is shown.


Figure 3.7e: Window Displayed When Creating A New Network Link

Target RTU: (0-249) The address of the RTU to communicate with.
System ID: This is the communications sync character used at the start of outgoing messages. An RTU will only respond to messages that begin with the same System ID as the RTU's own system ID (as configured in Configuration, System Parameters). Standard system IDs are as follows:

- AE - Default for Series 2 RTUs. It is recommended that AE be used for all Series 2 RTUs except Store and Forward RTUs as illustrated below.
- AC - Series 1 CPU3 or Series 1 CPU1 with version 3 EPROM
- A5 - Series 1 CPU1 with version 2 or prior EPROM


For the above system, RTU3 receives messages from RTU1 at the same time RTU2 receives them. To prevent both RTU2 and RTU3 responding at the same time, RTU2 is given a different system ID. If RTU3 is unable to receive RTU1 messages directly, then RTU2 can also use a system ID of AE. Note: System IDs 00 and FF are reserved and should not be used.

A Series 2 RTU knows it has a Series 1 network link whenever a system ID of AC or A5 is used. When a Series 2 RTU receives a Modbus output command for a Series 1 outstation, it will convert the message into Series 1 format. Note: A master RTU will not convert Citect Kingfisher driver outputs into Series 1 format for Series 1 outstation RTUs.

Direct/Indirect: Direct means the RTU is directly connected to the target RTU (eg. via a private line or radio link). Indirect means the RTU must communicate via one or more other RTUs (called store-and-forward RTUs) to access the target RTU. When an RTU hears a message that is not for itself, it will store and forward (or relay) the message to the destination RTU if it has a network link to that destination RTU.

Port \# / Via RTU \#: For a Direct connection, this is the port number (as configured in the Port List) to be used to communicate with the target RTU. For an Indirect connection, this is the RTU via which the message must be sent to reach the target RTU.

Message Retries: The number of times the RTU will retry sending a message to the target RTU if the previous attempts have failed. The maximum number of attempts is one more than the 'Message Retries' setting.

Timeout: The time that an RTU will wait for a reply to its first message. If Message Retries is set to 1 or greater, the RTU will try sending the message again. The time waited for a reply to all other message attempts depends on how many message attempts have already been sent and on the Global Timeout setting (as defined in Configuration, System Parameters) as detailed below.

| Attempt | Time waited for reply (milliseconds) |
| :---: | :--- |
| 1 | Timeout |
| 2 | Timeout + Global Timeout |
| 3 | Timeout + (Global Timeout $\times(1<$ Random $<2))$ |
| 4 | Timeout + (Global Timeout $x(2<$ Random $<4))$ |
| 5 | Timeout + (Global Timeout $\times(4<$ Random $<8))$ |
| etc |  |

Where 'Random' is a random number between the upper and lower limits defined above. Example: Timeout=4000 ms, Global Timeout=1000 ms. The wait time after each message attempt is therefore in the following ranges:
After attempt 1: Wait $=4000 \mathrm{~ms}$
After attempt 2: $\quad$ Wait $=5000 \mathrm{~ms}$
After attempt 3: $5000<$ Wait < 6000 ms
After attempt 4: $\quad 6000<$ Wait $<8000 \mathrm{~ms}$
After attempt 5: $\quad 8000<$ Wait $<12000 \mathrm{~ms}$
IP Address: (For CP-xx RTUs only) The IP (internet protocol) address of the Target RTU. A local area network may be used to communicate with a CP-xx RTU that has an ethernet option board. A valid IP address may be obtained from your network administrator. Each number in the IP address can have values in the range of 0-255.

CTCSS freq: This is the frequency to use for encoding outgoing FSK radio messages. CTCSS frequencies can be configured from 67.0 to 250.3 Hz . CTCSS frequencies are used to modulate (encode) a TX signal so that only radios that have the corresponding CTCSS frequency can decode and hear the TX signal. CTCSS encoding is only available with PC-1/MC-1 radio option boards and must be ordered as an extra.

Wake Up RTU From Power-Down Mode ? (Only applicable to radio ports) When this option is ticked, the message will be preceded by 4000ms of carrier signal. This will cause a powereddown outstation RTU to wake-up if the outstation RTU port is enabled to wake the RTU up. After waking an RTU up (after the first successful message), subsequent messages do not have 4000 ms of Pre-Tx carrier. However, another wakeup message is generated if the local port has been inactive for more than 2 minutes and the last message is not from the powered-down RTU.

### 3.8 Configuration - I/O Modules List

The I/O Modules list is a list of all the modules to be used in the RTU. If the I/O Modules List is configured, Toolbox will check that it matches the modules in the local RTU before downloading the configuration. A warning message will appear if there are any differences. The I/O modules list also allows the various module options to be defined eg. AI-4 scanning rate, DO-2 failsafe outputs or AI-10 input range.


Figure 3.8a: Example I/O Modules List

To add an I/O module to the list, you will need to know the slot address of the module or be connected to the RTU with Toolbox. For a description of slot addresses, please see the appendix - RTU Data, IO Modules.

Add: Adds a module to the list.
Delete: Deletes a module from the list.
Configure: Allows the user to configure the options of the selected module. The various options are detailed in the next section.

Import Module List from RTU: Interrogates the RTU and uploads the module details into the list.

## Configuration - I/O Modules List Options

Scan Priority: (All IO modules) Three priorities are available - High (read IO every scan interval), Medium (read IO once every 3 scan intervals) and Low (read IO once every 10 scan intervals). By default, the scan priority is set to High. For some large RTUs, rapidly scanning all the analog inputs slows down the RTU and is unnecessary. To speed up large RTUs, the analog input modules can be configured to have a Low Scan Priority. Note: a Scan Priority of High is always used by PC-1 RTUs.

Scan Rate: (Al-4 only) The Al-4 module has a configurable scan rate of 1-10 seconds. When not configured, the scan rate defaults to 8 seconds.

Failsafe Outputs? (DO-1, DO-2/5, IO-2/3) If the box is ticked and there is no comms activity between the processor and any module on the backplane for 10 seconds the IO module assumes that the processor has failed and turns off its outputs. If not ticked (default), all digital outputs will hold their last value. Note: to use failsafe outputs the IO module must contain I/O code version A17 or newer. This can be determined using the module register \#YMVERss=17+ (where ss=slot number) eg. to determine the I/O code version of a module in slot 14 , use ladder logic to copy \#YMVER14 to a local register. The local register will then contain the code version. Note: failsafe outputs are not currently implemented for the IO-4 module.

Channel Range: (Al-10 only) The current or voltage input range for all 8 channels. The available options are: (none), $0-20 \mathrm{~mA}$ [default], $+/-40 \mathrm{~mA}(10 \mathrm{~V}),+/-20 \mathrm{~mA}(5 \mathrm{~V})$ and $+/-10 \mathrm{~mA}$ $(2.5 \mathrm{~V})$. When '(none)' is selected, no configuration is downloaded to the $\mathrm{Al}-10$ module and the default $0-20 \mathrm{~mA}$ range is used.

The AI-10 sets bit 16 of the analog input register if the current is negative. Note: if the input goes slightly negative (when floating around $0 \%$ ), the analog input register will return a very large value ( 0 neg. to $-20 \mathrm{~mA}=65535$ to 32768 respectively). To prevent unnecessary exception reports, ladder logic should not take any action if bit 16 is set or live zero scaling can be used (please see below).

Live Zero scaling: (Al-10 only) Ticking the Live Zero scaling box changes the input to read zero when below 4 mA for the $0-20 \mathrm{~mA}$ range setting. With Live Zero Scaling, $4-20 \mathrm{~mA}=0-100 \%$ $=0-32767$. All negative current/voltages will also return zero.

Battery Type: (PS-11/21 only) Generic, Sealed Lead-Acid or NiCad. The PS-11 has intelligent battery charging that is varied according to the battery type.

Battery: (PS-11/21 only) 6.5 to 25AH. The size of the battery to charge.

## Configuration - DI-10

The DI-10 Module is a 16 channel Digital Input module with configurable Frequency or Pulse or Quadrature counting and Sequence-of-Events recording. The configuration window for this module is shown below (this window is accessed from Configuration, IO Modules List, Configure [DI-10].) Please ensure that you have the latest firmware loaded in the CPU module when using this DI-10 functionality (as detailed in protocols.pdf available from www.rtunet.com ).


Figure 3.8b: DI-10 Configuration, IO Modules List

Slot Address: (1 to 64) The slot address of the DI-10.
Channel Inversion: These tick boxes allow channel inversion to be configured for any input channel. The 'All ON' and 'All OFF' buttons provide an easy way to select or de-select all the channels. By default, a high voltage applied to a digital input channel will result in a logical 1 in the digital input register and the input LED on the module to be set ON. A zero or low voltage level will result in a logical 0 in the digital input register, and the input LED will be OFF. By configuring channel inversion, the situation is reversed, ie. a high voltage results in a logical 0 and the LED is set OFF; a low voltage results in a logical 1 state and the LED is set ON.

Sequence-of-Events: These tick boxes allow Sequence Of Events (SOE) recording to be configured for any input channel. The 'All ON' and 'All OFF' buttons provide an easy way to select or de-select all the channels. When SOE is enabled, any change of state of the input channel (an event) is logged to 1 millisecond accuracy. This event is automatically included in the Event Log List of the RTU. The DI-10 has a timer that is automatically synchronised with the real-time clock of the processor module. Note: The DI-10 has an internal buffer with enough space for 1000 event logs. This means that a DI-10 can cope with bursts of up to 1000 events at a time. Events are uploaded into the processor module at a maximum rate of 100 events per second allowing the DI-10 to cope with events at a sustained rate of 100 events per second. Events are stored in a circular buffer - which causes the oldest event to be overwritten with the
newest event when the buffer is full. Note: memory must be allocated for event logging for SOE to work. Please see the topic Configuration - Memory, Event Logs.

Debounce Filters: These software debounce filters are grouped into configurable filters for channels 1-4, 5-8, $9-12$, and 13-16. Filtering can be selected from the available options: none, $1 \mathrm{~ms}, 3 \mathrm{~ms}, 10 \mathrm{~ms}, 30 \mathrm{~ms}, 100 \mathrm{~ms}, 250 \mathrm{~ms}$ and AC Filter. If a software debounce filter is selected, the logical input in the digital input register will not change to a new state until the actual input has been at the new state continuously for the specified filter time. Note: the sample time for the software debounce filters is in excess of 10 kHz ( $<0.1 \mathrm{~ms}$ between samples). If debounce filtering is selected, this will limit the accuracy of SOE recording on that input channel. 'AC Filter' is used when connecting AC inputs to the DI-10 module.

Counter Inputs: The DI-10 can have up to 7 counter inputs which are stored as 16 -bit unsigned integer values in the analog input registers. These can each be configured as Frequency, Pulse or Quadrature counters for any input channel. Note: quadrature counting works on pairs of input channels. Channel pairs are 1\&2, 3\&4, 5\&6, 7\&8, 9\&10, 11\&12, 13\&14 and 15\&16. So selecting Quad Count on channel 1 will actually work with quadrature on channels 1 and 2 . Selecting Quad Count on channel 2 will also work with quadrature on channels 1 and 2 , but will reverse the phase of the inputs. The same applies to the other channel pairs used for quadrature inputs.

## Sequence-Of-Events Logs:

User Type: (1-31) Used to group similar types of logs. For example, analog inputs could be type 1, digital status signals type 2, digital alarm signals type 3 and so on. When uploading the logs from the RTU, you may choose which type of logs to upload instead of uploading all the logs.

Priority: (0-7) Allows separation of logs within each User Type category.
Mapping, Base Reg: (NONE, KF or DNP3)
NONE: SOE logs are logged directly as the I/O point. Eg. a SOE log for channel 3 of a DI-10 module in slot 5 would be logged as \#DI5.3.
KF: re-maps the I/O points to the local register specified in the 'Base Reg.' field. The 16 channels are mapped to the 16 register bits. Eg. if Base Register = \#R100, channel 3 would be logged as \#R100.3.
DNP3: re-maps the I/O points to consecutive local registers starting at the specified 'Base Reg' The 16 channels are mapped to 16 consecutive local registers. The logged value is also modified to suit DNP3: the least significant bit (bit 1) indicates 'module online' and is always set ON; bit 7 indicates the state of the input. Eg. if Base Register = \#R101, channel 3 would be logged as \#R103. When the channel is ON, a value of 129 is logged; when the channel is OFF, a value of 1 is logged.

ON Status Reg, OFF Status Reg: (Blank or \#R1 to \#R2048) Allows fast rising edge transitions (ON Status Reg.) or falling edge transitions (OFF Status Reg) to be detected. When a DI-10 input changes, the corresponding channel in the status register is set ON. These channels can be used to detect momentary alarms that would be missed by ladder logic. Notes:

- The status register channel must be reset using ladder logic (it is not reset by the $\mathrm{DI}-10$ ).
- The same local register can be specified for both the ON and OFF Status Reg. A channel will then be set if there is a change of state of the $\mathrm{DI}-10$ input.
- ON and OFF Status registers will only work for channels that have sequence of events enabled (the channels are triggered from the SOE logs).


### 3.9 Configuration - Phone Directory

The phone directory is used to specify up to 256 phone numbers that an RTU can dial (or up to 512 phone numbers including the secondary phone numbers) and is configured using the menu Configuration, Phone Directory. By clicking on one of the row buttons the window shown below is displayed.


Figure 3.9: Phone Directory Configuration Window

Target RTU: (0-249) The RTU that is to be dialed. When using leased line modems (PSTN modems that are hard-wired), the 'Target RTU' must be defined even though a phone number is not dialed.

Primary Phone Number: The number to dial for each odd numbered dialing attempt (ie. dialing attempt $1,3,5, \ldots$ ).

Secondary Phone Number: The number to dial for each even numbered dialing attempt (ie. dialing attempt 2,4,6...). If there is only one phone number to dial for the Target RTU, the Secondary Phone Number should be the same as the Primary Phone Number.

If a 'T' (tone dialing) or a 'P' (pulse dialing') is used in the 'Init String' of the port list, then this is the default dialing method to be used with all phone numbers. Alternatively, a 'T' or a 'P' can be used as a prefix to the phone number which will cause the RTU to use tone or pulse dialing for that number while ignoring the 'Init String' setting.

### 3.10 Configuration - TMR Directory

The TMR (Trunk Mobile Radio) directory is similar to the phone directory and allows up to 30 TMR addresses to be configured (for up to 30 RTUs). The protocol used for communicating with a TMR radio is called MAP27 and uses a TMR address comprised of a 7-bit prefix and a 13-bit identity. To be able to use TMR communications, a TMR radio must be connected to one of the CPU's serial ports (port 1 or 2), the port must be configured as type 'TMR' and the RTU must be configured with a special version of firmware containing the TMR operating code. The prefix and identity of each TMR radio is available from your local TMR dealer.

IMR Directory Configuration $\mathbf{X}$


Figure 3.10: TMR Directory Configuration Window

Target RTU: (1-255) The RTU to communicate with.
TMR Prefix: (0 to 127)
TMR Identity: (0-8191)

### 3.11 Configuration - Pager Configuration

When paging is configured, RTU250 is automatically added to the Network List and is used for the paging communication fail and success counters.

The RTU will send each pager message up to 3 times. Each time the pager message is transmitted, it can be sent to the same group of pager receivers or to a different group of pager receivers. The pager message will not be sent to the next group of pager receivers if the RTU receives an acknowledge within the configured time.

The three groups of pager receivers to send each pager message to are called a sequence. Up to 5 different pager sequences can be defined. When a pager message is configured in ladder logic, the paging sequence to use must be specified. This allows different types of pager messages to be sent to different groups of pager receivers.

A new pager message is sent to the first group of pager receivers in the sequence. If an acknowledgment is not received by the RTU within the first acknowledge time, the pager message is then sent to the second group of pager receivers. If an acknowledgment is not received by the RTU within the second acknowledge time, the pager message is then sent to the third group of pager receivers. If an acknowledgment is not received by the RTU within the third acknowledge time, the RTU will flag a communication fail for RTU250 and increment the fail counter.

Note: to use paging, the RTU must have the paging driver loaded (PAGINGxx.Dxx).


Figure 3.11a: Pager Configuration Window for Telstra PET SMS paging in Australia.

Pager Type: The type of paging service to be used. The following options are available:

- None: Paging is not configured. Selecting 'None' prevents the paging parameters from being downloaded into the RTU and avoids Toolbox checking if the RTU contains the paging driver.
- PET protocol (TAP): Standard paging protocol.
- Airtouch: USA Paging service.
- Pagenet: USA Paging service.
- Radio Pager: Imark pager transmitter radio.
- Link PET protocol: As used by Link Communications and Orange in Australia (8 data bits, no parity, 1 stop bit).
- POCSAG protocol: POCSAG pager transmitter radio.
- GSM SMS: GSM short message service. For paging from a GSM unit directly to a digital mobile phone (does not need to dial a paging service).
- PET SMS: PET short message service. For paging to digital mobile phones using a dial-up paging service. As used by Telstra in Australia ( 7 data bits, even parity, 1 stop bit).

Password: (Optional) Some paging services require a password for validation. Up to 12 characters can be specified. For a Telstra PET SMS, mnmail can be used for the password. This will allow one message to be sent to one Pager Number each time the paging service is dialled. Telstra also supports sending one message to multiple Pager Numbers but you will need to obtain your own password from Telstra. To obtain a password, call Telstra Wireless Data Support on 1800200010 and ask about SMS Access Manager.

Phone Number: (Optional) The phone number to dial for the paging service. A Phone Number is not required for a radio pager or GSM SMS. Note: when using a dial-up modem for sending pager messages, any error correction and compression options may need to be disabled (ie. use $\backslash N 0$ in the initialisation string). For Telstra PET SMS, the phone number is 125107 or to dial the service from overseas it is [international dialling code] + 61439125107.

Direct / Indirect: Configure as direct if the pager transmitter is connected to the local RTU or as Indirect if the pager transmitter is connected to another RTU.

Via: The port or the RTU address that the pager transmitter is connected to. Any RTU serial port can be used for paging when using paging driver PAGING11.Dxx or newer.

1st Group, 2nd Group, 3rd Group: This is specified as a local register (ie. \#R) or as pager number indexes (ie. 1 to 12) separated by commas (eg. 1,4,7). When a register is used, the lowest 12 channels correspond to the 12 pager receivers respectively. The pager message is sent to each pager receiver that has its channel set ON.

Wait For Ack: The number of minutes to wait for the pager message to be acknowledged (by clearing the acknowledge bit as configured in the pager message ladder block) before transmitting the pager message to the next group of pager receivers. Note: the initiating RTU (the RTU that generates the pager message) can have up to 5 pager messages that are waiting for an acknowledge at any one time. Any additional pager messages will not be sent during this time. Each acknowledge bit will remain ON until manually reset.

Pager Numbers: The pager numbers or RIC codes corresponding to pagers 1 to 12 . These can be up to 14 digits long and should all be the same length (requires PAGING11 driver or newer).

## Relaying Pager Messages

When a pager message is to be relayed, the initiating RTU will send the text (plus time and date) and the pager number indexes to the pager RTU. This means the RTU that initiates the pager message uses its own pager sequences but not its own pager numbers. The pager numbers configured in the pager RTU (the RTU that dials the paging service or has the pager radio) are used to target the pager receivers. If the pager message is not acknowledged after notifying the first group of pager receivers, the initiating RTU will send a second pager command that targets the second group of pager receivers. To acknowledge the pager message, a zero is written to the acknowledge bit in the initiating RTU (the acknowledge bit is the bit configured in the pager message block in ladder logic).

## Fails And Successes

After a pager message is sent to a dial-up paging service, an SMS network or to a pager radio, the RTU does not know if the pager receiver or mobile phone received the pager message (the pager receiver may have been switched off or was out of range). However, with dial-up paging or an SMS network, the RTU is able to test whether the service provider received the message OK.

- RTU sends own pager messages: If the dial-up paging service or SMS network accepts the message or a pager radio is being used, the success counter of RTU 250 is incremented. If the dial-up paging service does not accept the message, the message is retried every 60 seconds for the maximum number of dial retries as specified for the PSTN port and then a fail is recorded. If the SMS network does not accept the message, the message is retried 5 to 12 times and then a fail is recorded. The fail counter of RTU 250 is also incremented when a pager message is not acknowledged.
- RTU relays own pager messages: In this case, the pager message is passed on to another RTU (the pager RTU). If the pager RTU accepts the message, the success counter for RTU 250 in the local RTU will be incremented. The fail counter of RTU 250 is incremented when a pager message is not acknowledged.
- Pager RTU sends pager messages from other RTUs: this is the same as when an RTU sends its own pager messages except the RTU does not require the pager messages to be acknowledged.

Please see the topic Example - SMS Pager Messages.

### 3.12 Configuration - Inactivity Monitors

Superseded in Toolbox 1.44 d or newer! If an RTU has redundant CPUs, the duty CPU can be programmed to test for inactivity on any of the 16 ports. If a port does not receive a message for the specified time period, the duty CPU will assume that the port is faulty and will try to pass control to the standby CPU. If successful, the duty CPU will change to standby mode and the standby CPU will change to duty mode. Inactivity monitors should not be used when there is no redundant CPU.

Target Port: (1-16) The port that will be monitored by the duty CPU.
Inactivity Time: (0-65535) After this time has elapsed since the last message received on the Target Port, the duty CPU will try to pass control over to the standby CPU.

Units: (Hours, minutes or seconds) The units in which the inactivity time is entered.

### 3.13 Configuration - PC Setup

The PC setup contains the Toolbox communication settings. A standard PC Setup is shown below. These settings do not usually need to be changed except if you are communicating with an RTU over a network. When communicating over a network, it may be necessary to set Comms Timeout to 5 or more seconds and set the number of retries to 1 or more (especially when downloading an RTU configuration over the network).


Figure 3.13a: Example PC Setup Window

PC Port: (COM 1-16 or Ethernet) The PC's communication port to use.
IP Address (Ethernet Only): A local area network may be used to communicate with a CP-xx RTU with an ethernet option board. The IP (internet protocol) address may be obtained from your network administrator. Each of the four numbers in the IP address may have values in the range of $0-255$. The IP Address is only used when 'PC Port' is set to 'Ethernet'.

Baud Rate (Serial Only): (300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 bps) The baud rate used between the PC and the RTU. If 'PC Port' is set to Ethernet, the Baud Rate is ignored.

Comms Timeout (sec): The time Toolbox will wait for a response to a message attempt before performing the next message attempt or flagging a communications fail. This setting needs to
be extended when communicating with an outstation RTU via a master RTU (for a 1200 baud radio network, 4 or more seconds is recommended.)

Comms Repeat Rate (sec): (Continuous, $0.1,0.2,0.5,1,2,5,10,30,60$ ) The rate at which Toolbox generates a new message request. For example, when viewing the local registers with a Comms Repeat Rate of 0.5 seconds, a read request for local registers will be sent every 0.5 seconds. If a message fails, Toolbox will wait until the failed message has timed out (after 'Comms Timeout' seconds) and then will send the next message at the next 0.5 second time interval. When the Comms Repeat Rate is set to 'Continuous' or when downloading files (eg. firmware or configuration files) messages are continuously transmitted and received without pausing between messages. Note: setting the Comms Repeat Rate to 'Continuous' may cause the PC or RTU to be overloaded with comms messages (especially if 'PC Port' is set to 'Ethernet').

PC's Network Address (251-255): The PC is treated like another RTU when it sends or requests data from an RTU and so the PC must have its own unique address. Addresses 251 to 255 are reserved for this purpose. If two or more PCs are connected to the same RTU, each PC should have its own unique address to avoid communication fails. Note: SCADA software (eg. Citect) may use address 255 by default and will clash with Toolbox if Toolbox also uses address 255. Note: if the DNP3 protocol is being used in the network, PC Network Address 251 should not be used. This is because DNP3 RTU addresses above 250 use the network list entry for RTU251.

Number Of Retries: (0-9) The maximum number of attempts (after the first attempt) Toolbox will have at sending a message to the RTU if the previous attempts have failed. It is more reliable to set the Number Of Retries to 1 or more when downloading an RTU Configuration or Ladder Logic over the network.

### 3.14 Configuration - Download RTU Configuration

Once communications have been established with the RTU (for more information please see the topic Getting Started - Communicating With An RTU), the RTU is now ready to be configured.

Before downloading a completely new configuration to the local RTU it is recommended that the RTU is first Cold Started (Utilities, Advanced, Cold Start.) This clears all the registers, ladder logic and most of the communication settings.

Caution! It is recommended that you do not cold start an RTU over the network. After a cold start, an RTU will remember the communication settings for the first 4 ports ( 8 ports for a $\mathrm{PC}-1$ ) but it is possible that you will not be able to communicate with the RTU afterwards.

Once the RTU has been cold started, select Configuration, Download RTU Config. This causes all the configuration settings (as defined in the Filename.SDB file) to be downloaded to the RTU.

It is possible to download a configuration to the local RTU (the one connected to the computer) or to a network RTU (an RTU that the local RTU is able to communicate with). If you attempt to download a configuration with a different address to the local RTU then you will be prompted with the option as shown below.


Figure 3.14a: Local or Network Download Option Window

If you would like to download a new configuration to the local RTU then click 'Local'. This will cause the RTU address of the local RTU to be updated. If you would like to download a new configuration to a network RTU then click 'Network'. You will then be prompted for the address of the network RTU you would like to download to (note: it is possible to change the address of a network RTU). Normally, the address of the network RTU will be the same as the address of the configuration.

If the configuration is downloaded to the RTU successfully, the message 'RTU configuration has been downloaded. Download ladder logic now?' will appear on the screen otherwise the message 'Cannot communicate with RTU' will appear.

A warm start will occur after downloading the RTU configuration. This is equivalent to a power reset which causes the RTU to perform self-diagnostics and to initialise the communication ports. A warm start does not reset module inputs or outputs.

Before ladder logic can be downloaded, it must first be compiled. Please see the topic Downloading Ladder Logic (at the end of the ladder examples) for more information.

## CHAPTER 4 LADDER LOGIC

Ladder Logic is used to add intelligence to the RTU. It can be programmed to monitor inputs, control outputs and communicate with other RTUs or devices.

Ladder Logic is composed of a series of logic blocks arranged in the shape of a physical ladder. Processing of the blocks occurs from left to right and from top to bottom of the ladder. A ladder can be continually processed up to approximately 300 times per second (depending on how busy the RTU is) which allows for very quick responses to changing data conditions. A simple example of ladder logic is shown below.


Ladder logic blocks are configured on 'pages'. Each page can have up to 7 lines (or rungs) of ladder logic. Hundreds of pages of ladder logic can be configured for each RTU.

Each ladder rung is either logically true or false. Ladder rungs have 5 input blocks (contacts) and 1 output block (coil). Multiple rungs can also be linked together to trigger one or more output blocks. An output block is processed whenever a complete path or rung of input blocks are logically true and are connected to the output block. If all paths to the output block are logically false, the output block is ignored and the next rung is processed.

Ladder logic is configured using the menu Logic, Edit. Before configuring ladder logic, it is recommended that a variables list is created first.

The next section details the type of parameters that can be used in ladder logic blocks and in the variables list. This is followed by a description of how to create the variables list and an overview of how to edit ladder logic. Details about each type of ladder logic block are then described.

## Multiple Ladder Files

Up to 16 ladder logic files (Filename.LL) can be added to each RTU site by using Project, Add A Site Or Logic File and then selecting the additional ladder file. All the ladder logic files can then be compiled into a single output file by selecting the site's SDB window and selecting Logic, Compile. An LLO file will be generated that has the same name as the RTU site and is now ready for downloading. Multiple ladder files are commonly used when using function blocks. Note 1: Please ensure that each ladder logic file is saved before compiling otherwise any unsaved changes will not be included in the compiled output file.
Note 2: Multiple ladders are compiled in the order that they are added to the RTU site. The top ladder is compiled first. The order may be changed by editing the SDB file using a text editor or by deleting the logic files and adding them again to the project.
Note 3: Ladder logic defined after the first function block will not be regularly scanned. When adding a logic file containing function blocks to Filename.SDB, ensure that the logic file appears under Filename. LL in the project window.

### 4.1 Ladder Logic - Parameters

A Kingfisher RTU stores all I/O points, configuration settings and data variables in 16-bit 'registers'. Ladder logic is able to read and write to most of these registers allowing the RTU to perform a wide range of functions - including the ability to reconfigure itself. In addition to these registers, constants and indirect addressing may also be used for ladder logic parameters (where applicable) as detailed in the following sections.

RTU Register Types

| \#Alss.c | Analog Input (read only) |
| :--- | :--- |
| \#AOss.c | Analog Output |
| \#DIss.cc | Digital Input (read only) |
| \#DOss.cc | Digital Output |
| \#Rxxxx | Local Register |
| \#Fyyyy | Floating Point Register (32 bit) |
| \#Lyyyy | Long Register (32 bit) |
| \#NRrrr.xxxx | Network Register |
| \#NArrr.ss.c | Network Analog Register |
| \#NDrrr.ss.cc | Network Digital Register |
| \#NFrrr.yyyy | Network Float Register |
| \#NLrrr.yyyy | Network Long Register |
| \#Ttt | Timer Register |
| \#Y... | System Register |
| \#YP... | Port Register |
| \#YL... | Network Link Register |
| \#YM... | Module Register |
| Where: |  |
| ss = Slot number, 1-64 |  |
| cc = Channel number, 1-16 |  |
| c= Channel number, 1-8 |  |
| xxxx = Register number, 1-2048 |  |
| yyyy = Register number (odd numbers only) $1,3,5 . . .2047$ |  |
| rrr = RTU address, 1-249 |  |
| tt = Timer number, 1-64 |  |

A complete listing of all the available RTU registers and their descriptions is contained in the appendix - RTU Data.

## Constants

Constants can be used in ladder logic in the following formats:
Integer: 0 to 65535 (default format)
Hexadecimal: 16\#0 to 16\#FFFF. For an explanation of hexadecimal numbers, please see the appendix - Hexadecimal Numbers.

Floating Point: Floating point numbers can have up to 7 decimal digits of precision and can have values in the range of $3.4 \mathrm{e}-38$ to $3.4 \mathrm{e}+38$. Floating point constants can be defined in two formats as shown below.

- [-]nnnn.nnn
- [-]nnnn.nnne[-]nnn
where 'nnnn.nnn' can be up to 7 decimal digits (0-9) and '-' denotes a negative number or a negative exponential (optional). Egs. -1.0, 1.234e-3 (which can also be expressed as 0.001234 ). Floating point numbers must always contain a decimal point as this distinguishes them from integer constants.

Long: A signed 32 bit number in the range: $-2,147,483,648$ to $2,147,483,647$.
Bit: 0 or 1.

## Indirect Addressing

When addressing a register, the register number is usually hardcoded in the address eg. \#R1. The register number can also be specified indirectly by putting the register number in another register (the 'pointer' register) and then using indirect addressing. If the pointer register contains a value that will point out of range (eg. 0 or 3000), the indirect register address will return an incorrect value. Indirect addressing is extremely useful for reducing the amount of ladder logic required to perform a repetitious task (eg. calculating the average rainfall per minute for the last 60 minutes).

| Indirect Address | Description | Example |
| :---: | :---: | :---: |
| $\begin{aligned} & \left.\begin{array}{l} \# R[R x] \\ \# F[R x] \\ \# L[R x] \end{array}\right] \end{aligned}$ | Indirect local, float or long register | $\begin{aligned} & \begin{array}{l} \# R 1=2 \\ \# R 2=1000 \\ \text { \#R[R1] }=\# R 2=1000 \end{array} \end{aligned}$ |
| \#Rx.[Ra*] | Indirect local bit. Local register Ra is used to point to a bit of register Rx | $\begin{aligned} & \text { \#R1 = } 16 \\ & \text { \#R2.16 = }=\text { ON } \\ & \text { \#R2.[R1] }=\text { \#R2.16 = } 1(\mathrm{ON}) \end{aligned}$ |
| \#R[Rx].[Ra*] | Indirect local register and bit | $\begin{aligned} & \text { \#R1 }=3 \\ & \text { \#R2 }=16 \\ & \text { \#R3 }=8000 \mathrm{Hex}(\text { (Bit } 16 \mathrm{ON}) \\ & \text { \#R[R1].[R2] }=\# \mathrm{R} 3.16=1 \text { (ON) } \end{aligned}$ |
| \#NR[Ra*].n $(\mathrm{n}=1$ to 2048$)$ | Indirect network RTU | $\begin{aligned} & \text { \#R1 }=2 \\ & \text { \#NR2.1 }=1000 \\ & \text { \#NR[R1]. } 1=\text { \#NR2. } 1=1000 \\ & \hline \end{aligned}$ |
| \#NR[Ra*].[Rx] | Indirect network RTU and register | $\begin{aligned} & \text { \#R1 }=2 \\ & \text { \#R2 }=5 \\ & \text { \#NR2.5 }=1000 \\ & \text { \#NR[R1].[R2] }=\text { \#NR2. } 5=1000 \\ & \hline \text { Int } \end{aligned}$ |
| \#NR[Ra*].[Rx].[Rb*] | Indirect network RTU, register and bit | $\begin{aligned} & \text { \#R1 }=2 \\ & \text { \#R2 }=1 \\ & \text { \#R3 }=16 \\ & \text { \#NR2.1.16 = }=\mathrm{ON} \\ & \text { \#NR[R1].[R2].[R3] }=\text { \#NR2.1.16 =1 = ON } \end{aligned}$ |
| \#R[Rx+nnn] or \#R[Rx-nnn] (nnn =-128 to +127 ) | Indirect local register with offset. 'nnn' is an offset that is added or subtracted to the pointer register Rx | Useful when a block of local registers is used to store a number of values. One register would be used as a pointer to the first register in the array, then any of the other registers in the array could be accessed from the same pointer register |

* Ra, Rb and Rc must be in the range of R1 to R256 due to memory limitations of indirect addressing.
'Rx' can be any local register (R1 to R2048)
Please see the topic Example - Indirect Addressing or Example - Time Based Rolling Averages for examples of indirect addressing.


### 4.2 Ladder Logic - Variables List

A variables list is a list of all the inputs, outputs and data values to be used in ladder logic. The variables list is used to configure the parameters in each ladder logic block by selecting the appropriate variable from the list. This reduces configuration errors, saves time and maintains consistency in labeling ladder logic blocks. The variables list can also be used to create a database of RTU data to read and write for use by SCADA software.

When configuring a project of RTU sites, the variables from all the RTU sites in the project are included in the variable selection list. This allows ladder blocks in one RTU site to be configured with variables from another RTU site without the need to remember register addresses or labels from that site. When using a variable from another RTU site, the variable address is automatically converted into a network address ready for use by the local RTU.

After creating an RTU site (Filename.SDB), the variables list is accessed from the menu Logic, Variables List (this menu is only available when Filename.SDB is the active window). An example variables list is shown below.


Figure 4.2a: Example Variables List
Add: Add a new variable to the variables list. Each variable has four fields as shown below.

- Label: (1-17 characters). Can include spaces and other ASCII characters (eg. - + < > ? !). Each label can only be used once in the variables list. Note: it is recommended that labels are 12 characters or less as only the last 12 characters are displayed in ladder logic.
- Type: Bit $(0,1)$, Integer ( $0-65535$ ), Long or Float.
- Parameter: Any Kingfisher register or constant. Each parameter can only be used once in the variables list.
- Description: (Optional) 0-32 character description of the variable.

Delete: Delete the selected variable.
Modify: Modify the selected variable.
Replicate: Replicate the selected variable into a number of similar variables (up to 999 variables). Please see the next section - Replicating Variables for details).

Import from I/O Modules List: Generates a variable for each data point of each module configured in the IO Modules List.

Import from Ladder Logic: Generates variables from an existing Ladder Logic file. A report file must first be generated from the ladder logic (using the menu File, Report File when the ladder window is displayed). This will generate a file 'Filename.RPT' describing the variables used in the ladder logic. The import option then uses the RPT file to generate new entries in the Variables List. The comment for each ladder block is used as the label in the Variables List. If a comment was not used, a default label is generated.

## Variables List Format

The variables list is saved as a text file 'Filename.VAR' for each RTU site. A single VAR file can be used for all the RTUs in a telemetry system by creating a copies of the master VAR file and renaming them to match each RTU site. The VAR file can be edited using Microsoft Notepad or Excel. Note: if using Excel, ensure the file is saved as a Text (Tab delimited) file. You will then need to rename the file from 'Filename.VAR.txt' back to 'Filename.VAR'. Excel is useful for copying existing variables in the list and incrementing label names and parameters. Alternatively, you can use the Replicate function of the Variables List as detailed in the next section.

Using Variables In Ladder Logic
To access the variables list from ladder logic, the RTU site must be included in a currently open project. Double click on the block parameter to select a variable from the list. Parameters can be viewed as addresses or as labels (Ladder, View Points as Labels). When labels are selected, Toolbox automatically searches the Variables List to find the label associated with each address. When editing ladder logic, the user can then enter a parameter using a label from the variables list.

## Replicating Variables

After clicking on a variable in the variables list and then clicking the Replicate button, a replication template will appear that initially uses the settings of the selected variable. For example, the replication template for 'Counter1' is shown below.


Figure 4.2b: Replication template for Counter1

Characters in the template are replaced with wildcards or left as they are to be copied into the new variables as shown below.


Figure 4.2c: Replication template with wildcards inserted.

The variables created when OK is clicked are shown below.


Figure 4.2d: Example variables list showing replicated variables

The following wildcards can be used to replace characters in the replication template:
$(\mathbf{x T}+\mathbf{y}, \mathbf{a}, \mathbf{b})$ or ( $\mathbf{x T}-\mathbf{y}, \mathbf{a}, \mathbf{b})$ or \# or *

```
X (Optional) Number of characters in the starting template to modify
T Type of conversion: 'c' = character conversion, 'n' = number conversion.
    Character conversions apply to characters in the range (A-Z, a-z, 0-9) and
    number conversions apply to integer numbers. A ' }9\mathrm{ ' will be incremented to '0'
    in a character conversion, but to '10' in a number conversion. The length of the
    text is fixed in a character conversion but it is variable in a number conversion.
+ or - Increment (+) or decrement (-) applied before each replication
y Amount to increment or decrement for each replication. Can also be a fraction
    (eg. 1/3). If a fraction, will update after 2 or more replications after a complete
    unit is counted.
,a,b (Optional) Minimum limit (a) and Maximum limit (b). Only applies to number
    conversions.
# Copy this character from the template variable into the new variable
* Copy the complete string (or remaining portion of the string) from the template
    variable into the new variable.
```

Note: variables will only be replicated if each new variable has a different address and a different label to the original variable.

[^56]
### 4.3 Ladder Logic - Editing

Double clicking or pressing Enter with the highlight on a ladder block will allow you to edit that block. Double-clicking or pressing Enter on an empty ladder position will display a list of available blocks and you will able to create a new block.

The various types of ladder logic blocks that can be configured are detailed throughout this chapter.

Ladder logic can be copied, cut and pasted using the same standard key commands as a word processor as detailed below. Ladder logic can also be copied from one ladder to another if two or more sites are open in Toolbox.

Selecting blocks: Hold the right mouse button and then drag the highlight over the required blocks. Alternatively, hold the Shift key down and then use the arrow keys.

Copying ladder blocks: Press CTRL+C or Insert. This copies the selected blocks into the memory buffer and causes the highlight to disappear. The blocks can then be pasted into ladder logic by pressing CTRL+V or Insert.

Moving ladder blocks: Press CTRL+X or delete. This copies the selected blocks into the memory buffer and deletes them from the ladder page. The blocks can then be pasted into ladder logic by pressing CTRL+V or Insert.

Changing the block type: First delete the block (by pressing Delete or CTRL+X with the highlight on the block) and then create a new block (by pressing Enter and selecting a new block type). The old block's comment and parameter settings are automatically copied into the new block.

Moving to the start or end of a rung: The Home key moves the highlight to the first block and the End key moves the highlight to the last block of the rung.

Moving to the start or end of ladder: CTRL+Home moves the highlight to the first block and CTRL+END moves the highlight to the last block of ladder logic.

Ladder Logic Search: (CTRL+S) Searches for a block comment (label) or parameter in ladder logic. Searching is restricted to the currently displayed ladder page if the 'Search This Page Only' box is ticked.

Repeat Search: (CTRL+R) Searches for the next occurrence in ladder of the block comment or parameter as entered in 'Ladder Logic Search'.

Ladder Logic Translate (Search and Replace): (CTRL+T) Searches for a block comment or parameter and replaces it with the new block comment or parameter.

### 4.4 Ladder Logic - Inputs

Each type of ladder input block has a 12-character comment field that is used to describe the active state of the block (ie. when it is logically TRUE). For a single parameter block, the comment is used as a 'tagname' (a data descriptor) to describe the active state of that parameter eg. Pump1Running. For multiple parameter blocks, the comment can be used to describe the purpose of the block eg. Lev>HiSetpt?.

## Ladder Logic - Comment Block

Each comment block is one line of up to 64 characters.

## Ladder Logic - Horizontal Bar

(SHIFT+F2) A horizontal bar allows ladder blocks to be connected together. A horizontal bar is always TRUE and can have a 12-character comment.

## Ladder Logic - Vertical Bar

(SHIFT+F3) Each input block has a tick box 'Vertical Bar'. When ticked, a vertical bar will be inserted on the right, lower side of the block. A vertical bar is always TRUE and allows blocks to be linked between rungs.

## Ladder Logic - Contact

Test Bit: Any addressable bit. Eg. \#R1.5, \#DI14.1, \#YSYS.SCAN1, \#YPST2.1, \#NR2.1.5, \#ND2.14.1. For more Test Bit options, please see the appendix - RTU Data.

R1. 1 ON?
\#R1. 1


Block is true when the Test Bit is ON (or closed). As used in the topic Example - Initialising Variables On First Scan.

## R1.1 OFF?

\#R1. 1
N $/ \uparrow$ Normally Closed Contact
Block is true when the Test Bit is OFF (or open).

## Ladder Logic - Compare

All comparisons use unsigned values. This means that negative numbers are treated as large positive numbers.


Block is true when parameter 1 is less than parameter 2. Eg. if \#R1 is less than \#R2. As used in the topic Example - Exception Reporting Analogs.


Block is true when parameter 1 is less than or equal to parameter 2. Eg. if R1 is less than or equal to R2.


Block is true when parameter 1 is equal to parameter 2. Eg. if $R 1$ is equal to R2.


Block is true when parameter 1 is not equal to parameter 2. Eg. if $R 1$ is not equal to $R 2$.


Block is true when parameter 1 is greater than parameter 2. Eg. if $R 1$ is greater than $R 2$. As used in the topic Example - Exception Reporting Analogs.


Block is true when parameter 1 is greater than or equal to parameter 2. Eg. if R1 is greater than or equal R2. As used in the topic Example - Flow Totalisation.

## Ladder Logic - Logical Mask

Logical masking allows individual register bits to be selected and used for a Boolean operation. Each Logical Mask block is configured using two parameters as follows:

Test Register: Any 16-bit register.
Bit Mask: (Constant) The Bit Mask parameter is normally entered as a hexadecimal number in the format $16 \# x x x x$ - where ' $x x x x^{\prime}$ ' is the hexadecimal number. For a description of hexadecimal numbers please see the appendix - Hexadecimal Numbers.

```
R1chs1orgON
        #R1
[OR_HMSK]
    16#101
Logical OR Mask
```

Block is true when any of the masked bits in the test register are ON. Eg. if channel 1 or channel 9 are on in \#R1.

```
R1chs1890N
    ##1
[MND MASK]
    16#101
    Logical AND Mask
```

Block is true when all of the masked bits in the test register are ON. Eg. if channels 1 and 9 are on in \#R1.

```
R1chs1g90FF
    #R1
    [NOR_MASK]
    16#101 Logical NOR Mask
```

Block is true when all of the masked bits in the test register are OFF. Eg. channels 1 and 9 are off in \#R1.

```
R1ch=1orgofF
    #R1
-[NHND_MSK]
    16#101 Logical NAND Mask
```

Block is true when any of the masked bits in the test register are OFF. Eg. channels 1 or 9 are off in \#R1.

## Ladder Logic - Edge Trigger

## A blocks. <br> F1 Eit1 0->1 <br> \#R1. 1 <br> [UP-EDGE] Positive Edge Trigger

Caution! After downloading ladder logic, a Positive Edge Trigger or Change block will be TRUE for one ladder scan if the test bit is TRUE. This can be prevented by also testing the system register flag \#YSYS.ENABLE. Note: a warm start or a power reset will not affect these

Block is true for one ladder scan when the test bit makes an OFF to ON transition (0 to 1). Eg. bit 1 of R1 makes a 0 to 1 transition. As used in the topic Example - Counting Pulses And Starts.

## R1 Bit1 1->0

\#R1.1
-[DOTNS-EDGE]

## Negative Edge Trigger

Block is true for one ladder scan when the test bit makes an ON to OFF transition (1 to 0). Eg. bit 1 of R1 makes a 1 to 0 transition.

## R1 Eit1 cos

\#R1. 1
[CHMNGE] Change Detect
Block is true for one ladder scan when the parameter changes value. The parameter can be a single bit or a register. Eg. bit 1 of R1 makes a 0 to 1 or a 1 to 0 transition (change of state). When the parameter is a register, all 16-bits are monitored for change. As used in the topic Example - Rolling Totals Over At Midnight.

## Ladder Logic - Timer

The following parameters are used by each Timer block:
Timer Register: (\#T1 to \#T64) Each timer register can only be used once in ladder logic.
Period: (Constant or \#R). Specifying a local register allows the period to be changed while the ladder is running.

Units: 100ths (of a second), Seconds, Minutes, Hours, Days, Weeks, Months or Years.
Timer Accuracy: One Unit (as configured above). Eg a 10 minute timer will have an accuracy of 1 minute. While a 600 second timer (also 10 minutes) will have an accuracy of 1 second. Timers use the real-time clock to determine when to increment. When the specified time unit changes in the real-time clock, the timer increments. This means that if a timer is started using an ONDELAY or an OFF-DELAY block, the timer could increment very soon or up to 1 time unit later depending on when the timer units in the real-time clock change.


An on-delay timer is always used with one or more contacts. The on-delay timer becomes true when the contacts on its left-hand side are true and have stayed true for at least the specified time period. When the left-hand side contacts become false, the on-delay contact becomes false also. Eg. the on-delay contact will become true when bit 1 of R1 is ON for 5 seconds and will remain true while bit 1 remains ON. As used in the topic Example - Exception Reporting Digitals.


An off-delay timer is always used with one or more contacts. The off-delay timer will keep the left-hand side of the rung true for the specified time period after the left-hand side of the rung becomes false. Eg. the off-delay contact will stay true (and cause the rung to remain true) for 5 seconds after bit 1 of R1 becomes false.

```
Do Every 1DE
    #T1
    [PERIOD]
    10 Seconds
Periodic Timer
```

A periodic timer requires 3 parameters - a timer register (\#Txx), the time period (0-32767) and the time units (100ths [of a second], seconds, minutes, hours, days, weeks, months, years). This contact becomes true for one ladder scan every time period. As used in the topic Example - Timer Flag.

### 4.5 Ladder Logic - Outputs

The right-most column of ladder logic is used for Ladder Output blocks. These blocks cause something to happen - like a register bit to be set, a message to be transmitted or a calculation to be performed. Ladder Output blocks are processed when connected to a ladder rung that is logically true. The various types of ladder outputs are detailed in the following sections.

## Ladder Logic - Coil

A coil parameter can be any read/write bit. These include local register bits (eg. \#R1.1), hardware register bits (eg. \#DO3.16), internal register bits (eg. \#YDIAG.1) and network bits (eg. \#NR5.1.1, \#ND2.14.9).

```
Setr1 ON/OFF
    #R1.1
Normal Coil
```

When the input condition is true, the parameter is turned ON. When the input condition is false, the parameter is turned OFF. Eg. bit 1 of R1 is turned ON when the rung is true and is turned OFF when the rung is false. As used in the topic Example - Timer Flag.

```
Setr1 OFF/ON
    #R1.1
    (/)
```

When the input condition is true, the parameter is turned OFF. When the input condition is false, the parameter is turned ON. Eg. bit 1 of R1 is turned OFF when the rung is true and is turned ON when the rung is false.

Fet R1.1 ON
\#R1. 1
(5) Set Coil

When the input condition is true, the parameter is turned ON. No action is taken when the input condition is false. Eg. bit 1 of R1 is turned ON when the rung is true and is unchanged when the rung is false.

```
Set R1.1 OFF
    #R1.1
    (B)
    Reset Coil
```

When the input condition is true, the parameter is turned OFF. No action is taken when the input condition is false. Eg. bit 1 of R1 is turned OFF when the rung is true and is unchanged when the rung is false.

## Ladder Logic - Copy Functions

```
Copy R2 toR1
    #R1
    (Copy)
    #R2
    Single Copy
```

Copies a Source bit or register (eg. \#R2) to a Destination bit or register (eg. \#R1).
Source: Constant, bit, 16-bit register, float or long. Any addressable bit (eg. \#R1.5, \#DI14.1, \#YLST2.1, \#NR2.1.5, \#ND2.14.1) or register (eg. \#R1, \#F1, \#DI14, \#YLSUCC2, \#YSEC) can be used. For more Source options, please see the appendix - RTU Data.

Destination: Bit, 16-bit register, float or long.

## Type Conversions

When copying between the 3 register types (16-bit, float and long), the copy block performs a data type conversion. When a local register or a long is used as the source, it is treated as a signed number (bit 16 is the sign bit of a local register). When converting floats to 16 -bit or to Long, the decimal places are truncated.

Caution! If the range of the destination register is exceeded, the result will be undefined.

```
Copy20REgs
    #R101
-(BlockCopy)
    #R1
```


## Block Copy

Copies one block of registers to another block of registers or copies a constant into a block of registers.

Destination: (16-bit register, float or long) The first destination register to copy to.
Source: (Constant, 16-bit register, float or long) The first source register or constant to copy from. If the source is a constant, the constant is copied into all the destination registers. If the source is a register, a block of source registers is copied to a block of destination registers. Note: it is possible to copy the contents of a single register into a block of registers by using a source register that is one less that the destination. Please see the example below.

Count: The number of consecutive registers to copy. Note: network registers are stored in blocks of 64 registers in RTU memory. When sourcing from or copying to network registers, it is not possible to cross a network register block boundary (eg. \#NR1.64, \#NR1.128, \#NR1.192 etc). Therefore, the maximum number of network registers (\#NA, \#ND, or \#NR) that can be block copied is 64 . If the starting point is midway in a network block, then only the number of registers to the next boundary can be copied.

## Examples:

Destination: \#R1, Source: 100, Count: 50
Fills \#R1 to \#R50 with the value 100.
Destination: \#R2, Source: \#R1, Count: 50
Fills \#R2 to \#R51with contents of \#R1.

## Copy String \#R101 <br> -(StrCopy) - String Copy

Copies up to 31 text characters (a string) to consecutive local registers. Each character is stored as an 8-bit ASCII number and the string is null terminated. Two characters are stored in each local register. For each pair of characters, the left character is stored in channels 1-8 and the right character is stored in channels $9-16$. For an LP-1, the characters are stored in reverse order. Eg. string 'XY' is copied to a local register

| CPU Type | Chs 9-16 | Chs 1-8 |
| :--- | :---: | :---: |
| PC-1, CP-x | $59 \mathrm{Hex}(\mathrm{Y})$ | $58 \mathrm{Hex}(\mathrm{X})$ |
| LP-1 | $58 \mathrm{Hex}(\mathrm{X})$ | $59 \mathrm{Hex}(\mathrm{Y})$ |

A string copy can be used with indirect pager messages. The pager message 'Line 1 ' is configured as a local register '\#Rx'. A String Copy is then used to copy the required text to a block of registers beginning at '\#Rx' before the pager message is triggered. Note: multiple strings can be joined together by copying over the null terminator of the first string with the beginning of the second string.

Destination: (\#R1 - \#R2048) The first local register to copy the characters to. Characters are stored in consecutive registers until the end of the string is reached (a maximum of 16 registers are used)

Source: Up to 31 text characters to copy to the local registers.
Swap Bytes? When checked, the 2 characters stored in each local register will be swapped (this function is used for the DV1000 protocol driver).


A Multi Copy is the same as a Single Copy block but allows you to perform up to 16 individual copies at the same time. This is useful for minimising the number of ladder rungs used. A Multi Copy block showing various types of copies is shown below.


Note: multicopy blocks can use a considerable amount of processing power. To free up the processing time, multi copy blocks should be processed once a second or less by using a \#YTICK.SEC contact in the multicopy rung as shown below.


## Ladder Logic - Maths

## 16-bit Register Range

$0-65535$ (unsigned) or -32768 to +32767 (signed). Values overflowing the storage limit are counted from zero again. Eg. $65535+1$ is stored as $0,65535+2$ is stored as 1 . Values less than zero are counted backwards from 0. Eg. -1 is stored as $65535,-2$ is stored as 65534 . All Kingfisher addresses (ie. \#R, \#AI, \#AO, \#DI, \#DO, \#NR, \#NA, \#ND, \#Y, \#T) are 16-bit registers except for Floating point (\#F) and Long (\#L) registers which are 32-bit registers and provide a greater numerical range.

## Mixing Register Types

The Add, Subtract, Multiply and Divide maths blocks allow the 3 register types (16-bit, Float or Long) to be used in any combination. If the destination register is a different type to either parameter, a type conversion is used to obtain the result.


Increments the parameter by one. Eg. R1=R1+1. As used in the topic Example - Flow Totalisation.

Parameter: 16-bit register (read/write) or Long register (not Float)

| R1=R1-1 <br> \#R1 <br> (Dec) |  |
| :---: | :---: |
|  | Decrement |

Decrements the parameter by one. Eg. R1=R1-1.
Parameter: 16-bit register (read/write) or Long register (not Float).
$\mathrm{R} 1=\mathrm{R} 2+\mathrm{R} 3$
$\left[\begin{array}{cc}\# \mathrm{R} 1 \\ = & \# \mathrm{R} 2 \\ + \\ \# \mathrm{R} 3\end{array}\right]$ Add

Parameter 2 (R3) is added to Parameter 1 (R2) and the result is put in the Destination (R1). As used in the topic Example - Flow Totalisation.

Destination: 16-bit register (read/write), Long or Float register.
Parameter 1, Parameter 2: 16-bit register (read/write), Long, Float or constant. Register types can be mixed in any order.

Caution! It is possible to exceed the range of the destination register and produce an undefined result.


Parameter 2 (R3) is subtracted from Parameter $1(\mathrm{R} 2)$ and the result is put in the Destination (R1). As used in the topic Example - Flow Totalisation.

Destination: 16-bit register (read/write), Long or Float register.
Parameter 1, Parameter 2: 16-bit register (read/write), Long or Float register or constant. Register types can be mixed in any order.
Caution! It is possible to exceed the range of the destination register and produce an undefined result.


Parameter $2(\mathrm{R} 3)$ is multiplied with Parameter $1(\mathrm{R} 2)$ and the result is put in the Destination (R1). The Multiply block treats 16-bit registers as signed numbers ( -32767 to +32767 , highest bit = sign).

Destination: 16-bit register (read/write, signed), Long or Float register.
Parameter 1, Parameter 2: 16-bit register (read/write, signed), Long or Float register or constant. Register types can be mixed in any order.

Caution! It is possible to exceed the range of the destination register and produce an undefined result.


Parameter 1 (R2) is divided with Parameter 2 (R3) and the result is put in the Destination (R1). The Divide block treats 16 -bit registers as signed numbers ( -32767 to +32767 , highest bit $=$ sign).

Destination: 16-bit register (read/write, signed), Long or Float register.
Parameter 1, Parameter 2: 16-bit register (read/write, signed), Long or Float register or constant. Register types can be mixed in any order.
Caution! It is possible to exceed the range of the destination register and produce an undefined result. Note: the result is undefined after a divide by zero.


Calculates the modulus of Parameter 1 divided by Parameter 2 and returns the result in the Destination. The modulus is the remainder after division and is represented by the percentage symbol (\%). Eg. $10 \% 3=1$ (10 divided by 3 equals 3, with a remainder of 1 ). The Modulus block treats 16 -bit registers as signed numbers $(-32767$ to +32767 , highest bit $=$ sign).

Destination: 16-bit register (read/write, signed) or Long register (not Float).
Parameter 1, Parameter 2: 16-bit register (read/write, signed), Long register or constant (not Float). Register types can be mixed in any order.

Caution! It is possible to exceed the range of the destination register and produce an undefined result.

```
F1=Sqrt RZ
    #R1
    (Sqrt)
    #R2
    Square Root
```

The square root of the Source (R2) is put in the Destination (R1).
Destination: Float register (\#F).
Source: Float register (\#F) or constant.

```
Flow 0-10000
    #AI14.2
    10000
    32760
Multiply/Divide
```

Multiplies the 'Source' with the 'Multiply By' parameter, then divides the result with the 'Divide By' parameter and then puts the result in 'Destination'. The Multiply/Divide block treats 16-bit registers as signed numbers $(-32767$ to +32767 , highest bit $=$ sign $)$.

Destination: 16-bit register (read/write, signed).
Source, Multiply By, Divide By: 16-bit register (read/write, signed) or constant. Note: a divide by zero causes the destination to remain unchanged.

The Multiply/Divide block is very useful for scaling analog values into engineering units within the RTU. The above example shows an analog input being converted to a number in the range $0-10,000$ which could then be displayed as $0-100.00 \%$ (Series II analog inputs are stored as a number in the range $0-32760=0-100 \%$ ). The Multiply/Divide block allows high accuracy when scaling a number as it uses a 32 bit total for its calculations and then returns the lowest 16-bits as the result. If the result is greater than 65535 (16-bit limit), the Multiply/Divide block returns a value of 8000 Hex (32767). Note: It is generally recommended to use separate Multiply and Divide blocks with floating point parameters for scaling calculations as they can store a much wider range of numbers, including fractional numbers, and are not likely to go out of range.


Calculates Parameter 1 (F3) to the power of Parameter 2 (F5) and returns the result in the Destination (F1).

Destination: Float register.
Parameter 1, 2: Float register or constant.
$F 1=\operatorname{LOG} F 3$
$(\# F 1$
$\binom{$ Iog 10$)}{\# F 3}$

Logarithm
Calculates the Logarithm (base 10) of the Source (F3) and stores the result in the Destination (F1).

Destination: Float register.
Source: Float register or constant.


Calculates the Sine of the Source (F3) and stores the result in the Destination (F1). Angles are defined in radians. Note: $1^{\circ}=2 \pi / 360=0.017453$ Radians.

Destination: Float register.
Source: Float register or constant.

$$
\# F 1
$$

    (Cos)
    \#F3
    Cosine

Calculates the Cosine of the Source (F3) and stores the result in the Destination (F1). Angles are defined in radians. Note: $1^{\circ}=2 \pi / 360=0.017453$ Radians.

Destination: Float register.
Source: Float register or constant.

```
F1 = TAN FG
    #F1
    (Tan)
    #F3
Tangent
```

Calculates the Tangent of the Source (F3) and stores the result in the Destination (F1). Angles are defined in radians. Note: $1^{\circ}=2 \pi / 360=0.017453$ Radians.

Destination: Float register.
Source: Float register or constant.

```
ECDtoEinary
    #R2
    (ECD-Ein)
    #R1
BCD To Binary
```

Converts a BCD number (\#R1) to binary format (\#R2). BCD uses a group of 4 bits to represent each decimal digit (0-9).

Destination: 16-bit register (read/write).
Source: 16-bit register (read/write) or constant.

```
EinaryToECD
    #RR
    -(Ein-ECD)
    #R1
Binary To BCD
```

Converts a binary number (\#R1) to BCD format (\#R2). BCD uses a group of 4 bits to represent each decimal digit (0-9).

Destination: 16-bit register (read/write).
Source: 16-bit register (read/write) or constant.

## Ladder Logic - Logic

For each of the following Logic Functions, the input parameters can be 16-bit registers or constants. These functions all perform bit-wise operations; ie. they treat the registers as 16 individual bits.

```
R1 = INV R2
    #R1
-(InvERT)
    #R2
Invert
```

The Source (R2) is inverted, and placed in the Destination (R1).
An Invert causes all the 16-bits in the register to be changed (ie. 1's are changed to 0's and 0's are changed to 1 's).


Parameters 1 and $2(R 2, R 3)$ are ANDed together and the result is placed in the Destination (R1). This means only the bits which are a ' 1 ' in both parameters, will be a ' 1 ' in the destination. All other bits will be 0 .


Parameters 1 and $2(R 2, R 3)$ are ORed together and the result is placed in the Destination (R1). This means that all the bits which are a ' 1 ' in either parameter will be a ' 1 ' in the destination. All other bits will be 0 .


Parameters 1 and $2(R 2, R 3)$ are NANDed together and the result is placed in the Destination (R1). This means that the bits which are a ' 1 ' in both parameters will be a ' 0 ' in the destination. All other bits will be 1 .

```
R1=R2 NOR. R3
    #P1
    NOR
    ##2
NOR
```

Parameters 1 and 2 (R2, R3) are NORed together and the result is placed in the Destination (R1). This means that all the bits which are a ' 1 ' in either parameter will be a ' 0 ' in the destination. All other bits will be 1.


Parameters 1 and 2 (R2, R3) are XORed together and the result is placed in the Destination (R1). This means that all the bits which are the same in both parameters will be a ' 0 ' in the destination. All other bits will be 1 .

```
RotR1LeftEy1
    #R1
    POL
    #R1
ROL (Rotate Left)
```

Parameter 1 is rotated left by the number of bits specified in Parameter 2, and the result placed in the Destination.
Eg. Destination = \#R1, Parameter $1=$ \#R1, Parameter $2=1$
If \#R1 initially contains the value 10 hex (0000 000000010000 binary), it will contain 20 hex (0000 000000100000 binary) after calling this function. If \#R1 initially contains the value 8000 hex (1000 000000000000 binary), it will contain 1 hex ( 0000000000000001 binary) after calling this function.


Parameter 1 is rotated right by the number of bits specified in Parameter 2, and the result placed in the Destination.
Eg. Destination = \#R1, Parameter $1=$ \#R1, Parameter $2=1$
If \#R1 initially contains the value 2 hex ( 0000000000000010 binary), it will contain 1 hex (0000 000000000001 binary) after calling this function. If \#R1 initially contains the value 1 hex (0000 000000000001 binary), it will contain 8000 hex (1000 000000000000 binary) after calling this function.

## Ladder Logic - Event Logging

Event logs allow the RTU to record time and date stamped data. An event log can be created periodically, after data changes or on any configurable event.

Event logs are kept in a circular buffer that is "max. number of logs" long (as detailed by the Memory configuration, Check memory usage button). When the buffer is full, the oldest logs are overwritten. The RTU uses an internal "current pointer" which always points to the latest log added to the buffer.

## Accumulating Event Logs From Other RTUs

Event logs received from other RTUs are all stored in one event log buffer. To keep track of which logs have been received, a master RTU uses a local log pointer for each outstation RTU. Each of these pointers is then used to point to the last log polled from the outstation RTU. For greater flexibility, a local log pointer can be set to point to the latest log in an outstation RTU or it can be set to point to a log that occurred a number of minutes ago in the outstation RTU.

## RTU Communications

Most of the event log blocks initiate messages and should be used in a similar way to other communication blocks by first checking if the port is available before sending a message. For an example of using event log blocks, please see the topic Example - Polling Event Logs.

Log \#AII4.2
Type 1
(Event Log)
\#\#.I14. 2
Event Log
Logs the value or state of a variable along with the user type and priority of the event log. Please see the topic Example - Event Logging. Note: a maximum of 250 Event Log blocks can be used per RTU.

Comment: A 12-character description.
Ref: Prior to 1.30a firmware, each event log was automatically assigned a different reference number when the ladder was compiled. No longer used.

Variable: Bit, 16-bit register, Long (\#L) or Float (\#F).
User Type: (0-31) Used to group similar types of logs. For example, analog inputs could be type 1, digital status signals type 2, digital alarm signals type 3 and so on. When uploading the logs from the RTU, you may then choose which type of logs to upload instead of uploading all the logs.

Priority: (0-7) Allows separation of logs within each User Type category. 0 is used for the highest priority logs.

```
SendNewLogs
    RTU 1
    -(Tx Iogs)
        #R1
Tx Event Logs
```

Superseded! Transmits up to 10 new event logs to the destination RTU ('Dest RTU'). Supported by firmware V134C and older. Use 'Tx Update Event Logs' block to upgrade.

Dest. RTU: (1-249) The target RTU to send event logs to.
Event Log Pointer: The local register (\#R) that points to the next log to transmit. Note: this register should not be used by any other part of the ladder as it is automatically updated by the RTU after each Tx Event Logs block.
'Finished' flag: A register bit (\#R.cc) that is set ON when the newest log has been transmitted. The Finished flag is set OFF when the newest log has not been transmitted by the Tx Logs block. Note: this flag is only updated each time the Tx Logs block is processed.

Filter Logs By: Only event logs that match the filter settings are transmitted.

```
SendOwnLoge
    RTU 1
-(TXUED LOGS)
    #R1
Tx Update Event Logs
```

This block is designed to update event logs in a standby master RTU. It also updates the event log pointers for the remote RTUs in the standby master. The block checks if new logs need to be transmitted to the destination RTU and then sends them 10 at a time until it has sent the maximum limit of event logs or until the end of the event log list is reached. Requires driver 'TXUPDATE.Dxx'. Care must be taken to initiate only one Tx or Rx Update block at a time otherwise unpredictable results may occur. The pending flag detailed below can be used to determine when the Tx Update block has finished.

Destination RTU: (1-249) The target RTU to send event logs to.
Event Log Pointer: (\#R) The local register which the RTU uses to remember where it is up to in the event log list. It is automatically updated after the TX Update block is successfully completed.

Status Register: (\#R) A local register used to indicate the status of the block as follows:

- Channel 1: Pending Flag. Channel 1 is set ON when the block is activated and set OFF when the block is finished.
- Channel 2: Status Flag. Channel 2 is written to after the block is finished. Channel 2 is set OFF if the update was successful or is set ON if the update failed (due to communications failure).
- Channel 3: Finished Flag. Channel 3 indicates whether the Event Log list contains any more entries and is written to after a block of event logs has been successfully transferred.
Channel 3 is set ON if all the event logs have been sent or is set OFF if there are more logs.
Max. number of logs: (0-65535) The maximum number of logs to transmit each time the Tx Update Event Logs block is activated.

```
GetNewLags
    RTU 1
    (Rx Loge)
    ##R1
Rx Event Logs
```

Superseded! Requests up to 10 new event logs from the 'Source RTU'. Supported by firmware V134C and older. Use 'Rx Update RTU Info' block to upgrade.

Source RTU: (1-249) The target RTU to read event logs from.
Event Log Pointer: (\#R) The local register that points to the latest log received from the source RTU. Note: this register should not be used by any other part of the ladder as it is automatically updated by the RTU.
'Finished' flag: (\#R.cc) A register bit that is set ON when the newest log is received. The Finished flag is set OFF when the newest log has not been received yet. Note: this flag is only updated when the Rx Logs block is processed.

Filter Logs By: Only event logs that match the filter settings are retrieved.

## GetRTU2Lags RTU 2 <br> (RxLog Time) \#R1 <br> Rx Event Logs from Specific Period

Polls event logs that occurred over a specific time period from a remote RTU. It will keep polling groups of 10 logs at a time until it has received the maximum limit of logs or until the end of the event log list is reached.

RTU: (1-249) The target RTU to poll the event logs from.
Status Register: (\#R or blank) When a local register is specified, the channels are defined as follows:

- Channel 1: Pending Flag. This bit is set ON when the block is activated and then set OFF after the block has finished.
- Channel 2: Status Flag. This bit is written after the block is finished. The status flag is set OFF if the block was successful or set ON if the block failed (communications failure).

Start Time (minutes before now), Period: A constant (0-32767) or a local register (\#R). These fields are used to specify the time period for uploading logs.

Filter Logs by: Only event logs that match the specified priority or user type are uploaded. The maximum number of logs to upload can also be specified.

```
OwnMewLogs
Local RTU
(Iag Count)
    #R1
Get Event Log Count
```

Superseded! Counts the number of new logs in the buffer from the Event Log Pointer to the latest event log entry. This block is useful for determining when unread logs are about to be overwritten. Supported by firmware V134C and older.

RTU (0 for local logs): (0-249). The RTU to obtain the event log count from. When '0' is specified, the event logs are counted in the local RTU itself. If a non-zero number is specified, a Log Count message is initiated to get the log count from that RTU.

Event Log Pointer: (\#R) The local register that points to the event log to start counting from.
Destination: (\#R) The local register used to store the result of the Log Count.
Filter Logs By: Only event logs that match the filter settings are counted.

```
ResetownEtr
    RTU 0
-(SetLogPtr)
    #R1
Set Event Log Pointer
```

Superseded! Sets the local Event Log Pointer to point to the latest event log in an outstation RTU or sets the pointer to point to an event log that occurred a number of minutes ago in an outstation RTU. Supported by firmware V134C and older.

RTU (1-255, 0 for local): The address of the remote RTU with the target event log.
Log Pointer override: (\#R) The RTU's own local register that is used to point to the latest log received from the remote RTU. If 'Log Pointer override' is left blank, the local system register \#YLLOGIDXrrr will be updated instead (where 'rrr' is the RTU address).

Time before now (minutes): (\#R or 0-32767) The local RTU will request the address of the event log that occurred 'Time before now' minutes ago from the remote RTU. This address will then be used to set the local event log pointer. Entering '0' will disable this field.

FackownIogs

## -(FackIogs) - Pack Event Logs

Compacts the local Event Log list by deleting event logs that are older than the specified period.
Log Retention Period: These fields indicate time in hours before now. They specify the period for which logs of each priority will be retained. All event logs older than the specified period will be deleted.

## Warnings:

- The 'Pack Event Logs' block will cause event logs to be re-ordered in the event log buffer. Therefore any pointers to the event log buffer which are not current will be invalid and using these pointers for transferring logs will result in inconsistent behavior (logs may be uploaded twice or out of order).
- It is possible to generate many thousands of event logs in an RTU. Once the event log list becomes large, any blocks which require searching through this list will become slow, and will therefore cause delays in scanning I/O points and processing ladder logic.


## Ladder Logic - Tx / Rx Comms

The following sections detail the Kingfisher TX Comms and RX Comms blocks. Popular "Other Comms Drivers" are detailed in the chapter - Communication Drivers.

## Ladder Logic - Transmit / Receive Data

Whenever data is transferred from one RTU to another, the data is always placed in network registers. When communicating with an RTU connected with a PSTN modem link, the RTU will automatically dial the number configured for that RTU.

```
ExRepToRTU1
    RTU 1
    -(TX DATA)
    #R1
```


## Series 2: Transmit Data

Transmits up to 32 16-bit registers to a destination RTU. As used in the topic Example Sending The Exception Report.

Comment: A 12-character description.
RTU \#: (1-249) The destination RTU that the data is sent to (note: addresses 250-255 are reserved for paging and PC use).

Registers: The registers to transmit to the destination RTU. Can enter \#R, \#F, \#L, \#DI, \#AI, \#NR, \#ND or \#NA registers in any order. Note: If one or more of the registers is a network register (\#N...), then a maximum of 25 registers can be entered. Float (\#F) and Long (\#L) registers count as two registers each. The 16 channels of a digital module can be transferred as one 16-bit register (eg. \#DI14) while analog channels must be transferred individually (eg. \#Al15.1, \#Al15.2) as each channel is stored in one register. For more details about each type of register, please see the appendix - RTU Data.

```
Foll RTUZ
    RTU 2
    (RX_DATA
    ##1
```


## Series 2: Receive Data

Polls up to 32 registers from a source RTU. As used in the topic Example - Polling Data.
Comment: A 12-character description.
RTU \#: (1-249) The source RTU that the data is received from (note: addresses 250-255 are reserved for paging and PC use).

Registers: The registers to poll from the source RTU. Can enter \#R, \#F, \#L, \#DI, \#AI, \#NR, \#ND or \#NA registers in any order. Note: If one or more of the registers is a network register (\#N...), then a maximum of 25 registers can be entered. Float (\#F) and Long (\#L) registers count as two registers each. For more details about each type of register, please see the appendix - RTU Data.

## Ladder Logic - Tx/Rx Update Network RTU Images

Care must be taken to initiate only one Tx or Rx Update block at a time otherwise unpredictable results may occur. The pending flags detailed below can be used to determine when the block has finished before generating new Tx or Rx update messages.

## UpdateMaster <br> RTU 1 <br> -(TX_IMAGES)-Series 2: Tx Update Network RTU Images

Sends new network data to a destination RTU. It is possible to update the network data for up to 32 RTUs using one TX Images block. Network data is stored in an RTU as blocks of 64 registers. The TX Images block works by requesting the CRC for each block from the destination RTU ('RTU \#') and if the CRCs are different, the local RTU updates the block in the destination RTU. Only network blocks that are different are updated which minimises communication time. Requires driver 'TXUPDATE.Dxx'. As used in the appendix topic Redundancy, Redundant RTUs.

Comment: A 12-character description.
RTU \#: (1-249) The destination RTU that the network data is sent to.
RTUs: (1-249) The network data for these RTUs is compared between the destination RTU and the local RTU and then the data in the destination RTU is updated if necessary.

```
UpdateSecMas
    RTU 1
(RX_IMAGES)
    0
```


## Series 2: Rx Update Network RTU Images

The RX Images block is used to get new network data from a source RTU. It is possible to update the network data blocks of up to 16 RTUs at a time using one RX Images block. An RX Images block works by requesting the CRCs for each network block from the source RTU. If the CRCs are different to the local RTU, the local RTU polls the new network blocks from the source RTU. Only network blocks that are different are updated which minimises communication time. Requires driver 'RXUPDxx.Dxx'.

Comment: A 12-character description.
RTU: (1-249) The source RTU to receive network data from.
RTUs to update: (1-249) The network data blocks (images) of these RTUs are requested from the source RTU. The network data for up to 16 RTUs can be requested at once.

## Selection and Status Controls

These fields control the RTU images to update and indicate the current status of the block.
Realtime Data Mask: Local register (\#R), 'ALL' (all RTUs in the list are updated), or 'NONE' (none of the RTUs in the list are updated). When a local register is used, the 16 register channels correspond to the 16 RTUs to update respectively. When a channel is set ON, the data for the corresponding RTU will be updated. After a successful data update, the channels are not reset. The default value for this field is 'ALL'.

Pending flags: 'NONE' or a local register (\#R). Each of the 16 channels indicates the pending status of the corresponding RTU in the 'RTUs to update' list. All the channels are set ON when the RX Images block is activated. After the network data for each RTU is updated, the channel corresponding to that RTU is set OFF.

Status flags: 'NONE' or a local register (\#R). Each of the 16 channels indicates the success/failure status of the corresponding RTU in the 'RTUs to update' list. Each flag is written to after the network data of that particular RTU has been updated. A flag is set OFF if the update is completed successfully or is set ON if the update has failed.

## Ladder Logic - Rx Update RTU Info

```
Updateallinf
    RTU 2
-(RX_UPDAT) - Series 2: Rx Update RTU Info
```

Polls data and event logs from up to 16 RTUs. An RX Update block can also issue a 'Sync Clock' command to each of the RTUs. The Rx Update block works by requesting the CRC for each network block from each RTU and then requests the blocks that have changed. Only network blocks that are different are updated which minimises communication time. Event logs that match the priority and user type are uploaded until the maximum limit is reached or until there are no more event logs. Requires driver 'RXUPDxx. Dxx'. Care must be taken to initiate only one Tx or Rx Update block at a time otherwise unpredictable results may occur. The pending flags detailed below can be used to determine when the Rx Update block has finished. As used in the topic Example - Polling Event Logs.

Note: for local and hardware registers, the source RTU controls which of its network data blocks will be checked or uploaded. The system parameters 'Update Register Blocks' and 'Update Hardware Blocks' are configured in the outstation RTU to control this function (please see the topic Configuration - System Parameters).

Comment: A 12-character description.
RTUs to update: (1-249) A list of up to 16 RTUs to request data from.

## Selection Controls

These fields identify which update functions (update real-time data, update event logs, synchronize clocks) apply to each of the listed RTUs. If a local register (\#R) is specified, the 16 channels correspond to each of the 16 RTUs to update. When a channel is set ON, the corresponding RTU will be updated. Alternatively, 'ALL' (all RTUs in the list are updated), or NONE (none of the RTUs in the list are updated) can be specified. The default value for each of these fields is 'ALL'.

Realtime Data mask: If a register channel is set ON, real-time data will be polled from the corresponding RTU. The channel is NOT reset after a successful data update.

Event Logs mask: If a register channel is set ON, event logs will be polled from the corresponding RTU according to the 'Event Log Control' fields. The channel is reset when all event logs have been received from the RTU.

Sync Clocks mask: If a register channel is set ON, the clock of the specified RTU will be synchronized to the local RTU's own clock. The channel is reset if the RTU is synchronized successfully.

Status Controls
These fields indicate the current status of the Rx Update function. When set to 'NONE', the status controls are not used.

Pending flags: 'NONE' or a local register (\#R). Each of the 16 channels indicates the pending status of the corresponding RTU in the 'RTUs to update' list. Each channel is set ON when the RX Update block is activated and then set OFF when polling of that particular RTU has finished. Note: the local register is not automatically set to zero after a warm start.

Status flags: 'NONE' or a local register (\#R). Each of the 16 channels indicates the success/failure status of the corresponding RTU in the 'RTUs to update' list. Each flag is written to after polling of the particular RTU has finished. A flag is set OFF if the update is completed successfully or is set ON if the update has failed.

Event Log Controls
Max. Logs to Upload: The maximum number of logs to upload each time the RX Update block is activated.

Priority, User Type: Only event logs that match the Priority and User Type settings are retrieved.


Series 2: Rx Update RTU Info, single RTU
Polls data and event logs from a single RTU. An RX Update block can also issue a 'Sync Clock' command to the RTU. The Rx Update block works by requesting the CRC for each block and then requesting the blocks which have changed. Only network blocks that are different are updated which minimises communication time. Event logs that match the priority and user type are uploaded until the maximum limit is reached or until there are no more event logs. Requires driver 'RXUPDxx.Dxx'. Care must be taken to initiate only one Tx or Rx Update block at a time otherwise unpredictable results may occur. The pending flag detailed below can be used to determine when the Rx Update block has finished.

This block is also useful for copying event logs from a submaster RTU to a master RTU. The Rx Update Single block ignores the source of the event logs in the submaster RTU and simply copies all the logs from the submaster RTU to the master RTU.

Note: for local and hardware registers, the outstation RTU controls which of its network data blocks will be checked or uploaded. The system parameters 'Update Register Blocks' and 'Update Hardware Blocks' are configured in the outstation RTU to control this function (please see the topic Configuration - System Parameters).

Fields are the same as for an Rx Update block for multiple RTUs except for:
Control Register: Local register (\#R) or blank. A blank entry causes real-time data and event logs to be updated, the clock to be synchronized and to not use the pending or status flags. When a local register is specified, the channels must be configured as follows:

- Ch1: Real-time Data Flag. If this channel is set ON, real-time data will be polled from the specified RTU. Channel 1 is NOT reset after a successful data update.
- Ch2: Event Logs Flag. If this channel is set ON, event logs will be polled from the specified RTU according to the 'Event Log Control' fields. Channel 2 is reset when all event logs have been retrieved from the RTU.
- Ch3: Sync Clock Flag. If this channel is set ON, the clock of the specified RTU will be synchronized to the local RTU's own clock. Channel 3 is reset if the RTU is synchronized successfully.
- Ch4: Pending Flag (set by Rx Update block). Indicates the pending status of the RX Update block. Channel 4 is set ON when the block is activated and is set OFF when the block has finished.
- Ch5: Status Flag (set by Rx Update block). Indicates the success/failure status of the RX Update. Channel 5 is written to after polling of the RTU has finished. Channel 5 is set OFF if the update is completed successfully or is set ON if the update has failed.


## Ladder Logic - Pager Message

Eattery Low
\#R1. 1
(PAGER)
Pager Message
Sends a 32-character pager message to up to 12 pager receivers. The pager message can also be sent with a time and date stamp. Requires driver 'PAGINGxx.Dxx'.

A pager message will initially be sent to the pager receiver(s) configured in Group 1 of the selected pager sequence. If an acknowledge is received within the time specified in the 'Wait for Ack' field (by writing a 0 to the acknowledge bit), the sequence is completed and no further action is taken. If an acknowledge is not received, the same message is then sent to the Group 2 pagers (if any pagers have been configured for Group 2). If an acknowledge is not received within the 'Group 2 Wait for Ack' time, the message is sent to the Group 3 pagers. If an acknowledge is not received within the 'Group 3 Wait for Ack' time, the RTU will flag a fail for RTU250 (RTU250 is reserved for paging statistics) and increment the fail counter. Please see the topic Example - SMS Pager Messages.

Comment: A 12-character description.
Message: A local register (\#R1 - \#R2048 specified on 'Line 1') or up to 2 lines of 16 characters. A local register can be used to point to the beginning of a block of registers that contain the pager message text. When using a local register, no other text can be included on 'Line 1' or 'Line 2'. The String Copy block is used to store text characters in local registers for use by the pager message block.

Prepend Site Address \& Name: If ticked, 'Site: FILENAME' is added to the start of the message; where 'FILENAME' is the name of the SDB file loaded in the RTU.

Append Date/Time Stamp: If ticked, a time and date stamp is added to the end of the pager message as follows 'DD-MM HH.MM.SS' - ie. day-month hour.minutes.seconds. The year is not included.

Pager Seq (1-5): Indicates which pager sequence to use for this message (as configured in Configuration, Pager Configuration). A pager sequence defines which pager receivers to send the pager message to.

Acknowledge Bit: This bit is set when the pager message is first sent. Resetting the bit to zero (eg. using SCADA software) will acknowledge that the pager message is received and no further messages will be sent.

For more information, please see the topic Configuration - Pager Configuration and Example SMS Pager Messages.

## Ladder Logic - Function And Program Blocks

Function Blocks allow commonly used pieces of logic to be defined once and then re-used as many times as necessary. Function blocks for DNP3 objects are available from the RTUnet website.

Up to 32 variables can be passed to a function block and then used within the function block. Variables are referenced by "\%number"; eg. the third parameter would be referenced as "\%3".

A function block definition commences with a 'Start Function Block', and ends with a 'Return from Function Block'. The function block is called or run from ladder logic by using a 'Call Function Block'.

A function block can be configured as a 'contact' by defining a boolean (true or false) return parameter, or as a 'coil' by not defining a return parameter as detailed below. A function block can also be used to call another function block. This can occur multiple times so that one function block call can trigger a string of function block calls.

## Rules for Configuring Function Blocks

- All function blocks must be placed at the end of a ladder logic configuration after the normal (main loop) ladder logic. The compiler will search for the first 'Function Block Start' and terminate the normal ladder logic there.
- All function blocks must end with an unconditional 'Return from Function Block', ie. one directly connected to the left power rail. However, a function block may contain any number of conditional returns.
- Function block names are case sensitive: the name in a 'Call Function Block' must exactly match the name in a 'Start Function Block'.
- The number of variables and the data types in a 'Call Function Block' must exactly match those defined in the corresponding 'Start Function Block'.
- A function block defined without any return parameter can only be called from a coil position (the right-most column).
- A function block defined with a boolean return parameter can only be called from a contact position (any column except the right-most one).
- Timer and edge trigger ladder blocks cannot be used within function blocks. (Note: a timer can be created using \#YTICK.SEC to increment or decrement a register. An edge trigger requires the current value to be compared to the previous value (a bit or register), to see if it has changed. The current value is then copied to the previous value for use in the next scan.)
- Up to 500 Call, Jump and Start Function blocks (in total) can be used per RTU.

Function blocks defined in another ladder logic file may be called by the main ladder logic file by using a Project file. This is useful when there are many RTU sites that all use the same piece of ladder logic. If a change needs to be made, only the one ladder logic file needs to be updated and then the ladder logic for each site is re-compiled. Please see the topic Ladder Logic, Multiple Ladder Files.

```
Eumpl Fault
    -( CALL )
Fump Fault
Call
```

Calls a function defined in the ladder. Note: DNP3 function blocks are available from RTUnet.
Call Function: The name of the function block to call. This name must be entered exactly as it appears in the corresponding Start Function block (it is case sensitive). To be used as a contact, the function block called must have a return variable of 'Boolean'. To be used as a coil, the function block called must have a return variable of 'None'.

Variables: A list of all variables (registers, constants, etc) to be passed to the function block. Eg. the above call function passes pump 1 parameters to the 'Pump Fault' function. 'Pump Fault' then returns True or False. Note: Ladder logic processing is transferred to the specified function block, until a 'Return from Function Block' is encountered. Ladder then continues being processed from after the function block call.

## FUNC ELOCK <br> Eump Fault <br> Start Function Block

Defines the start of a function block. It must be located on its own ladder rung above the function block ladder logic that it denotes the start of.

Function Name: The name of the function block. This is a 12 -character case-sensitive name that can include spaces.

Variables: (Optional) A function block can be passed up to 32 variables when it is called using the Call function block. The data type of each variable passed must be defined here as Boolean (bit), Integer ( 16 -bit register), Float or Long. Each variable can be assigned a 15 -character label that can include spaces and other ASCII characters. This label is then displayed as a comment alongside each variable when the function block is called using a Call function block.

Return Variable Type: None or Boolean (True or False). If defined as None, it is a coil function. If defined as Boolean it is a contact function.

```
End Of Fumc
    (RETUPN)
TRUE
Return
```

Transfers ladder logic processing back to the next rung or coil after the 'Call Function Block'. If this is a 'coil' function, the return value must be 'none'; if it is a 'contact' function, return value must be 'True' or 'False'.

Return Value: (None, True or False) The result returned by the function.


Jump to label 'Label1'. Can jump forwards and backwards. Labels are defined in the comment field of the first block on the rung and must have the format: 'LabelName:' ie. the label name followed by a colon. Labels cannot be defined in a 'Comment Field' block.


Stops processing of the ladder at that point. This can improve the scan rate of ladder logic by preventing the unnecessary scanning of ladder logic located after the End block. An End block is automatically inserted into the compiled output file just before the definition of the first function block.
4 Caution! An End block must NEVER be used within a function block as it will prevent the function block from correctly finishing and may cause the RTU to behave unpredictably.

Ladder Logic - P.I.D. Block

Flow EID
\#R1
(E.I.D.)
\#AI14.2

The PID block is used to monitor a process variable (eg. flowrate) and compare it to a setpoint (eg. desired flowrate). According to the difference between the actual value and the setpoint value, the PID block sets a Control Variable (eg. valve position) to reduce the error. The control variable is gradually changed until the desired setpoint is achieved within the deadband limits.

The rate of change of the Control Variable is configurable so that for delicate processes, the output rate of change can be small and for robust processes requiring quick responses, the output rate of change can be high.

The example shown below is used to control a valve to achieve a setpoint flowrate. The output of the PID is stored in \#R1 (which is used to control the valve position). The actual valve position is read from \#Al14.2, and the required flowrate is stored in \#R2. The PID block uses reverse action and a proportional gain of 1 so that a drop of say $5 \%$ in flowrate (\#Al14.2) will result in an increase of $5 \%$ in valve position (\#R1). In addition an Integral Factor of 0.1 units $/ \mathrm{min}$ is used so that the valve position will be increased at a rate of $0.5 \%$ each minute until the flowrate is within 1\% (327) of the setpoint. As the PID block is in Auto mode, the Raise and Lower parameters are not used.


Figure 4.6.12a: Example PID Block

Comment: A 12-character description.
Block Number (1-32): The PID block number in the ladder. Up to 16 PID blocks can be configured in ladder logic.

Control Variable: (16-bit register) The output of the PID block used to control a process to produce the desired Set Point. This can be a hardware register or a local register.

Process Variable: (16-bit register) The input that is monitored by the PID block. Process error is determined from the difference between the Process Variable and the Set Point. The process variable is usually an analog input which is stored in the RTU as a number in the range 0-32760 (equivalent to 0.00-100.00\%).

Set Point: (16-bit register or constant [0 to 32767]) This is the desired process result. The PID output will be continually adjusted until the Process Variable reaches this setpoint. The setpoint is given the same units or scaling as the Process Variable and so if an analog input is being monitored the setpoint should have a range of 0-32760 (0.00-100.00\%)

Kp Proportional Gain (100 = Gain of 1): (16-bit register or constant [0 to 32767]) The proportional response is the proportional change in the control variable (the output) in response to a change in the process variable (the input). Hence, Proportional Response $=\mathrm{Kp} / 100 \times$ (input change). Eg. If $\mathrm{Kp}=100$ then a change of 3 units in the input will result in a proportional response of 3 units in the PID output. Similarly, if $\mathrm{Kp}=200$ then a change of 3 units in the input will result in a proportional response of 6 units in the PID output

Ki Integral Factor ( $\mathbf{1 0 0}=\mathbf{1 r p t} / \mathrm{min}$ ): (16-bit register or constant [0 to 32767]) The integral response is the rate of change of the process variable (the output) that will occur after the proportional change in order to reduce the error between the Set Point and the process variable (the input). Integral response is defined as: Integral Response [units/min] $=\mathrm{Ki} / 100 \times$ (Input Error). Eg. If $\mathrm{Ki}=10$ and the error is 200, then the integral response $=10 / 100 \times 200=20$ units every minute. This means the output will be changed unit by unit up to a total of 20 units over the minute interval (the output will be changed by 1 every 3 seconds).

Kd Derivative Factor (min): (16-bit register or constant [0 to 32767]) The PID task keeps track of the last three errors (ie. the difference between the input and the setpoint) and according to the rate of change in the error will take the appropriate action. This usually results in a dramatic change in the output and so Kd is not used in many applications. Derivative response is defined as: Derivative Response $=\mathrm{Kd} / 100 \times 600 /(S a m p l e ~ P e r i o d) \times($ Error Change). Eg. If Kd=100, Sample Period=10 (1 second) and the error increased by 1 in the last second (since the PID block was last processed), then the integral response $=100 / 100 \times 600 / 10 \times 1=60$ units. To disable this function leave Kd set to 0 . Note: a derivative factor is not recommended for any fragile process.

Slew Time (sec): (0=freeze output or 1 to 32767) Slew time is the total amount of time it takes for the output to go from 'Output Min' to 'Output Max' or vice versa. This should be set to match the slew rate of the controlled actuator or other device to prevent damage caused by the PID control variable changing too rapidly.

Sample Period (x 100ms): (0 to 32767) How often the PID block is processed. One unit $=0.1$ seconds (100 ms).

Direct (0) / Reverse (1): (Bit) This determines whether the Control Variable (the output) will be increased or decreased for a given error between the Set Point and the Process Variable (the input). The direct action taken for the various conditions is detailed below:

| Control <br> Type | Process Variable (PV) <br> (Input) Condition | Control Variable (CV) <br> Direct Response* |
| :--- | :--- | :--- |
| Proportional | PV increases | CV increases |
|  | PV decreases | CV decreases |
| Integral | PV > Set Point | CV increases |
|  | PV < Set Point | CV decreases |
| Derivative | Rate of change of PV <br> increases | CV increases |
|  | Rate of change of PV <br> decreases | CV decreases |

* For Reverse Action PID, the control variable response is reversed


Auto (0) / Man (1): (Bit) When in manual mode, the PID block uses the Raise and Lower parameters to control the output. When in auto mode, the PID block adjusts the Control Variable until it is within the Deadband settings of the Set Point.

Raise (1 = Raise O/P): (1=enabled, 0=disabled) Only used in manual mode. When enabled, the output is continuously raised at the rate specified by the Slew Time. 'Raise' and 'Lower' should not be enabled at the same time as the output will be unpredictable. If neither are enabled the output will remain constant.

Lower (1 = Lower O/P): (1=enabled, 0=disabled) Only used in manual mode. When enabled, the output is continuously lowered at a rate specified by the Slew Time.

Deadband +: (0 to 32767) The allowable positive error between the Process Variable (the input) and the Set Point. When used with analog inputs this is a number in the range 0 to 32760. Error is calculated from Process Variable minus Set Point and so positive error occurs when the process variable is above the setpoint. The PID block will continue to change the output until the positive error is less than or equal to this setting. Eg. For a 1\% Deadband for an analog input, 327 would be used.

Deadband -: (0 to 32767) The allowable negative error between the Process Variable (the input) and the Set Point. When used with analog inputs this is a number in the range 0 to 32760. Error is calculated from Process Variable minus Set Point and so negative error occurs when the process variable is below the setpoint. The PID block will continue to change the output until the negative error is less than or equal to this setting. Eg. For a 1\% Deadband for an analog input, 327 would be used.

Output Max: (0 to 32767) The maximum allowable PID output. If the PID output is being used to set an analog output, then this parameter should be set in the range 0-32760 corresponding to 0-100\%.

Output Min: ( 0 to 32767) The minimum allowable PID output. If the PID output is being used to set an analog output, then this parameter should be set in the range 0-32760 corresponding to 0-100\%.

Ladder Logic - AGA-8

```
Gas AGAB Calc
    #F25
    (AGA-8)
    #F11
AGA-8 Gas Compressibility (Gross calculation)
```

Uses the American Gas Association standard AGA-8 for calculating gas compressibility. Requires driver 'AGA8.Dxx'.


Comment: A 12-character description.
Temperature (deg C): (Float) Gas temperature.
Pressure (MPa): (Float) Gas pressure.
Mole Fraction N2: (Float) Mole fraction of Nitrogen in the gas mixture.
Mole Fraction CO2: (Float) Mole fraction of Carbon Dioxide in the gas mixture.
Specific Gravity: (Float) Specific gravity (relative density) of the gas mixture.
Ref. Temperature (deg C): (Float) Reference temperature.
Ref. Pressure (MPa): (Float) Reference pressure.
Compressibility: (Float) AGA-8 compressibility factor of the gas.
Status: (Local register) AGA-8 calculation status. The following channels are used:

- Ch 1: calculation error
- Ch 2: pressure out of range error (allowed range is 0 to 12 MPa )
- Ch 3: temperature out of range error (allowed range is -8 to $62^{\circ} \mathrm{C}$ )

Example:

| Temperature | $0^{\circ} \mathrm{C}$ |
| :--- | :--- |
| Pressure | 0.6894757 Mpa |
| Mole N2 | 0.002595 |
| Mole CO2 | 0.005956 |
| Specific Gravity | 0.581078 |
| Reference Temperature | $15.56{ }^{\circ} \mathrm{C}$ |
| Reference Pressure | 0.101560 Mpa |
| Result: Compressibility=$=0.982387$, Status=0. |  |

## AGA-7 Gas Flow

This formula uses the compressibility output from the AGA-8 block and can be written in ladder to evaluate the AGA-7 gas flow (note: an example configuration is available from the RTUnet website).

Qv = Qf x P/Pgr x Tgr/Tx Zb/Zf

Qv = Volumetric flow, cubic metres/second
Qf = Flowrate at flowing conditions, cubic metres/second
$\mathrm{P}=$ Pressure, MPa
$\mathrm{Pgr}=$ Reference pressure for specific gravity, MPa
$\mathrm{T}=$ Temperature, ${ }^{\circ} \mathrm{C}$
$\mathrm{Tgr}=$ Reference temperature for specific gravity, ${ }^{\circ} \mathrm{C}$
Zb/Zf = Compressibility factor (output from AGA-8 block)

## AGA-3 Gas Flow

The AGA-3 gas flow can be obtained by writing the following formula in ladder logic (note: an example configuration is available from the RTUnet website):
$Q v=N 1{ }^{*} C d * E v * Y^{*} d^{\wedge} 2^{*} \operatorname{sqrt}(d P / p)$
Qv = Volumetric flow
N1 = Unit conversion factor (orifice flow)
Cd = Orifice plate coefficient of discharge
$\mathrm{Ev}=$ Velocity of Approach Factor $=1 /$ sqrt ( $1-\mathrm{b}^{\wedge} 4$ )
$b=\quad$ Orifice bore to meter tube diameter ratio $=d / D$
$d=\quad$ Orifice plate bore diameter $=d r$ * $\left(1+a^{*}(T f-T r)\right)$
$\mathrm{dr}=$ reference orifice plate bore diameter at Tr
$\mathrm{a}=$ linear coefficient of thermal expansion
$\mathrm{Tf}=$ temperature of fluid at flowing conditions
$\mathrm{Tr}=$ reference temperature (eg. from analog input channel)
$\mathrm{D}=$ Meter Tube internal diameter $=\mathrm{Dr}{ }^{*}\left(1+\mathrm{a}^{*}(\mathrm{Tf}-\mathrm{Tr})\right)$
$\mathrm{Dr}=$ reference meter tube internal diameter at Tr
$Y=$ Expansion factor
$\mathrm{dP}=$ Orifice differential pressure (eg. from analog input channel)
$p=\quad$ Density of fluid at flowing conditions

AGA-8 Gas Compressibility (Detailed calculation)
Uses the American Gas Association standard AGA-8 for calculating gas compressibility using the detailed characterization method. Requires driver 'AGA8DET.Dxx'.

The driver is based entirely on "Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases", AGA Transmission Measurement Committee Report No. 8, Second Edition, November 1992.


Comment: A 12-character description.
Compressibility: (Float) AGA-8 compressibility factor of the gas.
Status: (Local register) AGA-8 calculation errors and warnings. The following channels are used:

- Ch1: Internal calculation error. The AGA8 Detail calculation is a fairly complicated nonlinear calculation that includes a couple of iteration loops (ie. it repeats a calculation many times until the result converges to a solution). The AGA8 driver limits these loops to a maximum of 100 iterations each, to limit the time taken to perform the calculation. An Internal calculation error' indicates that after 100 iterations the result was still varying slightly (a valid result is still returned by the AGA8 calculation block). The reason for the variation may be that the input parameters are close to the limits specified in the AGA8 Detailed specification. For further details about the parameter limits and the tolerance levels, please refer to the actual AGA8 Standard. If very precise accuracy is required from the result, the 'internal calculation error' bit can be used as a warning flag, otherwise it can be ignored.
- Ch2: Pressure out-of-range error (allowed range is 0 to 280 MPa )
- Ch3: Temperature out-of-range error (allowed range is -130 to $400^{\circ} \mathrm{C}$ )
- Ch4: Firmware driver error
- Ch5: Gas components outside 'normal' range
- Ch6: Gas components outside 'expanded' range

Temperature (deg C): (Float) Input variable representing gas temperature.
Pressure (MPa): (Float) Input variable representing gas pressure.
Input Components, Molar Fractions: These parameters represent the relative proportions of each component in the gas mixture. They can be entered in any units (percentages, fractions, etc).

## Ladder Logic - AGA-9 Steam Flow Calc

## SteamplowCalc苟F17 <br> -(SteamFlow) *F19

Calculates steam flow using the AGA-9 standard and the published tables of superheated steam density. Requires driver 'AGA9.Dxx'.


Volumetric steam flow is calculated using the formula:

```
\(Q v=K \times \operatorname{sqrt}(F) \times \operatorname{sqrt}(d P)\)
\(\mathrm{dP}=\) differential pressure
\(F \quad=\) steam density (from steam tables; function of \(T, P\) )
\(\mathrm{T}=\) temperature
\(\mathrm{P} \quad=\) pressure
K = calculation constant \(=\) Fna \(\times\) K' x Fra \(\times\) Fm x Faa \(\times\) F1 x D^2
Fna = units correction factor
\(K^{\prime} \quad=\) flow coefficient
Fra = Reynolds number correction
Fm = manometer correction factor
Faa = thermal expansion factor
FI = gauge location factor
D = pipe diameter
```

Comment: A 12-character description.

Temperature (deg C): (Float) Steam temperature.
Pressure (kPa): (Float) Steam pressure.
Diff. Pressure (kPa): (Float) Differential steam pressure.
K (calculation constant): (Float) Calculation constant K (as detailed above).
Volumetric Steam Flow: (Float) AGA-9 volumetric steam flow (cubic metres/second).
Steam Density: (Float) AGA-9 calculated steam density (kg/cubic metre).
Status: (Local register) AGA-9 calculation status. The following channels are used:

- Ch1: Calculation error (indicates steam is saturated)
- Ch2: Pressure out-of-range error (allowed range is 0 to 7000 MPa )
- Ch3: Temperature out-of-range error (allowed range is 100 to $700^{\circ} \mathrm{C}$ )

Examples:
Temperature $\quad 190^{\circ} \mathrm{C}$
Pressure $\quad 2000 \mathrm{kPa}$
Differential Pres. 20 kPa
K 0.05
Result: Volumetric Steam Flow=0, Steam Density=0, Status=1 (saturated)

Temperature $\quad 200^{\circ} \mathrm{C}$
Pressure $\quad 1000 \mathrm{kPa}$
Differential Pres. 100 kPa
K 0.1
Result: Volumetric Steam Flow=2.20318, Steam Density=4.854, Status=0

## Ladder Logic - Clock Synchronization

## 12AM Sync <br> RTU 2 <br> -(ClockSync) -

Synchronizes the RTU's real-time clock. There are two modes of operation:

- Single RTU Sync: Forces the real-time clock of the target RTU to match the local RTU.
- Global RTU Sync: Sends a global command to synchronize all RTUs that are connected to the same comms port as the target RTU.
In both modes of operation, the communication delay is first measured between the local RTU and the target RTU. The clock synchronisation message is then adjusted to compensate for this delay. Note: if communications to the target RTU fail, a global clock synchronization is not carried out.

Comment: A 12-character description.
RTU \# (1-255): Target RTU to be synchronized and to be used for calculating the communication delay.

Global Sync Command? Indicates whether to issue a single or global sync command. Do not use a Global Sync Command when the target RTU is indirectly connected (ie. via a store-andforward RTU) as the longer communication delay will be added to the clocks of all the directly connected RTUs when the global clock synchronization message is sent.

## Ladder Logic - Report Printer

## Erint Report

Eort 2
(ErintRpt) -
Prints a text file to a serial printer. The text file may contain RTU variables. The text file is compiled with the ladder logic and stored in the RTU. Requires driver 'REPORT.Dxx'.

Comment: A 12-character description.
Filename: The filename is automatically generated and a text file is created with that name. The file can then be edited and various variables and text added as detailed below. When the ladder logic is compiled, the text file is included with the compiled code.

Port: (1-16) The serial port to print from.
Report File: The report file has 3 sections: Text, Variables and End.

- TEXT: This section contains all the text and variables that will be sent to the serial printer line by line. A variable is included by writing a '\%' followed by an integer (1-65535) and then declaring the variable under the Variables section. Eg.. Pump 1 Starts Today: \%1 (\%1 is then declared under the variables section)
- VARIABLES: All the 'live' variable information is declared in this section. Variables may include local registers (\#R), network registers (\#N), system registers (\#Y) and any other parameter that can be used in ladder logic. The number and order of Variable declarations must match the number and order of variables (\%n) used in the Text section. There is no error checking.
- END: Denotes the end of the report file.

Example report file:
TEXT:
Pump 1 Starts Today: \%1
Pump 1 Status: \%2
PC-1 Battery Status: \%3
RTU2 Comms Status: \%4
VARIABLES:
\#R1 \%05i
\#R2.1 \%b STOPPED RUNNING
\#DI13.3 \%b LOW OK
\#YLST2.1 \%b OK FAIL
END

Each variable is defined using the following layout:
Address Format Additional strings
Where:
Address: Any variable as used in ladder logic (eg. \#R1, \#YDIAG.1).
Format: A string defining the display format of the variable. The format string has the following structure: (Note: '[ ]' denotes an optional parameter)
\% [Flags] [Width] [.Prec] [_dp] [I] Type

| Format parameter | Options | Description |
| :---: | :---: | :---: |
| Flags | - | Left justified |
|  | + | Value starts with a '+' or '--' |
|  | \# | If type is 0 , value begins with a 0 <br> If type is $x$ or $X$, value starts with $0 x$ <br> If type is e, E or f, value will have a decimal point. <br> If type is $g$ or $G$, value will have a decimal point and trailing zeros will not be removed. |
|  | <Blank> | If negative, value starts with '-' |
| Width | n | At least n characters are printed. The value is padded with blanks. |
|  | On | At least n characters are printed. The value is padded with leading zeros. |
| .Prec | . 0 | For e, E, f types, no decimal point is printed. |
|  | .n | n characters or n decimal places are printed. For e, E, f, g , G types, the last digit printed is rounded. |
|  | <Blank> | Defaults to '. 1 ' for d, i, o, u, x, X types. <br> Defaults to '. 6 ' for e, E, $f$ types. <br> Displays all significant digits for g , G types. |
| _dp | -n | Decimal places. A decimal point is inserted in the output with $n$ digits following. For $\mathrm{d}, \mathrm{i}, \mathrm{u}$ types only. |
| I (long) | 1 | Displays d, i, o, u, x, X types as long values. |
| Type | d | Signed decimal integer |
|  | i | Signed decimal integer |
|  | 0 | Unsigned octal integer |
|  | U | Unsigned decimal integer |
|  | X | Unsigned hexadecimal integer using lower-case letters a-f |
|  | X | Unsigned hexadecimal integer using capital letters A-F |
|  | f | Floating point signed value of the form [-]dddd.dddd |
|  | e | Floating point signed value of the form [-]d.dddd or e[+/-]ddd |
|  | E | Same as e, but with capital E for exponent |
|  | g | Floating point signed value in either the $f$ or $e$ form based on given value and precision |
|  | G | Same as g, but with E for exponent if e format is used |
|  | b | Bit string. Displays the first string if the bit is False or displays the second string if the bit is True. Strings must be separated by either tabs or spaces. |
|  | a | Animated string. If the value of the variable is 0 , the first string is printed. If the value is 1 the second string is printed, etc. If the value exceeds the number of given strings the last string is printed. Strings must be separated by either tabs or spaces. |

## Ladder Logic - Image Monitoring Functions

Setup Camera
Module 0
(ConfigImage) Configure Image Parameters
Configures an image channel before it is used for the first time or when changing to a new channel. PC-1/CP-1 requires driver 'IMAGExx.DRV' to support an MC-xx with an Image Capture option board. Please see the topic Example - Kingfisher Images.

Slot Address: (0-64) The slot address of the module with the image option board. Set to '0' for a CP-xx or LP-1 or set to the slot address for an MC-xx.

Channel Number: The image capture input channel (1-4). A port 2 image board (or port 4 on an LP-1) uses channels 1 and 2. A port 3 image board uses channels 3 and 4 . The top connection on each image board corresponds to the lower channel number.

Resolution: $0=\mathrm{PAL}$, large ( $352 \mathrm{~W} \times 288 \mathrm{H}$ pixels), $1=\mathrm{PAL}$, medium ( $176 \mathrm{~W} \times 144 \mathrm{H}$ pixels), $2=$ PAL, small ( $88 \mathrm{~W} \times 72 \mathrm{H}$ pixels), $16=$ NTSC, large ( $320 \mathrm{~W} \times 240 \mathrm{H}$ pixels), $17=$ NTSC, medium (160W $\times 120 \mathrm{H}$ pixels), $18=$ NTSC, small ( $80 \mathrm{~W} \times 60 \mathrm{H}$ pixels). Note: setting a resolution of small is the same as setting a medium resolution.

Quality Factor: The JPEG image quality (1-100). 1 = lowest quality ( $2-3$ KB per image) and 100 $=$ highest quality (10-15 KB per image). A quality factor of at least 80 (approx. 10KB per image when resolution $=0$ ) is recommended.

```
Get New Image
Module 0
(Capture Imag)}\mathrm{ Capture Image
```

Captures a single image. The image is then added to a circular buffer of images. Before an image can be captured, the image channel must first be setup using the Configure Image Parameters block (as detailed above). PC-1/CP-1 requires driver 'IMAGExx.DRV' to support an MC-xx with an Image Capture option board.

Slot Address: (0-64) The slot address of the module with the image option board. Set to '0' for a CP-xx or LP-1 or set to the slot address for an MC-xx.

Monitors the RTU's image memory buffer. PC-1/CP-1 requires driver 'IMAGExx.DRV' to support an MC-xx with an Image Capture option board.

Slot Address: (0-64) The slot address of the module with the image option board. Set to '0' for a CP-xx or LP-1 or set to the slot address for an MC-xx.

Total Images: (Optional local register) The total number of images that are stored in the RTU. Once the RTU's image buffer is full, this number will not change.

Unread Images: (Optional local register) The total number of images that have never been read by Image Manager or any other software.

Next Image Number: (Optional local register) Image number to be assigned to the next image captured.

Image Pointer: (Optional Local register or FFFF) A local register that points to a particular image in the buffer. Used by Image Manager to keep track of the last image uploaded from the RTU.

Total Images After Pointer: (Optional local register) The total number of images in the buffer after the image specified by Image Pointer above. When Image Pointer is set to FFFF (or to a value outside the range of images in the RTU), Total Images After Pointer will return the total number of images in the RTU (the same as Total Images above).

First Image After Pointer: (Optional local register) The first image after the image specified by Image Pointer above. When Image Pointer is set to FFFF (or to a value outside the range of images in the RTU), First Image After Pointer will return the image number of the oldest image in the RTU.

## CHAPTER 5 LADDER LOGIC EXAMPLES

Once the RTU settings and communications have been configured (as per the Configuration chapter), intelligence can now be added to the RTU. This chapter details various ladder logic examples.

Ladder logic is created and edited using the menu - Logic, Edit.

## Register Usage

When designing RTUs, it is useful to first decide which local registers will be used and what they will be used for. The register 'map' can then be used as a standard layout for every RTU in the telemetry system when configuring the variables list. The register map should allow for the maximum amount of equipment that is used at all the sites (eg. pumps, valves, tanks) and should also allow for expansion. Eg. if the largest site has 4 pumps, the register map could be designed to allow for 5 pumps.

### 5.1 Example - Initialising Variables On First Scan

Variables can be initialised after ladder logic is downloaded by using the logic below. To initialise variables after a warm start or power reset or after downloading the SDB file, use \#YSYS.SCAN1 instead of \#YSYS.ENABLE.


Figure 5.1a: Initialising variables on the first ladder scan

### 5.2 Example - Timer Flag

An RTU has 64 timer registers that can be used once each in ladder logic. Although the amount of timer registers may appear to be low, each timer register can be used to regularly set and reset a register bit. The register bit can then be used an unlimited number of times in the ladder to rollover totals or to regularly copy data into registers etc. In addition to timers, there are also a number of periodic system registers which can also be used an unlimited number of times. Please see the appendix - RTU Data, System Registers, Clock Registers. The '3.6 Sec Flag' below is true once every 3.6 seconds and is true for one scan of the ladder.


Figure 5.2a: 3.6 Second Periodic Flag (used for counting hours run)

### 5.3 Example - Counting Pulses And Starts

## Counting Pulses Using A Standard Digital Input (DI-1, IO-x)

An RTU is capable of counting input pulses up to a rate of at least 10 Hz . The actual pulse rate that the RTU can count depends on how often it is able to scan its ladder. Since pulses are counted by counting the rising or falling edges of digital inputs, the ladder needs to be scanned fast enough to allow the RTU to register the pulse in the ACTIVE and in the INACTIVE states. Assuming that a pulse has a $50 \%$ duty cycle then the maximum pulse rate that can be counted is half the maximum ladder scanning rate (as displayed by the RTU Status). An example of an acceptable pulse input is shown below.


Figure 5.3a: Acceptable Pulse Input That The RTU Is Able To Count.
Figure 5.3b shows how to count pules using a rising edge trigger. Every time there is a new pulse, the 'Pulses Today' register is incremented.


Figure 5.3b: Counting Standard DI Pulses

## Shaft Encoder - Quadrature Pulse Counting

A shaft encoder has two pulse outputs. Each time the level changes, a pulse is generated on each output. Depending on which output pulsed first, the direction of the level change can be determined. By beginning with a default level (eg. say $50 \%$ ), the total can be incremented or decremented according to whether the level change is positive or negative. In the example below, \#R15 contains the Shaft Encoder Level. The level is set to a default of 1000 after a warm start and is incremented or decremented depending on the order of the pulses from LP-1 digital channels 1 and 2. Note: the accuracy of this type of quadrature counting depends on the RTU scanning fast enough to capture each pulse (a scan rate of at least 100 times a second is recommended). For greater accuracy, a DI-10 module can be used.


Figure 5.3c: Quadrature Pulse Counting From a Shaft Encoder

## Counting Pulses Using A DI-5

A DI-5 Counter Module automatically keeps pulse totals for its first four digital input channels. For fast pulse rates (up to 10 kHz ), the pulse totals will reach the maximum value of 65535 very quickly. To prevent a pulse total from overflowing, it can be rolled over every 1000 pulses as shown below. In the example, \#Al14.2 is the number of digital input 1 pulses (0-999) and \#R14 is the number of thousands of pulses ( $0-65535 \mathrm{k}$ ) for a DI-5 module in slot 14.


Figure 5.3d: Counting DI-5 Pulses (up to 10kHz)

## Counting Starts

Counting starts is exactly the same as counting pulses using a standard digital input. The start and stop signals are like a very slow pulse. The ladder below shows how to count starts using a rising edge trigger. Every time there is a new start, the 'P1 StartsTdy' register is incremented.


Figure 5.3e: Counting Pump Starts

### 5.4 Example - Hours Run

The example below records how long pump 1 has been running for in decimal hours. Every 3.6 seconds ( 0.001 Hrs ) the ladder checks if pump 1 is running and if it is, 'P1 HrsRunTdy' (\#R6) is incremented. Local register \#R6 then contains the number of 0.001 hour intervals that the pump has been running for ie. 0-65,535 $=0-65.535$ Hrs. 'P1 HrsRunTdy' is rolled over at midnight (as shown in section 5.6 - Rolling Totals Over At Midnight) so that the total will not overflow after a few days. The ladder makes use of the ' 3.6 Sec Flag' from the topic Example - Timer Flag.


Figure 5.4a: Counting Hours Run Today

### 5.5 Example - Flow Totalisation

The following example shows how to accumulate a flow volume from a flowrate analog input. For this example, the flowrate engineering units are $4-20 \mathrm{~mA}=0-100 \mathrm{~L} / \mathrm{s}$. Each second, the number of litres that have flowed ('FlowLastSec', \#R10) is calculated by dividing the analog input by 32760 (the raw analog input range) and then multiplying by 100 (the high limit of the engineering units). This number of litres is then added to the 'FlowTdy(L)' total (\#R11). When 'FlowTdy(L)' equals or exceeds 1000 litres, it is rolled over into another register 'FlowTdy(kL)' (\#R12).


Figure 5.5a: Flow Totalisation

### 5.6 Example - Rolling Totals Over At Midnight

When the real time clock reaches midnight, or the RTU detects that the day has changed, a '12AMRollover' flag can be set. This flag stays true for 1 ladder scan and can be used to roll over totals at midnight.


Figure 5.6a: 12AM Rollover Flag

The example shown below rolls over 'P1 StartsTdy' by copying the total to 'P1 StartsYes' register and then resetting 'P1 StartsTdy' to zero. Note: a number of rollovers can be combined into a single Multi-Copy block.


Figure 5.6b: Rolling Over Totals At Midnight

### 5.7 Example - Exception Reporting Analogs

Analog values can be exception reported to the master RTU when there has been a percentage change (of the analog range) from the last reported value. This is done by using two registers, a constant and an analog input. The constant is used to specify the amount the analog value must change by before an exception report is generated. The registers are used to store the last reported value plus the constant and the last reported value minus the constant. When the analog value moves above or below these register values, an exception report is generated and the registers are updated.

The lower register limit must be checked if it is negative as a negative number is stored as a very large integer value and can cause continuous exception reports as the low limit comparison block is always true.

The constant to use is calculated as percentage of the analog or register range. For analog inputs which have a range of 0-32760 (32767 for an AI-10), a 1\% change is represented in the RTU by a change of about 327. Similarly, a $5 \%$ change is represented in the RTU by a change of 1638 ( $0.05 \times 32760$ ).


Figure 5.7a: Exception Reporting IO-4 Analog Channels 1 and 2.

### 5.8 Example - Exception Reporting Digitals

An exception report can be generated when a single digital bit changes state or when any of the 16 channels in a hardware or local register change state.

The example below shows how to exception report a PC-1 mains power fail. The 30 second ondelay is used to prevent false exception reports caused by the discharge LED flickering ON and OFF (which can happen when the battery is fully charged or is not connected). After 30 seconds of continuous battery discharge, the mains power to the PC-1 is said to be OFF.


Figure 5.8a: Exception Reporting A Single DI Channel.

The example below shows how to monitor all 16 channels from a register or from a DI module and to exception report when any channel changes state.


Figure 5.8b: Exception Reporting 16 DI Channels

The example below shows how to monitor specific channels from a register or from a DI module. Parameter 2 in the AND block is a constant that has all the channels set to 1 that need to be monitored. Eg. to monitor channels 5-16, the hexadecimal constant 16\#FFF0 (65520) is used (for a description of hexadecimal numbers and masking please see the appendix Hexadecimal Numbers).


Figure 5.8c: Exception Reporting Specific DI Channels.

### 5.9 Example - Sending The Exception Report

An RTU usually has a number of inputs and conditions that can trigger an exception report. Rather than exception report every change separately, it is better if all these conditions set a common flag that causes a single exception report to be sent containing all the RTU data. As shown in the previous sections for exception reporting analogs and digitals, the 'Update RTU1' flag was set when an exception report was required. The ladder used to send the exception report is shown below.


Figure 5.9a: Exception Reporting Using Port 2


Figure 5.9b: Exception Reporting Using Port 5

### 5.10 Example - Event Logging

## Event Log Pointers

Event logs are kept in a circular buffer that is 'Max number of logs' long (as defined in the topic Configuration - Memory). When the buffer is full, the oldest logs are overwritten. The RTU uses an internal "current pointer" to point to the latest log added to the buffer.

If an outstation RTU sends its event logs to more than one master RTU, the outstation should use a different pointer for each master RTU. This allows the initiating RTU to know how many event logs it has sent to each RTU.

## Moving Event Logs Through An RTU Network

Event logs can be transmitted over an RTU network and accumulated in the master RTU. The event logs from all the outstations are stored in the one event log buffer in the master RTU.

It is not advisable to have the master RTU requesting logs and the outstations sending logs in the one system. This is because the event log pointers in the master RTU and in each outstation RTU will not be synchronized and the event logs already sent by the outstation will be requested again by the master and vice versa. This results in two identical event logs in the master for each outstation event log. Therefore event logs should only be moved in one direction (ie. either the outstations can send the event logs OR the master can poll the event logs).

Generating Event Logs
Before generating event logs, some memory must first be allocated for storing the logs (please see the topic Configuration, Memory, Event Logs. Eg. 32kB of memory can store 2730 logs). Event logs can then be generated using ladder logic as shown below.


Figure 5.10a: Generating Event Logs

### 5.11 Example - Polling Data

Polling is usually performed by the master RTU in order to get a regular update of outstation RTU data and to determine if communications to the outstation RTUs have failed.

The Series II protocol allows for full-duplex communications which means that the RTU can simultaneously transmit and receive. However, since most radios are half-duplex, which means that the RTU cannot transmit and receive simultaneously, it is necessary to force the RTU to wait for a reply to each transmit message. Unless the RTU is forced to wait, it will transmit all the polling messages one after the other - which can take a few seconds. Because of the delay, the first polling message will have timed out before the RTU is able to receive a reply as the RTU is still busy transmitting. The following examples show how to force the RTU to wait for a reply to each message when polling.

## Basic polling

An example of regularly polling 3 outstation RTUs is shown below. Every 15 minutes poll flags 2,3 and 4 are set. As the master RTU polls each outstation, the poll flag is reset. The example checks if port 2 is waiting for a reply to a message (\#YPST2.2) before polling the next outstation. If port 3 was used to poll the outstations, \#YPST3.2 would be used to test for 'P3 Waiting'. Note: the port number to use is the port used to communicate with that outstation RTU as defined in the Port List.


Figure 5.11a: Polling 3 RTUs Every 15 Minutes Using PC-1 Port 2.

## Polling After Data Has Expired

If an outstation RTU has exception reported to the master RTU recently, it is not necessary to poll the outstation RTU until the data is older than ' $X$ ' minutes (where ' $X$ ' is ideally a SCADA setpoint with a default value of say 30 minutes). If exception reports are generated frequently, it may never be necessary to poll the outstation RTU. Communication statistics are still accumulated as a success is recorded for each exception report received. Communication Fails are also recorded as the master will still effectively check comms every ' X ' minutes if it has not heard from the outstation RTU. Note: the registers that are exception reported should be the same as the registers that are polled. If a Maximum Quiet Time setpoint is used, this should be loaded with a default value on the first ladder scan.

Advantages:

- Minimises communications over the network.
- User can set the maximum age of data before a poll.


## Disadvantages:

- Takes more effort to test.


Figure 5.11b: Polling An RTU After No Exception Reports For 'X' Minutes

### 5.12 Example - Polling Event Logs

An Rx Update block can be used to poll event logs and data from up to 16 RTUs. The system parameters - 'Update Register Blocks' and 'Update Hardware Blocks' are configured in the outstation RTU to control which of the data blocks will be checked or read from the RTU (please see the topic Configuration - System Parameters for more information). The RX Update block can also poll all the event logs that match the configured priority and user type until the maximum limit is reached or until there are no more event logs. In order to use the Rx Update block, the RTU requires the RX Update driver - 'RXUPDxx.Dxx' to be loaded.

In the example shown below, the RTU checks if the Rx Update block is finished (ie. all the pending flags are set off) before initiating a new Rx Update. This avoids initiating multiple RX Update messages which could cause unpredictable results (event logs may be lost or overwritten). A single Rx Update block can generate many messages causing the port pending bit to be set and reset many times. New message blocks should not be initiated from the same port until the Rx Update block is completely finished.
\#R52 is used for the 'Pending Flags' register in the Rx Update block. On the first ladder scan, \#R52 is initialised to zero as \#R52 is not reset to zero after a warm start. This clears any pending flags that may still be set if the RTU was stopped in the middle of an RX Update.


Figure 5.12a: Example RX Update Ladder To poll multiple RTUs.


Figure 5.12b: Rx Update block used in Figure 5.12a to poll event logs from RTUs 2, 3, 4.

### 5.13 Example - Comms Fails Today And Yesterday

Communication fails give a good indication of the state and reliability of the RTU communications network. Communication statistics are automatically recorded by the RTU in Network Link Registers. These network link registers can be accessed by SCADA software by copying them to local registers. At midnight, the fails today values can be copied to fails yesterday registers and then the network link registers reset to zero. Communication status is updated after each poll or when an exception report is received (which clears the comms fail).


Figure 5.13a: Managing Comms Attempt Fails For Today And Yesterday

It is usually more accurate to record the number of message fails instead of the number of attempt fails. A message fail occurs when all of the configured attempts fail (eg. 3 attempts at each poll message). The example below shows how to count message fails and how to flag a communications fail after 10 consecutive attempt fails for RTU2.


Figure 5.13b: Managing RTU2 Poll Fails For Today And Yesterday

### 5.14 Example - Using PSTN Modems and GSMs

PSTN Modems and GSMs can be used on any serial port of the RTU by configuring the following items (a GSM is treated like a PSTN modem by the RTU):

- Configuration, Port List. Set the port Type to PSTN and then click the 'Configure' button. Set the initialisation string for the type of modem being used. If the modem or GSM is to be used for dialling a paging service, the default initialisation string may need to be changed as detailed in the topic Configuration, PSTN, Init String.
- Configuration, Network List. Set Target RTU to the address of the RTU to dial and 'Port \#' to the port number configured above. The default Timeout of 2000 ms can be used in most cases. Note: a network link is not required if the RTU is only answering calls.
- Configuration, Phone Directory. Set Primary Phone Number and Secondary Phone Number to the phone number of the target RTU to dial. Note: the phone directory does not have to be configured if the RTU is only answering calls
- Configure a communications block (eg. RX_DATA) in ladder logic to communicate with the target RTU. The RTU will then automatically dial the number configured above.

Connecting a GSM: In order to dial into a GSM unit, a data telephone number is required. This is a second telephone number. To obtain a Telstra data number in Australia, call Telstra Mobile on 1800200 010. When a SIM card is obtained, please ensure that it does not require a PIN number (a PIN number is not supported by a GSM) and also ensure that it is a non-transparent data number. If the GSM unit is only used for dialling out from the RTU, a data number is not required and the normal voice number can be used. The SIM card can be checked that it is enabled on the network by installing it in a mobile phone.

### 5.15 Example - Using Radios

Various types of external radios require various types of RTU ports and cables. The external radios that are commonly used by RTUnet and the RTU setup for each radio is detailed below. Note: the spread spectrum radio option board is detailed in the topic Driver - Spread Spectrum Radio.

| Radio | RTU Option <br> Board | Port Type | Port <br> Baud <br> Rate | Port <br> Pre / Post <br> TX (ms) | Network <br> Link min. <br> Timeout |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Trio MR450 with no modem <br> Trio TC-450SR, TC-900SR <br> Maxon SD-125 <br> Tait T2010 | PC-1/MC-1 Radio | Radio | 1200 | $300 / 100$ | 2200 |
| Trio MR450 with 2400 / 4800 / / <br> 9600 modem | Any Serial board | RS232 <br> Radio | $2400 /$ <br> $4800 /$ <br> 9600 | $0 / 0$ | 2000 |
| Trio TC-450SR with 24SR <br> Trio TC-900SR with 24SR | Any Serial board | RS232 <br> Radio | 2400 | $0 / 100$ | 2000 |
| Trio TC-450SR with 48SR <br> Trio TC-900SR with 48SR | Any Serial board | RS232 <br> Radio | 4800 | $0 / 100$ | 2000 |
| Trio TC-450DR <br> Trio TC-900DR | Any Serial board | RS232 <br> Radio | $4800 / 200 / 100$ <br> 9600 | 2200 |  |

### 5.16 Example - Using CDMA Modems

CDMA Modems can be used on any serial port of the RTU. The following setup is for a Maxon MM-5100. When a message is transmitted by a CDMA modem through the CDMA network, a delay of about 1 second is often inserted in the message. The receiving RTU must have firmware and a Post Tx setting that allows for this delay otherwise communications errors will occur. Dialup SMS paging is supported if the CDMA modem is only used for paging and not for RTU communications*.

- A Maxon MM-5100 CDMA modem requires a few AT commands to get it to work properly for incoming data calls. After connecting the CDMA modem to your PC (you can use an RJC-ADP-26 cable and an ADP-08 adaptor from RTUnet), use Toolbox terminal at 115200 baud (the default MM-5100 baud rate) to set the following AT commands:

| AT\$QCVAD=4 | Allows the modem to receive data calls |
| :--- | :--- |
| ATS0=2 | Answer after 2 rings |
| AT+CRM=0 | Select circuit switched data mode. Note: when set to packet <br> switched data mode, dialling out by the CDMA modem is disabled! |
| AT+IPR=9600 | Sets baudrate to 9600 between the modem and the RTU (after <br> this AT command, Toolbox will need to be set to 9600 baud) |
| AT\&W1 | Store above settings in user profile 1 |
| AT\&F1 | Load above settings into the active profile |

- RTUs that receive messages from a remote RTU with a CDMA modem need to use the latest firmware that supports CDMA (as detailed in protocols.pdf available from www.rtunet.com ). Messages received from the CDMA network are often broken up after 31 characters. The newer firmware allows the receiving RTU to wait long enough until the complete message is received. Note: older firmware is able to receive up to 5 local registers at a time from the CDMA network as this is a short message that is not broken up.
- Configuration, Port List. Set the port Type to PSTN and Baud Rate to 9600. Click the 'Configure' button to set the initialisation string to AT\&F1TE0V0S0=2 (using '\&W' will cause an error). If an RTU will receive messages from a CDMA RTU, set Post Tx to 1100 ms (this allows for breaks in messages received from the CDMA network). When using a dial option board to dial into a CDMA RTU, set the initialisation string of the dial option board to AT\&FTEOVOSO=2\&W (ie ensure X0 is removed otherwise connection problems will occur).
- Configuration, Network List. Set Target RTU to the address of the RTU to dial and 'Port \#' to the port number configured above. Set Timeout to 3000 ms (or greater). Note: a network link is not required if the RTU is only answering calls.
- Configuration, Phone Directory. Set Primary Phone Number and Secondary Phone Number to the phone number of the target RTU to dial. Note: the phone directory does not have to be configured if the RTU is only answering calls.
- Configure a communications block (eg. RX_DATA) in ladder logic to communicate with the target RTU. The RTU will then automatically dial the number configured above.

Connecting a CDMA Modem: Unlike a GSM, only one standard voice number is required. A second data number is not necessary and will cost extra. For a CDMA modem to work properly, all extra services must be disabled ie. no 'Call Waiting', no 'Call Diversion', no 'Message Bank' and no 'Other' features. To check if these services are enabled for a Telstra CDMA modem (in Australia), ring Telstra Wireless Data Customer Support on 1800200010 or 1300131816. CDMA units do not have SIM cards and have ESN numbers instead. Telstra will allocate a phone number to the CDMA modem when connected.

* A CDMA modem can be used as a PSTN modem to dial Telstra's SMS Access Manager (allows SMS messages to be sent to mobile phones). SMS Access Manager requires a data format of 7 data bits, even parity and 1 stop bit. The CDMA modem can be set to communicate in this format by using the AT command: AT $+I C F=5,1<C R>$ (this will need to be done using the Toolbox Terminal program after carrying out the first step above). Save this setting using AT\&W $1<C R>$ and then AT\&F1<CR>. Pager messages can then be configured as detailed in the topic Example - SMS Pager Messages. After setting this data format the CDMA modem is not able to automatically switch to other data formats as required for RTU to RTU communications.


### 5.17 Example - Using Satellite Phones

A satellite phone is treated like a PSTN modem by the RTU and can be used on any serial port. The following setup is for a Motorola 9522 satellite phone.

- First ensure that the latest firmware supporting Satellite Phones is loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- When a satellite phone is first obtained, it usually requires a PIN number to boot up (if this has not already been disabled). Use AT+CPIN? to check if it needs a PIN. To set the PIN number use $A T+C P I N=" 1111 "<C R>$ (1111 is the default PIN number). The command AT+CLCK="SC",0,"1111"<CR> should then be used to disable the need for a PIN number.
- The satellite phone antenna must have a very clear view of the sky and not be near any buildings or objects (it should have a 150 degree uninterrupted view of the sky). Use $A T+C S Q$ to query signal strength. This will return a number in the range $0-5$ where $3-5$ is good.
- Configuration, Port List. Set the port Type to PSTN, Pre Tx to 20,000 ms. Click the 'Configure' button to set the initialisation string. Use the default string for an external modem (AT\&FTEOV0S0=2\&W). Note: a Pre TX delay of 20,000 ms must be used as the satellite phone uses the off hook signal to set carrier detect. The satellite phone signals that a carrier is detected and that it is online before the handshaking has occurred with the remote modem. Configuring a Post Tx delay of $20,000 \mathrm{~ms}$ forces the RTU to wait for 20 seconds before attempting to send a message.
- Configuration, Network List. Set Target RTU to the address of the RTU to dial and 'Port \#' to the port number configured above. The default Timeout of 2000 ms can be used. Note: a network link is not required if the RTU is only answering calls.
- Configuration, Phone Directory. Set Primary Phone Number and Secondary Phone Number to the phone number of the target RTU to dial. Note: the phone directory does not have to be configured if the RTU is only answering calls. The international dialling code for a satellite phone to dial out is 00 <country code><area code><phone number>. The prefix '00' is always needed by a satellite phone when dialling a phone number. Eg. to dial RTUnet (Australia) use 0061395356200 where 61 is the country code and 3 is the area code.
- Configure a communications block (eg. RX_DATA) in ladder logic to communicate with the target RTU. The RTU will then automatically dial the number configured above.

SMS Pager Messages: A satellite phone can send pager messages to the Telstra PET SMS service. In the Pager Configuration window, set Phone No. to 0061439125107 (the international Telstra SMS Access Manager phone number). The satellite phone can currently only send SMS messages directly to other satellite phones.

Dialling A Satellite Phone: Each satellite phone has a data number and a voice number. An RTU uses the data number. To dial the satellite phone from Australia use 0011 <satellite phone data number>. Eg. 0011881612345678 where 0011 is the international dialling code when in Australia and 881612345678 is the satellite phone data number.

Communicating With A GSM: Dialling a GSM modem using a satellite phone is unreliable and not recommended.

### 5.18 Example - Using GPRS Modems

GPRS (General Packet Radio Services) modems maintain a continuous connection to the GSM mobile network and provide faster data transmission rates than GSM modems. However, data transmissions are not continuous. Data is broken into 'packets', allowing multiple GPRS modems to share the same channel. This can cause some data transfers to take up to 10 seconds. The following setup is for a Wavecom Fastrack GPRS modem (with TCP/IP stacking enabled) connected to an RTU serial port.

- First ensure that the GPRS driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- A Wavecom Fastrack GPRS modem requires a few AT commands to get it to work properly. After connecting the GPRS modem to your PC (you can use an RJC-ADP-22 cable and an ADP-08 adaptor from RTUnet), use Toolbox terminal at 115200 baud (the default Wavecom Fastrack baud rate) to set the following AT commands:

| AT\#APNSERV= | Sets the Access Point Server Name (xxxxx.corp) as <br> obtained from your service provider. |
| :--- | :--- |
| AT\#APNNUN="user@ | Sets the Access Point User name (user@xxxxx.tpips. <br> xxxxx.tpips.com.au" <br> com.au) as obtained from your service provider. |
| AT\#APNPW="zzzzz" | Sets the Access Point Password (zzzzz) as obtained from <br> your service provider. |
| AT+DIALN1="*99***1\#" | Sets the Dial Number <br> Note: this is different for different service providers. |

- To verify the GPRS modem is setup and functioning correctly, the following AT commands can be used:

| AT\#VALL | Lists all of the details, including IP details of the modem. <br> AT+CGMR <br> Displays the firmware version of the modem. <br> Recommended version is "641_0999.Q2406B 1328940 <br> AT\#VVERSION111903 18:23" (or newer). <br> Displays the software version of the TCP/IP Stack. <br> Recommended version is "eDsoft_W302_V2.10 1166 86 <br> Dec 10 2003 12:20:17" (or newer). <br> AT\#VGPRS <br> Displays the configured server name, user name and <br> AT+CSQpassword. <br> Displays the signal strength. Returns 0 to 31 or 99 (no <br> signal). The minimum value for successful <br> communications is 15 or higher. |
| :--- | :--- |

- Configuration, Port List. Set the port Type to GPRS, Baud Rate to 115200 and Post Tx to 1500 ms. Click the 'Configure' button to set the GPRS parameters. Set Dial Retries to 2 and Dial Timeout, Online Inactivity and Hang Up After to 60 seconds. Note 1: Toolbox cannot communicate with a port configured as GPRS. At least one port (preferably port 1) must be configured for Kingfisher Series 2 protocol. To restore Toolbox communications on a GPRS port, remove the CPU RAM battery link to clear the configuration. Note 2: Online Inactivity and Hang Up After timeouts should not be set to 0 seconds as this will cause the GPRS modem to stay online indefinitely. If the local GPRS modem disconnects while the remote GPRS modem is configured to stay online indefinitely, it will not be possible to communicate with the remote GPRS modem until it is reset.
- Configuration, Network List. Set Target RTU to the address of the RTU to contact and 'Port \#' to the port number configured above. Set Timeout to 6000 ms (or greater). Set IP Address to the IP address of the GPRS modem of the Target RTU. Note: a network link is not required if the RTU is only receiving calls.
- Configure a communications block (eg. RX_DATA) in ladder logic to communicate with the target RTU.
- Additional GPRS information can be obtained from the port registers \#YPSIGnn (signal strength), \#YPSTnn. 6 (online status) and \#YPERRnn (initialisation status).

Connecting a GPRS Modem

It is very important to request fixed IP addresses for all GPRS modems. You will also need a SIM card and the following information:

- Access Point Server Name - xxxxx.corp where xxxxx could be Telstra or your company name eg. Acme.corp
- Access Point User Name - user@xxxxx.tpips.com.au where 'xxxxx' is your company name and 'user' is the name of the GPRS modem.
- Access Point Password

More Information
Please see the document "GPRS Version Xxx.PDF" available from RTUnet.

### 5.19 Example - RS485 Communications

RS485 can be used on any CP-xx isolated serial port or PC-1 serial port 2.

- Configuration, Port List. Set Type to RS485 and set the Baudrate to match the remote device (eg. 9600). Set Pre and Post Tx to 10 ms as illustrated below (note: Post Tx can be set to 1 ms for fast response RS485 devices).

- Configuration, Network List. Set Target RTU to the address of the RTU to communicate with and 'Port \#' to the port number configured above. Note: a network link is not required if the RTU is not initiating messages.
- Configure a communications block (eg. RX_DATA) in ladder logic to communicate with the target RTU.

Note 1: The length of the RS485 cable should be at least 1 m .
Note 2: Each end of the RS485 cable should be terminated with a 120 ohm resistor when using 38,400 baud and faster. Please see the Kingfisher Hardware manual, CP-xx Serial Option Board wiring diagram for details.
Note 3: If problems persist, add a Pre TX delay to the remote device or decrease the baudrate (do not use less than 4800 baud).

### 5.20 Example - SMS Pager Messages

The following example uses a PSTN modem to dial Telstra SMS paging in Australia and send an SMS message to one mobile phone. The RTU has a PSTN modem on port 2 of the CPU. The phone numbers of the mobile phones are 0414123456,0415123456 and 0416123456. The phone number of the Telstra PET SMS paging service is 125 107. The figure below shows how these paging parameters have been configured from Configuration - Pager Configuration. Note: please see the topic Configuration - PSTN for details on setting up modem initialisation strings for dialling a paging service.

Note: the password below will allow one message to be sent to one Pager Number each time the paging service is dialled. Telstra also supports sending one message to multiple Pager Numbers but you will need to obtain your own password from Telstra. To obtain a password, call Telstra Wireless Data Support on 1800200010 and ask about SMS Access Manager.


Figure 5.20a: Pager Configuration Window for Telstra SMS paging to two digital mobile phones.
The ladder below shows how a register bit is used to trigger a pager message.


Figure 5.20b: Ladder Logic Used To Generate A Pager Message


Figure 5.20c: Pager Message Block Used in Figure 5.20a

Since the pager message is only transmitted once, the Acknowledge Bit (\#R100.16) is not used. If the pager message was to be transmitted more than once (by configuring a '1' in the '2nd Group' and '3rd Group' of the 1st Sequence), writing a 0 to \#R100.16 would acknowledge the pager message and stop the pager message from being re-transmitted.

## GSM SMS Pager Messages

A GSM can be used on any CPU port (PC-1, CP-1, CP-xx, LP-1) to send an SMS message to any mobile phone (Optus, Vodaphone, Telstra etc). When using a GSM instead of a PSTN modem, configure Pager Type as 'GSM SMS' and leave 'Phone No.' and 'Password' blank (these settings are not used). A GSM allows a single pager message to be sent to multiple phones when a sequence with multiple phone numbers is used (eg. as shown in the $4^{\text {th }}$ Sequence above).

## Dial-Up SMS Pager Messages - Sending To Multiple Mobile Phones

After obtaining a password, Telstra's SMS Access Manager allows each pager message to be sent to multiple pager numbers (this would occur if a pager message block was configured with Pager Sequence 4 as shown above). If the paging service only allows one message to be sent to one phone number at a time (eg. if using the Telstra paging service and the 'mnmail' password), a message can be sent to multiple phones by:

- Configure 1 phone number in each pager sequence (eg. as shown in pager sequences 1 to 3 above)
- Configure ladder logic that triggers 1 pager message block for each phone number when an alarm occurs. Each pager message block should be configured to use a different sequence number that corresponds to the phone number.

The example below shows how each time the Mains Fail alarm occurs, 3 pager messages are triggered that target different phone numbers.


Figure 5.20d: Ladder Logic Used To Send A Pager Message To 3 Phones


Figure 5.20e: Pager Message Blocks Used in Figure 5.20d

## Telemetry System Paging

It is best to configure all the pager messages in the master RTU for two reasons:

- The amount of communications in the telemetry system is minimised.
- To enable or disable the pager receivers that messages are sent to, the bits in only one group register need to be changed instead of changing the group register in every RTU that initiates pager messages.
New data is usually exception reported to the master RTU and so this new data can be used to trigger a pager message.

If say \#Rxx is used for all three groups in the first sequence configured in Configuration, Pager Configuration, then SCADA software can be used to set and reset the individual bits of \#Rxx corresponding to the pager receivers to enable or disable. These bits could also be cleared during certain times to prevent pager messages at inconvenient times.

### 5.21 Example - Pager Messages With Variables

A pager message can send a text string of up to 31 ASCII characters instead of a fixed message. The string is stored in local registers with two characters in each register ( 8 bits are used for each character). Before the pager message containing the string is transmitted, the string can be overwritten with the current value of a variable.

A string can be created using a String Copy block which allows you to create a string up to 31 characters long. The String Copy then terminates the string with a null character ( 00 Hex ).

To transmit a string in a pager message, 'Line 1' of the pager message block is configured as the local register (\#R1 to \#R2048) that contains the first character of the string (in bits 1-8).

The example shown below converts a tank level stored as 0-999 in \#R2 into ASCII characters and then transmits the tank level as a string in a pager message whenever \#DI14.1 (Tank overflow alarm) is triggered. 0-999 is converted into ASCII characters by separating the number of $100 \mathrm{~s}, 10 \mathrm{~s}$ and 1 s . Each digit is then converted into ASCII by adding 30 Hex (represented by 16\#30 in ladder logic) to each digit. A standard string is created using the String Copy block containing 'xxxxxxxxxxx_Tank_Level_nn.n_\%' and then 'nn.n' is overwritten by the tank level ASCII characters. When overwriting the string with the tank level characters, care must be taken to overwrite the correct character positions. In this example the tank level is stored in characters 23-26 of the string. Since the string starts at \#R401 (as configured in the String Copy block) and there are two characters in each register, the tank level is then stored in \#R412 and \#R413 as illustrated below. The first character in each register (ie. the left character) is stored in bits 1-8 (LSB). The second character is stored in bits 9-16 (MSB). Note: the LP-1 stores the left character in the MSB and the right character in the LSB.

| Register \# | 401 | 402 | 403 | 404 | 405 | 406 | 407 | 408 | 409 | 410 | 411 | 412 | 413 | 414 | 415 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Characters | xx | xx | xx | xx | xx | T | an | k | Le | ve | I | nn | . n | $\ldots$ | n |

Note: letters denoting the site name can be used instead of the x's at the start of the string.


Figure 5.21a: Generating A Pager Message Containing A Variable 'nn.n'


Figure 5.21b: String Copy block used to make the basic pager message string


Figure 5.21c: Pager message block used to transmit a string containing a variable.

### 5.22 Example - Kingfisher Images

To configure an RTU to capture images:

- First ensure that the latest firmware is loaded in the CPU or MC module (as detailed in protocols.pdf available from www.rtunet.com ). The CPU firmware version can be checked by viewing the RTU Status and the MC firmware version can be checked by viewing the Hardware Overview and clicking on the MC module.
- If a PC-1/CP-1 is being used with an MC-xx, then the image capture driver (IMAGExx.DRV) will need to be downloaded into the PC-1 or CP-1 using the menu - Utilities, Advanced, Download Firmware Driver. When this is downloaded, "Image" will appear in the "Firmware drivers included" section of the RTU Status.
- Configure enough memory in the RTU for image storage using the menu - Configuration, Memory, Image Buffer. A good quality large image uses 10 KB of memory. It is recommended that enough memory is allocated to store at least 2 images. When the image buffer is full, the oldest image is over-written by the newest image. When using an MC module, 256 kB of memory is automatically allocated for image storage in the MC module.
- Configure the image capture port using the menu - Configuration, Port List. The image capture option board is treated like a communications port. Set the following options: Module = CP-x P2 or CP-x P3 or CP-x P4 (LP-1 only) or MC-x P2 or MC-x P3 (ie. the location of the image capture option board) Type $=$ Image Capture All other parameters are irrelevant and are ignored.
- After downloading the RTU configuration, images can now be captured using the Image Manager program. This program allows the image capture port to be configured, images to be captured and then uploaded from the RTU.
- Alternatively, the RTU can use ladder logic to configure the image capture port and then capture images (please see the example below).

An example of setting up a single camera on port 3 of a CP-xx module and capturing images when a digital input is triggered is shown below. Every scan, the image buffer statistics are copied to local registers. As soon as a new image is added to the memory buffer (ie. when the value of Next Image Number changes) or after 2 seconds of the camera not ready, the 'CameraReady' flag is set and the RTU is now ready to capture the next image. Note: care must be taken when capturing new images. If a new image is captured before the last image has finished, the last image will be corrupted.


Figure 5.22a: Capturing Images Using A Single Camera


Figure 5.22b: Details of the Image blocks used in figure 5.22a


Figure 5.22b: Details of the Image blocks used in figure 5.22a

## Using Multiple Cameras

Each CP-xx, LP-1 or MC-xx module is treated as a 4 channel image capture module. One memory buffer is allocated for all the images from the 4 channels. Each MC-xx also has its own image buffer ( 256 KB ). Before capturing an image, the image channel must first be configured (using the 'Configure Image Capture Parameters' ladder block). It takes about 0.5 seconds for the image option board to be armed and ready to capture an image. Multiple images can then be captured from the one channel (these take about 0.5 to 1 second each to capture). Before using another camera channel, the new channel must first be configured and then after another delay of about 0.5 seconds, an image can be captured on the new channel. Note: each time the RTU is warm started or has its power reset, the image capture parameters need to be configured again.

## Displaying RTU Images

RTU images can be uploaded and displayed on a PC using the Image Manager program. This program reads the images from a local or remote RTU, stores the image as a JPEG file and then displays the image on the PC. Images can also be deleted on the PC using Image Manager and deleted in the RTU by using the Warm Start command.

## Trouble Shooting Image Capture Option Boards

When the CP-xx module is clicked on from the Hardware Overview (View, Hardware Overview) A window will appear, indicating which option boards have been detected on the CP-xx. The following settings can appear for the image board:

- "none" - the image board has not been detected. Check that the image board is installed correctly.
- "image" - the image board has been detected.

For details of the ladder logic image blocks, please see the topic Ladder Logic - Image Monitoring Functions.

### 5.23 Example - Low Power Mode

The RTU has two low power modes - 'IO power saving' and 'power down'. IO power saving mode is configured from Configuration, System Parameters, I/O Power Saving Control. In IO power saving mode, the RTU can be configured to switch off various output voltages (eg. 24 VDC from the BA-4 and from IO modules such as the AI-1, IO-4 etc) but in this mode the processor (eg. PC-1) keeps running. Like IO power saving mode, power down mode switches off the various RTU output voltages. However, power down mode also puts the processor to sleep. This is advantageous as the processor module uses more than 100mA at +5 VDC . Putting the processor to sleep reduces the current consumption by over half. It is recommended that only one power saving mode be used - 'IO power saving' or 'power down'.

Power Down mode is controlled from ladder logic using two parameters \#YPDTIME and \#YPDSTAT (as detailed in the appendix RTU Data, System Registers). The RTU can be woken up in three ways: the power down time (\#YPDTIME) expires, a cable with a CTS/RTS loop is connected to a configured serial port or a 'Wakeup' message is received. To wake up the RTU using a cable with a CTS/RTS loop or using a Wakeup message, the RTU must be told which port(s) to monitor by setting the appropriate bit(s) in \#YPDSTAT. An RTU may then be woken up with a Wakeup message if the initiating RTU has 'Wakeup RTU From Power Down Mode?" checked in the network link for the powered-down RTU.

The example below shows how an RTU is put to sleep for 50 minutes at five minutes past the hour. The RTU will wake up after 50 minutes or if a serial cable with a CTS/RTS loop (eg. an RJ45 cable with an ADP-05 adapter) is connected to ports 1 or 2 or a Wakeup message is received on ports 1 or 2.


Figure 5.23a: Power Down Ladder Logic

### 5.24 Example - RTU Diagnostics / Trouble Shooting

Sometimes it may be difficult to know why an RTU is behaving strangely. By logging the value of the RTU status register (\#YSTAT) or another diagnostic register (eg. \#YDIAG, \#YFLAGS), the history of the RTU can be determined from the event logs.


Figure 5.25a: RTU Diagnostics by logging the RTU status register on any change.

### 5.25 Example - Indirect Addressing

This example shows how to add 10 consecutive local registers by using indirect addressing. Indirect addressing can reduce the amount of ladder logic required for repetitious tasks.

The following registers are used:
\#R1 = pointer register (initial value is used to address the first of 10 consecutive registers to add)
\#R2 = loop counter
\#R3 = total
\#R101 to \#R110 = registers to add


Figure 5.26a: Adding 10 registers using indirect addressing

### 5.26 Example - Time Based Rolling Averages

This example counts the number of rainfall pulses each minute and then adds the total to a 60register queue. Each minute a new value is added to the queue and the oldest value is removed and then the average value of all the one-minute totals is re-calculated. This provides the average rainfall per minute for the last hour. The amount of ladder logic required is greatly reduced by using indirect addressing as shown below.

The following registers are used:
\#R498 Current number of rain pulses for this minute
\#R499 Total number of rain pulses for the last minute
\#R500 Average rainfall (pulses) per minute for the last 60 minutes (updated every minute)
\#R501-560 Last 60 rainfall totals, oldest to newest totals respectively
\#R1001 Queue pointer (pointer to next register to add)
\#R1002 Loop counter
\#R1003 Accumulated total (for averaging)


Figure 5.27a: Averaging 60 rainfall totals using indirect addressing

### 5.27 Example - Polling RTUs Using A Function Block

The amount of ladder logic required to poll a number of RTUs can be greatly reduced by using a function block as shown below.

The function block allows the RTU address (\%1) and the polling period in seconds (\%2) to be specified. The RTU is only polled if a successful exception report has not been received for the last 'period' seconds. The registers that are exception reported should be the same as the registers that are polled. The 'PollRoutine' function block will poll the same registers from each RTU as defined in the RX Data block (these may need to be adjusted).

The following registers are used:
\#NRrrr. 63 The last value of the success counter for RTU 'rrr"
\#NRrrr. 64 Quiet Timer. The amount of seconds since the last successful message to or from RTU 'rrr'.
\#R200 Temporary storage of the RTU address


Figure 5.28a: RTU polling function block

The details for the various ladder blocks are shown below.


Figure 5.28b: Polling function block details

### 5.28 Example - Synchronizing RTU Clocks

Each RTU has a clock that can be synchronized periodically to ensure that data is logged with a precise time stamp.

There are various factors that affect the accuracy of clock synchronizing: drifting of the RTU's own clock, transmission time to set the clock, and accuracy of the source clock.

- The most accurate way to maintain clock accuracy is to use a CP-21 GPS option board. This allows the RTU's clock to be set within 10 milliseconds (10 thousandths of a second) of GMT. Please see the topic Driver - GPS.
- RTUs are also able to synchronize time between themselves. A master RTU can send a command to one or more outstations to synchronize all their clocks to its own clock. The RTU clocks will then be accurate to within 15 milliseconds. Please see the topic Ladder Logic - Clock Synchronization for details.
- An RTU clock can be manually updated by setting the hours, minutes, seconds and milliseconds registers of the RTU clock using Toolbox or SCADA software. Accuracy is dependent on the person or device used to set these registers. An example of doing this is shown below.

- RTUs also recognise a DNP3 or Kingfisher protocol function code that allows their clock to be set to millisecond accuracy.


### 5.29 Downloading Ladder Logic

Ladder logic must be compiled before it can be downloaded into the RTU. This is performed from the Ladder/Logic, Compile menu. After a successful compilation, the window below will be displayed. Note: if using RTU firmware prior to V1.30A, the firmware version will need to be changed for the ladder compiler from the menu - Ladder/Logic, Target Firmware Version.


Figure 5.29a: Window displayed when ladder logic is compiled.
If compilation is not successful, then the errors and the rung number of the error will be listed in the window.

After the ladder has been successfully compiled, select Ladder, Download To RTU. If downloading is successful, the message 'Download Complete!' will be displayed otherwise 'Comms Failure' will be displayed. Note: the SDB site configuration file must be downloaded first.

## Download Changes to RTU

This option allows the user to only download changes since the last download. It is faster than performing a full download and is very useful when dealing with a large amount of logic or a slow communications link. Note: whenever an RTU is cold started or its memory configuration is changed, ladder logic is erased. It is then necessary to perform a complete download of ladder logic.

When ladder logic is compiled, an LLO file is created (ie. Filename.LLO). When the complete ladder logic configuration is successfully downloaded, Toolbox copies the LLO file and makes an LLX file (Filename.LLX). The LLX file is used to denote the ladder logic that is in the RTU. When downloading changes, Toolbox compares data blocks between the new LLO file and the last LLX file. Any new data blocks are then downloaded and then the LLO file is copied over the LLX file again.

Whenever ladder changes are downloaded to the RTU, a CRC is also downloaded. The RTU calculates its own CRC and compares it with the downloaded CRC. If they do not match, a 'Ladder Error' flag is triggered and the ladder logic will be disabled. A 'Ladder Error' flag will be triggered, if the LLX file in the PC does not match the ladder logic in the RTU. After downloading changes to the RTU, you can check if the download was successful by viewing the RTU Status. If an error has occurred, 'Ladder Error' will be displayed and ladder logic will be disabled. To fix a 'Ladder Error' flag, download the complete ladder.

## Downloading The Ladder Edit File

It is possible to store the ladder edit file (Filename.LL) in RTU memory so that future edits can be made by uploading the ladder edit file from the RTU, performing the edits and then downloading the compiled ladder logic and the new ladder edit file. When the ladder edit file is stored in the RTU, the date and time is also stored. This allows the file version to be checked using - Logic, Advanced, Upload .LL File Details From RTU (note: the Logic menu is available when the SDB site configuration window is in front).

The Ladder Edit File is automatically stored in the RTU whenever ladder logic is downloaded if the 'Store ladder logic files in RTU' check box is ticked in the memory configuration or it can be manually downloaded using Logic, Advanced, Download . LL File To RTU. A ladder edit file may be uploaded from the RTU using the menu Logic, Advanced, Upload .LL File From RTU.

### 5.30 Logic - Compare Ladder Version In RTU

When the SDB file is the active window (in front), the Logic menu option will appear. By selecting Logic, Advanced, Compare ladder version in RTU, the compiled ladder version in the RTU can be compared with the compiled ladder version in the PC.

To check if the ladder edit file (Filename.LL) in the PC corresponds to the compiled ladder logic in the RTU, compile the ladder logic in your PC (Logic, Compile) and then select Compare ladder version in RTU. This will compare the compiled ladder logic file (Filename.LLO) file in the PC with the compiled ladder logic file in the RTU. If the Size and Crc of the two files match, then all is OK as illustrated below. Different file dates are unimportant.


Date: Date and time when the ladder logic was compiled.
Size: Number of bytes in the compiled ladder file. Since comments are not included in the compiled file, changing comments and re-compiling will not affect the LLO file size.

Crc: Returns the hexadecimal value of the CRC ('Ox' denotes hexadecimal). Since comments are not included in the compiled file, changing comments and re-compiling will not affect the CRC. Note: Always returns 0 when compiled and downloaded using Toolbox 1.41 n and older.

Toolbox Version: Toolbox version used to generate the compiled ladder logic file.

### 5.31 Debugging Ladder Logic

To allow debugging of ladder logic, it is possible to view the state of the various ladder blocks and the contents of registers. This is accessed from the menu Ladder, Debug. Blocks that are logically true are shown in red. Debug simply reads all the data values from the RTU and displays all the current states and values in the ladder. Debug does not sequentially step through the ladder performing one rung, reading the data then performing the next rung and reading the data etc. Debug simply shows the current value of each address after the complete ladder has been processed.

## CHAPTER 6 COMMUNICATION DRIVERS

This chapter details some of the common communication drivers that are used to communicate with a range of PLCs, RTUs and other devices. Most of the communication drivers that are available are listed under 'Protocols' in the topic Configuration - Port List or for a comprehensive list, please see the document 'protocols.pdf' available from www.rtunet.com ).

### 6.1 Driver - Kingfisher Series I

Kingfisher Series I RTUs use two types of processor modules - CPU3 or CPU1. The following two ladder blocks are used for both processor types.

A Series I RTU has two possible locations for data, its SDT (scan data table) and its NDT (network data table). An SDT is comprised of 240 registers called 'IDs' while the NDT is comprised of 240 blocks of 30 registers ( 7200 network registers in total). When a Series II RTU receives data from a Series I RTU, it is always stored in network registers.

ExRepToRTU1
RTU 1
(TX_CEU3)
WDT 002 TX Series 1
Transmits up to 30 Series II local registers to a Kingfisher Series I RTU.
Comment: A 12-character description.
RTU \#: (1-255) The destination RTU that the data is sent to (note: addresses 250-255 are reserved for paging and PC use).

NDT No. (1-240; 0=SDT): When sending data to the NDT of a Series I RTU, usually 'NDT No.' is chosen to correspond to the local RTU's own address. Eg. If RTU2 was sending data to Series I RTU1, NDT No. would be 2. When data is transferred to the SDT, registers are stored at the IDs corresponding to each register number (ie. R1 is stored at ID1, R2 is stored at ID2 etc).

Registers: Only local registers R1 to R240 can be transferred to a Series I RTU as series I RTUs only have 240 IDs (each ID is equivalent to a local register). To transfer hardware registers (\#AI, \#AO, \#DI, \#DO) or network registers (\#N), these must first be copied into local registers (\#R1 to \#R240).

Foll SI RTUZ RTU 2
-( Rx _CPU3)
SDT
Rx Series 1
Polls up to 30 Series 1 IDs or an NDT block from a Kingfisher Series I RTU.
Comment: A 12-character description.
RTU \#: (1-255) The source RTU that the data is read from (note: addresses 250-255 are reserved for paging and PC use).

NDT No. (1-240; 0=SDT): When 'NDT No' is set to 0 , data is read from the SDT otherwise it is read from the NDT block specified.

Registers: Only local registers R1 to R240 can be read from a Series I RTU as Series I RTUs only have 240 IDs (each ID is equivalent to a local register). When polling an NDT from a Series I RTU, it is not necessary to specify any registers as the 30 values of the NDT block are copied
to 30 network registers of the NDT block number. The network registers used correspond to the IDs in the NDT block.

## Sending Series I Data To A Series II RTU

IDs that are received from a Series I RTU are stored in network registers corresponding to the Series I RTU address. When an NDT block is received from a series I RTU, it is stored in the network registers corresponding to the NDT block number. The four types of Series I data transfers and the data storage locations are detailed below.

- SDT to SDT: IDs are stored in network registers corresponding to the IDs defined in the "Set Values Per ID Bank".
- SDT to NDT: IDs are stored in network registers corresponding to the IDs defined in the "Get Values Per ID Bank".
- NDT to NDT: IDs are stored in network registers corresponding to the IDs in the Series I NDT block.
- NDT to SDT: IDs are stored in network registers corresponding to the IDs defined in the "Set Values Per ID Bank".

Eg. Get ID Bank 1 contains IDs 1 and 31, Set ID Bank 2 contains IDs 201 and 202, NDT3 contains the IDs 61 and 62 and the Series I RTU sending the data is RTU2.

| Series I Data <br> Transfer | Get Bank <br> $(1,31)$ | Set Bank <br> $(201,202)$ | NDT <br> Override | Series II Storage <br> Locations |
| :--- | :---: | :---: | :---: | :--- |
| SDT to SDT | 1 | 2 | 0 | \#NR2.201, \#NR2.202 |
| SDT to NDT | 1 | 0 | 0 | \#NR2.1, \#NR2.31 |
| NDT to NDT | 0 | 0 | 3 | \#NR3.61, \#NR3.62 |
| NDT to SDT | 0 | 2 | 3 | \#NR3.201, \#NR3.202 |

## Polling Series I Data From A Series II RTU

When IDs are polled from a Series II RTU, the Series II RTU will reply with its own local registers (R1 to R240) corresponding to the ID numbers. When an NDT is polled from a Series II RTU, the Series II RTU will reply with the first 30 values from the network registers corresponding to the NDT number.

## Communicating With A Kingfisher Series I RTU

When using a TX_CPU3 or an RX_CPU3 block the RTU should be configured as follows:

- First ensure that the latest firmware and Kingfisher Series 1 driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- $\quad$ Set the port protocol as S1 Ctrl [controller] or S1 Outstn [outstation] in Configuration, Port List depending on whether the Series II RTU is to act like a master or outstation Series I RTU. Note: the "No CRC" port protocol option should only be selected when communicating with a CPU1 module over an RS232 line.
- Set the port baudrate in Configuration, Port List.
- Add the address of the Series I RTU to the network list in Configuration, Network List (this must be a unique address in the RTU network). Specify a system ID of AC Hex (for a CPU3 or CPU1 with version 3 EPROM) or A5 Hex (for CPU1 prior to version 3 EPROM).


### 6.2 Driver - Omron PLC

## TxToCmroneld <br> ELC \#2 <br> (TX OMRON) <br> 

Transmits one or more consecutive local registers to one or more consecutive addresses in an Omron PLC and then returns a response code from the Omron PLC.

Comment: A 12-character description.

PLC Unit no: (1-99) The Omron address. The local RTU treats an Omron PLC as if it is another RTU in the network. This means that the Omron PLC's address must be a unique RTU address in the Network List.

Command: The Omron area to send the data to. The available options are: IR (Internal Relay) Area Write, HR (Holding Relay) Area Write, AR (Auxiliary Relay) Area Write, LR (Link Relay) Area Write, and DM (Data Memory) Area Write.

RTU Register: (\#R1 to \#R1024) The starting local register to transmit to the Omron PLC.
PLC Data Address: The starting address in the Omron PLC where the data is stored. The following addresses can be specified for each Command:

- IR Area Write: 0 to 235
- HR Area Write: 0 to 99
- AR Area Write: 0 to 27
- LR Area Write: 0 to 063
- DM Area Write: 0 to 999

Data Length: (1-30) The Number of consecutive 16-bit registers to send.

## Response Codes

The following response codes are stored in \#NRxx. 1 after each TX_OMRON block (where $x x$ is the address assigned to the Omron PLC):

| Response | Description |
| :---: | :--- |
| 0 | Normal completion |
| 1 | Not executable in RUN mode |
| 2 | Not executable in MONTOR mode |
| 3 | Not executable with PROM mounted |
| 4 | Address over (data overflow) |
| 11 | Not executable in PROGRAM mode |
| 16 | Parity error |
| 17 | Framing error |
| 18 | Overrun |
| 19 | FCS error |
| 20 | Format error (parameter length error) |
| 21 | Entry number data error (parameter error, data code error, data length error) |
| 22 | Instruction not found |
| 24 | Fame length error |
| 25 | Not executable (due to unclearable error, memory error, unwriteable <br> EEPROM, missing IO table, etc) |
| 34 | No memory unit mounted |
| 35 | User memory is write protected |
| 160 | Aborted due to parity error in transmit data |
| 161 | Aborted due to framing error in transmit data |
| 162 | Aborted due to overrun in transmit data |
| 164 | Aborted due to format error in transmit data |
| 165 | Aborted due to entry number data error in transmit data. |
| 168 | Aborted due to frame length error in transmit data |
| Other | Probably produced by noise. Execute command again |
|  |  |
| 1 |  |

## ExFromomron ELC \#2 <br> (RX OMRON) <br> IR Read <br> Rx Omron PLC

Reads one or more consecutive Omron data words and stores them in the Kingfisher RTU's network registers.

Comment: A 12-character description.
PLC Unit no: (1-99) The Omron address. The local RTU treats an Omron PLC as if it is another RTU in the network and will store the Omron PLC data in network registers corresponding to this address. This means that the Omron PLC's address must be a unique RTU address in the Network List.

Command: The Omron area to read the data from. The available options are: Status Read, IR (Internal Relay) Area Read, HR (Holding Relay) Area Read, AR (Auxiliary Relay) Area Read, LR (Link Relay) Area Read and DM (Data Memory) Area Read.

PLC Data Address: The starting address in the Omron PLC where data is to be read from. The following addresses can be specified for each Command:

- Status Read: 1
- IR Area Read: 0 to 235
- HR Area Read: 0 to 99
- AR Area Read: 0 to 27
- LR Area Read: 0 to 63
- DM Area Read: 0 to 999 (read/write) and 1000 to 1999 (read only)

RTU Register: (\#R2 to \#R1024) Specified as a local register but indicates the first network register to begin storing the data from. Note: the first network register is reserved for the response code returned by the PLC after each message.

Data Length: (1-30) The Number of consecutive 16-bit registers to read.

## Communicating With An OMRON PLC

When using a TX_OMRON or an RX_OMRON block the RTU should be configured as follows:

- First ensure that the Omron driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- Set the port protocol as OMRON in Configuration, Port List.
- Set the port baudrate in Configuration, Port List.
- Add the station address of the PLC to the network list in Configuration, Network List (this must be a unique address in the RTU network).


### 6.3 Driver - Allen Bradley

Kingfisher RTUs communicate with Allen Bradley PLC's using the DF1 protocol in half duplex slave mode with a 2 -byte CRC. The data format is 8 data bits, 1 stop bit and no parity.

The Allen Bradley PLC returns an error code after each message. The error code is stored in the first network register corresponding to the address assigned to the PLC. The STS error code is stored in the lower 8 bits of the register and the EXT STS error code in the high 8 bits. A valid message will reset the value to 0 .

## TxToABradley <br> FLC \#2 <br> — (TX_AE) Tx Allen Bradley

Transmits up to 100 consecutive local registers from a Kingfisher RTU to an Allen Bradley PLC (PLC5 or SLC500).

Comment: A 12-character description.
Station No. (decimal): (1-249) Station address configured in the Allen Bradley PLC. An Allen Bradley PLC is treated like another RTU in the network. This means that the station address must be different to all the other RTU addresses in the RTU's Network List.

Destination Register: Destination address in the Allen Bradley PLC where data is stored. This should be a string reference like N10:1.

Source Register: (\#R1 to \#R1024) Local register of the RTU to read the data from.
No. Of Registers: (1-100) Number of 16 -bit registers to send. Note: each floating point value uses two 16 -bit local registers. The maximum number of bytes that a message sent by an RTU can contain is 250. The number of bytes sent varies depending on the contents of the message. In rare cases, the TX-AB message can exceed this limit and so the message is not sent and an error code of 65535 is returned in the first network register of the corresponding 'Station No' RTU. It is therefore recommended that a maximum of 50 registers be written to the PLC in one message.

PLC Type: PLC5 / SLC500.

AxFromillenE
PLC \#24

- (RX_AB) RX Allen Bradley

Receives up to 100 consecutive registers from an Allen Bradley PLC (PLC5 or SLC500).
Comment: A 12-character description.
Station No. (decimal): (1-249) Station address configured in the Allen Bradley PLC. An Allen Bradley PLC is treated like another RTU in the network. This means that the station address must be different to all the other RTU addresses in the RTU's Network List.

Destination Register: (2-1024) Network register of the Kingfisher RTU to begin storing the data from. Note: the first network register is reserved for the error code returned by the PLC after each message.

Source Register: Source address in the Allen Bradley PLC where data is read from. This should be a string reference like N10:1.

No. Of Registers: (1-100) Number of 16-bit registers to read. Note: each floating point value uses two 16-bit local registers.

PLC Type: PLC5 / SLC500.

## Communicating With An Allen Bradley PLC

When using a TX_AB or an RX_AB block the RTU should be configured as follows:

- First ensure that the Allen Bradley driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- Set the port protocol as ALLEN BRADLEY in Configuration, Port List.
- Set the port baudrate in Configuration, Port List.
- Add the station address of the PLC to the network list in Configuration, Network List (this must be a unique address in the RTU network).

Note 1: The simplest way to connect between an RTU serial port and an Allen Bradley PLC is to use an RS232 null modem cable (can use the RTUnet ADP-05 adaptor and an RJ45 to RJ45 lead). The Allen Bradley PLC requires a RS232 DB9 male port. An Allen Bradley SLC5/03 CPU has a DB9 male port while the SLC5/02 CPU only has an RS485 RJ45 port and must have a communications module installed.
Note 2: if using ethernet to communicate, the Allen Bradley driver uses TCP/IP port 2222 to talk to the Allen Bradley PLC.
Note 3: If a 1785-KE interface module is used between the PLC and the RTU, the 1785-KE station number must also be configured in the network list. The PLC should then be configured as an indirect link via the 1785 -KE station address.

### 6.4 Driver - Inline Flow Computer

FxF romInline
RTU 002
-(RX_INLINE)-Rx Inline
Receives one data parameter from an Inline flow computer.
Comment: A 12-character description.
RTU \#: (1-255) The RTU address assigned to the Inline flow computer (note: addresses 250255 are reserved for paging and PC use).

Command: The data parameter to read. The available options are: read RTC (real-time clock), read pressure, read temperature, read corrected volume, read uncorrected volume, read correction factor, read maximum hourly demand, read maximum daily demand, read current hourly usage, read current daily usage, read volumes at end of the day and read flow rate.

The data returned from the Inline flow computer is placed in the network registers of the corresponding RTU address. The network registers that are used for each command are shown below.

| Command | Received Data |  |
| :--- | :--- | :--- |
| Read real-time clock | \#R1 | seconds, 0-59 |
|  | \#R2 | minutes, 0-59 |
|  | \#R3 | hours, 0-23 |
|  | \#R4 | day of week, 1-7 (1 = Sunday) |
|  | \#R5 | day of month, 1-31 |
|  | \#R6 | month, 1-12 |
|  | \#R7 | year, 0-99 |
|  | \#R9 | least significant word of correction factor |
|  | \#R10 | most significant word of correction factor |
| Read correction |  |  |
| factor | \#R11 | least significant word of pressure |
| Read pressure | \#R12 | most significant word of pressure |
|  | \#R13 | pressure flags |
|  | \#R13.8 | 1=Manual, 0=Auto |
|  | \#R13.7 | 1=Error |
|  | \#R13.6 | 1=Gauge, 0=Absolute |
|  | \#R13.5 | 1=PSI, 0=kPa |
|  | \#R13.4 | decimal point: 1 = x 0.01, 0 = x 0.1 |
| Read temperature | \#R15 | most significant word of temperature |
|  | \#R16 | least significant word of temperature |
|  | \#R17 | temperature flags |
|  | \#R17.8 | 1=Manual, 0=Auto |
|  | \#R17.7 | 1=Error |
|  | \#R17.6 | 1=Deg F, 0=Deg C |
|  | \#R19 | least significant word of corrected volume |
|  | \#R20 | most significant word of corrected volume |
|  | \#R21 | corrected volume flags |
|  | \#R21.8 | 1=cubic feet, 0=m3 |
|  |  |  |
| Read corrected |  |  |
|  |  |  |


| Command | Received Data |  |
| :--- | :--- | :--- |
| Read uncorrected <br> volume | \#R23 | least significant word of uncorrected volume |
|  | \#R24 | most significant word of uncorrected volume |
| \#R25 | uncorrected volume flags |  |
| \#R25.8 | 1=cubic feet, 0=m3 |  |

## Communicating With An Inline flow computer

When using an RX_INLINE block the RTU should be configured as follows:

- First ensure that the Inline driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- Set the port protocol as INLINE or INLINE2 in Configuration, Port List. 'INLINE2' is the newer Inline protocol. Note: the Inline driver must be configured on a serial port.
- Set the port baudrate in Configuration, Port List.
- Add the Inline flow computer address to the network list in Configuration, Network List (this should be a unique address in the RTU network). Also set the message time out to at least 3000 ms.
- Ensure that the RTU has the correct time and date to allow the RTU to read the volumes at the end of the day.


### 6.5 Driver - Fuji PLC

There are currently 2 Fuji PLC drivers - Micrex-F and NJ Series. The following information applies to both PLC types.

## TxToFujiEIC

## RTU 2

-(TX_MICREX)-Tx Micrex / Tx Fuji NJ
Transmits up to 58 consecutive local registers from a Kingfisher RTU to a Fuji PLC. Returns a response code in the first network register corresponding to the address assigned to the Fuji PLC.

Comment: A 12-character description.
PLC number: (1-249) The RTU address assigned to the Fuji PLC.
RTU Source: (\#R1 to \#R2048) The starting local register to transmit to the Fuji PLC.
PLC Destination: The data address in the Fuji PLC to write the data to. Eg. K0
Number of registers: $(1-58)$ Number of registers to be written to the Fuji PLC.

RxFromFuji
RTU 2
-(RX_MICREX)-Rx Micrex / Rx Fuji NJ
Reads up to 106 consecutive registers from a Fuji PLC and stores them in the RTU's network registers. Returns a response code in the first network register corresponding to the address assigned to the Fuji PLC.

Comment: A 12-character description.
PLC number: (1-249) The RTU address assigned to the Fuji PLC.
PLC Source Address: The starting address in the Fuji PLC from where the data is read. Eg. BD12.

RTU Destination: (\#R2 to \#R1024) Specified as a local register but indicates the first network register to begin storing the data from. Note: the first network register is reserved for the response code returned by the PLC after each message.

Number of registers: (1-58) Number of registers to read.

Response Codes (hexadecimal values)
Fuji Micrex-F
00 Processing is completed normally.
12 Data is written in program area.
20 Specified command code does not exist.
21 Input data does not sequence correlation to command. Example: Read or write by not using 4 byte units for 32-bit area.
22 Operation is available by loader only.
24 Module designated does not exist.
32 Oversized address for model number is designated.
A0 Communication module number error.
A1 Communication module busy.
A2 Exceeded number of data.
A3 Not suitable communication module.
A6 No data module.
A7 Unidentified boundary of data module to be transferred with receive byte number.
A8 Command error

Fuji NJ PLC
00 Processing is completed normally.
01 Data is written to ROM.
02 Specified command code does not exist.
03 Inconsistent data (parameter error).
04 Processing is impossible due to transmission interlock by another device or loader.
05 Incorrect module No.
06 Search item not found.
07 An address exceeding the module's range was specified (during writing)
08 An instruction error was found in a writing program.
09 Program execution cannot continue due to an error.
OA After sending a WAK, a command other than cancel or continue was received.
OB Mismatched loader type (a command was sent to a loader that cannot be connected to the NJ series PLC).
OC Mismatch password.
0E Connection to network is impossible.
0F Another loader is communicating over the network.
21 Now processing.
A7 Transmission error.

## Communicating With A Fuji PLC

When using a TX/RX_MICREX or TX/RX_FUJI_NJ block the RTU should be configured as follows:

- First ensure that the Fuji driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- Set the port protocol as 'Fuji Micrex-F' or 'Fuji NJ-Series' in Configuration, Port List.
- $\quad$ Set the port baudrate in Configuration, Port List. A serial port is used to communicate with a Fuji PLC.
- Add the address of the PLC to the network list in Configuration, Network List (this must be a unique address in the RTU network).
- The Kingfisher RTU uses 8 data bits, no parity, 1 stop bit and CRC checking for communications with the Fuji controller. To enable CRC checking on the communication messages, the Fuji controller needs to be configured with an initialization file. The initialization table has to be defined in the ladder logic program and the message module registration has to be setup.


### 6.6 Driver - ASCII

The ASCII protocol allows a Kingfisher RTU to request information from an external device using an ASCII or hexadecimal protocol. Data returned from the device is stored in network registers corresponding to the address assigned to the ASCII device (note: an LP-1 stores the data in local registers).

The ASCII driver transmits a zero terminated string and then stores the received string in registers or scans the string for floating point variables.

Each character is stored as an 8-bit ASCII number. Two characters are stored in each local register. For each pair of characters, the left character is stored in channels 1-8 and the right character is stored in channels 9-16. For an LP-1, the characters are stored in reverse order.

The string sent to the external device can be a fixed string entered in the ladder logic or a string stored in local registers. The string must be zero terminated and can therefore not contain any zeros. The difference between the RX_ASCII and TX_ASCII ladder functions is that the TX ASCII ladder function sends a byte string and returns a byte string. The RX ASCII ladder function sends a byte string and returns a number of floating point variables. The received message string is scanned for any digits. Each set of digits is converted to a floating point value and stored in the network registers corresponding to the device address. The number of floating point values returned is configured in the ladder block. If less decimal numbers are found in the message than floating point values configured, the remaining floating point values are returned as zero.

## TxASCII Data <br> RTU 33 <br> $-\left(T X X_{-A}^{A} S C I I\right)-T x$ ASCII

Comment: A 12-character description.
RTU Number: (1-249) The RTU address assigned to the ASCII device.
String: Characters to be sent or first local register (\#R) where string is stored.
Max. bytes in reply: (1-200) Maximum number of bytes to return.
Reply \# bytes: (\#R1-\#R2048) Specified using a local register but indicates the network register where the number of bytes received is reported. Note: an LP-1 stores the data in local registers instead of network registers.

Reply destination: (\#R1-\#R2048) Specified using a local register but indicates the first network register where the received message bytes are reported. Note: an LP-1 stores the data in local registers instead of network registers.

FxF romascil
RTU 12
-(RX_ASCII) - Rx ASCII

Comment: A 12-character description.
RTU Number: (1-249) The RTU address assigned to the external ASCII device.
String: Characters to be sent or first local register (\#R) where string is stored.
Destination: (\#F1 to \#F2047) First network float register where received floating point variables are reported. Specified using a local float register. Note: an LP-1 stores the data in local registers instead of network registers.

No. of variables: (1-40) Number of floating point variables contained in the reply message. Can also specify a local register (\#R) that contains the 'No. of variables' setting.

## Communicating With An ASCII Device

When using a Tx or Rx ASCII block the RTU should be configured as follows:

- First ensure that the ASCII driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- Set the port protocol as 'ASCII No Parity' or 'ASCII Even Parity' in Configuration, Port List. The ASCII protocol can only be used on MC or LP-1 ports.
- Set the port baudrate in Configuration, Port List.
- Add the address of the ASCII device to the network list in Configuration, Network List (this must be a unique address in the RTU network).


## Driver Limitations

- Transmit string can not contain any zero bytes.
- Data format must be 8 bits, no or even parity and 1 stop bit.
- There is no validity checking of the reply message by the driver.
- Maximum length of a transmit string is 200 bytes.


### 6.7 Driver - Hart

The Hart protocol allows a Kingfisher RTU to request information from a Hart Field Communication device. Data returned from the Hart device is stored in local registers. The driver is based on Hart protocol revision 5.

## ExFromHart

Device \#5
-(RX_HART) - Rx Hart
Comment: A 12-character description.
Hart Device Number: (0-15) The address of the Hart field device. Address 0 is only used for point to point installations.

Command: The following commands are supported:
(Note: each command is followed by the Hart function code (FC). Some manufacturers have different descriptions for the various Hart commands. PV stands for 'primary variable').

| Universal Commands | FC |
| :--- | :--- |
| Read Unique Identifier | 0 |
| Read PV [primary variable] | 1 |
| Read Current and \% of range | 2 |
| Read Current and 4 dyn vars | 3 |
| Write Polling Address | 6 |
| Read Unique Identifier with Tag | 11 |
| Read Message | 12 |
| Read Tag, Descriptor, Date | 13 |
| Read PV Sensor Information | 14 |
| Read [PV] Output Information | 15 |
| Read Final Assembly Number | 16 |
| Write Message | 17 |
| Write Tag, Descriptor, Date | 18 |
| Write Final Assembly Number | 19 |


| Common Practice Commands | FC |
| :--- | :--- |
| Read Transmitter Variables | 33 |
| Write [PV] Damping Value | 34 |
| Write [PV] Range Values | 35 |
| Set [PV] Upper Range Value | 36 |
| Set [PV] Lower Range Value | 37 |
| Reset Configuration Changed Flag | 38 |
| EEPROM Control | 39 |
| Enter/Exit Fixed Current Mode | 40 |
| Perform Transmitter Self Test | 41 |
| Perform Master Reset | 42 |
| Set PV Zero | 43 |
| Write PV Units | 44 |
| Trim [PV Current] DAC Zeros | 45 |
| Trim [PV Current] DAC Gain | 46 |
| Write [PV] Transfer Function | 47 |
| Read Additional Transmitter Status | 48 |
| Write PC Sensor Serial Number | 49 |
| Read Dynamic Variable Assignments | 50 |
| Write Dynamic Variable Assignments | 51 |
| Set Transmitter Variable Zero | 52 |
| Write Transmitter Variable Units | 53 |
| Read Transmitter Variable Info | 54 |
| Write Transmitter Variable Damping Value | 55 |
| Write Transmitter Variable Sensor Serial No | 56 |
| Read All Dynamic Variables | 108 |

RTU: (1-255) The RTU address assigned to the Hart device.
Destination Register: (\#R1 to \#R2048) The local register where the return variables are stored.

Device Address (3 regs): (\#R1 to \#R2046) The first of 3 consecutive local registers that are used to store the extended address of the Hart device.

Source Register: (\#R1 to \#R2048) The local register where variables for writing operations are stored.

Status: (\#R1-\#R2048) Optional. The local register where the status and response codes of the Hart device are stored. Channels 1-8 = status code, channels $9-16=$ response code.

## Communicating With A Hart Device

When using an Rx Hart block the RTU should be configured as follows:

- First ensure that the Hart driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ). The RTU must also have a Hart option board installed on port 2 or port 3.
- Configure the port as follows (from Configuration, Port List): Type=RS-232, Baud Rate $=1200$, Pre TX $=10 \mathrm{~ms}$, Post TX=15ms and Protocol=Hart. Note the Pre TX and Post TX times may need to be increased (eg. Post Tx=45ms) to suit the particular Hart device.
- Add the configured 'RTU' address to the network list in Configuration, Network List (this must be a unique address in the RTU network).


## Notes

- Data returned by commands 1, 2 and 3 is formatted and stored in local registers as follows (where $\mathrm{x}=$ the local register number configured in 'Destination Register'):

| Command | Data Returned (\#F = 32-bit float, \#R = 16-bit register) |
| :---: | :--- |
| 1 | $\# F x=$ Value, \#Rx+2 = Units |
| 2 | $\# F x=$ Primary Variable (PV) current, \#Fx+2 = PV \% of range |
| 3 | $\# F x=$ Primary Variable current <br> $\# F x+2=$ Primary Variable (PV) value, \#Fx+4 $=$ PV units <br>  <br> $\# F x+6=$ Second Variable (SV) value, \#Fx+8 = SV units <br> $\# F x+10=$ Third Variable (TV) value, \#Fx+12 = TV units <br> $\# F x+14=$ Fourth Variable (FV) value, \#Fx+16 = FV units |

Eg. Destination Register = \#R101. For command 1, \#F101 = value (uses \#R101 and \#R102) and \#R103 = units.

- All other data written to and from the RTU will be in a raw format of 2 bytes per register, as returned by the external Hart Device.
- ASCII data, as returned by the Hart Protocol, is in a six-bit packed format and is stored in the RTU in this format, with 2 bytes per local register.


### 6.8 Driver - GPS



Allows a Kingfisher RTU to determine its location and synchronize its clock within 10 milliseconds of universal time anywhere in the world.

Comment: A 12-character description.
Device \#: (1-249) Address assigned to the GPS option board. Data returned from the GPS option board is stored in network registers corresponding to this address.

Update Freq (secs): (1-255, typically 1 sec) Setting determines how often the GPS option board sends the new GPS data to the RTU.

Time Offset (mins): (0-1440) Enter the time offset to the Greenwich mean time of the local RTU. (eg. Melbourne $=$ GMT +600 mins).

Synchronize Clock?: If ticked, the RTU real time clock is updated at the rate specified by the Update Frequency above.

Dest. For Position: (\#R1 to \#R2043) Specified as a local register but indicates the first network register to begin storing the position data from.
\#Rx = degrees of latitude
\#Fx+1 = float 0-59.999999 (6 decimal places) minutes of latitude
$\# R x+3$ = degrees of longitude
\#Fx+4 = float 0-59.999999 (6 decimal places) minutes of longitude
Dest. For Time: (\#R1 to \#R2045) Specified as a local register but indicates the first network register to begin storing the time data from.
\#Rx = hours (0-23)
$\# R x+1=$ minutes (0-59)
\#Fx+2 = float 0-59.999 seconds

Dest. For Altitude: (\#R1, \#R3 ... \#R2047 odd registers) Specified as a local register but indicates the network float register to store the altitude data in. \#Fx = float of altitude.

Dest. For \#Satellites: (\#R1 to \#R2048) Specified as a local register but indicates the network register to store the number of satellites data in. This is the number of satellites that are currently in contact with the GPS option board.

## Communicating With A GPS Option Board

When using a GPS option board the RTU should be configured as follows:

- First ensure that the GPS option board is supported by the type of RTU you are using and that the latest firmware is loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- Configure the port as follows (from Configuration, Port List): Type=GPS Internal, Baud Rate $=19200$, Pre TX=0ms, Post TX=0ms and Protocol=GPS.
- Add the configured 'Device' address and port number of the GPS option board to the network list in Configuration, Network List (this must be a unique address in the RTU network). Specify a Timeout of 2000 ms .
- The GPS option board must be configured on the first ladder scan using the RX GPS block.


### 6.9 Driver - User Defined

The User Defined protocol allows new comms protocols to be developed completely in ladder logic. The User Defined protocol is similar to the ASCII protocol driver but is more useful because it is not limited to null-terminated ASCII strings, can accept unsolicited incoming messages and will work on all communication ports.


Transmits a string up to 200 characters long to an external device and then receives and stores the response string (if any). If any bytes are received, the success counter corresponding to the device number is incremented (Note: this protocol does not verify any checksum or CRC bytes in the message). If no bytes are received within the timeout period, the fail counter is incremented. Tx User also works with other port protocols (other than User Defined eg. Series 2). All characters received while the Tx User function is active, are treated as the Tx User response string.

Comment: A 12-character description.
Device Number: (1-249) The RTU address assigned to the external device. Note: the Device Number is only used to access the communications parameters stored in the Network List (and Phone List for PSTN devices); it does not have to correspond to the physical address of the external device. The network link configured for this Device Number is used to control communications.

TxData Source: (\#R1 to \#R2048) Local register containing the first character of the string to be transmitted.

Tx no. bytes: (\#R1 to \#R2048 or 1 to 200) The number of bytes of the string to transmit. Can be specified as a local register or a constant.

RxData destination: (\#R1 to \#R2048) First local register to begin storing the received string in.
Rx No. bytes (max): (\#R1 to \#R2048 or 0 to 250) Maximum number of bytes expected in the response. This can be specified as a local register or a constant. Enter 0 if no reply is expected. If non-zero, after the Tx message string has been sent, the RTU will wait for a reply. The RTU will stop waiting after the timeout specified in the Network List has expired. If a local register is specified, the register will be updated after the function has completed to correspond to the actual number of bytes received. Note: a maximum of 250 bytes can be received on a processor port.

Status Register: (\#R1 to \#R2048 or Blank) If a register is specified, it will be updated with the status of the Tx User function as follows:

- Ch1: Waiting flag. Set ON when the block is activated and set OFF when the block is finished.
- Ch2: Status flag. Written to after the block is finished. Set OFF if the update was successful or set ON if the update failed (due to communications failure).

Use network registers ?: If this box is selected, the function will read and write to network registers for the specified device instead of local registers. This applies to the Tx and Rx data strings, the number of bytes and the status register.

Local link ?: If this box is selected, the function will send the messages to the local device. When using PSTN, GSM, GPRS or similar communications, the Tx User message will be sent to the local modem itself. Eg. Local Link is used when reading SMS messages from a GSM or sending other AT commands.

The example shown below transmits a string of 10 characters from local registers starting at \#R200 to the external device assigned to RTU100. A maximum of 50 characters are expected as a reply and the reply is stored in local registers starting at \#R101. If any characters are received, success counter \#YLSUCC100 is incremented, otherwise fail counter \#YLFAIL100 is incremented. Note: if more than 50 characters are in the receive buffer, only the first 50 characters will be read.


Figure 6.9a: Example Tx User block


Rx User allows an incoming message string to be received and stored. When bytes are received, the success counter corresponding to the device number is incremented (Note: this function cannot verify any checksum or CRC bytes in the message). If no bytes are received after triggering an Rx User block, the fail counter is incremented. Rx User will not work with other port protocols (always returns 0) because any characters received are processed as the other protocol.

The port register \#YPRXCnn can be used to determine if there are any received characters/bytes in the buffer of port 'nn' (nn=1 to 16). When \#YPRXCnn is non zero, the 'RxUser' function can then be used to retrieve the message and store it in local registers.

Comment: A 12-character description.
Device Number: (1-249) The RTU address assigned to the external device. Note: the Device Number is only used to access the communications parameters stored in the Network List (and Phone List for PSTN devices); it does not have to correspond to the physical address of the external device. The network link configured for this Device Number is used to control communications.

RxData destination: (\#R1 to \#R2048) First local register to begin storing the received string in.

Rx No. bytes (max): (\#R1 to \#R2048 or 0 to 250) Maximum number of bytes expected in the response. This can be specified as a local register or a constant. The RTU will attempt to receive the specified number of bytes. It will wait until the timeout specified in the Network List has expired. If a local register is specified, the register will be updated after the function has completed to correspond to the actual number of bytes received.

Status Register: (\#R1 to \#R2048 or Blank) If a register is specified, it will be updated with the status of the Rx User function as follows:

- Ch1: Waiting flag. Set ON when the block is activated and set OFF when the block is finished.
- Ch2: Status flag. Written to after the block is finished. Set OFF if the update was successful or set ON if the update failed (due to communications failure).

Use network registers ?: If this box is selected, the function will read and write to network registers for the specified device instead of local registers. This applies to the Rx data string, the number of bytes and the status register.

The example shown below continuously monitors port 2 for messages. When any characters are received and the previous Rx User command has finished (tests the configured Status Register \#R2.1), the 'Rx User' function reads up to 100 characters from the port 2 comms buffer. These characters are then stored in local registers starting at \#R120 and then the actual number of received characters are reported in \#R1. Success counter \#YLSUCC100 is incremented each time characters are received. RTU100 is configured as 'Direct via Port 2' in the Network List.


Figure 6.9b: Example ladder logic used to receive characters


Figure 6.9c: Rx User block used in Figure 6.9b.

## Handling Messages of Unknown Size:

There are two different ways of receiving messages of unknown size:

- Specify the maximum possible message size in the 'Rx No. bytes' field, and allow the RTU to report the actual number of characters received.
- Initially specify just the first few bytes of the message in the 'Rx no. bytes' field. Most comms protocols include a header at the start which can be decoded to work out the complete message size. When this has been done (in ladder logic), the 'Rx User' function can be called again, specifying the actual expected size of the remaining part of the message, and if necessary specifying a new 'RxData Destination'.


## Communicating With A User Device

When using a Tx or Rx User block the RTU should be configured as follows:

- First ensure that the User Defined protocol is supported by the type of RTU you are using and that the latest firmware and driver is loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- Configure the port for the correct baudrate and set the port protocol to 'User-Defined' (not necessary for Tx User). After selecting 'User Defined', another configuration box will appear. The number of data bits (7 or 8), the parity (none, even or odd) and the number of stop bits (1 or 2) can then be specified (default setting: 8 data bits, no parity, 1 stop bit). Note: the Tx User function can be used with any other port protocol eg. Series II or paging. When using multiple protocols on the same port, Tx User messages must only be initiated when the port is completely free (pager messages must also be completed - ie. ensure \#YLST250.2 is OFF) otherwise communication errors will occur.
- Assign an RTU address to the external device and add this to the network list. Configure the port number, the timeout and the number of retries to be used when communicating with the external device.


## Error Checking

No validity checking (eg. checksum or CRC) of incoming messages is performed by the 'RxUser' or 'TxUser' functions. Messages are accepted regardless of any CRC or checksum bytes and so message integrity must be checked using ladder logic.

### 6.10 Driver - Modbus

The Modbus driver allows the RTU to respond to and initiate Modbus messages. If the RTU only needs to respond to messages (eg. from an operator panel) then the Tx Modbus and Rx Modbus ladder blocks are not used

```
Update FICZ
    RTU 002
    (TX_MEUS)
    40001
Tx Modbus
```

Transmits 16-bit registers or digital channels to a Modbus device.
Comment: A 12-character description.
RTU \#: (\#R1 to \#R2048 or 1 to 249) The destination RTU (or PLC) address. Can be specified as a local register or a constant.

Register: The starting register or bit (channel) to send to the destination RTU. Allowable 'Register' settings are: \#Rxxxx, \#Rxxxx.cc where xxxx=local register number (1-2048) and cc=channel number (1-16). Network registers (\#N...) cannot be used. Note: before sending floating point or long registers to a Modbus device, the 2 Kingfisher local registers used to store the number will need to be reversed. Please see 'Modbus Floating Point and Long Registers' below for more information.

MODBUS Address: (1 to 49999 or L000001 to L465535 when using extended addressing) The starting address to store the registers from in the destination PLC (or RTU). The registers are stored at consecutive addresses starting from the address specified here.

No. of Points: (\#R1 to \#R2048 or 1 to 123) The number of consecutive 16-bit registers or channels (single bits) to send. Can be specified as a local register or a constant. If a register bit is specified for 'Register' above (e.g. \#DI3.1, \#R1.1) then the 'Number of Points' is the number of bits to send otherwise the 'No. of Points' is the number of registers (or analog channels) to send. Note: when sending analog channels (\#AO or \#AI) every analog module is assigned 8 points and every digital module is assigned 16 points. A multi IO module with analog channels (such as the IO-4 or IO-3) is also assigned 8 points. Note: two points must be specified for each float or long that is sent.

## Examples:

1. To send Chs 1-16 of \#DI3 and \#DI4
2. To send Chs 1-8 of \#AI6 and \#AI7
3. To send AI Chs 1-4 of IO-3 Modules 14 and 15

Register Points
\#DI3.1 32
\#Al6.1 16
\#Al14.2 12

Example 3 shown above will send \#Al14.2, \#Al14.3, \#Al14.4, \#Al14.5, \#Al14.6 (not used), \#Al14.7 (not used), \#Al14.8 (not used), \#Al15.1 (not used), \#Al15.2, \#Al15.3, \#Al15.4 and \#Al15.5. Alternatively, two TX Modbus blocks could be used that sent 4 points each.

```
Read 10 Rege
    RTU 002
    -(RX MEUS)
    41001
```


## Rx Modbus

Polls 16-bit registers or digital channels from a Modbus device. The data received from a Modbus device is stored in network registers corresponding to the address of the Modbus device. The Modbus address range is mapped to various local and hardware registers as detailed below (since they do not all fit in the network registers of a single RTU address).

Comment: A 12-character description.
RTU \#: (\#R1 to \#R2048 or 1 to 249) The source Modbus RTU (or PLC) to poll the data from. Can be specified as a local register or a constant.

Dest. Offset: (-9999 to 9999 [or 0 to -65535 when using extended addressing]) When data is polled from a Modbus device it is mapped to RTU registers (as detailed in 'Modbus Address Mapping' below). An RTU is unable to store the complete Modbus register range. Modbus registers that are out of range can be moved into the correct range by using a Destination Offset. Modbus registers that are in range but would be stored in Network Analog or Network Digital registers can also be offset so that they are stored in the more easily accessible Network Registers. Examples are shown below.


Note: If a positive Destination Offset is required, normal Modbus addressing must be used.
MODBUS address: (1 to 49999 or L000001 to L465535 when using extended addressing) The starting address to request the registers or digital channels from in the source RTU (or PLC). The registers or channels are requested from consecutive addresses starting from the address specified here.

No. of Points: (\#R1 to \#R2048 or 1 to 123) The number of consecutive 16-bit registers or bits (channels) to poll. Can be specified as a local register or a constant. If a digital address is specified for 'MODBUS address' above (00,000 or 10,000 range) then the 'Number of Points' is the number of bits to poll otherwise the 'No. of Points' is the number of registers (or analog channels) to poll. Note: two points must be specified for each float or long that is polled.

## Modbus Address Mapping

Due to memory limitations, the RTU does not store the complete Modbus address range. To fit the Modbus address range into the RTU register structure, the RTU stores the Modbus data as shown below.

| Modbus Address | Extended Modbus Address | Mapped to RTU Address * |
| :--- | :--- | :--- |
| 00,001 to 01,024 | L000,001 to L001,024 | \#NDrrr.1.1 to \#NDrrr.64.16 |
| 01,025 to 02,000 | L001,025 to L002,000 | Not Stored |
| 02,001 to 09,999 | L002,001 to L009,999 | \#NRrrr.1.1 to \#NRrrr.500.15 |
|  | L010,000 to L065,535 | Not Stored |
| 10,001 to 11,024 | L100,001 to L101,024 | \#NDrrr.1.1 to \#NDrrr.64.16 |
| 11,025 to 12,000 | L101,025 to L102,000 | Not Stored |
| 12,001 to 19,999 | L102,001 to L109,999 | \#NRrrr.1.1 to \#NRrrr.500.15 |
|  | L110,000 to L165,535 | Not Stored |
| 30,001 to 39,999 | L300,001 to L309,999 | Same as 40,001 to 49,999 |
| 40,001 to 40,512 | L400,001 to L400,512 | \#NArrr.1.1 to \#NArrr.64.8 |
| 40,513 to 41,000 | L400,513 to L401,000 | Not Stored |
| 41,001 to 43,048 | L401,001 to L403,048 | \#NRrrr.1 to \#NRrrr.2048 |
| 43,049 to 49,999 | L403,049 to L409,999 | Not Stored |
|  | L410,000 to L465,535 | Not Stored |

* Where 'rrr' is the source RTU (or PLC) address (where the data came from)

Note: The 00,000 Modbus address range (digital outputs) is stored at the same locations as the 10,000 address range (digital inputs) in the RTU. The 30,000 Modbus address range (analog inputs) is also stored at the same locations as the 40,000 address range (analog outputs) in the RTU.

## Communicating With A Modbus Device

When using a Tx or Rx Modbus block or responding to Modbus messages, the RTU should be configured as follows:

- First ensure that the Modbus driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- From Configuration, Port List configure the port for the correct baudrate and set the port protocol to one of the Modbus options eg. 'Mbus SCADA, S2'.
- If initiating Modbus messages from ladder logic, assign an address to the external device and add this address to the network list.
- Note: RTU address 174 should not be used as this corresponds to the Sync character at the start of Kingfisher Series II messages (AE). If a Modbus message is sent to RTU174, RTU174 will think it is a Kingfisher message.


## Data Format

Kingfisher RTUs use a data format of 8 data bits, no parity bit and 1 stop bit and support the 'RTU' Modbus data format. Note: an MC-xx module can also initiate Modbus messages in ASCII format ( 7 data bits, even parity and 1 stop bit).

## Modbus Floating Point and Long Registers

Each float or long number is stored in two 16-bit registers. A Modbus device stores the two 16bit registers in reverse order to a Kingfisher RTU (Kingfisher RTUs store the lower 16 bits in the lower register number). Before using floats or longs from a Modbus device or writing floats or longs to a Modbus device, the two 16-bit registers used for each float or long will need to be swapped as illustrated below.



Figure 6.10: Example ladder logic used to poll 2 Modbus floating point numbers and then swap the 16 -bit register order (note: \#NR100.64 is used for temporary storage).

## Modbus Addressing

The standard Modbus address ranges are as follows:

- Digital Outputs:
0,001-9,999
- Digital Inputs:

10,001-19,999

- Analog Inputs:

30,001-39,999

- Analog Inputs/Outputs: 40,001-49,999


## RTU Mapping Formulas

Hardware and local registers are mapped to Modbus addresses using the following formulas.
Where 'SLOT\#' is the slot address of the IO module (1-64), 'CH\#' is the channel number (1-16 for digitals or 1-8 for analogs) and 'REG\#' is the local register number (1-2048).

| Data Point | Formula |
| :---: | :---: |
| Digital Input | $\begin{aligned} & =10,000+[(\text { SLOT\# }-1) \times 16]+\text { CH\# } \\ & =10,001 \text { to } 11,024 \end{aligned}$ |
| Digital Output | $\begin{aligned} & =00,000+[(\text { SLOT\# -1)x16] }+ \text { CH\# } \\ & =00,001 \text { to } 01,024 \end{aligned}$ |
| Analog Input/Output | $\begin{aligned} & =40,000+[(\text { SLOT\#-1)x8] }+ \text { CH\# } \\ & =40,001 \text { to } 40,512 \end{aligned}$ |
| Register Bit (Read only) | $\begin{aligned} & =12,000+[(\text { REG }-1) \times 16]+\text { CH\# } \\ & =12,001 \text { to } 19,999 \text { * } \end{aligned}$ |
| Register Bit (Read/Write) | $\begin{aligned} & =2,000+[(\text { REG\# -1) x16] }+\mathrm{CH} \# \\ & =02,001 \text { to } 09,999 \text { * } \end{aligned}$ |
| Register (Read/Write) | $\begin{aligned} & =41,000+\text { REG\# } \\ & =41,001 \text { to } 43,048 \end{aligned}$ |

* It is only possible to access up to Ch15 of Register 500 (corresponding to address 09,999 or 19,999 .) Ch16 of R500 (and after) cannot be accessed as a digital input or output. However, it is possible to read and write to all of the local registers using integer values.


## Lookup Tables

The following tables provide the Modbus address or address range for the first 16 slot addresses and selected local registers.

| Analog I/O <br> (eg. Al-1/4/10, AO-2) |  |  |
| :---: | :---: | :---: |
| Slot \# | Ch | Address |
| 1 | 1-8 | 40,001-40,008 |
| 2 | 1-8 | 40,009-40,016 |
| 3 | 1-8 | 40,017-40,024 |
| 4 | 1-8 | 40,025-40,032 |
| 5 | 1-8 | 40,033-40,040 |
| 6 | 1-8 | 40,041-40,048 |
| 7 | 1-8 | 40,049-40,056 |
| 8 | 1-8 | 40,057-40,064 |
| 9 | 1-8 | 40,065-40,072 |
| 10 | 1-8 | 40,073-40,080 |
| 11 | 1-8 | 40,081-40,088 |
| 12 | 1-8 | 40,089-40,096 |
| 13 | 1-8 | 40,097-40,104 |
| 14 | 1-8 | 40,105-40,112 |
| 15 | 1-8 | 40,113-40,120 |
| 16 | 1-8 | 40,121-40,128 |
| .. |  | .. |
| 64 | 1-8 | 40,505-40,512 |


| Register Read/Write <br> (eg. \#R1)* |  |
| :--- | :--- |
| Register | Address |
| 1 | 41,001 |
| 2 | 41,002 |
| 3 | 41,003 |
| 4 | 41,004 |
| 5 | 41,005 |
| 6 | 41,006 |
| 7 | 41,007 |
| 8 | 41,008 |
| 9 | 41,009 |
| 10 | 41,010 |
| 11 | 41,011 |
| 12 | 41,012 |
| 13 | 41,013 |
| 14 | 41,014 |
| 15 | 41,015 |
| 16 | 41,016 |
| .. |  |
| 2048 | 43,048 |

*When used with a bit mask, these addresses can also be used for bit read/writes.

| Digital Input (eg. Dl-1 Channel 1) |  |  |
| :--- | :--- | :--- |
| Slot \# | Ch | Address |
| 1 | $1-16$ | $10,001-10,016$ |
| 2 | $1-16$ | $10,017-10,032$ |
| 3 | $1-16$ | $10,033-10,048$ |
| 4 | $1-16$ | $10,049-10,064$ |
| 5 | $1-16$ | $10,065-10,080$ |
| 6 | $1-16$ | $10,081-10,096$ |
| 7 | $1-16$ | $10,097-10,112$ |
| 8 | $1-16$ | $10,113-10,128$ |
| 9 | $1-16$ | $10,129-10,144$ |
| 10 | $1-16$ | $10,145-10,160$ |
| 11 | $1-16$ | $10,161-10,176$ |
| 12 | $1-16$ | $10,177-10,192$ |
| 13 | $1-16$ | $10,193-10,208$ |
| 14 | $1-16$ | $10,209-10,224$ |
| 15 | $1-16$ | $10,225-10,240$ |
| 16 | $1-16$ | $10,241-10,256$ |
| .. |  | .. |
| 64 | $1-16$ | $11,009-11,024$ |

Register Bit Read (eg. \#R1.1)

| Reg. | Bit | Address |
| :--- | :--- | :--- |
| 1 | $1-16$ | $12,001-12,016$ |
| 2 | $1-16$ | $12,017-12,032$ |
| 3 | $1-16$ | $12,033-12,048$ |
| 4 | $1-16$ | $12,049-12,064$ |
| 5 | $1-16$ | $12,065-12,080$ |
| 6 | $1-16$ | $12,081-12,096$ |
| 7 | $1-16$ | $12,097-12,112$ |
| 8 | $1-16$ | $12,113-12,128$ |
| 9 | $1-16$ | $12,129-12,144$ |
| 10 | $1-16$ | $12,145-12,160$ |
| 11 | $1-16$ | $12,161-12,176$ |
| 12 | $1-16$ | $12,177-12,192$ |
| 13 | $1-16$ | $12,193-12,208$ |
| 14 | $1-16$ | $12,209-12,224$ |
| 15 | $1-16$ | $12,225-12,240$ |
| 16 | $1-16$ | $12,241-12,256$ |
| . |  | . |
| 500 | $1-15$ | $19,985-19,999$ |


| Register Bit Read/Write <br> (eg. \#R1.1) |  |  |
| :--- | :--- | :--- |
| Reg. | Ch | Address |
| 1 | $1-16$ | $02,001-02,016$ |
| 2 | $1-16$ | $02,017-02,032$ |
| 3 | $1-16$ | $02,033-02,048$ |
| 4 | $1-16$ | $02,049-02,064$ |
| 5 | $1-16$ | $02,065-02,080$ |
| 6 | $1-16$ | $02,081-02,096$ |
| 7 | $1-16$ | $02,097-02,112$ |
| 8 | $1-16$ | $02,113-02,128$ |
| 9 | $1-16$ | $02,129-02,144$ |
| 10 | $1-16$ | $02,145-02,160$ |
| 11 | $1-16$ | $02,161-02,176$ |
| 12 | $1-16$ | $02,177-02,192$ |
| 13 | $1-16$ | $02,193-02,208$ |
| 14 | $1-16$ | $02,209-02,224$ |
| 15 | $1-16$ | $02,225-02,240$ |
| 16 | $1-16$ | $02,241-02,256$ |
| . |  | .. |
| 500 | $1-15$ | $09,985-09,999$ |

### 6.11 Driver - Trio E-Series Radio

GetTrioData
RTU 101
\{RX_TRIO_E\}
\#R1

## Rx Trio E-Series Radio

Reads status or statistical information from a Trio E-Series radio.
Comment: A 12-character description.
RTU \# (1-255): Address assigned to the Trio radio. Data returned from the Trio radio is stored in network registers corresponding to this address.

Radio ID: (0 or long constant) When set to 0 , communicates with the local radio. Otherwise set to the serial number of the target radio. Specifying 0 will allow the local radio to be replaced without having to update the RTU configuration each time.

Command: (Read Status Data or Read Statistics Data) Returns data as follows (where \#Rx is the Destination Register defined below):

Read Status Data (returns eight 16-bit signed registers)

| Data Description | Register | Units | Example |
| :---: | :---: | :---: | :---: |
| Temperature | \#Rx | 0.1 Deg C | $245=24.5 \mathrm{deg} \mathrm{C}$ |
| Signal Indicator (RSSI) | \#Rx+1 | 0.1 dBm | $-701=-70.1 \mathrm{dBm}$ |
| Fwd Tx Power (Remote)* | \#Rx+2 | 0.1 dBm | $204=20.4 \mathrm{dBm}$ |
| Supply Volts | \#Rx+3 | 0.1 V | $138=13.8 \mathrm{~V}$ |
| Rx Freq Error | \#Rx+4 | 0.1 Hz | $254=25.4 \mathrm{~Hz}$ |
| Rev Tx Power (Remote)* | \#Rx+5 | 0.1 dBm | $77=7.7 \mathrm{dBm}$ |
| Fwd Tx Power (Base Station) * | \#Rx+6 | 0.1 dBm | $126=12.6 \mathrm{dBm}$ |
| Rev Tx Power (Base Station) * | \#Rx+7 | 0.1 dBm | $34=3.4 \mathrm{dBm}$ |

* If connected to a base station radio, the Fwd and Rev Tx Power (Remote) fields will be set to 0 . Similarly, if connected to a remote radio, the Fwd \& Rev Tx Power (Base Station) fields will be set to 0 .

Read Statistics Data (returns four 32-bit long registers)

| Data Description | Register |
| :--- | :--- |
| Bad Frame Count | \#Lx |
| Good Frame Count | \#Lx+2 |
| Lost Sync Count | \#Lx+4 |
| Lost RSSI Count | \#Lx+6 |

Destination Register: (\#R1 to \#R2048) Specified as a local register but indicates the first network register to begin storing the data from. When the Read Statistics Data command is being used, an odd numbered local register should be specified (\#R1, \#R3...\#R2047) to allow the received data (in Long format) to be correctly displayed using Toolbox.

## Communicating With A Trio E-Series Radio

When using an Rx Trio_E block, the RTU should be configured as follows:

- First ensure that the Trio E-Series Radio driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- From Configuration, Port List configure the port for the correct baudrate (Trio radio default is 19200) and set the port protocol to 'TRIO Eseries'.
- Assign an address to the Trio radio and add this address to the network list in Configuration, Network List (this must be a unique address in the RTU network).
- Configure an RX TRIO ladder block to poll the local or remote Trio radio. To poll the local radio set Radio ID to 0 . To poll a remote Trio radio set Radio ID to the serial number of the remote radio.
- Both ports of the local Trio radio must be used if the radio is also used for RTU to RTU communications. Trio radio port A is used for RTU to RTU communications while Port B allows the radio data to be polled.



### 6.12 Driver - Spread Spectrum Radio

GetRadigData
RTU 2
(RX_5SRADIO' -
\#R11

## Rx Spread Spectrum Radio

Reads diagnostic information from a spread spectrum radio.
Comment: A 12-character description.
RTU \# (1-255): Address assigned to the spread spectrum radio. Data returned from the radio is stored in network registers corresponding to this address.

Destination Register: (\#R1 to \#R2045) Specified as a local register but indicates the first network register to begin storing radio data from. The following data is returned (where \#Rx is the configured Destination Register):

| Data Description | Register | Range | Units | Example |
| :--- | :--- | :--- | :--- | :--- |
| Board voltage | \#Rx | $280-575$ | 0.01 Volts | $511=5.11$ Volts |
| Signal strength of last <br> received message packet | \#Rx+1 | 110 to 40 <br> or $32768^{\star}$ | -dBm | $63=-63 \mathrm{dBm}$ <br> $32768=$ Undetermined |
| Number of receive errors <br> (message packets) | \#Rx+2 | 0 to 65535 | Errors |  |
| Number of valid received <br> message packets | \#Rx+3 | 0 to 65535 | Successes |  |

* Note: Signal strength returns 32768 (undetermined) when no message packets have been received since the radio was powered up.


## Communicating With A Spread Spectrum Radio

When using an Rx SS RADIO ladder block, the RTU should be configured as follows:

- First ensure that the Spread Spectrum Radio driver is supported by the type of RTU you are using and that the latest firmware and driver are loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com/support)
- From Configuration, Port List set the port Type to 'SS_RADIO' and Baud Rate to 9600 (for 9XTend US / Australian radio) or 19200 (for 24XStream International radio). Pre and Post TX can be left set to 0 . Protocol can also be left set to 'Series 2'. Note: port Type can be set to 'RS232' if the radio does not need to be configured with an initialisation string.
- From Configuration, Network List assign an address to the spread spectrum radio (this should be a unique address in the RTU network). The network registers of this address will be used to store the spread spectrum radio data. Set Port \# to the spread spectrum radio port number and Timeout to 4000 ms .
- When communicating between RTUs using spread spectrum radios, the Timeout of the network link to the remote RTU should be set to 2000 ms .
- Configure an RX SSRADIO ladder block to poll the local SS radio. An example is shown below.


## Reading Radio Data

The example below shows how radio data can be obtained after a successful message is received from RTU2 or RTU3. The radio has been assigned address 100. RTU2 radio data is stored from RTU100 network register 1 ('Destination Register' = \#R1). RTU3 radio data is stored from network register 5 ('Destination Register' = \#R5).


Figure 6.12: Example ladder logic used to read radio data for RTUs 2 and 3 (assumes spread spectrum radio is connected to port 2)

## CHAPTER 7 VIEW MENU

RTU data and information can be viewed or read from the RTU using the View menu. Many registers can also be written to. The options contained in the View menu are shown below and are described in this chapter.

| RTU Status | F3 |
| :--- | :--- |
| Hardware Overview | F4 |
| Local Registers | F5 |
| Network Registers | F6 |
| Timer Registers | F7 |
| Freeform Display |  |
| Event Logging |  |
| RTU Comms Statistics | F9 |
| PC Comms Statistics | F10 |
| Read Drivers Info |  |
| Auto Detect | F2 |

Figure 7a: View Menu

### 7.1 View - RTU Status

You can view the current state of the RTU using the menu - View, RTU Status. An example RTU Status window is shown below.


Figure 7.1a: RTU Status Window
The RTU status displays the following information:
RTU Address: (1 to 249) Address of the RTU that Toolbox is communicating with.
Processor Type: PC-1, CP-1, CP-10/11, CP-21, SBX, ERS Micro, LP-1, SB-1 or Micro-4.
RAM Size: Battery backed RAM size.
Firmware Version: Version of the operating code as stored in flash memory.
I/O Processing: Enabled or Disabled. Status of IO module scanning.
Ladder Processing: Enabled or Disabled. Status of ladder logic processing.
Netblocks Used: The number of network register blocks that have been used. The upper limit is determined by the 'Max. Network Blocks' setting in Configuration, Memory, Check memory usage button. If the maximum limit is exceeded a 'Netblks Overrun' system flag is displayed.

Date, Time: Real time clock settings in the RTU. The displayed time is updated every time Toolbox polls the RTU. The polling rate is determined by the Comms Repeat Rate of the PC Communications Setup (Configuration, PC Setup).
I/O Scan Rate (scans/sec): Rate of scanning the IO modules and processing ladder logic (if enabled).
System Flags: General RTU operation flags (from the system register \#YFLAGS). Note: the flags 'Scan Overrun' and 'Log Overrun' are status indications only.

Firmware drivers included: The names of firmware drivers and special functions that have been successfully loaded in the RTU. Some drivers are included in firmware.

### 7.2 View - Hardware Overview

The type and position of modules plugged in the backplane are automatically detected by the RTU. There can be up to 4 racks of 16 modules that can be of almost any mix and position on the rack. The module types and their rack positions can be viewed from the menu - View, Hardware Overview. The window that is displayed for the hardware overview is shown below.


Figure 7.2a: Hardware Overview Window
If the modules have appeared in the wrong slot positions, this can be changed by powering down the RTU and setting the DIP switches on the backplane to the correct rack number (please see the instructions on the backplane or the Kingfisher Hardware Manual).

By clicking the Slot button alongside a module (ie. 1 to 64), the module IO details are displayed on the screen. You can then view analog or digital inputs and write analog or digital outputs. The hardware overview window for the IO-4 is shown below. If the RTU is running ladder logic that controls an output, any setting from Toolbox will be immediately overwritten by the RTU. To manually set outputs without the RTU overwriting them, first disable ladder logic processing using the menu Utilities, Enable/Disable, Disable Logic Processing.


Figure 7.2b: IO-4 Hardware Overview

### 7.3 View - Local Registers

Displays a page of 64 local registers at a time. All the local registers ( 1 to 2048) can be viewed by paging through the list (click the PageUp or PageDown buttons) or by jumping to the relevant register (click the GotoReg button). Any local register can also be written to by clicking on the register button and entering a value.

The registers can be viewed and written to in a number of formats. The display and writing format can be changed by clicking on the 'Display As' button and selecting one of the following options:

- Unsigned: (0 to 65535 Raw 16-bit numbers.
- Signed: (-32768 to +32767 Signed 15-bit numbers. If channel 16 is ON, the number is negative.
- Hex: (0 to FFFF Hex) Hexadecimal numbers.
- Binary: (! = ON, : = OFF) Displays the state of each bit. Right-most bit (LSB) is channel 1, left-most bit (MSB) is channel 16.
- Float: $\left(3.4 \times 10^{-38}\right.$ to $\left.3.4 \times 10^{38}\right)$ Signed 32 -bit numbers. To be able to store numbers of this size, the RTU stores floating point numbers in 2 consecutive local registers and so only odd numbered float registers are displayed. Eg. \#F5 uses \#R5 and \#R6 while \#F7 uses \#R7 and \#R8. Float numbers can be entered as a signed decimal number or by using the exponential format 'yX.XXXXeyZZ' where 'X.XXXX' is the number, 'y' is the sign (+ or -) and 'ZZ' is the exponential power.
- Long: (-2,147,483,648 to $2,147,483,647)$ Signed 32-bit numbers. Like float numbers, long numbers use two consecutive local registers and so only odd numbered long registers are displayed. Eg. \#L5 uses \#R5 and \#R6 while \#L7 uses \#R7 and \#R8.

Example windows showing local registers displayed in Binary and Long format are shown below.


Figure 7.3a: Local Registers Displayed In Binary Format ('!' = channel ON)

| Local RTU Re | isters Over | iew |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Register | Value | Register | Value | Register | Value | Register | Value |
| \#L 1 | -21474836 |  |  | \#L 33 | 0 |  |  |
| \#L 3 | 1044480 |  |  | \#L 35 | 0 |  |  |
| \#L 5 | 51301 |  |  | \#L 37 | 0 |  |  |
| \#L 7 | 0 |  |  | \#L 39 | 0 |  |  |
| \#L 9 | 0 |  |  | \#L 41 | 0 |  |  |
| \#L 11 | 0 |  |  | \#L 43 | 0 |  |  |
| \#L 13 | 0 |  |  | \#L 45 | 0 |  |  |
| \#L 15 | 0 |  |  | \#L 47 | 0 |  |  |
| \#L 17 | 0 |  |  | \#L 49 | 0 |  |  |
| \#L 19 | 0 |  |  | \#L 51 | 0 |  |  |
| \#L 21 | 0 |  |  | \#L 53 | 0 |  |  |
| \#L 23 | 0 |  |  | \#L 55 | 0 |  |  |
| \#L 25 | 0 |  |  | \#L 57 | 0 |  |  |
| \#L 27 | 0 |  |  | \#L 59 | 0 |  |  |
| \#L 29 | 0 |  |  | \#L 61 | 0 |  |  |
| \#L 31 | 0 |  |  | \#L 63 | 0 |  |  |
| OK | Page Up | PageDown | GotoReg | Display As | Help | Long | Pg: 01/32 |

Figure 7.3b: Local Registers Displayed In Long Format

### 7.4 View - Timer Registers

Displays the current values in the 64 timer registers. These timers are also read/write and can be written to by clicking the timer's button and entering a value. If ladder logic is using a timer register, the timer register's value can still be manually changed.

The various display formats are detailed in the topic View - Local Registers. An example window showing the timer registers is shown below.

| Timer Registers Overview |  |  |  |  |  |  |  | X |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Register | Value | Register | Value | Register | Value | Register | Value |  |
| \#T1 | 15 | \#T17 | 0 | \#T33 | 0 | \#T49 | 0 |  |
| \#T 2 | 65535 | \#T18 | 0 | \#T34 | 0 | \#T50 | 0 |  |
| \#T 3 | 0 | \#T19 | 0 | \#T35 | 0 | \#T51 | 0 |  |
| \#T 4 | 0 | \#T20 | 0 | \#T36 | 0 | \#T52 | 0 |  |
| \#T 5 | 0 | \#T21 | 0 | \#T37 | 0 | \#T53 | 0 |  |
| \#T 6 | 0 | \#T22 | 0 | \#T38 | 0 | \#T54 | 0 |  |
| \#T 7 | 0 | \#T23 | 0 | \#T39 | 0 | \#T55 | 0 |  |
| \#T 8 | 0 | \#T24 | 0 | \#T40 | 0 | \#T56 | 0 |  |
| \#T 9 | 0 | \#T25 | 0 | \#T41 | 0 | \#T57 | 0 |  |
| \#T10 | 0 | \#T26 | 0 | \#T42 | 0 | \#T58 | 0 |  |
| \#T11 | 0 | \#T27 | 0 | \#T43 | 0 | \#T59 | 0 |  |
| \#T12 | 0 | \#T28 | 0 | \#T44 | 0 | \#T60 | 0 |  |
| \#T13 | 0 | \#T29 | 0 | \#T45 | 0 | \#T61 | 0 |  |
| \#T14 | 0 | \#T30 | 0 | \#T46 | 0 | \#T62 | 0 |  |
| \#T15 | 0 | \#T31 | 0 | \#T47 | 0 | \#T63 | 0 |  |
| \#T16 | 0 | \#T32 | 0 | \#T48 | 0 | \#T64 | 0 |  |
| OK |  |  |  | Display As | Help | Unsigned |  |  |

Figure 7.4a: Example Timer Registers Window

### 7.5 View - Network Registers

Network Registers are used by the local RTU to store data from other RTUs.
After selecting the menu View, Network Registers, the window shown below is displayed. You can then select which RTU you would like to view data from and the type of network data. Note: entering a Network RTU Number of 0 or the address of the local RTU allows you to view the local RTU's own hardware registers.


Figure 7.5a: Window Displayed Before Viewing Network Registers

An example window showing the Network Analogs for RTU2 is shown below.

| Network Registers Overview, RTU \#2 |  |  |  |  |  |  |  | X |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Register | Value | Register | Value | Register | Value | Register | Value |  |
| HNA 1.1 | 0 | \#NA 3.1 | 6 | \#NA 5.1 | 0 | \#NA 7.1 | 0 |  |
| \#NA 1.2 | 0 | \#NA 3.2 | 12800 | \#NA 5.2 | 0 | \#NA 7.2 | 0 |  |
| \#NA 1.3 | 0 | \#NA 3.3 | 16128 | \#NA 5.3 | 0 | \#NA 7.3 | 0 |  |
| \#NA 1.4 | 0 | \#NA 3.4 | 0 | \#NA 5.4 | 0 | \#NA 7.4 | 0 |  |
| \#NA 1.5 | 0 | \#NA 3.5 | 11520 | \#NA 5.5 | 0 | \#NA 7.5 | 0 |  |
| \#NA 1.6 | 0 | \#NA 3.6 | 0 | \#NA 5.6 | 0 | \#NA 7.6 | 0 |  |
| \#NA 1.7 | 0 | \#NA 3.7 | 0 | \#NA 5.7 | 0 | \#NA 7.7 | 0 |  |
| \#NA 1.8 | 0 | \#NA 3.8 | 0 | \#NA 5.8 | 0 | \#NA 7.8 | 0 |  |
| \#NA 2.1 | 0 | \#NA 4.1 | 0 | \#NA 6.1 | 0 | \#NA 8.1 | 0 |  |
| \#NA 2.2 | 0 | \#NA 4.2 | 0 | \#NA 6.2 | 0 | \#NA 8.2 | 0 |  |
| \#NA 2.3 | 0 | \#NA 4.3 | 0 | \#NA 6.3 | 0 | \#NA 8.3 | 0 |  |
| \#NA 2.4 | 0 | \#NA 4.4 | 0 | \#NA 6.4 | 0 | \#NA 8.4 | 0 |  |
| \#NA 2.5 | 0 | \#NA 4.5 | 0 | \#NA 6.5 | 0 | \#NA 8.5 | 0 |  |
| \#NA 2.6 | 0 | \#NA 4.6 | 0 | \#NA 6.6 | 0 | \#NA 8.6 | 0 |  |
| \#NA 2.7 | 0 | \#NA 4.7 | 0 | \#NA 6.7 | 0 | \#NA 8.7 | 0 |  |
| \#NA 2.8 | 0 | \#NA 4.8 | 0 | \#NA 6.8 | 0 | \#NA 8.8 | 0 |  |
| OK | Page Up | PageDown | GotoReg | Display As | Help | Unsigned | Pg: 1/8 |  |

Figure 7.5b: Network Analogs For RTU2 (only slot 3 has analog inputs)

### 7.6 View - Freeform Display

Freeform Display allows pages of registers to be defined in a text file and then displayed live. The registers are updated each time Toolbox communicates with the RTU. Different pages of registers can be selected and displayed by using the PAGEUP and PAGEDOWN keys.

The freeform text file consists of a number of pages of text and can include variables (registers). Each variable must be defined at the end of the text file. Variables are referred to using \%n where n is a number in the range $1-999$. Up to 100 variables can be defined on each page. Note: in freeform display, variables are overwritten by text representing the current value of these variables. Care should be taken when designing these pages, to allow enough 'space' characters after the dynamic variable for the value to be correctly displayed.

Page breaks are specified using \%NEWPAGE. The beginning of the variable definitions is specified using \%VARIABLES.

## Example Freeform Text File

```
This is a test freeform display, showing:
Register 1 as an unsigned integer value: %1
Register 10.1 as a binary value: %2
Register 10.1 as a string value: %3
(Note: it is important to leave spaces at the end of each line so
Toolbox can overwrite the spaces with the register value)
%NEWPAGE
...and on page 2 we have:
Floating point register 3: %4
(Note: floating point numbers can sometimes generate long strings)
Long register 11: %5
Pump1Status: %6
(Note: this depends on 'Pump1Status' being defined in the Variables
List of a site, and that site being selected when this display window
is opened)
RTU address: %7
Firmware version: %8
%VARIABLES
1 #R1 %5u
2 #R10.1 %2i
3 #R10.1 %b "OFF" "ON "
4 F3 %6.2f
5 #L11 %lu
6 \text { PumplStatus \%b "OK " "FAULT"}
7 #YADDRESS %03u
8 #YFIRMW %4X
```

Each line in the \%VARIABLES section is used to define a variable as follows:
Variable number Address or tagname Format Additional strings
Variable number: The number of the \%n dynamic variable used in the text section.
Address or tagname: Any variable as used in ladder logic (eg. \#R1, \#YDIAG.1) or the TagName of any variable defined in the Variables List of the currently selected RTU.

Format: A string defining the display format of the variable. The format string has the following structure (note: [ ] denotes an optional parameter):
\% [Flags] [Width] [.Prec] [dp] [I] Type

| Format parameter | Options | Description |
| :---: | :---: | :---: |
| Flags | - | Left justified |
|  | + | Value starts with a '+' or '-' |
|  | \# | If type is 0 , value begins with a 0 . If type is $x$ or $X$, value starts with $0 x$. If type is $\mathrm{e}, \mathrm{E}$ or f , value will have a decimal point. If type is g or G , value will have a decimal point and trailing zeros will not be removed. |
|  | <Blank> | If negative, value starts with '-' |
| Width | n | At least n characters are printed. The value is padded with blanks. |
|  | On | At least n characters are printed. The value is padded with leading zeros. |
| .Prec | . 0 | For e,E,f types, no decimal point is printed. |
|  | .n | n characters or n decimal places are printed. For e, E, f, g, G types, the last digit printed is rounded. |
|  | <Blank> | Defaults to '. 1 ' for d, i, o, u, x, X types. Defaults to '. 6 ' for e, $\mathrm{E}, \mathrm{f}$ types. Displays all significant digits for $\mathrm{g}, \mathrm{G}$ types. |
| dp | _n | Decimal places. For $\mathrm{d}, \mathrm{i}, \mathrm{u}$ types only. A decimal point is inserted in the output with n digits following. |
| 1 (long) | I | Displays d , $\mathrm{i}, \mathrm{o}, \mathrm{u}, \mathrm{x}, \mathrm{X}$ types as long values. |
| Type | d | Signed decimal integer |
|  | i | Signed decimal integer |
|  | 0 | Unsigned octal integer |
|  | u | Unsigned decimal integer |
|  | X | Unsigned hexadecimal integer using lower-case letters a-f |
|  | X | Unsigned hexadecimal integer using capital letters A-F |
|  | f | Floating point signed value of the form [-]dddd. dddd |
|  | e | Floating point signed value of the form [-]d.dddd or e[+/-]ddd |
|  | E | Same as e, but with capital E for exponent |
|  | g | Floating point signed value in either the $f$ or e form based on given value and precision |
|  | G | Same as g , but with E for exponent if e format is used |
|  | b | Bit string. Displays the first string if the bit is False or displays the second string if the bit is True. Strings must be separated by either tabs or spaces. |
|  | a | Animated string. If the value of the variable is 0 , the first string is printed. If the value is 1 the second string is printed, etc. If the value exceeds the number of given strings the last string is printed. Strings must be separated by either tabs or spaces. |

### 7.7 View - Event Logging

If there are no logs in the RTU, the message 'No Logs In RTU!' will be displayed otherwise the window shown below will be displayed.


Figure 7.7a: Initial Event Log Upload Window
Only the logs corresponding to the Priority, User Type, Date/Time and RTU settings will be uploaded. The maximum number of event logs to upload can also be specified.


Figure 7.7b: Example Event Log Window
The Event Log window has the following options:

- Upload: Upload specified event logs from the RTU.
- Save As: Save the uploaded logs in a DBF file (standard database format).
- Open: (To be implemented) Open an existing DBF log file for viewing.
- Clear: Clear all the event logs in the RTU.
- Label View: Displays register addresses as labels if the register address is defined in the Variables List of an RTU site in the currently opened project.
- Done: Close the Event Log window


### 7.8 View - RTU Comms Statistics

An RTU automatically counts communication (comms) successes and fails for each RTU it communicates with. Toolbox allows you to display the communication statistics from any RTU in the network. The comms statistics for a small network is illustrated below.


Figure 7.8a: RTU Comms Statistics Stored In A Small Network
A success is recorded when a valid message is received or when a reply is received to a message sent to an RTU. A fail is recorded each time there is no reply to a message attempt within the timeout period. An example of Comms Statistics logged by RTU1 for communications to RTU2 are shown below.


Figure 7.8b: Viewing RTU Comms Statistics For RTU2

### 7.9 View - PC Comms Statistics

Displays the total number of communication successes and fails for all messages sent by Toolbox. The statistics can be cleared by clicking the Reset button.


Figure 7.9a: Viewing PC Comms Statistics

### 7.10 View - Read Drivers Info

Displays important information about all the firmware drivers loaded in the RTU. An example is shown below.


Figure 7.10a: Viewing Driver Information
If a driver has been partly overwritten or has an error, 'CRC Fail' will be displayed and a 'Driver Error' system flag will be shown in the RTU Status.

The 'Read Drivers Info' window displays the firmware driver version and its location in RTU memory.

### 7.11 View - Auto Detect

After connecting a communications cable between the RTU and the PC, communications can be tested by using Auto Detect. If communications are successful, the address of the detected RTU will be displayed as shown below.


Figure 7.11a: Auto Detect Window When Toolbox Uses The Correct Baud Rate
Auto Detect will first try to communicate with the local RTU at the baud rate configured in PC Setup. If the baud rate matches the RTU and communications are successful, Auto Detect will return the RTU's address. If the baud rate is different, an option will appear asking if you would like to Auto Detect to automatically search at the other baud rates. Auto Detect will then try every other configurable baud rate until communications are successful.


Figure 7.11b: Auto Detect Window When Toolbox Has A Different Baud Rate
The main reasons why Toolbox will not communicate with the local RTU are:

- Incorrect COM port (as configured in Configuration, PC Setup) or IP Address (if using ethernet).
- Incorrect baud rate (as configured in Configuration, PC Setup). Not applicable for ethernet.
- The PC cable is not connected or is faulty.
- The PC cable is not connected to an RTU serial (or ethernet) port.
- The RTU port has been incorrectly configured. The RTU configuration can be cleared by removing the battery link on the back of the CPU module and waiting for about 2 minutes. Note: the battery link for an LP-1 is inside the case.
- The address of the RTU configuration loaded in Toolbox does not match the address of the local RTU. To prevent this problem, create a new site (which has address zero) or download the RTU configuration that is loaded in Toolbox. Note: All RTUs will respond to address zero.


## CHAPTER 8 UTILITIES MENU

The options contained in the Utilities menu are shown below and are described in this chapter.

| Unlock RTU Port |
| :--- |
| Diagnostic Test |
| Set Real-Time Clock |
| Warm Start RTU |
| Comms Analyser |
| Comms Terminal |
| Dial Site |
| Hangup Site |
| Carrier Test |
| Upload RTU Variables to file |
| Download RTU Variables from file |
| EnablejDisable |
| Advanced |

Figure 8a: Utilities Menu

### 8.1 Utilities - Unlock RTU Port

Changes the security level of the RTU port to equal the security level of Toolbox (provided the Toolbox security level offers greater access). Changing the security level to 0 will allow an RTU to be re-configured.

After two minutes of comms inactivity, the RTU will automatically switch the port back to its configured security level.

Please see the appendix - RTU Security for more information.

### 8.2 Utilities - Diagnostic Test



Figure 8.2a: Example RTU Diagnostic Window
A tick indicates that the diagnostic test has passed (is successful). The test for the RAM Chips is only carried out after a cold start. The other diagnostic tests are continually updated as the RTU runs.

I/O Bus: Test is passed if an IO module is detected. If the CPU loses communications with an IO module or is unable to detect an IO module, the IO bus is denoted as unknown (blank).

C/M Bus: (Communications Bus) Test is passed if a communications module is detected (such as an MC module). If the CPU loses communications with a communications module or is unable to detect a communications module, the $\mathrm{C} / \mathrm{M}$ bus is denoted as unknown (blank).

Real Time Clock: Test is passed if the seconds field of the real time clock has changed within 2 seconds. Otherwise displayed as failed.

RAM: Passed if the battery backed RAM is OK.
Clicking the 'Advanced' button on the Diagnostic window displays the following information:


Figure 8.2b: Advanced Diagnostic Window
The Advanced Diagnostic window displays the number of restarts (Watchdog Count) of the RTU and the number of cold starts. The Watchdog count is incremented each time the RTU is powered up or the Watchdog timer forces a restart. Both the Watchdog Count and the Cold Start Count can be reset to 0 by clicking the respective Reset button.

### 8.3 Utilities - Set Real-Time Clock

Correct RTU time and date can be important when using event logs or other ladder functions. When the Set Real-Time Clock option is selected, Toolbox reads the PC's current time and date and these values are used for the defaults. You can change the date and time defaults to the desired settings and then choose to send these settings to the RTU by clicking 'OK.'

### 8.4 Utilities - Warm Start RTU

A Warm Start is equivalent to a power reset which causes the RTU to perform self-diagnostics and to set communication buffers to their default states. A warm start does not reset IO module outputs or inputs. A warm start will also occur after downloading the RTU configuration but not after downloading ladder logic.

### 8.5 Utilities - Comms Analyser

The Comms Analyser displays all the messages received and transmitted on a specified port in hexadecimal format. The analysed port MUST BE DIFFERENT to the port used to send analyser messages to Toolbox.

Caution! Communications will be overloaded if analysing the radio port of a remote RTU if the same radio port is used to send the analyser messages back to Toolbox. Communications can be restored by performing a carrier test on the local radio port and then sending a warm start to the remote RTU while the carrier test is in progress.

Comms Analyser can be used for the 'Local PC Port' (which uses the COM port configured in PC Setup), or for a 'Remote RTU Port'. To access a remote RTU port, a valid RTU address (1249) and port number (1-16) must be entered. 'Include KF2 Command Parser' can also be selected which will interpret the characters into Kingfisher Series II messages. This will display the target and initiating RTU addresses, the Kingfisher Series II command number and a message description.


Figure 8.5a: Comms Analyser Options
Comms Analyser will display the last 16 messages (approx.) with the newest message displayed at the top of the window. All messages are also written to the file - ANALYSER.TXT in the program file folder (eg. C:\Program Files\Kingfisher\Kingfisher Toolbox\ANALYSER.TXT). The analyser display can be paused by pressing CTRL-Q. When CTRL-Q is pressed again, the analyser display will continue updating.

When monitoring a CPU port, the analyser will detect any character being received or transmitted (even if it is part of an unrecognised protocol). When monitoring an MC port, the analyser will only detect complete protocol messages of the protocol which has been configured for that port.

Care should be taken when using the Remote Comms Analyser in a busy network, as it will generate a significant amount of network traffic (slightly more than the amount of traffic on the port being monitored).

The comms analyser works best when all other Toolbox communications windows are closed (eg. RTU Status).

Caution! You must close the analyser screen or close Toolbox before disconnecting from the RTU otherwise the RTU will continue to broadcast the messages from the monitored port indefinitely. Closing the analyser screen causes a 'stop analyser mode' message to be sent to the monitored RTU. Analyser mode can be forced to stop by restarting the Toolbox analyser for the relevant RTU port and then closing the analyser again.

### 8.6 Utilities - Comms Terminal

Toolbox has a terminal window for sending and receiving characters via the configured COM port or from any RTU port in the telemetry system. Terminal can also be used with a PSTN modem to dial into a remote RTU for remote diagnostics and configuration.

Comms Terminal can be used for the 'Local PC Port' (which uses the COM port configured in PC Setup), or for a 'Remote RTU Port'. To access a remote RTU port, a valid RTU address (1249) and port number (1-16) must be entered. 'Echo Characters' can also be selected, which will echo any send characters back to the display window.


Figure 8.6a: Comms Terminal Options
Once the port has been specified, a terminal window is then opened. ASCII characters can be sent to the specified port (CPU or MC ports) and characters received can be viewed (for CPU only). Characters received on MC ports cannot be viewed.

Comms Terminal is very useful for communicating with dial option boards. Some Hayes AT modem commands and responses are shown below.

| Text | Command / <br> Response | Description |
| :--- | :--- | :--- |
| AT | Command | General command to check if modem is OK |
| OK | Response | Response from modem. Modem is OK |
| ATDT 03 9123 4567 | Command | Number to be tone dialed (phone number of <br> remote RTU) |
| ATDL | Command | Dial last number again |
| CARRIER 9600 <br> PROTOCOL: LAP-M <br> COMPRESSION: <br> V.42BIS <br> CONNECT 9600 | Response | Connection information. After the CONNECT <br> 9600 statement appears, Toolbox can be <br> used to view the RTU status, download a <br> configuration or perform any other function <br> that would be possible if Toolbox were <br> directly connected to the remote RTU with a <br> cable. If Toolbox is used to interrogate the <br> RTU before this message appears, <br> communication problems may occur. |
| +++ | Command | Tells sthe modem that the next characters are <br> a command |
| OK | Response | Ready for command |
| ATH | Command | Hang up modem |
| OK | Response | Command carried out. Modem disconnected |

### 8.7 Utilities - Dial Site / Hangup Site

Tells the local RTU to dial a remote RTU or hangup from a remote RTU. After specifying the RTU to dial (1-249), the local RTU will dial the phone number configured for that RTU in the Configuration, Phone Directory menu.

### 8.8 Utilities - Carrier Test

A carrier test will force the specified radio or private line port (1-16) to transmit for a number of seconds (1-999). A carrier test will not operate on serial ports. A carrier test is very useful when wanting to test the radio signal strength from a remote RTU. By forcing the remote RTU to transmit continuously for say 60 seconds, the RX power at the local RTU can be measured. This is especially useful when there are a number of outstation RTUs as it allows you to know which RTU is transmitting.
A. Caution! Radio carrier tests should not be longer than 60 seconds in order to prevent overheating and damage to the radio.

### 8.9 Utilities - Upload/Download RTU Variables

RTU registers can be uploaded to, or downloaded from a text file. This is useful when an RTU needs to be cold-started or have new firmware loaded as the contents of all the registers are cleared. The RTU register values can be uploaded to a PC before cold starting the RTU and then downloaded back into the RTU afterwards.

Local registers (\#R1 to \#R2048), event log pointer registers (\#YLLOGIDX1 to 255) and communication fail (\#YLFAIL) and success (\#YLSUCC) registers can all be read from the RTU and saved to a file.

The register file is stored in tab-delimited ASCII format and can be edited using any text editor. When editing the file, registers may be removed, added or have their values changed to any positive integer in the range of 0 to 65535 . Only registers remaining in the file will be downloaded into the RTU. Comments can also be added to the file by beginning the comment with a semicolon (;). Comments can be inserted on new lines or added to the end of existing lines.

Example:

- Select 'Upload RTU Variables to file' and then choose a filename.
- If the file does not exist you will be prompted for which RTU registers to upload. If the file does exist, then only the registers specified in the file will be uploaded.
- After completing the cold-start or the firmware upgrade, select 'Download RTU Variables from file', then choose the same file to download the registers back into the RTU.

NOTE: This function enables the user to overwrite local register values. If the logic includes things like accumulated totals, edge triggers or register mapping, these may be overwritten or triggered when uploading and downloading RTU variables.

### 8.10 Utilities - Enable / Disable I/O Scanning

An RTU will automatically attempt to scan all its IO modules at the configured IO Scan Interval (Configuration, System Parameters). The RTU can be made to 'hold' its last inputs or outputs by disabling IO scanning.

### 8.11 Utilities - Enable / Disable Logic Processing

An RTU will attempt to processes its ladder logic at the configured IO Scan Interval (Configuration, System Parameters). Sometimes it is useful to disable ladder logic processing in order to fault-find and this can be done using the menu Disable Logic Processing. The RTU Status shows the current state of logic processing and will also display 'Logic Processing: Disabled' if the RTU does not have any ladder logic loaded (ladder logic is cleared after a cold start).

### 8.12 Utilities - Advanced

## Utilities - Download CPU / MC Firmware

As new features become available, you may need to upgrade the firmware in your processor or communications module (MC-x). You can tell what firmware is currently loaded in the processor from the 'Firmware Version' field of the RTU Status window. The firmware version of an MC module can be determined from the hardware ovenview (View, Hardware Overview) by clicking the button next to the MC module.

CPU Firmware can be downloaded locally by plugging into port 1. This is the top port on the CPU module (PC-1, CP-x and LP-1). CPU Firmware may also be downloaded remotely over the RTU communications network.

Caution! An RTU will be cold started after downloading firmware. After a cold start, an RTU will remember the configuration settings for the first 4 ports ( 8 ports for a PC-1/CP-1) but it is possible that you will not be able to communicate with the RTU after a remote download.

MC firmware may only be updated locally by plugging into port 1 (the top port) of the MC module.

The various firmware files that may be downloaded are listed below.

| Module | Firmware Name <br> (where $\mathbf{x}$ = version) | Example |
| :--- | :--- | :--- |
| SBX-2, PC-1, CP-1 | Vxxxx.HEX | V139E.HEX |
| CP-10/11, CP-21 | Vxxxx.H32 | V140E.H32 |
| LP-1 | LP1Fxxxx.BIN | LP1F141D.BIN |
| MC-1 | MC1_Cxx.HEX | MC1_C30.HEX |
| MC-10/11 | MC10Cxxx.H32 | MC10C141.H32 |

When choosing to download firmware you will be prompted by the window shown below. By selecting a non-zero RTU address, you can download firmware over the RTU communications network.


Figure 8.12a: Window Displayed When Ready To Download Firmware
Once you have specified an RTU address, Toolbox will first check if it can communicate with the RTU and then will allow you to select a firmware file for downloading. While downloading firmware locally, the RX LED on Port 1 will stay on. After a processor download is complete, the RTU is ready to be reconfigured.

## Utilities - Download Firmware Driver

Drivers can be downloaded into flash memory (non-volatile) or SRAM (battery backed). Drivers in SRAM are cleared after a cold-start while drivers in flash memory are preserved after a coldstart. Drivers can be downloaded locally (by plugging into the RTU) or remotely (over the RTU communications network).

Caution! An RTU will be cold started after downloading a driver to flash memory (does not cold start after downloading to SRAM). After a cold start, an RTU will remember the configuration settings for the first 4 ports ( 8 ports for a PC-1/CP-1) but it is possible that you will not be able to communicate with the RTU after a remote download.

- Downloading new firmware clears all drivers in flash memory and SRAM and therefore new firmware should be downloaded before downloading any drivers. Please ensure the RTU is running the minimum required firmware and that you have the latest version of the driver ready for downloading by checking the driver listing in 'protocols.pdf' (available from the RTUnet website www.rtunet.com ).
- It is recommended that drivers are downloaded into flash memory if space is available. Available driver memory:

| CPU Type | Flash Memory (kB) | SRAM (kB) |
| :--- | :---: | :--- |
| PC-1 | 28 | Configurable |
| CP-1 | 32 | Configurable |
| CP-10/11 | 64 | Configurable |
| CP-21* | N/A | N/A |
| LP-1 | 0 | Configurable |

* All CP-21 drivers are included in firmware and are not downloaded separately.
- Before downloading drivers into SRAM (if required), memory space must be allocated in the RTU configuration (please see the topic Configuration - Memory, Firmware Drivers) and the RTU configuration downloaded into the RTU. If you also want to load drivers into flash memory, these should be downloaded before downloading the RTU configuration as the RTU is cold-started after downloading each driver to flash memory.
- After selecting Utilities, Advanced, Download Firmware Driver, Toolbox will attempt to communicate with the RTU to determine its CPU type. If communications are successful, you can then select the firmware driver to download (PC-1/CP-1 drivers use the file extension DRV, CP-10/11 drivers use the file extension D32 and LP-1 drivers use the file extension DHI).
- The first driver is downloaded (into flash memory or SRAM) using an address offset of 0 kB . The second driver is downloaded after the first driver by using an address offset greater than or equal to the total size of the previous drivers (memory space can be left between drivers). An example of downloading 3 drivers into a CP-10/11 is detailed below. Note: when downloading drivers into a PC-1 / CP-1, the maximum address offset that can be used is 15 K and so the largest driver can be downloaded last.

| Driver Name | File Size (kB) | Offset (kB) |
| :--- | :---: | :---: |
| TXUPDATE.D32 | 6 | 0 |
| PAGING11.D32 | 12 | 6 |
| MODBUS03.D32 | 10 | 18 |

Note 1: The DRIVERS.VER file is used by Toolbox to ensure the RTU has the minimum required firmware before allowing a driver to be downloaded. Please ensure you have the latest DRIVERS.VER file located in your Toolbox program files folder when downloading firmware drivers. The latest versions of DRIVERS.VER and standard firmware drivers (eg. Paging, Series I, TX Update, RX Update and Modbus) are all available from the RTUnet web site:
www.rtunet.com ).
Note 2: The CP-1 redundancy driver is downloaded into a reserved area of flash memory and does not use any of the flash memory allocated for standard drivers.

Note 3: Each redundancy driver is designed to work with the corresponding firmware version. Eg. The redundancy driver 'red_139e.drv' is used with firmware version 1.39e.

## Utilities - Upload Configuration

This option will upload all the SDB configuration file settings from the RTU (except for the site description and TMR directory as these are not stored in the RTU). Ladder Logic can also be uploaded from the RTU if the ladder edit file (FILENAME.LL) was stored in the RTU. The uploaded SDB information can be saved as a configuration file by selecting Site, Save. You will then be prompted for a filename.

Note: ladder logic is stored in the RTU by checking the 'Store ladder logic source files in RTU' box in Configuration, Memory and then downloading the RTU Configuration. Ladder logic can then be uploaded from the RTU by using Logic, Advanced, Upload .LL File from RTU. The logic menu is available when the SDB window is active (displayed in front).

## Utilities - Cold Start

A cold start clears all the RAM (including the local, hardware and network registers) and sets all the IO modules to the default state. A cold start is recommended before downloading a new configuration into a local RTU.

Caution! It is recommended that you do not cold start an RTU over the network. After a cold start, an RTU will remember the configuration settings for the first 4 ports (8 ports for a PC$1 / C P-1$ ) but it is possible that you will not be able to communicate with the RTU afterwards.

## Utilities - Swap Master

When using redundant CPUs, this command will swap the duty CPU and the standby CPU. For more information, please see the appendix - Redundancy.

## Utilities - PC System ID

This option is no longer available in Toolbox 1.44d or newer! When communicating with RTUs using Toolbox, the PC is treated like another RTU. The local RTU will only respond if the PC has the same system ID. By default, AE Hex is used.

## Utilities - Read/Write System Reg

Advanced use.

## Utilities - Upload Memory

Advanced use. Reads data from an RTU memory location and writes it to two files <filename>.BIN and <filename>.TXT. The two files are stored in the Toolbox program folder. <filename> should be specified without a path or extension. Eg. MEMORY1 not C:IMEMORY1.TXT.

## APPENDIX A PRINTING LADDER LOGIC

## Printing Ladder Logic Using A Text Editor

Ladder logic can be printed to a text-only file by first displaying ladder logic in Toolbox using text characters (the display mode can be toggled between line draw characters and text characters using the menu File, Select LineDraw/Text Chars). Once the ladder is displayed as text characters, select File, Print To File. FILENAME.PRN will then be a file containing standard text characters and can be opened and printed using a basic text editor (eg. WRITE, WORDPAD).

## Printing Ladder Logic Using Microsoft Office

A macro has been created for Microsoft Word that automatically converts and formats a ladder PRN file ready for printing. The document containing the macro is available from the RTUnet website (www.rtunet.com/support).

- Using Toolbox, open the ladder logic you want to print. Select File, Print To Text File. Filename.PRN will then be created.
- Check that macros are enabled in Word by selecting Tools, Macro, Security. 'Medium' or 'Low' should be selected.
- Open the document 'PrintingLadderLogic.DOC' using Word.
- Insert the Filename.PRN file into the document by selecting Insert, File... If asked 'Select the Encoding that makes your document readable', select 'Windows (default)'.
- Run the ladder conversion macro included with the document by selecting Tools, Macro, Macros. Double-click 'ConvertLadderSymbols'.
- Ladder is now ready to print (File, Print).


## APPENDIX B RTU SECURITY

Access to RTU communication ports by Toolbox software and by the Modbus protocol can be restricted by loading the Security driver in the RTU and configuring each port with a security level. Communications between RTUs using any protocol (except Modbus) are not affected by the security system.

A number of different security levels can be configured for each port as follows:

| RTU Port <br> Security <br> Level | Read <br> Access | Write Access | Notes |
| :---: | :--- | :--- | :--- |
| 0 | Everything | Everything | Highest access level. Only <br> this level can be used to <br> download a configuration. |
| 1 | Everything | Everything except <br> System Registers <br> and Ladder Logic | System Registers include all <br> configuration parameters. |
| 2 | Everything | \#R1 to \#R512 only |  |
| 3 | Everything | Nothing |  |
| 4 | \#R1 to <br> \#R512 only | Nothing | Nothing |
| 5 | Nothing | RTU can only be accessed <br> by first unlocking the port <br> using Toolbox. |  |

Each RTU Communication Port has a default security level of 0 (full access). Other security levels may be configured from Configuration, Port List. By configuring all RTU ports in a network with security levels of 3,4 or 5 , the network is then secure against unauthorised reconfiguration and can only be reconfigured by an authorised Toolbox user after unlocking the RTU comms port as detailed in the next section. If the security driver is not loaded, all ports default to full access (level 0).

## Toolbox Security Levels

If security has been enabled, when Toolbox is started you will be asked for a username and password as shown below.


Each username has a configurable security level (0-5). The default Usernames and Passwords supplied with Toolbox are shown below.

| Username | Password | Security <br> Level | Toolbox Functionality <br> and Menu Options |
| :---: | :---: | :---: | :--- |
| action0 | action0 | 0 | Full access |
| action1 | action1 | 1 | Full access except <br> downloading an RTU <br> configuration |
| action2 | Action2 | 2 | Can view configuration but <br> cannot make any changes |
| action3 | Action3 | 3 | Same as level 2 |
| action4 | Action4 | 4 | Cannot view or change the <br> RTU configuration |

Usernames and passwords can be added or changed by running the Kingfisher Security program.

## Configuring RTU Security

- First ensure that the Security driver is supported by the type of RTU you are using and that the latest firmware is loaded in the RTU (as detailed in protocols.pdf available from www.rtunet.com ).
- Run the Kingfisher Security program provided with Toolbox. When asked to 'Enter Access Code' enter actionuser. Click the plus (+) button and add the username admin and a password (eg. admin). Note: the admin password will then become the new Kingfisher security Access Code. Once the admin username is added, the security system is now enabled.
- Whenever passwords, usernames or security levels are changed, it is necessary to redownload the security driver into each RTU. Note: the security driver must not be read-only otherwise the security list cannot be changed. The security driver properties can be viewed and changed by right clicking on the driver using Windows Explorer, selecting 'Properties' and then unchecking the read-only box. A custom Username (up to 16 characters), Password (case-sensitive, up to 16 characters) and Security Level (0-5) can be defined for each user by running the Kingfisher Security program.
- Download the security driver into the RTU. Note: the passwords configured using the Kingfisher Security program are embedded into the security driver when it is downloaded. The RTU uses these embedded passwords to ensure that security messages are valid. For a CP-21, the security driver will need to be downloaded into SRAM after downloading the RTU configuration (with at least 6K of memory allocated for firmware drivers) in the next step below.
- Setup port security by configuring the Port List in the RTU configuration file. Set 'Port Security' for each port from Configuration, Port List. Once you have configured port security, download the configuration into the RTU.
- A secured RTU port can then be accessed by using the menu Utilities, Unlock RTU Port. This command changes the security level of the RTU port to equal the security level of Toolbox (provided the Toolbox security level offers greater access). After two minutes of comms inactivity, the RTU will automatically switch the port back to its configured security level.


## Recovering A Secured RTU

For the highest level of security, the security driver can be loaded in flash memory (as usual). However, if the passwords are lost and the port security level is 2 or higher, it will not be possible to reconfigure the RTU and it may not be possible to communicate with the RTU (if the security level is 5). The RTU can be recovered if passwords are lost by downloading firmware locally into port 1 of the CPU. Alternatively, the security driver can be loaded in SRAM (the recommended method). There are two reasons for this:

- If the user database is updated and the security driver is re-downloaded into SRAM, the RTU will keep its configuration. When the driver is downloaded into flash memory, the RTU is cold started and loses its configuration.
- If passwords are lost, it is possible to recover the system by removing the CPU battery link and clearing the SRAM. This will erase the driver and allow full access to the RTU. If the driver is loaded into flash memory, it will not be erased by removing the battery link and the RTU will remain password protected.


## Security Audit Trail

Whenever an RTU receives a command to unlock one of its ports, an event log is generated (if the RTU has memory configured for event logs) called 'System Log'. The 'usertype' of the event log is set to the index number of the user who unlocked the port. The index number is the number, or order, of the user in the user database (as displayed by the Kingfisher Security program or the 'users.dbf' file). A value of 0 indicates the first user in the list, 1 indicates the second user etc.

## APPENDIX C HEXADECIMAL NUMBERS

Hexadecimal is a numbering scheme similar to decimal but instead of counting from 0 to 9 , hexadecimal counts from 0 to 15 . The hexadecimal, decimal and binary equivalents are shown below.

| Hex | Decimal | Binary |
| :---: | :---: | :---: |
| 0 | 0 | 0000 |
| 1 | 1 | 0001 |
| 2 | 2 | 0010 |
| 3 | 3 | 0011 |
| 4 | 4 | 0100 |
| 5 | 5 | 0101 |
| 6 | 6 | 0110 |
| 7 | 7 | 0111 |


| Hex | Decimal | Binary |
| :---: | :---: | :---: |
| 8 | 8 | 1000 |
| 9 | 9 | 1001 |
| A | 10 | 1010 |
| B | 11 | 1011 |
| C | 12 | 1100 |
| D | 13 | 1101 |
| E | 14 | 1110 |
| F | 15 | 1111 |

In Kingfisher RTUs, the mask value is a 4 digit hexadecimal value corresponding to channels 1 to 16. The mask used to enable one channel (or bit) only is as follows:

| Ch1 | 0001 Hex | Ch9 0100 Hex |
| :--- | :--- | :--- |
| Ch2 | 0002 Hex | Ch10 0200 Hex |
| Ch3 | 0004 Hex | Ch11 0400 Hex |
| Ch4 | 0008 Hex | Ch12 0800 Hex |
| Ch5 | 0010 Hex | Ch13 1000 Hex |
| Ch6 | 0020 Hex | Ch14 2000 Hex |
| Ch7 | 0040 Hex | Ch15 4000 Hex |
| Ch8 | 0080 Hex | Ch16 8000 Hex |

To enable more than one channel at a time, the mask value must have each of the required channels set ON.

Examples:

| To Enable <br> Channels | Use Hex <br> Number | Binary Equivalent |
| :---: | :---: | :--- |
| $1,2,3$ | 0007 | 0000000000000111 |
| 1,16 | 8001 | 1000000000000001 |
| $1,7,8,13$ | 10 C 1 | 0001000011000001 |

Hexadecimal numbers are specified in Kingfisher RTUs using the format $16 \# x x x x$ where $x x x x$ is the hexadecimal number and can be 1 to 4 digits long.

## APPENDIX D REDUNDANCY

Redundancy allows an RTU to cope with equipment failures and continue operating normally. The RTU shown below has redundant power supplies, CPUs and communications. The setup of these components is detailed in the following sections. Another way of coping with equipment failures is to have two separate RTUs as detailed in the topic Redundant RTUs.


Figure D.1a: RTU with redundant power supplies, CPUs and communications

## D. 1 Redundant CPUs

An RTU can have two redundant CP-10/11 modules with one CPU in duty mode and one CPU in standby mode. If the duty CPU fails or is removed, the standby CPU takes over full control of the RTU. Note: redundancy is no longer supported by CP-1 or CP-21 firmware.

A system with redundant CPUs must always have one CPU in an odd slot address and one CPU in an even slot address (note: the CPUs do not have to be physically next to each other on the backplane). When the system starts up, the CPU in the even slot will become the duty and the CPU in the odd slot will become the standby (indicated by the L2 LED flashing).

The duty CPU does all the same things as a single CPU system and also scans the standby CPU to check if it is still in standby mode and then updates the standby CPU's registers with its own values.

## Updating The Standby CPU

- Digital and analog hardware registers are updated whenever a value is written to a digital or analog output module.
- Network data is updated whenever a new data message is received by the duty CPU.
- Local registers and event logs are updated every couple of seconds.
- The real time clock is synchronized every hour and whenever the duty clock is written to.
- Network data, timer registers, system registers, inactivity parameters, network configuration variables and most port configuration variables are checked a couple of times per minute and any differences are updated.
- Ladder logic, telephone numbers, ethernet parameters (eg. IP address), PSTN parameters, paging parameters and TMR parameters are not updated.


## Automatic Changeover

A standby CPU will turn into a duty CPU if:

- The standby CPU cannot hear any communications on the I/O bus and the communications bus for approximately 5 seconds.
- The duty CPU detects inactivity on a port greater than the configured time period (as detailed in Configuration - Inactivity Monitors) and forces a changeover.
- The duty CPU loses communications on the communications bus or the IO bus and forces a changeover.
- The value of the system register \#YEXCEP is set to $16 \# 800$ from ladder logic.
- A Utilities, Advanced, Swap Master command is issued from Toolbox to either the duty or to the standby CPU. Note: if the CPU that requests the swap gets no response from the other CPU, no action is taken as it is assumed there is no other CPU present.
- Ladder logic is disabled while downloading firmware drivers or after a cold start or firmware download. Note: the CPUs will not swap over if ladder is manually disabled using the Toolbox command Utilities, Advanced, Enable/Disable, Disable Logic Processing.
- A warm start command (Utilities, Warm Start RTU) is issued to either CPU when the standby CPU is in duty mode. This causes both CPUs to start up in their default state (the CPU in the even slot will become the duty).


## Replacing CPUs

CPUs can be replaced after powering down the RTU or while the RTU is still running (not recommended). When a CPU is replaced, the RTU will automatically warm start itself.

- The standby CPU (installed in an odd slot address) can be replaced at any time without losing new data if it is running in standby mode (L2 LED is flashing).
- The duty CPU (installed in an even slot address) can be replaced at any time but any new data that is received by the standby CPU (now running in duty mode) will be over written. To avoid losing the new data, the replacement duty CPU can be forced to start up in standby mode, allowing the standby CPU to copy the new data to the replacement duty CPU. To force a CPU to start up in standby mode, set the system register 2471 Hex to 1 (using the menu Utilities, Advanced, Read/Write System Reg). This will cause a one-shot start up in standby mode and then the system register 2471 will be automatically cleared. After waiting about 5 minutes to ensure all the data has been updated in the replacement duty CPU, the CPUs can be swapped over (if desired) using the command - Utilities, Advanced, Swap Master.


## Configuring Redundant CPUs

- Redundant CPUs are configured one at a time by plugging one CPU into the backplane and then downloading firmware (optional), drivers (optional) and the RTU configuration. After removing the first CPU, the second CPU is plugged into the backplane and the same software is downloaded again. Note: please specify slot 0 when configuring all CPU ports to avoid confusion. Different ladder logic can be loaded in the duty and standby CPUs if required.
- If ethernet communications are being used, different IP addresses can be used for the ethernet port of the duty CPU and the ethernet port of the standby CPU. If the same IP address is used for both CPUs, only the duty mode CPU keeps its ethernet port active. Both CPUs can keep their ethernet ports active if they are configured with different IP addresses and \#YMODE. 4 is set to 1 using ladder logic in the standby CPU. This will allow both CPUs to be polled while connected to the same LAN or a second (redundant) LAN can be used for the standby CPU.
- Install one configured CPU in an even slot address and the other configured CPU in an odd slot address. The even slot CPU will become the duty and the odd slot CPU will become the standby.
- To force a changeover between the redundant CPUs or monitor the changeover status using ladder logic, please see the system register \#YEXCEP.
- Prior to 1.41a firmware, a redundancy driver (that matched the firmware version) needed to be downloaded into each CPU before downloading the RTU configuration.


## Example

The example below shows how to changeover the CPUs if the duty CPU's real-time clock fails. The ladder logic is also used to display the state of the duty CPU (\#R100.8) and the standby CPU (\#R100.9).


Figure D.1a: Redundant CPUs ladder logic

## D. 2 Redundant Power Supplies

Two PS-xx power supplies can be plugged into a backplane and both will run normally, sharing the power load. If one power supply is removed or fails, the other power supply will supply the complete power load. Ladder logic is not required when using two of these power supplies on the one backplane.

## D. 3 Redundant Communications

It is possible to change the port and/or communications path used to communicate with a remote RTU if there is a communications fail.

The first example below shows how to automatically change which RTU port is used. The second example shows how to automatically change which network path is used.

For both examples the following will happen,

- The RTU initially uses the primary link and if there is a communications failure it switches to the secondary link.
- While using the primary link, the secondary link is tested every 10 minutes.
- When using the secondary link, the primary link is tested every 10 minutes or immediately after the secondary link fails.
- If the primary link is still bad, the network link reverts back to the secondary link.
- If both links fail, the RTU will alternate between the two links every 10 minutes.
\#R20.1 is used to show comms fail for the primary link and \#R20.2 is used to show comms fail for the secondary link. The comms status for each link is only updated after a message has been sent via that link.

Note: to force a CP-10/11 to close its existing ethernet socket and use the new network link settings, please see the Network Link register \#YLSTrrr.11.

## Port Redundancy - Changing The RTU Communications Port

The example below shows how to use CP-xx port 2 as the primary port and MC-11 port 2 (RTU port 5) as the secondary port. The network list is initially configured with a direct network link to RTU7 via port 2.


## Network Link Redundancy - Changing The Comms Path

The example below shows how to swap between a direct comms link to RTU7 (primary) to an indirect comms link via RTU10 (secondary). The network list is initially configured with a direct network link to RTU7 via port 2. Note: to prevent RTU7 "overhearing" indirect messages sent to RTU10, RTU10 should have a different System ID eg. AF Hex.


## D. 4 Redundant RTUs

It is useful to have a primary and a secondary RTU for a number of reasons:

- All the telemetry system data can be viewed from either RTU
- If the primary RTU fails, the secondary RTU can take control of the system (optional)
- Using completely separate RTUs maximises electrical and physical isolation


Field RTUs
A primary master RTU and a secondary master RTU are configured like any other RTUs with unique addresses. The primary RTU polls the outstations and acknowledges exception reports while the secondary RTU simply listens to all the messages from the outstations and updates its own network data. This prevents both master RTUs acknowledging the same message.

Both RTUs need to know the address of the other master RTU (configured in ladder using \#Y2NDRTU). Each master RTU is then configured to be in either listen or control mode (configured in ladder using \#Y2NDSTAT). When in listen mode, the secondary master RTU updates its network data when it hears new data from an outstation RTU but does not acknowledge or initiate messages. When in control mode, the secondary master RTU acts the same way as the primary master RTU.

There are various ways to configure primary and secondary RTUs with varying complexity. Two different ways are shown below.

## Transferring Data Between Two RTUs

To transfer all the data from one RTU to another (including event logs) over a dedicated comms link (eg. modem or ethernet), the first RTU can use a TX Images block to transfer all its network data, and a TX Update Event Logs block to transfer all its event logs if required. A primary / secondary setup is not required in this instance. The main disadvantage with this arrangement is that data will not be received simultaneously by both RTUs as the second RTU is not able to 'overhear' messages to the first RTU and must wait for the new data to be relayed on. However, data can be updated in the second RTU relatively fast if the first RTU monitors when its network data has changed (using \#YLUPDC) and then initiates a TX Images message to the second RTU. New event logs can also be relayed quickly by monitoring when the event log pointer changes (YLOGIDX) and then initiating a TX Update Event Logs message.

## Secondary RTU Always Listens

For this example, the Primary RTU has polling ladder logic while the secondary RTU behaves like an outstation RTU and does not have polling ladder logic.

The example below shows the primary RTU always in control mode and the secondary RTU always in listen mode. This method prevents any clashing of the master RTUs caused when both RTUs think they are in control but does not allow the secondary RTU to take control if the primary RTU fails. If the secondary RTU does not hear from the primary RTU for 35 minutes
(waits for a bit longer than 2 polls), the secondary RTU flags a primary RTU comms fail but does not take control. The example includes polling for 2 outstation RTUs and includes a periodic check of the secondary RTU (using the TX IMAGES block) to ensure it has the latest data. The TX IMAGES block checks that the secondary RTU has the same data for RTUs 3 and 4.

When using SCADA software at the primary and secondary RTUs, primary RTU data, setpoints and communication registers need to be transferred by the primary RTU to the secondary RTU in order to view this data at the secondary RTU.


Figure D.4a: Primary RTU Always In Control Mode


Figure D.4b: Secondary RTU Always In Listen Mode

## Secondary RTU Takes Control

For this example, the master RTUs use the same ladder logic and are identical except for their RTU address. Edits only need to be made to the primary RTU's ladder logic and then a copy of the ladder logic is used for the secondary RTU.

Primary RTU1 starts up in primary listen mode and then sends a message to secondary RTU2 to make sure it is in secondary listen mode (when RTU2 receives any message from RTU1 it changes to secondary listen mode). If the message is not successful, the primary RTU will keep trying to send a message every minute to secondary RTU2. If the message is successful or a 'Force Control' command is received, primary RTU1 changes to primary control mode and begins polling RTU3 and RTU4 every 15 minutes. Secondary RTU2 starts up in Secondary Listen mode and if it has not heard from primary RTU1 for 35 minutes (waits a bit longer than 2 polls), it changes to Secondary Control and begins responding to any messages for primary RTU1 and carrying out polling. When secondary RTU2 is in control mode, it checks if RTU1 is OK at the start of each system poll. If this message is successful, secondary RTU2 immediately reverts to secondary listen mode and will not carry out the system poll.

## SCADA Software

The same SCADA software configuration can be used with both the primary and secondary RTUs. The RTU will respond with either its own local data or its network data depending on what RTU address is requested by the SCADA software.

Data common to both masters is read from the primary RTU address (eg. 1). This could include comms success and fail counters for each outstation RTU (stored in local registers in RTU1). When the primary master is active, it updates these counters after any comms successes or fails and then sends these counter values to the secondary master (RTU2). While the secondary master is in listen mode, it overwrites its own comms counters (also stored in local registers) with the network data from RTU1.

If the primary master fails and the secondary master becomes active, the secondary master begins managing its own comms counters. These counters already contain the values last received from RTU1. While the secondary master RTU2 is active, it copies the new value of its own comms counters over the old comms counters stored in network registers for RTU1. This allows the secondary master SCADA software to display the correct value for the comms counters at all times.

Note: some SCADA software drivers (eg. Modbus) allow data to be read from RTU address 0. All RTUs will respond to this address which simplifies some of the data management.


Figure D.4c: Managing Common Registers In The Primary And Secondary RTUs


Figure D.4d: Primary/Secondary RTU Ladder Logic - PART A


Figure D.4d: Primary/Secondary RTU Ladder Logic - PART B

## APPENDIX E VERSION CONTROL

Whenever ladder is compiled, Toolbox keeps a check of which functions are used and which versions of firmware are required in order for the ladder logic to run correctly.

After compilation, Toolbox has a record of the oldest and newest firmware versions on which the ladder will run and also has a record of any special firmware drivers that are required. All of this information is then embedded in the header of the compiled ladder file (FILENAME.LLO).

When ladder logic is downloaded into an RTU, Toolbox first requests the RTU Status. The RTU Status provides the firmware version and a list of the firmware drivers that are loaded. Toolbox then checks this against the information stored in the compiled ladder header and if any incompatibilities are found, Toolbox reports the error and prevents the code from being downloaded.

## Target Firmware Version

By default, ladder logic will always be compiled to run on the latest (most recent) firmware version. However, some functions in older versions of firmware are incompatible with newer firmware and therefore some ladder compiled for the latest firmware will not run on older firmware. With this menu option it is possible to compile the ladder logic to run on older versions of firmware.

Options currently are:
Version 1.30a or later
Version 1.28a to V1.29f
Version 1.21e to 1.27b
Version 1.21 d or before

## Changes made in firmware 1.30a

Event logging format was changed. Event log comments are no longer stored. New event logging ladder logic blocks were added.

## Changes made in firmware 1.28a

Floating point functions were implemented. The square root function was added (note: the square root function available in previous versions allowed only integer parameters and is incompatible with the new function). An Error handler was implemented for maths exceptions. Previously, it was necessary to compile special code for the Divide and Multiply/Divide functions to ensure that divide-by-zero never happened. A new method of writing to Network Registers was implemented. The number of PID blocks allowed was reduced from 64 to 32 . The number of Timer Registers available was increased from 16 to 64.

## Changes made in firmware 1.21e

The parameter passing structure (used by the firmware to execute ladder logic) was changed in this version requiring a number of the functions to be compiled differently from older firmware (prior to version 1.21e).

## Latest Versions

Text files detailing the features added to each version of Toolbox and firmware are available from the RTUnet web site.

## APPENDIX F IEC COMPLIANT REGISTER NAMES

## IEC Register Naming Conventions

The IEC-61131.3 standard specifies register names in the following format:
\% (type) (size) (address)
type: I = input, Q = output, M = memory
size: $X=$ bit, $B=$ byte ( 8 bit), $W=$ word (16 bit), $D=$ double word (32 bit), $L=$ long word ( 64 bit) address: can be any number of fields, separated by periods (.)

Only Input, Output, and Memory types are allowed in the naming convention. There is no facility for differentiating between Network Registers or System Registers, or any explicit way of differentiating between Analogs and Digitals (other than by size). For greater flexibility an extra address field is used to distinguish between the different Memory register types, and to give them unique IEC 61131.3 compatible names.

## IEC Kingfisher Registers

The table below shows the corresponding IEC-compliant name for all register types. For example, \#R13 corresponds to \%MW13; \#DO3.16 corresponds to \%QX3.16, etc. ('ch' denotes channel number).

| Kingfisher Name | IEC-1131.3 Name | Description |
| :---: | :---: | :---: |
| \#Al(module).(ch) | \%IW(module).(ch) | Analog Input (16 bit) |
| \#AO(module).(ch) | \%QW(module).(ch) | Analog Output |
| \#DI(module).(ch) | \%IX(module).(ch) | Digital Input (1 bit) |
| \#DO(module).(ch) | \%QX(module).(ch) | Digital Output |
| \#DI(module) | \%IW(module) | Digital Input (as 16 bit word) |
| \#DO(module) | \%QW(module) | Digital Output (as 16 bit word) |
| \#R(number) | \%MW1.(number) | Local Register |
| \#R(number).(ch) | \%MX1.(number).(ch) | Local Register Bit |
| \#NR(rtu).(number) | \%MW2.(rtu).(number) | Network Register |
| \#NR(rtu).(number).(ch) | \%MX2.(rtu). (number).(ch) | Network Register Bit |
| \#NA(rtu).(module).(ch) | \%MW3.(rtu).(module).(ch) | Network Analog |
| \#ND(rtu).(module).(ch) | \%MX4.(rtu).(module).(ch) | Network Digital |
| \#ND(rtu).(module) | \%MW4.(rtu).(module) | Network Digital (as 16 bit word) |
|  |  |  |
| \#T(number) | \%MW5.(number) | Timer Register |
| \#Y(sys reg type) | \%MW6.(sys reg \#) | System Register (Note 1) |
| \#Y(sys reg type).(ch) | \%MX6.( sys reg \#).(ch) | System Register Bit (Note 1) |
| \#YMTYPE(module) | \%MW7.(module). 1 | System Register : Module Type |
| \#YMVER(module) | \%MW7.(module). 2 | System Register : Module Version |
|  |  |  |
| \#YP(type)(port \#) | \%MW8.(port \#).(type \#) | Port Register (Note 2) |
| \#YP(type)(port \#).(ch) | \%MW8.(port \#).(type \#).(ch) | Port Register Bit (Note 2) |
| \#YL(type)(link \#) | \%MW9.(link \#).(type \#) | Network Link Register (Note 3) |
| \#YL(type)(link \#).(ch) | \%MW9.(link \#).(type \#).(ch) | Network Link Reg. Bit (Note 3) |
| \#Y(type) | \%MW10.(type \#) | Time/date Register (Note 4) |
| \#YTICK.(type) | \%MW10.8.(type \#) | Timer Tick Bit (Note 5) |


| Note | 1 : System Register Numbers | Note | 3 : Network Link Register Numbers |
| :---: | :---: | :---: | :---: |
| 1 : | \#YADDRESS | 1 : | \#YLDIR |
| 2 : | \#YPRIORITY | 2 : | \#YLVIA |
| 3 : | \#YRETRIES | 3 : | \#YLTOUT |
| 4: | \#YTIMEOUT | 4: | \#YLST |
| 5 : | \#YQUIET | $5:$ | \#YLFC |
| 6 : | \#YSYSID | 6 : | \#YLFAIL |
| 7: | \#YSTAT | 7: | \#YLSUCC |
| 8 : | \#YDIAG | 8 : | \#YLSID |
| 9: | \#YFIRMW | 11: | \#YLUPDC |
| 10: | \#YIMPL | 13: | \#YLLOGIDX |
| 11: | \#YEXCEP |  |  |
| 27: | \#YFLAGS | Note | 4 : Time/date Registers |
| 31: | \#Y2NDRTU | 1 : | \#YSEC |
| 32. | \#Y2NDSTAT | 2 : | \#YMIN |
| 34: | \#YRELAYRTU | 3 : | \#YHOUR |
| 36: | \#YMATHSTAT | 4: | \#YDAY |
| 38: | \#YPDTIME | $5:$ | \#YMONTH |
| 39: | \#YPDSTAT | 6 : | \#YYEAR |
| 40: | \#YPAGERS | 7: | \#YWEEKDAY |
| 41: | \#YLOGIDX | 8 : | \#YTICK |
| 56: | \#YMODE |  |  |
| Note | 2 : Port Register Numbers | Note | 5 : Timer Tick Numbers |
| 1 : | \#YPMOD | 1: | 100TH |
| 2 : | \#YPADDR | 2 : | TENTH |
| 3 : | \#YPTYP | 3 : | SEC |
| 4: | \#YPSP | 4: | 10SEC |
| 5 : | \#YPPRE | 5: | MIN |
| 6 : | \#YPPOS | 6 : | 10MIN |
| 7: | \#YPINAC | 7: | HOUR |
| 8: | \#YPPCOL | 8 : | DAY |
| 22: | \#YPST |  |  |

## APPENDIX G COMBINING SERIES I AND SERIES II RTUS

## Using Series I Communications With A Series II RTU

A Series 2 RTU will respond to Series 1 messages when the port is configured with the S1 option (please see the topic Configuration - Port List, Protocol) and the RTU has the Series 1 driver loaded. A Series II RTU will also relay Series 1 messages if the port which the message enters the RTU on is configured as a Series 1 controller ('S1 Ctrl'). To relay a message from a serial port out of a radio port (eg. to relay an output message from Citect), only the serial port needs to be configured as 'S1 Ctrl'. The radio port can be configured as 'S1 Outstn'.

## Communicating With Series I And Series II RTUs

KIM software is used to configure and communicate with Series 1 RTUs. Since a Series 2 RTU is able to relay Series 1 messages, KIM can be used to talk through a Series 2 master to Series 1 outstations. It is then possible to carry out the complete range of commands and functions (as if KIM was communicating through a Series 1 master) including downloading a KIM configuration to the outstation RTU.

A Series 2 RTU itself will only respond to KIM's RTU Status command. The KIM RTU Status for a Series 2 RTU only contains the RTU's current time and date with all other fields blank (you can tell the responding RTU is a Series II RTU as the battery voltage is zero). A Series 2 RTU will not respond to any other KIM commands such as Get Single or Upload All so in order to read or write data to a Series 2 RTU, Toolbox must be used.

Series 1 RTUs are unable to relay Series 2 messages and so in order to use Toolbox to talk to a Series 2 outstation, the master RTU must be Series 2 or the PC must be directly connected to the Series 2 outstation.

## Converting A Series I Configuration To Series II

Ladder Logic
Series I ladder logic can be converted to Series II format by loading and saving it with the Toolbox DOS Ladder editor (please contact RTUnet for details). Since Series I only uses 8 digital channels which are stored in the top 8 channels of the 16 channel ID, Toolbox increments all Series I ladder channels by 8 . This means that Series I digital channels 1 to 8 are converted to Series II digital channels 9 to 16 as this keeps the digital data in the top 8 channels. Note: when creating new Series II ladder that is to be used to send digital data to Series I RTUs, digital channels 9 to 16 should only be used as Series I is unable to access digital data in the lower 8 channels.

## Analog Inputs

Series I RTUs store analog inputs as a number in the range of 0 to 10,000 while Series II store analog inputs as a number in the range of 0 to 32,760 . When using a Series I analog input in a Series II RTU, care must be taken to clear the bad value flag which is set when the analog input is $<4 \mathrm{~mA}$ (Series I RTUs set Ch16 of the analog input value to ON if the analog input is bad). This must be done before the Series II ladder uses the value because Series II will treat the bad value as a large value of $32768(8000 \mathrm{H})$ instead of as a value of zero.

Digital Inputs
Series I RTUs store 8 digital inputs per ID (or register) and these are stored in the MSB of the ID (equivalent to Series II digital channels 9 to 16).

## Setting Modbus Outputs To A Series I RTU

A Series I RTU will accept Modbus slave messages on port 2 only (CPU3 'P2'). These Modbus messages can only be used to read and write to the RTU itself as a Series I RTU is unable to relay Modbus outputs to other RTUs. This functionality was designed for local operator interface panels that are directly connected to Series I RTUs.

In order to set Modbus outputs to a Series I outstation through a master RTU, the master RTU must be a Series II RTU. The Series II master is configured to relay outputs by configuring the port as 'S1 Ctrl, Mbus, S2' (please see the topic Configuration - Port List, Protocol). When relaying outputs to a Series I outstation (an RTU that has a system ID of 'AC' in the Network List), the Series II RTU automatically converts the output to the Series I protocol and then relays the output to the outstation. It is necessary to do this as the output usually goes to the radio port of the Series I RTU (CPU3 P1) which only communicates with the Series I protocol. When relaying digital outputs, the Series II RTU sends the digital output in the MSB and the digital mask in the LSB which allows individual channels in the one ID to be set ON or OFF.

When defining the Modbus output addresses for Series I, these are defined the same way as for Series II (please see the topic Driver - Modbus). It should be noted that a Series I RTU only has the equivalent of registers 1 to 240 (IDs 1 to 240) and only uses 8 digital channels per register. These 8 digital channels are stored in the MSB or the equivalent of Series II channels 9 to 16. Note: outputs to the lower 8 channels of a Series I register (ID) are ignored by the Series II master.

The Modbus output address ranges for Analog and Digital Outputs are shown below.

| Series I Analog <br> Outputs |  |
| :--- | :--- |
| ID | Address |
| 1 | 41,001 |
| 2 | 41,002 |
| 3 | 41,003 |
| 4 | 41,004 |
| 5 | 41,005 |
| 6 | 41,006 |
| 7 | 41,007 |
| 8 | 41,008 |
| 9 | 41,009 |
| 10 | 41,010 |
| 11 | 41,011 |
| 12 | 41,012 |
| 13 | 41,013 |
| 14 | 41,014 |
| 15 | 41,015 |
| 16 | 41,016 |
| .. |  |
| 240 | 41,240 |


| Series I Digital Outputs |  |  |
| :--- | :--- | :--- |
| ID | Channel | Address |
| 1 | $1-8$ | $02,009-02,016$ |
| 2 | $1-8$ | $02,025-02,032$ |
| 3 | $1-8$ | $02,041-02,048$ |
| 4 | $1-8$ | $02,057-02,064$ |
| 5 | $1-8$ | $02,073-02,080$ |
| 6 | $1-8$ | $02,089-02,096$ |
| 7 | $1-8$ | $02,105-02,112$ |
| 8 | $1-8$ | $02,121-02,128$ |
| 9 | $1-8$ | $02,137-02,144$ |
| 10 | $1-8$ | $02,153-02,160$ |
| 11 | $1-8$ | $02,169-02,176$ |
| 12 | $1-8$ | $02,185-02,192$ |
| 13 | $1-8$ | $02,201-02,208$ |
| 14 | $1-8$ | $02,217-02,224$ |
| 15 | $1-8$ | $02,233-02,240$ |
| 16 | $1-8$ | $02,249-02,256$ |
| .. |  | .. |
| 240 | $1-8$ | $05,833-05,840$ |

## Sending Series I Pager Messages

Series I pager messages operate the same way as used in Series I systems. The pager message type and target port defined in the Series I pager message are ignored. The settings defined in the Series II paging RTU are used instead. (this is the 'Target Site Address RTU' that is configured in the Series I pager message ID).

## APPENDIX H CALIBRATING RTU MODULES

## RT-1 Resistance Temperature Module

The RT-1 module is a resistance/temperature module designed to be used with up to four Pt100 resistance/temperature devices. These devices typically have a resistance of 100 ohms at 0 degrees Celsius but tend to vary slightly in resistance value. The RT-1 module caters for these variances and for the tolerances of its internal components by allowing the user to calibrate the module by setting two different resistance / temperature setpoints. The hardware overview for this module is shown below.


Figure H.1: Hardware Overview For The RT-1 Module
The RT-1 Module operates by scaling the resistance range of the Pt100 to the temperature range of -150 to $400^{\circ} \mathrm{C}$. Once the module is calibrated, it uses its complete $0-100 \%$ range ( $0-$ 32760 ) to represent the standard temperature range ( -150 to $400^{\circ} \mathrm{C}$ )

## Calibrating The RT-1 Module

Each channel of the RT-1 module can be calibrated by clicking on the channel calibration button in the hardware overview. When the channel button is clicked the window shown below is displayed.


Figure H.2: RT-1 Channel Calibration Window

## Calibration Method

- Click the Reset button. This will clear the calibration registers in the RT-1 module. If this operation is successful the message "Reset Successfully" will be displayed.
- Connect a resistance to the RT-1 corresponding to the resistance of the Pt100 at a known temperature.
- Click the 'Check Temp 1' button.
- Enter the temperature corresponding to this resistance (the allowable range is -150 to $400^{\circ} \mathrm{C}$ ).
- Connect a resistance to the RTU corresponding to the resistance of the Pt100 at a second known temperature.
- Click the 'Check Temp 2' button.
- Enter the temperature corresponding to this resistance ( -150 to $400^{\circ} \mathrm{C}$ )
- Click the 'Calibrate' button. If the setpoints are in range, they will be sent to the RT-1 module and then the message "Calibrate Data Sent Successfully!" will be displayed.


## RT-1 Scaling

Say the resistance of a Pt100 device at $-150^{\circ} \mathrm{C}$ is 40 Ohms and at $400^{\circ} \mathrm{C}$ is 250 Ohms . After resetting the RT-1 module, these two resistances might be displayed in Toolbox as $7 \%$ and $83 \%$ respectively. By entering $-150^{\circ} \mathrm{C}$ for Temp1 and $400^{\circ} \mathrm{C}$ for Temp2, and calibrating the RT-1 module, the $40-250$ Ohms resistance range would then be displayed as $0-100 \%$ in Toolbox.

When the 'Check Temp1' or 'Check Temp2' button is clicked, Toolbox records the current input percentage. These input percentages are then used with the temperature setpoints to determine an input/temperature characteristic. The figure below illustrates the input/temperature characteristic of a correctly calibrated module.


Figure H.3: Output from RT-1 Module After Calibration

## Out Of Range Calibration Setpoints

Sometimes the values entered for Temp1 and Temp2 and their corresponding input percentages will not allow the RT-1 module to display the complete -150 to $400^{\circ} \mathrm{C}$ temperature range. If this occurs the message "Value is out of range!" will be displayed.

For example, after resetting the RT-1 module, Toolbox displayed $100^{\circ} \mathrm{C}$ as $40 \%$ and $0^{\circ} \mathrm{C}$ as $10 \%$. This is illustrated below. In order to cover the complete -150 to $400^{\circ} \mathrm{C}$ range, the RT- 1 module would need to use the input range of -35 to $130 \%$ which it is unable to do as it is limited to 0-100\% (0-32760).


Figure H.4: RT-1 Calibration Setpoints That Are Out Of Range.
Any input/temperature setpoints that will allow the RT-1 module to display -150 to $400^{\circ} \mathrm{C}$ within $0-100 \%$ will be in range and will allow the RT- 1 module to be correctly calibrated. An example of acceptable setpoints are $100^{\circ} \mathrm{C}=30 \%$ and $0^{\circ} \mathrm{C}=20 \%$ and these are shown below.


Figure H.5: RT-1 Calibration Setpoints That Are In Range

## IO-4 Combination Analog/digital IO Module

The IO-4 module is a combination IO module with 2 analog inputs, 8 digital inputs and 2 digital outputs. The first analog input is designed to be used with a $4-20 \mathrm{~mA}$ (or $0-20 \mathrm{~mA}$ ) input or with a strain gauge $0-50 \mathrm{mV}$ input. When used for a strain gauge input, channel 1 can be calibrated to allow for the different strain gauge characteristics and tolerances of the IO-4's internal components.

There are two hardware versions of the IO-4 module - version 1.2 and version 1.3. The version number is marked on the top of the printed circuit board and is visible through the side of the case. A different Hardware Overview window appears in Toolbox for each version as detailed below.

Note: An IO-4 module is supplied with two 4-20mA analog input channels as standard. To use a strain gauge input on channel 1, the IO-4 must be ordered from RTUnet with this option.

## IO-4 Module V1.3

When the 'Calibrate Ch. O1' button is clicked in the IO-4 hardware overview (View, Hardware Overview), additional buttons and fields are displayed as shown below.


Figure H.6: IO-4 Channel 1 Calibration Window

## Calibration Method:

- Click the Reset Calibration button. This will clear the calibration registers in the IO-4 module. If this operation is successful, the message "Reset Successfully!" will be displayed.
- Click the 'Enable Calibrate' button. This tells the RTU that channel 1 is about to be calibrated.
- Apply the first voltage input to channel $1(0-50 \mathrm{mV})$.
- Enter the percentage corresponding to this voltage (in the box above the 'Accept Perc 1' button) and then click 'Accept Perc 1'.
- Apply the second voltage input to channel 1.
- Enter the percentage corresponding to this second voltage (in the box above the 'Accept Perc 2 ' button) and then click 'Accept Perc 2'.
- Click the 'Send Calibration' button. This will cause the setpoints to be sent to the IO-4 module and then the message "Calibrate Data Sent Successfully!" will be displayed.


## Example Calibration

The IO-4 is to be calibrated for a strain gauge input used to measure the water level in a tank. The tank has a depth of 5 m . Note: it is more accurate if the strain gauge is calibrated when the tank is full.

- Click the Reset Calibration button.
- Click the 'Enable Calibrate' button.
- For the first input, lift the strain gauge out of the water (this will probably produce a voltage of about 1 mV into the IO-4).
- Enter 0\% (corresponding to an empty tank) in the box above the 'Accept Perc 1' button and then click 'Accept Perc 1'.
- Put the strain gauge back into the water to a known depth of say $2 m$ (this may produce a voltage of say 11 mV into the IO-4. The actual voltage will depend on the calibration of the strain gauge). If the tank is full then put the strain gauge all the way into the tank.
- Enter $40 \%$ (corresponding to $40 \%$ of $5 \mathrm{~m}=2 \mathrm{~m}$ or enter $100 \%$ if the tank is full) in the box above the 'Accept Perc 2' button and then click 'Accept Perc 2'.
- Click the 'Send Calibration' button. The IO-4 module is now calibrated.


## IO-4 Module V1.2

The original IO-4 module (version 1.2) allows channel 1 to be calibrated using fixed percentage setpoints of $0 \%$ and $100 \%$. The hardware overview for an IO-4 module, version 1.2 is shown below


Figure H.7: Hardware Overview For The IO-4 Module V1.2

## Calibration Method:

- Click the 'Reset Ch.01' button. This will clear the calibration registers in the IO-4 module.
- Click the 'Enable Ch.01' button. This tells the RTU that channel 1 is about to be calibrated.
- Apply the first voltage input corresponding to $0 \%$ to channel $1(0-50 \mathrm{mV})$.
- Click 'Set Ch. 01 Min'.
- Apply the second voltage input corresponding to $100 \%$ to channel $1(0-50 \mathrm{mV})$.
- Click 'Set Ch. 01 Max'. The IO-4 is now calibrated.


## Example Calibration

The IO-4 is to be calibrated for a strain gauge input used to measure the water level in a tank. Note: the tank must be full to allow the IO-4 to be calibrated.

- Click the 'Reset Ch.01' button.
- Click the 'Enable Ch.01' button.
- For the first input, lift the strain gauge out of the water (this will probably produce a voltage of about 1 mV into the IO-4).
- Click 'Set Ch. 01 Min'.
- Put the strain gauge back into the full tank (this may produce a voltage of say 48 mV into the IO-4. The actual voltage will depend on the calibration of the strain gauge).
- Click 'Set Ch. 01 Max'. The IO-4 is now calibrated.


## Strain Gauge Test Input

Sometimes it is useful to manually set the strain gauge voltage input and this can be done by using a $0-50 \mathrm{mV}$ voltage source as shown below.


Figure H.8: Circuit for a 0-50mV Strain Gauge Test Device

## APPENDIX I RTU COMMISSIONING

After an RTU has been installed on site, it needs to be made operational. The process of powering up the RTU, downloading software, checking hardware inputs and outputs and establishing communications is referred to as commissioning. The following sections detail the steps involved in the most common commissioning situations.

## RTU Standard Commissioning

- Check if the correct modules are installed in the correct slots (Refer to RTU Layout Drawings).
- Check backup battery voltage (should be $>12 \mathrm{~V}$ ).
- Check that the power supply has been correctly wired (polarity and voltage) and then power up the RTU. Note: if a radio is present, ensure the antenna is properly connected before powering up the RTU and radio.
- For AC powered PC-1 sites, ensure that the PSU-3 voltage is set to 13.8VDC.
- For solar sites, check if the supply voltage from the Solar Regulator is in the desired voltage range.
- Check if the RTU will communicate with Toolbox by viewing the RTU Status.
- Check that all the modules appear in the Hardware Overview and in the correct slots. If the slot numbers are incorrect, the backplane rack switches will probably need to be changed (please see the Kingfisher Hardware Manual or the information written on the backplane).
- Download the RTU configuration and ladder logic (compile the ladder first).
- Check functionality of I/O modules. Simulate a digital input by hard-wiring 12 or 24 VDC to the digital input channel. Check that Digital Output channels can be turned ON and OFF using Toolbox.
- If the RTU includes a PS-1/11, RT-1 or IO-4 strain gauge input, calibrate the module according to the appendix - Calibrating RTU Modules.


## Radio Commissioning

- Check that the antenna is correctly mounted and connected to the radio.
- Connect the radio test-set as shown below.

- Measure RX Signal Strength. (This can be done by initially leaving the antenna connected to the radio, performing a 60 second carrier test on the remote RTU using Toolbox Utilities, Carrier Test; powering down the local RTU and then connecting the antenna to the test-set as shown above). Ensure that the antenna is pointing in the right direction by using a compass bearing or by using line of sight. Adjust the direction and height of the antenna to get the best signal strength.
- Connect the radio test-set and watt meter as shown below.

- Perform a carrier test on the local RTU by using Toolbox.
- Measure forward and reverse power. There should not be any reverse power. Forward power is typically 1 to 5 watts.
- Measure Frequency Deviation and Error. There should be a frequency deviation of 3 kHz for wideband radios and 2 kHz for narrowband radios. The Frequency Error should be between -1 kHz and +1 kHz .
- (Optional) Connect the radio test-set and watt meter as shown below.

A Caution! Do not connect the radio cable to the antenna input on the radio test set. Note the transmit power level when the carrier detect LED on the RTU turns ON and OFF.


## Private Line Commissioning

A private line is commissioned by establishing communications between 2 RTUs. If the RTUs are unable to communicate, carry out the following steps:

- Telstra sockets and plugs (in Australia) use pins 4 and 6 for private line communications. Ensure that these two wires are being used or that the same pair of wires at each end of the line are being used.
- Kingfisher RTUs use the two outer pins on their private line ports for communications (ie. the top and bottom pins). Ensure that these two outer pins are connected to pins 4 and 6 of the Telstra socket.
- To test whether a signal is getting through, perform a carrier test on the remote RTU using Toolbox (Utilities, Carrier Test) and then check to see if you can measure 300 to 500 AC millivolts across the receiving line.
- Ensure the port is configured correctly. Please see the topic Configuration - Port List, Type.


## PSTN Modem Commissioning

A modem link is commissioned by establishing communications between 2 RTUs. If the RTUs are unable to communicate reliably, carry out the following steps:

- Telstra sockets and plugs (in Australia) use pins 2 and 6 for PSTN communications. If there is no ringtone, check if these two wires are being used.
- Using the modem directly connected to the PC, use the Toolbox Utilities, Terminal program to manually dial the remote site. Check that the modems connect at the correct baud rate and that you can then obtain an RTU status. If the modems will not connect, check that the same error correction settings are in both modems (try disabling error correction). If you can connect, ensure that you can stay on line for at least 60 seconds by continuously viewing the RTU Status (this will test the line quality).
- Ensure that the local RTU has been configured to wait long enough for the remote RTU to answer (please see the topic Configuration - PSTN, Dial Timeout). For GSM communications, this may take up to 60 seconds.


## RTU Troubleshooting

| Symptom | Probable Cause | Remedy |
| :---: | :---: | :---: |
| Cannot communicate with the RTU | PC not connected to the RTU | Connect the PC/RTU communications cable between the PC and the RTU. |
|  | RTU not powered | Connect power supply and ensure power status LEDs are energised. |
|  | Wrong Toolbox communications port setup | Check the Toolbox communication port parameters (Configuration, PC Setup). These must be the same as the RTU's port parameters. Try an Auto Detect (View, Auto Detect). |
|  | RTU sleeping or in an unknown state | Power down RTU, remove battery link, wait up to 10 minutes for the RAM to clear and try again. |
| Ladder Logic will not run | Old version of ladder logic in the RTU | Compile the ladder logic and download it again. |
|  | Ladder logic was not downloaded into the RTU | Compile the ladder and download it into the RTU. |
| RTU not Powered | No AC/DC and battery flat or not connected | Check the AC or DC source and the battery. If the battery is faulty then replace it with a fully charged battery. |
|  | Power supply installed or wired incorrectly | Check if the PC-1 or PS-xx is plugged firmly into the backplane and wired up correctly. If OK, try a replacement PC-1 or PS-xx. |
|  | AC OK and Battery is flat | Check cable connections to the RTU. Is there a device that continuously drains the battery when the AC and RTU are switched OFF? |
| PC-1 charge and discharge LEDs are flashing | Battery voltage is at least 0.5 V less than the 12 V supply input causing more than 1 A current to be drawn by the battery. | Irrespective of the charge and discharge LEDs, if the battery voltage is less than the 12 V supply, the battery will be charging. Once the battery charges to a level that it draws less than 1A the flicker will disappear. |
| Analog input readings incorrect | Analog link wrongly configured | Check link is on for 4-20mA and off for 020 mA . |
| Analog output readings incorrect | Analog link wrongly configured | Check link is on for $4-20 \mathrm{~mA}$ and off for 0 20 mA . |
|  | Incorrect load | Check that load is correct ( 250 ohms = 1-5V). |
| No 24V Aux output | Power saving enabled | Disable RTU's power saving feature. |
|  | RTU not fitted with a 24V converter | Ensure that the RTU is fitted with a converter (optional). |
| Digital output fuse indicator on | Digital output common incorrectly wired for DC. | Check Hardware Manual or module terminal cover for correct wiring. |


| Symptom | Probable Cause | Remedy |
| :--- | :--- | :--- |
| One or more <br> modules <br> periodically <br> disappears from <br> hardware <br> overview | Incorrect backplane <br> terminator settings | Check terminator settings and adjust for the <br> required backplane arrangement. Please see <br> the Hardware Manual or backplane labels for <br> details. |
| RTU loses <br> configuration <br> and ladder logic <br> when powered | Internal battery is flat | Return to RTUnet for replacement of internal <br> battery. |
| RTU loses <br> configuration <br> and ladder when <br> powered down | Battery link not installed | Fit a link on the back of the processor <br> module. For the PC-1, fit the link across the <br> upper 2 pins. |
| Modules in <br> wrong slots in <br> hardware <br> overview | Incorrect backplane dip <br> switch settings | Adjust backplane dip switch settings to the <br> correct backplane rack. Turn power off and <br> on again. |
| Timing is <br> incorrect | RTU Real Time Clock is <br> not set | Set the RTU Real time clock to the current <br> time using Toolbox. |
| Battery link is not fitted | Fit a jumper on the back of the processor <br> module. For the PC-1, fit the jumper across <br> the upper 2 pins. |  |
| RTU cannot <br> send pager <br> messages using <br> a modem | Modem is not correctly <br> configured | Disable any error correction and compression <br> settings in the modem (ie. use NO in the <br> initialisation string). |

## Commissioning Site Report

| SITE NAME: |  |
| :--- | :--- |
| LOCATION: |  |
| DATE: |  |
| COMMISSIONED BY: |  |


| ITEM | RESULT |
| :--- | :---: |
| All Kingfisher modules installed with correct options |  |
| All hardware present and connected (eg. modem) |  |
| Fuses installed |  |
| Antenna (if present) connected and properly aligned |  |
| Mains power wired correctly |  |
| DC power wired correctly (correct polarity to battery, radio and <br> 24V Aux supply) |  |
| Battery voltage |  |
| RTU Powers up correctly. All OK LEDs ON. |  |
| DC Supply Voltages OK (12 and 24V outputs) |  |
| RTU configuration loaded |  |
| RTU ladder logic loaded |  |
| RTU time and date set |  |
| RTU detects all modules (Hardware Overview) |  |
| Radio (if present) RX Level From Master/Sub Master |  |
| Radio (if present) RX Level From Outstation <br> (for store and forward sites) |  |
| Radio (if present) TX Frequency | MHz |
| Radio (if present) RX Frequency | MHz |
| Radio (if present) TX Power | W |
| Radio (if present) TX Reverse Power |  |
| RTU can communicate with other RTUs |  |
| Site successfully commissioned |  |

NOTES

|  |
| :--- |
|  |
|  |

## APPENDIX J COMMUNICATING WITH A G3

If the G3 is setup as a 'Remote IO' device, then the G3 can communicate with a Kingfisher Series II RTU using the Kingfisher Series II protocol and a spread spectrum radio. Remote IO mode allows exception reports to be sent by the G3 and outputs to be set in the G3.

## Kingfisher Series II RTU Setup

- Ensure that the spread spectrum radio option board and driver are supported by the type of Series II RTU you are using and that the CPU is loaded with the latest firmware and driver (latest versions are listed in the document Protocols.pdf available from www.rtunet.com/support).
- $\quad$ Set the RTU address in the range 1 to 249.
- Port List - for the spread spectrum radio port, set the baudrate to 9600 (for 9XTend) or 19200 (for 24XStream). The pre and post TX settings should be set to 0 . The port type must be SS Radio. The port protocol must be Series II. For information about setting radio initialisation strings, please see the topic Configuration, Spread Spectrum Radio.
- Network List - add a link with the G3 device address and the port number of the spread spectrum radio as configured above.


## Polling A G3

Configure ladder logic to poll network registers from the G3 using the RX DATA block (an example is shown below)


The above example polls the G3 (address 2 ) every 60 seconds, provided that port 3 is not busy. The RX Data block was setup as shown below.


## G3 Data Registers

Note: when a G3 exception reports it sends the first 12 registers as detailed below.

| G3 Register * | Description |
| :---: | :---: |
| \#NRrrr. 1 | Ch 1 = Digital input 1 status Ch 2 = Digital input 2 status |
| \#NRrrr. 2 | Analog input $1.0-26208=0-100 \%=0-20 \mathrm{~mA}$ or $4-20 \mathrm{~mA}$ For over-range: <br> $0-20 \mathrm{~mA}$ input: $0-32760=0-125 \%=0-25 \mathrm{~mA}$ <br> $4-20 \mathrm{~mA}$ input: $0-34398=0-131.25 \%=4-25 \mathrm{~mA}$ |
| \#NRrrr. 3 | Analog input 2. Same range as above. |
| \#NRrrr. 4 | General alarms <br> Ch 1 ON = Comms fail from G3 to Series II <br> Ch 2 ON = Low Voltage alarm <br> Ch 3 ON = Incorrect PIN alarm |
| \#NRrrr. 5 | Supply Voltage to the G3 (0 to 300 = 0.0 to 30.0V) |
| \#NRrrr. 6 | SS radio received signal strength. There are two ranges depending on which type of radio is installed. $0=$ no signal received <br> 9XTend radio (900MHz): -110 (weak) to -40 (strong) dBm 24XStream radio (2.4GHz): 6 (weak) to 54 (strong) <br> The 9XTend signal strength is stored as <br> 65426 to 65496 (unsigned) $=-110$ to -40 (signed) dBm. |
| \#NRrrr. 7 | G3 internal temperature. -20 to $70^{\circ} \mathrm{C}$ (already scaled) |
| \#NRrrr. 8 | Status indications <br> Ch 1 ON = IO Scanning ON <br> Ch $2 \mathrm{ON}=$ if G3 in override mode, IO data has changed. <br> Ch 3 ON = log buffer is $\geq 90 \%$ full ( $=900$ logs) <br> Ch $4 \mathrm{ON}=$ new counter 1 value <br> Ch 5 ON = new counter 2 value <br> (Remote G3 sends counter value and then resets it back to zero) |
| \#NRrrr. 9 and \#NRrrr. 10 | Counter 1. 32-bit long integer (1 to 4,294,967,296) |
| \#NRrrr. 11 and \#NRrrr. 12 | Counter 2. 32-bit long integer (1 to 4,294,967,296) |
| \#NRrrr. 13 | Counter periods. Used by remote G3 for frequency generator outputs. <br> Ch 1-15: Index into counter table <br> Ch $16 \mathrm{ON}=$ Use table (ms): 500, 1000, 5000, $30000,60000,90$ <br> 000, 180 000, 360000,86400000 <br> Ch 16 OFF = Use table (s): 0, 60, 3600, 21 600, 43 200, 604800 |
| \#NRrrr. 14 | Ch 1 = DO1 raw output state - Write only \# Ch $2=\mathrm{DO} 2$ raw output state - Write only ${ }^{\text {\# }}$ |
| \#NRrrr. 15 | AO1 raw output value. $0-26208=0-100 \%$ - Write only ${ }^{\#}$ |
| \#NRrrr. 16 | AO2 raw output value. $0-26208=0-100 \%$ - Write only ${ }^{\#}$ |
| \#NRrrr. 17 | Ch 1 = DO1 actual output state - Read only Ch $2=$ DO2 actual output state - Read only |
| \#NRrrr. 18 | AO1 actual output value. 0-26208=0-100\% - Read only |
| \#NRrrr. 19 | AO2 actual output value. 0-26208=0-100\% - Read only |

## Setting Outputs in a G3

The following network registers can be sent to a G3 to set the outputs:

## \#NRrrr. 14 Ch 1 = DO1 output state <br> Ch $2=$ DO2 output state

\#NRrrr. 15 AO1 output value ( $0-26208=0-100 \%$ )
\#NRrrr. 16 AO2 output value ( $0-26208=0-100 \%$ )
Where 'rrr' is the G3 address to set the outputs in.

## Notes:

- Only network registers (eg \#NR2.14) can be sent to the G3. Local registers (eg \#R14) will not be accepted.
- To set outputs in a G3, first set the network register(s) in the Series II and then send the network register(s) to the G3 using a TX DATA block.
- When sending a digital output, the whole register is sent to the G3 (eg \#NRrrr. 14) and not just a single bit (eg \#NRrrr.14.1).
- The G3 applies any configured output options and events to all new outputs.

An example TX Data block that will write to all the G3 outputs (address 2 ) is shown below.


## Polling The G3 Outputs

To check the state of the G3 outputs, the read-only registers \#R17, \#R18 and \#R19 can be polled from the G3. These registers contain a copy of the actual G3 outputs.

The output registers \#R14, \#R15 and \#R16 can also be polled. However, if a user is about to set the G3 outputs in the Series II RTU and a poll occurs at the same time, the user settings will be overwritten by the polled data.

## Uploading Event Logs From A G3

Event logs can be uploaded from a G3 using a Kingfisher Series II RTU and the Rx Update ladder logic block. The Series II RTU will upload all the logs since the index of the last log that was uploaded. If no logs have been uploaded then all the logs in the G3 will be uploaded by the Series II RTU.

## APPENDIX K RTU DATA

## K. 1 RTU Data - Local Registers

There are 2048* local registers in an RTU which can be used for general purpose data storage. Local registers can be accessed as either 16 -bit registers or as single bits.

Format: \#Rxxxx (16-bit register) or \#Rxxxx.cc (single channel) where xxxx=register number (1-2048) and cc=channel number (1-16)
Examples: \#R3 register 3
\#R3. 3 register 3, bit 3

* Additional registers are available as Network Registers. Network registers of unused RTU addresses can be used as if they were additional local registers. Providing there is enough memory allocated for Network Register Blocks, an additional 2048 network registers are available for each RTU address allowing up to 509,952 ( $249 \times 2048$ ) data registers per RTU.


## K. 2 RTU Data - Floating Point Registers

Floating Point Registers are 32-bit numbers used for storing fractional numbers, very large or very small numbers and numbers where high precision is required. Each floating point register uses two consecutive local registers and can have up to 7 digits of precision. Floating point registers can store signed numbers in the range of $3.4 \mathrm{e}-38$ to $3.4 \mathrm{e}+38$.

Format: $\quad$ \#Fyyyy where yyyy =an odd numbered register (1,3,5...1023)
Examples: \#F3 floating point register 3 (uses local registers 3 and 4)
\#F5 floating point register 5 (uses local registers 5 and 6)
It is recommended that long registers be used for counting instead of floating point registers as a floating point register can only count up to $16,777,216$ whereas a long register can count up to $2,147,483,647$. To convert between floating point and integer format (as used by 16-bit registers), the Copy or Multi-Copy ladder blocks are used.

## K. 3 RTU Data - Long Registers

Long Registers are 32-bit numbers used for storing large signed integers. Each long register uses two local registers and can store numbers in the range of $-2,147,483,648$ to $2,147,483,647$.

Format: \#Lyyyy where yyyy =an odd numbered register (1,3,5...1023)
Examples: \#L3 long register 3 (uses local registers 3 and 4) \#L5 long register 5 (uses local registers 5 and 6)

To convert between long and integer format (as used by 16-bit registers), the Copy or MultiCopy ladder blocks are used.

## K. 4 RTU Data - Network Registers

Network Registers are used to store Hardware and Local registers from another RTU. When transferring data to another RTU, local registers are stored in the destination RTU's network registers and hardware registers are stored in the destination RTU's network analog or network digital registers. A network register can also be transferred between RTUs.

The following notation is used:

| rrr | RTU address, 1-249 |
| :--- | :--- |
| xxxx | Local register, 1-2048 |
| ss | Slot address, 1-64 |
| c | Channel number, 1-8 |
| cc | Channel number, 1-16 |

Network Registers are local registers received from another RTU. Note: Network Float
Registers and Network Long Registers are pairs of local registers received from another RTU.
Format: \#NRrrr.xxxx (16-bit register) or \#NRrrr.xxxx.cc (single channel)
Examples: \#NR2.100 RTU2 network register 100
\#NR2.100.3 RTU2 network register 100, bit 3
Network Analog Register (read only) are hardware analog inputs or outputs received from another RTU.
Format: \#NArrr.ss.c (16-bit register)
Example: \#NA2.21.3 RTU2, analog module in slot 21, channel 3
Network Digital Register (read only) are hardware digital inputs or outputs received from another RTU.
Format: \#NDrrr.ss (16-bit register) or \#NDrrr.ss.cc (single channel)
Example: $\quad$ \#ND4.11.7 RTU4, digital module in slot 11, channel 7

## K. 5 RTU Data - Timer Registers

Timer Registers are used with the Timer ladder blocks. Note: many standard periodic contacts are available as system registers ( \#YTICK ) for which timer registers are not required. Each timer register can only be used once in ladder logic.

Format: \#Ttt (16-bit register) where tt=timer number (1-64)
Example: \#T12 Timer register 12

## K. 6 RTU Data - IO Modules

It is possible for one RTU to have up to 64 modules. Kingfisher Series II hardware is designed so that there can be up to 4 racks of 16 modules each. Backplanes have 4,6 or 12 slots and these may be linked together using jumper cables that form part of an RS485 bus. Since the longest backplane is 12 slots (to fit in a 19-inch rack), a 4-slot backplane can be used with a 12slot backplane to create a rack of 16 modules. The slot addresses on a BA-4/40 are hardcoded to follow on from a BA-12 according to the rack number ( 1 to 4 ). For the first rack, the BA-12 has slot addresses 1-12 and the BA-4/40 has slot addresses 13-16. The rack number is set using DIP switches on the backplane.

To read data from or write data to each IO module, the module's slot address (or position on the backplane) must be known. The slot address can be determined from the type of backplane (BA-4/40, BA-6 or BA-12) and the rack number (1-4) of the backplane. The slot addresses for each type of backplane in each rack position are shown below.


Figure J.6a: Slot Addresses For Each Type Of Backplane In Each Rack Position
The easiest way to check the slot address of a module when the RTU is powered up is from the hardware overview ( View, Hardware Overview). The hardware overview displays the slot address for each module.

Most IO modules have 8 internal registers for storing their inputs and outputs. Digital modules (eg. DI-1, DO-2) only use their first register as they only require 16 digital bits (each register has 16-bits of information). Analog modules can use all 8 registers (eg. Al-1 modules) as they have up to 8 analog values (each analog value is stored in one register).

## RTU Data - Standard IO Modules

An RTU can have four types of inputs or outputs as follows:

- Digital input: an open or closed contact switched into the RTU.
- Digital output: an open or closed relay switched out of the RTU.
- Analog input: a $0-20 \mathrm{~mA}$ or $4-20 \mathrm{~mA}$ variable current flowing into the RTU (can also be a $0-50 \mathrm{mV}$ strain gauge input).
- Analog output: a $0-20 \mathrm{~mA}$ or $4-20 \mathrm{~mA}$ variable current flowing out of the RTU.

Standard IO modules have only one type of input or output and are named according to the type of IO the module supports (as detailed below). Each IO module is scanned and updated automatically by the RTU.

| Module | Data Address (ss = slot 1-64) | Raw Scale | Description |
| :---: | :---: | :---: | :---: |
| Al-1/4 | \#Alss. 1 to 8 | 0-32760 | 8-channel analog input module. Uses a 12-bit ADC. Analog values are stored as 16-bit numbers by left shifting the number by 3 bits and adding a leading sign bit (not used). Analog values are thus stored in the RTU as a number from 0 to 32760 (maximum value is 32767 minus 7 as the lower 3 bits are not used and are set to 0 ). |
| Al-10 | \#Alss. 1 to 8 | $\begin{aligned} & \text { Signed } \\ & -32768 \text { to } \\ & +32767 \end{aligned}$ | 8-channel analog input module. Uses a 16-bit ADC. Analog values are stored as 15-bit numbers with a leading sign bit. The sign bit is set when the current or voltage input is negative. |
|  | \#Alss. 12 <br> Bits 1 to $8^{\#}$ | N/A | Channels 1 to 8 under range respectively. Triggered when input is less than 4mA for the $4-20 \mathrm{~mA}$ range or when the input is negative for the $0-20 \mathrm{~mA}$ range. |
|  | \#Alss. 12 Bits 9 to 16 * | N/A | Channels 1 to 8 over range respectively. Triggered when input is greater (more positive or more negative) than the configured range. |
| RT-1 | \#Alss. 1 to 4 | $\begin{aligned} & 0-32760 \\ & =-150 \text { to } \\ & +400^{\circ} \mathrm{C} \\ & \hline \end{aligned}$ | 4-channel Pt100 temperature input module with a standard temperature range as shown. Note: other temperature ranges are available. |
| AO-2 | \#AOss. 1 to 4 | 0-32760 | 4-channel analog output module. Uses a 12-bit DAC. |
| DI-1 | \#DIss. 1 to 16 * | N/A | 16-channel digital input module |
| DO-1 | \#DOss. 1 to 8* | N/A | 8-channel digital output module |
| DO-2/5 | \#DOss. 1 to 16 * | N/A | 16-channel digital output module |

* All channels can be addressed simultaneously by not specifying the channel number.
\# Over and under range status bits are stored in an analog register in the AI-10. To access these as digital bits, first copy \#Alss. 12 to a local register. Eg. copy \#Alss. 12 to \#R10. \#R10.1 is then channel 1 under range status, \#R10.9 is channel 1 over range status etc.

Examples:
\#Al6. 2
Analog module (eg AI-10) in slot 6, channel 2
\#Al6.12 Al-10 module in slot 6, channels 1 to 8 under and over range status bits
\#DI4.10 Digital input module in slot 4, channel 10
\#DO31.12 Digital output module in slot 31, channel 12

A
Caution! CPU and MC modules also have hardware registers that can be set using the \#DO and \#AO data addresses. Writing to these registers will cause the CPU or MC module to behave unpredictably and should be avoided.

## RTU Data - IO-x Modules

Some modules have a combination of input and output types and are called Multi-IO modules. Multi-IO modules use their 8 internal registers for both analog and digital values. The first register is used for the digital channels and the other registers (registers 2 to 7) are used for the analog channels. This means that when reading the first analog channel from a multi IO module, the second register must be read (eg. the first analog input channel for an IO-3 in slot 14 is \#Al14.2). Multi-IO modules are treated as if they are two or more standard IO modules in the one slot. To read digital inputs, a multi-IO module is treated as if it was a digital input module. Similarly, to read analog inputs, a multi-IO module is treated as if it was an analog input module. However, as mentioned, the channel assignments are different to a standard IO module and these register/channel assignments are detailed below.

| Module | Internal Register | Data Address (ss = slot 1 to 64) | Raw Scale | Description |
| :---: | :---: | :---: | :---: | :---: |
| 10-2 | 1 | \#DIss. 1 to 8 \#DOss. 9 to 16 | N/A | 8 digital input channels and 8 digital output channels |
|  | 2 to 8 | N/A | N/A | Not used |
| 10-3 | 1 | $\begin{aligned} & \text { \#DIss. } 1 \text { to } 4 \\ & \text { \#DOss. } 9 \text { to } 12 \end{aligned}$ | N/A | 4 digital input channels and 4 digital output channels |
|  | 2 | \#Alss. 2 | 0-32760 | Analog input channel 1 |
|  | 3 | \#Alss. 3 | 0-32760 | Analog input channel 2 |
|  | 4 | \#Alss. 4 | 0-32760 | Analog input channel 3 |
|  | 5 | \#Alss. 5 | 0-32760 | Analog input channel 4 |
|  | 6 | \#AOss. 6 | 0-32760 | Analog output channel 1 |
|  | 7 to 8 | N/A | N/A | Not used |
| 10-4 | 1 | \#DIss. 1 to 8 \#DOss. 9 to 10 | N/A | 8 digital input channels and 2 digital output channels |
|  | 2 | \#Alss. 2 | 0-32760 | Analog input channel 1 |
|  | 3 | \#Alss. 3 | 0-32760 | Analog input channel 2 |
|  | 4 to 8 | N/A | N/A | Not used |

Examples for a multi-IO module in slot 14 :
\#DI14.1 First digital input
\#DO14.9 First digital output
\#DI14 All digital inputs and outputs
\#Al14.2 First analog input (not applicable for an IO-2)
\#AO14.6 IO-3 analog output

## RTU Data - DI-5 Counter Module

The DI- 5 counter module has all the functionality of a DI-1 and also counts pulses on the first 4 digital input channels and provides an isolated 12 V output for powering the inputs. It is able to count up to 10 kHz on channels 1 and 2 and can count up to 255 Hz on channels 3 and 4 . The counter totals and the pulse rate for each counter are stored in internal registers 2 to 8 of the DI5 and are detailed below. Note: pulses can also be counted using any other digital input (eg. DI5 Chs 5-16, DI-1, IO-2, IO-3, IO-4) using ladder logic. Please see the topic Example - Counting Pulses and Starts for more information.

| Internal <br> Register | Data Address <br> (ss = slot 1 to <br> 64) | Raw <br> Scale | Description |
| :---: | :--- | :--- | :--- |
| 1 | \#DIss.1 to 16 | N/A | Digital input channels 1 to 16 |
| 2 | \#Alss.2 | $0-65535$ | Digital Input 1 Total Pulses |
| 3 | \#Alss.3 | $0-65535$ | Digital Input 2 Total Pulses |
| 4 | \#Alss.4 | $0-65535$ | Digital Input 3 Total Pulses |
| 5 | \#Alss.5 | $0-65535$ | Digital Input 4 Total Pulses |
| 6 | \#Alss.6 | $0-65535$ | Digital Input 1 Pulse Rate (Hz) |
| 7 | \#Alss.7 | $0-65535$ | Digital Input 2 Pulse Rate (Hz) |
| 8 | \#Alss.8 | $0-255$ | Low Byte: DI 3 Pulse Rate * (Hz) <br> High Byte: DI 4 Pulse Rate * (Hz) |

* If the maximum pulse rate is exceeded ( $>255 \mathrm{~Hz}$ ), each byte will contain the lowest 8 bits of the actual pulse rate. Results are unpredictable at pulse rates greater that 1 kHz .

Each of the pulse counters (internal registers 2-8) can be written to from ladder logic to clear the total or force a rollover. To write to the internal registers, address each register as \#AO instead of \#AI.

Examples for a DI-5 in slot 14:
\#DI14.5 Digital input 5 status
\#Al14.2
Digital input 1 total pulses (read this address to obtain the total)
\#AO14.2 Digital input 1 total pulses (write to this address to clear the total)
\#Al14.6 Digital input 1 pulse rate

## RTU Data - DI-10 Intelligent Counter Module

The DI-10 module has all the functionality of a $\mathrm{DI}-1$ and also has configurable Frequency or Pulse or Quadrature counting and Sequence-of-Events recording (using event logs). The counter totals for up to 7 user-defined channels are stored in internal registers 2 to 8 of the DI10 and are detailed below. Note: up to 50 Hz (approx.) pulses can also be counted using a standard digital input (eg. DI-1, IO-2, IO-3, IO-4) using ladder logic. Please see the topic Example - Counting Pulses and Starts for more information.

The DI-10 module is configured using the Toolbox menu - Configuration, IO Modules List, Configure [DI-10]. Please see the topic Configuration- DI-10 for more information.

| Internal <br> Register | Data Address <br> (Ss = slot 1 to <br> 64) | Raw <br> Scale | Description |
| :---: | :--- | :--- | :--- |
| 1 | \#DIss.1 to 16 | $\mathrm{N} / \mathrm{A}$ | Digital input channels 1 to 16 |
| 2 to 8 | \#Alss.2 to 8 | $0-10000$ <br> or <br> $0-65535$ | Channel 'x' (as configured in the IO <br> Modules list) Frequency (0-10kHz <br> max.) or Total Pulses (0-65535) or <br> Quadrature Count (0-65535) |

Each of the counter registers (internal registers 2-8) can be written to from ladder logic to clear the total or to force a rollover. To write to the internal registers, address each register as \#AO instead of \#AI.

Examples for a $\mathrm{DI}-10$ in slot 14 with pulse counting configured on channel 1 and frequency counting configured on channel 2 :

| \#DI14.5 | Digital input 5 status |
| :--- | :--- |
| \#Al14.2 | Digital input 1 total pulses (read this address to obtain the total) |
| \#AO14.2 | Digital input 1 total pulses (write to this address to clear the total) |
| \#Al14.3 | Digital input 2 frequency |

## RTU Data - Power Supply Modules

Power supply modules are similar to the multi IO modules because they have a combination of analog and digital inputs and outputs. Like most other IO modules, each power supply module has 8 internal registers for storing its inputs and outputs. Digital inputs and outputs are stored in the first register while analog inputs are stored in registers 2 to 8.

The data that is available for each type of power supply module is detailed below.

| PC-1 |  |  |  |
| :---: | :---: | :---: | :---: |
| Description | Data Address | Raw Scale | Eng. Units or Example |
| PC-1 supply voltage This voltage is either the 12 V supply voltage or the battery voltage. Note: the PC-1 is not AC powered. | \#AI13.2 | 0-32640 | 0 to 32.27V |
| Battery charging current (into the battery) | \#Al13.3 | 0-32640 | -1 to +1A |
| Module temperature | \#Al13.5 | 0-32640 | -20 to +80 C |
| PC-1 supply current | \#Al13.6 | 0-32640 | 0 to +2 A |
| Aux 24V Failure or Not Present | \#DI13.2 | N/A | $1=24 \mathrm{~V}$ failure |
| Battery Not Low (OFF = battery low) | \#DI13.3 | N/A | 0 = battery low |
| Battery is being charged (Current into battery > 100 mA ) | \#DI13.11 | N/A | $\begin{aligned} & \hline \begin{array}{l} 1=\text { battery } \\ \text { charging } \end{array} \\ & \hline \end{aligned}$ |
| Battery is being discharged (Current out of battery >60mA) | \#DI13.12 | N/A | $\begin{aligned} & 1 \text { = battery } \\ & \text { discharging } \end{aligned}$ |
| AC mains fail * | N/A | N/A | N/A |

* A PC-1 is powered by +12 VDC and so cannot directly monitor AC mains power. To determine AC mains power fail, the battery discharging input is monitored for when it is continuously ON for more than 30 seconds. An example of how to do this is detailed in the topic Examples - Exception Reporting Digitals.

PS-10/11/20/21 Analog Data

| Description | Data <br> Address <br> (ss= slot <br> 1-64) | Raw <br> Scale | Eng. Units |
| :--- | :--- | :--- | :--- |
| Supply voltage - the DC voltage supplied to <br> the RTU modules on the backplane <br> (typically 12V) and used to charge the <br> battery. This voltage is sourced from the <br> battery if there is no input supply present. | $0-32736$ | 0 to 32.27V |  |
| Battery charge/discharge current. Current <br> is positive when charging. | \#Alss.3 | $0-32736$ | -4 to +4 A |
| Total current supplied by the power supply <br> to the RTU modules and battery. | \#Alss.4 | $0-32736$ | -4 to +4 A |
| Module temperature | \#Alss.5 | $0-32736$ | -20 to +80 degC <br> 0 degC $=6547$ |
| Battery parameters (PS-11/21 only) <br> Chs 1-8 = Battery Type. <br> 0 = Default, 1 = Lead-Acid, 2 = Ni-Cad <br> Chs 9-16 = Battery Size (x 0.1AH) <br> 0 to 250 = 0 to 25.0AH Max. | \#Alss.7 | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ |
| Internal temperature sensor (PS-11/21 <br> only) | \#Alss.14 | $0-32736$ | -20 to +80 degC <br> 0 degC = 6547 |

PS-10/11/20/21 Digital Data

| Description | Data Address (ss=slot 1 to 64) | Example |
| :---: | :---: | :---: |
| AC Power ON (PS-10/11 only) DC Input Power ON (PS-20/21 only) | \#DIss. 1 | 1 = AC power ON |
| Aux 24V Failure or Not Present | \#DIss. 2 | 1 = 24 V failure |
| Battery Low (note: active low) * | \#DIss. 3 | 0 = battery low |
| Power supply model (PS-11/21 only) ON=PS-21, OFF=PS-11 | \#DIss. 4 | 1 = PS-21 |
| Float State | \#DIss. 5 | 1 = float state |
| Charge State | \#DIss. 6 | 1 = charge state |
| Boost State | \#DIss. 7 | 1 = boost state |
| Temperature Sensor Error | \#DIss. 8 | 1 = sensor error |
|  |  |  |
| Manual control of radio and 24 V power (and Mains Supply for PS-11) | \#DOss. 9 | 0 = automatic control (default) <br> 1 = manual control |
| Radio power OFF (only when manual control enabled) | \#DOss. 10 | 1 = radio off (if \#DIss.9=1) |
| Aux 24V OFF (only when manual control enabled) | \#DOss. 11 | $\begin{array}{\|l\|} \hline \begin{array}{l} 1=24 \mathrm{~V} \text { off } \\ \text { (if \#DIss. } \end{array} \\ \hline \end{array}$ |
| Inhibit AC Supply Input Circuit (PS-11 only) (only when manual control enabled) | \#DOss. 12 | $\begin{aligned} & \hline \begin{array}{l} 1=\text { inhibit AC } \\ \text { (if \#DIss. } 9=1 \text { ) } \end{array} \\ & \hline \end{aligned}$ |

* This bit does not indicate if a battery is present as Battery Low is cleared whenever the input supply is active. If the input supply is OFF (\#DIss. $1=0$ ), a battery is present if the RTU is still running.

Data registers for the PS-1 and PSU-1 are detailed in the topic RTU Data- Superseded Modules.

## K. 7 RTU Data - System Registers

System registers contain configuration parameters, general settings, real-time clock settings and various other RTU parameters. Most of these registers are read / write which means they can be changed by ladder while the RTU is running.

For the following registers, 'cc' is the register channel (1 to 16) where applicable.




\#YRTUTYPE $\quad 1=\mathrm{CP}-1,2=\mathrm{PC}-1,3=\mathrm{CP}-10 / 11,4=\mathrm{CP}-21,5=\mathrm{SBX}, 6=$ ERS Micro, $7=$ LP-1, $8=$ SB-1, $9=$ Micro-4
\#YSOCKETx (CP-21 only) Returns the network usage of the 32 possible ethernet sockets (where $x=$ socket number) on the LAN. $0=$ not used, 1-255=the address of the RTU using that socket. A LAN can have up to 32 sockets continuously in use at any time. When more sockets are required, a socket is closed and reused.
\#YSTAT.cc
RTU status register
Ch1 Please see Chs 6-8
Ch2 $1=$ CPU in slave mode, $0=$ CPU in master mode
Ch3 $\quad 1=I / O$ scanning enabled, $0=I O$ scanning disabled
Ch4 $1=$ logic enabled, $0=$ logic disabled
Ch5 $\quad 1=$ RTU in program mode (IO and logic scanning disabled)
$0=$ RTU in run mode
Ch1, CPU / RTU type
Ch6-8 Ch8 Ch7 Ch6 Ch1 Description

| 0 | 0 | 0 | 0 | $C P-1$ |
| :--- | :--- | :--- | :--- | :--- |

$0 \quad 0 \quad 0 \quad 1 \quad$ SBX-2
$0 \quad 0 \quad 1 \quad 0 \quad$ PC-1
$\begin{array}{lllll}0 & 0 & 1 & 1 & P C-1\end{array}$
$\begin{array}{lllll}0 & 1 & 0 & 0 & C P-20 / 21\end{array}$

| 0 | 1 | 1 | 0 | $C P-10 / 11$ |
| :--- | :--- | :--- | :--- | :--- |

10010 ERS
$1 \quad 0 \quad 1 \quad 1 \quad$ Micro-3
$1 \quad 1 \quad 0 \quad 0 \quad$ LP-1
$1 \quad 1 \quad 0 \quad 1 \quad$ Micro-4
Ch12- RAM size
Ch14 CP-1, PC-1, SBX-2 CP-10/11, CP-20/21
Ch12 $1=$ RAM $>=128 \mathrm{~K} \quad 1=R A M>=512 \mathrm{~K}$
$0=R A M<128 K \quad 0=R A M<512 K$
Ch13 $1=$ RAM $>=256 \mathrm{~K} \quad 1=$ RAM $>=1024 \mathrm{~K}$
$0=R A M<256 \mathrm{~K} \quad 0=\mathrm{RAM}<1024 \mathrm{~K}$
Ch14 $1=$ RAM $>=512 \mathrm{~K} \quad 1=$ RAM $>=2048 \mathrm{~K}$
$0=$ RAM $<512 \mathrm{~K} \quad 0=\mathrm{RAM}<2048 \mathrm{~K}$
Ch15 1 = RAM Fault, $0=$ RAM OK
Ch16 1 = RAM Fault, 0= RAM OK
\#YSYS.ENABLE $\quad$ = First scan of ladder after downloading ladder logic or after a Toolbox 'Enable Logic Processing' command is received.
\#YSYS.SCAN1 1 = First scan of ladder logic after a warm start, a power reset or after downloading the SDB file. Not activated when waking up from sleep mode or after downloading ladder logic.
\#YSYS.WARMST 1 = Warm reset CPU (Setting this bit will warm start the RTU). $0=$ Normal CPU operation

## Clock Registers

Note: continuously writing to the real-time clock registers will cause the clock to stop or behave erratically.
\#YMSEC The current milliseconds (0-999). Resolution is currently 10 ms .
\#YSEC $\quad$ The current second (0-59)
\#YMIN The current minute (0-59)
\#YHOUR The current hour (0-23). 0=12 AM (midnight), 23=11 PM
\#YWEEKDAY Day of the week (1-7). 1=Sunday, 7=Saturday
\#YDAY Day of the month (1-31)
\#YMONTH Month of the year (1-12)
\#YYEAR Current year since 1900 (0-170). Eg. 1=1901, 104=2004

## Timer Flags

These are system register bits that are periodically active for one scan of the ladder logic. Timer flags are ladder contact addresses that be used multiple times in ladder logic and are useful for triggering events periodically.
\#YTICK.100TH Hundredth of a second timer tick. Activated every $1 / 100$ of a second (10ms). Note: if the ladder scan rate is less than 100 times a second, some of the times when YTICK.100TH is true will be missed by the ladder logic.
\#YTICK.TENTH Tenth of a second timer tick - activated every $1 / 10$ of a second (100ms)
\#YTICK.SEC One second timer tick
\#YTICK.10SEC Ten second timer tick
\#YTICK.MIN One minute timer tick
\#YTICK.10MIN Ten minute timer tick
\#YTICK.HOUR One hour timer tick
\#YTICK.DAY One day timer tick

## K. 8 RTU Data - Port Registers

Port Registers contain the parameters for each port. For the following registers, 'nn' is the port number (1-16) and 'cc' is the register channel where applicable.

| \#YPMODnn | (0-255) Module Type. Please see \#YMTYPE for definitions. |
| :---: | :---: |
| \#YPADDRnn | (1-64) Slot Address |
| \#YPTYPnn | Port Type. Port type returns the following values: $0=$ RS232, $1=$ RS485, 2=Radio, 3=Pline, 4=PSTN, 5=TMR, 6=RADIO_HOT, $9=$ RS422, $8=$ Mobitex, $10=$ Ethernet, $11=$ Video, $12=$ RS232 RADIO, $13=$ MicroX RADIO, 14 = GPS Internal, 15 = GPS External, 16 = Line- 2 . |
| \#YPSPnn | corresponding to the baud rate. |
| \#YPPREnn | Pre-Tx Delay (ms) |
| \#YPPOSnn | Post-Tx Delay (ms) |
| \#YPINACnn | $(0-60,000)$ Inactivity Timer. The number of seconds since the last valid message received. If the timer reaches 60,000 seconds it will stop |
| \#YPRXCnn | Received Characters. The number of unread bytes/characters currently in the receive buffer of port ' $n n$ '. This parameter is used with the Rx User ladder block to determine when to read the port buffer. |
| \#YPERRnn <br> \#YPSIGnn | For GPRS, returns the signal strength and quality as a single number - Result=Signal strength $\times 100$ + Signal quality. Eg. If \#YPSIGnn=1204 (decimal), then the signal strength is 12 and the signal quality is 4 . Note: $65535=$ invalid response. |
| \#YPSTnn.cc | Port status |
|  | Ch1 Reserved |
|  | Ch2 1 = Message Pending (Port message waiting for a reply) |
|  | Ch3 1 = Port online (PSTN and TMR only) |
|  | Ch4 1 = Off Hook (TMR only) |
|  | Ch5 1 = Calling / incoming call (TMR only) |
|  | Ch6 $1=\operatorname{In}$ Service (TMR, Mobitex radio and GPRS only) For GPRS, $1=$ modem connected to the network in listen mode. |
|  | Ch7 1 = Link Active (Ethernet T option board, TMR, Mobitex \& DV1000 only). Note: supported by ethernet T option boards version 1.1 and newer (port is labeled 'E'NET-T 1.1'). |
|  | Ch8 1 = Last Dial Failed |
|  | Ch9 1 = Block message pending. A block message generates other 'child' messages to retrieve the information required. A block message can generate hundreds of child messages and be active for minutes. The block message bit is set while the block message is still in progress. If a block message has multiple target RTUs then the block message pending bit is referenced to the port (and RTU address) of the first RTU in the list. It is recommended that only one block message be initiated at any one time. This prevents overloading of the message buffer and prevents the RTU toggling between the child messages of the block messages. While a block message is in progress, the child messages still cause the message pending bits for the port and network link to be set and reset. |
|  | Ch10 1 = Port error (Mobitex radio only) |
|  | Ch14 1= CTS Active. Eg: The CTS pin on the port can be wired to the ring indicator on a modem to monitor an incoming call. |
|  | Ch15 Character error. RTU use only |
|  | Ch16 1 = Data Carrier Detected |
| \#YPPCOLnn | Port protocol (read only). Series 2=0, Mbus slave, $\mathrm{S} 2=1$, Mbus SCADA S2=2. Note: setting \#YPPCOLnn=100. |
| \#YPRTUnn | Online RTU address (for PSTN). Returns the RTU address (1-249) of the remote RTU that the local RTU is currently connected to via PSTN. For GPS_NMEA protocol (for a GPS device), used to set which network registers store the GPS information. Eg if \#YPRTU2 is set to 5 , the GPS information will be stored in the network registers for RTU5 ie \#NR5.xx. Please refer to the GPS_NMEA protocol document for more information. |

## K. 9 RTU Data - Network Link Registers

Network Link Registers contain the configuration parameters and communication statistics for the network links to each outstation RTU. Most of these registers are read / write which means they can be changed while the RTU is running by using ladder logic.

For the following parameters 'rrr' is the destination RTU address (1-249) and 'cc' is the register channel (1-16) where applicable.

| \#YLSIDrrr | System ID |
| :---: | :---: |
| \#YLDIRrrr | Direct or indirect link. Returns an integer value. $1=$ Direct Connect (via port), $0=$ Indirect (via RTU). |
| \#YLVIArrr | Via port number or RTU address (1-16 or 1-249 respectively) |
| \#YLRETRIESrrr | (1-255) The number of retries for each message |
| \#YLTOUTrrr | Comms timeout (ms) |
| \#YLIPADLrrr | (0-65535) Lower half of IP address 'A.B.C.D'. Chs 1-8=C, Chs 9-16=D. |
| \#YLIPADHrrr | (0-65535) Higher half of IP address 'A.B.C.D'. Chs 1-8=A, Chs 9-16=B. |
| \#YLFCrrr * | Comms attempt fails since last success (0-65535) |
| \#YLSUCCrrr * | Counter of comms successes (0-65535) since last reset. The success counter is incremented when an exception report is received or a reply is received to an initiated message. An RTU does not increment the success counter when relaying (store and forwarding) a message to another RTU. |
| \#YLFAILrrr * | Counter of comms attempt failures ( $0-65535$ ) since last reset. The fail counter is only incremented when there is no reply to an initiated message (or the message has timed out). An RTU does not increment the fail counter when relaying (store and forwarding) a message to another RTU. |
| \#YLSTrrr.cc * | Link Status |
|  | Ch1 1 = Last message failed (all attempts failed). Cleared when a reply is received to an initiated message or an unsolicited message is received eg. the RTU is polled by a remote RTU or an exception report is received. |
|  | Ch2 1 = Message pending (RTU message waiting for a reply) |
|  | Ch3 1 = RTU online |
|  | Ch5 1 = Dialling |
|  | Ch8 1 = Last dial failed |
|  | Ch9 1 = Block message pending. Please see \#YPSTnn.cc Ch9 for details. |
|  | Ch11 1 = Establish new CP-10/11 ethernet connection. When set, forces the RTU to close the existing socket and use the new network link settings. |
|  | Ch13 1 = Last initiated message failed. Same as \#YLSTrrr. 1 but only set or reset after an initiated message. This parameter is only updated when used with the Kingfisher or DNP3 protocols. |
| \#YLUPDCrrr | The number of times the network data has been updated since last reset. Each time a network register is changed, the update counter is incremented. After receiving a block of data values (eg. from an exception report or as a reply to a poll message), the update counter will be incremented once for each new data value in the block of data. |
| \#YLLOGIDXrrr | (0-65535) Event log current index pointer. Points to the last log in RTU 'rrr' that was uploaded by the local RTU. |
| \#YLPENDINGrrr | The number of messages pending (waiting for a reply) for RTU 'rrr'. |

[^57]
## K. 10 RTU Data - Module Registers

Module Registers contain the module type number and monitor code version of each module in the RTU.

For the following registers, 'ss' is the slot address (1-64) of the module.
\#YMTYPEss Module type (1-255)
1 Al-1 / Al-4
2 AO-2
3 RT-1
5 DI-1
6 DI-5
7 DO-1
8 DO-2 / DO-5
9 DI-10
10 IO-1
11 IO-2
12 IO-3
13 SBX / IO-3
14 IO-4
19 AI-10
25 LM-2
26 RD-1
29 CP-x slave (for redundancy)
30 CP-x master
31 PSU-1, PS-1, PS-10/11/20/21
45 PC-1
57 LM-1
59 MC-x
255 No module
\#YMVERss The software version number of the IO module. Each IO module has a microcontroller (8051) that is programmed with the current monitor code and labeled with a version number. YMVER returns an integer value in the range $0-255$ where 0 is the oldest version. Eg. An original PSU-1 (with a fan) in slot 1 will return \#YMVER1=0. The later PSU-1 (without a fan) in slot 1 will return \#YMVER1=1. The 12V PS-1 returns \#YMVER1=2.

## K. 11 RTU Data - Superseded Modules

## Power Supply Modules - PSU-1/PS-1

- PSU-1 Version 0: 24VDC output, includes an on board fan
- PSU-1 Version 1: 24VDC output, same as version 0 but does not have a fan and has a different temperature measurement.
- PS-1: 12VDC or 24VDC output with processor controlled battery charging.


## Digital Inputs

(ss = slot address 1-64)

| Active State (Channel ON) | PS-1 | PSU1 V0 | PSU1 V1 |
| :--- | :--- | :--- | :--- |
| AC Power ON | \#DIss.1 | \#DIss.1 | \#DIss.1 |
| Aux 24V Failure / Not Present | \#DIss.2 | \#DIss.2 | \#DIss.2 |
| Battery OK (OFF = battery low) | \#DIss.3 | \#DIss.3 | \#DIss.3 |
| AC/DC operation (OFF=solar) | N/A | \#DIss.4 | \#DIss.4 |
| Temp > 50 deg C | N/A | N/A | \#DIss.9 |
| Float State | \#DIss.5 | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ |
| Charge State | \#DIss.6 | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ |
| Boost State | \#DIss.7 | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ |
| Temperature Sensor Error | \#DIss.8 | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ |
| Battery is being charged <br> (Current into battery > 100mA) | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ | N/A |
| Battery is being discharged <br> (Current out of battery > 60mA) | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ |

## Digital Outputs

(ss = slot address 1-64)

| Output <br> (Channel <br> ON) | PS-1 | PSU1 V0 | PSU1 V1 |
| :--- | :--- | :--- | :--- |
| \#Doss.9 | Supply Voltage Trimming * | Fan ON ${ }^{\text {\# }}$ | N/A |
| \#Doss.10 | Supply Voltage Trimming * | Charge <br> control off | Charge <br> control off |
| \#Doss.11 | Supply Voltage Trimming * | N/A | N/A |
| \#DOss.12 | Supply Voltage Trimming * | N/A | N/A |
| \#DOss.13 | Supply Voltage Trimming * | N/A | N/A |
| \#DOss.14 | N/A | N/A | N/A |
| \#DOss.15 | N/A | N/A | N/A |
| \#DOss.16 | Manual Trim Control | N/A | N/A |

* Supply Voltage Trimming (0-31). The number of voltage steps between the minimum and maximum DC output voltage. For a 12 V PS-1, there are 31 steps of approximately 100 mV between 12 and 15 volts. For a 24 V PS-1 there are 31 steps of approximately 250 mV between 24 and 32 Volts.
\# Only controllable during first 5 minutes after switching on.


## Analog Inputs

(ss = slot address 1-64, PS = power supply).

| Module | Description | Data Address | Eng. Units | Raw Scale |
| :---: | :---: | :---: | :---: | :---: |
| PSU1 V0 | Supply voltage to PS | \#Alss.2: | 0 to 32.27 V | 0-32640 |
|  | Battery charging current | \#Alss.3: | -2 to +2 A | 0-32640 |
|  | Battery Voltage | \#Alss.4: | 0 to 32.27 V | 0-32640 |
|  | Module temperature | \#Alss.5: | -25 to $+227^{\circ} \mathrm{C}$ | 16128-32640 |
| PSU1 V1 | Supply voltage to PS | \#Alss.2: | 0 to 32.27V | 0-32640 |
|  | Battery charging current | \#Alss.3: | -2 to +2 A | 0-32640 |
|  | Battery Voltage | \#Alss.4: | 0 to 32.27 V | 0-32640 |
|  | Module temperature | \#Alss.5: | -55 to $+125^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { Signed, -18688 } \\ & \text { to } 32576, \\ & \left(0^{\circ} \mathrm{C}=0\right) \\ & \hline \end{aligned}$ |
| PS-1 | Supply voltage - the DC voltage supplied to the RTU modules on the backplane (typically 12 V ) and used to charge the battery. This voltage is sourced from the battery if there is no input supply present. | \#Alss.2: | 0 to 32.27 V , | 0-32736 |
|  | Battery charge/discharge current. Current is positive when charging. | \#Alss.3: | -4 to +4 A, | 0-32736 |
|  | Total current supplied by the PS to the RTU modules and battery. | \#Alss.4: | -4 to +4 A | 0-32736 |
|  | Module temperature | \#Alss.5: | -20 to $+80^{\circ} \mathrm{C}$ | $\begin{aligned} & 0-32736 \\ & \left(0^{\circ} \mathrm{C}=6528\right) \end{aligned}$ |

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## SERIES II RTU

 Product Overview
## KINGFISHER TELEMETRY



KINGFISHER TELEMETRY - Internationally acknowledged as a leader in remote systems technology, providing reliable practical solutions for automated control and monitoring.

KINGFISHER RTUs are found in a wide range of applications that include water distribution, waste water collection, gas distribution, chemical storage, oil and gas wellhead control, substation and switchyard monitoring, broadcasting, mining, irrigation and pipeline management systems.

## FLEXIBILITY

## INNOVATION, INTEGRATION CONFORMANCE

Kingfisher RTUs feature intelligent microprocessor-based hardware with self-configuration, diagnostic and advanced control capabilities. Comprehensive communications are also vital components of your SCADA system solution. Our RTUs are designed to accommodate multiple protocols and communications media.


## Features of Kingfisher RTUs

## Intelligence

Powerful Intel 16 and 32 bit processors, large memory capacity and a real-time operating system provide the power for logic processing, communications and data storage. Kingfisher RTUs provide control capabilities that were previously only available in PLCs.

Good Connections
Kingfisher RTUs connect to all traditional telemetry communications mediums including dedicated radio, packet radio, satellite, PSTN dial-up, cellular (voice grade and dedicated data), two-wire and four-wire leased line, ISDN, RS232/RS485/RS422, Ethernet and fibre optic.
Kingfisher RTUs can initiate alpha-numeric pager messages and use multiple protocols on each communications port.

## Talks the Talk

Kingfisher RTUs communicate using a wide range of protocols which provide connection to local devices such as PLCs, flow computers, shaft encoders, smart transducers, circuit breakers and trunk mobile radios. Connection to communications networks is also provided, including support of Hayes AT command set, DNP3 protocol, MODBUS protocol, TCP/IP and emulation of other RTU and PLC manufacturers' protocols.

## Smart Data

Kingfisher RTUs provide flexible scan rates, event logging, standard gas and steam flow calculations, and time-tagged data. Time-tagged data and fast scan rates of less than one milli-second allow sequence of event recording and archiving of data according to time of occurrence, rather than the time the host received the data.

## Flexibility

Choose from our wide range of modules to create an RTU solution. Kingfisher offers analog, digital and mixed analog/digital modules. Input/output solutions are expandable from four I/O to thousands of I/O. Standard I/O modules have four, eight and sixteen channels, allowing connection to RTD inputs, analog I/O and digital I/O. Multi I/O modules have a combination of analog and digital I/O - for example IO-3 features four AI, four DI, one AO and four DO.

## Power Saving

Kingfishers advanced power management features reduce power consumption by up to 90 per cent. Kingfisher RTUs can control power to I/O and their transducers, allowing field power to be shut down

## KINGFISHER TELEMETRY

between scans. They can also maintain the main processor in a low idle state until it is awakened for periodic operations or by incoming messages.

## Redundancy

Adding another power supply module, processor module, communications module or I/O module is a quick and easy task. Provision of multiple power supplies and/or processors, and also dual master RTUs in large systems, safeguards your working environment and efficiency.

## Friendly Configuration

TOOLBOX, a Windows-based RTU configuration and diagnostic program, offers on-line help, configuration examples, and drag and drop capabilities. TOOLBOX features IEC 61131-3 compliant editing and allows you to configure RTUs remotely or centrally, on-line or off-line, and from RTU to RTU, or personal computer to RTU.

## RTU Self - Configuration

The Kingfisher RTU auto-detects which modules are present on the backplane(s). This allows the RTU to monitor the backplane(s) for module "presence" and generate alarms and if a module fails or is inserted in the wrong location. This functionality also allows modules to be "hot swapped" or added while the RTU is running.

## Ready to Work

Kingfisher's large range of modular RTU products are designed to plug in and go to work for you with a minimum of fuss. Our systems engineering experts can also assist with a packaged or boxed solution which is customised to your particular site, application and communication requirements.


## Expertise

Our considerable systems expertise is applied to every product we develop and manufacture, which means our customers get a workable, useful system which smoothly integrates RTUs, field devices, computer hardware and software, and communication networks.
Kingfisher's large range of modular products facilitates a building block approach to the creation of flexible system solutions. The advanced communications techniques, and wide range of protocols and interface standards ensure easy connection to various media and existing devices.

## Quality

Our quality control throughout the entire manufacturing and testing phases includes thorough systems staging and factory acceptance testing in accordance with ISO 9001 and ISO 9002 quality accreditation.

Kingfisher's customers are assured of immediate availability, prompt delivery and factory support. All products are covered by a 12-month warranty.

With Kingfisher, you have the power to create fully integrated systems with small to large modular RTUs. Master, submaster and out-stations are simply defined during the configuration process, using the same hardware modules.

## Overview

A Kingfisher SERIES II RTU is created from a set of power supply, processing, communications and I/O modules as required for each application. Each RTU may use up to 16 communications ports and up to 64 modules. The basic RTU comprises of a power supply, processor and backplane. Backplane capacities include 4,6 and 12 slots (one module per slot).


## Power Supplies

| PS-10 | $90-260 \mathrm{~V}$ AC INPUT |
| :--- | :--- |
| PS-20 | $20-60 \mathrm{~V}$ DC INPUT |

## Processors

| PC-1 | Combined P/S \& CPU |
| :--- | :--- |
| CP-10 | 38625 MHz CPU, 1MB RAM |
| CP-20 | 38625 MHz CPU, 2MB RAM |

## Communications \& Option Boards

| MC-10 | Communications Module |
| :--- | :--- |
| 'S' | RS232/RS422/RS485 port |
| 'I' | Isolated version of 'S' |
| 'D' | 33.6 kbps dial up port |
| 'L' | 2/4 wire V.23 FSK line port |
| 'V' | 2 channel video capture port |
| 'E' | ethernet (CP-20 port2 only) |
| 'F' | fibre optic port | MC-10 only

## I/O Modules

| AI-1 | 8 channel analog input |
| :--- | :--- |
| Al-4 | 8 ch isolated analog input |
| AO-2 | 4 channel analog output |
| DI-1 | 16 channel digital input |
| DI-5 | 16 ch DI with10kHz pulse |
| DO-1 | 8 channel digital output |
| DO-2 | 16 channel digital output |
| RT-1 | 4 channel RTD (Pt 100) |

## Mixed I/O Modules

| $\mathrm{IO}-2$ | $8 \times \mathrm{DI}, 8 \times \mathrm{DO}$ |
| :--- | :--- |
| $\mathrm{IO}-3$ | $4 \times \mathrm{Al}, 4 \times \mathrm{DI}, 4 \times \mathrm{DO}, 1 \times \mathrm{AO}$ |
| $\mathrm{IO}-4$ | $2 \times \mathrm{AI}, 8 \times \mathrm{DI}, 2 \times \mathrm{DO}$ |

## Backplanes

| BA-4 | 4 slot backplane |
| :--- | :--- |
| BA-6 | 6 slot backplane |
| BA-12 | 12 slot backplane |




For medium to large RTU applications a PS-10 power supply and CP-10 processor module are typically used with a 6 slot or 12 slot backplane. In even larger applications multiple backplanes may be chained together.

## General RTU Specifications

| Inputs \& Outputs |  |
| :---: | :---: |
| Total I/O | 1024 |
| Racks | 4 |
| Total Modules | 64 |
| I/O per Rack | 192 |
| I/O Configuration | Auto/Manual |
| Slots per rack | 4/6/12 |
| Removable Connectors | Yes |
| Digital module | 8/16 |
| Analog module | 4/8 |
| Processor Unit |  |
| Type | 80C188/80C386 |
| Flash RAM | 128-1024K |
| RAM | 128-1024K |
| Real Time Clock | Yes |
| Battery Backup | RAM/RTC |
| Serial Ports | 2/3 |
| RTU Address | 1-255 |
| Radio Interface | Yes |
| Private Line Interface | Yes |
| PSTN (Dial-up/answer) | Yes |
| Scan Rate |  |
| Digital | $0.5 \mathrm{mS} / \mathrm{module}$ |
| Analog | 1.5 mS . module |
| PID | 4/sec. |
| Communications |  |
| Total Ports/RTU | 16 |
| Line Modem Standards | $\begin{aligned} & \text { V23, V22, } \\ & \text { V22BIS, V32 } \end{aligned}$ |
| Radio Modem Standards | V23 |
| Serial Standards | RS 232/485/422 |
| Master/Slave | Yes |
| Peer-to-Peer | Yes |
| Fall back levels | Yes |
| PC link | Yes |
| Protocol | Kingfisher, <br> Modbus, DNP3 <br> + many more |
| Protocol Emulation | Yes |
| Configuration |  |
| Auto | Yes |
| Local (Portable PC) | Yes |
| Network | Yes |



## Creating an RTU Solution

## Using a 4 slot backplane

For small RTU applications one or more 4 slot backplanes may be used. The BA-4 (4 slot) backplane differs from the 6 and 12 slot backplanes in that it allows the PC-1 combined power supply and processor module to be used. All modules used on a 4 slot backplane must be 12 V type modules (6 and 12 slot backplanes may use 12 V or
 24V type modules).
The PC-1 module has power supply circuitry to enable charging and monitoring of a standby battery and auxillary outputs of 12 V and 24 V (the 24 V output requires an optional DC-DC converter to be installed within the PC-1 module). Both the auxillary outputs may be turned on/off by the RTU logic. An external DC power supply is used to provide 12V DC input power to the PC-1 via the BA-4 9 way removable power connector.

Note: The left slot of the BA-4 (slot 13) is the only location where a PC-1 module may be located.

## Using 6 and 12 slot backplanes

For larger RTU applications 6 and 12 slot backplanes are used. The BA-6 ( 6 slot) backplane may be flush mounted while the BA-12 (12 slot) backplane may be flush mounted or fitted with optional brackets to allow 19 inch rack mounting. There are two choices of power supply modules to suit AC or DC input voltages that provide monitoring and control of standby battery charging and RTU power consumption. There are also two choices of 80386 based processor modules that include the CP-10 and CP-20 processors. The processors modules share a common circuit board, however the CP-20 has additional RAM memory loaded and ethernet capability.


## KINGFISHER RTUs

## Kingfisher Series II RTU HARDWARE MANUAL



## SAFETY WARNINGS

## RF Exposure

## 9Xtend Spread Spectrum Radio, 900 MHz

This equipment is approved only for mobile and base station transmitting devices. Antenna(s) used for this transmitter must be installed to provide a separation distance of at least $30 \mathbf{~ c m}$ from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

## XStream Spread Spectrum Radio, 2.4 GHz

This equipment is approved only for mobile and base station transmitting devices. Separation distances of (i) 20 centimetres or more for antennas with gains $<6 \mathbf{d B i}$ or (ii) 2 meters or more for antennas with gains $\geq 6 \mathbf{d B i}$ should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended.

## Modifications

Use of unauthorised antenna or other changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this product.
CAUTION

## Lithium Battery

This product contains a lithium battery. Risk of explosion if battery is replaced by an incorrect type. Dispose of used batteries in accordance with local regulations or return to the supplier.

## Fire Risk

A supply voltage above the specified limits may cause fire.

## Document Control

|  | Document Title | Kingfisher Series II Hardware Manual |
| :---: | :---: | :---: |
|  | Master File Name | KingfisherHardware4.2.doc |
|  | Master Location | RAD\release\manuals\series 2\hardware |
|  | Creation Environment | MS-Word 97/2000 |
| 을$\frac{0}{9}$0.00 | Copyright | Copyright © RTUnet (Australia) Pty Ltd. ABN 35006805910 <br> info@rtunet.com, www.rtunet.com |
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| Revision History |  |  |
| :---: | :---: | :---: |
| Rev. | Date | Remarks |
| 4.0 | 11/11/2004 | Added a new version of the DO-5 relay board - TER-REL-003. Created a new chapter - Custom Products. |
| 4.01 | 25/11/2004 | Updated specifications for the TER-REL-002 relay board. |
| 4.02 | 27/01/2005 | Added note for BA-12 mounting brackets - MBR-3 to allow fitting in tight 19" racks. |
| 4.03 | 31/03/2005 | Fixed descriptions for CP-21 ethernet LEDs. Added note for the PC-1 radio option board - must be modified to suit Trio radios. Updated LED descriptions for PS11/21. Added option board pictures. Added Spread Spectrum radio option board. Updated video option board block diagram for new revision. |
| 4.04 | 1/9/2005 | Renamed Video option board to Image option board and updated specifications. Relabeled DO-5 relay option boards from 'DO-5 TER RLY 00x' to 'TEL REL 00x' ( $\mathrm{x}=1,2,3$ ). Updated description for Hart option board. Hart option board is supported by CP-10/11 modules (not MC-10/11). Changed terminology 'Flash RAM' to 'Flash Memory'. Updated adaptor wire colors. Improved backplane switch drawings. Spread Spectrum radio is available for the USA only. Updated description for adaptor ADP-16. |
| 4.05 | 16/2/2006 | Updated description and specifications for the image option board. Updated spread spectrum radio specifications. Added LED display drawings and information for each module. Updated information on linking backplanes. Removed revision history prior to revision 4.0. Added safety warnings on page 2. Updated current consumption data for 10 modules. Updated RJC-ADP-26 CDMA cable (CTS link). |
| 4.06 | 1/6/2006 | Update to RS485 wiring diagram. Added ON/OFF voltage levels for DI-5. Some updates to Spread Spectrum radio option board. AI-10 accuracy specification updated. Updated description for ADP-16 cable. Added new cables ADP-28, RJC-ADP-30 and ADP-31. Added battery information for the PS-11/21. Added 'Features' table at the beginning of each module section. |
| 4.1 | 13/7/2006 | Updated analog accuracy specifications. Improved clarity of backplane dimension drawings. Added module dimensions. New spread spectrum option board part numbers (R2, R3, R4). Added backup battery information for PC-1 and CP-xx. Added ADP-29 adaptor. |
| 4.11 | 20/7/2006 | Added note for Ethernet T and A option boards. Removed IO module block diagrams. |
| 4.2 | 14/12/2006 | Added custom product DI-10-1-48 (higher threshold voltage). Added PS-11 low voltage startup / shutdown information. Added adaptor drawings. Added adaptor ADP-08-M for external spread spectrum radio. Added interface cable wiring for TEL REL 00x relay boards. |

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## Chapter 1 Introduction to the Series II RTU

The Series II RTU is easy to install and configure, offers small to large RTUs with common components, advanced communications with integrated telephone line and radio modems, powerful programming features and is designed for compatibility with Series I RTUs. Through the use of today's advanced technology, the Series II RTU provides a cost-effective platform for small to large size applications.

The primary objectives of the Series II RTUs are:

- To provide a complete RTU package
- To provide small, easy-to-use RTUs
- To provide for improved cost effectiveness while providing the latest technology.
- To provide ease of installation and configuration


### 1.1 Series II RTU Hardware

The Series II RTU system components include:

- 4, 6 and 12-slot backplanes
- Up to 60 Watt power supply ( 90 to 260 VAC or 20 to 60 VDC input)
- Various CPUs to suit processing requirements
- Leased line and PSTN telephone line communications
- Radio modem communications
- Analog eight channel modules with up to 16-bit resolution
- Digital eight and sixteen channel modules
- Up to four racks of modules per CPU
- PC based configuration software

The CPU architecture is based on an Intel 80C386 microprocessor as the main processing element for the CP-11/21 and an 80C188 microprocessor for the PC-1.

### 1.2 Series II RTU Features

The Series II RTU combines the desired features of the traditional RTU with many improvements and product enhancements. The features traditionally found in most RTUs include:

- Remote acquisition and control of industrial I/O signals
- Flexible and efficient communications to remote sites
- Operation on low cost, low grade radio and telephone line communication links
- An industrial computer that has been hardened to operate in the harsh environment of remote locations
- Battery backup
- Low power operation - suitable for low cost solar installation
- Electrical isolation of I/O and communication circuits

The Series II RTU adds an array of features including:

- High speed scanning of I/O signals
- Simultaneous operation of multiple communication circuits
- Ladder logic programming for control applications
- Powerful analog processing capability including PIDs
- Supports multiple protocols - Kingfisher, Modbus, DNP3, Allen Bradley, Omron etc.
- Event and polled operation
- Time and date stamped data
- Redundant processors and power supply capability
- Self configuring of I/O modules at startup
- Powerful configuration and diagnostic tools in PC based software - Toolbox
- On-line and remote configuration


### 1.3 Product Description

The Series II RTU offers many desirable features in addition to the above items, including small physical size for ease of mounting and handling, changeable port types (e.g. RS232/485, PSTN, radio modem), front panel status and diagnostic display.

Series II RTUs may be configured to user I/O, communication circuit requirements, power supply requirement and processing functionality by selecting the appropriate modules from the range. Selected modules are simply mounted to the base plates with little restrictions and are secured with a single captive screw.

The smallest Series II RTU is configured using the BA-4 backplane, a PC-1 processor and an I/O module (Note the LP-1 single board RTU is also available - please contact your Kingfisher supplier). Larger RTUs are configured from BA-6 or BA-12 backplanes together with a CP-11/21 processor module, a power supply, I/O modules and communication modules.

The Series II RTU's size permits flexible and simple mounting in industry standard enclosures. An RTU using a BA-12 backplane can be 19" rack mounted.

## Series II RTU Capacities

| Processor <br> Module | Speed <br> $(\mathrm{MHz})$ | Processor | Max. <br> Inputs/ <br> Outputs | Back- <br> planes | Max. <br> Comms <br> Ports | Memory |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | FLASH | SRAM |  |  |  |
| CP-11 | 32 | 80 C 386 | 1024 | BA-6/12 <br> BA-40 | 16 | 1024 K | 1024 K |
| CP-21 | 32 | 80 C 386 | 1024 | BA-6/12 <br> BA-40 | 16 | 1024 K | 2048 K |
| PC-1 | 16 | 80 C 188 | 128 | BA-4 | 16 | 128 K | 256 K |

## Series II Backplane Configurations

The following figures illustrate various RTU layouts. Each RTU requires a backplane, a power supply and a CPU module. An RTU may also have an assortment of IO modules and communication modules.


Figure 1a: Small RTUs


Figure 1b: Medium RTU


Figure 1c: Large RTU (only one processor module is required for the entire RTU)

### 1.4 General Specifications

General specifications for the Series II RTU are listed in the following table.

| Inputs \& Outputs |  | Configuration Types |  |
| :---: | :---: | :---: | :---: |
| Maximum I/O | 1024 | Analog Value Test | Yes |
| Racks | 4 | PID Control | Yes |
| I/O per Rack | 256 | Ladder Logic | Yes |
| I/O Configuration | Auto/Manual |  |  |
| Slots per rack | 4-16 | Diagnostics |  |
| Removable Connectors | Yes | Pre-programmed | Yes |
| Digital module | 8/16 | I/O modules | LEDs |
| Analog module | 4/8 | CPU modules | LEDs |
|  |  | Power Supply modules | LEDs |
| Processor Unit |  | Report via network | Yes |
| Type | 80C188 / 80C386 |  |  |
| Flash Memory | $128-1024 \mathrm{~K}$ | Debug |  |
| RAM | 128-2048K | Local Watch Dog Timer | Yes |
| Real Time Clock | Yes | Communication Status | Yes |
| Battery Backup | RAM/RTC | Configuration Display | Yes |
| Serial Ports | 1-3 | I/O Status | Yes |
| RTU Address | 1-255 | Debug | Yes |
| Radio Interface | Yes |  |  |
| Private Line Interface | Yes | Power |  |
| PSTN (Dial-up) | Yes | AC Supply | 90-260V |
|  |  | DC Supply | 20-60V |
| Scan Rate |  | Solar Supply | 12 V |
| Digital | $0.5 \mathrm{mS} / \mathrm{module}$ | Power Down Modes | Yes |
| Analog | $1.5 \mathrm{mS} / \mathrm{module}$ | Battery Backup | Yes |
| PID | 4/sec. | Battery Size | Various |
| Communications |  |  |  |
| Total Ports/RTU | 16 | Redundancy Levels |  |
| Line Modem Standards | $\begin{aligned} & \text { V23, V22, } \\ & \text { V22BIS, V32 } \end{aligned}$ | CPUs/rack | 2 |
| Radio Modem Standards | $\begin{aligned} & \text { V23, MSK, } \\ & \text { GMSK } \end{aligned}$ | Power Supplies/rack | 2 |
| Serial Standards | RS 232/485/422 |  |  |
| Master/Slave | Yes | Radio Modules |  |
| Peer-to-Peer | Yes | VHF 136-208 MHz | Yes |
| Fall back levels | Yes | UHF $400-520 \mathrm{MHz}$ | Yes |
| PC link | Yes | 800/900 MHz | Yes |
| Battery Charging Option | Yes |  |  |
| Protocol | Kingfisher + more | Environmental |  |
| Protocol Emulation | Yes | Ambient Temperature | -20 to $70^{\circ} \mathrm{C}$ |
|  |  | Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Configuration |  | Humidity | 5\% to $98 \%$ noncondensing |
| Auto | Yes | Dielectric Strength | $\begin{array}{\|l} \hline 3000 \mathrm{~V}, \\ 1 \mathrm{~min} \\ \hline \end{array}$ |
| Local (using PC) | Yes | Noise Immunity | IEEE 472 |
| Network | Yes |  |  |
|  |  |  |  |

Table 1a: General Specifications

### 1.5 Series II RTU Components

The rack-type Series II RTU I/O system provides the interface between the Series II RTU and user supplied input and output devices. The I/O modules must be fitted to a backplane system that must contain the required number of power supplies, processors and communication modules. The following table lists the types of modules available:

| Catalog <br> Number | Description |
| :--- | :--- |
| PS-11 | AC Supply Input 90-260VAC |
| PS-21 | DC Supply Input 20-60VDC |
| PSU-3 | AC Input Supply 90-260VAC (Low Cost) |
|  |  |
| CP-11 | Standard Processor Module, 2 Option Ports |
| CP-21 | Enhanced Processor Module, 2 Option Ports |
| PC-1 | Power \& Processor Module, 1 Option Port |
|  |  |
| MC-11 | Multi Communications Module, 2 Option Ports |
|  |  |
| AI-1 | Analog Current Input - 8 Channel |
| AI-10 | High Performance Analog Current Input - 8 Channel |
| AO-2 | Analog Current Output - 4 Channel |
|  |  |
| DI-5 | Digital Dry Contact Input, 16 Point |
| DI-10 | Digital AC/DC Input - 16 Point |
| DO-1 | Digital Relay Output NO/NC - 8 Point |
| DO-2 | Digital Relay Output NO - 16 Point |
| DO-5 | Digital Relay Driver Output - 16 Point |
|  |  |
| IO-2 | Combination Digital I/O Module - 8 Inputs, 8 Outputs |
| IO-3 | Combination Analog/Digital I/O Module - 13 Points |
| IO-4 | Combination Analog/Digital I/O Module - 12 Points |
| BA-4/40 | Backplane - 4 Slot |
| BA-6 | Backplane - 6 Slot |
| BA-12 | Backplane - 12 Slot |

Table 1b: Module Types

### 1.6 System Grounding Procedures

All components of a RTU system and the devices it is monitoring and controlling must be properly grounded. This is particularly important for the reasons listed below.

- A low resistance path from all parts of a system to earth minimises exposure to shock in the event of short circuits or equipment malfunction.
- The Series II RTU system requires proper grounding for correct operation.


## Ground Conductors

- Ground conductors should be connected in a tree fashion with branches routed to a central earth ground point. This ensures that no ground conductor carries current from any other branch. This method is shown in the following figure.
- Ground conductors should be as short and as large in size as possible. Braided straps or ground cables (typically green insulation with a yellow tracer - AWG \#12/5mm ${ }^{2}$ or larger) can be used to minimise resistance. Conductors must always be large enough to carry the maximum short circuit current of the path being considered.

The importance of a properly grounded system cannot be over emphasized.


Figure 1d: Recommended System Grounding

## Series II RTU Equipment Grounding

Equipment grounding recommendations and procedures are listed below. These grounding procedures must be properly followed for safe operation of your Series II RTU system.

## Safety and Reference Ground

The metal back of the backplane is grounded when properly installed. Safety and Reference ground connections should be made from one of the mounting tabs to earth ground using a minimum AWG\#12 wire and a ring terminal. Use of a nut and star washer for each wire on the ground connection lug is recommended to ensure adequate grounding. Ensure the paint coating is removed for the lug to make good electrical contact.

## WARNING

The backplane must be grounded to minimise electrical shock hazard that may result in severe personal injury.

All backplanes grouped together in a Series II RTU system must have a common ground connection. This is especially important for backplanes that are not mounted in the same control cabinet.

The best way to provide proper ground connections is to ensure that the Series II RTU backplane metal frame is directly connected to the control panel in which the backplane or backplanes are mounted. This can be accomplished by connecting a ground strap from one of the ground lugs on either side of the backplane to the control panel or cabinet following applicable electrical safety codes.

## Shield Ground

The steel backplane is used for module shield grounding. Shield connections to the user terminal connector on the module are routed to the backplane through conductors on the module.

## Chapter 2 Series II Power Supply Modules

### 2.1 PS-11 AC Supply Input - 90 to 260VAC \& PS-21 DC Supply Input - 20 to 60VDC

| FEATURES |  |
| :---: | :---: |
| Monitoring - battery and input supply | 4 AC Input Supply (PS-11 only) |
| Redundancy - up to 4 power supplies per backplane | ${ }_{\square}^{+}$DC Input Supply |
| 约 | Low Voltage Battery Protection |

The PS-11 power supply provides AC to DC conversion, DC voltages for the backplane, battery and radio (or an external device), a monitoring processor and an optional isolated 24VDC output. The PS-21 power supply offers the same functionality as the PS-11 except it is powered by DC instead of AC.

An isolated 24 VDC output rated at 10 Watts $(400 \mathrm{~mA})$ is an option available for powering a limited number of analog loops or digit input circuits. It cannot be used with inductive loads such as coils, contactors etc. Power for these is to be provided from a separate supply.

In addition the module has limited charging capacity for externally connected lead acid or NiCad batteries. The temperature compensated charging capacity is designed for float operation and short term boost of batteries already charged and in good condition. Use of this supply on flat or fully discharged batteries may cause damage to the power supply module.

When the AC supply fails and the system is powered from the backup battery (if connected), the voltage monitoring circuit provides battery cut-off (for battery preservation) when battery cell voltage drops to $10.5 \mathrm{~V} \pm 0.2 \mathrm{~V}$.

The PS-11/PS-21 has battery voltage, battery current, regulated supply current, and internal or external temperature monitoring circuits that enable the processor module to access these as analog and digital points in the system.

The PS-11/PS-21 is supplied with an internal and external temperature sensor. When a backup battery is connected, the external sensor should be mounted close to the negative terminal of the battery to ensure correct charging operation. The lowest temperature is monitored by the monitoring processor and used by the temperature compensated battery charging (in normal operation the internal temperature sensor will indicate a higher temperature than the external sensor).

There is a connection on the DC terminal block for powering low power radios. This output is switched off on low battery voltage for battery protection and can also be controlled by the RTU configuration.

A power supply module can be installed in any I/O slot of a 4,6 or 12 slot backplane. Up to 4 Power Supply modules of any type can be installed on a backplane thus providing redundant and alternative power source configurations.

PS-11/PS-21 - Specifications

| Input Supply | $\begin{aligned} & 90 \text { to } 260 \text { VAC } 50 / 60 \mathrm{~Hz} \text { (PS-11) } \\ & \text { +96 to +340VDC (PS-11) } \\ & \text { +20 to +60 VDC or }-20 \text { to -60 VDC (PS-21) } \end{aligned}$ <br> Note: both modules can also be powered using 12 to 13.8 VDC when powered from the backup battery terminals. |
| :---: | :---: |
| Backup Battery | 12VDC, 26AH max. Sealed Lead-Acid or NiCad <br> Note: the battery input does not have auto-resetting protection against reverse polarity! Reverse connection will result in failed protection components within the power supply, requiring the unit to be serviced. |
| Battery Overload Protection | If battery charging current exceeds 8 A , the power supply will shutdown. The power supply will try to restart every 10 seconds until the overload is removed. |
| Outputs | +5V @ 3A Max. to Bus <br> +12V @ 4A Max. to Bus <br> +12V @ 4A Max. to Battery <br> +13.8V @ 4A Max. to Radio <br> +24 V Isolated @ 400mA Max. to Field (optional) <br> Max. output power: 60W (for ambient temperatures up to $50^{\circ} \mathrm{C}$ for PS-21) |
| Isolation | 3kV AC input/DC output PS-11 3 kV DC input/DC output PS-21 3kV Isolated 24VDC output |
| Deep Discharge Protection ${ }^{\text {\# }}$ | RTU Shutdown at $10.8 \mathrm{~V} \pm 0.2 \mathrm{~V}$ RTU Startup at $11.6 \mathrm{~V} \pm 0.2 \mathrm{~V}$ |
| Supply Fuse | Slow blow internal <br> 1.6A (PS-11) or 6.3A (PS-21) |
| Battery Fuse | 4A Polyfuse (self-resetting) |
| Connector | Removable for AC/DC connections |
| Monitoring | Item $\quad$ Accuracy |
|  | Battery Current $\pm 10 \%$ <br> Battery Voltage * $\pm 2 \%$ <br> Supply Current * $\pm 10 \%$ <br> Temperature $\pm 1^{\circ} \mathrm{C}$ <br> AC present N/A <br> Battery low N/A <br> Aux. 24V present N/A |
| Control Circuits | Aux. 24V on/off Radio power on/off |

* The battery voltage is monitored when the input supply is disconnected. While the input supply is connected, the module will measure the regulated voltage and current output of its AC (PS-11) or DC (PS-21) input circuit.
\# When mains power is restored, a PS-11 will switch from battery power to mains power within 30 seconds provided the battery voltage is less than 13.8 V . If the battery voltage is higher, the PS-11 will continue to run on the battery until the battery voltage drops below 13.8 V . If a battery powered PS-11 shuts down due to low battery voltage, it will startup again within 60 seconds after the battery voltage exceeds 11.5 V or mains power is restored.

PS-11/PS-21 - LED Display

PS-11

| OK | BATT |
| :--- | :--- |
| CHG |  |
| Vsup | FL |
| Vb | Bo |
| SV | LO |
| Vaux |  |


| LED |  |
| :---: | :--- |
| OK | Module is functioning OK. OK LED will flash when <br> communications is lost with the processor module |
| Vsup | AC (PS-11) or DC (PS-21) input supply is powered |
| Vb | Battery voltage supply is OK. This LED should always be on and <br> means that the power supply is able to charge a battery or is <br> being powered by the battery input. |
| 5 V | Internal 5V supply is OK. This LED should always be on as the <br> 5 V supply is used to power all the modules. |
| Vaux | Auxiliary 24V supply is OK (will only display if the 24V converter <br> is installed). Controllable if a monitoring processor is fitted. |
| BATT CHG | Battery is being charged. LED will flash every 4 seconds when <br> current into or out of the battery is less than 100 mA. |
| FL | Battery is in float charge mode |
| BO | Battery is in boost charge mode |
| LO | Battery has reached discharged condition $(<11.5 \mathrm{~V} \pm 0.2 \mathrm{~V})$. <br> LO LED is cleared when battery > $12.4 \mathrm{~V} \pm 0.2 \mathrm{~V}$ |

## Battery Charging

Whenever the battery begins to draw more than 100mA out of the power supply (eg when the power supply is first turned on or a battery is connected), the power supply measures the initial battery current. The initial battery current is used to estimate how long the battery will need to be Boost charged for. After Boost charging the battery for the estimated time ( $3-10$ hours), the power supply will switch to Float charging. Note: if the battery charging current falls below 100 mA at any stage during Boost or Float charging, the Power Supply will stop charging the battery.

## Part Numbers

PS-11-C AC input, Auxiliary 24V converter fitted
PS-11-0 AC input, Auxiliary 24V converter not fitted
PS-21-C DC input, Auxiliary 24V converter fitted
PS-21-0 DC input, Auxiliary 24V converter not fitted

PS-11/PS-21 - Block Diagram


PS-21 Wiring Diagram


PS-11 Wiring Diagram - AC Supply


## PS-11 Wiring Diagram - DC Supply

A low voltage DC supply can be fitted to the battery input terminals or a higher voltage DC supply can be fitted to the AC input circuit.


### 2.2 PSU-3 AC Supply Input, 35 Watts (Low Cost)

| FEATURES |  |  |  |
| :--- | :--- | :--- | :---: |
| 4 A. $A C$ Input Supply |  | $\stackrel{+}{2}$ |  |

The PSU-3 AC/DC power supply is used as a stand-alone unit to provide +13.8VDC (adjustable) to PC-1 RTUs. The PSU-3 does not have power monitoring functions. Power supply monitoring is performed by the PC-1 module.

PSU-3 Specifications

| Input Supply | 90 to $260 \mathrm{VAC} 50 / 60 \mathrm{~Hz}$ |
| :--- | :--- |
| Load Capacity | 35 Watts |
| Outputs | +13.8 VDC @ 3A |
| Isolation | $2.5 \mathrm{kV} \mathrm{AC} \mathrm{input/DC} \mathrm{output}$ |
| Supply Fuse | 1.6 A slow blow internal |
| Monitoring Circuits | Nil |
| Status Indicators | Nil |
| Connector | Screw Terminals |
| Weight | 430 grams |

PSU-3 Block Diagram


## PSU-3 Mounting and Connection Information

The following figure provides information for connecting field wiring to the user terminal board on the Power Supply Module.


PSU-3 Output Characteristics

OUTPUT POWER (W)


### 2.3 Calculating Power Requirements

All currents were measured at the supply. Module consumption includes the combined power from the +12 V bus and the +5 V bus. Power for all I/O was taken from the RTU itself. ('N/A' used below denotes 'not applicable').

| Item | Current Consumption (mA) |  |  |
| :--- | :---: | :---: | :---: |
|  | CP-11 <br> MC-11 | CP-21 | PS-11 |
| Basic Module, No Options | 110 | 127 | 77 |
| 24VDC Auxiliary Converter Installed | N/A | N/A | +19 |
| Monitoring Processor Installed | N/A | N/A | N/A |

Table 2-3a: CP-11/21, MC-11 and PS-11 Current Consumption (@13.8VDC)

| Option Board | mA |
| :--- | :---: |
| Serial | +2 |
| Isolated Serial | +18 |
| Dial (PSTN) | +59 |
| Line (original version) | +32 |
| Line-2 | +3 |
| Image Capture | +180 |
| CP-21 Ethernet (ENET-E) | +5 |
| CP-10/11 Ethernet (ENET-T) | +22 |
| CP-10/11 Ethernet, Fibre (ENET-A) | +22 |
| Fibre Optic | +14 |
| Hart | +3 |
| 24XStream (50mW) Spread Spectrum Radio, Receive | +30 |
| 24XStream (50mW) Spread Spectrum Radio, Transmit | +35 |
| 9XTend (1W) Spread Spectrum Radio, Receive | +90 |
| 9XTend (1W) Spread Spectrum Radio, Transmit | +900 |

Table 2-3b: CP-xx / MC-xx Option Board Current Consumption (@13.8VDC)

| Part No. | Basic <br> Module, | $24 V D C$ <br> Aux. <br> No <br> Conv. <br> Options <br> (mA) | Current <br> For 'R' <br> Option <br> Installed <br> Board <br> $(m A)$ | Current <br> For 'P' <br> Option <br> Board <br> $(m A)$ | Current <br> For 'S' <br> Option <br> Board <br> $(m A)$ | Current <br> For 'M' <br> Option <br> Board |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| PC-1 | 54 | +53 | +8 | +5 | +5 | +3 |

Table 2-3c: PC-1 Current Consumption (@13.8VDC)

| Part No. | 24VDC Conv. OFF, <br> All IO Inactive (mA) | 24VDC Conv. ON, All IO Inactive (mA) | Extra Current Per Analog Input at 100\% (mA) | Extra Current Per Analog Output at 100\% (mA) | Extra Current Per Digital Input Active (mA) | Extra Current Per Digital Output Active (mA) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Al-1-1 | 11 | 80 | +50 [+0] | N/A | N/A | N/A |
| Al-10-1 | 25 | 185 | +62 [+3] | N/A | N/A | N/A |
| AO-2-1 | 11 | 113 | N/A | +38 | N/A | N/A |
| DI-1 | 7 | N/A | N/A | N/A | [+4] | N/A |
| DI-5 | 23 | N/A | N/A | N/A | +7 [+2] | N/A |
| DI-10 | 40 | N/A | N/A | N/A | +11 [+5] | N/A |
| DO-1-1 | 7 | N/A | N/A | N/A | N/A | +31 |
| DO-2-1 | 7 | N/A | N/A | N/A | N/A | +13 |
| DO-5-1 | 3 | N/A | N/A | N/A | N/A | +1 |
| IO-2-1 | 5 | N/A | N/A | N/A | [+3] | +12 |
| IO-3-1 | 10 | 53 | +46 [-1] | +42 | +10 [+1] | +12 |
| IO-4-1 | 8 | 44 | +44 [-2] | N/A | +9 [+1] | +12 |

Table 2-3d: IO Module Current Consumption (@13.8VDC) Values shown are for inputs powered by the IO module itself when power is available. Values in brackets '[ ]' denote current consumption when inputs are powered by an external supply.

| Item | Current Consumption (mA) |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  | $12 \mathrm{~V} *$ | 20 V | 24 V | 48 V | 60 V |
| Basic Module, No Options | 33 | 34 | 30 | 20 | 19 |
| 24VDC Aux. Conv. Installed | +21 | +15 | +12 | +7 | +6 |

* Powered using the battery terminals

Table 2-3e: PS-21 Current Consumption at various DC supply voltages

## Total Power Required

Total current required from the power supply is:
$I_{\text {Tmax }}=$ Total Module Load $\left(\mathrm{I}_{\mathrm{M}}\right)+$ Total Field Load $\left(\mathrm{I}_{\mathrm{F}}\right)$
Total power required is therefore:
$\mathrm{P}_{\text {MAX }}=13.8 \times \mathrm{I}_{\boldsymbol{\mathrm { max }}}$ Watts

## Chapter 3 Series II Processors

### 3.1 PC-1 Power \& Processor Module

| FEATURES |  |
| :---: | :---: |
| 4. Monitoring - battery and input supply | $\stackrel{\square}{+}$ DC Input Supply |
| Two modules in one - Power Supply and Processor | $\underset{\sim}{\boldsymbol{T X} X} \boldsymbol{R}$ Up to 2 Comms Ports |
| \% | Low Voltage Battery Protection |
| NTHEI Intel CPU, 16MHz | 256kB RAM |

The PC-1 combines the functions of a power supply and a processor module. The PC1 can only be installed in the first slot of a 4-slot backplane (BA-4) and operates from a nominal +12VDC supply (typically 13.8VDC). The module has one fixed RS232C port and one option port.

The RAM battery is enabled at shipping time by the factory. A link at the rear of the module allows the user to enable/disable the RAM battery - see figure below. A second link enables +12 V power to the serial port connections for powering external modems etc.


Link for RAM
battery (LK1)
Link for +12 V supply
to ports 1 and 2 .
Note: +12 V is always
enabled on port 2
radio boards
Factory default:
RAM link installed
+12 V link not installed

Figure 3-1a: PC-1 Rear Module and RAM Battery Link Location

## Part Numbers

The PC-1 is available with 3 options (A, P, M) as detailed below.
Part No. PC-1-A PM

| A <br> 24V 10W Auxiliary <br> Supply Converter | P <br> Port 2 <br> Option Board Type | M <br> Memory |
| :--- | :--- | :--- |
| 0=Not Fitted | 0= Not Fitted <br> C=Fitted | R Radio, V.23 FSK * <br> P= 2-Wire Line, V.23 FSK |
|  | 0=No Extra RAM Fitted <br> (128K) <br> S Serial RS232/RS485 <br> M= 4-Wire Line, V.23 FSK | 1=Extra RAM (Total 256K) |
|  |  |  |

## Example:

PC-1-CR1 PC-1 with auxiliary converter, radio option port and extra RAM

* Radio option boards must be factory modified to suit Trio radios (resistor R15 [150K] is replaced with a 2 K 2 resistor). Please add the comment "for Trio radio" when ordering a radio option board for use with a Trio radio.


## PC-1 LED Display



Both of the communications ports have Tx, Rx, RTS and CD LEDs in a vertical group as shown above.

| PC-1 LED | Description |
| :---: | :--- |
| OK | ON when module is functioning OK |
| DC +5V | ON when the internal 5V supply is OK. This LED should always <br> be on |
| +12 V | ON when the internal 12V supply is OK. This LED should always <br> be on (software controlled) |
| T1 | Test LED 1. Flashes during Power Down mode. |
| +Vs | ON when the Auxiliary 24V supply is OK (will only display if the <br> 24 V converter is installed). |
| BATT CHG* | ON when the battery is being charged |
| DIS* | ON when the battery is being discharged |
| LO | ON when the battery voltage is low (For a PC-1 this occurs when <br> the supply voltage is less than about 11.2V) |
| T2 | Test LED 2. Not currently used. |
| Tx | ON when port is transmitting |
| Rx | ON when port is receiving |
| RTS | Request to send. Set ON to begin transmitting |
| CD | Carrier detect. ON while a communications signal is detected. |
| WD | Processor Watchdog Timer. Set ON when the processor is reset. |

* The battery charging (BATT CHG) and battery discharging (DIS) LEDs will sometimes flicker on and off when the battery is charged to the optimum level or if no battery is connected.


## PC-1 Specifications

| PROCESSOR |  |
| :---: | :---: |
| Processor Type | Intel 80C188 |
| Word Size | 16 Bit internal data bus 8 Bit external data bus |
| Clock Speed | 16 MHz |
| BIOS | Yes |
| Flash Memory | 128K Total. 28 K for firmware drivers. |
| Static CMOS RAM | 256K |
| Real-time Clock (RTC) | Yes |
| Watchdog Timer | Yes |
| Status Indication | Yes |
| Battery Type | Lithium. Not rechargeable. |
| Battery Life - module unpowered | 15 Years min. (128K) RAM 10 Years min. (256K) RAM |
| Battery Replacement | At above intervals |
| Communication Ports | 2 |
| Port 1 (RS232) | Serial, 300 to 115200 Baud |
| Port 2 (Optional) | Serial, Radio, 2-Wire Line or 4-Wire Line 300 to 115200 Baud (depending on port type) |
| Modem Port 2 CCITT V23 (Optional) | 1200 Baud |
| Communications | Master / Outstation |
| Configuration Software | Toolbox |
| Diagnostics Software | Yes |
| Basic Configuration | Auto on power-up |
| Complex Configuration | Toolbox |
| RTU Address Range | 1-249 |
| Communications Protocol | Kingfisher, Modbus, + many more |
| Analog Block Processing | Yes |
| PID Block Processing | Yes |
| Logic Processing | Ladder |
| CPUs per RTU | 1 |
| Internal Power Consumption | 120mA from +5VDC |
| Auxiliary 24V Converter | 10 Watts, 400mA @ 24VDC |
| I/O Bus Data Rate | $250 \mathrm{kBit} / \mathrm{s}$ |
| CM Bus Data Rate | $83 \mathrm{kBit} / \mathrm{s}$ |
| Cyclic Redundancy | Port 1 and 2 |
| Operating Temperature | -20 to 70C |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \% \mathrm{RH}$ non-condensing |


| PC-1 POWER SUPPLY |  |  |
| :---: | :---: | :---: |
| Input Supply to PC-1 | 11.5-15VDC @ 4A Max (50W) <br> Typically 13.8 VDC if backup battery connected |  |
| Outputs From PC-1 | +5 VDC @ 1A (5W) to Bus* <br> +12VDC @ 4A Max to Bus* <br> +12VDC @ 2A Max to Vr* <br> +24VDC @ 400mA (10W) to Optional <br> Auxiliary Output (3kV Isolation) \# |  |
| Backup Battery * | 12V, 7AH typical. 26AH max |  |
| Deep Discharge Protection | RTU Shutdown at 10.6 V RTU Startup at 11.8 V |  |
| Supply Fuse | 8A (Maximum Current into the PC-1) |  |
| Battery Fuse | 8 A (Maximum Current into or out of battery) |  |
| Combined Vr and 24VDC Fuse | 3A Polyfuse |  |
| Monitoring | Item | Accuracy |
|  | Battery Current <br> PC-1 Supply Voltage <br> PC-1 Supply Current <br> PC-1 Temperature <br> Battery low <br> Battery Charging <br> Battery Discharging <br> Aux. 24V present <br> AC present (determined from <br> Battery Discharging signal) | $\begin{aligned} & \pm 10 \% \\ & \pm 5 \% \\ & \pm 10 \% \\ & \pm 5 \% \\ & \text { N/A } \\ & \text { N/A } \\ & \text { N/A } \\ & \text { N/A } \\ & \text { N/A } \end{aligned}$ |

* Note: power output is dependent on power supply to the PC-1. Most PC-1s are powered using the 35W PSU-3 power supply.
\# The +24 V converter is optional and must be ordered with the PC-1.


## PC-1 Connections

The PC-1 module has one serial port and one option port accessible by the RJ45 and RJ12 connectors on the front of the module and covered by the snap on cable cover. Port 1 is at the top for RS232 connections only and Port 2 is below for either Serial or Radio / Line connections.


Figure 3-1b: PC-1 Front Module and Port Identification

| Port 1 <br> RJ45 Pin | Direction | RS232C |
| :---: | :---: | :---: |
| 1 | OUT | TXD |
| 2 | IN | RXD |
| 3 | IN | CTS |
| 4 | COM | GND (0V) |
| 5 | IN | DCD |
| 6 | OUT | RTS |
| 7 | OUT | +12 V low power |
| 8 | OUT | DTR |



PC-1 Block Diagram


### 3.2 CP-xx Processor Modules

| FEATURES |  |
| :---: | :---: |
| Redundancy (CP-10/11) | $T X \Rightarrow$ Up to 3 Comms Ports |
| Intel CPU, 25MHz | 1MB RAM (CP-10/11) <br> 2 MB RAM (CP-21) |

CP-xx (CP-10, CP-11, CP-21) processor modules provide all processing, I/O scanning, logic, control and communications functions required in any of the RTU configurations that may be adopted. The processor module has up to three independent communications ports. Ports 2 and 3 can use plug-in option boards while port 1 is fixed as RS232C.

RTUs may have up to $2 \mathrm{CP}-11$ modules that can serve up to four backplanes in a hot standby configuration (note one processor should be in an odd numbered backplane slot and the other in an even numbered backplane slot). One processor controls I/O module scanning and communications while the other redundant processor listens. The redundant processor module will take control under the following conditions:

- Failure of I/O module scan
- Failure of Communications on selected ports
- Toolbox command
- Ladder command

The CP-10/11 has 1MB of flash memory for the storage of all operating code and selected system parameters, and 1MB of battery backed static RAM for all configuration and event storage data.

The CP-21 has 1MB of flash memory for the storage of all operating code and selected system parameters, and 2MB of battery backed static RAM for all configuration and event storage data. The CP-21 is also loaded with an ethernet driver chip that allows use of an 'E' ethernet option board on port 2 only.

The RAM battery is enabled at shipping time by the factory. The user can disconnect the RAM battery (to clear the RAM) by removing the link at the rear of the module see figure below.


Figure 3-2a: CP-xx Rear View of Module Showing RAM Battery Link Location

## CP-xx Option Boards

| Port Type | Port <br> Label | Description |
| :---: | :---: | :--- |
| 0 | N/A | Communications interface not fitted |
| S | SER-S | Serial interface, RS232 only |
| I | SER-I | Isolated serial interface, RS232/RS485/RS422 |
| D | V34-D | PSTN interface, V34 38400 bps dialup modem |
| Z | V22-d | PSTN low cost interface, V22 2400 bps dialup modem |
| L | LINE-2 | 2/4 wire line interface, V.23 1200bps suitable for 2 and 4 wire <br> leased line (including multi-drop) and for analog radio |
| J | IMAGE-J | Image capture (dual channel) in JPEG format |
| E | ENET-E | Ethernet interface (CP-21 port 2 only) |
| T | ENET-T | Ethernet interface (CP-10/11 only) |
| A | ENET-A | Ethernet fibre optic interface (CP-10/11 only) |
| F | - | Fibre optic interface |
| H | HART | Hart / Bell 202 interface |
| G | - | GPS (Global Positioning System) interface (CP-21 only) |
| R2 | - | 9XTend spread spectrum radio for Australia (CP-10/11 only) |
| R3 | - | $24 X S t r e a m ~ s p r e a d ~ s p e c t r u m ~ r a d i o ~ I n t e r n a t i o n a l ~(C P-10 / 11 ~$ <br> only) |
| R4 | - | $9 X T e n d ~ s p r e a d ~ s p e c t r u m ~ r a d i o ~ f o r ~ U S A ~ n o n ~ e n c r y p t e d ~(C P-~$ <br> $10 / 11 ~ o n l y) . ~ N o t e: ~ e n c r y p t i o n ~ a v a i l a b l e ~ o n ~ r e q u e s t ~ f o r ~ U S A . ~$ |

## CP-xx LED Display



| CP-xx LED | Description |
| :---: | :--- |
| OK | ON when module is functioning OK |
| Tx | ON when port is transmitting |
| Rx | ON when port is receiving |
| RTS | Request to send. Set ON to begin transmitting |
| CD | Carrier detect. ON while a communications signal is detected. |
| L2 | Flashes once per second when CPU is in Standby Mode (only <br> applies when using a redundant CPU) |
| L1,Vbak | Not used |

CP-xx (CP-10, CP-11, CP-21) Specifications

| Processor | Intel 80C386EX |
| :---: | :---: |
| Word Size | 32 Bit internal data bus 16 Bit external data bus |
| Clock Speed | Selectable 16-33MHz (Default 25MHz) |
| BIOS | Y |
| Flash Memory | 1MB total 64K for drivers (CP-10/11) |
| Static CMOS RAM | $\begin{aligned} & 1 \mathrm{MB}(\mathrm{CP}-10 / 11) \\ & 2 \mathrm{MB}(\mathrm{CP}-21) \end{aligned}$ |
| Battery Type | Lithium. Not rechargeable. |
| Battery Life - module unpowered | 10 Years min. (CP-10/11) <br> 7 Years min. (CP-21) |
| Battery Replacement | At above intervals |
| Realtime clock | Y. Accuracy $\pm 1$ minute/month |
| Watchdog timer | Y |
| Status Indication | Y |
| Communication Ports | 1-3 (1 fixed, 2 option ports) |
| Port 1 (RS232) | 300 to 115200 Baud |
| Ports 2 and 3 (Optional) | For supported port types, please see CP-xx Option Boards above |
| Configuration Software | Toolbox |
| Diagnostics Software | Y |
| Complex Configuration | Toolbox |
| RTU Address Range | $1-249$ (expandable to 2000 by using multiple masters) |
| Communications Protocol | Kingfisher, Modbus + many more |
| Analog Block Processing | Y |
| PID Block Processing | Y |
| Logic Processing | Ladder |
| CPUs per RTU | 1 or 2 |
| Internal Power Consumption | 275 mA from +5VDC bus on backplane |
| I/O Bus Data Rate | 250 kBit/s |
| CM Bus Data Rate | $83 \mathrm{kBit} / \mathrm{s}$ |
| Operating Temperature | -20 to $70{ }^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85{ }^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to 98\% RH non-condensing |

## CP-xx Connections

The CP-xx processor modules feature up to three communications ports accessible by connectors on the front of the module (covered by the snap on cable cover). Port 1 is at the top for RS232 connections only. Port 2 and 3 can be configured using plug-in option boards.


Figure 3-2b: CP-xx Front Module and Port Identification

| Port 1 <br> RJ45 Pin | Direction | RS232C |
| :---: | :---: | :---: |
| 1 | OUT | TXD |
| 2 | IN | RXD |
| 3 | IN | CTS Socket |
| 4 | COM | GND (OV) |
| 5 | IN | DCD |
| 6 | OUT | RTS |
| 7 | N/C | Reserved |
| 8 | OUT | DTR |

## CP-xx Block Diagram



## Chapter 4 Series II Communication Modules

### 4.1 MC-10/11 Multi Communications Module

| FEATURES |  |  |
| :--- | :--- | :--- |
| $\boldsymbol{T X} \Rightarrow$ | Up to 3 Comms Ports per MC |  |
| $\boldsymbol{R} \boldsymbol{X}$ | module |  | 1MB RAM

The multi communications module for the Series II Remote Terminal Unit provides additional ports in any RTU configuration. This module has up to three independent communications ports. Ports 2 and 3 may use optional plug-in option boards while port 1 is fixed as RS232C.

This module consumes power from the +5 VDC bus on the backplane. It also requires to +12VDC. Up to five MC-10/11 modules can be installed in any I/O slot of a 4, 6 or 12 slot backplane. An RTU may have up to a total of 16 ports.

## MC-xx Option Boards

| Port Type | Port Label | Description |
| :---: | :---: | :--- |
| 0 | N/A | Communications interface not fitted |
| S | SER-S | Serial interface, RS232 only |
| I | SER-I | Isolated serial interface, RS232/RS485/RS422 |
| D | V34-D | PSTN interface, V34 38400 bps dialup modem |
| L | LINE-2 | 2/4 wire line interface, V.23 1200bps suitable for 2 and 4 wire <br> leased line (including multi-drop) and for analog radio |
| J | IMAGE-J | Image capture (dual channel) in JPEG format |
| F | - | Fibre optic interface |
| R2 | - | 9Xtend spread spectrum radio for Australia |
| R3 | - | 24Xstream spread spectrum radio International |
| R4 | - | 9Xtend spread spectrum radio for USA non encrypted. <br> Note: encryption available on request for USA. |

## MC-xx LED Display

## MC-xx

ok L1 L2 Vbak


| Bx | Fx | Bx |
| :--- | :--- | :--- | :--- | :--- |

 CD CD CD

| MC-xx LED | Description |
| :---: | :--- |
| OK | ON when module is functioning OK |
| Tx | ON when port is transmitting |
| Rx | ON when port is receiving |
| RTS | Request to send. Set ON to begin transmitting |
| CD | Carrier detect. ON while a communications signal is detected. |
| L1,L2,Vbak | Not used |

MC-10/11 Specifications

| Processor | Intel 80C386EX |
| :--- | :--- |
| Word Size | 32 Bit internal data bus <br> 16 Bit external data bus |
| Clock Speed | 25 MHz |
| BIOS | Y |
| Flash Memory | 1 MB |
| Static CMOS RAM | 1 MB |
| RTC | Y |
| WDT | Y |
| Status Indication | Y |
| Communication Ports | $3-3$ (1 fixed, 2 option ports) |
| Port 1 (RS232) | For supported port types, please see <br> MC-xx Option Boards above |
| Ports 2 and 3 (Optional) | Toolbox |
| Configuration Software | Y |
| Diagnostics Software | Kingfisher, Modbus RTU + many more |
| Communications Protocol | Maximum of 16 ports per RTU <br> Eg. Can use 5 MCs if each has 3 ports |
| MC-10/11s per RTU | $275 m A$ from +5VDC bus on backplane |
| Internal Power Consumption | $83.3 / 250$ kBit/s |
| CM Bus Data Rate | -20 to $70^{\circ} \mathrm{C}$ |
| Operating Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Storage Temperature | 5 to $98 \%$ RH non-condensing |
| Operating Humidity |  |

MC-10/11 Block Diagram


## MC-10/11 Connections

The MC-10/11 module features up to three serial ports accessible by RJ45 connectors on the front of the module and covered by the snap on cable cover. Port 1 is at the top for RS232 connections only. Port 2 and 3 can be configured using plug-in option boards.


Figure 4-2b: MC-10/11 Front Module and Port Identification

| Port 1 <br> RJ45 Pin | Direction | RS232C |
| :---: | :---: | :---: |
| 1 | OUT | TXD |
| 2 | IN | RXD |
| 3 | IN | CTS Socket |
| 4 | COM | GND (OV) |
| 5 | IN | DCD |
| 6 | OUT | RTS |
| 7 | N/C | Reserved |
| 8 | OUT | DTR |

## Chapter 5 CP-xx, MC-xx, LP-1 Option Boards

Communication Option Boards add versatility to the Series II RTU. The option boards plug into the communication or processor module and can be changed by opening the module case, unplugging one option board and then plugging in another.

CP-10/11/21, MC-10/11 and LP-1 modules all use the same version of communication option boards. Some option boards are supported by all these modules and some are not (as detailed in the title for each option board). CP-xx/MC-xx/LP-1 option boards are not interchangeable with PC-1/MC-1 option boards.

CP-10/11/21 and MC-10/11 modules can have option boards installed on ports 2 and 3 while LP-1 modules can have one option board installed on port 4.

### 5.1 CP-xx, MC-xx, LP-1 Serial Option Board (Standard or Isolated)

The isolated serial option board (I) provides an RS232C, RS485 or an RS422 interface. The port is software configurable for any of these modes. The non-isolated serial option board (S) provides an RS232C interface only. When RS485 is configured for an isolated serial option board, the RTS and CD LEDs are set on and when RS422 is configured the RTS LED is set on (there are no LEDs set on for RS232). RS485 requires a 120-Ohm terminating resistor at each end of the transmission line and RS422 requires a 100-Ohm terminating resistor at the receiver end of the transmission line only (please see the wiring diagrams in this section).

SER-S (Standard)

## SER-I (Isolated)



## CP-xx Serial Option Board Specifications

| Baudrate | $300-115200 \mathrm{Bps}$ |
| :--- | :--- |
| Configuration Software | Toolbox |
| Internal Power Consumption | 15 mA from +5 VDC Bus on backplane |
| Operating Temperature | -20 to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH non-condensing |
| RS422 Line drive | 10 Receivers |
| RS485 Line drive | 32 Receivers |
| Communications | No parity bit, 8 data bits, 1 stop bit |
| Isolation ('l' option board only) | 2.5 kV |

## CP-xx Serial Option Board Connections

| RJ45 Pin | Direction | RS232C | RS485 | RS422 / <br> RS485 |
| :---: | :---: | :---: | :---: | :---: |
| 1 | OUT | TXD | - LINE * | - TX |
| 2 | IN | RXD | N/A | - RX |
| 3 | IN | CTS | N/A | + RX |
| 4 | COM | GND (0V) | GND | GND |
| 5 | IN | DCD | N/A | $\mathrm{N} / \mathrm{A}$ |
| 6 | OUT | RTS | + LINE * | + TX |
| 7 | OUT | $4.3 V$ | N/A | $\mathrm{N} / \mathrm{A}$ |
| 8 | OUT | DTR | N/A | $\mathrm{N} / \mathrm{A}$ |



* Polarity is opposite to PC-1 and MC-1 RS485 ports.

RS232 Wiring Diagram (Null Modem Cable)


## RS485 Wiring Diagram

Each RTU can transmit/receive to any RTU, one at a time Maximum RS485 Wire Length: 600m.


Line termination recommended for 38400 baud and higher

## CP-xx Serial Option Board RS422 4-Wire Wiring Diagram

(Master RTU can transmit/receive to any one outstation RTU at any time or each outstation can transmit/rec eive to master RTU, one at a time. Note: outstation RTUs cannot communicate with each other)


### 5.2 CP-xx, MC-xx, LP-1 Dial Option Board

The dial option board ('D') provides a V34 PSTN interface. The port speed is software configurable. The dial option board is designed to be compliant with British standards that are also used in Australia and Hong Kong. The ' $Z$ ' option board provides a lowcost, low-speed V22 PSTN interface capable of baud rates up to 2400 baud.

## V34-D (38.4 kbps)



V22-d (2400 bps)


Three types of dial option boards have been manufactured to date.

1. Original D option board (port label 'V34-D’) with on-board speaker. Circuit board is labeled 'S2-DOB REV 1.0'.
2. New D option board (same port label 'V34-D') with on-board speaker and second soldered-on circuit board. Circuit board is labeled 'S2-V3420 REV x.x'.
3. Z option board (port label 'V22-d') with no on-board speaker.

In order for the original dial option board to recognise dial tone and other signals, the AT initialisation string in the Toolbox PSTN Port Configuration needs to include the country parameter (*NCxx) as shown below.

CP-xx Dial Option Board Connections

| RJ45 Pin | PSTN Function |
| :---: | :---: |
| 1 | - |
| 2 | - |
| 3 | Reserved |
| 4 | Line + |
| 5 | Line - |
| 6 | Reserved |
| 7 | - |
| 8 | - |



## CP-xx Dial Option Board Specifications

| Data Rate | V.34, 300 to 38400 Baud (D option) V.22, 600 to 2400 Baud (Z option) |
| :---: | :---: |
| RTU PSTN Port Baudrate | As above |
| Configuration Software | Toolbox |
| Line Impedance | 600 ohm |
| Approval | AUSTEL |
| Transmit level | -10dBm |
| Receive level | -43dBm to -9dBm |
| Dialing | pulse or Tone |
| Internal Power Consumption | 175mA from +5VDC Bus on backplane |
| Operating Temperature | -20 to $70{ }^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85{ }^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to 98\% RH non-condensing |
| Recommended Initialisation String | New 'D': AT\&FEOVOSO=2\&W (standard setup) <br> Original 'D':AT\&FEOVOSO $=2 \times 0 \& W$ <br> (ignores dial tone)  <br>  Alternative strings using country <br>  timing parameter: |

### 5.3 CP-xx, MC-xx, LP-1 Line/Radio Option Board

The line option board provides a Private Line or Radio interface and is software configurable for either of these modes. There are two revisions of the line option board. The original revision 'LINE-L' had a configurable output level (using Toolbox software). The newer revision 'LINE-2' has a fixed output level. Both have the same specifications.

LINE-2


CP-xx Line Option Board Connections

| RJ45 Pin | Direction | Line / Radio <br> Function |
| :---: | :---: | :---: |
| 1 | OUT | Tx + |
| 2 | IN | Rx + |
| 3 | IN | 12 V |
| 4 | IN | GND |
| 5 | IN | CD |
| 6 | OUT | RTS/PTT |
| 7 | IN | Rx - |
| 8 | OUT | Tx - |



## CP-xx Line/Radio Option Board Specifications

| Baudrate | 1200 Baud |
| :---: | :---: |
| Modulation | FSK, CCITT V. 23 |
| Carrier detect input | Optical isolation <br> Active low or high <br> Min. input 2mA (70VDC max.) |
| RTS/PTT output <br> Microwave networks typically use a negative supply rail for the carrier detect circuit. The more positive rail should be connected to pin \#6 (RTS/PTT) and the difference between the rails must not exceed 30VDC. | Optical isolation <br> Open collector output <br> Active low <br> 30 VDC max. at 20 mA max. |
| Output impedance | 30 K ohm |
| Input impedance | 30 K ohm |
| Line termination | 600 ohm |
| Line configuration | 2 or 4 wire <br> The port is not full duplex and cannot use the full duplex functionality of a 4-wire configuration. <br> 4-wire configurations eliminate the ability to communicate peer to peer but allow an increased number of drops on one link. |
| Line drive in multidrop configuration | 10 drops for 2 wire 20 drops for 4 wire |
| Transmit output level | -6 dBm (LINE-2) <br> -6 to -21 dBm software configurable (LINE-L) |
| Receive level | -43dBm to -9dBm |
| Transmission Distance | Allowing 3dB for background noise and a 10 dB fade margin, up to 24 dB of cable loss can be tolerated. Therefore, transmission distance $=24$ / cable loss per Km (dB). Note: if there are more than 2 RTUs (or other devices) on the line, reduce the allowable cable loss (24) by 1 dB per additional RTU or device. |
| Configuration Software | Toolbox |
| Internal Power Consumption | 85 mA from +5VDC Bus on backplane |
| Operating Temperature | -20 to $70{ }^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85{ }^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to 98\% RH non-condensing |
| Isolation | 3.88 kV |

## Connecting A Radio

As the port is isolated it is necessary to use an external voltage source (normally from the RTU 'radio' connection +12 V ) to power not only the radio but also the carrier detect circuit.

Some radios have a very low audio interface level (TX Audio), e.g. Maxon DM 0530, DM-2850, SD-125 and Tait T2010 / 2015. These radios will most likely require a resistor network external to the port to drop the TX Audio level.

Some radios (e.g. Maxon) have an internal pull up resistor to +5 V on the carrier detect line, if +12 V is used on the carrier detect opto-coupler and then run to the carrier detect output on the radio, the opto will always be driven. There are several ways to get around this:

1. Use a radio without an internal pull up to +5 V (Trio SR, possibly Tait)
2. Modify the radio by removing the internal pull up, as per manufacturers instructions.
3. Use +5 V to supply the carrier detect opto circuit. (DO NOT USE +5 V FROM THE BACKPLANE UTILUX CONNECTOR AS IT IS NOT ISOLATED)


Figure 5-3a: Line / Radio Option Board Interface

CP-xx 2-Wire and 4-Wire Line Wiring Diagrams (Also for PC-1, MC-1 'M' port)


4-WIRE LINE, MULTIDROP


### 5.4 CP-xx Ethernet Option Board

There are three versions of the Ethernet option board labelled E'NET-E or E'NET (T or A options). The E option board is designed for port 2 of a CP-21 module only while the T and A option boards are designed for port 2 or 3 of a CP-10/11 module. The A option board uses fibre optic cable to communicate and must be handled very carefully (please see below).

E'NET-E (E option)
E'NET (T option)
E'NET (A option)


CP-xx Ethernet Option Board Specifications

|  | E Option | T Option | A Option |
| :---: | :---: | :---: | :---: |
| Baudrate | 10 Mbits/s | 10 or $100 \mathrm{Mbits} / \mathrm{s}$ * <br> - auto ranging | 100 Mbits/s |
| Compliance | Ethernet/IEEE 802.3 10base-T | Ethernet/IEEE 802.3 10base-T | Ethernet/IEEE 802.3u 100 Base-FX |
| Connector | RJ45 | RJ45 | MT-RJ |
| Internal Power Consumption | 10 mA from +5VDC Bus on backplane | 10 mA from +5VDC Bus on backplane | 75 mA from +5VDC Bus on backplane |
| Operating Temperature | -20 to $70{ }^{\circ} \mathrm{C}$ | -20 to $70{ }^{\circ} \mathrm{C}$ | 0 to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85{ }^{\circ} \mathrm{C}$ | -40 to $85{ }^{\circ} \mathrm{C}$ | -40 to $100{ }^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH noncondensing | 5 to $98 \%$ RH noncondensing | 5 to $98 \%$ RH noncondensing |
| Number of Sockets | 24 | 4 | 4 |
| Functionality | Client (responding) and Server (Initiating) | Client (responding) and Server (Initiating) | Client (responding) and Server (Initiating) |
| Communication Format | Half duplex | Full duplex | Full duplex |
| Response Time | 25ms | 5 ms | 5 ms |
| RTU Hardware Required | CP-21 Port 2 only | CP-10/11 Port 2 or 3 | CP-10/11 Port 2 or 3 |
| Protocols Supported | TCP/IP | TCP/IP, UDP | TCP/IP, UDP |
| Connection Cable | UTP unshielded twisted pair | UTP unshielded twisted pair | Multimode fibre optic |

* Early revision T option boards (prior to version 1.40 circuit board) will only operate at 10 Mbits/s.

Note: Original T and A option boards (labeled 'E'NET') may generate excessive network traffic if the ethernet cable is disconnected, an RTU message is initiated and then the cable is reconnected. Reset the RTU (warm start or power reset) with the ethernet cable connected to return to normal operation. Newer option boards labeled E'NET-T or E'NET-A when used with CP-10/11 firmware 1.42e and newer will not generate excessive network traffic.

## Fibre Optic Ethernet Option Board - Recommended Handling

If dust enters the fibre optic connector on the option board, the option board may no longer work. Please ensure that the dust cover (as supplied with the option board) is fitted whenever the fibre optic cable is not connected.

Ethernet Option Board RJ45 Connector (E and T options)

| RJ45 Pin | Ethernet Function |
| :---: | :---: |
| 1 | TxD + |
| 2 | $\mathrm{TxD}-$ |
| 3 | $\mathrm{RxD}+$ |
| 4 | $\mathrm{~N} / \mathrm{C}$ |
| 5 | $\mathrm{~N} / \mathrm{C}$ |
| 6 | $\mathrm{RxD}-$ |
| 7 | $\mathrm{~N} / \mathrm{C}$ |
| 8 | $\mathrm{~N} / \mathrm{C}$ |



CP-10/11 Ethernet LED Display (T and A options)

| CP-10/11 | Description |
| :---: | :--- |
| Tx | 100Mbits/s activity. Flashes when communicating <br> otherwise ON continuously |
| Rx | 10Mbits/s activity. Flashes when communicating <br> otherwise ON continuously |
| RTS | Collisions detected |
| CD | Link established (port is connected to an ethernet <br> network) |

## CP-21 Ethernet LED Display (E option)

| CP-21 | Description |
| :---: | :--- |
| Tx | 10Mbits/s activity. Flashes when communicating <br> otherwise OFF continuously |
| Rx | Link established (port is connected to an ethernet <br> network) |
| RTS, CD | Not used |

### 5.5 CP-xx, MC-xx, LP-1 Image Capture Option Board

The Kingfisher Image Capture option board is used to capture and store images in the RTU. These images can then be downloaded via the existing Kingfisher RTU/SCADA communications network. Images can be captured automatically by the Image Manager application software or by using RTU ladder logic (eg. if a movement sensor switch is triggered).

Images are stored in the RTU memory in JPEG format. A good quality image uses about 10kB of RTU memory. Each image has the RTU time and date encoded into the JPEG file along with other RTU identifying information.

Images can be downloaded into a PC using Image Manager and then viewed along with all the encoded RTU information.

Note: Camera not included.

IMAGE-J


CP-xx Image Capture Option Board Specifications

| General |  |
| :---: | :---: |
| Configuration Software | Kingfisher Toolbox |
| Camera Trigger | RTU Ladder Logic or Image Manager Software |
| Image Uploading/Viewing | Kingfisher Image Manager |
| Maximum Resolution | PAL $352 \times 288$ pixels (101K pixels) |
| Color Coding | 16 bits/pixel - luminance and chrominance |
| Number of Camera Inputs | 2 per option board Can install up to 15 option boards per RTU |
| Camera Input Socket Type | SMB Male (on option board) |
| Camera Input Signal * | 75 ohm composite video (analog) PAL or NTSC |
| Camera Input Levels | 0.5 Vpp to 1.9 Vpp (peak to peak) 1 Vpp recommended ${ }^{\text {\# }}$ |
| Camera Connection Cable Recommendations | Up to 100m: RG-59 Up to 250m: RG-6 Up to 400 m : RG-11 |
| Image Sizes |  |
| Small | PAL $176 \times 144$ / NTSC $160 \times 120$ pixels |
| Large | PAL $352 \times 288$ / NTSC $320 \times 240$ pixels |


| Electrical |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Camera Input Impedance | 75 Ohm nominal |  |  |  |
| Camera Input Bandwidth | 7 MHz nominal |  |  |  |
| Normal Camera Input levels | 0.5 V to 1.9 V peak, 1.0 V nominal |  |  |  |
| Absolute Camera Input Levels | -0.7V to 6.0V peak |  |  |  |
| Option Board Consumption | 500 mA from +5VDC bus on backplane |  |  |  |
| Environmental Parameters |  |  |  |  |
| Operating Temperature | $0^{\circ} \mathrm{C}$ to $70^{\circ} \mathrm{C} / 32^{\circ} \mathrm{F}$ to $158{ }^{\circ} \mathrm{F}$ |  |  |  |
| Storage Temperature | -40 ${ }^{\circ}$ to $125^{\circ} \mathrm{C} /-40^{\circ} \mathrm{F}$ to 257\% |  |  |  |
| Operating Humidity | 5 to 95\% non-condensing |  |  |  |
| Accessories (Included with each option board) |  |  |  |  |
| Camera Connection Cable | 2.5m long RG179, SMB female to BNC female. Camera requires a BNC male to connect to the cable. |  |  |  |
| Encoded Image Information (JPEG APP ${ }_{10}$ data segment) |  |  |  |  |
| Description | Offset | Field Name | Length (Bytes) | Range |
| $\mathrm{APP}_{10}$ marker | 0 | $\mathrm{APP}_{10}$ | 2 | 0xFFEA |
| Length of segment | 2 | Length | 2 | 26 |
| Zero terminated application identifier "RTUnet" | 4 | Identifier | 7 | $\begin{aligned} & \hline 0 \times 525455 \\ & 0 \times 6 \mathrm{E} 6574 \\ & 0 \times 00 \\ & \hline \end{aligned}$ |
| Version Number | 11 | Version | 2 | 0x0100 |
| System ID number | 13 | SystemID | 1 | 0x01-0xFF |
| RTU Address | 14 | RTUAddr | 1 | 0x01-0xFF |
| Slot Number | 15 | Slot | 1 | 0x01-0x40 |
| Channel Number | 16 | Channel | 1 | 0x01-0x10 |
| RTU Clock Timestamp, seconds since 1970 | 17 | Time | 4 |  |
| $0=\mathrm{PAL}, 1$ = NTSC | 21 | PicFormat | 1 | 0x00-0x01 |
| Vertical size in pixels | 22 | Vsize | 2 | $\begin{aligned} & \hline 0 \times 0001- \\ & 0 \times 8000 \end{aligned}$ |
| Horizontal size in pixels | 24 | Hsize | 2 | $\begin{aligned} & 0 \times 0001- \\ & 0 \times 0300 \end{aligned}$ |
| Reserved for future use | 26 | RSVD | 2 |  |

* The camera input can be powered using the composite video output from analog TVs, VCRs, DVD players and camcorders (typically 1Vpp).
\# For poor video signals, a Video Distribution Amplifier can be used to boost the signal level.

Image Capture Example Setups


## Camera Installation

It is important to avoid grounding the camera. Grounding the camera (e.g. by attaching a metal camera to a steel pole mounted in the ground) can cause an earth loop between the camera and the RTU which will cause distortion of the images. Cameras should only be earthed by the RTU (the cable shield is earthed by the RTU when the camera lead is connected).

Image Option Board Block Diagram


Image File Sizes And Upload Times

| Image Size | Image Quality | Typical File Size (kB) | Approx. Upload time (seconds) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{gathered} \text { GSM } \\ 9600 \mathrm{bps} \end{gathered}$ | Ethernet | Serial 9600 bps |
| NTSC small | 1 | 1.27 | 10.7 | 0.5 | 2.3 |
|  | 20 | 1.32 | 11.7 | 0.6 | 2.5 |
|  | 40 | 1.41 | 12.4 | 0.6 | 2.7 |
|  | 60 | 1.56 | 13.3 | 0.6 | 2.9 |
|  | 80 | 1.85 | 14.9 | 0.7 | 3.3 |
|  | 100 | 2.66 | 20.5 | 0.8 | 4.3 |
| NTSC large | 1 | 2.88 | 21.9 | 0.9 | 5.0 |
|  | 20 | 3.02 | 22.9 | 1.0 | 5.1 |
|  | 40 | 3.26 | 25.0 | 1.2 | 5.5 |
|  | 60 | 3.64 | 27.5 | 1.3 | 6.2 |
|  | 80 | 4.38 | 32.9 | 1.6 | 7.2 |
|  | 100 | 6.98 | 50.5 | 2.2 | 11.2 |
| PAL small | 1 | 1.61 | 13.0 | 0.7 | 2.9 |
|  | 20 | 1.72 | 13.7 | 0.7 | 3.1 |
|  | 40 | 1.87 | 14.9 | 0.8 | 3.2 |
|  | 60 | 2.13 | 16.2 | 0.8 | 3.7 |
|  | 80 | 2.64 | 19.3 | 0.9 | 4.4 |
|  | 100 | 4.07 | 29.0 | 1.3 | 6.4 |
| PAL - large | 1 | 3.89 | 28.1 | 1.3 | 6.6 |
|  | 20 | 4.15 | 30.0 | 1.4 | 6.8 |
|  | 40 | 4.58 | 32.5 | 1.5 | 7.5 |
|  | 60 | 5.29 | 37.7 | 1.7 | 8.6 |
|  | 80 | 6.55 | 46.5 | 2.1 | 10.5 |
|  | 100 | 11.44 | 78.6 | 3.4 | 17.9 |

## Calculating Image Upload Times

The upload time for an image is dependent on

- The number of messages required to transmit the image (128 image bytes are transferred by each image message)
- The time it takes for each image message to be transmitted and acknowledged

Some typical message times are shown below.

| Communications Type | Approx. message <br> time (seconds) |
| :--- | :---: |
| Ethernet | 0.04 |
| Direct serial at 9600 bps | 0.19 |
| GSM modem at 9600 bps | 0.87 |

\# Message Time $=138$ bytes image message + CPU turnaround time +10 bytes acknowledgment. Ten bits are used to transmit each byte.

Example: A 10 kByte image is to be uploaded using a 9600 baud direct serial link. The number of messages required is: 10,000 bytes / 128 image bytes per message = 81 messages (rounded up, plus two - one message for the start and one message for the end of image).
Upload time $=81$ messages * 0.19 seconds per message $=\sim 15.4$ seconds

### 5.6 CP-xx, MC-xx, LP-1 Fibre Optic Option Board

The fibre optic option board (F) provides a serial interface via a fibre optic cable. A fibre optic port is treated the same way as a standard serial port except a fibre optic cable is used for the communications medium. A fibre optic link offers excellent electrical isolation and a high data rate. Two fibre optic cables are required for each fibre optic port.


CP-xx Fibre Optic Option Board Specifications

| Maximum Baudrate | 115.2 kbps (equivalent to RS232 port) |
| :--- | :--- |
| Communications | No parity bit, 8 data bits, 1 stop bit |
| Maximum Fibre Optic Cable <br> Length | Approx. 4km (depends on cable and other <br> factors) |
| Supported Fibre Optic Cables | Multimode $50 / 125 \mathrm{um}, 62.5 / 125 \mathrm{um}, 100 / 140$ <br> um, and 200 um HCS |
| Configuration Software | Toolbox |
| Option Board Connectors <br> (use male connectors on cable) | Tx: ST female (light grey port) <br> Rx: ST female (dark grey port) |
| Power Consumption (Tx) | 200 mA max. from +5VDC Bus on backplane |
| Operating Temperature | -20 to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH non-condensing |
| Line drive | 1 Receiver (point to point) |
| Electrical Isolation | 15 kV |



### 5.7 CP-10/11 Hart Option Board

The Hart option board provides a Bell 202 interface to devices supporting the Hart protocol. Each Hart option board can communicate with up to 15 Hart devices. Two Hart option boards can be installed on the one RTU allowing up to 2 point-to-point circuits or 2 multidrop circuits.

In a point-to-point installation, the loop current can be measured using an RTU analog input channel. If using two separate point to point circuits and reading the loop current in each, the RTU analog input channels must be isolated from each other.

In a multidrop installation, the loop current is not used or measured.
HART


Hart Option Board Specifications

| Baudrate | 1200 Baud, $1 / 2$ Duplex |
| :--- | :--- |
| Modulation | Bell 202 |
| Logical Frequencies | $1=1200 \mathrm{~Hz}$ <br> $0=2200 \mathrm{~Hz}$ |
| Configuration Software | Toolbox |
| Internal Power Consumption | 1 mA from +5 VDC Bus on backplane |
| Operating Temperature | -20 to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH non-condensing |
| Maximum No. Hart Devices | 15 (multidrop) |
| Data Available | Hart and loop current for point-to-point <br> Hart only for multidrop |

## Hart Option Board Connections

| RJ45 Pin | Hart Function |
| :---: | :---: |
| 1 | Line - |
| $2-7$ | N/C |
| 8 | Line + |



## Hart Option Board Wiring Diagrams

## Multidrop (up to 15 Hart devices)



* If using two multidrop circuits on the one RTU, please ensure power supplies are isolated from each other.
\# The more Hart devices that are connected, the closer the resistor value needs to be to 50 ohms.

Point To Point


### 5.8 CP-21 GPS Option Board

The GPS (Global Positioning System) option board allows a Kingfisher Series II RTU to determine its location and synchronize its clock to universal time anywhere in the world. Location and time information is obtained by connecting a GPS antenna to the option board SMB-F connector which then allows the option board to communicate with nearby satellites.

GPS Option Board Specifications

| Baudrate | 19200 Baud |
| :---: | :---: |
| Data Format | 8 data bits, no parity, 1 stop bit |
| Max. Update Rate | 1 Hz |
| Typical Acquisition Time | 60 seconds (first time powered up) 2-6 seconds (powered down for < 2hrs) |
| Operational Limits | Altitude < 60,000 ft |
| Position Accuracy | Approx. 5m |
| Antenna Type | Passive |
| Option Board Antenna Socket | SMB Female. Antenna cable requires an SMB Male connector to connect. |
| Antenna Cable | RG174 $0-7 \mathrm{~m}$ cable runs <br> RG58 $0-20 \mathrm{~m}$ cable runs <br> RG213 $0-60 \mathrm{~m}$ cable runs |
| Configuration Software | Toolbox |
| Available Data | Position (degrees and minutes of latitude and longitude) <br> Time (hours, minutes and thousandths of seconds) <br> Altitude <br> Number of available satellites |
| Internal Power Consumption | 140 mA from +5VDC Bus on backplane |
| Operating Temperature | -20 to $70{ }^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85{ }^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to 98\% RH non-condensing |

### 5.9 CP-10/11, MC-xx, LP-1 Spread Spectrum Radio

The Spread Spectrum radio option board uses the MaxStream 9Xtend or the 24Xstream RF module to provide a high speed data link. This radio uses the public frequency band and does not need to be licensed.

9XTend


24XStream (low power)


CP-xx Spread Spectrum Radio Option Board Specifications

| Parameter | 9XTend | 24XStream * |
| :--- | :---: | :---: |
| Countries Supported | US, Canada, Australia | International |
| Frequency | $902-928 \mathrm{MHz}$ | $2.4000-2.4835 \mathrm{GHz}$ |
| Transmit Power | $1-1000 \mathrm{~mW}$ configurable | 50 mW |
| Range Indoors | 900 m | 180 m |
| Range Outdoors | 22 km | 5 km |
| Range with Yagi | Up to 32 km | Up to 8 km |
| Comms - RTU to Radio | 9600 bps | 19200 bps |
| Comms - Radio to Radio | 115200 or 9600 bps | 9600 bps |
| Power Consumption | 3.7 W maximum | 0.75 W maximum |
| Spread Spectrum Type | FHSS (Frequency Hopping Spread Spectrum) |  |
| Encryption | None ${ }^{\text {\# }}$ |  |
| Antenna Connector | RPSMA (reverse polarity SMA) Male (on radio) |  |
| Receiver Sensitivity | $-110 \mathrm{dBm} @ 9600$ bps | -105 dBm |
| Operating Temperature | -20 to $70^{\circ} \mathrm{C}$ |  |

* Note: the 24XStream International spread spectrum radio will only fit into port 3 of a CP-10/11 or MC-10/11 module due to physical constraints. The 24XStream radio will also not fit into an LP-1.
\# Encryption by special request in the USA only.
Please see www.maxstream.net/products for more information.

CP-10/11 Spread Spectrum Port LED Display

| CP-10/11 | Description |
| :--- | :--- |
| TX, RX, RTS | Not used. |
| CD | Always ON when board operating correctly <br> (whether the antenna is connected or not) |

## Chapter $6 \quad$ PC-1 Option Boards (Also for MC-1)

Communication Option Boards add versatility to the Series II RTU. The option boards plug into the communication or processor module and can be changed by opening the module case, unplugging one option board and then plugging in another.

Option boards for the PC-1 and MC-1 are identical and interchangeable. All references to PC-1 option boards also apply to MC-1 option boards. PC-1 option boards are not interchangeable with the newer CP-xx option boards.

The PC-1 processor has one RS232 port and one option port (port 2). The MC-1 communication module has two RS232 ports and one option port (port 3).

The part number for each option board is shown in the headings below.

### 6.1 PC-1 Serial (S) Option Board

The serial option board provides a RS232C or RS485 interface. The port is software configurable for either of these modes. When RS485 is used, a 120-Ohm terminating resistor is required at each end of the transmission line.


PC-1 Serial Option Board Specifications

| Baudrate | $300-115200 \mathrm{Bps}$ |
| :--- | :--- |
| Configuration Software | Toolbox |
| Internal Power Consumption | 15 mA from +5 VDC Bus on <br> backplane |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH non-condensing |
| Communications | No parity bit, 8 data bits, 1 stop bit |

PC-1 Serial Option Board Connections

| RJ45 Pin | Direction | RS232C | RS485 |
| :---: | :---: | :---: | :---: |
| 1 | OUT | TXD | + LINE * |
| 2 | IN | RXD | N/A |
| 3 | IN | CTS | N/A |
| 4 | COM | GND (0V) | GND (0V) |
| 5 | IN | DCD | N/A |
| 6 | OUT | RTS | - LINE * |
| 7 | OUT | $+12 V$ <br> low power | N/A |
| 8 | OUT | DTR | N/A |



* Polarity is opposite to CP-xx


## RS485 Wiring Diagram

Please see CP-xx Serial Option Board RS485 Wiring Diagram.

### 6.2 PC-1 2-Wire Line (P) / Radio (R) Option Board

The Radio option board provides an FSK interface to external radios (typically Maxon or Trio). When used with a Trio radio, one of the resistors must be factory modified.

The 2-Wire ('Private') line option board provides a 2-wire point-to-point connection to another RTU with a line option board. For multidrop connections please use the PC-1 'M' option board.

## Radio



2-Wire Line


PC-1 2-Wire Line /Radio Option Board Specifications

| Data Rates and Modulation | 1200 Bps CCITT V.23FSK |
| :--- | :--- |
| Transmit Level (into 600 ohm <br> load) | -26 dBm (default): for Maxon SD125 data radios. <br> OR <br> -10 dBm : for Trio radio (option board resistor <br> R15 must be factory modified from 150K to 2K2) |
| Receive Level | 100 mVpp to 1Vpp |
| Connection | RJ12 (line) <br> RJ45 (radio) |
| Line Termination | Not required. A 600 ohm termination is included <br> on the line option board. |
| Line Isolation | 4 kV |
| Radio Signals | CTS: Active low. Not currently supported by <br> software <br> GND: 0 Volt common <br> DCD: Active low, pull down by external open <br> collector transistor 2mA max. |
|  | RTS: Open collector transistor. Active low. <br> $30 V D C ~ m a x ~ a t ~ 20 m A ~ m a x . ~ C o n n e c t e d ~ t o ~ P T T ~$ |
| circuit of radio to key transmitter. |  |
| $+12 \mathrm{~V}:$ Low power supply for Maxon radios with |  |
| internal series resistor for current limiting (Not to |  |
| be used for powering other radios.) |  |

## PC-1 Radio Option Board Connections

| RJ45 Pin | Direction | Radio Function |
| :---: | :---: | :---: |
| 1 | OUT | TXA |
| 2 | IN | RXA |
| 3 | IN | CTS |
| 4 | COM | GND (OV) |
| 5 | IN | DCD |
| 6 | OUT | RTS |
| 7 | OUT | +12 V low power |



PC-1 2-Wire Line Option Board Connections

| RJ12 Pin | 2-Wire Line Function |
| :---: | :---: |
| 2 | Line + |
| 5 | Line - |

RJ12 Plug
RJ12 Socket


PC-1 2-Wire Line Wiring Diagram


### 6.3 PC-1 4-Wire Line (M)

The line modem option board (V. 231200 Baud FSK) provides a telephone line interface and data exchange function for remotely connected units over leased wire circuits - 2 and 4 wire. The unit can be connected to perform the following functions:

- 2 wire point-to-point
- 2 wire multi-drop
- 4 wire point-to-point
- 4 wire multi-drop


PC-1 4-Wire Line Option Board Specifications

| Data Rates and Modulation | 1200 Bps CCITT V.23FSK |
| :--- | :--- |
| Data Pump | SSI 312 |
| Equaliser (adaptive) | Y |
| Transmit Level | -10 dBm in 2x 600 ohm |
| Scrambler/Descrambler | Y |
| Receive Level | 0 dBm to -43 dBm |
| Data Formats | Asynchronous |
| Bit Error Rate (BER) | $10^{-6}$ @ S/N 22dB |
| Connection | 2 or 4 wire RJ12 |
| Termination | 600 ohm at each end of line per pair |
| Line Isolation | 4 kV |
| Line drive in multidrop configuration | 10 drops for 2 wire <br> 20 drops for 4 wire |

PC-1 4-Wire Line Option Board Connections

| RJ12 Pin | 4-Wire Line <br> Function |
| :---: | :---: |
| 2 | $\mathrm{Tx}+$ |
| 3 | $\mathrm{Rx}+$ |
| 4 | $\mathrm{Rx}-$ |
| 5 | $\mathrm{Tx}-$ |



## PC-1 4-Wire Line Option Board Wiring Diagrams

Please see CP-xx Line Option Board wiring diagrams.

## Chapter 7 Series II I/O Specifications

This chapter contains general specifications and wiring information for Series II I/O modules. The various types of I/O modules are listed below.

Table 7a: Standard I/O Modules

| Part <br> Number | Description of Module | I/O <br> Points | Commons <br> per Module |
| :--- | :--- | :---: | :---: |
| AI-1-1 | Analog Input - 4-20mA Common Isolation | 8 | 1 |
| AI-10-1 | Analog Input - High Performance | 8 | 1 |
| AO-2-1 | Analog Output - 4-20mA Channel Isolation | 4 | 4 |
| RT-1-1 | RTD Input - Isolated | 4 | 1 |
| DI-5-1 | Digital Input - Dry Contact | 16 | 1 |
| DI-10-1 | Digital Input - Intelligent AC/DC Input | 16 | 1 |
| DO-1-1 | Relay Output - 4A NO/NC | 8 | 4 |
| DO-2-1 | Relay Output - 2A NO | 16 | 2 |
| DO-5-1 | Relay Driver Output | 16 | 2 |
| IO-2-1 | Digital I/O - 8 Inputs, 8 Relay Outputs 2A | 16 | 2 |
| IO-3-1 | Analog I/O - 4 Inputs, 1 Output <br> Digital I/O - 4 Inputs, 4 Outputs | 13 | 4 |
| IO-4-1 | Analog I/O - 2 Inputs <br> Digital I/O - 8 Inputs, 2 Relay Outputs 4A | 12 | 3 |

Table 7b: List of Fuses

| Module <br> Type | Current <br> Rating | Qty per <br> Module | RTUnet Part No. | Schurter Part No. |
| :--- | :---: | :---: | :---: | :---: |
| DO-1 | 10 A | 4 | 82100180 | 0034.4834 |
| DO-2 | 10 A | 2 | 82100180 | 0034.4834 |
| IO-2 | 7 A | 1 | 82100190 | $0034-4831$ |
| IO-3 | 7A | 1 | 82100190 | $0034-4831$ |
| IO-4 | 7A | 1 | 82100190 | $0034-4831$ |

### 7.1 Analog Modules for the Series II RTU

Analog modules provide inputs and outputs with continuous values, as compared with digital input and output modules which have discrete values of ON or OFF. Analog modules convert analog signals to digital words (two bytes), or digital words to analog signals depending on whether the module is an input module or an output module.

## Hardware Description of Analog Modules

## Inputs

The \#AI data table is a storage location within the Series II CPU where the input information is stored. The Series II RTU has several types of analog input modules however the CPU does not recognise a difference between the types of analog modules. The Series II RTU system is self-configuring and after power up each analog input channel will correspond to two bytes in the data table.


Figure 7-1a: Analog Input Block Diagram
The analog inputs are isolated from the logic side and modules generally have isolated power supplies for powering field transducers. The input modules provide filtering and surge suppression to protect.

## Outputs

The \#AO data table is a storage location within the Series II RTU where the output information is stored. The Series II RTU does not recognise the difference between the types of analog outputs. The Series II system is self-configuring and after power up each analog output channel has a corresponding two-byte value in the data table.


Figure 7-1b: Analog Output Block Diagram

## Connecting An Analog Input

An analog device (or transducer) can be connected using loop power (power from the module) or the analog device can be self powered.

A loop-powered analog device behaves like a variable load on the module. It is a twowire device with the positive wire being connected to the module's +24 V output and the negative wire being connected to the analog input of the module as illustrated below.


A self-powered analog device behaves like a current supply to the module. A selfpowered device has 3 wires. One wire is connected to a +24 V external supply (this voltage can also be supplied by the module). The second wire is connected to the analog input of the module and the third wire is connected to the module's ground pin as illustrated below.


## CPU Interface to Analog Modules

The Series II RTU uses the data within the \#AO and \#AI data tables to drive or record analog values as shown in the above figures. Each analog value is comprised of 16 bits. The most significant bit is the sign bit. 12 bits are used to store the analog value and the three least significant bits are not used (a 12 bit analog to digital converter is used). Analog values are stored as a number in the range 0 to 32760 representing 0 to $100 \%$.

## Performance Measures

The performance of analog modules can be measured by resolution, accuracy, linearity, and cross-channel rejection. Resolution of the module is the weight assigned to the least significant bit in the conversion process. For example, $5 \mu \mathrm{~A} / \mathrm{b}$ it is the resolution of the analog current output module. A module with $10 \mu \mathrm{~A} /$ bit has half the resolution. The resolution of a module is determined by the converter used in the analog module. The accuracy of the module is dependent upon the tolerances of components used in the module's circuitry. Accuracy is the maximum difference between the expected and measured values. Linearity is the difference between the measured change and the ideal one LSB change between any two adjacent channels. Cross channel rejection is the influence on one channel when the input to another channel is changed.

## Field Wiring

Connections to an analog module from user devices are made to screw terminals on a removable 20 -terminal connector block mounted on the front of the module. Actual terminals used are shown in the specifications for the individual modules.

Technological advances used in the analog modules are aimed at making equipment smaller, faster, or more sensitive. This effort increases the concern for electrical noise. Therefore, shielding and grounding are important when installing a Series II RTU system. It is impossible to provide a practical guide for installation of equipment that covers all possible situations. However, some guidelines are suggested below. To minimise capacitive loading and noise, all field connections to the module should be wired to the I/O terminal board using a good grade of twisted, shielded instrumentation cable.

## Shielding for Analog Input Modules

Generally, the shield for inputs to a module should be grounded at the analog source with one point on the shield tied to the module as shown in the following figure.


Figure 7-1c: Shield Connections for Analog Input Modules

## Shielding for Analog Output Modules

For analog output modules, the shield is normally grounded at only the source end (the module). The shield connection provides access to the backplane (frame ground) resulting in superior rejection of noise caused by any shield drain currents. In extreme noise environments, a ground braid may be used to connect the frame ground on the base plate connector to earth ground. This additional connection will bypass noise around the module. An internal link is factory fitted on each module for the GND connection and may be removed where high isolation for cabling is required.


Figure 7-1d: Shield Connections for Analog Output Modules

## Chapter 8 Series II Analog Modules

### 8.1 Analog Input Test Circuit, 4-20mA

Each Series II analog input uses a 250 ohm resistor. This allows a couple of external resistors to be connected to a voltage source to produce a $4-20 \mathrm{~mA}$ input into the module as shown below.


### 8.2 Al-1 Analog Current Input - 8 Channel

| FEATURES |  |
| :---: | :---: |
| B8:P8 12-Bit Resolution | Isolated DC Output For Loop Power |
| Z | 0-20 or 4-20 mA Current Inputs |
| 2 ms Scan Rate | $0-5$ or 1-5V Voltage Inputs (requires factory modification) |

The analog input - 8 channel module for the Series II Remote Terminal Unit provides eight input channels, each capable of converting an analog input signal to a digital signal for use as required by your application. This module provides two input ranges. The default range is 4 to 20 mA . A link on the rear of the module selects $4-20 \mathrm{~mA}$ or $0-$ 20 mA for all channels.

The module can also be factory modified to handle voltage inputs of $0-5 \mathrm{~V}$ DC or $1-5 \mathrm{~V}$ DC.

Conversion speed for each of the eight channels is $20 \mu \mathrm{~S}$ and this provides an update rate of two milliseconds for the module. Resolution of the converted signal is 12 bits binary ( 1 part in 4096) over the range. The placement of the 12 bits from the A/D converter in the \#Al data word is shown below.

MSB
LSB

| 0 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | 0 | 0 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

If the current source is reversed into the input, or is less than the low end of the current range, then the module will output a data word corresponding to the low end of the current range $(0000 \mathrm{H}$ in \#AI). If an input that is out of range is entered (i.e. greater than 20 mA ), the A/D converter will output up to full scale (corresponding to 7 FF 8 H in \#AI).

Scaling of the input is shown below.



Fi
gure 8-2a: AI-1 Scaling for Analog Current Input

Input protection for the module is sufficient to guarantee operation with reduced performance with up to 1500 V common-mode. The module provides electrical isolation of externally generated noise between field wiring and the backplane through the use of optical isolation.

To minimise the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields can be connected to GND. The GND connection provides access to the backplane (frame ground).


Figure 8-2b: Al-1 Rear Module and Link Location
An insert goes between the inside and outside surface of the hinged door. The surface towards the inside of the module (when the hinged door is closed) has circuit wiring information and circuit identification information can be recorded on the outside surface. The outside left edge of the insert is color-coded blue to indicate a lowvoltage module.

This module can be installed in any I/O slot of a 4, 6 or 12-slot backplane. Up to 10 Analog Current Input modules can be installed on a single 12-slot backplane.

## Module LEDs

## A-1

| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON | Normal |
| FU | OFF | Fuse OK |
|  | ON | Fuse fail |
| A1-A8 | OFF | Channel Input level < 1\% |
|  | ON | Channel Input level $>1 \%$ |

## Al-1 Specifications

| Input Current Ranges | $4-20 \mathrm{~mA}$ and $0-20 \mathrm{~mA}$ |
| :--- | :--- |
| Input Voltage Ranges | $1-5 \mathrm{~V}$ and $0-5 \mathrm{~V}$ * |
| Calibration | Factory calibrated to $5 \mu \mathrm{~A}$ |
| Update Rate | 2 msec (all eight channels) |
| Accuracy | $\pm 0.1 \%$ @ $25^{\circ} \mathrm{C} . \pm 0.25 \%$ @ -20 to $70^{\circ} \mathrm{C}$ |
| Resolution | 12 bit (no sign bit) |
| Common Mode Voltage | 1500 Volts |
| Linearity | $<1$ Least Significant Bit |
| Isolation | 1500 Volts RMS between field and logic |
| Common Mode Rejection | $>70$ dB at DC; $>70$ dB at 60 Hz |
| Cross-Channel Rejection | $>80 \mathrm{~dB}$ from DC to 1 kHz |
| Input Impedance | 250 ohms (Current input) or 100 k ohms* (Voltage |
| input) |  |

* Analog inputs can be modified from current inputs to voltage inputs by lifting one leg of the 250 ohm channel resistor. Each channel has its own resistor, so any combination of channels can be converted. If necessary, the response time of the analog input can be improved by replacing the 250 ohm resistor with a 100 k resistor. It is recommended that modules be returned to RTUnet for factory conversion if required. No responsibility will be taken by RTUnet for damage caused to boards during modification performed by clients. The circuit board resistors to change are: channels 1-8=R9-R16.


## Al-1 Wiring Diagram

Terminals 5, 10, 15 and 20 can be used to connect the cable shield. Any combination of 2,3 or 4 -wire transmitters (analog inputs) can be used on each module.


Wiring Examples


### 8.3 Al-10 High Performance Analog Input - 8 Channel

| FEATURES |  |
| :---: | :---: |
| E8:ER 16-Bit Resolution | Isolated DC Output For Loop Power |
|  | - - - Various Current and Voltage Inputs (software configurable) |
| $\frac{1-\text { - }}{\text { F- }}$ Channel to Channel Isolation | 10ms Scan Rate per channel |

The AI-10 is an 8 channel analog input module that has high electrical isolation between the field terminals and the RTU logic and also has channel-to-channel isolation.

The AI-10 provides a 24 volt output for use with loop powered sensors. If the module +24 V is used to supply two or more inputs, channel isolation is disabled between those inputs (inputs supplied by the module +24 V must use the same ground connection which prevents channel isolation). However, isolation is still maintained between the field and the RTU logic.

The AI-10 is fully compatible with previous analog input modules (AI-1 and AI-4) allowing for 8 input channels of $0-20 \mathrm{~mA}$ or $4-20 \mathrm{~mA}$. However, the input wiring has been changed to allow for enhanced channel isolation and the raw scaling of each input is now 0-32767 instead of 0-32760 due to the greater resolution of the ADC.

In addition to the default 0-20mA input range, the AI-10 supports various current and voltage inputs as follows:

| Inputs Supported | Selectable Range |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 10mA |  | 20mA (default) |  | 40mA |  |
|  | Standard | Live Zero | Standard | Live Zero | Standard | Live Zero |
| Positive Current | 0-10mA | 2-10mA | 0-20mA | 4-20mA | 0-40mA | 8-40mA |
| Bipolar Current | -10 to +10 | N/A | -20 to +20 | N/A | -40 to +40 | N/A |
| Positive Voltage | 0-2.5V | 0.5-2.5V | 0-5V | 1-5V | 0-10V | 2-10V |
| Bipolar Voltage | -2.5 to +2.5 | N/A | -5 to +5 | N/A | -10 to +10 | N/A |

Each input has a 250 ohm load resistor mounted inside the module. If a voltage transducer requires a higher input impedance, these input resistors can be factory removed.

The AI-10 module provides an isolated 16-bit ADC that is fully solid state and has an indefinite life. The data from the 16 -bit ADC is converted to a signed 15 -bit binary ( 1 part in 32768) over the range. The placement of the 15 bits from the A/D converter in the \#AI data word is shown below.

MSB
LSB

| $\pm$ | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

l.e. the signal range is + full scale=32767, - full scale $=32768$

To minimise the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields can be connected to ground.

An insert goes between the inside and outside surface of the hinged door. The surface towards the inside of the module (when the hinged door is closed) has circuit
wiring information and circuit identification information can be recorded on the outside surface. The outside left edge of the insert is color-coded blue to indicate a lowvoltage module.

This module consumes power from the +5 VDC and +12 V DC bus. A 24 VDC DC-DC converter mounted within the module is used to provide isolated power to the ADC to provide transmitter loop power (if required).

This module can be installed in any I/O slot of a 4,6 or 12 slot backplane. Up to 11 Analog Input modules can be installed on each backplane.

## Module LEDs

## A-10

ok (L1) pcok
1 5 (F)1 (775



| 4 | 8 | (F)4 |
| :--- | :--- | :--- | :--- |


| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module Fault (no power) |
|  | ON * | Module OK |
|  | One second flash* | Module Fault |
| (L1) | OFF | Normal |
|  | One second flash | Al-10 comms failed to CPU or AI-10 loop power <br> OFF (triggered after 15sec) |
|  | ON | Not defined |
| OC OK | OFF | Al-10 loop power OFF |
|  | ON | Al-10 loop power ON |
|  | OFF | OFF |
|  | ON | Channel Input level < 1\% |
|  | ON | Channel Input level > 1\% |

Note: On power up some LED's may come on for a short time.

* Early revision modules used ON (a very fast flash) to denote module normal and ON bright (steady ON) to denote module fault.


## Al-10 Specifications

| Sub System Isolation | The analog subsystem of the AI-10 is fully isolated from the RTU and digital system. |
| :---: | :---: |
| Isolation | 5000 Volts field to RTU logic |
| Channel Isolation | 40VDC channel-to-channel <br> Note: channel isolation is disabled between channels commonly powered by the module 24 V supply. |
| Input Voltage ranges * | 1-5, 0-5, $\pm 2.5, \pm 5, \pm 10$ Volts DC (software selectable) |
| Input Current ranges | 4-20, 0-20, $\pm 10, \pm 20, \pm 40 \mathrm{~mA}$ (software selectable) |
| Live Zero | Software configurable (e.g. 0-20 becomes 4-20mA) |
| Input | Fully differential inputs |
| Input bias current | <2 nA |
| Input impedance | 250 Ohm (default) <br> 1 Gigaohm / 100 pF (optional - the internal load resistors can be factory removed if high impedance voltage inputs are required) |
| Maximum sensor source impedance | 10 k ohms if high speed scanning is used, 100 k ohms if medium speed scanning in use. |
| Common mode range active selected channel | $\pm 12$ Volts on 10V range, $\pm 7$ on other ranges |
| Common mode range non selected channel | $\pm 15$ Volts |
| Common mode rejection | 80 dB minimum |
| Accuracy | $\pm 0.1 \%$ @ 25 ${ }^{\circ} \mathrm{C}$ + 0.25\% @ -20 to 70C |
| Resolution | 16 bit (15 data bits and 1 sign bit) |
| Scanning Rate | The actual measurement sub-system is capable of scanning at better than 10 milliseconds per channel. In the 50 Hz rejection mode this reduces to one channel per 20 milliseconds (plus time to make the zero and calibration checks). |
| DC Fast Mode | >100 readings per second |
| Fast 50Hz Rejection Mode | Average rate of 25 channels per second |
| Fast 60Hz Rejection Mode | Average rate of 30 channels per second |
| Fault Mode - protection | The input multiplexer integrated circuits are designed to withstand pulses of up to 100 Volts. In addition the input protection circuit will clamp differential mode voltages above 12 Volts and common mode input pulses above 28 Volts to ground using high speed Tranzorbs. |
| Fault Mode - interference with other channels | The channel in fault mode (e.g. 50 Volts different to common potential) cannot be measured while in fault mode. The effect on other channels will depend on the input impedance of the other channel. With an input impedance of less than 1000 ohms the effect of leakage currents from channels in fault condition of 50 Volts is likely to cause less than $0.1 \%$ error to the other channel. |
| AC Measurements | Not available in release version 1. |
| Output Power | Isolated 24VDC @ 160mA |

* Analog inputs can be modified from current inputs to voltage inputs by lifting one leg of the 250 ohm channel resistor. Each channel has its own resistor, so any combination of channels can be converted. If necessary, the response time of the analog input can be improved by replacing the 250 ohm resistor with a 100 k resistor. It is recommended that modules be returned to RTUnet for factory conversion if required. No responsibility will be taken by RTUnet for damage caused to boards during modification performed by clients. The circuit board resistors to change are: channels 1 to $8=$ R64 to R71.


## Al-10 Wiring Diagram

Any combination of 2, 3 or 4 -wire transmitters can be used on each module.


* When using the +24 V output to power a transmitter, the negative input terminal of the analog input channel ( $2,4,6,8,12,14,16$ or 18 ) must be wired to the OV terminal (10 or 20). This will complete the current loop due to electrical isolation between the input channel and the module +24 V supply.

Note: Any channels sharing the same power source (e.g. +24 V from module or a field power supply) are no longer isolated from one other.

### 8.4 AO-2 Analog Current Output - 4 Channel

| FEATURES |  |
| :---: | :---: |
| B8:P成 12-Bit Resolution | \| - - 0-20 or 4-20mA Outputs |
| Fy/ 3kV Field to Logic Isolation | $\stackrel{\mid-\Theta^{-}}{\boldsymbol{\rho}^{-}}$Channel to Channel Isolation |

The AO-2 provides four current output channels that use 12-bit digital to analog converter (DAC). The sign bit is not used in the conversion process. The placement of the 12 bits within the data word is shown below.
MSB

| 0 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | 0 | 0 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

If the module is sent data that is out of range (less than 0 or greater than 32767 ), the software does not accept the value.

This module provides two output ranges. The default range is 4 to 20 mA with user data scaled so that a count of 0 corresponds to 4 mA and a count of 32760 corresponds to 20 mA . A range link (on the rear of the module) selects either $4-20 \mathrm{~mA}$ or $0-20 \mathrm{~mA}$ for all four channels. The default condition is $4-20 \mathrm{~mA}$ with the link on. The module provides 12 bits of resolution in either range. Scaling of the output is as shown below.



Figure 8-5a: AO-2 Scaling for Current Output
An isolated voltage source of +24 V is generated in the module to drive the current loop outputs and the D/A converter. The current loop drivers on the module are source type drivers. Two output drivers share a common DC/DC converter. To minimise the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields should be connected to $E$ (Shield) on the user terminal connector block. The E connection provides access to the backplane (frame ground) resulting in superior rejection of noise caused by any shield drain currents. The module provides electrical isolation of externally generated noise between field wiring and the backplane through use of optical isolation.

This module can be installed in any I/O slot of a 4, 6 or 12 slot backplane in a system.


Link for $4-20 \mathrm{~mA}$
operation. Remove
for $0-20 \mathrm{~mA}$
operation.
Factory default:
Link installed

Figure 8-5b: AO-2 Rear Module and Link Location

## Module LEDs

## AO-2

OK
${ }^{81}$
B2
${ }^{\text {B }}$
${ }^{84}$

| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON * | Normal |
| B1-4 | OFF | Channel output level $<1 \%$ |
|  | ON | Channel output level $>1 \%$ |

## AO-2 Load Current Characteristics



## AO-2 Specifications

| Output Current Range | 4 to 20 mA and 0 to 20 mA |
| :--- | :--- |
| Calibration | Factory calibrated to $5 \mu \mathrm{~A}$ per count |
| Supply Voltage (nominal) | +5 V and +12 VDC backplane |
| Update Rate | 250 msec (all channels) Determined by I/O scan <br> time and is application dependent |
| Resolution | 12 bit (no sign bit) |
| Accuracy | $\pm 0.2 \%$ @ $25^{\circ} \mathrm{C} . \pm 0.5^{2} \%$-20 to $700^{\circ} \mathrm{C}$ |
| User Load | 0 to 850 ohms |
| Output Load Capacitance | 2000 pF |
| Output Load Inductance | 1 H |
| Isolation | 3000 Volts RMS between field and logic |
| 1500 Volts RMS between channel groups |  |
| Operating Temperature | -20 to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH non-condensing |

AO-2 Wiring Diagram


## Wiring Example



## Chapter $9 \quad$ Series II Digital Modules

### 9.1 DI-5 DC Input, 16 Channel

| FEATURES |  |
| :---: | :---: |
| 』 L Pulse Counting on 4 Inputs | Isolated DC Output For Powering Inputs |
| 子 $\backslash 1 / 2 \mathrm{CV}$ Field to Logic Isolation | Positive or Negative Polarity inputs |

The DI-5 provides 16 dry contact input points in one group with common power for field contacts. A wide range of input devices that are powered by the module can be used such as push buttons, limit switches and electronic proximity switches (these provide dry contact closures). Alternatively inputs can accept 10 to 28 Volts DC from an externally powered input.

Closure of the field contact results in a logic 1 in the status register.
The DI-5 counter module is similar to the DI-1, 16 channel digital input module (the DI5 also has 16 digital inputs and can act like a DI-1). However, the DI-5 also counts pulses on the first 4 digital inputs. It is able to count up to 10 kHz on inputs 1 and 2 and can count up to 255 Hz on inputs 3 and 4 . Inputs 5 to 16 are normal digital input channels. The pulse total and the pulse rate for each of the first 4 digital inputs are stored in internal registers.

This module can be installed in any I/O slot of a 4,6 or 12 slot backplane system.

## Module LEDs



| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON | Normal |
| A1-A8 | OFF | Digital input OFF |
|  | ON | Digital input ON |

## DI-5 Specifications

| Output Power | 12VDC @ 80mA (1W) isolated, supplied by module |
| :---: | :---: |
| Input Voltage Range | $\pm 10$ to 28 VDC (can use reverse polarity) ( 0 to $3.5 \mathrm{~V}=\mathrm{OFF}, 7.5$ to $28 \mathrm{~V}=\mathrm{ON}$ ) |
| Inputs per Module | 16 |
| Isolation | 1000 Volts RMS between field and logic |
| Contact Current | 4mA (typical) |
| Input Characterist |  |
| On-state Current | 4.3 mA minimum |
| Off-state Current | 1 mA maximum |
| On response Time | Digital Inputs 1 and 2: $50 \mu$ s maximum Digital Inputs 3 and 4:500 $\mu \mathrm{s}$ maximum Digital Inputs 5 to 16: 10ms maximum |
| Off response Time | Digital Inputs 1 and 2: $50 \mu \mathrm{~s}$ maximum Digital Inputs 3 and 4:500 4 s maximum Digital Inputs 5 to 16: 17ms maximum |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to 98\% non-condensing |
| Pulse Totalisation | Digital Inputs 1 to 4: 0-65535 Pulses |
| Pulse Rates / Frequency | Digital Inputs 1 and 2: 10kHz maximum Digital Inputs 3 and 4: 255 Hz maximum |

## DI-5 Wiring Diagram



## Wiring Examples



### 9.2 DI-10 AC or DC Input, 16 Channel

| FEATURES |  |  |
| :---: | :---: | :---: |
| $\llbracket$ | Frequency or Pulse or Quadrature Counting on any 7 Inputs |  |
| hn | Software Debounce Filter | 4 - AC or DC Inputs |
| $\frac{\\|}{t+1}$ | Sequence of Events Recording | 子寿 3kV Field to Logic Isolation |

The DI-10 provides 16 input points in one group with common power for field contacts. The inputs are designed for wide ranging DC and AC input signals from external devices. A wide range of input devices that are powered by the module can be used such as push buttons, limit switches and electronic proximity switches (these provide dry contact closures). Alternatively inputs can be powered externally by DC and AC input signals.

Closure of the field contact results in a logic 1 in the status register.
The DI-10 module provides all the functionality of the DI-1 and DI-5 modules except the field voltage polarity cannot be reversed. It has software configurable debounce filters, channel inversion and Sequence-of-Events recording selectable on any channel(s). Frequency, pulse or quadrature counting can also be configured for any 7 input channels.

This module can be installed in any I/O slot of a 4,6 or 12 slot backplane system.

## Module LEDs



| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module Fault (no power) |
|  | ON | Normal OK |
| PCON | OFF | DI-10 output power OFF |
|  | ON | DI-10 output power ON |
| A1-A8, <br> B9-B16 | OFF | ON |
|  | Digital input OFF |  |

## Configurable Functions

The first 4 channels are high speed inputs, capable of counting up to 10 kHz ; the other 12 inputs can count up to 1 kHz . The DI-10 module has 7 user-configurable counter inputs, which appear as 16-bit unsigned integer values in the analog input registers. These can each be configured as frequency counters for any input channel to 1 Hz resolution, or pulse counters, or quadrature counters which work with quadrature inputs on pairs of channels.

Channel inversion can be configured on any input channels. Normally a high voltage level applied to a digital input channel will result in a logical 1 state in the digital input register, and the LED on the front panel of the module being set ON. A low voltage level will result in a logical 0 state in the digital input register, and the LED will be OFF. By configuring channel inversion, the situation is reversed: a high voltage level results in a logical 0 state and the LED is set OFF; a low voltage level results in a logical 1 state and the LED is set ON.

Software Debounce Filters can be configured for any input channel, with a time constant from 1 millisecond to 250 milliseconds. When using AC inputs, the input channels must be configured with a debounce filter of 'AC Filter'.

## Sequence-of-Events Recording

Sequence-of-Events (SoE) recording can be configured for any input channel. When SoE is enabled, any event (change of state) on the input channel is logged to 1 millisecond accuracy. This event is automatically included in the Event Log of the RTU. The DI-10 module has a timer that is automatically synchronised with the realtime clock of the processor module.

The DI-10 module has an internal buffer with enough space for 1000 events. The DI10 module can therefore cope with bursts of up to 1000 events at a time. Events are uploaded into the processor module at a maximum rate of 100 events per second allowing the Dl-10 module to cope with events at a sustained rate of 100 events per second.

## Dl-10 Specifications

| Output Power | 12VDC @ 80mA (1W) isolated, supplied by module |
| :---: | :---: |
| Input Voltage Range | $+6 \text { to }+130 \mathrm{VDC}(0-4.9 \mathrm{~V}=\mathrm{OFF}, 5.2-130 \mathrm{~V}=\mathrm{ON})$ <br> (Note: a negative DC supply can be used provided that the channel input voltage is more positive than the common) <br> 20 to 260VAC |
| Inputs per Module | 16 |
| Isolation | 3000 Volts RMS between field and logic |
| Contact Current | 4mA (typical) |
| On-state Current | 4.3mA minimum |
| Off-state Current | 1 mA maximum |
| On response Time | Digital Inputs 1 to 4: $50 \mu \mathrm{~s}$ maximum* Digital Inputs 5 to 16: $500 \mu$ s maximum |
| Off response Time | Digital Inputs 1 to 4: $50 \mu$ s maximum* (DC) Digital Inputs 5 to 16: $500 \mu \mathrm{~s}$ maximum (DC) Digital Inputs 1-16: 30ms (AC) |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to 98\% non-condensing |
| Pulse Rates / <br> Frequency | Digital Inputs 1 to $4: 10 \mathrm{kHz}$ maximum* Digital Inputs 5 to $16: 1 \mathrm{kHz}$ maximum |
| Frequency Counting | 1 Hz resolution on any input(s) (7 counters max.) |
| Pulse Totalisation | 0-65535 Pulses on any input(s) (7 counters max.) |
| Quadrature Counting | 0-65535 Pulses on any input(s) (7 counters max.) |
| Channel Inversion | Selectable on any input(s) |
| Debounce Filtering | Time constant 1-250 ms on any input(s) or AC Filter (for AC inputs). |
| Sequence of Events | 1 millisecond resolution <br> Buffering for 1000 events, uploaded to CPU at 100 events/second Selectable on any input(s) |

* Version 1.1 and older DI-10 modules are rated at 1 kHz for all 16 channels.


## DI-10 Wiring Diagram



Wiring Examples


### 9.3 DO-1 Isolated Relay Output, NO/NC, 8 Channel



The DO-1 provides 8 normally-open or normally closed relay circuits for controlling output loads. Output channels are isolated from the other channels and each pair of channels has a separate common terminal. The relay outputs can control a wide range of user-supplied load devices, such as: motor starters, solenoids and indicators. The user must supply the AC or DC power to operate the field devices connected to this module. Internal fuses protect the relay contacts should ratings be exceeded.

The insert in the hinged cover of the terminal strip has circuit wiring information. Circuit identification information can be recorded on the outside surface of the insert. The outside left edge of the insert is color-coded red to indicate a high-voltage module.

## Module LEDs

DO-1


| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON | Normal |
| FU | OFF | Fuse OK |
|  | ON | Fuse fail |
| A1, A2 | OFF | Digital output OFF (open) |
|  | B3, , C4 | ON |
| C5, C6 |  | Digital output ON (closed) |
| D7, D8 |  |  |

DO-1 Specifications

| Outputs per Module | 8 |
| :--- | :--- |
| Commons | 4 (each common supplies 2 outputs) |
| Relay Type | SPDT (Single Pole, Double Throw) |
| Rated Load (per contact) | 5 A at 250VAC Resistive <br> 5 A at 30VDC Resistive <br> (20A maximum per DO-1 module) |
| Maximum Operating Voltage | $380 \mathrm{VAC}, 125 \mathrm{VDC}$ |
| Maximum Switching Power - Resistive | $1250 \mathrm{VA}, 150 \mathrm{~W}$ |
| Maximum Switching Power - Inductive | $375 \mathrm{VA}, 80 \mathrm{~W}$ |
| Minimum Load | 10 mA at 5VDC |
| Relay Operations | 100,000 minimum at 1800 operations <br> per hour at rated load |
| Operating Temperature | -25 to $70^{\circ} \mathrm{C}$ (no icing) |
| Humidity | $5 \%$ to $85 \%$ |
| Isolation | 3 kV coil to contacts <br> 500 V between channel groups |
| Coil Rated Voltage | 12 VDC @ 16.7mA |
| Coil Resistance | 480 Ohm @ 12VDC |
| Relay Part Number | Omron G6B-2114P-US (datasheet is <br> available from www.europe.omron.com) |

CAUTION! Contacts can be protected with appropriate suppression devices when wired with inductive loads to increase life of relays. Contacts should also be protected with external fusing.

## Switching Inductive Loads

When switching inductive loads, relay contact life can be maximised by using suppression circuits (as shown below). These circuits suppress the large back current and EMF generated when an inductive load is switched off.


DO-1 Wiring Diagram


### 9.4 DO-2 Relay Output, NO, 16 Channel



The DO-2 provides 16 normally-open relay circuits for controlling output loads provided by the user. The output points are arranged in two groups of eight points each. Each group has one common terminal. The relay outputs can be used to control a wide range of devices such as motor starters, solenoids, and indicators. Internal fuses protect the DO-2 relay contacts should ratings be exceeded.

The insert in the hinged cover of the terminal strip has circuit wiring information. Circuit identification information can be recorded on the outside surface of the insert. The outside left edge of the insert is color-coded red to indicate a high-voltage module.

## Module LEDs



| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON | Normal |
| FU | OFF | Fuse OK |
|  | ON | Fuse fail |
| A1-A16 | OFF | Digital output OFF (open) |
|  | ON | Digital output ON (closed) |

DO-2 Specifications

| Outputs per Module | 16 |
| :--- | :--- |
| Commons | 2 (each common supplies 8 outputs) |
| Relay Type | SPST-NO (Single Pole, Single Throw) |
| Rated Load (per output) | 5 A at 250VAC Resistive <br> 5 A at 30VDC Resistive <br> (8A maximum per common) |
| Isolation | 3 kV coil to contacts |
| Maximum Operating Voltage | $250 \mathrm{VAC}, 30 \mathrm{VDC}$ |
| Maximum Switching Power - Resistive | $1250 \mathrm{VA}, 150 \mathrm{~W}$ |
| Minimum Load | 10 mA at 5VDC |
| Contact Resistance | $100 \mathrm{~m} \Omega$ maximum |
| Relay Operations | 100,000 minimum at 1800 operations <br> per hour at rated load |
| Operating Temperature | -40 to $70^{\circ} \mathrm{C}$ (no icing) |
| Humidity | $5 \%$ to $85 \%$ |
| Coil Rated Voltage | $12 \mathrm{VDC} \mathrm{@} \mathrm{16.7mA}$ |
| Coil Resistance | 720 Ohm @ 12VDC |

CAUTION! Contacts can be protected with appropriate suppression devices when wired with inductive loads to increase life of relays (please see DO-1 for suppression circuits). Contacts should also be protected with external fusing.

## DO-2 Wiring Diagram



* Optional link for DC SUPPLY ONLY. Enables fuse fail LED 'FU' on module. CAUTION! Damage will occur if link installed when using $A C$ to power Common.
* Optional link for DC SUPPLY ONLY. Enables fuse fail LED 'FU' on module. CAUTION! Damage will occur if link installed when using AC to power Common.


### 9.5 DO-5 Relay Driver Output - 16 Channel

## FEATURES



| 16 Open Collector Outputs - <br> designed to operate the TEL <br> REL 002 relay board | $\mp$ | DC Output for Powering |
| :--- | :--- | :--- |
| Output Circuits |  |  |

The DO-5 provides 16 open collector output circuits for controlling the TEL REL 002 relay board. Power for the external relay circuits is provided by the +12 VDC bus on the backplane with a maximum of three DO-5 modules per backplane/PS-xx power supply.

The insert in the hinged cover of the terminal strip has circuit wiring information. Circuit identification information can be recorded on the outside surface of the insert. The outside left edge of the insert is color-coded red to indicate a high-voltage module.

## Module LEDs

## DO-5

| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON | Normal |
| FU | OFF | Fuse OK |
|  | ON | Fuse fail |
| A1-A16 | OFF | Digital loutput OFF (open) |
|  | ON | Digital output ON (closed) |

DO-5 Specifications

| Outputs per Module | 16 |
| :--- | :--- |
| Commons | 2 (8 outputs per common) |
| Rated Voltage | 12 VDC |
| Operating Voltage | 5 to 32 VDC |
| Output Type | Transistor, Open Collector |
| Isolation | None |
| Maximum Load <br> (outputs powered by module) | 50 mA per channel <br> 800 mA maximum per module |
| Minimum Load | 0.1 mA |
| Maximum Inrush | 300 mA |
| On Response Time | 15 ms maximum |
| Off Response Time | 15 ms maximum |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $+85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ non-condensing |

DO-5 Wiring Diagram


## Wiring Examples



When output is energised, output channel is shorted to the 0 V terminal.

### 9.6 TEL REL 002, SPDT Relay Board For DO-5

| FEATURES |  |
| :---: | :---: |
| 16 Relay Outputs - SPDT | 気这 5 kV Coil to Contact Isolation |
| 1 Common Per Channel | 4 Can Switch AC or DC Voltages |

The 16 point relay board is designed for use with the DO-5 module and provides 16 $S P D T$ voltage free output contacts. The relay contacts are terminated on a Phoenix double height PCB terminal unit arranged in a dual three way terminal (please see wiring diagram). These terminals can take wire sizes up to $4 \mathrm{~mm}^{2}$.

Each relay consumes $43 \mathrm{~mA} @+12 \mathrm{VDC}$ from the backplane power supply. An external supply can be connected to a screw terminal on the PCB if required (not if used with the standard cable supplied with the DO-5 module).

LED indicators are provided for each relay on the relay board. LED ON = relay active.

Relay Output Terminal Board - TEL REL 002 Specifications

| Outputs per Terminal Board | 16 |
| :---: | :---: |
| Commons | 16 (1 common per channel) |
| Relay Type (per channel) | SPDT (Single Pole, Double Throw) |
| Rated Load (per contact) | 16A @ 250VAC Resistive 16A @ 30VDC Resistive |
| Maximum Operating Voltage | 380VAC, 125VDC |
| Maximum Switching Power - Resistive | 16A @ 30VDC 5A @ 48VDC 0.6A @ 125VDC |
| Maximum Switching Power - Inductive | $\begin{aligned} & \text { 16A @ 12VDC } \\ & \text { 8A @ 30VDC } \\ & 0.7 A @ 48 V D C \\ & 0.45 A @ 125 V D C \end{aligned}$ |
| Minimum Load | 100 mA at 5VDC |
| Contact Resistance | $100 \mathrm{~m} \Omega$ maximum |
| Relay Operations | 100,000 minimum at 1800 operations per hour at rated load |
| Operating Temperature | -40 to $70{ }^{\circ} \mathrm{C}$ (no icing) |
| Humidity | 5\% to 85\% |
| Isolation | 5 kV coil to contacts |
| Coil Rated Voltage | 12VDC @ 43mA |
| Coil Resistance | 275 @ @ 12VDC |
| Dimensions | $253 \mathrm{~mm}(\mathrm{~L}) \times 90 \mathrm{~mm}(\mathrm{~W}) \times 70 \mathrm{~mm}(\mathrm{H})$ (280mm long with 2 end clamps) |
| Mounting | 35 mm DIN rail |
| Interface cable length (for connection to the DO-5 module) | 0.8 m to 3.0 m (made to order) |
| Relay Part Number | Omron G2R-1-E (datasheet is available from www.europe.omron.com) |

CAUTION! Contacts can be protected with appropriate suppression devices when wired with inductive loads to increase life of relays (please see DO-1 for suppression circuits). Contacts should also be protected with external fusing.

Relay Output Terminal Board - TEL REL 002 Wiring Diagram


Terminal Layout For Each Output Channel


Interface Cable - DO-5 To TEL REL 00x Relay Board

To DO-5 Module


| Belden 9431 Cable Color | Fujicon Pin | DO-5 | Multi-core cable Belden 9431 cable | Relay Board Panduit 20way Header |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Black | 1 | CH1 |  | 1 | CH1 |
| White | 2 | CH 2 |  | 2 | CH2 |
| Red | 3 | CH3 |  | 3 | CH3 |
| Green | 4 | CH4 |  | 4 | CH4 |
| Orange | 5 | CH5 |  | 5 | CH5 |
| Blue | 6 | CH6 |  | 6 | CH6 |
| White/Black | 7 | CH7 |  | 7 | CH7 |
| Red/Black | 8 | CH8 |  | 8 | CH8 |
| Green/Black | 9 | OV |  | 9 | OV |
| Orange/Black | 10 | OV |  | 10 | OV |
| Blue/Black | 11 | CH9 |  | 11 | CH9 |
| Black/White | 12 | CH10 |  | 12 | CH10 |
| Red/White | 13 | CH11 |  | 13 | CH11 |
| Green/White | 14 | CH12 |  | 14 | CH12 |
| Blue/White | 15 | CH13 |  | 15 | CH13 |
| Black/Red | 16 | CH14 |  | 16 | CH14 |
| White/Red | 17 | CH15 |  | 17 | CH15 |
| Orange/Red | 18 | CH16 |  | 18 | CH16 |
| Blue/Red | 19 | +12V |  | 19 | +12V |
| Green/Red | 20 | +12V |  | 20 | +12V |

# Chapter 10 Combination I/O Modules 

### 10.1 IO-2 Combination Digital I/O Module



This module can be installed in any I/O slot of a 4, 6 or 12 slot backplane in a system

## Digital Inputs

The digital inputs are designed to be powered using an external power supply. A wide range of digital input devices can be used such as push buttons, limit switches and electronic proximity switches. Current through an input (in either direction) results in a logic 1 in the status register. Power to operate the field devices must also be supplied by the user.

## Digital Outputs

The output points are arranged in one group of eight points with one common. The output switching capacity of each output is 2 amps. The relay outputs can control a wide range of load devices such as motor starters, solenoids and indicators. Power for the internal relay circuits is provided by the +12VDC bus on the backplane. The user must supply the AC or DC power to operate the field devices. An internal fuse protects the relay contacts should ratings be exceeded.

## Module LEDs



| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON | Normal |
| FU | OFF | Fuse OK |
|  | ON | Fuse fail |
| A1-A8 | OFF | Digital input OFF |
|  | ON | Digital input ON |
| B1-B8 | OFF | Digital output OFF (open) |
|  | ON | Digital output ON (closed) |

## IO-2 Load Current Limitations

| Operating Voltage | Maximum Current |  | Typical Number <br> of Operations |
| :---: | :---: | :---: | :---: |
|  | Resistive | Lamp or Solenoid* | 200,000 |
| $240 V A C, 120 V A C$, <br> $24 V D C$ | 2 amps | 0.6 amps | 400,000 |
| $240 V A C, 120 V A C$, <br> $24 V D C$ | 1 amp | 0.3 amps | 800,000 |
| $240 V A C, 120 V A C$, <br> $24 V D C$ | 0.5 amps | 0.1 amp | 2 |

* For inductive loads

CAUTION! Contacts can be protected with appropriate suppression devices when wired with inductive loads to increase life of relays (please see DO-1 for suppression circuits). Contacts should also be protected with external fusing.

## IO-2 Wiring Diagram

Note: Input and output groups have separate commons allowing separate power supplies

## Wiring Examples



IO-2 Specifications

## DIGITAL INPUTS

| Rated Voltage | 24 Volts AC/DC (can use reverse polarity) |
| :--- | :--- |
| Input Voltage Range | 0 to 30 Volts AC/DC |
| Inputs per Module | 8 |
| Isolation | 3000 Volts RMS between field and logic |
| Input Current | 4 mA (typical) at rated voltage |
| Input Characteristics: |  |
| On-state Voltage |  |
| Off-state Voltage | 11.5 to 30 Volts AC/DC |
| On-state Current | 3.2 mA minimum |
| Off-state Current | 1 mA maximum |
| On response Time | 10 ms typical |
| Off response Time | 17 ms typical |
| DIGITAL OUTPUTS |  |


| DIGITAL OUTPUTS |  |
| :--- | :--- |
| Rated Voltage | 24 Volts DC, $120 / 240$ Volts AC |
| Operating Voltage | 5 to 30 Volts DC <br> 5 to 250 Volts AC, $50 / 60 ~ H z ~$ |
| Outputs per Module | 8 |
| Isolation | 3000 Volts RMS between field and logic |
| Maximum Load | 2 amps pilot duty maximum per output <br> 8 amps maximum per common |
| Minimum Load | 10 mA |
| Maximum Inrush | 5 amps |
| On Response Time | 15 ms maximum |
| Off Response Time | 15 ms maximum |
| GENERAL | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Operating Temperature | $-40^{\circ}$ to $+85^{\circ} \mathrm{C}$ |
| Storage Temperature | 5 to $95 \%$ non-condensing |
| Humidity |  |

### 10.2 IO-3 Combination Analog/Digital I/O Module

| FEATURES |  |
| :---: | :---: |
| 4. 4 Relay Outputs - SPST | - 4 Digital Inputs |
| F- 4 Analog Inputs | \|- 1 Analog Output |

This module can be installed in any I/O slot of a 4,6 or 12 slot backplane system.

## Analog I/O

This module provides two signal ranges, 0 to 20 mA and 4 to 20 mA . The default range is $4-20 \mathrm{~mA}$. A link on the rear of the module selects $4-20 \mathrm{~mA}$ (link installed) or $0-20 \mathrm{~mA}$ I/O for all channels.

Resolution of the converted signals is 12 bits binary (1 part in 4096). The sign bit is not used in the conversion process. All channels are updated four times per second. The placement of the bits within the data word is shown below.
MSB

| 0 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | 0 | 0 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

Scaling of the input is shown below.



Figure 10-2a: IO-3 Scaling for Analog Current Input
All inputs share a single common and all outputs share a separate common at the zero volt rail.

Input protection for the module is sufficient to guarantee operation with reduced performance with up to 1500 V common-mode. The module provides electrical isolation of externally generated noise between field wiring and the backplane through the use of optical isolation.

To minimise the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields can be connected to E. The E connection provides access to the backplane (frame ground).


Figure 10-2b: IO-3 Rear Module and Link Location

## Digital I/O

Input characteristics are compatible with a wide range of user supplied input devices, such as push buttons, limit switches and electronic proximity switches, whilst outputs can control a wide range of user supplied load devices such as: motor starters, solenoids and indicators. Power for the internal relay circuits is provided by the +12 VDC bus on the backplane. The user must supply the AC or DC power to operate field devices. An internal fuse protects the relay contacts should ratings be exceeded.

## Module LEDs



| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON | Normal |
| FU | OFF | Fuse OK |
|  | ON | Fuse fail |
| A1-A4 | - | Not used |
| B1 | - | Not used |
| C1-C4 | OFF | Digital input OFF |
|  | ON | Digital input ON |
| D1-D4 | OFF | Digita loutput OFF (open) |
|  | ON | Digital output ON (closed) |

IO-3 Analog Specifications

| ANALOG INPUTS |  |
| :---: | :---: |
| Input Current Ranges | 4 to 20 mA and 0 to 20 mA |
| Input Voltage Ranges* | 1 to 5 V and 0 to 5 V * |
| Calibration | Factory calibrated to $5 \mu \mathrm{~A}$ |
| Update Rate | 2 msec (all four channels) |
| Accuracy | $\pm 0.1 \%$ @ 25 ${ }^{\circ}$. $\pm 0.25 \%$ @ -20 to 70C |
| Resolution | 12 bit (no sign bit) |
| Common Mode Voltage | 1500 Volts |
| Linearity | <1 Least Significant Bit |
| Isolation | 1000 Volts RMS between field and logic |
| Common Mode Rejection | $>70 \mathrm{~dB}$ at DC; $>70 \mathrm{~dB}$ at 60 Hz |
| Cross-Channel Rejection | $>80 \mathrm{~dB}$ from DC to 1 kHz |
| Input Impedance | 250 ohms (100 ohms optional) |
| Input Filter Response | 325 Hz |
| ANALOG OUTPUT |  |
| Output Current Range | 4 to 20 mA and 0 to 20 mA |
| Calibration | Factory calibrated to $68 \mu \mathrm{~A}$ per count |
| Supply Voltage (nominal) | +5V and +12VDC from backplane |
| Update Rate | 250 msec (all channels) Determined by I/O scan time, and is application dependent |
| Accuracy | $\pm 0.2 \%$ @ 25C. $\pm 0.5 \%$ @ -20 to 70 ${ }^{\circ} \mathrm{C}$ |
| Resolution | 12 bit (no sign bit) |
| User Load | 0 to 850 ohms |
| Output Load Capacitance | 2000 pF |
| Output Load Inductance | 1H |
| Isolation | 1000 Volts RMS between field and logic |

* Analog inputs can be modified from current inputs to voltage inputs by lifting one leg of the 250 ohm channel resistor. Each channel has its own resistor, so any combination of channels can be converted. If necessary, the response time of the analog input can be improved by replacing the 250 ohm resistor with a 100 k resistor. It is recommended that modules be returned to RTUnet for factory conversion if required. No responsibility will be taken by RTUnet for damage caused to boards during modification performed by clients. The circuit board resistors to change are: channels $1-4=$ R 39, R41, R43 and R45

IO-3 Digital And General Specifications

| DIGITAL INPUTS |  |
| :---: | :---: |
| Rated Voltage | 24 Volts AC/DC |
| Input Voltage Range | 0 to 30 Volts AC/DC |
| Inputs per Module | 4 |
| Isolation | 1000 Volts RMS between field and logic |
| Input Current | 4 mA (typical) at rated voltage |
| Input Characteristics: |  |
| On-state Voltage | 11.5 to 30 Volts AC/DC |
| Off-state Voltage | 0 to +4 Volts AC/DC |
| On-state Current | 3.2 mA minimum |
| Off-state Current | 1 mA maximum |
| On response Time | 10 ms typical |
| Off response Time | 17ms typical |
| DIGITAL OUTPUTS |  |
| Rated Voltage | 24 Volts DC, 120/240 Volts AC |
| Operating Voltage | $\begin{aligned} & 5 \text { to } 30 \text { Volts DC } \\ & 5 \text { to } 250 \text { Volts AC, } 50 / 60 \mathrm{~Hz} \end{aligned}$ |
| Outputs per Module | 4 |
| Isolation | 1000 Volts RMS between field and logic 500 Volts RMS between groups |
| Maximum Load | 2 amps pilot duty maximum per output 8 amps maximum per common |
| Minimum Load | 10 mA |
| Maximum Inrush | 5 amps |
| On Response Time | 15 ms maximum |
| Off Response Time | 15 ms maximum |
| GENERAL |  |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $+85^{\circ} \mathrm{C}$ |
| Humidity | 5 to 95\% non-condensing |
| Output Power | 24VDC @ 125mA (3W) Isolated |

CAUTION! Contacts can be protected with appropriate suppression devices when wired with inductive loads to increase life of relays (please see DO-1 for suppression circuits). Contacts should also be protected with external fusing.

## IO-3 Wiring Diagram

There are three separate isolated groups - one for the analog input/output, one for the digital input and one for the digital output. Each group may be powered from a separate source.


Wiring Examples


### 10.3 IO-4 Combination Analog/Digital I/O Module



This module can be installed in any I/O slot of a 4,6 or 12 slot backplane system.

## Analog Inputs

This module provides two signal ranges, 0 to 20 mA and 4 to 20 mA . The default range is $4-20 \mathrm{~mA}$. A link on the rear of the module selects $4-20 \mathrm{~mA}$ (link installed) or $0-20 \mathrm{~mA}$ I/O for all channels.

Channel 1 can be optionally configured in the factory for a strain gauge input of range approximately 50 mV . 5 V excitation voltage is also supplied from this module. Calibration of the transducer can be performed using Toolbox software and the calibration constants are held in non-volatile memory.

Resolution of the converted signals is 12 bits binary (1 part in 4096). The sign bit is not used in the conversion process. The placement of the bits within the data word is shown below.

MSB LSB

| 0 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | 0 | 0 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

Scaling of the input is shown below.



Figure 10-3a IO-4 Scaling for Analog Current Input

All inputs share a single common and all outputs share a separate common at the zero volt rail.

Input protection for the module is sufficient to guarantee operation with reduced performance with up to 1500 V common-mode. The module provides electrical isolation of externally generated noise between field wiring and the backplane through the use of optical isolation.

To minimise the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields can be connected to E . The E connection provides access to the backplane (frame ground).


Figure 10-3b: IO-4 Rear Module and Link Location

## Digital I/O

Input characteristics are compatible with a wide range of user supplied input devices, such as push buttons, limit switches and electronic proximity switches, whilst outputs can control a wide range of user supplied load devices such as: motor starters, solenoids and indicators. Power for the internal relay circuits is provided by the +12 VDC bus on the backplane. The user must supply the AC or DC power to operate field devices. An internal fuse protects the relay contacts should ratings be exceeded.

## Module LEDs



| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module fault (no power) |
|  | ON | Normal |
|  | OFF | Fuse OK |
|  | ON | Fuse fail |
| A1-A8 | OFF | Digital Input OFF |
|  | ON | Digita linput ON |
| B1-B2 | OFF | Digital output OFF (open) |
|  | ON | Digital output ON (closed) |

IO-4 Analog Specifications

| ANALOG INPUTS |  |
| :---: | :---: |
| Input Current Ranges | 4-20mA and 0-20mA |
| Input Voltage Ranges * | $1-5 \mathrm{~V}$ and $0-5 \mathrm{~V}$ * |
| Calibration | Factory calibrated to $5 \mu \mathrm{~A}$ |
| Update Rate | 2 msec (all four channels) |
| Accuracy | $\pm 0.1 \%$ @ $25^{\circ} \mathrm{C} . \pm 0.25 \%$ @ -20 to 70 |
| Resolution | 12 bit (no sign bit) |
| Common Mode Voltage | 1500 Volts |
| Linearity | <1 Least Significant Bit |
| Isolation | 1000 Volts RMS between field and logic |
| Common Mode Rejection | $>70 \mathrm{~dB}$ at DC; $>70 \mathrm{~dB}$ at 60 Hz |
| Cross-Channel Rejection | $>80 \mathrm{~dB}$ from DC to 1 kHz |
| Input Impedance | 250 ohms (100 ohms optional) |
| Input Filter Response | 325 Hz |
| STRAIN GAUGE (optional - note: module requires factory modification) |  |
| Input Range | 0-50mV (max) |
| Calibration | Software by user and Toolbox |
| Excitation Supply | +5V @ 4mA (max) |
| Update Rate | 250 msec Determined by I/O scan time and is application dependent |
| Resolution | 12 bit (no sign bit) |
| Accuracy | $\pm 0.1 \%$ @ 25 ${ }^{\circ} \mathrm{C}$. $\pm 0.25 \%$ @ -20 to 70\% |
| Load Capacitance | 2nF |
| Load Inductance | 10 mH |
| Isolation | 1000 Volts RMS between field and logic |

* Analog inputs can be modified from current inputs to voltage inputs by lifting one leg of the 250 ohm channel resistor. Each channel has its own resistor, so any combination of channels can be converted. If necessary, the response time of the analog input can be improved by replacing the 250 ohm resistor with a 100 k resistor. It is recommended that modules be returned to RTUnet for factory conversion if required. No responsibility will be taken by RTUnet for damage caused to boards during modification performed by clients. The circuit board resistors to change are: channels 1-2 = R85 \& R41

IO-4 Digital And General Specifications

| DIGITAL INPUTS |  |
| :---: | :---: |
| Rated Voltage | 24 Volts AC/DC |
| Input Voltage Range | 0 to 30 Volts AC/DC |
| Inputs per Module | 8 |
| Isolation | 1000 Volts RMS between field and logic |
| Input Current | 4 mA (typical) at rated voltage |
| Input Characteristics: |  |
| On-state Voltage | 11.5 to 30 Volts AC/DC |
| Off-state Voltage | 0 to +4 Volts AC/DC |
| On-state Current | 3.2 mA minimum |
| Off-state Current | 1 mA maximum |
| On response Time | 10ms typical |
| Off response Time | 17 ms typical |
| DIGITAL OUTPUTS |  |
| Rated Voltage | 24 Volts DC, 120/240 Volts AC |
| Operating Voltage | $\begin{aligned} & 5 \text { to } 30 \text { Volts DC } \\ & 5 \text { to } 250 \text { Volts AC, } 50 / 60 \mathrm{~Hz} \end{aligned}$ |
| Outputs per Module | 2 |
| Isolation | 1000 Volts RMS between field and logic 500 Volts RMS between groups |
| Maximum Load | 2 amps pilot duty maximum per output 8 amps maximum per common |
| Minimum Load | 10 mA |
| Maximum Inrush | 5 amps |
| On Response Time | 15 ms maximum |
| Off Response Time | 15 ms maximum |
| GENERAL |  |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $+85^{\circ} \mathrm{C}$ |
| Humidity | 5 to 95\% non-condensing |
| Output Power | 24VDC @ 125mA (3W) Isolated |

CAUTION! Contacts can be protected with appropriate suppression devices when wired with inductive loads to increase life of relays (please see DO-1 for suppression circuits). Contacts should also be protected with external fusing.

## IO-4 Wiring Diagram

There are three separate isolated groups - one for the analog input, one for the digital input and one for the digital output. Each group may be powered from a separate source. Analog input channel 1 can be factory modified to support a strain gauge input.

Wiring Examples


## Chapter 11 Series II Backplanes

Series II backplanes allow the processor module to communicate with all the other modules in the RTU. The backplane also allows power to be supplied to each module. Backplanes are available in four versions:

- BA-4 4-slot backplane for use with a PC-1 processor only
- BA-6 6-slot backplane for use with a CP-xx processor
- BA-12 12-slot backplane for use with a CP-xx processor
- BA-40 4-slot backplane for use with a CP-xx processor or as a second backplane for a PC-1 RTU.

Every RTU requires at least one power supply (PSU-3 with a PC-1 or PS-xx) and at least one CPU module (eg PC-1 or CP-xx).

Multiple backplanes can be linked together to create an RTU with up to 64 modules. Please see the section - Linking Backplanes in this chapter for more information.

All backplanes can be surface mounted. BA-12 backplanes can also be mounted in a 19" rack.

## Module Dimensions

(Module shown mounted on a backplane. Dimensions shown in millimetres)


### 11.1 Installing Modules onto a Backplane

Installation of modules onto a backplane is carried out by first hooking the module bottom tab into the notched portion of the backplane while tilting the module forward a little. Once located the module is then tilted back until securely seated onto the backplane connector. Next tighten the securing screw. The following figure is an illustration of how this is done.


Step 2
Rotate module up to mate
firmly with backplane socket


Step 3
Use securing screw to lock module onto base


Figure 11-1a: Inserting Modules Onto Backplanes

### 11.2 BA-4 / BA-40 Backplane - 4 Slot

A BA-4 backplane is for use with the PC-1 (power \& processor module) in the far left slot and any I/O or communication modules in the other 3 slots. A BA-40 backplane is similar to the BA-4 backplane except the J5 (PC-1 lower connector) and SL-9 (PC-1 power) connectors have been removed to allow various modules to be installed in the leftmost slot. A BA-40 can be used with a PS-xx power supply and a CP-xx processor module or can be linked to any other backplane when more slots are required.

There are four (4) connectors at the far right of a BA-4 backplane. The two (2) small 8 way connectors are for inter-backplane communication links, the six way connector is for an external power supply ( +5 V and +12 V DC), and the lower 9 way connector is used for incoming and outgoing power. A BA-40 does not have the lower 9-way SL-9 connector.

The 4-slot backplane is designed for surface mounting. Mounting brackets (2 pieces) are supplied for user fitting.


Figure 11-2a: BA-4 / BA-40 Dimensions (mm)
(BA-40 does not have J5 or SL9 connectors)

## BA-4 / BA-40 External Connections

## J14 Power Connector (viewed from the top)

| 24 V | 12 V |
| :--- | :--- |
| 5 V | PCON |
| 0 V | 0 V |

PCON = Processor controlled power enable.
The 24 V pin is not used by the PC-1. The 12 V and 5 V output pins can be used to power a second backplane (e.g. BA-40). These pins are supplied by the PC-1 when a battery or input supply is connected to the orange BL9 connector.

J13 (in), J15 (out) Inter-rack Backplane Comms Connectors

| 1 | 8 |
| :--- | :--- |
| 2 | 7 |
| 3 | 6 |
| 4 | 5 |

Pin 1: IO+ Serieal I/O link
Pin 2: CM + Serial CM link
Pin 3: 0 Volt - Signal ground
Pin 4: IO-Serial I/O link
Pin 5: CM- Serial CM link
Pin 6: 0 Volt - Signal ground
Pin 7: CSR
Pin 8: PCON Processor controlled power enable

## Orange SL9 connector

(BA-4 only, viewed from the top without the plug inserted)

+24 V Aux. Supply Output (optional)
OV Aux. Supply Output (optional)
+12V To/From Battery
OV To/From Battery
+12V To Radio
OV To Radio
+12V Input Supply
OV Input Supply
Earth
To power the PC-1, the +12 V and 0 V Input Supply pins need to be wired to a suitable power supply (e.g. connect a PSU-3 power supply).

The +24 V Aux. Supply is only available if the PC-1 is fitted with a DC-DC converter (optional). Two battery terminals are supplied for charging of a backup battery. The +12 V Radio terminals can be used to power a radio or other external equipment.

### 11.3 BA-6 Backplane - 6 Slot

The 6-slot backplane will accommodate a variety of module types in different configurations. I/O modules and power supplies may be placed in any of the six (6) positions. This backplane is not designed for use with the SBX-2 or PC-1 modules.

There are three (3) connectors at the far right of the backplane. The two (2) small 8way connectors are for inter-backplane communication links and the larger 6 way connector is for external power ( +5 V and +12 V DC ) if the standard supply is not fitted.

This backplane is designed for surface mounting. Mounting brackets (2 pieces) are supplied for user fitting.


Figure 11-3a: BA-6 Dimensions (mm)

## BA-6 External Connections

J14 Power Connector (viewed from the top)

| 24 V | $12 \mathrm{~V}^{*}$ |
| :--- | :--- |
| 5 V | PCON |
| 0 V | 0 V |

PCON = Processor controlled power enable.
*CAUTION: The 24V and 12V pins are shorted on early revision backplanes (prior to revision 1.3). Early revision backplanes were designed for 24 V only.

J13 (in), J15 (out) Inter-rack Backplane Comms Connectors

| 1 | 8 |
| :--- | :--- |
| 2 | 7 |
| 3 | 6 |
| 4 | 5 |

Pin 1: IO+ Serieal I/O link Pin 2: CM + Serial CM link
Pin 3: 0 Volt - Signal ground
Pin 4: IO-Serial I/O link
Pin 5: CM- Serial CM link
Pin 6: 0 Volt - Signal ground
Pin 7: CSR
Pin 8: PCON Processor controlled power enable

### 11.4 BA-12 Backplane-12 Slot

The 12-slot backplane will accommodate a variety of module types in different configurations. I/O modules and power supplies may be placed in any of the twelve (12) positions. This backplane is not designed for use with the SBX-2 or PC-1 modules.

There are three (3) connectors at the far right of the backplane. The two (2) small 8way connectors are for inter-backplane communication links and the larger 6-way connector is for external power ( +5 V and +12 V DC) if the standard supply is not fitted.

This backplane is designed for surface mounting. Mounting brackets (2 pieces) are supplied for user fitting. Mounting in a 19" rack may be achieved using the alternative MBR-3 rack mounting brackets.


Figure 11-4a: BA-12 Dimensions (mm)

## BA-12 External Connections

J14 Power Connector (viewed from the top)

| 24 V | $12 \mathrm{~V}^{*}$ |
| :--- | :--- |
| 5 V | Pcon |
| 0 V | 0 V |

PCON = Processor controlled power enable.
*CAUTION: The 24 V and 12 V pins are shorted on early revision backplanes (prior to revision 1.3). Early revision backplanes were designed for 24 V only.

J13 (in), J15 (out) Inter-rack Backplane Comms Connectors

| 1 | 8 |
| :--- | :--- |
| 2 | 7 |
| 3 | 6 |
| 4 | 5 |

Pin 1: IO+ Serieal I/O link
Pin 2: CM + Serial CM link
Pin 3: 0 Volt - Signal ground
Pin 4: IO-Serial I/O link
Pin 5: CM- Serial CM link
Pin 6: 0 Volt - Signal ground
Pin 7: CSR
Pin 8: PCON Processor controlled power enable

### 11.5 MBR-3 Mounting Brackets - Rack

The MBR-3 mounting brackets are designed to install a BA-12 backplane in a 19-inch rack. The MBR-3 brackets replace the small surface mount brackets supplied with BA12 backplanes. The following figures show mounting dimensions.

Installation Note: The holes in the MBR-3 brackets that are used to attach the brackets to the back of the backplane are purposely drilled oversize to accommodate slight variances in racking equipment. By loosening these screws, pushing the brackets toward the centre of the backplane and then re-tightening the screws, the unit will fit freely into any correctly sized 19-inch rack.


Figure 11-5a: MBR-3 Dimension Details (mm)

### 11.6 Linking Backplanes

An RTU can have up to 64 modules. This is achieved by linking 2 or more backplanes together using power and data cables.

Each backplane has a hard-coded slot address range. Slot addresses are used by the CPU module to obtain data from the other modules. Linked backplanes must have different slot addresses otherwise address clashing will occur.

The slot address range can be changed to 4 different settings called the rack number. The rack number is set using switches on the backplane (please see the following sections for details).

Up to 4 racks of 16 modules can be used in one RTU as shown below. The hardcoded slot addresses for each backplane in each rack position are also shown. The slot addresses of a BA-4/40 are hard-coded to follow on from a BA-12.


Figure 11.6a: Slot Addresses For Each Type of Backplane in Each Rack Position
Identical backplanes in one RTU must have different rack numbers. Eg when linking 2 BA- 6 backplanes, the second BA-6 must be rack 2. Note: this also applies to BA-4 and BA-40 backplanes. A BA-4 cannot have the same rack number as a BA-40.

To allow a single CPU to communicate with all the modules, the backplanes must be linked using data cables. Power cables are also required if a backplane does not have a power supply module. Each rack usually requires its own power supply (eg one PS11 per rack). The number of power supplies required depends on how many modules are installed and their power requirements. Please see the section - Calculating Power Requirements in chapter 2 for more information.

Data cable connectors have two beveled corners. When installing data cables, please ensure the beveled corners of the connectors align with the beveled corners of the sockets (J13, J15) as illustrated below.

Data Cable Socket (J13 or J15)


The example below shows how to combine two 4-slot backplanes.


Figure 11.6b: Linking a BA-4 With a BA-40 Backplane (Rev. 2.2)

## Linking Backplanes: Summary

- Each backplane must be powered. A backplane is powered by using a power supply module (BA-4's use PC-1 modules and BA-6/12's use PS-xx modules) or by connecting a power cable ( $\mathrm{p} / \mathrm{n}$ BPC-0x) from J14 of a powered backplane to J14 of an unpowered backplane (as shown above). Each BA-12 should have its own PS-xx power supply.
- The backplane data busses must be linked. This allows a single processor module to access all the I/O modules on the linked backplanes. Backplane data busses are linked using BAC-0x data cables.
- The rack number ( 1 to 4 ) of each backplane may need to be set (default is 1 ). Backplanes of the same type must have different rack numbers so that each IO module has a unique slot address.
- For two or more linked backplanes, bus terminators should be ON for the first and last backplanes in the chain. Bus terminators are resistors that are required for reliable RS485 communications. All backplanes should have terminators switched on (factory default) when used by themselves.
- For backplanes prior to revision 2.1, if problems arise with detecting modules on linked backplanes, it is recommended that all terminators be turned off. If problems persist please contact your Kingfisher representative.

The following figures show backplane switch settings and how to connect data cables for 1 or more backplanes for all the backplane revisions.

## Backplane Revision 2.1 / 2.2

The DIP switch settings and data cable connections for the various backplane combinations are shown below.


## Backplane Revision 2.0

The DIP switch settings and data cable connections for the various backplane combinations are shown below. This information supersedes the instructions written on the backplanes themselves.


## Backplane Revisions 1.1-1.5

The DIP switch settings and data cable connections for the various backplane combinations are shown below. The following information supersedes the instructions written on the backplanes themselves. Revision 1.1 backplanes have only 6 DIP switches. Ensure that terminators are also switched off on these backplanes when used by themselves.


## Chapter 12 Trouble Shooting

## Hardware / Software Faults

In order to provide technical support for suspected hardware or software faults, the following information is commonly required:

- CPU firmware version (e.g. V141A)
- Protocol driver version (e.g. PAGING09.DRV)
- The model numbers of the Kingfisher modules (e.g. PC-1-CRO, AI-1, IO-4, MC-11-SS etc)
- Toolbox version (e.g. 1.43c)


## Return Of Goods

If you would like to return RTU modules or equipment for testing or repair, please carry out the following steps:

- Request a ERN number from your Kingfisher representative
- Complete all details on a ERN form (please use the supplied form as a master copy or download one from the RTUnet web site www.rtunet.com)
- Return ERN form with goods


## Chapter 13 Superseded Products

### 13.1 PS-1/PSU-1 AC Supply Input

The AC supply input module provides AC to DC conversion, DC voltages for the backplane, battery and radio (or an external device), an optional isolated 24VDC output and various monitoring functions.

The PSU-1 was manufactured to power a 24 V backplane, 24 V battery and 24 V radio. The PS-1 was manufactured in two models. PS-1-1: powers a 12 V backplane, 12 V battery and 12 V radio. PS-1-2 (similar to the PSU-1): powers a 24 V backplane, 24 V battery and 24 V radio.

The module has limited charging capacity for externally connected lead acid batteries. The charging capacity is designed for float operation and short term boost of batteries already charged and in good condition. Use of this supply on flat or fully discharged batteries may cause damage.

An optional isolated 24VDC output rated at 10 Watts $(400 \mathrm{~mA})$ is available for powering a limited number of analog loops or digit input circuits. It cannot be used with inductive loads such as coils, contactors etc. Power for these is to be provided from a separate supply.

The PS-1/PSU-1 features supply, voltage, current and temperature monitoring circuits that enable the processor unit to access these as analog and digital points in the system. When the AC supply fails and the system is powered from external lead acid batteries if connected the voltage monitoring circuit provides battery cut-off (for battery preservation) when battery cell voltage reaches +10.5 V (12V battery) or 21VDC ( 24 V battery). The load capacities for each output of the power supply are shown in the following table.

This module can be installed in any I/O slot of a 3, 6 or 12 slot backplane in a system. Up to 4 Power Supply modules of any type can be installed in a backplane thus providing redundant and alternative power source configurations.

## PS-1 Battery Charging States

- Charge State: The power supply starts up in the Charge State. In the Charge State the Power supply will charge the battery with the highest possible current. This current is determined by the maximum current the power supply can supply and the maximum battery charge current. The maximum battery charge current is typically 0.25 * the battery capacity. E.g. if the battery capacity is 6.5 AH the maximum charge current will be 0.25 * $6.5=1625 \mathrm{~mA}$. To achieve the desired charge current the supply voltage will be slowly increased. If the supply voltage reaches 14.25 V at $25^{\circ} \mathrm{C}$ the charge mode will be terminated and the Boost mode will be entered.
- Boost State: In the Boost State the supply voltage will be maintained at 14.25 V at $25^{\circ} \mathrm{C}$ as long as the battery charge current and the maximum supply current are not exceeded. The Boost State lasts $8 \%$ of the charging time. If the charging time was less than 12 minutes the Boost State will be skipped and the Float State will be entered.
- Float State: In the Float State the power supply wants to maintain 13.8 V at $25^{\circ} \mathrm{C}$ as long as the maximum supply current is not exceeded. The voltage will be very slowly decreased from 14.25 V (Boost/Charge voltage) to 13.8 V . The maximum adjustment rate is one adjustment every 2 minutes. This is done to let the battery float down to this voltage. The float state is also entered when the power supply is in Charge or Boost mode and AC power is lost. If the AC power returns, the power supply will enter the Charge State.
- No Battery State: If the power supply is in any of the above states and the battery current is less than 10 mA and greater than -10 mA for longer than 5 minutes, then the No Battery state is entered. In this state the power supply wants to maintain 12.5 V at any temperature. If the battery current becomes greater than 15 mA or less than 15 mA the No battery state is terminated and the Charge state is entered.
- Manual State: If the Manual bit in the power supply is set, the Manual state is entered. In Manual state there is no control except that the supply voltage will be reduced if the maximum supply current is exceeded. Resetting the Manual bit will cause the power supply to enter the Charge State.

* These voltages are temperature compensated. The voltage shown is the voltage at $25^{\circ} \mathrm{C}$. The voltages are increased by 22 mV for each degree Celsius the temperature decreases. If the temperature is $80^{\circ} \mathrm{C}$ or $-20^{\circ} \mathrm{C}$ (minimum or maximum values) the temperature sensor is assumed to be faulty. An error will be flagged and a temperature of $25^{\circ} \mathrm{C}$ will be assumed.


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Notes:

- A condition has to be valid for 3 seconds before the trim voltage is adjusted.
- In float state the trim voltage will only be decreased at a maximum rate of once every 2 minutes.
- In every state the maximum supply current is continuously monitored and the voltage is reduced if exceeded.


## PS-1/PSU-1 Specifications

| Specification | PS-1-1 (12V backplane) | PS-1-2 / PSU-1 (24V backplane) |
| :---: | :---: | :---: |
| Input Supply | 90 to $220 \mathrm{VAC} 50 / 60 \mathrm{~Hz}$ USA \& Asia <br> 150 to 250VAC Aus. \& Asia | 90 to 220VAC $50 / 60$ Hz USA \& Asia 150 to 250VAC Aus. \& Asia |
| Load Capacity | 50 Watts | 25 Watts up to S/N 11723 <br> 50 Watts S/N 11910 and higher |
| Outputs | $\begin{aligned} & +5 \mathrm{~V} @<10 \text { Watts to Bus } \\ & +12 \mathrm{~V} @<50 \text { Watts to Bus } \\ & +12 \mathrm{~V} @<50 \text { Watts to Battery } \\ & +13.8 \mathrm{~V} @ 2 \mathrm{~A} \text { to Radio } \\ & +24 \mathrm{~V} \text { Isolated } @<10 \mathrm{~W} \text { to Field } \\ & \quad \text { (optional) } \end{aligned}$ <br> Total 50 Watts max. | $+5 \mathrm{~V} @<10$ Watts to Bus <br> +24 V @ $<50$ Watts to Bus <br> +24V @ <50 Watts to Battery <br> +27.6V @ 1A to Radio (PS-1-2 only) <br> +24 V Isolated @ <10W to Field <br> (optional) <br> Total 50 Watts max. |
| Backup Battery | 12VDC, 26AH max. Sealed Lead-Acid | 24VDC, 15AH max. Sealed LeadAcid |
| Isolation | 2.5 kV AC input/DC output 2.5 kV Isolated 24 VDC output | 2.5 kV AC input/DC output 2.5 kV Isolated 24 VDC output |
| Deep Discharge Protection | RTU Shutdown at 10.5 V | RTU Shutdown at 21V |
| Startup Voltage | 11.8 Volts | 23.6 Volts |
| Supply Fuse | 1.6A slow blow internal | 1.6A slow blow internal |
| Monitoring Circuits | Battery Current and Voltage, Temperature, AC Supply, DC Supply | Battery Current and Voltage, Temperature, AC Supply, DC Supply |
| Status Indicators | Voltage Supplies and Battery on Front Bezel | Voltage Supplies and Battery on Front Bezel |
| Connector | Removable for AC/DC connectors | Removable for AC/DC connectors |

## Output Characteristics

The output voltage is controlled to limit the output to below 50 watts at $25^{\circ} \mathrm{C}$. High ambient temperatures will cause automatic supply derating in accordance with the curve shown below.


PS-1/PSU-1 Block Diagram


PS-1/PSU-1 LED Display

| LED | Description |
| :---: | :--- |
| OK | ON when module is functioning OK |
| DC +5V | ON when the internal 5V supply is OK. This LED should <br> always be on |
| + Vs | PSU1: ON when the Auxiliary 24V supply is OK (will only <br> display if the 24V converter is installed). <br> PS-1: AC Power ON |
| + Va | PS-1: ON when the Auxiliary 24V supply is OK (will only <br> display if the 24V converter is installed) |
| BATT CHG | Battery is being charged |
| FL | Battery is in float charge mode |
| BO | Battery is in boost charge mode |
| LO | Battery has reached its discharged condition - (<22 Volts <br> for PSU-1/PS-1-2 or <11.3V for PS-1-1) |
| +24 V | PSU1: ON when the internal 24V supply is OK. This LED <br> should always be ON. |

## PS-1 - Additional Features

The PS-1-1 has an additional 13.8 V for powering external low power radio units. The connections are on the DC terminal block. This output is limited to 2 A maximum at $10 \%$ duty cycle and is switched off on low battery voltage for battery protection.

NOTE: The PS-1 is supplied with a battery temperature sensor that must be fitted to the negative (-) terminal of the battery to ensure correct charging operation.

## PSU-1 Wiring Diagram

It is recommended that the battery charging Current Limiter is used when using backup batteries with the PSU-1 to prevent overloading. Note: External loads are to be wired directly off the PSU-1, not off the Battery.


PS-1 Wiring Diagram - AC Supply


## PS-1 Wiring Diagram - DC Supply

The battery input of the PS-1 can also be used as a DC supply input. The following diagram shows how the PS-1 is wired for a DC supply.


### 13.2 PS-10 AC Supply Input - 90 to 260VAC \& PS-20 DC Supply Input - 20 to 60VDC

The PS-10 power supply provides AC to DC conversion, DC voltages for the backplane, battery and radio (or an external device), an optional isolated 24VDC output and an optional monitoring processor. The PS-20 power supply offers the same functionality as the PS-10 except it has a DC supply input instead of an AC supply input.

The PS-10 and PS-20 are manufactured to power a 12 V backplane, 12 V battery and 12 V radio. The PS-10 and PS-20 are available as a 24 V module by special order (please see below for specifications).

An isolated 24 VDC output rated at $10 \mathrm{Watts}(400 \mathrm{~mA})$ is an option available for powering a limited number of analog loops or digit input circuits. It cannot be used with inductive loads such as coils, contactors etc. Power for these is to be provided from a separate supply.

In addition the module has limited charging capacity for externally connected lead acid batteries. The temperature compensated charging capacity is designed for float operation and short term boost of batteries already charged and in good condition. Use of this supply on flat or fully discharged batteries may cause damage.

When the AC supply fails and the system is powered from external lead acid batteries (if connected), the voltage monitoring circuit provides battery cut-off (for battery preservation) when battery cell voltage drops to $10.5 \mathrm{~V} \pm 0.2 \mathrm{~V}$.

The PS-10/20 has an optional monitoring processor that can be factory fitted. This allows battery voltage, battery current, regulated supply current, and internal or external temperature to be monitored.

If no monitoring circuit is loaded, the PS-10/PS-20 will not be able to communicate with the processor module and therefore will not show up in the hardware overview. In addition, there will be no power supply monitoring information (i.e. indication of battery current, battery voltage, temperature, battery low, AC present, Aux 24 V present) in the system. On/off control of the radio power and auxiliary 24 V output power will be under control of the processor module.

A power supply module can be installed in any I/O slot of a 3,6 or 12 slot backplane in a system. Up to 4 Power Supply modules of any type can be installed on a backplane thus providing redundant and alternative power source configurations.

Part numbers:
PS-10-CU, PS-20-CU
'C'= Auxiliary 24V DC to DC converter fitted. ' 0 ' = Not fitted.
'U'= Power supply monitoring processor fitted. '0'=Not fitted.

PS-10/PS-20 - Standard Specifications

| Input Supply | $\begin{aligned} & 90 \text { to } 260 \text { VAC } 50 / 60 \mathrm{~Hz} \text { (PS-10) } \\ & \text { +20 to +60 VDC or }-20 \text { to }-60 \text { VDC (PS-20) } \end{aligned}$ <br> Note: the module can also be powered using 12 to 13.8 VDC when powered from the backup battery terminals. |
| :---: | :---: |
| Backup Battery | 12VDC, 26AH max. Sealed Lead-Acid |
| Outputs | +5 V @ 2A Max. to Bus <br> +12V @ 4A Max. to Bus <br> +12V @ 4A Max. to Battery <br> +24V Isolated @ 400mA Max. to Field (optional) <br> +13.8V @ 3.6A Max. to Radio <br> Maximum output power: 50W |
| Isolation | 3kV AC input/DC output 3kV Isolated 24VDC output |
| Deep Discharge Protection | RTU Shutdown at $10.5 \mathrm{~V} \pm 0.2 \mathrm{~V}$ RTU Startup at $11.8 \mathrm{~V} \pm 0.2 \mathrm{~V}$ |
| Supply Fuse | Slow blow internal <br> 1.6A (PS-10) or 6.3A (PS-20) |
| Battery Fuse | 4A Polyfuse (self-resetting) |
| Connector | Removable for AC/DC connections |
| LED indicators (Standard) | Vsup DC voltage present <br> Vb Battery voltage present <br> 5V 5V present <br> Vaux Auxiliary converter present |
| Monitoring Processor (Optional) | Monitoring Circuits: <br> Battery Current <br> Battery Voltage * <br> Supply Current * <br> Temperature <br> Detection circuits: <br> AC present <br> Battery low <br> Aux. 24V present <br> Control circuits: <br> Aux. 24 V on/off <br> Radio power on/off <br> LED indicators: |

* The battery voltage is monitored when the input supply is disconnected. While the input supply is connected, the module will measure the regulated voltage and current output of its AC (PS-10) or DC (PS-20) input circuit.

PS-10-2/PS-20-2 - 24V Specifications
The 24 V power supply has the same specifications as the 12 V power supply (PS-101, PS-20-1) except it supplies 24VDC to the backplane, battery and radio as detailed below.

| Outputs | +5 V @ 2A to Bus |
| :--- | :--- |
|  | +24 V @ 2A Max. to Bus |
|  | +24 V @ 2A Max. to Battery |
|  | +24 V Isolated @ 400mA to Field (optional) |
|  | +27.6 V @ 1.8A to Radio |
|  | Maximum output power: 50 Watts. |

PS-10/PS-20 - Block Diagram


PS-10/PS-20 - LED Display

| LED | Description (when ON) |
| :---: | :--- |
| OK * | Module is functioning OK |
| Vsup | AC supply input is powered. For PS-20, ON when DC input <br> circuitry is powered. |
| Vb | Battery voltage supply is OK. This LED should always be on and <br> means that the power supply is able to charge a battery or is <br> being powered by the battery input. |
| 5 V | Internal 5V supply is OK. This LED should always be on as the <br> 5 V supply is used to power all the modules. |
| Vaux | Auxiliary 24V supply is OK (will only display if the 24 V converter <br> is installed). Controllable if a monitoring processor is fitted. |
| BATT CHG * | Battery is being charged |
| FL * | Battery is in float charge mode |
| BO * | Battery is in boost charge mode |
| LO * | Battery has reached discharged condition (< $11.5 \mathrm{~V} \pm 0.2 \mathrm{~V})$. <br> LO LED is cleared when battery > 12.4V $\pm 0.2 \mathrm{~V}$ |
| Only enabled when a monitoring processor is fitted (optional for the PS-10 and PS-20) |  |

## PS-10/PS-20 - Additional Features

The PS-10 and PS-20 have an additional DC output for powering low power radios. The connections are on the DC terminal block. This output is switched off on low battery voltage for battery protection and can be controlled when the monitoring processor is fitted.

The PS-10/PS-20 is supplied with an internal and external temperature sensor. When a battery is connected, the external sensor should be mounted close to the negative terminal of the battery to ensure correct charging operation. The lowest temperature is monitored by the monitoring processor and used by the temperature compensated battery charging (in normal operation the internal temperature sensor will indicate a higher temperature than the external sensor).

PS-10 Wiring Diagram - AC Supply


PS-10 Wiring Diagram - DC Supply
The battery input of the PS-10 can be used as a DC supply input.


PS-20 Wiring Diagram


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### 13.3 PSU-2 DC Supply Input - 18 to 36VDC

The DC supply input ( 18 to 36 VDC ) module for the Series II Remote Terminal Units provides the DC to DC conversion, galvanic isolation, $+12 \mathrm{VDC},+5 \mathrm{VDC}$ and various monitoring functions to power other modules in the Series II family.

An isolated 24 VDC output rated at $10 \mathrm{Watts}(400 \mathrm{~mA})$ is available for powering a limited number of analog loops or digit input circuits. It cannot be used with inductive loads such as coils, contactors etc. Power for these is to be provided from a separate supply.

The PSU-2 features optional supply, voltage, current and temperature monitoring circuits that enable the processor unit to access these as analog and digital points in the system. When the DC supply fails and the system is powered from external lead acid batteries if connected the voltage monitoring circuit provides battery cut-off (for battery preservation) when battery cell voltage reaches 10.5 VDC . The load capacities for each output of the power supply are shown in the following table. Note: the specifications shown are for the 12 V model of the PSU-2. The PSU-2 was also available as a 24 V model.

PSU-2 Specifications

| Input Supply | 18 to 36VDC Nominally 24VDC |
| :---: | :---: |
| Outputs | +5 VDC @ <10 Watts to Bus <br> +12VDC @ <50 Watts to Bus <br> +12VDC @ <50 Watts to Battery <br> +24VDC Isolated @ 10 Watts to Field <br> Total 50 Watts max. |
| Isolation | 2.5 kV DC input/DC output <br> 2.5kV Isolated 24VDC output |
| Deep Discharge Protection | RTU Shutdown at 10.5 V RTU Startup at 11.8 V |
| Supply Fuse | 4A slow blow internal |
| Monitoring Circuits | Battery Current and Voltage, Temperature, DC Supply |
| Status Indicators | Supplies and Battery on Front Bezel |
| Connector | Removable for DC connectors |

PSU-2 Block Diagram


## PSU-2 LED Display

Three red LEDs labeled $+5 \mathrm{~V},+12 \mathrm{~V}$ and V s are on when the various power supply sections are functioning correctly. The Vs LED indicates when the isolated 24 Volt/10 Watt output is activated. This output is under the main processor control (CP-1 or SBX-2) but is normally in the on state. A green LED at the top of the face plate is ON when the microcontroller of the monitoring circuit and the power conversion circuits are operating correctly. An additional four red LEDs labeled CHG, FL, BO and LO indicate the condition of a connected battery which are:-

CHG Battery is being charged
FL Battery is in float charge mode
BO Battery is in boost charge mode
LO Battery has reached its discharged condition (<22 Volts)
This module can be installed in any I/O slot of a 3, 6 or 12 slot backplane in a system. Up to 4 Power Supply modules of any type can be installed in a backplane thus providing redundant and alternative power source configurations.

PSU-2 Wiring Diagram


PSU-2 Output Characteristics


### 13.4 PSU-4 AC Supply Input, 60Watts (Low Cost)

The AC supply input ( 90 to 260VAC) module for the Series II Remote Terminal Units provides the AC to DC conversion, DC to DC with galvanic isolation, +12 V or +24 VDC and +5 VDC . Power monitoring functions are not available in this module. This module is not mounted on the backplane.

PSU-4 Specifications

| Input Supply | 90 to $260 \mathrm{VAC} 50 / 60 \mathrm{~Hz}$ |
| :--- | :--- |
| Load Capacity | 60 Watts |
| Outputs | $+5 \mathrm{VDC} @ 3 \mathrm{~A}$ <br> $+24 \mathrm{VDC} @$ to Bus 1.8 A or $+12 \mathrm{~V} @ 3 \mathrm{~A}$ |
| Isolation | $2.5 \mathrm{kV} \mathrm{AC} \mathrm{input/DC} \mathrm{output}$ |
| Supply Fuse | 1.6 A slow blow internal |
| Monitoring Circuits | Nil |
| Status Indicators | Nil |
| Connector | Screw Terminals |
| Weight | 530 grams |

PSU-4 Block Diagram


PSU-4 Mounting and Connection


PSU-4 Output Characteristics


### 13.5 CP-1 Standard Processor Module

The standard processor module for the Series II Remote Terminal Unit provides all processing, I/O scan, logic, control and communications functions required in any of the RTU configurations that may be adopted. This module has two independent serial ports; one of which, port 2 (P2) may be software configured for RS232C or RS485 circuit interfaces. Port 1 is fixed at RS232C.

In addition this module is available in two memory configurations. The standard configuration is 256 K of FLASH MEMORY for the storage of all operating code and selected system parameters, and 256K of battery backed static RAM for all configuration and event storage data. This memory configuration is ordered as CP-10 . An optional extended memory configuration adds 512 K of static RAM and is ordered as CP-1-2. The extended memory configuration is only required in very large systems employing many field RTUs which report back to a master RTU - all data being held in the master RTU.

The RAM battery in earlier production units is enabled at shipping time by the factory. Later production units allow the user to enable the battery by a link at the rear of the module - see figure below.


Figure 13-5a: CP-1 Rear View And Link Location
Two groups of four (4) LEDs show the status of ports 1 and 2. Each port has TXD, RXD, RTS and CD LEDs in a vertical group. A green LED at the top of the face plate is ON when the module is operating correctly. This module consumes power from the +5 VDC bus on the backplane. The module can be installed in any I/O slot of a 6 or 12 slot backplane in a system. Up to two processor modules can be installed in an RTU system. For example these two may reside anywhere in one, two, three or four backplane systems.

CP-1 Specifications

| Processor | Intel 80C186 |
| :---: | :---: |
| Word Size | 16 Bit |
| Clock Speed | 16 MHz |
| BIOS | Y |
| FLASH MEMORY | 256K (32K used for drivers) |
| Static CMOS RAM | 256K or 768K |
| RTC | Y |
| WDT | Y |
| Status Indication | Y |
| Battery Life - module unpowered | 15 Years (256K) <br> 10 Years (768K) |
| Communication Ports | 2 |
| Serial Port 1 (RS232) | 300 to 115200 Baud |
| Serial Port 2 (RS232/RS485) | 300 to 115200 Baud |
| Communications | Master or Outstation |
| Configuration Software | Toolbox |
| Diagnostics Software | Y |
| Basic Configuration | Auto on power-up |
| Complex Configuration | Toolbox |
| RTU Address Range | 1-249 |
| Communications Protocol | Kingfisher, Modbus, + many more |
| Analog Block Processing | Y |
| PID Block Processing | Y |
| Logic Processing | Ladder |
| CPUs per RTU | 1 or 2 |
| Internal Power Consumption | 120 mA from +5VDC Bus on backplane |
| I/O Bus Data Rate | $250 \mathrm{kBit} / \mathrm{s}$ |
| CM Bus Data Rate | $83 \mathrm{kBit} / \mathrm{s}$ |
| Cyclic Redundancy | Port 1 and 2 |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH noncondensing |

CP-1 Block Diagram


## CP-1 Connections

The CP-1 module features two serial ports accessible by the RJ45 connectors on the front of the module and covered by the snap on cable cover. Port 1 is at the top for RS232 connections only and Port 2 is below for either RS232 or RS485 connections. Earlier CP-1 modules have two serial ports accessible by the DB9 connectors on the front of the module and covered by the snap on cable cover. Port 1 is at the top for RS232 connections only and Port 2 is below for either RS232 or RS485 connections.


EARLY MODELS
Figure 13-5b: CP-1 Front Module and Port Identification

| RS232C <br> Function | CP-1 Ports 1,2 <br> RJ45 |  | CP-1 Ports <br> 1,2 DB9-M |  |
| :---: | :---: | :---: | :---: | :---: |
| TXD | 1 | OUT | 3 | OUT |
| RXD | 2 | IN | 2 | IN |
| CTS | 3 | IN | 8 | IN |
| GND (OV) | 4 | COM | 5 | COM |
| DCD | 5 | IN | 1 | IN |
| RTS | 6 | OUT | 7 | OUT |
| +12V low <br> power | 7 | OUT |  |  |
| DTR | 8 | OUT | 4 | OUT |

Note: Port 2 RTS and CTS do not function on Rev. C boards

| RS485 <br> Function | CP-1 Port 2 <br> RJ45 | CP-1 Port 2 <br> DB9-M |
| :---: | :---: | :---: |
| +L | 1 | 6 |
| -L | 6 | 4 |



### 13.6 SBX-2 Mini Processor Unit

The SBX-2 mini processor unit provides all processing, I/O scan, logic, control and communications required in a small RTU. This unit has two independent serial ports; one of which, port 2 (P2) may be software configured for RS232C or RS485 circuit interfaces. Port 1 is fixed at RS232C. This unit is manufactured as an option board for the combination IO-3 module and must be fitted to this module prior to installing on a BA-3 backplane. The SBX-2 is used with a 3-slot 24VDC backplane (BA-3). The two serial ports are accessed using cables that connect to the backplane.

In addition this unit is available in two memory configurations. The standard configuration is 128 K of flash memory for the storage of all operating code and selected system parameters, and 128K of battery backed static RAM for all configuration and event storage data. This memory configuration is ordered as SBX-2/IO-3-0. An optional extended memory configuration adds 128 K of static RAM and is ordered as SBX-2/IO-3-1. The extended memory configuration is only required in special circumstances and intended users should consult the factory.

The RAM battery is enabled by a link at the rear of the module - see figure below.


Figure 13-6a: SBX-2 Rear Module IO-3 and RAM Battery Link Location

LEDs showing status of the serial ports are present on the IO-3 module and reference to this module should be made. This module consumes power from the +5VDC bus on the backplane. The module can be installed only in slot 2 of a BA-3 backplane in a system.

## SBX-2 Specifications

| Processor | Intel 80C188 |
| :---: | :---: |
| Word Size | 16 Bit internal data bus <br> 8 Bit external data bus |
| Clock Speed | 16 MHz |
| BIOS | Y |
| Flash Memory | 128K |
| Static CMOS RAM | 128K or 256 K |
| RTC | Y |
| WDT | Y |
| Status Indication | N |
| Battery Life - module unpowered | 15 Years (128K) 10 Years (256K) |
| Communication Ports | 2 |
| Serial Port 1 (RS232) | 300 to 19.2 kB |
| Serial Port 2 (RS232/RS485) | 300 to 19.2 kB |
| Communications | Outstation |
| Configuration Software | Toolbox |
| Diagnostics Software | Y |
| Basic Configuration | Auto on power-up |
| Complex Configuration | Toolbox |
| RTU Address Range | 1-249 |
| Communications Protocol | Kingfisher, Modbus, + many more |
| Analog Block Processing | Y |
| PID Block Processing | Y |
| Logic Processing | Ladder |
| CPUs per RTU | 1 |
| Internal Power Consumption | 120 mA from +5VDC Bus on backplane |
| I/O Bus Data Rate | $250 \mathrm{kBit} / \mathrm{s}$ |
| CM Bus Data Rate | $83 \mathrm{kBit} / \mathrm{s}$ |
| Cyclic Redundancy | Port 1 and 2 |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to 98\% RH non-condensing |

SBX-2 Block Diagram


## SBX-2 Connections

| SBX-2 Ports 1,2 <br> Cable DB9 Male | Function |
| :---: | :--- |
| 1 | Carrier Detect CD |
| 2 | Receive Data RXD |
| 3 | Transmit Data TXD |
| 4 | Port 1: Data Terminal Ready DTR <br> Port 2: RS485- |
| 5 | Signal Ground GND |
| 6 | RS485+ |
| 7 | Request to Send RTS |
| 8 | Clear to Send CTS |
| 9 | Do Not Connect |

### 13.7 LM-2 Line Modem Module, Dual Leased Line 2Wire

The line modem module, LM-2 for the Series II Remote Terminal Unit provides a telephone line interface and data exchange functions for remotely connected units over leased circuits. This module is equipped with two ports that may be used simultaneously. The integral modems are standard V22BIS devices allowing speeds up to 1200bps. Using this module simplifies the user interface in that a great deal of the setup procedure has been eliminated.

The LM-2 modules primary function is to provide a leased line interface to two separate telephone lines into the RTU at speeds up to 1200 bps . All communications flow control is managed by the CP-1 or SBX-2 processor module. This module cannot be used in a stand-alone system (i.e. it must be used with the Series II rack and processor).

The module also incorporates dual RJ45 connectors to allow use with external radio transceivers up to 1200 bps in CCITT V23 mode. This is a non-isolated interface and therefore must be close coupled with a compatible transceiver if used. The 0V of the radio must be connected to the 0 V of the backplane.

Red LEDs on the front bezel show the status of data transfer, for port 1 and port 2. A green LED at the top of the faceplate labeled OK is ON when the module is operating correctly. This module consumes power from +5VDC bus on the backplane. The module can be installed in any I/O slot of a 6 or 12 slot backplane and in slot no. 3 of a BA-3 backplane and any slot except slot 1 of a BA-4 backplane. Up to four modem modules can be installed in an RTU system.

## LM-2 Specifications

| Data Rates and Modulation | 1200 bps CCITT V23 FSK |
| :--- | :--- |
| Data Pump | SSI324 |
| Equaliser (Adaptive) | Y |
| Transmit Level | -10 dBm |
| Scrambler/Descrambler | Y |
| Receive Level | 0 dBm to -43dBm |
| Data Formats | Asynchronous |
| Remote RTS Signaling | Y |
| Bit Error Rate (BER) | $10^{-6}$ @ S/N 22dB |
| Connection | 2 Wire |
| Line Isolation | 4 kV |
| Processor | Intel 80C51 |
| Word Size | 8 bit |
| Flash Memory | 4 K |
| Static CMOS RAM | 32 K |
| Configuration Software | Toolbox |
| CM Bus Data Rate | 83 kBits/sec |
| Modem Modules per RTU | 4 |
| Internal Power Consumption | 65 mA from +5 VDC Bus on backplane |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \% ~ R H$ non-condensing |

## LM-2 Block Diagram



## LM-2 Connections

The LM-2 module features a dual RJ12 socket for connection to two leased lines (PL) and a dual RJ45 connector for the external VF (voice frequency) interface to external radio. These connectors are covered by a snap-on cable cover. Earlier models are fitted with a high density DB15 connector instead of the dual RJ45s.


EARLY MODELS

| Radio Function | LM-2 Ports 1\&2 <br> RJ45 |  |
| :---: | :---: | :---: |
| TXA | 1 | OUT |
| RXA | 2 | IN |
| CTS | 3 | IN |
| GND (OV) | 4 | COM |
| DCD | 5 | IN |
| RTS | 6 | OUT |
| +12V low power | 7 | OUT |
| DTR | 8 | COM |



| Radio Function | LM-2 (Earlier <br> Models) <br> DB15HD Connector |  |
| :---: | :---: | :---: |
| TXA1 @ -7dBm | 1 | OUT |
| RTS1 | 2 | OUT |
| CTS1 | 3 | IN |
| DCD2 | 4 | IN |
| DCD1 | 5 | IN |
| RTS2 | 6 | OUT |
| TXA2 @ -7dBm | 7 | OUT |
| NC | 8 | - |
| RXA2 @ 0 to - | 9 | IN |
| 30dBm | 10 | COM |
| DTR1 | 11 | COM |
| DTR2 | 12 | COM |
| OV | 13 | COM |
| OV | 14 | IN |
| CTS2 | 15 | IN |
| RXA1 @ 0 to - |  |  |
| 30dBm | $1 . d B m$ is | $2 n$ |

Notes: 1. dBm is referenced to 600 ohms
2. RTS, CTS \& CD signals active low to OV

| Private Line <br> Function | LM-2 Ports 1, 2 <br> RJ12 Connector |
| :---: | :---: |
| Line + | 2 |
| Line - | 5 |

### 13.8 LNA-6 Line Amplifier Module, Leased Line

The line amplifier module, LNA-6 is packaged in Series II Remote Terminal Unit housings and provides a matched leased line interface for up to six (6) leased circuits from a single modem. Modems with speeds up to 2400 bps may be connected via the VF circuit interface that is bussed to the backplane connector. Kingfisher Series I and Series II provide optional VF interfaces from their CCITT V23 and V22BIS modems.

There are six (6) RJ12 sockets on the front panel for connection to leased circuits. The module provides galvanic isolation and surge protection from the line to the equipment side and signal voltage limiting, line matching from the equipment side to the line side.

This module must be located within a BAX-6 backplane and cannot be fitted or mixed with standard Series II modules.

LNA-6 Specifications

| Line Isolation | 3000 VAC <br> 5000 VDC |
| :--- | :--- |
| Transmit Level | -10 dBm with -10dBm input |
| Receive Level | 0 dBm to -43dBm |
| Signal Limiting | $+/-4$ Volts Peak |
| Surge Clamping | 360 Volts |
| Max. Number of Modules | 4 |
| Internal Power Consumption | $36 m \mathrm{~m}$ from +5 VDC <br>  <br> Bus on backplane |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH non-condensing |

LNA-6 Block Diagram


## LNA-6 Connections



| Function | LNA-6 <br> RJ12 Connector |
| :---: | :---: |
| Line + | 2 |
| NC | 3 |
| NC | 4 |
| Line - | 5 |

### 13.9 MC-1 Multi Communications Module

The multi communications module for the Series II Remote Terminal Unit provides additional ports in any RTU configuration. This module has three independent serial ports. Ports 1 and 2 are fixed at RS232C and Port 3 is hardware configurable to RS232/RS485 or CCITT V23 modem (for radio or private line).

This module consumes power from the +5 VDC bus on the backplane. Up to five MC-1 modules can be installed in any I/O slot of a 4,6 or 12 slot backplane. An RTU can have up to 16 communications ports.

## MC-1 Part Numbers

The MC-1 is available with one port option as detailed below.
Ordering Information
Part No. MC-1-P
POptions:

| P |
| :---: |
| Option Port 3 Type |

$0=$ Not Fitted
R= Radio, V. 23 FSK
$\mathrm{P}=2$-Wire Line, V. 23 FSK
S= Serial RS232/RS485
M=4-Wire Line, V. 23 FSK
Example: MC-1-R MC-1 with radio option port

MC-1 LED Display
Three groups of four (4) LEDs show the status of ports 12 and 3. Each port has Tx, Rx, RTS and CD LEDs in a vertical group.

| MC-1 LED | Description |
| :---: | :--- |
| OK | ON when module is functioning OK |
| Tx | ON when port is transmitting |
| Rx | ON when port is receiving |
| RTS | Request to send. Set ON to begin transmitting |
| CD | Carrier detect. ON while a communications signal is detected. |
| WD | Processor Watchdog Timer. Set ON when the processor is reset. |
| DR1, DR2, <br> T1, T2 | Not used |

MC-1 Specifications

| Processor | Intel 80C188 |
| :---: | :---: |
| Word Size | 16 Bit internal data bus 8 Bit external data bus |
| Clock Speed | 16 MHz |
| BIOS | Y |
| Flash Memory | 128K |
| Static CMOS RAM | 128K |
| Status Indication | Y |
| Communication Ports | 3 |
| Ports 1\&2 (RS232) | Serial, 300 to 115200 Baud |
| Port 3 (optional) | Not fitted, Serial, Radio, 2-Wire Line or 4-Wire Line. 300 to 115200 Baud (depending on port type) |
| Communications | Master or Outstation |
| Configuration Software | Toolbox |
| Diagnostics Software | Y |
| Communications Protocol | Kingfisher, Modbus, + many more |
| MC-1s per RTU | 5 |
| Internal Power Consumption | 120 mA from +5VDC Bus on backplane |
| CM Bus Data Rate | $83 \mathrm{kBit} / \mathrm{s}$ |
| Cyclic Redundancy | Port 1, 2 and 3 |
| Operating Temperature | -20 to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | -40 to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH non-condensing |

MC-1 Block Diagram


## MC-1 Connections

The MC-1 module features two serial ports accessible by the RJ45 connectors on the front of the module and covered by the snap on cable cover. Port 1 is at the top and Port 2 is immediately below for RS232 connections only. Port 3 is optional and is detailed in the PC-1 Option Boards chapter.


Figure 4-1a: MC-1 Port Identification and Link Location

| RS232C <br> Function | MC-1 Ports 1,2 <br> RJ45 Connector |  |
| :---: | :---: | :---: |
| TXD | 1 | OUT |
| RXD | 2 | IN |
| CTS | 3 | IN |
| GND (OV) | 4 | COM |
| DCD | 5 | IN |
| RTS | 6 | OUT |
| +12V low power <br> (requires link) | 7 | OUT |
| DTR | 8 | OUT |
| DSR |  |  |
| RI |  |  |



### 13.10 BA-3 Backplane - 3 Slot

The 3-slot backplane will accommodate a variety of module types in different configurations. I/O modules and power supplies may be placed in any of the three (3) positions. In addition the centre position will accommodate an SBX-2 and/or I/O-1, 2 or 3 module. It is not possible to fit a CP-1 or any communication modules to this position.

There are five (5) connectors at the far right of the backplane. The two (2) small 8-way connectors are for inter-backplane communication links. The longer six way connector is for external power ( +5 V and +24 V DC), if the standard supply is not fitted. The two lower 10 way pin headers are for the two serial ports of an SBX-2 module, if used.

This backplane is designed for surface mounting. Mounting brackets (2 pieces) are supplied for user fitting.


Figure 13-9a: BA-3 Mounting Details

## BA-3 External Connections

## J14 Power Connector Pinout (viewed from the top)

| 24 V | $12 \mathrm{~V}^{*}$ |
| :--- | :--- |
| 5 V | PCoN |
| 0 V | 0 V |

PCON = Processor controlled power enable.
The 24 V pin is not used by the PC-1. The 12 V and 5 V output pins can be used to power a second BA-4 backplane. These pins are supplied by the PC-1 when the 12 V battery or 12 V input supply is connected to the orange BL9 connector.
*CAUTION: The 24 V and 12 V pins are shorted on early revision backplanes (prior to revision 1.3). Early revision backplanes were designed for 24 V only.

J13 (in), J15 (out) Inter-rack Backplane Comms Connectors


Pin 1: IO+ Serieal I/O link
Pin 2: CM + Serial CM link
Pin 3: 0 Volt - Signal ground
Pin 4: IO-Serial I/O link
Pin 5: CM- Serial CM link
Pin 6: 0 Volt - Signal ground
Pin 7: CSR
Pin 8: PCON Processor controlled power enable

| J17, J18 | Serial Ports (P1, P2) |
| :--- | :--- |
| Pin 1 | CD Carrier data detect |
| Pin 2 | RXD Receive Data |
| Pin 3 | TXD Transmit Data |
| Pin 4 | NC or I/O (RS485) Port 2 only |
| Pin 5 | 0 Volt (RS232 and RS485) |
| Pin 6 | NC or +lO (RS485) Port 2 only |
| Pin 7 | RTS Request to send |
| Pin 8 | CTS Clear to send |
| Pin 9 | NC |
| Pin 10 | NC |

### 13.11 BAX-6 Backplane - 6 Slot for LNA-6 Module

The 9-slot backplane is designed to accommodate four (4) LNA-6 modules and an optional power supply module in the far left slot location.

There are two connectors in the far right position which provide access to the UF signals that are bussed along the backplane to each of the module positions. A third connector ( 6 way) on the far right is for the external power supply input ( +5 V ).

This backplane is designed for surface mounting. Mounting brackets (2 pieces) are supplied for user fitting.


Figure 13-10a: Backplane Mounting Details - BAX-6

## External Connections

| J5 | Power |
| :--- | :--- |
| Pin 1 | NC |
| Pin 2 | +5V Supply |
| Pin 3 | 0 Volt |
| Pin 4 | 0 Volt |
| Pin 5 | NC |
| Pin 6 | NC |


| J9 - VF Signal Interface (Mini DIN-8) |  |
| :--- | :--- |
| Pin 1 | CTS - Clear to send |
| Pin 2 | 0 Volt - Signal ground |
| Pin 3 | NC |
| Pin 4 | TXA - Transmit analog (-10dBm) |
| Pin 5 | NC |
| Pin 6 | PTT - Request to send (Press to talk) |
| Pin 7 | CD - Carrier data detect |
| Pin 8 | RXA - Receive analog (-10dBm) |


| J9 - VF Signal Interface (Mini DIN-8) |  |
| :--- | :--- |
| Pin 1 | TXA - Transmit Analog (-100dBm) |
| Pin 2 | PTT - Request to send (Press to talk) |
| Pin 3 | CTS - Clear to send |
| Pin 4 | 0 Volts - Signal ground |
| Pin 5 | 0 Volts - Signal ground |
| Pin 6 | +5 Volts |
| Pin 7 | +5 Volts |
| Pin 8 | GND Chassis ground |
| Pin 9 | GND Chassis ground |
| Pin 10 | +5 Volts |
| Pin 11 | +5 Volts |
| Pin 12 | 0 Volts - Signal ground |
| Pin 13 | 0 Volts - Signal ground |
| Pin 14 | CD - Carrier data detect |
| Pin 15 | RXA - Receive analog (-10dBm) |

NOTE: PTT, CTS and CD are active low referred to 0 Volt

### 13.12 DI-1 12-24 Volt AC or DC Input, 16 Point

The DI-1 provides 16 input points in one group with common power input terminals. This input module is designed to have either positive or negative logic characteristics in the DC input mode. Input characteristics are compatible with a wide range of usersupplied input devices, such as: push buttons, limit switches, and electronic proximity switches. Current into an input point results in a logic 1 in the input status table (\#DI). The digital inputs are powered using an external power supply (the module does not provide field power).

LED indicators that provide the ON/OFF status of each point are located at the top of the module. This LED block has four vertical columns with four red LEDs in each column, the left two columns labeled A1 through 8 (points 1 through 8) and the right two columns labeled B1 through 8 (points 9 through 16). An insert goes between the inside and outside surface of the hinged door. The surface towards the inside of the module (when the hinged door is closed) has circuit wiring information, and circuit identification information can be recorded on the outside surface. The outside left edge of the insert is color-coded blue to indicate a low-voltage module. This module can be installed in any I/O slot of a 3, 4, 6 or 12 slot backplane system.

## DI-1 Specifications

| Rated Voltage | 12 or 24 Volts AC/DC |
| :--- | :--- |
| Input Voltage Range | 0 to +30 Volts AC/DC |
| Inputs per Module | 16 (two groups each with separate common) |
| Isolation | 3000 Volts RMS between field and logic |
| Input Current | 4 mA (typical) at rated voltage |
| Input Characteristics: |  |
| On-state Voltage |  |
| Off-state Voltage |  |
| On-state Current | 0 to +4 Volts AC/DC |
| Off-state Current |  |
| On response Time | 4.3 mA minimum |
| Off response Time |  |
| Operating Temperature | 10 ms typical |
| Storage Temperature | 17 ms typical |
| Operating Humidity | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |

## Dl-1 Wiring Diagram

There are two isolated input groups. Each group of 8 channels can be powered by a separate DC source.


### 13.13 DI-2 48 Volt AC or DC Input, 16 Point

The 48-volt DC input module for the Series II Remote Terminal Unit provides 16 input points in one group with a common power input terminal. This input module is designed to have either positive or negative logic characteristics in the DC input mode. This input module is designed to function with DC user inputs. Input characteristics are compatible with a wide range of user-supplied input devices, such as: push buttons, limit switches, and electronic proximity switches. Current into an input point results in a logic 1 in the input status table (\#DI). Power to operate the field devices must be supplied by the user.

LED indicators which provide the ON/OFF status of each point are located at the top of the module. This LED block has four vertical columns with four red LEDs in each column, the left two columns labeled A1 through 8 (points 1 through 8) and the right two columns labeled B1 through 8 (points 9 through 16). An insert goes between the inside and outside surface of the hinged door. The surface towards the inside of the module (when the hinged door is closed) has circuit wiring information, and circuit identification information can be recorded on the outside surface. The outside left edge of the insert is color-coded blue to indicate a low-voltage module. This module can be installed in any I/O slot of a 4,6 or 12 slot backplane system.

## DI-2 Specifications

| Rated Voltage | 48 Volts AC or DC |
| :--- | :--- |
| Input Voltage Range | 0 to 60 Volts AC or DC |
| Inputs per Module | 16 (two groups, each with separate common) |
| Isolation | 3000 Volts RMS between field and logic |
| Input Current | 4 mA (typical) at rated voltage |
| Input Characteristics: |  |
| On-state Voltage | 23 to 60 Volts DC |
| Off-state Voltage |  |
| On-state Current | 0 to 20 Volts DC |
| Off-state Current | 4.8 mA minimum |
| On response Time | 2.2 mA maximum |
| Off response Time |  |
| Operating Temperature | 10 ms maximum |
| Storage Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Operating Humidity | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |

## DI-2 Wiring Diagram

There are two isolated input groups. Each group of 8 channels can be powered by a separate DC source.


## Wiring Example



### 13.14 DI-3 120 Volt AC Input, 16 Point

The 120-volt AC input module for the Series II DI-3 Remote Terminal Unit provides 16 input points with two common power input terminals. The input circuits are reactive (resistor/capacitor) inputs. Current into an input point results in a logic 1 in the input status table (\#DI). Input characteristics are compatible with a wide range of usersupplied input devices, such as: push buttons, limit switches and electronic proximity switches. Power to operate the field devices must be supplied by the user. This module requires an AC power source; it cannot be used with a DC power source for field inputs.

LED indicators that provide the ON/OFF status of each point are located at the top of the module. This LED block has four vertical columns with four red LEDs in each column, the left two columns labeled A1 through 8 (points 1 through 8) and the right two columns labeled B1 through 8 (points 9 through 16). An insert goes between the inside and outside surface of the hinged door. The surface towards the inside of the module (when the hinged door is closed) has circuit wiring information, and circuit identification information can be recorded on the outside surface. The outside left edge of the insert is color-coded red to indicate a high-voltage module. This module can be installed in any I/O slot of a 3, 4, 6 or 12 slot backplane system.

## DI-3 Specifications

| Rated Voltage | 120 Volts AC |
| :--- | :--- |
| Input Voltage Range | 0 to 132 Volts AC, $50 / 60 \mathrm{~Hz}$ |
| Inputs per Module ${ }^{*}$ | 16 (two groups, each with separate common) |
| Isolation | 3000 Volts RMS between field and logic |
| Input Current | 12 mA (typical) at rated voltage |
| Input Characteristics: |  |
| On-state Voltage | 74 to 132 Volts AC |
| Off-state Voltage |  |
| On-state Current | 0 to 20 Volts AC |
| Off-state Current | 6 mA minimum |
| On response Time | 2.2 mA maximum |
| Off response Time |  |
| Operating Temperature | 34 ms maximum maximum |
| Storage Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Operating Humidity | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |

* Number of inputs on is dependent upon ambient temperature as shown below


## DI-3 Wiring Diagram

There are two isolated input groups. Each group of 8 channels can be powered by a separate AC source.


## DI-3 Output Characteristics



### 13.15 DI-4 240 Volt AC Input, 16 Point

The 240 volt AC input module for the Series II DI-4 Remote Terminal Unit provides 16 input points with two common power input terminals. The input circuits are reactive (resistor/capacitor) inputs. Current into an input point results in a logic 1 in the input status table (\#DI). Input characteristics are compatible with a wide range of usersupplied input devices, such as: push buttons, limit switches and electronic proximity switches. Power to operate the field devices must be supplied by the user. This module requires an AC power source; it cannot be used with a DC power source.

LED indicators that provide the ON/OFF status of each point are located at the top of the module. This LED block has four vertical columns with four red LEDs in each column, the left two columns labeled A1 through 8 (points 1 through 8) and the right two columns labeled B1 through 8 (points 9 through 16). An insert goes between the inside and outside surface of the hinged door. The surface towards the inside of the module (when the hinged door is closed) has circuit wiring information, and circuit identification information can be recorded on the outside surface. The outside left edge of the insert is color-coded red to indicate a high-voltage module. This module can be installed in any I/O slot of a 4,6 or 12 slot backplane system.

## DI-4 Specifications

| Rated Voltage | 240 Volts AC |
| :--- | :--- |
| Input Voltage Range | 0 to 264 Volts AC, $50 / 60 \mathrm{~Hz}$ |
| Inputs per Module * | 16 (two groups, each with separate common) |
| Isolation | 3000 Volts RMS between field and logic |
| Input Current | 12 mA (typical) at rated voltage |
| Input Characteristics: |  |
| On-state Voltage |  |
| Off-state Voltage |  |
| On-state Current | 0 to 40 Volts AC 264 Volts AC |
| Off-state Current | 6 mA minimum |
| On response Time | 2.2 mA maximum |
| Off response Time | 15 ms maximum |
| Operating Temperature | 34 ms maximum |
| Storage Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Operating Humidity | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |

* Number of inputs on is dependent upon ambient temperature as shown below.


## Dl-4 Wiring Diagram

There are two isolated input groups. Each group of 8 channels can be powered by a separate AC source.


## DI-4 Output Characteristics



### 13.16 TEL REL 001, DPDT Relay Board For DO-5

The 16 point relay board for the Series II Remote Terminal Unit provides 16 DPDT voltage free output contacts, each rated at 5A AC/DC. The relay contacts are terminated on a Phoenix double height PCB terminal unit arranged in a dual three way terminal (refer to drawing following). These terminals may take wire sizes up to $4 \mathrm{~mm}^{2}$.

Each relay consumes 30 mA @ +12VDC or 15 mA @ +24VDC backplane supply. An external supply can be connected to a screw terminal on the PCB if required (not if used with the standard cable supplied with the DO-5 module).

This relay board is connected to the DO-5 using a standard cable.
LED indicators are provided for each relay on the relay board - LED on = relay active.

Relay Board - TEL REL 001 Specifications

| Outputs per Terminal Board | 16 |
| :--- | :--- |
| Commons | 32 (2 commons per channel) |
| Relay Type (per channel) | DPDT (Double Pole, Double Throw) |
| Rated Load (per contact) | 5 A at 250VAC Resistive <br> 5 A at 30VDC Resistive |
| Maximum Current | 5 A |
| Maximum Operating Voltage | $380 \mathrm{VAC}, 125$ VDC (2A max.) |
| Maximum Switching Power | $750 \mathrm{VA}, 90$ Watts Resistive |
| Minimum Load | 10 mA at 5VDC |
| Contact Resistance | 50 m Ohm maximum |
| Relay Operations | $>10,000,000$ |
| Operating Temperature | $-40^{\circ}$ to $70^{\circ} \mathrm{C}$ (no icing) |
| Humidity | $35 \%$ to $85 \%$ |
| Isolation | 5 kV coil to contacts |
| Coil Rated Voltage | $12 \mathrm{VDC} \mathrm{@} \mathrm{40mA/coil}$ |
| $24 \mathrm{VDC} \mathrm{@} \mathrm{15mA/coil}$ |  |
| Coil Resistance | 400 Ohm @ 12V or 1600 Ohm @ 24V |
| Dimensions | $253 \mathrm{~mm}(\mathrm{~L}) \times 90 \mathrm{~mm}(\mathrm{~W}) \times 70 \mathrm{~mm}(\mathrm{H})$ |
| $(280 \mathrm{~mm}$ long with 2 end clamps) |  |
| Mounting | 35 mm DIN rail |
| Interface cable length <br> (for connection to the DO-5 module) | 0.8 m to 3.0m (made to order) |

## CAUTION!

1. Contacts must be protected with appropriate suppression devices when wired with inductive loads for maximum life.
2. Contacts should also be protected with external fusing.

Relay Board - TEL REL 001 Wiring Diagram


Terminal Layout For Each DO-5 Channel


Interface Cable - DO-5 To TEL REL 00x Relay Board

To DO-5 Module


| Belden 9431 Cable Color | $\begin{aligned} & \text { Fujicon } \\ & \text { Pin } \end{aligned}$ | DO-5 | Multi-core cable Belden 9431 cable | Relay Board Panduit 20way Header |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Black | 1 | CH1 |  | 1 | CH1 |
| White | 2 | CH 2 |  | 2 | CH2 |
| Red | 3 | CH3 |  | 3 | CH3 |
| Green | 4 | CH 4 |  | 4 | CH4 |
| Orange | 5 | CH5 |  | 5 | CH5 |
| Blue | 6 | CH6 |  | 6 | CH6 |
| White/Black | 7 | CH7 |  | 7 | CH7 |
| Red/Black | 8 | CH8 |  | 8 | CH8 |
| Green/Black | 9 | OV |  | 9 | OV |
| Orange/Black | 10 | OV |  | 10 | OV |
| Blue/Black | 11 | CH9 |  | 11 | CH9 |
| Black/White | 12 | CH10 |  | 12 | CH10 |
| Red/White | 13 | CH11 |  | 13 | CH11 |
| Green/White | 14 | CH12 |  | 14 | CH12 |
| Blue/White | 15 | CH13 |  | 15 | CH13 |
| Black/Red | 16 | CH14 |  | 16 | CH14 |
| White/Red | 17 | CH15 |  | 17 | CH15 |
| Orange/Red | 18 | CH16 |  | 18 | CH16 |
| Blue/Red | 19 | +12V |  | 19 | +12V |
| Green/Red | 20 | +12V |  | 20 | +12V |

### 13.17 Al-4 Analog Current Input - 8 Channel (flying capacitor)

The analog input - 8 channel module for the Series II Remote Terminal Unit provides eight individually isolated input channels, each capable of converting an analog input signal to a digital signal for use as required by your application. This module provides two input ranges. The default range is 4 to 20 mA with user data scaled so that 4 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32760 with each 1000 counts representing $0.5 \mu \mathrm{~A}$. A link on the rear of the module selects $4-20 \mathrm{~mA}$ or 0 20 mA for all channels.

Conversion speed for each of the eight channels is 250 milliseconds. By default the update rate is 8 seconds but can be configured in the range of 1-10 seconds.
Resolution of the converted signal is 12 bits binary ( 1 part in 4096) over the range. User data in the \#AI registers is in 16-bit 2'x complement format. The placement of the 12 bits from the A/D converter in the \#AI data word is shown below.

MSB
LSB

| 0 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | 0 | 0 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

If the current source is reversed into the input, or is less than the low end of the current range, then the module will output a data word corresponding to the low end of the current range $(0000 \mathrm{H}$ in \#AI). If an input that is out of range is entered (i.e. greater than 20 mA ), the A/D converter will output up to full scale (corresponding to 7FF8H in \#AI).

Scaling of the input is shown below.


Figur
e 8-3a: Al-4 Scaling for Analog Current 4 to 20 mA

Input protection for the module is sufficient to guarantee operation with reduced performance with up to 1500 V common-mode. The module provides electrical isolation of externally generated noise between field wiring and the backplane through the use of flying capacitor relay scanning system.

To minimise the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields can be connected to GND. The GND connection provides access to the backplane (frame ground).


Figure 8-3b: Al-4 Rear Module and Link Location
Eight red LEDs labeled A1 to A8 on the face plate are ON when current is $1 \%$ above the input range (i.e. 4.16 mA for $4-20 \mathrm{~mA}$ and 0.2 mA for $0-20 \mathrm{~mA}$ range). A green LED at the top of the face plate is ON when the module is operating correctly. This module also consumes power from the +5 VDC and +12 VDC bus.

An insert goes between the inside and outside surface of the hinged door. The surface towards the inside of the module (when the hinged door is closed) has circuit wiring information and circuit identification information can be recorded on the outside surface. The outside left edge of the insert is color-coded blue to indicate a lowvoltage module.

This module can be installed in any I/O slot of a 4,6 or 12 slot backplane in a system. Up to 10 Analog Current Input modules can be installed in a backplane.

## Al-4 Specifications

| Input Current Ranges | 4 to 20 mA and 0 to 20 mA |
| :--- | :--- |
| Input Voltage Ranges * | 1 to 5 V and 0 to 5 V * |
| Calibration | Factory calibrated to $5 \mu \mathrm{~A}$ |
| Update Rate | 1 to 10 seconds (all eight channels) |
| Scanning Life Expectancy <br> (for G6A-234P-ST relay) | 100 million scans or 31.7 years @ 10 s update rate |
| Resolution | $5 \mu \mathrm{~A}(1 \mathrm{LSB}=5 \mu \mathrm{~A}$ ) |
| Absolute Accuracy | $0.1 \%$ full scale $+0.1 \%$ reading |
| Common Mode Voltage | 1500 Volts |
| Linearity | $<1$ Least Significant Bit |
| Isolation | 1500 Volts RMS between field and logic and <br> between channels |
| Common Mode Rejection | $>70 \mathrm{~dB}$ at DC; $>70 \mathrm{~dB}$ at 60 Hz |
| Cross-Channel Rejection | $>80 \mathrm{~dB}$ from DC to 1 kHz |
| Input Impedance | 250 ohms |
| Input Filter Response | 2 kHz |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $+85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to $98 \%$ RH non-condensing |

* Analog inputs can be modified from current inputs to voltage inputs by lifting one leg of the 250 ohm channel resistor. Each channel has its own resistor, so any combination of channels can be converted. If necessary, the response time of the analog input can be improved by replacing the 250 ohm resistor with a 100 K resistor. It is recommended that modules be returned to RTUnet for factory conversion if required. No responsibility will be taken by RTUnet for damage caused to boards during modification performed by clients. The circuit board resistors to change are: channels $1-8=\mathrm{R} 1-\mathrm{R} 8$.


## Al-4 Block Diagram



## Al-4 Wiring Diagram



Wiring Example


4-wire trans mitter (must be powered externally)

### 13.18 RT-1 Analog RTD Input - 4 Channel

The RTD input - 4 channel module for the Series II Remote Terminal Unit provides four input channels for Pt100 Resistance Temperature Devices, each capable of converting the 100 ohm (DIN standard) temperature sensor to a digital signal for use as required by your application. Modules are available in the standard range of -150 to $400^{\circ} \mathrm{C}$ or can be manufactured to special order with minimum $100^{\circ} \mathrm{C}$ span in the -150 to $400^{\circ} \mathrm{C}$ range.

Conversion speed for each of the four channels is $20 \mu \mathrm{~S}$ and this provides a maximum update rate of two milliseconds for the module. Resolution of the converted signal is 12 bits binary ( 1 part in 4096) over the range. The placement of the 12 bits from the A/D converter in the \#AI data word is shown below. The relationship between the temperature and the data from the A/D converter is shown in the figure below.

MSB
LSB

| 0 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | 0 | 0 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

The input circuit features a constant current RTD excitation using the third lead of the RTD to sense and compensate for the RTD lead resistance, resulting in an accurate RTD temperature measurement. The RTD voltage is then amplified and fed to the 12bit ADC. The module is factory calibrated to provide $0.1 \%$ resolution of span.

To ensure accurate operation each input is factory calibrated using Toolbox software. The calibration is stored in EPROM on the RT-1 and is therefore non-volatile.


Figure 8-6a: RT-1 Scaling

Input protection for the module is sufficient to guarantee operation with reduced performance with up to 1500 V common-mode. The module provides electrical isolation of externally generated noise between field wiring and the backplane through the use of optical isolation.

To minimise the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields can be connected to E. The E connection provides access to the backplane (frame ground).

Four red LEDs labeled A1 to A4 on the faceplate are ON when an RTD is connected. A green LED at the top of the faceplate is ON when the module is operating correctly. This module also consumes power from the +5VDC and 12VDC bus. A 24VDC isolated converter is used to provide power to the RTD conditioning and ADC circuits. This module can be installed in any I/O slot of a 4,6 or 12 slot backplane in a system. Up to 10 RTD modules can be installed in a backplane.

## RT-1 Specifications

| RTD Type | Pt100, 100 ohm, 0.00385 ohm/ohm $/{ }^{\circ} \mathrm{C}$ (DIN <br> standard) |
| :--- | :--- |
| Range | -150 to $+400^{\circ} \mathrm{C}$ Standard <br> -50 to $+150^{\circ} \mathrm{C}$ (Special order) <br> 0 to $+100^{\circ} \mathrm{C}$ (Special order) <br> Other ranges within the Standard range (-150 to <br> $\left.+400^{\circ} \mathrm{C}\right)$ can be supplied on request. |
| Leadwire Resistance | 40 ohms maximum |
| Leadwire Effect | Less than $1 \%$ of span error |
| Accuracy | $0.1 \%$ (+/- $0.5^{\circ} \mathrm{C}$ ) |$|$| Resolution | 2 bit (no sign bit) |
| :--- | :--- |
| Update Rate | 100 msec typical |
| Response Time | 1500 Volts |
| Common Mode Voltage channels) | 3000 Volts RMS between field and logic |
| Isolation | $>70 \mathrm{db}$ from DC to 60 Hz |
| Common Mode Rejection | $>80 \mathrm{db}$ from DC to kHz |
| Cross-Channel Rejection | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Operating Temperature | 20 to $98 \%$ RH |
| Operating Humidity | $-40^{\circ}$ to $+85^{\circ} \mathrm{C}$ |
| Storage Temperature |  |

## RT-1 Block Diagram



RT-1 Wiring Diagram


## Chapter 14 Custom Products

### 14.1 TEL REL 003, SPST Relay Board For DO-5

The 16 point relay board is designed for use with the DO-5 module and provides 16 SPST voltage free output contacts. The relay contacts are terminated on a Weidmuller single height PCB terminal unit (please see wiring diagram). These terminals can take wire sizes up to $4 \mathrm{~mm}^{2}$. The TEL-REL-003 relay board has a superior inductive load rating than the TEL-REL-002 relay board.

LED indicators are provided for each relay on the relay board - LED ON = relay active.

Relay Output Terminal Board - TEL REL 003 Specifications

| Outputs per Terminal Board | 16 |
| :---: | :---: |
| Commons | 16 (1 common per channel) |
| Relay Type (per channel) | SPST (Single Pole, Single Throw) |
| Rated Load (per contact) | 8A at 250VAC Resistive 8A at 30VDC Resistive 1 A at 125 VDC Inductive |
| Maximum Operating Voltage | 380VAC, 125VDC |
| Maximum Switching Power Resistive | 2000VA, 240W |
| Contact Resistance | $100 \mathrm{~m} \Omega$ maximum |
| Relay Operations | 100,000 minimum at 1800 operations per hour at rated resistive load 50,000 minimum at 360 operations per hour at rated inductive load |
| Operating Temperature | -40 to $70{ }^{\circ} \mathrm{C}$ (no icing) |
| Humidity | 5\% to 85\% |
| Isolation | 5 kV coil to contacts |
| Coil Rated Voltage | 12VDC @ 66mA |
| Coil Resistance | $180 \Omega$ @ 12VDC |
| Dimensions | $253 \mathrm{~mm}(\mathrm{~L}) \times 90 \mathrm{~mm}(\mathrm{~W}) \times 70 \mathrm{~mm}(\mathrm{H})$ <br> (280mm long with 2 end clamps) |
| Mounting | 35mm DIN rail |
| Interface cable length (for connection to the DO-5 module) | 0.8 m to 3.0 m (made to order) |
| Relay Part Number | Omron G2RG-2A4-DC12 (datasheet is available from www.europe.omron.com) |

## CAUTION!

Contacts can be protected with appropriate suppression devices when wired with inductive loads to increase life of relays. Contacts should also be protected with external fusing.

Relay Output Terminal Board - TEL REL 003 Wiring Diagram


Terminal Layout For Each Output Channel


Interface Cable - DO-5 To TEL REL 00x Relay Board

To DO-5 Module


| Belden 9431 Cable Color | $\begin{aligned} & \text { Fujicon } \\ & \text { Pin } \end{aligned}$ | DO-5 | Multi-core cable Belden 9431 cable | Relay Board Panduit 20way Header |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Black | 1 | CH1 |  | 1 | CH1 |
| White | 2 | CH 2 |  | 2 | CH2 |
| Red | 3 | CH3 |  | 3 | CH3 |
| Green | 4 | CH 4 |  | 4 | CH4 |
| Orange | 5 | CH5 |  | 5 | CH5 |
| Blue | 6 | CH6 |  | 6 | CH6 |
| White/Black | 7 | CH7 |  | 7 | CH7 |
| Red/Black | 8 | CH8 |  | 8 | CH8 |
| Green/Black | 9 | OV |  | 9 | OV |
| Orange/Black | 10 | OV |  | 10 | OV |
| Blue/Black | 11 | CH9 |  | 11 | CH9 |
| Black/White | 12 | CH10 |  | 12 | CH10 |
| Red/White | 13 | CH11 |  | 13 | CH11 |
| Green/White | 14 | CH12 |  | 14 | CH12 |
| Blue/White | 15 | CH13 |  | 15 | CH13 |
| Black/Red | 16 | CH14 |  | 16 | CH14 |
| White/Red | 17 | CH15 |  | 17 | CH15 |
| Orange/Red | 18 | CH16 |  | 18 | CH16 |
| Blue/Red | 19 | +12V |  | 19 | +12V |
| Green/Red | 20 | +12V |  | 20 | +12V |

## 14．2 DI－10－1－48 High Input Threshold

| FEATURES |  |  |
| :---: | :---: | :---: |
| $\rrbracket \square$ | Frequency or Pulse or Quadrature Counting on any 7 Inputs | 彩 Isolated DC Output For |
| $7$ | Software Debounce Filter | 4 －AC or DC Inputs |
| $\frac{\\|}{1+1}$ | Sequence of Events Recording | 予生3kV Field to Logic Isolation |

The DI－10－1－48 is the same as a DI－10－1 except it has a higher input voltage threshold （the voltage when the channel switches ON ）．For systems that use a high channel voltage（eg 48 or 120 VDC），the negative rail is often not at 0 V and can float upwards and turn on the channel falsely．The DI－10－1－48 has different zener diodes to a standard DI－10 module that raise the input voltage threshold and prevent this problem．

The DI－10 provides 16 input points in one group with common power for field contacts． The inputs are designed for wide ranging DC and AC input signals from external devices．A wide range of input devices that are powered by the module can be used such as push buttons，limit switches and electronic proximity switches（these provide dry contact closures）．Alternatively inputs can be powered externally by DC and AC input signals．

Closure of the field contact results in a logic 1 in the status register．
The DI－10 module provides all the functionality of the DI－1 and DI－5 modules except the field voltage polarity cannot be reversed．It has software configurable debounce filters，channel inversion and Sequence－of－Events recording selectable on any channel（s）．Frequency，pulse or quadrature counting can also be configured for any 7 input channels．

This module can be installed in any I／O slot of a 4,6 or 12 slot backplane system．

Module LEDs
DH10
OK poow


| A2 | A6 | B10 | B14 |
| :--- | :--- | :--- | :--- | :--- |



| A4 | A8 | B12 | B16 |  |
| :--- | :--- | :--- | :--- | :--- |
|  |  |  |  |  |


| LED | State | Description |
| :--- | :--- | :--- |
| OK | OFF | Module Fault（no power） |
|  | ON | Normal OK |
| PCON | OFF | DI－10 output power OFF |
|  | ON | DI－10 output power ON |
| A1－A8， | OFF | Digital input OFF |
|  | ON | Digital input ON |

## Configurable Functions

The first 4 channels are high speed inputs, capable of counting up to 10 kHz ; the other 12 inputs can count up to 1 kHz . The DI-10 module has 7 user-configurable counter inputs, which appear as 16-bit unsigned integer values in the analog input registers. These can each be configured as frequency counters for any input channel to 1 Hz resolution, or pulse counters, or quadrature counters which work with quadrature inputs on pairs of channels.

Channel inversion can be configured on any input channels. Normally a high voltage level applied to a digital input channel will result in a logical 1 state in the digital input register, and the LED on the front panel of the module being set ON. A low voltage level will result in a logical 0 state in the digital input register, and the LED will be OFF. By configuring channel inversion, the situation is reversed: a high voltage level results in a logical 0 state and the LED is set OFF; a low voltage level results in a logical 1 state and the LED is set ON.

Software Debounce Filters can be configured for any input channel, with a time constant from 1 millisecond to 250 milliseconds. When using AC inputs, the input channels must be configured with a debounce filter of 'AC Filter'.

## Sequence-of-Events Recording

Sequence-of-Events (SoE) recording can be configured for any input channel. When SoE is enabled, any event (change of state) on the input channel is logged to 1 millisecond accuracy. This event is automatically included in the Event Log of the RTU. The DI-10 module has a timer that is automatically synchronised with the realtime clock of the processor module.

The DI-10 module has an internal buffer with enough space for 1000 events. The DI10 module can therefore cope with bursts of up to 1000 events at a time. Events are uploaded into the processor module at a maximum rate of 100 events per second allowing the DI-10 module to cope with events at a sustained rate of 100 events per second.

## DI-10 Wiring Diagram



## Wiring Examples



DI-10-1-48 Specifications

| Output Power | 12VDC @ 80mA (1W) isolated, supplied by module |
| :---: | :---: |
| Input Voltage Range | $+35 \text { to }+130 \mathrm{VDC}=\mathrm{ON}, 0 \text { to }+34 \mathrm{VDC}=\mathrm{OFF}$ $27 \text { to } 260 \mathrm{VAC}=\mathrm{ON}, 0 \text { to } 26 \mathrm{VAC}=\mathrm{OFF}$ <br> (Note: a negative DC supply can be used provided that the channel input voltage is more positive than the common) |
| Inputs per Module | 16 |
| Isolation | 3000 Volts RMS between field and logic |
| On response Time | Digital Inputs 1 to $4: 50 \mu$ s maximum* Digital Inputs 5 to 16: $500 \mu$ s maximum |
| Off response Time | Digital Inputs 1 to 4:50 5 s maximum* (DC) <br> Digital Inputs 5 to $16: 500 \mu \mathrm{~s}$ maximum (DC) <br> Digital Inputs 1-16: 30ms (AC) |
| Operating Temperature | $-20^{\circ}$ to $70^{\circ} \mathrm{C}$ |
| Storage Temperature | $-40^{\circ}$ to $85^{\circ} \mathrm{C}$ |
| Operating Humidity | 5 to 98\% non-condensing |
| Pulse Rates / <br> Frequency | Digital Inputs 1 to $4: 10 \mathrm{kHz}$ maximum* Digital Inputs 5 to $16: 1 \mathrm{kHz}$ maximum |
| Frequency Counting | 1 Hz resolution on any input(s) (7 counters max.) |
| Pulse Totalisation | 0-65535 Pulses on any input(s) (7 counters max.) |
| Quadrature Counting | 0-65535 Pulses on any input(s) (7 counters max.) |
| Channel Inversion | Selectable on any input(s) |
| Debounce Filtering | Time constant 1-250 ms on any input(s) or AC Filter (for AC inputs). |
| Sequence of Events | 1 millisecond resolution <br> Buffering for 1000 events, uploaded to CPU at 100 events/second Selectable on any input(s) |

* Version 1.1 and older DI-10 modules are rated at 1 kHz for all 16 channels.


## Chapter 15 Port Adaptors and Cables

Port adaptors (labeled 'ADP-xx') allow a communications device to be used by the RTU. The adaptor plugs into the communications device and then an RJ45 cable is connected between the RTU port and the base of the adaptor. The adaptor has internal wires for each RJ45 pin and these are connected to the various pins of the adaptor DB9 or DB25 socket as required.

Some types of cables require external power wires or use connectors that are not available as adaptors. These cables are prefabricated and are labeled 'RJC-ADP-xx'.

| RJ45 <br> Pin | Adaptor Internal <br> Wire Color * | RJ45 Cable |
| :---: | :---: | :---: |
| 1 | White or Grey | Brown |
| 2 | Brown | Brown/White |
| 3 | Yellow | Orange |
| 4 | Green | Blue/White |
| 5 | Red | Blue |
| 6 | Black | Orange/White |
| 7 | Orange | Green |
| 8 | Blue | Green/White |



Note: the above RJ45 pinout is different to some conventions

* Colors may vary according to adaptor supplier



## ADP-04 <br> PC-1/MC-1 Radio Port to Tait T2010 or Maxon RDM01 Radio (SD125)

To Kingfisher RTU
Radio Port (RJ45)

## ADP-05 <br> RTU Serial Port to PC Serial Port (Creates a null modem cable)

To Kingfisher RTU
Serial Port (RJ45)


| RJ45 | Adaptor wirecolors |  | Wires inside the adaptor | DB9 |
| :---: | :---: | :---: | :---: | :---: |
| Pin |  |  | Female |
| 1 | GREY | TXD |  | RXD 2 |
| 2 | BROWN | RXD |  |  | TXD 3 |
| 4 | GREEN | GND |  | GND 5 |
| 3 | YELLOW | CTS |  | RTS 7 |
| 6 | BLACK | RTS |  | CTS 8 |

ADP-07 RTU Serial Port to External PSTN Modem

| To Kingfisher RTU Serial Port (RJ45) |  |  | RJ45 socket | DB25 Male | To PS Mode |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| RJ45 | Adaptor wirecolors |  | Wires inside the adaptor |  | DB25 Male |  |
| Pin |  |  |  |  |
| 1 | GREY | TXD |  |  | TXD | 2 |
| 2 | BROWN | RXD |  |  |  |  | RXD | 3 |
|  |  |  |  |  | RTS | 4 |
|  |  |  |  |  | CTS | 5 |
| 4 | GREEN | GND |  |  | GND | 7 |
| 5 | RED | DCD |  |  | CD | 8 |
| 3 | YELLOW | CTS |  |  | DTR | 20 |
| 6 | BLACK | RTS |  |  |  |  |

RJ45 to DB9 Female Converter (Straight Connect) (Note: when coupled with an ADP-05 forms a null modem cable DB9 female to DB9 female)
To Kingfisher RTU
Port (RJ45)

## ADP-08-M Serial Port to MaxStream External Spread Spectrum Radio (eg MaxStream XTend-PKG or XStream-PKG radios)

To Kingfisher RTU
Serial Port (RJ45)

ADP-09 Serial Port to HITECH or Nematron Display Panel
To Kingfisher RTU
Serial Port (RJ45)

## ADP-16 Serial Port to Trio D-Series Radio (eg TC-900DR) or

 Trio E Series Radio (eg TC-450ER)

## RJC-ADP-17 PC-1/MC-1 Radio Port to Trio S- Series Radio (eg TC-450SR, TC-900SR) or RTU Serial Port to Trio S-Series Radio with 24/48SR modem fitted



## RJC-ADP-18 CP-xx Line Option Board to Maxon Radio

 (Maxon SD-125)

RJC-ADP-20 CP-xx Line Option Board to Trio S Series Radio (eg TC-450SR, TC-900SR)

To Kingfisher RTU Line Option Board (RJ45)


RJC-ADP-21 CP-xx Line Option Board to Tait T2010 Radio

To Kingfisher RTU Line Option Board (RJ45)


RJC-ADP-22 Serial Port to GSM Phone (Wavecom WM02-G900) or GPRS Modem (Wavecom Fastrack)
To Kingfisher RTU Serial
Port (RJ45)

RJC-ADP-23 PC-1/MC-1 Radio Port/Serial Port to Trio S- Series (SB) Repeater

To Kingfisher RTU Port (RJ45)


RJC-ADP-26 RTU Serial Port to Maxon MM-5100 CDMA Modem


## RJC-ADP-27 RTU Serial Port to Motorola 9522 Satellite Transceiver



ADP-28
RTU Serial Port to Trio H-Series Spread Spectrum Radio

To Kingfisher RTU
Serial Port (RJ45)


| RJ45 | Adaptor wirecolors |  | Wires inside the adaptor | DB9 Male |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Pin |  |  |  |  |  |
| 1 | GREY | TXD |  | TXD | 3 |
| 2 | BROWN | RXD |  | RXD | 2 |
| 4 | GREEN | GND |  | GND | 5 |
| 6 | BLACK | RTS |  |  |  |
| 3 | YELLOW | CTS |  |  |  |


| ADP-29 | Serial Port to Trio M-Series Radio <br> (with modem fitted) Eg. MR450 |
| :--- | :--- |

To Kingfisher RTU
Serial Port (RJ45)


| RJ45 | Adaptor wire <br> colors |  | Wires inside the adaptor | DB9 Male |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Pin | COLD |  |  |  |  |
| 1 | GREY | TXD |  | TXD | 3 |
| 2 | BROWN | RXD |  | RXD | 2 |
| 4 | GREEN | GND |  | GND | 5 |
| 5 | RED | DCD | $\square$ | CD | 1 |
| 6 | BLACK | RTS | $\square$ |  |  |

## RJC-ADP-30 CP-xx Line Option Board to Trio M-Series Analog

 Radio (no modem fitted) Eg. MR450

To Kingfisher RTU
Radio Port (RJ45)


To Trio Radio

DB9 Male
RJ45 Adaptor wire
Pin
1
1
2
4
5
3
6

| colors |  | Wires inside the adaptor |  |  |
| :--- | :--- | :--- | :--- | :--- |
| GREY | TXD | TXD | 3 |  |
| BROWN | RXD | RXD | 2 |  |
| GREEN | GND | GND | 5 |  |
| RED | DCD |  | CD | 1 |
| YELLOW | CTS | $-\quad$ RTS | 7 |  |

## ERN FORM



## 14. Amalgamated

 Instruments
# Panel Mount Indicators <br> New generation space saving design PM6-LP-4C 4 digit 2-wire loop powered indicator 

## Scalable indication of $4-20 \mathrm{~mA}$ or $\mathbf{1 0 - 5 0 m A}$ loop



## Features

- Pushbutton configurable to scale/calibrate, select decimal point, digital filter and resolution
- $4-20 \mathrm{~mA}$ or $10-50 \mathrm{~mA}$ (user selectable)
- 4 digit display for high accuracy and readability
- Scaling without test equipment or special tools
- Square root function standard
- High contrast LCD display
- Remote input to perform special functions e.g. maximum, minimum, peak hold, display hold or tare
- Programmable digital filter improves display stability by smoothing out short term noise
- Rugged construction
- Computer tested
- 2 year guarantee
- 66 mm depth behind bezel to minimise panel depth



## Description

The second generation PM6-LP-4C microprocessor based panel 2-wire loop powered display has been designed to be accommodated in shallow panel installations. The PM6-LP-4C is a 4 digit indicator with a high contrast LCD display with 12.7 mm digits to ensure excellent visibility. All function settings and calibration is achieved by user programmable pushbuttons (pushbutton functions include decimal point, digital filter, resolution, square root extractor etc.). The display is fully scalable to read in engineering units. The PM6 is supplied factory calibrated and computer tested. Since the instrument utilises pushbutton setup it can be scaled and configured without test equipment or the need to dismantle to select components. The instrument is powered from the loop and will accept $4-20 \mathrm{~mA}$ or $10-50 \mathrm{~mA}$ current loops (user configurable).

Electrical connections are made via plug in terminal blocks. A terminal with no internal connections is provided, as a convenient connector for the loop cable. The programmable digital filter improves stability by smoothing out short term interference. An external input is configurable to perform one of various functions e.g. maximum value, minimum value, peak hold, display hold or tare. The PM6-LP is housed in a rugged DIN panel mount enclosure with a bezel size of $48 \times 96 \mathrm{~mm}$ and requires a depth behind the bezel of only 66 mm (with a small extra allowance for cabling).

Order Code: PM6-LP-4C

PM6LP-1.0-0

## Technical Specifications

Input
Current range

Input protection
Voltage Drop
ADC resolution:
Decimal points:
Calibration range:
Overrange indication:
Accuracy:
Sample rate:
Display update:
Ambient temp:
Humidity:
Display:
Power supply:

Physical Characteristics
Bezel size:
Case size:
Panel cut out:
Connections:
Weight:
$4-20 \mathrm{~mA}$ or $10-50 \mathrm{~mA}$
(user selectable)
Measurable 3.5 mA to 22 mA
(4-20mA input)
Measurable 9.0 mA to 55 mA
( $10-50 \mathrm{~mA}$ input)
150 mA either direction
2 V at $4 \mathrm{~mA}, 2.3 \mathrm{~V}$ at 20 mA nominal 15 bit
0 to 3 decimal point places
(selectable)
Anywhere within the instrument display range
-.-- on display
$0.025 \%$ of full scale when calibrated $\pm 50 \mathrm{ppm} /{ }^{\circ} \mathrm{C} \pm 1$ digit
2.5 updates per second
2.5 times per second
$-10^{\circ} \mathrm{C}$ to $50^{\circ} \mathrm{C}$
5 to $95 \%$ non condensing 4 digit 12.7 mm liquid crystal display
Powered by the $4-20 \mathrm{~mA}$ or $10-50 \mathrm{~mA}$ loop

DIN $48 \mathrm{~mm} \times 96 \mathrm{~mm} \times 9 \mathrm{~mm}$
$44 \mathrm{~mm} \times 91 \mathrm{~mm} \times 66 \mathrm{~mm}$ behind face of panel
$45 \mathrm{~mm} \times 92 \mathrm{~mm}(+1 \mathrm{~mm} \&-0 \mathrm{~mm})$
Plug in screw terminals (max $2.5 \mathrm{~mm}^{2}$ wire)
180 g unpacked

PM6-LP electrical connections


PM6-LP panel mounting details


A model with 6 digits is also available
The 6 digit model can be configured as a rate/total display
Model: PM6-LP-6C
Ask for brochure for the PM6-LP-6C or download
pm6lp6c.pdf (http:/ /www.aicpl.com.au/brochures/pm6lp6c.pdf)

Visit AIC's website (http:/ /www.aicpl.com.au) for information about all Amalgamated Instrument Co (AIC) products.

# Panel model model PM6-LP-4C and field mount model RT6-LP-4C Display <br> Operation and Instruction Manual 

ACN: 001589439
e-mail: sales@aicpl.com.au
Internet: www.aicpl.com.au

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## 1 Introduction

### 1.1 General description

This manual contains information for the installation and operation of the panel mount model PM6-LP-4C and IP65 field mount model RT4-LP-4C monitors. These two wire loop powered displays will accepts an input of 4 to $20 \mathrm{~mA} \mathrm{DC} \mathrm{(or} 10$ to 50 mA if selected). The instruments may be calibrated to display the input in engineering units. The instruments provide features such as display rounding, digital filtering (improves stability by reducing susceptibility to noisy signals) and visual over/under level warning. Unless otherwise specified at the time of order, your PM6 or RT6 has been factory set to a standard configuration.

Like all other PM6 and RT6 series instruments the configuration and calibration is easily changed by the user via push button functions. The instrument is totally powered by the measured current loop and requires no additional power supply. Since these displays require a 2.3 volt nominal loop voltage drop, they are especially suitable for current loops that would otherwise exceed their power supply capacity with too many devices connected.

The PM6 series of panel mount monitors are designed for high reliability in industrial applications. The RT6 series of field mount monitors provides the same features of the PM6-LP-4C loop powered displays in an IP65 enclosure. The high contrast LCD displays provide good visibility especially in areas with high ambient light levels.


## 2 Mechanical Installation

Choose a mounting position as far away as possible from sources of electrical noise such as motors, generators, fluorescent lights, high voltage cables/bus bars etc.

## PM6 Mechanical details

An IP65 access cover which may be installed on the panel and surrounds is available as an option to be used when mounting the instrument in damp/dusty positions. A wall mount case is available, as an option, for situations in which panel mounting is either not available or not appropriate. An optional portable carry case is also available.

Prepare a panel cut out of $45 \mathrm{~mm} \times 92 \mathrm{~mm}+1 \mathrm{~mm} /-0 \mathrm{~mm}$ (see diagram below). Insert the instrument into the cut out from the front of the panel. From the rear of the instrument fit the two mounting brackets into the recess provided (see diagram below). Whilst holding the bracket in place, tighten the securing screws being careful not to over-tighten, as this may damage the instrument. Hint: use the elastic band provided to hold the mounting bracket in place whilst tightening securing screws.


## RT6 Mechanical details

Mounting hole locations for surface mounting are provided with 90 mm and 60 mm centers. Remove the lid to gain access to the mounting holes. A PG9 cable gland is provided for cable entry, drill a 16 mm dia. hole for this gland in a suitable position in the bottom section of the case. Remove top section of the case before drilling to protect the circuit boards. Note that there is a keyway on the top right hand corner of the lid (male key) and base (female key), ensure the keyway is in correct orientation before fixing the base to a surface. The lid will not fit correctly unless the keyways match.

Keyway on lid/base


## 3 Electrical installation

### 3.1 Electrical installation

The PM6 and RT6 loop powered displays are designed for continuous operation and no power switch is fitted.

The screw type terminal blocks allow for wires of up to $2.5 \mathrm{~mm}^{2}$ to be fitted, PM6 connectors are plug in type screw connectors. Connect the wires to the appropriate terminals as indicated below. Wiring to the remote inputs is required only if a remote input function e.g. peak hold is selected.

When loop power is applied the instrument will cycle through a display sequence indicating the software version and other status information, this indicates that the instrument is functioning. The use of screened cable is recommended for signal inputs.

### 3.2 PM6 rear panel



### 3.3 PM6 data label (located on top of case)

| 1 CASE GGOUND | 7 REMDIE INPUT 2 |
| :---: | :---: |
| 2 LODP Cownection |  |
| 3 4-2knh infut -ve |  |
| 4 A-2ban thput -VE |  |
| 5 REMOTE INFUT 1 |  |
| 6 RLMOIL INPUT COMmON |  |
| PME-1. P-45 | SERTAL Mo. |

### 3.4 PM6 connection to a transmitter



### 3.5 PM6 connection with two displays in one loop



### 3.6 RT6 electrical connections



### 3.7 RT6 connection to a transmitter



### 3.8 RT6 connection with two displays in one loop



## 4 Function tables - summary of setup functions

Functions in this first table are available in Func or CRL mode

| Display | Function | Range | Default | Your <br> record | Ref/Page |
| :---: | :---: | :---: | :---: | :---: | :---: |
| drnd | Display rounding | $\mathbf{i}$ to $\mathbf{5 0 0} \boldsymbol{0}$ | $\mathbf{i}$ |  | $5.1 / 11$ |
| Fitr | Digital filter | $\mathbf{E}$ to $\mathbf{8}$ | $\boldsymbol{己}$ |  | $5.3 / 12$ |

Functions in this second table are available only in ©RL mode or if $\boldsymbol{P C} \boldsymbol{5} \boldsymbol{5}$ is set to PLL

| Display | Function | Range | Default | Your record | Ref/Page |
| :---: | :---: | :---: | :---: | :---: | :---: |
| dCPE | Decimal point | ©, ©. : etc. | 0 |  | $5.2 / 11$ |
| CRL | First live input calibration scaling point | Any display value | n/a |  | $5.4 / 12$ |
| CRLS | Second live input calibration scaling point | Any display value | n/a |  | $5.5 / 12$ |
| $\begin{aligned} & \text { CRL } \\ & \text { OFSt } \end{aligned}$ | Calibration offset | Any display value | n/a |  | $5.6 / 12$ |
| $\begin{gathered} \text { SELE } \\ \text { Enit } \end{gathered}$ | 4 mA input scale | Any display value | n/a |  | 5.7 / 12 |
| $5[: E$ Encs | 20 mA input scale | Any display value | n/a |  | $5.8 / 13$ |
| UCRL | Uncalibrate | n/a | n/a |  | $5.9 / 13$ |
| ¢. | Remote input 1 function | Mone, <br> P.HLd, d.HLd, H, Lo | תone |  | 5.10 / 13 |
| 5.182 | Remote input two (external input) function | MOHE <br> P.HLd, d.HLd, H, Lo | ת日תe |  | 5.11 / 14 |
| $\begin{gathered} \text { Lo } \\ \text { di } 5 p \end{gathered}$ | Low overrange visual warning limit value | Any display value or DFF | OFF |  | 5.12 / 14 |
| $\begin{aligned} & H: 9 H \\ & \text { d: 5P } \end{aligned}$ | High overrange visual warning limit value | Any display value or CFF | BFF |  | 5.13 / 14 |
| d) $5 P$ | Display visual warning flashing mode | $\begin{aligned} & \text { FiSH or } \\ & \text {-or } \end{aligned}$ | FiSH |  | 5.14 / 15 |
| HE55 | Access mode | DFF ManE or RLL | OFF |  | $5.15 / 15$ |
| 59-t | Square root mode | On or SFF | BFF |  | $5.16 / 15$ |
| - $n P$ Pt | Input range $4-20 \mathrm{~mA}$ or $10-50 \mathrm{~mA}$ | $\begin{gathered} 4-20 \text { or } \\ 60.50 \end{gathered}$ | 4-20 |  | 5.17 / 16 |

## 5 Explanation of functions

Setup and calibration functions are configured through a push button sequence. The three push buttons located at the rear of the PM6 are used to alter settings. Two basic access modes are available:

Func mode (simple push button sequence) allows access to commonly set up functions such as decimal point.
[AL mode (power up sequence plus push button sequence) allows access to all functions including calibration parameters.

Once [RL or Firfe mode has been entered you can step through the functions, by pressing and releasing the $\boldsymbol{F}$ push button, until the required function is reached. Changes to functions are made by pressing the or push button (in some cases both simultaneously) when the required function is reached. See the flow chart example on the following page.

Note: if the RE[5 function is set to RL: then access to all functions can be made via Finc mode, this allows access to all functions without the need to power down.

2. When the "wake up" messages have finished and the display has settled down to its normal reading press, then release the $F$ button.
Move to step 3 below.

3. Within 2 seconds of releasing the $\boldsymbol{F}$ button press, then release the $\boldsymbol{\nabla}$ and $\boldsymbol{\nabla}$ buttons together. The display will now indicate Fune followed by the first function.

## Entering Finct Mode

No special power up procedure is required to enter FLIC mode.

1. When the "wake up" messages have finished and the display has settled down to its normal reading press, then release the $\boldsymbol{F}$ button.

2. Within 2 seconds of releasing the $\boldsymbol{F}$ button press, then release the $\boldsymbol{\nabla}$ and $\boldsymbol{\nabla}$ buttons together. The display will now indicate Furie followed by the first function.

Example: Entering [RL mode to change SMrt function from ©FF to on


## Explanation of Functions

### 5.1 Display rounding

```
Display: drnd
Range: : to 5000
Default Value: :
```

Displays and sets the display rounding value. This value may be set to $1-5000$ displayed units. Display rounding is useful for reducing the instrument resolution without loss of accuracy in applications where it is undesirable to display to a fine tolerance. To set the display rounding value go to the drad function and use the $\boldsymbol{\square}$ or push buttons to set the required value then press $\boldsymbol{\nabla}$ to accept this selection.

## Example:

If set to $\boldsymbol{1 0}$ the display values will change in multiples of 10 only i.e. display moves from $\mathbf{i 0}$ to 20 to $\mathbf{3 0}$ etc.

### 5.2 Decimal point

| Display: | $d[P E$ |
| :--- | :--- |
| Range: | $\mathbf{O}, \boldsymbol{C}$. etc. |
| Default Value: | $\mathbf{0}$ |

Displays and sets the decimal point. By pressing the or pushbutton at the $\boldsymbol{d} \boldsymbol{\square} \boldsymbol{P} \boldsymbol{E}$ function the decimal point position may be set. The display will indicate as follows: $\boldsymbol{\mathcal { O }}$ (no decimal point), ©. ( 1 decimal place), $\mathbf{0 . 0 2}$ (2 decimal places) or $\mathbf{0 . 0 0 3}$ (3 decimal places). Note if the decimal point is altered the display will need to be recalibrated.

### 5.3 Digital filter

| Display: | Fitr |
| :--- | :--- |
| Range: | $\mathbf{G}$ to $\mathbf{B}$ |
| Default Value: | $\mathbf{?}$ |

Displays and sets the digital filter value. Digital filtering uses a weighted average method of determining the display value and is used for reducing display value variation due to short term interference. The digital filter range is selectable from $\boldsymbol{\Xi}$ to $\boldsymbol{B}$, where $\boldsymbol{\Xi}=$ none and $\mathbf{B}=$ most filtering. Use $\boldsymbol{\triangle}$ or at the $\boldsymbol{F} \boldsymbol{L} \boldsymbol{r}$ function to alter the filter level if required. Note that the higher the filter setting the longer the display may take to reach its final value when the input is changed, similarly the relay operation and any output options will be slowed down when the filter setting is increased. To set the digital filter value go to the Fitr function and use the $\boldsymbol{\Delta}$ or $\boldsymbol{\nabla}$ push buttons to set the required value then press $\boldsymbol{\nabla}$ to accept this selection.

### 5.4 First calibration scaling point

| Display: | CRL : |
| :--- | :--- |
| Range: | Any display value |
| Default Value: | $\mathrm{n} / \mathrm{a}$ |

First scaling point for 2 point calibration scaling - See "Calibration" chapter, section 6.1.

### 5.5 Second calibration scaling point

| Display: | CRL $\boldsymbol{Z}$ |
| :--- | :--- |
| Range: | Any display value |
| Default Value: | $\mathrm{n} / \mathrm{a}$ |

Second scaling point for 2 point calibration scaling - See "Calibration" chapter, section 6.1 .

### 5.6 Calibration offset

## Display: CRL OFSt

Range: Any display value
Default Value: n/a
Calibration offset - See section 6.2.

### 5.7 4 mA input scale

| Display: | SELEERH |
| :--- | :--- |
| Range: | Any display value |
| Default Value: | $\mathrm{n} / \mathrm{a}$ |

4 mA input scale value, use only as an alternative to [RL $\mathbf{I}$ and $\boldsymbol{C R L}$ calibration - See "Calibration" chapter, section 6. This function will be displayed as SELE En ig if set for 10-50mA input.

### 5.820 mA input scale

Display: SELE EnZD<br>Range:<br>Any display value<br>Default Value:<br>n/a

20 mA input scale value, use only as an alternative to $\boldsymbol{C A L} \mathbf{:}$ and $\boldsymbol{C R L} \boldsymbol{Z}$ calibration - See "Calibration" chapter, section 6 . This function will be displayed as SELE En50 if set for $10-50 \mathrm{~mA}$ input.

### 5.9 Uncalibrate

| Display: | UCRL |
| :--- | :--- |
| Range: | $\mathrm{n} / \mathrm{a}$ |
| Default Value: | $\mathrm{n} / \mathrm{a}$ |

Uncalibrate, resets calibration - required only when a calibration problem occurs and it is necessary to clear the calibration memory. At the UCRL function press the $\boldsymbol{\square}$ and buttons simultaneously. The message CRL CLr should be seen to indicate that the calibration memory has been cleared.

### 5.10 Remote input 1 function

| Display: | R.inf |
| :--- | :--- |
| Range: | חine, P.HLd, d.HLd, H, Lo |
| Default Value: | Hone |

Remote input function - terminals 8 and 9 at the rear of the instrument are the remote input terminals. When these terminals are short circuited via a switch, relay, keyswitch etc. the instrument will perform the selected remote input function. A message will flash to indicate which function has been selected when the remote input pins are short circuited. The remote input functions are as follows:

- ROHE - no remote function required i.e. activating the remote input has no effect.
- P.HLd-display peak hold. The display will show the peak value (highest positive value) only whilst the remote input terminals are short circuited i.e. the display value can rise but not fall whilst the input terminals are short circuited. The message P.H: $\boldsymbol{d}$ will appear briefly every 8 seconds whilst the input terminals are short circuited to indicate that the peak hold function is active.
- d.H:d - display hold. The display value will be held whilst the remote input terminals are short circuited. The message d.H.d will appear briefly every 8 seconds whilst the input terminals are short circuited to indicate that the display hold function is active.
- H, - peak memory. The peak value stored in memory will be displayed if the remote input terminals are short circuited, if the short circuit is momentary then the display will indicate the peak memory value then return to normal measurement after 30 seconds. To reset the memory hold the remote input closed for 2 to 3 seconds or remove power from the instrument. The message $\boldsymbol{P} \boldsymbol{H}$, will appear briefly every 8 seconds whilst the input terminals are short circuited to indicate that the peak memory function is active.
- Lo - valley memory. The minimum value stored in memory will be displayed. The message $\boldsymbol{P}$ Lo will appear briefly every 8 seconds whilst the input terminals are short circuited to indicate that the peak memory function is active. Otherwise operates in the same manner as the $\boldsymbol{H}$, function described above.


### 5.11 Remote input 2 function

| Display: | F.BE |
| :--- | :--- |
| Range: | Mone, P.HLd, d.HLd, H, Lo |
| Default Value: | Hane |

Remote input two functions, operates in the same manner as the first remote input but uses
 essential that $\boldsymbol{\Gamma}$. $\boldsymbol{P}$ and $\boldsymbol{\Gamma} . \boldsymbol{\sim} \boldsymbol{\sim}$ are not set for the same function.

### 5.12 Low overrange visual warning limit value

```
Display: Lo di 5P
Range: Any display value or 0FF
Default Value: OFF
```

Low overrange limit value - the display can be set to show an overrange message if the display value falls below the Lo di 5P setting. For example if $\mathbf{L o}$ of $\mathbf{5 P}$ is set to $\mathbf{5 0}$ then once the display reading falls below $\mathbf{5 0}$ the message -or - will flash on and off or the display value will flash on and off instead of the normal display units (see di:5P function 5.14). This message can be used to alert operators to the presence of an input which is below the low limit. If this function is not required it should be set to $\boldsymbol{\text { GFF}}$ by pressing the $\boldsymbol{\square}$ and buttons simultaneously at this function.

### 5.13 High overrange visual warning limit value

| Display: | H: $\mathbf{9 H} \mathbf{d :} \mathbf{5 P}$ |
| :--- | :--- |
| Range: | Any display value or ©FF |
| Default Value: | GFF |

High overrange limit value - the display can be set to show an overrange message if the display value rises above the $\mathbf{H :} \mathbf{9 H} \mathbf{d} \mathbf{5 P}$ setting. For example if $\mathbf{H :} \mathbf{9 H} \mathbf{d :} \mathbf{5 P}$ is set to $\mathbf{8 0 0}$ then once the display reading rises above $\mathbf{6 0 0 5}$ the message -or - will flash on and off or the display value will flash on and off instead of the normal display units (see d: 5P function 5.14). This message can be used to alert operators to the presence of an input which is above the high limit. If this function is not required it should be set to $\boldsymbol{O F F}$ by pressing the $\boldsymbol{\square}$ and buttons simultaneously at this function.

### 5.14 Display visual warning flashing mode

| Display: | di 5P |
| :--- | :--- |
| Range: | FLSH or -or - |
| Default Value: | FL5H |

Display overrange warning flashing mode - this function is used in conjunction with the La d: 5P and $\mathbf{H :} \mathbf{9 H} \mathbf{d} \mathbf{5 P}$ functions. The $\mathbf{d} \mathbf{5 P}$ function can be set to $\mathbf{F} \mathbf{L} \mathbf{5 H}$ or -or- . If the display warning value set at the $\mathbf{L o d} \mathbf{~} \mathbf{5 P}$ or $\mathbf{H}: \mathbf{9 H} \mathbf{d}: \mathbf{5 P}$ function is exceeded and the $\mathbf{d} \mathbf{5 P}$ function is set to $\mathbf{F L} \mathbf{5 H}$ then the display value will flash on and off every second as a visual warning. If the display warning value set at the $\mathbf{L o d} \mathbf{5 P}$ or $\mathbf{H} ; \mathbf{G H} \boldsymbol{d} \mathbf{5 P}$ function is exceeded and the $\boldsymbol{d} ; \mathbf{5 P}$ function is set to -or - then the -or - message will flash on and off once a second as a visual warning. The warning flashes will cease and the normal display value will be seen when the value displayed is higher than the low limit and lower than the high limit.

### 5.15 Access mode

| Display: | RECS |
| :--- | :--- |
| Range: | GFF. AOBE or RLL |
| Default Value: | GFF |

Access mode - the access mode function R[E5 has three possible settings namely ©FF. $\boldsymbol{\operatorname { H O R E }}$ and $\boldsymbol{P L L}$. If set to $\boldsymbol{G F F}$ the function has no effect. If set to $\boldsymbol{\operatorname { H O R E }}$ there will be no access to any functions via Firic mode, entry via CRL mode must be made to gain access to functions. If set to RLL then access to all functions, including calibration functions, can be gained via FURE mode i.e. when set to $\boldsymbol{R L L}$ there is no need to power down to gain access to all functions.

### 5.16 Square root mode

| Display: | 59rt |
| :--- | :--- |
| Range: | on or GFF |
| Default Value: | OFF |

Square root - selects the square root scaling to on or GFF. When set to an a square root function is applied to the input. When set to $\mathbf{G F F}$ the calibration is a linear function. When the square root facility is used the scaled displayed value follows the square root of the percentage of the full scale input value. The upper and lower input limits are set as normal as are the values to be displayed at these limits.
Notes: It is essential that the display is rescaled, using [AL $\mathbf{t}$ and [RLZ or SELEEn4 and SELEEnCD, whenever the square root function is turned on or off. The [RL OFSE function cannot be used when the $\mathbf{5 q} \boldsymbol{r} \boldsymbol{t}$ function is set to or. The square root operation will not work if the rate is scaled to show negative values.

## Example:

For a $4-20 \mathrm{~mA}$ input if you wish to display 0 at 4 mA and 1000 at 20 mA the square root function will calculate as follows:
At $20 \mathrm{~mA}(100 \%)$ the display will be $\mathbf{1 0 \Omega O}$ i.e. $\sqrt{1} \times 1000$.
At $16 \mathrm{~mA}(75 \%)$ the display will be $\mathbf{8 5 5}$ i.e. $\sqrt{0.75} \times 1000$.
At $12 \mathrm{~mA}(50 \%)$ the display will be $\mathbf{7 0} \mathbf{7}$ i.e. $\sqrt{0.5} \times 1000$ and so on.

### 5.17 Input range

| Display: | $\mathcal{A P E}$ |
| :--- | :--- |
| Range: | $4-20$ or $\mathbf{1 0 . 5 0}$ |
| Default Value: | $4-20$ |

Selects the input range to be used as $4-20 \mathrm{~mA}$ or $10-50 \mathrm{~mA}$.

### 5.18 Returning to normal measure mode

When the calibration has been completed it is advisable to return the instrument to the normal mode (where calibration functions are less likely to be tampered with). To return to normal mode, turn off power to the instrument, wait a few seconds and then restore power.

### 5.19 Error messages

SPRT Err - calibration span error. Live inputs used at [RL $\mathbf{t}$ and [RLD too close in value. Recalibrate using inputs further apart in value. If you are certain that the inputs are far enough apart but still see the SPRF Err message then ignore the message and continue with the two point calibration. At the end of the calibration check to see if the display calibration is correct and if not recalibrate using the same inputs.

Unstable display - if the display is not stable the usual cause is either that the input signal is unstable or that the calibration scaling was incorrectly attempted. If the calibration scaling was unsuccessful then uncalibrating the display at the UCAL function should return the display to stable readings but the previous calibration scaling values will be lost. If the display is still not stable after uncalibrating then check the input for stability and noise.

Display shows " - - -" - this message indicates that the input signal is higher than the range selected e.g. higher than 20 mA (or 50 mA if set for $10-50 \mathrm{~mA}$ ).

Display shows "-or -" - this message indicates either that the number is too big to display e.g. above $\mathbf{9 9 9 9}$ or that the $\boldsymbol{d} \mathbf{5 P}$ function has be set to -or - and either the $\mathbf{L o d} \mathbf{5 P}$ or $\mathbf{H ;} \mathbf{9 H}$ d: 5P limits have been exceeded.

Display value flashes on and off - this indicates that disp function has be set to $\mathbf{F} \mathbf{L S H}$ and either the $\mathbf{L}$ od: $\mathbf{5 P}$ or $\mathbf{H} \mathbf{9 H}$ d: $\mathbf{5 P}$ limits have been exceeded.

Display shows RO RCE - this indicates that the REC5 function has been set to ROME blocking entry to FLIC mode. Enter functions via CRL mode to gain entry to functions and if required change the REC5 function setting.

## 6 Calibration

The instrument can be calibrated via a two point live input calibration method using functions CRL : and CRL 2 . An alternative method allows display scaling without live inputs using the SELE EnH and SELE EnEO or SELE En GO and SELE EnSO functions. Each of thes methods and other calibration scaling function are described in this chapter.

In order to gain access to the calibration functions you must be in ©RL mode or have the $\boldsymbol{A C E S}$ function set to $\boldsymbol{A L L}$, refer to Chapter 5, page 10 which shows the method of entering $\mathbb{C A L}$ mode.

### 6.1 Live signal input calibration

 display, values for both ᄃRL $\mathbf{A}$ and CRL $\boldsymbol{Z}$ must be set when using this scaling method. The CRL: function sets the first calibration point for live input calibration. When using this method different signal level inputs must be present at the input terminals for CRL : and CRL $\mathcal{C}$. Note: ©RL $\mathbf{4}$ and [RLI $\boldsymbol{Z}$ can be set independently.

The procedure for entering the first scaling point [RL $\mathbf{:}$ is as follows:
a. Ensure that an input signal is present at the input terminals, this will usually be at the low end of the signal range e.g. 4 mA .
b. At the [RL: function press and simultaneously then release them. The display will show the live input value. Do not be concerned at this stage if the live input display value is not what is required. It is important that the live input value seen is a steady value, if not then the input needs to be investigated before proceeding with the scaling.
c. Press then release the $\mathbf{F}$ button. The display will indicate 5E: $\mathbf{t}$ followed by a value. Use the $\boldsymbol{\square}$ or button to change this value to the required display value at this input. e.g. if 4 mA was input and the required display at 4 mA was $\boldsymbol{0}$ then ensure $\mathbf{0}$ is entered at 5[i i. Press the $\boldsymbol{F}$ button to accept changes. If the scaling has been accepted the $\boldsymbol{C A L}$ End message should be seen.



The procedure for entering the second scaling point $\mathbb{C R L} \mathcal{Z}$ is as follows:
a. Ensure that an input signal is present at the input terminals, this will usually be at the high end of the signal range i.e. close to 20 mA . The change in input signal from the $\boldsymbol{C R L}$ input must be at least 2 mA .
b. At the [RL己 function press $\boldsymbol{\square}$ and simultaneously then release them. The display will show the live input value. Do not be concerned at this stage if the live input display value is not what is required. It is important that the live input value seen is a steady value, if not then the input needs to be investigated before proceeding with the scaling.
c. Press then release the $\boldsymbol{F}$ button. The display will indicate $\mathbf{5 E L} \boldsymbol{Z}$ followed by a value. Use the $\boldsymbol{\Delta}$ or button to change this value to the required display value at this input. e.g. if 20 mA was input and the required display at 20 mA was $\mathbf{5 0 0}$ then ensure $\mathbf{5 0 0}$ is entered at $\mathbf{5 C L 己}$. Press the $\boldsymbol{F}$ button to accept changes. If the scaling has been accepted the [RL End message should be seen.

Example - Flow chart showing scaling using two live inputs



Note: If the "live" display at any scaling point is not stable then check the input signal for stability.

### 6.2 Offset calibration

[RL OFSt - Calibration offset - the calibration offset is a single point adjustment which can be used to alter the calibration scaling values across the entire measuring range without affecting the calibration slope. This method can be used instead of performing a two point calibration when a constant measurement error is found to exist across the entire range. To perform a calibration offset press the $\boldsymbol{\triangle}$ and buttons simultaneously at the [AL OFSt function. A "live" reading from the input will be seen, make a note of this reading. Press the $\boldsymbol{F}$ button, the message $\mathbf{5} \boldsymbol{L} \boldsymbol{E}$ will now be seen followed by the last scale value in memory. Use the $\boldsymbol{\square}$ or button to adjust the scale value to the required display value for that input. For example if the "live" input reading was $\mathbf{5 0}$ and the required display value for this input was $\mathbf{7 0}$ then adjust the $\mathbf{S E L E}$ value to $\mathbf{7 0}$. Press the $\boldsymbol{F}$ button to accept changes or the $\mathbf{P}$ button to abort the scaling. If the scaling has been accepted the message $\mathbf{0 F} \boldsymbol{5} \boldsymbol{E}$ End should be seen.

### 6.3 Alternative $4-20 \mathrm{~mA}$ or $10-50 \mathrm{~mA}$ scaling

This scaling method which uses functions SELE En'4 and SELE EnCO allows the display scale values for 4 mA and 20 mA to be directly entered without live input. When a sensor is subsequently connected a check for zero offset in the sensor should be made by viewing the display value at a point where the sensor output should be at 4 mA output. A remote input zero or calibration offset
 the slope of the sensor output is not correct then ᄃRL: and $\boldsymbol{C A L} \boldsymbol{Z}$ methods will have to be used.

SELEEN4-4mA input scaling without a live input - The instrument can be scaled for a $4-20 \mathrm{~mA}$ input without a live input i.e. this is an alternative method to the $\boldsymbol{C R L}:$ and $\boldsymbol{C R L} \boldsymbol{Z}$ method of scaling. To perform the first point $(\boldsymbol{E} \boldsymbol{n} \mathbf{4})$ scaling simply press the $\boldsymbol{\Delta}$ and buttons simultaneously when the SELEEn'4 function is displayed. The display will now indicate a value. Use the $\boldsymbol{\Delta}$ or button to change this value to the display value required for a 4 mA input. Press the $\boldsymbol{F}$ button to accept changes or the $\mathbf{P}$ button to abort the scaling. If the scaling has been accepted the $\mathbf{C R L}$ End message should be seen. Note: for $10-50 \mathrm{~mA}$ inputs the messages will be SELE En $\mathbf{E C}$ and SELE EnSO.

SELE EnCD - 20mA input scaling without a live input - this calibration method can be used with $4-20 \mathrm{~mA}$ inputs only. To perform the second point $(\boldsymbol{E} \boldsymbol{\sim} \boldsymbol{\mathcal { S }})$ scaling simply press the $\boldsymbol{\Delta}$ and buttons simultaneously when the $\mathbf{U S E F} \operatorname{EnCD}$ function has been reached. The display will now indicate a value. Use the or button to change this value to the display value required for a 20 mA input. Press the $\mathbf{F}$ button to accept changes or the $\mathbf{P}$ button to abort the scaling. If the scaling has been accepted the [RL End message should be seen. Note: for $10-50 \mathrm{~mA}$ inputs the messages will be SELE En $\mathbf{I C}$ and SELE EnSO.

### 6.4 Uncalibration

UCRL - Uncalibrate - used to set the instrument back to the factory calibration values. This function should only be used when calibration problems exist and it is necessary to clear the calibration memory. To clear the calibration memory press the $\boldsymbol{\Delta}$ and buttons simultaneously at the U[AL function. The message [RL ELr will be seen to indicate that the memory has cleared.

## $7 \quad$ Specifications

### 7.1 Technical specifications for PM6-LP-4C and RT6-LP-4C

Input type:
Loop voltage drop:
Current range:
Input protection:
ADC resolution:
Decimal points:
Accuracy:
Sample Rate:
Display update:
Ambient temperature:
Humidity:
Display:

4 to 20 mA or 10 to 50 mA selectable
2 Volts at $4 \mathrm{~mA}, 2.3$ Volts at 20 mA nominal
Measurable from 3.5 to 22 mA or 9 to 55 mA
150 mA in either direction
15 bit
Up to 3 decimal point places selectable $0.025 \%$ of full scale when calibrated $\pm 50 \mathrm{ppm} /{ }^{\circ} \mathrm{C}$
$\pm 1$ display digit
2.5 samples per second
2.5 times per second
-10 to $50^{\circ} \mathrm{C}$
5 to $95 \%$ non condensing
LCD 4 digit 12.7 mm

### 7.2 Physical Characteristics

## PM6

Bezel Size:
Case Size:
Panel Cut Out:
Connections:
Weight:
DIN $48 \mathrm{~mm} \times 96 \mathrm{~mm} \times 9 \mathrm{~mm}$
$44 \mathrm{~mm} \times 91 \mathrm{~mm} \times 66 \mathrm{~mm}$ behind face of panel $45 \mathrm{~mm} \times 92 \mathrm{~mm}+1 \mathrm{~mm} /-0 \mathrm{~mm}$
Plug in screw terminals (max. $2.5 \mathrm{~mm}^{2}$ wire)
180 gms

## RT6

Case Size:
Connections:
Weight:
IP rating:
$110 \mathrm{~mm}(\mathrm{w}) \times 80 \mathrm{~mm}(\mathrm{~h}) \times 68 \mathrm{~mm}$ (d)
Screw terminals (max. $2.5 \mathrm{~mm}^{2}$ wire)
250 gms
Mounting holes:
IP65

Hole centres 90 and 60 mm

## 8 Guarantee and service

The product supplied with this manual is guaranteed against faulty workmanship for a period of 2 years from the date of dispatch.

Our obligation assumed under this guarantee is limited to the replacement of parts which, by our examination, are proved to be defective and have not been misused, carelessly handled, defaced or damaged due to incorrect installation. This guarantee is VOID where the unit has been opened, tampered with or if repairs have been made or attempted by anyone except an au authorised representative of the manufacturing company.

Products for attention under guarantee (unless otherwise agreed) must be returned to the manufacturer freight paid and, if accepted for free repair, will be returned to the customers address in Australia free of charge.

When returning the product for service or repair a full description of the fault and the mode of operation used when the product failed must be given. In any event the manufacturer has no other obligation or liability beyond replacement or repair of this product.

Modifications may be made to any existing or future models of the unit as it may deem necessary without incurring any obligation to incorporate such modifications in units previously sold or to which this guarantee may relate.

This document is the property of the instrument manufacturer and may not be reproduced in whole or part without the written consent of the manufacturer.

This product is designed and manufactured in Australia.

## 15. Omniflex

## PT2000C \& PT5000C PSU/Charger

## - A Complete solution for small battery-backed dc instrument power systems.

## - Supply 12 Vdc or 24 Vdc systems with continuous power during ac line interruptions without the need for inverters or mains UPS's

- Ideal for RTU's, dataloggers, remote field instrumentation, alarm systems, remote access systems etc.


## FEATURES

- DIN Rail mounting
- Available in 12 Vdc or 24 Vdc output versions.
- Operates from 115 Vac or 230 Vac supply
- 4 Amp continuous load - (10Amp peak)
- Under-voltage cutout to protect battery from deep discharge.
- Charging characterised for sealed lead-acid cells.
- Independently current limited battery charging for optimum battery life.


## OVERVIEW

The PT5000C is a combined Power Supply and Battery Charger system with integrated standby battery management for small uninterruptable instrument supply applications.
Just connect mains supply, standby battery and load for an industrial grade standby power supply system.

This DIN rail mounted product is ideal for providing dc power to instrument systems where battery backup is necessary to ensure continuous system operation during power failure. Applications include RTU's, dataloggers, remote field instruments, alarm systems and access controllers.
Managing battery-backed systems for optimum backup time and battery life can be tricky and expensive.

This product incorporates many features that make installing such systems simple and foolproof


- Over-current protection to protect wiring against faults.
- Charger shutdown input for battery testing.
- AC detect output for mains monitoring.
- Optional temperature sensor for optimum battery float voltage control in wide ambient operating environments.
- Independent battery and load terminals for ease of installation.


## PROTECTION

Batteries are capable of delivering enormous currents under system fault conditions that can damage wiring and equipment. The PT5000C incorporates an autoresettable load cutout, which disconnects the load under over-current fault condition.

During prolonged power outages, the back-up battery will eventually discharge. If the load remains connected, the battery enters its "deep" discharge phase, which can cause irreparable damage to the battery, and reduce its capacity and life. The PT5000C incorporates an undervoltage cutout that disconnects the load when the battery voltage begins to fall.
Batteries can be kept on continuous charge as long as the charging current and float voltage are kept below their specified maximum values. The maximum charging current is based upon the Ampere-hour capacity of the battery. This is can be less than the rated load current depending upon the capacity of the battery chosen. The

## PT2000C \& PT5000C PSU/Charger

Model C2176 (1.5 Amp load) \& C2177 (4 Amp load) Power Supply/ Battery Charger

PT5000C incorporates an independent charge current control circuit to prevent overcharge of the battery, even on no load. This has the added benefit of allowing the PT5000C to deliver maximum rated load even when the battery is discharged and under full charge. The maximum float voltage necessary to ensure full charge, but not overcharge, is temperature dependent. If the battery is installed in an environment with widely fluctuating temperature, then use of the external temperature probe is recommended.

## SYSTEM MONITORING

Batteries need to be checked regularly to ensure that
they are in good order. The PT5000C provides facilities to allow the batteries to be tested in location.

A charger shutdown input is provided. On activating this input, the charger is disconnected, allowing the battery voltage under load to be measured. By monitoring this voltage over a short time for any droop, the state of health of the battery can be determined.
The PT5000C also provides an AC detect output. This output can be used to detect power failures.

## Typical System Connection Diagram



Mechanical Details


## SPECIFICATIONS

| AC Input |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Model: | PT2000C |  | PT5000C |  |
| $A C$ input voltage range | 85-264Vac |  | 85-132 Vac on 115 Vac input. $170-264 \mathrm{Vac}$ on 230 Vac input. |  |
| AC input frequency | $47-63 \mathrm{~Hz}$ |  |  |  |
| Input current at full load | $<1.5 \mathrm{~A}$ rms at 115 Vac $<0.7 \mathrm{~A}$ rms at 230 Vac |  | $<3$ A rms at 115 Vac $<1.5 \mathrm{~A}$ rms at 230Vac |  |
| Switch-on inrush current | 11 A for $<10 \mathrm{~ms}$ ( 80 A for $<1 \mathrm{~ms}$ ) |  | 22A for $<10 \mathrm{~ms}$ (160A for < 1 ms ) |  |
| Surge withstand | 2.5kA 8/20microsecond pulse 40 joules max. |  |  |  |
| Fast Transients | 2 kV |  |  |  |
| Load Ouput |  |  |  |  |
| Model: | PT2000C |  | PT5000C |  |
| Voltage | 12V | 24V | 12V | 24 |
| Output Voltage | $\begin{aligned} & 13.0 \mathrm{~V}- \\ & 14.0 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 26.0 \mathrm{~V}- \\ & 28.0 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 13.0 \mathrm{~V}- \\ & 14.0 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 26.0 \\ & 28.0 \end{aligned}$ |
| Max continuous rated load | 2.5A | 1.5A | 4A | 4A |
| Max Full Load Operating Ambient Temperature | $60^{\circ} \mathrm{C}$ | $50^{\circ} \mathrm{C}$ | $60^{\circ} \mathrm{C}$ | $50^{\circ} \mathrm{C}$ |
| Temperature derating up to $65^{\circ} \mathrm{C}$ maximum | derate $4 \% /{ }^{\circ} \mathrm{C}$ | derate $3 \% /{ }^{\circ} \mathrm{C}$ | $\begin{aligned} & \text { derate } \\ & 3 \% /{ }^{\circ} \mathrm{C} \end{aligned}$ |  |
| Overload protection | $\cong 3 \mathrm{~A}$ | $\cong 2 \mathrm{~A}$ | $\cong 6 \mathrm{~A}$ | $\cong 6$ |
| AC line regulation | 0.5\% max over 85-132Vac/170-264Vac |  |  |  |
| Load Regulation | 2\% max over 10-100\% |  |  |  |
| Temperature Regulation (excl. effect of external temperature sensor) | $<0.05 \% /{ }^{\circ} \mathrm{C}$ |  |  |  |
| Battery Charger |  |  |  |  |
| Model: | PT2000C PT5000C |  |  |  |
| Charging method | Constant voltage/Constant Current |  |  |  |
| Float Voltage (at $20^{\circ} \mathrm{C}$ ) | $13.5 \mathrm{~V}-13.8 \mathrm{~V}$ on 12 V versions $27.0 \mathrm{~V}-27.6 \mathrm{~V}$ on 24 V versions |  |  |  |
| Max. Charging Current | 0.5 Amp |  | 1 Amp |  |
| Under-voltage cutout |  |  |  |  |
| Option | 12 V versions |  | 24 V versions |  |
| Cut out Voltage | $11+0.5$ Volt |  | $22+-0.8$ Volt |  |
| Restore Voltage | $9.5+$ - 0.5 Volt |  | 19 +-1.0 Volt |  |
| Battery drain when cut out | 300uA max |  | 300uA max |  |
| Shutdown Input |  |  |  |  |
| Type | Switch to 0 Volts |  |  |  |
| Max. open circuit voltage | 30 V dc |  |  |  |
| Max. closed circuit current | 20 mA |  |  |  |
| AC Detect Output |  |  |  |  |
| Type | Normally open contact - closed when $A C$ power is healthy. |  |  |  |
| Max. operating voltage | 30 V dc |  |  |  |
| Max. closed circuit current | 20 mA |  |  |  |


| Optional Temperature Sensor Input |  |  |
| :---: | :---: | :---: |
| Option | 12 V versions | 24V versions |
| Sensor Type | Thermistor |  |
| Accuracy | +-2 ${ }^{\circ} \mathrm{C}$ |  |
| Float voltage change from $20^{\circ} \mathrm{C}$ | $-20 \mathrm{mV} /{ }^{\circ} \mathrm{C}$ | $-40 \mathrm{mV} /{ }^{\circ} \mathrm{C}$ |
| Environment \& Safety |  |  |
| Operating Temperature | See Load Output Section for details |  |
| Storage Temperature | $-10^{\circ} \mathrm{C}-70^{\circ} \mathrm{C}\left(+14^{\circ} \mathrm{F}-158^{\circ} \mathrm{F}\right)$ |  |
| Insulation Resistance (100\% tested) | 100 Mohm at 500 Vdc input to outputs to ground. |  |
| Insulation Breakdown (100\% tested) | 1500 Vac input to earth for 1 s 1000 Vac output to earth for 1 s |  |
| Safety Conformance | Conforms to IEC950; EN60950 |  |
| Electromagnetic Interference | Conforms to EN55011; EN50082-2 |  |
| Design Life at $50^{\circ} \mathrm{C}$ full load | 50 000hours |  |
| Mechanical |  |  |
| Model: | PT2000C | PT5000C |
| Width | 100 mm | 150 mm |
| Height | 120 mm |  |
| Depth | 70 mm |  |
| Weight |  |  |
| Model: | PT2000C | PT5000C |
| Unpacked | 450gm approx. | 850gm approx. |
| Packed | 550 gm approx. | 950gm approx. |

Compliance to Standards

| Safety | EN 60950:1995 |
| :--- | :--- |
| Emissions | EN 55011 and EN50081-2:1994 Group I, |
| Class A |  |$|$| Immunity - ESD | IEC 61000-4-2:1995, level 3 |
| :--- | :--- |
| Immunity - RF Fields | IEC 61000-4-3:1995, level 3 |
| Immunity - | IEC 61000-4-4:1995 |
| Fast Transients | 2 kV - DC power port <br> 1 kV - input/output lines |
| Supply Variations | IEC 61000-4-7:1991, 24 V dc +15\% -10\% |


| Ordering Information |  |
| :--- | :--- |
| ORDER CODE | DESCRIPTION |
| C2176-1 | PT2000C with 12Volt output <br> (2.5A load max; 0.5A Charging max) |
| C2176 | PT2000C with 24Volt output <br> (1.5A load max; 0.5A Charging max) |
| C2177-1 | PT5000C with 12Volt output <br> (4A load max; 1A Charging max) |
| C2177 | PT5000C with 24Volt output <br> (4A load max; 1A Charging max) |
| C0003 | External Temperature Probe |

[^58]Solutions by Design
http://www.omniflex.com

## APPLICATION NOTES

## BATTERY SELECTION

The PT2000C and PT5000C are designed to operate with sealed lead acid type batteries also known as Valve Regulated Lead Acid (VRLA) batteries. This type of battery is sealed except for a valve that opens when the internal gas pressure exceeds the design limits. (That is why it is important not to overcharge VRLA batteries). Generally, these batteries can be used in confined areas and can be mounted in any orientation. (see the specific manufacturer's data for details.)
There are two types of VRLA batteries on the market: Absorbent Glass Mat (AGM) and Gel-Cell. This refers to the method used to immobilise the electrolyte in the battery. Either of these two types of battery may be used with these chargers.

In order to select a battery for your application, follow these simple steps:

1. Calculate the Ampere-hours of standby time required, by multiplying the number of hours of standby required by the average standing load in Amps.
2. To take into account deterioration of battery capacity over the life of the battery ( $20 \%$ over 48 months typical), and residual charge remaining at cutoff ( $20 \%$ remaining) multiply this figure by 1.6 (This figure may vary from application to application)
3. If the battery is required to provide full standby time at temperatures lower than $20^{\circ} \mathrm{C}$, then increase this capacity by a further $10 \%$ for each $10^{\circ} \mathrm{C}$ below $20^{\circ} \mathrm{C}$.
4. An additional factor of $15 \%$ may be added to the battery capacity if the recharge time to required capacity from discharged state is an important factor of the design. (see section on Recharge time).
5. This then gives the minimum Ampere-hour capacity battery required for the application. In general, the larger the battery the better in any given application (size and cost being the compromise).

## AC DETECT OUTPUT

A contact output across terminals 7 and 8 is provided to detect the presence/absence of the AC supply.
This contact monitors the Power Supply output (on the DC side). A closed contact confirms that the Power Supply is healthy and that the AC supply is present. The contact will open when the AC supply fails or when the Shut Down Test input is activated.

A green light labelled 'AC' on the front of the PT2000C/PT5000C is a visual indication of the state of this contact and the AC supply. When this light is on, then the AC Supply is present, and the contact is closed.
It is normal for this contact to open then close again momentarily during a power failure as the battery takes over from the Power Supply.

## SHUTDOWN TEST INPUT

Connecting terminals 5 and 6 together will disconnect the AC supply from the battery and load for the purpose of testing the battery.
By monitoring the battery voltage over a short time interval, while holding the AC supply off, the state of the battery can be determined. This will enable the health of the battery to be checked even when the AC supply is present. This can be used, for example, in remote RTU applications where regular system checks are necessary.

## LOW VOLTAGE CUTOUT

When the battery voltage drops during discharge to a preset cut-off point, a cut-off relay in the PT2000C/PT5000C will disconnect the
battery from the load. This prevents the battery from entering into a state of deep-discharge, protecting it from permanent damage.

When the AC supply returns, the cut-out relay will automatically reconnect the battery to the charger and load only if the battery is above the (lower) restore voltage point. This protects against danger or damage from reverse connected or dead batteries.
A red lamp labelled 'DC' on the front of the PT2000C/PT5000C when on, indicates that there is DC supply to the load. During battery backup, the Green lamp will be off and the Red lamp will be on. After the battery has been disconnected by the cut-out, both lamps will be off.

## USE OF TEMPERATURE COMPENSATION

A Lead Acid Battery is constructed of a series string of cells of approx. 2.3 volts each when fully charged. A 12 Volt battery has 6 such cells. This fully charged voltage varies by approximately $-3.3 \mathrm{mV} /{ }^{\circ} \mathrm{C}$ per cell. This does not sound much but, over 12 cells in a 24 Volt application, this amounts to a change of 0.4 V over a $10^{\circ} \mathrm{C}$ temperature swing.
If the float voltage of the charger does not compensate for this change, then it is possible to over-charge the battery at high temperatures and under-charge the battery at low temperatures.
These PSU/Chargers are supplied from the factory with a resistor fitted to the temperature sensor terminals to set the float voltage for $25^{\circ} \mathrm{C}$ operation. Over a normal ambient working range of 15 to $35^{\circ} \mathrm{C}$ this is considered quite satisfactory, and no further temperature compensation is required.
If the average ambient temperature is likely to be outside of this range, then this resistor may be changed to simulate this environment. If the ambient temperature is likely to swing by more than about 15 to $20^{\circ} \mathrm{C}$ then it is advisable to fit the external temperature sensor. This sensor is fitted with a 500 mm extension lead to allow it to be mounted with the battery, avoiding the possibility of erroneous temperature readings possible with chargers with integrated temperature compensation.

## CHARGING TIME

The PT2000C and PT5000C are dual-mode chargers. This means that the battery is charged in two phases. When the AC power returns after the battery has been on load, and requires recharging, the charger will enter into "bulk" mode charging. In this mode the battery will be charged with a constant current until the battery reaches its bulk charge voltage. The charger then switches into "float" charge mode, and the voltage is reduced to its "float" voltage, where the battery can remain indefinitely.

The bulk mode charge rate is chosen to ensure that the battery reaches $85-95 \%$ charge in the shortest possible time within the constraints of the battery specifications. The remaining 5-15\% charge is then topped up more slowly during the float charge cycle.

If it is important in the application that the battery be at design capacity within the 'bulk' charge phase, then it is wise to over-rate the battery by up to $15 \%$, and to consider the battery fully charged when it reaches this 85-95\% capacity.

- Supply both 12 Vdc 1 Amp and 24 Vdc 3 Amps average power to loads in a single product.
- Ideal for RTU's, dataloggers, remote field instrumentation, alarm systems, etc. where 24 Volts is required for instrumentation and 12 Volts is required for radios etc.
- Battery Management Functions include Low Voltage Cut-out, temperature compensation and current limited dual mode battery charging.


## FEATURES

- True $\mathbf{1 2} / 24$ Volt Split Battery Charge Equalisation
- Under-voltage cut-out to protect battery from deep discharge.
- AC detect output for mains monitoring.

- Temperature compensation for optimum battery float voltage in changing ambient temperatures.
- Universal $85-264 \mathrm{Vac}$ mains supply
- DIN Rail mounting with small panel footprint


## OVERVIEW

The Powerterm L120C-D is a combined Power Supply and Battery Charger for small uninterruptible instrument supply applications where 12 Volts and 24 Volts are required.
Providing both 24 Volts and 12 Volts in battery standby systems can be inconvenient and costly. While 12Volts is available in 24 Volt battery systems by centre-tapping the two series connected 12 Vdc batteries, this has been impractical to use until now because of the different charging requirements of the two batteries.
The unique PTL120C-D dual voltage charger now makes this possible by the provision of true split rail battery charging to provide balanced charging to both batteries even when 12Volts loads are tapped from the battery set.
The Powerterm L120C-D is the only charger component required for the system, reducing space and cost.
And unlike the use of 24 V to 12 V converters, the 12 Volt load is connected to the battery, providing a low impedance supply required by some radio transmitters. This configuration also allows larger currents to be drawn intermittently from the 12 Volts such as radio transmit currents which can be much larger than the average current required when receiving.
Applications include RTU's, dataloggers, remote field instruments and alarm systems where the requirement exists to power both 12 Volt equipment (such as radios) and 24 Volt instruments.

## BATTERY MANAGEMENT

During prolonged power outages, the back-up batteries will eventually discharge. If the load remains connected, the batteries can enter their "deep" discharge phase, which can cause irreparable damage to the batteries, and reduce their capacity and life expectancy.

The PTL120C-D incorporates a low voltage cut-out that disconnects the loads when either battery voltage falls below its low voltage threshold.
The maximum float voltage necessary to ensure full charge, but not overcharge, is temperature dependent for lead-acid batteries. If the installation is in an environment with widely fluctuating temperature, then fixed voltage chargers will either under-charge or over-charge the batteries.
The PTL120C-D is provided with external temperature compensation so that the float voltage to the batteries is held at its optimum value at all times. Use Model C0003 Temperature probe (supplied separately).

## DUAL MODE CHARGING

All sealed lead acid battery manufacturers specify a maximum charging current for the correct life and safe operation of sealed lead acid batteries. This maximum charging current for a battery is based upon the Ampere-hour capacity of the battery. Many conventional switch mode power supplies do not control their maximum delivered current and can cause batteries to be charged from flat with current levels that exceed the manufacturer's recommendation. The PTL120C-D provides dual-mode charging, with a well defined battery current limit, so that even when the batteries are discharged, the charging current will be controlled.

## SYSTEM MONITORING

The PTL120C-D provides an AC OK contact output. This output can be used to detect power failures without the need for an additional mains detection relay.

## BATTERY TESTING

Using the Test Input, the health of the batteries can be checked. This function can be included in programmable remote equipment for highest availability of the standby system.

## Powerterm L120C-D Dual Voltage PSU/Battery Charger Model C2197B 120W 12/24Volt Power Supply/ Battery Charger

## Typical System Connection Diagram



## Mechanical Details

MECHANICAL DETAILS


Powerterm L120C-D Dual Voltage PSU/Battery Charger Model C2197B 120W 12/24Volt Power Supply/ Battery Charger

## SPECIFICATIONS

| AC Input |  |  |
| :---: | :---: | :---: |
| $A C$ input voltage range | 85-264Vac |  |
| $A C$ input frequency | $47-63 \mathrm{~Hz}$ |  |
| Input current at full load | $<2.2 \mathrm{~A}$ rms at 115 Vac <br> <1.0A rms at 230Vac |  |
| Switch-on inrush current | 15A for <10ms |  |
| Surge withstand | 2.5kA $8 / 20$ us pulse 40 joules max. |  |
| Fast Transients | 2 kV |  |
| DC Ouput |  |  |
| Nominal Output Voltage | 12V | 24V |
| Output Voltage at $20^{\circ} \mathrm{C}$ | 13.7 $\pm 0.1 \mathrm{~V}$ | $27.4 \pm 0.2 \mathrm{~V}$ |
| Voltage change from $20^{\circ} \mathrm{C}$ | $-20 \mathrm{mV} /{ }^{\circ} \mathrm{C}$ | $-40 \mathrm{mV} /{ }^{\circ} \mathrm{C}$ |
| Maximum load output voltage range over all conditions of battery, temperature and AC input. | 10.6V-14.3V | 21.2V-28.6V |
| Maximum Continuous Total Power | 120 Watts from 12 V and 24 V combined at $60^{\circ} \mathrm{C}$ |  |
| Rated Load current | 1A Continuous | 3A Continuous |
| Battery Charging Current (current limited in charger) | 1.2A min ${ }^{1}$ <br> 1.5A typical | $1 \mathrm{Amp} \mathrm{min}^{2}$ 1.2 Amp typical |
| Total current capacity (Load + Battery) | 1.5A typical | 4.2A typical |
| Maximum Peak Load (drawn from the battery) | 6 A for 10 s | 6 A for 10s |
| Charging Notes: <br> 1. 12 Volt power is available for 12 Volt battery charging and 12 V load supply. Therefore average 12 Volt load +12 Volt charge current will not exceed this value. |  |  |
| 2. 24 V charge current is limited independently of load current at 1 Amp nominal allowing 24 V loads up to 3 A without affecting 24 Volt battery charging. To derate supply at temperatures above 60 deg $C$ reduce 24 Volt dc load accordingly. |  |  |
| AC line regulation | 0.5\% max over 85-132 \& 170-264Vac |  |
| Load Regulation | $2 \%$ max over $10-100 \%$ of total load (output load + battery charge current) |  |
| Recommended Batteries (not included) |  |  |
| Quantity | 2 |  |
| Type | 12 Volt Sealed Lead Acid |  |
| Minimum Battery Capacity | 7Ah minimum recommended |  |
| Under-voltage cutout |  |  |
| Output | 12V | 24V |
| Cut out Voltage | $11+0.5$ Volt | 22 +-0.8 Volt |
| Battery drain when cut out | 1 mA max | 1 mA max |
| OK Output |  |  |
| Type | Normally open contact - closed when $A C$ is $O N$ and $D C$ power is healthy. |  |
| Max. operating voltage | 30 V dc |  |
| Max. closed circuit current | 1A |  |
| Temperature Sensor Input |  |  |
| Type | Model C0003 Temperature Sensor (order separately) |  |
| Temperature Accuracy | $\pm 2^{\circ} \mathrm{C}$ |  |

## TEST Input

| Type | Connect Test Input to 0 V to test. |  |
| :--- | :--- | :--- |
| Max. open circuit voltage | 30 V dc |  |
| Max. closed circuit current | 5 mA |  |
| Test Voltage | 12 V max | 24 V max |
| Test Method | When the test input is closed, the charger float <br> voltages are lowered to just above the cut-out <br> voltages. <br> If the battery terminal voltages are above these <br> settings, the batteries will take over supply to the <br> loads. |  |
| By checking the terminal voltages over a short <br> time interval, the health of the batteries can thus <br> be checked. |  |  |

Indicator Lights

| AC (Green) | ON when AC input is ON and charger <br> is charging. (indicates OK output is on) |
| :--- | :--- |
| DC (Red) | ON when cut-out relays are closed <br> and DC output is present. |

## Environment

Operating Temperature
Temperature derating
Storage Temperature
Design Life at $50^{\circ} \mathrm{C}$ full load
0 to $+60^{\circ} \mathrm{C}$ at continuous full load
derate 4 Watts $/{ }^{\circ} \mathrm{C}$ up to $70^{\circ} \mathrm{C}$ max
$-10^{\circ} \mathrm{C}-70^{\circ} \mathrm{C}\left(+14^{\circ} \mathrm{F}-158^{\circ} \mathrm{F}\right)$
50 000hours
Mechanical

| Width | 80 mm |
| :--- | :---: |
| Height | 110 mm |
| Depth | 120 mm (including terminals) |

Weight

| Unpacked | 750gm approx. |
| :--- | :--- |
| Packed | 780gm approx. |

## Compliance to Standards

| Safety | IEC950; EN60950:1995 |
| :--- | :--- |
| Emissions | EN 55011 and EN50081-2:1994 Group I, <br> Class A |
| Immunity - ESD | IEC 61000-4-2:1995, level 3 |
| Immunity - RF Fields | IEC 61000-4-3:1995, level 3 |
| Immunity - |  |
| Fast Transients | IEC 61000-4-4:1995 <br> $2 \mathrm{kV}-\mathrm{AC} \mathrm{\&} \mathrm{DC} \mathrm{power} \mathrm{ports}$ <br> 1 kV - other input/output lines |
| Insulation Resistance <br> (100\% tested) | 100Mohm at 500Vdc input to outputs to <br> ground. |
| Insulation Breakdown <br> (100\% tested) | 1500Vac input to earth for 1s 1000Vac <br> output to earth for 1s |
| Ordering Information |  |
| ORDER CODE | DESCRIPTION |
| C2197A | Powerterm L120C-D <br> Dual voltage 12/24Vdc PSU/Charger |
| C0003 | Powerterm Temperature Sensor <br> (with 500mm lead) |

## APPLICATION NOTES

## BATTERY CONSIDERATIONS

The PTL120C-D is designed to operate with sealed lead acid (SLA) type batteries also known as Valve Regulated Lead Acid (VRLA) batteries. This type of battery is sealed except for a valve that opens when the internal gas pressure exceeds safe limits. (That is why it is important not to overcharge SLA batteries). Generally, these batteries can be used in confined areas and can be mounted in any orientation. (see the specific manufacturer's data for details.)
There are two types of SLA batteries on the market: Absorbent Glass Mat (AGM) and Gel-Cell. This refers to the method used to immobilise the electrolyte in the battery. Either of these two types of battery may be used with these chargers.

CALCULATING AVERAGE LOAD
In many applications the load can vary significantly. A typical example is in the use of radios, where the radio would draw much more in Transmit mode, than in Receive Mode. In most installations it is not necessary to base the battery capacity on the worst case load, because the average can easily be calculated.
Example:
A 12 Volt radio is used that consumes 300 mA in receive mode, and 3 Amps in transmit mode.
The system design requires the radio to transmit for 10 seconds every 15 minutes.
In this case, the average load provided by the radio can be calculated as follows:
The radio would transmit for 10 seconds every 15 minutes $=1.1 \%$ of the time, and therefore the radio would be in receive mode for $100 \%-1.1 \%=98.9 \%$ of the time.
Average Load $=1.1 / 100 \times 3 \mathrm{Amps}+98.9 / 100 \times 0.3 \mathrm{~A}=0.33 \mathrm{Amps}$.
The Powerterm L120C-D is well suited to this application, because the average load is well under the 1A maximum, and the peak load of 3 Amps is well under the 6Amp peak load specified for the L120C-D.

## BATTERY SELECTION

In order to select the batteries for your application, follow these simple steps:
For each load - 12 Volts and 24 Volts:

1. Calculate the Ampere-hours (Ah) of standby time required, by multiplying the number of hours of standby required by the average load in Amps.
2. To take into account deterioration of battery capacity over the life of the battery ( $20 \%$ over 48 months typical), and residual charge remaining at cutoff ( $20 \%$ remaining) multiply this figure by 1.6 (This figure may vary from application to application)
3. If the battery is required to provide full standby time at temperatures lower than $20^{\circ} \mathrm{C}$, then increase this capacity by a further $10 \%$ for each $10^{\circ} \mathrm{C}$ below $20^{\circ} \mathrm{C}$.
4. An additional factor of $15 \%$ may be added to the battery capacity if the recharge time to required capacity from discharged state is an important factor of the design. (see section on Charging time).
This then gives a design minimum Ampere-Hour (Ah) rating for each load on standby. Batteries can then be chosen as follows:

When choosing a battery, select the next highest standard size available from your chosen manufacturer in each case.

Choose the 12Volt Battery ' B ' to have capacity at least equal to the SUM of the capacities required for BOTH the 12 Volt and 24 Volt loads as a minimum. (This is because Battery ' $B$ ' is delivering current to both the 12 Volt and 24 Volt loads).

Choose the 24Volt Battery 'A' to have capacity at least equal to the 24 Volt Ampere-Hour rating calculated above.

## Example:

A standby time of 2 hours is required from a standby system that will operate over the temperature range $0-60^{\circ} \mathrm{C}$.

The average 12 Volt load has been calculated at 0.33 Amps
This gives a required Ah rating for the 12 Volts of:

$$
0.33 \mathrm{~A} \times 2 \mathrm{~h}=0.66 \mathrm{Ah}
$$

The average 24 Volt load has been given as 2.5 Amps
This gives a required Ah rating for the 24 Volts of:

$$
2.5 \mathrm{~A} \times 2 \mathrm{~h}=5 \mathrm{Ah}
$$

Taking into account the factors for battery life and the low temperature operation given above, these ratings are increased by the factor:

$$
1.6 \times 1.2=1.92
$$

Therefore:
24 Volt Battery Size $=5 \times 1.92=9.6 \mathrm{Ah}$ minimum
12 Volt Battery Size $=0.66 \times 1.92+9.6 \mathrm{Ah}=10.4 \mathrm{Ah}$ minimum
Two 12Volt 12Ah Sealed Lead Acid batteries would be suitable for this application.

## SHUTDOWN TEST INPUT

Connecting terminal 15 to 0 V (via pin 14 or another 0 V connection) will reduce the charger float voltage to just above the battery cut-out voltage for the purpose of testing the battery. A healthy charged battery will be above this voltage, and will take over supply of the load during the test.

By checking the battery voltage while in the test mode, the charge state of the battery can be estimated. If this voltage is monitored for droop over a short time interval (upwards of 15 seconds), then the health of the battery can also be established. This enables the batteries to be checked even when the AC supply is present. This can be done automatically, for example, in remote RTU applications where regular system checks are necessary to ensure availability of the standby batteries when the ac mains fails.

## AC DETECT OUTPUT

A contact output across terminals 11 and 12 is provided to detect the presence of the AC supply, and the correct operation of the charger.

A closed contact confirms that the AC supply is present, and that the charger is successfully charging. The contact will open when the AC supply fails, or the charger is not able to charge for any reason.
A green light labelled 'AC' on the front of the PTL120C-D is a visual indication of the state of this contact and the AC supply. When this light is on, then the AC Supply is present, and the contact is closed.
Note: It is normal for this contact to open then close again momentarily during a power failure as the battery takes over from the AC supply.

## LOW VOLTAGE CUTOUT

When either battery voltage drops during discharge to its preset cut-off point, the cut-off relay in the PTL120C-D will disconnect both batteries from the loads. This prevents the batteries from entering into a state of deep-discharge, protecting them from permanent damage.
When the AC supply returns, the cut-out relay will automatically reconnect the batteries.

A red light labelled 'DC' on the front of the PTL120C-D when on, indicates that there is DC supply to the load. During battery backup, the Green lamp will be off and the Red lamp will be on. After the battery has been disconnected by the cut-out, both lamps will be off.

These states are shown in this table below:

| AC | DC | STATE |
| :---: | :---: | :--- |
| ON | ON | Batteries are connected and AC is on. |
| OFF | ON | Mains has failed \& load is powered from batteries. |
| OFF | OFF | Mains has failed and batteries are flat. |
| ON | OFF | Charger Malfunction. |

## USE OF TEMPERATURE COMPENSATION

A Lead Acid Battery is constructed of a series string of cells of approx. 2.3 volts each when fully charged. A 12 Volt battery has 6 such cells. This fully charged voltage varies by approximately $-3.3 \mathrm{mV} /{ }^{\circ} \mathrm{C}$ per cell. This does not sound much but, over 12 cells in a 24 Volt application, this amounts to a change of 0.4 V over a $10^{\circ} \mathrm{C}$ temperature swing.
If the float voltage of the charger does not compensate for this change, then it is possible to over-charge the battery at high temperatures and under-charge the battery at low temperatures.
These PSU/Chargers are supplied from the factory with a resistor fitted to the temperature sensor terminals to fix the float voltage for $25^{\circ} \mathrm{C}$ operation. Over a normal ambient working range of 15 to $35^{\circ} \mathrm{C}$ this is considered quite satisfactory, and no further temperature compensation is required.
If the ambient temperature is fixed but outside of this range, then this resistor may be changed to simulate this environment. See the chart below for the correct resistor to use in this case.

If the ambient temperature is likely to swing by more than $20^{\circ} \mathrm{C}$ then it is strongly recommended that the external Powerterm Temperature Sensor be purchased and fitted in place of this resistor. This temperature sensor is fitted with a 500 mm extension lead to allow it to be mounted near to the batteries, to best measure the ambient temperature of the batteries.

| Temperature | Resistor | Float (12V) | Float(24) |
| :---: | :---: | :---: | :---: |
| $0^{\circ} \mathrm{C}$ | 33 k | 14.25 V | 28.5 V |
| $5^{\circ} \mathrm{C}$ | 27 k | 14.22 V | 28.45 V |
| $10^{\circ} \mathrm{C}$ | 22 k | 14.18 V | 28.35 V |
| $15^{\circ} \mathrm{C}$ | 15 k | 14.05 V | 28.10 V |
| $20^{\circ} \mathrm{C}$ | 12 k | 13.97 V | 27.95 V |
| $25^{\circ} \mathrm{C}$ | 10 k | 13.90 V | 27.80 V |
| $30^{\circ} \mathrm{C}$ | 8.2 k | 13.80 V | 27.60 V |
| $35^{\circ} \mathrm{C}$ | 6.8 k | 13.70 V | 27.40 V |
| $40^{\circ} \mathrm{C}$ | 5.6 k | 13.60 V | 27.20 V |
| $45^{\circ} \mathrm{C}$ | 4.7 k | 13.50 V | 27.00 V |
| $50^{\circ} \mathrm{C}$ | 3.9 k | 13.36 V | 26.72 V |

Tolerance
+/- 250mV
(default)

## CHARGING TIME

The PTL120C-D is a dual-mode charger. This means that the batteries are charged in two phases. When the AC power returns after the battery has been on load, and requires recharging, the charger will enter into "boost" mode charging. The charger then switches into "float" charge mode, and the voltage is reduced to its "float" voltage, where the battery can remain indefinitely.

The boost mode charge rate is chosen to ensure that the battery reaches $85-95 \%$ charge in the shortest time within the constraints of the battery specifications. The remaining $5-15 \%$ charge is then topped up more slowly during the float charge cycle.

## 16. Mean Well



Features:

- Universal AC input / Full range
- Protections:Short circuit / Overload / Over voltage / Over temperature
- Cooling by free air convection
- Can be installed on DIN rail TS-35/7.5 or 15
- UL 508(industrial control equipment)approved
- LED indicator for power on
- $100 \%$ full load burn-in test
- Fix switching frequency at 50 KHz
- 3 years warranty

SPECIFICATION

| MODEL |  | DR-75-12 | DR-75-24 | DR-75-48 |
| :---: | :---: | :---: | :---: | :---: |
| OUTPUT | DC VOLTAGE | 12 V | 24 V | 48 V |
|  | RATED CURRENT | 6.3 A | 3.2A | 1.6A |
|  | CURRENT RANGE | 0~6.3A | 0~3.2A | $0 \sim 1.6 \mathrm{~A}$ |
|  | RATED POWER | 76W | 76.8W | 76.8W |
|  | RIPPLE \& NOISE (max.) Note. 2 | 100 mV p-p | 150 mVp -p | 240 mV p-p |
|  | VOLTAGE ADJ. RANGE | $12 \sim 14 \mathrm{~V}$ | $24 \sim 28 \mathrm{~V}$ | $48 \sim 53 \mathrm{~V}$ |
|  | VOLTAGE TOLERANCE Note. 3 | $\pm 2.0 \%$ | $\pm 1.0 \%$ | $\pm 1.0 \%$ |
|  | LINE REGULATION | $\pm 0.5 \%$ | $\pm 0.5 \%$ | $\pm 0.5 \%$ |
|  | LOAD REGULATION | $\pm 1.0 \%$ | $\pm 1.0 \%$ | $\pm 1.0 \%$ |
|  | SETUP, RISE TIME | $1000 \mathrm{~ms}, 60 \mathrm{~ms} / 230 \mathrm{VAC} \quad 1800 \mathrm{~ms}, 60 \mathrm{~ms} / 115 \mathrm{VAC}$ at full load |  |  |
|  | HOLD UP TIME (Typ.) | $60 \mathrm{~ms} / 230 \mathrm{VAC} \quad 12 \mathrm{~ms} / 115 \mathrm{VAC}$ at full load |  |  |
| INPUT | VOLTAGE RANGE | $85 \sim 264 \mathrm{VAC}$ 120 ~370VDC |  |  |
|  | FREQUENCY RANGE | $47 \sim 63 \mathrm{~Hz}$ |  |  |
|  | EFFICIENCY (Typ.) | 76\% | 80\% | 81\% |
|  | AC CURRENT (Typ.) | 1.6A/115V 0.96A/230V |  |  |
|  | INRUSH CURRENT (Typ.) | COLD START 20A/115VAC 40A/230VAC |  |  |
|  | LEAKAGE CURRENT | <1mA/ 240VAC |  |  |
| PROTECTION | OVERLOAD | 105 ~ 150\% rated output power |  |  |
|  |  | Protection type : Constant current limiting, recovers automatically after fault condition is removed |  |  |
|  | OVER VOLTAGE | 15~16.5V | $29 \sim 34 \mathrm{~V}$ | $58 \sim 65 \mathrm{~V}$ |
|  |  | Protection type : Shut down o/p voltage, re-power on to recover |  |  |
|  | OVER TEMPERATURE | $85^{\circ} \mathrm{C} \pm 5^{\circ} \mathrm{C}$ (TSW1) detect on heat sink of power transistor |  |  |
|  |  | Protection type : Shut down o/p voltage, recovers automatically after temperature goes down |  |  |
| ENVIRONMENT | WORKING TEMP. | $-10 \sim+60^{\circ} \mathrm{C}$ (Refer to output load derating curve) |  |  |
|  | WORKING HUMIDITY | $20 \sim 90 \%$ RH non-condensing |  |  |
|  | STORAGE TEMP., HUMIDITY | $-20 \sim+85^{\circ} \mathrm{C}, 10 \sim 95 \% \mathrm{RH}$ |  |  |
|  | TEMP. COEFFICIENT | $\pm 0.03 \% /{ }^{\circ} \mathrm{C}\left(0 \sim 50^{\circ} \mathrm{C}\right)$ |  |  |
|  | VIBRATION | $10 \sim 500 \mathrm{~Hz}, 2 \mathrm{G} 10 \mathrm{~min} . / 1$ cycle, period for 60min. each along X, Y, Z axes; Mounting: Compliance to IEC60068-2-6 |  |  |
|  <br> EMC <br> (Note 4) | SAFETY STANDARDS | UL508, TUV EN60950-1 approved |  |  |
|  | WITHSTAND VOLTAGE | I/P-O/P:3KVAC I/P-FG:1.5KVAC O/P-FG:0.5KVAC |  |  |
|  | ISOLATION RESISTANCE | I/P-O/P, I/P-FG, O/P-FG:100M Ohms/500VDC |  |  |
|  | EMI CONDUCTION \& RADIATION | Compliance to EN55011,EN55022 (CISPR22) Class B |  |  |
|  | HARMONIC CURRENT | Compliance to EN61000-3-2,-3 |  |  |
|  | EMS IMMUNITY | Compliance to EN61000-4-2,3,4,5,6,8,11, ENV50204, EN55024, EN61000-6-2 (EN50082-2), heavy industry level, criteria A |  |  |
| OTHERS | MTBF | 123.1 K hrs min. MIL-HDBK-217F ( $25^{\circ} \mathrm{C}$ ) |  |  |
|  | DIMENSION | $55.5 * 125.2^{*} 100 \mathrm{~mm}$ (W* ${ }^{*}$ D $)$ |  |  |
|  | PACKING | $0.6 \mathrm{Kg} ; 20 \mathrm{pcs} / 13 \mathrm{Kg} / 1.29 \mathrm{CUFT}$ |  |  |
| NOTE | 1. All parameters NOT specially mentioned are measured at 230 VAC input, rated load and $25^{\circ} \mathrm{C}$ of ambient temperature. <br> 2. Ripple \& noise are measured at 20 MHz of bandwidth by using a $12^{\prime \prime}$ twisted pair-wire terminated with a 0.1 uf $\& 47$ uf parallel capacitor. <br> 3. Tolerance : includes set up tolerance, line regulation and load regulation. <br> 4. The power supply is considered a component which will be installed into a final equipment. The final equipment must be re-confirmed that it still meets EMC directives. |  |  |  |



## Output Derating



Output Derating Vs Input Voltage


## 75W Single Output DIN Rail Power



- Universal AC input / Full range
- UL508 listed
- Installed on DIN rail TS35 / 7.5 or 15
- Protections: Short circuit / Overload / Over voltage / Over temp.
- Fixed switching frequency at 50 KHz
- Approvals: UL / CUL / TUV / CB / CE
- LED indicator for power on
- Cooling by free air convection
- 100\% full load burn-in test
- 3 years warranty

AC input voltage range ........... 85~264VAC; 120~370VDC
AC inrush current ................. Cold start, 20A at 115VAC, 40A at 230VAC
DC adjustment range ............. 12V: 12~14V, $24 \mathrm{~V}: 24 \sim 28 \mathrm{~V}, 48 \mathrm{~V}: 48 \sim 53 \mathrm{~V}$
Overload protection
105\%~150\% constant current limiting, auto-recovery
Over voltage protection $121 \% \sim 142 \%$ rated output voltage
Setup, rise, hold up time $\ldots \ldots . .1000 \mathrm{~ms}, 60 \mathrm{~ms}, 60 \mathrm{~ms}$ at full load and 230VAC
Withstand voltage I/P-O/P:3KVAC, I/P-FG:1.5KVAC, 1 minute
Working temperature $-10 \sim 60^{\circ} \mathrm{C}$ (refer to output derating curve)
Safety standards UL508, TUV EN60950-1 approved
EMC standards
EN55022 class B, EN61000-3-2,3, EN61000-6-2, EN61000-4-2,3,4,5,6,8,11, ENV50204

Connection I/P: 3 poles, O/P: 4 poles screw DIN terminal
Packing
$0.6 \mathrm{~kg} ; 20 \mathrm{pcs} / 13.0 \mathrm{~kg} / 1.1 \mathrm{CUFT}$

| Stock No. | Model No. | Output | Tol. | R\&N | Effi. |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 10531 | DR-75-12 | $12 \mathrm{~V}, 0 \sim 6.3 \mathrm{~A}$ | $\pm 2 \%$ | 100 mV | $76 \%$ |
| 10532 | DR-75-24 | $24 \mathrm{~V}, 0 \sim 3.2 \mathrm{~A}$ | $\pm 1 \%$ | 150 mV | $80 \%$ |
| 10533 | DR-75-48 | $48 \mathrm{~V}, 0 \sim 1.6 \mathrm{~A}$ | $\pm 1 \%$ | 240 mV | $81 \%$ |

## 17. Configuration Files

I/O Sheet

Job No
Job Name
ITP Description
Component

0007985
O Keefe St Switchboard - RTU
Site I/O, Devices \& Functionality Checks

Kingfisher RTU

| DI | Slot | Digital Inputs | Terminal | Logic State On | Logic State Off |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 4 | Supply Authority Power Failure | T1 | Normal | Fault |
| 2 | 4 | D.C. Power Supply OK | T2 | Fault | Normal |
| 3 | 4 | Tamper Alarm | T3 | Normal | Alarm |
| 4 | 4 | Flowmeter 1 Pulse | T4 | Pulse | Normal |
| 5 | 4 | High Probe Alarm | T5 | Alarm | Normal |
| 6 | 4 | Surcharge Imminent | T6 |  |  |
| 7 | 4 | WaterVoid | T7 | Fault | Normal |
| 8 | 4 | DryWellFlood | T8 | Fault | Normal |
| 9 | 4 | SumpPumpRunning | T11 | Running | Stopped |
| 10 | 4 | SumpPumpFault | T12 | Fault | Normal |
| 11 | 4 | VentFanRunning | T13 | Running | Stopped |
| 12 | 4 | VentFanFault | T14 | Fault | Normal |
| 13 | 4 | Generator Running | T15 | Running | Stopped |
| 14 | 4 | Generator Fault | T16 | Fault | Normal |
| 15 | 4 | Generator Tamper | T17 | Fault | Normal |
| 16 | 4 | Multitrode Probe Failsafe Alarm | T18 | Alarm | Normal |
| DI | Slot | Slot | Terminal | Logic State On | Logic State Off |
| 1 | 5 | Pump 1 Run | T10 | Running | Stopped |
| 2 | 5 | Pump 1 Fault | T11 | Normal | Fault |
| 3 | 5 | Pump 1 Auto | T12 | Auto | Not Auto |
| 4 | 5 | Fire Alarm | T13 | Alarm | Normal |
| Al | Slot | Analogue Inputs | Terminal | 0\% | 100\% |
| 1 | 5 | Pump 1 Speed | T1 |  |  |
| 2 | 5 | Spare | T2 |  |  |
| 3 | 5 | Hydrostatic Well Level - LIT 1 | T3 | 0\% | 100\% |
| 4 | 5 | Delivery Flow | T4 |  |  |
| Do | Slot | Digital outputs | Terminal | Logic State On | Logic State Off |
| 1 | 5 | Pump 1 Run Relay | T15 | Run | Stop |
| 2 | 5 | Spare | T16 |  |  |
| 3 | 5 | RTU Comms Fault | T17 | Alarm | Normal |
| 4 | 5 | Station Fault Relay | T18 | Fault | Normal |
| AO | Slot | Analogue Outputs | Terminal | Min | Max |
| 1 | 5 | Pump 1 Speed Command | T7 | 37.5 Hz | 50 Hz |


| DI | Slot | Digital Inputs | Terminal | Logic State On | Logic State Off |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 6 | Pump 2 Run | T10 | Running | Stopped |
| 2 | 6 | Pump 2 Fault | T11 | Normal | Fault |
| 3 | 6 | Pump 2 Auto | T12 | Auto | Not Auto |
| 4 | 6 | Pump2 Water In Oil | T13 |  |  |
| AI | Slot | Analogue Inputs | Terminal | 0\% | 100\% |
| 1 | 6 | Spare | T1 |  |  |
| 2 | 6 | Spare | T2 |  |  |
| 3 | 6 | Ultrasonic Well Level - LIT 2 | T3 | 0\% | n/a |
| 4 | 6 | Delivery Pressure | T4 | n/a | n/a |
| Do | Slot | Digital outputs | Terminal | Logic State On | Logic State Off |
| 1 | 6 | Pump 2 Run Relay | T15 | Run | Stop |
| 2 | 6 | Spare | T16 |  |  |
| 3 | 6 | Overflow Earth Test Relay | T17 | Test | Normal |
| 4 | 6 | Station Fault Reset | T18 | Reset | Normal |
| AO | Slot | Analogue Outputs | Terminal | Min | Max |
| 1 | 6 | Pump 2 Speed Command | T7 | 37.5 Hz | 50 Hz |

SPS Switchboard Replacement




Commissionning Recobrd
Thursday, 1 July 2010
5:32:25 PM

| IDENTITY- |  |
| :---: | :---: |
| Unit Name  <br>  O Keefe <br> Location $\boxed{ }$ <br> Unit Serial No. $\boxed{60736}$ <br> SID Code $\boxed{0}$ <br>  $\boxed{\text { ESeries }}$ |  |

Last Poll Results

| TEMP | 24C (75F) |  |  |
| :---: | :---: | :---: | :---: |
| Rx Sig | -48 dBm | Fwr PWR | 30 dBm |
| FREQ Err | 250 Hz | Rev PWR | 3 dBm |
| DC Volts | 14.3 V | Ret. Loss | 26.9 dB |
|  |  | VSWR | 1.1:1 |
| 1/07/2010 5:31:44 PM |  |  |  |


-Packet Error Test Results

| Tx Packets: | 31 |
| :---: | :---: |
| Rx Packets: | 31 |
| Lost Packets: | 0 |
| Error \%: | 0.0 |
| Normalised BER: | 0.00E+00 |
| 1/07/2010 | $2: 23$ |

Comment

| Function |
| :--- |
| ＋Speed Refernce $\mathrm{Ai}^{2}$ <br> - Speed Refernce Com <br>   <br>  24 <br> Digital Input Common Li 1 <br> Run Li 3 <br> Preset speed High Level 50Hz Li 4 <br> Reset Li 5 <br> Local／Remote Li 6 <br> PTC Probe OV <br> PTC Probe  <br>  R 1 A <br>  R 1 C <br> Fault Relay Contact R 2 A <br> Fault Relay Contact R 2 C <br>   <br> Run Relay Contact  <br> Run Relay Contact  <br>   |


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[^0]:    Testing Officer Comments \& Notes:

[^1]:    Ipswich Water
    Sewerage Pump Station Control System Design

[^2]:    Ipswich Water
    Sewerage Pump Station Control System Design

[^3]:    Ipswich Water
    Sewerage Pump Station Control System Design

[^4]:    Sewerage Pump Station Control System Design

[^5]:    Ipswich Water
    Sewerage Pump Station Control System Design

[^6]:    Ipswich Water
    Sewerage Pump Station Control System Design

[^7]:    Ipswich Water
    Sewerage Pump Station Control System Design

[^8]:    Table 16 - IO-3 Processor Specifications

[^9]:    ${ }^{1)}$ Connect screen to ground terminal. Connect ground terminal on the outside of the housing as prescribed. The two terminals are galvanically connected.

[^10]:    ${ }^{2)}$ For customer-specific versions, already connected with blue (-) when shipped.

[^11]:    7) Determined according to the limit point method according to IEC 60770, incl. non-linearity, hysteresis and non-repeatability.
    ${ }_{9)}^{8)}$ Limited by the overpressure resistance of the measuring cell.
    ${ }^{9}$ Limitation by the pressure-tightness of the cable connection.
[^12]:    ${ }^{10)}$ Tested according to the regulations of German Lloyd, GL directive 2.

    1) With VEGADIS 12: 200 m (656 ft)
[^13]:    ${ }^{12)}$ Deviating data in Ex applications：see separate safety instructions．

[^14]:    1) for instrument versions with flow software (FMU90 - *2**********)
    2) BST: British Standard
    3) French standard NFX 10-311
    4) for instruments with software for additional pump control (FMU90-*3********** or FMU90-*4**********)
[^15]:    5) according to NAMUR EN 61298-2
    6) after calibration
[^16]:    1) for instrument versions with flow software (FMU90 - *2**********)
    2) BST: British Standard
    3) French standard NFX 10-311
    4) for instruments with software for additional pump control (FMU90-*3********** or FMU90-*4**********)
[^17]:    5) according to NAMUR EN 61298-2
    6) after calibration
[^18]:    Notes: ${ }^{1}$ ) $=A C 23 B$ values $/ A C 23 A=105 A$.

[^19]:    See following pages

[^20]:    © $\leq 220 \mathrm{~V}$ ．

[^21]:    (1) Duty Cycle or Load Factor - Defined as the "on" time for a given operating cycle per hour including the "start time." A 40\% Duty Cycle is calculated in the following manner:
    Contactor switches six (6) times per minute (tpm), 250ms start time; 40\% duty cycle.
    To determine the "on" time and "off" time:

    - Operations per hour $=360$; [60 $\mathrm{min} \times 6 \mathrm{tpm}=360]$
    - One operating cycle $=10 \mathrm{sec}$; $[60 \mathrm{~min} \div 6 \mathrm{tpm}=10 \mathrm{sec}]$
    - "On" time at $40 \%$ duty cycle $=4 \mathrm{sec}$; $[10 \mathrm{sec} \times 0.4(40 \%)=4 \mathrm{sec}]$
    - 4 sec "on" time includes the start time of 250 ms
    - "Off" time at $40 \%$ duty cycle $=6 \mathrm{sec}$; $[10 \mathrm{sec}-4 \mathrm{sec}=6 \mathrm{sec}]$

[^22]:    ANSI is a registered trademark of the American National Standards Institute. IEC is a registered trademark of the International Electrotechnical Commission. IEEE is a registered trademark of the Institute of Electrical and Electronics Engineers, Incorporated. NEMA is a registered trademark of the National Electrical Manufacturers Association. UL is a registered trademark of Underwriters Laboratories, Inc.
    WARNING
    ERICO products shall be installed and used only as indicated in ERICO's product instruction sheets and training materials. Instruction sheets are available at www.erico.com and from your ERICO customer service representative. Improper installation, misuse, misapplication or other failure to completely follow ERICO's instructions and warnings may cause product malfunction, property damage, serious bodily injury and death.

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    CADDY, CADWELD, CRITEC, ERICO, ERIFLEX, ERITECH, and LENTON are registered trademarks of ERICO International Corporation

[^23]:    Typical installation.

[^24]:    (1) Grounded systems only. 240D and 480D should not be used on high-leg or ungrounded systems

[^25]:    Due to a policy of continual product development, specifications are subject to change without notice.

[^26]:    (1) Should not be connected in all modes of these systems. Refer to Power Distribution Systems and SPD Installation, Pages 11-12

[^27]:    (1) Form $C=$ Change-over contact (Form C dry contact), 400V~/3A $1 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ (\#18AWG to \#10AWG) connecting wire

[^28]:    ${ }^{*} A$ dual voltage $230 / 400 \mathrm{~V}$ socket-outlet with $3 P+N+E$ accepts a 400 V plug with $3 P+N+E$ or $3 P+E$ as well as a 230 V plug with $1 P+N+E$ (see front cover flap)

[^29]:    Tension cord

[^30]:    Your distributor

[^31]:    Support for Galvanic Isolation
    The power supply PC board is isolated from other control PC board, thereby assuring safety.

[^32]:    - DeviceNet
    - LonWorks Network
    - PROFIBUS DP
    - CC-Link
    - RS-485 communications (terminal block type)

[^33]:    - Aso, if we let the $\mathrm{CO}_{2}$ emissions coefficient be $0.555 \mathrm{~kg} / \mathrm{kWh}$ (enviommenal satasisisf toom the Enviommental Departnentiof

[^34]:    ＊1 Fuji＇s 4－pole standard motor

[^35]:    *1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
    (Example) If the setting range is from -200.00 to 200.00 , the incremental unit is as follows:
    "1" for -200 to $-100, " 0.1 "$ for -99.9 to $-10.0, ~ " 0.01 "$ for -9.99 to $-0.01, " 0.01 "$ for 0.00 to 99.99 , and " $0.1 "$ for 100.0 to 200.0
    *2 Symbols used in the data copy column:
    Y: Copied
    Y1: Not copied if the inverter capacity differs.
    Y2: Not copied if the voltage series differs.
    N : Not copied

[^36]:    *2 The H86 through H91 are displayed, but they are reserved for particular manufacturers. Unless otherwise specified, do not access these function codes.

[^37]:    （＊）To get out of the error state indicated by a blinking

[^38]:    Note 1）A box（■）in the above table replaces S（Standard type），E（EMC filter built－in type），or H （DCR built－in type）depending on the product specifications．
    2）A box（ $\square$ ）in the above table replaces $\mathrm{A}, \mathrm{C}, \mathrm{E}$ ，or J depending on the shipping destination．

[^39]:    Note
    To prevent noise from causing malfunctioning, separate signal wires for the control circuit as far apart as possible from those for the main circuits. Also, inside the inverter, bundle and fix the wires for the control circuit so that they do not come into direct contact with live parts of the main circuits (for example, the main circuit terminal block).

[^40]:    Note A box（ $\square$ ）in the above table replaces A，C，E，or J depending on the shipping destination．

[^41]:    Note A box（ $\square$ ）in the above table replaces A，C，E，or J depending on the shipping destination．

[^42]:    ${ }^{* 1}$ If a required (load torque + acceleration toque) is more than $50 \%$ of the constant torque, it is recommended to apply the linear V/f pattern (factory default).

[^43]:    Note
    Avoid abrupt voltage or current change for the analog frequency command. Otherwise, a broken wire condition may be recognized.
    When E65 is set at 999 (Disabled), though the command loss detection signal (REF OFF) is issued, the reference frequency remains unchanged (the inverter runs at the analog frequency command as specified).
    When E65 is set at " 0 " or 999 , the reference frequency level that the broken wire has been recognized as fixed is " $\mathrm{fl} \times 0.2$."
    When E65 is set at $100 \%$ or higher, the reference frequency level of the broken wire fixing is " $\mathrm{f} 1 \times 1$."
    The command loss detection is not affected by the setting of Analog input adjustment (filter time constants: C33, C38, and C43).

[^44]:    Note
    For reactance, choose the value at the base frequency (F04).

[^45]:    Note
    If automatic deceleration is enabled, deceleration may take a longer time. This is designed to limit the torque during deceleration, and is therefore of no use where there is a braking load.
    Disable the automatic deceleration when a braking unit is connected. The automatic deceleration control may be activated at the same time when a braking unit starts operation, which may make the acceleration time fluctuate. In case the set deceleration time is so short, the DC link bus voltage of the inverter rises quickly, and consequently, the automatic deceleration may not follow the voltage rise. In such a case, prolong the deceleration time.
    Even if the time period of 3 times of the deceleration time 1 (F08) has elapsed after the inverter entered automatic deceleration, there may be a case that the motor does not stop or the frequency dose not decrease. In this case, cancel the automatic deceleration forcibly for safety and decelerate the motor according to the set deceleration time. Prolong the deceleration time also.

[^46]:    Note 1）The carrier frequency fc is： 2 kHz for $* 1,15 \mathrm{kHz}$ for $* 2$ ， 10 kHz for $* 3$ ，and 6 kHz for $* 4$
    2）A box（ $\square$ ）in the above table replaces $S$（Standard type），E（EMC filter built－in type），or H （DCR built－in type）depending on the product specifications．
    3）A box（ $\square$ ）in the above table replaces A，C，E，or J depending on the shipping destination．

[^47]:    The purpose of this instruction manual is to provide accurate information in handling, setting up and operating of the FRENIC-Eco series of inverters. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

    In no event will Fuji Electric FA Components \& Systems Co., Ltd. be liable for any direct or indirect damages resulting from the application of the information in this manual.

[^48]:    Terminal R0, T0 (Common to all types): Screw size M3.5, Tightening torque 1.2 ( $\mathrm{N} \cdot \mathrm{m}$ )
    Terminal R1, T1: Screw size M3.5, Tightening torque $0.9(\mathrm{~N} \cdot \mathrm{~m})$ (for the models of 200 V series 45 kW or above, for 400 $V$ series 55 kW or above

    * The applicable motor rating of FRN4.0F1S-4E to be shipped for EU is 4.0 kW .

    Note: A box ( $\square$ ) in the above table replaces A, K, or E depending on the shipping destination.

[^49]:    Note

    - Route the wiring of the control terminals as far from the wiring of the main circuit as possible. Otherwise electric noise may cause malfunctions.

[^50]:    *1 Values in parentheses () in the above table denote default settings for the EU version.

[^51]:    * If a required (load torque + acceleration toque) is more than $50 \%$ of the linear torque, it is recommended to apply the linear V/f pattern (factory default).

[^52]:    The purpose of this instruction manual is to provide accurate information in handling, setting up and operating of the FRENIC-Eco series of inverters. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

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[^53]:    * The control PCB is equipped with either a screw terminal base or Europe type terminal block, supporting [FMP] or [FMI], respectively. Note that terminals [FMP] and [FMI] cannot coexist in an inverter so that the function code, F35 shares the identical function selection for these terminals.

[^54]:    *1 Values in parentheses ( ) in the above table denote default settings for the EU version.

[^55]:    *1 When you make settings from the keypad, the incremental unit is restricted by the number of digits that the LED monitor can display.
    (Example) If the setting range is from -200.00 to 200.00 , the incremental unit is:
    "1" for -200 to $-100, ~ " 0.1 "$ for -99.9 to -10.0 and for 100.0 to 200.0, and " 0.01 " for -9.99 to -0.01 and for 0.00 to 99.99 .
    *2 The H86 through H91 are displayed, but they are reserved for particular manufacturers. Unless otherwise specified, do not access these function codes.
    *3 Select 0.10 for models of 45 kW or above ( 200 V series) and 55 kW or above ( 400 V series), 0.20 for models of 37 kW or below ( 200 V series) and 45 kW or below ( 400 V series).
    *4 Select 2 for models of 45 kW or above ( 200 V series) and 55 kW or above ( 400 V series), 0 for models of 37 kW or below ( 200 V series) and 45 kW or below ( 400 V series).

[^56]:    Example 2:
    Original Label: XYZ_Pump1Status
    Replication Label: $(3 \mathrm{c}+1 / 2)$ _Pump $(\mathrm{n}+1,1,2)^{*}$
    Description:
    Takes the first 3 characters from the original label and increments them by one for every second new variable. Copies the next 5 characters from the original label. Takes the number in the next character position, and increments it by one for each new variable, but limited to a minimum value of 1 and a maximum value of 2 . Copies the rest of the original label into each new variable.
    New Variables: XYZ_Pump2Status,
    XZA_Pump1Status
    XZA_Pump2Status
    XZB_Pump1Status
    XZB_Pump2Status

[^57]:    * These parameters are reset to 0 after a warm start or after a power up. Communication fail counters are incremented for each message attempt. If all dialling attempts fail, a communication fail is also recorded.
    \# DNP3 Protocol: As for Series II protocol, the success counter is incremented when a message is received. If the message is a multi-fragment message (more than 2048 data bytes have been requested) then the RTU will reply with two or more fragments of data and will expect to receive an 'ACK' after each fragment (except the last one). A success is then recorded for each 'ACK' received or a fail is recorded if no ACK is received.

[^58]:    Copyright Omniflex - Subject to change without notice
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