BRISBANE CITY COUNCIL

## Sewage Pump Station SP210

## Nudgee Beach

Contract: BW 70103-033<br>Job Number: WT400075

## ELECTRICAL INSTALLATION

## OPERATIONS and MAINTENANCE MANUAL

## VOLUME 1

INSTALLATION BY:
SJ Electric (Qld) Pty Ltd 19 Elliot Street Albion Qld 4010

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## Page 1

### 1.1 General Workplace Health and Safety

- The Workplace Health and Safety Act (1995) sets out the laws about Workplace Health and Safety for all workplaces, workplace activities and specified high risk plant. The Electrical Safety Act (2002) sets out the laws covering electrical safety. Nothing in this document is designed, in any way, to undermine the authority of the Acts.
- All reasonable care must always be taken to ensure the plant is without risk to the health and safety of personnel operating and maintaining plant and equipment.
- Employers have an obligation to ensure the workplace health and safety of all personnel at work.
- It is employer responsibility to ensure that all persons entering or working on the premises use appropriate personal protective equipment.
- Personal protective equipment includes gloves, safety glasses, hard hats, ear protection, safe foot ware and, where necessary, specialist protective clothing for hazardous areas.
- Any item of equipment should always be isolated before maintenance or repairs commence to ensure that inadvertent operation of the item does not result in risk to the health and safety of any person.
- Where the item is isolated, any total or partial shutdown should not allow a hazardous situation to be created,
- Where the item cannot be isolated, another person should be stationed at the controls of the item and an effective means of direct communication should exist between the persons carrying out the maintenance and the person at the controls.


## Page 2

## General Operating Principles

- All persons working the premises must be qualified Electrical Engineers or electrical trades persons capable of performing the required tasks competently. All personnel must also be familiar with plant and equipment.
- Adequate information, instruction, training and supervision must be provided to enable personnel to perform work without risk to health and safety.
- Work in an orderly way.
- Plan work in advance to avoid hazardous situations.
- Warn others of any hazards.
- Make inquiries before starting work, particularly on any unfamiliar installation or equipment.
- Before any work begins ensure that any instructions received or given are fully understood.
- Concentrate on the task on hand.
- Do not distract others or allow yourself to be distracted by foolish actions.
- Work from a safe and convenient position that provides a maximum working space that you do not have to over reach, you cannot slip, trip or stumble and so endanger yourself and others.
- Keep the working area tidy and free of unwanted materials and equipment.
- Use insulated tools where possible.
- Inspect tools and equipment regularly and ensure that any necessary maintenance is carried out.
- Keep yourself in good health.
- Do not work if ill or over tired, to the extent that your concentration, movement or alertness is affected. Illness or fatigue can endanger yourself and others.


## Page 3

### 1.2 Project Overview

Contract BW70103-033 was for the manufacture and testing of (1) new pump station switchboards for Nudgee beach Brisbane.

Equipment provided by SJ Electric ensures safe and efficient operation of the pump stations. Equipment supplied and installed by SJ Electric includes: -

- Switchboards
- Instrumentation
- Civil Works

The switchboard incorporates the latest technology in motor control, power monitoring, and instrumentation. It is important engineers, technicians and operators are familiar with the equipment installed before attempting any adjustments, modifications or maintenance.

The following Sections of this manual contain a comprehensive description of all equipment supplied, by SJ Electric. It is recommended that this manual be referred to before carrying out any work on any equipment.

### 1.3 Plant Maintenance

To ensure proper operation of the plant the following should be observed: -

- The plant should be kept clean and tidy at all times. Not only is this of aesthetic value, it extends equipment life.
- Check that all plant and equipment is operating correctly. Correctly operating equipment promotes overall plant efficiency.
- All items and areas of equipment should be hosed down and cleaned regularly.


## WARNING

- Avoid directly hosing any drive motor or electrical item.
- All maintenance, service, modifications and significant deviations from Normal operating conditions should be recorded in the Plant Service Log
- After a month of operation, check the tension of all bolts associated with the plant and thereafter periodically. Bolted connections on painted surfaces can loosen due to thinning of the paint underneath the bolt head-bearing surface. Motor mounting bolts and other bolted connections subjected to vibration should be periodically checked for loosening.


## WARNING

- Before starting work on any item ensure that the power supply is isolated, tagged off, and the item cannot be started.
- The importance of preventative maintenance cannot be over-emphasized. Regular maintenance and suitable care of the equipment will ensure a long and reliable service life of the equipment.
- Many stoppages can be avoided by following the recommended maintenance procedures. Do not wait until you hear the grinding of equipment that has broken down. If you see any item wearing down, replace it, before it causes damage to other associated items.


## Preventive Maintenance

Maintenance procedures recommended to extend switchboard life are outlined as follows: -

- Switchboard exterior should be regularly wiped down with a solvent base cleaner such as "Spray \& Wipe". This will ensure longevity of the powder-coated surface.
- Accessible areas like distribution boards and motor starter panels should be cleaned with a vacuum cleaner to remove dust and foreign matter.
- RTU panels should be maintained as dust free as possible. Dusting with a dry rag is recommended - taking care not allows dust inside the I/O modules or processor.
- When removing or installing RTU modules care should be taken to ensure that power is turned off to the rack before modules are removed or installed.
- Connections and efficient operation of circuit breakers, contactors and isolators should be checked every 12 months - especially where connected to busbars.
- Busbar connections should be checked every 12 months.
- Globes for indicator lights should be checked on a weekly basis with any faulty lamps replaced.
- Cubicle Fans Filter should be inspected and cleaned frequently.


## Page 6

### 1.4 Electrical Control System

## General Description

The switchboards are manufactured from 3 mm aluminium and are suitable for location outdoors; the switchboards have been designed by Brisbane Water and contain several separate sections including:

- Incoming Section.
- Metering.
- Motor Starter Section.
- Distribution Section.
- RTU Section.


### 1.5 Control and Monitoring System.

The control and monitoring of the system is performed by the Brisbane Water telemetry system and was not included in this contract.

Q-Pulse Id TMSSTU24

# TECHNICAL DATA SHEET 

For

## SEWAGE PUMP STATION SP210 Nudgee Beach

Equipment Type:
Circuit Breaker

Location:

Model Numbers:
XS400

## Manufacturer:

Supplier:
NHP Pty Ltd

25 Turbo Drive
Coorparoo QLD 4151
Ph: 0738916008
Fx: 0738916139

## TemBreak MCCBs

## XS400 series thermal magnetic type

- Adjustment range 63-100\% of nominal current rating.
- Standards AS 2184/AS/NZS 3947-2.
- Adjustable thermal and magnetic trip.

XS400CJ ( 35 kA ) 3 pole

| Ampere <br> rating | Min | Max | Cat. No. |
| :--- | :--- | :--- | :--- |
| 250 | 160 | 250 | XS400CJ 250 3 |
| 400 | 250 | 400 | XS400CJ 400 3 |
| 400 | Non-Auto (5 kA for 0.3 sec$)^{1}$ ) | Refer page 5-48 |  |



XS400CJ ( 35 kA ) 4 pole

| 250 | 160 | 250 | XS400CJ 2504 |
| :--- | :--- | :--- | :--- | :--- |
| 400 | 250 | 400 | XS400CJ 400 4 |


| XS400NJ (50 kA) 3 pole |  |  |  |
| :--- | :--- | :--- | :--- |
| 250 | 160 | 250 | XS400NJ 250 3 |
| 400 | 250 | 450 | XS400NJ 400 3 |

XS400NJ (50 kA) 4 pole

| 250 | 160 | 250 | XS400NJ 2504 |
| :--- | :--- | :--- | :--- |
| 400 | 250 | 400 | XS400NJ 4004 |


| Short circuit capacity <br> Model |  | I/C |
| :--- | :--- | :--- |$\quad$ Voltage $\quad$.

Refer to ratings chart at the front of this section.
For ratings to AS/NZS 3947-2 and AS 2184, and Ics/Icu.


Notes: ${ }^{1}$ ) Load-break isolating switch only - no protection.
${ }^{2}$ ) MCCBs only.
${ }^{3}$ ) Poles in series. Refer applications Section 13.

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| Base standards A | Approvals |
| IEC 60947-2 A | ASTA/UK, Aust. standards |
| BS EN 60947 Part 2 N | Marine |
| VDE 0660 Part 1 N | NK/JAPAN |
| AS/NZS 3947-2/Aust./NZ Llay | Lloyds R/UK |
| AS 2184-1990/Australia ${ }^{2}$ ) A | ABS/USA |
| JIS C 8372/JAPAN G | GL/GERMANY |
| JEC 160/JAPAN | BV/FRANCE |
|  | DNV NORWAY |

## Standard TemBreak circuit breaker Selection guide



Standard TemBreak circuit breaker Selection guide



MCCB operational characteristics \& dimensions
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## MCCB Technical data

## Thermal Magnetic MCCBs

Thermal-Magnetic MCCBs are available from 125 AF to 800 AF. Depending on the type of MCCB thermal and/or magnetic trip setting may be adjustable.

| MCCB type | Fixed <br> thermal | Adjustable <br> thermal | Fixed <br> magnetic | Adjustable <br> magnetic |
| :--- | :---: | :---: | :---: | :---: |
| XS125CS, XS125NS | - | - | - |  |
| XS125CJ, XS125NJ | - |  | - |  |
| XH125NJ, XH125PJ, TL100NJ | - |  | - |  |
| XH160PJ | - | - | - |  |
| XE225NC | - | - | - |  |
| XS250NJ, XH250NJ | - | - | - |  |
| XH250PJ | - | - | - |  |
| XS400CJ, XS400NJ, XH400PJ, TL250NJ | - | - | - |  |
| XS630CJ, XS630NJ, XH630PJ | - | - | - |  |
| XS800NJ | - | - | - |  |
| XH800PJ |  | - | - |  |

Note: Yes

- No

Access to setting dials
From 125 AF to 250 AF the thermal adjustment is visible from the front of the MCCB. At 400 AF and above a protective cover must be removed to gain access to the settings. To achieve access to the settings, the cover screw under the 'sealed' label must be removed. To adjust the individual trip settings, turn the setting dial with a flat bladed screwdriver.
Once set, secure the cover and apply a new sealing label.


XH250NJ


[^0]
## MCCB Technical data

## Thermal Adjustment

TemBreak MCCBs have a wide thermal adjustment range, one of the largest on the market. The rated current ' $1 r$ ' is continuously adjustable from $63 \%$ to $100 \%$ of its nominal current ' l .' There are three main points of calibration marked at $63 \%, 80 \%$ and $100 \%$, as shown in the diagram below.

## Magnetic Adjustment

The magnetic adjustment is available on MCCBs of 400 AF and above. The magnetic setting ' 1 m ' is continuously adjustable from $500 \%$ to $1000 \%$ of its rated current ' 1 n '. There are five main points of calibration marked as multiples of $\ln ; 5,6,7.1,8.5$ and 10 . These are shown in the diagram below.


## Examples

1. XS125NJ/125A MCCB set at $\mathrm{I}_{\mathrm{r}}=0.8$, the rated current is calculated as $125 \times 0.8=100 \mathrm{~A}$
2. $X S 400 \mathrm{NJ} / 400 \mathrm{~A}$ MCCB set at $\mathrm{Im}=6$, the magnetic setting is calculated as $400 \times 6=2400 \mathrm{~A}$
3. XS630NJ/630A MCCB set at $\mathrm{I}_{\mathrm{t}}=0.8$ and $\mathrm{I}_{\mathrm{m}}=5.0$

The rated current is calculated as $630 \times 0.8=504 \mathrm{~A}$
The magnetic setting is calculated as $630 \times 5=3150 \mathrm{~A}$
Note that the magnetic setting is a multiple of the nominal current In and not the rated current Ir.
All thermal and magnetic trip settings are expressed as AC RMS values.
All MCCBs are calibrated at $45^{\circ} \mathrm{C}$ unless otherwise specified.
Breakers with adjustable magnetic trip

|  | Rated <br> current (A) |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Breaker | Scale 10 | $\mathbf{8 . 5}$ | $\mathbf{7 . 1}$ | $\mathbf{6}$ | $\mathbf{5}$ |  |  |
| XS400CJ | 250 | 2500 | 2125 | 1775 | 1500 | 1250 |  |
| XS400NJ | 400 | 4000 | 3400 | 2840 | 2400 | 2000 |  |
| XH400PJ | 400 | 4000 | 3400 | 2840 | 2400 | 2000 |  |
| XS630CJ | 400 | 4000 | 3400 | 2840 | 2400 | 2000 |  |
| XS630NJ | 630 | 6300 | 5355 | 4473 | 3780 | 3150 |  |
| XH630PJ | 630 | 6300 | 5355 | 4473 | 3780 | 3150 |  |
| X5800NJ | 800 | 8000 | 6800 | 5680 | 4800 | 4000 |  |
| XH800PJ | 800 | 8000 | 6800 | 5680 | 4800 | 4000 |  |

Note: Settings; 3 -poles can be adjusted simultaneously with one adjustment dial.

## MCCB Technical data

Time/current characteristic curves


Ambient compensating curves


## Example 1

The XS250NJ set at its maximum thermal setting of 250A experiences an overload of 1000A. What would be the tripping time?

Solution
As the axis are 'percent' rated current the overload as a percentage to rated current is

$$
\frac{100 \mathrm{~A}}{250}=400 \%
$$

The maximum and minimum on the curve are the tolerance bands. Therefore at $400 \%$ overload the tripping time would be as follows:
Maximum trip time $\approx 30$ seconds
Minimum trip time $\approx 10$ seconds
Average trip time $\approx 20$ seconds
Due to strict quality control of the manufacturing and calibration processes, the characteristic curve of most MCCBs will follow the 'average' curve within the tolerance band.

## Example 2

The XS250NJ is calibrated at 250 A for $45^{\circ} \mathrm{C}$ ambient. If the temperature rose to $55^{\circ} \mathrm{C}$ what effect would this have?

## Solution

At $55^{\circ} \mathrm{C}$ the ambient compensating factor is $93 \%$, i.e. $250 \times 0.93=232.5 \mathrm{~A}$

In other words the XS250NJ would act as an MCCB set at 232.5 A , in $55^{\circ} \mathrm{C}$.

## MCCB Technical data

## XS125CS, XS125NS

## Time/current characteristic curves



Ambient compensating curves


XS125CJ, XS125NJ, XH125NJ, XH125NJ
Time/current characteristic curves


Ambient compensating curves


## MCCB Technical data

## XE225NC

Time/current characteristic curves


Percent Rated Current

XH160PJ, XS250NJ, XH250NJ
Time/current characteristic curves


Ambient compensating curves


## MCCB Technical data

## XH250PJ, XS400CJ, XS400NJ, XH400PJ

Time/current characteristic curves


Ambient compensating curves


XS630CJ, XS630NJ, XH630PJ

Time/current characteristic curves



## ( $)$ TERASAKI

## MCCB Technical data

## XS800NJ, XH800PJ

Time/current characteristic curves


Ambient compensating curves


XM30PB
Time/current characteristic curves


Ambient compensating curves


## MCCB Technical data

## TL30F

Time/current characteristic curves


Ambient compensating curves


TL100NJ
Time/current characteristic curves



## MCCB Technical data

## TL250NJ

Time/current characteristic curves


Ambient compensating curves


## MCCB Technical data

## Microprocessor based characteristics and adjustments

## Characteristics

The standard microprocessor based MCCB from Terasaki has the most flexible characteristics on the European market. In addition to the standard overload and short circuit protection, there are a number of options available to meet specific applications.


Note: - Standard

- Optional
- Not available
${ }^{1}$ ) Includes TL400NE \& XV400NE
${ }^{7}$ ) Includes TL630NE to TL1250NE
${ }^{3}$ ) Includes XV630, 800 \& 1250

| Legend |  | Application |  |  |
| :--- | :--- | :--- | :--- | :--- |
| LTD | Long Time Delay | Overload protection, True RMS |  |  |
| STD | Short Time Delay | Short circuit protection and selectivity |  |  |
| INST | Instantaneous | Short circuit protection, fast acting | Standard for all <br> TemBreak |  |
| I2t RAMP |  | Provides easier grading with downstream fuses | Microprocessor <br> MCCBS |  |
| Pick-up LED |  | Lights on LTD overload, flashes on PTA pick-up |  |  |
| Test Port |  | Facility for TNS-1 OCR checker for calibration checking |  |  |
| PTA | Pre-Trip Alarm | Useful for loadshedding application |  |  |
| GFT | Ground Fault Trip | Protection against ground faults |  |  |
| LEDs | Light Emitting Diodes | Indication of fault for faster diagnosis |  |  |
| HI-INST | High Instantaneous | High inrush applications, increased selectivity |  |  |

## Access to setting dials

To adjust the settings on the microprocessor TemBreak, the sealed label must be broken and the cover fixing screws removed. To adjust the individual trip settings, turn the setting dial with a flat bladed screwdriver. Align the setting required between the black dots marked on the dial.


## MCCB Technical data

## Microprocessor based characteristics adjustments, operation, settings

Standard time current curves


Standard microprocessor adjustments


The ${ }^{1}{ }^{2}$ ramp switch, which is provided as standard, assists in discrimination with downstream fuses.

With the switch off, the STD operates with a definite time characteristic: $L$ with the switch on, the characteristic alters to a ramp: $\Delta$, cutting off the corner which poses a potential selectivity problem.

| Setting Dial |  | Available adjustments |  |
| :--- | :--- | :--- | :--- |
| Base current setting | $I_{0}$ | $0.63-0.8-1.0 \times \mathrm{I}_{\mathrm{n}}$ | Amps |
| LTD pick-up | $\mathrm{I}_{1}$ | $0.8-0.85-0.9-0.95-1.0 \times \mathrm{I}_{0}$ | Amps |
| LTD setting | $\mathrm{T}_{1}$ | $5-10-15-20-25-30\left(\right.$ at $\left.\mathrm{I}_{1} \times 600 \%\right)$ | Secs |
| STD pick-up | $\mathrm{I}_{2}$ | $2-4-6-8-10 \times \mathrm{I}_{0}$ | Amps |
| STD setting | $\mathrm{T}_{2}$ | $0.1-0.15-0.2-0.25-0.3$ | Secs |
| INST pick-up | $\mathrm{I}_{3}$ | $3-12-\times \mathrm{I}_{0}$ (continuously adjustable) | Amps |

Note: A special generator $T_{1}$ setting adjustment of $1-5 \mathrm{sec}$ (at $\mathrm{I}_{1} \times 600 \%$ ), is also available. Please contact NHP for details.

## MCCB Technical data

## Adjustment of TemBreak (electronic type) tripping characteristics

Electronic models of TemBreak come standard with an 8-bit microprocessor overcurrent relay (OCR). It is the OCR which provides the functions necessary for protection, while maintaining a high level of reliability.

Note: The ground fault trip and pre-trip alarm cannot be used simultaneously in a single breaker.

The wide OCR adjustment range allows the circuit breaker to be set-up in order to trip under certain conditions. Adjustments can be made to the tripping current as well as the tripping time of the breaker.

Front view


Figure 1. Electronic OCR adjustment possible (with label removed).

## Adjustment method

Remove the sealing label, loosen and remove the cover fixing screws and remove the cover. To adjust the individual trip settings, turn the setting dial with a flat bladed screwdriver.

Note: Align the groove (end marked with dots) between the bands for the required setting.
For example, the diagram right shows $\mathrm{l} 0=1.0$.
The INST and GFT pick-up currents are continuously adjustable.


Secure the cover and apply the sealing label.

## (1) TERASAKI

## MCCB Technical data

## Microprocessor based characteristics - adjustments, operation and examples

## Overload adjustment

The rated current of the microprocessor based TemBreak is adjusted using two current multipliers. This process achieves high accuracy adjustment from $50 \%$ to $100 \%$. These are the LTD pick-up dial ( 11 ) and the Base Current ( 10 ) selector switch. The rated current (LTD pick-up) is achieved as follows:
$I_{\text {rated }}=\ln \times l_{0} \times l_{1}$
In the example shown on the right the rating would be:
$I_{\text {ratied }}=1250 \times 1.0 \times 1.0=1250 \mathrm{~A}$
In total there are 15 possible increments of adjustment between 50 and $100 \%$ as shown below.


Example - Settings
In the example shown on the right, what are all the settings in Amps?

## Solution

Irating LTD pick-up $=\ln \times \operatorname{lo} \times \ln _{1}$ $1250 \times 0.8 \times 0.9=900 \mathrm{~A}$

| STD pick-up $=$ | $\ln \times 10 \times \mathrm{I}_{2}$ |
| ---: | :--- |
|  | $1250 \times 0.8 \times 4=4000 \mathrm{~A}$ |
| INST pick-up $=$ | $\ln \times 10 \times \mathrm{I}_{3}$ |
|  | $1250 \times 0.8 \times 12=12,000 \mathrm{~A}$ |
| GFT pick-up $=\quad$ | $\ln \times 16$ |
|  | $1250 \times 0.1=125 \mathrm{~A}$ |

(Note that GFT is a function of $\mathrm{In}_{\mathrm{n}}$ and not $\mathrm{I}_{0}$ )


Example - Time/Current curves



7-14

## MCCB Technical data

## Options (electronic type) TemBreak

## Pre-trip alarm (PTA)

The PTA continuously monitors the true RMS value of the load current. When the load current exceeds the pre-set current (Ip) an LED gives local alarm that the MCCB is approaching an overload situation.
Should the current Ip be exceeded for 40 secs a (N/O) contact will close to provide remote indication and/or load shedding.

## PTA specifications

Pick up current (A): [l|]


Adjustable steps of 70, 80, 90, 100 \% of the selected rated current [ 11 ].
Setting tolerance $\pm 10 \%$
Note: The long time-delay trip does not operate 'first' when the pick-up current is adjusted to $100 \%$ of the rated current [ 11 ].

PTA characteristics


Operating time ( s ) $[1 \mathrm{p}]$ Output contact

40 secs (fixed definite time-delay) setting tolerance is $\pm 10 \%$ Normally open contact. (1a) Integral lead is standard length ( 450 mm )

|  |  |  | Resistive load | Inductive load |
| :--- | :--- | :--- | :--- | :--- |
|  | Rating of <br> contact | 250 V AC | $125 \mathrm{VA}(2 \mathrm{~A}$ max) | $20 \mathrm{VA}(2 \mathrm{~A} \mathrm{max})$ |
| PTA indication |  | Pick-up LED flickers | $60 \mathrm{~W}(2 \mathrm{~A} \mathrm{max})$ | $10 \mathrm{~W}(2 \mathrm{~A} \mathrm{max})$ |



## MCCB Technical data

## Adjustment of TemBreak electronic type OCR with ground fault

## Ground fault trip

The GFT pick-up current is continuously adjustable from $10 \%$ to $\mathbf{4 0} \%$ of the rated CT current.
Notes: The ground fault trip and pre-trip alarm cannot be used simultaneously in a single breaker. XS400SE, XH400SE are not available with ground fault function.
When a three pole breaker is used in a 3 phase, 4 wire system. a separate CT is required for the neutral line. (refer NHP).
GFT specifications
Pick-up current (A): [IG]


Io X ler
Time-delay (S): [TG]


The GFT has a definite time-delay characteristic and is adjustable in steps of $0.1,0.2,0.3,0.4,0.8 \mathrm{~s}$. Total clearing time is +50 ms and resettable time is -20 ms for the preset time delay.
GFT characteristics
Ta SEC

4th CT for GFT


| Rating (A) | Type |
| :--- | :--- |
| 2500 | UXOY0007A |
| 2000 | UXOY0006A |
| 1600 | UXOY0005A |
| 1250 | UXOY0004A |
| 1000 | UXOY0003A |
| 800 | UXOY0002A |
| 630 | UXOY0001A |



Dimensions (mm)

| Rating (A) | A | B | C | D | E | F | H | CH | M | N |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $2500-1000$ | 140 | 110 | 50 | 10 | 80 | 85 | 145 | 75 | 85 | 35 |
| $800-630$ | 105 | 100 | 40 | 8 | 50 | 75 | 110 | 57 | 50 | 20 |

7-16

## MCCB Technical data

## TemBreak electronic type with ground fault

## External neutral sensor (4th CT)

External neutral sensors are required whenever optional earth fault is used on 3 phase 4 wire systems

The position and direction of 4th CT


The direction of 4th CT


## (4) TERASAKI

## MCCB Technical data

## Trip indicators

The LEDs when lit, indicate which trip function tripped the breaker eg, long-time-delay (LTD), short-time delay/ instantaneous

Note: If a pre-trip alarm (PTA) is fitted, the LED control power can be used (common).
(STD/INST) or ground fault (GFT) (control power required).
Trip indicator display (1250 AF and above)


Trip indicator display (400 AF to 800 AF ) and OCR controller example: XS, XH400
An optional feature available with TemBreak electronic type are An external trip indicator box is required with 400AF models. fault indication contacts - these are voltage free and provide a signal of the cause of a trip (long time, STD/INST).


Notes: For dimensions of XS/XH800SE and PE refer to pages 7-40 and 7-41, add dimensions of OCR controller and trip indication box (above).

## MCCB Technical data

OCR controller (PTA and trip indication)

OCR controller mounting position


Dimension table (mm)

| Ampere frame | Type of MCCB | A |  | B |
| :---: | :---: | :---: | :---: | :---: |
|  |  | With UVT controller | Without UVT controller |  |
| 400 | XS400 | 34 | 97 | 48 |
|  | XH400/TL400NE | 34 | 97 | 48 |
| 630 | XS630/XV | 64 | 151 | 60 |
|  | XH630 | 64 | 151 | 60 |
| 800 | XS800/XV | 64 | 151 | 60 |
|  | XH800 | 64 | 151 | 60 |
| 1250 | XS1250SE/XV | 51 | 114 | 72 |
| 1600 | XS1600SE/TL-NE | 51 | 114 | 92 |
| 2000 | XS2000NE | 54 | 180 | 115 |
| 2500 | XS2500NE | 54 | 180 | 115 |

OCR controller (PTA and trip indication)
The OCR controller is installed in the left hand side of the breaker (standard). This can also be installed externally to the breaker (please specify when ordering).
OCR controller specifications
Control power source
Rated voltage $100-120 \mathrm{~V} \mathrm{AC}$ or $200-240 \mathrm{~V} \mathrm{AC}$
Consumption 2 VA

Note: The permissible range of control power is $85-110 \%$ of the rated voltage.

OCR controller connection diagram ') ${ }^{2}$ )


OCR controller dimensions
(Installed external to the breaker)


Notes: ${ }^{1}$ ) Standard torque for the terminal screws M3.5-0.88-1.18 Nm (9~12 Kgf.cm). ${ }^{2}$ ) Connected cable size - Max $2.0 \mathrm{~mm}^{2}$.

## MCCB Technical data

## Time/Current curves XS400, XH400, TL400NE, XV400

Time/current characteristic curves


Overcurrent tripping characteristics

| CT rated current (A) ( $1_{0}$ ) | 250, 400 |
| :---: | :---: |
| Base current setting (A) (10) | $\left(1_{n}\right) \times(0.63-0.8-1.0)$ |
| Long time-delay pick-up current (A): ( $\mathrm{l}_{1}$ ) | (10) $\times(0.8-0.85-0.9-0.95-1.0)$ Non-tripping at (1) setting $\times 105 \%$ and below. Tripping at $125 \%$ and above. |
| Long time-delay time settings ( S ) ( $\mathrm{T}_{1}$ ) | (5-10-15-20-30) at ( $\mathrm{h}_{1}$ ) $\times 600 \%$ current. <br> Setting tolerance $\pm 20 \%$ |
| Short time-delay pick-up current (A): ( $\mathrm{l}_{2}$ ) | (10) $\times$ (2-4-6-8-10) Setting tolerance $\pm 15 \%$ |
| Short time-delay time settings (S) $\left(\mathrm{T}_{2}\right)$ | Opening time ( $0.1,0.15,0.2,0.25,0.3$ ) in the definite time-delay. Total clearing time is +50 ms and resettable time - 20 ms for the timedelay setting |
| Instantaneous trip pick-up current (A) ( $\mathrm{l}_{3}$ ) | Continuously adjustable from (10) $\times(3$ to 12$)$ Setting tolerance $\pm 20 \%$ |
| - Pre-trip alarm pick-up current (A) (1p) | ( 1 ) $\times(0.7,0.8,0.9,1.0)$ Setting tolerance $\pm 10 \%$ |
| - Pre-trip alarm time setting (S) ( $\mathrm{T}_{\text {F }}$ ) | 40 fixed definite time-delay. Setting tolerance $\pm 10 \%$ |

Note: - Optional.
Underlined values will be applied as standard ratings unless otherwise specified when ordering.

XS630, XH630, XS800, XH800, XV630, XV800
Time/current characteristic curves


Overcurrent tripping characteristics

| CT rated current (A) (b) | 630,800 |
| :---: | :---: |
| Base current setting (A) (b) | (l) $\times(0.63-0.8-1.0)$ |
| Long time-delay pick-up current (A): (h) | (b) $\times(0.8-0.85-0.9-0.95-1.0)$ Non-tripping at ( 1 ) setting $\times 105 \%$ and below. Tripping at $125 \%$ and above. |
| Long time-delay time settings $(\mathrm{S})\left(\mathrm{T}_{1}\right)$ | (5-10-15-20-30) at ( l ) $\times 600 \%$ current. <br> Setting tolerance $\pm 20 \%$ |
| Short time-delay pick-up current (A): (k) | (1.) $\times$ (2-4-6-8-10) Setting tolerance $\pm 15 \%$ |
| Short time-delay time settings (S) ( $\mathrm{T}_{2}$ ) | Opening time ( $0.1 .0 .15,0.2,0.25,0.3$ ) in the definite time-delay. Total clearing time is +50 ms and reseltable time - 20 ms for the time-delay setting |
| Instantaneous trip pick-up current (A) (h) | Continuously adjustable from (t) $\times$ ( 3 to 12 ) <br> Setting tolerance $\pm 20 \%$ |
| - Pre-trip alarm pick-up current (A) (b) | (1.) $\times(0.7,0.8,0.2, ~ 1.0)$ Setting tolerance $\pm 10 \%$ |
| - Pre-trip alarm time setting (S) (T) | 40 fixed definite time-delay. Setting tolerance $\pm 10 \%$ |
| - Ground fault trip pick-up current (A) (k) | Continuously adjustable from ( 1 l ) $\times(0.1$ to 0.4$)$ <br> Setting tolerance $\pm 15 \%$ |
| - Ground fault trip time setting (S) (T) | Opening time ( $0.1-0.2-0.3-0.4-0.8$ ) in the definite time-delay. Total clearing time is +50 ms and resettable time is -20 ms for the time-delay settings |

Note: - Optional.
Underlined values will be applied as standard ratings unless otherwise specified when ordering.

## MCCB Technical data

## Microprocessor based characteristics and adjustments

XS1250SE, XS1600SE, XS2000NE, XS2500NE, TL630NE, TL800NE, TL1250NE \& XV1250

Time/current characteristic curves


Overcurrent tripping characteristics

| CT rated current (A) ( 1.$)$ | 1000, 1250, 1600, 2000, 2500 |
| :---: | :---: |
| Base current setting (A) (10) | (L) $\times(0.63-0.8-1.0)$ |
| Long time-delay pick-up current (A): (l) | (b) $\times$ (0.8-0.85-0.9-0.95-10) Non-tripping at (h) setting $\times 105 \%$ and below. Tripping at $125 \%$ and above. |
| tong time-delay time settings (5) (1) | (5-10-15-20-30) at ( 01 ) $\times 600 \%$ current <br> Setting tolerance $\pm 20 \%$ |
| Short time-delay pick-up arrent (A): ( 1 ) | (b) $\times(2-4-6-8.10)$ Setting tolerance $\pm 15 \%$ |
| Short time-delay time settings (S) ( $\mathrm{T}_{2}$ ) | Opening time $(0.1,0.15,0.2,0,25,0.3)$ in the deflinite time-delay, Total clearing time is +50 ms and resetuable time -20 ms for the time-delay setting |
| Instantaneous trip pick-up current (A) | Continuously aduustable from (10) $\times(3$ to 12$)$ Setting tolerance $\pm 20 \%$ |
| - Pre-trip alarm pick-up curemt (A) (b) | (h) $\times(0.7,0.8,02,1.0)$ Setting tolerance $\pm 10 \%$ |
| - Pre-trip alarm time setting ( 5 ) (T) | 40 fued definte time-dely. Setting tolerame $210 \%$ |
| - Ground fault trip pick-up current (A) (t) | Continuously agustable from ( k$) \times(\mathrm{O} .1$ to 0.4$)$ <br> Setting tolerance $\pm 15 \%$ |
| - Ground fault trip time setting (5) (T) | Opering time ( $0.1-0.2-0.3-0.4-0.8$ ) in the definite time-deday. Total clearing time is +50 ms and resettable time is -20 ms for the time delay settings |

Note: - Optional.
Underlined values will be applied as standard ratings unless otherwise specified when ordering.

## MCCB Technical data

## Time/Current curves - Mathematical analysis

## MCCB curves

A microprocessor MCCB has three major regions on its overcurrent tripping characteristic, namely Long Time Delay (LTD) for overload protection, Short Time Delay (STD) and Instantaneous (INST), both for short-circuit protection.
The following is an insight into how these curves interact and could act as a guide for hand-drawing the curves. TemCurve Selectivity Analysis Software is available for computerised generation of curves (refer to page 7 -24).
Firstly consider the following basic characteristic curve shown in figure 1. The LTD takes the form of a curve and has the following characteristic equation:

$$
(12-1) \cdot t=k
$$

where ' $k$ ' is a constant. To determine $k$, the calibration point of the LTD should be used, i.e. $t=T_{1}$ at $\mathrm{l}_{1}=6(600 \%)$,
IEC - 60947-2 states that a breaker must not trip below $105 \%$ of its rated current, and always. trip at $130 \%$ of its rated current.
Terasaki microprocesssor MCCBs however are calibrated to trip between $105 \%$ and $125 \%$, giving them a higher degree of accuracy. If the middle point is taken then the pick-up of the MCCB is $115 \%$ of its rated current.
The STD and INST parts of the curve can be drawn more easily as they are simply a series of horizontal and vertical lines determined by the $\mathrm{I}_{2}$ and $\mathrm{T}_{2}$ settings for the STD, and $\mathrm{I}_{3}$ setting for the INST.

## Example

If we assume that we have:
XS1250SE with 1250A CTs and
$\mathrm{I}_{0}=1, \mathrm{I}_{1}=0.8, \mathrm{~T}_{1}=30$ secs,
$\mathrm{I}_{2}=8, \mathrm{~T}_{2}=0.2 \mathrm{sec}$ and
$\mathrm{I}_{3}=1_{2}$ (dial setting on OCR)
then the characteristic curve can be constructed as follows.
To draw the LTD we firstly need to determine the constant $k$, as follows:
$\mathrm{k}=\left(\mathrm{I}^{2}-1\right) \mathrm{t}=\left(6^{2}-1\right) 30=1050$
giving the characteristic equation:
$\left(1^{2}-1\right) \mathrm{t}=1050$
By simple arithmetic the tripping times for each level of overload can now be determined.
For $400 \%$ overload (for the example this is equivalent to $1250 \times 1.0 \times 0.8$ $\times 4=400 \mathrm{~A}$ ).

$$
\mathrm{t}=\frac{1050}{\left(1^{2}-1\right)}=\frac{1050}{\left(4^{2}-1\right)}=70 \text { secs }
$$

The STD and INST can be constructed as follows with
$\mathrm{I}_{2}=\mathrm{I}_{\mathrm{n}} \times \mathrm{I}_{0} \times \mathrm{I}_{2}$
$I_{3}=I_{n} \times I_{0} \times I_{3}$
Please note that 20 ms is taken as an average time for the INST trip of the MCCB as it is the maximum time it will take the MCCB to trip. In practice the breaker will open much faster, particularly at high faults where the current limiting qualities of the MCCB become more effective.

Fig. 1




## MCCB Technical data

OCR checker, inspection and maintenance


## TemCurve

## Selectivity Analysis Software

Our objective is to provide you with the tools necessary to ensure your time is managed as effectively and efficiently as possible.

TemCurve has been developed wholly by NHP for the Australian market, but will also be used within the Terasaki organisation throughout the world.

Circuit breaker selection and set-up can be a laborious and time-consuming task. NHP has ensured that TemCurve 4.0, for "Windows" 98 , 2000, NT and XP is now even simpler to operate.

Hence, accurate results can be gained in a matter of minutes.

The database within TemCurve holds the characteristic curves for all Terasaki devices presently available from NHP. In addition to this, the extensive database of non-Terasaki devices allows you to produce accurate grading from the transformer primary side to the point of final distribution.

High quality prints can be output, including the characteristic curves for each chosen device, as well as a complete list of device settings.

> For further information please contact your local NHP office or agent.

## MCCB Technical data

TemBreak XM30PB
Outline dimensions (mm)


ASL: Arrangement standard line L: Handle frame centre line Drilling plan conductor


Rear connected (optional)

$\$ 15$ for accessory wiring when necessary

Panel cut-out


Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

Plug-in (optional)
Drilling plan


## ( () TERASAKI

## MCCB Technical data

TemBreak XS125CS, CJ, NS, NJ, XH125NJ, PJ and TL30F MCCBs


## MCCB Technical data

TemBreak TL100F/TL100EM - TL100NJ
ASL: Arrangement standard line H: Handle frame centre line Outline dimensions (mm)


Drilling plan


Rear connected

## Bold stud type



Panel cut-out


Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

Note: Interpole barriers standard on TL100NJ.

## (7) TERASAKI

## MCCB Technical data

Motor operators (XMB type) for XS125, XH125, TL100NJ, TL30F $\left.{ }^{1}\right)^{2}$ )


Rear connected (optional)


Notes: ๆ For dimensions of 7MB-3BA2 used for TL100F refer to NHP.
${ }^{7}$ ) Dimensions for TL100NJ not showing length of MCCB. Refer page 7-27.
Above outline dimensions are for AC motors. Contact NHP for details for DC motors.

## MCCB Technical data

TemBreak XE225NC

## Outline dimensions (mm)

ASL: Arrangement standard line
it: Handle frame centre line

## Front connected (standard)



Panel cut-out


Panel cut-out dimensions shown give an allowance of 1.5 mm around the handle escutcheon.

## Rear connected (optional)



Note: In the standard shipment mode, terminals on both the line side and the load side are in a horizontal orientation.

## (1) TERASAKI

## MCCB Technical data

## Motor operators for XE225NC



Rear connected (optional)


Note: In the standard selection mode, terminals on both the line side and load side are in a horizontal orientation.

## MCCB Technical data

## TemBreak XS250NJ

## Outline dimensions (mm)

ASL: Arrangement standard line It: Handle frame centre line

Front connected (standard)


Breakers with terminal bars available on request.


## MCCB Technical data

## Motor operators (XMB type) for XS250NJ



- Breakers with terminal bars available on request.


Plug-in (optional)


## Mounting block

Note: For dimensions and selection of motors for TL225F refer to NHP.

## MCCB Technical data

## TemBreak XH160PJ and XH250NJ



Note: Breakers with terminal bars available on request.


Note: In the standard shipment mode, terminals on both the line side and the load side are in a horizontal orientation.

Panel cut-out


Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

Plug-in (optional)
Details of connections

> Mounting block


## Drilling plan

## (ศ) TERASAKI

## MCCB Technical data

## Motor operators for XH160PJ and XH250NJ



Rear connected (optional)


Note: In the standard selection mode, terminals on both the line side and the load side are in a horizontal orientation.

Plug-in (optional)


7-34

MCCB Technical data
TemBreak TL225F, TL250NJ


Front connected


## MCCB Technical data

TemBreak XS400, XH400, XH250PJ, XV400

Outline dimensions ( mm )
Front connected (standard)
Optional extension busbars


Rear connected (optional)


ASL: Arrangement standard line H: Handle frame centre line

Drilling plan


Panel cut-out


Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

Note: In the standard selection mode, terminals on both the line side and the load side are in a horizontal orientation.


Plug-in (optional)


## MCCB Technical data

## TemBreak TL400NE

Outline dimensions ( mm )
ASL: Arrangement standard line H: Handle frame centre line

Front connected


Rear connected


Panel cut-out


Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

## MCCB Technical data

Motor operators (XMC type) for XS400, XH400, XV400, TL250NJ, TL400NE ${ }^{1}$ )

ASL: Arrangement standard line
H: Handle frame centre line

Outline dimensions ( mm )

Drilling plan


Panel cut-out
 handle escutcheon.

Plug-in (optional)

Mounting block


Note: ${ }^{1}$ ) TL250NJ and TL400NE length dimension not shown. Refer pages 7-35 and 7-37.

## MCCB Technical data

TemBreak 630 AF XS630, XH630


## MCCB Technical data

TemBreak 800 AF XS800, XH800


Rear connected (optional)


## MCCB Technical data

Motor operators (XMC type) for XS630, XH630, XS800, XH800

ASL: Arrangement standard line
H: Handle frame centre line
Outline dimensions (mm)
Front connected (standard)



Rear connected (optional)


Panel cut-out

Panel cut-out dimensions shown give an allowance of 1.0 mm around the motor operator frame.


Note: In the standard selection mode, terminals on both the line side and the load side are in a horizontal orientation.

Drilling plan


## MCCB Technical data

TemBreak XS1250, XV1250

## Outline dimensions (mm)

ASL: Arrangement standard line
H: Handle frame centre line
Front connected (standard)


Drilling plan


Rear connected (optional)


In the standard shipment mode, terminals on both the line side and the load side are in a horizontal orientation.

Mounting block


Drilling plan

## MCCB Technical data

Motor operators (XMD type) for XS1250, XV1250


Rear connected (optional)

Note: In the standard selection mode, terminals on both the line side
Panel cut-out
Drilling plan


Plug-in (optional)

## Mounting block

Drilling plan


## MCCB Technical data

TemBreak XS1600SE, TL630, TL800, TL1250NE


Rear connected with motor operator

Panel cut-out


Panel cut-out dimensions shown give an allowance of 1.5 mm around the handle escutcheon.

Draw-out (optional)


## MCCB Technical data

Motor operators (XMD type) for XS1600SE types, TL630NE, TL800NE, TL1250NE


Draw out


## (\%) TERASAK

## MCCB Technical data

Motor operators for XS1600 TL630NE, TL800NE, TL1250NE
Outline dimensions (mm)
Front connected (standard)

Draw out

## Drilling plan



## MCCB Technical data

TemBreak XS2000NE


## MCCB Technical data

## TemBreak XS2500NE

## Outline dimensions (mm)

ASL: Arrangement standard line

Rear-connected (RC standard, no FC version)



- Panel cut-out dimensions shown give an allowance of 2 mm around the handle escutcheon.

Note: RC - Rear connected, FC - Front connected.

## MCCB Technical data

Motor operators (XMB type) for XS2000NE \& XS2500NE

MCCB accessories

ASL: Arrangement standard line 4: Handle frame centre line

## Outline dimensions (mm)



Rear connected (standard)


Draw-out (optional)


## (9) TERASAKI

## MCCB Technical data

Motor operators XMB types for XS2000NE \& XS2500NE

## Outline dimensions (mm)

## MCCB accessories

ASL: Arrangement standard line H: Handle frame centre line

Front connected (standard)


Drilling plan
Note: ${ }^{1}$ ) Use non-magnetic angle

## -

(SUS 304 etc )


## MCCB Technical data

AC power watts loss - 3 Pole MCCBs


Notes: Standard terminal arrangements.
125-1600 front connection.
2000 and above rear connection.
${ }^{1}$ ) Watts loss figures are for 3 poles.
e.g. An XH125NJ operating at 125 A, will have a total watts loss of 41 watts.
${ }^{2}$ ) Watts loss values are approximate and will vary according to ambient conditions and switchboard construction.

## NH:

## NHP and PowerCad working together

PowerCad has established itself as the standard for electrical engineering design software for electrical engineering building services.
PowerCad contains a suite of electrical design software which provides solutions ranging from basic cable sizing up to complete electrical design and modelling. There are 5 software packages which have a stepped level of features. These are: QuickCable-LT ${ }^{\text {m }}$ QuickCable ${ }^{\mathrm{is}}$. PowerCalc ${ }^{19}$, PowerCalc- $\mathrm{H}^{\mathrm{M}}$, while the final and most powerful version is called PowerCad- $5^{\mathrm{m}}$


The aloove is a typucal screen representation providing a circuit schematic. along with an open window showurg a protective device picture its various device OCR seltings. Cat No, and other device details.

PowerCad 5 - application
Starting with a network single line diagram, the designer is able to assign the loads in the system from which the software calculates maximum demands, determines the appropriate cable sizes, and selects suitable protective devices and can finally undertake a powerful harmonic modelling function of the entire system. In order for the software to accurately model the protective devices in the system. PowerCad includes various device characteristic data as a library within its software, including Terasaki circuit breakers.

[^1]

PowerCad 5 features:

- Maximum demand
- Cable sizing
- Conduit sising
- Fault-loop impedance
- Cable voltage drop caiculations
- Cable thermal stress
- Short circuit calculations
- Let-through energy
- Harmonic analysis
- Harmonic mitigation
- Power tactar correction
- Network resonance
- L.V Distribution Netwark Modelling
- Single Line diagram
- Single Line diagram export to AutoCad
- AutoGad interface for loads input
- Automatic mans \& submains cable selections
- Automatic final subcircuit cable sizing
- Circuit breaker selection
- Co-ordination time current curves
- Co-ordination curve on screen CB adjustment
- Substation sizing
* Motor Libraries and light fitting
- Luminare Libraries
- Extensive reporting with print preview
- Direct online support
- Standar ds AS/NZS, IEC, BS and CP5
- Generator sizing
- Harmonic active liltering
- Reactor passive filtering
- Transler switches


# TECHNICAL DATA SHEET 

## For

## SEWAGE PUMP STATION SP210 <br> Nudgee Beach

Equipment Type: Motor Contactors
Location: Motor Starter Section
Model Numbers:CA7-9
Manufacturer: Sprecher \& Schuh
Supplier:
NHP Pty Ltd
25 Turbo Drive
Coorparoo ..... QLD ..... 4151
Ph: 0738916008Fx: 0738916139

Attent o prevent electrical shock, disconnect from power -..... before installing or servicing. Install in suitable
...-C30 /...-30 enclosure. Keep free from contaminants
...-C37 /...-37
Achtung: Vor Installations- oder Servicearbeiten Stromversorgung unterbrechen, um Unfälle zu vermeiden. Die Geräte müssen in einem passenden Gehäuse eingebaut und gegen Verschmutzung geschützt werden.
Attenzione: Per prevenire infortuni, togliere tensione prima dell'installazione o manutenzione. Installare in custodia idonea. Tenere lontano da contaminanti.
Attention: Avant le montage et la mise en service, couper l'alimentation secteur afin d'éviter tout accident. Prévoir une mise en coffret ou armoire appropriée. Protéger le produit contre les environnements agressifs. Atención: Desconectar la alimentación eléctrica antes de realizar el montaje y la puesta en servicio, con el objeto de evitar accidentes. Instalado en una caja o armario apropiado. Proteger el producto de los ambientes agresivos.


IEC 60947-1/-4-1 EN 60947-1/-4-1



-Min. distance lateral to grounded parts or walls $=6 \mathrm{~mm}$
-Min. seitlicher Abstand zu geerdeten Teile oder Wände $=6 \mathrm{~mm}$
-Distance latéral min. enver pièces mises à terre ou parois $=6 \mathrm{~mm}$
-Distanza laterale min. verso pezzi a massa o pareti $=6 \mathrm{~mm}$ -Oistancia lateral min. a chasis o paredes $=6 \mathrm{~mm}$

 OBSERVACION (IIEC/EN GO947-1) Este producto se puede usar en el ambiente A. El uso en el
ambiente B puede causar perturbaciones eloctromagnéicas. En ese caso de uso, el usuario debe to ambientie 8 puede causar oenturbationes etectromagneticas
meididas de diminuir las perturbaciones electromanditicas.

## Series CA7 Contactors



## Save space, save money

The CA7 contactor series includes ten contactors within four frame sizes. The two smallest sizes house capacities up to 25 HP (@460V) and 30 HP (@575V). They measure only $45 \mathrm{~mm}\left(1-3 / 4^{*}\right)$ in width Even the largest of the contactors - the CA7-85, controlling motors to 60 HP - measures only $72 \mathrm{~mm}\left(2-3 / 4^{*}\right)$ wide. The space you save with CA7 translates to smaller panels and lower cost.


## Maximum flexibility

The CA7 contactor is designed for ultimate flexibility. Coil terminals can be supplied on the top or bottom, and are field-reversible to suit individual wiring needs. Auxiliary contacts can be mounted on the top and sides, for the most efficient use of panel space. In reversing applications where space may be tight, the mechanical interlock has a built-in auxiliary to save room.

Field-reversible coil terminals provide additional flexibility


Dual terminal technology provides additional wiring options, as well as increased reliability and a faster wiring process.

Dual wiring terminals speed installation

## State-of-the-art technology

CA7 contactors utilize the latest design technology. Combined with Sprecher + Schuhis CEP7 solid state electronic overload relay, the CA7 becomes the most accurate and reliable motor starter available. Mechanically linked contacts provide safety for all applications. In addition, snap-on electronic timers and a PLC interface are also available.


## Modular design

The CA7 contactor series includes universal accessories to fit every frame size. This provides incredible flexibility, and eliminates the need to purchase size-specific components.

Because of their modular design, CA7 contactors are easily joined to form complete starter combinations. The CA7 is specially designed for electrical and mechanical compatibility with our overload and motor circuit controllers.

## CA7 Selected Technical Data

| Catalog Number | AC-1 Amp Rating $40^{\circ} \mathrm{C}$ | Maximum Horsepower |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Single Phase |  |  | Three Phase |  |  |  |
|  |  | 115 V | 230 V | 200 V | 230 V | 460 V | 575 V |  |
| CA7-9 | 32 | $1 / 3$ | 1 | 2 | 2 | 5 | 7-1/2 | 9 |
| CAT-12 | 32 | $1 / 2$ | 2 | 3 | 3 | 7-1/2 | 10 | 9 |
| CA7-16 | 32 | 1 | 3 | 5 | 5 | 10 | 15 | 9 |
| CA7-23 | 32 | 2 | 3 | 5 | 7-1/2 | 15 | 15 | 9 |
| CA7-30 | 50 | 2 | 5 | 7-1/2 | 10 | 20 | 25 | 9 |
| CA7-37 | 50 | 3 | 5 | 10 | 10 | 25 | 30 | 9 |
| CA7-43 | 85 | 3 | 7-1/2 | 10 | 15 | 30 | 30 | 8 |
| CA7-60 | 100 | 5 | 10 | 15 | 20 | 40 | 50 | 8 |
| CA7-72 | 100 | 5 | 15 | 20 | 25 | 50 | 60 | 8 |
| CA7-85 | 100 | 7-1/2 | 15 | 25 | 30 | 60 | 60 | 8 |

See Sprecher + Schuh's general catalog for complete information and pricing on CA7 contactors.

Sprecher + Schuh US Division Headquarters 15910 International Plaza Dr., Houston, TX 77032 Tel: (281) 442-9000; Fax (800) 739-7370 'ww.ssusa.ce
uthliction W: F-CAT-R1 1002

Sprecher + Schuh Canadian Division
3610 Nashua Dr., Unit 10, Mississauga, Ontario L4V 1 L2 Tet: (905) 677-7514; Fax: (905) 677-7663 www.sscdn.ce


# Broad cuirent range Compact dlimensions Maximum filexilbilility 

## Series CA7 Contactors

Controls Motors<br>to 60HP (@460/575V)

As Little as 45mm Wide

## Reduces Panel Space

## Mechanically Linked Auxiliaries



Compact dimensions with maximum performance! Our CA7 contactors control motors up to 60 HP , in frame sizes ranging from $45 \mathrm{~mm}\left(1-3 / 4^{\prime \prime}\right)$ to a maximum of $72 \mathrm{~mm}\left(2-3 / 4^{\prime \prime}\right)$ wide.

Because of its modular design, CA7 is flexible and easy to use. All CA7 contactors use the same accessories, reducing the need to stock additional inventory. They are also mechanically and electrically compatible with Sprecher + Schuh's CEP7 electronic
overload relay and KT7 motor circuit controller. This provides easy, clean installation for a variety of motor starter applications.

Whether part of a system or for individual use, the CA7 is the right contactor for the job.

## sprecher + schuh

## Contact Block

Performance \& Selection

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## Contact Block Considerations

## Contact Material

Contact Construction

A combination of many factors affect the dependability, life expectancy, and suitability of a contact block in any given application. Understanding the most important of those factors can help you select the best switch for your needs. In the pages that follow you'll gain a basic understanding of switch materials and properties, and how they affect switch performance.

The contact material forms the surfaces that come in contact with each other to establish an electrical circuit. Typical contact materials include fine silver, nickel-silver, and silver alloys. Fine silver provides low electrical resistance between the movable and stationary contact interface. Silver alloys form harder surfaces to reduce wear and help prevent contact welding.

In low voltage applications (below 48 V DC and 0.1 A , or below 24 V AC and 0.4 A ) where excess oil or dust is present, the use of more noble alloys (such as palladium, gold, and their alloys) in the contact material is recommended. These alloys are highly reliable in this type of environment.

Silver alloys are susceptible to chemical attack which can affect reliability at low voltages. Noble metals resist chemical attack, but are susceptible to frictional polymer formation, which can affect reliability. Combining gold and palladium will resist frictional polymer formation.

The perimeter of the contact is often shaped like a circle or rectangle and may have little effect on contact performance. The shape of the faces where the fixed and movable contacts meet is more important. This interface should not have two flat surfaces meeting. If one of the contacts has a flat surface, the other contact should be a rounded surface to provide a more defined and controlled touch point.

Figure 1. Bifurcated Spanner Example


The bifurcated style of construction provides a higher degree of reliability than the butt spanner because it divides each movable contact into two sections at the tip of the spanner. This minimizes the chance of foreign materials accumulating on contact surfaces and preventing the completion of the circuit. Even if foreign material accumulates on one of the contact tips, the second tip will most likely touch a clean spot establishing the circuit. Typically, the bifurcated spanner is designed for use in full voltage applications, where the arc between the spanner and stationary contacts will bum off small amounts of contamination in most cases. To aid contact cleaning the contact spanner is designed to flex, which wipes the stationary surface and allows each finger to act independently.

Figure 2. Pentafurcated and Quadfurcated Spanner Examples


In low voltage applications (below 48 V DC and 0.1 A or below 24 V AC and 0.4 A ) pentafurcated/quadfurcated styles of construction provide the highest degree of reliability because they divide each movable spanner contact side into separate flexible fingers. Every part in the system is corrosion-resistant and the flexible spanner is designed to wipe the stationary contacts clean every time the circuit is opened or closed. This is important since the absence of an arc in low voltage environments means that contaminants will not be burned off, but will be eliminated by the wiping action. Therefore, the pentafurcated or quadfurcated are the most reliable styles of spanners available.

Some manufacturers use protrusions such as bars or nibs raised on the face of either the movable or stationary contact to help establish the circuit under low power conditions. These raised surfaces will tend to penetrate non-conducting films that may be present on contact surfaces. They may also lessen the chance of foreign matter preventing completion of the circuit. Such protrusions may, however, quickly burn away under arcing or higher current conditions.

Base materials to which the contact material is attached include copper alloys and steel. Copper alloy is preferable because of its thermal conductivity, electrical conductivity, and corrosion properties.

## Contact Size/ Volume Stationary vs. Movable

Contact size refers to the size of the face of the contact or the areas that meet to form the interface between the movable and stationary contacts. Volume is the total amount of contact material.

It is desirable to make one of the contacts smaller than the other so it stays within the perimeter of the other contact when switch action takes place. This arrangement provides greater assurance that alignment of contacts is maintained under repeated operation and resulting wear. Misalignment can cause severe contact wear and shorten switch life.

In the contact set, the movable contact is most often the smaller contact in both size and volume, so that its mass and resulting inertia can be minimized. Partly because of its low volume, the movable contact operates at a higher temperature than the stationary contact. Consequently, the stationary contact will also contribute to a greater rate of wear on the movable contact. The stationary contact is generally attached to a more massive base structure that provides a better heat sink than the movable contact structure.

In alternating current applications, the higher temperature of the movable contact can cause material to be expelled from the surface of the contact. The higher temperature can cause transfer of material to the cooler surface of the stationary contact as well. In direct current applications, the relative polarity of the contacts has a major effect on how the contact material is transferred from one surface to the other.

## Contact Block Considerations

Contact reliability pertains to the ability of contacts to establish a circuit across the interface between the stationary and movable contact set(s) each time the switch is operated. This reliability can be most often adversely affected by two conditions:

- Mechanical debris within the switch
- Non-conducting films that form on the contact surfaces

Mechanical debris or dirt can be introduced into the switch during assembly. Dirt and debris can also be interjected during installation or can be a product of switch action. The wear produced by internal switch components sliding past one another during operation can generate dirt. Care must be taken in the design of moving mechanisms to keep this wear to a minimum.

Non-conducting film and oxides can he formed from gaseous contaminants that enter the switch from an extemal environment as well as being formed from intemally generated reactants. Sealing methods have been developed to isolate the switch interior from the extemal environment. An understanding of the relationship of all the material used in the construction of a switch is required to eliminate the internally generated reactants. This requires knowledge of the post curing outgassing of any plastics, elastomers, paint, and other components used in the construction of the system. Some gases will react in the presence of an electric arc to form non-conducting films that will cause reliability problems if deposited on the contact face. The tendency of many thermoset plastics to continue to outgas for a period of time after curing has led to the use of thermoplastic materials in switch interiors.

## Contact Resistance

Contact resistance pertains to resistance across the interface between a pair of movable and stationary contacts. The higher the value of this resistance, the more difficult it is to establish a circuit when the contacts close. This is especially true in low power circuits. Higher resistance also contributes to contact heating.

The initial contact resistance of hoth fine silver contacts and nohle contact materials (gold, palladium, and their alloys) is $10 \ldots 15$ milliohms. However, the resistance of noble contact materials will remain relatively constant during their lifetime compared to silver contacts, which typically increase over time. These resistance values could vary with the ambient conditions in the vicinity of the contacts themselves

Sealed switches have slightly higher initial contact resistances compared to silver contacts ( $80 \ldots 150$ milliohms, depending on type), but they remain stable over the life of the device.

## Switch Design Considerations

In addition to the physical characteristics of the materials used in manufacturing, design considerations also affect the performance of a switching mechanism. In this section you'll gain an overview of those switch design fundamentals and how they affect switch performance.

Single Break vs. Double Break

Figure 3. Single Break Design


Figure 4. Double Break Design


Single break and double break refer to the number of contact pairs that are used to make or break the electrical circuit. Single break means the electrical circuit is controlled by one set of contacts. Double break means the electrical circuit is controlled by two sets of contacts in series.

In a single break design, the contact pair tends to repeatedly make and break the circuit on the same spot on the contact faces. This helps to keep the contact touch point clean, enhancing the contact reliability.

The double break design provides twice the length of air gap in the electrical circuit using the same stroke of the actuating member as with the single break design. The result is the electrical arc that is created by the opening of the circuit will be extinguished sooner and with less actuator movement as compared to a single break design.

Also, since the energy in the arc created upon contact opening is distributed across two air gaps, there is less tendency for the contacts to weld in the double break design.

On the other hand, because of the nature of the double break design, the contact points of the spanner may vary slightly with each actuation. This variation may, over time, affect switch reliability.

Contact motion refers to the relative motion of the contact faces as they begin to touch one another. Various design techniques are utilized to increase the reliability of the contacts establishing the circuit as they meet.

A wiping or sliding action will help clear surfaces of dirt and oxides and break any nonconducting film that may have formed on contact surfaces. This type of action must be carefully controlled, especially with precious metal contacts, to avoid excessive mechanical wear of the contacts.

Contact tips on the end of the spanner must be capable of flexing and twisting to establish a seat on the surfaces of bifurcated/quadfurcated/pentafurcated stationary contacts. A sliding action of one contact against the other could cause continuity interruptions if the moving contact slides up over a piece of debris.

## Switch Design Considerations

Spring Force

## Overtravel

Contact Underlap vs. Contact Overlap

The spring force discussed in the following paragraphs is the force provided within the contact block that returns the contact structure to its normal or unoperated state when the external force applied to the device operator is removed. This force holds the contact structure in its normal state until an extemal force is again applied to the device operator.

The amount of spring force is determined by the force required to insure contact reliability under the conditions in a variety of applications. Sufficient force is required to break through contaminants that may be present on the contact faces on the normally closed (N.C.) contacts. The force should insure that contacts stay stable under possible shock and vibration. Light welds created by contact arcing on the normally open (N.O.) contacts should be able to be broken by spring force. The spring force required to maintain circuit reliability is dependant on the contact material hardness. Greater force is required for harder materials.

Spring force directly affects the external force required to operate and to some extent contribute to internal switch friction. Consideration must be given to these factors when determining the spring force used.

Overtravel in a switch pertains to the amount of travel occurring in a switch beyond what is required to operate. Overtravel allows for wear within the switch mechanism. It helps to insure the switch will continue to function as the contacts wear or erode. Overtravel also provides contact stabilization under conditions of shock and vibration.

Contact underlap and overlap refer to the relative action of the N.O. and N.C. contacts when the switch is actuated.

Underlap is the more common type of switch action. As the device operator is moved from its rest position to initiate switch action, the following events take place in order:

1. The N.C. contact opens.
2. There is a duration where no electrical continuity is present.
3. The N.O. contact closes.

In overlap type switch action, the N.O. contact makes its circuit before the N.C. contact breaks its circuit. There is never a period of time when electrical continuity is absent:

1. The N.O. contact closes.
2. There is a duration where both circuits are active.
3. The N.C. contact opens.

The type of switch action selected is dependant on the requirements of the specific user circuit application.

## Switch Design Considerations

Direct Drive

Contact Action

NFPA 79 and EN 418 both require that emergency stops must be a direct drive design. A direct drive design switch will have continuous mechanical linkage from the external operating member to the contact carrier. It will not employ the use of any resilient members or springs in the mechanical actuating path to open the N.C. contacts.

A special case of direct drive design is a switch that complies with IEC 60947-5-1. It is designed so that contact separation will take place even though the contacts may have been welded or "sticking" during fault circuit conditions. A direct drive switch is designed to allow contact separation even if the contacts have been lightly welded during fault circuit conditions. The manufacturer provides the fusing level requirements needed to protect these contacts from welding. The actuator movement and actuator force required affecting contact separation are specified by the switch manufacturer.

This type of switch construction is used to help ensure that contact action takes place when the external operating member is actuated. By avoiding the use of any springs in the actuating path, a solid connection is provided directly from the external mushroom operator to the contacts.

Contact opening should always take place at the same point in the actuating stroke and with the same operating force. By their nature, these types of switches fall into the slow break/slow make category of devices although some special designs have been developed that provide positive opening in snap action devices. With increased awareness of safety concerns and the movement toward designing devices that are used globally, greater emphasis has been placed on the direct drive feature.

Contact action refers to how contacts make and/or break the electrical circuit they intend to control. There are two basic types of contact action: slow make/slow break and snap action.

In slow make/slow break action, the contact carrier and contacts move at the same rate of travel as the actuating mechanism. This action is most often obtained with direct drive switch designs. Since the rate of movement of the contacts is solely dependant on the speed of the external actuator, it can result in slow separation of contacts and create a condition called "teasing".

In the teasing condition, the air gap created to break the electrical circuit opens so slowly that arcing occurs between the faces of the stationary and moveable contacts. This arcing is detrimental to the contacts because of accelerated contact wear and material transfer and can cause the contacts to weld rather than separate. The arcing can also cause circuit problems by introducing noise.

Snap action design incorporates a resilient member or springs between the actuator and contact carrier. The springs cause the contacts to move independently of the actuating mechanism. The mechanism is designed so that when actuator movement takes place, not only does the contact carrier movement take place, but energy is also built up in the spring system. Prior to the point in the travel of the actuator where contact separation takes place, the contact carrier and spring system are designed to go into an overcenter mode.

## Switch Design Considerations

## Mechanically Linked Contacts

Time Delay

At the overcenter point, sufficient energy is available in the spring system allowing the carrier to move independently of any further actuator motion and the contacts snap open. This rapid opening prevents teasing and minimizes contact welding. Some snap action devices also incorporate direct opening action. The direct opening action occurs slightly later in the travel than the normal snapover point if the contacts were slightly welded.

This construction has also been known as "positively guided contacts". It combines a N.C. and N.O. contact combination to prevent N.C. and N.O. contacts from closing at the same time. This nomenclature is generally applied to control relays, but is also applicable to push buttons, pressure and temperature switches, and other control circuit devices. It is generally used for checking control circuit functions.

Time delay of a switching device is the interval between the time when the external operator of the switching device is actuated and the time when the contact action actually occurs.

In a switching device where time delay is provided, contact action takes place at a predetermined time interval after physical action has taken place to displace the extemal operator in a sufficient manner to operate the device. This time delay is fixed in some devices and adjustable in others to meet circuit requirements. Pneumatic timers are commonly used to perform this function.

A switching device that has been designed for stacking has provisions for attaching multiple contact elements to the operator.

Stacking provides a means for multiple circuits to be actuated from a single extemal operator. A switching device with this capability can perform multiple functions or combinations of functions depending on the type of external operator. A selector switch type operator with several positions in combination with multiple contact elements is one example of this type of device.

## Switch Design Considerations

Wiring Termination
The following are examples of some of the more common methods of termination used.

## Binding Head Screw

This screw has a larger than normal head. The underside of the screw head has a groove where the wire seats and is secured when the screw is tightened. It is most effective when used with solid wire. A cup washer can be added to accommodate stranded wire, but care must be exercised to ensure that all strands are secured

## Saddle Clamp

This is a U-shaped clamp with a screw in the center. The screw threads into a flat conductor on the switching device and the legs of the $U$ slide over the edges of the flat conductor in order to trap the wire.

Figure 5.


The saddle clamp should be designed so it tilts to securely clamp a single wire on one side or a different wire size on each side of the clamp.

Barrel Type - This is similar to the saddle clamp design, but instead of a U-shaped clamp, the clamp is rectangular.

Figure 6.


The screw is not threaded into the flat conductor but rather bears against its top surface. This causes the barrel to be drawn upward clamping the wire between the undersurface of the flat conductor and the lower portion of the barrel. A major advantage is the wire is easy to insert into the clamping area.

## Pressure Plate

A pressure plate is essentially a flat piece of material with a screw in the center. As with the saddle clamp, the screw threads into the flat conductor on the switching device. Even though the pressure plate is flat, it is designed to force the individual strands of wire to the center of the face plate that comes in contact with the conductor on the switching device where they are restrained. In addition, features are often designed into the body of the switching device that prevent any wire strands from escaping the pressure plate clamping action.

Switch Design Considerations

## Stab Type

This type of termination is often termed quick-connect, push-on, fast-on, etc. The connection between the switching device and the wire is made with special complementary connection parts. The male part is normally built into the switching device and the female part is mechanically attached to the wire end. Termination is accomplished by mating the connector parts. This method provides a quick way to attach wires to the switching device and it is easy to remove the wires for service.

## PC Pin

These are switching devices that can be soldered directly to a printed circuit board or plugged with pin connectors into receptacles mounted on the board.

## Lugs and Ferrules

These devices are mechanically secured to the wire end. They make it easier to attach the wire to the switch terminal. They are normally used with stranded wire.

- Lugs provide a flat projection that is usually shaped like a fork or ring. The projection can be inserted under the head of the screw, inserted into saddle clamps, or slipped under pressure plates.
- Ferrules provide a pin type projection well suited for use with saddle clamps, pressure plates, and barrel type terminals.


## Solder

Solder can be applied to the end of stranded wire to prevent the individual strands of wire from separating. The end of the wire becomes solid when soldered and can be used with saddle clamps, pressure plates, and barrel type terminals. It should be noted that the solder end will be quite hard and will resist the crushing effect of clamping means. Because of the irregular shape obtained through soldering, only partial contact between the wire and the terminal could result.

## Spring-Clamp

This termination style is designed to minimize wiring time. The optimized spring-clamp is designed to reduce stress relaxation while maintaining contact force. An opening force is applied by a lever. The wire is then inserted and the opening force is removed. Upon force removal, the spring-clamp closes on the wire. This design is good for vibration environments.

Because of the large variety of termination options and the importance of establishing and maintaining a reliable connection between the switching device and the circuit, standards have been developed to address this area. The Underwriters Laboratories Pullout and Secureness test is used to insure that termination methods have sufficient strength to retain the wire under conditions of use. This test also determines if the wire strands have been damaged during the wiring process or are susceptible to breakage under conditions of use.

## Switch Design Considerations

Finger-Safe
A finger-safe device provides a degree of protection from accidental, casual contact of live electrical parts by personnel. Only those components meeting or exceeding the requirements of IEC standard IP2X (listed under IEC 529) can be considered finger-safe.

Those standards describe a model test finger, along with guidelines for the manner in which the test finger is to be manipulated in the vicinity of the wiring terminals to determine if the switching device provides the required degree of protection.

Some switching devices achieve the finger-safe condition by basic device design while others require an external attachment.

The finger-safe feature is becoming more prevalent as safety issues take on added importance. Higher voltage levels pose a greater risk of injury and liability. A concem of finger-safe design is it may provide a false sense of security to personnel who have access to the area where electrical terminations are made.

## Environmental <br> Considerations

Every switch serves as just one element in a complete system. Where and how that system operates plays a significant role in which switch will deliver the most cost-effective performance over time. In the section that follows, you'll gain a better understanding of some of the extraordinary issues involved in switch specification.

Careful consideration of the environment to which the switching device is subjected will help ensure proper operation and acceptable service life. Consideration of external environmental conditions of the operators includes temperature and humidity, shock and vibration, and exposure to washdown, cutting fluids, etc., encountered during operation.

In installations where an unfriendly external environment exists, the switching device should be housed in an enclosure designed to isolate it from the environment. Various enclosure ratings have been developed for use in specific environments and these ratings are regulated by industry standards. The external environment of the switching device can have a profound effect on the operation of the device and on its service life.

Conditions generated within enclosures can also have a negative effect on switch operation and life. Condensation, internally generated chemicals, or trapped dirt are some of the more common problems. In addition, since each switching device is made of a variety of materials, each produces its own internal environment. Caution must be taken during the design of the switching device to ensure the materials selected are proper for this kind of device and are compatible with one another.

The following information points out some key internal and external conditions affecting switching devices, as well as their effects.

## Temperature

All electrical devices have a maximum operating temperature rating and this rating is generally understood by the user. The maximum storage temperature and the effects of low temperature are not as well-understood.

Exceeding the high temperature limits can cause degradation of materials within the switch. This degradation can weaken switch parts or release gases from plastics and elastomers. A change in physical dimensions may occur, affecting operational travel and force. A very low temperature environment can cause sticking of the actuator and compromise the return action provided by the internal springs within the switching devices. Great care should be taken to exclude freezing liquids from the vicinity of the external operator or the switch may be inoperative under available levels of operating force.

Large fluctuations in temperature can lead to condensation of water or other liquids, and result in the problems relating to humidity, chemicals, and gases listed below (in those cases it is generally helpful to ventilate the enclosure).

## Humidity

Moisture can cause the formation of rust and corrosion on metallic parts as well as contribute to electrical problems such as arc tracking.

## Chemicals and Gases

This class of contaminants can cause degradation of material used in the product in a

## Switch Design Considerations

variety of ways. Corrosion of metallic parts and the degradation of physical properties of plastics and elastomers are among the most common effects. The formation of conductive films on the surface of the insulation can cause arc tracking.

## Dirt and Debris

Whether originating internally from wear or damage, or externally, this material can cause friction between moving parts, increase wear, and reduce switch life. Dirt on contacts increases resistance and contributes to contact reliability problems.

## Shock and Vibration

Consideration must be given to the shock and vibration to which the switching device is subjected. Severe shocks can cause unintended momentary contact operation that could result in circuit malfunction. Long term exposure to vibration can cause premature wear of the switch elements and generation of internal dirt. Even a poorly designed panel door can repeatedly subject a switching device to damaging shock and vibration.

It's also important to handle a switch with care during installation to avoid damaging shock.

## Physical Abuse

Improper handling of the switching device during shipping or installation can cause damage to device components that could affect operation.

## Environmentally Sealed Devices

An environmentally sealed device isolates the contact area from the environment.
The most common type of construction has the contacts hermetically sealed within a glass envelope. Prior to sealing, the interior of the glass envelope is filled with an inert gas that keeps the environment around the contacts stable. This construction keeps out explosive gases or contaminants that could affect contact reliability. Since the contacts are not accessible for actuation by mechanical means, they are operated by means of magnetic flux.

A special version of the sealed switch known as a logic reed is used in logic circuits. The logic reed is characterized by very short contact bounce, typically less than 0.5 milliseconds.

Contact isolation can also be accomplished by mechanical means such as a flexible diaphragm. These methods do not, however, provide a true hermetic seal, and are more susceptible to wear and degradation.

## Switch Design Considerations

## Standards and Approvals

Standards have been developed by industry groups and governmental units to help ensure that switching devices meet certain requirements with regard to installation criteria, safe operation, load carrying ability, minimum mechanical and electrical life, etc.

Once a particular design has met the requirements of a specific standard, a marking may be affixed to devices constructed according to that design indicating that the standards of that particular agency have been met.

Users need to be aware of which standards pertain to the products used in their locations and which approvals are required. Requirements vary depending on the application and the governmental unit having jurisdiction. Some of the standards that apply to switching devices are listed below:

- UL 508
- NEMA ICS 5 part 1
- IEC 60947-5-1
- CSA 22.2 No. 14

Switch life can be defined in a variety of ways. It can be defined as the time when the switch physically fails and can no longer provide contact action. It can also be defined as the point when the operating characteristics change to such a degree that switch action is no longer reliable or the parameters fall outside those required for that application. Examples of the latter would be an increase in operating force or excessive travel to obtain contact action.

A switching device may wear out due to mechanical considerations. Repeated operations cause physical wear of parts due to friction, shock, and stress, and can lead to eventual component failure. Dirt and debris generated by the moving mechanism can cause binding and can be a source of contact contamination.

The electrical life of a switch is not necessarily related to its mechanical life. The electrical life of a switch is primarily load dependant, because the electrical load is the main source of heating in - and damage to - current carrying components. High current loads can also contribute to arcing at the contacts during contact action. This arcing action results in contact erosion and deformation and can lead to welding of the contacts. As a result, it is good practice to evaluate both mechanical and electrical life ratings before selecting a switching device.

The switch environment can cause corrosion. This may lead to friction, physical failure of components, and dirt or corrosion in the contact areas.

Low level switching and infrequent use may allow buildup of film on contact faces, affecting contact reliability. Logic reed switches or switches with precious metal contacts are ideal in these applications.

## Special Considerations

Shock and Vibration

Shock and vibration refer to the physical conditions that are present in the environment where the switch operates. These conditions often introduce undesirable motion into the device mechanism.

Sources of shock can be the normal motion of the equipment where the device is mounted or the expected movement of the entire control system. Such motion may be repetitive in nature or may occur only periodically under specific situations such as startup, etc. The user may try to anticipate random, abnormal conditions which could result in a high shock situation. One-time mishandling during shipping and installation can cause damage that will affect operation.

Another source of high shock is the slamming of control panel doors where the switching devices are mounted. In order to minimize the effect of known vibration, the axis of actuation of the switching device should not lie on the same plane as that of the direction of normal equipment vibration.

Contact reliability can be affected by shock and vibration. Continual vibration causes mechanical wear and under load conditions, arcing can lead to welding of contacts. A severe shock can cause unintended, momentary contact operation that could result in circuit malfunction.

The mechanical wear caused by long term exposure to vibration can result in the generation of dirt and debris which affects contact reliability and causes added friction in the sliding portions of the mechanism.

Dielectric strength is a measure of the ability of the insulation used in the switching device to withstand the application of a voltage across its surface or through its mass. This will determine the maximum electrical rating of the device.

Degradation of the dielectric strength of insulation can lead to failure of the device. Unintended electrical continuity may be established between circuit elements and ground. In either case, the result is a failure of the switch to perform its intended function.

The most common type of failure is due to arc tracking across the surface of the insulation. The combination of a particular insulation and environmental conditions such as moisture and/or certain gases in the presence of an electrical arc can result in the buildup of a conducting path.

## Special Considerations

Contact Block Ratings

The contact block rating of a switching device is the electrical load that the device is capable of switching. This rating is expressed in voltage and current and typically refers to the maximum values that can be switched in a specified number of operations. Although contact blocks are usually rated for maximum conditions, there is a practical low load limit that the contacts will switch in a reliable manner.

Exceeding the high loads can cause burning and pitting of the contacts leading to welding and contributing to arc tracking. If the load to be switched is of a very low energy level, any contaminants or non-conducting films on the contacts may prevent a circuit from being established when the contacts are operated. If loads below 48 V DC and 0.1 A , or below 24 V AC and 0.4 A , are to be switched, the user must be cautious when selecting the contact materials. If the switching is within a typical Type $4 / 4 \mathrm{X} / 13$ environment, the quadfurcated/ pentafurcated blocks should be used for ultimate reliability. If the switching is within Class I and 2 Division 2 environment, without a sealing well or a conduit seal off, logic reed, sealed switch, or stackable sealed switch contact blocks should be used. If this type of switch is used at the high end of the rating, then caution should be exercised if these contacts are used for switching low energy loads. The feature built in for establishment of low energy loads may have been burned away during high load switching operations.

Due to the growing popularity of solid-state devices being used in control circuits, the trend in industry is toward lower energy loads.

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## TECHNICAL DATA SHEET

## For

## SEWAGE PUMP STATION SP210

## Nudgee Beach

| Equipment Type: | Surge Diverter |
| :--- | :--- |
| Location: | Main Incomer |
| Model Numbers: |  |
|  |  |
| Manufacturer: | Critec |
|  |  |
| Supplier: | Energy Correction Options |
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## ㅋNTECH



## 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 $\Pi T$ 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 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 ${ }^{\text {m }}$ 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 standard postulates that under a LPL I the magnitude of a direct strike to the structure's LPS may be as high as 200 kA $10 / 350$. 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* 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 $10 \mathrm{kA} 8 / 20$, while under Scenario II it is considered to be 10kA 10/350 (exposure Level 3).

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 ${ }^{\circledR}$ 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

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 helps ensure 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* 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 3. To meet the abnormal over-voltage testing of UL 1449 Edition 3, 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 an SPD 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 SPD 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.


## TDS 130

## CRITEC ${ }^{\circledR}$ TDS Surge Diverter - TDS 130 Series

## Features

- CRITEC TD

Technology with thermal disconnect protection

- Compact package, modular DIN rail mounting for limited space requirements
- Three modes of protection: L-N, L-PE \& N-PE
- Indication flags and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates replacement of a failed surge module
- 15kA $8 / 20 \mu$ s surge rating per mode
- CE, UL* 1449 Edition 3 Listed

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 TDS130 series of surge suppressors provide economical and reliable protection from voltage transients on power distribution systems. The TDS130 is specifically designed for the protection of single phase power supplies within instrumentation and control applications. They are conveniently packaged for easy installation on 35 mm DIN rail within control
 panels.
CRITEC ${ }^{*}$ TD technology helps ensure reliable and continued operation during sustained and abnormal over-voltage events. Internal thermal disconnect devices help ensure safe behavior at end-of life. A visual indicator flag provides user-feedback in the event of such operation. The TDS130 provides a set of optional voltagefree contacts for remote signaling that maintenance is required.
The convenient plug-in module
 and separate base design facilitates replacement of a failed surge module without needing to undo installation wiring.

| Model | TDS1302TRI50 | \|TDS1301TR240 |
| :---: | :---: | :---: |
| trem Number for Europe | 702421 | 702422 |
| Nominal Voltage, $\mathrm{U}_{3}$ | 120-150 VAC | 220-240VAC |
| MaxCont Operating Voltage, $\mathrm{V}_{5}$ | 170VAC | 275 VAC |
| Stand-off Vottage | 230VAC | 44OVAC |
| Frequency | 0.100Hz |  |
| Nominal Discharge Current, ${ }_{6}$ | 816A \%/20 |  |
| Max Discharge Current, Lex | $\begin{aligned} & 15 \mathrm{kA} 8 / 20 \mathrm{pI} \text { L-N } \\ & 15 \mathrm{kA} 820 \mathrm{JSL} \text { LPE } \end{aligned}$ |  |
| Protection Modes | L-G, L-N, N-G |  |
| Technology | ID Technology with thermal disconnect |  |
| Short Circuit Curnent Rating, | 200kAIC |  |
| Back-up Overcurrent Protection | 63 Ag L if supply $>63 \mathrm{~A}$ |  |
| Voltage Protection Level, $\mathrm{U}_{3}$ | $\begin{aligned} & 500 \mathrm{~V} / 3 \mathrm{kA}(L+N-G) \\ & 800 \mathrm{~V} \text { e } 3 \mathrm{kA}(\mathrm{~L}-\mathrm{N}) \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { 800V 3kA }(\mathrm{L}+\mathrm{N}-\mathrm{G}) \\ & 1500 \mathrm{Ve} 3 \mathrm{kA}(\mathrm{LN}) \\ & \hline \end{aligned}$ |
| Status | N/O, N/C Change-over contact, $250 \mathrm{~V}-10.5$ Mechanical flac / remote contacts (R mod | $\qquad$ only) |
| Modula Width | 1 M |  |
| Dimensions $\mathrm{H} \times \mathrm{DXW}$ : mm (in) | $90 \times 68 \times 18(3.54 \times 2.68 \times 0.71)$ |  |
| Weight: kg (ibs) | $0.12(0.26)$ |  |
| Enclosure | DIN 43880 , ULS4V-0 thermoplastic, IP 20 | [EMA-1) |
| Connection | $1 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ ( $/ 18 A W \mathrm{~W}$ to 10 AWG ) Une and Neutral Terminals $\$ 35 \mathrm{~mm}^{2}$ ( (AAWG) stranded $\leqslant 35 \mathrm{~mm}^{2}$ (12AWG) solld PE Terminal |  |
| Mounting | 35 mm top hat Din rall |  |
| 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 | CE, IECP 61643-1, UL ${ }^{\text {d }} 1449$ Ed 3 Recogniz | Component Type 2 |
| Surge Rated to Meet | ANSWEEEE C62.41.2 Cat A, Cat B <br> IEC 61643-1 Class II <br> UL' 1449 Ed3 In 3 kA mode |  |
| Replacement Module | IDS130M150 | TDS130M240 |
| Replacement Module (Europe) | 702432 | 702424 |

- 50kA $8 / 20 \mu \mathrm{~s}$ 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, ULe 1449 Edition 3 Listed


## CRITEC ${ }^{\circledR}$ TDS Surge Diverter - TDS 150 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 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 ${ }^{\bullet}$ TD technology helps ensure reliable and continued operation during sustained and abnormal
 over-voltage events. Internal thermal disconnect devices help ensure safe behavior at end-of-life. A visual indicator flag provides userfeedback in the event of such operation. As standard, the TDS150 provides a set of voltage-free contacts for remote signaling that maintenance is required.
The convenient plug-in module and separate base design facilitates replacement of a failed surge module without needing to undo installation wiring.


| Mode! | ITDS15015R150 | ITD515015R240 | DS515015R277 | TDS15015R560 |
| :---: | :---: | :---: | :---: | :---: |
| tiem Number for Europe | 702404 | 702406 | 702407 | 702408 |
| Nominal Voltage, $\mathrm{U}_{2}$ | 120-150 VAC | 220240 VAC | $240-277 \mathrm{VAC}$ | $480-560 \mathrm{VAC}$ |
| MaxCont. Operating Voltage, Us | 170VAC | 275VAC | 320VAC | 610 VAC |
| stand-off Vortage | 240VAC | 440VAC | 480 VAC | 700VAC |
| Frequency | 0-100 Hz |  |  |  |
| Short Craut Current Rating, is | 200 kAIC |  |  |  |
| Back-up Overcurrent Protection | 125A9L if supp | $>100 \mathrm{~A}$ |  |  |
| Technology | T0 with therma | disconnect |  |  |
| Max Discharge Current, ${ }^{\text {bem }}$ | 50kA 820]s |  |  |  |
| Nominal Discharge Current, $h$ | 25kA $8 / 2015$ | [201kA880 |  |  |
| Protection Modes | Single mode (L- | L-NorN-G) |  |  |
| Voltage Protection Level U, | $\begin{aligned} & 400 \mathrm{~V} 03 \mathrm{kA} \\ & 1.0 \mathrm{kV} \mathrm{In} \end{aligned}$ | $\begin{aligned} & 700 \mathrm{~V} \odot 3 \mathrm{kA} \\ & 1.2 \mathrm{kV} \text { in } \end{aligned}$ | $\begin{aligned} & 800 \mathrm{~V} 93 \mathrm{kA} \\ & 1.6 \mathrm{kV} \text { in } \end{aligned}$ | $\begin{aligned} & 1.8 \mathrm{kV} \text { 3kA } \\ & 2.4 \mathrm{kV} \text { In } \\ & \hline \end{aligned}$ |
| status | N/O, N/C Chang terminals Mechanical flac | over contact, 25 remote contact | V-10.5A. max 1.5 <br> (R model only) | $\mathrm{mm}^{2}(14 \mathrm{AWG})$ |
| Dimensions HDDXW : mm (in) | $90 \times 68 \times 183.5$ | $\times 2.68 \times 0.69)$ |  |  |
| Module Width | 1 M |  |  |  |
| Weight: kg (los) | $0.12(0.26)$ |  |  |  |
| Enclosure | DIN $438880 . \mathrm{UL}$ | V -0 thermoplas | IP20(NEMA-1) |  |
| Connection |  | ) stranded ) solid |  |  |
| Mounting | 35 mm top hat | in rail |  |  |
| Temperature | $-40^{\circ} \mathrm{C}$ to $80^{\circ} \mathrm{CL}$ | FF to 176\% ${ }^{\text {\% }}$ |  |  |
| Humidity | 0\% to $90 \%$ |  |  |  |
| Approvals | CE, IECC 61643 -1 | UL 1449 Ed 3 R | cognized Compo | ent Type 2 |
| Surge Rated to Meet |  | 11.2 Cat $A$, Cat $B$ 41.2 Scenario II, II 20kA mode | posure 2, 50kA | $\text { 20 } \mu \mathrm{s}$ |
| Replacement Module | TOSI50M150 | 1IDS150M240 | 1T0S150M277 | ITDS150M560 |

## TDS1 100

## CRITEC ${ }^{\circledR}$ TDS Surge Diverter - TDS 1100 Series

## Features

- CRITEC 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 flags and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates replacement of a failed surge module
- 100kA $8 / 20 \mu \mathrm{~s}$ 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 1449

Edition 3 Listed

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 ${ }^{\circ}$ TD technology helps ensure reliable and continued operation during sustained and abnormal over-voltage events. Internal thermal disconnect devices help ensure safe behavior
 at end-of-life. A visual indicator flag provides user-feedback in the event of such operation. As standard, the TDS 1100 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 | [10511002S8150 | TDSIT0025R240 | TDSTI002S827] | [TDSTIT002SR560 |
| :---: | :---: | :---: | :---: | :---: |
| m Number for Europe | 702409 | 1702411 | 702412 | 702413 |
| Nominal Voltage, $\mathrm{Un}_{5}$ | 120.150 VAC | 220-240 VAC | $1240-271$ VAC | 4.58 .560 VAC |
| Max Cont Operating Voltane. $L_{\text {L }}$ | 170VAC | 275 VAC | 320VAC | 610VAC |
| Stand-oft Votage | 240VAC | 140VAC | 48SOVAC | 700VAC |
| Frequency | $0-100 \mathrm{~Hz}$ |  |  |  |
| Short Crcult Current Rating, is | 200 kAC |  |  |  |
| Badkup Overcurrent Protection | 125 AO L 1 if supol | 100 A |  |  |
| Technology | TD with thermal | ixconnect |  |  |
| Max Discharge Current, ${ }^{\text {bes }}$ | 100kA820]s |  |  |  |
| mpuse Current ${ }^{\text {ane }}$ | 12.54A 10/350us |  |  |  |
| Nominal Discharge Cument, ${ }^{\text {ch }}$ | 50kA 820 H | 140kA $/ 20015$ |  |  |
| Protection Modes | single mode (l-G | (-NorN-G) |  |  |
| Voltage Protection Level, $\mathbf{w}_{\text {, }}$ | 400 V 3kA | $\begin{aligned} & 700 \mathrm{~F} 3 \mathrm{kA} \\ & 1.2 \mathrm{kV} e 20 \mathrm{kA} \end{aligned}$ | $\begin{aligned} & 500 \mathrm{~V} 3 \mathrm{kA} \\ & 1.6 \mathrm{kV}=20 \mathrm{kA} \end{aligned}$ | $\begin{aligned} & 1.8 \mathrm{kV} e 3 \mathrm{kA} \\ & 2.4 \mathrm{kV} e 20 \mathrm{kA} \end{aligned}$ |
| Status | NO, NCC Change Mechanical flag | ver contact, 250 V emote contacts | $5 A$ odel only) | 14AWG) terminals |
| Dimensions $\mathrm{H} \times \mathrm{D} \times \mathrm{W}: \mathrm{mm}$ (in) | $90 \times 68 \times 3513.5$ | (2.68 $\times 1.38)$ |  |  |
| Module Widh | 2 M |  |  |  |
| Welaht: kg (bss) | $0.24(0.53)$ |  |  |  |
| Endosure | DIN 43880, ULT | -0 thermoplastic, | O(NEMA-1) |  |
| Connection | $\begin{aligned} & \frac{25 \mathrm{~mm}^{2}}{35 \mathrm{~mm}^{2}} \mathbf{3} \text { (3AWG } \end{aligned}$ | stranded solid |  |  |
| Mounting | 35 mm top hat D | Irail |  |  |
| Temperature | -40 $0^{\circ} \mathrm{C}$ to $80^{\circ} \mathrm{C}(-40$ | Fto $176{ }^{\circ}$ ) |  |  |
| Humidity | 0\%to90\% |  |  |  |
| Approvals | CE, IEC $61643-1$ | $10^{\circ} 14919$ Ed 3 Reco | zzed Component | pe2 |
| Surge Rated to Meet |  | 2 Cat A Cat B, C 1.2 Scenario II, Exp and Class II kA mode | re $3,100 \mathrm{kA} 820$ | 10kA 10350us |
| Replacement MOVModule | IDSIS0Miso | IIDS150M240 | 175150M27 | T105150M560 |

## CRITEC ${ }^{\circledR}$ TDS Surge Diverter - TDS350 Series

## Features

- CRITEC 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 flags and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates replacement of a failed surge module
- 50kA $8 / 20 \mu \mathrm{~s}$ 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® 1449

Edition 3 Listed

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.
CRITEC ${ }^{\bullet}$ TD technology helps ensure reliable and continued operation during sustained and abnormal over-voltage events. Internal thermal disconnect devices help ensure safe behavior at end-of-life. A visual indicator flag provides user-feedback in the
 event of such operation. As standard, the TDS 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 | \|TDS350TNC150 | DS50120240 | TDS5350TNC277 | TDS350TT150 | TDS350T1277 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Item Number for Europe | 702414 | 1702419 | 702417 | 702416 | 702418 |
| Nominal Vottage, $\mathrm{U}_{\mathbf{n}}$ | 120-150 VAC |  | $240-277$ VAC | 120-150 VAC | 240-277 VAC |
| Max Cont. Operating Voltage, $U_{\text {c }}$ | 170/295VAC | [2401480VAC | 320/536VAC | 170/295VAC | 320/536VAC |
| Stand-off Votage | $240 / 415 \mathrm{VAC}$ | 240/480VAC | 480/813VAC | 2401/415VAC | 480/813VAC |
| Freguency | $0-100 \mathrm{~Hz}$ |  |  |  |  |
| Short Crauit Current Rating, $\mathrm{l}_{\mathbf{k}}$ | 200kAlC |  |  |  |  |
| Back-up Overcurrent Protection | 125AgL, if supply > 100A |  |  |  |  |
| Technology | TD with thermal disconnect |  |  |  |  |
| Max Discharge Current, Lem | 50kA 8/20us |  |  | $\begin{aligned} & 12.5 \mathrm{kA} 10 / 350 \mu \mathrm{~s} \mathrm{~N}-\mathrm{PE} \\ & 50 \mathrm{kA} 820 \mu \mathrm{~s} \end{aligned}$ |  |
| Nominal Discharge Current, 1 | 25kA 8/20]s |  | 20kA $8 / 20$ | 25kA 8/20us [20kA $8 / 20$ |  |
| Protection Modes | L-N | [L-N, N-PE | L-N | L-N, N-PE |  |
| Voltage Protection Level, $U_{p}$ | $\frac{1400 \mathrm{~V}}{} \text { 3kA }$ |  | 800 V e 3 kA | $1.0 \mathrm{kV} \odot \mathrm{In}$ | $\begin{aligned} & 800 \mathrm{~V} \text { e } 3 \mathrm{kA} \\ & 1.6 \mathrm{kV} \text { O } \mathrm{ln} \\ & \hline \end{aligned}$ |
| Status | NOO, NC Change-over contact, 250V-/0.5A, max $1.5 \mathrm{~mm}^{2}(114 \mathrm{AWG})$ terminals Mechanical flaq/ remote contacts |  |  |  |  |
| Dimensions $\mathrm{H} \times \mathrm{D} \times \mathrm{W}$ : mm ( m ) | $90 \times 68 \times 53(3.54 \times 2.68 \times 2.07)$ |  |  | $90 \times 68 \times 70(3.54 \times 2.68 \times 2.76)$ |  |
| Module Width | 3M |  |  | 4 M |  |
| Weight: kg (lbs) | 0.36 (0.79) |  |  | 0.5 (1.10) |  |
| Encosure | DIIN 43 880, ULS4V-0 thermoplastic, IP 20(NEMA-1) |  |  |  |  |
| Connection | $\begin{aligned} & 525 \mathrm{~mm}^{2} \text { (\#4AWG) stranded } \\ & \leq 35 \mathrm{~mm}^{2} \text { (\#\#AWG) solid } \end{aligned}$ |  |  |  |  |
| 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\% |  |  |  |  |
| Approvals | CE, IEC $61643-1$, UL 01449 Ed 3 Recognized Component Type 2 |  |  |  |  |
| Surge Rated to Meet | ANsionteE ${ }^{\circ}$ C62.41.2 Cat A, Cat B, Cat C <br> ANSIصEEE* C62.41.2 Scenario II, Exposure 2, 50kA 8/20 1 s IEC 61643-1 Class II <br> UL• 1449 Ed3 $\ln 20 \mathrm{kA}$ mode |  |  |  |  |
| Replacement MOV Module | TDS150M150 TDS150M277 |  |  | STSSD150M150 ${ }^{\text {S }}$ TDS 150 M 277 |  |
| Replacement GDT Module |  |  |  |  |  |
| Replacement GDT Module (Europe) |  |  |  | 702403 |  |

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## 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.

# TECHNICAL DATA SHEET 

## For

## SEWAGE PUMP STATION SP210

## Nudgee Beach

Equipment Type: Surge Filter
Location:Main Incomer
Model Numbers: ..... TDF-10A-240V
Manufacturer:Critec
Supplier:
Energy Correction Options PO Box 431
Kelvin Grove, QLD. 4059
Ph: 0733560577
Fx: 0733561432
Web: www.ecoptions.com.au

## Features

- CRITEC ${ }^{\text {© }}$ Transient Discriminating (TD) Technology provides increased service life
- 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
- LED status indication and opto-isolated output - for remote status monitoring
- CE, UL ${ }^{\circ} 1449$ Ed. 3 Listed


## CRITEC ${ }^{\circledR}$ Transient Discriminating Filter

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 $\mathbf{1 1 0 - 1 2 0 \mathrm { V }} \mathrm{ac} / \mathrm{dc}$ and $\mathbf{2 2 0 - 2 4 0 \mathrm { Vac }}$ circuits.

The TDF is a series connected, single phase surge filter providing an aggregate surge capacity of $50 \mathrm{kA}(8 / 20 \mathrm{\mu s})$ 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 | ITPFAT20V | TDE3A240V | ITDF10AI20V | [DF 10A240V | \|rDFzoal20V | [DF20A240V |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| tem Number for Europe | 700001 | 700002 | 700003 | 700004 | 700005 | 700006 |
| Nominal Voltage, $\mathrm{W}_{2}$ | 110-120V | 220-240V | 110-120V | 220-240 V | 110-120V | 220-240V |
| Distribution System | TN-CS, TN-S |  |  |  |  |  |
| Max Cont. Operating | 170VAC | 340 VAC | 17 OVAC | 340VAC | 170 VAC | 340VAC |
| Stand-off Voltage | 240 V | 400 V | 240 V | 400 V | 240 V | 400 V |
| Frequency | $0-60 \mathrm{~Hz}$ | 50160 Hz | 0-60H2 |  |  | 50\%60H2 |
| Max Line Current, $\frac{1}{}$ | 3A |  | 10A |  | 120A |  |
| Operating Current ${ }^{\text {OU }}$ | 135 mA | 250 mA | 240 mA | 480 mA | 240 mA | 480 mA |
| Max Discharge Current, | $\begin{aligned} & \text { 10kA } 8 / 20 \text { ps N-PE } \\ & \text { 20kA } 8201 \mathrm{LS} \text { L-N } \\ & \text { 20kA } 820 \mathrm{HS} \text { L.PE } \\ & \hline \end{aligned}$ |  |  |  |  |  |
| Protection Modes | All modes protected |  |  |  |  |  |
| rechnology | In-line series low pass sine wave filter TD Technology |  |  |  |  |  |
| Voltage Protection Level, $\mathrm{U}_{\mathrm{p}}$ | $\begin{aligned} & 500 \mathrm{~V} \text { e } 500 \mathrm{~A} \\ & 250 \mathrm{~V} \text { e 3kA } \end{aligned}$ | $\begin{aligned} & 700 \mathrm{~V} \text { e } 500 \mathrm{~A} \\ & 600 \mathrm{~V} \text { e } 3 \mathrm{kA} \end{aligned}$ | $\begin{aligned} & 500 \mathrm{~V} \text { e 500A } \\ & 250 \mathrm{~V} \text { - 3kA } \end{aligned}$ | $\begin{aligned} & 700 \mathrm{~V} \text { E 500A } \\ & 600 \mathrm{~V} \text { - 3kA } \end{aligned}$ | $\begin{aligned} & 500 \mathrm{~V} \text { e } 500 \mathrm{~A} \\ & 250 \mathrm{~V} \text { e 3kA } \end{aligned}$ | 700 V e 500A 600 V - 3kA |
| filtering |  |  |  |  | -53d8 9100 k |  |
| Status | Green LED. On=Ok. Isolated opto-coupler output |  |  |  |  |  |
| $\text { pimensions } \mathrm{H} \times \mathrm{D} \times \mathrm{W} \text { : }$ $\mathrm{mm}(\mathrm{in})$ | $90 \times 68 \times 72$ $90 \times 68 \times 144$ <br> $(3.54 \times 2.68 \times 2.83)$ $(3.54 \times 2.68 \times 5.67)$ |  |  |  |  |  |
| Module Width | 4.M |  | 8 M |  |  |  |
| Welght kg (bs) | 0.7 (1.54) |  | 1148 (3.25) |  | 1.57 (3.46) |  |
| Endosure | DIN 43880, UL94V-0 thermoplastic, IP 20 (NEMA ${ }^{\text {a }}$-1) |  |  |  |  |  |
| Connection | $1 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ (18AWG to 10 ) |  |  |  |  |  |
| Mounting | 35 mm top hat DIN rail |  |  |  |  |  |
| 3ack-up Overcurrent Protection | 3 3 |  | 10A |  | 20A |  |
| Remperature | $-35^{\circ} \mathrm{C}$ to $55^{\circ} \mathrm{C}\left(-31^{\circ} \mathrm{F}\right.$ to $\left.131^{\circ} \mathrm{F}\right)$ |  |  |  |  |  |
| Humidity | 0\% to 90\% |  |  |  |  |  |
| Approvals | C-TIC, CE (NOM 3A 120V), CSA 22.2, U[ ${ }^{1283,}$ ULO 1449 Ed 3 Recognized Component Type 2 |  |  |  |  |  |
| Surge Rated to Meet | ANSP/EEEE C62.41.2 Cat A, Cat B, Cat C |  |  |  |  |  |

(1) Opto-coupler output can be connected to DINUNE Alarm Relay (DAR275V) to provide Form C dry contacts.

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## ERITECH

## Features

- 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


## CRITEC ${ }^{\circledR}$ 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 $\mathbf{2 4 V a c} / \mathrm{dc}$ signaling and control systems.
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.


| Model | DSF6A30V | [DSF6A150V | [DSF6A275V | DSF20A275V |
| :---: | :---: | :---: | :---: | :---: |
| tem Number for Europe | 702090 | 701000 | 701030 | 701020 |
| Nominal Voltage, $\mathrm{U}_{\mathbf{n}}$ | 24 | 110-120V | 220-240 V |  |
| Distribution System | 1Ph2W+G |  |  |  |
| System Compatibility | TNW, TN-C.S |  |  |  |
| Max Cont. Operating Voltage, Uc | 30VAC, 38VDC | 150VAC | 275VAC |  |
| Frequency | 0.60Hz | 50/60Hz |  |  |
| Max Line Current, L | 6 A |  |  | 20 A |
| Operating Current OU $^{\text {a }}$ | 7 mA |  |  |  |
| Max Discharge Current, | 4kA 8/20 ${ }^{\text {/ }}$ | 16kA 8/20]s |  | $\begin{aligned} & \text { 15kA } 8 / 20 \mu \mathrm{~L} \text { L-N } \\ & \text { 15kA } 820 \mu \mathrm{~S} \text { L.PE } \\ & \text { 25kA } 820 \mathrm{~N} \text { N-PE } \\ & \hline \end{aligned}$ |
| Protection Modes | All modes protected |  |  |  |
| rechnology | In-line series filter MOV |  |  |  |
| Voltage Protection Level, $\mathrm{U}_{\mathrm{p}}$ | 110 V e 3kA | 1400V 03 kA | 750Ve3kA | 710V 3 3kA |
| filtering | -3dBe 300 kHz |  |  | -3dB 062 kHz |
| status | LED power indicator |  |  | Status indicator |
| Dimensions H x D XW: mm (in) | $\begin{aligned} & 90 \times 68 \times 36 \\ & (3.54 \times 2.68 \times 1.42) \end{aligned}$ |  |  | $\begin{aligned} & 90 \times 68 \times 72 \\ & (3.54 \times 2.68 \times 2.83) \end{aligned}$ |
| Module Width | 2 M |  |  | 4M |
| Weight $\mathrm{kg}(\mathrm{lf})$ | 0.2 (0.441) |  |  | 0.7 (1.543) |
| Endosure | DIN 43880, ULAVV-0 thermoplastic, IP 20 (NEMA-1) |  |  |  |
| Connection | $1 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ (18AWG to 10 PWG ) |  |  |  |
| 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 | C-TIck, CE, NOM, UL 1449 Ed 3 <br> Recognized Component Type 2 C-Tick, CE |  |  |  |
| Surge Rated to Meet | ANSIPIEEE C62.41.2 Cat A, Cat B |  |  |  |

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## 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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## INSTALLATION INSTRUCTIONS



> MODEL NUMBER
> TDF-3A-120V
> TDF-10A-120V
> TDF-20A-120V
> TDF-3A-240V
> TDF-10A-240V
> TDF-20A-240V

## 1. PREPARATION

DANGER: Electrical shock or burn hazard. Installation of this Transient Voltage Surge Suppressor should only be made by qualified personnel. 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 be sure that power has been removed from all associated wiring, electrical panels, and other electrical equipment.

## CAUTION NOTES:

1. The installation of this Surge Protector should follow all applicable electrical codes, such as the National Electrical Code, or the Canadian Electrical Code.
2. Check to make sure line voltage does not exceed Surge Protector voltage requirement.
3. Prior to installation ensure that the TDF is of the correct voltage, current, and frequency rating for your application.
4. The earth terminal must be connected to a low impedance earth (< 10 ohms) for correct operation.
5. Do not perform a "Flash Test" or use a Mega-Ohm Meter (Megger) to test circuits that are protected with TDF modules. Damage may occur to the TDF modules.
6. Follow all instructions to ensure correct and safe operation.
7. Do not attempt to open or tamper with the TDF units in any way as this may compromise performance and will void warranty.

## 2. INTRODUCTION

Transient Discriminating Filters (TDF) are packaged in "DIN 43 880 " profile enclosures for simple installation onto 35 mm DIN
rails. They can be selected for use on distribution systems with nominal RMS voltages of 120 Vac or 240 Vac at frequencies of $50 / 60 \mathrm{~Hz}$. The 120 Vac unit also operates on nominal 125 Vdc supplies.

## 3. QUICK INSTALLATION OVERVIEW

Install in the following manner:

1. Ensure that power is removed from the area and the circuits that will be connected.
2. Snap lock the TDF module to the DIN rail.
3. Install the appropriate upstream overcurrent protection.
4. Connect wiring to the indicated $i / p$ and $o / p$ terminals.
5. Apply power and observe correct operation of the Status Indication, and alarm facilities if provided - see Section 11.

## 4. PROTECTION CONCEPTS

To optimize effectiveness of the TDF protection, the unprotected and protected wiring should be separated. Wiring from the exposed transient source to the TDF should be considered unprotected and kept approximately $12^{\prime \prime}$ ( 300 mm ) from all other wiring wherever possible. Wiring on the equipment side of the TDF should be considered protected.

The separation of protected and unprotected wiring is recommended to minimize the risk that transients conducted on unprotected wiring may cross couple onto protected circuits, and diminish the level of protection available from the TDF module.
The terminals on the TDF module are labeled "INPUT/LINE" (unprotected side) and "OUTPUT/LOAD" (protected side) assuming that the source of the transients is on the input side of the TDF module.
For applications where the transient source is on the load side of the TDF module, the TDF should be reverse connected with the INPUT/LINE terminals connected to the load side, toward the source of the transients.

## 5. MOUNTING

TDFs are designed to clip to 35 mm DIN rails (standard EN50022). Unless otherwise mechanically restrained, use horizontal DIN rails with the TDF module spring clips to the bottom and the label text the correct way up.

NOTE: TDFs must be installed in an enclosure or panel that:

- prevents the TDF unit temperature from exceeding $122^{\circ} \mathrm{F}\left(50^{\circ} \mathrm{C}\right)$
- provides adequate electrical and safety protection
- prevents the ingress of moisture and water
- allows TDF status indicators to be inspected


## 6. GROUND FAULT CIRCUIT INTERRUPTION (GFCI)

Where GFCI protectors (RCDs/ELCBs) are used, it is preferable that the TDF modules be installed prior to these devices (i.e. upstream). If this is not done, nuisance tripping of the GFCIs may occur during transient activity.

## 7. CONDUCTOR TERMINATION

Each TDF terminal is designed to accept wire sizes from 10 to 18 AWG ( $1.5 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ ) solid or stranded conductor. The wire insulation should be stripped back $5 / 16^{\prime \prime}(8 \mathrm{~mm})$.
NOTE: Do not use greater than 9inlbs ( 1 Nm ) of torque when tightening the terminals. For UL compliance, where two wires may need to be terminated into one terminal, the permissible wire size is 18AWG each.

## 8. FUSING AND ISOLATION

Overcurrent protection must be installed in the upstream circuit of every TDF to provide protection to the unit itself, the load and the wiring in case of fault situations. The current rating of the breaker or fuse used should be determined according to below. However, the current rating should be less than the rating of the wiring. For example, if a 20A TDF were installed in a circuit with wiring that can carry 15A, then a 15A overcurrent device must be installed upstream to protect both the TDF and wiring from overload.

| MAX FUSE SIZES: | TDF RATING | FUSE RATING |
| :---: | :---: | :---: |
|  | 3 A | 4 A |
|  | 10 A | 10 A |
|  | 20 A | 20 A |

## 9. STATUS INDICATION

TDF modules have a single Status Indicator on the front panel. When power is applied and full surge capacity is available, the Status Indicator will be illuminated. Should power be applied and the indicator fail to illuminate, the TDF should be replaced, as optimum protection is no longer provided.

## 10. MAINTENANCE \& TESTING

Before removing a TDF module from service, ensure that the power has been removed from the module. Replacement of a

TDF module should only be undertaken by qualified personnel.
NOTE: TDF units should be inspected periodically, and also following any periods of lightning or transient voltage activity. Check the Status Indicator and replace the module if it is not illuminated as detailed in Section 9 STATUS INDICATION.

## 11. DINLINE ALARM RELAY (DAR)

The TDF status monitoring circuit which provides the visual Status Indicator, also provides a low voltage opto-coupler alarm output circuit. Should voltage free alarm contacts be required, the ERICO Inc, DINLINE ALARM RELAY (DAR) should be used.

The DAR module provides a fully isolated dry contact alarm output. One DAR can be used per TDF, or up to 16 TDFs can be connected in series to one DAR to provide a common dry contact alarm output.

Ensure that the voltage rating of the alarm wiring is rated in accordance with the other voltages present in the equipment. This would normally be the same voltage rating as that used for the TDF module input wiring.
It is recommended that the DAR unit be powered from the outputload side of the TDF being monitored, however the DAR can be powered from other circuits. This allows for example, one DAR unit to be connected to separate TDFs which are protecting a three phase circuit.
NOTE: Depending upon the usage of the DAR output contacts, failure of power to the DAR may be interpreted as a failure of one or more TDFs. Visual inspection of the DAR and TDF Status Indicator is required to clarify this situation.

## 12. USE OF OTHER INTERFACES

ERICO, Inc. DAR units are recommended for the interfacing of equipment to the TDF opto-coupler alarm output circuit. The direct connection of other equipment to the TDF opto-coupler alarm output circuit may not provide sufficient isolation or exceed the opto-coupler specifications. This may damage the TDF and/or the connected equipment. Warranty may be voided under such circumstances. However, the specifications for TDF alarm output has been provided for those who desire to use the TDF opto-coupler output directly.
The TDF alarm opto-coupler output is available on terminals 3 and 5 . Terminal 3 is the positive and 5 is the negative side. This output is an open collector transistor output of the optocoupler. When the opto-coupler is driven on, it should be arranged to have 2 mA flowing through it. For use with 24 Vdc circuits, a $12 \mathrm{k} \Omega$ current limiting burden resistor is required. For use with 12 Vdc circuits, a $5.6 \mathrm{k} \Omega$ current limit resistor is required. For use with 5 Vdc circuits, a $2.2 \mathrm{k} \Omega$ current limit resistor is required.
NOTE: In connecting to the TDF opto-coupler alarm output, do not reverse the +/-connections or exceed the maximum


## TECHNICAL DATA SHEET

For

## SEWAGE PUMP STATION SP210 Nudgee Beach

Equipment Type:

## Location:

Model Numbers:

Manufacturer:

Supplier:

Surge Filter Alarm Relay

Main Incomer

DAR-275V

Critec

Energy Correction Options
PO Box 431
Kelvin Grove, QLD. 4059
Ph: 0733560577
Fx: 0733561432
Web: www.ecoptions.com.au

## INSTALLATION INSTRUCTIONS



## MODEL NUMBER <br> DAR 275V

## 1. PREPARATION



DANGER: Electrical shock or burn hazard. Installation of this device should only be made by qualified personnel. Failure to lockout electrical power during installation or maintenance can result in fatal electrocution or severe burns. Before making any connections be sure that power has been removed from all associated wiring, electrical panels, and other electrical equipment.

## CAUTION NOTES:

1. The installation of this device should follow all applicable electrical codes, such as the National Electrical Code.
2. Check to make sure line voltage does not exceed DAR275V voltage ratings.
3. Follow all instructions to ensure correct and safe operation.
4. Do not attempt to open or tamper with the DAR in any way as this may compromise performance and will void warranty. No user serviceable parts are contained.

## 2. INTRODUCTION

Selected DSD, TDS \& TDF DINLINE Surge Protection Devices include status monitoring circuits which provide visual status display of device capacity. They may also provide a low voltage opto-coupler alarm output circuit that can be connect to the DAR to provide potential free (Form C) change-over contacts. The DAR alarm contacts may be used to provide output to external alarm systems or remote monitoring circuits.

One DAR can be used per DSD/TDS/TDF opto-coupler alarm or up to 16 DSD opto-coupler alarms can be connected in series to the one DAR to provide a common output. It is recommended that the DAR be powered from the same power circuit that feeds the device(s) being monitored, however the DAR can be powered from other circuits. This allows for example, one DAR unit to be connected to separate SPDs that are protecting a three phase circuit.

Note. Depending upon the usage of the DAR output contacts, failure of power to the DAR may be interpreted as a failure of one or more of the SPDs being monitored. Visual inspection of the DAR and SPDs status displays would determine this.

## 3. MOUNTING

The DAR is designed to clip to 35 mm (top hat) DIN rails (standard EN50022). Unless otherwise mechanically restrained, use horizontal DIN rails with the DAR module spring clips to the bottom and the label text the correct way up.
NOTE: The DAR must be installed in an enclosure or panel that

- prevents the DAR temperature from exceeding $131^{\circ} \mathrm{F}\left(55^{\circ} \mathrm{C}\right)$
- provides adequate electrical and safety protection
- prevents the ingress of moisture and water
- allows DAR status indicators to be inspected


## 4. ELECTRICAL CONNECTION

The interconnecting wiring should:

- be of size \#10 b \#14 AWG ( $2.5 \mathrm{~mm}^{2}$ to $6 \mathrm{~mm}^{2}$ ) solid or stranded conductor.
- The wire insulation should be stripped back $5 / 16^{\circ \prime}(8 \mathrm{~mm})$.
- NOTE: Do not use greater than 9inlbs ( 1 Nm ) of torque when tightening the terminals.


## CONNECTION TO TELECOMMUNICATIONS NETWORKS

The DAR is approved for use in Australia where the alarm contacts may be connected to private lines or building cabling associated with the telecommunications network. NO direct connection to the public switched network should be made.

DINLINE ALARM RELAY

## INSTALLATION INSTRUCTIONS

## 5. INTERCONNECTION

When connecting the DAR to a single opto-coupler output the + terminal of the SPD should connect to the + terminal on the DAR. The - terminal should connect to the - terminal.


When connecting the DAR to multiple opto-couplers the optocouplers should be connected in series with + terminal of one connected to the - terminal of the next. The DAR + terminal should connect to + SPD terminal at one end of the series connection and the - DAR terminal connect to the - SPD terminal at the other end of the series connection.


## 5. STATUS INDICATION



## 6. FUSING AND ISOLATION

Overcurrent protection must be installed in the upstream circuit of the power supply to the DAR to provide protection to the unit itself and the wiring in case of fault conditions.

The fuse rating should be based on the wiring size used to connect to the DAR Ph \& N terminals. Australian regulations AS3000-1991, Table B2 specifies the following upstream protection for single phase circuits, unenclosed in air.

| Cable Size | HRC Fuse or | CB Rewirable Fuse |
| :--- | :---: | :---: |
| $1.5 \mathrm{~mm}^{2}$ | 16 A | 12 A |
| $2.5 \mathrm{~mm}^{2}$ | 20 A | 16 A |
| $4 \mathrm{~mm}^{2}$ | 25 A | 20 A |
| $6 \mathrm{~mm}^{2}$ | 32 A | 25 A |

Where overcurrent protection of the appropriate rating or smaller is already fitted in the upstream circuit, overcurrent protection at the DAR will not be required

## 6. MAINTENANCE \& TESTING

Before removing a DAR unit from service, ensure that the power has been removed. Maintenance, testing and replacement should only be undertaken by qualified personnel.
Testing of a DAR unit which is connected to a fully functional DSD unit can be accomplished by removing power to the DSD only. The DAR Status indication and output contacts should alter from the Normal to Fault condition.
Testing of the DAR unit alone may be accomplished by disconnecting the $+/$-connections to the unit. When power is applied the DAR "Fault" Status Indicator should be illuminated. By connecting the $+/$ - terminals together, the "Normal" Status Indicator should be illuminated. The output contacts should alter to the appropriate state.

## 7. USE OF OTHER INTERFACES

Only DAR units are recommended for the interfacing of equipment to the DSD, TDS \& TDF opto-coupler alarm output circuit(s). The direct connection of other equipment to these opto-coupler alarm outputs may not provide sufficient isolation or exceed the opto-coupler specifications. This may damage the SPD and/or the connected equipment. Warranty may be voided under such circumstances.
NOTE: In connecting to the SPD opto-coupler alarm output(s), do not reverse the +/- connections as damage may occur

# TECHNICAL DATA SHEET 

## For

## SEWAGE PUMP STATION SP210

Nudgee Beach

| Equipment Type: | Phase Failure Relay |
| :--- | :--- |
| Location: | Common Control |
| Model Numbers: | 252 -PS GW |
| Manufacturer: | Crompton |

Supplier:
Crompton Instruments. PO Box 5108
Minto Business Center
Minto NSW, 2566

Ph: 0296032066
Fx: 0296039335

Page 1 of 2
Ref: IW250PMSH - Rev 6 - March 02

## Models Covered

| 252-PMM 252-PMT | 252-PSF |  |
| :--- | :--- | :--- | :--- |
| 253-PH3 | 252-PMM | 252-PMT |

## Introduction

Thermistor Trip Relay (252-PMM \& 252-PMT).
The trip inputs are monitored within settable limits. In the event of the input moving outsite,these linuts, the unit will initiate a trip signal via a double pole chanigeover retay. An illuminated green LED indicates when the thermistor - : temperature is within normal working timits: The unit is designed such that the atarm relay is energised when normal temperatures are reactred.
Model 252-PMM has the facility for manual resetting, so that the trip condition remains after normal operating temperature is reached, until manual intervention occurs.

## Phase Balance Retay (252-PSF \& 252-PSG)

Trip inputs are monitored within settable limits. In the event of the input moving outside these limits, the unit will initiate a trip signal via a double pole changeover relay. An illuminated red LED indicates that the supply is within limits.

Speed Sensing Relay (253-PH3)
Trip inputs are manitored within settable limits. In the event of the input moving oytside these limits, the unit will initiate a trip signal. The illuminated red LED's indicates that the single pole output relays are in an energised state and at normal running speed all three retays should be energised. Units are factory adjusted for normal running speed $=0.75 \mathrm{~mA}$. output. The meter adjuist pot on the product front is used for this requirement, which also ensures the trip levels are set to the calibrated values. Terminal 8 is connected to terminal 5 intemally. Terminals 15 and 16 give a $0 / 1 \mathrm{~mA}$ signal proportional to speed.

No. 1 Relay energises on rising speed
No. 2 Relay energises on rising speed
No. 3 Relay de-energises on nising speed
This product is designed for use onty with magnetic coil inductive sensors.

## Waming

- During normal operation, vottages hazardous to life may be present at some of the terminals of this unit. Installation and servicing shoutd be performed onty by qualified, properly trained personnel' abiding by local regulations. Ensure all supplies are de-energised before attempting connection or other procedures.
- It is recommended adjustments be made with the:supplies de-energised, but if this is not possibile, then extreme caution shöuld be exercised:-
-     - Terminals sčould not be user accessible after installation and extemal installation provisions must be sufficient to prevent hazards under fault conditions.
- This unit is not intended to function as part of a system providing the sole means of fault protection - good engineering practice dictates that any critical function be protected by at least two independent and diverse means.
Never open circuit the secondary winding of an energised current transformer.


## Protector Trip Relays

DIN Rail \& Wall Mounted 250 Series Thermistor Trip, Speed Sensing $\&$

## Phase Angle

Installation
The Protector should be instafled in a dry position, not in direct-sunlight and where the ambient temperature is reasonably stable and will not be outside the range 0 to 60 degrees Celsius: Mounting will normally be on a vertical surface but other positions will not affect the operation. Vibration should be' kept to a minimum:-The Protectors are designed for mounting on a 35 mm rail to DIN 46277. Alternatively they may be screw fixed; a special adaptor is supplied to mount 252 types.

To mount a procector on a DIN rail, the top edge of the cartout on the back is hooked over one edge of the rail and the botiom edge cariying the release clip clicked into place. Check that the und is firmly fixed. Removal or repositioning may be achieved by levering down the release ctip and lifting the unit up and of fre rail:

Connection diagramis should be carefully followed to ensure conrect potanty and phase rotation where applicable.
Extemad voltege tuanstormers may be used on 252-PSF and
$\div$ 252-PSG to exterd the range.
252-PMM 252-PITT \& 253-PH3
Pick up, input and output leads should be kept separate from any other wising:

Setting Controls (252-PSF, 252'PSG)
$\angle$ These products have two calitration facilities that can be set en
to suitoperāting requirements and they are lactory callibrated as follows:-
1.: \% unbalance set points

Voltages of and below 380 votis L-L are calibrated to $1.0 \%$ class index of rated voltege. Voltages above 380 volts L-L are calibrated to $1.5 \%$ class index of rated voltage.
2. Time Delay

For all valtage ranges $10 \%$ maximum delay.
3. Voltage Withstand

Continuous overioad $=1.35 \times$ rated voltage

## Setting Up (all other models)

The calibration marks around the controls are provided as a guide if the installer does not have access to accurate equipment. The maximum eitor of the calibration marks is typically $10 \%$ of the span of the control concemed.

## Maintenance

The unit should be inspected to normal standards for this class of equipment. For example remove accumulations of dust and check all connections,for tightness and corrosion. In the unlikety event of a repär' being "necessary it is recommended that the unit be retumed to the factory or to the nearest Crompton Instruments Service Centre

## Electromagnetic Compatibility

This unit has been designed to provide protection against EM (electro-magnetic) interference in line with requirements of EU and other regulations. Precautions necessary to provide proper operation of this and adjacent equipment will be installation dependent and so the following can only be general guidance:-

- Avoid routing wiring to this unit alongside cables and producis that are, or could be, a source of interference.


## Ref: IW250PMSH - Rev 6-March 02

## Protector Trip Relays DIN Rail \& Wall Mounted 250 Series Thermistor Trip, Speed Sensing \& Phase Angle

- The auxiliary supply to the unit should not be subject to excessive interference. In some cases, a supply line filter may be required.
- To protect the product.against incorrect operation or permanent damage, surge transients must be controlled. It is good EMC practice to suppress differential surges to 2 kV or less at the source. The unit has been designed to automatically recover fromsypical transients, however - in extreme circumstances it may be necessary to temporarily disconnect the auxiliary supply for a period - of greater than'5 seconds to restore correct operation.
- Screened communication and small siginal leads are recommended and may be required. These and other connecting leads may require the fitting of 'RF suppression components, such as ferrite absorbers; line filters etc., if. RF fields cause problems.
-ilt is good practice to Install sensitive efectronic instiuments that are performing critical funotionejin-EME encósures that protect against electrical interference causing a disturbance in function.


The Intormation contalned in these installation instuctions is tor use onty by installers trained to make electrical power installations and is intended to describe the correct method ol installation tor tits procuct. However, Tyco Electronics has no control over the liatd conditions, witich influance product instanation.
 Ek bes' standard Condillong of Sale tor this product and in no case will Tywo Electronies be llable.tor any other inctrental, indirect or consequential damages artirry itom the use or misuse of the products. Crompion is a trade mark.

# TECHNICAL DATA SHEET 

## For

## SEWAGE PUMP STATION SP210

## Nudgee Beach

Equipment Type: ..... Level Relay
Location:
Common Control
Model Numbers:MTR 240VAC
Manufacturer:Multitrode
Supplier:
Multitrode Pty Ltd
130 Kinston Road
Underwood. QLD 4119Tel: 0733407000Fax: 0733407077
 3

## Introduction

The MultiTrode level control relay is a solid-state electronic module in a hi-impact plastic case with a DIN rail attachment on the back, making a snap-on-snap-off installation. Any number of relays can be easily added to the DIN metal rail then wired together to form a complex pumping system that other wise may have to be controlled and operated by a programmed PLC.
The relay is normally matched with the Multitrode probe which works in conjunction with the relay and uses the conductivity of the liquid to complete an electrical circuit.

## 2 Electrical Overview

 shown, we fook at the bottom terminals (left to right):
-. Lo - (Chàrge mode). This is the point when the probe is dry
.t the relay will turn on.

- LO-(Discharge mode). This is the point when the probe in the tank is dry the relay will turn off.
- Hi - (Charge mode). This is the point when the probe in the tank is wet a relay will turn off
- Hi-(Discharge mode). $\mathrm{T}^{\text {This }}$ is the point when the probe in the tank is wet a relay will turn on.
- $C$ - is common earth. All earth bonding must be terminated here for correct operation.
- " $L$ " is "live" (240V AC)
- $\mathrm{N}^{-1 \mathrm{~s}^{4}}$ neutral" (240VAC)

If the tank is plastic, or if you are conducting tests in a plastic bucket, or the vessel has no earth point inside, you must install an earth rod within the tank, vessel or bucket and make sure that it is bonded back to $C$ on the relay unit.

## 3 DIP Switches

### 3.1 DIP Switches

(See Wiring Diagram forfull program functions:)

### 3.1.1 DIP 1 \& 2

DIP 1 and 2:control the Sensitivity, in other words the cleaner, the liquid the higher the sensitivity setting must be. Concentrated acids, minerals are by their own chemical composition highly conductive, so a low level of sensitivity is required, purified water is almost an insulator against electrical current flow so a higher sensitivity inside the relay is required.

### 3.1.2 DIP 3,4 \& 5

DIP switches 3, 4 and 5, control delay on activation. For example, in discharge mode with. DIP switches 3. 4 and 5 set to 10 seconds, when the Hi point becomes wet it will activate the motor and it will take 10 seconds of continual coverage of the probe sensor to make the relay close and start the pump., This, is invaluable when the probe is in a turbulent, part of a well where fluid is splashing around touching the sensors momentarily, and false activation cannot be tolerated.

### 3.1.3 DIP 6

DIP switch 6 controls the charge/discharge function: Set "ON" for charge, and "OFF" for discharge

### 3.2 Relay Contacts \& their Applications

### 3.2.1 Contacts 15, 16 \& 18

Contacts $15,-16$, and 18 are used for electronic or visual notification of a change in state at the pumpitself: Contacts 15; 16, and 18 are used for more advanced applications because they are a changeover relay, their state may be the same as contacts 25,28 or the opposite. Both sets of contactors are triggered simultaneously. An example is when in discharge mode, (see Figure 1).

You have a gravity flow coming in so the fluid reaches the lower sensor PB1, contacts 15 and 18 are open ( 15 being common to both contact 16 and 18) contacts 25 and 28 are also normally open but: contacts 1516 in this current situation are closed; whether PB1 is wet or dry is of no concern all will stay the same: The level now rises to PB2 and both reays change state, contacts 25 and 28 close to turnon-mat the pump, contacts 15 and 16 are open, with 15 and 18 closed.
In advanced applications this state change may be fed into a logic device to indicate the pump is running or the pump has stopped and perhaps light an LED or incandescent light source for visual confirmation that a change has occurred in the relay:

### 3.2.2 Contacts 25 \& 28

Contacts 25 and 28 are used to control pump states. Contacts 25 and 28 are mostly used for turning on motors via a starting relay or solenoid, so, these sets of contacts react to the rising of falling levels of the fluid inside the tank, they will operate to tum on a pump in discharge mode when the top sensor is wet and in charge mode tum on the pump when the bottom sensor is dry.

## 4 Practical Overview

### 4.1 Discharge Mode - DIP switch 6 set to "OFF"



Figure 1 - Discharge Mode
Figure 1 shows two probes, (PB1 connected to Lo and PB2 connected to Hi ). The pit is mostly underground and there is a gravity-fed inlet at the top left-hand side. The pit is empty with PB1 completely dry. Dipswitch 6 is set to "OFF."


The relay operation depends on the electrical conductivity of liquid in the pit, i.e. no liquid = no current flow. The level starts to rise and covers. PB1.

This is a discharge operation so we do not want the relay to close and start a pump until the wellis full so as the water rises it reaches PB2, the relay closes and the pump starts. The level now drops below PB2

### 4.2 Charge Mode - DIP switch 6 set to "On"



Figure 2 - Charge Mode
Note: ... "C" is connected to common bonded earth. The unit will not operate correctly if not earthed.
Let's look at the same relay but in a tank that is charging (DIP 6 is now on). See Figure 3, where liquid is being pumped into a tank, and discharging through-a gravity-feed; the tank-is-onsteel stands " $x$ " metres above the ground.


With the tank full; PB1 and PB2 will be wet, the relay is off, and the pump has stopped: Water is slowly fed out from the bottom, and now as PB2 (HI) becomes dry nothing happens; the water now drops to below PB1 (LO); and the pumps restarts to fill the tank.
The pump will continue to fill the tank until PB2 (HI), becomes wet again.

### 4.3 MTRA Relay with Alarm (Discharge Application's Only)



Figure 3 -MITRA: Operation

The MTRA relay works in the same way as the MTR relay except the MTRA has a separate alarm output, and does not have a charge mode. The planned application is to close a contact to illuminate a warning alarm light. . Various other applications have included introducing a third probe to latch another relay.
In Figure 2 we see three probes in a pit that is plastic, note the steel rod in the tank. (In a plastic vessel a steel rod must be used to create an earth return in the liquid so probes can function.) PB1, PB2, and PB3 are dry, and the relay power LED is on. When water enters the pit and wets PB1, nothing happens, water now reaches PB2 causing contacts 13 and 14 to close, the pump LED to light, and the water to drop.
If, for example, the pump has its inlet partially blocked, the level continues to rise and wets PB3. This closes a separate relay that can activate a red flashing light, an audible fog horn or send a 5 volt pulse into another device with the common cause to wam human beings that a spill is due to occur. If the pumps become unclogged and PB3 becomes dry the alarm opens again and breaks the circuit that stops the light from flashing or the foghorn from sounding.

## 5 Most Common Installation Problems

The relay requires a path between the probes to earth through the liquid. If you are testing in a plastic bucket, have installed the probe in a plastic tank or have no good earthing in the vessel you will need to install a separate earth and make sure all earth bonding comes back to the $C$ terminal. Most problems like these are traced back to a lack of or poor earthing, or open circuits in the probe wiring.
Now is the time to check the relay by using "the bridge testing line technique" remember you must simulate a fluid flow to correctly ascertain a good relay or a bad one. (All DIPswitch settings from 1 to 6 should be off.)

Cut two pieces of insulated flexible copper wire one black one red 250 mm long, strip both ends back 10 mm on both cables, and join one black end and one red end. Insert the joined ends into C on the relay box, observing all safe electrical practises. You should have one black wire and one red wire free.

Set your relay for discharge mode (DIP switch 6 is off) with no sensors connected to the unit, connect the red wire to Lo - nothing should happen (if it does return the relay for replacement or repair*). Now connect the black wire to the Hi terminal the relay activated LED should light instantly (if it does not, the relay should be returned for repair*).

## 6 Troubleshooting

| I have checked all the DIPswitches and settings but in discharge mode as soon as the bottom sensor gets wet the pump turns on then turns off almost straight away. | - This is the most common problem encountered with relay set up and commissioning, the probe in the bottom of the tank is wired into the Hi terminal instead of the Lo terminal. |
| :---: | :---: |
| The installation went fine but now and again the pump will not turn on even though 1 am sure the probe is wet. | - Check the sensitivity level set on the relay, some times the level is set for foul water but due to changes in the flow the water becomes grey or clear, try changing the selting from $20 \mathrm{~K} \Omega$ to $80 \mathrm{~K} \Omega$ and monitor the results carefully. |
| All wiring is complete and all DIPswitches have been checked but the pump will not turn on at all. | - If you have completed the test schedule for the relay and it passed then check the wiring to the sensors - for this is now where the problem lies or in the earthing arrangements. If possible check the resistance between the sensor cable and the steel sensor on the probe to prove a solid connection. |

* Please contact your distributor or agent before returning any product for repair or warranty claim.


# TECHNICAL DATA SHEET 

For

## SEWAGE PUMP STATION SP210

## Nudgee Beach

Equipment Type: ..... Radio
Location:
RTU Section
Model Numbers: DR900-06A02-D0
Manufacturer: ..... Trio
Supplier: Brisbane Water

## TC－900DR USER GUIDE

ロ円T円CロM
41 Aster Avenue Carrum Downs 3201 Australia Tel： 61397750505 Fax： 61397750606

## GENERAL

The Trio DataCom TC－900DR is a full duplex 900 MHz Radio featuring a fully integrated 4800／9600 bps data radio modem and antenna diplexer．Configuration of the unit is fully programmable，with parameters held in non volatile memory（NVRAM）．All configuration parameters are accessible using the TC－DRPROG installation package， consisting of a programming lead，manual and software which will run on a PC under Windows $95 / 98 / \mathrm{NT}$ ．It is essential that each unit is programmed to suit individual requirements prior to operation．For detailed information refer to the TC－900DR Handbook．

## DATA CONNECTION

The data connection is via a DB9 connector labeled＇Port A＇（shown below），which is wired as a DCE．

## User Serial＂Port A＂Pin Assignment．

EXTERNAL VIEW OF｀pORT A
NOTE：Pin 6 and pin 9 provide a dual function which depends on the mode that the TC－900DR is operating in．


## User Serial＂Port B＂Pin Assignment．

Port $B$ can be used as a secondary data steam （independent of Port A）once configured by the programmer．Port $B$ also has one connection that may be of use for installation．This connection（Pin 9）is Receive Signal Strength Indicator（RSSI）output．0－5V where 1.5 V typically indicates -1.10 dBm and every 0.5 V increase indicates an improvement of » 10 dBm ．
EXTERNAL VIEW OF＇PORT B＇

NOTE：Port B Pin 9 output has a high impedance of around 50K OHMS and loading will decrease accuracy of the RSSI measurement．

## POWER CONNECTIONS

The power required is 13.8 VDC nominal，at $600 \mathrm{~mA}(\mathrm{Tx})$ nominal．If the POWER LED indicator is not illuminated once power is applied，check the internal 1Amp fuse fitted within the unit．


The auxiliary connector is primarily for use with the optional audio handset．The connections to this auxiliary 6 pin RJ11 connector are as follows：

| PIN NUMBER | FUNCTION | External view |
| :---: | :---: | :---: |
| 1 | 8 VOLTS | of Socket |
| 2 | AUDIO OUT | Top |
| 3 | GROUND |  |
| 4 | MIC INPUT／SENSE |  |
| 5 | GROUND |  |
| 6 | MANUAL PTT |  |

The optional audio handset is recommended as an aid in checking installations for radio path viability．This audio handset will only function when fitted prior to applying power to the unit．
The modem upon power up will check the presence of the handset and will inhibit data being transmitted so that voice communications can be established．
Once the path tests have been conducted the audio handsets MUST be REMOVED and the unit powered up with the handset removed before data communication can commence．

## USER INDICATIONS

The TC－900DR provides 4 LED＇s that show status information to the user－POWER，RXSIG，SYNC，and TXMIT indications．
The POWER is indicated by a green LED and simply signifies that power has been applied to the unit．
The RXSIG LED（yellow）indicates the level of RSSI signal from the radio IF strip，compared to a threshold level set in the configuration data programmed by the user．If the signal is above the threshold，then the LED indicator is turned on．
In all operation modes except＂Programmer mode＂，the SYNC LED（yellow）indicates when the modem has detected a valid data stream．The SYNC LED is activated， when the modem detects a valid HDLC flag sequence，and remains active until an invalid sequence of seven or more consecutive＂ 1 ＂bits is detected．
The SYNC LED will not be turned on if the RSSI signal strength（as indicated by the RXSIG LED）is below the minimum threshold．This prevents false SYNC detection from noise．
The TXMIT LED（red）indicator is connected directly to the modem＇s PTT output transistor．Whenever the radio is transmitting，this TXMIT LED indicator will be on．

## SPECIAL MODES OF OPERATION

Part of the power-up/reset initialisation phase of the TC-9000R are tests to determine if the modem should enter one of 3 "special operation" modes. In these modes the TC-900DR won't operate in its standard run mode.

- Programmer mode
- Bit error rate test mode.
- Handset mode.

These modes are only entered if the required setup conditions are present at power up. An error mode of operation can also be entered into, if during normal operation, an error condition occurs.

## PROGRAMMER MODE

CABLE - Pins 2, 3, 4, 5 straight through with Pin 6 on the DB9 connector of Port $A$, connected to pin 5 . When the modem is powered up with this fitted, the controller senses this and attempts to enter "Programmer mode" and the "SYNC" LED will flash approx. once per second. (Note, the TC-DRPROG programming software and lead has the required connections). Failure to supply the correct password in time, will cause the modem to abandon the "Programmer mode" attempt, and go on with it's normal power-up procedure.

## BIT ERROR RATE TEST MODE

Pin 9 of the DB9 connector of Port $A$, is normally the Ring Indicate output line. However, if this pin is driven positive (connecting it to pin 6 [DSR] and pin 7 [RTS]), then the modem's data transmitter and receiver will enter the BER test mode. This will activate the RF transmitter, and generate a scrambled bit pattern which should be decoded at a receiver as a constant logic "1" level in the unscrambled data. Any errors in the decoded bitstream, will be " 0 ", and the receiver portion of the modem in this mode, will activate the SYNC LED every time it sees a "0" bit.
Note: As the TC-900DR is full duplex this test can operate in both directions simultaneously.
Every error bit detected, will activate the SYNC LED. For error rates of 1 in $10^{3}$ and above, the SYNC LED will be ON most of the time. A 1 in $10^{4}$ error rate will show the SYNC LED active for approximately $10 \%$ of the time. This function provides a crude indication of Bit Error Rate for installation purposes. Note: Error count messages
(ET:XXXX) for every 10,000 bits are presented to Port A for the user. If pin 9 ceases to be driven positive, then the BER Test mode is terminated, and the modem restarts it's initialisation phase.

## HANDSET MODE

The DFM4-9 modem tests for the presence of a handset plugged into the handset auxiliary port at power up. If a handset is plugged in, the modem will not generate a data stream. However, it will continue to indicate received RF signal strength. The handset has a PTT button, and this signal is connected across the modem's PTT output. Thus the handset PTT switch will activate the TXMIT LED. It is essential to remove the handset from the unit and reapply power to the unit in order to return to normal operation.

## ERROR INDICATION MODES

There are 3 error conditions that cause the RXSIG \& SYNC LEDs to be used for error indications and not their normal purpose. Two are fatal conditions, that cause the modem to restart after the duration of the error indication phase.

## TRANSMIT POWER LOW

While the modem activates the radio transmitter, it periodically checks the transmit power. If the power measurement is less than a threshold set in the non-volatile memory, then the RXSIG and SYNC LEDs are made to alternate, approximately 4 times per second. The TXMIT LED will also be on during this process. This indication condition will persist for the duration of the transmission. As soon as the transmission is discontinued, the error indication will cease, and the two LEDs revert to their normal function. Factory set to 100 milliWatts.

## NVRAM READ ERROR

The DFM4-9DR modem accesses the non-volatile memory as part of it's initialisation phase, to read programming configuration data. If the communication protocol with the device is violated, or the non-volatile memory CRC checksum is found to be incorrect, then the modem indicates this by flashing the RXSIG and SYNC LEDs twice alternately. That is, one LED operates ON and OFF twice, then the other. A total of five cycles of this occurs, then the modem restarts initialisation.

## SYNTHESISER LOCK DETECT ERROR

If at any time during normal operation, BER mode, or handset mode, the TBB206 frequency synthesiser indicates an out of lock condition, the modem enters an error indication mode for a short time before restarting.

One LED is turned ON ( $)$ ), the LEDs are swapped, then both turned OFF ( $\bullet$ ). Then the latter LED ON again, swap LEDS, and then OFF. This will give the appearance of a sweeping motion between the LEDs. The following table shows all error condition displays

| TxPWR Err |  | NVRAM Err |  | SYNTH Err |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| RXSIG | SYNC | RXSIG | SYNC | RXSIG | SYNC |
| 0 | $\bullet$ | 0 | $\bullet$ | 0 | $\bullet$ |
| $\bullet$ | 0 | $\bullet$ | $\bullet$ | $\bullet$ | 0 |
| 0 | $\bullet$ | 0 | $\bullet$ | $\bullet$ | $\bullet$ |
| $\bullet$ | 0 | $\bullet$ | $\bullet$ | $\bullet$ | 0 |
| 0 | $\bullet$ | $\bullet$ | 0 | 0 | 0 |
| 0 | 0 | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ |
| 0 | $\bullet$ | $\bullet$ | 0 |  | repeat |
| 0 | 0 | $\bullet$ | $\bullet$ |  |  |

## MOUNTING AND ANTENNA CONNECTION

The TC-900DR should be mounted in a cool, dry, vibration free environment, whilst providing easy access to screws and connections. There are 4 mounting holes on the unit. The antenna should be an external yagi antenna but can be a ground independent dipole mounted via a feeder to the antenna connector (SMA type) for short range applications. However the whole radio modem should be clear of the associated data equipment to prevent mutual interference.

## ASSEMBLY OF POWER LEAD

A small plastic bag containing a molex connector (M5557-2R) and two pins (M5556-TL) is provided in the packing box.
The pins are designed to take 18-24 (AWG) wire size with insulation range 1.3-3.10mm.
Please take care when crimping the pins.
04/01

## TC-900DR

## 900 MHz <br> Full Duplex Data Transceiver

## User Manual

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## IMPORTANT NOTICE

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## Modifications

| Issue 1 | February 1993 (Preliminary) |
| :---: | :---: |
| Issue 2 | May 1993 Major Changes to Section 3 |
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|  | Removed Filter Alignment Setup Diagram |
|  | Inserted RSSI Level cf Received Signal (typical) |
| Issue 4 | February 1994 |
|  | Minor Changes to all sections |
|  | Additions to Section 3 for Firmware V2.2 and Synchronous Operation |
| Issue 5 | March 1994 |
|  | Addition of section 5.2.6.1 and 5.2.6.4 |
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Replaced Section 5

Issue 12 July 2000
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Change of Company Name

## SECTION 1

## INTRODUCTION

## 1 INTRODUCTION

### 1.1 GENERAL

The TC-900DR is a Full Duplex 900 MHz Radio, featuring a fully integrated 4800 or 9600 bps data modem.

The entire unit is housed in a robust metal enclosure that provides a compact and transportable means for the transmission of data over radio.

The product has been fully designed and developed in Australia, by an Australian owned and managed company.

The TC-900DR meets the ACA SP4/89 specification which covers radio data transmissions over point-to-point and point-to-multipoint systems.

It is ideally suited for applications such as :
, Transaction Processing.
, Public Utility Telemetry Systems.
, Alarm Monitoring.
" Supervisory Control and Data Acquisition.
, Energy Distribution.
" Inventory Control
, Common Carrier Data Services.
, Temporary Installations
The modem provides byte oriented packet data communications over narrow band FM systems, using digital filtered binary FSK modulation.

The TC-900DR can be supplied for use with $12.5 \mathrm{kHz}, 15 \mathrm{kHz}, 25 \mathrm{kHz}$ or 30 kHz channel spacings. Its operational parameters can be programmed with the TC-D Series installation programmer. This is a separate software package that runs on an IBM compatible PC under Windows 95/98/NT.

### 1.2 FACTORY QUALITY ASSURANCE

The TC-900DR has been designed and manufactured with particular emphasis placed on the following points :
\{ State of the art design techniques.
\{ Simple assembly/disassembly.
\{ Minimal alignment requirements.
\{ Manufactured using quality components.
All units have been manufactured using automated assembly procedures. This assures attention to detail and a high level of quality control.

All components used are of high quality, and conform to Trio DataCom's required specifications. The component suppliers provide batch, date and manufacturing criteria that are required to meet quality control standards.

Each unit is individually tested with an inbuilt self diagnostic program. It is then passed through a set of automatic test procedures with minimal human intervention. This ensures a consistently manufactured and performing product. Many of the alignments are factory set and should not require re-alignment in the field.

Trio DataCom's quality control does not finish here. Once each unit has passed its individual tests, it is placed in a cyclic heat/cooling chamber. This chamber is automatically cycled from $-10^{\circ} \mathrm{C}$ to $+65^{\circ} \mathrm{C}$, twice, over a twenty hour period. During this time, the modem controller - using external precision calibrated test equipment - monitors and stores frequency stability versus temperature data. The TC-900DR uses this information to achieve its temperature compensated, frequency stability level of 1 ppm .

Power output is measured during the temperature cycling. This is achieved by having the unit connected to a PC and various test equipment via a GPIB. Units that fail any of these tests are reported by the test program and corrective action taken before going through the complete cycle once again. Each unit shipped from the factory comes with a factory alignment printout which details:

```
Configuration.
    Transmit frequency.
" Receive frequency.
" Receiver sensitivity.
" Transmitter power output.
, Transmitter modulation.
```

In most cases, the radio transmitter as shipped from the factory will require no re-alignment.

It is this care and quality control that ensures that the purchaser of a TC-900DR radio modem, obtains a consistently manufactured and performance specified product, which has been "burned in" to minimise any operational failures.

### 1.3 FEATURES

Advanced microwave and digital techniques were employed during the design phase of the TC-900DR, ensuring an innovative and state of the art product.

Features include :
\{ Fully integrated full duplex radio and modem
\{ Built in antenna diplexer
\{ Power output +30 dBm (1 Watt nom) at antenna connector
\{ Radio meets ACA SP4/89 requirements $2 / 90$
\{ In-built transparent remote diagnotics capability.
\{ Custom single chip modem - digital signal processing
\{ 4800 \& 9600 bps transfer rates, full duplex
\{ Selectable 110..19k2 asynchronous RS-232 host interface
\{ Unique collision avoidance facilities
\{ Integrated supervisory signalling channei
\{ Software selectable configuration parameters
\{ Configurable bit error rate testing
\{ Excessive temperature power fold-back
\{ Auxiliary port for use with an optional supervisory audio handset

### 1.4 SPECIFICATIONS

### 1.4.1 RADIO SECTION

Rx frequency range
Tx frequency range
Channel spacing

Frequency stability : $1 \mathrm{ppm}\left(-10^{\circ} \mathrm{C}\right.$ to $65^{\circ} \mathrm{C}$ amb), $\left[\mathrm{opt}-30^{\circ} \mathrm{C}\right.$ to $70^{\circ} \mathrm{C}$, aging $<=1 \mathrm{ppm} /$ Annum

Power output
at Antenna connector
Duty cycle
Output impedance
Timeout timer
Tx key up time
Rx sensitivity
Rx intermodulatio
Rx spurious responses
Tx spurious emissions :
Full duplex with single antenna.

Note 1. The reciprocal frequency option for point-to-point operation or point to multi-point base repeaters is available as follows :

- Rx frequency range 847 MHz to 857 MHz .
- Tx frequency range 923 MHz to 933 MHz .

Note 2. The transmitter is normally supplied, with its frequency offset from the receiver by 76 MHz .

### 1.4.2 MODEM SECTION

| User Ports | $:$ | DB-9 connector, EIA RS232, DCE, serial <br> asynchronous, $300 . .19 \mathrm{k} 2$ baud, $7 / 8 \mathrm{bit}$, <br> no/odd/even parity. |
| :--- | :--- | :--- |
| Data Rate | $:$ | $4800 / 9600$ bps Full Duplex. |
| BER | $:$ | Less than 10E-6 @ -105dbm measured at antenna port |
| Data Format | $:$ | Narrow band digital filtered binary FSK Modulation, <br> using Trio DataCom's DFM4-9 digital modem chipset, <br> including Trio's unique supervisory signalling channel <br> C/DSMA collision avoidance scheme. |
| Synchronisation Delay: | 20 milliseconds. |  |

### 1.4.3 RADIO AND MODEM SECTIONS COMBINED

Occupied bandwidth : Meets ACA SP4/89 guidelines for point-to-point and point-to-multipoint assignments.

Mean deviation : $\pm 1.5 \mathrm{kHz}$ (4800bps), $\pm 2.75 \mathrm{kHz}$ (9600bps)

Power requirements
14 Volts $A C 10 \mathrm{VA}$ or 13.8 Volts $D C$ ( 11 to 16 V Max).
Transmit current $<=$ to 600 mA .

Receive current Size 175 mA . $241 \mathrm{~mm} \times 161 \mathrm{~mm} \times 65 \mathrm{~mm}$.

Weight
1.3 Kg.

### 1.4.4 CONNECTORS

| User RS-232 Connection | DB9 female wired as DCE (modem). <br> (AMP Part \# 747844-5) |
| :---: | :---: |
| Mating connectors | DB9 male solder type. <br> (AMP Part \# 747983-3) <br> Backshell to suit. <br> (AMP Part \# 205729-1). <br> Optional supplied to order. |
| Antenna Connection | Gold plated SMA female bulkhead. (E.F.JOHNSON Part \# 142-0701-501) |
| Mating connector | SMA male to RG223 crimp type. (E.F.JOHNSON Part \# 142-0407-006) Optional supplied to order |
| AC/DC Power Connector | 2 pin locking (9A rating). <br> (PCB SOCKET MOLEX Part \# M5569-2A2) |
| Mating connector | (RECEPTACLE MOLEX Par\# M5557-2R) (RECEPT PINS MOLEX Part \# M5556-TL). Supplied with standard unit. |
| Supervisory Audio |  |
| Handset Connector | 6 pin modular jack. <br> (AMP Part \# 520250-3) |
| Mating connector | 6 pin modular jack plug. <br> (AMP Part \# 5-641337-3). <br> Supplied with optional audio handset. |

### 1.5 OPTIONAL ACCESSORIES

Trio stock a large range of ancillary devices including coax cables, RF connectors, antennas, lightning protection, power supplies, etc.

Please contact Sales for futher information.

## SECTION 2

## HARDWARE TECHNICAL DESCRIPTION

## 2 HARDWARE TECHNICAL DESCRIPTION

### 2.1 GENERAL

The TC-900DR is a 900 MHz full duplex radio complete with radio modem and antenna diplexer. In this and subsequent descriptions to follow, references have been made to block diagrams, circuit diagrams and component loading diagrams.

These can be found in appendix $A$, at the rear of this manual.
The unit can be divided into five major sub-blocks :
Radio section.
Antenna diplexer section.
Audio handset.
Modem section.
Unit housing assembly.

### 2.2 RADIO SECTION

The radio section is built on a single PCB with approximate dimensions of $193 \mathrm{~mm} \times$ $152 \mathrm{~mm} \times 1.6 \mathrm{~mm}$.

This section consists of the following main blocks :
Receiver.
Transmitter.
Frequency control.
Interfaces.
Each of these blocks can be further broken down as follows :
Receiver.
Pre-amplifier.
Mixer.
45 MHz I.F. filter.
FM I.F. \& Demodulator
Audio processing.

- Data.
- Voice.

RSSI processing.
Transmitter.
Audio processing.

- Data.
- Voice.

Modulator.
Multiplier.
Mixer.
Power amplifier.
Control.

- PTT.
- Power.

Frequency control
Synthesiser.
Local oscillator.
AFC
Interfaces
Modem section.
Antenna diplexer.
Audio handset.

### 2.2.1 RECEIVER

The general form of the receiver circuitry is shown in diagrams "DR9 Macro Block Diagram" (drawing number TC01-05-19 sheet 3/3), and "900 MHz Radio - Block Diagram" (drawing number TC01-05-19 sheet 2/3).

### 2.2.1.1 PRE-AMPLIFIER

The receiver pre-amplifier obtains signal direct from the antenna diplexer port connector X2. It consists of two stages. The first stage is optimised to give a low noise figure, while the second is optimised to produce gain.

The central devices used are MRF5711 high frequency transistors. They provide the basis for a wide band amplifier that can receive from the lowest band frequency range of 852 to 854 MHz to the higher band frequency range of 928 to 930 MHz .

The RF selectivity is provided by the diplexer filter.
Strip line impedance matching networks are employed to ensure optimum performance of the amplifier.

The overall gain of the pre-amplifier is set to 20 dB .

### 2.2.1.2 MIXER

The receiver mixer consists of a 180 "rat race hybrid ring" followed by a passive Schottky mixer diode.

The mixer injection frequency is set 45 MHz from the required receive frequency, (high side injection for 930 MHz receive and low side for 850 MHz receive). This results in an I.F. frequency output of 45 MHz .

The level of the injection is set to 6 dBm by the amplifier stage Q 3 .

### 2.2.1.3 FIRST I.F. STRIP FILTER

The required receiver mixer product is filtered by the first I.F. filter. The filter is a bandpass crystal controlled device, centred on 45 MHz , and provides image rejection for the second IF Mixer.

The filter is aligned for optimum response by adjustment of inductors L4,L3 and L5.

### 2.2.1.4 FM IF and DEMODULATOR

The heart of the demodulator section is an NE615D high performance low power mixer FM IF system IC.

This device incorporates a mixer/oscillator, two limiting intermediate frequency amplifiers, a quadrature detector, muting circuitry, logarithmic RSSI, and a voltage regulator.

The input to the device is from the output of the 45 MHz first IF strip filter. This is applied at $R F_{\text {in }}$ and $R F_{\text {bypass }}$ pins (U2-p1,p2).

This signal is applied internally to a Gilbert cell mixer, which is set to convert the signal down to 455 kHz .

The mixer injection is supplied by an internal oscillator, which is driven by an external oscillating signal applied at the XTAL OSC pins (U2-p3,p4).

The basic injection frequency is governed by the 44.545 MHz crystal XTAL1. This produces a mixer output product of 455 kHz .

The output of the mixer is available at MIXER OUT (U1-p20). This is applied to a 455 kHz centred bandpass filter. This acts as the "front end" filter, CF1.

The bandwidth and rolloff characteristics of this filter are set, depending on the required baud rate of the data being used on the modem, and the required channel spacing. Refer to Circuit Diagram for filter types.
The filtered output is then applied to the input of the internal IF amplifier, IF AMPIN (U1-p18). The bandwidth of the amplifier is about 40 MHz , with a gain of about 39 $\mathrm{dB}(\mathrm{uv})$. C 10 and C11 provide IF amplifier decoupling.

The output is available at IF AMP OUT (U1-p16). This is applied to a 455 kHz centered bandpass filter. This acts as the "rear end" filter, CF2.

Again the filter selection depends on the required bandwidth. Refer to Circuit Diagram for filter types.

The filtered output is then applied to the input of the internal IF limiter, LIMITER IN (U1-p14). The bandwidth of the limiter is about 28 MHz , with a gain of about 62 dB (uv). C13 and C14 provide IF limiter decoupling.

The signal from the second limiting amplifier is passed to an internal Gilbert cell quadrature detector, as well as to LIMITER OUT (U1-p11).

One of the Gilbert cell ports is driven directly by the IF, the other by a tuned quadrature network, which is driven by the IF signal from LIMITER OUT. The tuned network is based around a ceramic resonator CF3. The Q of the network is varied depending on the required baud rate used by the modem. For 9600 baud the link LK3 is inserted, giving a higher damping factor than that required for 4800 baud, where the link is removed.

This gives the two input signals applied to the Gilbert cell a 90 degree phase relationship, the output of which is the demodulated audio/data signal.

The output signal is available at UNMUTED AUDIO OUT (U1-p9). A gated output is also available at MUTED AUDIO OUT (U1-p8).

### 2.2.1.5 AUDIO PROCESSING

### 2.2.1.5.1 DATA

The demodulated data signal output has been assigned to the UNMUTED AUDIO OUT pin (U1-p9). This ensures no interruption to the flow of data.

The signal is filtered by the C22, R20, R29 and C23 filter network. This is to remove any high frequency components produced at the output of the quadrature detector.

It is then amplified and DC level shifted by op-amp U1:C. The amount of DC bias applied to the signal can be varied by the potentiometer VR2. For correct processing by the modem, this level is set to 2 V . The AC level of the signal is set to about $1 \mathrm{~V}_{\mathrm{p}-\mathrm{p}}$

### 2.2.1.5.2 AUDIO

The demodulated audio signal output has been assigned to the MUTED AUDIO OUT pin (U1-p8). This allows switching control of the audio passed to the handset earpiece.

The signal is filtered by R23 and C17. This is to remove any high frequency components produced at the output of the quadrature detector.

It is then buffered, amplified and level shifted by op-amp U1:D, and presented to the handset via coupling capacitor C20 and connector X3-p2.

The mute control signal is applied to the NE615 (FM IF system IC) MUTE IN pin (U2-p5). When active, the audio output signal from the IC is attenuated by greater than 60 dB .

### 2.2.1.6 RSSI

The RSSI output is presented by the NE615 at RSSI OUT (U2-p7). This signal is logarithmic with an output range greater than 90 dB . It is used for audio mute processing, and by the modem section as a data qualifier signal.

The signal is first passed through a unity gain buffer, op-amp $\cup 1: B$, before it is split.
The RSSI level is compared with the setting of "audio mute adj" potentiometer VR1, by op-amp U1:A. The result is passed to the MUTE IN pin of the NE615.

This allows a suitable mute cutoff point to be set for the received audio sent to the handset earpiece.

The RSSI signal is also passed to the modem section for processing via R19 and connector X1-p21.

### 2.2.2 TRANSMITTER

The general form of the transmit circuitry is shown in diagrams "DR9 Macro Block Diagram" (drawing number TC01-05-19 sheet $3 / 3$ ), and " 900 MHz Radio - Block Diagram" (drawing number TC01-05-19 sheet 2/3).

### 2.2.2.1 AUDIO PROCESSING

### 2.2.2.1.1 DATA

The transmit data signal enters the radio section via connector $J * 3-p 13$, from the modem section. It is biased via R68 and R75 to a DC level of about 0.86 V . The signal is then passed through a level setting potentiometer VR2, used to set the level of transmit deviation.

It is then presented to the input of the modulator circuit.

### 2.2.2.1.2 VOICE

The transmit voice signal enters the radio section via connector $X 3-\mathrm{p} 4$, from the microphone in the handset. The pre-amp in the microphone circuit is given some bias via R76.

The signal is first passed through a clipping circuit. This consists of back to back clamping diode pair D2, AC-coupled via C154. This ensures that a maximum transmit deviation level is imposed.

The modulator circuitry is based around a low power FM transmitter system IC,MC2833. Included in this device is a microphone amplifier and clipper. The audio is passed to the amplifier via R76 at the MIC AMP INPUT pin (U7-p5).

Feedback for gain is supplied by R76, and band limiting by C50. The amplifier output is presented at MIC AMP OUTPUT (U7-p4).

Further low pass filtering is provided by the network of R71, C49, R59.. and C42... C43 provides a rising response below 100 Hz . This filtering is needed to shape the base band signal, so as the transmit frequency spectrum stays within channel boundaries.

The audio is coupled into the modulator circuit at the MODULATOR INPUT pin of the MC2833 (U7-p3).

### 2.2.2.2 MODULATOR

The heart of the modulator section is an MC2833 low power FM transmitter system IC. This device is a one chip FM transmitter subsystem designed for FM communication equipment. It includes a microphone amplifier, a variable reactance modulator, a voltage controlled oscillator, and two auxiliary transistors.

Data is fed directly to the input of the reactance modulator at the MODULATOR INPUT pin (U7-p3). The audio channel is fed via an inbuilt clipper amplifier in the MC2833. The output of this variable reactance circuit is used to modulate the FM carrier.

The carrier frequency of the modulator is provided by an internal oscillator, which is driven by an external oscillating signal applied at the RF OSC pins (U7-p15,p16).

This oscillating signal is governed by the 20.166 MHz crystal XTAL3. The actual applied frequency is set by the modulating signal, which slightly varies ("pulls") the crystal frequency. This is achieved by connection of the crystals circuit to the output of the variable reactance circuit VARIABLE REACTANCE OUTPUT (U7-p1). This output is coupled to the crystal via a frequency trimming coil L6.

The output FM signal is presented at the RF OUTPUT pin (U7-p14).

### 2.2.2.3 MULTIPLIER

The output of the modulator is passed to a frequency tripler stage employing auxiliary transistor TR2. This places the carrier frequency at 60.5 MHz .

It then passes to a frequency doubler stage employing auxiliary transistor TR1, where the carrier is moved up to 121 MHz .

The signal is amplified through these stages to a level of about -4 dBm at 121 MHz .

### 2.2.2.4 MIXER

The transmit FM signal at 121 MHz when mixed with the VCO frequency by U 8 produces a transmitter signal 76 MHz from the receiver frequency.

The mixer employed is an MCL SBL-1X monolithic doubly balanced mixer (U8).
The transmit VCO signal is amplified to a level of about +6 dBm by Q2, and applied to the "L" input of the mixer. The 121 MHz signal is applied to the " 1 " input of the mixer.

To select the correct mixing product for the transmitter, a tunable filter using C78 and a coupled stripline circuit is used.

The output signal is then buffered by two MRF5711 transistors Q4 and Q5, to provide about +4 dBm of signal level, which is applied to the final amplifier section.

### 2.2.2.5 POWER AMPLIFIER

The power amplifier provides an overall gain of about 30 dB . This is achieved by three stages of amplification.

The first stage uses an MRF5711 transistor (Q8). This device is primarily designed for high gain, low-noise, small signal amplifiers, and is ideal for a transmitter pre amplifier. This stage provides about 13 dB of gain. The power control circuit acts on this stage to provide constant power at the PA. output connector.

The second stage uses an MRF8372 transistor (Q9). This device is primarily designed for wideband, large signal predriver stages, in the 800 MHz range. This provides a further 10 dB of gain.

The final stage uses two MRF8372 transistors (Q10, Q11) in a parallel configuration to provide the final output power. Each of these stages provides about 10 dB of gain. The output impedance is matched to 50 ohms via the use of balanced impedance strip lines.

The transmitted signal is presented at connector X 4 , at a level of about +32 dBm , where it is passed to the diplexer section.

### 2.2.2.6 CONTROL

### 2.2.2.6.1 PTT

PTT must be activated for the TC-900DR to transmit an RF signal. There are two sources of PTT, the audio handset, and the modem section.

PTT from the audio handset is referred to as "manual PTT". It enters the radio section via connector X3-p6. It is passed to the PTT control switch transistor Q12. PTT is active LOW, and turns on Q12 when applied.

PTT from the modem section enters the radio section via connector X1-p12, "/PTT". It is connected to the PTT control switch transistor Q12.

When PTT is not activated the transmitter is totally disabled. All stages of the transmit chain are turned off. This is to ensure that power consumption is kept to a minimum.

The PTT signal connects to the start of the transmit chain at the multiplier stage.
The internal transistors of the MC2833 IC, TR1 and TR2 have their bases effective grounded, turning off the devices. Similarly the mixer output buffer and amplifier transistors Q4 and Q5 are turned off as are the final amplifier stages employing Q8, Q9, Q11 and Q10.

When the PTT is activated, bias is applied to all these stages and transmission is possible.
Note : Tx enable must also be active to allow transmission.

### 2.2.2.6.2 TRANSMIT ENABLE

Transmit enable is a further control placed on the transmitter circuits. No transmission is possible unless the transmit enable signal is active. The signal enters the radio section via connector X1-p11, "TTX EN", from the modem section.

This signal basically enables the PTT switching transistor Q12, thus providing VCC for the 20.166 MHz oscillator section of the MC2833 modulator IC, and bias to the handset microphone.

### 2.2.2.6.3 POWER

The RF power output of the TC-900DR can be set to two levels. Low power level is 200 mW , and high power is 1 W .

This level is controlled by two dc levels. One signal is a control level from the modem section, the other from an RF detector located at the output of the transmitter itself. These two signals are used in conjunction to hold the output power constant.

The signal from the modem section enters the radio section via connector X1-p10, "TXPWR". The signal is fed to an op-amp comparison circuit U9:A, via level setting potentiometer VR4.

The level is compared to that actually detected at the output of the transmitter, by the circuit based around diode D3. The comparator output is then used to bias the first stage of the P.A. section (Q8) of the transmitter, hence varying the transistor gain performance and ultimately the output RF power. This basic feedback network is required to keep the power at a constant level, regardless of any external conditions.

The detected output power level is also fed back to the modem section for monitoring and analysis via connector X1-p9, "TXPWR SENSE".

### 2.2.2.6.4 TEMPERATURE SENSE

A temperature sensing device is included in the radio section. The device used is an LM335 precision temperature sensor, U6. It is operated as a two terminal zener diode, with a breakdown voltage directly proportional to absolute temperature, with an output of +10 mV per degree kelvin.

The temperature data output is passed to the modem section for analysis and processing via connector X 1 -p14, "TEMP SENSE".

During the "Burn In" cycle, that the TC-900DR is passed through during production, the unit calibrates the output of the sensor to the test temperature. In particular it stores the hottest temperature reached by the test cycle (about 65C).

If the unit reaches this maximum temperature setting while operating in the field, the modem section of the TC-900DR will automatically signal the power control circuit to place the transmitter into low power mode $(200 \mathrm{~mW})$.

This low level of output power is retained until the temperature sensor signals the modem section, that the temperature has fallen back below the maximum temperature. When this occurs the transmitter is placed back to its previous power setting. A hysteresis is built into the microprocessor control circuitry to stop power jitter.

This scheme is referred to as "High Temperature Fold Back". It is used to protect the transmitter final power transistors from any damage that may be encountered under extreme temperature conditions.

### 2.2.3 FREQUENCY CONTROL

### 2.2.3.1 SYNTHESISER

The synthesiser section provides a local oscillator for use by the receiver and transmitter sections.

The synthesiser circuitry is based around a TBB206 PLL frequency synthesiser IC.
This device is a complex PLL circuit in CMOS technology for processor controlled frequency synthesis. The processor resides in the modem section, and three basic control lines are used to interface to the device. The enable "EN", data "DA" and clock "CL" control signals are passed to the TBB206 via connector X1-p16,p17,p18 respectively.

The reference frequency for the synthesiser is applied to the "RI" pin of the TBB206 (U3-p2). This reference is provided by a 12.000 MHz voltage adjustable temperature compensated crystal oscillator (VTCXO), XTAL2. This input has a sensitive preamplifier for a 16-bit (R)eference divider. C33 provides AC coupling for the input.

The VCO frequency is applied to the "FI" input pin of the TBB206 (U3-p8). This input has a highly sensitive preamplifier for a 12-bit N divider and a 7-bit A divider. C29 provides AC coupling for the input.

The actual signal applied to the "FI" input is from the output of a TBB202 dual modulus divider IC (U4-p4). This is to transform the actual VCO frequency of between 786 MHz and 996 MHz , down to a frequency acceptable for use by the "FI" input.

The divider ratio selected by the TBB202 is determined by the state of the "MOD" input pin (U4-p6). If the signal is HIGH, then a ratio of $1: 128$ is used. If the signal is LOW, a ratio of $1: 129$ is used. The state of this signal is controlled by the TBB206 synthesiser "MOD" output pin (U3-p7). The TBB206 drives this output LOW at the beginning of a cycle. When the A divider has reached its set value, the "MOD" output is set to HIGH. When the $N$ divider reaches its set value, the output is set LOW again and the cycle is repeated.

The input to the TBB202 divider is from the VCO output via a strip line impedance matching network. The signal is applied to the "I1" pin (U44-p1).

The TBB202 can be placed into standby mode, when not in use. This is achieved by connection of the "STB" pin (U4-p7), to the multi function output port of the TBB206 synthesiser (U3-p6). This port is driven by the DFM4-9 modem IC located in the modem section.

The phase detector signal is provided on the "PD" pin of the TBB206 (U3-p12). This signal has especially short anti backlash pulses to avoid any "dead zones", and to neutralise any small phase deviations. This signal is passed to the loop filter of the VCO circuit.

A lock detect indication is given by the TBB206 synthesiser at the "LD" output pin (U3-p14). This signal is filtered and shaped by the network using R47 and C36, and presented to the modem section for monitoring and processing, via connector X1-p19.

### 2.2.3.2 VCO

The VCO used is an MQC309 series VCO. The exact device used depends on the required frequencies that the unit has to work with.
Two types are used :
A. MQC309 798 - Frequency range of 784 MHz to 816 MHz

Gives unit frequency ranges of :

- Transmit : 905 MHz to 937 MHz
- Receive: 829 MHz to 861 MHz
B. MQC309 978 - Frequency range of 962 MHz to 994 MHz

Gives unit frequency ranges of :

- Transmit : 841 MHz to 873 MHz
- Receive : 917 MHz to 949 MHz

The 798 type employs low side injection to the mixers, whereas the 978 type employs high side injection.

The loop filter consists of R44, C40, C41 and R43.
The output of the VCO is passed to the receiver mixer via RXMIX, and to the transmitter mixer via TXMIX signal lines. Each of these is impedance matched by strip line circuits for optimum performance.

The layout and selection of all these components has been done in such a way so as to minimise VCO noise being impressed onto either the transmitted or received RF signals.

### 2.2.3.3 VCO TEMPERATURE COMPENSATION

Frequency temperature compensation is provided for by an input to the reference oscillator circuit.

During the "Burn $\operatorname{In}$ " cycle, that the TC-900DR is passed through during production, the unit calibrates the output of the temperature sensor to the test temperature and to any frequency variations that occur, and stores the results.
When the unit is operating in the field, the temperature of the unit is constantly being analysed. Should a frequency offset be required based on the calibration measurements, the modem section signals to the 12.000 MHz reference oscillator to vary its frequency slightly. This signal is passed to the radio section via connector X1-p15, "TEMP COMP". The voltage on this line "pulls" the reference oscillator XTAL2 onto a new frequency, which corresponds to the correct offset required.

Note : Because the temperature compensation for the installed VTCXO is held in the NVRAM of the modem it is imperative that modems and radio boards are maintained as matched pairs. Should either the VCO or NVRAM require replacement it is highly recommended that the unit be retumed to the manufacturer for re-calibration.

### 2.2.3.4 RECEIVER AFC

Automatic frequency control is provided for the received signal. The control signal is applied to the radio section from the modem section via connector X1-p22, "AFC CTL".

The basic injection frequency to the front end mixer of the NE615 FM demodulator IC (U2), is governed by the 44.545 MHz crystal XTAL1. The actual applied frequency can be set by the level of the AFC signal, which slightly varies ("pulls") the XTAL1 crystal frequency via the varactor diode DV1.

The modem section monitors the average DC level of the received signal (DATA signal X1-p13), which gives an indication of received frequency drift.

From this the modem section calculates the required compensation necessary and applies it to the "AFC CTL" signal line.

A reference signal is passed back to the modem section from the radio section via connector X1-p23, "AFC REF". This is processed by the modem section, and used to help determine the level of AFC signal level.

### 2.2.4 INTERFACES

### 2.2.4.1 MODEM SECTION

The radio section interfaces to the modem section via connector X 1 . Attached permanently to this connector is a 90 mm length of 26 way ribbon cable, fitted with a female 26 way connector at the other end. This attaches to connector JX3 on the modem section PCB.

Refer to interface diagram "RADIO MODEM INTERFACE", drawing number TC01-05-18 sheet $1 / 3$.

CONNECTOR $\times 1 / J \times 3$ SIGNAL DESCRIPTION
PIN NUMBERS

| 1 | 13V8 POWER SUPPLY RAIL |  |
| :--- | :--- | :--- |
| 2 | $13 V 8$ POWER SUPPLY RAIL |  |
| 3 | 13V8 POWER SUPPLY RAIL |  |
| 4 | GROUND |  |
| 5 | GROUND |  |
| 6 | GROUND |  |
| 7 | $8 V$ POWER SUPPLY |  |
| 8 | 8V POWER SUPPLY |  |
| 9 | TXPWR SENSE | (o/p- TRANSMIT POWER SENSE) |
| 10 | TXPWR | (i/p-TRANSMIT POWER LEVEL) |
| 11 | TXX EN | (i/p-TRANSMIT ENABLE) |
| 12 | IPTT | (i/p-PRESS TO TALK) |
| 13 | DATA | (i/p-TRANSMIT DATA) |
| 14 | TEMP SENSE | (o/p-TEMPERATURE SENSOR) |
| 15 | TEMPCOMP | (i/p-TEMPERATURE COMPENSATION) |
| 16 | EN | (i/p-ENABLE FOR SYNTH) |
| 17 | DA | (i/p-DATA FOR SYNTH) |
| 18 | CK | (i/p-CLOCK FOR SYNTH) |
| 19 | LD | (o/p-LOCK DETECT FROM SYNTH) |
| 20 | DATA OUT | (o/p-RECEIVED DATA) |
| 21 | RSSI | (o/p-RSSI SIGNAL) |
| 22 | AFC CTL | (i/p-AFC CONTROL) |
| 23 |  | (UNUSED) |
| 24 | SUPPLY/MIC | (UNUSED) |
| 25 | TEST1 | (UNUSED) |
| 26 | TEST2 | (UNUSED) |

### 2.2.4.2 ANTENNA DIPLEXER

The interface between the radio section and the antenna diplexer section is via coaxial connectors $X 4$ and $X 2$, and low loss coaxial cables.

| CONNECTOR | SIGNAL DESCRIPTION |
| :--- | :--- |
| $X 4$ | TRANSMITTER OUTPUT |
| $x 2$ | RECEIVER INPUT |

### 2.2.4.3 AUDIO HANDSET

The interface between the radio section and the audio handset is via the modular- 6 pin connector X3.

| CONNECTOR X3 <br> PIN NUMBERS | SIGNAL DESCRIPTION |
| :---: | :--- |
| 1 | 8V POWER SUPPLY |
| 2 | AUDIO OUT (o/p - AUDIO TO EARPIECE) |
| 3 | GROUND |
| 4 | MIC (i/p - MICROPHONE AUDIO) |
| 5 | GROUND |
| 6 | MANUAL PTT (i/p-HANDSET PTT) |

### 2.3 ANTENNA DIPLEXER SECTION

### 2.3.1 GENERAL

The antenna diplexer section of the TC-900DR is a separate plug in module, that "piggy backs" the radio section PCB.

The diplexer performs two major tasks. Firstly it couples both the transmit and receive RF paths to the antenna while providing high isolation between them, and secondly it provides image and spurious rejection for each of these paths, with high $Q$ bandpass filters.

The isolation between the transmit side and the receive side is greater than 50 dB .
The diplexer consists of two teflon PCB's bonded together using a critical temperature and pressure process. The top and bottom outer layers are connected via brass eyelets, that are pressed through the PCB. This eliminates the need for through hole plating of Teflon, which requires the use of dangerous chemicals.

The design is essentially two continuous ground planes, filled in between, with laminate dielectric, and stripline filter tracks which are centrally located between these ground planes.

The etching of the filter tracks is closely monitored and controlled to ensure an accuracy of better than $0.001^{\prime \prime}$ in track width and spacing.

The diplexer has been factory tested to ensure bandpass and performance characteristics are met. The diplexer has approximately 3 dB of loss at 930 MHz and 2 dB of loss at 850 MHz .

This diplexer requires no alignment in the field.

### 2.3.2 INTERFACES

The antenna diplexer connects to the radio section via low loss coaxial cables and connectors, and to the units antenna via a SMA connector.

Two versions of the diplexer are available, depending on the transmit and receive frequencies used. The difference between the two is the loading of the SMA connector.

TYPE-A CONNECTIONS (Transmit frequency $=930 \mathrm{MHz}$ range)

DIPLEXER CONNECTOR
850 MHz port 930 MHz port ANT port

SIGNAL DESCRIPTION AND DESTINATION
RF RECEIVE - RADIO SECTION X2
RF TRANSMIT - RADIO SECTION X4
ANTENNA

TYPE-B CONNECTIONS (Transmit frequency $=850 \mathrm{MHz}$ range)

DIPLEXER CONNECTOR
850 MHz port
930 MHz port
ANT port

SIGNAL DESCRIPTION AND DESTINATION
RF TRANSMIT - RADIO SECTION X4
RF RECEIVE - RADIO SECTION X2
ANTENNA

### 2.4 AUDIO HANDSET SECTION

### 2.4.1 GENERAL

Refer to diagram "MTCU HANDSET MAIN PCB \& MIC PCB CIRCUIT DIAGRAM", drawing number 5015-A200-50.

The handset provides an audio link between units, to assist in link setup and commissioning. It is not intended for general use and the equipment is not licensed for voice operation only.

Caution : When the handset is inserted into the TC-900DR, reliable data transmission or reception is not possible. Unintentional voice traffic on a point to multi point system may cause data corruption to other units.

The data transmission section of the modem is totally disabled, if the handset is plugged in when the TC-900DR is turned on.

The handset contains two PCB's, a receive board and a microphone board, which are connected by a 10 way ribbon cable. Acoustic padding is also included in the handset for improved performance.

The microphone board contains an ECM30 electret microphone, along with a common emitter preamplifier stage (Q1), to provide transmit voice audio.

There are four indication LED's that are not used by the TC-900DR.
The receiver board contains a 78L05 5V voltage regulator (REG1). This is used to supply power to the LF353 receive amplifier (U2-p7), which drives a DH32-30 ohm earpiece.

The sidetone circuit provided by U2-p1 is disabled and not used by the TC-900DR. Similarly, the LED drivers are disabled.

The PTT switch places a ground connection onto its output signal line, for processing by the radio section.

### 2.4.2 INTERFACES

The audio handset connects directly to the radio section via the RJ11 connector, X3. Attached to the handset is an 8 way flexible curly cord.

| PIN NUMBER | HANDSET <br> CONNECTOR | X3 PIN <br> NUMBER | RADIO SECTION <br> CONNECTOR X3 |
| :--- | :--- | :--- | :--- |
|  | LED CLK | - | UNUSED |
| 2 | LED DATA | - | UNUSED |
| 3 | $13 V 2$ | 1 | 8 POWER SUPPLY |
| 4 | DGND | 3 | GROUND |
| 5 | PTT | 6 | MANUAL PTT |
| 6 | MIC | 4 | MIC |
| 7 | MIC RET | 5 | GROUND |
| 8 | EAR PHONE | 2 | AUDIO OUT |

### 2.5 MODEM SECTION

The modem section is built on a single PCB with approximate overall dimensions of $165 \mathrm{~mm} \times 152 \mathrm{~mm} \times 18 \mathrm{~mm}$.

It consists of the following main blocks :
Modem control

- DFM4-9 modem.
- Reset and watchdog.
- Memory.
- External NVRAM.
- External RAM.

Host interface.
Radio interface.
Transmit signal conditioning.
Receive signal conditioning.

- Data recovery.
- Clock recovery.

User indications.
Power supply
Interfaces.

- Radio section.
- Port A.
- Port B.
- Power.


### 2.5.1 MODEM CONTROL

### 2.5.1.1 DFM4-9 MODEM

The modem section is controlled by a DFM4-9 Trio DataCom modem IC, (U5).
This device is specifically designed to provide data communications from a host computer over a radio channel.
The DFM4-9 is capable of full duplex operation, at data rates of 4800 baud or 9600 baud over the radio channel. The transmitter and receiver data rates may be set independently. The host computer interface provides two RS232 asynchronous serial ports, configurable for a variety of baud rates, and data formats.

In the standard delivery format of the modem, only one asynchronous serial port is operational. (Port A).

Advanced data recovery techniques are employed to ensure excellent performance in both good and noisy signal environments.

The data transmission method used, employs advanced optimal waveform shaping techniques. This maximises the recovered signal at the destination receiver, while remaining within the allocated RF channel bandwidths. The method uses computer generated Finite Impulse Response (FIR) techniques, to derive the transmitted waveform data.

The modem features a unique supervisory signalling channel, which embeds low speed data in the primary bit-stream, and is transparent to the user of the primary channel.

To drive the DFM4-9 modem clocking circuits, an external resonator is required. A 19.6608 MHz crystal (XTAL1) is applied to the OSC pins (U5-p9,10) of the device to achieve this.

A 4 way DIP switch is supplied to set up some configuration parameters of the modem. These are only read by the DFM4-9 at device power up. They connect to the "ESx" pins of the device (U5-p3,p5,p6,p7). Switches 1 and 2 are presently unused, switches 3 and 4 are defined in section 4.5.1.

### 2.5.1.2 RESET AND WATCHDOG

A MAX690 reset and watchdog IC (U3), is used to perform a variety of ancillary functions. This device provides a fixed length reset pulse for the proper initialisation of the modem chip on power up and reinitialisation. The MAX690 monitors the level of the VCC power supply line. If the voltage moves out of specification, the reset output is activated. This ensures that the modem chip recovers correctly in the event of a power failure. The reset signal is applied to the "RESET" pin of the modem (U5-p8).

The MAX690 provides a power monitoring function, which gives advance warning of imminent power supply failure. The DFM4-9 modem checks this signal, applied to its "PF" pin (U5-p2), before performing any transactions with the non-volatile memory, thus preventing accidental corruption of the contents of this memory. This "advance warning", is the length of time that the power supply capacitors hold their charge, after loss of power, before the Vcc supply rail drops below its cutoff level, and a reset pulse is generated.

The MAX690 also includes a "watchdog" timer. This timer must be strobed at a minimum rate, to prevent a reset pulse being generated. The DFM4-9 provides this signal at its "WDO" pin (U5-p22). Should the DFM4-9 modem operation go astray for some reason, it is probable that it will no longer perform this strobing function correctly. This condition is treated as irrecoverable and the MAX690 will timeout on its watchdog function and re-initialise the modem.

### 2.5.1.3 MEMORY

### 2.5.1.3.1 EXTERNAL NVRAM

The DFM4-9 modem, has a wide variety of configurable operating parameters, all of which are stored in an ST24C04 NVRAM IC, (U4). These parameters are read at power up, and determine the operating characteristics of the modem.

The NVRAM has 4096 bits of memory. It is accessed using the standard $I^{2} C$, two wire, bus interface. A feature of this particular device, is a write protect function for one area of the memory.

This write protect feature prevents configuration data being inadvertently corrupted should some anomaly in modem operation occur. A hardware signal line is used to override this write protection feature, so that the configuration data may be changed by manual means. This signal can be accessed via the front panel connector, and is used when the TC-DFM9IP modem programmer is connected.

### 2.5.1.3.2 EXTERNAL RAM

External RAM is used to store data frames.
The RAM used may be either a $6264-8 \mathrm{~K}$ or $62256-32 \mathrm{~K}$ byte IC (U9). The standard TC-900DR is supplied with an 8 K package. The DFM4-9 modem, tests the size of the attached RAM on power up.

All of the externally connected RAM is used to store packet data, and is allocated evenly between transmit and receive data. This memory is connected to the modem chip, by an 8 bit bus, and 3 control lines.

Two 8 bit 74 HC 573 latches ( U 8 and U 10 ), are used to latch the memory address off the bus, before the data read or write cycle. The read/write control line to the RAM, is passed as the top address line in the MSB address latch.
The RAM read cycle operates as follows :

- The modem sets the two latch control lines, LADR_EN and HADR_EN, high.
- The high-address/R_select is then placed on the 8 bit bus.
- The HADR_EN line is set low to latch the data into U8.
- The lower eight address bits are placed on the bus.
- The LADR_EN line is set to low to latch the data into U10.
- The modem bus port is set to input mode.
- The RAM CE line is set low.
- The modem reads the data off the bus.

The RAM write cycle operates as follows :

- The modem sets the two latch control lines LADR_EN and HADR_EN, high.
- The high-address/W_select is then placed on the 8 bit bus.
- The HADR_EN line is set low to latch the data into U8.
- The lower eight address bits are placed on the bus.
- The LADR_EN line is set to low to latch the data into U10.
- The modem bus port is set to output mode.
- The modem writes the data to the bus.
- The RAM CE line is set low to write the data into the RAM.


## Note: WARNING

A modem containing a $32 K$ RAM package will not be compatible with a modem containing an 8 K RAM package if end to end flow control is being used over the data link.

### 2.5.2 HOST INTERFACE

The host interface is provided by two RS232 ports, configured as DCE. These ports are presented to the user as 9 way female DMIN connectors, designated as PORT A and PORT B.

With the standard TC-900DR, only PORT A is operational.
The RS232 level translation is performed by two LT1081/MAX232 line transceivers (U1 and U2). These require a single five volt supply, and include internal charge pumps to generator the required +10 V and -10 V rails.

The four input and four output lines implement one full duplex serial port with RTS/CTS/DTR and DCD. This is PORT A. A second full duplex port with no handshake lines is provided on PORT B.

### 2.5.3 RADIO INTERFACE

The interface to the radio is via a 26 pin PCB header connector, X 4 .
The modem section has full control over the connected radio transceiver. It provides :

- Four lines for synthesiser control (used for RF channel selection).
- RSSI detection.
- Temperature sense input.
- Transmit power sense input.
- Temperature compensation for the synthesiser reference frequency.
- Receiver AFC.
- PTT control.
- Analogue lines for receive and transmit data signals.
- Regulated +13.8 V and +8 V power supplies.

Input to the receiver signal port, RXSIG, is offset by 2.0 V DC, with a signal level of $1 \mathrm{Vp}-\mathrm{p}$ AC.

The transmit signal output, TXSIG, has a signal level of $1 \mathrm{Vp}-\mathrm{p}$ for 4800 BPS , and $2 \mathrm{Vp}-\mathrm{p}$ for 9600 BPS , with a nominal DC offset of 2.0 V . This offset may vary by $\pm 1 \mathrm{v}$ according to the modulator temperature compensation requirements.

An ADC0834 four channel ADC (U6), is used to monitor various analogue quantities within the radio. The DFM4-9 modem communicates with the ADC by controlling 3 lines. An active high chip select, "ADCS" line (U5-p33), a data clock, "DCLK" line (U5-p35), and a serial data, "SD" line (U5-p36).

The state of the data line from the ADC is clocked into internal registers of the DFM4-9 on the rising edge of the clock line. The data stream consists of a four bit preamble, which includes the channel address. From the 5th clock pulse onward, the ADC drives the data line with the data of the conversion, MSB first. The transaction is terminated with the CS line being set to inactive low.

The first channel is used to monitor temperature, by measuring the voltage from an LM335 monolithic temperature sensor U6. The LM335 is situated in the radio section, adjacent to the 20.1666 MHz XTAL and VCXO synthesiser reference oscillator, and is fed into the modem section via connector $\mathrm{X} 4-\mathrm{p} 14$, ADC0.

The second channel is used to monitor RSSI, by measuring the RSSI output of the NE615 IF circuit. This signal is fed to the modem section from the radio section via connector X4-p21, ADC1.

The third channel is used to monitor the power level output by the RF transmitter, by measuring a voltage derived in the power control section of the radio. This is used to determine the "health" of the radio transmitter. This signal is fed to the modem section from the radio section via connector $\mathrm{X} 4-\mathrm{p9}, \mathrm{ADC2}$.

The fourth channel of the ADC, is used to measure the voltage of the +13.8 volt supply rail and to sense the presence of the audio handset at power up. The handset derives microphone bias from the modulator stage, and the voltage at this point is measured and compared with a fixed nominal value, to determine if the handset is connected at the time of TC-900DR power up. This signal is fed to the modem section from the radio section via connector $\mathrm{X} 4-\mathrm{p} 24, \mathrm{ADC3}$. This 4 th ADC channel is also multiplexed to measure the AFC control voltage so that an indication of received signal frequency can be made. U14:D is used to perform this switching function.

An auxiliary latch (U11) is provided to supply some of the output control to the radio section.

The latch receives data from the same data buss as the RAM. The lower six bits are fed to an R/2R ladder network DAC (RN2), which is used to present an analogue voltage to the radio's local oscillator synthesiser frequency reference. This correction voltage provides for excellent temperature stability of the radio. This signal is fed to the radio section via connector X4-p15, TEMP COMP.

The two top bits of the latch, drive auxiliary functions within the radio section.
Bit 6 is used to control the power of the RF transmitter in the radio section. This can be set to a HIGH level of 1 W , or to a LOW level of 200 mW . This signal is fed to the radio section via connector X4-p10, TXPWR.

Bit 7 provides the RF transmitter enable signal to the radio section. No RF signal can be transmitted unless this signal is set to active. This signal is fed to the radio section via connector X4-p11, TX EN.

### 2.5.4 TRANSMIT SIGNAL CONDITIONING

The transmit section of the DFM4-9 modem, outputs a byte of data, four times per bit period, on the "TDx" pins (TD1..TD7, U5-p56..49).
The parallel data is presented to an eight bit R/2R ladder network (RN1). This is a simple DAC which produces the transmit waveform at its output.

This signal is fed into opamp (U13:C) for amplification and filtering. This stage is a single pole low pass filter, used to attenuate clocking noise in the waveform. Two more filter stages follow, U13:B and U13:D.

By using 4 samples per bit, and an 8 bit resolution, precise control of the waveform shape is possible.

The gain and pole frequency of amplifier stage U13:C is switched by the DFM4-9 modem, via a 74 HC 4066 CMOS FET switches (U14:A). This is to produce the required waveform for the two data rates currently available. The bit rate output signal, "BRO" is provided at U5-p44.

For 4800 baud, components C43 and R45, are "included" in the feedback loop of the amplifier stage. When 9600 baud is selected, switch U14:A is turned OFF, and the components are "excluded" from the circuit.

### 2.5.5 RECEIVE SIGNAL CONDITIONING

The data receiver, consists of several functional blocks. Some of these are implemented by internal functions of the modem IC, and the remainder by external circuitry.

The incoming analogue signal, is routed to two separate sections of circuitry. One to process the received clock, the other to process the received data.

### 2.5.5.1 DATA RECOVERY

The data recovery is based around an "Integrating Data Slicer" circuit.
This circuit consists of a non-inverting, resetable integrator (U16:A, U12:C and U15:D), a dual peak detector ( $\mathrm{U} 12: \mathrm{A}, \mathrm{B}$ ) and a reference divider.

The received signal is passed into the modem section from the radio section via connector X4-p20, "RXSIG".

The signal is integrated by the non-inverting integrator formed by U16:A, and U12:C, and then forwarded on to a comparator ( $U 7: B$ ), where it is "squared up", ready to be read by the DFM4-9 modem.

An output signal is provided by the modem IC, to indicate the sampling point. In fact this signal, called "RxCLKOUT", is pulsed high immediately after the sampling operation has taken place.

The integrator is reset at the end of each bit period, by the 74HC4066 FET switch, U15:D, after the value of the bit has been read. The DFM4-9 provides this reset signal at the reset integrator "RxCLKOUT" pin (U5-p19).

The integrated receive signal, is then fed to the dual peak detector, where the positive and negative peaks of the integrated signal are detected, and stored on the capacitors C28 and C27.

The peak detector's attack time is determined by the output resistance of the opamps ( $\mathrm{U} 12: \mathrm{A}, \mathrm{B}$ ) and the bulk resistance of the diodes (D7, D4). The decay time however is determined by the values of the hold capacitors (C28, C27) and the summing resistors (R24, R25).

Four diodes (D5, D6, D8, D9) are used to clamp the reference rail. If the incoming signal has a large $D C$ shift, this clamping arrangement ensures that the data slicer reference level is quick to settle somewhere near its final operating point. This clamp however does impose a maximum allowable input signal level. Exceeding this level will cause the integrated signal to directly modulate the reference rail. The derived reference voltage level, is amplified and output back to the radio section, where it is used for AFC in the receiver.

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### 2.5.5.2 CLOCK RECOVERY

The received clock signal is presented to the DFM4-9 modem at its "RXCLK" input (U5-p4).

Within the DFM4-9, a phase-locked-loop is used for data clock recovery, which relies on level transitions in the data signal.

This mechanism maintains the data sampling point in the center of the bit cells by comparing the signal's level transitions with an internal clock.

An error in the relative phase of the RXCLK signal and the internal clock, causes the internal clock to increase or decrease in speed, to bring the phase error to zero.

The phase-locked-loop clock recovery mechanism within the DFM4-9 modem, maintains the sampling point in the center of the bit cells, but the use of the integrator demands that this take place at the end of the bit cell. This means that the signal fed to the DFM4-9 modem RXCLK input must be delayed by half a bit period.

To obtain this, the received signal is passed through a half bit delay, low-pass filter (U16:D, U12:D, U7:A). The delay characteristics of this filter, are switchable between the available data rates of 4800 and 9600 baud operation, by five 74 HC 4066 FET switches. These switches are controlled by the "BRO" output of the DFM4-9.

### 2.5.6 USER INDICATIONS

There are four indication LED's supplied for user information. POWER, TXMIT, SYNC and RXSIG. The POWER LED is green, TXMIT LED is red and the other two are yellow.

The POWER LED (LED4), is driven from the 13 V 8 power supply line. When supply is present the LED is activated.

The TXMIT LED (LED3), is activated when PTT is present. It is driven when the switching transistor Q3 is turned ON by the DFM4-9 modem "PTT" output going active (UX3-p38).

The SYNC LED (LED2), is activated when a valid data stream has been detected. It is driven when the switching transistor Q2 is turned ON by the DFM4-9 modem "SYNC" output going active (U5-p43).

The RXSIG LED (LED1), is activated when the received signal level is at a usable level. It is driven when the switching transistor Q1 is turned ON by the DFM4-9 modem "RXSIG" output going active (U5-p43).

### 2.5.7 POWER SUPPLY

The power supply is based around the use of three voltage regulators that supply +13 V 8 , +8 V and +5 V .

The incoming power is applied to a bridge rectifier (BR1), Normally two legs of this bridge are linked out, so it provides only reverse polarity protection shunt diodes. A special manufacturing option allows for AC input, where the links are removed. A 2200uF electrolytic capacitor (C2), provides filtering for $A C$ inputs.

This is then applied to an LT1086 low dropout regulator (REG1). The output of this is set to 13 V 8 and feeds the RF final amplifier, and the following two regulators.

The 8 V regulator (REG2) takes it's input directly from the 13 V 8 rail, its output is routed to the radio section, and provides supply for one of the amplifier devices.

The 5 V regulator (REG3) provides the supply rail for the modem section logic circuits. It takes it's input from the 13 V 8 rail via diode D1. Extra filtering capacitance is provided by C7.

### 2.5.8 INTERFACES

### 2.5.8.1 RADIO SECTION

The modem section interfaces to the radio section via connector JX3. The physical link between the two sections is achieved via a 90 mm length of 26 way ribbon cable.

Refer to interface diagram "RADIO MODEM INTERFACE", drawing number TC01-05-18 sheet $1 / 3$.

## CONNECTOR JX3 SIGNAL DESCRIPTION PIN NUMBER

| 1 |  |  |
| :--- | :--- | :--- |
| 2 | 13V8 POWER SUPPLY RAIL |  |
| 3 | 13V8 POWER SUPPLY RAIL |  |
| 3 | 13V8 POWER SUPPLY RAIL |  |
| 4 | GROUND |  |
| 5 | GROUND |  |
| 6 | GROUND |  |
| 7 | $8 V$ POWER SUPPLY |  |
| 8 | $8 V P O W E R ~ S U P P L Y ~$ |  |
| 9 | ADC2 | (i/p-TRANSMIT POWER SENSE) |
| 10 | TXPWR | (o/p-TRANSMIT POWER LEVEL) |
| 11 | TXEN | (op - TRANSMIT ENABLE) |
| 12 | /PTT OUT | (o/p-PRESS TO TALK) |
| 13 | TXSIG | (o/p-TRANSMIT DATA) |
| 14 | ADC0 | (i/p-TEMPERATURE SENSOR) |
| 15 | TEMPCOMP | (o/p-TEMPERATURE COMPENSATION) |
| 16 | EN | (o/p-ENABLE FOR SYNTH) |
| 17 | DA | (o/p-DATA FOR SYNTH) |
| 18 | CK | (o/p-CLOCK FOR SYNTH) |
| 19 | LD | (i/p-LOCK DETECT FROM SYNTH) |
| 20 | RXSIG | (i/p-RECEIVED DATA) |
| 21 | ADC1 | (i/p-RSSI SIGNAL) |
| 22 | AFCCTL | (o/p-AFC CONTROL) |
| 23 | SPARE | (UNUSED) |
| 24 | ADC3 | (FOR SUPPLY/HANDSET) |
| 25 | TEST1 | (UNUSED) |
| 26 | TEST2 | (UNUSED) |

### 2.5.8.2 PORT A

The modem section interfaces to the host user via the 9 way female DMIN type connector JX1.

CONNECTOR JX1 SIGNAL DESCRIPTION
PIN NUMBER

| 1 | DATA CARRIER DETECT | (DCD) |
| :--- | :--- | :--- |
| 2 | RECEIVE DATA OUTPUT | (RXD) |
| 3 | TRANSMIT DATA IN | (TXD) |
| 4 | DATA TERMINAL READY | (DTR) |
| 5 | COMMON | (COM) |
| 6 | DATA SET READY/prog mode | (DSR) |
| 7 | REQUEST TO SEND | (RTS) |
| 8 | CLEAR TO SEND | (CTS) |
| 9 | RING INDICATE/BER Test Mode | (RI) |

Note: Pin 6 and pin 9 provide a dual function which depends on the mode that the TC-900DR is operating in.

### 2.5.8.3 PORT B

For the standard delivery version of the TC-900DR, port $B$ is normally not enabled. This port provides no handshake lines except DCD (parallel connected with DCD on Port A) and DSR which is wired active.

```
CONNECTOR JX1 SIGNAL DESCRIPTION
PIN NUMBER
```

| 1 | DATA CARRIER DETECT | (DCD) |
| :--- | :--- | :--- |
| 2 | RECEIVE DATA OUTPUT | (RXD) |
| 3 | TRANSMIT DATA IN | (TXD) |
| 4 |  |  |
| 5 | COMMON | (COM) |
| 6 | DATA SET READY/prog mode | (DSR) |
| 7 |  |  |
| 8 |  |  |
| 9 | RECEIVE SIGNAL STRENGTH INDICATOR | (RSSI) |

Pin 9 is used to output the RSSI signal for external measurement.
The RSSI output ranges from 0 to 5 Volts, where 5 volts indicates the strongest signal. It is important to note that this port output has a high impedance of around 50 K ohms and loading will decrease accuracy of the recorded measurement.

### 2.5.8.4 POWER

Power is supplied to the modem section via connector $X 1$. Typically +13.8 V DC is applied to the top pin, with the common connected to the bottom pin.

## SECTION 3

## OPERATIONAL DESCRIPTION

## 3 OPERATIONAL DESCRIPTION

### 3.1 GENERAL

The Trio DataCom TC-900DR radio modem, is a full duplex 4800/9600 bits per second device, which converts digital data into an analogue form suitable for transmission over a radio channel. It uses specially filtered direct binary frequency modulation techniques to achieve this. It conversely, converts the analogue signal derived from a radio channel into a digital data signal.

The heart of the unit is the DFM4-9 modem IC. This performs all waveform shaping, randomising and de-randomising, NRZ/NRZI conversion, clock recovery, and HDLC framing and CRC error generation and checking. These functions are performed simultaneously, allowing full duplex operation at up to 9600 bps .

The modem is fully HDLC compatible. The user is provided with two RS232 compatible ports, which may each be configured with a standard PAD interface or SLIP/KISS protocol driver. The unit may also be configured for repeater operation.

It may be configured to use RS232 handshake lines, or XON/XOFF flow control on Port A.

The modem features a unique supervisory signalling channel, which embeds low speed data in the primary bit-stream, and is transparent to the user of the primary channel.

The supervisory signalling channel can be disabled if not required. It could be used to pass low speed data such as E and M status or C/DSMA control schemes.

The data rate of the supervisory signalling channel can be set independently for transmit and receive. It can range from about 40 to 533 bps with the primary channel rate at 4800 baud, and 80 to 1067 bps at a primary channel rate of 9600 baud.

NOTE: with the supervisory signalling channel active, the bit-stream is not compatible with standard HDLC interface devices (such as 8530).
The host user port may be configured for baud rates of 300 to 19 K 2 , with 7 or 8 bit character size, 1 or 2 stop bits, and parity off/odd/even.

The DFM4-9 modem includes several data tables which are used to generate waveforms with different characteristics. This is primarily for optimum performance at differing baud rates. A custom data table can be placed into the NVRAM of the modem, for specialised applications.

Configuration of the modem is fully programmable, with parameters held in non-volatile memory. All configuration parameters are accessible with the TC-DFM9IP Installation Program.

Configuration parameters include but are not limited to:
Supervisory Signalling Channel rate.
XON/XOFF or RTS/CTS/DTR/DCD handshake mode.
Default transmitter lead in delay.
Constant specifying minimum RF RSSI for valid receive.
Constant specifying minimum Tx power level.
Asynchronous serial port parameters.
User interface operating mode :

- User port interface protocol
- PAD Parameters


### 3.2 TC-900DR MODEM FIRMWARE REVISION VA2.3.0

### 3.2.1 FUNCTIONAL CHANGES AND ADDITIONS

The Diagnostics " M " command (serial port Mode) completed. The implementation of this command was not finished in time for VA2.2 release. This command is used to configure either of the two user ports, for character length, number of stop bits, parity odd/even/off.

1 Bit 7 is used to address which port is being referenced (set to " 0 " for Port $B$, or set to "1" for Port A).

2 Bit 6 determines the character size. Set to " 0 " for 8 bit, or "1" for 7 bit character size.

3 Bit 5 is set to " 1 " to enable parity, " 0 " to disable parity.
4 Bit 4 determines Odd (set bit to "1"), or Even (set bit to " 0 ") parity if Bit 5 is set.
5 Bit 3 determines the number of stop bits. Set to " 0 " for 1 stop bit, or set to " 1 " for 2 stop bits.

6 Bits 2, 1, and 0 are used to select the baud rate. The following table shows the available rates. The 19.2 K baud selection should only be made for Port A if Port $B$ is disabled. The last selection of 110 baud may be deleted from future firmware revisions.

| Bit | Bit 1 | Bit 0 | Baud Rate |
| :---: | :---: | :---: | ---: |
| 0 | 0 | 0 | 300 |
| 0 | 0 | 1 | 600 |
| 0 | 1 | 0 | 1,200 |
| 0 | 1 | 1 | 2,400 |
| 1 | 0 | 0 | 4,800 |
| 1 | 0 | 1 | 9,600 |
| 1 | 1 | 0 | 19,200 |
| 1 | 1 | 1 | 110 |

Channel Access Strategy 3 is now defined. This is selected by setting bits 1 and 0 ( $\mathrm{T} \times \operatorname{Ctr} 11$ and TxCtrl0) in "Config1", both to "1". This mode forces a randomly generated delay before transmission begins, even if the channel is perceived to be clear. This delay mechanism is similar to that used in Channel Access Strategy 2 when the channel is perceived to be busy. This operating mode is useful in systems that include remote terminals that generate reports at regular fixed intervals. In such a system, slight differences in this interval between two remotes, would cause them to become synchronised for some time, and thus transmissions from them would consistently
collide. Inserting a randomly generated delay before all transmissions will reduce the incidence of this effect.

The RS232 DCD handshake line now becomes active only during output of received data. Formerly, the DCD line indicated real time SYNC status of the modem data receiver. To facilitate the use of RS232 to RS422/RS485 converters, the DCD line is driven active a short time (approximately 0.5 mS ) before the received data is output to the user port, and lingers for approximately 2 to 3 character times (i.e. is proportional to baud rate of user port). The modem generates only one DCD function, which is available on pin 1 of both Port A and Port B. Thus the DCD pin of both user ports will be activated when either port is outputting received data.

### 3.2.2 OTHER ENHANCEMENTS

Improvements in handling of the RS232 RTS line (Port A), makes the modem more tolerant in the timing of rapid OFF transitions of this handshake line, immediately after the end of the last character of a message. It has been observed that communications drivers in many PLCs turn their RTS output line OFF very shortly after the end of a message, resulting in the loss of the last character of the message with previous modem firmware revisions. This revision does not suffer this problem.

The random number generator used for the Channel Access Timer, has been improved to make it more random.

### 3.3 FACILITIES AND CONFIGURATION INFORMATION FIRMWARE VERSION 2.2

### 3.3.1 GENERAL

The TC-900DR provides fully transparent remote diagnostics facilities, and expanded data stream switching, which supports advanced stream trunking applications.

The diagnostics core, supports the reporting of current analogue conditions, including temperature, RSSI (Received Signal Strength Indication), RF transmitter power, AFC (i.e. received signal frequency offset), and supply voltage. Also, an extensive range of operating parameters may be changed remotely, including remote (RF) channel change.

Configuration options, allow various system topology's, so that the location of the system's diagnostics controller is flexible.

The data stream switching mechanism has been upgraded to allow either MUX/DeMUXing or multi-stream routing functions, independently for each port.

A few other minor upgrades to previous revisions of firmware are:

* Two different "ticker clocks" implemented, one running at 1 mS , and used for a) PAD Character Input Timers, and b) Channel Access Timer when running in Collision Avoidance mode. The other "ticker clock" runs at 10 mS , and is used for the PTT timer, and a host of other internal functions, not accessible by configuration programming.
* When XON/XOFF flow control is enabled on PortA, the CTS output line continues to operate correctly, indicating the flow control state. XON/XOFF characters are generated in addition to, and reflect state changes on this line. As before, the DTR input line is ignored while XON/XOFF flow control is set, and the RTS line is not required to be true to validate transmit data.
* The modem stores data for transmission in buffer memory, which is limited. It also keeps track of frame boundaries of the stored data, and the number of frames it can manage is also limited by the amount of memory used to record the position of the frame boundaries. Thus it is possible that the modem can approach overflow before exhausting data buffer space, if frames are small. This flow control state is activated when the "frame boundary memory" approaches half full, for similar reasons used in data buffer management.
* If the Supervisory Signalling Channel is enabled in both transmit and receive directions, and PortA is configured in Repeater Mode, then the received Supervisory Signalling Channel data is also repeated, by being copied from the Supervisory Signalling Channel receiver to the Supervisory Signalling Channel transmitter.
* RSSI measurements are full eight bit conversion, so the "min_RSSI" configuration parameter lies in the range $0-255$ (decimal). This is only important when setting this parameter without the aid of the DRPROG programmer.


### 3.3.2 INTERNAL DATA STREAM ROUTING

Essentially, all data streams travelling in both directions (transmit and receive), are examined and tested for a match with the diagnostics receive SID header code. If this match test is successful, then the data frame is copied into a buffer for the diagnostics core to process. The data frame also continues in the original direction as well. Thus diagnostics frames received from the radio channel (receive data), and from the stream switcher (transmit data, from one of the physical ports), are copied as they pass between the HDLC "device" and the data stream "switcher". Messages generated by the diagnostics core in response to received commands, are always sent back to the source of the command. That is, if a status request is received from the radio channel side of the modem, then the response is directed back out of the radio channel.

This dual access structure, allows the diagnostics controller to be located on either side of the modem, and thus supports any system topology.

### 3.3.3 DIAGNOSTICS REPEAT FUNCTION

Some applications will require that the "base" unit in a point to multi-point system repeats diagnostics frames. This will be the case where the system diagnostics controller is attached to a remote terminal in the system, and polls the system population from this point. The "base" unit must re-transmit diagnostics frames which are not addressed to itself. A "diagnostics repeat" configuration bit enables this function.

### 3.3.4 DIAGNOSTICS FRAME STRUCTURE

Diagnostics data frames, are structured according to a defined protocol. A frame consists 1st of the SID header code, which would normally (but not necessarily) be 00 . Following this is a three byte address of the destination unit, followed by a three byte source address. An addressed unit responding to a diagnostics command, will swap these two address fields around, in the response frame. The destination address in a diagnostics frame to a TC-900DR unit, is in fact the unique (factory) serial number of the unit. By convention, the diagnostics controller (a DOS based PC), will use a unique address for itself, outside the range of permissible TC-900DR addresses (e.g. 000000). Following the two address fields, is a single character command/response code, which is in turn followed by any operands that may or may not be required for the command/response. Total frame size is limited to 17 bytes. After the SID header, address fields, and command/response mnemonic, this allows up to nine bytes of data to be transferred per diagnostics frame.

### 3.3.5 DIAGNOSTICS COMMAND SET

The following is a list of the command set recognised by the diagnostics core in the TC-900DR Firmware. Also is tabulated the response to each command. The following examples use address 123456 for the TC-900DR unit address, and 000000 for the address of the system diagnostics controller. For the purposes of clarity only, each byte in the example messages is separated by a comma. Mnemonics are represented in quoted form to indicate an ASCII character (e.g. " $C$ " is actually binary byte $h^{\prime} 43$ ).

## B Warm Boot Command.

This command forces the addressed unit to perform a "warm boot". Previous to this, the unit will have been halted (see " H " command), and one or more parameters changed with "P" and "W" commands.

Syntax:-
Command:- $\quad 12,34,56,00,00,00$, "B"
Response:- $\quad 00,00,00,12,34,56, " b "$

## C Calibration Constant Poll.

This command requests the addressed unit to reply with it's internal Analogue To Digital Converter (ADC) calibration constants. These are necessary to accurately interpret the data sent in Status Poll ("S") replies. This command has no operands, and the response mnemonic is " c ". The form of the command and reply is:

Syntax:-
Command:- - 12,34,56,00,00,00,"C"
Response:- $\quad 00,00,00,12,34,56, " c ", t t, r r, p p, f f, s s$
Where:-
$\mathrm{tt}=$ Temperature calibration code
$\mathrm{rr}=$ RSSI calibration code
pp = Transmit Power calibration code
ff = Received Frequency Offset calibration code
ss = Power Supply calibration code

## D Powered Up Response

This command is sent from the modem to the controller in response to a status poll ("S") immediately after the modem has been powered up. The modem will continue to send this command in response to a status poll until the controller acknowledges the command with a " $d$ ". The modem will then respond normally to a status poll.

This mechanism is used by the controller to determine whether it requires calibration data from the modem.

Syntax:-
Command:- 00,00,00,12,34,56"D"
Response:- $\quad 12,34,56,00,00,00 " d "$

F Set New RF Synthesiser Frequency.
This command forces the unit to set the RF synthesiser to a new frequency, thus selecting another radio channel. This command has one operand, which defines the source of the synthesiser data. A value of zero, indicates that the frequency data has already been set with a parameter set command. Values from one to four select one of the channels stored in the NVRAM of the modem configuration. The addressed unit responds with an " $f$ " reply, before executing the channel change command (i.e. on the old channel).

Syntax:-
Command:- $\quad 12,34,56,00,00,00$, " ${ }^{\prime \prime}$ "nn
Response:- $\quad 00,00,00,12,34,56$, "f"
Where:-
$\mathrm{nn}=00$ to 04 to select data source .

## H Halt Command.

This command forces the addressed unit to halt all internal operations, except diagnostics processing. This is necessary, when changing some parameters, before a warm boot command is issued to the re-configured unit.

Syntax:-
Command:- $\quad 12,34,56,00,00,00, " H "$
Response:- $\quad 00,00,00,12,34,56, " \mathrm{h"}$

## M Set Serial Port Mode.

This command forces the addressed unit to change the operating mode of one or both serial ports. Parameters such as character size, number of stop bits, parity etc. are changed with this command. It should be noted, that data may be lost while the operating mode of the serial ports is changed.

Syntax:-
Command:- $\quad 12,34,56,00,00,00, " M ", x x$
Response:- $\quad 00,00,00,12,34,56, " m "$
Where:-
$\mathrm{xx}=$ Serial port address bit and mode data

P Parameter Set command.
This command stores the contents of the operand string to a storage buffer. No other action is taken. This command should be immediately followed by a "W" command. See "W" command below. The parameter may be either a bit quantity, a byte quantity, a word quantity, or a string quantity. The diagnostics core in the modem firmware determines this from the parameter indentifier, which indexes an internal lookup table. String quantities are of indefinite length, and determined by the length of the operand string in the received "P" command. The "P" command response ("p"), echoes the complete received string. This is unique to the " P " and " $W$ " commands.

## Syntax:-

Command:- $\quad 12,34,56,00,00,00, " P ", n n, a a, b b, c c, \ldots$
Response:- $\quad 00,00,00,12,34,56, " p ", n n, a a, b b, c c, \ldots$
Where:-
$\mathrm{nn}=$ parameter identifier
$\mathrm{aa}, \mathrm{bb}, \mathrm{cc}, \ldots$ are data value(s) for selected parameter

## R Parameter Readback command.

This command forces the addressed unit to read the state of the addressed parameter, and send this data back the the command originator (diagnostics controller) in a reply message. Again the size of the parameter (bit, byte, word, or string) is determined by the parameter identifier. String parameters are returned as a string of eight consecutive bytes.

Syntax:-
Command:- $\quad 12,34,56,00,00,00, " R ", n n$
Response:- $\quad 00,00,00,12,34,56, " r ", n n, a a, b b, . . . h h$

## S Status Poll.

This command requests the addressed unit to reply with the current value of analogue quantities, present temperature, last/present received RSSI, transmit power of last transmission, received frequency offset of last/present received signal, and present supply voltage.

Syntax:-
Command:- $12,34,56,00,00,00, " S "$
Response:- $\quad 00,00,00,12,34,56$,"s",tt,rr,pp,ff,ss
Where:-
$\mathrm{tt}=$ Temperature conversion code
rr = RSSI conversion code
$p p=$ Transmit Power conversion code
$\mathrm{ff}=$ Received Frequency Offset conversion code
ss $=$ Power Supply conversion code

## T Diagnostics Watchdog Timer command.

This command forces the addressed unit to (re)set a special watchdog timer. The operand value is a word (16_bit) quantity. A zero value will disable the timer. A non-zero value will initialise the timer. This timer, while non-zero, will be decremented periodically. If the timer is decremented to zero, then the TC-900DR will perform a cold boot, thus restoring operating parameters from the NVRAM configuration memory. This command should be used in conjunction with parameter set and write commands. If a parameter change renders the unit in-operable, then either it will not continue to receive further "T" commands to reset the timer, or the system diagnostics controller may cease to send the timer reset commands, thus will eventually cause the unit to cold boot.

Syntax:-
Command:- 12,34,56,00,00,00,"T",nnnn
Response:- $\quad 00,00,00,12,34,56, " t "$
Where:-
nnnn = timer reset value ( 16 bit value)
$\checkmark$ Request Firmware Version String command.
This command requests the addressed unit to reply with a string indicating it's firmware version number. Future firmware versions may provide further facilities that may then be used, by sending appropriate commands.

Syntax:-
Command:- $\quad 12,34,56,00,00,00, " \mathrm{~V} "$
Response:- $\quad 00,00,00,12,34,56, " v ", " A 2.2 .0 "$

## W Write Parameter command

This command is used in conjunction with the "P" parameter set command. This parameter write command must be identical to the previous parameter set command. Providing they are identical (excepting the command mnemonic), then the operand is written to the selected modem operating parameter. Changing some parameters while normal operation continues could produce improper operation, possibly resulting in corrupted parameters, so the unit should be halted with a HALT command before such parameters are changed.

Syntax:-
Command:- $\quad 12,34,56,00,00,00, " W ", n n, a a, b b, c c, \ldots$
Response:- $\quad 00,00,00,12,34,56, " w ", n n, a a, b b, c c, \ldots$
Where:-
$\mathrm{nn}=$ parameter identifier
$\mathrm{aa}, \mathrm{bb}, \mathrm{cc}, \ldots$ are data value(s) for selected parameter

### 3.3.6 PARAMETER SET

The following is a list of parameters which may be remotely set. Parameters marked with a "*", should only be changed while the unit is in a halted state, followed by a warm boot command. Parameters marked with a "\#", may only be referenced in an "R" readback command. Attempts to change these with "P" and "W" commands may produce unpredictable results.

| Parameter Identifier | Parameter Type(Size) | Parameter Name |
| :---: | :---: | :---: |
| 00 (^@) | undefined | not defined, reserved to facilitate future expansion |
| 01 (^A) | undefined | not defined, Trio DataCom test use only |
| 02 (^B) | byte | Drift_Offset |
| 03 (^${ }^{\text {C) }}$ | word | PTT_Time |
| 04 (^D) | string | Synthesiser Data for channel change |
| 05 (^E) | byte | min_RSSI |
| 06 (^F) | byte | Tx_LID |
| 07 (^G) | byte | Slot_Num |
| $08\left({ }^{\wedge} \mathrm{H}\right)$ | byte | Slot_Time |
| 09 (^) | word | SIDA1 and SIDA2 |
| OA (^J) | word | SIDB1 and SIDB2 |
| OB (^K) | word | SIDD1 and SIDD2 |
| OC (^L) | byte | KISS_adrA |
| OD (^M) | byte | KISS_adrB |
| 0 E (^N) | byte | EOMA_code |
| OF (^) | byte | EOMB_code |
| 10 (^P) | byte | input_timeA |
| 11 (^Q) | byte | input_timeB |
| 12 (^R) | byte | frame_sizeA |
| 13 (^S) | byte | frame_sizeB |
| 14 (^T) | bit * | SLIP/KISS_mode portA |
| 15 (^U) | bit * | SLIP/KISS_mode portB |
| 16 (^V) | bit | EOM_enable portA |
| 17 (^W) | bit | EOM_enable portB |
| 18 (^X) | bit * | KISS_mode portA |
| 19 (^Y) | bit * | KISS_mode portB |
| $\left.1 \mathrm{~A}{ }^{\wedge} \mathrm{Z}\right)$ | bit | RTS/CTS_interlock portA |
| 1B (^[) | bit * | PORTB_enable |
| 10 (^) | bit * | Repeat_Enable portA |
| 1D (^]) | bit * | Repeat_Enable portB |


| 1E (^^) | bit * | (Not defined, reserved for Error Recovery Enable) |
| :---: | :---: | :---: |
| 1F ( ${ }^{\text {A }}$ ) | bit * | (Not defined, reserved for Error Recovery Enable) |
| 20 () | bit | LiveFrame portA |
| 21 (!) | bit | LiveFrame portB |
| 22 (") | bit | XonXoffMode portA |
| 23 (\#) | bit | XonXoffMode portB |
| 24 (\$) | byte | PORTA_Config |
| 25 (\%) | byte | PORTB_Config |
| 26 (8) | bit | diags_repeat |
| 27 () | bit | TxPWR_HI/LOW |
| 28 () | bit | SID_Enable |
| 29 ()) | bit | RTS2PTT |
| 2A (*) | bit | SYNC2PTT |
| 2B(+) | bit | SCDO_Default |
| 2C (,) | bit | SupChnFunc |
| 2D (-) | bit | TxCtrl 1 |
| 2E (.) | bit | TxCtrl0 |
| $2 \mathrm{~F}(\mathrm{O}$ | byte | Config1 |
| 30 (0) | byte \# | SMR1 (portA serial port mode) |
| 31 (1) | byte \# | SMR0 (portB serial port mode) |
| 32 (2) | byte \# | BRR1 (portA serial port baud rate) |
| 33 (3) | byte \# | BRR0 (portB serial port baud rate) |
|  |  | Additions for version A2.3.0 |
| 34 (4) | byte | err_limit (Frame Error output for Base Station) |
| 35 (5) | byte | err_flags |
| 36 (6) | word | good_cnt |
| 37 (7) | word | bad_cnt |
| 38 (8) | word | lost_sync_cnt |
| 39 (9) | word | lost_RSSI_cnt |
|  |  | Additions for version A2.3.1 |
| $3 \mathrm{~A}(:)$ | byte | DCD_timeA |
| 3 B()$^{\text {) }}$ | byte | DCD_timeB |
| 3C(<) | byte | Diags_Delay |

### 3.3.7 ADVANCED STREAM ROUTING FUNCTIONS

The TC-900DR provides advanced stream routing functions. For each port, there is allocated two SID (Stream IDentifier) codes, and a configuration flag that determines how these two codes are used.

With the flag off, SIDx1 (where x is A or B for portA and portB respectively) defines the SID code of received frames that are de-multiplexed to the port, and SIDx2 defines the SID code that is inserted by the modem at the front of every frame it transmits. Thus only one data stream passes through the port, and the modem manages the insertion and extraction of SID header codes.

With the configuration flag on, SIDx1 and SIDx2 define a range of streams that will be passed from the received data to the port. SIDx1 defines the lowest stream, while SIDx2 defines the highest stream. The SID header codes remain on the received frames, and are passed to the port. For transmit data, the modem assumes that the SID header codes are already in place, being inserted by some external device, and no processing is performed on the transmit data. For this application, it is highly desirable that a SLIP (or KISS) driver be employed so that frame boundaries are defined.
These functions are independent for each port, so it is possible to construct (say), a multi-drop, multi-hop repeated data system, where one stream can be "peeled off" at each repeater site. There are many other possibilities, the TC-900DR product simply requiring suitable configuration to construct a vast range of network topologies.

### 3.4 FACILITIES AND CONFIGURATION INFORMATION VERSION 2

### 3.4.1 GENERAL

The TC-900DR, provides two independent user data streams, which are multiplexed onto the radio channel data stream. The stream switching protocol also provides for an embedded remote diagnostics facility.

The two (asynchronous) user ports can be configured for a variety of baud rates, character sizes, parity, and stop bits.

Flow control on user Port_A may be set to use RTS/CTS/DTR/DCD handshake lines, or XON/XOFF characters. Flow control for Port_B may be set to use XON/XOFF characters, or no flow control. Port_B is not supported by RTS/CTS/DTR handshake lines.

Data is transported in (HDLC) frames, protected by a 16 bit CRC error checking sequence, conforming to the CCITT standard. Received frames found to contain errors are discarded. The TC-900DR does not release received data frames to the user port, until completely received, and error checked.

Maximum frame size is configurable for each port independently, and may be set to any value between 4 and 255 . Frame size limiting is disabled by setting this parameter to zero (0).

Each user port, is supported with PAD functions conforming to X 3 , or SLIP $^{\star 1}$ or KISS* protocol interface.

For Point To Multipoint applications, a unique collision avoidance mechanism is available, with configurable channel access parameters.

All configuration parameters are held in a non-volatile memory. Normally, this memory can only be written when the radio modem is connected to a programmer.

### 3.4.2 BRIEF OVERVIEW OF MODEM INTERNAL OPERATION.

### 3.4.2.1 DATA TRANSMITTER

Each physical user port, is supported by a "driver", in this case a PAD (Packet Assembler/Dis-assembler) or SLIP/KISS. This function transfers the data from the port, to a buffer memory. This buffer not only stores the raw user data, but also keeps track of frame boundaries. Another functional block, retrieves that stored data, and feeds it to a third mechanism, which generates the data waveform which is applied to the radio transmitter modulator.

[^2]
### 3.4.2.2 DATA RECEIVER.

The receiver extracts data frames from the received signal, and stores the contents of the frames into buffer memory. It may also perform a steering function, if more than one port is enabled. A second function is to retrieve the stored data, and send it to the user port(s), consistent with some flow control regime.

### 3.4.3 SELECTING FRAME SIZE

The selection of maximum frame size is a compromise between channel through-put and data propagation time over the link.

The receiving modem collects and stores the incoming data frame, and on detecting the end of the frame, checks if an error has occurred. If not, then the stored data is released for transfer to the user data port. If an error has occurred, then the stored data is "flushed" from the data store. Thus a delay is introduced between the time the frame data begins to enter the destination radio modem, and the time this data begins to emanate from the user port. This delay is effectively the length of the data frame, which consists of the user's data, plus the framing overhead. This overhead will include at least 24 bits for the HDLC Flag and FCS (error checking data), plus another 8 bits if SID (Stream IDentifier) codes are enabled (refer to detailed description elsewhere in this document), plus the duration of the transmitter Lead-In-Delay, if the radio transmitter had to be started up to send the data. Thus larger frames reduce the proportional overhead, but increase the end to end propagation delay.

On the assumption that the radio transmitter was already on, and that the frames include the SID header, then every frame includes 32 bits of overhead.

Assuming that the user port is configured for 8 bit character size ( 8 bit data no parity, or 7 bit data and parity), and 1 stop bit, then each character is carried as a 10 bit sequence on the asynchronous user channel. On the radio channel data stream, user data is stripped of the start and stop bits used on the asynchronous user port, and transmitted as eight bit "octets", and so the character rate is $1 / 8$ th of the bit rate, while on the asynchronous user port, the character rate is $1 / 10$ th of the bit rate. For every 16 user characters 32 bits are stripped off, so if the maximum frame size parameter is set to 16 , and the nominal baud rates are the same, then the effective character rates on the asynchronous user channel and the synchronous radio data channel will be the same. This also assumes that the supervisory signalling channel is not enabled, and does not allow for the overhead introduced by the HDLC "dummy zero" stuffing mechanism.

### 3.4.4 CONFIGURING PAD PARAMETERS

The Packet Assembler/Dis-assembler (PAD) can be configured with a variety of parameters. Each user port is supported by an identical but independent PAD.

The configuration parameters of the PAD, control how the user data (to be transmitted) is framed. There are three distinct mechanisms that can cause the frame that will carry the user data to be closed.

The first of these is the Maximum Frame Size parameter, already discussed above. As each character is input to the modem, a counter is incremented, and when this counter reaches the set maximum frame size, the data storage mechanism that operates within the modem, will close the frame. This function may be disabled, by setting the parameter to zero

The second mechanism, is the use of a specified End Of Message (EOM) character. This function is enabled/disabled by a flag in a configuration byte for the port driver. The EOM character may be any 8 bit character. When the EOM function is enabled, all incoming user data is compared to the selected EOM character code, and in the event of a match, the current frame is closed. Note that this match only triggers the frame closure mechanism. The matching character is not deleted from the user data stream, and in fact becomes the last user character in the frame.

The third mechanism, is the implementation of a timer. If the timer is enabled, each character received from the user port re-starts the timer. If the time duration between successive user characters allows the timer to expire, then the frame closure mechanism is invoked. The timer counts in units of "ticker clocks", which is a time interval generated by the modem internally, and is approximately 2.5 mS . The reload value for the timer can be set from 1 to 255 ticker clocks. The timer mechanism is disabled by setting the PAD timer parameter to zero.

There is a single bit configuration flag, that allows the radio modem to begin transmitting user data, even before the frame is deemed to be complete. In this case, as soon as there is any data in the storage buffer, the modem begins the transmission procedure. Providing that the input character rate is greater than or equal to the character rate on the synchronous radio channel, then there is no danger of an under-run condition, where the modem transmitter runs out of data before the PAD deems a frame end. However, should this occur, the modem data transmitter function simply closes the frame itself. Further data is carried in the next frame. This may or may not cause problems elsewhere in a system context. If higher protocol layers are employed (e.g. X.25, AX. 25 etc.), where address and control fields normally occupy fixed positions in data frames, then the above scenario should not be allowed to occur.

The major advantage of allowing the radio modem to begin the transmission procedure before the frame is deemed to be complete, is that it avoids a (store and forward) delay in the modem transmitter, similar to that required in the receiver. For applications where a transparent point to point link is all that is required, this mode provides the most time efficient transport mechanism.
In fact with the immediate transmission function enabled, there is little necessity to enable the EOM or timer functions of the PAD.

### 3.4.5 SUPERVISORY SIGNALLING CHANNEL: APPLICATIONS \& CONFIGURATION.

The reader is referred to drawing number TC01-05-18, which provides a diagramatic view of this section.

The Supervisory Signalling Channel (SSC) is implemented by the insertion of extra data bits in the primary bit-stream on the synchronous radio channel. These extra bits are inserted between primary data octets, at a rate which can be set to range from once every octet, to once every 15 octets. The SSC operates independently for transmit and receive directions, and can be disabled by setting the rate variable to zero.

The SSC, when enabled, can be configured either to provide end-to-end flow control for Port_A data, or implement the collision avoidance mechanism.

### 3.4.5.1 PORT_A END TO END FLOW CONTROL APPLICATION.

In this configuration, the SSC is used to carry flow control information for data on Port_A at each end of the link.

SSC data inserted into the transmitted bit-stream, relates to the flow of the primary data stream received. When handshake lines are employed, the DTR line locally controls the flow of receive data to the user port. The state of this line is also logically combined with the "fill" state of the receive buffer, and the result is then sent as SSC data in the transmit data stream. Thus the state of the transmitted SSC data bit is one ("1") if the DTR line is in a "false" state, OR the receive buffer is more than half (approximately) full. In the case where XON/XOFF flow control is used, the DTR line input is instead replaced with the state of the last received XON or XOFF control character.

SSC data extracted from the received bit-stream, is logically combined with the "fill" state of the transmit buffer, and the result is output to the CTS line of the modem. The CTS output line is set to "false" if the transmit buffer is more than half (approximately) full, OR the received SSC data bit is a one ("1"). Thus the CTS line is set to "false" if the local transmit buffer is more than half (approximately) full, OR the remote receive buffer is more than half full, OR the remote DTR input line is "false" (or equivalent XOFF received).

Data flow control is exercised only at the user port. No flow control is used on the radio channel, so once data is entered into the transmit buffer, it will be transmitted. This is the reason why the buffers are only allowed to become half full before the flow control mechanism engages. If the flow of receive data is stopped by deactivating the DTR line, the remaining data in the transmit buffer will not overflow the receive buffer. It should be noted that some hysteresis is used in the buffer occupancy tests, to prevent the CTS line from changing state too often, as some hosts (e.g. DOS machines) appear to get confused when this happens.

If the SSC is not configured for end to end flow control, or is disabled, then the flow control mechanisms still operate at a local level. That is, the CTS line (or equivalent XON/XOFF control regime) reflects the fill state of the local transmit buffer.

### 3.4.5.2 COLLISION AVOIDANCE APPLICATION.

When the SSC is allocated to transporting collision avoidance data, the transmitted SSC data reflects the state of the radio receiver. Other processes in the modem, measure the RSSI signal from the radio receiver, and compare this measurement to a preset threshold level. This threshold value is also held in the non-volatile configuration memory. The result of the comparison is copied to the modem pin that drives the RXSIG LED. The transition of the RXSIG signal from off to on, (re)starts an internal timer. This time is a fixed value of $35 \pm 5 \mathrm{mS}$. The SSC data transmitted, is simply a copy of the RXSIG pin state, until the timer terminates, and there-after, the modem data receiver must be "SYNC' d " to maintain the " 1 " state of the SSC transmit data. Thus the SSC data transmitted by the modem will indicate that the radio channel receiver is busy, using only RSSI for the first $35 \pm 5 \mathrm{mS}$, but after this time, data receiver SYNC is used to qualify this state. This prevents low level RF interference from effectively blocking the channel.

At the receiving end, the recovered SSC data is used by the radio modem to determine when the receiver of the destination station is free. This data can then be used to control it's channel access strategy. Channel access strategies are dealt with in more detail elsewhere in this document.

In such a data transport system, there is a single unit which performs the function of Master, and two or more stations which operate as Slaves. The SSC need only operate in one direction, that from Master to Slaves. In the reverse direction, the SSC can be disabled. That is the SSC in the Slaves is enabled in the data receiver only, while in the Master, it is enabled only in the data transmitter.

### 3.4.5.3 RECEIVED SSC DATA DEFAULT STATE

The received SSC data bit is stored in an internal latch. This latch is updated each time a SSC data bit is extracted from the incoming bit-stream. However, if the radio receiver looses signal, then a default state is forced into the latch. This default state is configurable.

For applications which use the SSC for collision avoidance, this configuration bit would normally be set to " 1 ", so that the remote station would not attempt channel access while the signal from the base is lost.

For applications which use the SSC for end to end flow control, setting the default state of the SSC receive data latch to " 0 ", would cause the CTS output line to indicate local flow control status only, until the destination unit enables it's transmitter, where-upon the received SSC data would reflect the state of the destination receive buffer and DTR input line. Alternatively, setting the default state to "1", would ensure that the CTS output line would be in a "FALSE" state, until the destination unit enables it's transmitter, where-upon the received SSC data would reflect the state of the destination receive buffer and DTR input line.

An associated configuration bit, is one that allows the automatic activation of the radio transmitter, whenever the data receiver attains SYNC. When this configuration bit is set to " 1 ", the modem will automatically activate the radio transmitter's PTT control line when the data receiver is SYNC'd. This could be used at the base end of a small point to multipoint network, using the SSC for flow control, and would not require the host connected to base, to specifically activate the radio transmitter to establish the end to end link.

### 3.4.6 SLIP/KISS PROTOCOL DRIVERS

In addition to a generic PAD, two other host interface protocols are supported, "Serial Line Interface Protocol", SLIP, which hails from the world of UNIX(tm), and an extension of SLIP, KISS "Keep It Simple Stupid", (a rather unfortunate phrase in the present context, but a protocol standard proposed by Phil Kahn, USA, specifically for the control of radio connected data terminals) which includes a facility to send commands which are addressed to the DCE device itself. These commands set operating parameters of the radio-modem DCE, such as transmitter lead-in delay, or radio channel (RF frequency).

Neither of these protocol standards, specify anything about the construction of data packets on the radio channel. Allocation of address, control, and information fields is the user's responsibility.

As standard, the modem is equipped with an 8K (8192 bytes, 32K optional) data storage memory to hold transmit and receive data. This memory is divided equally between transmit and receive buffer space, and equally between the two user ports, so the largest frame size is 4095 bytes, if only PortA is enabled, (or 2047 bytes each if both user ports are enabled), before the frame check sequence (FCS)is appended.

Additionally, the modem can store up to sixty four separate frames for each direction, again split between the two user ports if both are enabled, though the total byte count is still limited to 8192 total.

### 3.4.6.1 SLIP Protocol Description/Definition

The SLIP protocol, is a data transport protocol, originated and used extensively in UNIX(tm) based systems, and thus also closely associated with TCP/IP networked systems. Although not truly a "standard" it is so widely used that it has become the defacto standard for serial interface in UNIX and many other networked systems. SLIP is a method of framing messages containing binary data, on asynchronous channels. The asynchronous serial channel is configured for eight bit character size, no parity, and one stop.

A specific binary code called FEND (Frame End, hexadecimal value=C0) is reserved to define a frame boundary. Should this same code occur in the data message to be transferred across the channel controlled under SLIP, then an escape sequence is used so that the message byte will not be confused for a FEND. This escape sequence, involves replacing the message hexadecimal CO code with a two byte sequence FESC, TFEND. FESC (Frame Escape) is the binary code hexadecimal DB, and TFEND (Transposed FEND) is binary code hexadecimal DC. Likewise, if the FESC character ever appears in the user data, it is replaced with the two character sequence FESC, TFESC (Transposed FESC). The TFESC is the binary code hexadecimal DD. The following table clarifies this.

| ABBREVIATION | DESCRIPTION | HEX.VALUE |
| :---: | :--- | :--- |
| FEND | Frame end | C0 (192) |
| FESC | Frame escape | DB (219) |
| TFEND | Transposed frame end | DC (220) |
| TFESC | Transposed frame escape | DD (221) |

As characters arrive at the SLIP receiver, they are appended to a buffer containing the current frame. Receiving a FEND marks the end of the frame, and consequently, succeeding bytes are considered part of the next frame.

Receipt of a FESC code puts the SLIP receiver into "escaped mode", causing it to translate a following TFESC or TFEND back to a FESC or FEND code, appending it to the buffer, and resuming it's normal state. Receipt of any byte other than TFESC or TFEND while in escaped mode, is an error. No translation occurs, and the SLIP receiver leaves escaped mode. A TFESC or TFEND received while not in escaped mode is treated as an ordinary character and stored accordingly. Reception of consecutive FEND characters, causes no action to be taken (i.e. is not interpreted as zero length frames).

An example of a typical SLIP frame is shown below. The message consists of the string DA,C4,C0,C5,DB, 20,BD,DC,DD. The SLIP frame will be:-

$$
\begin{aligned}
& \text { <FEND>,DA,C4,<FESC>,<TFEND>,C5,<FESC>,<TFESC>,20,BD,DC,DD,<FEND> } \\
& ==>\quad C 0, D A, C 4, D B, D C, C 5, D B, D D, 20, B D, D C, D D, C 0
\end{aligned}
$$

### 3.4.6.2 KISS Protocol Description/Definition

The KISS protocol is an extension of SLIP. It uses the same method of framing packets, using FEND, FESC, TFEND, and TFESC codes. However, the first byte in each frame is reserved as a control code, that defines the function/content of the frame, and also contains an address.

This addressing scheme allows up to sixteen "Terminal node controllers" (TNC's), to share a multidrop buss. The top nibble of the control code carries the TNC address, and the lower nibble carries the command code. Normally the address is set at zero for installations containing only one TNC. Note that some extensions have been proposed for the KISS protocol, that properly support addressed multidrop line operation of multiple TNCs, that the present TC-900DR modem firmware does not implement. The following table shows the commands defined by KISS, and the comment column indicates how the TC-900DR modem interprets them.

## COMMAND FUNCTION

0 Data Frame
1 TxDelay

2 Slotnum
3 Slot-Time
4 TxTail

5

6 SetHardware

F ExitKISS

## COMMENTS

The rest of the frame is data to be transmitted.
The next byte is the RF transmitter key-up delay in octets.

The next byte is the Slotnum parameter.
The next byte is the "Slot" interval in "ticker clocks".
The next byte is the time to hold up the RF transmitter after the closing FLAG has been sent. This command is obsolete, and not implemented in the TC-900DR.

The next byte is zero for half duplex, non-zero for full duplex. This command is not implemented in the TC-900DR, as it always operates in full duplex mode.

Specific for each TNC. This parameter has values between 00 and 03, and commands the TC-900DR to set RF channels 0 to 3 . Values above 3 are ignored by the present modem firmware, but may be used in future versions.

Exit KISS and return control to higher level TNC control program. This command is not implemented in the TC-900DR.

### 3.4.7 RF TRANSMITTER CONTROL AND CHANNEL ACCESS STRATEGIES

There are three conditions which cause the modem to activate the radio transmitter. These are: a) receiver SYNC if enabled, as described above; b) RTS if enabled, as described below; and c) the existence of a data frame ready for transmission. The first two mechanisms are absolute, and if enabled, cause an immediate activation of the radio transmitter. There are two configuration bits that control how the availability of a data frame, will activate the radio transmitter, and thus gain access to the channel. For the purposes of this description, these are referred to as Modes A, B, and C.

In Mode A, channel access is immediate. The radio transmitter is activated, and the modem then proceeds to send a preamble sequence, followed by the data. The preamble sequence is necessary for receiver synchronisation, and the length is a configuration parameter. Further discussion of these aspects of the modem configuration are dealt with elsewhere in this document.

In Mode B, the modem will attempt channel access only if the radio receiver is NOT receiving a signal (i.e. the measured RSSI level is below the minimum RSSI threshold as described elsewhere in this document). This method could be used for small point to multipoint systems, where the base station would enable it's radio transmitter on receiving a transmission. Typically this would be done at the base unit by enabling the SYNC-PTT function, as described above. This implements a basic collision avoidance system, without the use of the Supervisory Signalling Channel, which then remains available for flow control applications.

In Mode C, the modem will attempt channel access only if the data receiver is SYNC'd, and the SSC data is "0" (i.e. base receiver free). This is the full Collision Avoidance system as described in detail above.

In the latter two cases, if another data frame is ready for transmission at the time the present one is ending, then it is automatically appended as another frame, and the transmission continues. Obviously since the radio transmitter is already enabled, no preamble is required or sent. The modem itself does not limit the number of consecutive frames it will transmit. If data continues to be input to the modem, once channel access is gained, it continues to be transmitted. It is the responsibility of the user to manage any maximum channel access time in overall system design. However, if the PTT timer is enabled (dealt with in detail elsewhere in this document), and the set time is reached, then the modem will disable the radio transmitter PTT line. User data will now be lost.

For the two latter strategies, if channel access fails (i.e. signal at radio receiver in the former case, or SSC=1 in latter case), then the modem uses a timed delay mechanism before testing for channel availability again.

### 3.4.7.1 SELECTING "SLOTIME" AND "SLOTNUM" VALUES

This delay time is necessary to prevent multiple remotes from attempting to gain access to the channel as soon as it is signalled to be clear after another transmission has finished, as this would result in the transmissions from all these remotes colliding. Instead, when a modem fails to gain channel access, it generates a randomly selected delay time, and when this time has expired, it again tests for channel availability.

There are two parameters which are used to generate the delay time. The "Slotime" parameter defines the size of the time increment used in selecting the delay. This value defines a time counted in "ticker clocks" (approximately 2.5 mS ), and has an allowable range of 0 to 255 . The "SlotNum" parameter defines the upper limit of the random number generator. The random number generator selects an integer between one and the value of "SlotNum", and then multiplies this by the value of "Slotime" to derive the delay time. The "SlotNum" parameter has a maximum allowable range of 1 to 16 .

These two parameters together provide a very flexible method of tuning the channel access characteristics of a system, and should be regarded as system tuning parameters. In the absence of any knowledge of a system configuration, Trio DataCom's set default values for these to parameters to 4 and 16 for "Slotime" and "SlotNum" respectively.

### 3.4.7.2 PTT CONTROL BY RTS LINE

Applications relying on establishing a point to point link before data is transferred, would normally require some "manual" method of activating the radio transmitter. A configuration bit enables the RTS input line to be used as a PTT control. The modem is always generating a data signal. During the time when no user data is available, the modem continually generates an "idle" bit-stream of HDLC FLAGs. This sequence produces no data output at the receiving radio modem.

### 3.4.8 SELECTING FLOW CONTROL REGIMES

The type of flow control to be used on the radio modem port(s), depends on the user's application and capabilities of the equipment which the user interfaces to the TC-900DR.

Port_A, which is always active, can be configured to use the standard RS232 handshake lines RTS/CTS/DTR, or use XON/XOFF protocol.

### 3.4.8.1 PORT_A, HARDWARE HANDSHAKE FLOW CONTROL

If hardware handshake lines are configured, then RTS must be active to validate characters input to the modem for transmission. As each character is received (i.e. at the end of each character bit sequence) the state of the RTS input line is tested to validate the character. If the RTS line is tested "true", then the character is stored ready for transmission. If "false", then the character is discarded. The modem provides flow control of transmit data with the CTS line. The CTS line is set "false" to indicate that no more transmit data should be input. Normally, most terminals or hosts will still send one or two more characters after the CTS line is set "false", and this is normal and allowed for in the CTS control logic. In fact the modem will continue to accept and store transmit data (providing the RTS line is still active) even though it has set the CTS line to "false", however the user then risks the occurrence of an overflow condition. If the transmit buffer becomes full, then further data is discarded.

A configuration bit, further controls the state of the CTS output line in relation to the RTS input line. If the bit is clear, then the CTS output will always indicate the flow control state, regardless of the state of the RTS input. If the bit is set, the CTS line is conditional on the state of the RTS input. If the RTS input is "false", then the CTS output is also "false". If the RTS input is "true", then the CTS output indicates the flow control state. This latter configuration is typical of a "wired" modem.

The modem's internal data store holds both the raw user data, and records the position of frame boundaries (as defined by PAD operation) in the data. A limited amount of memory is allocated to storing the frame boundary data. When this memory space is full, the modem sets the CTS output to false, even though the character storage space may not be full. The frame boundary storage space is sufficient to hold data for 64 frames. If the modem has both ports (Port_A and Port_B) enabled, then this space is evenly divided between the two, or if Port_B is disabled, then up to 64 frames can be stored for Port_A. If data continues to be input when the CTS line has been set to "false" because no more frame boundaries can be recorded, then the frame closure mechanism may abort. This has the effect that a frame will not be closed when defined by PAD configuration. An example of this, is where the PAD is configured to close the frame on receiving a <CR> (carriage return) EOM. If the frame boundary space is full, when a <CR> is input, then the subsequent characters will be appended to the same frame. Another attempt to create a new frame will not occur until the same or another frame close condition (as defined by PAD configuration) occurs, in this case another <CR>. This logic avoids the unnecessary loss of data.

Situations where the data storage space or frame boundary storage space become full, would be rare, and would only be likely to occur if the transmitter could not gain access to the channel, or the input data rate exceeds the channel transmission rate for some time.

Normally the TC-900DR is manufactured with an 8 kilobyte memory for data storage. This memory space is divided equally between transmit and receive data storage. If both user ports are enabled, then each half is equally divided between the ports (i.e. $2 \mathrm{~K} / 2 \mathrm{~K} / 2 \mathrm{~K} / 2 \mathrm{~K}$ for Port_A transmit, Port_A receive, Port_B transmit, Port_B receive). If Port_B is disabled, then 4 K is available for each of the transmit and receive data storage functions for Port_A.

The DTR line controls the flow of receive data to the user port. While the DTR input line is "true", available received data is output from the port. If the DTR input is "false", then receive data output ceases.

### 3.4.8.2 PORT_A XON/XOFF FLOW CONTROL PROTOCOL

When XON/XOFF flow control is configured for Port_A, the CTS line is set "true", the RTS input line is not required to validate input data, and receive data is not dependent on the state of the DTR line. Instead of controlling the CTS line, the modem sends XON/XOFF characters (embedded in the receive data stream), to the port. The flow of receive data is controlled by the receipt of XON/XOFF characters in the transmit data stream. These control characters are trapped out of the transmit data stream, and are not transmitted.

The underlying flow control logic is the same as RTS/CTS/DTR control. An XON is sent instead of a "false" to "true" transition of the CTS line, and an XOFF is sent instead of a "true" to "false" transition on the CTS line. A received XON is recorded by an internal flag that emulates a "true" state on the DTR line, and a received XOFF is recorded by the flag to emulate a "false" state on the DTR line.

This method of flow control would be considered to be less reliable, since a lost XON or XOFF control character could cause either an overflow condition, or data flow to stop altogether.

### 3.4.8.3 PORT_B FLOW CONTROL

User Port_B can be configured for no flow control, or XON/XOFF flow control. When XON/XOFF flow control is configured, it operates identically to Port_A, except that this port has no CTS line to set "true". Flow control on Port_B operates at a local level only, since end to end flow control via the SSC is available only for Port_A.

If XON/XOFF flow control is disabled, then no flow control is used on Port_B, as there are no RTS/CTS/DTR lines implemented on Port_B. Users should be careful to avoid overflow conditions, to avoid loss of data.

It will now be obvious that the RTS input line on Port_A can be used by more than one function in the modem. RTS can have no function, or be used in Port_A flow control, and/or provide a manual PTT facility.

### 3.4.9 SETTING MINIMUM RSSI LEVEL

The data receiver of the modem is continually running. It will be in one of two states. It is not SYNC'd, and thus looking for HDLC FLAGs in the radio receiver signal, or it is SYNC'd, and recovering frame data to be checked and stored. If the radio receiver is not receiving a signal, then the recovered signal applied to the data receiver of the modem, will consist only of noise. To prevent the modem from erroneously locking onto noise, a minimum RSSI level must be present to validate the recovered signal applied to the modem data decoder. This threshold level, is stored in the non-volatile configuration memory. It should be set by applying a signal to the radio receiver, which produces a desired SiNaD result, a desired bit error rate, or more crudely, a predetermined absolute signal level into the antenna connector of the TC-900DR. The modem (operating in Test/Program mode) is then commanded to measure the RSSI level, which produces a response of a message indicating the measured level, in hexadecimal. This process should be repeated several times, then an average taken. The analogue to digital conversion performed in this way, is an eight bit conversion. In normal operation, the modem performs a six bit conversion when measuring the RSSI level, so the average of the levels measured in the test mode should now be divided by four. The result should now be stored in the configuration memory, at the address reserved for it.

### 3.4.10 SETTING PTT TIMER

The modem implements a PTT timer. This timer can be disabled entirely by setting the PTT Timer configuration value to zero. The timer value is a 16 bit number, that counts in "ticker clocks". If the timer is enabled, whenever the modem activates the PTT control to the radio transmitter, it initialises the timer with the configured value. The timer is decremented while the PTT control remains active, and if it terminates, the PTT control is deactivated. No other action is taken, and all other functions within the modem are oblivious to this condition, so data frames continue to be output, and thus lost. The PTT timer is to be considered an emergency override mechanism only, in case an error occurs in the operation of the user's host equipment and/or software. To reset this time-out state, conditions must be met that would cause the modem to normally deactivate the PTT control. The PTT timer will then be re-initialised the next time the PTT control is activated. The time-out period may be set in "ticker clock" ( 2.5 mS ) increments to over 160 seconds.

### 3.4.11 DATA STREAM SWITCHING, SELECTING AND ENABLING SID CODES

The TC-900DR radio modem includes a feature that provides data stream switching. This is achieved by placing a Stream Identifier code (SID) at the beginning of every frame. This code functions as a simple addressing function. If both user ports of the TC-900DR are enabled, then SID codes should also be enabled, so that data frames carry a code which identifies the originating port ( A or B ), thus the port to which the frame data should be directed when the frame is received at the destination station.

However this stream switching mechanism is not only confined to this simple application. The SID codes for each user port, are contained in the configuration memory, and are thus "soft". It would be possible to engineer a small (up to 256 stations) network using an individual SID code for each remote station. Since the modem receiver will discard frames which are headed by an SID code which is not recognised, only frames specifically addressed would be stored and passed on to the attached host. The SID code is allocated to the port, so the modem uses the same SID code both for transmission and receipt of frames. Therefore in such a system, the master would be configured with SID codes disabled. The host attached to the master would preface each message with the eight bit address of the destination remote. The message from the remote emanating from the port will have the SID code removed. A message received from a remote, will have the SID code of the sending station at the beginning as the first byte. The remote modem itself places this code at the head of the frame.

Another application of the stream switching feature, is a remote diagnostics facility. This is a facility which is planned for release in the next firmware version. A reserved SID code will be used to address a diagnostics function within the modem. A command/addressing protocol is being developed that employs the units own unique serial number for addressing. "Stay tuned for further updates!".

The SID code is placed in the first octet of each frame. This provides up to 256 unique codes. However, to avoid possible future compatibility problems where higher level protocols are in use on the same channel (e.g. AX.25, etc.), it is suggested that the SID codes used have bit0 set to "1". Such higher level protocols normally use extended addressing where more than one octet is used to carry the destination/source address. A frame using an SID code with bit0 set, will fail an address test and be discarded by such systems. Conversely, if this modem receives a frame containing a higher level protocol, bit 0 of the first octet will normally be set to " 0 ", so will not match any SID code stored in the configuration memory, and be discarded.

By default, Trio DataCom sets the SID codes to 03 and 05 for ports A and B respectively. We have also reserved SID code 00 for the diagnostics facilities.

### 3.4.11.1 Separate Tx And Rx SID Codes. (Firmware Revision V2.1 onwards)

Firmware revision V2.1.0 onwards allows the Transmit and Receive SID codes to be different. Normally the RxSID and TxSID parameters (separate for each port) would be programmed the same. By programming them to be different, means that a TC-900DR unit will receive frames carrying a SID code that matches the configured RxSID code, but transmit frames which carry a SID code that is specified by the TxSID code configuration parameter. Applications for this feature are in small point to multipoint systems, using a central "community" repeater.

### 3.4.11.2 Repeater Operation Mode. (Firmware Revision V2.1 onwards)

The TC-900DR radio modem may also be configured in a repeater mode. The repeater function is enabled as a protocol driver on a port. Thus each user port driver can individually be configured for repeater operation. Essentially, what this does is automatically routes the received data frames back to the transmitter. If SID codes are enabled, then the original SID codes are stored as part of the data frame, and thus the retransmitted frame is identical to that received. Note that only frames received error free will be repeated.
When a port driver is configured for repeater operation, the RxSID and TXSID codes stored in configuration data in the NVRAM are used to define a range of streams to be repeated. The RxSID code configuration parameter defines the lowest SID stream to be repeated, and the TxSID code configuration parameter defines the highest SID stream that will be repeated. Thus it is possible to configure a unit to perform a repeater function for two separate ranges of streams, by configuring both user ports with a repeater driver, or to configure one end of a data link to also be a repeater for a range of other streams.

### 3.4.12 SETTING TRANSMITTER LEAD_IN_DELAY

Whenever the radio transmitter is activated a timer is started. No data frames are transmitted until this timer terminates, so that the destination unit receiver has time to synchronise it's data receiver before frame data is begun. The radio transmitter is very fast, reaching final output power and frequency stability in a matter of a few hundred microseconds (other sections of this document deal with the receiver synchronising aspects). This timer counts in octets, not "ticker clocks" as most other timed functions do, so the actual time elapsed is a function of the radio channel bit rate. However, the synchronisation time is primarily a function of the number of bits to the receiver. Trio DataCom would suggest a value of 25 to 50 (decimal) for this parameter, but it's final value will depend on signal strength and quality at the receiving point, and should best be determined by test.

### 3.5 FACTORS AFFECTING MODEM SYNCHRONISATION TIME

### 3.5.1 (UN)SCRAMBLER AND HDLC STATE MACHINE

It can be shown, that the un-scrambler in the receiving unit will synchronise to the scrambler in the sending unit in 17 bits maximum.

The receiving unit must then detect an HDLC FLAG, which will take another 15 bits maximum. Thus the HDLC state machine and unscrambler should be synchronised in 32 bits maximum.

### 3.5.2 PHASE LOCKED LOOP

Before valid data can be read for the unscrambler, the phase locked loop (PLL) must lock. The time required for this to occur is affected by signal quality and content. The PLL relies on level transitions of the binary signal, on which to lock. It essentially compares the phase of an internal counter, with the phase of the incoming data bits. A detected phase error, will cause the internal counter to speed up or slow down, to reduce the phase error. The greater the error, then the greater the speed adjustment to the internal counter.

If the incoming data stream has few transitions, then the internal counter will "catch up" to it quicker, since it's speed is adjusted less often. The PLL will synchronise to within $90 \%$ of the correct phase (from 0\%), in 16 to 36 bits time, depending on the number of transitions.

In practice, even though the PLL has not reached $90 \%$ lock, meaningful data will still be obtained as long as a good strength, clean signal is available.

### 3.5.3 ERROR CONTROL

Having recovered the raw data, the modem then applies the bit-stream to a de-ramdomiser, which is based on a recursive tapped shift register, described by the polynomial:

$$
X^{17}+X^{12}+1
$$

The output of the de-randomiser is then fed through another conversion function, to convert the NRZI data to NRZ.

The data is now an HDLC data stream, conforming to ISO3309. It is then applied to a function which detects HDLC FLAGs, and extracts "dummy zeros", which were inserted by the transmitter. Frame boundaries are detected at this point.

The modem calculates and appends a 16 bit Cyclic Redundancy Checksum (CRC) word to the end of each frame. This calculation uses the polynomial:

$$
X^{16}+X^{12}+X^{5}+1
$$

This is sometimes referred to as CRC-CCITT since it is a CCITT standard.

The 1's complement is taken of the calculation result and this FCS is appended to the end of the data frame and sent MSB first. (Refer to ISO 3309 for more information)

At the receiver, this calculation is repeated on the received data, and the result checked. A detected error, will cause the receiver to discard the entire frame. A higher protocol level (determined by the user) will detect the lost packet, and initiate a re-send of the packet.

In terms of the reliability of this FCS, it can be claimed that the following will be detected: 2

> All single bit errors.
> All double bit errors.

Any odd number of errors.
Any burst error less than 16 bits long.
Most large burst errors.
From here emanates the original frame data, provided the FCS was correct. If not then the frame data is discarded. The data is stored in externally addressed memory, connected to the modem IC. Maximum data packet size is determined by the amount of available memory. Normally the modem is fitted with an 8 K CMOS RAM, of which half ( 4096 bytes) is allocated to the receiver. The modem can be fitted with an external memory up to 32 K with no other modifications. The receiver section of the modem can store up to 32 separate data packets.

How this data is handled from this point on, depends on the user protocol implemented by the modem on the user interface.

### 3.5.4 TRANSMISSION FORMAT AND TIMING

The data to be transmitted is input to the modem, via the user interface protocol implemented on the user interface. The modem stores the data packet(s) in externally addressed memory, connected to the DFM4-9 modem IC. Maximum data packet size is determined by the amount of available memory. Normally the modem is fitted with an 8 K CMOS RAM, of which half ( 4096 bytes) is allocated to the transmitter. The modem can be fitted with an external memory up to 32 K with no other modifications. The transmitter section of the modem can store up to 32 separate data packets.

Most of the transmitter functions are performed internally in the modem IC, with only a DAC (Digital to Analogue Converter) and final low pass filter implemented by external circuitry.

The data is placed into an HDLC frame (consistent with ISO3309), complete with dummy zeroes where required. During transmission, a CRC calculation (CRC-CCITT) is performed, and when the end of the data packet is reached, this FCS (Frame Check Sequence) is appended to the end of the frame, before the closing HDLC FLAG.

Where two or more consecutive frames are sent, only one FLAG octet is used to delimit the frames. All frames are composed of an integral number of octets.

[^3]Data from the HDLC formatting stage is fed through a function, to convert the NRZ data to NRZI format.

The NRZI encoded data stream is now fed to a data randomiser, to ensure that there is no DC component to the data stream. This is based on a recursive seventeen bit shift register with two taps.

### 3.5.5 COLLISION AVOIDANCE SCHEME

The unique supervisory signalling channel facility available in this product is ideally suited to the implementation of a highly effective collision avoidance mechanism. This is a highly desirable feature in a multipoint data network, in that it allows vastly increased usage of the available channel capacity.

For instance, take a point-to-multipoint network, with a central base station, and a large number of remote data terminals scattered around the central station.

This is a split frequency duplex channel, where the central station is able to transmit on frequency F1, and simultaneously receive on frequency F2. Remote stations transmit on frequency F2, and receive on frequency F1.

If a transmission by one remote station is "crashed" by a transmission by another remote station, then the base station may not get the message correctly, and thus not acknowledge it. If there is no control over when the remote stations transmit, then because the remote stations cannot "hear" each other, their transmissions will begin to collide more often as the data traffic increases. This type of system will suffer a total blockage as the total traffic requirement approaches about $50 \%$ of the channel capacity.

Now, if the base station could quickly inform all other remote terminals, when the base receiver is busy because one of the remote terminals is transmitting, then this message can be delivered to the base receiver without being "jumped on" by another terminal blindly "crashing in". The next terminal can then deliver it's message when the receiver is signaled to be free. Of course collisions are still possible, but the occurrence of these can be dramatically reduced by this type of scheme.

Now to implementation specifics. The supervisory signalling channel in the modem, can be set independently for transmit and receive directions. For the purposes of this collision avoidance scheme, the supervisory signalling channel is only required in the base transmit direction. In the reverse direction, the supervisory signalling channel is disabled. The base transmitter is active full time, sending only FLAGs when it has no real data to send. The base controller, then indicates to the whole population of remote terminals, the current status of the base receiver, in the value of the supervisory signalling channel data bits.

The remote data terminals are programmed so that they will not begin a transmission if the received supervisory signalling channel data indicates that the base receiver is currently busy. This would result in remote terminals queuing for access to the base receiver. To prevent all these remote terminals all beginning a transmission as soon as the base indicates a free receiver, a "windowed" timing mechanism would be implemented, with a random factor added in the terminal's selection of a "window".

There are many factors that would determine the quantification of system variables, but this short description serves to illustrate a basic approach.

### 3.6 TEMPERATURE COMPENSATION

Periodically, the modem controller reads the voltage on the temperature transducer mounted on the radio section. This value is then used in a table look-up procedure, to derive correction data to be applied to the modulator circuitry via a transmit waveform offset voltage. This is provided by the output of the six bit DAC (UX8/RN2), which is fed to the correction voltage input of the 12 MHz reference oscillator.

The offset table is constructed in the temperature calibration cycle performed during the factory testing procedure. The radio-modem is temperature cycled twice from -10C to +65 C . During this time, the necessary data is determined to correct the temperature induced frequency errors. At the end of the cycle, the final database is constructed and written to the non-volatile memory.

### 3.7 USER INDICATIONS

The TC-900DR provides three LED's that show status information to the user - RXSIG, SYNC, and TXMIT indications.

In all operation modes of the modem except "Programmer mode" (see the section below on special modes of operation), the RXSIG LED indicates the level of the RSSI signal from the radio IF strip, compared to a threshold set in the configuration data read from the non-volatile memory. If the signal is above the threshold, then the LED indicator is turned on. There is no hysteresis applied in this process.

In normal operation, the SYNC LED indicates when the modem has detected a valid data stream. The SYNC LED is activated, when the modem detects a valid HDLC flag sequence, and remains active until an invalid sequence of seven or more consecutive "1" bits is detected. The SYNC LED will not be turned on if the RSSI signal strength (as indicated by the RXSIG LED) is below the minimum threshold. This prevents false SYNC detection from noise. While the modem is SYNC'd, it does not continue to measure RSSI levels.

The TXMIT LED indicator is connected directly to the modem's PTT output transistor. It is active whenever the PTT line to the radio section is active low.

### 3.8 SPECIAL MODES OF OPERATION

### 3.8.1 GENERAL

Part of the power-up/reset initialisation phase of the TC-900DR modem, is a set of tests to determine whether the modem should enter a special operation mode.

There are three of these "special" modes. Whilst in these modes the TC-900DR will not operate in its standard run mode.

- Programmer mode.
- Bit error rate test mode.
- Handset mode.

These modes are only entered if the required setup conditions are present at power up of the TC-900DR. An error mode of operation can also be entered into, if during normal operation of the TC-900DR modem, an error condition occurs.

### 3.8.2 PROGRAMMER MODE

Pin 6 on the DB9 connector of Port A, is normally the DSR line. This pin is pulled high by a resistor to +13.8 v , so that to a connected DTE the DSR signal implies that this DCE is ready.

However, if this pin is connected to pin 5 when the modem is powered up, the controller senses this, and attempts to enter "Programmer mode". The modem sends out of the serial port, an ASCII "?" (question mark) character, and waits for the programmer to reply with a password. The SYNC LED toggles on and off with every output of the "?" prompt until the correct password is entered. This mode is sustained for approximately 30 seconds. Failure to supply the correct password in time, will cause the modem to abandon the "Programmer mode" attempt, and go on with it's normal power-up procedure. This password protection scheme provides some defense against unauthorised tampering with the TC-900DR modems configuration data.


### 3.8.3 BIT ERROR RATE TEST MODE

Pin 9 of the DB9 connector of Port A, is normally the Ring Indicate output line. The modem includes a resistive pulldown to ground to show a negative condition on this line. However, if this pin is driven positive (typically by connecting it to pin 6), then the modem's data transmitter and receiver will enter the BER test mode.

It will activate the RF transmitter and generate a scrambled bit pattern which should be decoded at a receiver as a constant logic "1" level in the unscrambled data.

A test point on the modem section PCB, is available to monitor this point with a frequency counter. (In fact this test point is always active, and may be used to monitor the received data decoded by the DFM4-9 modem IC at any time). Any errors in the decoded bitstream, will be " 0 ", and the receiver portion of the modem in this mode, will activate the SYNC LED every time it sees a "0" bit.
An internal timer is used to generate a time equivalent to 1000 bits. Every error bit detected, will activate the SYNC LED, and restart the timer. If and when the timer expires, the SYNC LED is deactivated. Thus, for error rates of 1 in 103 and above, the SYNC LED will be ON most of the time. A 1 in 104 error rate will show the SYNC LED active for approximately $10 \%$ of the time. This function provides a crude indication of Bit Error Rate for installation purposes.

Other functions performed in this state include RXSIG indication, and temperature compensation. The state of pin 9 is constantly monitored in this mode. If the pin ceases to be driven positive, then the BER Test mode is terminated, and the modem restarts it's initialisation phase.

### 3.8.4 HANDSET MODE

The DFM4-9 modem tests for the presence of a handset plugged into the handset audio port at power up.

This is done by measuring the voltage on channel 4 of the analogue to digital converter (UX10-p6). This signal is passed into the modem section from the radio section via connector X4-p24, "ADC3".

If a handset is plugged in, then the measured voltage will be about 2 V , but if it isn't installed, then the voltage will be about 4 V . The measured voltage is compared to 3 V to determine whether the handset is plugged in. If this test succeeds, then the modem will not generate a data stream. However, it will continue to indicate received RF signal strength, and perform temperature compensation. The handset has a PTT button, and this signal is connected across the modem's PTT output. Thus the handset PTT switch will activate the TXMIT LED.

### 3.8.5 ERROR INDICATION MODES

### 3.8.5.1 GENERAL

There are three error conditions that will cause the RXSIG and SYNC LEDs to be used for error indications and not their normal purpose. Two of these are fatal conditions, that cause the modem to restart after the duration of the error indication phase.

### 3.8.5.2 TRANSMIT POWER LOW

While the modem activates the radio transmitter, it periodically checks the transmit power. If the power measurement is less than a threshold set in the non-volatile memory, then the RXSIG and SYNC LEDs are made to alternate, approximately four times per second. The TXMIT LED will also be on during this process. This indication condition will persist for the duration of the transmission. As soon as the transmission is discontinued, the error indication will cease, and the two LEDs revert to their normal function.

### 3.8.5.3 NVRAM READ ERROR

The DFM4-9DR modem accesses the non-volatile memory as part of it's initialisation phase, to get configuration data. If the communication protocol with the device is violated, or the non-volatile memory CRC checksum is found to be incorrect, then the modem indicates this by flashing the RXSIG and SYNC LEDs twice alternately. That is, one LED operates ON and OFF twice, then the other. A total of five cycles of this occurs, then the modem restarts it's initialisation from scratch.

### 3.8.5.4 SYNTHESISER LOCK DETECT ERROR

If at any time during normal operation, BER mode, or handset mode, the TBB206 frequency synthesiser indicates an out of lock condition, the modem enters an error indication mode for a short time before restarting. One LED is turned ON ( 0 ), the LEDs are swapped, then both turned OFF (*). Then the latter LED ON again, swap LEDS, and then OFF. This will give the appearance of a sweeping motion between the LEDs.

The following table shows all error condition displays for comparison.

| Tx PWR Error |  | NVRAM Error |  | TBB206 Error Synthesiser |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| RXSIG | SYNC | RXSIG | SYNC | RXSIG | SYNC |
| 0 | - | 0 | - | 0 | - |
| - | 0 | - | - | - | 0 |
| 0 | - | 0 | - | - | - |
| - | 0 | - | - | - | 0 |
| 0 | - | - | 0 | 0 | - |
| - | 0 | - | - | - | - |
| 0 | - | - | 0 |  | repeat |
| - | 0 | - | $\bullet$ |  |  |
| continue |  |  | repeat |  |  |

### 3.9 SYNCHRONOUS OPERATION MODE FIRMWARE REVISION: V2.1

### 3.9.1 GENERAL

The TC-900DR when operating in Synchronous mode, implements a V. 24 like interface. The unit uses a special wiring harness that converts the two 9 pin "D" connectors on the end panel of the TC-900DR to a standard 25 pin "D" connector for user interface.

Synchronous Mode implements a bit level interface. Data is carried on a bit by bit basis. No framing or error detection is performed. Modem operation is full duplex.

Current implementations of SYNC mode, do not provide a DCD signal in the 25 pin RS232 interface.

### 3.9.2 DATA RECEIVER

While sufficient RF signal is present into the radio receiver, the data decoder is continually extracting data bits from the received signal, and outputting these to the user interface connector. If the received RF signal into the radio receiver falls below the minimum threshold, then the data decoder stops.

### 3.9.3 SETTING MINIMUM RSSI LEVEL

The data decoder of the modem is continually running while sufficient RF signal is present into the radio receiver. If the radio receiver is not receiving a signal, then the recovered signal applied to the data decoder of the modem, will consist only of noise. To prevent the modem from erroneously locking onto noise and producing "garbage" at the RxD pin, a minimum RSSI level must be present to validate the recovered signal applied to the modem data decoder. This threshold level, is stored in the non-volatile configuration memory. It should be set by applying a signal to the radio receiver, which produces a desired bit error rate, a desired SiNaD result, or more crudely, a predetermined absolute signal level ' into the antenna connector of the TC-900DR. The modem (operating in Test/Program mode) is then commanded to measure the RSSI level, which produces a response of a message indicating the measured level, in hexadecimal. This process should be repeated several times, then an average taken. The analogue to digital conversion performed in this way, is an eight bit conversion. In normal operation, the modem performs a six bit conversion when measuring the RSSI level, so the average of the levels measured in the test mode should now be divided by four. The result should now be stored in the configuration memory, at the address reserved for it. The DR9_PRGM programmer available from Trio DataCom Pty Ltd facilitates this process.
*Use a signal generator modulated with a sine wave frequency of half the nominal bit rate of the unit (e.g. for a 4800 BPS unit, use 2400 Hz modulation).

### 3.9.4 DATA RECEIVER CLOCK OUTPUT

The receive section of the modem, includes a clock line driven by the modem. This signal is used to synchronise the transfer of receive data to the user system. The RCO (Rx_Clock_Output, pin17 in the DB25 connector) line changes from ON (TRUE) to OFF (FALSE) as the RxD (Receive_Data, pin3 in the DB25 connector) line outputs the next bit, and from OFF (FALSE) to ON (TRUE) in the nominal centre of the bit cell. This conforms to the V. 24 specification.

### 3.9.5 OTHER RS232 RECEIVER CONTROL LINES

The DSR (Data_Set_Ready) line is driven true by the modem. This line is in fact merely tied to the internal +13.8 volt rail via a 4 K 7 resistor. The DTR (Data_Terminal_Ready) input is unused in Synchronous mode.

### 3.9.6 DATA TRANSMITTER

The transmit data input is continually sampled and coded for transmission. This process consists of sampling the data input, randomising the bit pattern so that the DC component of the transmitted stream is zero, and generating a waveform suitable for application to the modulator of the FM radio transmitter.

### 3.9.7 DATA TRANSMITTER CLOCKS

The modem transmit data interface, includes two clock lines. One clock line, TCO (Transmit_Clock_Out, pin15 in DB25 connector) is driven by the modem, the other, TCl (Transmit_Clock_In, pin24 in the DB25 connector) can be enabled to allow the external user to supply a transmit data clock. This is implemented by synchronising the internal clock generator to the user's clock (within a small frequency range). This function is essentially a Phase Locked Loop, and effectively adjusts the phase of the internal clock to match that of the input clock. If the user clock source stops, then the modem will continue to generate the internal clock at it's nominal rate. In accordance with specification V.24, the state of the transmit data line (TxD, pin2 in the DB25 connector) is sampled on the ON to OFF transition of the clock, the bit cell boundary occurs with the OFF to ON transition of the clock.

### 3.9.8 TRANSMITTER RTS/CTS LINES

Two other control lines are included in the transmitter interface. The RTS (Ready_To_Send) input line, is used to control the radio RF transmitter. The CTS (Clear_To_Send) output line is driven by the modem, to indicate that the modem transmitter is ready to accept transmit data. The RTS to CTS time is determined by an internal timer. A configuration parameter is used to load the internal timer when the RTS line is activated, which must expire before the modem activates the CTS line. This time is necessary to allow the remote receiver to settle and synchronise to the data stream, before the user at the transmitting end begins sending data. However it should be noted, that the CTS signal does not perform any flow control function within the modem.

### 3.9.9 PHASE SYNCHRONISM WITH GLOBAL CLOCKS

When data is transferred over more than short distances, and synchronism must be maintained to some external global master clock (e.g. Telecom DDN network), then the propagation delay, and thus phase shift of the data becomes significant. A facility is provided, to introduce a phase delay in the transmitted data stream, of up to $3 / 4$ of a bit, in $1 / 4$ bit steps. This delay is adjusted so that minimum phase offset results at the receiver of the destination station.

### 3.9.10 TRANSMIT TIMER

The modem implements a transmit (PTT) timer. This timer can be disabled entirely by setting the PTT Timer configuration value to zero. The timer value is a 16 bit number, that counts in increments of 2.5 milliseconds. If the timer is enabled, whenever the modem activates the PTT control to the radio transmitter, it initialises the timer with the configured value. The timer is decremented while the RTS line remains active, and if it terminates, the PTT control is deactivated. No other action is taken, and all other functions within the modem are oblivious to this condition, including the CTS line, so data continues to be "carried", and thus lost. The PTT timer is to be considered an emergency override mechanism only, in case an error occurs in the operation of the user's host equipment and/or software. To reset this timeout state, the RTS line must be taken from ON to OFF. The PTT timer will then be re-initialised the next time the RTS line is activated. The timeout period may be set in 2.5 mS increments to over 160 seconds.

### 3.9.11 LED INDICATORS

### 3.9.11.1 Received Signal Strength Indication. RXSIG LED

In all operation modes of the modem except "Programmer Mode" (see section below on special modes of operation), the RXSIG LED indicates the level of the RSSI signal from the radio IF strip, compared to a threshold set in the configuration data read from the non-volatile memory. If the signal is above the threshold, then the LED indicator is turned on. There is no hysteresis applied in this process.

### 3.9.11.2 Data Carrier Detect Indication. SYNC LED

In "Synchronous" operation mode (V2.1.x), prior to modem hardware revision "D", and firmware revision "V2.1.4", the SYNC LED is superfluous and not driven.

## Note that firmware revision V2.1.5 onwards should only be used in SYNC mode.

From modem hardware Revision D onwards, the SYNC LED drive is used to generate a DCD function in the user interface connector, and requires firmware revision V2.1.4 onwards (i.e. firmware revision V2.1.4 onwards drives the SYNC LED ON 20 mS after the "leading edge" of the RxSig LED).

This means that the SYNC LED drive should always show this function and not be allowed to show low Tx Power (see Error indication modes section 3.8.5.2). To facilitate this the Min Tx Pwr parameter in the TC-900DR modem should be set to zero, when the modem is built for synchronous operation.

### 3.9.11.3 Radio Transmitter Active Indication. TXMIT LED

This LED indicator is connected directly to the modem's PTT output drive. It is illuminated whenever the PTT line to the radio board is active.

### 3.9.12 SPECIAL MODES OF OPERATION

### 3.9.12.1 Programmer Mode

Part of the power-up/reset initialisation phase of the modem, are tests to determine whether the modem should enter a special operation mode. The first, is a test for "Programmer Mode". Pin6 on the DB9 connector of Port A, is normally the DSR line. To this end, this pin is pulled high by a resistor to +13.8 v , so that to a connected DTE this signal says that this DCE is ready. However, if this pin is connected to pin5 (Com) when the modem is powered up, the modem senses this, and attempts to enter "Programmer Mode". The modem sends out of PORTA, an ASCII "?" (question mark) character, and waits for the programmer to reply with a password. Failure to supply the correct password in time, will cause the modem to abandon the "Programmer Mode" attempt, and go on with it's normal power-up procedure. This password protection scheme provides some defence against unauthorised tampering with the radio/modem's configuration data.

### 3.9.12.2 Bit Error Rate Test Mode

The next test, is one for "Bit Error Rate Test Mode". Pin9 of the DB9 connector of Port A, is normally the Ring Indicate output line. The modem includes a resistive pulldown to Gnd to show a negative condition on this line. However, if this pin is driven positive (typically by connecting it to pin6), then the modem's data transmitter and receiver will enter the BER test mode. It will activate the RF transmitter and generate a scrambled bit pattern which should be decoded at a receiver as a constant logic "1" level in the unscrambled data. A test point on the modem PCB, is available to monitor this point with


#### Abstract

a frequency/event counter. (In fact this test point is always active, and may be used to monitor the received data decoded by the modem IC). Each error bit in the decoded bitstream, will be " 0 ", and the receiver portion of the modem in this mode, will activate the SYNC LED every time it sees a "0" bit. An internal timer is used to generate a time equivalent to 1000 bits. Every error bit detected, will activate the SYNC LED, and restart the timer. If and when the timer expires, the SYNC LED is deactivated. Thus, for error rates of 1 in $10^{3}$ and above, the SYNC LED will be ON most of the time. A 1 in $10^{4}$ error rate will show the SYNC LED active for approximately $10 \%$ of the time. This function provides a crude indication of Bit Error Rate for installation purposes. Other functions performed in this state include RXSIG indication, and temperature compensation. The state of pin9 is constantly monitored in this mode. If the pin ceases to be driven positive, then the BER Test mode is terminated, and the modem restarts it's initialisation phase.


### 3.9.12.3 Order_Wire/Handset Mode

Failure of the BERT Mode test, brings the modem to test for the presence of a handset plugged into the handset audio port. This is done by measuring the voltage on channel 4 of the analogue to digital converter. If a handset is plugged in, then the measured voltage will be about 2 volt, but if it isn't installed, then the voltage will be about 4 volt. The measured voltage is compared to 3 volt to determine whether the handset is plugged in. If this test succeeds, then the modem will not generate a data waveform to the radio transmitter. However, it will continue to indicate received RF signal strength, and perform temperature compensation. The handset has a PTT button, and this signal is connected across the modem's PTT output. Thus the handset PTT switch will activate the TXMIT LED.

### 3.9.12.4 Error Indication Modes

There are three error conditions that will cause the RXSIG and SYNC LEDs to be used for error indications and not their normal purpose. Two of these are "fatal" conditions, that cause the modem to restart after the duration of the error indication phase.

### 3.9.12.5 Transmit Power Low

While the modem activates the radio transmitter, it periodically checks the level of the radio transmitter output power. If the power measurement is less than a threshold set in the non-volatile memory, then the RXSIG and SYNC LEDs are made to alternate, approximately four times per second. Of course, the TXMIT LED will also be on in this case. This indication condition will persist for the duration of the transmission. As soon as the transmission is discontinued, the error indication will cease, and the two LEDs revert to their normal function. The user should be aware that from Revision D of the modem PCB, this state will cause incorrect operation of the DCD output line. As stated above, the Min Tx Pwr parameter should be set to zero.

### 3.9.12.6 NVRAM Read Error

The modem accesses the non-volatile memory as part of it's initialisation phase, to get configuration data. If the communication protocol with the memory device is violated, or the non-volatile memory CRC checksum is found to be incorrect, then the modem indicates this by flashing the RXSIG and SYNC LEDs twice alternately. That is, one LED winks on and off twice, then the other. A total of five cycles of this occurs, then the modem restarts it's initialisation from scratch.

### 3.9.12.7 Radio Frequency Synthesiser, Lock Detect Error

If at any time during normal operation, BERT mode, or handset mode, the frequency synthesiser indicates an out of lock condition, the modem enters an error indication mode for a short time before restarting. One LED is turned ON, the LEDs are swapped, then both off. Then the latter LED ON again, swap LEDS, and OFF. This will give the appearance of a sweeping motion between the LEDs. The following table shows all three modes for comparison.

Tx PWR Error
NVRAM Error
TBB206 Error
Synthesiser

| RXSIG | SYNC | RXSIG | SYNC | RXSIG | SYNC |
| :--- | :--- | :--- | :--- | :--- | :--- |
| 0 | $\bullet$ | 0 | $\bullet$ | 0 | $\bullet$ |
| $\bullet$ | 0 | $\bullet$ | $\bullet$ | $\bullet$ | 0 |
| 0 | $\bullet$ | 0 | $\bullet$ | $\bullet$ | $\bullet$ |
| $\bullet$ | 0 | $\bullet$ | $\bullet$ | $\bullet$ | $\vdots$ |
| 0 | $\bullet$ | $\bullet$ | 0 | 0 | $\bullet$ |
| $\bullet$ | 0 | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ |
| 0 | $\bullet$ | $\bullet$ | 0 |  | repeat |
| $\bullet$ | 0 | $\bullet$ | $\bullet$ |  |  |
| continue |  |  |  | repeat |  |

3.9.13 WIRING ADAPTOR HARNESS FOR TC-900DR SYNCHRONOUS MODEL

| PORT A | 1 (DCD) | (RCO) | 17 | DB25F |
| :---: | :---: | :---: | :---: | :---: |
|  | 2 (RxD) | (RxD) | 3 |  |
|  | 3 (TxD) | (TxD) | 2 |  |
|  | 4 (DTR) | (DTR) | 20 |  |
|  | 5 (Com) | (Com) | 7 |  |
|  | 6 (DSR) | (DSR) | 6 |  |
|  | 7 (RTS) | (RTS) | 4 |  |
|  | 8 (CTS) | (CTS) | 5 |  |
|  | 9 (RI) |  |  |  |
| PORT B | 1 (DCD) | (DCD) | 8 |  |
|  | 2 (RxD) | (TCO) | 15 |  |
|  | 3 (TxD) | (TCI) | 24 |  |
|  | 4 |  |  |  |
|  | 5 (Com) |  |  |  |
|  | 6 (DSR) |  |  |  |
|  | 7 |  |  |  |
|  | 8 |  |  |  |
|  | 9 (RSSI) |  |  |  |

## SECTION 4

## ALIGNMENT PROCEDURE

## 4 ALIGNMENT PROCEDURE

### 4.1 GENERAL

This section details operational performance and alignment procedures that may be required for the TC-900DR. During servicing it may also be necessary to measure specific performance parameters as a means of verifying the presence of a fault condition.

### 4.2 TEST EQUIPMENT REQUIRED

The following list of test equipment is required to carry out all of the procedures detailed below.

Frequency counter accurate to better than 100 Hz at 1 GHz
FM Signal generator. 455 kHz to $1 \mathrm{GHz} .-120 \mathrm{dBm}$ to +10 dbm .
Synthesised in 100 Hz steps.
Spectrum analyser 10 MHz to 1 GHz . Dispersion down to $2 \mathrm{kHz} / \mathrm{cm}$. $80+$ dB dynamic range. IF b/w down to 1 kHz .

RF Power meter to $1 \mathrm{GHz} .-20$ to +30 dbm . Accuracy $\pm 0.25 \mathrm{~dB}$.
Digital volt meter.

- HP3406 RF Millivoltmeter or similar.
- RF Test leads, MCX male and SMA male.
- Audio noise and distortion test set.
- Audio oscillator.
- Surface mount repair tools.


### 4.3 TEST POINT LOCATIONS

Both the radio section PCB and the modem section PCB contain numerous test points. They are easily located on the PCB's, and are detailed below.

### 4.3.1 MODEM SECTION PCB

| TEST POINT | SIGNAL | DESCRIPTION |
| :---: | :---: | :---: |
| TP1 | TxCLK | Transmit clock |
| TP2 | BER TST | BER test output |
| TP3 | SYNC | Synchronised output |
| TP4 | RxCLKOUT | Integrator reset |
| TP5 | RxCLK | Receive clock |
| TP6 | RxDATA | Receive data |
| TP7 | DATA OUT | Transmit data |
| TP8 | INTEGRATOR | Rx integrator reset |

### 4.3.2 RADIO SECTION PCB

## TEST POINT SIGNAL DESCRIPTION

FINAL PA SECTION

TP31
TP25
TP27
TP14
TP15
TP20
TP28
TP29
TP26
TP33
TP30
121 MHz SECTION

| TP13 | DATA | Tx data input |
| :--- | :--- | :--- |
| TP17 | 60.5 MHz | Modulated 60.5 MHz |
| TP16 | 121 MHz | Output of doubler |
| TP18 | 121 MHz | Modulated 121 MHz |
| TP32 | MIC | Tx Mic audio input |

NE615 IF SECTION
TP6
TP9
TP8
TP10
TP7
TP4
TP1
TP2
TP3
TP5
TP19
TXPWR-2 Bias to Q8
TXPWR-3 Bias to Q8
TXPWR-4 Bias to Q9
+8v Power Supply
TXEN Transmit enable
RxMIXOUT Rx mixer bias
TXPA-1 Bias to Q10
TXPA-2 Bias to Q11
+13V8 Power supply
PWR CONT Power control supply
PTT+8V Press to talk

| SYNTHESISERNCO SECTION |  |  |
| :---: | :---: | :---: |
| TP12 | LOCK DET | Synthesiser lock detect |
| TP11 | +5 V | Synthesiser +5 v supply |

AUXILIARY HANDSET INTERFACE SECTION
TP21 MIC Tx mic audio input
TP22 PTT Manual press to talk
TP23 +8V Handset +8 V supply
TP24 AUDIO OUT Rxaudio output

### 4.4 ADJUSTMENT POINTS

All adjustment points are located on the radio section PCB. The following is a list of these adjustable components.

| COMPONENT | ADJUSTMENT |
| :---: | :---: |
| XTAL2 | VCO reference frequency |
| VR3 | Deviation level set |
| L10 | Tripler filter |
| L9 | Doubler filter |
| L7 | 121 MHz filter |
| L8 | 121 MHz final filter |
| L6 | Tx frequency set ( 121 MHz Osc ) |
| VR4 | Tx power control adjust |
| C78 | Tx mixer tunable filter |
| VR1 | Rx audio mute adjust |
| VR2 | Rx data DC BIAS offset adjust |
| L3 | 45 MHz filter alignment |
| L1 | 44.545 oscillator adjust |
| L4 | 45 MHz filter alignment |
| L5 | 45 MHz filter alignment |

### 4.5 LINK OPTIONS

Several options are set in the TC-900DR modem by the setting of links on the radio section PCB. Listed below is an option table for the various combinations.

| LINK NUMBER |  | SETTING |  |  |
| :--- | :--- | :--- | :--- | :--- |
|  | DESCRIPTION |  |  |  |
|  | IN |  | AFC option disabled |  |
|  | OUT |  | AFC option enabled | (factory standard) |
| LK4 | IN |  | PWR control disable |  |
|  | OUT | PWR control enabled |  |  |

### 4.6 HOUSING

The TC-9000R has been designed with the serviceability of the unit in mind. Construction of the unit is robust yet easily dismantled. The unit is primarily assembled in an aluminium extrusion with a central chassis that is fixed to the front panel.

### 4.6.1 DISASSEMBLY PROCEDURE

To disassemble the unit, simply remove the two silver screws on the underside of the unit and the six black screws located on the front panel (the front panel of the unit has the two DB9 connectors protruding from it). Ensure you do not loose the attached nylon washers, as these prevent the Lexan front panel label being damaged upon replacing and tightening the six screws. Simply slide the unit out of the extrusion clasping front panel and the complete unit is exposed to you.

Caution: When re-assembling be careful not to foul the ribbon cable against the case when sliding the unit into its case as this may inadvertently damage the cable.

### 4.6.2 MODEM AND POWER SUPPLY PCB

All components and connections to the modem section PCB are accessible without removing the PCB from the chassis. If access to the rear of the PCB is required, firstly remove two nuts that clamp the C TO-220 power supply regulator to the front panel. Once this is removed, simply remove the four screws securing the PCB to the chassis.

The PCB is now free to work on, and can be folded out so as to service the unit in an open accessible condition whilst still connected to the radio section PCB. If required, the modem section PCB can be separated from the radio section PCB by simply unplugging the ribbon cable.

NOTE: Regulators will need to have heat-sinks fitted if unit is to be operated in this condition for excessive time periods.

### 4.6.3 ANTENNA DIPLEXER

The antenna diplexer is mounted on top of the radio section PCB. It is easily removed by firstly disconnecting the two miniature RF connectors (MCX type) from the PCB.

Care should be taken when unplugging these connectors so as not to damage them, it is important to remove and insert connectors in a vertical direction.

Secondly, remove the nut securing the antenna output connector from the central mounting chassis. The last two remaining screws must be removed which secure the diplexer to two metal PCB standoffs on the radio section PCB. The diplexer can now be removed.

Testing of the radio section PCB can be continued without the antenna diplexer, by connecting to the receiver and transmitter ports separately.

Miniature MCX RF Connectors are available from Trio DataCom if required.

### 4.6.4 RADIO SECTION PCB

The radio section consists of a two sided PCB which has surface mount components on one side and conventional components on the other. Several critical test points are accessible on the component side of the PCB which minimises removal of the PCB from the chassis.

To remove the PCB from the chassis, fifteen screws must be removed. Upon removal of these screws, the PCB can be manoeuvred from the chassis and once again can fold out so as to be serviceable as a complete unit.

NOTE : It is essential that all RF Deck mounting bolts are fitted and secure upon reassembly as many of these bolts provide inter-stage isolation and secure grounding ensuring the product meets all specifications.

Once service of the unit is complete, reassembly is simply the reversal of the above procedures.

Care should be taken when sliding the complete chassis assembly back into the extrusion. Ensure that the ribbon cable connecting the modem and radio section PCB's is carefully "tucked" away within its designated slot so as not to damage the cable.

### 4.7 ALIGNMENT DESCRIPTION

CAUTION - As the TC-900DR is capable of full duplex operation, care should be taken to avoid damage to sensitive test equipment such as signal generators or spectrum analysers. It is recommended that a 30 db 2 Watt pad be connected between the unit and any test equipment prior to testing.

This section is for alignment/adjustment of the RF Deck and should be read in conjunction with Section 2 (Hardware Technical Description) and Section 7 (Fault Finding) if faults or difficulties are experienced.

For initial alignment, proceed in the following order :
Reference oscillator \& synthesiser.
121 MHz Tx modulated injection oscillator.
Tx final stage/Power control.
Receiver and audio mute

### 4.7.1 REFERENCE OSCILLATOR AND SYNTHESIZER

1 Check VCXO (XTAL2) for reference frequency o/p at a level of 550 mV rms with an RF Millivoltmeter, and the VCO o/p for an RF level of around 150 mV rms .

2 Check that the TBB202 dual modulus prescaler (U4) is producing an output of approximately 7 MHz and a level of 550 mV rms at the "IF" $\mathrm{i} / \mathrm{p}$ to the TBB206 synthesiser I.C.(U3-p8)

3 Ensure that the synthesiser has been programmed to a frequency within the range of the VCO, and check that the VCO is locked by observing a high ( 5 V ) level on Lock detect output of the synthesiser I.C.(U3-p14). Note that very short duration pulses to ground is normal.

4 Program the synthesiser with the following VCO frequencies according to VCO type and ensure lock occurs at both ends of the frequency range. These frequencies are 2 MHz beyond the published specification.
VCO TYPE: MQC-798
Maximum 786 MHz VCO $=907 \mathrm{MHz}$ Tx or 831 MHz Rx
Minimum 814 MHz VCO $=935 \mathrm{MHz}$ Tx or 859 MHz Rx
VCO TYPE: MQC-978
Maximum $\quad 996 \mathrm{MHz} \mathrm{VCO}=875 \mathrm{MHz}$ Tx or 951 MHz Rx
Minimum $\quad 960 \mathrm{MHz} \mathrm{VCO}=839 \mathrm{MHz}$ Tx or 915 MHz Rx
5 Program the VCO to a given frequency within the range as specified above and measuring the VCO o/p frequency, adjust the $12 \mathrm{MHz}(\mathrm{VCXO})$ reference trimmer to bring the frequency within 250 Hz of the VCO frequency.
Note: Unit is temperature compensated at factory and no field adjustment of Ref. Oscillator is possible. If VCO frequency is not correct ( $\pm 1500 \mathrm{~Hz}$ ), consult factory for service advice.
Note ensure that the VCXO control input is within its active range (1-4 Volts).

6 Check the VCO power o/p by monitoring the Rx mixer bias at TP20, where approximately 200 mVDC should be measured.

7 With a spectrum analyser set to the VCO frequency and a dispersion of about 5 or 10 kHz per cm , check that the reference sidebands are less than -60 dBc in the adjacent channel.

8 Check VTCXO Reference frequency is $F(t x)+121 \mathrm{MHz}$ for 853 remote units or $\mathrm{F}(\mathrm{tx})-121 \mathrm{MHz}$ for master units. If Reference is out by more than $\pm 1.5 \mathrm{kHz}$, drift offset should be applied via the programmer or unit should be returned for factory service. attempting to alter Reference trimmer will void temperature compensation process and should only be done in an emergency and as a temporary measure.

### 4.7.2 121 MHZ MODULATOR

Note - make sure the transmitter is loaded with a suitable attenuator on the antenna or Tx o/p socket before energising

1. For Initial alignment set all coil cores to their nominal positions as per the table below :

Miller coils
L9 5 turns from top of coil can
L10 2 turns
L7 4 turns
L8 5 turns
L6 0 turns
To prevent the final transmitter stages from producing excessive power whilst low level stages are being aligned, it is suggested that the Tx post mixer tunable filter be de-tuned. Energise the transmitter via manual PTT from the auxiliary handset.
2. Tune L 7 through L 10 for peak $\mathrm{o} / \mathrm{p}$. For initial alignment this can be done by monitoring the 121 MHz level at TP18 initially and then at the input to the SBL-1X transmit mixer (U8), where a level of about 75 mV should be measured by an RF millivoltmeter (e.g HP11960).

Typical RF millivoltmeter readings for each stage are :
TP17 125 mV RF $=0.25$ VDC on HP11960 probe.
TP16 $40 \mathrm{mVRF}=0.06$ VDC on HP11960 probe.
TP18 550 mV RF $=1.0$ VDC on HP11960 probe.
$121 \mathrm{MHz} \mathrm{i} / \mathrm{p}$ to mixer $\quad 75 \mathrm{mV}$ RF $=0.13 \mathrm{VDC}$ on HP11960 probe.
Note: The signal at TP17 is present as long as "Tx En" is active. The subsequent test points require PTT to also be active.

If the complete transmit chain is known to be operative then the 121 MHz o/p can be peaked by first de-tuning C78 on the tunable Tx filter until the Tx power o/p is less than 100 mW and then tuning Inductors L7 to L10 for maximum output at the Tx frequency.
3. With the radio section links set for the desired data rate (see link table above), set the peak deviation as per the chart below with VR3, and center frequency to 121.000 MHz with L6.

NOTE: THESE ADJUSTMENTS ARE INTERACTIVE. ENSURE ALL COILS ARE SECURE BAUD RATE 4800 bps

DEVIATION LEVEL 9600 bps $\pm 1.5 \mathrm{kHz}$ peak $\pm 2.75 \mathrm{kHz}$ peak
4. Note that temperature compensation is applied to the 121 MHz oscillator so attempting to adjust either VR3 or L6 will upset compensation and should only be done as a temporary measure. Return unit to factory for repair if errors $> \pm 500 \mathrm{~Hz}$ are detected.

### 4.7.3 TX FINAL

NOTE: It is essential that all RF Deck mounting bolts are fitted and secure upon reassembly as many of these bolts provide inter-stage isolation and secure grounding ensuring the product meets all specifications.

1 Ensure the 121 MHz Tx injection is operating correctly.
2 Check Q2,4,5,8, are all biased correctly as per the voltage chart. Temporarily disable the Tx power control circuitry by shorting LK4 located on the top side of the board near the ribbon cable.
Energise the transmitter via the manual PTT on the auxiliary handset.
3 Tune the Tx filter tuning capacitor C78 for a peak output power measured at Antenna port or X 4 .

4 With full drive, Q9 driver collector current as seen across TP26//TP27 should be approximately $45 \mathrm{~mA}(100 \mathrm{mVDC})$, and NOT MORE THAN 55 mA ( 120 mVDC ).

5 With full drive at Q9 each final transistor should be drawing around 175 $\mathrm{mA}(385 \mathrm{mVDC})$ as seen across TP26/TP29 or TP28. The output power measured directly at the final connector should be between +32 and +34 dbm without power control.

6 Re-enable the power control circuitry and with the 'Txpwr' control line set at +5 VDC, set VR4 for $+32 \mathrm{dbm}+/-0.25 \mathrm{~dB}$ at the tx o/p socket X 4 . Check that the current in EACH final collector does NOT EXCEED 225 mA .

7 Check with the spectrum analyser that the $T x$ o/p is free from spurious signals.
Note 1. Prior to the diplexer the VCO level is nominally about -20 dbc .
Note 2. Close in mixing products (less than $+/-30 \mathrm{MHz}$ ) must be greater than $65 d b$ below the carrier, as they are not attenuated by the diplexer filters.

## D.C. Voltages of Radio Section

RF Output Power set to +32 dbm at X 4 (diplexer input) with 13.8 VDC supply

| Transistor | Base | Emitter | Collector |
| :--- | :--- | :--- | :--- |
| Q2 | 1.66 VDC | 0.92 VDC | 6.96 VDC |
| Q4 | 1.79 VDC | 1.06 VDC | 6.46 VDC |
| Q5 | 1.80 VDC | 1.08 VDC | 7.51 VDC |
| Q8 | 1.05 VDC | 0.31 VDC | 4.02 VDC |
| Q9 | 0.47 VDC | 0 VDC | 13.35 VDC |
| Q10 | 0.28 VDC | 0 VDC | 13.05 VDC |
| Q11 | 0.29 VDC | 0 VDC | 13.16 VDC |
| Q12 | 7.17 VDC | 7.97 VDC | 7.88 VDC |
| Q1 | 7.29 VDC | 7.97 VDC | 7.91 VDC |
| Q13 | 4.56 VDC | 3.84 VDC | 7.97 VDC |
| Q7 | 1.14 VDC | 0.41 VDC | 6.68 VDC |
| Q6 | 1.13 VDC | 0.40 VDC | 7.52 VDC |
| Q3 | 1.06 VDC | 0.33 VDC | 7.59 VDC |

### 4.7.4 RECEIVER

The receiver section requires little or no alignment once factory aligned.

### 4.7.4.1 No AFC Models (Xtal $1=45.455 \mathrm{MHz}$ )

1 Adjust L1 for 45.455 MHz measured with pickup loop near L1.
2 In emergency adjust coils L3, L4 and L5 for best SINAD at TP8.
3 Adjust audio mute VR1 to mute handset audio at 10dB SINAD
4 Adjust VR2 for 2.0 VDC at TP8 whilst receiving data off-air.

### 4.7.4.2 AFC Models

Monitor 44.545 MHz with pickup at L1. Test for $44.545 \pm 1.5 \mathrm{KHz}$
Consult factory for alignment or service information.

## SECTION 5

## INSTALLATION AND COMMISSIONING

## 5 INSTALLATION OVERVIEW

All Data Radio Modem devices needs to be properly installed and commissioned in order to function reliably. It is important that installers are familiar with RF products / installations and are geared up with appropriate tools necessary to confirm the ongoing reliability of a communications system.

This chapter is intended as a short form checklist to ensure such radio devices are installed correctly and that important tests are made and recorded at each site for future reference should a problem eventuate.

Installers should check that each data radio has been programmed to suit their specific requirements before installation.

### 5.1 GENERAL

Installations play a critical role in network performance. Although this is a known fact, installations are often performed poorly or given little regard. It is essential that the installation is performed in a professional manner with careful attention and consideration to the following items :

1. Adequate primary power cable - relative to the length of cable to minimise voltage drop.
2. Shielded data cable between the unit and any external data equipment.
3. Low loss coax used for antenna feed line.
4. Careful termination of RF connectors.
5. A suitable antenna for the requirement.
6. Suitable placement of the antenna.
7. Adequate signal strength from the base station / other radio communications device.

### 5.2 INSTALLATION

The following information should assist when installing and commissioning data radio systems.

### 5.2.1 DATA CONNECTION

In industrial environments connection to any external device should be by shielded data cable with the shield connected to the connector shell to minimise data corruption, and/or radio interference.

### 5.2.2 MOUNTING

The radio modem should be mounted in a cool, dry, and vibration free environment. Mounting of the unit should be in a location providing easy access to screws and all connections.

### 5.2.3 POWER CONNECTIONS

The power required for 5 Watt ( $T x$ ) at 13.8 VDC , is typically 2.0 Amps . As the $T x$ key up current is significant, the gauge of primary power wiring should be considered. It is suggested that a minimum of 18 gauge stranded copper wire be used for distances of up to two metres and a minimum of 14 gauge for longer distances up to 5 metres.

Ensure correct polarity to avoid costly repairs.

### 5.2.4 COAX CABLE CONNECTION

It is important to select the correct cable and connectors for each application as a poor selection can seriously degrade the performance of the unit.

As an example, for each 3 dB of cable and connector loss, half the transmitter power is lost and twice the receiver signal power is required to produce the same bit error rate.

In some installations where strong signals are present, a compromise of cable and connector cost may be acceptable.
It is essential that all connector terminations are performed as per the manufacturers specifications (especially at 900 MHz and above) and if connectors are to be used outside, it is essential that a sealant such as amalgamating tape be used to seal connectors. DO NOT use acetic cure silicon to seal the connectors.

It is also important that coax cables are not stressed by tight bends, kinking or excessive flexing. Ensure that coax cables have sufficient strain relief and are secure. If large diameter rigid or semi rigid cable is used, it is recommended to use a short length of high quality RG58 or RG223 cable between the unit and main cable feed.

The following chart is a guide to losses in various types of coaxes at 400 MHz and 900 MHz over distance, please consider this when installing the unit.

| CABLE TYPE | Loss relative to distance |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 dB |  | 3 dB |  | 6 dB |  | 9 dB |  |
|  | 450 MHz | 900MHz | 450 MHz | 900 MHz | 450 MHz | 900 MHz | 450 MHz | 900 MHz |
| RG58C/U | 2.3m | 1.6 m | 7 m | 5 m | 14m | 10 m | 20 m | 15m |
| RG223/U | 3.1 m | 2.3 m | 9 m | 7m | 18m | 14m | 28m | 21m |
| RG213/U | 6.1 m | 4m | 18m | 12m | 37m | 24m | 55m | 37 m |
| $\begin{array}{\|l\|} \hline \text { HELIAX } \\ \text { LDF4-50A } \end{array}$ | 19m | 14m | 57m | 43m | 114m | 87m | 171m | 130m |
| $\begin{array}{\|l\|} \hline \text { HELIAX } \\ \text { LDF5-50A } \end{array}$ | 38m | 25m | 114m | 75m | 229m | 150 m | 343m | 225m |

### 5.3 ANTENNA INSTALLATION

The selection of antennas and their placement is one of the most important factors when installing a radio based network. People often use a simile, it is like putting square wheels on a Mercedes Benz..... very true comparison.

Antennas are generally mounted to a vertical pole with either vertical or horizontal polarisation as per the licence requirement.

Antennas should be mounted as high as practical and away from metal surfaces which can cause reflections.

Determining the type of antenna is very important and as a typical generic example, Point to Multipoint (PTMP) systems generally employ high gain ( 3,6 , or 9 dB gain) omni directional antennas at the base station sites and either omni directional whips (unity gain) or preferably high gain directional yagi antennas ( 9 or 14 dB gain) at the remote sites.

### 5.3.1 YAGI ANTENNAS

Yagi antennas not only provide signal gain and directivity, but also provides protection from interfering signals which are outside the beam width of the antenna. Yagi antennas are essential when communicating over very long distances.

Yagi antennas are polarised and must be mounted either vertically (elements pointing from the ground to the sky) or horizontally (elements in parallel with the horizon).

As a general rule, Point to Multipoint remote units are vertically polarised, while Point to Point links are horizontally polarised.

When mounting yagi antennas with vertical polarisation, it should be noted that the dipole (loop section of antenna) has a drain hole. The small drain hole on one end of the dipole must be pointed towards the ground so that water will drain out of the antenna.

### 5.3.2 OMNI DIRECTIONAL ANTENNAS

Omni directional antennas provide a radiation pattern of equal strength through $360^{\circ}$ in the horizontal plane. This makes them ideal for base antennas in point to multipoint systems because they can reach the remote antennas.

Omni directional antennas are also used at remote sites (although yagi antennas are preferred) and are typically ground independent "whip" type antennas. The main reason for using whips at remote sites is for aesthetics as they are far less obtrusive than a yagi.

Regardless of the type, antennas need to be mounted properly and in a suitable location as covered below.

### 5.3.3 ANTENNA PLACEMENT

Antenna placement is of paramount importance and plays a big part of the antennas and in turn systems performance.

When choosing antenna locations the aim is to find the largest path of unobstructed space and locate the antennas within that space. It is important to locate antennas as high as possible and definitely clear of any moving obstructions.

Where possible it is important to avoid mounting antennas:

1. Against or adjacent to steel structures.
2. In an area which will have constant intermittent obstructions - people walking past, vehicles driving past etc. That is, mount antennas well above such moving obstructions.
3. Near any electrical equipment.
4. Near metal beams, structures etc.
5. Inside any metal enclosures, tin sheds / warehouses etc. - note meshed wire fences act like a "brick wall" to RF transmissions.
6. Away from guard rails or support beams.

Note: Sometimes installations in such environments are unavoidable and where this is the case, certain care can be taken to still ensure a reliable installation. Please consult Trio for assistance on a case by case basis.

If tests indicate poor signal strength then the antennas at one or both ends of the link should be raised, and/or moved clear of obstructing objects, or if directional antennas are employed they should be checked for correct directional orientation and polarisation (horizontal or vertical signal orientation).

### 5.3.4 REFLECTIONS AND OUTPUT POWER

Ideally, the propagation path should be clear Line of Site (LOS).
The biggest problem with UHF radio when used within "steel" buildings or obstructed paths is the large presence of signals randomly reflected from the surrounding obstructions or "steel" walls. These signals cannot be eliminated, but by maintaining a 10 to 20 dB margin between the wanted and unwanted signals, problems should not be experienced. The simplest way to do this is to use directional gain antennas.

These antennas will provide attenuation to all signals arriving from a direction other than the direct path. Where steel walls or structure exist immediately behind the antenna location, the high front to back ratio of such antennas will negate such high level reflections. Power output should be set at the minimum level required to achieve a 25 dB fade margin, in order to minimise the amount of RF being reflected, and to avoid saturating the receiver front end and therefore reducing the margin between wanted and unwanted signals.

### 5.4 COMMISSIONING - RSSI LEVEL

When commissioning a data radio network, it is important to ensure that the incoming received signal strength (RSSI) is adequate to provide reliable communications.

Note: A good signal path should allow for approximately 30 dB fade margin.
Received signal strength (RSSI) of the incoming signal is available as an analogue output on Trio data radio modems. This RSSI output ranges from 0 to approx 4 Volts, where 4 Volts indicates the strongest signal. The actual values of received signal strength can be determined by comparing the output voltage against the calibrated graph supplied in the handbook.

By referring to the RSSI chart alignment of aerials can be optimised to achieve the greatest signal strength (highest output voltage).

Note: Be sure to stand clear of aerials when measuring this output voltage, touching or standing in close proximity to aerials will give inaccurate readings.

### 5.4.1 CHECKING DATA COMMUNICATIONS

If the host computer and remote equipment are capable of performing data integrity tests then connect the host and terminal data equipment to the radio modems.

Remove and re-apply power to each radio modem to ensure they are both in data comms mode, and run data tests on the link.

### 5.4.2 BIT ERROR RATE (BER) TESTING

If the connected data equipment is NOT capable of running data integrity tests then the TC-450DS modems can be put into a BER test mode, whereby the data channel can be tested in each direction to a reasonable level without external test equipment. To run a link test with the radio modems themselves, they must BOTH be put into BER test mode.

To place the unit in BER mode connect pin 6 and pin 9 of port $A$ together and apply power..

The transmitter can be activated by driving the RTS pin (7) of port A positive. The unit will then send a predefined pseudo random sequence which is tested for accuracy by the receiving unit and any errors displayed on the front panel 'SYNC' lamp.

Each error bit will illuminate the lamp for approximately 1000 bits duration, therefore error rates above 1 in 1000 will show an almost constant error indication.

To return the unit to normal data transmission mode simply power it up without pin 9 connected to pin 6.

For further information on radio path problems please contact Trio DataCom for detailed advice.

Note : BER testing is not viable in an operational point to multi-point environment as the BER test will interfere with other operative units.

### 5.4.3 OUTPUT POWER - VSWR

Upon installation of equipment an output power measurement should be done using a suitable power meter. Forward and reflected power should be measured at the antenna port and recorded for future reference. The reflected power measurement should be as a minimum $3: 1$ of the forward power. If this is not the case, investigate possible causes such as poor terminations, faulty antenna etc.

### 5.4.4 DATA CONNECTION

The data connection is via a DB9 connector labelled 'Port A', which is wired as a DCE as shown below. The port labelled 'Port $B$ ' is not used for the standard configuration but can be enabled by the programmer for use as a totally independent second data channel. In industrial environments connection to the modem should be by shielded data cable with the shield connected to the connector shell to minimise data corruption, and radio interference.

## - User Serial "Port A" Pin Assignment

PIN NO. \& FUNCTION

1. DATA CARRIER DETECT (DCD)
2. RECEIVE DATA OUTPUT (RXD)
3. TRANSMIT DATA IN (TXD)
4. DATA TERMINAL READY (DTR)
5. COMMON (COM)
6. PROGRAM PIN (PGM)
7. REQUEST TO SEND (RTS)
8. CLEAR TO SEND (CTS)

EXTERNAL VIEW OF 'PORT A'
9. BIT ERROR RATE PIN (BER)


NOTE: Pin 6 and pin 9 provide a dual function which depends on the mode that the TC-450DR is operating in.

## - User Serial "Port B" Pin Assignment.

Port B of the TC450DR is essentially unused in its standard configuration but can be enabled by the Programmer for use as a totally independent second data channel. This port is essentially used for specific applications and only has one connection that may be of use for installation purposes. This connection (Pin 9) is Receive Signal Strength Indicator (RSSI) output.

This RSSI output ranges from 0 to 5 Volts, where 5 Volts indicates the strongest signal. It is important to note that this Port output has a high impedance of around 10 K ohms and loading will decrease accuracy of the recorded measurement.

PIN NO. \& FUNCTION

1. DATA CARRIER DETECT
2. RECEIVE DATA O/P (RxD)
3. TRANSMIT DATA OIP (TxD)
4. DATA TERMINAL READY (DTR)
5. COMMON
6. DATA SET READY (DSR)
7. REQUEST TO SEND (RTS)
8. CLEAR TO SEND (CTS)
9. RECEIVE SIGNAL STRENGTH

EXTERNAL VIEW OF `PORT B'


### 5.5 GENERAL CHECKLIST

The following is a simple commissioning checklist which should be used at every site not only to ensure correct installation, but also as a reference list for problems which may eventuate.

| TRIO SITE COMMISSIONING CHECK LIST / RECORD |  |  |
| :--- | :--- | :--- |
| Company: | Operator: |  |
| Site Location: | Date: |  |
| Link to: | Serial \#: |  |
| Radio Type: | Config File Name: |  |
| Antenna Type / Gain | Path Distance |  |
| Tx Power at Radio | Measured RSSI Volts |  |
| Reflected Power |  | Fade Margin |
| VSWR |  | DC volts at Radio (Tx) |
| Tx Power at Antenna |  |  |
| Site QA Inspection: |  |  |

## SECTION 6

## FAULT FINDING

## 6 FAULT FINDING

This section is to assist with difficulties that may be experienced when installing or working on the TC-900DR.

### 6.1 MODEM/GENERAL

The following is a list of possible problem areas, and suggested checks that can be made to isolate any general problem that may have occurred.

1. POWER SUPPLY
a) Check for +13.8 Volts at supply input.
b) Check fuse on Modem PIS PCB ( 1 Amp SLO-BLOW).
c) Check supply volts:

Modem PIS i) 13.8 Volts
ii) 8 Volts
iii) 5 Volts

RF Deck i) 13.8 Volts
ii) 8 Volts
iii) 5 Volts

## 2. ANTENNA

a) Check antenna, cable and connectors for damage or water
b) Check forward and reflected power at antenna connector of unit.

VSWR should be <= 1.5:1

## 3. PROGRAMMING

Check programming information. e.g.
i) Transmit and receive frequencies are within the operating band of the unit
ii) User interface configuration.
4. INTERFACE
a) Check connections to Port A (DB9 Connector).
b) Check cable to host communications.
c) Interface commands to unit are incorrect or communications are not established correctly.
5. POOR TRANSMITTER PERFORMANCE
a) Check correct transmit frequency programmed.
b) Check transmitter carrier frequency.
c) Check transmitter deviation.
d) Check RF output power level.
6. POOR RECEIVER PERFORMANCE
a) Check correct receive frequency programmed.
b) Check receive sensitivity.
c) Check audio output level and DC bias to modem.
d) Check mute threshold.

### 6.2 RECEIVER

The following is a list of problem areas, and suggested checks that can be made to isolate any receiver specific problems that may have occurred.

### 6.2.1 RECEIVE SENSITIVITY LOW

1 Check mixer drive level by measuring DC bias developed across R27.
2 Check for correct DC bias conditions and supply volts on RF Amp, Local Osc buffer, and IF Strip, compared to voltage charts.

3 Ensure 44.545 MHz oscillator (part of NE615 IF IC) is within $\pm 250 \mathrm{~Hz}$. This is best carried out by using a communications test set such as an IFR1200 or similar in receiver mode with frequency error displayed.

4 Ensure that the local oscillator is netted to frequency by monitoring the Tx mixer injection with a pick up loop connected to a sensitive frequency counter of high stability. Adjust the VCXO frequency reference until correct L.O. frequency is observed. Note that the VCO and synthesiser use the VCXO as the frequency standard. Measure the Synthesiser LOCK signal to ensure the VCO is in phase lock.

5 With a 50 ohm signal generator tuned to 455 kHz , apply signal via a 1 nF capacitor to the inputs of the 1st and second IF Amp sections of the 615 IF IC and compare the level required to produce the correct RSSI level.

6 With a 50 OHM signal generator tuned to 45.000 MHz , apply signal to the points defined on the IF test chart and compare RF level required to produce the reference RSSI level as specified at TP4.

7 Apply signal frequency to the RF input connector at X2 and compare the level required to produce RSSI reference level at TP4 with that shown in the IF Level Chart.

8 Reconnect the Antenna Diplexer and apply the signal generator to the Antenna terminal of the diplexer. Adjust the generator level to provide the same Rx mixer bias from applied RF signal as was noted in 7) above. The level required should be no more than 3 dB ( Rx diplexer path loss) greater.

Note that the RSSI signal provided by the IF IC is a fairly accurate logarithmic scale between 0.5 and 4 VDC , providing about 0.5 VDC for each 10 dB of signal applied to the input of the IF Strip, and can be used as a reasonable measure of signal providing it is unmodulated and on center frequency at 455 kHz .

### 6.2.2 RECEIVER LEVEL CHART

The following chart lists the level (terminated) of a 50 OHM signal generator to produce 2.0VDC of RSSI at TP4 when applied as specified to the point shown and at the frequency indicated.

| FREQUENCY | CONNECTION POINT AND APPLICATION | NOM LEVEL |
| :--- | :--- | :--- |
| 455 kHz | Pin 20 of IC U2 NE615 via 1 nF | -72 dBm |
| 455 kHz | Pin 18 of IC U2 NE615 via 1nF | -74 dBm |
| 455 kHz | Pin 1(i/p) of IF Filter CF2 via 1nF | -58 dBm |
| 455 kHz | Pin 14 of IC U2 NE615 via 1nF | -43 dBm |
| 45 MHz | Rx i/p at X2 via coax direct | -49 dBm |
| 45 MHz | Mixer i/p following R.F. Amp | -62 dBm |
| 45 MHz | Mixer diode (D1) o/p across C100 | -61 dBm |
| 45 MHz | Junction of 1st \& 2nd 45 MHz crystal filter | -77 dBm |

### 6.3 TRANSMITTER

The following is a list of problem areas, and suggested checks that can be made to isolate any transmitter specific problems that may have occurred.

## 1. NO TRANSMIT

1. Check PTT circuit.
2. Check unit is programmed within its operational range.
3. Check if manual PTT (Rear Aux connector) keys transmitter.
4. Check if any transmitter output is present. Tuning required?

## 2. TRANSMITTER SPURIOUS EXCESSIVE

The probable cause is dependent upon the nature of the spurious as follows:
Carrier $\pm 910 \mathrm{kHz}$. - IF detector signal ( $2 \times 455$ ) modulating or mixing with carrier. Check 1 n bypass on reference $\mathrm{i} / \mathrm{p}$ to power control op-amp. Check bypasses on collectors and supply lines of low level transmitter stages, and L.O. buffer.

Carrier $\pm 20.166$ and/or 40.333. - Excessive harmonics of 20.166 crystal oscillator in 121 MHz FM driver IC (U7). Check all pins of IC (U7) for correct DC conditions. Check all tuning inductors for 'normal Q ', as 'soft' tuning will almost surely indicate an incorrect or faulty capacitor, or inductor.

Carrier $\pm$ VCXO reference frequency (approximately 7 MHz ). - Reference signal modulating VCO, or mixing with carrier in L.O.buffers. - Check Synthesiser supply bypasses, check for defective joints or components in and around the resistive divider at output of VCO .

Note that it is imperative that low frequency divider products be attenuated before they can reach the base/emitter junctions of the L.O. buffer transistors where they can mix with the VCO frequency.

Note also that poor SMD solder joints will provide nonlinear conductance and give rise to frequency mixing in this area. Check for faulty components or poor joints around the Synthesiser to VCO frequency control area, or VCO supply line bypassing.

Excessive Transmitter power radiated or conducted to the area of the VCO can also cause spurious effects and may enhance the levels of otherwise acceptable levels of spurious. If this is suspected, check that ALL chassis securing bolts are fitted and tight on the RF deck, and that ALL bypass capacitors and chokes are fitted and correct in and around the final Tx stages.

## 3. TRANSMITTER POWER LOW OR UNSTABLE :

1 Firstly - Ensure that ALL RF Deck mounting bolts are fitted and secure.
2 Check that the feed resistors used for current indication on all stages of the final are of correct value and firmly in circuit.

3 Check that the Tx L.O. buffer and post mixer buffers are correctly biased as per the voltage charts.

4 If necessary disconnect the final stages from the Tx post mixer buffers by removing the solder bridge between Q5 and Q8, and with an appropriate instrument measure the RF power available from the $T_{x}$ buffers to the final pre-driver.
Note that the o/p impedance of the buffer is 50 OHM and must be measured by a 50 OHM instrument. It is highly recommended that a measuring spectrum analyser be used here as this instrument will also display the relationship between the wanted signal and other spurious or unwanted mixing products.
The nominal display seen at this point by a spectrum analyser is shown on the spectrum charts attached.

5 To test the final stages separate from the buffers - inject a signal from a 50 OHM generator at Tx frequency into pre-driver (Q8) via C122. The level required to drive the final to full output is shown on the Tx level chart.

6 Check that the current drawn by the driver transistor as measured across the feed resistor (TP28 to TP27) is within spec, and if not check and or replace the driver transistor or associated components as necessary.

7 Check that the current drawn by each final transistor as indicated by the voltage across the 2.2 OHM ( $2 \times 4.7$ ohm in parallel) collector feed resistors (TP26 to TP28 and TP29) is within the range stated in the voltage charts, and that both are within $10 \%$ of each other. If in error check components around final pair and replace final transistors as necessary.

NOTE it is possible for power transistors to be partly defective due to current or thermal abuse, and the fact that the devices are actually drawing current does not always indicate that they are producing full power at the collector.

## TX LEVEL CHART :

| Frequency | Connection Point \& Application | Level Remarks |
| :---: | :---: | :---: |
| Base band | Data from modem section TP13 (4800 baud) | 2 VD.C |
| Base band | Applied data signal to modulator U7 pin 3 (4800 baud level from modem) | $1 \mathrm{~V}_{\text {p-p }}$ |
| Base band | Audio signal to modulator TP32 | 0.84 VD.C <br> $60 \mathrm{mV}_{\mathrm{p}-\mathrm{p}}$ for VR3 set for maximum value $400 \mathrm{mV}_{\text {p.p }}$ for VR3 set for minimum value |
| Base band | Audio signal to modulator U7- pin 4 | $\begin{aligned} & 1.3 \mathrm{VD.C} \\ & 0.5 \mathrm{~V}_{\mathrm{p}-\mathrm{p}} \end{aligned}$ |
| 121 MHz | Signal level at TP18:A | -5dBm |
| Final $T x$ frequency | Output to diplexer connector X 1 | $3 W$ at maximum power setting |

## SECTION 7

## APPENDIX A

## DRAWINGS

## 7 APPENDIX A DRAWINGS

TC01-08-12 Data Radio Mounting Details
TC01-08-11 Data Radio Assembly Details
TC01-04-05 Data Radio Basic Modem 9K6/4K8 Component Loading Details
TC01-00-05 450DR / 900DR Packet Modem (2 sheets)
TC01-08-10 PWB Manufacturing Details 900DR Data Radio - Radio Board (2 sheets)
TC01-00-10 Data Radio Project Sheet
TC01-00-10 Data Radio Final PA (AFC Fitted)
TC01-00-10 Data Radio 121 MHz OSC (AFC Fitted)
TC01-00-10 Data Radio - Synthesiser - VCO (AFC Fitted)
TC01-00-10 Data Radio - NE6154K8/9K6 (AFC Fitted)
TC01-04-15 850-930 MHz Antenna Diplexer Component Side Assembly
TC01-05-10 Radio Board Top Side (C/S) Test Point \& Adjustment Location Details
TC01-05-10 Radio Board Bottom Side (S/S) Test Point \& Adjustment Location Details

TC01-05-16 Duplex Radio BER/S+N/N vs Sig
TC01-05-17 AFC Alignment Setup - Block Diagram
TC01-05-12 4800/9600 BPS Modem Functional Diagram
TC01-05-23 Asynchronous Modem Functional Diagram
TC01-05-19 Macro Block Diagram
TC01-05-18 Radio Section - Modem Section Interface
DR9-BLOK 900 MHz Radio Block Diagram RSSI Level of Received Signal (typical)

## SECTION 8

## APPENDIX B

## GLOSSARY of TERMS and ABBREVIATIONS

## 8 APPENDIX B GLOSSARY

| ADC: | Analogue to digital converter. |
| :--- | :--- |
| AFC: | Automatic frequency control. |
| BER: | Bit error rate. |
| bps: | Bits per second. |
| C/DSMA: | Carrier or data sense, multiple access scheme. |
| COM: | Common. |
| CRC: | Cyclic redundancy checksum. |
| CTS: | Clear to send. |
| DAC: | Digital to analogue converter. |
| DCD: | Data carrier detect. |
| DCE: | Data communications equipment. |
| DFM4-9: | Trio DataCom digital modem chipset. |
| DIP: | Dual in line package. |
| DOTAC: | Department of Transport and Communications. |
| DSR: | Data set ready. |
| DTR: | Data terminal ready. |
| FCS: | Frame check sequence. |
| FEND: | Frame end. |
| FESC: | Frame escape. |
| FIFO: | First in first out. |
| FIR: | Finite impulse response. |


| FM | Frequency modulation. |
| :---: | :---: |
| FSK: | Frequency shift keying. |
| GPIB: | General purpose interface bus. |
| HADR_EN: | High address enable signal. |
| IC | Integrated circuit. |
| I.F | Intermediate frequency. |
| i/p: | Input. |
| KISS: | Keep it simple stupid. |
| LADR_EN: | Low address enable signal. |
| MSB: | Most significant bit. |
| NVRAM: | Non volatile RAM. |
| NRZ: | Non return to zero. |
| NRZI: | Non return to zero - inverted. |
| o/p: | Output. |
| PCB: | Printed circuit board. |
| PLL: | Phase locked loop. |
| PMP: | Point-to-multipoint. |
| ppm: | Parts per million. |
| PTP: | Point-to-point. |
| PTT: | Press to talk. |
| RF | Radio frequency. |
| RI | Ring indicate. |
| R_select: | RAM read select signal. |
| SIO: | Serial input/output. |
| RSSI: | Receive signal strength indication. |
| RTS: | Request to send. |
| Rx | Receive. |
| RXD: | Receive data output. |
| SCADA: | Supervisory control and data acquisition. |
| SLIP: | Serial line interface protocol. |

TC-900DR: Trio DataCom 900 MHz full duplex data transceiver.
TC-DFM9IP: Trio DataCom TC-900DR parameter programming software suite.
TFEND: Transposed Frame End.
TFESC: Transposed Frame Escape.
TNC: Terminal node controller.
Tx: Transmit.
TXD: Transmit data in.
VCO: Voltage controlled oscillator.
W_select: RAM write select signal

## TECHNICAL DATA SHEET

For

## SEWAGE PUMP STATION SP210 Nudgee Beach

Equipment Type:Impulse SuppressorLocation:RTU Section
Model Numbers: ..... IS-50NX-C2
Manufacturer: Polyphaser
Supplier:

Brisbane Water



# TECHNICAL DATA SHEET 

For

## SEWAGE PUMP STATION SP210 Nudgee Beach

Equipment Type:
Radio/DC Converter

## Location:

Model Numbers:

Manufacturer:

Supplier:
Brisbane Water

## PBIH Series

$15-150$ WATTS DC/DC SINGLE OUTPUT

## Features

- Wide selection of models
- 4 input voltage ranges
- High efficiency
- Low output ripple
- Proven reliability
- Good thermal margins


| Specifications INPUT |  |
| :---: | :---: |
| Input voltage | 12VDC (9.2-16) |
|  | $24 \mathrm{VDC}(19-32)$ |
|  | 48VDC (38-63) |
|  | 110VDC (85-140) |
| Inrush current | 20A max. for 110V only |
| OUTPUT |  |
| Output voltage | See table |
| Voltage adjustment | $\pm 10 \%, \pm 5 \%$ for PBIH-F |
| Output current | See table |
| Ripple \& noise | Output Volts $\times 1 \%+50 \mathrm{mV}$ to -100 mV pk-pk |
| Line regulation | $0.8 \%$ over input range |
| Load regulation | 0.9\%, 0\%-100\% load |
| Temperature coefficient | $0^{\circ} \mathrm{C}$ to $50^{\circ} \mathrm{C}, 0.03 \%$ per ${ }^{\circ} \mathrm{C}$ |
| Overvoltage protection | O.V. damp, PBIH-F Output shutdown, PBIH-G, , M, R-input must be switched off for at least 30 to reactivate |
| Overcurrent protection | Fold back - PBIH-F <br> Current limiting, PBIH-G, $, \mathrm{M}, \mathrm{R}$ (PBIH-R series is adjustable); PBIH110xxR models are not adjustable |
| Drift | Output V $\times 0.5 \%+15(\mathrm{mV})$ per 8 his after 1 hr warm-up |
| Rise Time | $\begin{aligned} & \text { 200mS max. - PBIH-F, M, R } \\ & 100 \mathrm{mS} \text { max. }- \text { PBIH-G, J (at } 25^{\circ} \mathrm{C} \text { ) } \end{aligned}$ |
| Holdup time | 10 ms (only 110 V input) |
| Remote sense | PBIH-R Series only |


| OPERATING |  |
| :---: | :---: |
| Efficiency | 70\%-89\% |
| Safety isolation (1 minute) | Type - $12,24,48 \mathrm{~V}$ input Input - Output: 1500VAC Input-Case: 1500VAC Output-Case: 500VAC Type- 110 V input Input-Output: 2000VAC Input-Case: 2000VAC Output-Case: 500VAC |
| Insulation resistance | 50M (500VDC) Input - Case |
| Parallel operation | Consult sales office for details |
| Remote control | PBIH-R Series: Open link: output normal Short link: output off |
| ENVIRONMENTAL |  |
| Operating temperature | $0^{\circ} \mathrm{C}$ to $50^{\circ} \mathrm{C}$ full load |
| Cooling | Convection cooled |
| Storage temperature | $-20^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ |
| Humidity | 85\% |
| Shock | 30G, PBIH-F, G and J |
| Vibration | ( $5 \mathrm{~Hz}-10 \mathrm{~Hz}, 10 \mathrm{~mm}$ ). ( $10 \mathrm{~Hz}-5 \mathrm{OHz}$ ) 2G, PBIH-F, G and I |
| STANDARDS AND APPROVALS |  |
| Safety | Designed to UL1950 |
| C.tick | ASINZS CISPR11 Group 1, Class A |
| MECHANICAL |  |
| Weight | PBIH-F:250g <br> PBIH-G: 380g <br> PBIH-I: 410 g <br> PBIH-M : 800g <br> PBIH-R: 1.4 kg |

## PBIH Series

15-150 WATTS DC/DC SINGLE OUTPUT

## Selection Table

| MODEL <br> NUMBER | INPUT | OUTPUT | OUTPUT <br> POWER |  |
| :--- | :---: | :---: | :---: | :---: |
| PBIH-1205F | $9.2-16 \mathrm{~V}$ | 5 V | 3 A | 15 W |
| PBIH-1212F | $9.2-16 \mathrm{~V}$ | 12 V | 1.2 A | 15 W |
| PBIH-1215F | $9.2-16 \mathrm{~V}$ | 15 V | 1 A | 15 W |
| PBIH-1224F | $9.2-16 \mathrm{~V}$ | 24 V | 0.62 A | 15 W |
| PBIH-2405F | $19-32 \mathrm{~V}$ | 5 V | 3 A | 15 W |
| PBIH-2412F | $19-32 \mathrm{~V}$ | 12 V | 1.2 A | 15 W |
| PBIH-2415F | $19-32 \mathrm{~V}$ | 15 V | 1 A | 15 W |
| PBIH-2424F | $19-32 \mathrm{~V}$ | 24 V | 0.62 A | 15 W |
| PBIH-4805F | $38-63 \mathrm{~V}$ | 5 V | 3 A | 15 W |
| PBIH-4812F | $38-63 \mathrm{~V}$ | 12 V | 1.2 A | 15 W |
| PBIH-4815F | $38-63 \mathrm{~V}$ | 15 V | 1 A | 15 W |
| PBIH-4824F | $38-63 \mathrm{~V}$ | 24 V | 0.62 A | 15 W |
| PBIH-11005F | $85-140 \mathrm{~V}$ | 5 V | 3 A | 15 W |
| PBIH-11012F | $85-140 \mathrm{~V}$ | 12 V | 1.2 A | 15 W |
| PBIH-11015F | $85-140 \mathrm{~V}$ | 15 V | 1 A | 15 W |
| PBIH-11024F | $85-140 \mathrm{~V}$ | 24 V | 0.62 A | 15 W |
| PBIH-1205G | $9.2-16 \mathrm{~V}$ | 5 V | 5 A | 25 W |
| PBIH-1212G | $9.2-16 \mathrm{~V}$ | 12 V | 2.1 A | 25 W |
| PBIH-1215G | $9.2-16 \mathrm{~V}$ | 15 V | 1.7 A | 25 W |
| PBIH-1224G | $9.2-16 \mathrm{~V}$ | 24 V | 1.1 A | 25 W |
| PBIH-1248G | $9.2-16 \mathrm{~V}$ | 48 V | 0.5 A | 25 W |
| PBIH-2405G | $19-32 \mathrm{~V}$ | 5 V | 5 A | 25 W |
| PBIH-2412G | $19-32 \mathrm{~V}$ | 12 V | 2.1 A | 25 W |
| PBIH-2415G | $19-32 \mathrm{~V}$ | 15 V | 1.7 A | 25 W |
| PBIH-2424G | $19-32 \mathrm{~V}$ | 24 V | 1.1 A | 25 W |
| PBIH-2448G | $19-32 \mathrm{~V}$ | 48 V | 0.5 A | 25 W |
| PBIH-4805G | $38-63 \mathrm{~V}$ | 5 V | 5 A | 25 W |
| PBIH-4812G | $38-63 \mathrm{~V}$ | 12 V | 2.1 A | 25 W |
| PBIH-4815G | $38-63 \mathrm{~V}$ | 15 V | 1.7 A | 25 W |
| PBIH-4824G | $38-63 \mathrm{~V}$ | 24 V | 1.1 A | 25 W |
| PB-11005G | $85-140 \mathrm{~V}$ | 5 V | 5 A | 25 W |
|  |  |  |  |  |


| MODEL <br> NUMBER | INPUT | OUTPUT | OUTPUT <br> POWER |  |
| :--- | :---: | :---: | :---: | :---: |
| PBIH-11012G | $85-140 \mathrm{~V}$ | 12 V | 2.1 A | 25 W |
| PBIH-11015G | $85-140 \mathrm{~V}$ | 15 V | 1.7 A | 25 W |
| PBIH-11024G | $85-140 \mathrm{~V}$ | 24 V | 1.1 A | 25 W |
| PBIH-11048G | $85-140 \mathrm{~V}$ | 48 V | 0.5 A | 25 W |
| PBIH-1205J | $9.2-16 \mathrm{~V}$ | 5 V | 8 A | 50 W |
| PBIH-1212J | $9.2-16 \mathrm{~V}$ | 12 V | 3.3 A | 50 W |
| PBIH-1215J | $9.2-16 \mathrm{~V}$ | 15 V | 2.7 A | 50 W |
| PBIH-1224J | $9.2-16 \mathrm{~V}$ | 24 V | 1.7 A | 50 W |
| PBIH-1248J | $9.2-16 \mathrm{~V}$ | 48 V | 0.8 A | 50 W |
| PBIH-2405J | $19-32 \mathrm{~V}$ | 5 V | 10 A | 50 W |
| PBIH-2412J | $19-32 \mathrm{~V}$ | 12 V | 4.3 A | 50 W |
| PBIH-2415J | $19-32 \mathrm{~V}$ | 15 V | 3.4 A | 50 W |
| PBIH-2424J | $19-32 \mathrm{~V}$ | 24 V | 2.5 A | 50 W |
| PBIH-2448J | $19-32 \mathrm{~V}$ | 48 V | 1 A | 50 W |
| PBIH-4805J | $38-63 \mathrm{~V}$ | 5 V | 10 A | 50 W |
| PBIH-4812J | $38-63 \mathrm{~V}$ | 12 V | 4.3 A | 50 W |
| PBIH-4815J | $38-63 \mathrm{~V}$ | 15 V | 3.4 A | 50 W |
| PBIH-4824J | $38-63 \mathrm{~V}$ | 24 V | 2.5 A | 50 W |
| PBIH-4848J | $38-63 \mathrm{~V}$ | 48 V | 1 A | 50 W |
| PBIH-11005J | $85-140 \mathrm{~V}$ | 5 V | 10 A | 50 W |
| PBIH-11012 | $85-140 \mathrm{~V}$ | 12 V | 4.3 A | 50 W |
| PBIH-11015J | $85-140 \mathrm{~V}$ | 15 V | 3.4 A | 50 W |
| PBIH-11024J | $85-140 \mathrm{~V}$ | 24 V | 2.5 A | 50 W |
| PBIH-11048J | $85-140 \mathrm{~V}$ | 48 V | 1 A | 50 W |
| PBIH-1205M | $9.2-16 \mathrm{~V}$ | 5 V | 18 A | 100 W |
| PBIH-1212M | $9.2-16 \mathrm{~V}$ | 12 V | 9 A | 100 W |
| PBIH-1215M | $9.2-16 \mathrm{~V}$ | 15 V | 7 A | 100 W |
| PBIH-1224M | $9.2-16 \mathrm{~V}$ | 24 V | 4.5 A | 100 W |
| PBIH-1248M | $9.2-16 \mathrm{~V}$ | 48 V | 2 A | 100 W |
| PBIH-2405M | $19-32 \mathrm{~V}$ | 5 V | 20 A | 100 W |
| PBIH-2412M | $19-32 \mathrm{~V}$ | 12 V | 9 A | 100 W |
| PBIH-2415M | $19-32 \mathrm{~V}$ | 15 V | 7 A | 100 W |
|  |  |  |  |  |


| MODEL <br> NUMBER | INPUT | OUTPUT | OUTPUT <br> POWER |  |
| :--- | :---: | :---: | :---: | :---: |
| PBIH-2424M | $19-32 \mathrm{~V}$ | 24 V | 5 A | 100 W |
| PBIH-2448M | $19-32 \mathrm{~V}$ | 48 V | 2 A | 100 W |
| PBIH-4805M | $38-63 \mathrm{~V}$ | 5 V | 20 A | 100 W |
| PBIH-4812M | $38-63 \mathrm{~V}$ | 12 V | 9 A | 100 W |
| PBIH-4815M | $38-63 \mathrm{~V}$ | 15 V | 7 A | 100 W |
| PBIH-4824M | $38-63 \mathrm{~V}$ | 24 V | 5 A | 100 W |
| PBIH-4848M | $38-63 \mathrm{~V}$ | 48 V | 2 A | 100 W |
| PBIH-11005M | $85-140 \mathrm{~V}$ | 5 V | 20 A | 100 W |
| PBIH-11012M | $85-140 \mathrm{~V}$ | 12 V | 9 A | 100 W |
| PBIH-11015M | $85-140 \mathrm{~V}$ | 15 V | 7 A | 100 W |
| PBIH-11024M | $85-140 \mathrm{~V}$ | 24 V | 5 A | 100 W |
| PBIH-11048M | $85-140 \mathrm{~V}$ | 48 V | 2 A | 100 W |
| PBIH-1205R | $9.2-16 \mathrm{~V}$ | 5 V | 27 A | 150 W |
| PBIH-1212R | $9.2-16 \mathrm{~V}$ | 12 V | 13 A | 150 W |
| PBIH-1215R | $9.2-16 \mathrm{~V}$ | 15 V | 10 A | 150 W |
| PBIH-1224R | $9.2-16 \mathrm{~V}$ | 24 V | 6.5 A | 150 W |
| PBIH-1248R | $9.2-16 \mathrm{~V}$ | 48 V | 3.3 A | 150 W |
| PBIH-2405R | $19-32 \mathrm{~V}$ | 5 V | 30 A | 150 W |
| PBIH-2412R | $19-32 \mathrm{~V}$ | 12 V | 14 A | 150 W |
| PBIH-2415R | $19-32 \mathrm{~V}$ | 15 V | 11 A | 150 W |
| PBIH-2424R | $19-32 \mathrm{~V}$ | 24 V | 7 A | 150 W |
| PBIH-2448R | $19-32 \mathrm{~V}$ | 48 V | 3.5 A | 150 W |
| PBIH-4805R | $38-63 \mathrm{~V}$ | 5 V | 30 A | 150 W |
| PBIH-4812R | $38-63 \mathrm{~V}$ | 12 V | 14 A | 150 W |
| PBIH-4815R | $38-63 \mathrm{~V}$ | 15 V | 11 A | 150 W |
| PBIH-4824R | $38-63 \mathrm{~V}$ | 24 V | 7 A | 150 W |
| PBIH-4848R | $38-63 \mathrm{~V}$ | 48 V | 3.5 A | 150 W |
| PBIH-11005R | $85-140 \mathrm{~V}$ | 5 V | 30 A | 150 W |
| PBIH-11012R | $85-140 \mathrm{~V}$ | 12 V | 14 A | 150 W |
| PBIH-11015R | $85-140 \mathrm{~V}$ | 15 V | 11 A | 150 W |
| PBIH-11024R | $85-140 \mathrm{~V}$ | 24 V | 7 A | 150 W |
| PBIH-11048R | $85-140 \mathrm{~V}$ | 48 V | 3.5 A | 150 W |
|  |  |  |  |  |

## PBIH Series

15-150 WATTS SINGLE OUTPUT

PBIH-G


| Terminal | Connection |
| :---: | :---: |
| 0 | FG |
| 1 | $\mathrm{DC}+\mathrm{V}$ in |
| 2 | 0 OV in |
| 3 | LFG |
| 4 | NO |
| 5 | NO |
| 6 | -V out |
| 7 | +V out |

PBIH-J


| Terminal | Connection |
| :---: | :---: |
| 1 | FG |
| 2 | $\mathrm{DC}+\mathrm{V}$ in |
| 3 | OV in |
| 4 | LFG |
| 5 | -V out |
| 6 | +V out |
| 7 | NC |

PBIH-M


| Terminal | Connection |
| :---: | :---: |
| 1 | $+V$ out |
| 2 | $+V$ out |
| 3 | $-V$ out |
| 4 | $-V$ out |
| 5 | $F G$ |
| 6 | $-V$ in |
| 7 | $+V$ in |

PBIH-R


| Terminal | Connection |
| :---: | :---: |
| 1,2 | $+V$ out |
| 3 | $+S$ |
| 4 | $-S$ |
| 5,6 | -V out |
| 7 | Remote |
| 8 | Control |
| 9 | $\mathrm{DC}+\mathrm{V}$ in |
| 9 | DC OV in |
| 10 | FG |

# TECHNICAL DATA SHEET 

For

## SEWAGE PUMP STATION SP210 Nudgee Beach

Equipment Type: Modem/Power Supply
Location:RTU Section
Model Numbers: ..... PB251
Manufacturer:PowerboxSupplier:Brisbane Water

## PB251 Series

## 220-330 WATTS DC UPS

## Features

- Ultra-low noise output
- Independent battery charging output
- DC output OK \& battery OK alarms \& LEDs
- Battery-LVD and alarm
- Over-temperature protection
- Battery fuse fail LED


Specifications
INPUT

| Voltage: | 190 to 264 vac, or 190 to 400 VDC |
| :--- | :--- |
| Line regulation: | $0.2 \%$ typical |
| Current: | 1.4 A maximum |
| Inrush current: | 10 A maximum |
| Frequency: | 45 to 65 Hz |

## OUTPUT

| Voltage | See table |
| :--- | :--- |
| Current | See table |
| Load regulation | $0.5 \%$ typical |
| Current limit type - load cct | Constant current |
| Current limit type - batt. cct | Constant current |
| Short circuit protection | Indefi nite, auto-resetting |
| Over-voltage protection | 17.5 to 20 V latching (13.8Vdc output) <br>  <br> Ripple \& noise <br> 100 MHz bandwidth |
| ENVIRONMENTAL | 28 mVp 年 (13.8V latching (27.6Vdc output) |

## Selection Table

## STANDARDS \& APPROVALS

| Safety | Complies with AS/NZS 60950, class 1, <br>  <br>  <br> NSW Office of Fair Trading Approval N20602 |
| :--- | :--- |
| EMC | Emissions comply with AS/NZS CISPR11, |
|  | Group 1, Class B. Complies with ACA EMC |
|  | Scheme, Safety \& EMC Regulatory Compliance |
|  | Marked |
| Isolation i/p-o/p | 4242VDC for 1 minute |
| i/p-ground | 2121VDC for 1 minute |
| o/p-ground | 707VDC for 1 minute |


| ALARMS \& BATTERY FUNCTIONS |  |
| :---: | :---: |
| Converter ON/OK alarm |  |
| green LED | ON=PSU OK |
| Battery low (\& fuse) alarm | 10.2 to 12.6 V for 12 V battery, adjustable 20.4 to 25.2 V for 24 V battery, adjustable Indicated by voltage-free changeover relay contacts \& green LED: $O N=B A T T$ OK |
| Low voltage disconnect | 9.6 to 12 V for 12 V battery, adjustable 19.2 to 24 V 2 for 4 V battery, adjustable |
| Charger over-load protection | Auto-resetting electronic circuit breaker |
| Reverse polarity protection | Internal battery fuse |
| Battery to load voltage drop | 0.2 to. 0.25 V typical |
| MECHANICAL |  |
| Case size | $264 \mathrm{~L} \times 172 \mathrm{~W} \times 67 \mathrm{Hmm}$ |
| Case size with heatsink | $264 \mathrm{~L} \times 186 \mathrm{~W} \times 67 \mathrm{Hmm}$ |
| Rack size | $232 \mathrm{D} \times 19^{\prime \prime} \mathrm{W} \times 2 \mathrm{RU}$ H |
| Weight | 1.9 kg |
| Weight with heatsink | 2.1 kg |
| Weight (rack mounted version) | 5.5 kg |


| MODEL <br> NUMBER | OUTPUT |  |  | $\begin{aligned} & \hline \text { OUTPUT } \\ & \hline \text { POWER } \end{aligned}$ | Note: Non standard battery charging current available on request. ie PB251-12CM-H-10 for 10A. |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | VDC | ILoad | $\mathrm{I}_{\text {BATt }}$ |  |  |
| PB251-12CM | 13.8 V | 16A | 2A | 220W |  |
| PB251-12CM-H | 13.8 V | 20A | 2A | 275W |  |
| PB251-24CM | 27.6 V | 11A | 2A | 300W |  |
| PB251-24CM-H | 27.6 V | 12A | 2A | 330W |  |
| PB251-12RML | 13.8 V | 20A | 4A | 275W |  |
| PB251-12B | 13.8 V | 20A | 4 A | 275W |  |
| PB251-24RML | 27.6 V | 12A | 2 A | 330W |  |

## PB251 Series

275-330 WATTS DC UPS

Technical Illustrations


## TECHNICAL DATA SHEET

For

## SEWAGE PUMP STATION SP210

## Nudgee Beach

Equipment Type: ..... Level Probe
Location: Common Control
Model Numbers: ..... 020130FSP
Manufacturer: Multitrode
Supplier: Multitrode Pty Ltd
130 Kinston Road
Underwood. QLD 4119
Tel: 0733407000Fax: 0733407077

## The MultiTrode Probe

## MultiTrode probes are unsurpassed for rugged reliability, cost effectiveness and simplicity. Designed for the tough, turbulent conditions found in water, sewage and industrial tanks and sumps, the probes can be found in the simplest and the most complex water and wastewater management systems around the world.

- Low maintenance
- Simple installation
- Excellent in turbulence
- Short \& long term cost savings
- Environmentally friendly
- Safe, low sensing voltage
- Unaffected by fat, grease, debris and foam
- Positive pump cut-out
- Safe - MTISB Barrier


## Reliable in all conditions

Operation is unaffected by build up of fat, grease debris and foam, which causes other systems such as floats, bubblers, pressure and ultrasonic transducers to fail. Turbulence does not affect the probe operation. The rugged, streamlined design eliminates tangling and is ideal for confined spaces.

## Positive pump cut-out

Operational consistency is important to longevity, low maintenance and cost control. The positive pump cut-out ensures pumps are turned off at the same level every time. This avoids damage due to pump over run and the cost of additional control equipment.

## Safe for people and environment

The extra low sensing voltage ensures operators and maintenance staff are protected. All MultiTrode products are environmentally safe, containing no mercury or other harmful contaminants.

## Cost savings

The low cost of equipment, installation and maintenance makes MultiTrode one of the most efficient level control systems available. Plus robust construction and longevity ensures continued cost savings when compared to other systems on the market.

## Standard and custom probes

MultiTrode manufactures a wide range of standard probes, from a single sensor $(200 \mathrm{~mm})$ to a ten-sensor probe $(1000 \mathrm{~mm}$ increasing to a maximum of nine metres). Custom probes can be manufactured to suit your requirements.

## Installation

Installation is straightforward. Probes are easy to install without entering the wet area. The probe is simply lowered in from the top and suspended by its own cable, using the mounting kit supplied.

## MTAK-1 Mounting Kit (Supplied)

The mounting bracket is a standard accessory supplied with all multi-sensor probes (not standard with 0.2/1-xx single sensor probe).
The MTAK-1 mounting bracket has an integral cleaning device. All metal components are stainless steel.


## MTAK-2 Mounting Kit (Optional extra)

This extended bracket provides up to 300 mm extra wall clearance. This bracket is not included as standard with probes.


Ordering Examples and Information

| Model <br> Code | Probe <br> Length <br> $(\mathbf{m} / \mathbf{i n})$ | Sensor <br> Separation <br> $(\mathbf{m m} / \mathbf{i n})$ | Cable <br> Length ${ }^{*}$ <br> $(\mathbf{m} / \mathrm{ft})$ | Number of <br> Sensors |
| :---: | :---: | :---: | :---: | :---: |
| $0.2 / 1-10$ | $0.2 / 8$ | $\mathrm{~N} / \mathrm{A}$ | $10 / 33$ | 1 |
| $0.5 / 3-10$ | $0.5 / 16$ | $150 / 6$ | $10 / 33$ | 3 |
| $1.0 / 10-10$ | $1 / 40$ | $100 / 4$ | $10 / 33$ | 10 |
| $1.5 / 10-30$ | $1.5 / 60$ | $150 / 6$ | $30 / 100$ | 10 |
| $2.0 / 10-30$ | $2 / 80$ | $200 / 8$ | $30 / 100$ | 10 |
| $2.5 / 10-30$ | $2.5 / 96$ | $250 / 10$ | $30 / 100$ | 10 |
| $3.0 / 10-30$ | $3 / 115$ | $300 / 12$ | $30 / 100$ | 10 |
| $6.0 / 10-30$ | $6 / 224$ | $600 / 24$ | $30 / 100$ | 10 |
| $9.0 / 10-30$ | $9 / 368$ | $900 / 40$ | $30 / 100$ | 10 |

*Cable Length $10 \mathrm{~m} / 33 \mathrm{ft}$ or $30 \mathrm{~m} / 100 \mathrm{ft}$


## MULTITRODE

www.multitrode.com

## MultiTrode Probe Immersion Table

## multitrode <br> WATER - WASTEWATER • PUMP STATION • TECHNOLOGY

PVC and AVESTA 254-SMO stainless steel comprise the major, exposed surfaces of the MultiTrode probe, and have been operated and tested in the following chemicals.

| ACETIC ACID | 50\% Aqueous | OXALIC ACID | 5\% |
| :---: | :---: | :---: | :---: |
| ADIPIC ACID | Saturated Aqueous | PHOSPHORIC ACID | Up to 30\% Aqueous |
| ALUMINIUM SULPHATE | 27\% | POTASSIUM BICHROMATE | 25\% |
| AMMONIUM CARBONATE | 50\% Aqueous | POTASSIUM CHLORATE | 36\% |
| AMMONIUM HYDROXIDE | All Concentrations | POTASSIUM CHROMATE | All Concentrations |
| AMMONIUM PHOSPHATE | All Concentrations | POTASSIUM CYANIDE | All Concentrations |
| AMMONIUM SULPHATE | All Concentrations | POTASSIUM PERMANGANATE | 5-10\% |
| AMMONIUM SULPHIDE | All Concentrations | POTASSIUM PERSULPHATE | Saturated |
| AMYL ALCOHOL |  | POTASSIUM SULPHATE | All Concentrations |
| ANILINE HYDROCHLORIDE | All Concentrations | SODIUM ACETATE | All Concentrations |
| BARIUM HYDROXIDE | All Concentrations | SODIUM BICARBONATE | All Concentrations |
| BEER |  | SODIUM BISULPHATE | 5\% |
| BORAX | All Aqueous | SODIUM BISULPHITE | 10\% |
| BORIC ACID | All Aqueous | SODIUM CHLORATE | 30\% |
| CALCIUM NITRATE | 50\% Aqueous | SODIUM FLUORIDE | 5-10\% |
| CHLORIC ACID | 10\% | SODIUM NITRATE | All Concentrations |
| CHROMIC ACID | 5\% | SODIUM PHOSPHATE | All Concentrations |
| FORMIC ACID | Up to 50\% Aqueous | SODIUM SILICATE | All Aqueous |
| GELATINE | All Concentrations | SODIUM SULPHATE | All Concentrations |
| GLUCOSE | All Concentrations | SODIUM SULPHIDE | 5\% |
| GLYCERINE | All Concentrations | SODIUM SULPHITE | 50\% |
| HYDROBROMIC ACID | 50\% Aquebus | SODIUM THIOSULPHATE | 16-25\% |
| HYDROCYANIC ACID | 100\% | SULPHUR DIOXIDE | Technically Pure Anhydrous |
| HYDROFLUORIC ACID | 1\% | SULPHURIC ACID | 98\% |
| HYDROGEN PEROXIDE | 30\% Aqueous | SULPHUROUS ACID | Saturated Aqueous |
| HYDROGEN SULPHIDE | Moist Gas or Saturated Aqueous solution | TANNIC ACID | All Aqueous |
| LACTIC ACID | 18\% Aqueous | TARTARIC ACID | All Aqueous |
| LEAD ACETATE | All Concentrations | TURPENTINE OIL | Technically Pure |
| MERCURY | 100\% | VINEGAR | 4-5\% |
| MILK | Sour | YEAST | All Aqueous |

Unless stated otherwise, all aqueous solutions are $100 \%$.

Note: $\quad$ MultiTrode probes can be used in many other aggressive applications and the list above is by no means complete.


# TECHNICAL DATA SHEET 

For

## SEWAGE PUMP STATION SP210 Nudgee Beach

Equipment Type: Variable speed drive
Location:
Drive section
Model Numbers:FC202
Manufacturer: Danfoss
Supplier:
DanfossUnit 3/8 Navigator PlaceHendra Qld 4011Tel: 0732923602Fax:07 32922122

VLT ${ }^{\text {® }}$ AQUA Drive Instruction Manual

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## 1 How to Read this Instruction Manual

## VLT AQUA Drive FC 200 Series Software version: 1.33

 C $\epsilon$

This guide can be used with all FC 200 adjustable frequency drives with software version 1.33 or later.
The current software version number can be read from par. 15-43 Software Version.

VLT ${ }^{\circledR}$ AQUA Drive Instruction Manual

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### 1.1.2 Available Literature for VLT ${ }^{\circledR}$ AQUA DriveFC 200

- VLT® AQUA Drive Instruction Manual MG.20.Mx.yy provides the neccessary information for getting the drive up and running.
- VLT® AQUA Drive High Power Instruction Manual MG.20.Px.yy provides the neccessary information for getting the HP drive up and running.
- VLT® AQUA Drive Design Guide MG.20.Nx.yy contains all the technical information about the drive and customer design and applications.
- VLT® AQUA Drive Programming Guide MN.20.Ox.yy provides information on how to program and includes complete parameter descriptions.
- VLT® AQUA Drive FC. 200 Profibus MG.33.Cx.yy
- VLT® AQUA Drive FC 200 DeviceNet MG.33.Dx.yy
- Output Filters Design Guide MG.90.Nx.yy
- VLT® AQUA Drive FC 200 Cascade Controller MI.38.Cx.yy
- Application Note MN20A102: Submersible Pump Application
- Application Note MN20B102: Master/Follower Operation Application
- Application Note MN20F102: Drive Closed-loop and Sleep Mode
- Instruction MI.38.Bx.yy: Installation Instruction for Mounting Brackets Enclosure type A5, B1, B2, C1 and C2 IP21, IP55 or IP66
- Instruction MI.90.Lx.yy: Analog I/O Option MCB109
- Instruction MI.33.Hx.yy: Panel through mount kit
$x=$ Revision number
$y y=$ Language code

Danfoss technical literature is also available online at www.danfoss.com/BusinessAreas/DrivesSolutions/Documentations/Technical+Documentation.htm.

VLT ${ }^{\circledR}$ AQUA Drive Instruction Manual

1 How to Read this Instruction Manual

### 1.1.3 Approvals



### 1.1.4 Symbols

Symbols used in this Instruction Manual.

## NOTE!

Indicates something to be noted by the reader.


Indicates a high-voltage warning.

* Indicates a default setting


## 2 Safety

### 2.1.1 Safety Note

The voltage of the adjustable frequency drive is dangerous whenever connected to line power. Incorrect installation of the motor, adjustable frequency drive or serial communication bus may cause damage to the equipment, serious personal injury or death. Consequently, the instructions in this manual, as well as national and local rules and safety regulations, must be complied with.

## Safety Regułations

1. The adjustable frequency drive must be disconnected from line power if repair work is to be carried out. Make sure that the line power supply has been disconnected and that the necessary time has passed before removing motor and line power plugs.
2. The [STOP/RESET] key on the control panel of the adjustable frequency drive does not disconnect the equipment from line power and is thus not to be used as a safety switch.
3. Correct protective grounding of the equipment must be established, the user must be protected against supply voltage, and the motor must be protected against overload in accordance with applicable national and local regulations.
4. The ground leakage currents are higher than 3.5 mA .
5. Protection against motor overload is set by par. 1-90 Motor Thermal Protection. If this function is desired, set par. 1-90 to data value [ETR trip] (default value) or data value [ETR warning]. Note: The function is initialized at $1.16 \times$ rated motor current and rated motor frequency. For the North American market: The ETR functions provide class 20 motor overload protection in accordance with NEC.
6. Do not remove the plugs for the motor and line power supply while the adjustable frequency drive is connected to line power. Make sure that the line power supply has been disconnected and that the necessary time has passed before removing motor and line power plugs.
7. Please note that the adjustable frequency drive has more voltage inputs than L1, L2 and L3 when load sharing (linking of the DC intermediate circuit) and external $24 \vee D C$ have been installed. Make sure that all voltage inputs have been disconnected and that the necessary time has passed before commencing repair work.

## Installation at High Altitudes



## Installation at high altitude:

380-480 V: At altitudes above $10,000 \mathrm{ft}$ [ 3 km ], please contact Danfoss Drives regarding PELV.
525-690 V: At altitudes above $6,600 \mathrm{ft}$ [ 2 km ], please contact Danfoss Drives regarding PELV.

## Warning against Unintended Start

1. The motor can be brought to a stop by means of digital commands, bus commands, references or a local stop, while the adjustable frequency drive is connected to line power. If personal safety considerations make it necessary to ensure that no unintended start occurs, these stop functions are not sufficient. 2. While parameters are being changed, the motor may start. Consequentiy, the stop key [RESET] must always be activated; following which data can be modified. 3. A motor that has been stopped may start if faults occur in the electronics of the adjustable frequency drive, or if a temporary overload or a fault in the supply line power or the motor connection ceases.


Warning:
Touching the electrical parts may be fatal - even after the equipment has been disconnected from line power.

Also make sure that other voltage inputs have been disconnected, such as external $24 \mathrm{~V} D C$, load sharing (linkage of DC intermediate circuit), as well as the motor connection for kinetic backup.

### 2.1.2 General Warning


#### Abstract

Leakage Current The ground leakage current from the VLT AQUA Drive FC 200 exceeds 3.5 mA . According to IEC 61800-5-1, a reinforced protective ground connection must be ensured by means of: a min. $0.016 \mathrm{in}^{2}$ [ $10 \mathrm{~mm}^{2}$ ] Cu or $0.025 \mathrm{in}^{2}$ [16 $\mathrm{mm}^{2}$ ] Al PE-wire, or an additional PE wire - with the same cable cross-section as the line power wiring - must be terminated separately. Residual Current Device This product can cause DC current in the protective conductor. Where a residual current device (RCD) is used for extra protection, only an RCD of Type B (time delayed) shall be used on the supply side of this product. See also RCD Application Note MN. $90.6 \times .02$. Protective grounding of the VLT AQUA Drive FC 200 and the use of RCDs must always follow national and local regulations.


### 2.1.3 Before Commencing Repair Work

1. Disconnect the adjustable frequency drive from line power.
2. Disconnect DC bus terminals 88 and 89
3. Wait at least the time mentioned above in the section General Warning.
4. Remove motor cable

### 2.1.4 Special Conditions

## Electrical Ratings:

The rating indicated on the nameplate of the adjustable frequency drive is based on a typical 3-phase line power supply within the specified voltage, current and temperature ranges, which are expected to be used in most applications.

The adjustable frequency drives also support other special applications, which affect the electrical ratings of the adjustable frequency drive. Special conditions that affect the electrical ratings might be:

- Single phase applications.
- High temperature applications which require derating of the electrical ratings
- Marine applications with more severe environmental conditions

Consult the relevant clauses in these instructions and in the VLT ${ }^{\text {® }}$ AQUA Drive Design Guide for information about the electrical ratings.

## Installation requirements:

The overall electrical safety of the adjustable frequency drive requires special installation considerations regarding:

- Fuses and circuit breakers for overcurrent and short-circuit protection
- Selection of power cables (line power, motor, brake, load sharing and relay)
- Grid configuration ( $\Pi, T N$, grounded leg, etc.)
- Safety of low-voltage ports (PELV conditions)

Consult the relevant clauses in these instructions and in the VLT ${ }^{*}$ AQUA Drive Design Guide for information about the installation requirements.

### 2.1.5 Caution

[^4]2 Safety


### 2.1.6 Avoid Unintended Start


#### Abstract

NOTE! While the adjustable frequency drive is connected to line power, the motor can be started/stopped using digital commands, bus commands, references or via the Local Control Panel.


- Disconnect the adjustable frequency drive from line power whenever personal safety considerations make it necessary to avoid an unintended start.
- To avoid unintended start, always activate the [OFF] key before changing parameters.
- Unless terminal 37 is turned off, an electronic fault, temporary overload, a fault in the line power supply, or lost motor connection may cause a stopped motor to start.


### 2.1.7 IT Line Power



## IT line power

Do not connect adjustable frequency drives with RFI filters to line power supplies with a voltage between phase and ground of more than 440 V for 400 V drives and 760 V for 690 V drives.
For $400 \mathrm{VT} \Pi$ line power and delta ground (grounded leg), AC line voltage may exceed 440 V between phase and ground. For $690 \mathrm{VT} \Pi$ line power and delta ground (grounded leg), AC line voltage may exceed 760 V between phase and ground.
par. 14-50 RFI 1 can be used to disconnect the internal RFI capacitors from the RFI filter to ground.

### 2.1.8 Disposal Instructions



Equipment containing electrical components may not be disposed of together with domestic waste. It must be separately collected with electrical and electronic waste according to local and currently valid legislation.

### 2.1.9 Safe Stop of the Adjustable Frequency Drive (optional)

For versions fitted with a safe stop terminal 37 input, the adjustable frequency drive can perform the safety function Safe Torque Off(As defined by draft CD IEC 61800-5-2) or Stop Category 0 (as defined in EN 60204-1).

It is designed and deemed suitable for the requirements of Safety Category 3 in EN 954-1. This function is called safe stop. Prior to integrating and using safe stop in an installation, a thorough risk analysis must be carried out on the installation in order to determine whether the safe stop functionality and safety category are appropriate and sufficient. In order to install and use the Safe Stop function in accordance with the requirements of Safety Category 3 in EN 954-1, the related information and instructions of the VLT AQUA Drive Design Guide MG.20.NX.YY must be followed! The information and instructions contained in the instruction Manual are not sufficient for a correct and safe use of the safe stop functionality!


## 3 Introduction

### 3.1.1 Type Code String - Medium Power




| Description | Pos.: | Possible choice |
| :---: | :---: | :---: |
| Product group \& VLT Series | 1-6 | FC 202 |
| Power rating | 7-10 | $0.34-1600 \mathrm{hp}[0.25-1200 \mathrm{~kW}]$ |
| Number of phases | 11 | Three phases ( $T$ ) |
| AC line voltage | 11-12 | S2: 220-240 V AC single phase S4: $380-480 \mathrm{VAC}$ single phase <br> T 2: 200-240 V AC <br> T 4: 380-480 V AC <br> T 6: 525-600 V AC <br> T 7. 525-690 V AC |
| Enclosure | 13-15 | ```E20: IP20 E21: IP 21/NEMA Type 1 E55: IP 55/NEMA Type 12 E2M: IP21/NEMA Type \(1 \mathrm{w} /\) line power shield E5M: IP 55/NEMA Type 12 w / line power shield E66: IP66 F21: IP21 kit without backplate G21: IP21 kit with backplate P20: \(1 \mathrm{P} 20 /\) chassis with backplate P21: IP21/NEMA Type 1 w/ backplate P55: IP55/NEMA Type \(12 \mathrm{w} /\) backplate``` |
| RFI filter | 16-17 | ```HX: No RFI filter H1: RFI filter class A1/B H2: RFI filter class A2 H3: RFI fitter class A1/B (reduced cable length) H4: RFI filter class A2/A1``` |
| Brake | $18^{\circ}$ | X: No brake chopper included <br> B: Brake chopper included <br> T: Safe Stop <br> U: Safe + brake |
| Display | 19 | G: Graphical Local Control Panel (GLCP) <br> N : Numeric Local Control Panel (NLCP) <br> $x$ : No Local Control Panel |
| Coating PCB | 20 | $\begin{aligned} & \text { X. No coated PCB } \\ & \text { C: Coated PCB } \end{aligned}$ |
| Line power option | 21 | D: Loadsharing <br> X: No line power disconnect switch <br> 8: Line Power Disconnect + Loadsharing |
| Cable entries | 22 | X: Standard cable entries <br> O: European metric thread in cable entries |
|  | 23 | Reserved |
| Software release | 24-27 | Current software version |
| Software language | 28 |  |

Table 3.1: Type code description.


Table 3.2: Type code description.

### 3.1.2 Adjustable Frequency Drive Identification

Below is an example of an identification label. This label is situated on the adjustable frequency drive and shows the type and the options with which the unit is equipped. See table 2.1 for details of how to read theType code string (T/C).


Figure 3.1: This example shows an identification label for the VLT AQUA Drive.

Please have T/C (type code) number and serial number ready before contacting Danfoss.

### 3.1.3 Abbreviations and Standards

| Abbreviations: | Termst | SI units: | I-P units: |
| :---: | :---: | :---: | :---: |
| a | Acceleration | $\mathrm{m} / \mathrm{s}^{2}$ | $\mathrm{ft} / \mathrm{s}^{2}$ |
| AWG | American wire gauge |  |  |
| Auto Tune | Automatic Motor Tuning |  |  |
| ${ }^{\circ} \mathrm{C}$ | Celsius |  |  |
| 1 | Current | A | Amp |
| Inm | Current limit |  |  |
| Joute | Energy | $\mathrm{J}=\mathrm{N} \cdot \mathrm{m}$ | E-lb, Btu |
| ${ }^{4} \mathrm{~F}$ | Fahrenheit |  |  |
| FC | Adjustable Frequency Drive |  |  |
| $f$ | Frequency | Hz | Hz |
| kHz | Kiloherts | kHz | kHz |
| LCP | Local Control Panel |  |  |
| mA | Milliampere |  |  |
| ms | Millisecond |  |  |
| min | Minute |  |  |
| MCT | Motion Control Tool |  |  |
| M-TYPE | Motor Type Dependent |  |  |
| Nm | Newton meters |  | in-libs |
| Inu | Nominal motor current |  |  |
| fran | Nominal motor frequency |  |  |
| Puor | Nominal motor power |  |  |
| UMN | Nominal motor voltage |  |  |
| par. | Parameter |  |  |
| PELV | Protective Extra Low Voltage |  |  |
| Watt | Power | W | Btwhr, hp |
| Pascal | Pressure | $\mathrm{Pa}=\mathrm{N} / \mathrm{m}^{2}$ | psi, psi, ft of water |
| Inve | Rated Inverter Output Current |  |  |
| RPM | Revolutions Per Minute |  |  |
| SR | Size Related |  |  |
| T | Temperature | C | F |
| t | Time | 5 | 5. hr |
| Tum | Torque limit |  |  |
| U | Voltage | V | V |

Table 3.3: Abbreviation and standards table.

## 4 Mechanical Installation

### 4.1 Before Starting

### 4.1.1 Checklist

When unpacking the adjustable frequency drive, make sure that the unit is undamaged and complete. Use the following table to identify the packaging:

| Enclosure type: | $\begin{gathered} \text { A2 } \\ \text { (IP } 20 / 21) \end{gathered}$ | $\begin{gathered} \text { A3 } \\ \text { (IP 20/21) } \end{gathered}$ | $\begin{gathered} \text { A5 } \\ \text { (IP } 55 / 66) \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{B} 1 / \mathrm{B3} \\ (\mathrm{IP} 20 / 21 / 55 / 66) \end{gathered}$ | $\begin{gathered} \mathrm{B} 2 / \mathrm{B4} \\ (\mathrm{IP} 20 / 21 / 55 / 66) \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{C} 1 / \mathrm{C} 3 \\ (\mathrm{IP} 20 / 21 / 55 / 66) \end{gathered}$ | $\begin{gathered} \text { C2/C4 } \\ \text { (IP20/21/55/66) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |
| Unit size (kW): |  |  |  |  |  |  |  |
| 200-240 V | 0.25-3.0 | 3.7 | 0.25-3.7 | $\begin{gathered} \hline 5.5-11 / \\ 5.5-11 \end{gathered}$ | $\begin{gathered} 15 / \\ 15-18.5 \end{gathered}$ | $\begin{gathered} 18.5-30 / \\ 22-30 \end{gathered}$ | $\begin{gathered} 37-45 / \\ 37-45 \end{gathered}$ |
| $380-480 \mathrm{~V}$ | 0.37-4.0 | 5.5-7.5 | 0.37-7.5 | $\begin{gathered} 11-18.5 / \\ 11-18.5 \end{gathered}$ | $\begin{gathered} 22-30 / \\ 22-37 \end{gathered}$ | $\begin{gathered} 37-55 / \\ 45-55 \end{gathered}$ | $\begin{gathered} 75-90 / \\ 75-90 \end{gathered}$ |
| 525-600 v |  | 0.75-7.5 | 0.75-7.5 | $\begin{gathered} 11-18.5 / \\ 11-18.5 \end{gathered}$ | $\begin{gathered} 22-37 / \\ 22-37 \end{gathered}$ | $\begin{gathered} 45-55 / \\ 45-55 \end{gathered}$ | $\begin{gathered} 75-90 / \\ 75-90 \end{gathered}$ |
| 525-690 V | - | - | - | $\%$ | $11-30 /$ | -/ | $37-901$ |

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Please note that a selection of screwdrivers (phillips or cross-thread screwdriver and torx), a side-culter, drill and knife is also recommended to have handy for unpacking and mounting the adjustable frequency drive. The packaging for these enclosures contains, as shown: accessory bag(s), documentation and the unit. Depending on options fitted, there may be one or two bags and one or more booklets.


Accessory bags containing necessary brackets, screws and connectors are included with the drives upon delivery.

* IP21 can be established with a kit as described in the section: IP 21/IP 4X/ TYPE 1 Enclosure Kit in the Design Guide.


### 4.2.2 Mechanical Dimensions

| Mechanical dimensions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Frame size (kW) : |  | A2 |  | A3 |  | AS |  |  |  |  | C1 | C2 | C3 | C4 |
| 200-240 V | T2 |  |  |  |  |  | $5.5-11$ | 15 | $5.5-11$ | $15-18.5$ | 18.5-30 | 37-45 | 22-30 | 37-45 |
| 380-480 V | T4 |  |  |  |  | 0.37-7.5 | 11-18.5 | 22-30 | 11-18.5 | 22-37 | 37-55 | 75-90 | 45-55 | 75-90 |
| 525-600 V | T6 |  |  |  |  | 0.75-7.5 | 11-18.5 | 22-30 | 11-18.5 | 22-37 | 37-55 | 75-90 | 45-55 | 75-90 |
| 525-690 V | 17 |  |  |  |  | - | - | 11-30 | - | - | - | 37-90 | - | - |
| IP |  | 20 | 21 | 20 | 21 | 55/66 | 21/55/66 | 21/55/66 | 20 | 20 | 21/55/66 | 21/55/66 | 20 | 20 |
| NEMA |  | Chassis | Type 1 | Chassis | Type 1 | Type 12 | Type 1/12 | Type 1/12 | Chassis | Chassis | Type 1/12 | Type 1/12 | Chassis | Chassis |
| Height (mm) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure | A** | 246 | 372 | 246 | 372 | 420 | 480 | 650 | 350 | 460 | 680 | 770 | 490 | 600 |
| ..with de-coupling plate | A2 | 374 | - | 374 | - | - | - | - | 419 | 595 | - | - | 630 | 800 |
| Backplate | A1 | 268 | 375 | 268 | 375 | 420 | 480 | 650 | 399 | 520 | 680 | 770 | 550 | 660 |
| Distance between mount. holes | a | 257 | 350 | 257 | 350 | 402 | 454 | 624 | 380 | 495 | 648 | 739 | 521 | 631 |
| Width (mm) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Enclosure | B | 90 | 90 | 130 | 130 | 242 | 242 | 242 | 165 | 231 | 308 | 370 | 308 | 370 |
| With one Coption | B | 130 | 130 | 170 | 170 | 242 | 242 | 242 | 205 | 231 | 308 | 370 | 308 | 370 |
| Backplate | B | 90 | 90 | 130 | 130 | 242 | 242 | 242 | 165 | 231 | 308 | 370 | 308 | 370 |
| Distance between mount. holes | b | 70 | 70 | 110 | 110 | 215 | 210 | 210 | 140 | 200 | 272 | 334 | 270 | 330 |
| Depth (mm) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Without option A/B | C | 205 | 205 | 205 | 205 | 200 | 260 | 260 | 248 | 242 | 310 | 335 | 333 | 333 |
| With option A/B | C* | 220 | 220 | 220 | 220 | 200 | 260 | 260 | 262 | 242 | 310 | 335 | 333 | 333 |
| Screw holes (mm) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | c | 8.0 | 8.0 | 8.0 | 8.0 | 8.2 | 12 | 12 | 8 | - | 12 | 12 | - | - |
| (Diameter $\varnothing$ | d | 11 | 11 | 11 | 11 | 12 | 19 | 19 | 12 | - | 19 | 19 | - | - |
| Diameter $\varnothing$ | e | 5.5 | 5.5 | 5.5 | 5.5 | 6.5 | 9 | 9 | 6.8 | 8.5 | 9.0 | 9.0 | 8.5 | 8.5 |
|  | $f$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 7.9 | 15 | 9.8 | 9.8 | 17 | 17 |
| $\begin{aligned} & \text { Max weight } \\ & \text { (kg) } \end{aligned}$ |  | 4.9 | 5.3 | 6.6 | 7.0 | 14 | 23 | 27 | 12 | 23.5 | 45 | 65 | 35 | 50 |
| * Depth of enctosure will vary with different options installed. <br> ** The free space requirements are above, and below the bare enclosure height measurement A. See section 3.2 .3 for further inform |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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### 4.2.3 Mechanical Mounting

All IP20 enclosure sizes as well as IP21/ IP55 enclosure sizes except A2 and A3 allow side-by-side installation.

If the IP 21 Enclosure kit (13081122 or 130B1123) is used on enclosure $A 2$ or A 3 , there must be a minimum of 2 in [ 50 mm ] of dearance between drives.

For optimal cooling conditions, allow a free air passage above and below the adjustable frequency drive. See table below.


1. Drill holes in accordance with the measurements given.
2. You must provide screws suitable for the surface on which you want to mount the adjustable frequency drive. Re-tighten all four screws.


Table 4.2: Mounting frame sizes A5, B1, B2, B3, B4, C1, C2, C3 and C4 on a non-solid back wall, the drive must be provided with a backplate A due to insufficient cooling air over the heatsink.

For heavier drives (BA, C3, C4), use a lift. First wall-mount the 2 lower bolts, then lift the drive onto the lower bolts. Finally, fasten the drive against the wall with the 2 top bolts.

### 4.2.4 Safety Requirements for Mechanical Installation

$\square$

The adjustable frequency drive is cooled by air circulation.
To protect the unit from overheating, it must be ensured that the ambient temperature does not exceed the maximum temperature stated for the adjustable frequency drive, and that the 24 -hour average temperature is not exceeded. Locate the maximum temperature and 24 -hour average in the paragraph Derating for Ambient Temperature.
If the ambient temperature is in the range of $113^{\circ}-131^{\circ} \mathrm{F}\left[45^{\circ}-55^{\circ} \mathrm{C}\right]$, derating of the adjustable frequency drive will become relevant, see Derating for Ambient Temperature.
The service life of the adjustable frequency drive is reduced if derating for ambient temperature is not taken into account.

### 4.2.5 Field Mounting

For field mounting the IP 21/IP 4X top/,TYPE 1 kits or IP 54/55 units are recommended.

### 4.2.6 Panel Through Mounting

A Panel Through Mount Kit is available for adjustable frequency drive series, VLT Aqua Drive and.

In order to increase heatsink cooling and reduce panel depth, the adjustable frequency drive may be mounted in a through panel. Furthermore, the builtin fan can then be removed.

The kit is available for enclosures A5 through $Q$.

## NOTE!

This kit cannot be used with cast front covers. No cover or IP21 plastic cover must be used instead.

Information on ordering numbers is found in the Design Guide, section Ordering Numbers.
More detailed information is available in the Panel Through Mount Kit instruction, MI.33.H1.YY, where $\mathbf{w}$ =language code.

## 5 Electrical Installation

### 5.1 How to Connect

### 5.1.1 Cables General



NOTE!
Always comply with national and local regulations on cable cross-sections.

Details of terminal tightening torques.

|  | Power (kW) |  |  | Torque ( Nm ) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Enclosure | 200-240 V | $380-480 \mathrm{~V}$ | $525-600 \mathrm{~V}$ | Line power | Motor | DC connec- tion | Brake | Ground | Relay |
| A2 | 0.25-3.0 | 0.37-4.0 |  | 1.8 | 1.8 | 1.8 | 1.8 | 3 | 0.6 |
| A3 | 3.7 | 5.5-7.5 | 0.75-7.5 | 1.8 | 1.8 | 1.8 | 1.8 | 3 | 0.6 |
| A5 | 0.25-3.7 | 0.37-7.5 | 0.75-7.5 | 1.8 | 1.8 | 1.8 | 1.8 | 3 | 0.6 |
| 81 | 5.5-11 | 11-18.5 | - | 1.8 | 1.8 | 1.5 | 1.5 | 3 | 0.6 |
| B2 |  | 22 | - | 4.5 | 4.5 | 3.7 | 3.7 | 3 | 0.6 |
|  | 15 | 30 | - | 4.52) | 4.52) | 3.7 | 3.7 | 3 | 0.6 |
| B3 | 5.5-11 | 11-18.5 | 11-18.5 | 1.8 | 1.8 | 1.8 | 1.8 | 3 | 0.6 |
| B4 | 15-18.5 | 22-37 | 22-37 | 4.5 | 4.5 | 4.5 | 4.5 | 3 | 0.6 |
| C1 | 18.5-30 | 37-55 | - | 10 | 10 | 10 | 10 | 3 | 0.6 |
| C2 | $\begin{aligned} & 37 \\ & 45 \end{aligned}$ | $75$ | - | $\begin{aligned} & 14 \\ & 24 \end{aligned}$ | $14$ | $14$ | $14$ | 3 3 | 0.6 0.6 |
| C3 | $\begin{gathered} 22 \\ 30 \end{gathered}$ | $\begin{aligned} & 45 \\ & \hline 55 \end{aligned}$ | $\begin{gathered} 45 \\ \hline 55 \\ \hline \end{gathered}$ | 10 | 10 | 10 | 10 | 3 | 0.6 |
| C4 | $\begin{gathered} 37 \\ 45 \end{gathered}$ | $\begin{gathered} 75- \\ 90 \end{gathered}$ | $\begin{gathered} 75 \\ 90 \end{gathered}$ | $\begin{gathered} 14 \\ 24^{1} \end{gathered}$ | $\begin{aligned} & \hline 14 \\ & 24^{1} \end{aligned}$ | 14 | 14 | 3 | 0.6 |

Table 5.1: Tightening of terminals

1. For different cable dimensions $x / y$ where $x \leq 0.147 \mathrm{in}^{2}$ [ $95 \mathrm{~mm}^{2}$ ] and $y \geq 0.147 \mathrm{in}^{2}$ [ $95 \mathrm{~mm}^{2}$ ]
2. Cable dimensions above 25 hp [ 18.5 kW ] $\geq 0.0542 \mathrm{in}^{2}\left[35 \mathrm{~mm}^{2}\right.$ ] and below 30 hp [ 22 kW ] $\leq 0.0155 \mathrm{in}^{2}$ [ $10 \mathrm{~mm}^{2}$ ]

### 5.1.2 Power and Control Wiring for Unshielded Cables



Induced Voltage!
Run motor cables from multiple drives separately. Induced voltage from output motor cables run together can charge equipment capacitors even with the equipment turned off and locked out. Failure to run output cables separately could result in death or serious injury.


Run drive input power, motor wiring, and control wiring in three separate metallic conduits or raceways for high frequency noise isolation. Failure to isolate power, motor, and control wiring could result in less than optimum controller and associated equipment performance.

Because the power wiring carries high frequency electrical pulses, it is important that input power and motor power are run in separate conduit. If the incoming power wiring is run in the same conduit as the motor wiring, these pulses can couple electrical noise back onto the building power grid. Control wiring should always be isolated from the high voltage power wiring.
When shielded/armored cable is not used, at least three separate conduits must be connected to the panel option (see figure below).

- Power wiring into the enclosure
- Power wiring from the enclosure to the motor
- Control wiring


Figure 5.1: Power and control wiring connection

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### 5.1.3 Grounding and IT Line Power

The ground connection cable cross-section must be at least $0.016 \mathrm{in}^{2}$ [ $10 \mathrm{~mm}^{2}$ ]or 2 rated line power wires terminated separately according to EN 50178 or IEC 61800-5-1 unless national regulations specify differently. Always comply with national and local regulations on cable cross-sections.

The line power is connected to the main disconnect switch if this is included.

## NOTE!

Make sure that the $A C$ line voltage corresponds to the $A C$ line voltage of the adjustable frequency drive nameplate.


Figure 5.2: Terminals for line power and grounding.


IT Line Power
Do not connect 400 V adjustable frequency drives with RFI filters to line power supplies with a voltage between phase and ground of more than 440 V .
For $\Pi$ line power and delta ground (grounded leg), AC line voltage may exceed 440 V between phase and ground.

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### 5.1.4 Line Power Wiring Overview



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### 5.1.5 AC Line Input Connections for A2 and A3




130BA262.10
Figure 5.4: When mounting cables, first mount and tighten ground cable.

The ground connection cable cross-section must be at least $0.016 \mathrm{in}^{2}$ [ $10 \mathrm{~mm}^{2}$ ] or 2 rated line power wires terminated separately according to EN 50178/IEC 61800-5-1.


Figure 5.5: Then mount line power plug and tighten wires.


NOTE!
With single phase $A 3$ use L1 and L2 terminals.

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### 5.1.6 AC Line Input Connections for A5




[^6]
### 5.1.7 AC Line Input Connections for B1, B2 and B3



## NOTE!

With single phase B1 use L1 and L2 terminals.

## NOTE!

For correct cable dimensions, please see the section General Specifications at the back of this manual.

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### 5.1.8 AC Line Input Connections for B4, C1 and C2



Figure 5.12: How to connect to line power and grounding for $B 4$.


Figure 5.13: How to connect to line power and grounding for C 1 and C 2 .

### 5.1.9 AC Line Input Connections for C3 and C4



Figure 5.14: How to connect C 3 to line power and grounding.


Figure 5.15: How to connect $C 4$ to line power and grounding.

### 5.1.10 How to Connect Motor - Introduction

See section General Specifications for correct dimensioning of motor cable cross-section and length.

- Use a shielded/armored motor cable to comply with EMC emission specifications (or install the cable in a metal conduit, see section Power and Control Wiring for Unshielded Cables).
- Keep the motor cable as short as possible to reduce the noise level and leakage currents.

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- Connect the motor cable shield/armor to both the decoupling plate of the adjustable frequency drive and to the metal of the motor. (The same applies to both ends of the metal conduit if used instead of a shield.)
- Make the shield connections with the largest possible surface area (by using a cable clamp or an EMC cable connector). This is done by using the supplied installation devices in the adjustable frequency drive.
- Avoid terminating the shield by twisting the ends (pigtails), as this will spoil high frequency shielding effects.
- If it is necessary to break the continuity of the shield to install a motor isolator or motor relay, the continuity must be maintained with the lowest possible HF impedance.


## Cable length and cross-section

The adjustable frequency drive has been tested with a given length of cable and a given cross-section of that cable. If the cross-section is increased, the cable capacitance - and thus the leakage current - may increase, thereby requiring that the cable length is reduced accordingly

## Switching frequency

When adjustable frequency drives are used together with sine wave filters to reduce the acoustic noise from a motor, the switching frequency must be set according to the sine wave filter instructions in par. 14-01 Switching Frequency.

## Precautions while using aluminum conductors

Aluminum conductors are not recommended for cable cross-sections less than $0.054 \mathrm{in}^{2}$ [ $35 \mathrm{~mm}^{2}$ ]. Terminals can accept aluminum conductors, but the conductor surface has to be clean, oxidation must be removed, and the area must be sealed by neutral acid-free Vaseline grease before the conductor is connected.
Furthermore, the terminal screw must be retightened after two days due to the softness of the aluminum. It is crucial to ensure that the connection makes a gas tight joint, otherwise the aluminum surface will oxidize again.
All types of three-phase asynchronous standard motors can be connected to the adjustable frequency drive. Normally, small motors are star-connected (230/400 V, D/Y). Large motors are delta-connected (400/690 V, $\mathrm{D} / \mathrm{Y}$ ). Refer to the motor nameplate for correct connection mode and voltage.


Figure 5.16: Terminals for motor connection


## NOTE!

In motors without phase insulation paper or other insulation reinforcement suitable for operation with the voltage supply (such as an adjustable frequency drive), fit a sine-wave filter on the output of the adjustable frequency drive. (Motors that comply with IEC 60034-17 do not require a sine-wave filter).

| No. | 96 | 97 | 98 | Motor voltage 0-100\% of AC line voltage. |
| :---: | :---: | :---: | :---: | :--- |
|  | U | V | W | 3 cables out of motor |
|  | U 1 | V 1 | W 1 | 6 cables out of motor, Delta-connected |
|  | W 2 | U 2 | V 2 |  |
|  | U 1 | V 1 | W 1 | 6 cables out of motor, Star-connected |
|  |  |  |  | $\frac{\mathrm{U} 2, \mathrm{~V} 2, \mathrm{~W} 2 \text { to be interconnected separately }}{\text { (optional terminal block) }}$ |
|  |  |  |  | Ground connection |
| No. | 99 |  |  |  |
|  | PE |  |  |  |

Table 5.3: 3 and 6 cable motor connection.
5.1.11 Motor Wiring Overview


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### 5.1.12 Motor Connection for A2 and A3

Follow these drawings step-by-step for connecting the motor to the adjustable frequency drive.


Figure 5.17: First terminate the motor ground, then place motor $U, V$ and $W$ wires in the plug and tighten them.


Figure 5.18: Mount cable clamp to ensure 360 degree connection between chassis and shield; ensure that the outer insulation of the motor cable is removed under the clamp.

### 5.1.13 Motor Connection for AS



Figure 5.19: First, terminate the motor ground, then insert the motor $\mathrm{U}, \mathrm{V}$ and W wires in the terminal and tighten them. Please ensure that the outer insulation of the motor cable is removed under the EMC clamp.

### 5.1.14 Motor Connection for B1 and B2



Figure 5.20: First terminate the motor ground, then place motor $U, V$ and $W$ wires in the terminal and tighten them. Please ensure that the outer insulation of the motor cable is removed under the EMC damp.

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### 5.1.15 Motor Connection for B3 and B4



Figure 5.21: First terminate the motor ground, then place motor $U, V$ and $W$ wires in the terminal and tighten them. Please ensure that the outer insulation of the motor cable is removed under the EMC clamp.


Figure 5.22: First terminate the motor ground, then place motor $\mathrm{U}, \mathrm{V}$ and W wires in the terminal and tighten them. Please ensure that the outer insulation of the motor cable is removed under the EMC clamp.

### 5.1.16 Motor Connection for C1 and C2



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### 5.1.17 Motor Connection for C3 and C4



Figure 5.24: First terminate the motor ground, then place motor $U, V$ and $W$ wires into the appropriate terminals and tighten. Please ensure that the outer insulation of the motor cable is removed under the EMC clamp.


Figure 5.25: First terminate the motor ground, then place motor $U, V$ and $W$ wires into the appropriate terminals and tighten. Please ensure that the outer insulation of the motor cable is removed under the EMC clamp.

### 5.1.18 DC Bus Connection

The DC bus terminal is used for DC back-up, with the intermediate circuit being supplied from an external source.

Terminal numbers used: 88,89


Please contact Danfoss if you require further information.

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### 5.1.19 Brake Connection Option

The connection cable to the brake resistor must be shielded/armored.

| Brake resistor |  |  |  |
| :--- | :---: | :---: | :---: |
| Terminal number | $\cdot$ | 81 | 82 |
| Terminals | $R-$ | $R+$ |  |

NoTE!

1. Use cable clamps to connect the shield to the metal cabinet of the adjustable frequency drive and to the decoupling plate of the brake resistor.

## 2. Dimension the cross-section of the brake cable to match the brake current.

## note!

Voltages up to 975 V DC (@ 600 VAC ) may occur between the terminals.


Figure 5.30: Brake connection terminal for B 3 .



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## NOTE!

If a short circuit in the brake IGBT occurs, prevent power dissipation in the brake resistor by using a line switch or contactor to disconnect the line power from the adjustable frequency drive. Only the adjustable frequency drive should control the contactor.

## NOTE!

Place the brake resistor in an environment free of fire risk and ensure that no external objects can fall into the brake resistor through ventilation slots.
Do not cover ventilation slots and grids.

### 5.1.20 Relay Connection

To set relay output, see par. group 5-4* Relays.

| No. | $01-02$ | make (normally open) |
| :--- | :--- | :--- |
|  | $01-03$ | break (normally closed) |
|  | $04-05$ | make (normally open) |
|  | $04-06$ | break (normally closed) |




Figure 5.34: Terminals for relay connection ( C 1 and C 2 enclosures).
The relay connections are shown in the cut-out with relay plugs (from the accessory bag) fitted.


Figure 5.35: Terminals for relay connections for B3. Only one relay input is fitted from the factory. When the second relay is needed, remove the knock-out.


Figure 5.36: Terminals for relay connections for $B 4$.


Figure 5.37: Terminals for relay connections for C3 and C4. Located in the upper right corner of the adjustable frequency drive.

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### 5.1.21 Relay Output

## Relay 1

## Relay 2

- Terminal 01: common
- Terminal 04: common
- Terminal 02: normal open 240 V AC
- Terminal 05: normal open 400 V AC
- Terminal 03: normal closed 240 V AC

Relay 1 and relay 2 are programmed in par. 5-40 Function Relay, par. 5-41 On Delay, Relay, and par. 5-42 Off Delay, Relay.

Additional relay outputs by using option module MCB 105.

- Terminal 06: normal closed 240 V AC



### 5.1.22 Wiring Example and Testing

The following section describes how to terminate and access control wires. For an explanation of the function, programming and wiring of the control terminals, please see chapter How to program the adjustable frequency drive.

### 5.1.23 Access to Control Terminals

All terminals to the control cables are located underneath the terminal cover on the front of the adjustable frequency drive. Remove the terminal cover with a screwdriver.


Figure 5.38: Access to control terminals for $A 2, A 3, B 3, B 4, C 3$ and C4 enclosures

Remove front cover to access control terminals. When replacing the front cover, ensure proper fastening by applying a torque of 2 Nm .


Figure 5.39: Access to control terminals for $\mathrm{A} 5, \mathrm{~B} 1, \mathrm{~B} 2, \mathrm{C} 1$ and C 2 enclosures

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### 5.1.24 Control Terminals

## Drawing reference numbers:

1. 10 -pole plug digital I/O.
2. 3-pole plug RS-485 bus.
3. 6-pole analog I/O.
4. USB connection.


Figure 5.40: Control terminals (all enclosures)


### 5.1.26 Electrical Installation and Control Cables



Figure 5.42: Diagram showing all electrical terminals. (Terminal 37 present for units with safe stop function only.)

| Terminal number | Terminal description | Parameter number | Factory default |
| :---: | :---: | :---: | :---: |
| $1+2+3$ | Terminal $1+2+3$-Relay1 | 5-40 | No operation |
| $4+5+6$ | Terminal $4+5+6$-Relay 2 | 5-40 | No operation |
| 12 | Terminal 12 Supply | - | $+24 \mathrm{VDC}$ |
| 13 | Terminal 13 Supply | - | +24VDC |
| 18 | Terminal 18 Digital Input | 5-10 | Start |
| 19 | Terminal 19 Digital Input | 5-11 | No operation |
| 20 | Terminal 20 | - | Common |
| 27 | Terminal 27 Digital Input/Output | 5-12/5-30 | Coast inverse |
| 29 | Terminal 29 Digital Input/Output | 5-13/5-31 | Jog |
| 32 | Terminal 32 Digital Input | 5-14 | No operation |
| 33 | Terminal 33 Digital Input | 5-15 | No operation |
| 37 | Terminal 37 Digital Input | - | Safe Stop |
| 42 | Terminal 42 Analog Output | 6-50 | Speed 0-HighLim |
| 53 | Terminal 53 Analog Input | 3-15/6-1*/20-0* | Reference |
| 54 | Terminal 54 Analog Input | 3-15/6-2*/20-0* | Feedback |

Table 5.5: Terminal connections

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Very long control cables and analog signals may, in rare cases and depending on the installation, result in $50 / 60 \mathrm{~Hz}$ ground loops due to noise from line power supply cables.

If this occurs, break the shield or insert a 100 nF capacitor between shield and chassis.

## NOTE!

The common of digital / analog inputs and outputs should be connected to separate common terminals 20,39, and 55 . This will prevent ground current interference among groups. For example, it prevents switching on digital inputs from disturbing analog inputs.

## NOTE!

To comply with EMC emission specifications, shielded/armored cables are recommended. If an unshielded/unarmored cable is used, see section Power and Control Wiring for Unshielded Cables.. For more information, see EMC Test Results in the Design Guide.

### 5.1.27 How to Test Motor and Direction of Rotation

## Note that unintended motor start can occur; make sure no personnel or equipment is in danger!



Figure 5.43:
Step 1: First, remove the insulation on both ends of a 1.972.76 in $[50-70 \mathrm{~mm}]$ piece of wire.


Figure 5.44:
Step 2: Insert one end in terminal 27 using a suitable terminal screwdriver. (Note: For units with the Safe Stop function, the existing jumper between terminal 12 and 37 should not be removed for the unit to be able to run!)


Figure 5.46:
Step 4: Power up the unit and press the [off] button. In this state, the motor should not rotate. Press [Off] to stop the motor at any time. Note that the LED on the [OFF] Dutton should be lit. If alarms or warnings are flashing, please see chapter 7 for more information.

Please follow these steps to test the motor connection and direction of rotation. Start with no power to the unit.


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Figure 5.48 :
Step 6: The speed of the motor can be seen in the LCP. It can be adjusted by pushing the up $\boldsymbol{\Delta}$ and down $\boldsymbol{\nabla}$ arrow buttons.


Figure 5.49:
Step 7: To move the cursor, use the left 4 and right - arrow buttons. This enables speed changes by larger increments.

Remove line power from the adjustable frequency drive before changing motor wires.

## 5 Electrical Installation

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### 5.1.28 Switches S201, S202, and S801

Switches S201 (A1 53) and S202 (Al 54) are used to select a current ( 0 -20 mA ) or a voltage ( 0 to 10 V ) configuration of the analog input terminals 53 and 54 respectively.

Switch S801 (BUS TER.) can be used to enable termination on the RS-485 port (terminals 68 and 69).

Please note that the switches may be covered by an option, if so equipped.

## Default setting:

S201 (AI 53) $=$ OFF (voltage input)
S202 (AI 54) $=$ OFF (voltage input)
5801 (Bus termination) $=$ OFF


### 5.2 Final Optimization and Test

### 5.2.1 Final Optimization and Test

To optimize motor shaft performance and optimize the adjustable frequency drive for the connected motor and installation, please follow these steps: Ensure that the adjustable frequency drive and the motor are connected, and power is applied to the adjustable frequency drive.

## NOTE!

Before power-up, ensure that connected equipment is ready for use.

## Step 1. Locate motor nameplate

## NOTE!

The motor is either star- $(Y)$ or delta-connected ( $\Delta$ ). This information is located on the motor nameplate data.


Step 2. Enter the motor nameplate data in the following parameter list.
To access the list, first press [QUICK MENU] key, then select "Q2 Quick Set-up".

| 1. | Motor Power [kW] <br> or Motor Power [HP] | par. 1-20 <br> par. $1-21$ |
| :--- | :--- | :--- |
| 2. | Motor Voltage | par. 1-22 |
| 3. | Motor Frequency | par. 1-23 |
| 14. | Motor Current | par. $1-24$ |
| 5. | Motor Nominal Speed | par. $1-25$ |

Table 5.6: Motor related parameters

## Step 3. Activate Automatic Motor Adaptation (AMA)

Performing an AMA ensures best possible performance. An AMA automatically takes measurements from the specific motor connected and compensates for installation variances.

1. Connect terminal 27 to terminal 12 or use [MAIN MENU] and set Terminal 27 par. 5-12 to No operation (par. 5-12 [0])
2. Press [QUICK MENU], select "Q2 Quick Set-up", scroll down to AMA par. 1-29.
3. Press $[O K]$ to activate the AMA par. 1-29.
4. Choose between complete or reduced AMA. If the sine wave filter is mounted, run only reduced AMA, or remove the sine wave filter during the AMA procedure.
5. Press the [OK] key. The display should show "Press [Hand on] to start."
6. Press the [Hand on] key. A progress bar indicates if the AMA is in progress.

## Stop the AMA during operation

1. Press the [OFF] key. The adjustable frequency drive enters into alarm mode and the display shows that the AMA was terminated by the user.

## Successful AMA

1. The display shows "Press [OK] to finish AMA".
2. Press the [OK] key to exit the AMA state.

## Unsuccessful AMA

1. The adjustable frequency drive enters into alarm mode. A description of the alarm can be found in the Troubleshooting section.
2.. "Report Value" in the [Alarm Log] shows the last measuring sequence carried out by the AMA before the adjustable frequency drive entered alarm mode. This number, along with the description of the alarm, will assist in troubleshooting. If contacting Danfoss Service, make sure to mention the number and alarm description.

## NOTE!

An unsuccessful AMA is often caused by incorrectly entered motor nameplate data or too big of a difference between the motor and the adjustable frequency drive power sizes.

## Step 4. Set speed limit and ramp time

Set up the desired limits for speed and ramp time.

| Motor Speed Low Limit | par. 4-11 or 4-12 |
| :--- | :--- |
| Motor Speed High Limit | par. $4-13$ or $4-14$ | Motor Speed High Limit $\quad$ par. 4-13 or 4-14

Ramp 1 Ramp-up Time [s] $\quad$ par. 3-41 Ramp 1 Ramp-down Time 1 [s] par. 3-42

## 6 Commissioning and Application Examples

### 6.1 Quick Set-up

### 6.1.1 Quick Menu Mode

The GLCP provides access to all parameters listed under the Quick Menus. To set parameters using the [Quick Menu] button:

Pressing [Quick Menu] the list indicates the different areas contained in the quick menu.

## Efficient parameter set-up for water applications

The parameters can easily be set up for the vast majority of the water and wastewater applications only by using the [Quick Menu].
The best way to set parameters using the [Quick Menu] is by following the steps below:

1. Press [Quick Set-up] for selecting basic motor settings, ramp times, etc.
2. Press [Function Set-ups] for setting up the required functionality of the adjustable frequency drive - if not already covered by the settings in [Quick Set-up].
3. Choose between General Settings, Open-loop Settings and Closed-loop Settings.

It is recommended to do the set-up in the order listed.

| Figure 6.1: Quick Menu view. | Раг. | Designation | [Units] |
| :---: | :---: | :---: | :---: |
|  | 0-01 | Language |  |
|  | 1-20 | Motor Power | [kW] |
|  | 1-22 | Motor Voltage | [V.] |
|  | $1-23$ | Motor Frequency | [ Hz ] |
|  | 1-24 | Motor Current | [A] |
|  | 1-25 | Motor Nominal Speed | [RPM] |
|  | 3-41 | Ramp 1 Ramp-up Time | [s] |
|  |  | Ramp 1 Ramp-down Time | [5] |
|  | 4-11 | Motor Speed Low Limit | [RPM] |
|  | 4-13 | Motor Speed High Limit | [RPM] |
|  | 1-29 | Automatic Motor Adaptation |  |
| Table 6.1: Quick Set-up parameters. Please see section Commonly Used Parameters - Explanations |  |  |  |
| If No Operation is selected in terminal 27 , no connection to +24 V on terminal 27 is necessary to enable start. <br> If Coast Inverse (factory default value) is selected in Terminal 27, a connection to +24 V is necessary to enable start. |  |  |  |
|  |  |  |  |
| NOTE! <br> For detailed parameter descriptions, please see the following section on Commonly Used Parameters - Explanations. |  |  |  |
|  |  |  |  |

### 6.2.1 Start/Stop

Terminal $18=$ start/stop par. 5-10 [8] Start
Terminal $27=$ No operation par. 5-12 [0] No operation (Default coast inverse

Par. 5-10 Digital Input, Terminal $18=$ Start (default)
Par. 5-12 Digital Input, Terminal $27=$ coast inverse (default)


### 6.2.2 Closed-loop Wiring

Terminal $12 / 13:+24 \vee D C$
Terminal 18: Start par. 5-18 [8] Start (Default)
Terminal 27: Coast par. 5-12 [2] coast inverse (Default)
Terminal 54: Analog input

L1-13: Line power terminals
$\mathrm{U}, \mathrm{V}$ and W : Motor terminals


6 Commissioning and Application Examples

### 6.2.3 Submersible Pump Application

The system consists of a submersible pump controlled by a Danfoss VLT AQUA Drive and a pressure transmitter. The transmitter gives a 4-20 mA feedback signal to the VLT AQUA Drive, which keeps a constant pressure by controlling the speed of the pump. To design a drive for a submersible pump application, there are a few important issues to take into consideration. Therefore, the drive used must be chosen according to motor current.

1. The motor is a what is known as a "Can motor" with a stainless steel can between the rotor and stator. There is a larger and a more magnetic resistant air-gap than on a normal motor hence a weaker field which results in the motor being designed with a higher rated current than a norm motor with similar rated power.
2. The pump contains thrust bearings which are damaged when run below minimum speed, which is normally 30 Hz .
3. The motor reactance is nonlinear in submersible pump motors and therefore Automatic Motor Adaption (AMA) may not be possible. However, normally submersible pumps are operated with very long motor cables that might eliminate the nonlinear motor reactance and enable the drive to perform AMA. If AMA fails, the motor data can be set from parameter group 1-3* (see motor datasheet). Be aware that if an AMA has been successful, the drive will compensate for voltage drop in the long motor cables, 50 if the advanced motor data are set manually, the length of the motor cable must be taken into considerations to optimize system performance.
4. It is important that the system be operated with a minimum of wear and tear of the pump and motor. A Danfoss Sine-Wave filter can lower the motor insulation stress and increase lifetime (check actual motor insulation and the adjustable frequency drive du/dt specification). It is recommended to use a filter to reduce the need for service.
5. EMC performance can be difficult to achieve due to the fact that the special pump cable, which is able to withstand the wet conditions in the well, is normally unshielded. A solution could be to use a shielded cable above the well and fix the screen to the well pipe if it is made of steel (can also be made of plastic). A Sine-Wave filter will also reduce the EMI from unshielded motor cables.

The special "can motor" is used due to the wet installation conditions. The drive needs to be designed for the system according to output current to be able to run the motor at nominal power.

To prevent damage to the thrust bearings of the pump, it is important to ramp the pump from stop to min. speed as quickly as possible. Well-known manufacturers of submersible pumps recommend that the pump be ramped to a min. speed ( 30 Hz ) in max. 2-3 seconds. The new VLT© AQUA Drive is designed with initial and final ramp for these applications. The initial and final ramps are 2 individual ramps, where Initial Ramp, if enabled, will ramp the motor from stop to min. speed and automatically switch to normal ramp, when min. speed is reached. Final ramp will do the opposite from min. speed to stop in a stop situation.

Pipe-fill mode can be enabied to prevent water hammering. The Danfoss adjustable frequency drive is capable of filling vertical pipes using the PID controller to slowly ramp up the pressure with a user specified rate (units/sec). If enabled, the drive will enter pipe fill mode, when it reaches min. speed after startup. The pressure will slowly be ramped up until it reaches a user-specified filled setpoint, after which the drive automatically disables pipe fill mode and continues in normal closed-loop operation.
This feature is designed for irrigation applications.

## Electrical Wiring

| Typical parameter settings (typical/recommended settings in brack- <br> ets.) |
| :--- |
| Parameters: |
| Motor Rated Power |
| Motor Rated Voltage |
| Motor Current Par. 1-20 / par. 1-21 <br> Motor Rated Speed Par. 1-22 <br> Enable Reduced Automatic Motor Adaptation (AMA in par. 1-29)  |

## note!

Note the analog input 2, (terminal (54) format must be set to mA. (switch 202).


| Min. Reference | Par. 3-01 | ( 30 Hz ) |
| :---: | :---: | :---: |
| Max. Reference | Par. 3-02 | ( $50 / 60$ Hz) |
| Initial Ramp-up Time | Par. 3-84 | ( 2 sec .) |
| Final Ramp-down Time | Par. 3-88 | (2 sec.) |
| Normal Ramp-up Time | Par. 3-41 | ( 8 sec . depending on size) |
| Normal Ramp-down Time | Par. 3-42 | (8 sec. depending on size) |
| Motor Min. Speed | Par. 4-11 | ( 30 Hz ) |
| Motor Max. Speed | Par. 4-13 | ( $50 / 60$ Hz) |


| Pipe Fill Mode |  |  |
| :---: | :---: | :---: |
| Pipe Fill Enable | Par. 29-00 |  |
| Pipe Fill Rate | Par. 29.04 | (Feedback units/sec.) |
| FFilled Setpoint | Par. 29-05 | (Feedback units) |



## 7 How to Operate the Adjustable Frequency Drive

### 7.1 Ways of Operation

### 7.1.1 Ways of Operation

The Adjustable Frequency Drive can be Operated in 3 Ways:

1. Graphical Local Control Panel (GLCP), see 6.1.2
2. Numeric Local Control Panel (NLCP), see 6.1.3
3. RS-485 serial communication or USB, both for PC connection, see 6.1.4

If the adjustable frequency drive is equipped with the serial communication option, please refer to the relevant documentation.

### 7.1.2 How to Operate the Graphical LCP (GLCP)

The following instructions are valid for the GLCP (LCP 102).

## The GLCP is divided into four functional groups:

1. Graphical display with Status lines.
2. Menu keys and indicator lights (LED5) - selecting mode, changing parameters and switching between display functions.
3. Navigation keys and indicator lights (LED5).
4. Operation keys and indicator lights (LEDs).

## Graphical display:

The LCD display is back lit with a total of 6 alpha-numeric lines. All data is displayed on the LCP, which can show up to five operating variables while in [5tatus] mode.

## Display lines:

a. Status line: Status messages displaying icons and graphics.
b. Line 1-2: Operator data lines displaying data and variables defined or chosen by the user. By pressing the [Status] key, up to one extra line can be added.
c. Status line: Status messages displaying text.

The display is divided into 3 sections:

Top section (a)
shows the status when in status mode, or up to two variables when not in status mode and in the case of an alarm/waming.


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The number of the Active Set-up (selected as the Active Set-up in par. 0-10) is shown. When programming in another set-up than the Active Set-up, the number of the set-up being programmed appears to the right in brackets.

## Middle section (b)

shows up to 5 variables with related unit, regardless of status. In the case of an alarm/warning, the warning is shown instead of the variables,
It is possible to toggle between three status readout displays by pressing the [Status] key.
Operating variables with different formatting are shown in each status screen - see below.

Several values or measurements can be linked to each of the displayed operating variables. The values/measurements to be displayed can be defined via par. 0-20, 0-21, 0-22, 0-23, and 0-24, which can be accessed via [QUICK MENU], "Q3 Function Set-ups", "Q3-1 General Settings", "Q3-11 Display Settings".

Each value / measurement readout parameter selected in par. 0-20 to par. 0-24 has its own scale and number of digits after a possible decimal point. Larger numeric values are displayed with few digits after the decimal point.
Ex.: Current readout
5.25 A; 15.2 A 105 A.

## Status display I

This read-out state is standard after start-up or initialization.

See the operating variables shown in the display in this illustration. 1.1, 1.2 and 1.3 are shown in small size. 2 and 3 are shown in medium size.

## Status display II

See the operating variables (1.1, 1.2, 1.3, and 2) shown in the display in this illustration.

In the example, Speed, Motor current, Motor power and Frequency are selected as variables in the first and second lines.
1.1, 1.2 and 1.3 are shown in small size. 2 is shown in large size.


## Status display III:

This state displays the event and action of the Smart Logic Control. For further information, see the section Smart Logic Control.


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Drive

## Bottom section

always shows the state of the adjustable frequency drive in status mode.


## Display Contrast Adjustment

Press [status] and [ $\mathbf{4}$ ] for darker display
Press [status] and [ $\mathbf{\nabla}$ ] for brighter display
Indicator lights (LEDs):
If certain threshold values are exceeded, the alarm and/or warning LED lights up. A status and alarm text appear on the control panel.
The On LED is activated when the adjustable frequency drive receives power from $A C$ line voltage, a $D C$ bus terminal, or an external 24 V supply. At the same time, the back light is on.

- Green LED/On: Control section is working.
- Yellow LED/Warn,: Indicates a warning.
- Flashing Red LED/Alarm: Indicates an alarm.



## GLCP keys

## Menu keys

The menu keys are divided into functions. The keys below the display and indicator lamps are used for parameter set-up, including choice of display indication during normal operation.


## [Status]

Indicates the status of the adjustable frequency drive and/or the motor. Three different readouts can be chosen by pressing the [Status] key: 5 line readouts, 4 line readouts or Smart Logic Control.
Use [Status] for selecting the mode of display or for changing back to display mode from either the quick menu mode, main menu mode or alarm mode. Also use the [Status] key to toggle single or double readout mode.
[Quick Menu]
Allows quick set-up of the adjustable frequency drive. The most common functions can be programmed here.
The [Quick Menu] consists of:

- Q1: My Personal Menu
- Q2: Quick Set-up.
- Q3: Function Set-ups
- Q5: Changes Made


## - Q6: Loggings

The function set-up provides quick and easy access to all parameters required for the majority of water and wastewater apptications including variable torque, constant torque, pumps, dosing pumps, well pumps, booster pumps, mixer pumps, aeration blowers and other pump and fan applications. Among other features, it also includes parameters for selecting which variables to display on the LCP, digital preset speeds, scaling of analog references, closedloop single zone and multi-zone applications and specific functions related to water and wastewater applications.

## 7 How to Operate the Adjustable Frequency Drive

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The quick menu parameters can be accessed immediately unless a password has been created via par. 0-60, 0-61, 0-65 or 0-66. It is possible to switch directiy between Quick Menu mode and main menu mode.

## [Main Menu]

is used for programming all parameters.
The main menu parameters can be accessed immediately unless a password has been created via par, 0-60, 0-61, 0-65 or 0-66. For the majority of water and wastewater applications it is not necessary to access the main menu parameters, but instead the quick menu, quick set-up and function set-ups provide the simplest and quickest access to the typical required parameters.
It is possible to switch directly between Main Menu mode and quick menu mode.
Parameter shortcut can be carried out by pressing down the [Main Menu] key for 3 seconds. The parameter shortcut allows direct access to any parameter.
[Alarm Log]
displays an alarm list of the five latest alarms (numbered A1-A5). To obtain additional details about an alarm, use the arrow keys to navigate to the alarm number and press [OK]. Information is displayed about the condition of the adjustable frequency drive before it enters alarm mode.

## [Back]

reverts to the previous step or layer in the navigation structure.

## [Cancel]

the last change or command will be canceled as long as the display has not been changed.
[Info]
displays information about a command, parameter, or function in any display window. [Info] provides detailed information when needed. Exit Info mode by pressing either [Info], [Back], or [Cancel].


Navigation Keys
The four navigation arrows are used to navigate between the different choices available in [Quick Menul, [Main Menu] and [Alarm Log]. Use the keys to move the cursor.
[OK]
is used for choosing a parameter marked by the cursor and for enabling the change of a parameter.


## Operation Keys

for local control are found at the bottom of the control panet.


## [Hand On]

enables control of the adjustable frequency drive via the GLCP. [Hand on] also starts the motor, and makes it possible to give the motor speed reference using the arrow keys. The key can be Enabled [1] or Disabled [0] via par. 0-40 [Hand on] Key on LCP.
The following control signals will still be active when [Hand on] is activated:

- [Hand on] - [Off] - [Auto on]
- Reset
- Coasting stop inverse (motor coasting to stop)
- Reversing
- Set-up select Isb - Set-up select msb
- Stop command from serial communication
- Quick stop
- DC brake


NOTE!
External stop signals activated by means of control signals or a serial bus will override a "start" command via the LCP.

## [Off]

stops the connected motor. The key can be Enabled [1] or Disabled [0] via par. 0-41 [Off] key on LCP. If no external stop function is selected and the [Off] key is inactive, the motor can only be stopped by disconnecting the line power supply.

## [Auto On]

enables the adjustable frequency drive to be controlled via the control terminals and/or serial communication. When a start signal is applied on the control terminals and/or the bus, the adjustable frequency drive will start. The key can be Enabled [1] or Disabled [0] via par. 0-42 [Auto on] key on LCP.


## NOTE!

An active HAND-OFF-AUTO signal via the digital inputs has higher priority than the control keys [Hand on] - [Auto on].

## [Reset]

is used for resetting the adjustable frequency drive after an alarm (trip). The key can be Enabled [1] or Disabled [0] via par. 0-43 Reset Keys on LCP.
The parameter shortcut
can be carried out by holding down the [Main Menu] key for 3 seconds. The parameter shortcut aliows direct access to any parameter.

### 7.1.3 How to Operate the Numeric LCP (NLCP)

The following instructions are valid for the NLCP (LCP 101).

## The control panel is divided into four functional groups:



## NOTE!

Parameter copy is not possible with Numeric Local Control Panel (LCP101).

1. Numeric display.
2. Menu key and LEDs - changing parameters and switching between display functions.
3. Navigation keys and LEDs.
4. Operation keys and LEDs.

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## Select one of the following modes:

Status Mode: Displays the status of the adjustable frequency drive or the motor.
If an alarm occurs, the NLCP automatically switches to status mode.

A number of alarms can be displayed.
Quick Set-up or Main Menu Mode: Display parameters and parameter settings.


Figure 7.1: Numerical LCP (NLCP)

## $817-$

Figure 7.3: Alarm display example

LEDs:

- Green LED/On: Indicates if control section is on.
- Yellow LED/Wm.: Indicates a warning.
- Flashing red LED/Alarm: Indicates an alarm


## Menu key

Select one of the following modes:

- Status
- Quick Set-up
- Main Menu


## Main Menu

is used for programming all parameters.
The parameters can be accessed immediately unless a password has been created via par. 0-60 Main Menu Password, par. 0-61 Access to Main Menu w/o Password, par. 0-65 Personal Menu Password or par. 0-66 Access to Personal Menu w/o Password.
Quick Set-up is used to set up the adjustable frequency drive using only the most essential parameters.
The parameter values can be changed using the up/down arrows when the value is flashing.
Select the main menu by pressing the [Menu] key a number of times until the main menu LED is lit.
Select the parameter group [ $\mathrm{xx}-$ _ ] and press [OK]
Select the parameter [ - -xX] and press [OK]
If the parameter is an array parameter, select the array number and press [OK]
Select the wanted data value and press [OK]

## Navigation keys

[Back]
for stepping backwards

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## Arrow [ ${ }^{\mathbf{4}}$ [ $\mathbf{\nabla}$ ]

keys are used for navigating between parameter groups, parameters and within parameters.
[OK]
is used for choosing a parameter marked by the cursor and for enabling the change of a parameter.


Figure 7.4: Display example


Figure 7.5: Operation keys of the numerical LCP (NLCP)

## [Hand on]

enables control of the adjustable frequency drive via the LCP. [Hand on] also starts the motor and it is now possible to enter the motor speed data by means of the arrow keys. The key can be Enabled [1] or Disabled [0] via par. 0-40 [Hand on] Key on LCP.

External stop signals activated by means of control signals or a serial bus will override a 'start' command via the LCP.

## The following control signals will still be active when [Hand on] is activated:

- [Hand on] - [Off] - [Auto on]
- Reset
- Coasting stop inverse
- Reversing
- Set-up select Isb - Set-up select msb
- Stop command from serial communication
- Quick stop
- DC brake
[Off]
stops the connected motor. The key can be Enabled [1] or Disabled [0] via par. 0-41 [Off] Key on LCP.
If no external stop function is selected and the [Off] key is inactive, the motor can be stopped by disconnecting the line power supply.


## [Auto on]

enables the adjustable frequency drive to be controlled via the control terminals and/or serial communication. When a start signal is applied on the control terminals and/or the bus, the adjustable frequency drive will start. The key can be Enabled [1] or Disabled [0] via par. 0-42 [Auto on] Key on LCP.

## NOTE!

An active HAND-OFF-AUTO signal via the digital inputs has higher priority than the control keys [Hand on] [Auto on].

## [Reset]

is used for resetting the adjustable frequency drive after an alarm (trip). The key can be Enabled [1] or Disabled [0] via par. 0-43 [Reset] Key on LCP.

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### 7.1.4 Changing Data

1. Press the [Quick Menu] or [Main Menu] key.
2. Use [ $\mathbf{4}$ ] and [ $\mathbf{V}$ ] keys to find parameter group to edit.
3. Press the $[\mathrm{OK}]$ key.
4. Use [ $\mathbf{\Delta}$ ] and [ $\mathbf{V}]$ keys to find parameter to edit.
5. Press the $[O K]$ key.
6. Use the [ $\mathbf{\Delta}$ ] and [ $\mathbf{\nabla}$ ] keys to select the correct parameter setting. Or, to move to digits within a number, use the keys. The cursor indicates the digit selected to be changed. The [ $\mathbf{\Delta}$ ] key increases the value, the [ $\mathbf{\nabla}$ ] key decreases the value.
7. Press the [Cancel] key to disregard the change, or press the [OK] key to accept the change and enter the new setting.

### 7.1.5 Changing a Text Value

If the selected parameter is a text value, it can be changed by using the up/down navigation keys.
The up key increases the value, and the down key decreases the value.
Place the cursor on the value to be saved and press [OK].


Figure 7.6: Display example.

### 7.1.6 Changing a Group of Numeric Data Values

If the chosen parameter represents a numeric data value, change the chosen data value by means of the [ -4 and $[\bullet]$ navigation keys as well as the up/down [ 4 ] [ $\boldsymbol{\nabla}$ ] navigation keys. Use the 4 ] and [ $\bullet$ ] navigation keys to move the cursor horizontally.


Figure 7.7: Display example.


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### 7.1.7 Changing of Data Value, Step-by-Step

Certain parameters can be changed step-by-step or by an infinite number of variables. This applies to par. 1-20 Motor Power [kw], par. 1-22 Motor Voltage and par. 1-23 Motor Frequency.
The parameters are changed both as a group of numeric data values, and as numeric data values using an infinite number of variables.

### 7.1.8 Readout and Programming of Indexed Parameters

Parameters are indexed when placed in a rolling stadk.
Par. 15-30 Alarm Log: Error Code to par. 15-32 Alarm Log: Timecontain a fault log which can be read out. Choose a parameter, press [OK], and use the up/down navigation keys to scroll through the value log.

Use par, 3-10 Preset Reference as another example:
Choose the parameter, press [OK], and use the up/down navigation keys to scrolf through the indexed values. To change the parameter value, setect the indexed value and press [OK]. Change the value by using the up/down keys. Press [OK] to accept the new setting. Press [Cancel] to abort. Press [Back] to leave the parameter.

### 7.1.9 Tips and Tricks

| * | For the majority of water and wastewater applications, the Quick Menu, Quick Set-up and Function Set-ups provide the simplest and quickest access to all of the typical parameters required. |
| :---: | :---: |
| * | Whenever possible, performing an AMA will ensure best shaft performance. |
| * | Display contrast can be adjusted by pressing [Status] and [ $\boldsymbol{\Delta}$ ] for a darker display, or by pressing [Status] and [ $\mathbf{V}$ ] for a brighter display. |
| * | Under [Quick Menu] and [Changes Made], all the parameters that have been changed from the factory settings are displayed. |
| * | Press and hold the [Main Menu] key for 3 seconds to access any parameter. |
| * | For service purposes, it is recommended to copy all parameters to the LCP, see par 0-50 for further information. |

Table 7.1: Tips and tricks

### 7.1.10 Quick Transfer of Parameter Settings when Using GLCP

Once the set-up of an adjustable frequency drive is complete, it is recommended to store (backup) the parameter settings in the GLCP or on a PC via MCT 10 Set-up Software Tool.

## NOTE!

Stop the motor before performing any of these operations.

## Data storage in LCP:

1. Go to par. 0-50 LCP CODY
2. Press the $[\mathrm{OK}]$ key.
3. Select "All to LCP"
4. Press the [OK] key.

All parameter settings are now stored in the GLCP indicated by the progress bar. When $100 \%$ is reached, press [OK].

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The GLOP can now be connected to another adjustable frequency drive and the parameter settings copied to this adjustable frequency drive.

Data transfer from LCP to adjustable frequency drive:

1. Go to par. 0-50 LCP Copy
2. Press the $[O K]$ key.
3. Select "All from LCP"
4. Press the $[O K]$ key.

The parameter settings stared in the GLOP are now transferred to the adjustable frequency drive indicated by the progress bar. When $100 \%$ is reached, press [OK].

### 7.1.11 Initialization to Default Settings

There are two ways to initialize the adjustable frequency drive to default: Recommended initialization and manual initialization. Please be aware that they have different impacts according to the below description.

## Recommended initialization (via par. 14-22 Operation Mode)

1. Select par. 14-22 Operation Mode
2. Press [OK]
3. Select "Initialization" (for NLOP select " 2 ")
4. Press [OK]
5. Disconnect the power from the unit and wait for the display to tum off.
6. Reconnecting the power resets the adjustable frequency drive. Note that first start-up takes a few more seconds
7. Press [Reset]
par. 14-22 Operation Mode initializes all except:
par. 14-50 RFII
par. 8.30 Protocol
par. 8-31 Address
par. \&-32 Baud Rate
par. 8-35 Minimum Response Delay
par. 8-36 Max Response Delay
par. 8-37 Max Inter-Char Delay
par. 15-00 Operating Hours to par. 15-05 Over Volts
par. 15-20 Historic Log: Event to par. 15-22 Historic Log: Thme
par. 15-30 Alarm Log: Error Code to par. 15-32 A/arm Log: Time

## NOTE!

Parameters selected in par. 0.25 My Personal Menu will remain present with the default factory setting.

## Manual inltialization

## NOTE!

When carrying out manual initialization, serial communication, RFI fiter settings and fault log settings are reset. Removes parameters selected in par. 0-25 my Personal menu

1. Disconnect from the line power and wait until the display turns off.

2a. Press [Status] - [Main Menu] - [OK] at the same time while powering up the Graphical LCP (GLCP)

2b. Press [Menu] while the LCP 101, Numerical Display is powering up.

## This parameter initializes all except:

par. 15-00 Operating Hours
par. 15-03 Power-ups
par. 15-04 Over Temps
par. 15-05 Over Volts
3. Release the keys after 5 s
4. The adjustable frequency drive is now programmed according to default seltings

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### 7.1.12 RS-485 Bus Connection

One or more adjustable frequency drives can be connected to a controller (or master) using the standard RS-485 interface. Terminal 68 is connected to the $P$ signal ( $T X+, R X+$ ), while terminal 69 is connected to the $N$ signal ( $T X-, R X-$ ).

If more than one adjustable frequency drive is connected to a master, use parallel connections.


In order to avoid potential equalizing currents in the shield, ground the cable screen via terminal 61 , which is connected to the frame via an RC link.

## Bus termination

The RS-485 bus must be terminated by a resistor network at both ends. If the drive is the first or the last device in the RS-485 loop, set the switch S801 on the control card to ON .
For more information, see the paragraph Switches S201, S202, and S801.

### 7.1.13 How to Connect a PC to the Adjustable Frequency Drive

To control or program the adjustable frequency drive from a PC, install the PC-based Configuration Tool MCT 10 .
The PC is connected via a standard (host/device) USB cable, or via the RS-485 interface as shown in the Design Guide, chapter How to Install > Installation of misc. connections.

NOTE!
The USB connection is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals. The USB connection is connected to protection ground on the adjustable frequency drive. Use only isolated laptop for PC connection to the USB connector on the adjustable frequency drive.


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### 7.1.14 PC Software Tools

## PC-based Configuration Tool MCT 10

All adjustable frequency drives are equipped with a serial communication port. Danfoss provides a PC tool for communication between PC and adjustrble frequency drive, PC-based Configuration Tool MCT 10. Pease check the section on Available Literature for detailed information on this tool.

## MCT 10 set-up software

MCT 10 has been designed as an easy to use interactive tool for setting parameters in our adjustable frequency drives. The software can be downloaded from the Danfoss internet site http://uww.Danfos5.com/Businessareas/Drives5olution5/Softwaredownload/DDPC + Software + Program.htm. The MCT 10 set-up software will be useful for:

- Planning a communication network off-line. MCT 10 contains a complete adjustable frequency drive database
- Commissianing adjustable frequency drives on-line.
- Saving settings for all adjustable frequency drives.
- Replacing an adjustable frequency drive in a network.
- Simple and accurate documentation of adjustable frequency drive seltings after commissianing.
- Expanding an existing network.
- Adjustable frequency drives developed in the future will be fully supported.

MCT 10 set-up software supports Profibus DP-V1 via a master class 2 connection. This makes it possible to access on-line read/write parameters in an adjustable frequency drive via the Profibus network. This will eliminate the need for an extra communication network.

## Save adjustable frequency drive settings:

1. Connect a PC to the unit via the USB COM port. (Note: Use a PC that is isolated from the line power, in conjunction with the USB port. Failure to do so may damage equipment.)
2. Open MCT 10 Set-up Software
3. Choose "Read from drive"
4. Choose "Save as"

All parameters are now stored on the PC.

## Load adjustable frequency drive settings:

1. Connect a PC to the adjustable frequency drive via the USB com port
2. Open MCT 10 Set-up software
3. Choose "Open"- stored files will be shown.
4. Open the appropriate file
5. Choose "Write to drive"

All parameter seltings are now transferred to the adjustable frequency drive.

A separate manual for MCT 10 Set-up Software is available: MG.10.RX.YY.

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The MCT 10 Set-up software modules
The following modules are included in the software package:

|  | MCT Set-up 10 Software |
| :---: | :---: |
|  | Setting parameters |
|  | Copy to and from adjustable frequency drives |
|  | Documentation and print-out of parameter settings ind. diagrams |
|  | Ext. user interface |
|  | Preventive Maintenance Schedule |
|  | Clock settings |
|  | Timed Action Programming |
|  | Smart Logic Controller Set-up |

## Ordering number:

Please order the CD containing MCT 10 Set-up software using code number 13081000 .

MCT 10 can also be downloaded from the Danfoss Internet: WWW.DANFOG5.COM, Business Ares: MODion Controls.

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## 8 How to Program the Adjustable Frequency Drive

### 8.1 How to Program

### 8.1.1 Parameter Set-up

## Overview of parameter groups

| Group | Title | Function |
| :---: | :---: | :---: |
| 0 | Operation/Display | Parameters related to the fundamental functions of the adjustable frequency drive, function of the LCP buttons and configuration of the LCP display. |
| 1- | Load/Motor | Parameter group for motor settings. |
| 2- | Brakes | Parameter group for setting brake features in the adjustable frequency drive. |
| $3-$ | Reference / Ramps | Parameters for reference handling, defining limitations, and configuring the reaction of the adjustable frequency drive to changes. |
| 4- | Limits/Warnings | Parameter group for configuring limits and warnings. |
| 5 | Digital In/Out | Parameter group for configuring the digital inputs and outputs. |
| 6 - | Analog In/Qut | Parametergroup for configuring the analog inputs and outputs. |
| 8 | Communication and Options | Parameter group for configuring communications and options. |
| 9 | Profibus | Parameter group for Profibus-specific parameters. |
| 10- | DeviceNet Serial Communication Bus | Parameter group for DeviceNet-specific parameters. |
| 13 | Smart Logic | Parameter group for Smart Logic Control |
| 14. | Special Functions | Parameter group for configuring special adjustable frequency drive functions, |
| 15- | Drive Information | Parameter group containing adjustable frequency drive information such as operating data, hardware configuration and software versions. |
| 16- | Data Readouts | Parameter group for data readouts, such as current references, voltages, control, alarm, warning and status words. |
| 18. | Info and Readouts | This parameter group contoins the last 10 Preventive Maintenance logs. |
| 20- | Drive Closed-loop | This parameter group is used for configuring the closed-loop PID controller that controls the output frequency of the unit. |
| 21- | Extended Closed-loop | Parameters for configuring the three extended closed-loop PID controllers. |
| 22- | Application Functions | These parameters monitor water applications. |
| 23- | Time-based Functions | These parameters are for actions to be performed on a daily or weekly basis, such as different references for working hours/non-working hours. |
| 25- | Basic Cascade Controller Functions | Parameters for configuring the basic cascade controller for sequence control of multiple pumps. |
| 26 | Analog I/O.Option MCB 109 | Parameters for configuring the Analog I/O Option MCB 109. |
| 27 | Extended Cascade Control | Parameters for configuring the extended cascade control. |
| 29: | Water Application Functions. | Parameters for selting water specific functions. |
| 31. | Bypass Option | Parameters for configuring the bypass option |

Table 8.1: Parameter Groups

Parameter descriptions and selections are displayed on the Graphic LCP or Numeric LCP in the display area (See Section 5 for details.) Access the parameters by pressing the [Quick Menu] or [Main Menu] key on the control panel. The quick menu is used primarily for commissioning the unit at startup by providing those parameters necessary to start operation. The main menu provides access to all the parameters for detailed application programming.

All digital input/output and analog input/output terminals are multifunctional. All terminals have factory default functions suitable for the majority of water applications but if other special functions are required, they must be programmed in parameter group 5 or 6 .

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### 8.1.2 Q1 My Personal Menu

Parameters defined by the user can be stored in Q1 My Personal Menu.

Select My Persona/Menu to display only the parameters, which have been pre-selected and programmed as personal parameters. For example, a pump or equipment OEM may have pre-programmed these to be in My Personal Menu during factory commissioning to make on-site cornmissioning / fine tuning simpler. These parameters are selected in par. 0-25 My Personal Menu. Up to 20 different parameters can be defined in this menu.
20-21.Setpoint 1 Q1 My Personal Menu

### 8.1.3 Q2 Quick Set-up

The parameters in Q2 Quick Set-up are the basic parameters which are always needed to set up the adjustable frequency drive for operation.

|  |  |
| :---: | :---: |
|  |  |
| 0 01 Language |  |
| 1-20 Motor Power | KW |
| 1-22 Motor Voltage | $V$ |
| 1-23 Motor Frequency | Hz |
| 1.24 Motor Current | A |
| 1-25 Motor Nominal Soeed | RPM |
| 3-41 Ramp 1 Ramp-up Time | 5 |
| 3-42.Ramp 1 Ramp-down Time | 5 |
| 4-11 Motor Speed Low Limit | RPM |
| 4.13 Motor Speed. High Limit | RPM |
| 1-29 Automatic Motor Adaptation (AMA) |  |

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### 8.1.4 Q3 Function Set-ups

The function set-up provides quick and easy access to all parameters required for the majority of water and wastewater applications including variable torque, constant torque, pumps, dosing pumps, well pumps, booster pumps, mixer pumps, aeration blowers and other pump and fan applications. Among other features, it also includes parameters for selecting which variables to display on the LCP, digital preset speeds, scaling of analog references, closedloop single zone and multi-zone applications and specific functions related to water and wastewater applications.

How to access the Function Set-up - example:


Figure 8.2: Step 2: Press the [Quick Menus] button (quick menu choices appear).

Figure 8.3: Step 3: Use the up/down navigation keys to scroll down to Function Set-ups. Press [OK].


Figure 8.5: Step 5: Use the up/down navigation keys to scroll down to, e.g., 03-12 Analog Outputs Press [OK].


Figure 8.7: Step 7: Use the up/down navigation keys to select between the different choices. Press [OK].
Figure 8.6: Step 6: Choose parameter 6-50 Terminal 42 Output Press [OK].



Figure 8.4: Step 4: Function Set-up choices appear. Choose 03-1 General Seltings. Press [OK].
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The Function Set-up parameters are grouped in the following way:

| Q3-1 General Settings |  |  |  |
| :---: | :---: | :---: | :---: |
| Q3-10 Clock Settings | Q3-11. Display Settings | Q3-12 Analog Output | Q3-13 Relays |
| 0.70 Set Date and Time | 0-20 Display Line 1.1 Small | 6-50 Terminal 42 Output | Relay $1=5-40$ Function Relay |
| 0-71 Date Format | 0-21 Display Line 1.2 Small | 6-51. Terminal 42 Output Min Scale | Relay $2 \Rightarrow 5-40$ Function Relay |
| 0-72 Time Format | 0-22 Display Line 1.3 Small | 6-52 Terminal 42 Output Max Scale | Option relay $7=5-40$ Function Relay |
| 0-74 DST/Summertime | 0-23 Display Line 2 Large |  | Option relay $8 \Rightarrow 5-40$ Function Relay |
| 0-76 DST/Summertime Start | 0-24 Display Line 3 Large |  | Option relay $9 \Rightarrow 5-40$ Function Relay |
| 0-77DST/Summertime End | 0-37 Display Text 1 |  |  |
|  | 0-38 Display Text 2 |  |  |
|  | 0-39 Display Text 3 |  |  |


| Q3-2 Open-1oop Settings |  |  |
| :---: | :---: | :---: |
| Q3-20 Digital Reference | Q3-21 Analog Reference |  |
| 3-02 Minimum Reference | 3-02 Minimum Reference |  |
| 3-03 Maximum Reference | 3:03 Maximum Reference |  |
| 3-10 Preset Reference | 6-10 Terminal 53 Low Voltage |  |
| 5-13 Terminal 29 Digital Input | 6-11 Terminal 53 High Voltage |  |
| 5-14 Terminal 32 Digital Input | 6-14 Terminal 53 Low Ref/Feedb. Value |  |
| 5-15 Terminal 33 Digital Input | 6-15 Terminal 53 High Ref/Feedb. Value |  |


| Q3-3 Closed-loop Settings |  |
| :---: | :---: |
| Q3-30 Feedback Settings | Q3-31 PID Settings |
| 1-00 Configuration Mode | 20-81 PID Normal/Inverse Control |
| [20-12 Reference/Feedb.Unit | 20-82-PID Start Speed [RPM] |
| 3-02 Minimum Reference | 20-21 Setpoint 1 |
| 3-03 Maximum Reference | 20-93 PID Proportional Gain |
| 6-20 Terminal 54 Low Voltage | 20-94 PID Integral Time |
| 6-21 Terminal 54 High Voltage |  |
| 6-24 Terminal 54 Low Ref/Feedb Value |  |
| 6-25 Terminal 54 High Ref/Feedb Value |  |
| 6-00 Live Zero Timeout Time |  |
| 6-01 Live Zero Timeout Function |  |

### 8.1.5 Q5 Changes Made

Q5 Changes Made can be used for fault finding.

## Select Changes made to get information about:

- The last 10 changes. Use the up/down navigation keys to scroll between the last 10 changed parameters.
- The changes made since default setting.

Select Loggings to get information about the display line readouts. The information is shown in graphs.
Only display parameters selected in par. 0-20 and par. 0-24 can be viewed. It is possible to store up to 120 samples in the memory for later reference.

Please notice that the parameters listed in the below tables for Q5 only serve as examples since they will vary depending on the programming of the particular adjustable frequency drive.


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### 8.1.6 Q6 Loggings

Q6 Loggings can be used for fault finding.

Please notice that the parameters listed in the table for Q6 below only serve as examples since they will vary depending on the programming of the particular adjustable frequency drive.

| Reference |
| :--- | :--- |
| Analog Input 53 |
| Motor Current |
| Frequency |
| Feedback |
| Energy Log |
| Trending Cont Bin |
| Trending Timed Bin |
| Trending Comparison |

### 8.1.7 Main Menu Mode

Both the GLCP and NLCP provide access to the main menu mode. Select main menu mode by pressing the [Main Menu] key. Figure 6.2 shows the resulting read-out, which appears on the display of the GLCP.
Lines 2 through 5 on the display show a list of parameter groups which can be chosen by toggling the up and down buttons.

Each parameter has a name and number which remain the same regardless of the programming mode. In main menu mode, the parameters are divided into groups. The first digit of the parameter number (from the left) indicates the parameter group number.

All parameters can be changed in the main menu. The configuration of the unit (par. 1-00 Configuration Mode) will determine other parameters available for programming. For example, selecting Closed-loop enables additional parameters related to closed-loop operation. Option cards added to the unit enable additional parameters associated with the option device.

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### 8.1.8 Parameter Selection

In main menu mode, the parameters are divided into groups. Select a parameter group using the navigation keys.
The following parameter groups are accessible:

| Group no. | Parameter group: |
| :---: | :---: |
| 0 | Operation/Display |
| 1 | Load/Motor |
| 2 | Brakes |
| 3 | References/Rarnps |
| 4. | Limits/Warning |
| 5 | Digital In/Out |
| 6 | Analog In/Out |
| 8 | Comm. and Options |
| 9 | Profibus |
| 10 | CAN Ser. Com, Bus |
| 11 | LonWorks. |
| 13 | Smart Logic |
| 14 | Special Fundtions |
| 15 | Drive Information |
| 16 | Data Readouts |
| 18 | Data Readauts 2 |
| 20 | Drive Closed-loop |
| 21 | Ext. Closed-loop |
| 22 | Application Functions |
| 23 | Time-based Functions |
| 24 | Fire Mode. |
| 25 | Cascade Controiler |
| 26 | Analog_I/O.Option MCB 109 |

Table 8.2: Parameter groups.

After selecting a parameter group, choose a parameter by means of the navigation keys.

The middle section on the GLCP display shows the parameter number and name, as well as the selected parameter value.


Figure 8.9: Display example.

### 8.2 Commonly Used Parameters - Explanations

### 8.2.1 Main Menu

The main menu includes all available parameters in the VLT* AQUA Drive FC 200 adjustable frequency drive.
All parameters are grouped logically with a group name indicating the function of the parameter group.
All parameters are listed by name and number in the section Parameter Options in this Instruction Manual.

All parameters included in the quick menus (Q1, Q2, Q3, Q5 and Q6) can be found in the following.

Some of the most commonly used parameters for VT3 AQUA Drive applications are also explained in the following section.

For a detailed explanation of all parameters, please refer to the VLT ${ }^{*}$ AQUA Drive Programrning Guide MG. $20 . O X . Y$ which is available at www.danfoss.com or by ordering it from the local Danfoss office.

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### 8.2.2 0-** Operation / Display

Parameters related to the fundamental functions of the adjustable frequency drive, function of the LCP buttons and configuration of the LCP display.


0-20 Display Line 1.1 Small Option:

## Function:

Select a variable for display in line 1, left position.

| $[0]$ | None | No display value selected |
| :--- | :--- | :--- |
| $[37]$ | Display Text 1 | Present control word |
| $[38]$ | Display Text 2 | Enables an individual text string to be written, for display in the LCP or to be read via serial com- <br>  |

[39] Display Text 3 Enables an individual text string to be written, for display in the LCP or to be read via serial communication.

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| [89] | Date and Time Readout | Displays the current date and time. |
| :---: | :---: | :---: |
| [953] | Profibus Warning Word | Displays Profibus communication warnings. |
| [1005] | Readout Transmit Error Counter | View the number of CAN control transmission errors since the last power-up. |
| [1006] | Readout Receive Error Counter | View the number of CAN control receipt errors since the last power-up. |
| [1007] | Readout Bus-off Counter | View the number of Bus Off events since the last power-up. |
| [1013] | Warning Parameter | View a DeviceNet-specific warning word. One separate bit is assigned to every warning. |
| [1115] | LON Warning Word | Shows the LON-specific warnings. |
| [1117] | XIF Revision | Shows the version of the external interface file of the Neuron C chip on the LON option. |
| [1118] | LON Works Revision | Shows the software version of the application program of the Neuron C chip on the LON option. |
| [1500] | Operating Hours | View the number of running hours of the adjustable frequency drive. |
| [1501] | Running Hours | View the number of running hours of the motor. |
| [1502] | kWh Counter | View the line power consumption in kWh. |
| [1600] | Control Word | View the control word sent from the adjustable frequency drive via the serial communication port in hex code. |
| [1601]* | Reference [Unit] | Total reference (sum of digital/analog/preset/bus/freeze ref./catch up and slow-down) in selected unit. |
| [1602] | Reference \% | Total reference (sum of digital/analog/preset/bus/freeze ref./catch up and slow-down) in percent. |
| [1603] | Status Word | Present status word |
| [1605] | Main Actual Value [\%] | One or more wamings in a Hex code |
| [1609] | Custom Readout | View the user-defined readouts as defined in par. 0-30, 0-31 and 0-32. |
| [1610] | Power [kW] | Actual power consumed by the motor in kW . |
| [1611] | Power [hp] | Actual power consumed by the motor in HP. |
| [1612] | Motor Vottage | Voltage supplied to the motor. |
| [1613] | Motor Frequency | Motor frequency, i.e., the output frequency of the adjustable frequency drive in Hz . |
| [1614] | Motor Current | Phase current of the motor measured as effective value. |
| [1615] | Frequency [\%] | Mator frequency, i.e., the output frequency from the adjustable frequency drive in percent. |
| [1616] | Torque [ Nm ] | Present motor load as a percentage of the rated motor torque. |
| [1617] | Speed [RPM] | Speed in RPM (revolutions per minute), i.e., the motor shaft speed in closed-loop based on the entered motor nameplate data, the output frequency and the load on the adjustable frequency drive. |
| [1618] | Motor Thermal | Thermal load on the motor, calculated by the ETR function. See also parameter group 1-9* Motor Temperature, |
| [1622] | Torque [\%] | Shows the actual torque produced, in percentage. |
| [1630] | DC Link Voltage | Intermediate circuit voltage in the adjustable frequency drive. |
| [1632] | BrakeEnergy/s | Present braking energy transferred to an external brake resistor, stated as an instantaneous value. |
| [1633] | BrakeEnergy/2 min | Braking energy transferred to an external brake resistor. The mean power is calculated continuously for the most recent 120 seconds. |
| [1634] | Heatsink Temp. | Present heatsink temperature of the adjustable frequency drive. The cut-out limit is $203^{\circ} \pm 9^{\circ} \mathrm{F}\left[95^{\circ}\right.$ $\pm 5^{\circ} \mathrm{C}$; culting back in occurs at $158^{\circ} \pm 9^{\circ} \mathrm{F}\left[70^{\circ} \pm 5^{\circ} \mathrm{C}\right]$. |
| [1635] | Thermal Drive Load | Percentage load of the inverters |
| [1636] | Inv. Nom. Current | Nominal current of the adjustable frequency drive |
| [1637] | Inv. Max. Current | Maximum current of the adjustable frequency drive |
| [1638] | SL Control State | State of the event executed by the control |
| [1639] | Control Card Temp. | Temperature of the control card. |
| [1650] | External Reference | Sum of the external reference as a percentage, i.e., the sum of analog/pulse/bus. |

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| [1652] | Feedback [Unit] | Signal value in units from the programmed digital input(s). |
| :---: | :---: | :---: |
| [1653] | DigiPot Reference | View the contribution of the digital potentiometer to the actual reference Feedback. |
| [1654] | Feedback 1 [Unit] | View the value of Feedback 1. See also par. 20-0*. |
| [1655] | Feedback 2 [Unit] | View the value of Feedback 2. See also par. 20-0*. |
| [1656] | Feedback 3 [Unit] | View the value of Feedback 3. See also par. 20-0*, |
| [1658] | PID Output [\%] | Returns the drive closed-loop PID controller output value in percent. |
| [1659] | Adjusted Setpoint | Displays the actual operating setpoint after it is modified by flow compensation. See parameters 22-8*. |
| [1660] | Digital Input | Displays the status of the digital inputs. Signal low $=0 ;$ Signal high $=1$. Regarding order, see par. $16-60$. Bit 0 is at the extreme right. |
| [1661] | Terminal 53 Switch Setting | Selting of input terminal 53. Current $=0$; Voltage $=1$. |
| [1662] | Analog Input 53 | Actual value at input 53 either as a reference or protection value. |
| [1663] | Terminal 54 Switch Setting | Setting of input terminal 54. Current $=0 ;$ Voltage $=1$. |
| [1664] | Analog Input 54 | Actual value at input 54 either as reference or protection value. |
| [1665] | Analog Output 42 [mA] | Actual value at output 42 in mA. Use par. 6-50 to select the variable to be represented by output 42. |
| [1666] | Digital Output [bin] | Binary value of all digital outputs. |
| [1667] | Freq. Input \#29 [Hz] | Actual value of the frequency applied at terminal 29 as a pulse input. - |
| [1668] | Freq. Input \#33 [Hz] | Actual value of the frequency applied at terminal 33 as a pulse input. |
| [1669] | Pulse Output \#27 [Hz] | Actual value of pulses applied to terminal 27 in digital .output mode. |
| [1670] | Pulse Output \#29 [Hz] | Actual value of pulses applied to terminal 29 in digital output mode. |
| [1671] | Relay Output [bin] | View the setting of all relays. |
| [1672] | Counter A | View the present value of Counter $A$. |
| [1673] | Counter B | View the present value of Counter $B$. |
| [1675] | Analog input $\times 30 / 11$ | Actual value of the signal on input $\times 30 / 11$ (General Purpose I/O Card. Option) |
| [1676] | Analog input X30/12 | Actual value of the signal on input X30/12 (General Purpose I/O Card. Optional) |
| [1677] | Analog output $\times 30 / 8$ [mA] | Actual value at output X30/8 (General Purpose I/O Card. Optional) Use Par. 6-60 to select the variable to be shown. |
| [1680] | Serial com. bus CTW 1 | Control word (CTW) received from the bus master. |
| [1682] | Serial com. bus REF 1 | Main reference value sent with control word via the serial communications network, e.g., from the BMS, PLC or other master controller. |
| [1684] | Comm. Option STW | Extended serial communication option status word. |
| [1685] | ADF Port CTW 1 | Control word (CTW) received from the bus master. |
| [1686] | AFD Port REF 1 | Status word (STW) sent to the bus master. |
| [1690] | Alarm Word | One or more alarms in a Hex code (used for serial communications) |
| [1691] | Alarm Word 2 | One or more alarms in a Hex code (used for serial communications) |
| [1692] | Waming Word | One or more warnings in a Hex code (used for serial communications) |
| [1693] | Warning Word 2 | One or more warnings in a Hex code (used for serial communications) |
| [1694] | Ext. Status Word | One or more status conditions in a Hex code (used for serial communications) |
| [1695] | Ext. Status Word 2 | One or more status conditions in a Hex code (used for serial communications) |
| [1696] | Maintenance Word | The bits reflect the status for the preventive maintenance events programmed in parameter group $23-1^{*}$ |
| [1830] | Analog Input X42/1 | Shows the value of the signal applied to terminal X42/1 on the Analog I/O card. |
| [1831] | Analog Input $\times 42 / 3$ | Shows the value of the signal applied to terminal $\times 42 / 3$ on the Analog I/O card. |
| [1832] | Analog Input X42/5 | Shows the value of the signal applied to terminal X42/5 on the Analog I/O card. |

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| [1833] | Analog Out $\mathrm{X} 42 / 7$ [V] | Shows the value of the signal applied to terminal $\times 42 / 7$ on the Analog $1 / 0$ card. |
| :---: | :---: | :---: |
| [1834] | Analog Out X42/9 [V] | Shows the value of the signal applied to terminal $\times 42 / 9$ on the Analog I/O card. |
| [1835] | Analog Out X42/11 [V] | Shows the value of the signal applied to terminal X42/11 on the Analog I/O card. |
| [2117] | Ext. 1 Reference [Unit] | The value of the reference for extended Closed-loop Controiler 1 |
| [2118] | Ext. 1 Feedback [Unit] | The value of the feedback signal for extended Closed-loop Controiler 1 |
| [2119] | Ext. 1 Output [\%] | The value of the output from extended Closed-loop Controiler 1 |
| [2137] | Ext. 2 Reference [Unit] | The value of the reference for extended Closed-loop Controller 2 |
| [2138] | Ext. 2 Feedback [Unit] | The value of the feedback signal for extended Closed-loop Controller 2 |
| [2139] | Ext. 2 Output [\%] | The value of the output from extended Closed-loop Controller 2 |
| [2157] | Ext. 3 Reference [Unit] | The value of the reference for extended Closed-loop Controller 3 |
| [2158] | Ext. 3 Feedback [Unit] | The value of the feedback signal for extended Closed-loop Controller 3 |
| [2159] | Ext. Output [\%] | The value of the output from extended Closed-loop Controller 3 |
| [2230] | No-Flow Power | The calculated No-Flow Power for the actual operating speed |
| [2580] | Cascade Status | Status for the operation of the cascade controller |
| [2581] | Pump Status | Status for the operation of each individual pump controiled by the cascade controller |
| [2791] | Cascade Reference | Reference output for use with follower drives. |
| [2792] | \% Of Total Capacity | Readout parameter to show the system operating point as a \% capacity of total system capacity. |
| [2793] | Cascade Option Status | Readout parameter to show the status of the cascade system. |
| 0-21 Display Line 1.2 Small |  |  |
| Optio |  | Function: |


| [1662] * Analog input 53 | The options are the same as those listed for par. 0-20 Display Line 1.1 Small. |
| :---: | :---: |
| 0022 Display Line 3 Small |  |
| Option: | Function: |
|  | Select a variable for display in line 1 , right position. |
| [1614] * Motor Current | The options are the same as those listed for par. 0-20. Display Line 1.1 Small. |
| Fit23 Display Line 2 Large |  |
| Option: | Function: |
|  | Select a variable for display in line 2. |
| [1615] * Frequency | The options are the same as those listed for par. 0-20 Display Line 1.1 Small |
|  |  |
| Option: | Function: |
| [1652] * Feedback [Unit] | The options are the same as those listed for par. 0-20 Display Line 1.1 Small. |
|  | Select a variable for display in line 2. |

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## 0-37 Display Text 1

Range:

## Function:

| $0 \mathrm{~N} / \mathrm{A}^{*}$ | [0.0 N/A] | In this parameter, it is possible to write an individual text string for display in the LCP or to be read via serial communication. If it is to be displayed permanently, select Display Text 1 in par. 0-20 Display Line 1.1 Small, par. 0-21 Display Line 1.2 Small, par. 0-22 Display Line 1.3 Small, par. 0-23 Display Line 2 Large or par. 0-24 Display Line 3 Large. Use the 4 or. $\mathbf{\nabla}$ buttons on the LOP to change a character. Use the and buttons to move the cursor. When a character is highlighted by the cursor, it can be changed. Use the $\pm$ or $\mathbf{V}$ buttons on the LCP to change a character. A character can be inserted by placing the cursor between two characters and pressing $\Delta$ or $\overline{\mathrm{V}}$. |
| :---: | :---: | :---: |

## 0-38 Display Text 2

| Range: |  | Function: |
| :---: | :---: | :---: |
| 0 N/A* | $[0-0 \mathrm{~N} / \mathrm{A}] .$ | In this parameter, it is possible to write an individual text string for display in the LCP or to be read via serial communication. If to be displayed permanently select Display Text 2 in par. 0-20 Display Line 1.1 Small, par. 0-21 Display Line 1.2 Small, par. 0-22 Display Line 1.3 Small, par. 0-23 Display Line 2 Large or par. 0-24 Display Line 3 Large. Use the $\mathbf{\Delta}$-or $\mathbf{V}$ buttons on the LCP to change a character. Use the $\leqslant$ and $\bullet$ buttons to move the cursor. When a character is highlighted by the cursor, this character can be changed. A character can be inserted by placing the cursor between two characters and pressing $\boldsymbol{\Delta}$ or $\mathbf{V}$. |

## 0-39 Display Text, 3

Range:

## Function:

| $0 \mathrm{~N} / \mathrm{A}^{*}$ | [ $0-0 \mathrm{~N} / \mathrm{A}$ ] | In this parameter, it is possible to write an individual text string for displày in the LCP or to be read via serial communication. If it is to be displayed permanently, select Display Text 3 in par. 0-20 Display Line 1.1 Small,par. 0-21 Display Line 1.2 Small, par. 0-22 Display Line 1.3 Small, par. 0-23 Display Line 2 Large or par. 0-24 Display Line 3 Large. Use the 4 or $\mathbf{v}$ buttons on the LCP to change a character. Use the and buttons to move the cursor. When a character is highlighted by the cursor, this character can be changed. A character can be inserted by placing the cursor between two characters and pressing $\boldsymbol{\Delta}$ or $\mathbf{V}$. |
| :---: | :---: | :---: |

## 0-70 Set Date and Time

Range:
2000-01-01 [2000-01-01 00:00]
00:00 -
2099-12-01
23:59*

## Function:

Sets the date and time of the internal clock. The format to be used is set in par. 0-71 and 0-72.

## NOTE!

This parameter does not display the actual time. This can be read in par. 0-89. The clock will not begin counting until a setting different from default has been made.

## 0-71 Date Format

## Option:

## Function:

| [0]* |
| :--- |
| $[1]$ DD-MM-MM-DD <br> [2] MM/DD $/ Y Y Y$ |

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| Option: | Function: |
| :---: | :---: |
| Sets the time format to be used in the LCP. |  |
| [0] * 24 h |  |
| [1] 12 h |  |
| 0-74 DST/Summertime |  |
| Option: | Function: |
|  | Choose how Daylight Saving Time/Summertime should be handled. For manual DST/Summertime enter the start date and end date in par. 0-76 DST/Summertime Start and par. 0-77 DST/Summertime End. |
| [0] * OFF |  |
| [2] Manual |  |
| Sot76 DST/Summertime Stant |  |
| Range: | Function: |
| $0 \mathrm{~N} / \mathrm{A}^{*} \quad[0-0 \mathrm{~N} / \mathrm{A}]$ | Sets the date and time when summertime/DST starts. The date is programmed in the format selected in par. 0-71 Date Format. |
| 0-77 DST/Summertime End |  |
| Range: | Function: |
| $0 \mathrm{~N} / \mathrm{A}^{*} \quad[0-0 \mathrm{~N} / \mathrm{A}]$ | Sets the date and time when summertime/DST ends. The date is programmed in the format selected in par. 0-71 Date Format. |

### 8.2.3 General Settings, 1-0*

Define whether the adjustable frequency drive operates in open-loop or closed-loop.

## 1-00 Configuration Mode

## Option:




NOTE!
When set for closed-loop, the commands reversing and start reversing will not reverse the direction of the motor.

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1-20 Motor Power [kW]

| Range: | Function: |
| :---: | :---: |
| $4.00 \mathrm{kW*}$ * [0.09-3000.00 kW] |  |
| 1-22 Motor Voltage |  |
| Range: | Function: |
| $\text { 400. V* } \quad[10 .-1000 . V]$ | Enter the nominal motor voltage according to the motor nameplate data. The default value corresponds to the nominal rated output of the unit. <br> This parameter cannot be adjusted while the motor is running. |
| 1-23 Motor Frequency |  |
| Range: | Function: |
| 50. Hz* $\quad[20-1000 \mathrm{~Hz}]$ | Select the motor frequency value from the motor nameplate data.For 87 Hz operation with 230/400 $\checkmark$ motors, set the nameplate data for $230 \mathrm{~V} / 50 \mathrm{~Hz}$. Adapt par. 413 Motor Speed High Limit [RPM] and par. 3-03 Maximum Reference to the 87.Hz application. |



## 1-24. Motor Cuirrent



## Function:

| $7.20 \mathrm{~A}^{*} \quad[0.10-10000.00 \mathrm{~A}]$ | Enter the nominal motor current value from the motor nameplate data. This data is used for cal- <br> culating motor torque, motor thermal protection, etc. |
| :--- | :--- |

1-25 Motor Nominal Speed


## Function:

Enter the nominal motor speed value from the motor nameplate data. This data is used for calculating automatic motor compensations.

## NOTE!

This parameter cannot be changed white the motor is running.

1-29 Automatic. Motor Adaptation (AMA)
Option:

## Function:

|  | $\ddots$ | The AMA function optimizes dynamic motor performance by automatically optimizing the advanced <br> motor parameters par. 1-30 Stator Resistance (Rs) to par. 1-35 Main Reactance $(X h)$ while the <br> motor is stationary. |
| :--- | :--- | :--- |
| 0$] *$ | Off |  |

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| Enable complete AMA | performs AMA of the stator resistance $R_{5}$, the rotor resistance $R_{r}$ the stator leakage reactance $X_{1,}$ <br> the rotor leakage reactance $X_{2}$ and the main reactance $X_{s}$. |
| :--- | :--- |

[2] Enable reduced AMA
performs a reduced AMA of the stator resistance $R$ s in the system only. Select this option if an LC filter is used between the adjustable frequency drive and the motor.

Activate the AMA function by pressing [Hand on] after selecting [1] or [2]. See also the section Automatic Motor Adaptation. Atter a normal sequence, the display will read: "Press [OK] to finish AMA". After pressing the [OK] key, the adjustable frequency drive is ready for operation.

Note:

- For the best adaptation of the adjustable frequency drive, run AMA on a cold motor
- AMA cannot be performed while the motor is running.



## NOTE!

It is important to set motor par. 1-2* Motor Data correctly, since these form part of the AMA algorithm. An AMA must be performed to achieve optimum dynamic motor performance. It may take up to 10 min ., depending on the motor power rating.


## NOTE!

Avoid generating external torque during AMA


## NOTE!

If one of the settings in par. 1-2* Motor Data is changed, par. 1-30 Stator Resistance (R5) to par. 1-39 Motor Poles, the advanced motor parameters, will return to the default setting.
This parameter cannot be adjusted while the motor is running.

## NOTE!

Full AMA should be run without filter only while reduced AMA should be run with filter.

See section: Application Examples > Automatic Motor Adaptation in the Design Guide.

### 8.2.4 3-0* Reference Limits

Parameters for setting the reference unit, limits and ranges.
0.000 Ref- [-999999.999-par. 3-03 Referen- Enter the Minimum Reference. The Minimum Reference is the lowest value obtainable by adding all erenceFeed-ceFeedbackUnit] backUnit** references together. The Minimum Reference value and unit matches the configuration choice made in par. 1-00 Configuration Mode and par. 20-12 Reference/Feedback Lnit, respectively.

## NOTE:

This parameter is used in open-loop only.

## Function:

Range:
Enter the maximum acceptable value for the remote reference. The Maximum Reference value and
50.000 Ref- [par. 3-02-999999.999 Referen- Enter the maximum acceptable value for the remote reference. The Maximum Reference value and erenceFeed-ceFeedbackUnit] oice made in par. 1-00 Configurabion Mode and par. 20-12 RefbackUnit* erence/Feedback Unit, respectively.


## NOTE!

If operating with par. 1-00, Configuration Mode set for Closed-loop [3], par. 20-14, Maximum Reference/Feedb. must be used.

3-10 Preset' Reference
Array [8]
Range:

## Function:

$0.00 \%$ * $[-100.00-100.00 \%]$




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## 

## Range:

## Function:

Enter the initial ramp-up time from zero speed to Motor Speed Low Limit, par. 4-11 or 4-12. Submersible deep well pumps can be damaged by running below minimum speed. A fast ramp time below minimum pump speed is recommended. This parameter may be applied as a fast ramp rate from zero speed to Motor Speed Low Limit.


## 

Range:

## Function:

$05^{*} \quad[0-605]$

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F58 Check valve Ramp Enid Speed [Hz]


## Function:

$0[\mathrm{~Hz}]^{*} \quad[0-$ Motor Speed Low Limit [Hz]]
Set the speed in [Hz] below Motor Speed Low Limit where the Check Vaive Ramp will no longer be active.


## 3383 Final Ramp Time

Range:
$0[s]^{*} \quad[0-60[s]]$

## Function:

Enter the Final Ramp Time to be used when ramping down from Motor Speed Low Limit, par, 4-11 or 4-12, to zero speed.
Submersible deep well pumps can be damaged by running below minimum speed. A fast ramp time below minimum pump speed is recommended. This parameter may be applied as a fast ramp rate from Motor Speed Low Limit to zero speed.


### 8.2.5 4-** Limits and Warnings

Parameter group for configuring limits and warnings.
4-11 Motor Speed Low Limit [RPM]
Range: Function:

| 0 RPM* | [0 - par. 4-13 RPM] | Enter the minimum limit for motor speed. The Motor Speed Low Limit can be set to correspond to <br> the manufacturer's recommended minimum motor speed. The Motor Speed Low Limit must not <br> exceed the setting in par. 4-13 Motor Speed High Limit [RPM]. |
| :--- | :--- | :--- |

4-13 Motor Speed High Limit [RPM]
Range: Function:
1500. RPM* [par. 4-11-60000. RPM] Enter the maximum limit for motor speed. The Motor Speed High Limit can be set to correspond to the manufacturer's maximum rated motor. The Motor Speed High Limit must exceed the setting in par. 4-11 Motor Speed Low Limit [RPM]. Only par. 4-11 Motor Speed Low Limit [RPM] or par. 4-12 Motor Speed Low Limit [Hz] will be displayed, depending on other parameters. in the main menu, and depending on default settings dependant on global location.

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## NOTE!

Max. output frequency cannot exceed $10 \%$ of the inverter switching frequency (par. 14-01 Switching Frequency).

## NOTE!

Any changes in par. 4-13 Motor Speed High Limit [RPM] will reset the value in par. 4-53 Warning Speed High to the same value as set in par. 4-13 Motor Speed High Limit [RPM].

### 8.2.6 5-** Digital In/Out

Parameter group for configuring the digital input and output.


## Please note that this parameter cannot be adjusted while the motor is running

### 8.2.7 5-1* Digital Inputs

Parameters for configuring the input functions for the input terminals.
The digital inputs are used for selecting various functions in the adjustable frequency drive. All digital inputs can be set to the following functions:

| Digital input function | Select | Terminal |
| :---: | :---: | :---: |
| No, operation | [0] | All *term 32, 33 |
| Reset | [1] | All |
| Coast inverse | [2] | All |
| Coast and reset inverse | [3] | All |
| OC brake inverse | [5] | All |
| Stop inverse | [6] | All |
| External interlock | [7] | All |
| Start | [8] | All *term 18 |
| Latched start | [9] | All |
| Reversing | [10] | All *term 19 |
| [Start reversing | [11] | All |
| Jog | [14] | All *term 29 |
| Preset reference on | [15] | All |
| Preset ref bit 0 | [16] | All |
| Preset ref bit 1 | [17] | All |
| Preset ref bit 2 | [18] | All |
| Freeze reference | [19] | All |
| Freeze output | [20] | All |
| Speed up | [21] | All |
| Slow | [22] | All |
| Set-up select bit 0 | [23] | All |
| Set-up select bit 1 | [24] | All |
| Pulse input | [32] | term 29, 33 |
| Ramp bit 0 | [34] | All |
| Line failure inverse | [36] | All |
| Run Permissive | [52] |  |
| Hand stait | [53] |  |
| Auto-start | [54] |  |
| DigiPot Increase | [55] | All |
| DigiPot Decrease | [56] | All |
| DigiPot Clear | [57] | All |
| Counter A (up) | [60] | 29,33 |


| Counter A (down) | [61] | 29,33 |
| :---: | :---: | :---: |
| Reset Counter A | [62] | All |
| Counter B (up) | [63] | 29, 33 |
| Counter B (down) | [64] | 29, 33 |
| Reset Counter B | [65] | All |
| Sleep Mode | [66] |  |
| Reset Maintenance Word | [78] |  |
| Lead Pump Start | [120] |  |
| Lead Pump Alternation | [121] |  |
| Pump 1 Interlock | [130] |  |
| Pump 2 Interlock | [131] |  |
| Pump 3 Interlock | [132] |  |

All $=$ Terminals $18,19,27,29,32, \times 30 / 2, \times 30 / 3, \times 30 / 4 . \times 30 /$ are the terminals on MCB 101.

Functions dedicated to only one digital input are stated in the associated parameter.

All digital inputs can be programmed to these functions:

| [0] | No operation | No reaction to signals transmitted to terminal. |
| :---: | :---: | :---: |
| [1] | Reset | Resets adjustable frequency drive after a TRIP/ALARM. Not all alarms can be reset. |
| [2] | Coast inverse. | Leaves motor in free mode. Logic ' 0 ' $=>$ coasting stop. (Default Digital input 27): Coasting stop, inverted input (NC). |
| [3] | Coast and reset inverse | Reset and coasting stop Inverted input (NC). <br> Leaves motor in free mode and resets the adjustable frequency drive. Logic ' 0 ' $=>$ coasting stop and reset. |
| [5] | DC brake inverse | Inverted input for DC braking (NC). <br> Stops motor by energizing it with a DC current for a certain time period. See par. 2-01 to par. 2-03. <br> The function is only active when the value in par. 2-02 is different from 0 . Logic ' 0 ' $=>D C$ braking. |
| [6] | Stop inverse | Stop Inverted function. Generates a stop function when the selected terminal goes from logical level ' 1 ' to ' 0 '. The stop is performed according to the selected ramp time (par. 3-42 and par. 3-52). |
|  |  | NOTE! <br> When the adjustable frequency drive is at the torque limit and has received a stop command, it may not stop by itself. To ensure that the adjustable frequency drive stops, configure a digital output to Torque limit \& stop [27] and connect this digital output to a digital input that is configured as coast. |
| [7] | External Interiock | Same function as Coasting stop, inverse, but External Interlock generates the alarm message 'external fault' on the display when the terminal which is programmed for Coast Inverse is logic ' 0 '. The alarm message will also be active via digital outputs and relay outputs, if programmed for External Interfock. The alarm can be reset using a digital input or the [RESET] key if the cause for the Externai Interlock has been removed. A delay can be programmed in par. 22-00, External Interlock Time. After applying a signal to the input, the reaction described above will be delayed with the time set in par. 22-00. |
| [8] | Start | Select start for a start/stop command. Logic ' 1 ' = start, logic ' 0 ' = stop. (Default Digital input 18) |
| [9] | Latched start | Motor starts, if a pulse is applied for min. 2 ms . Motor stops when Stop inverse is activated |
| [10] | Reversing | Changes direction of motor shaft rotation. Select Logic ' 1 ' to reverse. The reversing signal only changes the direction of rotation. It does not activate the start function. Select both directions in par. 4-10 Motor Speed Direction. <br> (Default Digital input 19). |
| [11] | Start reversing | Used for start/stop and for reversing on the same wire. Signals on start are not allowed at the same time. |
| [14] | Jog | Used for activating jog speed. See par. 3-11. |

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| (Default Digital input 29) |  |  |
| :---: | :---: | :---: |
| [15] | Preset reference on | Used for shifting between external reference and preset reference. It is assumed that Extemal/ preset [ 1 ] has been selected in par. 3 -04. Logic ' 0 ' = external reference active; logic ' 1 ' = one of the eight preset references is active. |
| [16] | Preset ref bit 0 | Enables a choice between one of the eight preset references according to the table below. |
| [17] | Preset ref bit 1 | Enables a choice between one of the eight preset references according to the table below. |
| [18] | Preset ref bit 2 | Enables a choice between one of the eight preset references according to the table below. |
|  |  | Preset ref. bit 2 1 0 <br> Preset. ref. 0 0 0 0 <br> Preset ref. 1 0 0 1 <br> Preset ref. 2 0 1 0 <br> Preset ref. 3 0 1 1 <br> Preset ref. 4 1 0 0 <br> Preset ref. 5 1 0 1 <br> Preset ref. 6 1 1 0 <br> Preset ref. 7 1 1 1 |
| [19] | Freeze ref | Freezes actual reference. The frozen reference is now the point of enable/condition for Speed up and Slow to be used. If Speed up/down is used, the speed change always follows ramp 2 (par. 3-51 and 3-52) in the range 0 - par. 3-03 Maximum Reference. |
| [20] | Freeze output | Freezes actual motor frequency (Hz). The frozen motor frequency is now the point of enable/condition for Speed up and Slow to be used. If Speed up/down is used, the speed change always follows ramp 2 (par. 3-51 and 3-52) in the range 0 - par. 1-23 Motor Frequency. |
|  |  | NOTE! <br> When Freeze output is active, the adjustable frequency drive cannot be stopped via a low 'start [13]' signal. Stop the adjustable frequency drive via a terminal programmed for Coasting inverse [2] or Coast and reset, inverse [3]. |


| [21] | Speed up | For digital control of the up/down speed is desired (motor potentiometer). Activate this function by selecting either Freeze reference or Freeze output. When Speed up is activated for less than 400 msec ., the resulting reference will be increased by $0.1 \%$. If Speed up is activated for more than 400 msec ., the resulting reference will ramp according to Ramp 1 in par. 3-41. |
| :---: | :---: | :---: |
| [22] | Slow | Same as Speed up [21]. |
| [23] | Set-up select bit 0 | Selects one of the four set-ups. Set par. 0-10 Active Set-up to Multi Set-up. |
| [24] | Set-up select bit 1 | Same as Set-up select bit 0 [23]. <br> (Default Digital input 32) |
| [32] | Pulse input | Select Pulse input when using a pulse sequence as either reference or feedback. Scaling is done in par. group 5-5*. |
| [34] | Ramp bit 0 | Select which ramp to use. Logic "0" will select ramp 1 while logic " 1 " will select ramp 2. |
| [36] | Line failure inverse | Activates par. 14-10 Line Failure. Line failure inverse is active in the Logic " 0 " situation. |
| [52] | Run Permissive | The input terminal, for which the Run permissive has been programmed must be logic " 1 " before a start command can be accepted. Run permissive has a logic 'AND' function related to the terminal which is programmed for START[8], J0g [14] or Freeze Output[20], which means that in order to start running the motor, both conditions must be fulfilled. If Run Permissive is programmed on multiple terminals, Run permissive needs only be logic ' 1 ' on one of the terminals for the function to be carried out. The digital output signal for Run Request (Start [8], Jog [14] or Freeze output [20]) programmed in par. 5-3* Digital outputs, or par. 5-4* Relays, will not be affected by Run Permissive. |
| [53] | Hand start | A signal applied will put the adjustable frequency drive into hand mode as if button Hand On on the LCP has been pressed and a normal stop command will be overridden. If disconnecting the signal, the motor will stop. To make any other start commands valid, another digital input must be assigned to Auto-Start and a signal applied to this. The Hand On and Auto On buttons on the LCP has no |

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|  |  | impact. The Off button on the LCP will override Hand Start and Auto-Start. Press either the Hand On or Auto On button to make Hand Start and Auto-Startactive again. If no signal on neither Hand Start nor Auto-Start, the motor will stop regardless of any normal Start command applied. If signal applied to both Hand Start and Auto-Start, the function will be Auto-Start. If pressing the Offbutton on the LCP, the motor will stop regardless of signals on Hand Start and Auto-Start. |
| :---: | :---: | :---: |
| [54] | Auto-start | A signal applied will put the adjustable frequency drive into auto mode as if the LCP button Auto On has been pressed. See also Hand Start [53] |
| [55] | DigiPot Increase | Uses the input as an INCREASE signal to the Digital Potentiometer function described in parameter group 3-9* |
| [56] | DigiPot Decrease | Uses the input as a DECREASE signal to the Digital Potentiometer function described in parameter group 3-9* |
| [57] | DigiPot Clear | Uses the input to ClEAR the Digital Potentiometer reference described in parameter group 3-9* |
| [60] | Counter A (up) | (Terminal 29 or 33 only) Input for increment counting in the SLC counter. |
| [61] | Counter A (down) | (Terminal 29 or 33 only) Input for decrement counting in the SLC counter. |
| [62] | Reset Counter A | Input for reset of counter $A$. |
| [63] | Counter B (up) | (Terminal 29 and 33 only) Input for increment counting in the SLC counter. |
| [64] | Counter B (down) | (Terminal 29 and 33 only) Input for decrement counting in the SLC counter. |
| [65] | Reset Counter B | Input for reset of counter 8 . |
| [66] | Sleep Mode | Forces adjustable frequency drive into sleep mode (see par. 22-4*, Sleep Mode). Reacts on the rising edge of signal applied! |

[78] Reset Preventive Maintenance Word Resets all data in par. 16-96, Preventive Maintenance Word, to 0.
The below setting options are all related to the cascade controller. Wiring diagrams and settings for parameter, see group 25-** for more details.

| [120] | Lead Pump Start | Starts/stops the lead pump (controiled by the adjustable frequency drive). A start requires that also a System Start signal has been applied, e.g., to one of the digital inputs set for Start [8]! |  |  |
| :---: | :---: | :---: | :---: | :---: |
| [121] | Lead Pump Alternation | Forces alternation of the lead pump in a cascade controller. Lead Pump Altemation, par. 25-50, must be set to either At Command [2] or At Staging or At Command [3]. Alternation Event, par. 25-51, can be set to any of the four options. |  |  |
| [130- | Pump1 Interlock - Pump9 Interlock | The function will depend on the setting in par. 25-06, Number of Pumps. If set to No [0], then Pump1 refers to the pump controlled by relay RELAY1 etc. If set to Yes [1], Pump1 refers to the pump controlled by the adjustable frequency drive only (without any of the built-in relays involved) and Pump2 to the pump controlled by the relay RELAY1. Variable speed pump (lead) cannot be interlocked in the basic cascade controller. <br> See below table: |  |  |
|  |  | Setting in Par. 25-06 |  |  |
|  |  |  | [0] No | [1] Yes |
| . | . | [130] Pump1 Interlock | Controiled by RELAY1 (only if not lead pump) | Adjustable frequency drive controlled (cannot be interlocked) |
|  |  | [131] Pump2 Interlock | Controlled by RELAY2 | Controlled by RELAY1 |
|  |  | [132] Pump3 Interlock | Controlled by RELAY3 | Controlled by RELAY2 |
|  |  | [133] Pump4 Interlock | Controlled by RELAY4 | Controlled by RELAY3 |
|  |  | [134] Pump5 Interlock | Controiled by RELAY5 | Controiled by RELAY4 |
|  |  | [135] Pump6 Interlock | Controlled by RELAY6 | Controlled by RELAY5 |
|  |  | [136] Pump7 Interiock | Controlled by RELAY7 | Controlled by RELAY6 |
|  |  | [137] Pump8 Interlock | Controlled by RELAY8 | Controlled by RELAY7 |
|  |  | [ [138] Pump9 Interlock | Controlled by RELAY9 | Controlled by RELAY8 |

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## YFi 3 Terminal 29 Digita in unt: <br> Option: <br> Function:

[0] * No Operation
Same options and functions as par. 5-1* Digital Inputs.

## 5 514 Terminal 32 Digita thput

Same options and functions as par. 5-1*, except for Pulse input:

| Option: |
| :--- |
| $[0]^{*}$ No operation Function: |



Same options and functions as par. 5-1* Digital Inputs.

| Option: |  | Function: |
| :---: | :---: | :---: |
| [0] * No operation |  |  |
|  |  |  |
| Option: |  | Function: |


| $[0]^{*} \quad$ No operation | Same options and functions as par. 5-3*. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |

H540 Function Relay

Select options to define the function of the relays.
The selection of each mechanical relay is realized in an array parameter.

| [0]* | No Operation |
| :---: | :---: |
| [1] | Control Ready |
| [2] | Drive Ready |
| [3] | Drive Ready/Remote |
| [4] | Stand-by/No Warning |
| [5] | Running |
| [6] | Running/No Warning |
| [8] | Run on Ref./No Warning |
| [9] | Alarm |
| [10] | Alarm or Warning |
| [11] | At Torque Limit |
| [12] | Out of Current Range |
| [13] | Below Current, low |
| [14] | Above Current, high |
| [15] | Out of Speed Range |
| [16] | Below Speed, low |
| [17] | Above Speed, high |
| [18] | Out of Feedb. Range |
| [19] | Below Feedback, low |
| [20] | Above Feedback, high |
| [21] | Thermal Warning |



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| [191] | Dry Pump |  |
| :---: | :---: | :---: |
| [192] | End of Curve |  |
| [193] | Sleep Mode |  |
| [194] | Broken Belt |  |
| [195] | Bypass Valve Control |  |
| [199] | Pipe Filling |  |
| [211] | Cascade Pump1 |  |
| [212] | Cascade Pump2 |  |
| [213] | Cascade Pump3 |  |
| [223] | Alarm, Trip Locked |  |
| [224] Bypass Mode Active |  |  |
| F553 Term. 29 High Ref./Feedb. Value |  |  |
| Range: |  | Function: |
| $\begin{aligned} & 100.000 \mathrm{~N} / \\ & \mathrm{A}^{*} \end{aligned}$ | [-999999.999-999999.999 N/A] | Enter the high reference value [RPM] for the motor shaft speed and the high feedback value, see also par. 5-58 Term. 33 High Ref./Feedb. Value. |

### 8.2.8 6-** Analog In/Out

Parameter group for configuring the analog input and output.
6:00 Live Zero Timeout Time
Range:

## Function:

| 10 s* | [1-99 s] | Enter the Live Zero Timeout time period. Live Zero Timeout Time is active for analog inputs, i.e., terminal 53 or terminal 54 , used as reference or feedback sources. If the reference signal value associated with the selected current input falls below $50 \%$ of the value set in par. 6-10 Terminal 53 Low Voltage, par. 6-12 Terminal 53 Low Current, par. 6-20 Terminal 54 Low Voltage or par. 6-22 Terminal 54 Low Current for a time period longer than the time set in par. 6-00 Live Zero Timeout Time, the function selected in par. 6-01 Live Zero Timeout function will be activated. |
| :---: | :---: | :---: |

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6-01 Live Zero Timeout Function

| Option: |  | Function: |
| :---: | :---: | :---: |
|  |  | Select the timeout function. The function set in par. 6-01 Live Zero Timeout Function will be activated if the input signal on terminal 53 or 54 is below $50 \%$ of the value in par. 6-10 Terminal 53 Low Voltage, par. 6-12 Terminal 53 Low Current, par. 6-20 Terminal 54 Low Voltage or par. 6-22 Terminal 54 Low Currentfor a time period defined in par. 6-00 Live Zero Timeout Time. If several timeouts occur simultaneously, the adjustable frequency drive prioritizes the timeout functions as follows: <br> 1. par. 6-01 Live Zero Timeout Function <br> 2. par. 8-04 Control Timeout Function <br> The output frequency of the adjustable frequency drive can be: <br> - • [1] frozen at the present value <br> - [2] overruled to stop <br> - [3] overruled to jog speed <br> - [4] overruled to max. speed <br> - [5] overruled to stop with subsequent trip |
| [0]* | Off |  |
| [1] | Freeze output |  |
| [2] | Stop |  |
| [3] | Jogging |  |
| [4] | Max. speed |  |
| [5] . | Stop and trip |  |


| Range: | Function: |
| :---: | :---: |
| 0.07 V * [0.00-par. 6-11 V] | Enter the low voltage value. This analog input scaling value should correspond to the low reference/ feedback value set in par. 6-14 Terminal 53 Low Ref./Feedb. Value. |
| 6-11 Terminal 53 High Voltage |  |
| Range: | Function: |
| $10.00 \mathrm{~V}^{*} \quad$ [par. 6-10 - 10.00 V] | Enter the high voltage value. This analog input scaling value should correspond to the high reference/feedback value set in par. 6-15 Terminal 53 High Ref./Feedb. Value. |

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| Range: | Function: |
| :---: | :---: |
| $0.000 \mathrm{~N} / \mathrm{A}^{*}$ [-999999.999-999999.999 N/A] | Enter the analog input scaling value that corresponds to the low voltage/low current set in par. 6-10 Terminal 53 Low Voltage and par. 6-12 Terminal 53 Low Current. |

6-15 Terminal 53 High Ref./Feedb. Value

| Range: | Function: |
| :---: | :---: |
| $\begin{aligned} & 50.000 \mathrm{~N} /[-999999.999-999999.999 \mathrm{~N} / \mathrm{A}] \\ & \mathrm{A}^{*} \end{aligned}$ | Enter the analog input scaling value that corresponds to the high voltage/high current value set in par. 6-11 Terminal 53 High Voltage and par. 6-13 Terminal 53 High Current. |
| 6-20 Terminal 54 Low Voltage |  |
| Range: | Function: |
| 0.07 V* [0.00-par. 6-21 V] | Enter the low voltage value. This analog input scaling value should correspond to the low reference/ feedback value, set in par. 6-24 Terminal 54 Low Ref./Feedb. Value. |
| 60-21 Terminal 54 High Voltage |  |
| Range: | Function: |
| $10.00 \mathrm{~V}^{\text {* }}$ [par. 6-20-10.00 V] | Enter the high voltage value. This analog input scaling value should correspond to the high reference/feedback value set in par. 6-25 Termina/ 54 High Ref./Feedb. Value. |
| [6-24 Terminal 54 Low Ref./Feedb, Value. $\quad \therefore \quad$, |  |
| Range: | Function: |
| $0.000 \mathrm{~N} / \mathrm{A}^{*} \quad[-999999.999-999999.999 \mathrm{~N} / \mathrm{A}]$ | Enter the analog input scaling value that corresponds to the low voltage/low current value set in par. 6-20 Terminal 54 Low Voltage and par. 6-22 Terminal 54 Low Current. |
| 8-25 Terminal 54 High Ref. / Feedb. Value |  |
| Range: | Function: |
| $\begin{aligned} & 100.000 \mathrm{~N} /[-999999.999-999999.999 \mathrm{~N} / \mathrm{A}] \\ & \mathrm{A}^{*} \end{aligned}$ | Enter the analog input scaling value that corresponds to the high voltage/high current value set in par. 6-21 Terminal 54 High Voltage and par. 6-23 Terminal 54 High Current |
| 86-50 Terminal 420 ¢tputy |  |
| Option: | Function: |
|  | Select the function of Terminal 42 as an analog current output. A motor current of 20 mA corresponds to $I_{\text {max }}$. |
| [0] * No operation |  |
| [100] Output frequency | : 0-100 Hz, (0-20 mA) |
| [101] Reference | : Minimum reference - Maximum reference, (0-20 mA) |
| [102] Feedback | : -200\% to +200\% of par. 20-14, (0-20 mA) |
| [103] Motor current | : 0 - Inverter Max. Current (par. 16-37), (0-20 mA) |
| [104] Torque rel to limit | : 0 - Torque limit (par. 416), (0-20 mA) |
| [105] Torq relate to rated | : 0 - Motor rated torque, ( $0-20 \mathrm{~mA}$ ) |
| [106] Power | : 0 - Motor rated power, (0-20 mA) |
| [107] * Speed | : 0-Speed High Limit (par. 4-13 and par. 4-14), (0-20 mA) |
| [113] Ext. Closed-loop 1 | : 0-100\%, ( $0-20 \mathrm{~mA}$ ) |

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[^7]5-51 Terminal 42 Output Min Scale

| NOTE! |  |  |
| :---: | :---: | :---: |
| Values for setting the minimum reference are found in open-loop par. 3-02 Minimum Reference and for closed-loop par. 20-13 Minimum Reference/ Feedb. - values for maximum reference for open-loop are found in par. 3-03 Maximum Reference and for closed-loop par. 20-14 Maximum Reference/ Feedb.. |  |  |
| 6.51 Terminal 42 OutputMinScale $\because$ 回 |  |  |
| Range: |  | Function: |
| 0.00 \%* | [0.00-200.00\%] |  |

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6-52 Terminal 42 Output Max Scale
Range: Function:
$100.00 \%$ * [0.00-200.00 \%]
EXAMPLE 1:
Variable value $=$ OUTPUT FREQUENCY, range $=0-100 \mathrm{~Hz}$
Range needed for output $=0-50 \mathrm{~Hz}$
Output signal 0 or 4 mA is needed at 0 Hz ( $0 \%$ of range) - set par. 6-51 Terminal 42 Output Min Scale to $0 \%$
Output signal 20 mA is needed at 50 Hz ( $50 \%$ of range) - set par. 6-52 Terminal 42 Output Max Scale to $50 \%$


## EXAMPLE 2:

Variable $=$ FEEDBACK, range $=-200 \%$ to $+200 \%$
Range needed for output= $0-100 \%$
Output signal 0 or 4 mA is needed at $0 \%$ ( $50 \%$ of range) - set par. 6-51 Terminal 42 Output Min Scale to $50 \%$ Output signal 20 mA is needed at $100 \%$ ( $75 \%$ of range) - set par. 6-52 Terminal 42 Output Max Scale to $75 \%$


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EXAMPLE 3:
Variable value $=$ REFERENCE, range $=$ Min ref - Max ref
Range needed for output= Min ref ( $0 \%$ ) - Max ref ( $100 \%$ ), 0-10 mA
Output signal 0 or 4 mA is needed at Min ref - set par. 6.51 Termina/ 42 Output Min Scale to 0\%
Output signal 10 mA is needed at Max ref (100\% of range) - set par. 6-52 Teminal 42 Output Max Scale to 200\%
( $20 \mathrm{~mA} / 10 \mathrm{~mA} \times 100 \%=200 \%$ ).


### 8.2.9 Drive Closed-loop, 20-**

This parameter group is used for configuring the closed-loop PID controller, which controls the output frequency of the adjustable frequency drive.
20-12 Reference/Feedback Unit

## Function:

Option:

| [0] | None |
| :---: | :---: |
| [1] * | \% |
| [5] | PPM |
| [10] | 1/min |
| [11] | RPM |
| [12] | Pulse/s |
| [20] | 1/s |
| [21] | $1 / \mathrm{min}$ |
| [22] | $1 / \mathrm{h}$ |
| [23] | $\mathrm{m}^{3} / \mathrm{s}$ |
| [24] | $\mathrm{m}^{3} / \mathrm{min}$ |
| [25] | $\mathrm{m}^{3} / \mathrm{h}$ |
| [30] | $\mathrm{kg} / \mathrm{s}$ |
| [31] | $\mathrm{kg} / \mathrm{min}$ |
| [32] | kg/h |
| [33] | t/min |
| [34] | t/h |
| [40] | $\mathrm{m} / \mathrm{s}$ |
| [41] | $\mathrm{m} / \mathrm{min}$ |
| [45] | m |

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| Range: | Function: |
| :---: | :---: |
| 0.000 Proc- [-999999.999-999999.999 Proc-essCtru- essCtrunit] | Setpoint 1 is used in closed-loop mode to enter a setpoint reference that is used by the adjustable frequency drive's PID controller. See the description of par. 20-20 Feedback Function. |
| nit* | NOTE! <br> Setpoint reference entered here is added to any other references that are enabled (see par. group 3-1*). |

## 20-81 PID Normal/Inverse Control

## Option: <br> Function:

[0] * Normal

| [1] Inverse | Norma/[0] causes the adjustable frequency drive's output frequency to decrease when the feedback <br> is greater than the setpoint reference. This is common for pressure-controlled supply fan and pump <br> applications. |
| :--- | :--- |
| Inverse[1] causes the adjustable frequency drive's output frequency to increase when the feedback |  |
| is greater than the setpoint reference. |  |

## 20-82 PID Start Speed [RPM]

Range:


## 20-93 PID Proportional Gaín

Range:
Function:
$0.50 \mathrm{~N} / \mathrm{A}^{*} \quad[0.00-10.00 \mathrm{~N} / \mathrm{A}]$

If (Error $x$ Gain) jumps with a value equal to what is set in par. 20-14 Maximum Reference/Feedb., the PID controller will try to change the output speed equal to what is set in par. 4-13 Motor Speed High Limit [RPM//par. 4-14 Motor Speed High Limit [Hz] but in practice of course limited by this setting. The proportional band (error causing output to change from $0-100 \%$ ) can be calculated by means of the formula:
$\left(\frac{1}{\text { Proportional Cain }}\right) \times($ Max Reference $)$
NOTE!
Always set the desired for par. 20-14 Maximum Reference/feedb. before setting the values for the PID controller in par. group 20-9*.
20-94 PID Integral Time
Range:

| Function: |
| :--- |
| $20.00 \mathrm{~s}^{*}[0.01-10000.00 \mathrm{~s}]$ |
| Over time, the integrator accumulates a contribution to the output from the PID controller as long |
| as there is a deviation between the reference/setpoint and feedback signals. The contribution is |
| proportional to the size of the deviation. This ensures that the deviation (error) approaches zero. |
| Quick response on any deviation is obtained when the integral time is set to a low value. Setting it |
| too low, however, may cause the control to become unstable. |
| The value set is the time needed for the integrator to add the same contribution as the proportional |
| part for a certain deviation. |
| If the value is set to 10,000, the controller will act.as a pure proportional controller. with a P-band |
| based on the value set in par: $20-93$ PID Proportional Gain. When no deviation is present, the output |
| from the proportional controller will be 0. |

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### 8.2.10 22-** Miscellaneous

This group contains parameters used for monitoring water/wastewater applications.

## -22-20 Low Power.Auto Set-up

Option:

## Function:

| When set for Enabled, an auto set-up sequence is activated, automatically setting speed to approx. |
| :--- |
| $50 \%$ and $85 \%$ of rated motor speed (par. 4-13 Motor Speed High Limit [RPM], par. 4-14 Motor |
| Speed High Limit [Hz]. At those two speeds, the power consumption is automatically measured |
| and stored. |
| Before enabling Auto Set-up: |

1. Close valve(s) in order to create a no-flow condition
2. The adjustable frequency drive must be set for open-loop (par. 1-00 Configuration
Mode).
Note that it is important also to set par. 1-03 Torque Characteristics.
[0] * OFF
[1] Enabled

## NOTE!

Auto set-up must be done when the system has reached normal operating temperature!

## NOTE!

It is important that the par. 4-13 Motor Speed High Limit [RPM] or par. 4-14 Motor Speed High Limit [Hz] is set to the max. operational speed of the motor!
It is important to do the auto set-up before configuring the integrated PI controller as settings will be reset when changing from closed to open-loop in par. 1-00 Configuration Mode.

## NOTE!

Carry out the tuning with the same settings in par. 1-03 Torque Characteristics, as for operation after the tuning.


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22-23 No-Flow Function
Option:
Function:

|  |  | Common actions for Low Power Detection and Low.Speed Detection (Individual selections not possible). |
| :---: | :---: | :---: |
| [0] * | OFF |  |
| [1] | Sleep Mode | * |
| [2] | Warning | Messages in the Local Control Panel display (if mounted) and/or signal via a relay or a digital output. |
| [3] | Alarm | The adjustable frequency drive trips and the motor stays stopped until reset. |
| 22-24 No-Flow Delay $\quad$, |  |  |
| Range: |  | Function: |
| $10 s^{*}$ | $[1-600 \mathrm{~s}]$ | Set the time. Low Power/Low Speed must remain detected to activate signal for actions. If detection disappears before the timer runs out, the timer will be reset. |
| 22-26 Dry Pump Function |  |  |
| Option: |  | Function: |
|  |  | Low Power Detection must be Enabled (par. 22-21 Low Power Detection) and commissioned (using either parameter group 22-3*, No Flow Power Tuning, or par. 22-20 Low Power Auto Set-up) in order to use Dry Pump Detection. |
| [0] * OFF |  |  |
| [1] | Warning | Messages in the Local Control Panel display (if mounted) and/or signal via a relay or a digital output. |
| [2] | Alarm | The adjustable frequency drive trips and the motor stays stopped until reset. |


| 22-27 Dry Pump Delay |
| :--- |
| Range: |
| $10 \mathrm{~s}^{*} \quad[0-600 \mathrm{~s}]$ |

## 22-30 No-Flow Power

Function:

| $0.00 \mathrm{kW*}$ | $[0.00-0.00 \mathrm{~kW}]$ | Readout of calculated no-flow power at actual speed. If power drops to the display value, the ad- <br> justable frequency drive. will consider the condition as a no-flow situation. |
| :--- | :--- | :--- |
| 22-31 Power Correction Factor |  |  |
| Range: | Function: |  |
| $100 \% *$ | $[1.400 \%]$ | Make corrections to the calculated power at par. $22-30$ No-Flow Power. <br> If No Flow is detected when it should not be detected, the setting should be decreased. However, <br> if No Flow is not detected when it should be detected, the setting should be increased to above <br> $100 \%$ |

## 22-32, Low Speed [RPM]

Range: Function:

| 0 RPM** | [0-par. 22-36 RPM] | To be used if par. 0-02 Motor Speed Unit has been set for RPM (parameter not visible if Hz selected). Set used speed to the $50 \%$ level. <br> This function is used for storing values needed to tune No-flow Detection. |
| :---: | :---: | :---: |

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22-34 Low SpegdPower [kw]


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## 22-4i Minimum Sleep Time

Range: Function:
$10 \mathrm{~s}^{*}[0-600 \mathrm{~s}] \quad \ddots$ Set the desired minimum time for staying in sleep mode. This will override any wake-up conditions.

## 22-42 Wake-up Speed [RPM]

Range:

## Function:

| 0 RPM* | [par. 4-11-par. 4-13 RPM] | To be used if par. 0-02.Motor Speed. Unit has been set for RPM (parameter not visible if Hz selected). |
| :---: | :---: | :---: |
|  |  | Only to be used if par. 1-00 Configuration Mode is set for open-loop and speed reference is applied by an external controller. |
|  | $\cdots$ - | Set the reference speed at which sleep mode should be canceled. |


| Range: |  | Function: |
| :---: | :---: | :---: |
| $0 \mathrm{~Hz}{ }^{*}$ | $\text { [par. 4-12-par. } 4-14 \mathrm{~Hz} \text { ] }$ | To be used if par. 0-02 Motor Speed Unithas been set for Hz (parameter not visible if RPM selected). Only to be used if par. 1-00 Configuration Mode is set for open-loop and speed reference is applied by an external controller controlling the pressure. <br> Set the reference speed at which sleep mode should be cancelled. |


| 22-44 Wake-upiRef./FB Difference |
| :--- |
| Range: |
| Function:  <br> $10 \% *$ Only to be used if par. 1-00, Configuration Mode, is set for closed-loop and the integrated PI con- <br> troller is used for controlling the pressure.  <br> Set the pressure drop allowed as a percentage of the setpoint for the pressure (Pset) before can-  <br> celing sleep mode.  |
| NOTE! <br> If used in application where the integrated PI controller is set for inverse control <br> in par. 20-71, PID, Normal/Inverse Control, the value set in par. $22-44$ will au- <br> tomatically be added. |

## 22-45 Setpoint Boost

Range:

## Function:

| $0 \% * \quad[-100-100 \%]$ | Only to be used if par. 1-00 Configuration Mode, is set for closed-loop and the integrated PI controller is used. For example, in systems with constant pressure control, it is advantageous to increase the system pressure before the motor is stopped. This will extend the time during which the motor is stopped and help to avoid frequent start/stop. <br> Set the desired overpressure/temperature as a percentage of the setpoint for the pressure (Pset)/ ternperature before entering sleep mode. <br> If set at $5 \%$, the boost pressure will be Pset*1.05. The negative values can be used, for'example, for cooling tower control, where a negative change is needed. |
| :---: | :---: |
| 22-46 Maximum Boost Time |  |
| Range: | Function: |
| $60 \mathrm{~s}^{*} \cdot[0-600 \mathrm{~s}]$ | Only to be used if par. 1-00 Configuration Mode is set for closed-loop and the integrated PI controller is used for controlling the pressuire. <br> Set the maximum time for which boost mode will be allowed. If the set time is exceeded, sleep mode will be entered and will not wait for the set boost pressure to be reached: |

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## 22-50 End of Curve Function

Option:

| $[0] *$ | OFF | Function: |
| :--- | :--- | :--- |
| $[1]$ | Warning | End of Curve monitoring not active. |
| $[2]$ | Alarm | A warning is issued in the display [W94]. |



NOTE!
Automatic restart will reset the alarm and start the system again.

### 22.51 End of Curve Delay

Range:

| $10 \mathrm{~s}^{*}[0-600 \mathrm{~s}]$ | When an end of curve condition is detected, a timer is activated. When the time set in this parameter <br> expires and the End of Curve condition has been steady in the entire period, the function set in <br> par. $22-50$ End of Curve Function will be activated. If the condition disappears before the timer <br> expires, the timer will be reset. |
| :--- | :--- |

22-80 Flow Compensation

## Function

[0] * Disabled
[0] Disabled. Setpoint compensation not active
[1] Enabled
[1] Enabled. Setpoint compensation is active. Enabling this parameter allows the Flow Compensated Setpoint operation.

222-81 Square-linear Curve Approximation
Range:
Function:
$100 \%$ * [0-100 \%]
Example 1:
Adjustment of this parameter allows the shape of the control curve to be adjusted.
$0=$ Linear
$100 \%=$ Ideal shape (theoretical).


## 22-82 Work Point Calculation

Option:

## Function:

|  | Example 1: Speed at System Design Working Point is known: |
| :---: | :---: |
|  |  |

From the data sheet showing characteristics for the specific equipment at different speeds, simply reading across from the $H_{\text {design }}$ point and the Qdesign point allows us to find point $A$, which is the system design working point. The pump characteristics at this point should be identified and the associated speed programmed. Closing the valves and adjusting the speed until HMiN has been achieved allows the speed at the no flow point to be identified.
Adjustment of par. 22-81 Square-linear Curve Approximation then allows the shape of the controi curve to be adjusted infinitely.

| [0]* | Disabled | Disabled [0]. Work Point Calculation not active. To be used if speed at design point is known (see table above). |
| :---: | :---: | :---: |
| [1] |  | Enabled [II. Work Point Calculation is active. Enabling this parameter allows the calculation of the unknown System Design Working Point at $50 / 60 \mathrm{~Hz}$ speed, from the input data set in |

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|  | par. 22-83 Speed at No-Flow [RPM] par. 22-84 Speed at No-Flow [Hz], par. 22-87 Pressure at NoFlow Speed, par. 22-88 Pressure at Rated Speed, par. 22-89 Flow at Design Point and par. 22-90 Flow at Rated Speed. |
| :---: | :---: |
| 222-83 Speed at No-Flow [RPM] |  |
| Range: | Function: |
| 300. RPM* [0-par. 22-85 RPM] | Resolution 1 RPM. <br> The speed of the motor at which the flow is zero and the minimum pressure HMin is achieved should be entered here in RPM. Alternatively, the speed in Hz can be entered in par. 22-84 Speed at NoFlow [HZ]. If it has been decided to use RPM in par. 0-02 Motor Speed Unit, then par. 22-85 Speed at Design Point [RPM]should also be used. Closing the valves and reducing the speed until minimum pressure $H_{\text {min }}$ is achieved will determine this value. |
| 22-84 Speed at No-Flow [Hz] |  |
| Range: | Function: |
| $50.0 \mathrm{~Hz}^{*} \quad$ [ 0.0 - par. $22-86 \mathrm{~Hz}$ ] | Resolution 0.033 Hz . <br> The speed of the motor at which flow has effectively stopped and minimum pressure $H_{\text {min }}$ is achieved should be entered here in Hz . Alternatively, the speed in RPM can be entered in par. 22-83 Speed at No-Flow [RPM]. If it has been decided to use Hz in par. 0-02 Motor Speed Unit, then par. 22-86 Speed at Design Point [Hz] should also be used. Closing the valves and reducing the speed until minimum pressure HMin is achieved will determine this value. |
| 22885 Speed 2 Design Point [RPM] |  |
| Range: | Function: |
| 1500. RPM* [par. 22-83-60000. RPM] | Resolution 1 RPM. <br> Only visible when par. 22-82 Work Point Calculation is set to Disable. The speed of the motor at which the system design working point is achieved should be entered here in RPM. Alternatively, the speed in Hz can be entered in par. 22-86 Speed at Design Point [Hz]. If it has been decided to use RPM in par. 0-02 Motor Speed Unit, then par. 22-83 Speed at No-Flow [RPM] should also be used. |
| 22-86 Speed at Design Point [ Hz ] |  |
| Range: | Function: |
| $\begin{aligned} & \text { 50/60.0. [par. 22-84-par. 4-19 Hz] } \\ & \mathrm{Hz}^{*} \end{aligned}$ | Resolution 0.033 Hz . <br> Only visible when par. 22-82 Work Point Calculation is set to Disable. The speed of the motor at which the system design working point is achieved should be entered here in Hz . Alternatively, the speed in RPM can be entered in par. 22-85 Speed at Design Point [RPM]. If it has been decided to use Hz in par. 0-02 Motor Speed Unit then par. 22-83 Speed at No-Flow [RPM] should also be used. |
| 22-87 Pressureatho-Flow Speed |  |
| Range: | Function: |
| $0.000 \mathrm{~N} / \mathrm{A}^{*} \quad$ [ $\left.0.000-\mathrm{par} .22-88 \mathrm{~N} / \mathrm{A}\right]$ | Enter the pressure Hmin corresponding to Speed at No Flow in Reference/Feedback Units. |
| 22-88 Pressume at atted Sped $\qquad$$\qquad$ 8 N- |  |
| Range: | Function: |
| 999999.999 [par. 22-87-999999.999 N/A] $\mathrm{N} / \mathrm{A}^{*}$ | Enter the value corresponding to the Pressure at Rated Speed, in Reference/Feedback Units. This value can be defined using the pump datasheet. |

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## 22-90 Flow at Rated Speed

Range: Function:

| $0.000 \mathrm{~N} / \mathrm{A}^{*}[0.000-999999.999 \mathrm{~N} / \mathrm{A}] \quad$ | Enter the value corresponding to Flow at Rated Speed. This value can be defined using the pump <br> datasheet. |
| :--- | :--- |

### 8.2.11 23-0* Timed Actions

Use Timed Actions for actions needing to be performed on a daily or weekly basis, e.g., different references for working hours / non-working hours. Up to 10 Timed Actions can be programmed in the adjustable frequency drive. The Timed Action number is selected from the list when entering parameter group 23-0* from the LCP. par. 23-00 ON Time - par. 23-04 Occurrence then refer to the selected Timed Action number. Each timed action is divided into an ON time and an OFF time, in which two different actions may be performed.

The actions programmed in timed actions are merged with corresponding actions from digital inputs, control work via bus and Smart Logic Controller, according to merge rules set up in 8-5*, digital/bus.

## NOTE!

The clock (parameter group 0-7*) must be correctly programmed for timed actions to function correctly.


```
NOTE!
The PC-based configuration tool MCT 10 includes a special guide for easy programming of timed actions.
```


## 23-00 ON Time

Array [10]

| Range: |  | Function: |
| :---: | :---: | :---: |
| 0 N/A* | [ $0-0 \mathrm{~N} / \mathrm{A}$ ] | Sets the ON time for the timed action. |
|  |  | NOTE! <br> The adjustable frequency drive has no backup of the dock function and the set date/time will reset to default (2000-01-01 00:00) after a power-down unless a Real Time Clock module with backup is installed. In par. 0-79 Clock Fault, it is possible to program a waming for cases when the clock has not been set properly, e.g., after a power-down. |

## 23-01 ON Action

Arra [10]

| Option: | Function: |
| :--- | :--- |
|   Select the action during ON Time. See par. 13-52 SL Controller Actionfor descriptions of the options. <br> $[0]^{*}$ DISABLED  <br> 1$]$ No action  |  |

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| [2] | Select set-up 1 |
| :---: | :---: |
| [3] | Select set-up 2 |
| [4] | Select set-up 3 |
| [5] | Select set-up 4 |
| [10] | Select preset ref 0 |
| [11] | Select preset ref 1 |
| [12] | Select preset ref 2 |
| [13] | Select preset ref 3 |
| [14] | Select preset ref 4 |
| [15] | Select preset ref 5 |
| [16] | Select preset ref 6 |
| [17] | Select preset ref 7 |
| [18] | Select ramp 1 |
| [19] | Select ramp 2 |
| [22] | Run |
| [23] | Run reverse |
| [24] | Stop |
| [26] | Dcstop |
| [27] | Coast |
| [28] | Freeze output |
| [29] | Start timer 0 |
| [30] | Start timer 1 |
| [31] | Start timer 2 |
| [32] | Set digital out A low |
| [33] | Set digital out 8 low |
| [34] | Set digital out C low |
| [35] | Set digital out 0 low |
| [36] | Set digital out E low |
| [37] | Set digital out F low |
| [38] | Set digitzal out A high |
| [39] | Set digital out B high |
| [40] | Set digital out C high |
| [41] | Set digital out 0 high |
| [42] | Set digital out E high |
| [43] | Set digital out F high |
| [60] | Reset Counter A |
| [61] | Reset Counter B |
| [70] | Start Timer 3 |
| [71] | Start Timer 4 |
| [72] | Start Timer 5 |
| [73] | Start Timer 6 |
| [74] | Start Timer 7 |

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```
NOTE!
For choices [32] - [43], see also par. group 5-3*, Digital Outputs and 5-4*, Relays.
```


## 23-02 OFF Time

Array [10]


| 23-03 | OFF Action | \% ${ }^{\text {a }}$ |
| :---: | :---: | :---: |
| Array [10] |  |  |
| Option: |  | Function: |
|  |  | Select the action during OFF Time. See par. 13-52. SL Controller Action for-descriptions of the options. |
| [0]* | DISABLED |  |
| [1]. | No action |  |
| [2] | Select set-up 1 |  |
| [3] | Select set-up 2 |  |
| [4] | Select set-up 3 |  |
| [5] | Select set-up 4 |  |
| [10] | Select preset ref 0 |  |
| [11] | Select preset ref 1 | . . . |
| [12] | Select preset ref 2 |  |
| [13] | Select preset ref 3 | - |
| [14] | Select preset ref 4 |  |
| [15] | Select preset ref 5 |  |
| [16] | Select preset ref 6 |  |
| [17] | Select preset ref 7 | . . ${ }^{\text {- }}$ |
| [18] | Select ramp 1 | . |
| [19] | Select ramp 2 |  |
| [22] | Run |  |
| [23] | Run reverse |  |
| [24] | Stop |  |
| [26] | Destop |  |
| [27] | Coast |  |
| [28] | Freeze output | - |
| [29] | Start timer 0 |  |
| [30] | Start timer 1 | $\cdot$ |
| [31] . | Start timer 2 |  |

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| [32] | Set digital out A low |
| :---: | :---: |
| [33] | Set digital out B low |
| [34] | Set digital out C low |
| [35] | Set digital out D low |
| [36] | Set digital out E low |
| [37] | Set digital out F low |
| [38] | Set digital out A high |
| [39] | Set digital out 8 high |
| [40] | Set digital out C high |
| [41] | Set digital out D high |
| [42] | Set digital out E high |
| [43] | Set digital out F high |
| [60] | Reset Counter A |
| [61] | Reset Counter B |
| [70] | Start Timer 3 |
| [71] | Start Timer 4 |
| [72] | Start Timer S |
| [73] | Start Timer 6 |
| [74] | Start Timer 7 |


| Option: | Function: |
| :--- | :--- |
|  Select the day(s) to which the timed action applies. Specify working/non-working days in <br> par. $0-81$ Working Days, par. 0-82 Additiona/ Working Days and par. 0-83 Additiona/ Non-Working <br> Days. <br> $[0] *$ All days <br> $[1]$ Working days <br> $[2]$ Non-working days <br> $[3]$ Monday <br> $[4]$ Tuesday <br> $[5]$ Wednesday <br> $[6]$ Thursday <br> $[7]$ Friday <br> $[8]$ Saturday <br> $[9]$ Sunday |  |

### 8.2.12 Water Application Functions, 29-**

The group contains parameters used for monitoring water/wastewater applications.

|  |  |  |
| :---: | :---: | :---: |
| Opt |  | Function: |
| [0]* | Disabled | Select Enabled to fill pipes at a user-specified rate. |
| [1] | Enabled | Select Enabled to fill pipes with a user specified rate. |

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## 29-01 Pipe Fill Speed [RPM]

| Range: | Function: |
| :---: | :---: |
| Speed Low [Speed Low Limit-Speed High LimLimit* it] | Set the filling speed for filling horizontal pipe systems. The speed can be selected in Hz or RPM depending on the choices made in par. 4-11 / par. 4-13 (RPM) or in par. 4-12 / par. 4-14 (Hz). |
| 129-02 Piperil Speed [Hz]. |  |
| Range: | Function: |
| ```Motor [Speed Low Limit - Speed High Lim- Speed Lowit} Limit*``` | Set the filling speed for filling horizontal pipe systems. The speed can be selected in Hz ar RPM depending on the choices made in par, 4-11/par. 4-13 (RPM) or in par, 4-12/par, 4-14 (Hz). |
|  |  |
| Range: | Function: |
| $0 \mathrm{~s} *$ [0-3600 s] | Set the specified time for pipe filling of horizontal pipe systems. |
| 129-04 Pipe Fill Rate , : , \% |  |
| Range: | Function: |
| $\begin{aligned} & 0.001 \text { units/ }[0.001-999999.999 \text { units/s] } \\ & \mathrm{s}^{*} \end{aligned}$ | Specifies the filling rate in units/second using the PI controller. Filling rate units are feedback units/ second. This function is used for filling vertical pipe systems but will be active when the filling time has expired, no matter what, until the pipe fill setpoint set in par. 29-05 is reached. |
| 29-05 Filled Setpoint |  |
| Range: | Function: |
| $0 \mathrm{~s} * \quad[0-999999,999 \mathrm{~s}]$ | Specifies the filled setpoint at which the pipe fill function will be disabled and the PID controller will take control. This function can be used both for harizontal and vertical plpe systems. |

### 8.3 Parameter Options

### 8.3.1 Default Settings

## Changes during operation:

"TRUE" means that the parameter can be changed while the adjustable frequency drive is in operation, and "FALSE" means that the adjustable frequency drive must be stopped before a change can be made.

## 4 set-up:

'All set-up': the parameter can be set individually in each of the four set-ups, i. e., one single parameter can have four different data values.
' 1 set-up': data value will be the same in all set-ups.
SR:
N/A:
Size related
No default value available.

## Conversion index:

This number refers to a conversion figure used when writing or reading by means of an adjustable frequency drive.

| Conv. index | 100 | 67 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | -1 | -2 | -3 | -4 | -5 | -6 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Conv. factor | 1 | 1/60 | 1000000 | 100000 | 10000 | 1000 | 100 | 10 | 1 | 0.1 | 0.01 | 0.001 | 0.0001 | 0.00001 | 0.000001 |


| Data trpe | Description | Type |
| :---: | :---: | :---: |
| 2 | Integer 8. | Int8 |
| 3 | Integer 16 | Int16 |
| 4 | Integer 32 | Int 32 |
| 5 | Unsigned 8 | Uint8 |
| 6 | Unsigned 16 | Uint16 |
| 7 | Unsigned 32 | Uint32 |
| 9 | visible String | Visstur |
| 33 | Normalized value 2 bytes | N2 |
| [35 | Bit sequence of 16 Boolean variables | V2 |
| 54 | Time difference w/o date | TimD |


|  | Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 10-0* Basic Settings |  |  |  |  |  |
|  | 0-01 Language | [0] English | 1 set-up | TRUE | - | Uint8 |
|  | 0-02_ MotorSpeed Unit | [0] RPM | 2 set-ups | FALSE | - | Uint8 |
|  | 0-03 Regional Settings | [0] International | 2 set-ups | FALSE | - | Uint8 |
|  | 0-04 Operating state at Power-up | [0] Resume | All set-ups | TRUE | - | Uint8 |
|  | 0-05 Local Mode Unit | [0] As Motor Speed Unit | 2 set-ups | FALSE | - | Uint8 |
|  | $0-1 *$ Set-up Operations . |  |  |  |  |  |
|  | 0-10 Active Set-up | [1] Set-up 1 | 1 set-up | TRUE | - | Uint8 |
|  | 0-11_Programming Set-up | [9] Active Set-up | All set-ups | TRUE | . | Uint8 |
|  | 0-12 This Set-up Linked to | [0] Not linked | All set-ups | FALSE | - | Uint8 |
|  | 0-13 Readout: Linked Set-ups | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
|  | 0-14 Readout: Prog. Set-ups / Channel | 0 N/A | All set-ups | TRUE | 0 | Int32 |
|  | 0-2* LCP Display |  |  |  |  |  |
| 30003$\sim$ | 0-20 Display Line 1.1 Small | 1601 | All set-ups | TRUE | - | Uint16 |
|  | $0-21$ Display Line_1.2 Small | 1662 | All set-ups | TRUE | - | Uint16 |
|  | 0-22 Display Line 1.3 Small | 1614 | All set-ups | TRUE | - | Uint16 |
|  | $0-23$ - Display Line 2 Large | 1613 | All.set-ups | TRUE | - | Uint16 |
|  | 0-24 Display Line 3 Large | 1652 | All set-ups | TRUE | - | Uint16 |
|  | 0-25 My Personal Menu | -. Expressiônlimit | 1 set-up | TRUE | 0 | Uint16 |
| $\leqslant$ | 0-3* LCP Cust. Readout |  |  |  |  |  |
| $\stackrel{\square}{6}$ | 0-30_ Custom Readout Unit | [1] \% | All set-ups | TRUE | - | Uint8 |
| ふ | 0-31 Custom Readout Min Value | ExpressionLimit | All set-ups | TRUE | -2 | Int32 |
| $\stackrel{\square}{\sim}$ | 0-32 Custom Readout Max Value | 100.00 CustomReadoutUnit | All set-ups | TRUE | -2 | Int32 |
| $\stackrel{\text { ®- }}{ }$ | 0-37 Display Text 1 | $0 \mathrm{~N} / \mathrm{A}$ | 1 set-up | TRUE | 0 | VisStr[25] |
| 尔 | $0-38$ - Display Text 2 | 0 N/A | 1 set-up | TRUE | 0 | VisStu[25] |
| त | 0-39 Display Text 3 | 0 N/A | 1 set-up | TRUE | 0 | VisStr[25] |
| $\bigcirc$ | 0-4* LCP Keypad |  |  |  |  |  |
| $\stackrel{\sim}{0}$ | 0-40 [Hand on] Key on LCP | [1] Enabled | All set-ups | TRUE | - | Uint8 |
| O | 0-41 [Off Key on LCP | [1] Enabled | All set-ups | TRUE | . | Uint8 |
| $\stackrel{\sim}{\sim}$ | 0-42 [Auto on] Key on LCP | [1] Enabled | All set-ups | TRUE | - | Uint8 |
| \% | [0-43 _ [Reset] Key on LCP | [1] Enabled | All set-ups | TRUE | - | Uint8 |
| 3 | 0-44 [Off/Reset] Key on LCP | [1] Enabled | All set-ups | TRUE | - | Uint8 |
| 믗 | [0-45 [Drive Bypass] Key on LCP | [1] Enabled | All set-ups | TRUE | - | Uint8 |
|  | 0-5* Copy/Save |  |  |  |  |  |
|  | 0-50 LCP Copy | [0] Nocopy | All set-ups | FALSE | - | Uint8 |
|  | 0-51 Set-up Copy | [0] No copy | All set-ups | FALSE | - | Uint8 |


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0-6* Password |  |  |  |  |  |
| 0-60 Main Menu Password | 100 N/A | 1 set-up | TRUE | 0 | Uint16 |
| 0-61_Access to Main Menu w/o Password | [0].Full access | 1. set-up | TRUE | - | Uint8 |
| 0-65 Personal Menu Password | 200 N/A | 1 set-up | TRUE | 0 | Uint16 |
| 0-66 Access to Personal.Menu w/o Password | [0] Full access | 1 set-up | TRUE | - | Uint8 |
| 0-7* Clock Settings |  |  |  |  |  |
| 0.70 Date and Time | ExpressionLimit | All set-ups | TRUE | 0 | Timeoflay] |
| 0.71 Date Format | [0] YYYY-MM-DD | 1 set-up | TRUE | - | Uint8 |
| 0 0-72 Time Format | [0] 24 h | 1. set-up | TRUE | $-$ | Uint8 |
| 0-74 OST/Summertime | [0] OFF | 1 set-up | TRUE | - | Uint8 |
| $0-76$ - 0 ST/Summertime,start | Expressionlimit. | 1.set-up | TRUE | 0 | Timeofinay |
| 0-77 DST/Summertime End | ExpressionLimit | 1 set-up | TRUE | 0 | TimeofDay |
| $0-79 \quad$ Clock Fault | null | 1 set-up | TRUE | , | Uint8 |
| 0-81 Working Days | null | 1 set-up | TRUE | - | Uint8 |
| 0-82 _ Additional Working Days | ExpressionLimit | 1 set-up | TRUE | 0 | Timeofinay |
| 0-83 Additional Non-Working Days | ExpressionLimit | 1 set-up | TRUE | 0 | Timeoflay |
| $0-89$ Date and Time Readout | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | VisStr[25]] |



| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conver- <br> sion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1-8* Stop Adjustments |  |  |  |  |  |
| 1-80 Function at Stop | [0]Coast | All set-ups | TRUE |  | Uint 8 |
| 1-81 M Min Speed for Function at Stop [RPM] | ExpressionLimit | All set-ups | TRUE | 67 | Uint16 |
| $1-82$ Min Speed for function at Stop [ $[\mathrm{Zz}$ ] | ExpressionLimit | All set-ups | TRUE | -1 | Uint16 |
| 1.86 Trip_Speed Low [RPM] | ORPM | All set-ups. | TRUE | 67 | Uint16 |
| 1-87 Trip Speed Low [ Hz ] | 0 Hz | All set-ups | TRUE | -1 | Uint16 |
| 1-9* Motor Temperature |  |  |  |  |  |
| 1-90 Motor Thermal Protection | [4] ETR trip 1 | All set-ups | TRUE | - | UintB |
| 1-91 Motor External Fan | -0]No | All set-ups | TRUE | $\underline{T}$ | Uint16 |
| 1-93 Thermistor Source | [0] None | All set-ups | TRUE | - | Uint8 |


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 2-0* DC Brake |  |  |  |  |  |
| 2-00 DC Hold/Preheat Current | 50\% | All set-ups | TRUE | 0 | Uint8 |
| 2-01 DC, Brake Current | 50\% | All set-ups | TRUE | 0 | Uint16 |
| 2-02 DC Braking Time | 10.0 s | All set-ups | TRUE | -1 | Uint16 |
| 2-03 DC Brake Cutin Speed [RPM] | ExpressionLimit | All set-ups | TRUE | 67 | Uint16 |
| $2-04$ DC Brake Cut-in Speed [ Hz ] | ExpressionLimit | All set-ups | TRUE | -1 | Uint16 |
| 2-1* Brake Energy Funct. |  |  |  |  |  |
| 2-10 Brake Function | [0] Off | All set-ups | TRUE | - | Uint8 |
| 2-11 Brake Resistor (ohm) | ExpressionLimit | All set-ups | TRUE | 0 | Uint16 |
| 2-12 Brake Power Limit (kW) | ExpressionLimit | All set-ups | TRUE | 0 | Uint32 |
| 2-13 - Brake Power Monitoring | [0] Off | All set-ups | TRUE | - | Uint8 |
| 2-15 Brake Check | [0] Off | All set-ups | TRUE | - | Uint8 |
| 2-16 AC Brake Max. Current | 100.0\% | All set-ups | TRUE | $-1$ | Uint32 |
| 2-17 Over-voltage Control | [2] Enabled | All set-ups | TRUE | - | Uint8 |

### 8.3.5 Reference / Ramps 3-**

| Par. No. \# Parameter description | Defautt value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 13-0* Reference Limits |  |  |  |  |  |
| 3-02 Minimum Reference | ExpressionLimit | All set-ups | TRUE | -3 | Int32 |
| [3-03 Maximum, Reference | ExpressionLimit. | All set-ups | TRUE | -3. | 1 10t32 |
| 3-04 Reference Function | [01. Sum | All set-ups | TRUE | - | Uint8 |
| 3-1* References |  |  |  |  |  |
| 3-10 Preset Reference | 0.00\% | All set-ups | TRUE | -2 | Int16 |
| [3-11 . 0 g speed [ Hz 2 ] | ExpressionLimit | All set-ups | TRUE | -1 | Uint 16 |
| 3-13 Reference Site | [0] Linked to Hand / Auto | All set-ups | TRUE | - | Uint8 |
| 3-14 Preset Relative Reference | 0.00\% | All set-ups | TRUE | -2, | Int32 |
| 3-15 Reference 1 Source | [1] Analog input 53 | All set-ups | TRUE | - | Uint8 |
| 3-16 Reference 2. Source | -(0) No function | All set-ups | TRUE | $\underline{-}$ | Uint-8 |
| 3-17 Reference 3 Source | [0] No function | All set-ups | TRUE | - | Uint8 |
| [3-19 Joq Speed [RPM] | ExpressionLimit | All set-ups | TRUE | 67 | Uint16 |
| 3-4* Ramp 1 |  |  |  |  |  |
| 13-41__Ramp 1 Ramp-up Iime | ExpressionLimit | All,set-ups | IRUE | -2. | Uint 32 |
| 3-42 Ramp 1 Ramp-down Time | ExpressionLimit | All set-ups | TRUE | -2 | Uint32 |
|  |  |  |  |  |  |
| 3-51 Ramp 2 Ramp-up Time | ExpressionLimit | All set-up5 | TRUE | -2 | Uint32 |
| 3.52.-Ramp 2 Rampodown Time | ExpressionLimit | All Set-ups | TRUE | -2 | Uint 32 |
| 3-8* Other Ramps |  |  |  |  |  |
| [3-80 Jog Ramp Time | ExpressionLimit | All set-ups | TRUE | -2 | Uint32 |
| 3-81 Quick Stop Ramp Time | ExpressionLimit | 2 set-ups | TRUE | -2 | Uint 32 |
| 3-84 _-_Initial Ramp Time | 0.005 | All set-upS | TRUE | -2 | Uint16 |
| 3-85 Check Valve Ramp Time | 0.00 s | All set-ups | TRUE | -2 | Uint16 |
| [3-86 . Check valve Ramp End Speed [8PM] | ExpressionLimit | All set-ups | TRUE | 67 | Uint16 |
| 3-87 Check Valve Ramp End Speed [ HZ ] | ExpressionLimit | All set-ups | TRUE | -1 | Uint16 |
| 1-88 Final Ramp Time | 0.00 s | All set-ups | TRUE | -2 | Uint16 |
| 3-9* Digital Pot. meter |  |  |  |  |  |
| 3-90 Step Size. | 0.10\% | All set-ups | TRUE | -2 | Uint16 |
| 3-91 Ramp Time | 1.005 | All set-ups | TRUE | -2 | Uint32 |
| 3-92 _ Power Restore | [0] Off | All set-ups | TRUE | - | Uint8 |
| 3-93 Maximum Limit | 100\% | All set-ups | TRUE | 0 | Int16 |
| 3-94 MinimumLimit | $0 \%$ | All Set-ups | TRUE | 0 | Int16 |
| 3-95 Ramp Delay | ExpressionLimit | All set-ups | TRUE | -3 | TimD |



### 8.3.7 Digital In/Out 5-**

| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 15-0* Digital I/O mode |  |  |  |  |  |
| 5-00 Digital I/O Mode | [0] PNP - Active at 24 V | All set-ups | FALSE | - | Uint8 |
| [5-01 Terminal 27 Mode | [0] Input | All set-ups | TRUE | - | Uint8 |
| 5-02 Terminal 29 Mode | [0] Input | All set-ups | TRUE | $\cdot$ | Uint8 |
| 5-1* Digital Inputs |  |  |  |  |  |
| 5-10 Terminal 18 Digital Input | [8] Start | All set-ups | TRUE | - | Uint8 |
| 5-11 Terminal 19 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-12 Terminal 27 Digital Input | null | All set-ups | TRUE | $\cdot$ | Uint8 |
| 5-13 Terminal 29 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-14 Terminal 32 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-15 Terminal 33 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-16 Terminal X30/2 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| [5-17 Terminal $\times 30 / 3$ Digital In put | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-18 Terminal X30/4 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-3* Digital Outputs |  |  |  |  |  |
| 5-30 Terminal 27 Digital Output | [0] No operation | All set-ups. | TRUE | - | Uint8 |
| 5-31 Terminal 29 digital Output | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-32 Term $\times 30 / 6$ Digi Qut (MCB 101) | [0] No operation | All set-ups | TRUE | - | Uint8 |
| $5-33$ - Term $\times 30 / 7$ Digi Out (MCB 101) | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-4* Relays |  |  |  |  |  |
| [5-40_Function Relay | null | All set-ups | TRUE | - | Uint8 |
| 5-41 On Delay, Relay | 0.01 s | All set-ups | TRUE | -2 | Uint16 |
| 5-42 Off Delay, Relay | 0.01 s | All set-ups | TRUE | -2 | Uint16 |
| 5-5* Pulse Input |  |  |  |  |  |
| 5-50 Term. 29 Low Frequency | 100 Hz | All set-ups | TRUE | 0 | Uint32 |
| 5-51 - Term. 29 High Frequency | 100 Hz | All set-ups | TRUE | 0 | Uint32 |
| 5-52 Term. 29 Low Ref./Feedb. Value | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 5-53 Term. 29 High Ref./Feedb. Value | $100.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 5-54 Pulse Filter Time Constant \#29 | 100 ms | All set-ups | FALSE | -3 | Uint16 |
| 5-55 Term. 33 Low Frequency | 100 Hz | All set-ups | TRUE | 0 | Uint32 |
| [5-56 - Term. 33 High Frequency | 100 Hz | All set-ups | TRUE | 0 | Uint32 |
| 5-57 Term. 33 Low Ref./Feedb. Value | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| [5-58 Term. 33 High Ref./Eeedb. Value | $100.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 5-59 Pulse Filter Time Constant \#33 | 100 ms | All set-ups | FALSE | -3 | Uint16 |
| [5-6* Pulse Output |  |  |  |  |  |
| 5-60 Terminal 27 Pulse Output Variable | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-62 Pulse Output Max Freg \$27 | 5000 Hz | All Set-ups | TRUE | 0 | Uint32 |
| 5-63 Terminal 29 Pulse Output Variable | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 5-65__ Pulse Output Max. Freq \#29 | 5000 Hz | All set-ups | TRUE | 0 | Uint32 |
| 5-66 Terminal X30/6 Pulse Output Variable | [0] No operation | All set-ups | TRUE | - | Uint8 |
| [5-68 Pulse Output Max Freq \# $\times 30 / 6$ | 5000 Hz | All set-ups | TRUE | 0 | Uint32 |
| 5-9* Bus Controlled |  |  |  |  |  |
| [5-90 Digital \& Relay Bus Control | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 5-93 Pulse Out \#27 Bus Control | $0.00 \%$ | All set-ups | TRUE | -2 | N2 |
| [5-94 Pulse Out \#27 Timeout. Presel | 0.00\% | 1. set-up | TRUE | -2 | Uint16 |
| 5-95 Pulse Out \#29 Bus Control | $0.00 \%$ | All set-ups | TRUE | -2 | N2 |
| 5-96 Pulse Out \#29 timeout Preset | 0.00\% | 1. set-up | TRUE | -2 | Uint16 |
| 5-97 Pulse Out \# $\times 30 / 6$ Bus Control | 0.00\% | All set-ups | TRUE | -2 | N2 |
| 5-98 Pulse_Out \#X30/6 Timeout Preset. | 0.00\% | 1 set-up | TRUE | 2 | Uint16 |



### 8.3.9 Comm. and Options 8 -**

| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 8-0* General Settings |  |  |  |  |  |
| 8-01 Control Site | null | All set-ups | TRUE | - | Uint8 |
| 8-02 Control Source | null | All set-ups | TRUE | - | Uint8 |
| 8-03 Control Timeout Time | ExpressionLimit | 1 set-up | TRUE | -1 | Uint32 |
| 8-04 Control Timeout Function | [0] Off | 1 set-up | TRUE |  | Uint8 |
| 8-05 End-of-Timeout Function | [1] Resume set-up | 1 set-up | TRUE | - | Uint8 |
| $8-06$ Reset Control Timeout | [0] Do not reset. | All set-ups | TRUE | - | Uint8 |
| 8-07 Diagnosis Trigger | [0] Disable | 2 set-ups | TRUE | - | Uint8 |
| 18-1* Contral Settings |  |  |  |  |  |
| 8-10 Control Profile | [0] FC profile | All set-ups | TRUE | - | Uint8 |
| 8-13 Configurable Status Word STW | [1] Profile Default | All set-ups | TRUE | - | Uint8 |
| 8-14 Configurable Control Word CTW | [1] Profile default | All set-ups | TRUE | - | Uint8 |
| 8-3* FC Port Settings |  |  |  |  |  |
| 8-30 Protocol | null | 1 set-up | TRUE |  | Uint8 |
| 8-31 Address | ExpressionLimit | 1. Set-up | TRUE | 0 | Uint8 |
| 8-32 Baud Rate | null | 1 set-up | TRUE | - | Uint8 |
| 8-33 Parity/Stop Bits | null | 1 set-up | TRUE |  | Uint8 |
| 8-35 Minimum Response Delay | ExpressionLimit | 1 set-up | TRUE | -3 | Uint16 |
| 8-36 Max Response Delay | ExpressionLimit | 1. set-up | TRUE | -3 | Uint16 |
| 8-37 Maximum Inter-Char Delay | ExpressionLimit | 1 set-up | TRUE | -5 | Uint16 |
| 8-4* FC MC protocol set |  |  |  |  |  |
| 8-40 Telegram selection | [1] Standard telegram 1 | 2 set-ups | TRUE | - | Uint8 |
| 8-5* Digital/Bus |  |  |  |  |  |
| 8-50 Coasting Select | [3] Logic OR | All set-ups | TRUE | - | Uint8 |
| 8-52 DC Brake Select | 3] Logic OR | All set-ups | TRUE | - | Uint8 |
| 8-53 Start Select | [3] Logic OR | All set-ups | TRUE | - | Uint8 |
| 8-54 Reverse Select | null | All set-ups | TRUE | . | Uint8 |
| 8-55 Set-up Select | [3] Logic OR | All set-ups | TRUE | - | Uint8 |
| 8-56 Preset Reference Select | [3] Logic OR | All set-ups | TRUE | - | Uint8 |
| 8-7* BACnet |  |  |  |  |  |
| 8-70 BACnet Device Instance | $1 \mathrm{~N} / \mathrm{A}$ | 1 set-up | TRUE | 0 | Uint32 |
| 8-72 MS/TP Max Masters | 127 N/A | 1 set-up | TRUE | 0 | Uint8 |
| 8-73 MS/TP Max Info Frames | 1 N/A | 1 set-up | TRUE | 0 | Uint16 |
| 8-74 "Startup I am" | [0] Send at power-up | 1 set-up | TRUE | - | Uint8 |
| 8-75 Initialization Password | ExpressionLimit | 1 set-up | TRUE | 0 | VisStr[20] |
| 8-8* FC Port Diagnostics |  |  |  |  |  |
| [8-80 Bus Message Count | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 8-81 8us Error Count | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 8-82 Slave Message Rcvd | 0 N/A | All set-ups | TRUE | 0 | Uint32 |
| 8-83 Slave Error Count | ON/A | All set-ups | TRUE | 0 | Uint32 |
| 8-9* Bus Jog |  |  |  |  |  |
| 8-90 Bus Jog 1 Speed | 100 RPM | All set-ups | TRUE | 67 | Uint15 |
| 8-91 Bus Jog 2 Speed | 200 RPM | All set-ups | TRUE | 67 | Uint16 |
| 8-94 Bus Feedback 1 | $0 \mathrm{~N} / \mathrm{A}$ | 1 set-up | TRUE | 0 | N2 |
| 8-95 Bus Feedback 2 | $0 \mathrm{~N} / \mathrm{A}$ | 1 set-up | TRUE | 0 | N2 |
| 8-96 Bus Feedback 3 | $0 \mathrm{~N} / \mathrm{A}$ | 1 set-up | TRUE | 0 | N2 |


| Par. No. \# | Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 9-00 | Setpoint | 0N/A | All set-ups | TRUE | 0 | Uint16 |
| 9-07 | Actual Value | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 9-15 | PCD Write Configuration | ExpressionLimit | 2 set-ups | TRUE | - | Uint16 |
| 9.16 | PCD Read Configuration | ExpressionLimit | 2 set-ups | TRUE | - | Uint16 |
| 9-18 | Node Address | $126 \mathrm{~N} / \mathrm{A}$ | 1 set-up | TRUE | 0 | Uint8 |
| 9-22 | Telegram Selection | [108] PPO 8 | 1 set-up | TRUE | - | Uint8 |
| 9-23 | Parameters for Signals. | 0 | All set-ups | TRUE | - | Uint16 |
| 9-27 | Parameter Edit | [1] Enabled | 2 set-ups | FALSE | - | Uint16 |
| 9-28 | Process Control | 1] Enable cyclic master | 2 set-ups | FALSE | - | Uint8 |
| 9-44 | Fault Message Counter | 0 N/A | All set-ups | TRUE | 0 | Uint16 |
| 9-45 | Fault Code | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint16 |
| 9-47 | Fault Number | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint16 |
| 9-52 | Fault Situation Counter | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint16 |
| $9-53$ | Profibus Warning Word | 0 N/A | All set-ups | TRUE | 0 | V2 |
| 9-63 | Actual Baud Rate | [255] No baud rate found | All set-ups | TRUE | $\cdots$ | Uint8 |
| 9-64 | Device Identification | 0 N/A | All set-ups | TRUE | 0 | Uint16 |
| 9-65 | Profile Number | 0 N/A | All set-ups | TRUE | 0 | OctStr[2] |
| 9-67 | Control Word 1 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | V2 |
| 9-68 | Status Word 1 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | V2 |
| 9-71 | Profibus Save Data Values | [0] Off | All set-ups | TRUE | - | Uint8 |
| 9-72 | ProfibusDriveReset | [0] No action | 1 set-up | FALSE | $\square$ | Uint8 |
| $9-80$ | Defined Parameters (1) | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 9-81 | Defined Parameters (2) | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 9-82 | Defined Parameters (3) | 0 N/A | All set-ups | FALSE | 0 | Uint16 |
| 9-83 | Defined Parameters (4) | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| $9-84$ | Defined Parameters (5) | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 9-90 | Changed Parameters (1) | 0 N/A | All set-ups, | FALSE | 0 | Uint16 |
| 9-91 | Changed Parameters (2) | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 9-92 | Changed Parameters (3) | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 9-93 | Changed Parameters (4) | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 9-94 | Changed parameters (5) | ON/A | All set-ups | FALSE | 0 | Uint16 |

# 8.3.11 CAN Fieldbus 10-** 

| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conver- <br> sion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 10-0* Common Settings |  |  |  |  |  |
| 10-00 CAN Protocol | null | 2 set-ups | FALSE | - | Uint8 |
| 10-01 Baud Rate Select | null | 2 set-ups | TRUE | - | Uint8. |
| 10-02 MAC ID | ExpressionLimit | 2 set-ups | TRUE | 0 | Uint8 |
| 10-05 Readout Transmit Error Counter | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint 8 |
| 10-06 Readout Receive Error Counter | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint8 |
| 10-07 Readout Bus Off Counter | ON/A | All set-ups | TRUE | 0 | Uint8 |
| 10-1* DeviceNet |  |  |  |  |  |
| 10-10 Process Data Type Selection | null | All set-ups | TRUE | - | Uint8 |
| 10-11 Process Data Config Write | ExpressionLimit | 2 set-ups | TRUE | - | Uint16 |
| 10-12 Process Data Config Read | ExpressionLimit | 2, set-ups | TRUE | - | Uint16 |
| 10-13 Warning Parameter | 0 N/A | All set-ups | TRUE | 0 | Uint16 |
| 10-14 Net Reference | [0]Off | 2 set-ups | TRUE | - | Uint8 |
| 10-15 Net Control | [0] Off | 2 set-ups | TRUE | - | Uint8 |
| 10-2* $\cos$ Filters |  |  |  |  |  |
| 10-20 COS Filter 1 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 10-21 COS Filter 2 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint15 |
| 10-22 Cos Filter 3 | 0 N/A | All set-ups | FALSE | 0 | Uint16 |
| 10-23 COS Filter 4 | 0 N/A | All set-ups | FALSE | 0 | Uint 16 |
| 10-3* Parameter Access |  |  |  |  |  |
| 10-30 Array Index | 0N/A | 2 set-ups | TRUE | 0 | Uint8 |
| 10-31 Store Data Values | [0] Off | All set-ups | TRUE | - | Uint8 |
| 10.32 Devicenet Revision | ExpressionLimit | All set-ups | TRUE | 0 | Uint16 |
| 10-33 Store Always | [0] Off | 1 set-up | TRUE | - | Uint8 |
| 10-34 Devicenet Product Code | $130 \mathrm{~N} / \mathrm{A}$ | 1 set-up | TRUE | 0 | Uint16 |
| 10-39 Devicenet F Parameters | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |

### 8.3.12 Smart Logic 13-**

| Par. No. \# Parameter description | Default value | 4-set-up | Change during oper- ation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 13-0* SLC Settings |  |  |  |  |  |
| 13-00 SL Controller Mode | null | 2 set-ups | TRUE | - | Uint8 |
| 13-01 Start Event | null | 2 set-ups | TRUE | - | Uint8 |
| 13-02 Stop Event | nu! | 2 set-ups | TRUE | - | Uint8 |
| 13-03. Reset SLC | [0]Do not reset SLC | All set-ups | TRUE | - | Uint8 |
| 13-1* Comparators |  |  |  |  |  |
| 13-10 Comparator Operand | null | 2 set-ups | TRUE | - | Uint8 |
| 13-11 Comparator Operator | null | 2 set-ups | TRUE | - | Uint8 |
| 13-12 Comparator value | ExpressionLimit | 2 set-ups | TRUE | -3 | Int32 |
| 13-2* Timers |  |  |  |  |  |
| 13-20 SL Controller Timer | ExpressionLimit | 1 set-up | TRUE | -3 | TimD |
| 13-4* Logic Rules |  |  |  |  |  |
| 13-40 Logic Rule Boolean 1 | null | 2 set-ups | TRUE | - | Uint8 |
| 13-41 Logic Rule Operator 1 | null | 2 set-ups | TRUE | - | Uint8 |
| 13-42 Logic Rule Boolean 2 | null | 2 set-ups | TRUE | - | Uint8 |
| 13-43 Logic Rule Operator 2 | null | 2 set-ups | TRUE | - | Uint8 |
| 13-44 Logic Rule Boolean 3 | null | 2 set-ups | TRUE | - | Uinti |
| 13-5* States |  |  |  |  |  |
| 13-51 SL Controller Event. | null | 2 set-ups | TRUE | - | Uint8 |
| 13-52 SL Controller Action | null | 2 set-ups | TRUE | - | Uint8 |

### 8.3.13 Special Functions 14-**

| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 14-0* Inverter Switching |  |  |  |  |  |
| 14-00 Swithing Pattern | null | All set-ups | TRUE | - | Uint8 |
| 14-01 Swithing Erequency | null | All set-ups | TRUE | - | Uint8 |
| 1403 Overmodulation | [1] On | All set-ups | FALSE | - | Uint8 |
| 14-04 PWM Random | [0] Off | All set-ups | TRUE | - | Uint8 |
| 14-1* Mains On/Off |  |  |  |  |  |
| 14-10_Line, Failure | [0] No function | All set-ups | FALSE | - | Uint8 |
| 14-11 _ Line Voltage at Line Fault | ExpressionLimit | All set-ups | TRUE | 0 | Uint16 |
| 14-12 Function at Mains Imbalance | [3] Derate | All set-ups | TRUE | $-$ | Uint8 |
| 14-2* Reset Functions |  |  |  |  |  |
| 14-20 Reset Mode | [10] Automatic reset $\times 10$ | All set-ups | TRUE | . | Uint8 |
| $14-21$ Automatic Restart Time | 10 s | All set-ups | TRUE | 0 | Uint16 |
| 1422 Operation Mode. | [0]Normal operation | All set-ups | TRUE | - | Uint8 |
| 14.23 Typecode Setting | null | 2 set-ups | FALSE | - | Uint8 |
| 14-25 Trin Delay at Torque Limit | 60 s | All set-ups | TRUE | 0 | Uint8 |
| 14-26 Trip Delay at Inverter Fault | ExpressionLimit | All set-ups | TRUE | 0 | Uint8 |
| 14-28 Production Settings | [0] No action | All set-ups. | TRUE | - | Uint8 |
| 14-29 Service Code | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Int32 |
| 14-3* Current Limit Ctrl. |  |  |  |  |  |
| 14-30 Current Lim Cont, Proportional Gain | 100 \% | All set-ups | FALSE | 0 | Uint16 |
| 14-31 Current Lim Contr, Integration Time | 0.020 s | All | FALSE | -3 | Uint16 |
| 14-32 Current Lim Ctrl, Filter Time | 27.0 ms | All set-ups | FALSE | -4 | Uint16 |
| 14-4* Energy Optimizing |  |  |  |  |  |
| 14-40 VT Level | 66 \% | All set-ups | FALSE | 0 | Uint8 |
| 14-41 AEOMinimum Magnetization | ExpressionLimit | All Set-ups | TRUE | 0 | Uint8 |
| 14-42 Minimum AEO Frequency | 10 Hz | All set-ups | TRUE | 0 | Uint8 |
| 14-43 Motor Cos-Phi | ExpressionLimit | All set-ups | TRUE | -2 | Uint16 |
| 14-5* Environment |  |  |  |  |  |
| $14-50$ REI 1 | [1] On | 1 set-up | FALSE | - | Uint8 |
| 14-52 Fan Control | [0] Auto | All set-ups | TRUE | - | Uint8 |
| 14.53 Fan Monitor | [1] Warning | All | TRUE | - | Uint8 |
| $14-55$ O_Otput Filter | [0] No Filter | 1 set-up | FAISE | - | Uint8 |
| 14-59 Actual Number of Inverter Units | ExpressionLimit | 1 set-up | FALSE | 0 | Uint8 |
| 14-6* Auto Derate |  |  |  |  |  |
| $14-60$ Function at Overtemperature | [1] Derate | All set-ups | TRUE | - | Uint8 |
| 14-61 Function at Inverter Overload | [1] Derate | All set-ups | TRUE | - | Uint8 |
| 14-62 Inv. Overload Derate Current | 95\% | All set-ups | TRUE | 0 | Uint16 |
| 14-8* Options |  |  |  |  |  |
| 14-80 Option Supplied by External 24VDC | [0] No | 2 set-ups | FALSE. | - | Uint8 |

8.3.14 Adj. Freq. Drive Information 15-**

| Par, No. \# Parameter description | Default value | 4-set-up | Change during operation | Conver- <br> sion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 15-0* Operating Data |  |  |  |  |  |
| 15-00 Operating Hours | 0 h | All set-ups | FALSE | 74 | Uint32 |
| 15-01 Running Hours | 0 h | All set-ups | FALSE | 74 | Uint32 |
| 15-02 kWh Counter | 0 kWh | All set-ups | FALSE | 75 | Uint32 |
| 15-03 Power-ups | 0N/A | All,set-ups | FALSE | 0 | Uint32 |
| 15-04 Over Temps | 0 N/A | All set-ups | FALSE | 0 | Uint16 |
| 15-05 Over Volts | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 15-06 Reset kWh Counter | [0) Do not reset | All set-ups | TRUE | - | Uint8 |
| 15-07 Reset Running Hours Counter | [0] Do, not reset | All set-ups | TRUE | - | Uint8 |
| 15-08 Number of Starts | $0 \mathrm{~N} / \mathrm{A}$ | Ali set-ups | FALSE | 0 | Uint32 |
| 15-1* Data Log Settings |  |  |  |  |  |
| 15-10 Logging Source | 0 | 2 set-ups | TRUE | - | Uint16 |
| 15-11 _ Logging Interval | ExpressionLimit | 2 set-ups. | TRUE | - 3 | TimD |
| 15-12 Trigger Event | [0] FALSE | 1 set-up | TRUE | - | Uint8 |
| 15-13 Logging Mode | [0] Log always | 2 set-up | TRUE | - | Uint 8 |
| 15-14 Samples Before Trigger | 50 N/A | 2 set-ups. | TRUE | 0 | Uint8 |
| 15-2* Historic Log |  |  |  |  |  |
| 15-20 Historic Log: Event | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint8 |
| 15-21 Historic Log Value | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint32 |
| 15-22 Historic Log: Time | 0 ms | All set-ups | FALSE | -3 | Uint32 |
| 15-23 Historic Log: Date and Time | ExpressionLimit | All set-ups | FALSE | 0 | Timeofbay |
| 15-3* Alarm Log |  |  |  |  |  |
| 15-30 Alarm Log: Error Code | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | faLSE | 0 | Uint 16 |
| 15-31 Alarm Log: Value | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Int16 |
| [15-32 Alarm Log: Time | 0 S | All set-ups | FALSE | 0 | Uint32 |
| 15-33 Alarm Log: Date and Time | ExpressionLimit | All set-ups | FALSE | 0 | Timeofoay |
| 15-34 Alarm Log: Setpoint | 0.000 Processctriunit | All set-ups | FALSE | - 3 | Int32 |
| 15-35 Alarm Log: Feedback | 0.000 Processctrilunit | All set-ups | FALSE | -3 | Int32 |
| 15-36 Alarm Logi Current Demand | 0\% | All set-ups | FALSE | 0 | Uint8 |
| 15-37 Alarm Log: Process Ctrl Unit | 101 | All set-ups | FALSE | - | Uint8 |
| 15-4* Drive Identification |  |  |  |  |  |
| 15-40 FC Type | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Visstr[6] |
| 15-41 Power Section. | 0.N/A | All. Set-ups | FALSE | 0 | VisStr [20]] |
| 15-42 Voltage | 0 N/A | All set-ups | FALSE | 0 | VisSti [20] |
| 15-43 - Sottware version | 0 N/A | All set-ups | FALSE | 0 | Visstr $[5]$ |
| 15-44 $\quad$ Ordered Typecode String | 0 N/A | All set-ups | FALSE | 0 | VisStr[40] |
| 15-45 Actual Typecode String | 0 N/A | Aill set-ups | FÁLSE | 0 | VisStr [40]] |
| 15-46 Adj Freq Dr Ordering No. | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | VisStr [ $[8]$ |
| 15-47 Power Card Ordering No. | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALISE | 0 | VisStir $[8]$ |
| 15-48 LCP ID Num. | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Vis5tr [20] |
| 15-49 - SW ID Control Card | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Visstr [20] $]$ |
| 15-50 SW LD Power Card | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | VisStr 20$]$ |
| [15-51 Adj Frea Dr Serial No. | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Visstr [10] |
| 15-53 Power Card Serial Number | ON/A | All set-ups | FALSE | 0 | VisStr[19] |


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 15-6* Option Ident |  |  |  |  |  |
| 15-60 Option Mounted | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | VisStr [ 30$]$ |
| 15-61 Option SW Version | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Visstr [20]] |
| 15-62 Option Ordering No | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | VisStr [8] |
| 15-63 Option Serial No | 0 N/A | All set-ups | FALSE | 0 | Visstr [18]] |
| 15-70 Option in Slot A | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups. | FALSE | 0 | Vis5tr[30] |
| 15-71 - Slot A Option, 5 W Version. | 0 N/A | All | FALSE | 0 | VisSti [20]] |
| 15-72_Option in Slot B | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | VisStr [30] |
| 15.73 Slat B Option SW Version | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | VisStir 20$]$ |
| 15-74 Option in Slot CO | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Visstr [30] |
| 15-75 Slot Co Option SW Version | $0 \mathrm{~N} / \mathrm{A}$ | All set-up | FALSE | 0 | Visstri20] |
| 15-76 Option in Slot C1 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | VisStr[30] |
| 15-77 Slat C1 Option SW Version | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | VisStr 2007 |
| 15-9* Parameter Info |  |  |  |  |  |
| 15-92 Defined Parameters | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 15-93 Modified Parameters | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |
| 15-98 Drive Identification | 0 N/A | All set-ups | FALSE | 0 | Vissti[40]] |
| 15-99 Parameter Metadata | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint16 |

### 8.3.15 Data Readouts 16-**

| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 16-0* General Status |  |  |  |  |  |
| 16-00 Control Word | 0 N/A | All set-ups | TRUE | 0 | V2 |
| 16-01 Reference [Unit] | 0.000 ReferenceFeedbackUnit | All set-ups | TRUE | -3 | Int32 |
| 16-02 Reference \% | 0.0\% | All set-ups | TRUE | -1 | Int16 |
| 16-03 Status Word | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | V2 |
| 16-05 Main Actual Value [\%] | 0.00\% | All set-ups | TRUE | -2 | N2 |
| 16-09 Custom Readout | 0.00 CustomReadoutUnit | All set-ups | TRUE | -2 | Int32 |
| 16-1* Motor Status |  |  |  |  |  |
| [16-10 Power [kW] | 0.00 kW | All set-ups | TRUE | 1 | Int32 |
| 16-11 Power [hp] | 0.00 hp | All set-ups | TRUE | -2 | Int32 |
| 16-12_Motor voltage | 0.0 V | All set-ups | TRUE | -1 | Uint16 |
| 16-13 Frequency | 0.0 Hz | All set-ups | TRUE | -1 | Uint16 |
| 16-14 Motor Current | 0.00 A | All set-ups | TRUE | -2 | Int32 |
| 16-15 Frequency [\%] | $0.00 \%$ | All set-ups | TRUE | -2 | N2 |
| 16-16 Torgue [ Nm ] | 0.0 Nm | All set-ups | TRUE | -1 | Int32 |
| 16-17 Speed [RPM] | 0 RPM | All set-ups | TRUE | 67 | Int32 |
| 16-18 Motor Thermal | 0.\% | All set-ups | TRUE | 0 | Uint8 |
| 16-22 Torque [\%] | $0 \%$ | All set-ups | TRUE | 0 | Int16 |
| 16-3* Drive Status |  |  |  |  |  |
| 16-30 DC Link Voltage | 0 V | All set-ups | TRUE | 0 | Uint16 |
| 16-32 Brake Energy/s | 0.000 kW | All set-ups | TRUE | 0 | Uint32 |
| 16-33 Brake Energy / 2 min | 0.000 kW | All set-ups | TRUE | 0 | Uint32 |
| 16-34 Heatsink Temp. | $0^{\circ} \mathrm{C}$ | All set-ups | TRUE | 100 | Uint8 |
| 16-35 Inverter Thermal | 0 \% | All set-ups | TRUE | 0 | Uint8 |
| 16-36-Inv. Nom. Current | ExpressionLimit | All set-ups | TRUE | -2 | Uint32 |
| 16-37 Inv. Max. Current | ExpressionLimit | All set-ups | TRUE | -2 | Uint32 |
| 16-38 - SL Controller State | ON/A | All set-ups | TRUE | 0 | Uint8 |
| 16-39 Control Card Temp. | $0^{\circ} \mathrm{C}$ | All set-ups | TRUE | 100 | Uint8 |
| 16-40 Logging Buffer Full | [0] No | All set-ups | TRUE | - | Uint8 |
| 16-5* Ref. \& Feedb. |  |  |  |  |  |
| 16-50 External Reference | $0.0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -1. | Int16 |
| 16-52 Feedback [Unit] | 0.000 ProcessCtr\|Unit | All set-ups | TRUE | -3 | Int32 |
| 16-53 Digi Pot Reference | 0:00 N/A | All set-ups | TRUE | -2 | Int16 |
| 16-54 Feedback 1 [Unit] | 0.000 ProcessCtrlunit | All set-ups | TRUE | -3 | Int32 |
| 16-55 Feedback 2. Unit] | 0.000 ProcessCtrilunit | All set-ups | TRUE | -3 | Int32 |
| 16-56 . Feedback 3 [Unit] | 0.000 ProcessCtrlunit | All set-ups | TRUE | -3 | Int32 |
| 16-58 PID Output [\%] | 0.0\% | All set-ups | TRUE | $-1$ | Int16 |
| 16-59 Adjusted Setpoint | 0.000 ProcessCtrlunit | All set-ups | TRUE | -3 | Int32 |


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 16-6* Inputs 8, Outputs |  |  |  |  |  |
| 16-60 Digital Input | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint16 |
| 16-61. Terminal 53 Switch Setting | [01.Current | All set-ups | TRUE |  | Uint8. |
| 16-62 Analog Input 53 | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 16-63 - Terminal 54 Switco Setting | [0] Current. | All, sel-ups | TRUE |  | Uint8 |
| 16-64 Analog Input 54 | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 16.65 Analog Output 42.[mA] | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int16 |
| 16-66 Digital Output [bin] | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Int16 |
| [16-67 Pulse input\#29 [Hz] | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Int32 |
| 16-68 Pulse Input \#33 [Hz] | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Int32 |
| 16-69 Pulse Output \#27 [Hz] | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Int32 |
| 16-70 Pulse Output \#29 [Hz] | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Int 32 |
| -16-71 Relay Output [bin] | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint16 |
| 16-72 Counter A | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Int32 |
| 16-73 Counter B | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Inti2 |
| 16-75 Analog In X $30 / 11$ | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 16-76 Analog In X $\times$ /0/12 | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32. |
| 16.77 Analog Out $\times 30 / 8[\mathrm{~mA}]$ | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int16 |
| 16-8* Fleldbus \& FC Port |  |  |  |  |  |
| 16-80 Fieldbus CTW 1 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | V2 |
| 16-82 Fieldbus REF 1 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | N2 |
| 16-84 Comm. Option Status | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | V2 |
| 16-85-FCPortCTW 1 | O.N/A | All set-ups | TRUE | 0 | $\sqrt{2}$ |
| 16-86 FC Port REF 1 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | N2 |
| 16-9* Diagnosis Readouts |  |  |  |  |  |
| 16.90 Alarm Word | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 16-91 Alarm word 2 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0. | Uint 32 |
| 16-92 Warning Word | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 16-93 Warning word 2 | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 16-94 Ext. Status Word | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 16-95 Ext. Status Word. 2. | QN/A | All set-ups | TRUE | 0 | Uint32 |
| 16.96 Maintenance Word | 0 N/A | All set-ups | TRUE | 0 | Uint32 |

### 8.3.16 Data Readouts 2 18-**

| Par. No. \# Parameter description | Default value | 4 set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 18-0* Maintenance Log |  |  |  |  |  |
| 18-00 Maintenance Log: Item | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint8 |
| 18-01 Maintenance Log: Action | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | 0 | Uint8. |
| 18-02 Maintenance Log: Time | 0 s | All set-ups | FALSE | 0 | Uint32 |
| 18-03 Maintenance Log: Date and Time | ExpressionLimit | All set-ups | FALSE | 0 | Timeoforay |
| 18-3* Inputs \& Outputs |  |  |  |  |  |
| 18-30 Analog Input X42/1 | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | -3 | Int32 |
| 18-31 Analog Input X42/3 | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | -3 | Int32 |
| 18-32 Analog Input X $42 / 5$ | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | -3 | Int32 |
| 18-33 Analog Out X42/7 [V] | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | -3 | Int16 |
| 18-34 Analog Out X42/9[V] | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | -3 | Int16 |
| 18-35 Analog Out X42/11 [V] | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | FALSE | -3 | Int16 |

### 8.3.17 Adj. Freq. Drive Closed-loop 20-**

| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 20-0* Feedback |  |  |  |  |  |
| 20-00 Feedback 1 Source | [2] Analog input 54 | All set-ups | TRUE | - | Uint8 |
| 20-01 Feedback 1 Conversion | [0]Linear | All Set-ups | FALSE | $-$ | Uint8 |
| 20-02 Feedback 1 Source Unit | null | All set-ups | TRUE | - | Uint8 |
| 20-03 Feedback 2 Source | [0] No function | All Set-ups | TRUE | - | Uint8. |
| 20-04 Feedback 2 Conversion | [0] Linear | All set-ups | FALSE | $\square$ | Uint8 |
| 20-05 Feedback 2 Source Unit | - nüll | All sel-ups | TRUE | $\cdots$ | Uint8 |
| 20-06 Feedback 3 Source | [0] No function | All set-ups | TRUE | - | Uint8 |
| 20-07 Feedback 3 Conversion | [0] Linear | All Set-iups | FALSE | - | Uint8 |
| 20-08 Feedback 3 Source Unit | null | All set-ups | TRUE | - | Uint8 |
| 20-12 Reference/Feedback Unit | null | All set-ups | TRUE | - | Uint 8 |
| 20-2* Feedback/Setpoint |  |  |  |  |  |
| 20-20 Feedback Function | [4] Maximum | All Set-vos | TRUE |  | Uint8 |
| 20-21 Setpoint 1 | 0.000 ProcessCtriunit | All set-ups | TRUE | -3 | Int32 |
| 20-22 Setpoint.2 | 0.000 ProcessCtriunit | All set-ups | TRUE | -3 | Int32 |
| 20-23 Setpoint 3 | 0.000 ProcessCtriunit | All set-ups | TRUE | -3 | Int32 |
| 20-7* PID Auto-tuning |  |  |  |  |  |
| 20-70 Closed-loop Type | [0] Auto | 2 set-ups | TRUE | - | Uint8 |
| 20-71-PID Performance | [0] Normal | 2 set-ups | TRUE | $\cdots$ | Uint8 |
| 20-72 PID Output Change | $0.10 \mathrm{~N} / \mathrm{A}$ | 2 set-ups | TRUE | -2 | Uint16 |
| 20-73 Minimum Feedbäck Level | -999999.000 Processctrilunit | 2. set-ups | TRUE | -3 | Int32 |
| 20.74 Maximum Feedback Level | 999999.000 ProcessCtriUnit | 2 set-ups | TRUE | -3 | Int32 |
| 20-79 PID Auto-tuning | [0]Disabled | All 5 et-ups | TRUE |  | Uint8 |
| 20-8* PID Basic Settings |  |  |  |  |  |
| 20-81 . FID Normal/Inverse Control | [0] Normal | All set-ups | TRUE | $-$ | Uint8. |
| $20-82$ PID Start Speed [RPM] | ExpressionLimit | All set-ups | TRUE | 67 | Uint16 |
| $20-83$ PID Start Speed [ $[\mathrm{Hz}]$ | ExpressionLimit | All.set-ups | TRUE | -1 | Vint16 |
| 20-84 On Reference Bandwidth | 5\% | All set-ups | TRUE | 0 | Uint8 |
| 120-9* PID Controller |  |  |  |  |  |
| 20-91 PID Anti Windup | [1]On | All set-ups | TRUE | , | Uint8 |
| 20-93 PID Proportional Gain | $2.00 \mathrm{~N} / \mathrm{A}$ | All set-upS | TRUE | - 2 | Uint16 |
| 20-94 PID Integral Time | 8.00 s | All set-ups | TRUE | -2 | Uint32 |
| 20-95-PID Differentiation Time | 0.005 | All set-ups | TRUE |  | Uint 16 |
| 20-96 PID Diff. Gain Limit | $5.0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -1 | Uint16 |

8.3.18 Ext. Closed-loop 21-**


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 21-5* Ext. CL 3 Ref./Fb. |  |  |  |  |  |
| 21-50 Ext. 3 Ref./Feedback Unit | [0] | All set-ups | TRUE | - | Uint8 |
| 21-51 Ext. 3 Minimum Reference | 0.000 ExtPID3Unit | All set-ups | TRUE | -3 | Int32 |
| 21-52 Ext. 3 Maximum Reference | 100.000 ExtPID 3Unit | All set-ups | TRUE | -3 | Int32 |
| 21-53 Ext. 3 Reference Source | [0] No function | All set-ups | TRUE | - | Uint8 |
| 21-54 Ext. 3 Feedback Source | [0] No function | All set-ups | TRUE | - | Uint8 |
| 21-55 Ext. 3 Setpoint | 0.000 ExtPID3Unit | All set-ups | TRUE | -3 | Int32 |
| 21-57 Ext. 3 Reference [Unit] | 0.000 ExtPID3Unit | All set-ups | TRUE | -3 | Int32 |
| [21-58 Ext, 3Feedback[ [Unit] | 0.000 ExtPID3Unit | All Set-ups | TRUE | -3 | Int32 |
| 21-59 Ext. 3 Output [\%] | 0\% | All set-ups | TRUE | 0 | Int32 |
| 21-6* Ext. CL 3 PID |  |  |  |  |  |
| 21-60 Ext. 3 Normal/Inverse Control | [0] Normal | All set-ups | TRUE | - | Uint8 |
| 21-61 Ext. 3 Proportional Gain | $0.50 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -2 | Uint16 |
| 21-62 Ext. 3 Integral Time | 20.00 s | All set-ups | TRUE | -2 | Uint32 |
| 21-63 Ext. 3 Differentation Time | 0.00 s | All set-ups | TRUE | -2 | Uint16 |
| 21-64 Ext. 3 Dif. Gain Limit | 5.0 N/A | All set-ups | TRUE | -1 | Uint16 |

8.3.19 Application Functions 22-**


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 22-8* Flow Compensation |  |  |  |  |  |
| 22-80 Flow Compensation | [0] Disabled | All set-ups | TRUE |  | Uint8 |
| [22-81 Square-linear Curve Approximation | 100\% | All set-ups | TRUE | 0 | Uint8 |
| 22-82 Work Point Calculation | [0] Disabled | All set-ups | TRUE | - | Uint8 |
| [22-83 _ Speed at No-Flow [RPM] | ExpressionLimit | All set-ups | TRUE | 67 | Uint16 |
| 22-84 Speed at No-Flow [Hz] | ExpressionLimit | All set-ups | TRUE | -1 | Uint16 |
| 22-85 - Speed at Design Point.[RPM] | ExpressionLimit | All set-ups | TRUE | 67 | Uint16 |
| 22-86 Speed at Design Point [ Hz ] | ExpressionLimit | All set-ups | TRUE | -1 | Uint16 |
| 22-87 Pressure at No-Flow Speed | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 22-88 Pressure at Rated Speed | $999999.999 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 22-89 Flow at Design Point | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 22-90 Flow at Rated Speed | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 23-0* Timed'Actions |  |  |  |  |  |
| 23-00 ON Time | ExpressionLimit | 2 set-ups | TRUE | 0 | TimeOfDayWoDate |
| 23-01 ONAction | [0] DISABLED | 2. set-ups | TRUE | - | Uint8 |
|  |  |  |  |  | TimeOfDay- |
| 23-02 OFF Time | ExpressionLimit | 2 set-ups | TRUE | 0 | WoDate |
| 23-03, OFF Action | [0]DISABLED | 2 set-ups | TRUE | - | Uint8 |
| 23-04 Occurrence | [0] All days | 2 set-ups | TRUE | - | Uint8 |
| 23-1* Maintenance |  |  |  |  |  |
| 23-10 Maintenance Item | [1] Motor bearings | 1 set-up | TRUE | - | Uint8 |
| 23-11 Maintenance Action | [1] Lubricate | 1. set-up | TRUE | - | Uint8 |
| 23-12 Maintenance Time Base | [0] Disabled | 1 set-up | TRUE | - | Uint8 |
| 23-13 Maintenance Time Interval | 1h | 1. set-up | TRUE | 74 | Uni32 |
| 23-14 Maintenance Date and Time | ExpressionLimit | 1 set-up | TRUE | 0 | TimeofDay |
| 23-1* Maintenance Reset |  |  |  |  |  |
| 23-15 Reset Maintenance Word | [0] Do not reset | All set-ups | TRUE | - | Uint8 |
| 23-16 Maintenance Text | ON/A | 1 set-up | TRUE | 0 | VisStr[20] |
| 23-5* Energy Log |  |  |  |  |  |
| [23-50 Energy Log Resolution | [5] Last 24.Hours | 2. set-ups | TRUE | - . | Uint8 |
| 23-51 Period Start | ExpressionLimit | 2 set-ups | TRUE | 0 | TimeofDay |
| 23-53 Energy Log | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 23-54 Reset Energy Log | [0] Do not reset | All set-ups | TRUE | - | Uint8 |
| 23-6* Trending |  |  |  |  |  |
| 23-60 Trend Variable | [0] Power [kW] | 2 set-ups | TRUE | - | Uint8 |
| 23-61 Continuous Bin Data | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32. |
| 23-62 Timed Bin Data | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint32 |
| 23-63 Timed Period Start | ExpressionLimit | 2 set-ups | TRUE | 0 | Timeoflay |
| 23-64 Timed Period Stop | ExpressionLimit | 2 set-ups | TRUE | 0 | TimeOfDay |
| 23-65 Minimum Bin Value. | ExpressionLimit | 2 set-ups | TRUE | 0 | Uint8 |
| 23-66 Reset Continuous Bin Data | [0] Do not reset | All set-ups | TRUE | - | Uint8 |
| 23-67 Reset Timed Bin Data | [0] Do not reset | All set-ups | IRUE | - | Uint8 |
| 23-8* Payback Counter |  |  |  |  |  |
| 123-80 Power Reference Factor | 100\% | 2 set-ups | TRUE | 0 | Uint8 |
| 23-81 Energy Cost | 1.00 N/A | 2 set-ups | TRUE | -2 | Uint32 |
| 23.82 Investment | $0 \mathrm{~N} / \mathrm{A}$ | 2 set-ups | TRUE | 0 | Uint32 |
| 23-83 Energy Savings | 0 kWh | All set-ups | TRUE | 75 | Int32 |
| 23-84 Cost Saving | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Int32 |

### 8.3.21 Cascade Controller 25-**

| Par. No. \# | Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 125-0* System Settings |  |  |  |  |  |  |
| 25-00 | Cascade Controller | null | 2 set-ups | FALSE | - | Uint8 |
| 25-02 | Motor Start | [0] Direct on Line | 2 set-ups | FALSE | - | Uint8 |
| 25-04 | Pump Cycling. | null | All set-ups | TRUE | - | Uint8 |
| 25-05 | Fixed Lead Pump | null | 2. set-ups | FALSE | - | Uint8. |
| 25-06 | Number Of Pumps | $2 \mathrm{~N} / \mathrm{A}$ | 2 set-ups | FALSE | 0 | Uint8 |
| 25-2* Bandwidth Settings |  |  |  |  |  |  |
| 25-20 | Staging Bandwidth | ExpressionLimit | All set-ups | TRUE | 0 | Uint8 |
| 25-21 | Qverride Bandwidth | 100\% | All set-ups | TRUE | 0 | Uint8 |
| 25-22 | Fixed Speed Bandwidth | Casco_staging_bandwidth (P2520) | All set-ups | TRUE | 0 | Uint8 |
| [25-23. | SBW Staging Delay | 15s | All set-ups | TRUE | 0 | Uint16 |
| 25-24 | SBW De-staging Delay | 15 s | All set-ups | TRUE | 0 | Uint16 |
| 25-25 | OBW Time | 10 s | All set-ups | TRUE | 0 | Uint16 |
| 25-26 | Destage At No-Flow | [0] Disabled | All set-ups | TRUE | - | Uint8 |
| [25-27 | Stage Function | null | All set-ups | TRUE | - | Uint8 |
| 25-28 | Stage Function Time | 155 | All set-ups | TRUE | 0 | Uint16 |
| 25-29 | Destage Function. | null | All set-ups | TRUE | - | Uint8 |
| 25-30 | Destage Function Time | 15 s | All set-ups | TRUE | 0 | Uint16 |
| 25-4* Staging Settings |  |  |  |  |  |  |
| 25-40 | Ramp-down Delay | 10.0 s | All set-ups | TRUE | -1 | Uint16 |
| 25-4.1 | Ramp-up Delay | 2.05 | All set-ups. | TRUE | -1. | Uint16 |
| 25-42 | Staging Thresthold | ExpressionLimit | All set-ups | TRUE | 0 | Uint8 |
| 25-43 | De-staging Threshoid | ExpressionLimit | All. Set-ups | TRUE | 0 | Uint8 |
| 25-44 | Staging Speed [RPM] | 0 RPM | All set-ups | TRUE | 67 | Uint16 |
| 25-45 | Staging Speed [ Hz ] | 0.0 Hz | All set-ups | TRUE | -1 | Uint 16 |
| 25.46 | De-staging Speed [RPM] | 0 RPM | All set-ups | TRUE | 67 | Uint16 |
| 25-47 | De-staging Speed [ Hz$]$ | 0.0 Hz | All set-ups | TRUE | -1 | Uint16 |
| 25-5* Alternation Settings |  |  |  |  |  |  |
| -25-50 | Lead Pump Alternation | null | All set-ups | TRUE | - | Uint8 |
| 25-51 | Alternation Event | [0] External | All set-ups | TRUE | - | Uint8 |
| 25-52 | Alternation Time Interval | 24. | All set-ups | TRUE | 74 | Uint16 |
| 25-53 | Alternation Timer Value | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | VisStr[7] |
| 25-54 _ Alternation Predefined Time. |  | ExpressionLimit | All set-ups | IRUE | 0 | TimeOfDayWoDate |
| 25-55 | Alternate if Load < 50\% | [1] Enabled | All set-ups | TRUE | $\bigcirc$ | Uints |
| 25-56 | Staging Mode at Alternation | [0] Slow | All set-ups | TRUE | $\cdots$ | Uuint8 |
| 25-58 | Run Next Pump Delay | 0.15 | All set-ups | TRUE | $-1$ | Uint16 |
| 25-59 | Run-on Line Delay | 0.55 | All set-up | TRUE | -1 | Uint16. |


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 25-8* Status |  |  |  |  |  |  |
| 25-80 Cascade Status | 0 N/A | All set-ups | TRUE | 0 | Vis 5 tr [25] | 응 |
| 25-81 Pump Status | $0 \mathrm{~N} / \mathrm{A}$ | All Set-ups | TRUE | 0 | VisStr[25]] | I |
| 25-82 Lead Pump | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Uint8 |  |
| 25-83 - Relay Status. | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | Vis5tr [4] |  |
| 25-84 Pump ON Time | 0 h | All set-ups | TRUE | 74 | Uint32 |  |
| 25-85 - Relay ON Time | 0 h | Allsel-ups | TRUE | 74 | Uint32 |  |
| 25-86 Reset Relay Counters | [0] Do not reset | All set-ups | TRUE | - | Uint8 |  |
| 25-9* Service |  |  |  |  |  |  |
| 25-90 Pump Interlock | [0] Off | All set-ups | TRUE | . | Uint8 |  |
| 25-91 Manual Alternation | 0 N/A | All set-ups | TRUE | 0 | Uint8: |  |

### 8.3.22 Analog I/O Option MCB 109 26-**

| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| [26-0* Analog. I/O Mode |  |  |  |  |  |
| 26-00 Terminal X42/1 Mode | [1] Voltage | All set-ups | TRUE | - | Uint8 |
| 26-01_Terminal X42/3 Mode | [1] Voltage | All , et-ups | TRUE | $\square$ | Uint8 |
| 26-02 Terminal X42/5 Mode | [1] Voltage | All set-ups | TRUE | - | Uint8 |
| [26-1* Analog Input X42/1. |  |  |  |  |  |
| 26-10 Terminal X42/1 Low Voltage | 0.07 V | All set-ups | TRUE | -2 | Int16 |
| 26-11 Terminal X42/1High voltage | 10.00 V | All.set-ups | TRUE | -2 | Int16 |
| 26-14 Term. X42/1 Low Ref./Feedb. Value | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 26-15 -Term. $\times 42 / 1$ High Ref./Feedb. Value | $100.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 26-16 Term. X42/1 Filter Time Constant | 0.001 s | All set-ups | TRUE | -3 | Uint16 |
| 26-17 Term. X42/1 Live Zero | [1] Enabled | All set-ups | TRUE | - | Uint8 |
| 26-2* Analog Input X42/3 |  |  |  |  |  |
| 26-20 Terminal X42/3 Low Voltage | 0.07 V | All set-ups | TRUE | -2 | Int16 |
| 26-21 Terminal X42/3 High Voltage | 10.00 V | All set-ups | TRUE | -2 | Int16 |
| 26-24 Term. X42/3 Low Ref. Feedb. Value | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 26-25 Term. X42/3 High Ref./Feedb. Value | $100.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 26-26 Term. X42/3 Filter Time Constant | 0.001 s | All Set-ups | TRUE | -3 | Uint16 |
| 26-27 Term. X42/3 Live Zero | [1] Enabled | All set-ups | TRUE | - | Uint8 |
| 26-3* Analog Input X42/5 |  |  |  |  |  |
| 26-30 Terminal X42/5 Low Voltage | 0.07 V | All set-ups | TRUE | -2 | Int16 |
| 26-31 Terminal $\times 42 / 5$ High Voltage | 10.00 V | All set-ups | TRUE | -2 | Int16 |
| 26-34 Term. X42/5 Low Ref./Feedb. Value | $0.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| [26-35 Term. X42/5 High Ref./Feedo. Value | $100.000 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | -3 | Int32 |
| 26-36 Term, X42/5 Filter Time Constant | 0.001 s | All set-ups | TRUE | -3 | Uint16 |
| 26-37 Term. X42/5 Live Zero | [1] Enabled | All set-ups | TRUE | - | Uint8 |
| 26-4* Analog Out X42/7 |  |  |  |  |  |
| [26-40 Terminal $\times 42 / 7$ Output | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 26-41 Terminal X42/7 Min. Scale | 0.00\% | All set-ups | TRUE | -2 | Int16 |
| 26-42 Terminal $\times 42 / 7$ Max. Scale | $100.00 \%$ | All set-ups | TRUE | -2 | Int16 |
| 26-43 Terminal $\times 42 / 7$ Bus Control | 0.00 \% | All set-ups | TRUE | -2 | N2 |
| 26-44 Terminal $\times 42 / 7$ Timeout Preset | 0.00\% | 1 set-up | TRUE | -2 | Uint16 |
| 26-5* Analog Out X42/9 |  |  |  |  |  |
| 26-50 Terminal $\times 42 / 9$ Output | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 26-51 Terminal X42/9 Min. Scale | 0.00\% | All set-ups | TRUE | -2 | Int16 |
| 26-52 Terminal X42/9 Max. Scale | 100.00\% | All set-ups | TRUE | -2 | Int16 |
| 26-53 Terminal X42/9 Bus Control | 0.00\% | All set-ups | TRUE | -2 | N2 |
| 26-54 Terminal X42/9 Timeout Preset | 0.00\% | 1 set-up | TRUE | -2 | Uint16 |
| 26-6* Analog Out X42/11 |  |  |  |  |  |
| 26-60 Terminal X42/11 Output | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 26-61 Terminal $\times 42 / 11$ Min. Scale | 0.00\% | All set-ups | TRUE | -2 | Int16 |
| 26-62 Terminal X42/11 Max. Scale | 100.00\% | All set-ups | TRUE | -2 | Int16 |
| 26-63 Terminal X42/11 Bus Control | 0.00\% | All set-ups | TRUE | - 2 | N2 |
| 26-64 Terminal X42/11 Timeout Preset | 0.00\% | 1 set-up | TRUE | -2 | Uint16 |



| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 27-5* Alternate Settings |  |  |  |  |  |
| 27-50 Automatic Alternation | [0] Disabled | All set-ups | FALSE | - | Uint ${ }^{\text {P }}$ |
| 27-51 Alternation Event | null | All set-ups | TRUE | $\stackrel{\square}{0}$ | Uint8. |
| 27-52 Alternation Time Interval | 0 min | All set-ups | TRUE | 70 | Uint16 |
| 27-53 Alternation Timer value | 0 min | All set-ups | TRUE | 70 | Uint16 |
| 27.54 Alternation At Time of Day | [0] Disabled | All set-ups | TRUE | - | Uint8 |
| 27-55 Alternation Predefined Time | ExpressionLimit | All set-ups | TRUE | 0 | TimeOfayWoDate |
| 27-56 Alternate Capacity is < | $0 \%$ | All set-ups | TRUE | 0 | Uint8 |
| 27-58 Run Next Pump Delay | 0.15 | All set-ups | TRUE | -1 | Uint16 |
| 27-6* Digital Inputs |  |  |  |  |  |
| 27-60_Terminal X66/1 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| $27-61$ Terminal X66/3 Digital Input | [0] No operation | Ail set-ups | TRUE | - | Uint8 |
| [27-62 Terminal X66/5 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 27-63 Terminal X66/7 Digital Input | [ 0$]$ ] No operation | All set-ups | TRUE | - | Uint8 |
| 27-64 Terminal X66/9 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 27-65 Terminal X66/11 Digital Input | [0] No operation | All set-ups | TRUE | - | Uint8 |
| 27-66 Terminal X66/13 Digital Input | [0] No operation | All set-ups. | TRUE | - | Uint8 |
| 27-7* Connections |  |  |  |  |  |
| 127-70 Relay | [0] Standard Relay | 2 set-ups | FALSE | - | Uint8 |
| 27-9* Readouts |  |  |  |  |  |
| [27-91 Cascade Reference | 0.0\% | All set-ups | TRUE | -1 | Int16 |
| 27-92 \% Of Total Capacity | $0 \%$ | All set-ups | TRUE | 0 | Uint16 |
| 27-93 Cascade Option Status | [0]Disabled | All set-ups | TRUE | - | Uint8 |
| 27-94 Cascade System Status | $0 \mathrm{~N} / \mathrm{A}$ | All set-ups | TRUE | 0 | VisStr[25] |


| Par. No. \# Parameter description | Default value | 4-set-up | Change during operation | Conversion index | Type |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 129-0* Pipe Fill |  |  |  |  |  |
| 29-00 Pipe Fill Enable | [0] Disabled | 2 set-ups | FALSE |  | Uint8 |
| 29-01 Pipe Fill Speed [RPM] | ExpressionLimit | All set-ups | TRUE | 67 | Uint16 |
| 29-02 - Pipe Fill Speed [ [ Hz ] | ExpressionLimit | All set-ups | TRUE | -1 | Uint16 |
| 29-03 - Pipe Fill Time | 0.00 S | All set-ups. | TRUE | -2 | Uint32 |
| 29-04 Pipe Fill Rate | 0.001 ProcessCtriUnit | All set-ups | TRUE | -3 | Int32 |
| 29-05 - Filled Setpoint. | 0.000 Processctriunit | Allset-ups | TRUE | -3 | Int32 |



## 9 Troubleshooting

### 9.1 Alarms and Warnings

A warning or an alarm is signaled by the relevant LED on the front of the adjustable frequency drive and indicated by a code on the display.

A warning remains adjue until its cause is no longer present. Under certain circumstances operation of the motor may still be continued. Warning messages may be critical, but are not necessarily so.

In the event of an alarm, the adjustable frequency drive will have tripped. Alarms must be reset to restart operation once their cause has been rectified.

## This may be done in four ways:

1. By using the [RESET] control button on the LCP control panel.
2. Via a digital input with the "Reset" function.
3. Via serial communication/optional serial communication bus.
4. By resetting automatically using the [Auto Reset] function, which is a default setting for VLT AQUA Drive, see par. 14-20 Reset Mode in VLT AQUA Drive Programming Guide

## NOTE!

After a manual reset using the [RESET] button on the LCP, the [AUTO ON] or [HAND ON] button must be pressed to restart the motor.

If an alarm cannot be reset, the reason may be that its cause has not been rectified, or the alarm is trip-locked (see also table on following page).

Alarms that are trip-locked offer additional protection, means that the line power supply must be switched off before the alarm can be reset. After being switched back on, the adjustable frequency drive is no longer blocked and may be reset as described above, once the cause has been rectified.

Alarms that are not trip-locked can also be reset using the automatic reset function in par. 14-20 Reset Mode (Warning: automatic wake-up is possible!)

If a warning and alarm is marked against a code in the table on the following page, this means that either a warning occurs before an alarm, or it can be specified whether it is a warning or an alarm that is to be displayed for a given fault.

This is possible, for instance, in par. 1-90 Motor Thermal Protection. After an alarm or trip, the motor carries on coasting, and the alarm and warning flash on the adjustable frequency drive. Once the problem has been rectified, only the alarm continues flashing.

| No. | Description | Warning | Alarm/Trip | Alarm/Trip Lock | Parameter Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 10 Volts.low | X |  |  |  |
| 2 | Live zero error | (X) | (X) |  | 6.01 |
| [3 | No motor. | (X) |  |  | 1.80 |
| 4 | Line phase loss | (x) | (X) | (X) | 14-12 |
| 5 | DC link voltage high | X |  |  |  |
| 6 | DC link voltage low | X |  |  |  |
| 7 | DC overvolt | X | X |  |  |
| 8 | DC undervolt | X | X |  |  |
| 9 | Inverter overloaded | X | X |  |  |
| 10 | Motor ETR overtemperature | (x) | (X) |  | 1-90 |
| 11 | Motor thermistor oventemperature | (X) | (X) |  | $1-90$ |
| 12 | Torque limit | X | X |  |  |
| 13 | Overcurrent. | X | X | X |  |
| 14 | Ground fault | X | X | X |  |
| 15 | Hardware mismatch |  | X | X |  |
| 16 | Short Circuit |  | X | X |  |
| 17 | Control word timeout | ( $\times$ | (X) |  | 8-04 |
| 23 | Internal Fan Fault | X |  |  |  |
| 24 | External Fan Fault | X |  |  | 14.53 |
| 25 | Brake resistor short-circuited | X |  |  |  |
| [26 | Brake resistor power limit | (X) | (X) |  | 2.13 |
| 27 | Brake chopper short-circuited | X | X |  |  |
| 28 | Brake check | (X) | (X) |  | 2-15 |
| 29 | Drive overtemperature | X | X | X |  |
| 30 | Motor phase U missing | (X) | (X) | (X) | 4-58 |
| 31 | Motor phase V missing | ( $\times$ ) | (X) | (X) | 4.58 |
| 32 | Motor phase W missing | (X) | L(X) | - (x) | 4-58 |
| 33 | Soft-charge fault |  | X | X |  |
| 34 | Serial communication fault | X | X |  |  |
| 35 | Out of frequency ranges | X | X |  |  |
| 36 | Line failure | X | X |  |  |
| 37 | Phase Imbalance | X | X |  |  |
| 39 | Heatsink sensor |  | X | X |  |
| 40 | Overload of Digital Output Terminal 27 | (X) |  |  | 5-00, 5-01 |
| 41. | Qverload of Digital Output Terminal 29 | (X) |  |  | 5-00, 5-02 |
| 42 | Overload of Digital Output On $\times 30 / 6$ | ( $\times$ |  |  | 5-32 |
| 42 | Overload of Digital Output on $\times 30 / 7$ | (X) |  |  | 5-33 |
| 46 | Pwr. card supply |  | X | X |  |
| 47. | 24 V supply low | X | X | X |  |
| 48 | 1.8 V supply low |  | X | X |  |
| 49 | Speed limit | X |  |  |  |
| 50 | AMA calibration failed |  | X |  |  |
| 51 | AMA check Unom and Inom |  | X |  |  |
| 52 | AMA low Inom |  | X |  |  |
| 53 | AMA motor too big |  | X |  |  |
| 54 | AMA motor too smali |  | X |  |  |
| 55 | AMA parameter out of range |  | X |  |  |
| 56 | AMA interrupted by user |  | X |  |  |
| 57 | AMA timeout. |  | X |  |  |
| 58 | AMA internal fault | X | X |  |  |
| 59 | Current limit | X |  |  |  |
| 60 | External Interiock | X |  |  |  |
| 62 | Output Frequency y at Maximum Limit | X |  |  |  |
| 64 | Voltage Limit | X |  |  |  |
| 65 | Control Board Overtemperature | X | X | X |  |
| 66 | Heatsink Temperature Low | X |  |  |  |
| 67 | Option Configuration has Changed. |  | X |  |  |
| 68 | Safe Stop Activated |  | $\mathrm{x}^{1}$ |  |  |
| 69 | Pwr. Card Temp |  | X | X |  |
| 70 | Illegal FC configuration |  |  | X |  |
| 71 | PTC 1 Safe Stop | X | $\mathrm{X}^{1)}$ |  |  |
| 72 | Dangerous Failure |  |  | $\mathrm{X}^{1}$ |  |
| 73 | Safe Stop Auto Restart |  |  |  |  |
| 76 | Power Unit Set-up | X |  |  |  |
| 79 | illegal PS config |  | X | X |  |
| 80 | Drive Initialized to Default Value |  | X |  |  |
| 91 | Analog input 54 wrong settings |  |  | X |  |
| 92 | NoFlow | X | X |  | 22-2* |
| 93 | Dry Pump | X | X |  | 22-2* |
| 94 | End of Curve | X | X |  | 22-5* |
| 95 | Broken Beit | X | X |  | 22-6* |
| 96 | Start Delayed | X |  |  | 22-7* |
| 97 | Stop Delayed | X |  |  | 22-7* |
| 98 | Clock Fault | X |  |  | 0-7* |

Table 9.1: Alarm/Warning code list

| No. | Description | Waming | Alarm/Trip | Alarm/Trip Lock | Parameter Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 220 | Overload Trip. |  | $X$ |  |  |
| 243 | Brake IGBT | X | X |  |  |
| 244 | Heatsink temp | X | X | X |  |
| 245 | Heatsink sensor |  | $X$ | $X$ |  |
| 246 | Pwr.card supply |  | X | X | . |
| 247 | Pwr,card temp |  | $X$ | $x$ |  |
| 248 | Illegal PS config |  | . $\times$ | $x$ |  |
| 250 | New spare part |  |  | X |  |
| 251 | New Type Code |  | X | X |  |

Table 9.2: Alarm/Warning code list
(X) Dependent on parameter

1) Cannot be auto reset via par. 14-20 Reset Mode

A trip is the action when an alarm has appeared. The trip will coast the motor and can be reset by pressing the reset button or make a reset by a digital input (Par. 5-1* [1]). The original event that caused an alarm cannot damage the adjustable frequency drive or cause dangerous conditions. A trip lock is an action that occurs in conjunction with an alarm, which may cause damage to the adjustable frequency drive or connected parts. A trip lock situation can only be reset by power cycling.


| Alarm Word and Extended Status Word |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Bit | Hex | Dec | Alarm Word | Warning Word | * Extended Status Word |
| 0 | 00000001 | 1 | Brake Check | Brake Check | Ramping, |
| 1 | 00000002 | 2 | Pwr. Card Temp | Pwr. Card Temp | AMA Running |
| 2 | 00000004 | 4 | Ground Fault | Ground Fault | Start CW/CCW |
| 3 | 00000008 | 8 | Ctri.Card Temp. | Corl Cäd Temp | Slow Down |
| 4 | 00000010 | 16 | Ctrl. Word TO | Ctrl. Word TO | Catch Up |
| 5 | 00000020 | 32 | Overcument | Overcurrent | Feedback High |
| 6 | 00000040 | 64 | Torque Limit | Torque Limit | Feedback Low |
| 7 | 00000080 | 128 | Motor Th Over. | Motor Thover | Output Current High |
| 8 | 00000100 | 256 | Motor ETR Over | Motor ETR Over | Output Current Low |
| 9 | 00000200 | 512 | Inverter Overld. | Inverter Overld. | Output Freg High. |
| 10 | 00000400 | 1024 | DC undervalt | DC undervolt | Output Freg Low |
| 11 | 00000800 | 2048 | DC. overvolt | DC overvolt | Brake Check OX |
| 12 | 00001000 | 4096 | Short Circuit | DC Voitage Low | Braking Max |
| 13 | 00002000 | - 8192 | Soft-charge Fault | DC Voltage High | Braking |
| 14 | 00004000 | 16384 | Line ph. Loss | Line ph. Loss | Out of Speed Range |
| 15 | 00008000 | 32768 | AMA NOTOK | No Motor | OVC Active |
| 16 | 00010000 | 65536 | Live Zero Error | Live Zero Error |  |
| 17 | 00020000 | 131072 | Internal Faul | 10VLow |  |
| 18 | 00040000 | 262144 | Brake Overload | Brake Overload |  |
| 19 | 00080000 | 524288 | $U$ phase Los5 | Brake Resistor. |  |
| 20 | 00100000 | 1048576 | $\checkmark$ phase Loss | Brake IGBT |  |
| 21 | 00200000 | 2097152 | W phase Loss | Speed Limit |  |
| 22 | 00400000 | 4194304 | Serial Communication Fault | Serial Communica |  |
| 23 | 00800000 | 8388608 | 24 V Supply Low | 24V_Supph_Low |  |
| 24 | 01000000 | 16777216 | Line Faiture | Line Failure |  |
| 25. | 02000000 | 33554432 | 1.8 V Supdly Low | Current Limit |  |
| 26 | 04000000 | 67108864 | Brake Resistor | Low Temp |  |
| 27 | 08000000 | 134217728 | Brake IGBT. | Voltage Limit. |  |
| 28 | 10000000 | 268435456 | Option Change | Unused |  |
| 29 | 20000000 | 536870912 | Drive Initialized | Unused |  |
| 30 | 40000000 | 1073741824 | Safe Stop | Unused |  |

Table 9.3: Description of Alarm Word, Warning Word and Extended Status Word

The alarm words, warning words and extended status words can be read out via serial bus or optional serial communication bus for diagnosis. See also par. 16-90 Alarm Word, par. 16-92 Warning Word and par. 16-94 Ext. Status Word.

## 9 Troubleshooting

 Instruction Manual
### 9.1.1 Fault Messages

## WARNING 1, 10 Volts low:

The 10 V voltage from terminal 50 on the control card is below 10 V . Remove some of the load from terminal 50 , as the 10 V supply is over loaded. Max. 15 mA or minimum $590 \Omega$.

## WARNING/ALARM 2, Live zero error:

The signal on terminal 53 or 54 is less than $50 \%$ of the value set in par. 6-10 Terminal 53 Low Voltage, par. 6-12 Terminal 53 Low Current par. 6-20 Terminal 54 Low Voltage, or par. 6-22 Terminal 54 Low Current respectively.

## WARNING/ALARM 3, No motor:

No motor has been connected to the output of the adjustable frequency drive.

WARNING/ALARM 4, Mains phs. loss:
A phase is missing on the supply side, or the line voltage imbalance is too high.
This message also appears in case of a fault in the input rectifier on the adjustable frequency drive.

Check the supply voltage and supply currents to the adjustable frequency drive.

## WARNING 5, DC link voltage high:

The intermediate circuit voltage (DC) is higher than the overvoltage limit of the control system. The adjustable frequency drive is still active.

## WARNING 6, DC link voltage low:

The intermediate circuit voltage ( $D C$ ) is below the undervoltage limit of the control system. The adjustable frequency drive is still active.

WARNING/ALARM 7, DC overvoltage:
If the intermediate circuit voltage exceeds the limit, the adjustable frequency drive trips after a time.

## Possible corrections:

Select $\underline{Q}$ ver Yoltage Control function in par. 2-17 Over-voltage Control

Connect a brake resistor
Extend the ramp time
Activate functions in par. 2-10 Brake Function
Increase par. 14-26 Trip Delay at Inverter Fault
Selecting OVC function will extend the ramp times.

| Alarm/warning limits: |  |  |  |
| :---: | :---: | :---: | :---: |
| Voltage Range | $\begin{gathered} 3 \times 200-240 \mathrm{~V} \\ A C \\ {[V D C]} \end{gathered}$ | $\begin{gathered} 3 \times 380-500 \mathrm{~V} \\ \mathrm{AC} \\ {[\mathrm{VDC}]} \\ \hline \end{gathered}$ | $\begin{gathered} 3 \times 550-600 \mathrm{~V} \\ A C \\ {\left[\frac{V D C}{[20}\right]} \\ \hline \end{gathered}$ |
| Undervoltage | 185 | 373 | - 532 |
| Voltage warning low | 205 | 410 | 585 |
| Voltage warning high (w/o brake - w/ brake) | 390/405 | 810/840 | 943/965 |
| Overvoltage | 410 | 855 | 975 |
| The voltages stated are the intermediate circuit voltage of the adjustable frequency drive with a tolerance of $\pm 5 \%$. The corresponding $A C$ line voltage is the intermediate circuit voltage ( $D C$ link) divided by 1.35 . |  |  |  |

## WARNING/ALARM 8, DC undervoltage:

If the intermediate circuit voltage ( DC ) drops below the "voltage warning low" limit (see table above), the adjustable frequency drive checks if 24 V backup supply is connected.
If no 24 V backup supply is connected, the adjustable frequency drive trips after a given time depending on the unit.
To check whether the supply voltage matches the adjustable frequency drive, see 3.1 General Specifications.

## WARNING/ALARM 9, Inverter overloaded:

The adjustable frequency drive is about to cut out because of an overload (too high current for too long). The counter for electronic, thermal inverter protection gives a warning at $98 \%$ and trips at $100 \%$, while giving an alarm. You cannot reset the adjustable frequency drive until the counter is below $90 \%$.
The fault is that the adjustable frequency drive is overloaded by more than nominal current for too long

## WARNING/ALARM 10, Motor ETR overtemperature:

According to the electronic thermal protection (ETR), the motor is too hot. You can choose if you want the adjustable frequency drive to give a warning or an alarm when the counter reaches $100 \%$ in par. 1-90 Motor Thermal Protection. The fault is that the motor is overloaded by more than nominal current for too long. Make sure that the motor par. 1-24 Motor Current is set correctly.

WARNING/ALARM 11, Motor thermistor overtemp:
The thermistor or the thermistor connection is disconnected. You can choose if you want the adjustable frequency drive to give a warning or an alarm in par. 1-90 Motor Thermal Protection. Check that the thermistor is connected correctly between terminal 53 or 54 (analog voltage input) and terminal 50 (+10 Volts supply), or between terminal 18 or 19 (digital input PNP only) and terminal 50. If a KTY sensor is used, check for correct connection between terminal 54 and 55 .

WARNING/ALARM 12, Torque limit:
The torque is higher than the value in par. 4-16 Torque Limit Motor Mode (in motor operation) or the torque is higher than the value in par. 4-17 Torque Limit Generator Mode (in regenerative operation).

## WARNING/ALARM 13, Overcurrent:

The inverter peak current limit (approx. 200\% of the rated current) is exceeded. The warning will last approx. 8-12 sec., then the adjustable frequency drive trips and issues an alarm. Turn off the adjustable frequency drive and check if the motor shaft can be turned and if the motor size matches the adjustable frequency drive.

## ALARM 14, Ground fault:

There is a discharge from the output phases to ground, either in the cable between the adjustable frequency drive and the motor or in the motor itself.
Turn off the adjustable frequency drive and remove the ground fault.

## ALARM 15, Incomplete hardware:

A fitted option is not handled by the present control board (hardware or software).

## ALARM 16, Short-circuit:

There is short-circuiting in the motor or on the motor terminals. Turn off the adjustable frequency drive and remove the short-circuit.

## WARNING/ALARM 17, Control word timeout:

There is no communication to the adjustable frequency drive.
The warning will only be active when par. 8-04 Control Timeout Function is NOT set to OFF.
If par. 8-04 Control 77meout Function is set to Stop and Trip, a warning appears and the adjustable frequency drive ramps down to zero speed, while giving an alarm.
par. 8-03 Control Timeout Time could possibly be increased.

## WARNING 23, Internal fans:

External fans have failed due to defect hardware or fans not mounted.

## WARNING 24, External fan fault:

The fan warning function is an extra protection function that checks if the fan is running / mounted. The fan warning can be disabled in par. 14-53 Fan Monitor, [0] Disabled.

## WARNING 25, Brake resistor short-circuited:

The brake resistor is monitored during operation. If it short-circuits, the brake function is disconnected and the warning appears. The adjustable frequency drive still works, but without the brake function. Turn off the adjustable frequency drive and replace the brake resistor (see par. 2-15 Brake (heck).

## ALARM/WARNING 26, Brake resistor power limit:

The power transmitted to the brake resistor is calculated as a percentage, as a mean value over the last 120 s , on the basis of the resistance value of the brake resistor (par. 2-11 Brake Resistor (ohm) and the intermediate circuit voltage. The warning is active when the dissipated braking energy is higher than $90 \%$. If Trip [2] has been selected in par. 2-13 Brake Power Monitoring, the adjustable frequency drive cuts out and issues this alarm, when the dissipated braking energy is higher than $100 \%$.

## WARNING/ALARM 27, Brake chopper fault:

The brake transistor is monitored during operation and if it short-circuits, the brake function disconnects and the warning comes up. The adjustable frequency drive is still able to run, but since the brake transistor has shortcircuited, substantial power is transmitted to the brake resistor, even if it is inactive.
Turn off the adjustable frequency drive and remove the brake resistor.


Warning: There is a risk of substantial power being transmitted to the brake resistor if the brake transistor is short-circuited.

## ALARM/WARNING 28, Brake check failed:

Brake resistor fault: the brake resistor is not connected/working.
WARNING/ALARM 29, Drive overtemperature:
If the enclosure is IP00 or IP20/Nema1, the cut-out temperature of the heatsink is $194^{\circ} \mathrm{F}$ [ $90^{\circ} \mathrm{C}$ ]. If IP54 is used, the cut-out temperature is $176^{\circ} \mathrm{F}\left[80^{\circ} \mathrm{C}\right]$.

## The fault could be:

- Ambient temperature too high
- Too long motor cable


## ALARM 30, Motor phase U missing:

Motor phase $U$ between the adjustable frequency drive and the motor is missing.
Turn off the adjustable frequency drive and check motor phase $U$.
ALARM 31, Motor phase V missing:
Motor phase $V$ between the adjustable frequency drive and the motor is missing.
Turn off the adjustable frequency drive and check motor phase V .
ALARM 32, Motor phase W missing:
Motor phase $W$ between the adjustable frequency drive and the motor is missing.
Turn off the adjustable frequency drive and check motor phase W.
ALARM 33, Inrush fault:
Too many power-ups have occurred within a short time period. See the chapter General Specifications for the allowed number of power-ups within one minute.

WARNING/ALARM 34, Fieldbus communication fault:
The serial communication bus on the communication option card is not working.

WARNING/ALARM 35, Option Fault:
Option fault. Please contact your supplier.
WARNING/ALARM 36, Mains failure:
This warning/alarm is only active if the supply voltage to the adjustable frequency drive is lost and parameter $\mathbf{1 4 - 1 0}$ is NOT set to OFF. Possible correction: check the fuses to the adjustable frequency drive

WARNING/ALARM 37, Phase Imbalance:
There is a current imbalance between the power units.
ALARM 39, Heatsink Sensor:
No feedback from the heatsink sensor.
WARNING 40, Overload of Digital Output Terminal 27
Check the load connected to terminal 27 or remove short-circuit connection. Check parameters 5-00 and 5-01.

WARNING 41, Overload of Digital Output Terminal 29:
Check the load connected to terminal 29 or remove short-circuit connection. Check parameters 5-00 and 5-02.

WARNING 42, Overload of Digital Output On $\times 30 / 6$ :
Check the load connected to $X 30 / 6$ or remove short-circuit connection. Check parameter 5-32.

WARNING 42, overload of Digital Output On $\times 30 / 7$ :
Check the load connected to $\times 30 / 7$ or remove short-circuit connection. Check parameter 5-33.

ALARM 46, Pwr. card supply:
The supply on the power card is out of range.
WARNING 47, 24 V supply low:
The external 24 V DC backup power supply may be overloaded, otherwise contact your Danfoss supplier.

## 9 Troubleshooting

ALARM 48, 1.8 V supply low:
Contact your Danfoss supplier.

## WARNING 49, Speed limit

The speed has been limited by range in par. 4-11 Motor Speed Low Limit [RPM] and par. 4-13 Motor Speed High Limit [RPM].

## ALARM 50, AMA calibration failed

Contact your Danfoss supplier.

## ALARM 51, AMA check Unom and Inom:

The setting of motor voltage, motor current, and motor power is presumably wrong. Check the settings.

## ALARM 52, AMA low Inom:

The motor current is too low. Check the settings.

## ALARM 53, AMA motor too big:

The motor is too big for the AMA to be carried out.
ALARM 54, AMA motor too small:
The motor is too small for the AMA to be carried out.

## ALARM 55, AMA par. out of range:

The par. values found from the motor are outside acceptable range.

## ALARM 56, AMA interrupted by user:

The AMA has been interrupted by the user.

## ALARM 57, AMA timeout:

Try to start the AMA again a number of times, until the AMA is carried out. Please note that repeated runs may heat the motor to a level where the resistances Rs and Rr are increased. In most cases, however, this is not critical.

WARNING/ALARM 58, AMA internal fault:
Contact your Danfoss supplier.
WARNING 59, Current limit:
The current is higher than the value in par. 4-18 Current Limit.

## WARNING 60, External Interlock:

External Interlock has been activated. To resume normal operation, apply 24 VDC to the terminal programmed for External Interlock and reset the adjustable frequency drive (via Bus, Digital I/O or by pressing [Reset]).

WARNING 62, Output Frequency at Maximum Limit:
The output frequency is limited by the value set in par. 4-19 Max Output Frequency

WARNING/ALARM/TRIP 65, Control Card Overtemperature:
Control card overtemperature: The cut-out temperature of the control card is $176^{\circ} \mathrm{F}\left(80^{\circ} \mathrm{C}\right)$.

## WARNING 66, Low Temp.:

The heatsink temperature is measured to be low. This could indicate that the temperature sensor is defective and thus the fan speed is increased to the maximum in case the power part or control card is very hot.

ALARM 67, Option Configuration has Changed:
One or more options has either been added or removed since the last power-down.

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## ALARM 68, Safe Stop:

Safe Stop has been activated. To resume normal operation, apply 24 VDC to terminal 37, then send a reset signal (via Bus, Digital I/O or by pressing [Reset]).

ALARM 69, Pwr. Card Temp:
Power card overtemperature
WARNING 76, Power Unit Set-up:
The required number of power units does not match the detected number of active power units.

ALARM 70, Illegal Adjustable Frequency Drive Configuration: Actual combination of control board and power board is illegal.

ALARM 90, Feedback Mon.:
ALARM 92, No-Flow:
A no load situation has been detected for the system. See parameter group 22-2*.

## ALARM 93, Dry Pump:

A no-flow situation and high speed indicates that the pump has run dry. See parameter group 22-2*

## ALARM 94, End of Curve:

Feedback stays lower than the setpoint, which may indicate a leakage in the pipe system. See parameter group 22-5*

## ALARM 95, Broken Belt:

Torque is below the torque level set for no load indicating a broken belt. See parameter group 22-6*

## ALARM 96, Start Delayed:

Start of the motor has been delayed due to short cycle protection being active. See parameter group 22-7*.
ALARM 220, Overtoad Trip:
Motor overload has tripped. Indicates excess motor load. Check motor and driven load. To reset press the "Off Reset" key. Then, to restart the system, press the "Auto On" or "Hand On" key.

## WARNING/ALARM 243, Brake IGBT:

The brake transistor is short-circuited or the brake function is disconnected. Turn off the adjustable frequency drive as a fire precaution. Report value indicates source of alarm (from left): 1-4 Inverter 5-8 Rectifier.

## WARNING/ALARM 244, Heatsink Temp:

Drive heatsink overtemperature: Report value indicates source of alarm (from left): 1-4 Inverter 5-8 Rectifier.

ALARM 245, Heatsink Sensor:
No feedback from the heatsink sensor. Report value indicates source of alarm (from left): 1-4 Inverter 5-8 Rectifier.

ALARM 246, Pwr. Card Supply:
The supply on the power card is out of range. Report value indicates source of alarm (from left): 1-4 Inverter 5-8 Rectifier.

ALARM 247, Pwr. Card Temp:
Power card overtemperature. Report value indicates source of alarm (from left): 1-4 Inverter 5-8 Rectifier.

## ALARM 248, Illegal PS Config:

Power size configuration fault on the power card. Report value indicates source of alarm (from left): 1-4 Inverter 5-8 Rectifier.

## ALARM 250, New Spare Part:

The power or switch mode power supply has been exchanged. The ad justable frequency drive type code must be restored in the EEPROM. Select the correct type code in Par 14-23 according to the label on unit. Remember to select 'Save to EEPROM' to complete.

## ALARM 251, New Type Code:

The adjustable frequency drive has a new type code.

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## 10 Specifications

### 10.1 General Specifications

10.1.1 Line Power Supply $1 \times 200-240$ V AC

| Adjustable frequency drive | P1K1 1.1 | P1K5 1.5 | P2K2 2.2 | P3K0 3.0 | $\begin{gathered} \hline \text { P3K7 } \\ 3.7 \end{gathered}$ | P5K5 | P7K5 | $\begin{gathered} \hline \text { P15K } \\ 15 \end{gathered}$ | $\begin{gathered} \hline \mathrm{P} 22 \mathrm{~K} \\ 22 \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Typical Shaft Output [kW] | 1.1 | 1.5 | 2.2 |  |  |  |  |  |  |
| Typical Shaft Output [HP] at 240 V | 1.5 | 2.0 | 2.9 | 4.0 | 4.9 | 7.5 | 10 | 20 | 30 |
| [IP 20/Chassis | A3 | $\cdots$ | $\cdots$ | - | $\cdots$ | - | 82 | C1 | , |
| IP 21 / NEMA 1 | - | B1 | B1 | B1 | B1 | B1 | 82 | C1 | C2 |
| [PP5/ 5 / ${ }^{\text {P/ }}$ | AS | B1 | B1 | 81 | B1 | B1 | 82 | C1 | C2 |
| IP 66 | A5 | B1 | B1 | B1 | B1 | B1 | B2 | C1 | C2 |
| Output current |  |  |  |  |  |  |  |  |  |
|  | 6.6 | 7.5 | 10.6 | 12.5 | 16.7 | 24.2 | 30.8 | 59.4 | 88 |
|  | 7.3 | 8.3 | 11.7 | 13.8 | 18.4 | 26.6 | 33.4 | 65.3 | 96.8 |
|  |  |  |  |  |  | 5.00 | 6.40 | 12.27 | 18.30 |
|  | 0.2-4 / 4-10 |  |  |  |  | Max. cable size: |  |  |  |
|  |  |  |  |  |  | 10/7 | 35/2 | 50/1/0 | 95/4/0 |
| Max. input current |  |  |  |  |  |  |  |  |  |
| $\begin{aligned} & \text { Continuous } \\ & (1 \times 200-240 \mathrm{~V})[\mathrm{A}] \end{aligned}$ | 12.5 | 15 | 20.5 | 24 | 32 | 46 | 59 | 111 | 172 |
| $\left[\begin{array}{l} \text { Intermittent } \\ (1 \times 200-240 \mathrm{~V})[\mathrm{Al}] \end{array}\right.$ | 13.8 | 16.5 | 22.6 | 26.4 | 35.2 | 50.6 | 64.9 | 122.1 | 189.2 |
| (1000 Max. pre-fuses ${ }^{1}$ [A] | 20 | 30 | 40 | 40 | 60 | 80 | 100 | 150 | 200 |
| Environment |  |  |  |  |  |  |  |  |  |
| Estimated power loss at rated max. load $[\mathbf{W}]^{4)}$ | 44 | 30 | 44 | 60 | 74 | 110 | 150 | 300 | 440 |
| $\rightarrow$ Weight enclosure IP 20 [kg] | 4.9 | . | - | - | $\underline{-}$ | - |  | - | - |
| Weight enclosure IP 21 [ kg ] |  | 23 | 23 | 23 | 23 | 23 | 27 | 45 | 65 |
| T Weight enclosure IP 55 [kg] | - | 23 | 23 | 23 | 23 | 23 | 27 | 45 | 65 |
| Weight enclosure IP 66 [ kg ] | - | 23 | 23 | 23 | 23 | 23 | 27 | 45 | 65 |
| [Efficiency ${ }^{3}$ ) | 0.968 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |

10.1.2 Line Power Supply $3 \times 200-240$ V AC

$10 / 12 / 2014$

| Line power supply $3 \times 200-240 \mathrm{~V}$ AC - Normal overload 110\% for 1 minute |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| \|IP 20 / NEMA Chassis <br> (B3+4 and C3+4 may be converted to IP21 using a conversion kit (Please contact Danfoss) | B3 | B3 | B3. | B4. | B4 | C3 | C3 | C4 | C4 |
| IP 21 / NEMA 1 | B1 | B1 | B1 | B2 | C1 | C1 | C1 | C2 | C2 |
| [PP 55/NEMA 12 | B1 | B1 | B1 | B2 | C1 | C1 | C1 | C2 | C2 |
| IP 66 | B1 | B1 | B1 | B2 | Cl | C1 | Cl | C2 | C2 |
| Adjustable frequency drive | P5K5 | P7K5 | P11K | P15K | P18K | P22K | P30K | P37K | P45K |
| Typical Shaft Output [kW] | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 |
| Typical Shaft Output [HP] at 208 V | 7.5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 |
| Output current |  |  |  |  |  |  |  |  |  |
| $\begin{aligned} & \text { Continuous } \\ & (3 \times 200-240 \mathrm{~V})[\mathrm{A}] \end{aligned}$ | 24.2 | 30.8 | 46.2 | 59.4 | 74.8 | 88.0 | 115 | 143 | 170 |
| $\left[\begin{array}{l} \text { Intermittent } \\ (3 \times 200-240 \mathrm{~V})[\mathrm{A}] \end{array}\right.$ | 26.6 | 33.9 | 50.8 | 65.3 | 82.3 | 96.8 | 127 | 157 | 187 |
| $\begin{aligned} & \text { Continuous } \\ & \mathrm{kVA}(208 \mathrm{VAC})[\mathrm{kVA}] \end{aligned}$ | 8.7 | 11.1 | 16.6 | 21.4 | 26.9 | 31.7 | 41.4 | 51.5 | 61.2 |
| M Max.cable size: |  |  |  |  |  |  |  |  |  |
| (line power, motor, brake) $\left[\mathrm{mm}^{2} / \mathrm{AWG}\right]^{2]}$ |  | 10/7 |  | 35/2 |  | 50/1/0 |  | 95/4/0 | $\begin{gathered} 120 / 250 \\ \text { MCM } \\ \hline \end{gathered}$ |
| Max. input current |  |  |  |  |  |  |  |  |  |
| Continuous $(3 \times 200-240 \mathrm{~V})[\mathrm{A}]$ | 22.0 | 28.0 | 42.0 | 54.0 | 68.0 | 80.0 | 104.0 | 130.0 | 154.0 |
| $\left[\begin{array}{l} \text { Intermittent } \\ (3 \times 200-240 \mathrm{~V})[\mathrm{A}] \end{array}\right.$ | 24.2 | 30.8 | 46.2 | 59.4 | 74.8 | 88.0 | 114.0 | 143.0 | 169.0 |
| Masos Max. pre-fuses ${ }^{12}$ [A] | 63 | 63 | 63 | 80 | 125 | 125 | 160 | 200 | 250 |
| Environment: |  |  |  |  |  |  |  |  |  |
| Estimated power loss at rated max. load $[W]^{4)}$ | 269 | 310 | 447 | 602 | 737 | 845 | 1140 | 1353 | 1636 |
| Weight enclosure IP20 [kg] | 12 | 12 | 12 | 23.5 | 23.5 | 35 | 35 | 50 | 50 |
| $\square$ Weight enclosure IP21 [kg] | 23 | 23 | 23 | 27 | 45 | 45 | 65 | 65 | 65 |
| Weight enclosure IP55 [kg] | 23 | 23 | 23 | 27 | 45 | 45 | 65 | 65 | 65 |
| Weight enclosure IP66 [kg] | 23 | 23 | 23 | 27 | 45 | 45 | 65 | 65 | 65 |
| Efficiency ${ }^{3)}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 |



### 10.1.4 Line Power Supply $3 \times 380-480$ V AC




2) American Wire Gauge
3) Measured using 16 ft [ 5 m ] shielded motor cables at rated load and rated frequency

The typical power loss is at normal load conditions and expected to be within $+/-15 \%$ (tolerance relates to variety in voltage and cable conditions).
Values are based on a typical motor efficiency (eff//eff3 border line). Lower efficiency motors will also add to the power loss in the adjustable frequency drive and vice versa.
CP and trpical centency is rased from nomial, operes may ise significanty.
Although measurements are made with state of the art equipment, some, measurement inaccuracy, must be allowed for ( $t / 25 \%$ )

### 10.1.5 Line Power Supply $3 \times 525-600$ V AC


Table 10.1: ${ }^{5)}$ Motor and line cable: $300 \mathrm{MCM} / 150 \mathrm{~mm}^{2}$
10.1.6 Line Power Supply $3 \times 525-690$ V AC

| Normal overload 110\% for 1 minute |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Size: |  | 911 K | P15K | P18K | P22K | P30K | P37K | P45K | P55K | P75K | P90K |
| Typical Shaft Output [kW] |  | 11 | 15 | 18.5 | 22 | 30 | 37 | 45 | 55 | 75 | 90 |
| Typical Shaft Output [ $\mathrm{HP}^{\text {P }}$ ] | at 575 V | 10 | 15.4 | 20.1 | 24 | 33 | 40 | 50 | 60 | 75 | 100 |
| IP 21 / NEMA 1 |  | B2 | B2 | B2 | B2 | B2 | C2 | C2 | C2 | C2 | C2 |
| IP 55/NEMA 12 |  | B2 | B2 | B2 | B2 | B2 | C2 | C2 | C2 | C2 | C |
| Output current |  |  |  |  |  |  |  |  |  |  |  |
|  | Continuous $(3 \times 525-550 \mathrm{~V})_{[ }[\mathrm{A}]^{2}$ | 14 | 19 | 23 | 28 | 36 | 43 | 54 | 65 | 87 | 105 |
|  | $\left[\begin{array}{l} \text { Intermittent } \\ (3 \times 525-550 \mathrm{~V})[\mathrm{A}] \end{array}\right.$ | 15.4 | 20.9 | 25.3 | 30.8 | 39.6 | 47.3 | 59.4 | 71.5 | 95.7 | 115.5 |
|  | Continuous $(3 \times 551-690 \mathrm{~V})[\mathrm{A}]$ | 13 | 18 | 22 | 27 | 34 | 41 | 52 | 62 | 83 | 100 |
|  | $\left[\begin{array}{l} \text { Intermittent } \\ (3 \times 551-690 \mathrm{~V})[\mathrm{A}] \end{array}\right.$ | 14.3 | 19.8 | 24.2 | 29.7 | 37.4 | 45.1 | 57.2 | 68.2 | 91.3 | 110 |
|  | Continuous ${ }^{\text {kVA }}$ ( 550 VAC ] [kVA] | 13.3 | 18.1 | 21.9 | 26.7 | 34.3 | 41 | 51.4 | 61.9 | 82.9 | 100 |
|  | Continuous kVA ( 575 V AC) [kVA] | 12.9 | 17.9 | 21.9 | 26.9 | 33.8 | 40.8 | 51.8 | 61.7 | 82.7 | 99.6 |
|  | Continuous kVA ( 690 VAC ] [ kVA$]$ | 15.5 | 21.5 | 26.3 | 32.3 | 40.6 | 49 | 62.1 | 74.1 | 99.2 | 119.5 |
|  | Max. cable size <br> (line power, motor, brake) $\left[\mathrm{mm}^{2}\right] /[\text { AWG }]^{2)}$ |  |  | $\begin{aligned} & 35 \\ & 1 / 0 \end{aligned}$ |  |  |  |  | $\begin{aligned} & 95 \\ & 4 / 0 \end{aligned}$ |  |  |
| Max. input current |  |  |  |  |  |  |  |  |  |  |  |
|  | Continuous $(3 \times 525-690 \mathrm{~V})[\mathrm{A}]$ | 15 | 19.5 | 24 | 29 | 36 | 49 | 59 | 71 | 87 | 99 |
|  | $\left[\begin{array}{l} \text { Intermiltent } \\ (3 \times 525-690 \vee)[A] \end{array}\right.$ | 16.5 | 21.5 | 26.4 | 31.9 | 39.6 | 53.9 | 64.9 | 78.1 | 95.7 | 108.9 |
|  | Max. pre-fuses ${ }^{1 /}$ [A] | 63 | 63 | 63 | 63 | 80 | 100 | 125 | 160 | 160 | 160 |
|  | Ervironment: |  |  |  |  |  |  |  |  |  |  |
|  | Estimated power loss at rated max. load [W] 4) | 201 | 285 | 335 | 375 | 430 | 592 | 720 | 880 | 1200 | 1440 |
|  | Weight: | 27 | 27 | 27 | 27 | 27 | 65 | 65 | 65 | 65 | 65 |
|  | IP55 [kg] | 27 | 27 | 27 | 27 | 27 | 65 | 65 | 65 | 65 | 65 |
|  | Efficiency ${ }^{4}$ | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |

Table 10.2: ${ }^{5)}$ Motor and line cable: $300 \mathrm{MCM} / 150 \mathrm{~mm}^{2}$

## 1) For type of fuse see section Fuses <br> 2) American Wire Gauge

3) Measured using $16 \mathrm{ft}[5 \mathrm{~m}]$ shielded motor cables at rated load and rated frequency
${ }^{4)}$ The typical power loss is at normal load conditions and expected to be within $+/-15 \%$ (tolerance relates to variety in voltage and cable conditions). Values are based on a typical motor efficiency (effz/eff border line). Lower efficiency motors will also add to the power loss in the adjustable frequency drive and vice versa.
If the switching frequency is raised from nominal the power losses may rise significantly. LCP and typical control card power consumptions are included. Further options and customer load may add up to 30 [W] to the losses. (Though typically only 4 [W] extra for a fully loaded control card, or options for slot A or slot B, each).
Although measurements are made with state of the art equipment, some measurement inaccuracy must be allowed for ( $+/-5 \%$ ).
${ }^{6)}$ Adding the F -enclosure option cabinet (resulting in the F3 and F4 enclosure sizes) adds 650 lbs [ 295 kg ] to the estimated weight.

| Normal overioad 110\% | P45K | P55K | P75K | P90K | P110 | P132 | P160 | P200 | P250 | P315 | P400 | P450 | P500 | P560 | P630 | P710 | P800 | P900 | P1M0 | P1M2 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Typical Shaft Output [kW] | 45 | 55 | 75 | 90 | 110 | 132 | . 160 | 200 | 250 | 315 | 400 | 450 | 500 | 560 | 630 | 710 | 800 | 900 | 1000 | 1200 |
| Typical Shaft Output [HP] at 575 V | 50 | 60 | 75 | 100 | 125 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 600 | 650 | 750 | 950 | 1050 | 1150 | 1350 |
| 1 IP 00 | 03 | D3 | D3 | D3 | D3 | D3 | D3 | 04 | D4 | D4 | D4 | E2 | E2 | E2 | E2 | - | - | - | - | - |
| IP 21 / Nema 1 | D1 | D1 | D1 | D1 | D1 | D1 | D1 | D2 | D2 | D2 | D2 | E1 | E1 | E1 | E1 | $\begin{aligned} & \hline \begin{array}{l} \text { F1/ } \\ \text { F3 } \end{array} \end{aligned}$ | $\begin{aligned} & \hline F 1 / \\ & F 3^{6} \end{aligned}$ | $\begin{aligned} & \hline \text { F1/ } \\ & \text { F3 } \end{aligned}$ | $\begin{aligned} & \mathrm{F} 2 / \\ & \mathrm{F} 4^{6)} \end{aligned}$ | $\begin{aligned} & \text { F2\| } \\ & \text { F4 }{ }^{6} \end{aligned}$ |
| IP 54 / Nema 12 | D1 | D1 | D1 | D1 | D1 | D1 | D1 | D2 | D2 | D2 | D2 | E1 | E1 | E1 | E1 | $\begin{aligned} & \text { F1/ } \\ & \mathrm{F}^{6} \text { ) } \end{aligned}$ | $\begin{aligned} & \text { F1/ } \\ & \text { F3 }{ }^{6} \end{aligned}$ | $\begin{aligned} & \mathrm{F1/} \\ & \mathrm{~F} 3^{69} \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { F1/ } \\ & \text { F3 } \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { F1/ } \\ & \mathrm{F}^{6} \text { ) } \end{aligned}$ |


Max. input current

| Continuous ( $3 \times 550 \mathrm{~V}$ [ $[\mathrm{A}]$ | 60 | 77 | 89 | 110 | 130 | 158 | 198 | 245 | 299 | 355 | 408 | 453 | 504 | 574 | 607 | 743 | 866 | 962 | 1079 | 1282 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Continuous ( $3 \times 575 \mathrm{~V}$ ) [A] | 58 | 74 | 85 | 106 | 124 | 151 | 189 | 224 | 286 | 339 | 390 | 434 | 482 | 549 | 607 | 711 | 828 | 920 | 1032 | 1227 |
| Continuous ( $3 \times 690$ V) [A] | 58 | 77 | 87 | 109 | 128 | 155 | 197 | 240 | 296 | 352 | 400 | 434 | 482 | 549. | 607 | 711 | 828 | 920 | 1032 | 1227 |
| Max, line power pre-fuses ${ }^{1}$ [ $[$ ] | 125 | 160 | 200 | 200 | 250 | 315 | 350 | 350 | 400 | 500 | 550 | 700 | 700 | 900 | 900 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Environment: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Estimated power loss at 690 VAC at rated max. load [W] ${ }^{\text {4) }}$ | 1458 | 1717 | 1913 | 2262 | 2662 | 3430 | 3612 | 4292 | 5156 | 5821 | 6149 | 6440 | 7249 | 8727 | 9673 | 11315 | $\begin{gathered} 1290 \\ 3 \end{gathered}$ | 14533 | $\begin{gathered} 1637 \\ 5 \end{gathered}$ | 19207 |
| Estimated power loss at 575 VAC at rated max. load [W] 4) | 1398 | 1645 | 1827 | 2157 | 2533 | 2963 | 3430 | 4051 | 4867 | 5493 | 5852 | 6132 | 6903 | 8343 | 9244 | 10771 | $\begin{gathered} \hline 1227 \\ \hline \\ \hline \end{gathered}$ | 13835 | $\begin{gathered} 1559 \\ 2 \\ \hline \end{gathered}$ | $18281$ |
| Weight enclosure IPOO [kg] | 82 | 82 | 82 | 82 | 82 | 82 | 91 | 112 | 123 | 138 | 151 | 221 | 221 | 236 | 277 | - | - | - | - | - | at rated max. load [ $W$ ] ${ }^{\text {4) }}$

$\qquad$ Weight endosure P21



- Electronic thermal motor protection against overload.
- Temperature monitoring of the heatsink ensures that the adjustable frequency drive trips if the temperature reaches $203^{\circ} \mathrm{F} \pm 41^{\circ} \mathrm{F}\left[95^{\circ} \mathrm{C} \pm\right.$ $5^{\circ} \mathrm{C}$. An overload temperature cannot be reset until the temperature of the heatsink is below $158^{\circ} \mathrm{F} \pm 9^{\circ} \mathrm{F}\left[70^{\circ} \mathrm{C} \pm 5^{\circ} \mathrm{C}\right.$ ] (Guideline - these temperatures may vary for different power sizes, enclosures etc.). VLT AQUA Drive has an auto derating function to avoid it's heatsink reaching $203^{\circ} \mathrm{F}\left[95^{\circ} \mathrm{C}\right]$.
- The adjustable frequency drive is protected against short-circuits on motor terminals $U, V, W$.
- If a line phase is missing, the adjustable frequency drive trips or issues a warning (depending on the load).
- Monitoring of the intermediate circuit voltage ensures that the adjustable frequency drive trips if the intermediate circuit voltage is too low or too high.
- The adjustable frequency drive is protected against ground faults on motor terminals $\mathrm{U}, \mathrm{V}, \mathrm{W}$.

Line power supply (L1, L2, L3):
Supply voitage
Supply voltage
Supply voltage
Supply voltage

AC line voltage low / line drop-out:
During low AC line voltage or a line drop-out, the adjustable frequency drive continues until the intermediate circuit voltage drops below the minimum stop level, which corresponds typically to $15 \%$ below the adjustable frequency drive's lowest rated supply voltage. Power-up and full torque cannot be expected at AC line voltage lower than $10 \%$ below the adjustable frequency drive's lowest rated supply voltage.

| Supply frequency | $50 / 60 \mathrm{~Hz}+4 /-6 \%$ |
| :---: | :---: |
| The adjustable frequency drive power supply is tested in accordance with IEC61000-4-28,50 Hz +4/-6\%. |  |
| Max. imbalance temporary between line phases | 3.0\% of rated supply voltage |
| True Power Factor ( $\lambda$ ) | $\geq 0.9$ nominal at rated load |
| Displacement Power Factor ( $\cos \varphi$ ) near unity | ( $>0.98$ ) |
| Switching on input supply L1, L2, L3 (power-ups) $\leq$ enclosure type A | maximum 2 times/min. |
| Switching on input supply L1, L2, L3 (power-ups) $\geq$ enclosure type B, C | maximum 1 time/min. |
| Switching on input supply L1, L2, L3 (power-ups) $\geq$ enclosure type D, E, F | maximum 1 time/2 min. |
| Environment according to EN60664-1 | category III/pollution degree 2 |

The unit is suitable for use on a circuit capable of delivering not more than 100.000 RMS symmetrica/ Amperes, $240 / 480 \mathrm{~V}$ maximum.
Motor output (U, V, W):
Output voltage
Output frequency
Switching on output
Ramp times

- Dependent on power size.

Torque characteristics:
Starting torque (Constant torque)
Starting torque
Overload torque (Constant torque)
*Percentage relates to VLT AQUA Drive's nominal torque.
Cable lengths and coss-sections:
Max. motor cable length, shielded/armored
Max. motor cable length, unshielded/unarmored
Max. cross-section to motor, line power, load sharing and brake * $110 \%$ for 1 min.
Maximum cross-section to control terminals, rigid wire
Maximum cross-section to control terminals, flexible cable
Maximum cross-section to control terminals, cable with enclosed core

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* See Line Power Supply tables for more information!

Control card, RS-485 serial communication:
Terminal number
Terminal number 61

The $R S-485$ serial communication circuit is functionally seated from other central circuits and ga/vanically isolated from the supply voltage (PELV).
Analog inputs:
Number of analog inputs
Terminal number
Modes
Mode select
Voltage mode
Valtage level
Input resistance, $R_{1}$
Max. voltage
Current mode
Current level
Input resistance, $R$

The analog inputs are galvanically isolated from the supply vattage (PELV) and other high-voltage terminals.


| Number of pragrammable analog outputs |  |
| :---: | :---: |
|  |  |
| Terminal number | 42 |
| Current range at analog output | 0/4-20mA |
| Max. resistor load to common at analog output | $500 \Omega$ |
| Accuracy on analog output | Max. error: $0.8 \%$ of full scale |
| Resolution on analog output | 8 bit |
| The analog output is galvanically isolated from the supply vortage (PELV) and other high-vottage terminals. |  |
| Digital inputs: |  |
| Programmable digital inputs | 4 (6) |
| Terminal number | $18,19,27^{11}, 29^{17}, 32,33$, |
| Logic | PNP or NPN |
| Voltage level | $0-24 \vee D C$ |
| Valtage level, logic'0' PNP | $\angle 5 V D C$ |
| Valtage level, logic' 1 ' PNP | $>10 \mathrm{VDC}$ |
| Voltage level, logic '0' NPN | $>19 \mathrm{VDC}$ |

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| Voltage level, logic '1' NPN | $<14 \mathrm{VDC}$ |
| :---: | :---: |
| Maximum voltage on input | 28 VDC |
| Input resistance, R | approx. 4 k |
| All digital inputs are galvanically isolated from the supply voltage (PELV) and other high-voltage terminats. <br> 1) Terminals 27 and 29 can also be programmed as output. |  |
| Digital output: |  |
| Programmable digital/pulse outputs | 2 |
| Terminal number | 27, $29{ }^{11}$ |
| Voltage level at digitalfrequency output | 0-24 V |
| Max. output current (sink or source) | 40 mA |
| Max. load at frequency output | 1 k ? |
| Max. capacitive load at frequency output | 10 nF |
| Minimum output frequency at frequency output | 0 Hz |
| Maximum output frequency at frequency output | 32 kHz |
| Accuracy of frequency output | of full scale |
| Resolution of frequency outputs | 12 bit |

1) Terminal 27 and 29 can also be programmed as input.

The digital output is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.
Pulse inputs:

| Programmable pulse inputs | 2 |
| :---: | :---: |
| Terminal number pulse | 29,33 |
| Max. frequency at terminat, 29, 33 | 110 kHz (push-pull driven) |
| Max. frequency at terminal, 29, 33 | 5 kHz (open collector) |
| Min. frequency at terminal 29, 33 | 4 Hz |
| Voltage level | see section on Digital input |
| Maximum voltage on input | $28 \vee D C$ |
| Input resistance, $\mathrm{R}_{1}$ | approx. $4 \mathrm{k} \Omega$ |
| Pulse input accuracy (0.1-1 kHz) | Max. error: $0.1 \%$ of full scale |
| Control card, 24 V DC output: |  |
| Terminal number | 12,13 |
| Max. laad | : 200 mA |

The 24 V DC supply is gatvanically isolated from the supply woltage (PELV), but has the same potential as the analog and digital inputs and outputs.
Relay outputs:
Programmable relay outputs 2
Relay 01 Terminal number $1-3$ (break), 1-2 (make)

| Max, terminal load (AC-1) ${ }^{1)}$ on 1-3 (NC), 1-2 (NO) (Resistive load) | 240 V AC, 2 A |
| :---: | :---: |

Max, terminal load (AC-15) ${ }^{1}$ (Inductive load @ $\cos \varphi 0.4$ )

Max. terminal load (DC-13) ${ }^{1) \text { (Inductive load) } 24 \mathrm{VDC}, 0.1 \mathrm{~A}}$
Relay 02 Terminal number $\quad$ 4-6 (break), 4-5 (make)
Max. terminal load (AC-1 $)^{1)}$ on 4-5 (NO) (Resistive load) 2)3)
Max. terminal load (AC-15) on 4-5 (NO) (Inductive load @ $\cos \varphi 0.4$ ) $240 \vee \mathrm{AC} 0.2 \mathrm{~A}$

Max. terminal load (DC-13) ${ }^{1}$ on $4-5(N O)$ (Inductive load)
Max. terminal load (AC-1) ${ }^{1)}$ on $4-6$ ( $N C$ ) (Resistive load) $240 \vee A C, 2 A$
Max. terminal load (AC-15) ${ }^{1)}$ on 4-6 (NC) (Inductive load @ $\cos \varphi 0.4$ ) $240 \vee \mathrm{VC}, 0.2 \mathrm{~A}$
Max. terminal load (DC-1) ${ }^{1}$ on $4-6$ (NC) (Resistive load) 50 V DC, 2 A
Max. terminal load (DC-13) ${ }^{1)}$ on 4-6 (NC) (Inductive load) $24 \vee D C, 0.1$.
Min. terminal load on 1-3 (NC), 1-2 (NO), 4-6 (NC), 4-5 (NO)
$24 \vee D C 10 \mathrm{~mA}, 24 \vee \mathrm{AC} 20 \mathrm{~mA}$

| Environment according to EN 60664-1 overvoltage category III/pollution degree 2 |  |
| :---: | :---: |
| 1) IEC 60947 part 4 and 5 |  |
| The relay contacts are galvanically isolated from the rest of the circuit by reinforced isolation (PELV). |  |
| 2) Overvoltage Category II |  |
| 3) Ul applications 300 V AC 2 A |  |
| Control card, 10 V DC output: |  |
| Terminal number | 50 |
| Output voltage | $10.5 \mathrm{~V} \pm 0.5 \mathrm{~V}$ |
| Max, load | 25 mA |
| The $10 \vee D C$ supply is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals. |  |
| Control characteristics: |  |
| Resolution of output frequency at $0-1000 \mathrm{~Hz}$ | $:+/-0.003 \mathrm{~Hz}$ |
| System response time (terminals 18, 19, 27, 29, 32, 33) | $\leq \leq 2 \mathrm{~ms}$ |
| Speed control range (open-loop) | 1:100 of synchronous speed |
| Speed accuracy (open-loop) | $30-4000 \mathrm{rpm}$ : Maximum error of $\pm 8 \mathrm{rpm}$ |
| All control charactenistios are based on a 4-pole asynchronous motor |  |
| Surroundings: |  |
| Enclosure type A | IP 20/Chassis, IP 21kit/Type 1, IP55/Type12, IP 66 |
| Enclosure type B1/B2 | IP 21/Type 1, IP55/Type12, IP 66 |
| Enclosure type B3/B4 | [P20/Chassis |
| Enclosure type C1/C2 | IP 21/Type 1, IP55/Type 12, IP66 |
| Enclosure type C3/C4 | IP20/Chassis |
| Enclosure type D1/D2/E1 | IP21/Type 1, IP54/Type12 |
| Enclosure type D3/D4/E2 | IP00/Chassis |
| Enclosure kit available s enclosure type A | IP21/TYPE 1/IP 4X top |
| Vibration test enclosure $\mathrm{A} / \mathrm{B} / \mathrm{C}$ | 1.0 g |
| Vibration test enclosure D/E/F | 0.79 |
| Max. relative humidity | 21-3-3; Class 3 K 3 (non-condensing) during operation |
| Aggressive environment (IEC 721-3-3), uncoated | class 3C2 |
| Aggressive environment (IEC 721-3-3), coated | class 3C3 |
| Test method according to IEC 60068-2-43 H2S (10 days) |  |
| Ambient temperature | Max. $122^{\circ} \mathrm{F}\left[50^{\circ} \mathrm{C}\right]$ |
| Derabing for high ambient temperature, see section on special conditions |  |
| Minimum ambient temperature during full-scale operation | $32^{\circ} \mathrm{F}\left[0^{\circ} \mathrm{C}\right]$ |
| Minimum ambient temperature at reduced performance | $14^{\circ} \mathrm{F}\left[-10^{\circ} \mathrm{C}\right]$ |
| Temperature during storage/transport | $-13^{\circ}-+^{\circ} 149 / /^{\circ} 158^{\circ} \mathrm{F}\left[-25^{\circ}+65^{\circ} / 70^{\circ} \mathrm{C}\right]$ |
| Maximum altitude above sea level without derating | $3280 \mathrm{ft}[1000 \mathrm{~m}]$ |
| Maximum albitude above sea level with derating | 9842 ft [ 3000 m ] |
| Derating for high altitude, see section on special conditions. |  |
| EMC standards, Emission | EN 61800-3, EN 61000-6-3/4, EN 55011, IEC 61800-3 |
|  | EN 61800-3, EN 61000-6-1/2, |
| EMC standards, Immunity | 000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6 |
| See section on special conditions | - . |
| Control card performance: |  |
| Scan interval | : 5 ms |
| Control card, USB serial communication: |  |
| USB standard | 1.1 (Full speed) |
| USB plug | USB type B "device" plug |

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10 Specifications

### 10.2 Special Conditions

### 10.2.1 Purpose of Derating

Derating must be taken into account when using the adjustable frequency drive at low air pressure (high elevations), at low speeds, with long motor cables, cables with a large cross-section or at high ambient temperature. The required action is described in this section.

### 10.2.2 Derating for Low Air Pressure

The cooling capability of air is decreased at a lower air pressure.

At an altitude lower than $3,280 \mathrm{ft}$ [ $1,000 \mathrm{~m}$ ], no derating is necessary, but above $3,280 \mathrm{ft}$ [ $1,000 \mathrm{~m}$ ], the ambient temperature ( $T_{\text {Ama }}$ ) or max. output current ( Iout) ) should be derated in accordance with the diagram shown.


Figure 10.1: Derating of output current versus altitude at $T_{\text {AMB, max }}$ for frame sizes $A, B$ and $C$. At altitudes above 6,600 feet [ 2 km ], please contact Danfoss regarding PELV.

An alternative is to lower the ambient temperature at high altitudes and thereby ensure $100 \%$ output current at high altitudes. As an example of how to read the graph, the situation at $6,600 \mathrm{ft}$ [ 2 km ] is elaborated. At a temperature of $113^{\circ} \mathrm{F}\left[45^{\circ} \mathrm{C}\right]\left(\mathrm{T}_{\text {AMB, }}\right.$ max $\left.-3.3 \mathrm{~K}\right), 91 \%$ of the rated output current is available. At a temperature of $107^{\circ} \mathrm{F}\left[41.7^{\circ} \mathrm{C}\right], 100 \%$ of the rated output current is available.



Derating of output current versus alditude at $T_{\text {AMB }}$ max for frame sizes $D, E$ and $F$.

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### 10.2.3 Derating for Running at Low Speed

When a motor is connected to an adjustable frequency drive, it is necessary to make sure that the cooling of the motor is adequate. The level of heating depends on the load on the motor as well as the operating speed and time.

## Constant torque applications (CT mode)

A problem may occur at low RPM values in constant torque applications. In a constant torque application, a motor may overheat at low speeds due to less cooling air from the motor integral fan.
Therefore, if the motor is to be run continuously at an RPM value lower than half of the rated value, the motor must be supplied with additional air-cooling (or a motor designed for this type of operation may be used).

An alternative is to reduce the load level of the motor by choosing a larger motor. However, the design of the adjustable frequency drive limits the motor size.

## Variable (quadratic) torque applications (VT)

In VT applications such as centrifugal pumps and fans, where the torque is proportional to the square of the speed and the power is proportional to the cube of the speed, there is no need for additional cooling or de-rating of the motor.

In the graphs shown below, the typical VT curve is below the maximum torque with de-rating and maximum torque with forced cooling at all speeds.

Maximum load for a standard motor at $104^{\circ} \mathrm{F}\left[40^{\circ} \mathrm{C}\right]$ driven by an adjustable frequency drive type VLT FCOOX


Legend: - - - -Typical torque at VT load $\rightarrow$ Max torque with forced cooling $\longrightarrow$ Max torque
Note 1) Oversyncronous speed operation will result in the available motor torque decreasing inversely proportional to the increase in speed. This must be considered during the design phase to avoid overloading the motor.

### 10.2.4 Automatic Adaptations to Ensure Performance

The adjustable frequency drive constantly checks for critical levels of internal temperakure, load current, high voltage on the intermediate circuit and low motor speeds. As a response to a critical level, the adjustable frequency drive can adjust the switching frequency and / or change the switching pattern in order to ensure the performance of the adjustable frequency drive. The capability to automaticaliy reduce the output current extends the acceptable operating conditions even further.

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# TECHNICAL DATA SHEET 

## For

## SEWAGE PUMP STATION SP210 Nudgee Beach

Equipment Type: Delivery Pressure Transmitter
Location: Common Control
Model Numbers: VEGABAR 74
Manufacturer: Vega
Supplier:
Vega398 The Boulevard
Kirrawee
NSW2232

## Operating Instructions VEGABAR 74 <br> 4 ... $20 \mathrm{~mA} / \mathrm{HART}$




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## Supplementary documentation

## i

## Information:

Depending on the ordered version, supplementary documentation belongs to the scope of delivery. You find this documentation in chapter "Product description".

## Instructions manuals for accessories and replacement parts

## i

Tip:
To ensure reliable setup and operation of your VEGABAR 74, we offer accessories and replacement parts. The associated documents are:

- Supplementary instructions manual 32036 "Welded socket and seals"
- Operating instructions manual 32798 "Breather housing VEGABOX 02"
- Operating instructions manual 20591 "External indicating and adjustment unit VEGADIS 12"


## 1 About this document

## 1．1 Function

This operating instructions manual provides all the information you need for mounting，connection and setup as well as important instructions for maintenance and fault rectification． Please read this information before putting the instrument into operation and keep this manual accessible in the immediate vicinity of the device．

## 1．2 Target group

This operating instructions manual is directed to trained personnel．The contents of this manual should be made available to these personnel and put into practice by them．

## 1．3 Symbolism used

iInformation，tip，note
This symbol indicates helpful additional information．
Caution：If this warning is ignored，faults or malfunc－ tons can result．
Warning：If this warning is ignored，injury to persons and／or serious damage to the instrument can result．
Danger：If this warning is ignored，serious injury to persons and／or destruction of the instrument can result．


## Ex applications

This symbol indicates special instructions for Ex applications．
－List
The dot set in front indicates a list with no implied sequence．
$\rightarrow \quad$ Action
This arrow indicates a single action．

## 1 Sequence

Numbers set in front indicate successive steps in a procedure．

## 2 For your safety

### 2.1 Authorised personnel

All operations described in this operating instructions manual must be carried out only by trained specialist personnel authorised by the operator.

During work on and with the device the required personal protection equipment must always be worn.

### 2.2 Appropriate use

VEGABAR 74 is a pressure transmitter for measurement of gauge pressure, absolute pressure and vacuum.

You can find detailed information on the application range in chapter "Product description".

Operational reliability is ensured only if the instrument is properly used according to the specifications in the operating instructions manual as well as possible supplementary instructions.

Due to safety and warranty reasons, any invasive work on the device beyond that described in the operating instructions manual may be carried out only by personnel authorised by the manufacturer. Arbitrary conversions or modifications are explicitly forbidden.

### 2.3 Warning about misuse

Inappropriate or incorrect use of the instrument can give rise to application-specific hazards, e.g. vessel overfill or damage to system components through incorrect mounting or adjustment.

### 2.4 General safety instructions

This is a high-tech instrument requiring the strict observance of standard regulations and guidelines. The user must take note of the safety instructions in this operating instructions manual, the country-specific installation standards as well as all prevailing safety regulations and accident prevention rules.

The instrument must only be operated in a technically flawless and reliable condition. The operator is responsible for troublefree operation of the instrument.

During the entire duration of use，the user is obliged to determine the compliance of the required occupational safety measures with the current valid rules and regulations and also take note of new regulations．

## 2．5 Safety approval markings and safety tips

The safety approval markings and safety tips on the device must be observed．

## 2．6 CE conformity

VEGABAR 74 is in CE conformity with EMC（89／336／EWG）， fulfils NAMUR recommendation NE 21 and is in CE conformity with LVD（73／23／EWG）．

Conformity has been judged according to the following standards：
－EMC：
－Emission EN 61326： 2004 （class B）
－Susceptibility EN 61326： 2004 including supplement A
－LVD：EN 61010－1： 2001
VEGABAR 74 is not subject to the pressure device guideline．${ }^{1)}$

## 2．7 Fulfilling NAMUR recommendations

VEGABAR 74 fulfills the following NAMUR recommendations：
－NE 21 （interference resistane and emitted interference）
－NE 43 （signal level for failure information）
－NE 53 （compatibility sensor and indicating／adjustment components）
VEGA instruments are generally upward and downward compatible：
－Sensor software to DTM VEGABAR 74 HART
－DTM VEGABAR 74 for adjustment software PACTware ${ }^{\text {TM }}$ The parameter adjustment of the basic sensor functions is independent of the software version．The range of available functions depends on the respective software version of the individual components．

The software version of VEGABAR 74 HART can be read out via PACTware ${ }^{\text {TM }}$ ．

[^8]You can view all software histories on our website www.vega. com. Make use of this advantage and get registered for update information via e-mail.

### 2.8 Safety instructions for Ex areas

Please note the Ex-specific safety information for installation and operation in Ex areas. These safety instructions are part of the operating instructions manual and come with the Exapproved instruments.

### 2.9 Environmental instructions

Protection of the environment is one of our most important duties. That is why we have introduced an environment management system with the goal of continuously improving company environmental protection. The environment management system is certified according to DIN EN ISO 14001.

Please help us fulfil this obligation by observing the environmental instructions in this manual:

- Chapter "Packaging, transport and storage"
- Chapter "Disposal"


## 3 Product description

## 3．1 Configuration

## Scope of delivery

## Components

The scope of delivery encompasses：
－VEGABAR 74 pressure transmitter
－Documentation
－this operating instructions manual
－Test certificate for pressure transmitters
－Ex－specific＂Safety instructions＂（with Ex－versions）
－if necessary，further certificates
VEGABAR 74 consists of the following components：
－Process fitting with measuring cell
－Housing with electronics
－Connection cable（direct cable outlet）
The components are available in different versions．


Fig．1：Example of a VEGABAR 74 with process fitting G11⁄2 A
1 Connection cable
2 Housing with electronics
3 Process fitting with measuring cell

## Area of application

## Functional principle

Supply

### 3.2 Principle of operation

VEGABAR 74 is a pressure transmitter for use in the paper, food processing and pharmaceutical industry. Thanks to the high protection class IP 68/IP 69K it is particularly suitable for use in humid environment. Depending on the version, it is used for level, gauge pressure, absolute pressure or vacuum measurements. Measured products are gases, vapours and liquids, also with abrasive contents.

The sensor element is the CERTEC ${ }^{\circledR}$ measuring cell with flush, abrasion resistant ceramic diaphragm. The hydrostatic pressure of the medium or the process pressure causes a capacitance change in the measuring cell via the diaphragm. This change is converted into an appropriate output signal and outputted as measured value.
The CERTEC ${ }^{\circledR}$ measuring cell is also equipped with a temperature sensor. The temperature value can be processed via the signal output.

Two-wire electronics $4 \ldots 20 \mathrm{~mA} / \mathrm{HART}$ for power supply and measured value transmission over the same cable.

The supply voltage range can differ depending on the instrument version.

The data for power supply are stated in chapter "Technical data" in the "Supplement".

### 3.3 Operation

VEGABAR $744 \ldots 20 \mathrm{~mA} / \mathrm{HART}$ can be adjusted with different adjustment media:

- with external adjustment/indication VEGADIS 12
- an adjustment software according to FDT/DTM standard, e.g. PACTware ${ }^{\text {TM }}$ and PC
- with a HART handheld

The kind of adjustment and the adjustment options depend on the selected adjustment component. The entered parameters are generally saved in the respecitive sensor, when adjusting with PACTware ${ }^{\top M}$ and PC optionally also in the PC.

3．4 Packaging，transport and storage
Your instrument was protected by packaging during transport． Its capacity to handle normal loads during transport is assured by a test according to DIN EN 24180.

The packaging of standard instruments consists of environ－ ment－friendly，recyclable cardboard．For special versions，PE foam or PE foil is also used．Dispose of the packaging material via specialised recycling companies．

Transport must be carried out under consideration of the notes on the transport packaging．Nonobservance of these instruc－ tions can cause damage to the device．

The delivery must be checked for completeness and possible transit damage immediately at receipt．Ascertained transit damage or concealed defects must be appropriately dealt with．

Up to the time of installation，the packages must be left closed and stored according to the orientation and storage markings on the outside．

Unless otherwise indicated，the packages must be stored only under the following conditions：
－Not in the open
－Dry and dust free
－Not exposed to corrosive media
－Protected against solar radiation
－Avoiding mechanical shock and vibration
－Storage and transport temperature see＂Supplement－ Technical data－Ambient conditions＂
－Relative humidity 20 ．．． $85 \%$

Materials, wetted parts

Temperature limits

## Connection

## 4．2 Mounting steps

Sealing／Screwing in threaded versions

Sealing／Screwing in flange
versions

Sealing／Screwing in hygienic fittings

Seal the thread with teflon，hemp or a similar resistant seal material on the process fitting thread $11 / 2$ NPT．
$\rightarrow$ Screw VEGABAR 74 into the welded socket．Tighten the hexagon on the process fitting with a suitable wrench． Wrench size，see chapter＂Dimensions＂．

Seal the flange connections according to DIN／ANSI with a suitable，resistant seal and mount VEGABAR 74 with suitable screws．

Use the seal suitable for the respective process fitting．You can find the components in the line of VEGA accessories in the supplementary instructions manual＂Welded socket and seals＂．

Note safety instructions

Take note of safety instructions for Ex applications


Select power supply

## 1

Selecting connection cable

## 5 Connecting to power supply

### 5.1 Preparing the connection

Always keep in mind the following safety instructions:

- Connect only in the complete absence of line voltage
- If overvoltage surges are expected, versions with integrated overvoltage arresters should be used or external overvoltage arresters should be installed

Tip:
We recommend the version of VEGABAR 74 with integrated overvoltage arrester or VEGA type ÜSB62-36G.X as external overvoltage arreaster.

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

Power supply and current signal are carried on the same twowire cable. The voltage supply range can differ depending on the instrument version.

The data for power supply are stated in chapter "Technical data" in the "Supplement".

Provide a reliable separation of the supply circuit from the mains circuits according to DIN VDE 0106 part 101.

VEGA power supply units VEGATRENN 149AEx, VEGASTAB 690, VEGADIS 371 as well as all VEGAMETs meet this requirement. When using one of these instruments, protection class III is ensured for VEGABAR 74.

Bear in mind the following factors regarding supply voltage:

- Output voltage of the power supply unit can be lower under nominal load (with a sensor current of 20.5 mA or 22 mA in case of fault message)
- Influence of additional instruments in the circuit (see load values in chapter "Technical data")

VEGABAR 74 is connected with standard two-wire cable without screen. An outer cable diameter of $5 \ldots 9 \mathrm{~mm}$ ensures the seal effect of the cable gland when connecting via VEGABOX 02 or VEGADIS 12. If electromagnetic interference is expected which is above the test values of EN 61326 for
industrial areas，screened cable should be used．For HART multidrop operation we recommend as standard practice the use of screened cable．


Fig．3：Connection of VEGABAR 74
1 Direct connection
2 Connection via VEGABOX 02 or VEGADIS 12

Cable screening and ground－ ing

## Select connection

 cable for Ex applica－ tions

If screened cable is necessary，connect the cable screen on both ends to ground potential．In the VEGABOX 02 or VEGADIS 12，the screen must be connected directly to the internal ground terminal．The ground terminal on the outside of the housing must be connected to the potential equalisation （low impedance）．

If potential equalisation currents are expected，the connection on the processing side must be made via a ceramic capacitor （e．g． $1 \mathrm{nF}, 1500 \mathrm{~V}$ ）．The low frequency potential equalisation currents are thus suppressed，but the protective effect against high frequency interference signals remains．

Take note of the corresponding installation regulations for Ex applications．In particular，make sure that no potential equal－ isation currents flow over the cable screen．In case of grounding on both sides this can be achieved by the use of a capacitor or a separate potential equalisation．

### 5.2 Connection procedure

## Direct connection

Via VEGABOX 01 or VEGADIS 12

Proceed as follows:
1 Wire the connection cable up to the connection compartment. The bending radius must be at least $25 \mathrm{~mm} .{ }^{2}$ )
2 Connect the wire ends to the screw terminals according to the wiring plan

Proceed as follows:
1 Snap connection housing onto the carrier rail or screw it to the mounting plate
2 Loosen the cover screws and remove the cover
3 Insert the cable through the cable entry into the connection housing housing
4 Loosen the screws with a screwdriver
5 Insert the wire ends into the open terminals according to the wiring plan
6 Tighten the screws with a screwdriver
7 Check the hold of the wires in the terminals by lightly pulling on them
8 Tighten the compression nut of the cable entry. The seal ring must completely encircle the cable
9 Connect the supply cable according to steps 3 to 8
10 Screw the housing cover back on
The electrical connection is finished.

## 5．3 Wiring plan

## Direct connection



Fig．4：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 01 to terminal $3^{33}$
4 Screen
5 Breather capillaries with filter element


Fig．5：Terminal assignment VEGABAR 74
1 To power supply or the processing system
2 Screen ${ }^{4}$

| Wire number | Wire colour／Polarity | VEGABAR 74 terminal |
| :--- | :--- | :--- |
| 1 | brown $(+)$ | 1 |
| 2 | blue（－） | 2 |
| 3 | Yellow | 2 |
|  | Screen | Ground |

3）For customer－specific versions already connected with blue（－）when being shipped．
4）Connect screen to ground terminal．Connect ground terminal on the outside of the housing as prescribed．The two terminals are galvanically connected．

## Connection via VEGADIS 12



Fig. 6: Terminal assignment, VEGADIS 12
1 To power supply or the processing system
2 Control instrument (4 ... 20 mA measurement)
3 Screen ${ }^{5}$
4 Breather capillaries
5 Suspension cable

| Wire number | Wire colour/Polarity | Terminal VEGADIS <br> 12 |
| :--- | :--- | :--- |
| 1 | brown $(+)$ | 1 |
| 2 | blue $(-)$ | 2 |
| 3 | Yellow | 3 |

5) Connect screen to ground terminal. Connect ground terminal on the outside of the housing as prescribed. The two terminals are galvanically connected.

## 6 Set up

### 6.1 Setup steps without VEGADIS 12

After mounting and electrical connection, VEGABAR 74 is ready for operation.
$\rightarrow$ Switch on voltage
The electronics now carries out a self-check for approx. 2 seconds. Then VEGABAR 74 delivers a current of $4 \ldots 20 \mathrm{~mA}$ according to the actual level.

### 6.2 Setup steps with VEGADIS 12

Adjustment volume

- zero - measuring range begin
- span - measuring range end
- ti - Integration time


## Adjustment system

Adjustment steps, adjustment
Proceed as follows for adjustment with VEGADIS 12:
1 Open housing cover
2 Connect hand multimeter to terminals 10 and 12
3 Meas. range begin: Set rotary switch to "zero"

4 Empty the vessel or reduce process pressure
5 Set a current of 4 mA with the［ +$]$ and［ -$]$ keys
6 Meas．range end：Set rotary switch to＂span＂
7 Fill the vessel or increase process pressure
8 Set a current of 20 mA with the［＋］and［－］keys
9 Operation：Set rotary switch to＂OPERATE＂
10 Close housing cover
The adjustment data are effective，the output current $4 \ldots 20 \mathrm{~mA}$ corresponds to the actual level．

Adjustment steps，integration time

Adjustment steps，scaling

Proceed as follows for the adjustment of the integration time with VEGADIS 12：

1 Open housing cover
2 Set rotary switch to＂$t$＂
3 By pushing the［－］key 10 －times，make sure that the integration time is set to 0 sec ．
4 For every 1 sec ．requested integration time，push the［ + ］ key once．
5 The integration time is the time required by the output current signal to reach $90 \%$ of the actual height after a sudden level change．
6 Set rotary switch to＂OPERATE＂
7 Close housing cover
The display outputs the current $4 \ldots 20 \mathrm{~mA}$ as bar graph and digital value．

With 4 mA no segment of the bar graph appears，with 20 mA all segments appear．This assignment is fix．

You can scale the digital value to any value between－9999 ．．． +9999 via the adjustment module．

Proceed as follows for scaling the indication of VEGADIS 12：
1 Open housing cover
2 Initial value：Set rotary switch to＂zero＂
3 Set the requested value，e．g． 0 with the［＋］and［－］keys
4 Final value：Set the rotary switch to＂span＂
5 Set the requested value，e．g． 1000 with the［＋］and［－］keys
6 Decimal point：Set the rotary switch to＂point＂
7 With the［＋］and［－］keys you can adjust the requested value，e．g． 8888 （no decimal point）

8 Set rotary switch to＂OPERATE＂
9 Close housing cover
The adjustment data are effective，the output current $4 \ldots 20 \mathrm{~mA}$ corresponds to the actual level．

## 7 Setup with PACTware ${ }^{\text {TM }}$

### 7.1 Connect the PC with VEGACONNECT 3

Connecting the PC to the signal cable

## 7．2 Connect the PC with VEGACONNECT 4

## Connection via HART



Fig．9：Connecting the PC via HART to the signal cable
1 VEGABAR 74
2 HART resistance 250 Ohm（optional depending on the processing）
3 Connection cable with 2 mm pins and terminals
4 Processing system／PLCNoltage supply

Necessary components：
－VEGABAR 74
－PC with PACTware ${ }^{\text {TM }}$ and suitable VEGA DTM
－VEGACONNECT 4
－HART resistance 250 Ohm（optional depending on the processing）
－Power supply unit or processing system

## Note：

With power supply units with integrated HART resistance （internal resistance approx． 250 Ohm），an additional external resistance is not necessary．This applies，e．g．to the VEGA instruments VEGATRENN 149A，VEGADIS 371，VEGAMET 381）．Also usual Ex separators are most of the time equipped with a sufficient current limitation resistor．In such cases， VEGACONNECT 4 can be connected parallel to the $4 \ldots 20 \mathrm{~mA}$ cable．

### 7.3 Parameter adjustment with PACTware ${ }^{\text {TM }}$

Further setup steps are described in the operating instructions manual "DTM Collection/PACTware ${ }^{\text {TM }}$ attached to each CD and which can also be downloaded from our homepage. A detailed description is available in the online help of PACTware ${ }^{\text {TM }}$ and the VEGA DTMs.

## Note:

Keep in mind that for setup of VEGABAR 74, DTM-Collection in the actual version must be used.

All currently available VEGA DTMs are provided in the DTM Collection on CD and can be obtained from the responsible VEGA agency for a token fee. This CD includes also the up-todate PACTware ${ }^{\text {M }}$ version. The basic version of this DTM Collection incl. PACTware ${ }^{\text {TM }}$ is also available as a free-ofcharge download from the Internet.

Go via www.vega.com and "Downloads" to the item "Software".

### 7.4 Parameter adjustment with AMS ${ }^{\text {TM }}$ and PDM

For VEGA sensors, instrument descriptions for the adjustment programs AMS $^{\text {M }}$ and PDM are available as DD or EDD. The instrument descriptions are already implemented in the current versions of $A M S^{\top M}$ and PDM. For older versions of $A M S^{T M}$ and PDM, a free-of-charge download is available via Internet.

Go via www.vega.com and "Downloads" to the item "Software".

### 7.5 Saving the parameter adjustment data

It is recommended to document or save the parameter adjustment data. They are hence available for multiple use or service purposes.

The VEGA DTM Collection and PACTware ${ }^{T M}$ in the licensed, professional version provide suitable tools for systematic project documentation and storage.

## 8 Maintenance and fault rectification

## 8．1 Maintenance

When used as directed in normal operation，VEGABAR 74 is completely maintenance free．

## 8．2 Fault clearance

## Reaction in case of failures

## Causes of malfunction

24 hour service hotline

Checking the 4 ．．． 20 mA sig－ nal

The operator of the system is responsible for taken suitable measures to remove interferences．

VEGABAR 74 offers maximum reliability．Nevertheless faults can occur during operation．These may be caused by the following，e．g．：
－Sensor
－Process
－Supply
－Signal processing
The first measures to be taken are to check the output signals as well as to evaluate the error messages via the indicating and adjustment module．The procedure is described below． Further comprehensive diagnostics can be carried out on a PC with the software PACTware ${ }^{\text {TM }}$ and the suitable DTM．In many cases，the causes can be determined in this way and faults can be rectified．

However，if these measures are not successful，call the VEGA service hotline in urgent cases under the phone no．＋49 1805 858550.

The hotline is available to you 7 days a week round－the－clock． Since we offer this service world－wide，the support is only available in the English language．The service is free of charge，only the standard telephone costs will be charged．

Connect a handheld multimeter in the suitable measuring range according to the wiring plan．
？ $4 \ldots 20 \mathrm{~mA}$ signal not stable
－Level fluctuations
$\rightarrow$ Adjust integration time via PACTware ${ }^{\text {TM }}$
－no atmospheric pressure compensation
$\rightarrow$ Check the capillaries and cut them clean
$\rightarrow$ Check the pressure compensation in the housing and clean the filter element, if necessary
? $4 \ldots 20 \mathrm{~mA}$ signal missing

- Wrong connection to power supply
$\rightarrow$ Check connection according to chapter "Connection steps" and if necessary, correct according to chapter "Wiring plan"
- No voltage supply
$\rightarrow$ Check cables for breaks; repair if necessary
- supply voltage too low or load resistance too high
$\rightarrow$ Check, adapt if necessary
? Current signal $3.6 \mathrm{~mA} ; 22 \mathrm{~mA}$
- electronics module or measuring cell defective
$\rightarrow$ Exchange instrument or return instrument for repair

In Ex applications, the regulations for the wiring of intrinsically safe circuits must be observed.

Reaction after fault rectification

## 9 Dismounting

## 9．1 Dismounting steps

## Warning：

Before dismounting，be aware of dangerous process con－ ditions such as e．g．pressure in the vessel，high temperatures， corrosive or toxic products etc．

Take note of chapters＂Mounting＂and＂Connecting to power supply＂and carry out the listed steps in reverse order．

## 9．2 Disposal

The instrument consists of materials which can be recycled by specialised recycling companies．We use recyclable materials and have designed the electronics to be easily separable．

## WEEE directive 2002／96／EG

This instrument is not subject to the WEEE directive 2002／96／
$E G$ and the respective national laws（in Germany，e．g．
ElektroG）．Pass the instrument directly on to a specialised recycling company and do not use the municipal collecting points．These may be used only for privately used products according to the WEEE directive．

Correct disposal avoids negative effects to persons and environment and ensures recycling of useful raw materials．

Materials：see chapter＂Technical data＂
If you cannot dispose of the instrument properly，please contact us about disposal methods or return．

## 10 Supplement

### 10.1 Technical data

## General data

Manufacturer
Type name
Parameter, pressure
Measuring principle
Communication interface

VEGA Grieshaber KG, D-77761 Schiltach VEGABAR 74
Gauge pressure, absolute pressure, vacuum
Ceramic-capacitive, dry measuring cell
None

## Materials and weights

Material 316L corresponds to 1.4404 or 1.4435
Materials, wetted parts

- Process fitting
- Diaphragm
- Seal
- Seal process fitting thread $G 1 / 2 A$, G11/2 A

Materials, non-wetted parts

- Housing
- Ground terminal
- Connection cable
- type label support on cable

Weight

316L
sapphire ceramic ${ }^{\circledR}$ ( $99.9 \%$ oxide ceramic) FKM (e.g. Viton), Kalrez 6375, EPDM, Chemraz 535
Klingersil C-4400

316L
316Ti/316L
PUR, FEP, PE
PE-HART
$0.8 \ldots 8 \mathrm{~kg}$ (1.8 ... 17.6 lbs ), depending on process fitting

## Output variable

Output signal
Failure signal
Max. output current
Damping ( $63 \%$ of the input variable)
Step response or adjustment time
Fulfilled NAMUR recommendations
$4 \ldots 20 \mathrm{~mA} / \mathrm{HART}$
$22 \mathrm{~mA}(3.6 \mathrm{~mA})$, adjustable
22.5 mA
$0 \ldots 10 \mathrm{~s}$, adjustable
70 ms (ti: $0 \mathrm{~s}, 0 \ldots 63 \%$ )
NE 43

## Additional output parameter - temperature

'rocessing is made via HART-Multidrop

Range
Resolution
Accuracy
－in the range of $0 \ldots+100^{\circ} \mathrm{C}$ $\left(+32 \ldots+212^{\circ} \mathrm{F}\right)$
－in the range of $-50 \ldots 0^{\circ} \mathrm{C}$ $\left(-58 \ldots+32^{\circ} \mathrm{F}\right)$ and $+100 \ldots+150^{\circ} \mathrm{C}$ （ $+212 \ldots+302^{\circ} \mathrm{F}$ ）
$-50 \ldots+150^{\circ} \mathrm{C}\left(-58 \ldots+302^{\circ} \mathrm{F}\right)$
$1^{\circ} \mathrm{C}\left(1.8^{\circ} \mathrm{F}\right)$
$\pm 3 \mathrm{~K}$
typ．$\pm 4 \mathrm{~K}$

## Input variable

## Adjustment

| Zero adjustable | $-20 \ldots+95 \%$ of the nominal measuring range |
| :--- | :--- |
| Span adjustable | $3.3 \ldots+120 \%$ of the nominal measuring rang $\epsilon$ |
| Recommended max．turn down | $10: 1$ |

## Nominal measuring ranges and overload resistance

| Nominal range |  |  |
| :--- | :--- | :--- | :--- |
| Gauge pressure |  |  |
| $0 \ldots 0.1 \mathrm{bar} / 0 \ldots 10 \mathrm{kPa}$ | $15 \mathrm{bar} / 1500 \mathrm{kPa}$ | $-0.2 \mathrm{bar} /-20 \mathrm{kPa}$ |
| $0 \ldots 0.2 \mathrm{bar} / 0 \ldots 20 \mathrm{kPa}$ | $20 \mathrm{bar} / 2000 \mathrm{kPa}$ | $-0.4 \mathrm{bar} /-40 \mathrm{kPa}$ |
| $0 \ldots 0.4 \mathrm{bar} / 0 \ldots 40 \mathrm{kPa}$ | $30 \mathrm{bar} / 3000 \mathrm{kPa}$ | $-0.8 \mathrm{bar} /-80 \mathrm{kPa}$ |
| $0 \ldots 1 \mathrm{bar} / 0 \ldots 100 \mathrm{kPa}$ | $35 \mathrm{bar} / 3500 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $0 \ldots 2.5 \mathrm{bar} / 0 \ldots 250 \mathrm{kPa}$ | $50 \mathrm{bar} / 5000 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $0 \ldots 5 \mathrm{bar} / 0 \ldots 500 \mathrm{kPa}$ | $65 \mathrm{bar} / 6500 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $0 \ldots 10 \mathrm{bar} / 0 \ldots 1000 \mathrm{kPa}$ | $90 \mathrm{bar} / 9000 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $0 \ldots 25 \mathrm{bar} / 0 \ldots 2500 \mathrm{kPa}$ | $130 \mathrm{bar} / 13000 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $0 \ldots 60 \mathrm{bar} / 0 \ldots 6000 \mathrm{kPa}$ | $200 \mathrm{bar} / 20000 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $-1 \ldots 0 \mathrm{bar} /-100 \ldots 0 \mathrm{kPa}$ | $35 \mathrm{bar} / 3500 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $-1 \ldots 1.5 \mathrm{bar} /-100 \ldots 150 \mathrm{kPa}$ | $50 \mathrm{bar} / 5000 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $-1 \ldots 5 \mathrm{bar} /-100 \ldots 500 \mathrm{kPa}$ | $65 \mathrm{bar} / 6500 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $-1 \ldots 10 \mathrm{bar} /-100 \ldots 1000 \mathrm{kPa}$ | $90 \mathrm{bar} / 9000 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $-1 \ldots 25 \mathrm{bar} /-100 \ldots 2500 \mathrm{kPa}$ | $130 \mathrm{bar} / 13000 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $-1 \ldots 60 \mathrm{bar} /-100 \ldots 6000 \mathrm{kPa}$ | $300 \mathrm{bar} / 30000 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| $-0.05 \ldots 0.05 \mathrm{bar} /-5 \ldots 5 \mathrm{kPa}$ | $15 \mathrm{bar} / 1500 \mathrm{kPa}$ | $-0.2 \mathrm{bar} /-20 \mathrm{kPa}$ |
| $-0.1 \ldots 0.1 \mathrm{bar} /-10 \ldots 10 \mathrm{kPa}$ | $20 \mathrm{bar} / 2000 \mathrm{kPa}$ | $-0.4 \mathrm{bar} /-40 \mathrm{kPa}$ |

[^9]| Nominal range | Overload, max. pres- <br> sure6) | Overload, min. pressure |
| :--- | :--- | :--- |
| $-0.2 \ldots 0.2 \mathrm{bar} /-20 \ldots 20 \mathrm{kPa}$ | $30 \mathrm{bar} / 3000 \mathrm{kPa}$ | $-0.8 \mathrm{bar} /-80 \mathrm{kPa}$ |
| $-0.5 \ldots 0.5 \mathrm{bar} /-50 \ldots 50 \mathrm{kPa}$ | $35 \mathrm{bar} / 3500 \mathrm{kPa}$ | $-1 \mathrm{bar} /-100 \mathrm{kPa}$ |
| Absolute pressure | $15 \mathrm{bar} / 1500 \mathrm{kPa}$ |  |
| $0 \ldots 0.1 \mathrm{bar} / 0 \ldots 10 \mathrm{kPa}$ | $35 \mathrm{bar} / 3500 \mathrm{kPa}$ |  |
| $0 \ldots 1 \mathrm{bar} / 0 \ldots 100 \mathrm{kPa}$ | $50 \mathrm{bar} / 5000 \mathrm{kPa}$ |  |
| $0 \ldots 2.5 \mathrm{bar} / 0 \ldots 250 \mathrm{kPa}$ | $65 \mathrm{bar} / 6500 \mathrm{kPa}$ |  |
| $0 \ldots 5 \mathrm{bar} / 0 \ldots 500 \mathrm{kPa}$ | $90 \mathrm{bar} / 9000 \mathrm{kPa}$ |  |
| $0 \ldots 10 \mathrm{bar} / 0 \ldots 1000 \mathrm{kPa}$ | $130 \mathrm{bar} / 13000 \mathrm{kPa}$ |  |
| $0 \ldots 25 \mathrm{bar} / 0 \ldots 2500 \mathrm{kPa}$ | $200 \mathrm{bar} / 20000 \mathrm{kPa}$ |  |
| $0 \ldots 60 \mathrm{bar} / 0 \ldots 6000 \mathrm{kPa}$ |  |  |

## Reference conditions and influencing variables (similar to DIN EN 60770-1)

Reference conditions according to DIN EN 61298-1

- Temperature
- Relative humidity
- Air pressure

Determination of characteristics

Characteristics
Reference installation position
.nfluence of the installation position
$+15 \ldots+25^{\circ} \mathrm{C}\left(+59 \ldots+77^{\circ} \mathrm{F}\right)$
45 ... 75 \%
860 ... $1060 \mathrm{mbar} / 86 \ldots 106 \mathrm{kPa}$ (12.5 ... 15.4 psi )

Limit point adjustment according to IEC 61298-2
linear
upright, diaphragm points downward $<0.2 \mathrm{mbar} / 20 \mathrm{~Pa}$ (0.003 psi)

Deviation determined according to the limit point method according to IEC 607707)
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) = nominal measuring range/set span.
Deviation

- Turn down 1:1 up to $5: 1$
- Turn down up to 10:1
$<0.075$ \%
$<0.015 \% \times$ TD
Deviation with absolutely flush process fittings EV, FT
- Turn down 1:1 up to 5:1
$<0.05$ \%
- Turn down up to $10: 1$
$<0.01 \% \times$ TD

7) Incl. non-linearity, hysteresis and non-repeatability.

Deviation with absolute pressure measuring range 0.1 bar
－Turn down 1：1 up to 5：1
$<0.25 \% \times$ TD
－Turn down up to 10：1

$$
<0.05 \% \times \text { TD }
$$

## 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）＝nominal measuring range／set span．

## Average temperature coefficient of the zero signal

In the compensated temperature range of $0 \ldots+100^{\circ} \mathrm{C}\left(+212^{\circ} \mathrm{F}\right)$ ，reference temperature $20^{\circ} \mathrm{C}\left(68^{\circ} \mathrm{F}\right)$ ：

Average temperature coefficient of the zero signal
－Turn down 1：1
$<0.05 \% / 10 \mathrm{~K}$
－Turn down 1：1 up to 5：1
$<0.1$ \％／10 K
－Turn down up to 10：1
＜0．15 \％／10 K
Outside the compensated temperature range：
Average temperature coefficient of the zero signal
－Turn down 1：1
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）＝nominal measuring range／set span．
Long－term drift of the zero signal $<(0.1 \% \times$ TD）／1 year

## Total deviation（similar to DIN 16086）

The total deviation（max．practical deviation）is the sum of basic accuracy and long－term stability：
$F_{\text {total }}=F_{\text {perf }}+F_{\text {stab }}$
$F_{\text {perf }}=\sqrt{ }\left(\left(F_{\mathrm{T}}\right)^{2}+\left(F_{\mathrm{KI}}\right)^{2}\right)$
With
－$F_{\text {total：}}$ Total deviation
－$F_{\text {pert：}}$ Basic accuracy
－$F_{\text {stab：}}$ Long－term drift

- $\mathrm{F}_{\mathrm{T}}$ : Temperature coefficient (influence of medium or ambient temperature)
- $\mathrm{F}_{\mathrm{KI}}$ : Deviation


## Ambient conditions

Ambient, storage and transport temperature

- Connection cable PE
$-40 \ldots+60^{\circ} \mathrm{C}\left(-40 \ldots+140^{\circ} \mathrm{F}\right)$
- Connection cable PUR, FEP $-40 \ldots+85^{\circ} \mathrm{C}\left(-40 \ldots+185^{\circ} \mathrm{F}\right)$


## Process conditions

The specifications of the pressure stage are used as an overview. The specifications on the ype plate are applicable.

Pressure stage, process fitting

- Thread 316L

PN 60

- Thread Alu

PN 25

- Hygienic fittings 316L

PN 10, PN 16, PN 25, PN 40

- Flange 316L, flange with extension 316L

PN 40 or $150 \mathrm{lbs}, 300 \mathrm{lbs}$

Product temperature depending on the measuring cell seal

- FKM (e.g. Viton)
$-20 \ldots+100^{\circ} \mathrm{C}\left(-4 \ldots+212^{\circ} \mathrm{F}\right)$
- EPDM
- Kalrez 6375 (FFKM)
$-40 \ldots+100^{\circ} \mathrm{C}\left(-40 \ldots+212^{\circ} \mathrm{F}\right), 1 \mathrm{~h}: 140^{\circ} \mathrm{C} /$ $284^{\circ} \mathrm{F}$ cleaning temperature
- Chemraz 535

Vibration resistance
Shock resistance
$-10 \ldots+100^{\circ} \mathrm{C}\left(+14 \ldots+212^{\circ} \mathrm{F}\right)$
$-30 \ldots+100^{\circ} \mathrm{C}\left(-22 \ldots+212^{\circ} \mathrm{F}\right)$
mechanical vibrations with 4 g and $5 \ldots 100 \mathrm{~Hz}^{8)}$
Acceleration $100 \mathrm{~g} / 6 \mathrm{~ms}^{9}$

## Electromechanical data

Connection cable

- Configuration
- Wire cross-section
- wire resistance
- Standard length

28432 ᄃ씨-070718
four wires, one suspension cable, one breather capillary, screen braiding, metal foil, mantle
$0.5 \mathrm{~mm}^{2}$ (AWG no. 20)
$<0.036 \mathrm{Ohm} / \mathrm{m}(0.011 \mathrm{Ohm} / \mathrm{ft})$
$6 \mathrm{~m}(19.685 \mathrm{ft})$
$200 \mathrm{~m}(656.168 \mathrm{ft})$
8) Tested according to the regulations of German Lloyd, GL directive 2.
9) Tested according to EN 60068-2-27.
－Min．bending radius at $25^{\circ} \mathrm{C} / 77^{\circ} \mathrm{F}$
－Diameter
－Colour－standard PE
approx． $8 \mathrm{~mm}(0.315 \mathrm{in})$
－Colour－standard PUR
Black
－Colour－Ex－version
Blue
Blue

## Voltage supply

Supply voltage
－Non－Ex instrument
$12 . . .36 \mathrm{~V}$ DC
－EEx ia instrument
12 ．．． 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


Fig．10：Voltage diagram VEGABAR 74
1 HART load
2 Voltage limit Ex instrument
3 Voltage limit non－Ex instrument
4 Voltage supply

Load in conjunction with VEGADIS 12
see diagram


Fig. 11: Voltage diagram VEGABAR 74 with VEGADIS 12
1 HART load
2 Voltage limit Ex instrument
3 Voltage limit non-Ex instrument
4 Voltage supply

## Integrated overvoltage protection

| Nominal leakage current $(8 / 20 \mu \mathrm{~s})$ | 10 kA |
| :--- | :--- |
| Min. response time | $<25 \mathrm{~ns}$ |

Electrical protective measures

Jrotection
Overvoltage category
Protection class

## Approvals ${ }^{10}$

ATEX ia

Ship approvals
Others

IP 68 (25 bar)/IP 69K
III
III

ATEX II 1G EEx ia IIC T6; ATEX II 2G EEx ia IIC T6

GL, LRS, ABS, CCS, RINA, DNV
WHG
10) Deviating data in Ex applications: see separate safety instructions.

## 10．2 Dimensions

## VEGABAR 74 －threaded fitting



Fig．12：VEGABAR 74 threaded fitting：$G V=G 1 / 2$ A manometer connection $E N 837, G I=G 1 / 2 A$ inner $G 1 / 4 A, G G=G 11 / 2 A$ ， $G N=11 / 2 N P T, G M=G 11 / 2 A 70 \mathrm{~mm}, G R=1 / 2$ NPT inner $1 / 4 N P T$

VEGABAR 74 - hygienic fitting 1


Fig. 13: VEGABAR 74 hygienic fitting: $C C=$ Tri-Clamp 11/2", $C A=$ Tri-Clamp 2", LA = hygienic fitting with compression nut F40, TA = Tuchenhagen Varivent DN 32, TB = Tuchenhagen Varivent DN 25, RARB = bolting DN 40/DN 50 according to DIN 11851
$28432^{-\cdots} .070718$

## VEGABAR 74 －hygienic fitting 2



Fig．14：VEGABAR $74 K A / K H=$ cone $D N 40, A A=D R D, S D / S E=$ Anderson $3^{\prime \prime} / \mathrm{long} /$ short fitting

VEGABAR 74 - flange connection


| (1) | DN | PN | D | b | k | d2 | d4 | 1 | RL | d5 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| EA | 40 | 40 | $529 / 32^{\prime \prime}$ | 45/64" | 421/64" | $4 \times 9$ 45/644 | 315/32" | $1 / 88^{\prime \prime}$ |  | - |
| FB | 50 | 40 | $61 / 2^{\prime \prime}$ | 25/32" | $459 / 64^{\prime \prime}$ | $4 \times 845 / 64{ }^{4}$ | 41/64" | $1 / 8^{\prime \prime}$ |  |  |
| FE | 80 | 40 | 77/8" | 15/18" | 619/64" | $8 \times 045 / 64{ }^{4}$ | 57/16" | $1 / 8^{\prime \prime}$ |  |  |


| (2) | " | Ibs | 0 | b | k | d2 | d4 | $f$ | RL | d5 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| FQ | $11 / 2{ }^{\prime \prime}$ | 150 | $5{ }^{\prime \prime}$ | 11/16" | 314/16" | 4×0 5/8" | 27/8" | 1/8" | . |  |
| FH | $2^{\prime \prime}$ | 150 | $6^{\prime \prime}$ | $3 / 4{ }^{4}$ | $43 / 4^{\prime \prime}$ | $4 \times 05 / 8^{\prime \prime}$ | $35 / 8{ }^{\prime \prime}$ | $1 / 8^{\prime \prime}$ | - |  |
| FI | $3^{\prime \prime}$ | 150 | $71 / 2{ }^{\prime \prime}$ | 3/4" | 6 | $4 \times 85 / 8{ }^{\prime \prime}$ | 6 | $1 / 8^{\prime \prime}$ | - | - |


| (3) | DN | PN | D | b | k | d2 | d4 | f | RL | d5 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| TV | 50 | 40 | $61 / 2^{\prime \prime}$ | $25 / 32^{\circ}$ | $459 / 64^{\prime \prime}$ | 4×0 45/64 ${ }^{\text {a }}$ | $41 / 64^{4}$ | $1 / 8^{\prime \prime}$ | (4) | $11 / 2^{\prime \prime}$ |
| TS | 80 | 40 | 77/8" | 15/16 ${ }^{\circ}$ | $619 / 64{ }^{\prime \prime}$ | $8 \times 045 / 64^{4}$ | $57 / 16^{\prime \prime}$ | $1 / 8{ }^{\prime \prime}$ |  | $11 / 2^{\prime \prime}$ |

Fig. 15: VEGABAR 74 - flange connection
1 Flange connection according to DIN 2501
2 Flange fitting according to ANSI B16.5
3 Flange with extension
4 Order-specific

## VEGABAR 74 －threaded fitting for paper industry



BA／BB

Fig．16：VEGABAR 74 －connection for paper industry：$B A / B B=M 44 \times 1.25$

VEGABAR 74 - extension fitting for paper industry


Fig. 17: VEGABAR 74 - extension fitting for paper industry: EV/FT = absolutely flush for pulper (EV 2-times flattened), EG = extension for ball valve fitting ( $L=$ order-specific)

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# TECHNICAL DATA SHEET 

For

## SEWAGE PUMP STATION SP210

## Nudgee Beach

Equipment Type:

Location:

Model Numbers:

Manufacturer:

Supplier:

Wet Well Level Transmitter

Common Control

FMX167

Endress \& Hauser

Unit 8/277 Lane Cove Rd
North Ryde
NSW
2113
Tel: 0288777000
Fax: 0288777099


Technical Information

## Waterpilot FMX167

## Hydrostatic Level Measurement

Reliable and rugged level probe with ceramic measuring cell Compact device for level measurement in fresh water, wastewater and saltwater


## Applications

The Waterpilot FMX167 is a pressure sensor for hydrostatic level measurement. Three versions of FMX107 are available at Endress + Hauser:

- FMXI 67 with an outer diameter $=22 \mathrm{~mm}$ ( 0.87 inch): Version very suitable for drinking water applications and for use in probe tubes with small diameters
- $\mathrm{FMX1} 167$ with an outer diameter $=42 \mathrm{~mm}$ ( 1.66 inch): Heavy version and very easy to clean thanks to the flush-mounted diaphragm. Very suitable for wastewater and sewage treatment plants
- FMX167 with an outer diameter $=29 \mathrm{~mm}$ ( 1.15 inch): Resistant version for use in saltwater and very suitable for applications on ships (e.g. ballast water tanks)


## Your benefits

- High mechanical resistance to overload and aggressive media
- High-precision and long-term stability ceramic measuring cell
- Resistant to climatic changes thanks to potted electronics and 2 -iilter pressure compensation system
- $4 . . .20 \mathrm{~mA}$ output signal with integrated oyervoltage protection
- Simultaneous level and temperature measurement by optional integrated temperature sensor Pt 100
- Drinking water approval: KTW, NSF, ACS
- Certifled to ATEX, FM and CSA
- Marine approval: GL, ABS
- Complete measuring point solutions through comprehensive accessories


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Function and system design

## Device selection

| Waterpilot FMX167 |  |  |  |
| :---: | :---: | :---: | :---: |
| Field of application | Hydrostatic level measurement in deep wells e.g. drinking water | Hydrostatic level measurement in wastewater | Hydrostatic level measurement in saltwater |
| Process connection | - Suspension clamp <br> - Extension cable mounting screw with Gl 1/2 A or $11 / 2$ NPT thread |  |  |
| Outer diameter $\mathrm{d}_{0}$ | 22 mm (0.87 inch) | 42 mm ( 1.00 inch) | Max. 29 mm (1.15 inch) |
| Seals | - FKM Viton <br> - EPDM ${ }^{11}$ | - FKM Viton | - FKM Viton <br> - EPDM |
| Measuring ranges | - Nine fixed pressure measuring ranges from $0 . . .0 .1$ bar to $0 . . .20$ bar $(0 . . .1 \mathrm{~m}$ $0 . .1 .5 \mathrm{psi}$ to $0 . . .300 \mathrm{psi} / 0 \ldots 3 \mathrm{ft} \mathrm{H}_{2} \mathrm{O}$ <br> - Customer-specific measuring ranges; | in bar, $\mathrm{mH}_{2} \mathrm{O}$, psi and $\mathrm{ftH}_{2} \mathrm{O}$, $\mathrm{H}_{2} \mathrm{O}$ to $0 \ldots 200 \mathrm{mH}_{2} \mathrm{O}$ / $100 \ldots .600 \mathrm{ftH}_{2} \mathrm{O}$ ) factory-calibrated | - Seven fixed pressure measuring ranges in bar, $\mathrm{mH}_{2} \mathrm{O}$, psi and $\mathrm{ftH}_{2} \mathrm{O}$, from $0 \ldots 0.1$ bar to $0 \ldots 4$ bar (0...1 $\mathrm{mH}_{2} \mathrm{O}$ to $0 . . .40 \mathrm{mH}_{2} \mathrm{O}$ ) <br> $0 . . .1 .5$ psi to $0 . . .60 \mathrm{psi} /$ <br> $0 . .3 \mathrm{ft}_{2} \mathrm{O}$ to $\left.0 \ldots 150 \mathrm{ftH}_{2} \mathrm{O}\right)$ <br> - Customer-specific measuring ranges; factory-calibrated |
| Overload | Up to 40 bar ( 580 psi ) |  | Up to 25 bar ( 362 psi ) |
| Process temperature | $-10 \ldots+70^{\circ} \mathrm{C}\left(-14 \ldots+158^{\circ} \mathrm{F}\right)$ |  | $0 \ldots+50^{\circ} \mathrm{C}\left(+32 \ldots+122^{\circ} \mathrm{F}\right)$ |
| Ambient temperature range | $-10 \ldots+70^{\circ} \mathrm{C}\left(-14 \ldots+158^{\circ} \mathrm{F}\right)$ |  | $0 \ldots+50^{\circ} \mathrm{C}\left(+32 \ldots+122^{\circ} \mathrm{F}\right)$ |
| Maximum measured error | $\pm 0.2 \%$ of upper range value (URV) |  |  |
| Supply voltage | $10 \ldots 30 \mathrm{~V}$ DC |  |  |
| Output | 4... 20 mA |  |  |
| Options | - Drinking water approva! <br> - Integrated Pt 100 temperature sensor <br> - Integrated Pt 100 temperature sensor and temperature transmitter TMT181 (4... 20 mA ). <br> - Marine approval | - Integrated Pt 100 temperature sensor <br> - Integrated Pt 100 temperature sensor and temperature transmitter TMT181 (4... 20 mA ) <br> - Marine approval | - Integrated Pt 100 temperature sensor <br> - Integrated Pt 100 temperature sensor and temperature transmitter TMT 181 ( $4 . . .20 \mathrm{~mA}$ ) <br> - Marine approval |
| Specialties | - Integrated overvoltage protection <br> - Large selection of approvals, including ATEX 112 G, FM and CSA <br> - High-precision, long-term stable and rugged ceramic measuring cell |  |  |

[^10]
## Measuring principle

The ceramic measuring cell is dry, i.e. pressure acts directly on the rugged ceramic diaphragm of Waterpilot FMX167 and causes it to move by max. 0.005 mm .
The effects of air pressure on the liquid surface are transferred via a pressure compensation tube through the extension cable to the rear of the ceramic diaphragm and compensated. Pressure-dependent changes in capacitance caused by diaphragm movement are measured at the electrodes of the ceramic carrier. The electronics convert the movement into a pressure-proportional signal which is linear to the medium level.


FMX107 measuring principle
1 Ceramic measuring cell
2 Pressure compensation tube
$h$ Level height
p Total pressure $=$ hydrostatic pressure + atmospheric pressure
$\rho \quad$ Medium density
$g$ Gravitational acceleration
$p_{\text {nydt. }}$ Hydrostatic pressure
$p_{\text {atm }}$ Atmospheric pressure

## Temperature measurement with optional Pt 100

Endress+Hauser offers an optional 4-wire Pt 100 resistance thermometer for Waterpilot FMX167 to measure level and temperature simultaneously. The Pt 100 belongs to Accuracy Class B to DIN EN 60751.

Temperature measurement with optional Pt 100 and temperature transmitter TMT181
To convert the Pt 100 signal to a $4 \ldots 20 \mathrm{~mA}$ signal, Endress + Hauser also offers the TMT181 temperature transmitter.

## Measuring system

The complete standard measuring system consists of Waterpilot FMX167 and a transmitter power supply unit with supply voltage of $10 \ldots 30 \mathrm{~V} \mathrm{DC}$.

Example for other measuring point solutions with transmitter and possible evaluation units from Endress+Hauser:


Application examples with FMXIO7
OP Overvoltage protection e.g. HAW from Endress + Hauser

1. Simple cost-effective measuring point solution: Power supply of Waterpilot in hazardous and nonhazardous areas using RN221N active barrier.
Power supply and additional control of two consumers, e.g. pumps, via limit switch RTA421 with onsite display.
2. Power supply, onsite display, two switch outputs and a signal adaptation (turn down) are integrated in evaluation devices RMA421 (for mounting on hat rails) and RIA250 (for panel mounting). The evaluation unit RMA421 also has a trend recognition function, e.g. optimizing pump control in stormwater overllow basins. This function detects and evaluates changes in a measurable value within a specific time period.
3. If several pumps are used, pump life can be prolonged by alternate switching. With alternating pump control, the pump which was out of service for the longest period of time is switched on. The evaluation units RIA452 (for panel mounting) and RMA422 (for mounting on hat rails) offer this function as well as several others.
4. State-of-the-art recording technology with monitor recorders from Endress+Hauser, e.g. Ecograph, Memograph or hardcopy recorders such as Alphalog for documenting, monitoring, visualizing and archiving.


Application examples with FMX167 with Pt 100
OP Overvoltage protection e.g. HAW from Endress + Hauser
5. If you want to measure, display and evaluate temperature as well as level, e.g. to monitor temperature in fresh water to detect temperature limits for germ formation, you have the following options:
The optional temperature transmitter can convert the Pt 100 signal into a $4 \ldots 20 \mathrm{~mA}$ signal and transfer it to any customary evaluation unit. Evaluation devices RMA421, RIA250 and RIA452 also offer a direct input for the Pt 100 signal.
6. If you want to detect and evaluate level and temperature with one device, choose the evaluation unit RMA422 with two inputs. It even includes the mathematical operation for linking the input signals.

## Input

| Measured variable | FMX167 + Pt 100 (optional) Temperature transmitter (optional) <br> - Hydrostatic pressure of a liquid  <br> - Pt 100: Temperature of a liquid - Temperature |
| :---: | :---: |
| Measuring range | - Nine fixed pressure measuring ranges in bar, $\mathrm{mH}_{2} \mathrm{O}$, psi and $\mathrm{ftH}_{2} \mathrm{O}$; <br> $\rightarrow$ Page 18, "Ordering information" Section <br> - Customer-specific measuring ranges; factory-calibrated <br> - Temperature measurement from $-10 \ldots+70^{\circ} \mathrm{C}\left(+14 \ldots+158^{\circ} \mathrm{F}\right)$ (optional with Pt 100 ) |
| Input signal | FMX167 + Pt 100 (optional) Temperature transmitter (optional) <br> - Change in capacitance - Pt 100 resistance signal, 4 -wire <br> - Pt 100: Change in resistance  |

## Output

| Output signal | FMX167 + Pt 100 (optional) <br> - FMX167: 4... 20 mA for hydrostatic pressure measured value, two-wire <br> - Pt 100: Temperature-dependent resistance of Pt 100 | Temperature transmitter (optional) <br> $4 . . .20 \mathrm{~mA}$ for temperature measured value, twowire |
| :---: | :---: | :---: |
| Load | FMX167 + Pt 100 (optional) | Temperature transmitter (optional) |
|  | $R_{t o t} \leq \frac{U_{b}-10 \mathrm{~V}}{0.0225 \mathrm{~A}}-2 \cdot 0.09 \frac{\Omega}{\mathrm{~m}} \cdot 1-R_{\mathrm{add}}$ |  |
|  | $\begin{aligned} R_{t o t}= & \text { Max. load resistance }[\Omega] \\ R_{\text {add }}= & \text { Additional resistances such as resistance of eval } \\ & \text { line resistance } \Omega \text { ] } \end{aligned}$ | device and/or display instrument, |
|  | $\begin{aligned} U_{b} & =\text { Supply voltage } M \\ l & =\text { Simple length of extension cable } / \mathrm{m} / \text { (cable resis } \end{aligned}$ | per wire $\leq 0.09 / \Omega \mathrm{m})$ |



Load chart FMX167 for estimating load resistance. Subtract the additional resistances, e.g. resistance of extension cable, from the calculated value as shown in the equation.


Load chart temperature transmitter for estimating load resistance. Subtract the additional resistances from the calculated value as shown in the equation.

## Power supply

Note!

- When using the measuring device in hazardous areas, national standards and regulations as well as the Safety Instructions (XAs) or Installation or Control Drawings (ZDs) have to be observed. $\rightarrow$ See also Page 20, "Safety Instructions" and "Installation/Control Drawings" Sections.
- Reverse polarity protection is integrated in the Waterpilot FMX167 and in the temperature transmitter TMT181. Changing the polarities has no impact on operation.
- The cable must end in a dry room or in a proper terminal box. For installation outside, use the terminal box (IP 66/IP 67) with a GORE-TEX ${ }^{\circledR}$ filter from Endress+Hauser. The terminal box can be ordered using the order code of FMX167 $\rightarrow$ see Page 18, "Ordering information" Section) or an accessory (order number: 52006252).

Waterpilot FMX167, standard


FMXI07 electrical connection, versions " 7 " or " 3 " for Feature 70 "Additional options" in the order code $(\rightarrow$ see Page 18).

Waterpilot FMX167 with Pt 100


FMX107 electrical connection with Pt 100, versions " $/$ " or "4" for Feature 70 "Additional options" in the order code $(\rightarrow$ see Page 18).

Waterpilot FMX167 with Pt 100 and TMT181 temperature transmitter ( $4 . . .20 \mathrm{~mA}$ )


FMX107 with Pt 100 and TMT181 temperature transmitter (4... 20 mA ),
version " 5 " for Feature 70 in the order code $\rightarrow$ see Page 18).
1 Not for FMXI 67 with outer diameter $=29 \mathrm{~mm}$ (l. 15 inch)

Wire colors: $\mathrm{RD}=$ red, $\mathrm{BK}=$ black, $\mathrm{WH}=$ white, $\mathrm{YE}=$ yellow, $\mathrm{BU}=$ blue, $\mathrm{BR}=$ brown

| Supply voltage |  |  |
| :---: | :---: | :---: |
|  | - When using the measuring device in hazardous areas, national standards and regulations as well as the safety instructions (XAs) or Installation or Control Drawings (ZDs) have to be observed. $\rightarrow$ See also Page 20, "Safety Instructions" and "Installation/Control Drawings" Sections. |  |
|  | FMX167 + Pt 100 (optional) | Temperature transmitter (optional) |
|  | - FMX167: $10 \ldots 30$ V DC <br> - Pt 100: 10 ... 30 V DC | - 8... 35 V DC |
| Cable specifications | FMX167 + Pt 100 (optional) <br> - Commercially available instrument cable <br> - Terminals, terminal housing FMX167: $0.08 \ldots 2.5 \mathrm{~mm}^{2}$ <br> - If the Pt 100 signal is directly connected to a display and/or evaluation unit, we recommend the use of a shielded cable. | Temperature transmitter (optional) <br> - Commercially available instrument cable <br> - Terminals, terminal housing FMX167: $0.08 \ldots . .2 .5 \mathrm{~mm}^{2}$ <br> - Connection, transmitter: Max. $1.75 \mathrm{~mm}^{2}$ |
|  |  |  |
| Power consumption | FMX167 + Pt 100 (optional) | Temperature transmitter (optional) |
|  | $\leq 0.675 \mathrm{~W}$ at 30 V DC | $\leq 0.875 \mathrm{~W}$ at 35 V DC |
| Current consumption | FMX167 + Pt 100 (optional) | Temperature transmitter (optional) <br> - Max. current consumption: $\leq 25 \mathrm{~mA}$ Min. current consumption: $\geq 3.5 \mathrm{~mA}$ <br> - Pt 100 via temperature transmitter: $\leq 0.6 \mathrm{~mA}$ |
|  | - Max. current consumption: $\leq 22.5 \mathrm{~mA}$ Min. current consumption: $\geq 3.5 \mathrm{~mA}$ <br> - Pt $100: \leq 0.6 \mathrm{~mA}$ |  |
| Residual ripple | FMX167 + Pt 100 (optional) | Temperature transmitter (optional) |
|  | No effect for $4 \ldots . .20 \mathrm{~mA}$ signal up to $\pm 5 \%$ residual ripple within permissible range | $\mathrm{U}_{\mathrm{ss}} \geq 5 \mathrm{~V}$ at $\mathrm{U}_{\mathrm{B}} \geq 13 \mathrm{~V}, \mathrm{f}_{\text {max, }}=1 \mathrm{kHz}$ |

## Performance characteristics

| Reference operating conditions | FMX167 + Pt 100 (optional) <br> DIN EN $60770 \mathrm{~T}_{\mathrm{U}}=25^{\circ} \mathrm{C}\left(77^{\circ} \mathrm{F}\right)$ | Temperature transmitter (optional) <br> Calibration temperature $23^{\circ} \mathrm{C} \pm 5 \mathrm{~K}\left(73^{\circ} \mathrm{F} \pm 5 \mathrm{~K}\right)$ |
| :---: | :---: | :---: |
| Maximum measured error | FMX167 + Pt 100 (optional) <br> - Non-linearity including hysteresis and nonrepeatability as per DIN EN 60770 : $\pm 0.2 \%$ of upper range value (URV) <br> - Pt 100: Max. $\pm 0.7 \mathrm{~K}$ (Class B to DIN EN 60751) | Temperature transmitter (optional) <br> - $\pm 0.2 \mathrm{~K}$ <br> - With Pt 100 : Max. $\pm 0.9 \mathrm{~K}$ |
| Long-term stability | FMX167 + Pt 100 (optional) <br> $\pm 0.1 \%$ of upper range value (URL) per year | Temperature transmitter (optional) $\leq 0.1 \mathrm{~K}$ per year |
| Influence of medium temperature on the hydrostatic level measurement of FMX167 | - Thermal change in zero signal and output span for typical application temperature range $0 \ldots+30^{\circ} \mathrm{C}\left(+32 \ldots+86^{\circ} \mathrm{F}\right)$ : $\pm 0.4 \%( \pm 0.5 \%)^{*}$ of the upper range limit (URL) <br> - Thermal change in zero signal and output span for the entire medium temperature range $-10 \ldots+70^{\circ} \mathrm{C}\left(+14 \ldots+158^{\circ} \mathrm{F}\right)$ : $\pm 1.0 \%( \pm 1.5 \%)^{*}$ of the upper range limit (URL) <br> - Temperature coefficient ( $\mathrm{T}_{\mathrm{K}}$ ) of zero signal and output span: $0.15 \% / 10 \mathrm{~K}(0.3 \% / 10 \mathrm{~K})^{*}$ of the upper range limit (URL) <br> * Specifications for sensors 0.1 bar ( $1 \mathrm{mH}_{2} \mathrm{O}, 1.5$ psi, $3 \mathrm{ftH}_{2} \mathrm{O}$ ) and 0.6 bar ( $6 \mathrm{mH}_{2} \mathrm{O}, 10$ psi, $20 \mathrm{ftH}_{2} \mathrm{O}$ ) |  |
| Warm-up period | FMX167 + Pt 100 (optional) <br> 20 ms | Temperature transmitter (optional) $4 \mathrm{~s}$ |
| Rise time | FMX167 + Pt 100 (optional) <br> - FMX167: 80 ms <br> - Pt 100: 160 s |  |

## Settling time

## FMX167 + Pt 100 (optional)

- FMX167: 150 ms
- Pt $100: 300 \mathrm{~s}$


## Installation

Installation instructions


Installation examples, here shown with FMXI67 with an outer diameter $=22 \mathrm{~mm}(0.87$ inch $)$
1 Extension cable mounting screw can be ordered via order code or as an accessory, $\rightarrow$ see Page 14 and 19
2 Terminal housing can be ordered via order code or as an accessory, $\rightarrow$ see Page 15 and 19
3 Extension cable bending radius $>120 \mathrm{~mm}(4.72 \mathrm{inch})$
4 Suspension clamp can be ordered via order code or as an accessory, $\rightarrow$ see Page 14 and 19
5 Extension cable up to $300 \mathrm{~m}(384 \mathrm{ft})$, for max. length $\rightarrow$ see Page 10 , "Extension cable" Section
$0 \quad$ Guide tube for FMX107 with outer diameter $=22 \mathrm{~mm}$ ( 0.87 inch) internal diameter $>23 \mathrm{~mm}$ ( 0.91 inch)
7 Additional weight can be ordered as an accessory for FMXI 67 with outer diameter $=22 \mathrm{~mm}(0.87$ inch $)$ and $29 \mathrm{~mm}(1.15 \mathrm{inch}) \rightarrow$ see Page 19
8 Protection cap

Note!

- A sideways movement of the level probe can lead to measuring errors. Therefore install the probe at a point free from flow and turbulence, or use a guide tube. The internal diameter of the guide tube should be at least $1 \mathrm{~mm}(0.04 \mathrm{inch})$ bigger than the outer diameter of the selected FMX167.
- The cable must end in a dry room or in a proper terminal box. The terminal box from Endress+Hauser provides optimum humidity and climatic protection and is suitable for outdoor installation.
- Protective cap: to avoid mechanical damage to the measuring cell, the device is provided with a protective cap, which should not be removed during transport and installation.
- After shortening of the cable, the filter must be re-fitted on the pressure compensation hose.


## Environment

| Ambient temperature range | FMX167 + Pt 100 (optional) <br> - FMX167 with outer diameter $=22 \mathrm{~mm}$ ( 0.87 inch ) and 42 mm ( 1.66 inch): <br> $-10 \ldots+70^{\circ} \mathrm{C}\left(+14 \ldots+158^{\circ} \mathrm{F}\right)$ ( $=$ medium temperature) <br> - FMX167 with outer diameter $\begin{aligned} & =29 \mathrm{~mm}(1.15 \text { inch }): 0 \ldots+50^{\circ} \mathrm{C}\left(+32 \ldots+122^{\circ} \mathrm{F}\right) \\ & (=\text { medium temperature }) \end{aligned}$ | Temperature transmitter (optional) $-40 \ldots+85^{\circ} \mathrm{C}\left(-40 \ldots+185^{\circ} \mathrm{F}\right)$ |
| :---: | :---: | :---: |
| Storage temperature | FMX167 + Pt 100 (optional) $-40 \ldots+80^{\circ} \mathrm{C}\left(-40 \ldots+185^{\circ} \mathrm{F}\right)$ | Temperature transmitter (optional) $-40 \ldots+100^{\circ} \mathrm{C}\left(-40 \ldots+212^{\circ} \mathrm{F}\right)$ |
| Degree of protection | FMX167 + Pt 100 (optional) <br> - IP 68 , permanently hermetically sealed <br> - Optional terminal box: IP 66/IP 67 | Temperature transmitter (optional) <br> - IP 00, moisture condensation permissible <br> - When mounted in the optional terminal boxes: IP 66/IP67 |
| Electromagnetic compatibility (EMC) | FMX167 + Pt 100 (optional) <br> - Interference emission to EN 61326 Class B equipment, interference immunity to EN 61326 Appendix A (Industrial) <br> - Maximum deviation: < $0.5 \%$ of span | Temperature transmitter (optional) <br> - Interference emission to EN 61326 Class B equipment, interference immunity to EN 61326 Appendix A (Industrial) |
| Overvoltage protection | FMX167 + Pt 100 (optional) <br> Integrated overvoltage protection to EN 61000-4-5 $\leq 1.2 \mathrm{kV}$ <br> Install overvoltage protection $\geq 1.2 \mathrm{kV}$, external if necessary | Temperature transmitter (optional) <br> Install overvoltage protection, external if necessary. |

## Process

## Medium temperature range

FMX167 + Pt 100 (optional)

- FMX167 with outer diameter
$=22 \mathrm{~mm}(0.87 \mathrm{inch})$ and 42 mm ( 1.66 inch):
$-10 \ldots+70^{\circ} \mathrm{C}\left(+14 \ldots+158^{\circ} \mathrm{F}\right)$
- FMX167 with outer diameter $=29 \mathrm{~mm}(1.15$ inch $): 0 \ldots+50^{\circ} \mathrm{C}\left(+32 \ldots+122^{\circ} \mathrm{F}\right)$


## Temperature transmitter (optional)

$-40 \ldots+85^{\circ} \mathrm{C}\left(-40 \ldots+185^{\circ} \mathrm{C}\right)$ ( $=$ ambient temperature), install temperature transmitter outside medium.

| Medium temperature limits | FMX167 + Pt 100 (optional) <br> - FMX167 with outer diameter $=22 \mathrm{~mm}(0.87 \mathrm{inch})$ and $42 \mathrm{~mm}(1.66 \mathrm{inch})$ : $-20 \ldots+70^{\circ} \mathrm{C}\left(-4 \ldots+158^{\circ} \mathrm{F}\right)$ <br> - FMX167 with outer diameter $=29 \mathrm{~mm}(1.15 \text { inch }): 0 \ldots+50^{\circ} \mathrm{C}\left(+32 \ldots+122^{\circ} \mathrm{F}\right)$ <br> fYou may operate the FMX167 in this temperature range. The specification can then be exceeded, e.g. measuring accuracy). |
| :---: | :---: |

## Mechanical construction

## Dimensions of level probe



## Versions of FMX107

1 FMX107, version " $A$ " or " $D$ " for Feature 30 "Probe tube" in the order code $(\rightarrow$ see Page 18)
2 FMX167, version "B" for Feature 30 "Probe tube" in the order code ( $\rightarrow$ see Page 18)
3 FMXI67, version "C" for Feature 30 "Probe tube" in the order code $(\rightarrow$ see Page 18)
4 Pressure compensation tube
5 Extension cable
6 Protection cap

## Dimensions of suspension

 clamp

Suspension clamp, version 2 for Feature 20 "Connection" in the order code $\rightarrow$ see Page 18)

Dimensions of extension cable mounting screws


Extension cable mounting screws
1 Extension cable mounting screw G / I/2 A, version "3" for Feature 20 "Connection" in the order code $\rightarrow$ see Page 18)
2 Extension cable mounting screw / //2 NPT, version "4" for Feature 20 "Connection" in the order code $\rightarrow$ see Page 18)

## Dimensions of the terminal

 box IP 66/IP 67 with filter

## Terminal box

Version "3", "4" or "5" for Feature 70 "Additional options" in the order code $\rightarrow$ see Page 18)
1 Dummy plug M $20 \times 1.5$
2 GORE-TEX ${ }^{\otimes}$ fitter
3 Terminals for $0.08 \ldots 2.5 \mathrm{~mm}^{2}$

Dimensions of temperature transmitter TMT181


Temperature transmitter TMT181 (4...20 mA)
Version "5" for Feature 70 "Additional options" in the order code $\rightarrow$ see Page 18). The temperature transmitter can be used in non-hazardous areas and for EEx nA.

| Weight | - Level probe, outer diameter $\approx 22 \mathrm{~mm}(0.87 \mathrm{inch}): 290 \mathrm{~g}$ <br> - Level probe, outer diameter $=42 \mathrm{~mm}$ ( 1.60 inch): 1150 g <br> - Level probe, outer diameter $=29 \mathrm{~mm}(1.15 \mathrm{inch}): 340 \mathrm{~g}$ <br> - Extension cable PE: $52 \mathrm{~g} / \mathrm{m}$ <br> - Extension cable FEP: $108 \mathrm{~g} / \mathrm{m}$ <br> - Suspension clamp: 170 g <br> - Extension cable mounting screw G $11 / 2$ A: 770 g <br> - Extension cable mounting screw $11 / 2$ NPT: 724 g <br> - Terminal box: 235 g <br> - Temperature transmitter: 40 g <br> - Additional weight: 300 g |
| :---: | :---: |


| Material | Level probe <br> - Level probe, outer diameter $=22 \mathrm{~mm}$ ( 0.87 inch): 1.4435 (AISI 316L) <br> - Level probe, outer diameter $=42 \mathrm{~mm}(1.60$ inch): 1.4435 (AISI 316L) <br> - Level probe, outer diameter $=29 \mathrm{~mm}$ ( 1.15 inch ): <br> - Level probe: 1.4435 (AISI 316L) <br> - Sensor sleeve: PPS (polyphenylene sulfide) <br> - Heat-shrink sleeve/cover: Polyolefin <br> Metal does not come into contact with the medium. <br> - Process ceramic: $\mathrm{Al}_{2} \mathrm{O}_{3}$ aluminium oxide ceramic <br> - Seal (internal): EPDM or Viton <br> - Protective cap: <br> - PE-HD (high-density polyethylene) for FMX167 with outer diameter $=22 \mathrm{~mm}$ and $29 \mathrm{~mm}(0.87$ inch and 1.15 inch). <br> - PFA (perfluoralkoxy) for FMX167 with outer diameter $=42 \mathrm{~mm}$ ( 1.66 inch). <br> - Extension cable insulation: Either PE-LD (low density polyethylene) or FEP (fluorinated ethylene propylene). For more information, see the next Section - "Extension cable" <br> - Suspension clamp: 1.4404 (AISI 316L) and glass fiber reinforced PA (polyamide) <br> - Extension cable mounting screw G 11/2 A: 1.4301 (AISI 304) <br> - Extension cable mounting screw 11/2 NPT: 1.4301 (AISI 304) <br> - Terminal box: PC (polycarbonate) <br> - Temperature transmitter: Housing PC (polycarbonate) |
| :---: | :---: |
| Extension cable | PE extension cable <br> - Slip-resistant extension cable with strain-relief members made of Dynemo; shielded using aluminium-coated film; insulated with polyethylene (PE), black; copper wires, twisted <br> - Pressure compensation tube with Tefion filter |
|  | FEP extension cable <br> - Slip-resistant extension cable; shielded using galvanized steel wire netting; insulated with fluorinated ethylene propylene (FEP), black; copper wires, twisted <br> - Pressure compensation tube with Teflon filter |
|  | Cross-section of PE and FEP extension cable <br> - Total outer diameter: $8.0 \mathrm{~mm} \pm 0.25 \mathrm{~mm}$ ( 0.315 inch $\pm 0.0098$ inch) <br> - FMX167: $3 \times 0.227 \mathrm{~mm}^{2}+$ pressure compensation tube with Tefion filter <br> - FMX167 with Pt 100 (optional): $7 \times 0.227 \mathrm{~mm}^{2}+$ pressure compensation tube with Teflon filter <br> - Pressure compensation tube with Teflon filter: <br> Outer diameter $=2.5 \mathrm{~mm}(0.098 \mathrm{inch})$, internal diameter $=1.5 \mathrm{~mm}(0.059 \mathrm{inch})$ |
|  | Cable resistance of PE and FEP extension cable <br> - Cable resistance per wire: $\leq 0.09 \Omega / \mathrm{m}$ |
|  | Cable length of PE and FEP extension cable <br> - Please also refer to Page 7, "Load" Section. <br> - When using the measuring device in hazardous areas, national standards and regulations as well as the safety instructions (XAs) or Installation or Control Drawings (ZDs) have to be observed. $\rightarrow$ See also Page 20, "Safety Instructions" and "Installation/Control Drawings" Sections. |
|  | Further technical data of PE and FEP extension cable <br> - Minimum bending radius: 120 mm ( 4.72 inch) <br> - Tensile strength: max. 950 N <br> - Cable extraction force: $\geq 450 \mathrm{~N}$ <br> (The extension cable could be extracted from the level probe at a tensile force of $\geq 450 \mathrm{~N}$.) <br> - Resistance to UV light <br> - PE: approved for use with drinking water |
| Terminals | - 3 standard terminals in terminal box <br> - 4-terminal strip can be ordered as accessory, Order No. 52008938 Wire cross-section $0.08 \ldots 2.5 \mathrm{~mm}^{2}$ |

## Certificates and approvals

| CE approval | By attaching the CE symbol, Endress+Hauser confirms that the instrument fulfills all the requirements of the relevant $E C$ directives. |
| :---: | :---: |
| Ex approval, type of protection | - ATEX II 2 G EEx ia IIC To ${ }^{1}$ <br> - ATEXII 3G EExnAIITo <br> - FM: IS, Class I, Division 1, Groups A-D ${ }^{1}$ <br> - CSA: IS, Class I, Division I, Groups A-D' |
|  | 1 Only for Waterpilot FMX167 without Pt 100 |
|  | Waterpilot FMX167 with outer diameter $=22 \mathrm{~mm}(0.87 \mathrm{inch})$ is only suitable for use in hazardous areas with the FKM Viton seal. |
|  | All explosion protection data are contained in separate explosion protection documentation which you can also request. Explosion protection documents are supplied as standard for all devices approved for use in explosion hazardous areas. $\rightarrow$ See also Page 20, "Safety Instructions" and "Installation/Control Drawings" Sections. |
| Drinking water approval (for FMX 167 with $\mathrm{d}_{\mathrm{O}}=22 \mathrm{~mm}(0.87 \mathrm{inch})$ ) | - KTW certificate <br> - NSF 61 approval <br> - ACS approval |
| Marine approval | - GL approval <br> - ABS approval |
| External standards and guidelines | DIN EN 60770 (IEC 60770): <br> Transmitters for use in industrial-control systems <br> Part 1: Methods for performance evaluation |
|  | DIN 16086: <br> Electrical pressure measuring instruments, pressure sensors, pressure transmitters, pressure measuring instruments, concepts, specifications on data sheets |
|  | EN 61326 (IEC 61326-1): <br> Electrical equipment for measurement, control and laboratory use - EMC requirements |
| Registered trademarks | GORE-TEX ${ }^{\text {® }}$ <br> Registered trademark of W.L. Core \& Associates, Inc., USA |

## Ordering information

FMX 167

$\rightarrow$ Ordering information for FMX167 continued on next page.


## Accessories

| Suspension clamp | - Endress+Hauser offers a suspension clamp for simple FMX167 mounting. $\rightarrow$ See also Page 14. <br> - Material: 1.4404 (AISI 316L) and glass fiber reinforced PA (polyamide) <br> - Order number: 52006151 |
| :---: | :---: |
| Terminal box | - Terminal box IP $66 /$ IP 67 with GORE-TEX ${ }^{\circledR}$ filter incl. 3 mounted terminals. The terminal box is also suitable for installing a temperature transmitter (Order No. 52008794) or for four additional terminals (Order No. 52008938). $\rightarrow$ See also Page 15. <br> - Order number: 52006152 |
| Additional weight <br> (for FMX167 with $\mathrm{d}_{\mathrm{O}}=22 \mathrm{~mm}$ ( 0.87 inch$)$ and $\left.\mathrm{d}_{\mathrm{O}}=29 \mathrm{~mm}(1.15 \mathrm{inch})\right)$ | - To prevent sideways movement leading to measuring errors or to ensure that the device lowers into a guide tube, Endress+Hauser provides additional weights. <br> You can screw several weights together. The weights are then attacbed directly to the FMX167. For FMX167 with outer diameter $=29 \mathrm{~mm}$ ( 1.15 inch), a maximum of 5 weights may be screwed on to FMX167. <br> - Material: 1.4435 (AlSI 316L) <br> - Weight: 300 g <br> - Order number: 52006153 |


| Temperature transmitter | - Temperature transmitter, 2 -wire, preset for measuring range from $-20 \ldots+80^{\circ} \mathrm{C}\left(-4 \ldots+176^{\circ} \mathrm{F}\right)$. This setting offers an easily displayable temperature range of 100 K . Note that the Pt 100 resistance thermometer is designed for a temperature range of $-10 \ldots+70^{\circ} \mathrm{C}\left(+14 \ldots+158^{\circ} \mathrm{F}\right) . \rightarrow$ See also Page 15. <br> - Order number: 52008794 |
| :---: | :---: |
| Extension cable mounting screw | - Endress+Hauser offers extension cable mounting screws to simplify the installation of the FMX167 and to close the measuring open. $\rightarrow$ See also Page 14. <br> - Material: 1.4301 (AlSI 304) <br> - Order number for extension cable mounting screw with G $11 / 2$ A thread: 52008264 <br> - Order number for extension cable mounting screw with 1 1/2 NPT thread: 52009311 |
| Terminals | - Four terminals in strip for FMX167 terminal box, suitable for wire cross-section of $0.08 \ldots 2.5 \mathrm{~mm}^{2}$ <br> - Order number: 52008938 |

## Test adapter

(for FMX167 with
$\mathrm{d}_{\mathrm{O}}=22 \mathrm{~mm}(0.87$ inch $)$ and
$\mathrm{d}_{\mathrm{O}}=29 \mathrm{~mm}(1.15$ inch $)$ )


## Test adapter

A Connection suitable for level probe FMX167
B Connection compressed air hose, internal diameter, quick hose gland 4 mm (0.157 inch)

- Endress+Hauser offers a test adapter to simplify the function test of level probes.
- Note the maximum pressure for the compressed air hose and the maximum level probe overload. $\rightarrow$ See also Page 18.
- The maximum pressure for the supplied quick hose gland is 10 bar ( 145 psi ).
- Adapter material: 1.4301 (AISI 304)
- Quick hose gland material: Anodized aluminium
- Adapter weight: 39 g
- Order number: 52011868


## Documentation

| Field of Activities | - Pressure Measurement: FA004P/00/en <br> - Recording Technology: FA014R/09/de <br> - System Components: FA016K/09/en |
| :---: | :---: |
| Technical Information | - Temperature Head Transmitter iTEMP PCP TMT181: T1070R/09/en |
| Operating Instructions | - Waterpilot FMX167: BA231P/00/en |
| Safety Instructions | - ATEX II 2 G EEx ia IIC T6: XA131P/00/a3 <br> - ATEX II 3 G EEX nA II T6: XA132P/00/a3 |
| Installation/ Control Drawings | - FM IS Class I, Div. 1, Groups A - D: ZD063P/00/en <br> - CSA IS Class I, Div. 1, Groups A - D: ZD064P/00/en |
| Drinking water approval | - SD126P/00/a3 |

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8. ELECTRIC

## BRISBANE CITY COUNCIL

## Sewage Pump Station SP210

## Nudgee Beach

Contract : BW 70103-033
Job Number: WT400075

ELECTRICAL INSTALLATION

## OPERATIONS and MAINTENANCE MANUAL

## VOLUME 2

INSTALLATION BY:<br>SJ Electric (Qld) Pty Ltd 19 Elliot Street Albion Qld 4010

## INDEX

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# Sewage Pump Station SP210 

## Nudgee Beach

## Electrical Drawing List 1

## Site Installation

| Sheet No. | Drawing No. | Title |
| :---: | :--- | :--- |
| 00 | $486 / 5 / 7-0172-000$ | Site Cover Sheet |
| 01 | $486 / 5 / 7-0172-001$ | Power Distribution Schematic Diagram |
| 02 | $486 / 5 / 7-0172-002$ | Pump 01 Schematic Diagram |
| 03 | $486 / 5 / 7-0172-003$ | Pump 02 Schematic Diagram |
| 04 | $486 / 5 / 7-0172-004$ | Dry well Sump Pump Schematic Diagram |
| 05 | $486 / 5 / 7-0172-005$ | [RESERVED] Generator Control Schematic Diagram |
| 06 | $486 / 5 / 7-0172-006$ | Common Controls Schematic Diagram |
| 07 | $486 / 5 / 7-0172-007$ | Common RTU I/O Schematic Diagram |
| 08 | $486 / 5 / 7-0172-008$ | RTU Power Distribution Schematic Diagram |
| 09 | $486 / 5 / 7-0172-009$ | RTU Digital Inputs Termination Diagram |
| 10 | $486 / 5 / 7-0172-010$ | RTU Digital Inputs Termination Diagram |
| 11 | $486 / 5 / 7-0172-011$ | RTU Digital Outputs Termination Diagram |
| 12 | $486 / 5 / 7-0172-012$ | RTU Analogs \& Miscellaneous Termination Diagram |
| 13 | $486 / 5 / 7-0172-013$ | Common Controls Termination Diagram |
| 14 | $486 / 5 / 7-0172-014$ | Equipment List |
| 15 | $486 / 5 / 7-0172-015$ | Cable Schedule |
| 16 | $486 / 5 / 7-0172-016$ | Switchboard Label Schedule |
| 17 | $486 / 5 / 7-0172-017$ | Switchboard Construction Details |
| 18 | $486 / 5 / 7-0172-018$ | Switchboard Construction Details |
| 19 | $486 / 5 / 7-0172-019$ | Level Probes and Pressure Transmitter Installation Details |
| 20 | $486 / 5 / 7-0172-020$ |  |
| 21 | $486 / 5 / 7-0172-021$ | Dry well Field Disconnection Box |
| 22 | $486 / 5 / 7-0172-022$ | Switchboard General Arrangement Elevations - Double Sided |
| 23 | $486 / 5 / 7-0172-023$ | Switchboard General Arrangement Sections - Double Sided |
| 24 | $486 / 5 / 7-0172-024$ | Reserved for Generator external connection box |
| 25 | $486 / 5 / 7-0172-025$ | Slab \& Conduit Details |
| 26 | $486 / 5 / 7-0172-026$ | Slab \& Conduit Details |
| 27 | $486 / 5 / 7-0172-026$ | Slab \& Conduit Details |

## SP210 NUDGEE BEACH SEWAGE PUMPING STATION ELECTRICAL DRAWINGS

## SITE COVER SHEET

| ELECTRICAL DRAWINGS INDEX |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| DWG ${ }^{\text {o }}$ | TITLE | SHEET | REVISIONS |  |  |
| 486／157－0172－000 | SIIE COVER SHEET | 00 |  |  |  |
| 486／5／77－0772－001 | POWER DIITRRIUUTION SCHEMATIC DIAGRAM | 01 | 0 |  |  |
| 486／5／7－0172－002 | PUUP 015 SHEMATC DIAGRAM | 02 | 0 |  |  |
| 4866／57－0172－003 | PUMP O2 SCHEMATC DIAGRAM | 03 |  |  |  |
| 486／577－077－004 | DRY WELL SUMP PUHP SCHEMAIC DIAGRAM | 06 | 。 |  |  |
| 486／577－0712－005 |  | 05 |  |  |  |
| 4866／57－017－006 | COMHON CONTROLS SCHEMATIL DIAGRAM | 06 | 0 |  |  |
| 486／577－077－007 | COMMON RTUI／O SCHEMATIC DIAGRAM | 07 |  |  |  |
| 486／577－017－008 | RTU POWER DIITRTBUTION SCHEMATIC DIAGRAM | 08 | 0 |  |  |
| 486／577－0172－009 | RTU DIGITAL INPUTS TERMINATON DIAGRAM | 09 |  |  |  |
| 486／5／7－0172－010 | RTU DIGITAL INPUTS TERMINATON DIAGRAM | 10 | 0 |  |  |
| 486／577－0172－011 | RTU DIGIAL OUTPUTS TERMMATHON DIAGRAM | 11 | 0 |  |  |
| 488／5／5－0717－012 | RTU ANALOGS 2 MISCELLANEOUS TERHINATION DIAGRAM | 12 | 0 |  |  |
| 486／5／7－0772－013 | COMMON CONTROL T TERHINATION DIAGGAM | 13 |  |  |  |
| 486／5／7－0172－014 | EOUPMENT LIST | 14 | 0 |  |  |
| 486／5／7－0172－015 | Cable schilile | 15 | 0 |  |  |
| $486 / 5 / 7-0772-016$ | SWITCHBOARD LABEL SCHEDLL | 16 | 0 |  |  |
| 486／577－0772－017 | SWITCHBOARD CONSTRUCTION DETALL | 17 |  |  |  |
| $486 / 577-0772-018$ | SWITCHBARD Construction detals | ${ }^{18}$ | 0 |  |  |
| $4866 / 577-0772-019$ | LEVEL PROBES A ANO PRESSURE TRANSMITTER INSTALLATION DETAILS | 19 | 0 |  |  |
| $466 / 5 / 7-0172-020$ | Ristercio llathaok Peotetion unel | 20 |  |  |  |
| $466 / 577-0772-021$ | DRY WELL PUMP PISCONXECTION BOX | 2 | 0 |  |  |
| 466／5／7－0717－022 | SWITCHOARD GENERRL ARRANGEMENT ELEVATONS－Dovile sided |  | 0 |  |  |
| $486 / 577-0772-023$ | SWITCHBAARO GENERAL ARRANGEMENT SECTIONS－Dovil siofo | 23 | 0 |  |  |
| 486／577－077－024 |  | 26 |  |  |  |
| 4866／577－0172－025 | SLAB \＆CONDUT DETALL－SHEET 1 of 3 | 25 | 0 |  |  |
| $486 / 57 /-017$－026 | SLAB \＆CONDUIT DETALLS－Shet 2 of 3 | ${ }^{26}$ | 0 |  |  |
| 486／577－017－027 | SLAB 2 Conduli det all－ShEET 3 of 3 | 27 | 0 |  |  |
|  |  |  |  |  |  |


| STANDARD VARIABLES |  |
| :---: | :---: |
| DESCRIPTION | Values |
| CTMEIERMGI ISCLATOR | nol APPULABLIE |
| NORHAL SUPPL Y MAN SWITCH | 135 A 580Ff／173 |
| GENERATOR SUPPLY MAIN SWITCH | 1831588007178 |
| PUMP1（IRCUIT BREAKER | ${ }^{63 \mathrm{~A}}$ S1856／1／3 |
| PUMP2 CIRCUTI RREAKER | ${ }_{63} 518561 / 63$ |
| DRY WELL SUMP PUMP CIRCUIT BREAKER | 164 dit63316c |
| PUMP VSD SIIE | ${ }_{\text {frever }}{ }^{\text {a }}$ |
| PUMP Rating | 2 mkN 3 ${ }^{\text {a }}$ |
| PUMP EESTITP CONTACTOR | C12－63 |
| PUMP SUPPLY CABLE | Vman＇ |
| PUUPP MOTOR CABLE | （mm |
| VSD 3 PHASE SUPPLY CABLE | Nom＇ |
| SUMP PUMP RATING | 2 zkN 4.8 A |
| SUMP PUMP CONTACTOR L TOL | （a7－16）（17－2， 2 |
| WET WELL LEVEL TRANSMTTER |  |
| EMERGENCY YTOPAGE WELL LIVEL TRANSMRT IER | NOT APPLICABLT |
| DELIVERY PRESSURE TRANSMITIER |  |
| WE T WEL LU Tran Sowl level sen | NOT APPULABET |
| flowneter range | $231 / 5$ |
| RADOO | DR890－01002－20 |
| EHERGEACY PUHPMGG TME | L005ee |
| No of SINGLE POINT PROBES | 6 |
| INCOMNG MANS SUPPLY CABLE | 50 ma ？ |
| MAIN EARTHING CABLE | 1 smm |
|  |  |
|  |  |


| STANDARD DESIGN OPTIONS |  |  |
| :---: | :---: | :---: |
| OPTION | DESCRIPTION | Fit |
| A | WOIVIDUAL PUMP MOISTURE IN OLI（MOO）SENSOR ANO FAULT RELAY | YES ${ }^{\text {K }}$ |
| 8 |  | de No |
| c | WOLVIDUAL PUUP REELUX VALVE PROXIMITY SWITCH | Yes 0 R |
| 0 |  | 区 |
| $\varepsilon$ | STATON DRY WELL SUMP PUMP ANO LEVEL NOICATION SENSORS ANO RELAYS | Yes ${ }^{\text {ax }}$ |
| F |  | ${ }^{\text {asa }}$ |
| 6 | STA TION EMERGEECY STOPAGE If VEL STENSOR | 豩 No |
| H | PUMPS 182 DELIVERY FLOWMEETERS－ 24 VOC ENDRESS \＆HAUSER | Yes ${ }^{\text {ck }}$ |
| 1 | BACKUP COMHUNCATION－GSH | Yes ${ }^{\text {a }}$ |
| ， | PUMP CONNECTION（Via dry Well 1 －80x） | Yes ${ }^{\text {ax }}$ |
| $k$ | CATHODC PROIECTION |  |
| 1 | MOTOR THERMISTORS（Via Dry Well 1 －Box） | YES $\mathrm{Sex}^{\text {d }}$ |
| M | ODOUP COWIFOL |  |
| N |  | ＊ No |
| 0 | PUUPS ELECTRICAL NTERLOCK Mains 8 Generator） | Yes ${ }^{\text {a }}$ |
| p | WET Well waikhr | 函 No |
| 0 | AUX PIT SUMP PUMP AAOL LEVEL PROBE | We ${ }^{\text {No }}$ |
| R | TELEMETRY RADIO | Yes $0^{\text {a }}$ |
| 5 |  | ${ }^{\text {ass }}$ N0 |
| T | DOUBLL SIDEE SWIICHBOARO PLINTH EXTENSION FITTED | Yes 0 |
| U | DELIVERY PRESSURE TRANSHITTER | Yesome |
| $v$ |  | Wes N |



| ${ }_{\mathrm{s}}^{\mathrm{sm}} \mathrm{P} 210$ <br> NUDGEE BEACH <br> SEWAGE PUMP STATION | STIE COVER SHEET |
| :---: | :---: |
| $11 \quad 12$ | is |

FOR CONSTRUCTION

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A A tive 10 T／2 $2 / 2014$
86／5／7－0172－000 ${ }^{\text {Nemer }} \mathrm{A}$

SP210 Parkland Street Nudgee SPS Electrical Installation Volume 1 OM Manual


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| (ile construction - Punp Dis onmet fox' 12 mm 5 | OPPRATMG P Paphitits |  |
| :---: | :---: | :---: |
| H15 \& Tlic velded vilh all visile seans and jonts tully welded. | ard | As 3399.1 |
| tree fron spalter and ground smoolh where needed. | Current \& frequeny | A $\mathrm{SSOH}^{\text {O }}$ |
| Exxernad doors and covers fitited with tmat w1-207 sell | Rated Operationa Valtage Ue | 45 vac |
| H6 Carth studs fived to the interiore of all doors and din | Rated hssulation Vatoge Ui | 660 V |
| and on afjecent cubicle interior surfices. | Rated Axxiliar volltge | $26 \mathrm{VaC} / 26$ |
| Door stitieners to be of stficient strength to prevent being deforree d wen | Rated Curent \|iussars) | 200 AMPS |
| subiectes to reasonoble lods. | Sthort Cricuit (uren lis | 20 kA |
| Provide Shrouting as shown on drawing to all busbers to P170 | Ouration of sc |  |
| Hinges (external) Selectrix HBB650ss-316. Stainless Steel | Degree of Proter | PS66 10 |
|  | Serrice Pondilions | Outbors |

DISCONNECTION BOX LABEL LIST

| texi |  |  | (Matigal | 5128 | OTY |
| :---: | :---: | :---: | :---: | :---: | :---: |
| PuTP Po? Disconmect box | iexternal) | 2 mm | S/steft - Black Text | 300x35 |  |
| WARNNG <br> 4 15 V BEHIND DOOR | ExxIERNAL | Nom | S/stel - Red Text | 160×60 |  |
| external label 1 imm thick. 316 GRADE STAINLess steel. FIXED WIIH M3 316 STANLESS STEEL METAL THREADS. |  |  |  |  |  |









## SSM089

## STANDARD SEWAGE PUMP STATION

## SWITCHBOARD CHANGEOVER COMMISSIONING PLAN



## In Attendance



## 1 INTRODUCTION

This document is the standard testing procedure for a switchboard change over at a sewage pumping station. The procedure ensures that for a two pump sewage pump station, at least one pump will be operational at all times. The basic cutover procedure is as follows:

1. Install temporary pumping system (pump controller and generator).
2. Disconnect sewage Pump \#2 from existing switchboard and connect to temporary pumping system.

## PUMP \#1 IS NOW RUNNING THE STATION FROM EXISTING SWITCHBOARD

3. Fully commission Pump \#2 on the temporary pumping system.

## PUMP \#2 IS NOW RUNNING THE STATION FROM TEMPORARY PUMPING SYSTEM

4. Disconnect Pump \#1, consumer mains, on site generator and all field instrumentation from the existing switchboard.
5. Install new switchboard and connect to consumer mains.
6. Connect Pump \#1 to the new switchboard and test in "emergency pumping" mode (via the "Emergency Start" switch).

## PUMP \#2 IS STILL RUNNING THE STATION FROM THE TEMPORARY PUMPING SYSTEM AND PUMP \#1 CAN BE RUN UNDER "EMERGENCY PUMPING" MODE FROM NEW SWITCHBOARD.

7. Connect all field instrumentation.
8. Test Pump \#1 on the new switchboard to operate in "Local" and "Remote" modes. Full commissioning done separately

## PUMP \#1 IS NOW RUNNING THE STATION FROM NEW SWITCHBOARD

9. Connect Pump \#2 to the new switchboard and Test on the new switchboard. Full commissioning done separately.
10. Complete the Site Acceptance Test (SAT) including pumps, RTU and SCADA testing.

NOTE: This testing procedure will only be acceptable on sites that do NOT need two pumps to run during the cut over procedure.
(Confirm the current running conditions of the existing switchboard before commencing).
For sites that require two pumps to run simultaneously under dry weather conditions during the proposed cut over period, a site-specific cut over procedure must be developed to incorporate adequate flow control measures (ie tankers or temporary pumps).

## 2 Pre-Change Over Works Checklist

The following checklist is to be completed and signed by the electrical contractor.

### 2.1 SWITCHBOARD FACTORY ACCEPTANCE TEST

| Contractor Task | Completed |
| :--- | :--- |
| FAT has been completed as per BW FAT Document and all defects that were <br> identified have been rectified. | OK ar |

### 2.2 CONCRETE SLAB EXTENSION

| Contractor Task | Result |
| :--- | :--- |
| Confirm the concrete slab extension is complete including all necessary conduits. | OK Q |

### 2.3 SUPPLY AUTHORITY



### 2.4 NEW RADIO ANTENNA MAST LOCATION

| Contractor Task | Result |
| :---: | :---: |
| Check the location of the antenna mast and ensure that the new position will not <br>  | Location <br> OK Antenna dir. 0 |

### 2.5 DISCHARGE MAINS PRESSURE TRANSDUCER

| Contractor Task | Completed |
| :---: | :---: |
| Install delivery pressure transducer on the discharge rising main. Transducer is calibrated to the specified range (as per spec). 0 kPA to $/ 000 . \mathrm{kPA}$ | $\begin{aligned} & \text { Installed OK } \\ & \text { Range } O_{(\mathrm{m}) \mathrm{to}} / \alpha_{\mathrm{m})} \end{aligned}$ |

### 2.6 TEMPORARY GENERATOR SIZE

| Contractor Task | Completed |
| :---: | :---: |
| Note the kW of each pump. <br> NB All electricity generating sets must comply with AS2790 and AS3010. | Pump \#1 $\frac{7 \cdot 5}{7 \cdot 5} \mathrm{~kW}$ Pump \#2 kW |
| If a Hire Generator is required NB All electricity generating sets must comply with AS2790 and AS3010. | Genset Size $\qquad$ kVA <br> Date Booked 11 <br> Delivery Date <br> 11 <br> Delivery Time $\qquad$ |



### 2.7 PUMP STATION PRELIMINARY OPERATIONAL CHECKS

| BW Task | Checked |
| :--- | :--- |
| These checks are helpful to ensure the pump station is fully operational and that <br> no delay will be incurred due to any pump station problem out side of the contract. <br> These tasks are desirable to have completed before the SAT but are not essential. <br> The job can proceed if they are not done. <br> Commissioning Manager to request networks maintenance to inspect and rectify if <br> necessary |  |
| The reflux valves and associated limit switches are working correctly. | OK $\square$ |
| The discharge pressure connection point is available and that the isolation valve is <br> functioning correctly. | OK |
| The dry well exhaust fan is working correctly and quietly. | OK |
| The wet well does not need pumping out. | OK |
| The flow meter is functioning correctly. | OK $\square$ |
| The stand bye generator can start and has sufficient fuel. | OK $\square$ |

### 2.8 TEMPORARY PUMPING SYSTEM FACTORY ACCEPTANCE TEST

| Contractor Task | Completed |
| :--- | :--- |
| Prior to the first SAT a FAT must be completed on the Temporary Pumping <br> System. The aim of the FAT is to ensure the temporary pumping system can <br> maintain flow control of the site during cut-over. This includes having at least two <br> pump starter units (one spare) wired and mounted appropriately with automatic <br> level control, provision of a generator and an independent audible battery backed <br> level alarm. |  |
| All defects that were identified during the Temporary Pump System FAT have |  |
| been rectified. | OK |

USING EXISTING ONSITE SWITCHBOARD
for Flow lonpeol. the 7/s/o


## 3 Change Over Works

The following sequence of change over works is the order in which they must be followed. One pump must be operational at all times. After each phase has been completed, the commissioning manager will record the results and instruct the commissioning team to commence work on the next phase.

### 3.1 INSTALL TEMPORARY PUMPING SYSTEM

### 3.1.1 Register with Control Room

| Contractor Task | Outcome |
| :--- | :--- |
| Call the Brisbane Water Control Room Operator (CRO) and inform him that you are <br> on site. Record the CRO's Name and Officer Code and record the time of the call. <br> Advise CRO that you are performing a switchboard changeover and that you will <br> initially be taking one pump off line. Give the operator your contact name and <br> number and advise the operator that communications will be lost to the pump <br> station until the job is finished. | Name: |

### 3.1.2 Existing Switchboard Parameters

| Contractor Task | Outcome |
| :--- | :--- |
| Ensure that the station is fully functional (pumps can run) |  |
| Record the direction of the installed antenna for later reference. | Antenna dir. |
| Record the kWhr meter serial numbers. | Pump \#1 |
| Record 3 phase motor currents | U.G.5v. 9.5 W .9 .5 |

### 3.1.3 Prepare and Install Temporary Pump Controller and Generator

| Contractor Task | Outcome |
| :--- | :--- |
| Position generator in an appropriate location. Locate away from the work site to <br> reduce noise and fumes. NB All electricity generating sets must comply with <br> AS2790 and AS3010. |  |
| Position fire extinguisher and oil spill bund as per risk analysis. | OK |
| Connect the temporary pump controller 3 phases to the generator. | OK |
| Install Multitrode level sensors and set the Start and Stop levels to be equivalent <br> to the current Start and Stop levels of the existing switchboard parameters. |  |
| Install the backup audible and visual alarm system (powered by separate <br> battery). Test electrodes back to temporary pump controller to confirm operation. | OK |
| Ensure that the generator fuel will be sufficient to enable the generator to run <br> loaded for 12 hours. (This may require extra fuel - arrange if required). | 420 OC |
| Start the generator and measure the 3 phase volts |  |



### 3.2 CONNECT PUMP \#2 TO TEMPORARY PUMPING SYSTEM

| Contractor Task | Outcome |
| :--- | :---: |
| On the existing switchboard, Isolate sewage pump (Pump \#2) as per BW Isolation <br> Tag and Lock Out procedure. (Unplug from Decontactor). | OK |
| Disconnect Pump \#2 from the existing switchboard and remove the power cables <br> from the switchboard. | OK |
| Connect Pump \#2 power cables to the temporary pump controller. |  |
| Electrically test Pump \#2 to temporary pump controller connections. | OK |
| Switch the existing switchboard to "Local" and confirm Pump \#1 is stopped. | OK $\square$ |
| Manual Test of Temporary Pumping System: (Confirm Pump Direction) <br> Manually start the submersible pump and closely monitor wet well level to confirm <br> that the level is dropping. When confirmed, stop pump. | OK |
| Auto Test of Temporary Pumping System: (Confirm Pump Cycle) <br> Allow the temporary pumping system to complete one full start and stop cycle <br> automatically to confirm complete system is functioning correctly. <br> This is a HOLD point. Do not proceed until the temporary pump is confirmed to <br> be controlling the wet well level. | TIME: |

### 3.3 DISCONNECT AND REMOVE EXISTING SWITCHBOARD

### 3.3.1 Disconnect Pump \#1 and Remove Existing Switchboard

| Contractor Task | Outcome |
| :--- | :---: |
| On the existing switchboard, Isolate sewage pump (Pump \#1) as per BW Isolation <br> Tag and Lock Out procedure. (Unplug from Decontactor). | OK $\square$ |
| Disconnect Pump \#1 from the existing switchboard and remove the power and <br> control cables from the switchboard consider the possible need for a quick <br> changeover from the temporary system, Pump \#2 to Pump \#1. if required. | OK $\square$ |
| Isolate main incomer at the switchboard. Ensure all secondary sources of power (ie <br> on site Generator) are also isolated from the switchboard. Confirm there is no load. | OK $\square$ |
| Remove primary 3-phase fuses from power pole. Lock fuses in lockout box as per <br> BW Isolation and Lock Out procedure. | OK $\square$ |
| Disconnect supply authority mains cable from the switchboard. | OK $\square$ |
| Disconnect all other control and communication cables from the switchboard then <br> remove the switchboard away from adjacent job site so not to interfer with the work. | OK $\square$ |

$$
3.2,3.3 .1 \text { NOT DONE }
$$

USED EX,sitinL switch Board Fan

Electrical Contractor's Supervisor



Signature: Dat


BW Commissioning Manager
Nameaton Cloy or Date: $27 / \mathrm{s} / 10$
$\phi$ Clam

Active Date: 1-12-17 Dec 2009
Owner: Gerard Anderson

Note: Printed copies of this document should be verified for currency against the published electronic copy.

### 3.4 INSTALL NEW SWITCHBOARD

### 3.4.1 Install new switchboard (For Sites with Option F Only)

| Contractor Task | Outcome |  |
| :---: | :---: | :---: |
| Install and connect the required (new or existing) earth cable | New <br> Existing | $\square$ |
| Install and connect the required (new or existing) mains cable | New <br> Existing | $8$ $\square$ |
| Record the 3 phases mains cable insulation resistance to earth. | $\begin{aligned} & A 200 \\ & B 20 \\ & C 20 \end{aligned}$ | Megohm <br> Megohm <br> Megohm |
| Record earth resistance |  | ohms |
| Point to point phase continuity | R to L1 <br> W to L2 <br> B to L3 <br> N to Nu | OKZ OKZ OKE OKE |

### 3.4.2 Install Supply Authority Metering

| Task | Outcome |
| :--- | :--- |
| Install the direct connected kWhr Meter |  |
| $4-12220270$ | OK口 |

### 3.4.3 Energise New Switchboard

| Contractor Task | Outcome |
| :---: | :---: |
| Retrieve mains 3-phase pole fuses from lock out box as per BW Isolation and Lock Out procedure. | OK ${ }^{7}$ |
| Ensure new switchboard main incomer is turned "Off". | OK $\square^{\square}$ |
| Install the 3-phase pole fuses. | OK $\square^{\square}$ |
| Turn on mains switch | OK |
| Check 3 phase voltages | $\begin{aligned} & \mathrm{AB} \text { Cers V } \\ & \mathrm{BC} \frac{\text { Coos } V}{C \text { Coo } V} \end{aligned}$ |
| Check phase rotation and ensure it is the same as determined earlier. | OK |
| Check MEN connection. | OK ${ }^{\circ}$ |



### 3.5 CONNECT PUMP \＃1 TO THE NEW SWITCHBOARD

| Contractor Task | Outcome |
| :---: | :---: |
| At the beginning of this procedure，Pump \＃2 is operating under the control of the temporary switchboard running from the Generator． | OK ${ }^{\text {d }}$ |
| Isolate submersible Pump \＃1 and Pump \＃2 at the new switchboard，as per BW Isolation and Lock Out procedure．（Decontactors） | OK $\square$ |
| Via the MERACHAL plug in sockets provided on the switchboard reconnect the power and control cables for Pump \＃1（this is the pump that is not connected to the generator set） | OK |
| Instail and connect the hydrostatic level probe to the transmitter． | Range 0 to |
| Confirm that level is indicating on the display． | OK ${ }^{\square}$ |
| Before beginning the next step ensure that the well level is between＇Start＇and ＇Stop＇level and Pump \＃2 is not running． <br> Isolate Pump \＃2 to prevent it from running during the next test | OK |
| De－isolate this now connected Pump \＃1．Check the rotation by starting the pump via the local＂Emergency Start＂switch and confirming the wet well level drops by at least 1\％． |  |
| Start Pump \＃ 1 again and Check the 3 phase motor current and compare with original readings． <br> PUMP \＃1 Can now be run in emergency and local，under the control of the new switchboard． |  |
| De－isolate Pump \＃2 so that the station is again under the control of the temporary switchboard． | OK |

### 3.6 CONNECT FIELD INSTRUMENTATION TO THE NEW SWITCHBOARD

## 3．6．1 Field Devices

| Contractor Task | Outcome |
| :---: | :---: |
| Connect the delivery pressure probe to the transmitter | OK［／ 0 to 6 Mtrs |
| Install and connect the Multitrode LR3 wet well high level relay Probe | OKD，at 3.5 F trs |
| Install and connect the Multitrode SIR surcharge imminent level relay Probe | OK $\square$ at \is ${ }^{\text {a }}$ Mtrs |
| Connect the thermistors for each pump（sites with option I only） | OKD N／A ${ }^{\text {a }}$ |
| Connect the moisture in oil sensor for each pump（sites with option A only） | OK口 N／A |
| Connect the moisture in stator for each pump（sites with option B1 only） | OKD N／A $\square$ |
| Connect the motor bearing temperature for each pump（sites with option B2 only） | OKD N／A $\square$ |
| Connect the reflux valve micro switch for each pump（sites with option C only） | OK $\triangle$ N／A $\square$ |
| Connect the upstream manhole surcharge imminent probe（sites with option D only） | OKロ ${ }^{\text {N／A }}$ C |
| Connect the Multitrode LR2 sump pump start／stop probes（sites with option E only） | OK $\sim$ N／A $\square$ |
| Connect the Multitrode LR4 sump pump high／trip probes（sites with option E only） | OK $冖 7 \sim$ N／A $\square$ |
| Connect the sump pump（sites with option E only） | OK $\quad$ N／A $\square$ |



### 3.7 CONNECT PUMP \#2 TO THE NEW SWITCHBOARD

### 3.7.1 Connect Pump \#2 to New Switchboard

| Contractor Task | Outcome |
| :---: | :---: |
| At the beginning of this procedure, Pump \#1 is operating under the control of the new switchboard running from the supply authority. | $\overline{\mathrm{OK} \square}$ |
| Shut down the generator and disconnect Pump \#2 from the temporary switchboard | OK |
| Ensure Pump \#2 circuit breaker at the new switchboard is still isolated and locked out as per BW Isolation and Lock Out procedure. | OK ${ }^{\prime}$ |
| Via the MERACHAL plug in sockets provided on the switchboard, connect the power and control cables for Pump \#2. | OK ${ }^{\prime}$ |
| De-isolate this now connected submersible pump. Check the rotation by starting the pump via the local "Emergency Start" switch and confirming the wet well level drops by at least $1 \%$. | OK |
| Start Pump \# 2 again and Check the 3 phase motor current and compare with original readings. <br> PUMP \#2 Can now be run in emergency and local, under the control of the new switchboard. |  |

### 3.8 COMMISSIONING OF THE PUMP STATION COMMUNICATIONS

### 3.8.1 Radio Antenna Installation

| BW Programmer Task | Outcome |
| :--- | :---: |
| Install new mast with Antenna, orientate antenna to the position determined in <br> section 3.1.2 connect coaxial cable plugs. | OK $\square$ |

### 3.8.2 Telemetry and SCADA Communications Checks

| BW Programmer Task | Outcome |
| :--- | :---: |
| Brisbane Water programmer must complete the following procedures |  |
| From the SSM086 Standard Fixed Speed Sewage Pumping Station (S.A.T.) | OK |
| Section 1: Setup and Pre-Commissioning Checks 1.1 to 1.8 |  |



### 3.9 COMMISSIONING OF THE PUMP STATION PUMPING SYSTEM

## 3．9．1 Commissioning of Pump \＃1 and Pump\＃2

| BW Programmer \＆Contractor Task | Outcome |
| :--- | :---: |
| Before beginning the next step ensure that the well level is between＂Start and <br> Stop＂level（Station under the control of the new board） | OK |
| Brisbane Water Programmer must complete the following procedures <br> From the SSM086 Standard Fixed Speed Sewage Pumping Station（S．A．T．） <br> Section2：On Site Commissioning Procedure 2．1 to 2．9 |  |

## 3．9．2 Commissioning of the SCADA Monitor and Control System

| BW Programmer \＆Contractor Task | Outcome |
| :--- | :---: |
| Brisbane Water Programmer must complete the following procedures |  |
| From the SSM086 Standard Fixed Speed Sewage Pumping Station（S．A．T．） | OK प |
| Section3：On Site Commissioning Procedure |  |

## 3．10 INSTALL GENERATOR MAINS（FOR SITES WITH PERMANENT GENERATORS－OPTION F）

| Contractor Task | Outcome |
| :---: | :---: |
| Record insulation resistance of the 3－phases $\mu / s$ | A $\qquad$ Megohm <br> B $\qquad$ Megohm． <br> C $\qquad$ Megohm |
| Record earth resistance | ohms |
| Connect the generator 10 cables | OK |
| Point to point phase continuity | R to $L 1$ OK口 <br> W to $L 2$ OK口 <br> B to $L 3$ OK口 |



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## 3．11 SITE ACCEPTANCE TESTING

## 3．11．1 Site Acceptance Testing（S．A．T）－Remaining Tests

| BW Programmer \＆Contractor Task | Outcome |
| :---: | :---: |
| Once pump 2 has been commissioned <br> Complete any remaining procedures in Section 2 <br> from the SSM086 Standard Fixed Speed Sewage Pumping Station（S．A．T．） | OKV1 |
| Check operation of SIR for 20 sec ．with probe to prove probe operation and operation of 2 pumps | OKए |
| Check operation LR3 with probe to prove RTU and probe | OKQ |
| Seal conduits with denso and grout under switchboard． | OK口 |
| Check Energex Phase Fail Input． | OK for |
| Confirm automatic control of pumps． | OK $\triangle$ |
| Check Parameter 203 of Soft Starter is a positive value VT0 | OK区 |
| Confirm correct operation of all door locks | OK® |
| Confirm Operation \＆Maintenance Manual left on site．N』Tワフ | OK $\square$ |

## 3．11．2 SCADA Testing

| BW Programmer \＆Contractor Task | Outcome |
| :--- | :--- |
| The Brisbane Water Programmer must complete the following procedures with the |  |
| assistance from the Commissioning Engineer and SCADA Commissioning Engineer |  |
| in the Control Room． |  |
| From the SSM086 Standard Fixed Speed Sewage Pumping Station（S．A．T．） |  |
| Section3 ：SCADA Commissioning Procedure | OK |

## 3．11．3 Preliminary Work Completion by Electrical Contractors

| Contractor Task | Outcome |
| :--- | :---: |
| Leave the site clean and tidy and hazard free． | OK |
| Confirm with BW that the job is complete and their staff can leave． | OK |
| Confirm with BW that BW staff will lock up the site on completion of the switchboard <br> change over work． |  |
| Note：If there is a problem with finishing the work due to unforeseen circumstance <br> refer to the Risk Analysis attached． | OK |

## 3．11．4 Register Control Room

| BW Programmer \＆Contractor Task | Outcome |
| :--- | :--- |
| Commissioning Engineer to call the Control Room Operator（CRO）and inform him <br> that the site works is complete and that the site is now fully in＂Remote＂control and <br> that all alarms are to be acted on as per the alarm instructions． | Name． |
| C．R．O．to confirm that the site is healthy and that there are no alarms active． | CRO |
| Record the C．R．O．＇s name and Officer Code and record the time of the call． | TIME： |

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## 4 Post Change Over Checklist

### 4.1 DELIVERABLES FROM RTU PROGRAMMER

| BW Programmer | Date Completed |
| :--- | :---: |
| Within 7 days of the change over the following must be completed and signed off by <br> the BW Programmer0 <br> Complete Section 4: Post Commissioning <br> from the SSM086 Standard Fixed Speed Sewage Pumping Station (S.A.T.) |  |
| The BW Programmer will ensure that the Control Room Acceptance (CRA) form is <br> signed by the Manager of the Control Room Officers. The form is to be handed to <br> the Contracts Manager (CM). | , 1, |

### 4.2 DELIVERABLES FROM ELECTRICAL CONTRACTOR

| Contractor Task | Date Completed |
| :--- | :---: |
| All documentation required under the contract is to be provided with the time <br> specified (AS BUILT's, Electrical Certificates etc). | $/ /$ |

### 4.3 DELIVERABLES FROM COMMISSIONING MANAGER

| Commissioning Manager | Date Completed |
| :--- | :---: |
| All documentation is handed to the Project Manager to that the new switchboard <br> asset can be capitalised and handed over to the customer. |  |
| Factory Acceptance Test Sheet - Completed \& signed off. | OK $\square$ |
| Electrical Inspection Sheet - Completed \& signed off. | OK $\square$ |
| Site Acceptance Test Sheet - Completed \& signed off. | OK $\square$ |
| Commissioning Plan - Completed \& signed off. | OK $\square$ |
| Control Room Acceptance Form - Completed \& signed off | OK $\square$ |
| As built Drawings have been updated, drafted and taken to site along with the Site <br> Specific Functional Specification, | ,$/$ |

### 4.4 SUGGESTIONS FOR IMPROVEMENT

| Suggestion | Recommended By |
| :--- | :--- |
|  |  |
|  |  |
|  |  |

BW Commissioning Manager
Name:
Date:

Signature:

TEST SHEET
CUSTOMER NAME: BRISBANE M AYER $\qquad$ SWITCHBOARD ID:..... SP 210 DATE: .27-5-2010 JOB No.: WTLLCe:O75 CUSTOMERS ADDRESS: $-1 . .$.


SERIAL NO: $\qquad$ IC NO: $\qquad$ 39850
test due date: $12 / 10 / 2010$
Q-Pulse Id TMS 1024
$\qquad$

TEST SHEET
customer name: ....trishane...................
switchboard id: brishame...water........io DATE: .....7/os/io.
$\qquad$ JOB No: ....个T4300 ! 6 CUSTOMERS ADDRESS: ......Nuchere......Beark.


TEST EQUIPMENT: $\qquad$ SCP .....Tester. SERIAL NO: $\qquad$ N. 5.5261 test due date: $\qquad$ $20.105 / 100$ $\qquad$
$\qquad$ Aaron Mar............... 53830 tIC. NO: $\qquad$ 53830 .....................................................
SIGNATURE: $\qquad$


|  |  |  |
| :---: | :---: | :---: |
|  |  |  |
| A | Y | Individual pump moisture in oil (MIO) sensor and fautl relay. |
| B |  | Individual pump molsture in stator (MIS) sensor and faull relay and/or bearing temperature fault sensor and faull relay |
| C | Y | Individual oump reflux valve micro swich. |
| D | - | Upstream Manhole Surcharge Imminent Probe |
| E | Y | Station dry well sump pump and level Indlcation sensors and relays. |
| F | - | Station permanent generator (ATS and control connections). |
| G |  | Station emergency storage level sensor. |
| H | Y | Station delivery flow moter. |
| K, |  | Bäckü; Commumication Options |
|  |  |  |
| K |  | Cathodic Protection. |
|  |  |  |
| M | - | Odaur Control |
|  | 82ayk |  |
| , |  |  |
| P |  | Wet Well Washer |
| Q | - | Vakve Pit Sump Pump and Level |
|  |  |  |
| 5 | - | Secondary Wet Well Level Sensor (Ultrasonic) |
|  |  |  |
| U | Y | Deliveny Pressure Transmliter |
| V | - | Chemical Dosing |





|  |  | SP210 Nudgee Beach Physical I.O. Spreadsheet | Digital Output Card 1 |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1/0 \# | MITS Tag | Description | Off State | On State | Term. \# | Wire \# | Schem | Term | 0 | Comment | FAT | SAT |
| 0 | pmploperate | Pump run command | Off | Run | 105 \& 106 | 0000 | 02 | 11 | - |  | O |  |
| 1 | pmplresetcmd | Pump faull reset | Off | Reset | 107 \& 108 | 0001 | 02 | 11 | - |  | $\square$ |  |
| 2 | pmplinterupt | Pump emergency mode interrupt | Off | Interupl | 1098110 | 0002 | 02 | 11 | $\cdot$ |  | $\square$ |  |
| 3 | pmphrunatmax | Pump VSD Run at Max command | Off | On | 1118112 | DO03 | 02 | 11 | $\wedge$ |  |  |  |
| 4 | wwllsignal Test | Wet well signal test | Off | On | 113 \& 114 | D004 | 07 | 11 | $\bigcirc$ |  | $\square$ | $\square$ |
| 5 |  |  |  |  | 115 \& 116 | D005 | 07 | 11 | $\overline{\mathrm{P}}$ |  |  |  |
| 6 | wwllst robe | Ory Well Station strobe light | Off | On | 117 \& 118 | D006 | 07 | 11 | E |  | $\square$ | $\square$ |
| 7 |  |  |  |  | 119 \& 120 | 0007 | 07 | 11 | M |  |  |  |


|  |  | SP210 Nudgee Beach Physical I.O. Spreadsheet | Digital | put Card |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1/0 \# | MITS Tag | Description | Off State | On State | Term. \# | Wire \# | Schem | Term | 0 | Comment | FAT | SAT |
| 8 | pmpzoperate | Pump run command | Off | Run | 123\&124 | 0008 |  | 11 | - |  | र्ז) |  |
| 9 | pinp2resetcmd | Pump faulireset | Off | Rese! | 1258126 | DO09 |  | 11 | - |  | - |  |
| 10 | pmp2interupt | Pump emergency mode interupt | Off | Interupt | 127 \& 128 | D010 |  | 11 | - |  | $\square$ |  |
| 11 | pmparunfimas | Pump VSD Run at Max command | Off | On | 129 \& 130 | D011 |  | 11 | $\stackrel{\square}{\square}$ |  |  |  |
| 12 |  |  |  |  | 131\&.132 | D012 |  | 11 | $\bar{F}$ |  |  |  |
| 13 |  |  |  |  | 133 \& 134 | D013 |  | 11 | K |  |  |  |
| 14 |  |  |  |  | 135\&136 | DO14 |  | 11 | K |  |  |  |
| 15 |  |  |  |  | 137 \& 138 | D015 |  | 11 | - |  |  |  |

Date 5151 c

SI'TE ACCEPTANCE TESTED GY: $\qquad$ Date 11

|  |  | SP210 Nudgee Beach Physical I.O. Spreadsheet | Ana | ut Car |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1/0 \# | MITS Tag | Description | 4 mA | 20 mA | Term. \# | Wire \# | Schem | Term | 0 | Comment | FAT | SAT |
| 0 | malirawsignal | Primary Wet well level raw signal |  |  | 147 \& 148 | A100+.A100- | 07 | 12 | - |  | 区 | $\square$ |
| 1 | oreirawSignal | Delivery pressure raw signal |  |  | 149 \& 150 | Al01+. $\mathrm{AlO1-}$ | 07 | 12 | U |  | $\square$ | $\square$ |
| 2 |  |  |  |  | 151\&152 | A102+,A102- | 07 | 12 | $\cdots$ |  |  |  |
| 3 | flwlrawSignal | Pump 1 Delivery flow raw signal |  |  | 153\%154 | Al03+,A103- | 07 | 12 | $\stackrel{\wedge}{\wedge}$ |  | T | $\square$ |
| 4 |  |  |  |  | 155 \& 156 | A104+. $\mathrm{AlO} \mathrm{C}_{-}$ | 07 | 12 | F |  |  |  |
| 5 |  |  |  |  | 1578158 | A105+.A105- | 07 | 12 | 5 |  |  |  |
| 6 |  |  |  |  | 159 \& 160 | A106+,A106- | 07 | 12 | K |  |  |  |
| 7 | flw2rawSlanal | Pump 2 Delivery llow raw signal |  |  | $161 \& 162$ | Al07+,Al07- | 07 | 12 | H |  | $\square^{6}$ | $\square$ |

_्_ACTORy acceptance tested by: Thax
Date 5,5710
SITE ACCEPTANCE TESTED BY:
Date $\quad 1 \quad 1$

 construction, alteration, addition or repair, it shall be inspected and tested to verify that the installation is safe to energize and that it will operate correctly in accordance with the requirements of AS3000:2007.
This section is aimed to ensure that the switchboard manufacturer has carried out and documented all applicable AS3000:2007 tests considered as mandatory, prior to execution of the Factory Acceptance Test.
AS/NZS 3017 Electrical Installations - Verification Guidelines provides inspection, test methods and test acceptance parameters to verify AS3000:2007 safety requirements, however these methods are provided for guidance and other alternative methods are acceptable, AS3017:2007 may be applied through legislative requirements made in each State and Territory of Australia and in New Zealand.

| Item | Activity Description | Results |  |  | Signed Qun-S | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. |  | Acc | ReL | N/A |  |  |
| A. 1 | Records for the verification of the continuity and resistance of the earthing system shall include: <br> a) Main earthing conductor <br> b) Protective earthing conductors <br> c) Earth bonding conductors. | $\begin{aligned} & V \\ & V \\ & V \end{aligned}$ |  |  |  | For acceptance criteria and test methods refer to: <br> AS3000:2007 Section 8.3.5 <br> AS3017:2007 Section 3.1 |


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| Item No. | Activity Description | Results |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | ReJ | N/A |  |  |
| A. 2 | Records for the verification of Insulation Resistance shall include: <br> a) Insulation resistance test of complete installation <br> b) Insulation resistance test of consumers mains <br> c) Insulation resistance test of single circuits | $\sqrt{ }$ $\sqrt{ }$ |  | $\checkmark$ |  | For acceptance criteria and fest methads refer to: <br> AS3000:2007 Section 8.3.6 <br> AS3017:2007 Section 3.2 |
| A. 3 | Records for the verification of Polarity Tests records shall include: <br> a) Consumer mains <br> b) Submains incorporating an earthing conductor <br> c) Submains not incorporating a protective earthing conductor <br> d) Subcircuit polarity connections test (including single pole switches) <br> e) Phase sequence tests | $\begin{aligned} & \sqrt{ } \\ & \sqrt{ } \end{aligned}$ |  | $\begin{aligned} & \mathcal{J} \\ & J \end{aligned}$ | 为 | For acceptance criteria and test methods refer to: <br> AS3000:2007 Section 8.3.7 <br> AS3017:2007 Sections 3.3 and 3.5 |

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| Item No. | Activity Description | Results |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | Rel | N/A |  |  |
| A. 4 | Records for the verification of Correct Circuit connection tests records shall include: <br> a) interconnection between conductors of different circuits <br> b) Socket-Outlet Sub-Circuits <br> c) Ligthing Points <br> d) Equipment Sub-circuits | $\begin{aligned} & f \\ & \mathcal{J} \\ & \mathcal{V} \end{aligned}$ |  |  | $\begin{aligned} & \text { 庰 } \\ & \text { per } \\ & \text { Bir } \end{aligned}$ | For acceptance criteria and test methods refer to: <br> AS3000:2007 Section 8.3.8 <br> AS3017:2007 Section 3.4 |
| A. 5 | Records for the verification of earth fault-loop for impedance shall include: <br> a) Circuits not protected by an RCD | $\mathcal{J}$ |  |  | $12 \%$ | For acceptance criteria and test methods refer to: <br> AS3000:2007 Section 8.3.9 <br> AS3017:2007 Section 3.6 |
| A. 6 | Records for the verification of operation of RCDs shall include: <br> a) Circuits protected by an RCD | / |  |  | A\% | For acceptance criteria and test methods refer to: <br> AS3000:2007 Section 8.3.10 <br> AS3017:2007 Section 3.7 |

## Contractor's Tester Signature

Queensland Urban Utilities Electrical Inspector

......John Clayton $\qquad$ Date $0.7 / 0.5 / 1 / 0$
Date . $2.7 .-1 . . .10$

## B. Testing Area, Documentation and Test Set Up Arrangements

This section is aimed to ensure that all documentation and test set up arrangements have been provided to allow execution and readiness to carry out the FAT.

| ltem No. | Activity Description | Results |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | Rel | $N / \mathrm{A}$ |  |  |
| B. 1 | Verify that a suitable test area has been provided, the test area shall be: <br> - Clearly identified and barsicaded <br> - Test bench with enough space for testing equipment and documentation <br> - Well ventilated | $\begin{aligned} & f \\ & \sqrt{\prime} \\ & / \end{aligned}$ |  |  |  |  |
| B. 2 | All testing equipment to simulate field inputs and outputs including field instruments and motors shall be pre-connected | $\checkmark$ |  |  | H |  |
| 8.3 | "As Buill" drawings marked up available. | 1 |  |  | Fers |  |
| B. 4 | "Point to Poinl" test drawing mark-ups provided | $\checkmark$ |  |  |  |  |

Contractor's Tester Signature
Queensiand Urban Utilities Electrical Inspector
, $\qquad$
.....John Clayfon. $\qquad$
Date 27....4....10
Date $0.7 / 0.512010$

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Owner: Allonso Chavez

## C. Visual Inspections - Sheet Metal / Mechanical Construction Works

The following visual inspections shall take place previous to energising the switchboard circuits. All power supplies shall be disconnected, including the main power supply, generator power supplies and battery power supplies.

| Item No. | Activity Description | Results |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | RCL | N/A |  |  |
| C. 1 | Switchboard dimensions correct as per contract drawings | ' |  |  | B |  |
| C. 2 | Panel layout as per drawings | / |  |  | $\mathscr{H}$ |  |
| C. 3 | All equipment is to be removable from switchboard via front access. | $\%$ |  |  | 17 |  |
| C. 4 | Power distribution chassis not to be installed too close to the left of the door aperture | 4 |  |  | 136 |  |
| C. 5 | Check operation and orientation of doors and door handles | ' |  |  |  |  |
| C. 6 | Switchboard mounling teet as per drawing | ' |  |  | $\mathrm{BE}$ |  |
| C. 7 | Material finish as per specification | ' |  |  | Ez |  |
| C. 8 | IP Rating as per specifications. Fitting of sun shields shall maintain IP56 rating. | ' |  |  |  |  |
| C. 9 | All bolts fitted / tight | \% |  |  | $\beta$ |  |
| C. 10 | All sheet metal edging to be de-burred, special attention given to handle/lock access heat shield cuts. | / |  |  | $\%$ |  |


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Major Projects \& Commercial Services
SQUV SP Reliability improve - Stoge?

| Item No. | Activity Description | Resulis |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | Rej | N/A |  |  |
| C. 11 | Door, hinges and locks are properly fitted to allow closing without forcing the door or being loose. | $j$ |  |  | /is |  |
| C. 12 | Lock barrels are mounted neatly. Door penetration and holes shall be suited to the particular lock barrel type. | $\int$ |  |  | 寿 |  |
| C. 13 | Lock barrel types are provided as required and operate correctly | $\checkmark$ |  |  | A\% |  |
| C. 14 | Energex Padlock Supplied | $\checkmark$ |  |  | 为 |  |
| C. 15 | All doors sealing shall be properly fitied and firmly secured to the switchboard. Glue shall be provided if necessary. | $7$ |  | $6^{4}$ | Pr |  |
| C. 16 | Verify thal proximity switch metal plates are fixed to doors as indicated in the drawings. | P6 |  | $\nearrow$ | \% |  |
| C. 17 | Ensure to pre-drill holes in plates that are difficult to access after the construction or installation of the switchboard on site. <br> Particular attention shall be given to internol borrier plates and access plate on distribution board. | $1$ |  |  | Ht |  |
| C. 18 | Cut outs from one cubicle to another please shall be large enough to accommodate all cables. | 1 |  |  | \% |  |
| C. 19 | Sealing between plinth and switchboard. | 7 |  |  | \% |  |
| C. 20 | Sealing of disconnect zone. |  |  | $\digamma$ | Hit |  |


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| Item No. | Activity Description | Results |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | ACC | Rel | N/A |  |  |
| C. 21 | Verify that portable generator cable access plate allows the generator plug pass into the switchboard and reach the generator connection outlet. | $/$ |  |  | \% |  |
| C. 22 | Inspection plates are properly labeiled and not used as gland plates. Inspection plates are only provided to ease access to field wiring. | ! |  |  | 8 |  |
| C. 23 | Verify that all gland entries are sealed - No splif gland plates | $J$ |  |  | 125 |  |
| C. 24 | All spare holes to be plugged with conduit plugs. | $7$ |  |  | 18 |  |
| C. 25 | Enclosure free of debris |  |  |  | 6 |  |
| C. 26 | Lap top support tray providedincluding 1/4 turn wing knob on laptop support shelf. Knobs types that cannot be operated by hand are not acceptable. | $\sqrt{1}$ |  |  | 4 |  |
| C. 27 | Drowings \& log book holder provided | $f$ |  |  | 18 |  |
| C. 28 | Aerial support is adjustoble |  |  | \% | $\sqrt{3}$ |  |
| C. 29 | A minimum clearance of 55 mm sholl be provided around the Redlion HMI to other components mounted in common controls door. | 1 |  |  | $+\frac{1}{3}$ |  |
| C. 30 | Check that selector switches are correctly engroved | 7 |  |  | $b$ |  |


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| :--- | :--- | :---: | :---: | :---: |
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Contractor's Tester Signature

Queensland Urban Utilities Electrical Inspector

......John Clayton

Date 27.7 .4 .10
Date 0..7...5./.20/0

## D. Visual Inspections- Neutral and Earthing

A visual inspection shall be made when work on an electrical instalation has been completed in order to verify that the work complies with the requirements of AS/NZS 3000.

The visual inspection shall be carried out before, or in association with testing, and as far as possible it should be made before the electrical installation is placed in service.

| Item No. | Activity Description | Resulis |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | Rej | N/A |  |  |
| D. 1 | N/L \& E/L have adequate bolts for main Neutral \& Earth | / |  |  | fior |  |
| D. 2 | Earth bar / earth connections fitted \& OK | $\checkmark$ |  |  | Px |  |
| D. 3 | All neutral conneclions are accessible | $\checkmark$ |  |  | 13 |  |
| D. 4 | MEN connections provided | $\checkmark$ |  |  | $\cdots$ |  |
| D. 5 | Neutral \& earth connections are not in CT section | $\int$ |  |  | Pr |  |
| D. 6 | Surge diverter earthed to adjacent stud. |  |  | 7 | 为 |  |
| D. 7 | Confirm a Direct connection from main earth bar to switchboard chassis | $\checkmark$ |  |  | $\theta$ |  |

## Contractor's Tester Signature

Queensland Urban Uilities Electrical Inspector
......John Clayton.

> Date $\ldots . . . . . . . . .$.
> Date $9 . .7 / \ldots 5 / 20 / 0$

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## E. Visual Inspections - Electrical Components Mounting, Wiring and Labelling

As a minimum a visual inspection shall be made when work on an electrical installation has been completed in order to verify that the work complies with the requirements of AS/NZS 3000. This visual inspection section includes AS/NZS 3000 checks as well as several checks to verify that the electrical installation meets the specific design and quality requirements and scope of work.

The visual inspection shall be carried out before, or in association with testing, and as far as possible it should be made before the electrical installation is placed in service.

| Item No. | Activity Description | Results |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | Rel | N/A |  |  |
| E. 1 | Busbars appropriately shielded | 7 |  |  | 4 |  |
| E. 2 | Verify that main switches/circuit breakers and fuses are supplied to the specification (equipment schedule) | $/$ |  |  | $y$ |  |
| E. 3 | Main switches lockable/ deteatable as per spec. | 7 |  |  | Pir | 1 |
| E. 4 | Check operation of Main Supply and Generator supply mechanical and/or key interlocks as applicable. | 7 |  |  | 13\% | MAIN-GENERATM SWIt C intanolf. Jams. - |
| E. 5 | Verify that metering fuses \& CT's are fed off from main switch line side | 7 |  |  | \% |  |
| E. 6 | verify that cable lugs are provided into CRITEC 20 kA surge filter circuit breaker (in most cases Q171 | \% |  |  | Mer |  |
| E. 7 | Equipment fed from line side shall be appropriately labelled. | 4 |  |  | \% |  |


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| Item No. | Acfivily Description | Results |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | Rel | N/A |  |  |
| E. 8 | Include 2nd label for Surge Diverter and Surge Diverter fuses "FED FROM LINE SIDE OF MAIN SWITCH" as applicable (ltems 37/38 on switchboard label schedule). | $\nearrow$ |  |  |  |  |
| E. 9 | All Circuit Breakers shall be set as indicated in the electrical schematic drawings. | 1 |  |  | $f$ |  |
| E. 10 | All circuit breakers shall be wired line side at the top / load side at the bottom | / |  |  | 10w |  |
| E. 11 | Verify that cables current carrying capacity is as indicated in the electrical schematic drawings. | 7 |  |  |  |  |
| E. 12 | Colour coding of wiring as per specification. | 1 |  |  |  |  |
| E. 13 | Wiring in PVC ducting shall be kept fidy. | 7 |  |  |  |  |
| E. 14 | Check cable access dimensions | 7 |  |  | $170^{6}$ |  |
| E. 15 | Check cable access \& routes for field cabling. | $\%$ |  |  | $9$ |  |
| E. 16 | Check phasing of circuits are as per draving. | $/$ |  |  |  |  |
| E. 17 | Electrical components fitted are as specified in the equipment schedule | $/$ |  |  |  |  |
| E. 18 | Verify that quantily and location of GPOs are provided as required in the drawings. | 7 |  |  |  |  |
| E. 19 | Confirm all idec relays are LED type and wired the correct polarity | 7 |  |  | $\sqrt{3}$ |  |


| Doc Id: | CA. 17 a a |
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Owner: Alfonso Chavez

[^12]CA17a - Factory Inspaction Tests
Major Projects \& Commerclal Services
SQUV SP Reliability Improve - Stage2

| Item No. | Activity Description | Resulis |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | Ac) | N/A |  |  |
| E. 20 | Verify that digital timer is mounted on its own specific base (IDEC base) as specified in the equipment list (Item 99 -EMGDT) | $1$ |  |  |  |  |
| E.21 | Check that generator plug has pratective cover fitted | 1 |  |  |  |  |
| E. 22 | Verify that power disconnection outlets ond plugs are supplied with the switchboard as required | / |  |  | 14 |  |
| E. 23 | Verity that terminals \& busbar connections are tight | $/$ |  |  | 绋 |  |
| E. 24 | Verify that terminals are identified as per drawings and spares are provided | $/$ |  |  |  |  |
| E. 25 | All terminals shall be correcl part number, shrouded to IP20 and labelled. | 7 |  |  |  |  |
| E. 26 | All coble cores ferruled \& numbered. | $\checkmark$ |  |  | F |  |
| E. 27 | 24 VDC power supply shall be mounted to prevent obstruction to the field instrument terminals. | $/$ |  |  |  |  |
| E. 28 | Mullicore cables shall be used for RTU harnesses to provide neal wiring installation. Use of individual wires for each l/O is not acceptable. | $/$ |  |  | $4$ |  |
| E. 29 | Verify that adequate access to RTU and communication plucj is provided | $/$ |  |  |  |  |
| E. 30 | Modbus communicatian cables (RS 485) shall be 120 ohm impedance twisted poir's. | 1 |  |  |  |  |


| Doc id: | CA-17a |
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Owner: Alfonso Chavez
Owner: Alfonso Chavez

Queensland Urban Utilities Confidenlial
Page 12 of 17

| Item No. | Activity Description | Results |  |  | Signed QUU | Comments |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Acc | Rel | N/A |  |  |
| E. 31 | Aerial surge arrestor shall be mounted with a small section of DIN rail the earthed as directly as possible | $\int$ |  |  | pr |  |
| E. 32 | When externally installing soft starter CT's for bypass circuit, verify proper size to match the SS and wiring polarity. fif SS is MSF-017 the corresponding CT shall be CTS-017] |  |  | $\checkmark$ | $\beta_{2}^{2}$ |  |
| E. 33 | When externally installing soft starter $C T$ 's for bypass circuit, please ensure proper Bypass operation parameter [340] shall be enabled. |  |  | $\sqrt{ }$ | $8$ |  |
| E. 34 | Motor Starter CT ratios are as specilied and mounted to correct polarily |  |  | $\checkmark$ | Pret |  |
| E. 35 | Soft starter CT leads to be cut to size / kept short. |  |  | - | 1 |  |
|  | ontractor's Tester Signature veensIand Urban Utilities Electrical Inspector |  |  |  | on.... |  |


| Doc Id: | CA-17a |
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## F. Live Power and Operational Tests

The following tests shall be made with all switchboard electrical circuits energized in order to check that the switchboard meets all operational requirements.

| Ifem | Activity Description | Results |  |  | Slgned QUU | Comments |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | AcC | Rel | N/A |  |  |  |
| F. 1 | Verify that all circuit breakers isolate their stated circuits | $/$ |  |  | 705 |  |  |
| F. 2 | Verify that all electrical components energize when power circuits are energized | 1 |  |  | $8$ |  |  |
| F. 3 | Switchboard lights operate | $\checkmark$ |  |  | 立湤 |  |  |
| F. 4 | Confirm that E-Stops actually stop its corresponding drive. | $\checkmark$ |  |  | 18 |  | -1/ 1 |
| F. 5 | Thermal overloads or soft starter protection appropriately set |  |  | $\checkmark$ |  | VFO PROTENION | Kuorraleln JeR. |
| F. 6 | Set up all of the soft starter parameters | $\checkmark$ |  | 4 | Fiv | $\text { senuf mil } \cup F D$ | $m(1)$ |
| F. 7 | Verify that all Soft starter operation and all display parameters are displaying correctly. Confirm current CTs are the correct polarity | $\checkmark$ |  | 2 | , er | VFD. |  |
| F. 8 | A copy of Soft Starter and/or VSD parameter configuration to match site equipment shall be provided to the switchboard manufacturer by the commissioning manager. | 1 |  |  | 1 |  |  |
| F. 9 | Record output of 24 VDC power supply when connected to 240 VAC main. | $\checkmark$ |  |  | $3 P^{2}$ | 13.74 voly |  |
| Doc Id:Pinted:Note: | CA-17a23/0,3/2010Printed copies of this document should be verified for currency | against the published electronic copy. |  |  |  | Rev: 12 <br> Owner: Alfonso Chavez | Qucensland Urban Ulilitics Confidential Page 14 of 17 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |



## Contractor's Tester Signature

$\qquad$

Queensland Urban Utilities Electrical Inspector ......John Clayton........... Date ...77....5. 20,0 \& Claypan

| Docild: | CA -17a |
| :--- | :--- |
| Printed: | $23 / 03 / 2010$ |
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G. Non-Conformances and Unauthorised Modifications


Contractor's Tester Signature

Queensland Urban Utilities Electrical Inspector
$\qquad$ Date $\qquad$

Date .....7......5/20) 0

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This section is to be completed only at the conclusion of the FAT:

| Final fat results | YES | NO | Comments |
| :---: | :---: | :---: | :---: |
| Pre-FAT Completed | $\sqrt{ }$ |  | Die to UFD Problems a AIProblen vot $100 \%$ checkerl. |
| Minor NCRs Generated | $\checkmark$ | / |  |
| Major NCRs Generated |  | $\checkmark$ |  |
| Pre-FAT Accepted | $\sqrt{ }$ |  |  |

## Notes:

1. FAT results to be recorded above by Coniractor.
2. FAT results to be approved by Queensland Urban Utilities Electrical Inspector.
3. Pre-FAT results to be approved by Queensland Urban Utilities Electrical inspector at Pre-FAT (if present) or at the start of the FAT.
4. NCRs are to be generated by the Queensland Urban Utilities Electrical inspector for all NCRs not resolved by the end of the test.

Contractor's Tester Signature
Date ...13/04/10


## Su _.ectric (Qld) Pty. Ltd.

## FACTORY ACCEPTANCE TEST SHEET 1:

| Project: Client: Job No. Equipment: Section: Drawing: |  | Pump Station SP 210 $\qquad$ QLD Urban Utilities $11430016$ <br> SP210 Switchboard <br> Incomer <br> $486 / 5 / 7-0172$ Sheet 1 |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Process Operation | * | Reference/ Acceptance Criteria | Passed |  |
| 1. | Ensure Insulation test as per QA3CH-15 have been completed |  | ```SJ QA3CH-15 AS 3000 Insulation resistance greater than 1 megohm ph to earth Hi pot test 2.5 kv ph-eth for 1 minute``` | $\checkmark$ | $9 / 4 / 10$ |
| 2. | Ensure Checks 1 to 11 as per QA3CH-020 have been completed |  | SJ QA3CH-020 <br> Point to Point check of schematics. <br> Visual Check of wiring. | , | 9/4/10 |
| 3. | Check Manual Transfer Switch is functioning by confirming power to the line and then load sides of the switches when energized and de-energized. |  | Drawing 486/5/7-0172 | 2 | $9 / 4 / 10$ |
| 4. | Check operation of Energex Power On phase failure relay PFRE and correct signal is being received by RTU |  | Drawing $486 / 5 / 7-0172$ $\qquad$ Remove one phase from relay sensing circuit to simulate loss of power. | $\cdots$ | $9 / 4 / 10$ |
| 5. | Check operation of Station Power On phase failure relay PFRS and correct signal is being received by RTU |  | Drawing $486 / 5 / 7-0172$ $\qquad$ Remove one phase from relay sensing circuit to simulate loss of power. | , | 9/4/10 |

Su n.actric (Qld) Pty. Ltd.

S. _..ectric (Qld) Pty. Ltd.

FACTORY ACCEPTANCE TEST SHEET 2 :


## SJ _.ぇctric (Qld) Pty. Ltd.

| 8. | Check operation of the following RCD's and note tripping times: <br> - Q11 <br> - Q12 <br> - Q13 <br> - Q19 <br> - Q21 | Drawing $486 / 5 / 7-0.72$ Tripping Time: | $9 / 4 / 10$ |
| :---: | :---: | :---: | :---: |



## FACTORY ACCEPTANCE TEST SHEET 3:

|  | Project: Client: Job No. Equipment: Section: Drawing: | Pump Station SP 210 <br> QLD Urban Utilities $\text { ST } 430016$ <br> SP210 Switchboard <br> RTU Connection $486 / 5 / 7-0172 \quad \text { Sheets } 1 \& 6$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Process Operation |  | Referencel Acceptance Criteria | Passed | Date |
| 1. | Ensure Insulation test as per QA3CH-15 have been completed |  | SJ QA3CH-15 <br> AS 3000 <br> Insulation resistance greater than 1 megohm ph to earth <br> Hi pot test 2.5 kv ph-eth for 1 minute | $\checkmark$ | 9/4/10 |
| 2. | Ensure Checks 1 to 11 as per QA3CH-020 have been completed |  | SJ QA3CH-020 <br> Point to Point check of schematics. Visual Check of wiring. | 1 | 9/4/10 |
| 3. | Ensure Laptop GPO, circuit breaker Q13 is "OFF" and operate RTU circuit breaker Q30 on DB Chassis and ensure: <br> RTU Power Supplies are operating correctly. |  | Drawing $488 / 5 / 7-0,72$ Sheet 1 240 vac ph to $n$ on power supply input. 24 vdc on power supply output | 1 | 9/4/10 |
| 4. | Close Laptop GPO Circuit Breaker and: Check GPO polarity. Check GPO switch is functioning. Check operation of RCD device. |  | Drawing $486 / 5 / 7-0172$ Sheet 1 | $\checkmark$ | 9/4/10 |
| 7. | Confirm operation of door switches. |  | Drawing $486 / 5 / 7-0172$ Sheet $1 \& 6$ | 1 | $9 / 4 / 10$ |

S $ل$ _.əctric (Qld) Pty. Ltd.

| Tests Completed By | Witnessed By | Accepted By |
| :--- | :--- | :--- |
| Aaron Markham | RQSS DAN |  |
| Date $\% / 4 / 10$ | Date | Date |
| Comments: |  |  |
|  |  |  |
|  |  |  |
| Instruments Used: |  |  |

SJ...3ctric (Qld) Pty. Ltd.
FACTORY ACCEPTANCE TEST SHEET 4:

|  | Project: <br> Client: <br> Job No. <br> Equipment: <br> Section: <br> Drawing: | Pump Station SP 210 <br> QLD Urban Utilities $\frac{6 T 430016}{S P 2,0 \text { Switchboard }}$ <br> Pump 1 $\qquad$ <br> $486 / 5 / 7-0172$ <br> Sheet 2 |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Process Operation |  | Reference/ Acce | Passed | Date |
| 1. | Ensure Insulation test as per QA3CH-15 have been completed |  | SJ QA3CH-15 <br> AS 3000 <br> Insulation resistan earth <br> Hi pot test 2.5 kv | $\checkmark$ |  |
| 2. | Ensure Checks 1 to 11 as per QA3CH-020 have been completed |  | SJ QA3CH-020 Point to Point che Visual Check of | $\checkmark$ |  |
| 3. | Check voltage is available on line side of motor circuit breaker Q4. |  | 415 vac ph to ph | $\checkmark$ |  |
| 4. | Ensure control circuit breaker Q4-1 is "OFF" and emergency stop is operated, close circuit breaker Q4 and confirm voltage is available on line side of circuit breaker Q4. |  | 415 vac ph to ph |  |  |
| 5. | Check voltage is available on line side of control circuit breaker Q4-1, close circuit breaker and ensure: <br> - 1K2 Control Supply Relay is operating correctly. |  | 240 vac ph to n |  |  |
| 6. | Release emergency stop and confirm operation of isolating contactor 1K1 and confirm voltage is available to VSD. |  | 415 vac ph to ph |  |  |
|  |  |  |  |  |  |

## SJ ఒactric (Qld) Pty. Ltd.

| 7. | Confirm operation of Pump 1 Digital Inputs. | Drawing $486 / 5 / 7-0,72$ Sheet 2 | Drawing $486 / 5 / 7-0 / 72$ Sheet 2 |
| :---: | :--- | :--- | :--- |
| 8. | Confirm Operation of Pump 1 Digital Outputs | Drawing $486 / 5 / 7-0,72$ Sheet 2 |  |
| 9. | Confirm Operation of Pump 1 Analog l/O | Drawing $486 / 5 / 7-0,72$ Sheet 2 |  |
| 10. | Confirm Operation of cubicle fan by manually operating the thermostat 1FC |  |  |


| Tests Completed By | Witnessed By | Accepted By |
| :--- | :--- | :--- |
|  | Date | Date |
| Date |  |  |
| Comments: |  |  |
|  |  |  |
|  |  |  |
| Instruments Used: |  |  |
|  |  |  |

## FACTORY ACCEPTANCE TEST SHEET 5:

| Project: | Pump Station SP 210 |
| :--- | :--- |
| Client: | QLD Urban Utilities |
| Job No. | $\frac{6 T 430016}{}$ Equipment: |
| Section: | Pump Switchboard |
| Drawing: | $\underline{486 / 5 / 7-0,72}$ Sheet 3 |


|  | Process Operation | Reference/ Acceptance Criteria | Passed | Date |
| :---: | :---: | :---: | :---: | :---: |
| 1. | Ensure Insulation test as per QA3CH-15 have been completed | SJ QA3CH-15 <br> AS 3000 <br> Insulation resistance greater than 1 megohm ph to earth <br> Hi pot test 2.5 kv ph-eth for 1 minute | $\checkmark$ |  |
| 2. | Ensure Checks 1 to 11 as per QA3CH-020 have been completed | SJ QA3CH-020 <br> Point to Point check of schematics. Visual Check of wiring. | $r$ |  |
| 3. | Check voltage is available on line side of motor circuit breaker Q5. | 415 vac ph to ph | $\checkmark$ |  |
| 4. | Ensure control circuit breaker Q5-1 is "OFF" and emergency stop is operated, close circuit breaker Q5 and confirm voltage is available on line side of circuit breaker Q5. | 415 vac ph to ph | $\checkmark$ |  |
| 5. | Check voltage is available on line side of control circuit breaker Q5-1, close circuit breaker and ensure: <br> - 2K2 Control Supply Relay is operating correctly. | 240 vac ph to n | $r$ |  |
| 6. | Release emergency stop and confirm operation of isolating contactor 2 K 1 and confirm voltage is available to VSD. | 415 vac ph to ph | 7 |  |
|  |  |  |  |  |

Sj Electric (Qld) Pty. Ltd.

| 7. | Confirm operation of Pump 1 Digital Inputs. | Drawing $486 / 5 / 7-0172$ Sheet 3 | $\bigcirc$ |  |
| :---: | :---: | :---: | :---: | :---: |
| 8. | Confirm Operation of Pump 1 Digital Outputs | Drawing 486/5/7-0172 Sheet 3 | , |  |
| 9. | Confirm Operation of Pump 1 Analog 1/O | Drawing 486/5/フ-0172 Sheet 3 | 2 |  |
| 10. | Confirm Operation of cubicle fan by manually operating the thermostat 2FC | Drawing 486/5/7-0,72 Sheet 3 |  |  |


| Tests Completed By | Witnessed By | Accepted By |
| :--- | :--- | :--- |
|  | Date |  |
| Date |  |  |
| Comments: |  |  |
|  |  |  |
|  |  |  |
| Instruments Used: |  |  |
|  |  |  |

## Sewage Pump Station SP210

## Nudgee Beach

## Electrical Drawing List 1

## Site Installation

| Sheet No. | Drawing No. | Title |
| :---: | :--- | :--- |
| 00 | $486 / 5 / 7-0172-000$ | Site Cover Sheet |
| 01 | $486 / 5 / 7-0172-001$ | Power Distribution Schematic Diagram |
| 02 | $486 / 5 / 7-0172-002$ | Pump 01 Schematic Diagram |
| 03 | $486 / 5 / 7-0172-003$ | Pump 02 Schematic Diagram |
| 04 | $486 / 5 / 7-0172-004$ | Dry well Sump Pump Schematic Diagram |
| 05 | $486 / 5 / 7-0172-005$ | [RESERVED] Generator Control Schematic Diagram |
| 06 | $486 / 5 / 7-0172-006$ | Common Controls Schematic Diagram |
| 07 | $486 / 5 / 7-0172-007$ | Common RTU I/O Schematic Diagram |
| 08 | $486 / 5 / 7-0172-008$ | RTU Power Distribution Schematic Diagram |
| 09 | $486 / 5 / 7-0172-009$ | RTU Digital Inputs Termination Diagram |
| 10 | $486 / 5 / 7-0172-010$ | RTU Digital Inputs Termination Diagram |
| 11 | $486 / 5 / 7-0172-011$ | RTU Digital Outputs Termination Diagram |
| 12 | $486 / 5 / 7-0172-012$ | RTU Analogs \& Miscellaneous Termination Diagram |
| 13 | $486 / 5 / 7-0172-013$ | Common Controls Termination Diagram |
| 14 | $486 / 5 / 7-0172-014$ | Equipment List |
| 15 | $486 / 5 / 7-0172-015$ | Cable Schedule |
| 16 | $486 / 5 / 7-0172-016$ | Switchboard Label Schedule |
| 17 | $486 / 5 / 7-0172-017$ | Switchboard Construction Details |
| 18 | $486 / 5 / 7-0172-018$ | Switchboard Construction Details |
| 19 | $486 / 5 / 7-0172-019$ | Level Probes and Pressure Transmitter Installation Details |
| 20 | $486 / 5 / 7-0172-020$ | [RESERVED] Cathodic Protection Unit |
| 21 | $486 / 5 / 7-0172-021$ | Dry well Field Disconnection Box |
| 22 | $486 / 5 / 7-0172-022$ | Switchboard General Arrangement Elevations - Double Sided |
| 23 | $486 / 5 / 7-0172-023$ | Switchboard General Arrangement Sections - Double Sided |
| 24 | $486 / 5 / 7-0172-024$ | Reserved for Generator external connection box |
| 25 | $486 / 5 / 7-0172-025$ | Slab \& Conduit Details |
| 26 | $486 / 5 / 7-0172-026$ | Slab \& Conduit Details |
| 27 | $486 / 5 / 7-0172-026$ | Slab \& Conduit Details |

## SP210 NUDGEE BEACH SEWAGE PUMPING STATION ELECTRICAL DRAWINGS

## SITE COVER SHEET

| ELECTRICAL DRAWINGS INDEX |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| DWG ${ }^{\circ}$ ． | TITLE | SHEET | REVISIONS |  |  |  |  |
| 486／5／7－0172－000 | Site cover shet | 00 | 0 |  |  |  |  |
| 486／5／7－0172－001 | POWER DISTRIBUTION SCHEMATIC DIAGRAM | 01 | 0 |  |  |  |  |
| 486／5／7－0172－002 | PUMP 015 SHEMA TIC DIAGRAM | 02 | 0 |  |  |  |  |
| 486／5／7－0172－003 | PUMP 02 SCHEMATIC DIAGRAM | 03 | 0 |  |  |  |  |
| 486／5／7－0172－004 | DRY WELL SUMP PUMP SCHEMATIC DIAGRAM | 04 | 0 |  |  |  |  |
| 486／5／7－0172－005 | Reserver memenememmat | 05 |  |  |  |  |  |
| 486／5／7－0172－006 | COMMON CONTROLS SCHEMATIC DIAGRAM | 06 | 0 |  |  |  |  |
| 486／5／7－0172－007 | COMMON RTUI／O SCHEMAIIC DIAGR AM | 07 | 0 |  |  |  |  |
| 486／5／7－0172－008 | RTU POWER DISTRIBUTION SChematic diagram | 08 | 0 |  |  |  |  |
| 486／5／7－0172－009 | RTU Digital inputs termination diagram | 09 | 0 |  |  |  |  |
| 486／5／7－0172－010 | RTU DIGITAL INPUTS TERMINATION DIAGRAM | 10 | 0 |  |  |  |  |
| 486／5／7－0172－011 | RTU Digital outputs termination dia gram | 11 | 0 |  |  |  |  |
| 486／5／7－0172－012 | RTU ANALOUS \＆Miscellaneous termination diagram | 12 | 0 |  |  |  |  |
| 486／5／7－0172－013 | common controls termination diagram | 13 | 0 |  |  |  |  |
| 486／5／7－0172－014 | EQUPMENT LIST | 14 | 0 |  |  |  |  |
| L86／5／7－0172－015 | Cable schedule | 15 | 0 |  |  |  |  |
| 486／5／7－0172－016 | SWIICHBOARD LABEL SCHEDULE | 16 | 0 |  |  |  |  |
| L86／5／7－0172－017 | SWITCHBOARD CONS SRUC TION DE TALLS | 17 | 0 |  |  |  |  |
| 486／5／7－0172－018 | SWITCHBOARD CONSTRUCTION DETALLS | 18 | 0 |  |  |  |  |
| 486／5／7－0172－019 | level probes ano pressure transmit ter installation detalls | 19 | 0 |  |  |  |  |
| 486／5／7－0172－020 |  | 20 |  |  |  |  |  |
| 486／5／7－0172－021 | DRY WELL PUMP DISCONNECTION BOX | 21 | 0 |  |  |  |  |
| 486／5／7－0172－022 | Swithboaro general arrangement elevations－double sioed | 22 | 0 |  |  |  |  |
| 486／5／7－0172－023 | SWITCHBOARD GENERAL ARRANGEMENT SECTIONS－Double siotd | 23 | 0 |  |  |  |  |
| 486／5／7－0172－024 |  | 24 |  |  |  |  |  |
| 486／5／7－0172－025 | SLAB \＆CONOUIT DETALIS－SHEET 1 of 3 | 25 | 0 |  |  |  |  |
| 486／5／7－0172－026 | SLAB \＆CONDUIT DETAILS－SHEET 2 of 3 | 26 | 0 |  |  |  |  |
| 486／5／7－0172－027 | SLAB \＆CONDUIT DETAILS－SHEET 3 of 3 | 27 | 0 |  |  |  |  |
|  |  |  |  |  |  |  |  |



| STANDARD DESIGN OPTIONS |  |  |
| :---: | :---: | :---: |
| OPTION | DESCRIPTION | Fitied |
| A | individual pump moisture in oil miol sensor ano faul telay | YES ${ }^{\text {den }}$ |
| 8 |  | 区 № |
| 1 | INOIVIOUAL PUMP REFLUX VALVE PRoXIMITY SWITCH | Yes axo |
| 0 |  | 四 № |
| E | Station dry well sump pump and level inoication sensors and relays | YES |
| F |  | 区 N0 |
| 6 |  | 四 No |
| H | PUMPS 182 DELIVERY FLOWME TERS－ 24 VOC ENDRESS 8 HAUSER | YES［x． |
| 1 | BACKUP COMHUNICATION－GSM | YES |
| J | PUMP CONNECTION（Via Dry Well J－Box） | YES ${ }^{\text {ana }}$ |
| K | （ximovic protecion | \％${ }^{\text {x }}$ |
| 1 | MOTOR THERMISTORS｜Via Dry Well 1 －Box｜ | YES $\times$ xab |
| M | ondur commat | 函 N0 |
| N |  | 函 N0 |
| 0 | PUMPS ELECTRICAL INTERLOCK Mains 8 Generator） | YES |
| P |  | 函 № |
| 0 | Luy | ＊No |
| R | TELEMETRY RAOIO |  |
| S |  | （1）${ }^{\text {No }}$ |
| I | DOUBLE SIIED SWITCHBOARD PLINTHEXIENSION FIITED | YES |
| U | DELIVERY PRESSURE TRANSMITTER | YES $\operatorname{ax}$ |
| $\checkmark$ | Emat ijsw | NO |















SP210 Parkland Street Nudgee SPS Electrical Installation Volume 1 OM Manual





## TEST CERTIFICATE

SJ Electric (Qid) Pty. Ltd.
19 Elliot Street.
Albion Old. 4010
R.E.C. 7623

## Attention: Wendy Wong <br> Level 2 TC Beime Centre, 315 Brunswick Street Mall, Fortitude Valley Q 4006

Work performed for Brisbane Water at SP210 at Fortitude st Nudgee beach 4014 under contract BW: 70103-033 (SJ0 Electric Job Number WT400075)

Installation Tested / Equipment Tested

- New Pump station switchboard
- New 50 mm 2 consumer mains
- New main earth
- Earth bonding to main earth link and all switchboard components.
- New pump cabling

All supporting test sheets attached.

## Test Date <br> 27/05/10

For the electrical installation, this certificate certifies that the electrical installation to the extent it is affected by the electrical work has been tested to ensure it is electrically safe and is in accordance with the requirements of the wiring rules and the electrical safety regulation 2002. C.J. Holmes (endorsee to electrical contracting license 7623)

For the electrical equipment, this certificate certifies that the electrical equipment, to the extent it is affected by the electrical work, is electrically safe. C.J. Holmes (endorsee to electrical contracting license 7623)

Signed.



[^0]:    7-2

[^1]:    Note: PowerCad is a product of PowerCad Software Pty Ltd. Purchases of this software can be obtained from PowerCad. www.powercad.com.au

[^2]:    $1 \quad$ * SLIP $\circledR^{\text {TM }}$ KISS $®^{\text {™ }}$

[^3]:    2 "Data and Computer Communications" William Stallings

[^4]:    !
    The adjustable frequency drive $D C$ link capacitors remain charged after power has been disconnected. To avoid an electrical shock hazard, disconnect the adjustable frequency drive from line power before carrying out maintenance. Wait at least as follows before doing service on the adjustable frequency drive:

[^5]:    Table 4.1: Unpacking table

[^6]:    NOTE!
    With single phase AS use L1 and L2 terminals.

[^7]:    NOTE!
    Values for setting the minimum reference are found in open-loop par. 3-02 Minimum Reference and for closed-loop par. 20-13 Minimum Reference/ Feedb. - values for maximum reference for open-loop are found in par. 3-03 Maximum Reference and for closed-loop par. 20-14 Maximum Reference/ Feedb..

[^8]:    1）Due to the flush diaphragm，no own pressure compartment is formed．

[^9]:    ${ }^{6}$ Limited to 200 bar according to the pressure device directive．

[^10]:    1) Recommended for drinking water applications, not suitable for use in hazardous areas
[^11]:    Rev: 12
    Owner: Alfonso Chavez

[^12]:    $N \alpha e$ : Printed copies of this document should be verified for currency against the published electronic copy

