BRISBANE CITY COUNCIL

Sewerage Pump Station SP144

Lavarack Av #1

Eagle Farm

Contract : **BW 70103-013**

Job Number : **WT400035**

Volume 1

ELECTRICAL INSTALLATION

OPERATIONS and MAINTENANCE MANUAL

INSTALLATION BY:

SJ Electric (Qld) Pty Ltd
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Albion Qld 4010

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1. General

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.

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.

1.2 Project Overview

Contract BW70103-013 was for the manufacture and testing of ten (1) new pump station switchboards for various locations throughout 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 <u>any</u> 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.
- PLC 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 PLC 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.

1.4 Electrical Control System

General Description

The switchboards are manufactured from 3mm 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.

2. Manufacturer's Technical Data

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

Equipment Type: Circuit Breaker

Location: Main Incomer
Pump Circuit Breakers

Model Numbers: XS 400

Manufacturer: Terasaki

Supplier: NHP Pty Ltd
25 Turbo Drive
Coorparoo QLD 4151

Ph: 07 3891 6008
Fx: 07 3891 6139

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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 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 250 4
400	250	400	XS400CJ 400 4

XS400NJ (50 kA) 3 pole

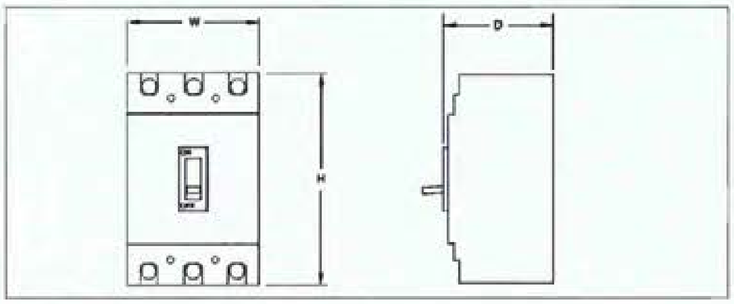
250	160	250	XS400NJ 250 3
400	250	450	XS400NJ 400 3

XS400NJ (50 kA) 4 pole

250	160	250	XS400NJ 250 4
400	250	400	XS400NJ 400 4

Dimensions (mm)

Description		Height	Width	Depth	kg
XS400CJ/NJ	3 pole	260	140	103	4.7
	4 pole	260	185	103	6.1



Notes:
[1] Load-break isolating switch only – no protection.
[2] MCCBs only.
[3] Poles in series. Refer applications Section 13.

Short circuit capacity

Model	I/C	Voltage
XS400CJ	35 kA (AS 2184)	415 V 50 Hz
XS400NJ	50 kA	415 V 50 Hz

DC use [3]	I/C	Voltage
XS400CJ	40 kA	250 V DC
XS400NJ	40 kA	250 V DC

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

Cross reference table	Section
Accessories	6
Selectivity & cascade	13
Application data	13
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Motor starting	13
Connection & mounting details	7 and 8
Detailed dimen. - MCCB only	7
- motor operators	7

Product extensions	Section
Chassis (TemWay, MHC, UHC)	6
TemCurve	13
Residual current relays	11

Base standards	Approvals
IEC 60947-2	ASTA/UK, Aust. standards
BS EN 60947 Part 2	**Marine**
VDE 0660 Part 1	NK/JAPAN
AS/NZS 3947-2/Aust./NZ	Lloyds R/UK
AS 2184-1990/Australia [2]	ABS/USA
JIS C 8372/JAPAN	GL/GERMANY
JEC 160/JAPAN	BV/FRANCE
	DNV NORWAY

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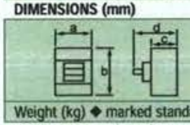
Standard TemBreak circuit breaker
Selection guide

Type		XM30PB		XS125CS			XS125CJ		XS125NS			XS125NJ	
Ampere frame		30A		125A					125A				
Number of poles		3P		1P [1])	2P [2]) ⓘ		3P	4P ⓘ	1P [1])	2P [2])		3P	4P
Outside view **Notes:** [1]) 1 Pole breaker only, XS125CS and XS125NS respectively. [2]) 2 pole breaker is a 3 pole breaker with the centre pole omitted. ◆ Supplied as standard. ○ Optional standard. ● Yes or available. – Not available ⓘ Indent only													
Rated current (A).In NRC – Nominal rated current		**NRC**		**NRC**		**NRC**	**ASR**		**NRC**		**NRC**	**ASR**	
ASR – Adjustable setting range							min	max				min	max
Rated current at 40°C		0.7	8.0	16	50	20	12.5	20	16	50	20	12.5	20
		1.4	10	20	63	32	20	32	20	63	32	20	32
		2.0	12	25	80	50	32	50	25	80	50	32	50
		2.6		32	100	63	40	63	32	100	63	40	63
		4.0		40	125	100	63	100	40	125	100	63	100
		5.0				125	80	125			125	80	125
AC RATED INSULATION VOLTAGE (Ui)		690		690					690				
AC RATED BREAKING CAPACITY sym RMS [kA]													
IEC 60947-2 [Icu] IEC 60947-2 [Ics]	1100V	–		–					–				
AS/NZS 3947-2 [Icu] AS/NZS 3947-2[Ics]	1000V	–		–					–				
Note: Rated Impulse withstand voltage	690V	–		–					–		5/2.5		
Uimp (kV) is 8kV on all XS, XE and XH MCCB's	660V	–		–					–		5/2.5		
	500V	–		–		7.5/3.8			–		12/6		
	440V	85		10/5		10/5			22/11		22/11		
	415V	85		14/7		14/7			25/13		25/13		
	400V	85		18/9		18/9			25/13		25/13		
	380V	85		18/9		18/9			30/15		30/15		
	240V	125		14/7		25/13			25/13		25/13		
AS 2184	440V	85		14					25				
	415V	85		18					30				
NEMA AB-1	600V	85		–					–		12		
	480V	85		–		10			–		22		
without Inst.	240-690V	–		–					–				
DC RATED BREAKING	250V	–		–		10			–		15		
CAPACITY (kA)	125V	–		10		15			15		20		
RATED SHORT TIME CURRENT RMS [kA] [Icw]				–					–				
DIMENSIONS (mm)													
	a	78		30		90		120	30		90		120
	b	148		155					155				
	c	98		86					86				
	d	116		104					104				
Weight (kg) ◆ marked standard type		1.3		0.51		1.3		1.58	0.51		1.3		1.58
CONNECTION AND MOUNTINGS													
front connect (FC)	terminal screw	◆		◆					◆				
	attached flat bar	–		–		○			–		○		
	solderless terminal (PWC)	○		○					○				
rear connect (RC)	bolt stud	○		–		○			–		○		
	flat bar stud	–		–					–				
plug-in (PM)	for switchboard	○		–		○			–		○		
	for distribution board	–		–		○			–		○		
draw-out (DO)		–		–					–				
STANDARD FEATURES													
	contact indicator	–		●					●				
	trip button	–		–		●			–		●		
PROTECTIVE FUNCTIONS													
Electronic type													
Adjustable LTD, STD & INST		–		–		–			–		–		
Adjustable GFT or Adjustable PTA (option)		–		–		–			–		–		
Trip indicators (option) (contacts)		–		–		–			–		–		
Thermal-magnetic type		fixed											
thermal and fixed magnetic trips		–		●		–			●		–		
thermal and adjustable magnetic trips		–		–					–				
adjustable thermal and fixed magnetic trips		–		–		●			–		●		
adjustable thermal and magnetic trips		–		–					–				
ACCESSORIES (option)	**CODE**												
Internally mounted auxiliary switch	**AUX**	●		–		●			–		●		
alarm switch	**ALT**	●		–		●			–		●		
shunt trip	**SHT**	●		●		●			●		●		
undervoltage trip	**UVT**	–		–		●			–		●		
Externally mounted motor operator	**MOT**	–		–		●			–		●		
external panel mounted type	**XFE**	–		–					–				
operating breaker mounted type	**TFJ**	●		–		●			–		●		
handle variable depth type	**XFH**	●		–		●			–		●		
IP 65 handle variable depth type	**TLK**	●		–		●			–		●		
extension handle		–		–					–				
mechanical interlock front type		●		–		●			–		●		
mechanical interlock rear type		–		–		●			–		●		
mechanical interlock cable type		–		–					–				
key interlock		●		–		●			●				
handle holder		●		●					●				
handle lock		●		●					●				
captive padlock attachment		–		●		●			●				
terminal cover front connect type		–		–		●			–		●		
terminal cover rear/plug-in type		–		–		●			–		●		
interpole barriers		–		–		●			–		●		
accessories lead terminals		●		–		●			–		●		
OCR sealing kit		–		–		●			–		●		

Standard TemBreak circuit breaker
Selection guide

XH125NJ			XE225NC			XS250NJ			XH250NJ			XS400CJ			XS400NJ		
125A			225A			250A			250A			400A			400A		
3P		4P	3P			3P		4P	3P		4P	3P		4P ℹ	3P		4P ℹ
																	
NRC	ASR		NRC			NRC	ASR		NRC	ASR		NRC	ASR		NRC	ASR	
	min	max					min	max		min	max		min	max		min	max
20	12.5	20	125	200		160	100	160	160	100	160	250	160	250	250	160	250
32	20	32	150	250		250	160	250	250	160	250	400	250	400	400	250	400
50	32	50	175														
63	40	63															
100	63	100															
125	80	125															
690			690			690			690			690			690		
												ICU/ICS			ICU/ICS		
–			–			–			–			–			–		
–			–			–			–			–			–		
8/4			–			8/4			15/7.5			16/8			18/9		
8/4			–			8/4			15/7.5			16/8			18/9		
25/13			10/5			22/11			25/13			22/11			30/15		
42/21			15/7.5			25/13			42/21			30/15			42/12		
50/25			15/7.5			25/13			50/25			30/15			50/25		
50/25			18/9			25/13			50/25			35/18			50/25		
50/25			18/9			35/18			50/25			35/18			50/25		
85/43			25/13			50/25			85/43			50/25			85/43		
50			15			30			50			36			50		
50			18			35			50			36			50		
25			–			22			25			22			30		
42			15			25			42			30			42		
–			–			–			–			–			–		
40			10			40			40			40			40		
40			15			40			40			40			40		
–			–			–			–			–			–		

90		120	105			105	140		105	140		140		185	140		185
155			165			165			165			260			260		
86			67			86			103			103			103		
104			82			107			124			131			131		
1.3		1.58	1.4			1.85	2.4		2.1	2.6		4.7		6.1	4.7		6.1

◆	◆	◆	◆	◆	◆
○	○ (Bar)	○ (Bar)	○ (Bar)	○ (Bar)	○ (Bar)
○	○	○	○	○	○
○	○	○	○	–	–
–	–	–	–	○	○
○	○	○	○	○	○
–	–	–	–	–	–
–	–	–	–	○	○

●	●	●	●	●	●
●	●	●	●	●	●

–	–	–	–	–	–
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–	●	–	–	–	–
–	–	–	–	–	–
●	–	●	●	–	–
–	–	–	–	●	●

●	●	●	●	●	●
●	●	●	●	●	●
●	●	●	●	●	●
●	–	●	●	●	●
●	●	●	●	●	●
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●	●	●	●	●	●
●	●	●	●	●	●
●	●	●	●	●	●
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●	●	●	●	●	●
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●	●	●	●	●	●
●	●	●	●	●	●
●	●	●	●	●	●
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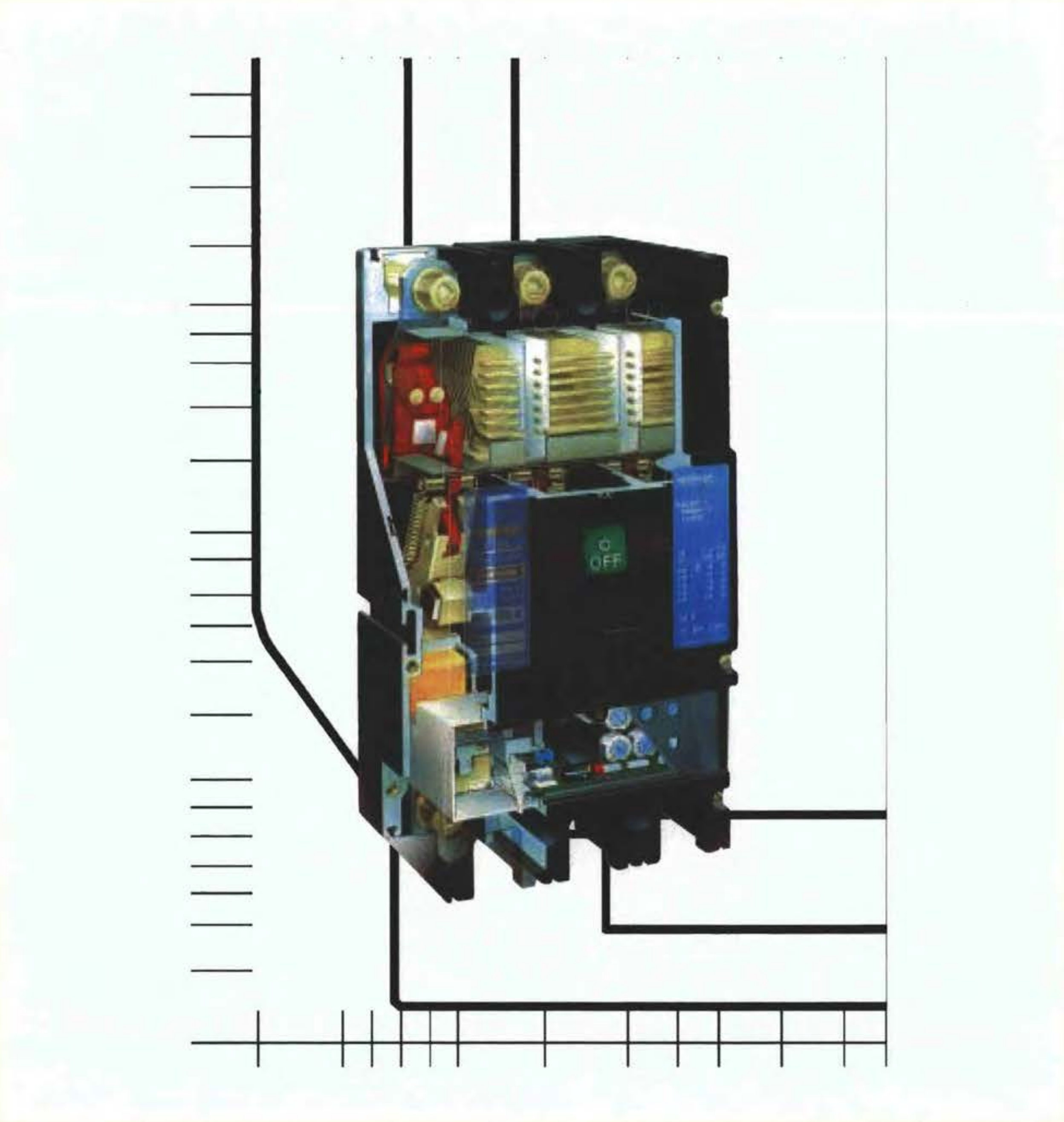
Section 7

MCCB operational characteristics & dimensions



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 thermal	Adjustable thermal	Fixed magnetic	Adjustable 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

XS400NJ

XS400NJ (cover removed)

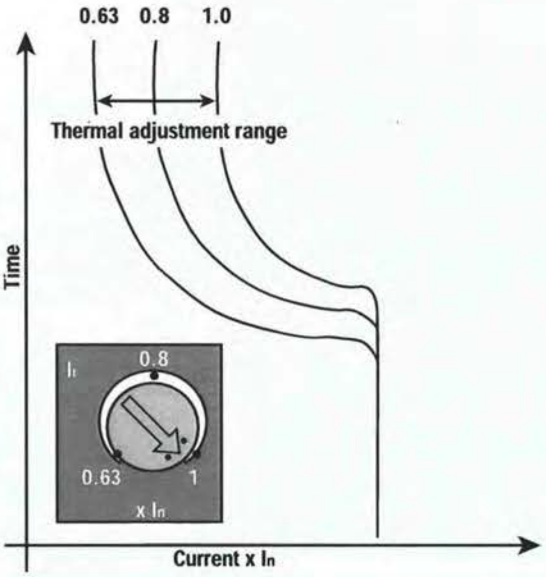
MCCB Technical data

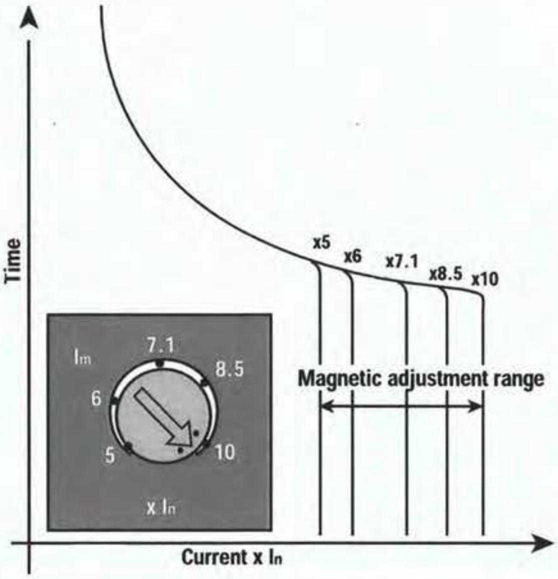
Thermal Adjustment

TemBreak MCCBs have a wide thermal adjustment range, one of the largest on the market. The rated current 'I_r' is continuously adjustable from 63 % to 100 % of its nominal current 'I_n'. 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 'I_m' is continuously adjustable from 500 % to 1000 % of its rated current 'I_n'. There are five main points of calibration marked as multiples of I_n; 5, 6, 7.1, 8.5 and 10. These are shown in the diagram below.





Examples

1. XS125NJ/125A MCCB set at I_r = 0.8, the rated current is calculated as 125 x 0.8 = 100 A
2. XS400NJ/400A MCCB set at I_m = 6, the magnetic setting is calculated as 400 x 6 = 2400 A
3. XS630NJ/630A MCCB set at I_r = 0.8 and I_m = 5.0

   The rated current is calculated as 630 x 0.8 = 504 A
   The magnetic setting is calculated as 630 x 5 = 3150 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 °C unless otherwise specified.

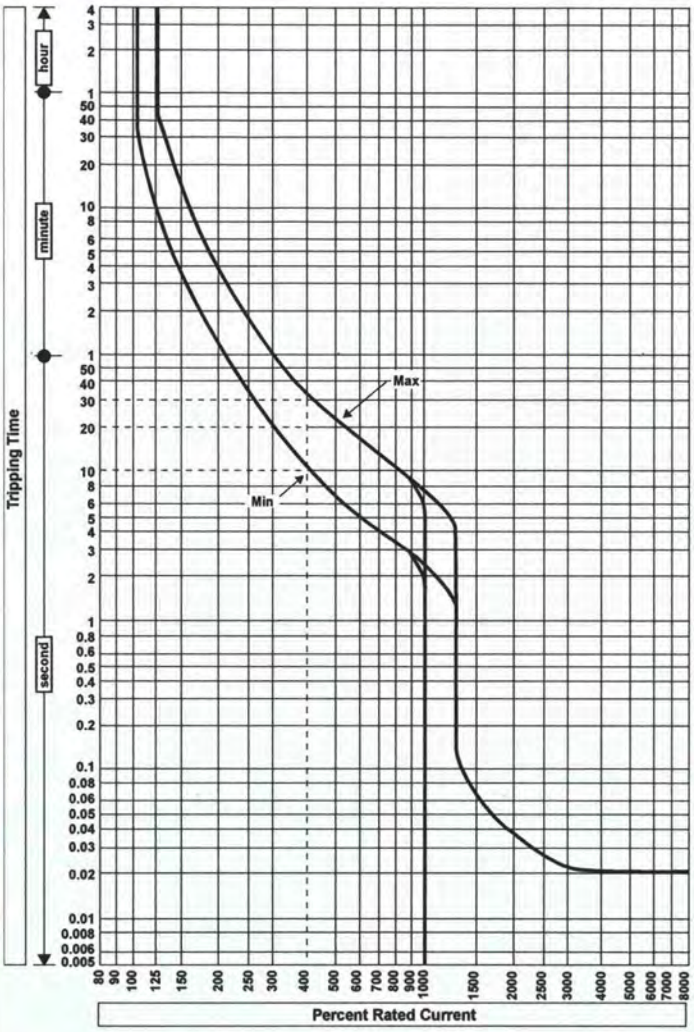
Breakers with adjustable magnetic trip

		Magnetic trip current (A)				
Breaker	**Rated current (A)**	**Scale 10**	**8.5**	**7.1**	**6**	**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
XS800NJ	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



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

$$\frac{100\text{ A} = 400\ \%}{250}$$

The maximum and minimum on the curve are the tolerance bands. Therefore at 400 % overload the tripping time would be as follows:

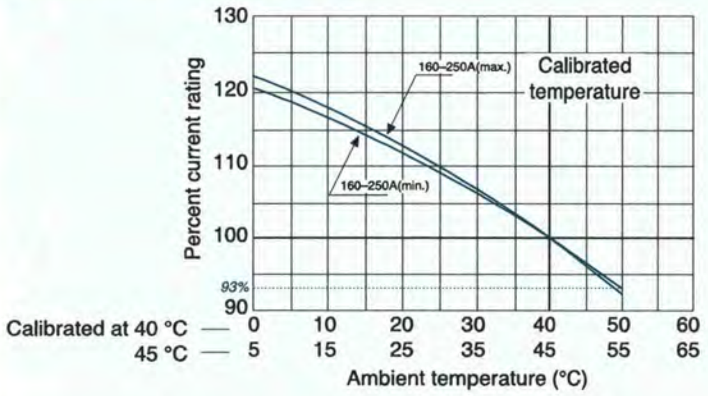
Maximum trip time ≈ 30 seconds

Minimum trip time ≈ 10 seconds

Average trip time ≈ 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.

Ambient compensating curves



Example 2

The XS250NJ is calibrated at 250 A for 45 ˚C ambient. If the temperature rose to 55 ˚C what effect would this have?

Solution

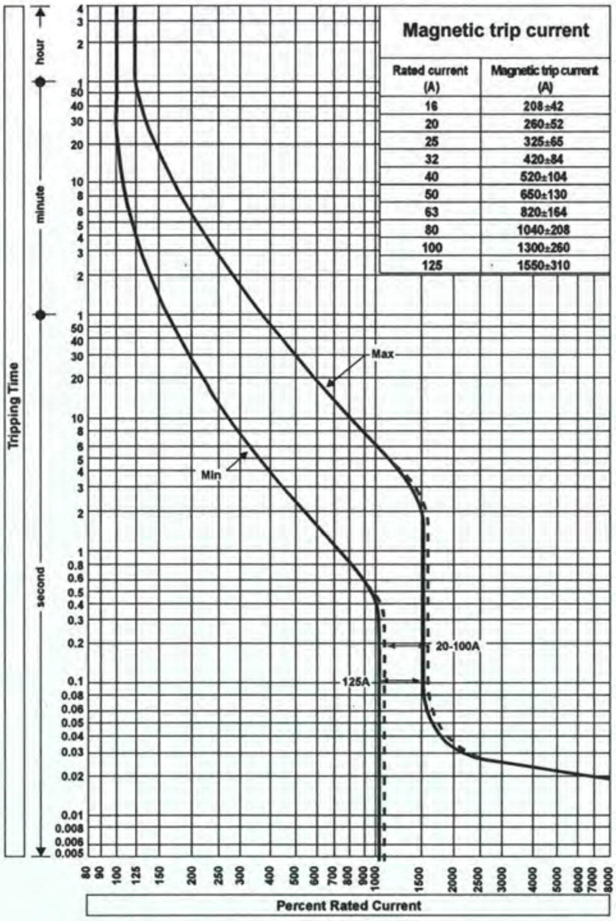
At 55 ˚C the ambient compensating factor is 93 %, i.e. 250 x 0.93 = 232.5 A

In other words the XS250NJ would act as an MCCB set at 232.5 A, in 55 ˚C.

MCCB Technical data

XS125CS, XS125NS

Time/current characteristic curves

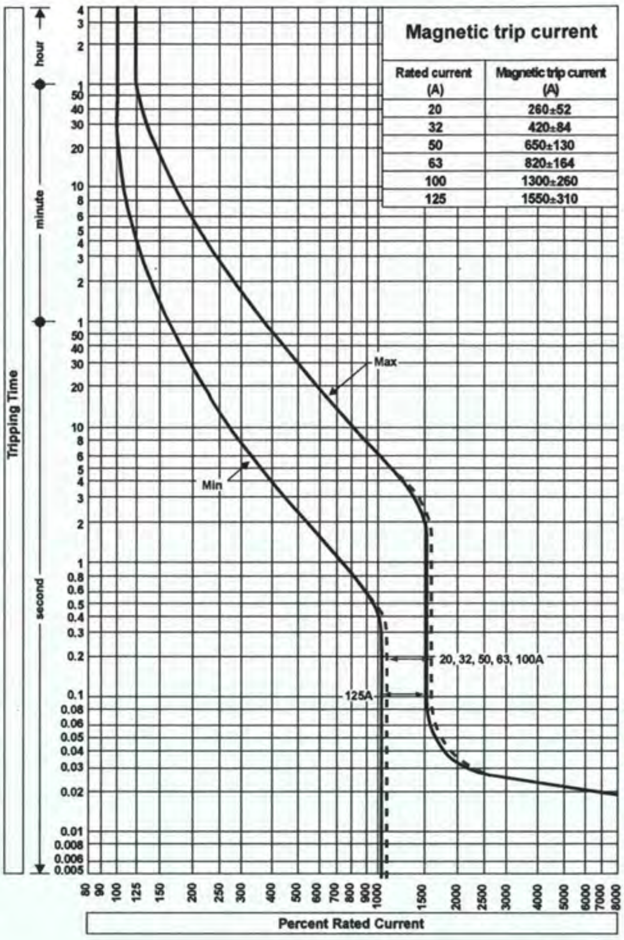


Magnetic trip current

Rated current (A)	Magnetic trip current (A)
16	208±42
20	260±52
25	325±65
32	420±84
40	520±104
50	650±130
63	820±164
80	1040±208
100	1300±260
125	1550±310

XS125CJ, XS125NJ, XH125NJ, XH125NJ

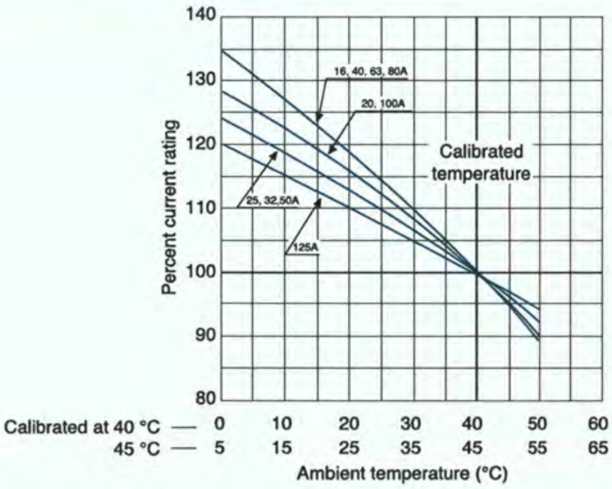
Time/current characteristic curves



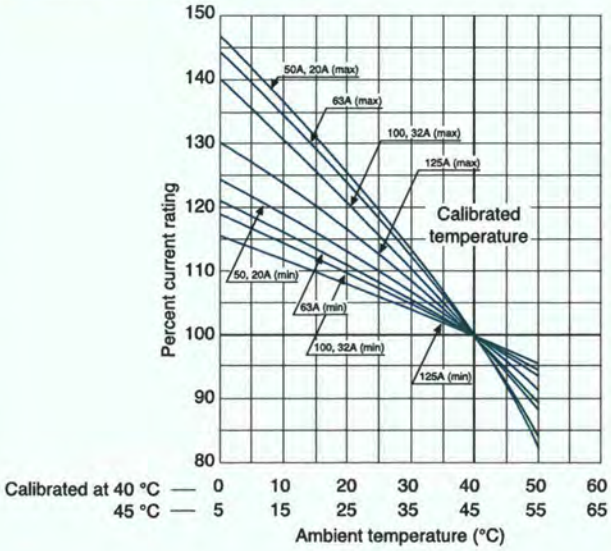
Magnetic trip current

Rated current (A)	Magnetic trip current (A)
20	260±52
32	420±84
50	650±130
63	820±164
100	1300±260
125	1550±310

Ambient compensating curves



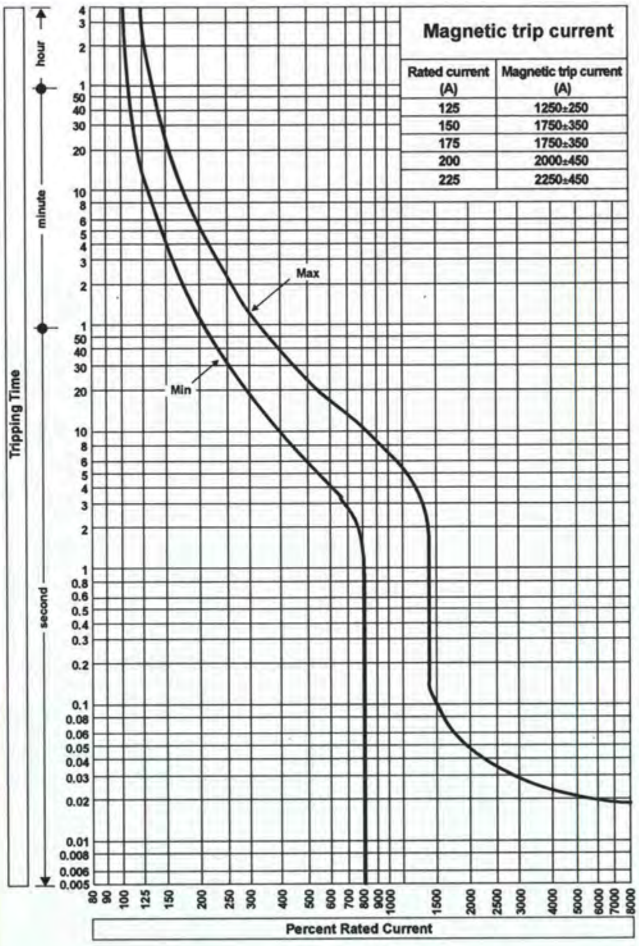
Ambient compensating curves



MCCB Technical data

XE225NC

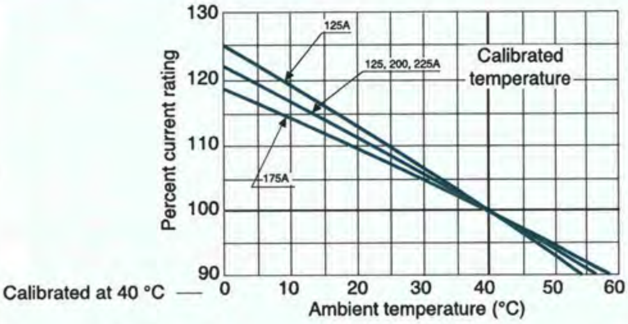
Time/current characteristic curves



Magnetic trip current

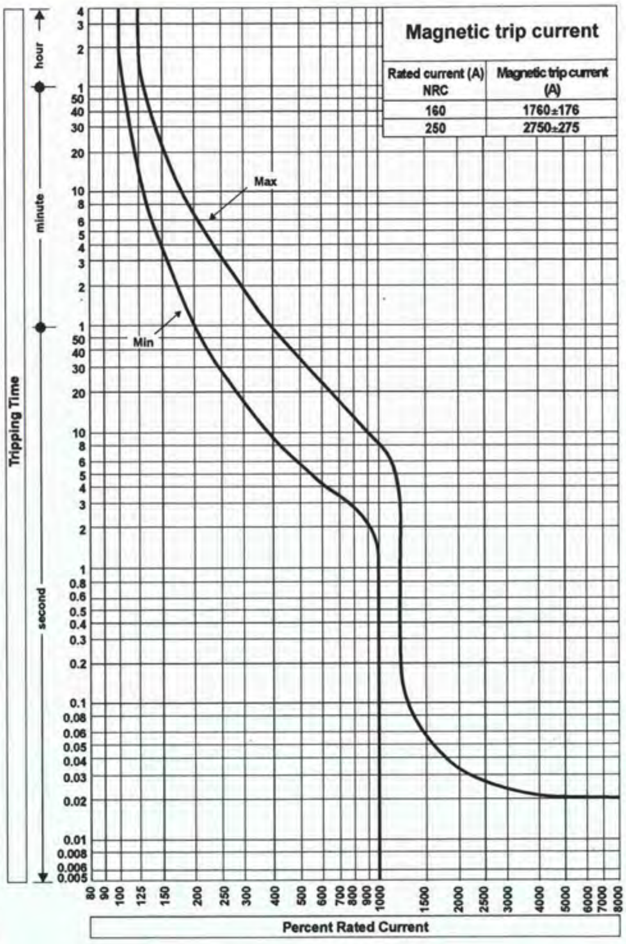
Rated current (A)	Magnetic trip current (A)
125	1250±250
150	1750±350
175	1750±350
200	2000±450
225	2250±450

Ambient compensating curves



XH160PJ, XS250NJ, XH250NJ

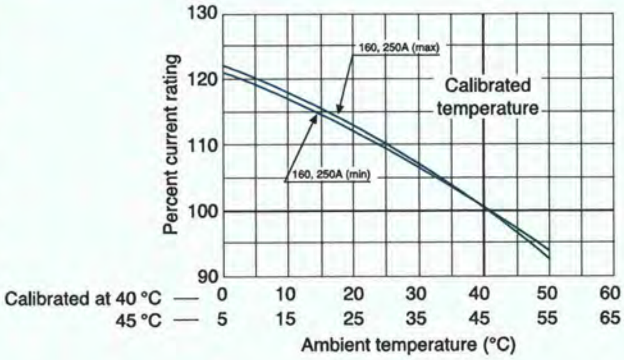
Time/current characteristic curves



Magnetic trip current

Rated current (A) NRC	Magnetic trip current (A)
160	1760±176
250	2750±275

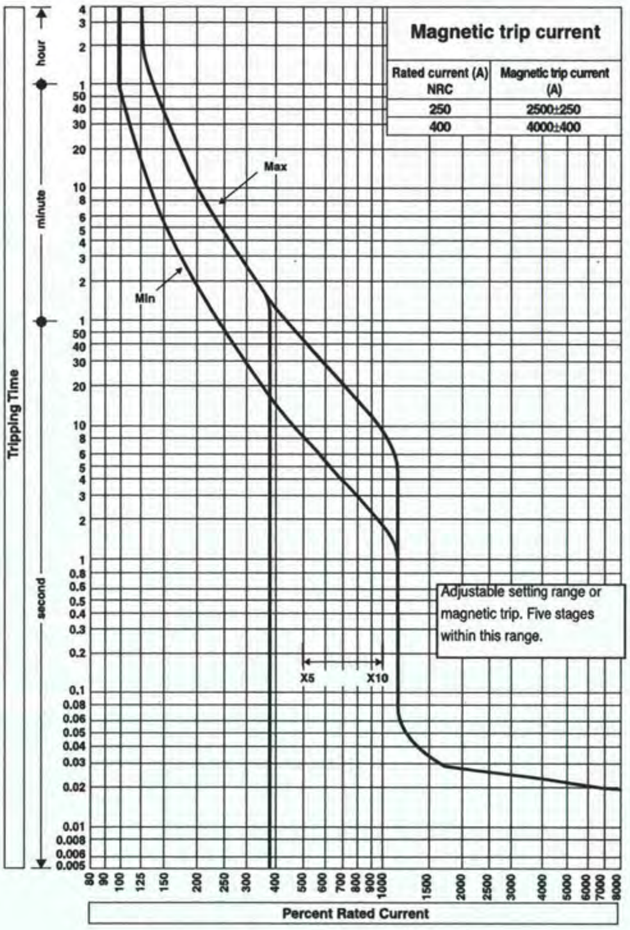
Ambient compensating curves



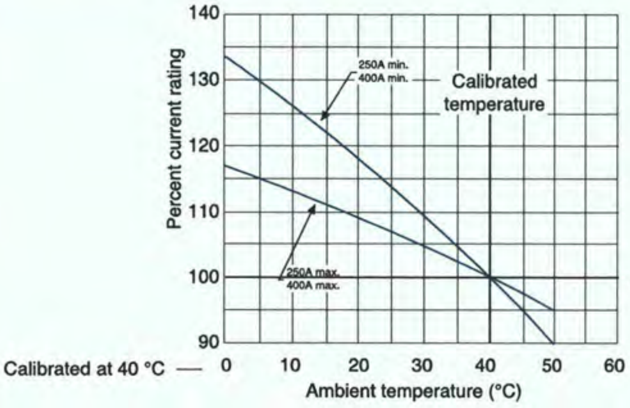
MCCB Technical data

XH250PJ, XS400CJ, XS400NJ, XH400PJ

Time/current characteristic curves

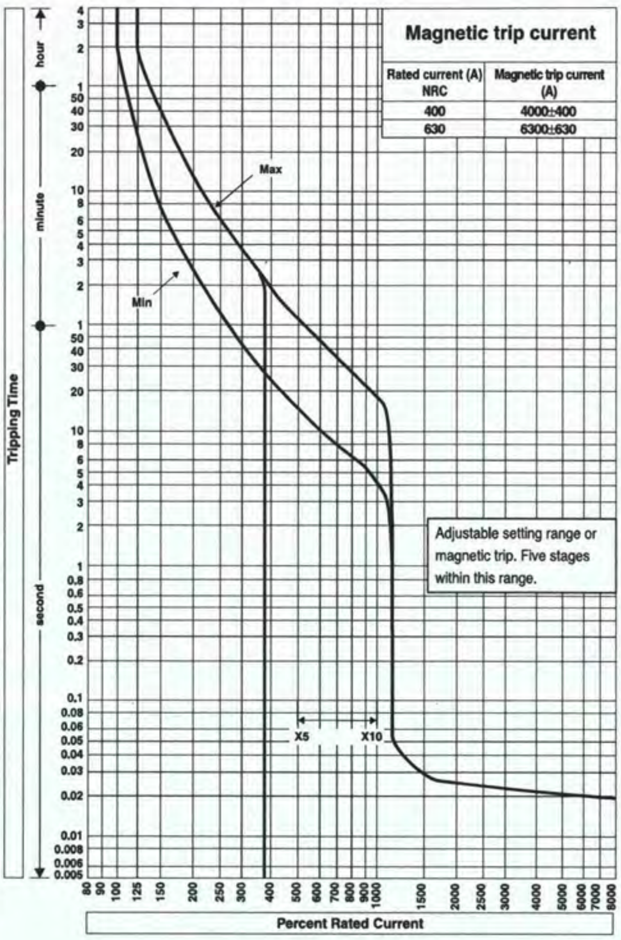


Ambient compensating curves

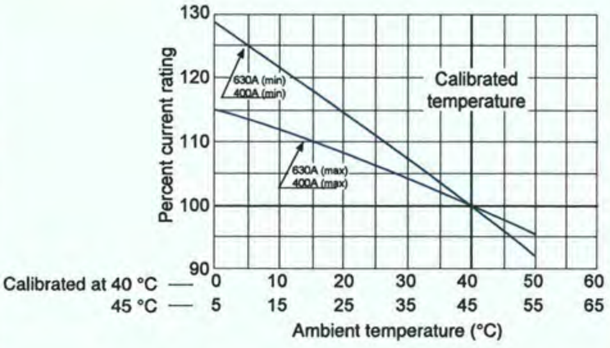


XS630CJ, XS630NJ, XH630PJ

Time/current characteristic curves



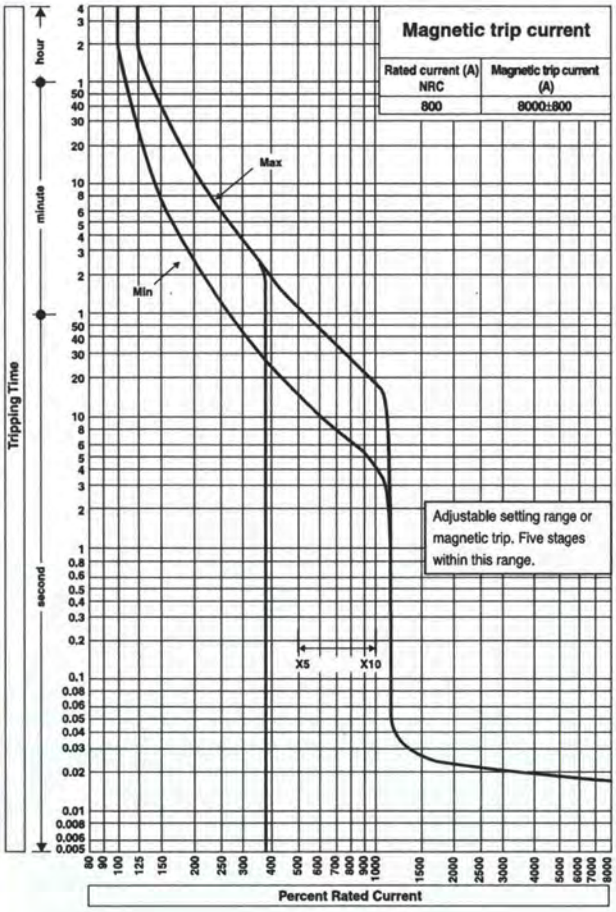
Ambient compensating curves



MCCB Technical data

XS800NJ, XH800PJ

Time/current characteristic curves



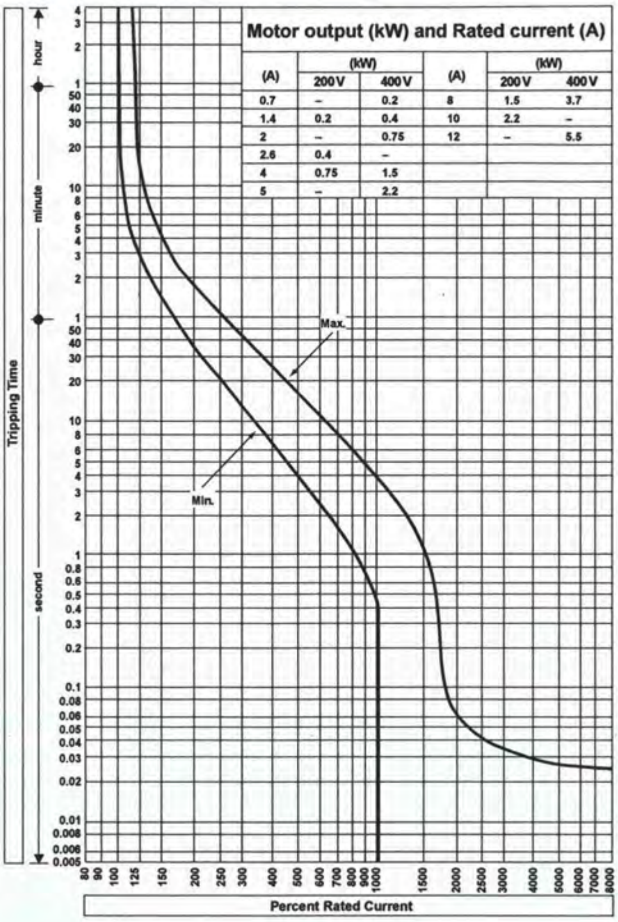
Magnetic trip current

Rated current (A) NRC	Magnetic trip current (A)
800	8000±800

Adjustable setting range or magnetic trip. Five stages within this range.

XM30PB

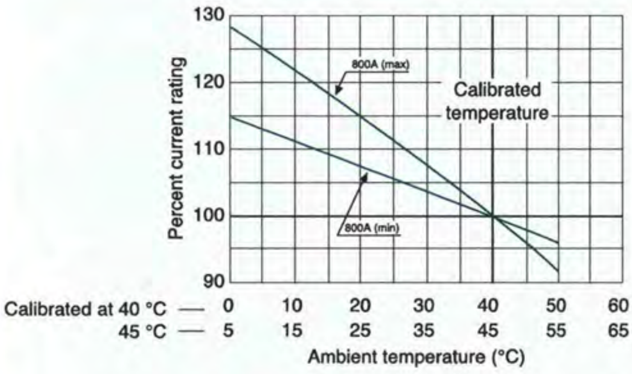
Time/current characteristic curves



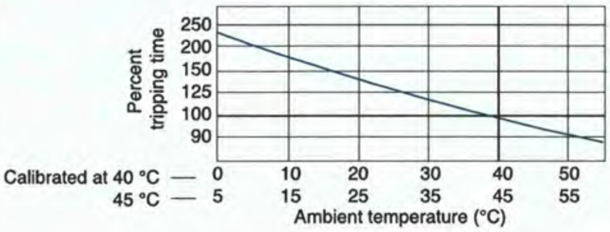
Motor output (kW) and Rated current (A)

(A)	(kW)		(A)	(kW)	
	200V	400V		200V	400V
0.7	–	0.2	8	1.5	3.7
1.4	0.2	0.4	10	2.2	–
2	–	0.75	12	–	5.5
2.6	0.4	–			
4	0.75	1.5			
5	–	2.2			

Ambient compensating curves



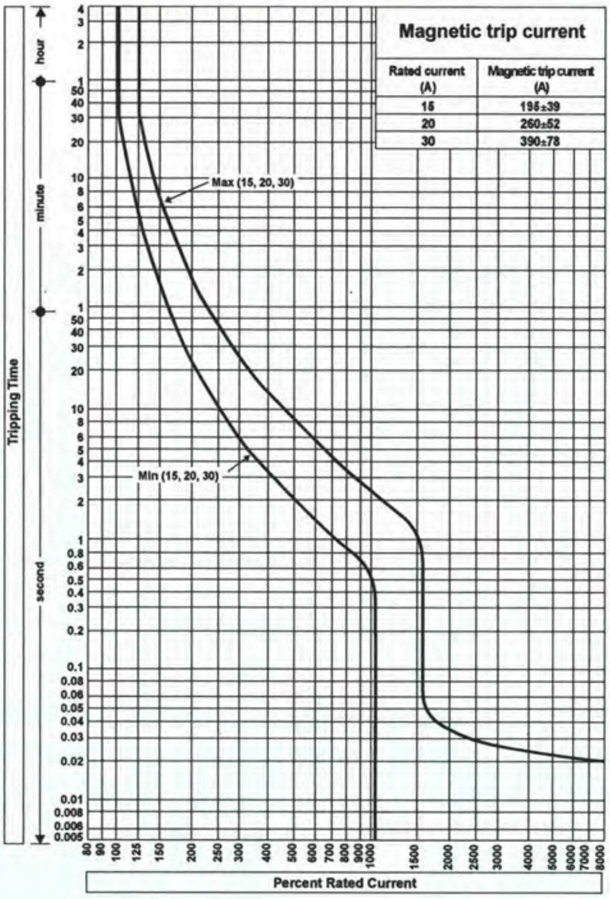
Ambient compensating curves



MCCB Technical data

TL30F

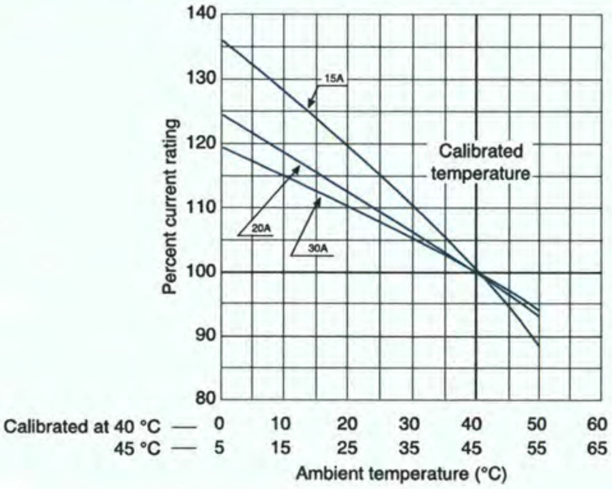
Time/current characteristic curves



Magnetic trip current

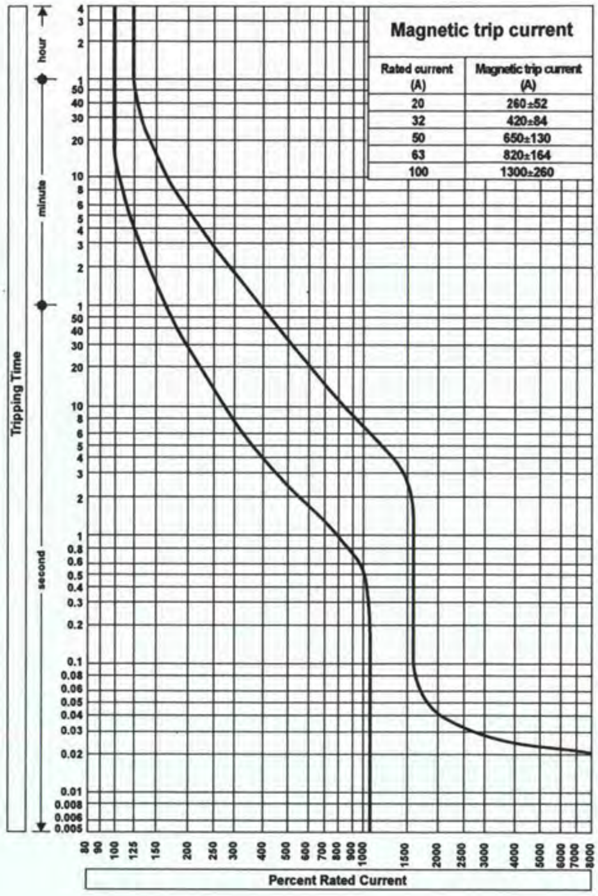
Rated current (A)	Magnetic trip current (A)
15	195±39
20	260±52
30	390±78

Ambient compensating curves



TL100NJ

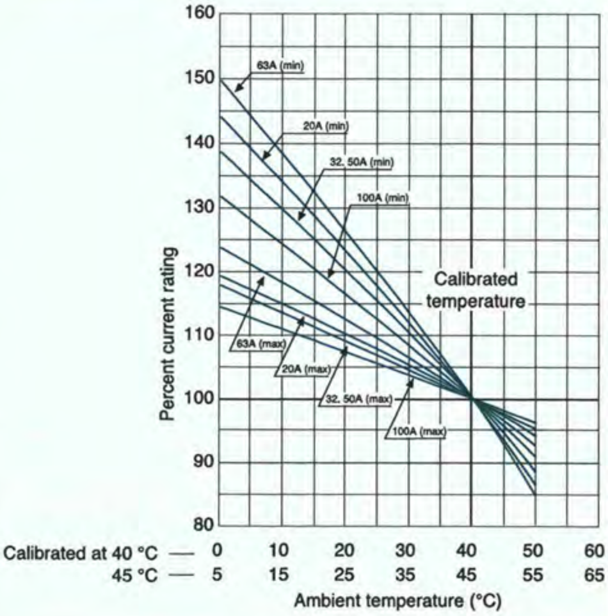
Time/current characteristic curves



Magnetic trip current

Rated current (A)	Magnetic trip current (A)
20	260±52
32	420±84
50	650±130
63	820±164
100	1300±260

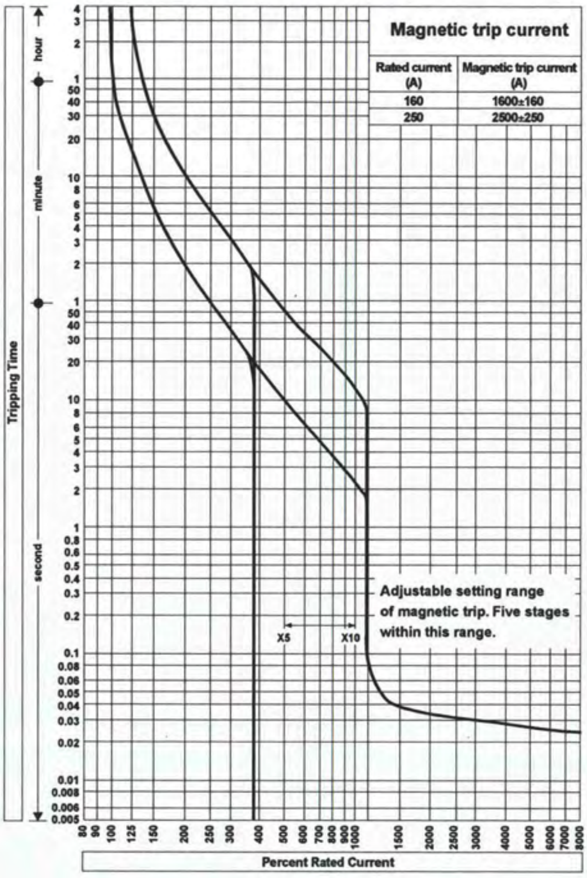
Ambient compensating curves



MCCB Technical data

TL250NJ

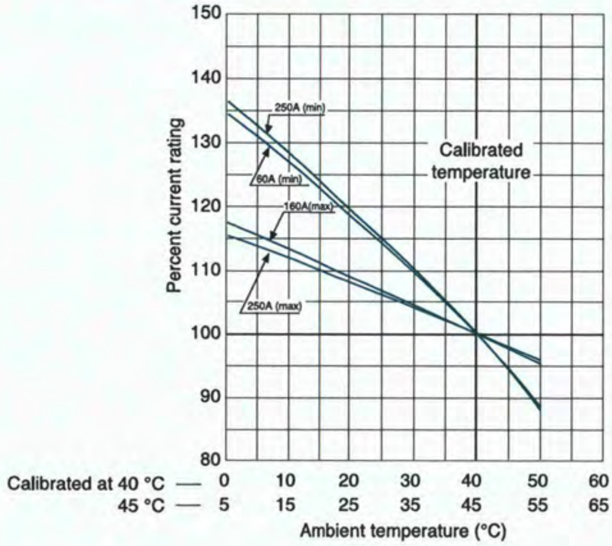
Time/current characteristic curves



Magnetic trip current

Rated current (A)	Magnetic trip current (A)
160	1600±160
250	2500±250

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.

MCCB type	LTD	STD	INST	I²T Ramp	Pick-up LED	Test port	PTA	GFT	internal LEDs	external LEDs
XS400, XH400 1)	●	●	●	●	●	●	◆	-	-	◆
XS630, XH630 3)	●	●	●	●	●	●	◆	◆	-	◆
XS800, XH800 3)	●	●	●	●	●	●	◆	◆	-	◆
XS1250SE 3)	●	●	●	●	●	●	◆	◆	◆	-
XS1600SE 2)	●	●	●	●	●	●	◆	◆	◆	-
XS2000NE	●	●	●	●	●	●	◆	◆	◆	-
XS2500NE	●	●	●	●	●	●	◆	◆	◆	-

Standard on all TemBreak Microprocessor MCCBs

Note: ● Standard
◆ Optional
\- Not available
1) Includes TL400NE & XV400NE
2) Includes TL630NE to TL1250NE
3) Includes XV630, 800 & 1250

Legend		Application	
LTD	Long Time Delay	Overload protection, True RMS	Standard for all TemBreak Microprocessor MCCBs
STD	Short Time Delay	Short circuit protection and selectivity	
INST	Instantaneous	Short circuit protection, fast acting	
I2t RAMP		Provides easier grading with downstream fuses	
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.

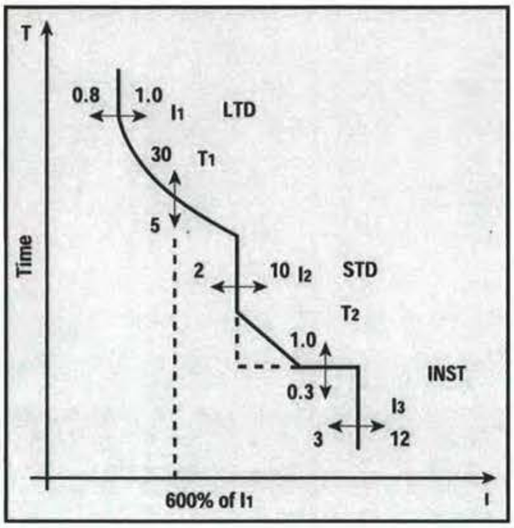
XH400SE

XH400SE (cover removed)

MCCB Technical data

Microprocessor based characteristics – adjustments, operation, settings

Standard time current curves

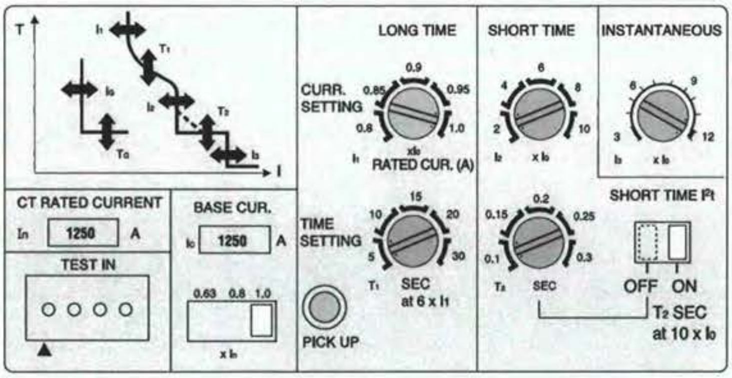


Each part of the characteristic curve can be independently adjusted. This unique adjustability of LTD, STD and INST enables the standard microprocessor MCCB to achieve more than 200,000 permutations of its time/current characteristic.

This makes the TemBreak microprocessor range one of the most flexible on the market.

To complement this range, NHP have developed TemCurve selectivity analysis software, which contains the full range of TemBreak MCCBs on database. This software package highlights the full benefit of having highly adjustable microprocessor MCCBs when involved with difficult selectivity problems.

Standard microprocessor adjustments



The I²t 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: └ with the switch on, the characteristic alters to a ramp: ∟ , 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 x I_n	Amps
LTD pick-up	I_1	0.8 - 0.85 - 0.9 - 0.95 - 1.0 x I_0	Amps
LTD setting	T_1	5 - 10 - 15 - 20 - 25 - 30 (at I_1 x 600 %)	Secs
STD pick-up	I_2	2 - 4 - 6 - 8 -10 x I_0	Amps
STD setting	T_2	0.1 - 0.15 - 0.2 - 0.25 - 0.3	Secs
INST pick-up	I_3	3 - 12 - x I_0 (continuously adjustable)	Amps

Note: A special generator T_1 setting adjustment of 1-5 sec (at I_1 x 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

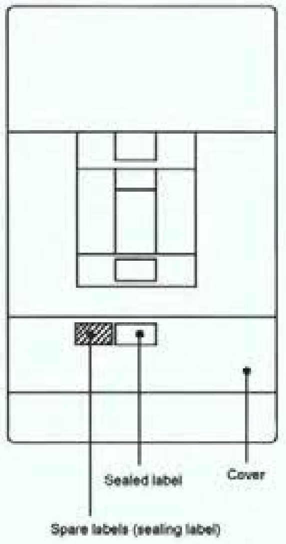
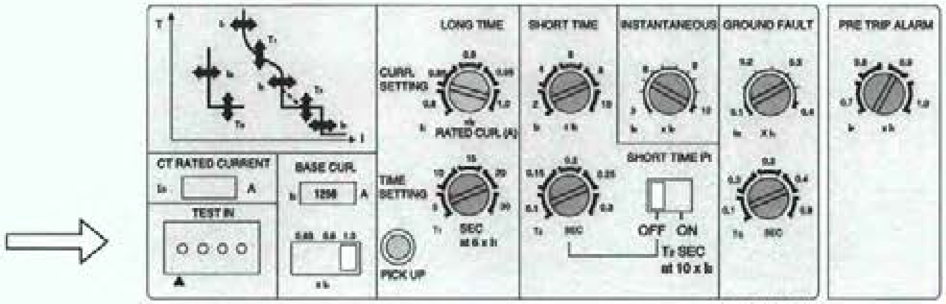


Figure 1. Electronic OCR adjustment possible (with label removed).

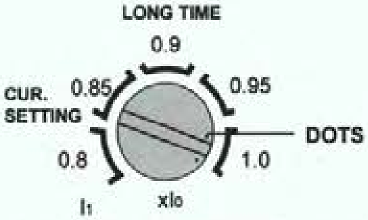


Example XS1250NE

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 Io = 1.0.
The INST and GFT pick-up currents are continuously adjustable.



Secure the cover and apply the sealing label.

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 (I_1) and the Base Current (I_o) selector switch.

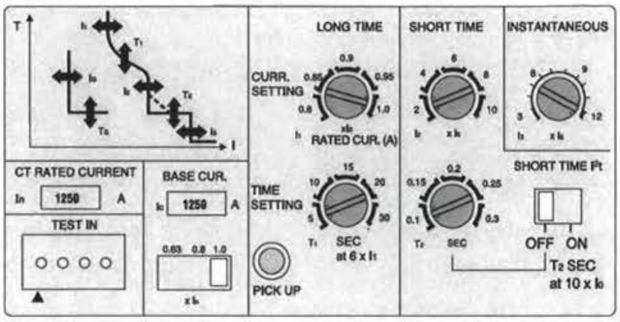
The rated current (LTD pick-up) is achieved as follows:

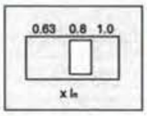
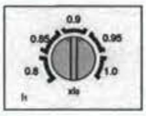
$I_{RATED} = I_n \times I_o \times I_1$

In the example shown on the right the rating would be:

$I_{RATED} = 1250 \times 1.0 \times 1.0 = 1250$ A

In total there are 15 possible increments of adjustment between 50 and 100 % as shown below.



Base current		63					80					100				
Current dial		80	85	90	95	100	80	85	90	95	100	80	85	90	95	100
		↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Breaker rated current	72% in this example	50	54	57	60	63	64	68	72	76	80	80	85	90	95	100

Example - Settings

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

Solution

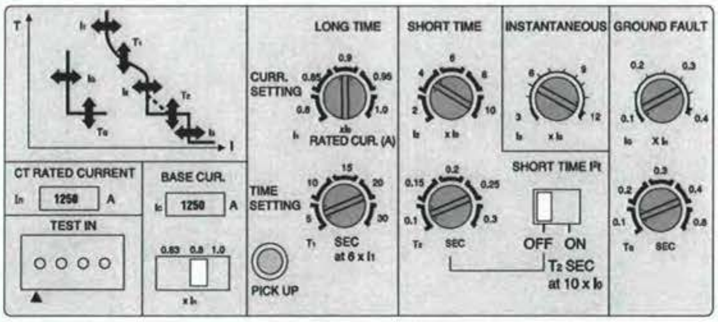
I_{RATING} LTD pick-up = $I_n \times I_o \times I_1$
$1250 \times 0.8 \times 0.9 = 900$ A

STD pick-up = $I_n \times I_o \times I_2$
$1250 \times 0.8 \times 4 = 4000$ A

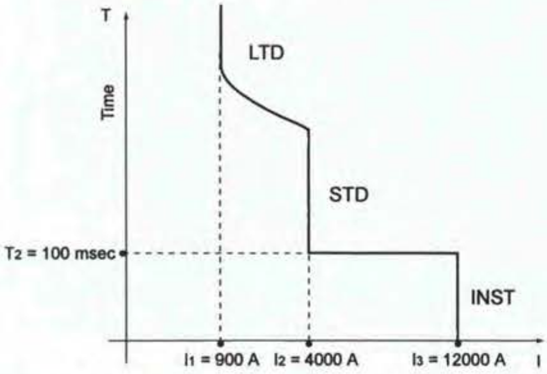
INST pick-up = $I_n \times I_o \times I_3$
$1250 \times 0.8 \times 12 = 12{,}000$ A

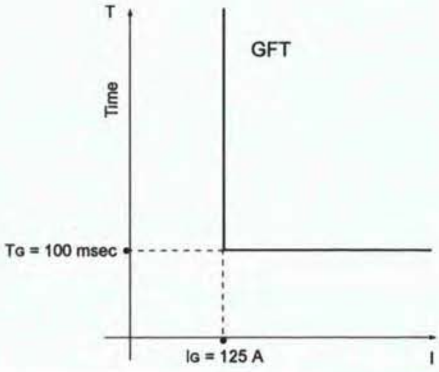
GFT pick-up = $I_n \times I_G$
$1250 \times 0.1 = 125$ A

(Note that GFT is a function of I_n and not I_o)



Example - Time/Current curves





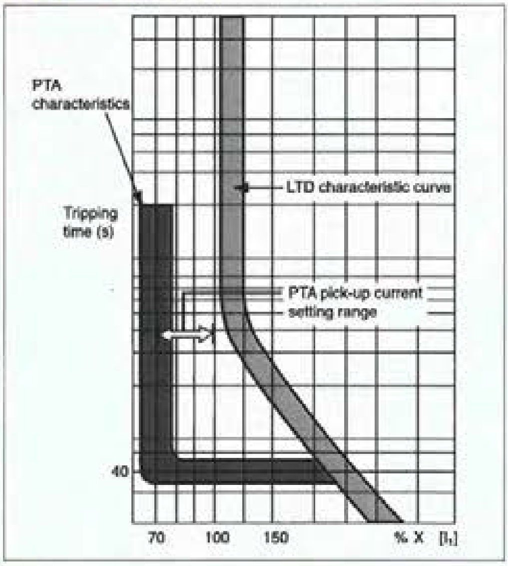
MCCB Technical data

Options (electronic type) TemBreak

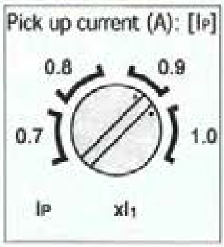
Pre-trip alarm (PTA)

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 characteristics



PTA specifications

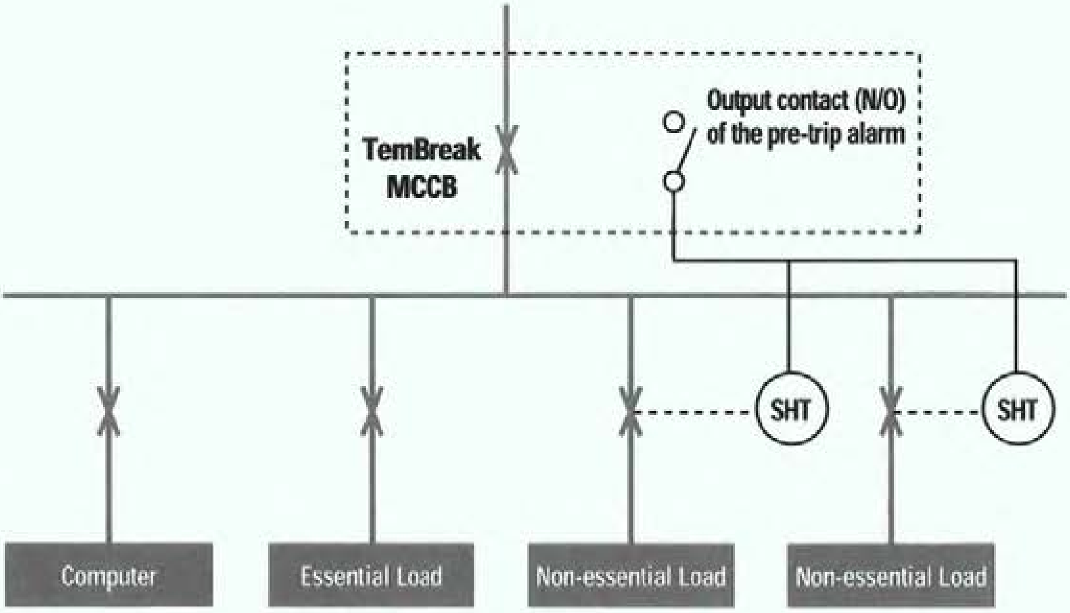


Adjustable steps of 70, 80, 90, 100 % of the selected rated current [I₁].

Setting tolerance ±10 %

Note: The long time-delay trip does not operate 'first' when the pick-up current is adjusted to 100 % of the rated current [I₁].

Operating time (s) [Ip]		40 secs (fixed definite time-delay) setting tolerance is ±10 %		
Output contact		Normally open contact, (1a) Integral lead is standard length (450 mm)		
			Resistive load	**Inductive load**
	Rating of contact	250 V AC	125 VA (2 A max)	20 VA (2 A max)
		220 V DC	60 W (2 A max)	10 W (2 A max)
PTA indication		Pick-up LED flickers		



MCCB Technical data

Adjustment of TemBreak electronic type OCR with ground fault

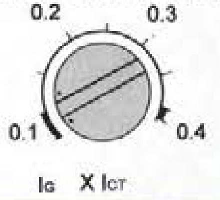
Ground fault trip

The GFT pick-up current is continuously adjustable from 10 % to 40 % 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).

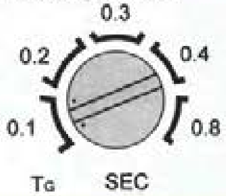
GFT specifications

Pick-up current (A): [IG]



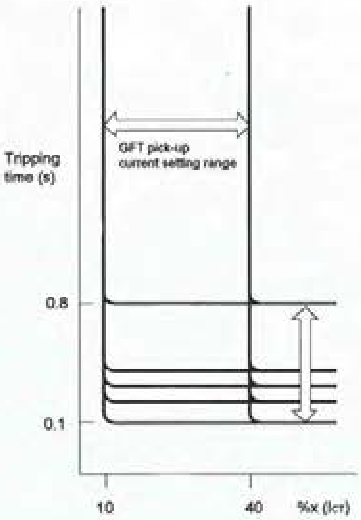
Continuously adjustable from 10 to 40 % of the rated CT current (Ict) setting tolerance is ± 15 %

Time-delay (S): [TG]



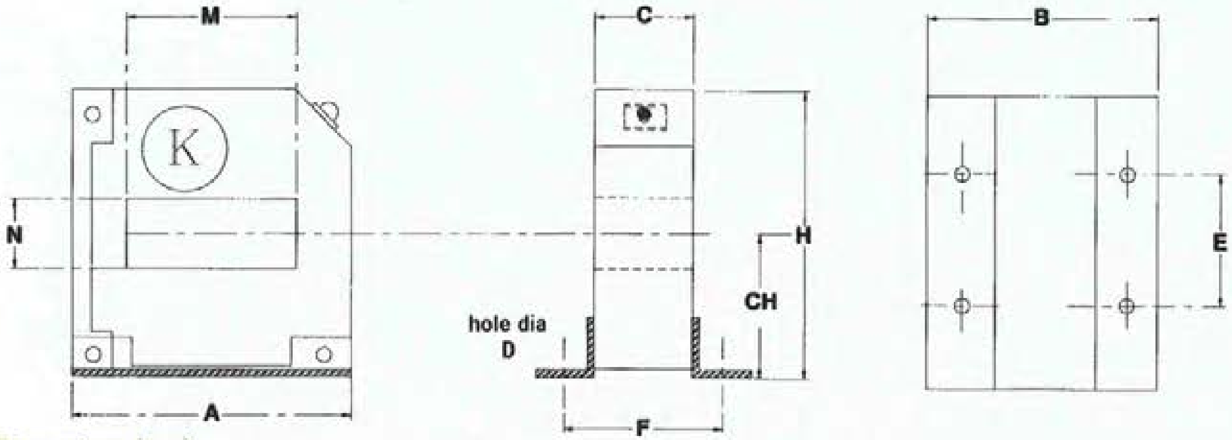
The GFT has a definite time-delay characteristic and is adjustable in steps of 0.1, 0.2, 0.3, 0.4, 0.8 s. Total clearing time is +50 ms and resettable time is −20 ms for the preset time delay.

GFT characteristics



4th CT for GFT

Rating (A)	Type
2500	UX0Y0007A
2000	UX0Y0006A
1600	UX0Y0005A
1250	UX0Y0004A
1000	UX0Y0003A
800	UX0Y0002A
630	UX0Y0001A



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

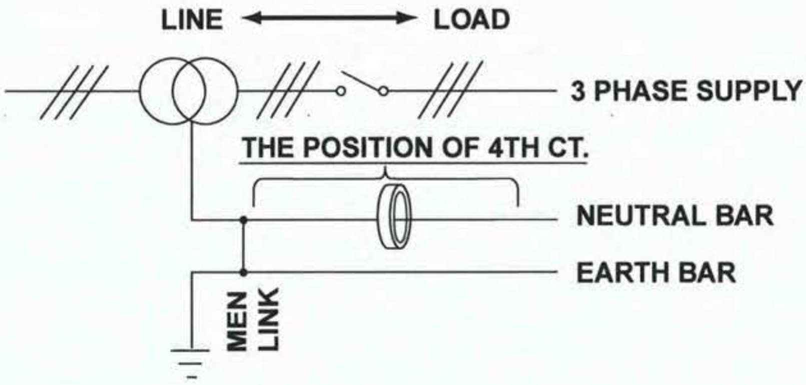
MCCB Technical data

TemBreak electronic type with ground fault

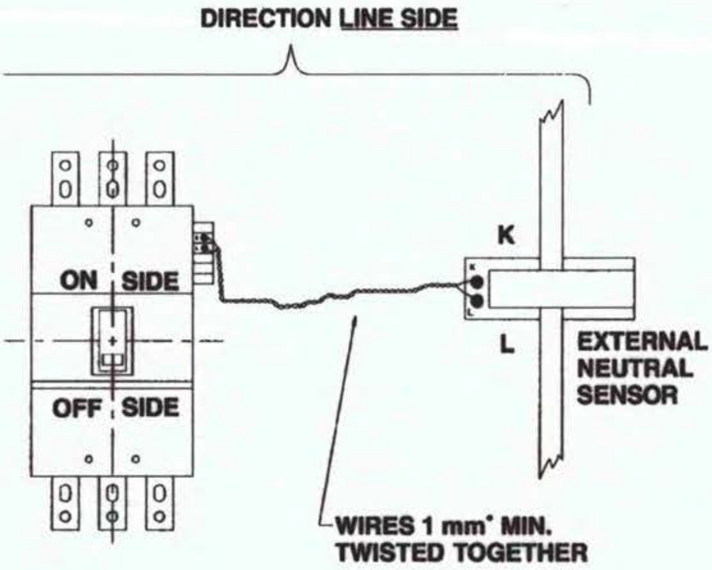
External neutral sensor (4th CT)

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



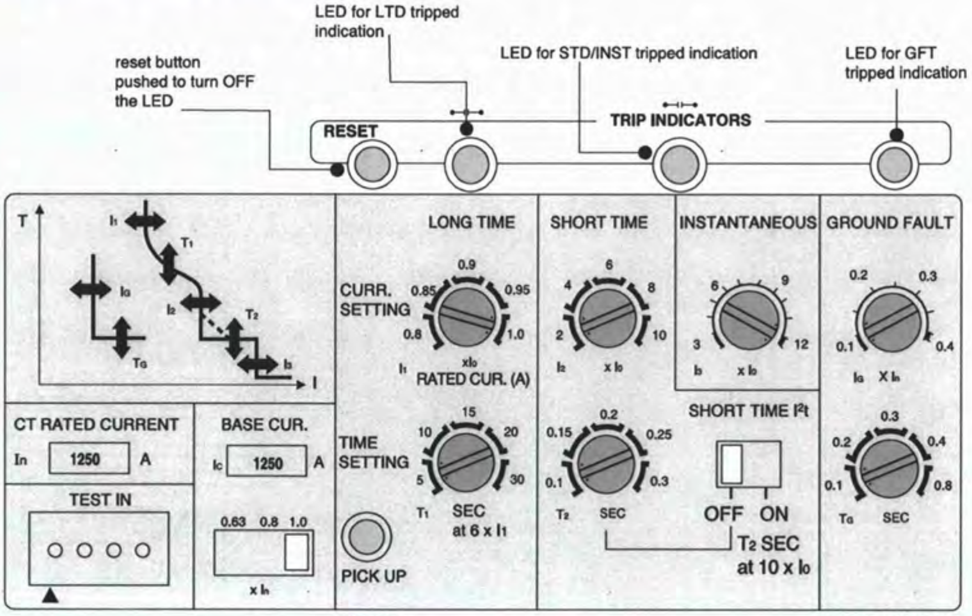
MCCB Technical data

Trip indicators

The LEDs when lit, indicate which trip function tripped the breaker eg, long-time-delay (LTD), short-time delay/ instantaneous (STD/INST) or ground fault (GFT) (control power required).

Note: If a pre-trip alarm (PTA) is fitted, the LED control power can be used (common).

Trip indicator display (1250 AF and above)



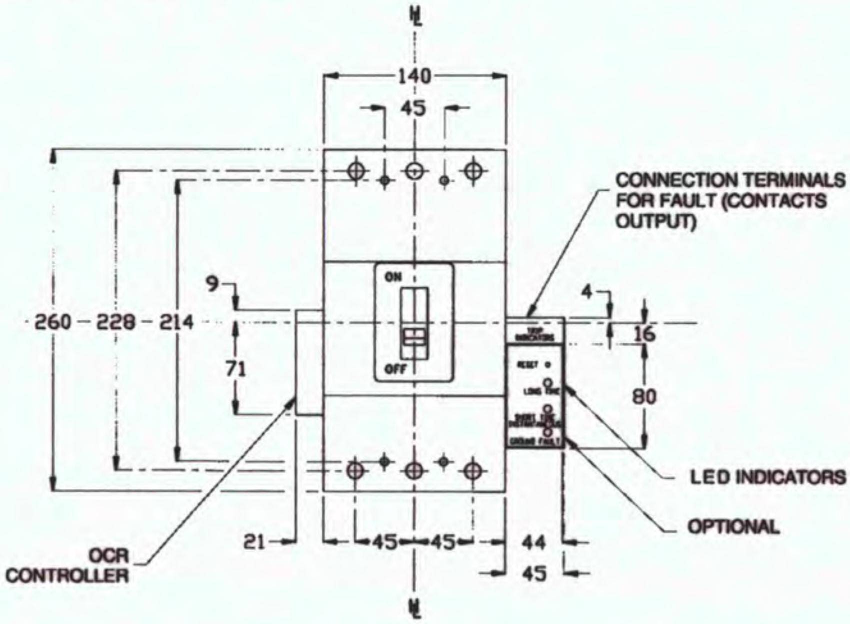
PICK UP
LED turns on when LTD function picks up.
In case PTA is fitted, this LED flickers when PTA function picks up. (seperate control power required).

Example XS1250SE

Trip indicator display (400 AF to 800 AF) and OCR controller example: XS, XH400

An optional feature available with TemBreak electronic type are fault indication contacts - these are voltage free and provide a signal of the cause of a trip (long time, STD/INST).

An external trip indicator box is required with 400AF models.

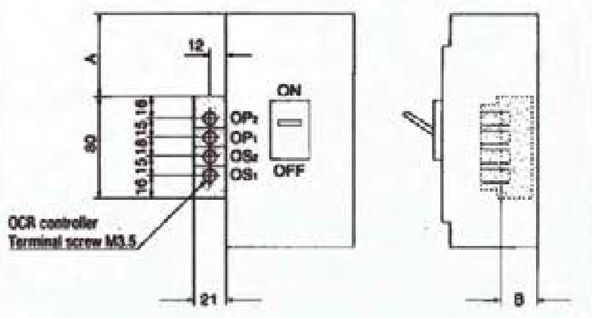


Notes: For dimensions of XS/XH800SE and PE refer to pages 7 - 40 and 7 - 41, add dimensions of OCR controller and trip indication box (above).

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

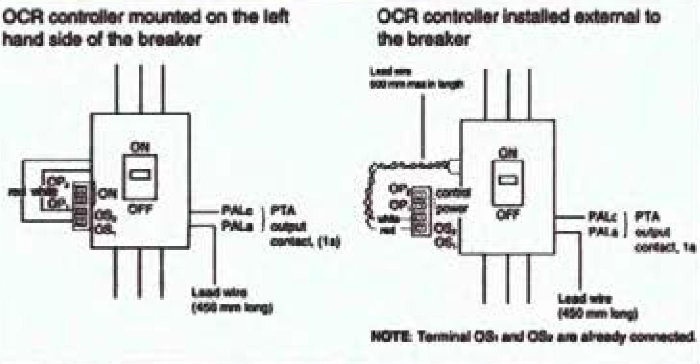
Control power source

Rated voltage 100-120 V AC or 200-240 V AC

Consumption 2 VA

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

OCR controller connection diagram [1] [2]

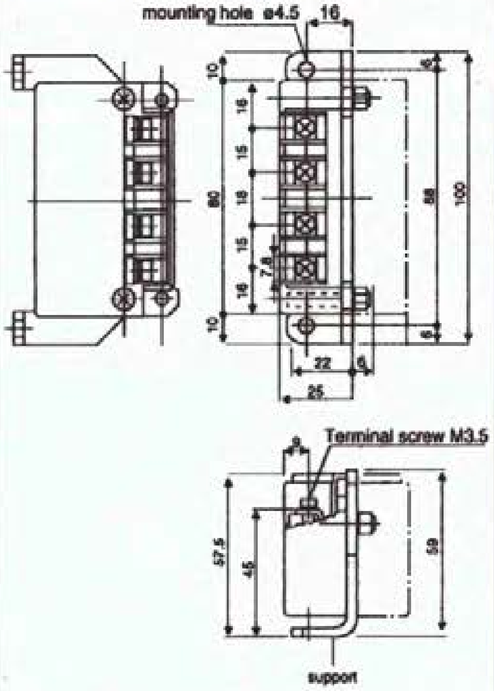

OCR controller mounted on the left hand side of the breaker

OCR controller installed external to the breaker

NOTE: Terminal OS₁ and OS₂ are already connected.

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 mm².

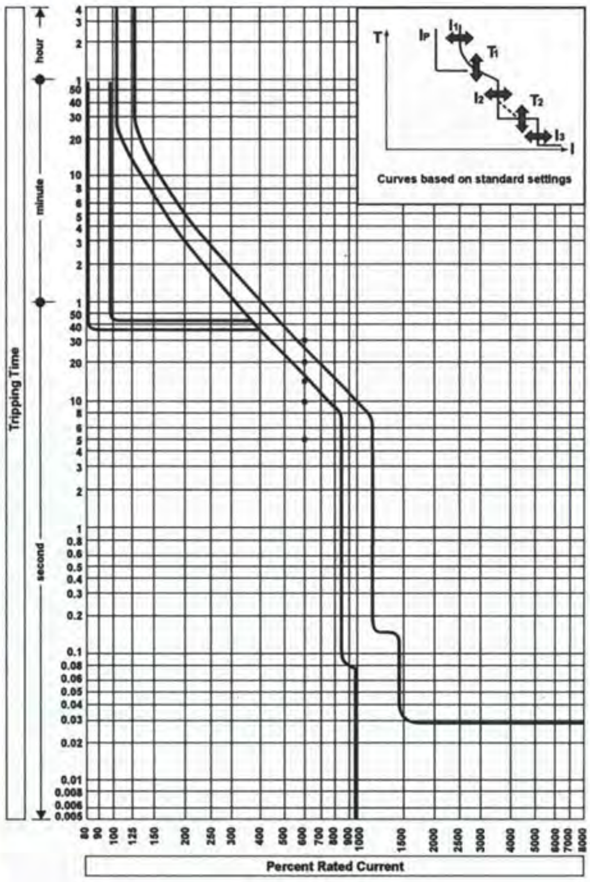
OCR controller dimensions
(Installed external to the breaker)



MCCB Technical data

Time/Current curves XS400, XH400, TL400NE, XV400

Time/current characteristic curves



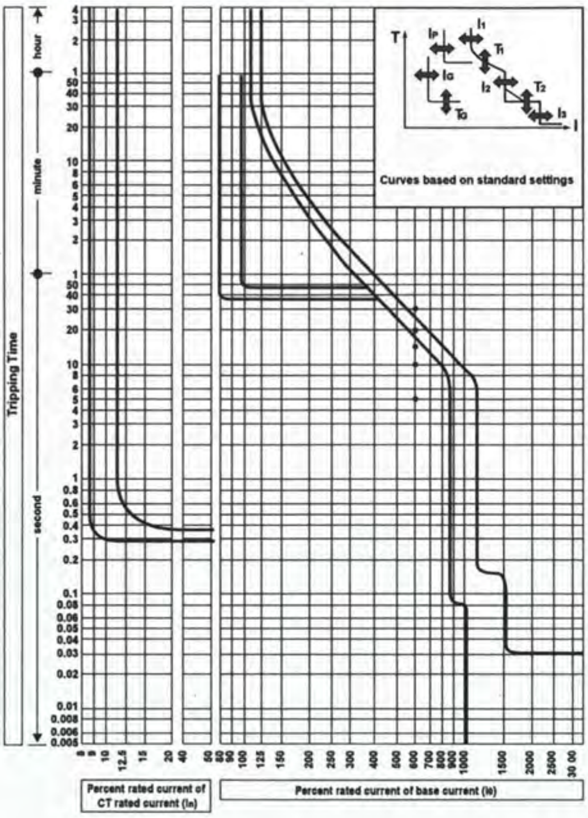
Overcurrent tripping characteristics

CT rated current (A) (I_n)	250, 400
Base current setting (A) (I_0)	(I_n) x (0.63-0.8-1.0)
Long time-delay pick-up current (A): (I_1)	(I_0) x (0.8-0.85-0.9-0.95-1.0) Non-tripping at (I_1) setting x 105 % and below. Tripping at 125 % and above.
Long time-delay time settings (S) (T_1)	(5-10-15-20-30) at (I_1) x 600 % current. Setting tolerance ± 20 %
Short time-delay pick-up current (A): (I_2)	(I_0) x (2-4-6-8-10) Setting tolerance ± 15 %
Short time-delay time settings (S) (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 resettable time - 20 ms for the time-delay setting
Instantaneous trip pick-up current (A) (I_3)	Continuously adjustable from (I_0) x (3 to 12) Setting tolerance ± 20 %
• Pre-trip alarm pick-up current (A) (I_P)	(I_1) x (0.7, 0.8, 0.9, 1.0) Setting tolerance ± 10 %
• Pre-trip alarm time setting (S) (T_P)	40 fixed definite time-delay. Setting tolerance ± 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) (I_n)	630, 800
Base current setting (A) (I_0)	(I_n) x (0.63-0.8-1.0)
Long time-delay pick-up current (A): (I_1)	(I_0) x (0.8-0.85-0.9-0.95-1.0) Non-tripping at (I_1) setting x 105 % and below. Tripping at 125 % and above.
Long time-delay time settings (S) (T_1)	(5-10-15-20-30) at (I_1) x 600 % current. Setting tolerance ± 20 %
Short time-delay pick-up current (A): (I_2)	(I_0) x (2-4-6-8-10) Setting tolerance ± 15%
Short time-delay time settings (S) (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 resettable time - 20 ms for the time-delay setting
Instantaneous trip pick-up current (A) (I_3)	Continuously adjustable from (I_0) x (3 to 12) Setting tolerance ± 20 %
• Pre-trip alarm pick-up current (A) (I_P)	(I_1) x (0.7, 0.8, 0.9, 1.0) Setting tolerance ± 10 %
• Pre-trip alarm time setting (S) (T_P)	40 fixed definite time-delay. Setting tolerance ± 10 %
• Ground fault trip pick-up current (A) (I_G)	Continuously adjustable from (I_n) x (0.1 to 0.4) Setting tolerance ± 15 %
• Ground fault trip time setting (S) (T_G)	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

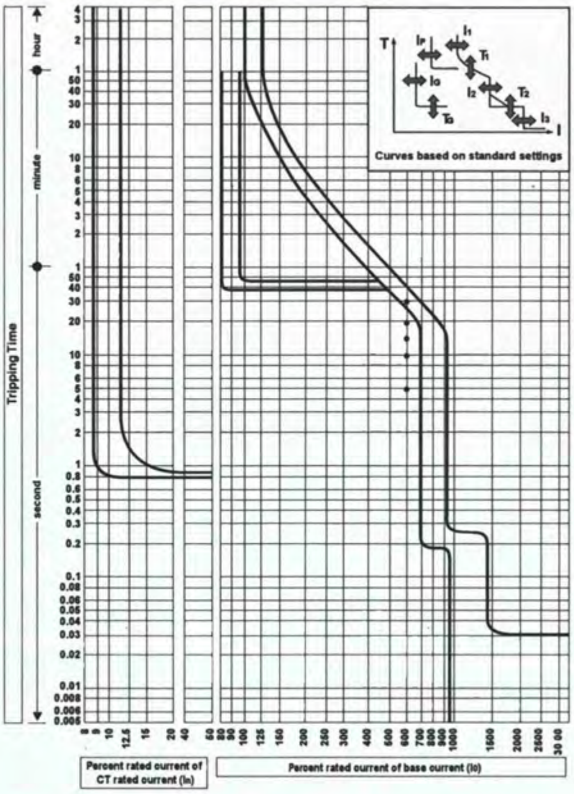
Note: • Optional.
Underlined values will be applied as standard ratings unless otherwise specified when ordering.

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) (I_n)	1000, 1250, 1600, 2000, 2500
Base current setting (A) (I_0)	(I_n) x (0.63-0.8-1.0)
Long time-delay pick-up current (A): (I_1)	(I_0) x (0.8-0.85-0.9-0.95-1.0) Non-tripping at (I_1) setting x 105 % and below. Tripping at 125 % and above.
Long time-delay time settings (S) (T_1)	(5-10-15-20-30) at (I_1) x 600 % current. Setting tolerance ± 20 %
Short time-delay pick-up current (A): (I_2)	(I_0) x (2-4-6-8-10) Setting tolerance ± 15 %
Short time-delay time settings (S) (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 resettable time - 20 ms for the time-delay setting
Instantaneous trip pick-up current (A) (I_3)	Continuously adjustable from (Io) x (3 to 12) Setting tolerance ± 20 %
• Pre-trip alarm pick-up current (A) (I_P)	(I_1) x (0.7, 0.8, 0.9, 1.0) Setting tolerance ±10 %
• Pre-trip alarm time setting (S) (T_P)	40 fixed definite time-delay. Setting tolerance ±10 %
• Ground fault trip pick-up current (A) (I_G)	Continuously adjustable from (I_n) x (0.1 to 0.4) Setting tolerance ± 15 %
• Ground fault trip time setting (S) (T_G)	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

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:

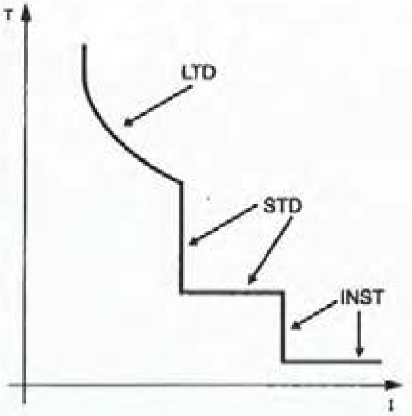
$$(I^2-1).\ t = k$$

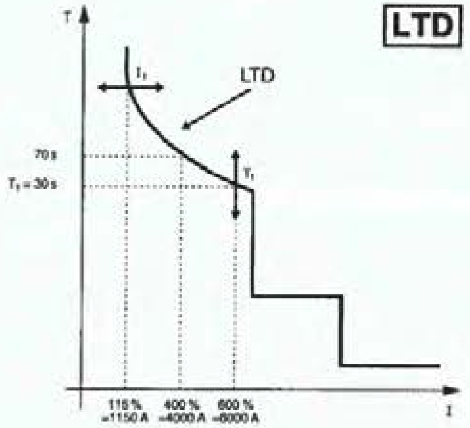
where 'k' is a constant. To determine k, the calibration point of the LTD should be used, i.e. $t = T_1$ at $I_1 = 6$ (600 %).

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 I_2 and T_2 settings for the STD, and I_3 setting for the INST.

Fig. 1





Example

If we assume that we have:

XS1250SE with 1250A CTs and

$I_0 = 1,\ I_1 = 0.8,\ T_1 = 30$ secs,

$I_2 = 8,\ T_2 = 0.2$ sec and

$I_3 = 12$ (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:

$k = (I^2 - 1)\ \ t = (6^2 - 1)\ \ 30 = 1050$

giving the characteristic equation:

$(I^2 - 1)\ \ t = 1050$

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 x 1.0 x 0.8 x 4 = 400 A).

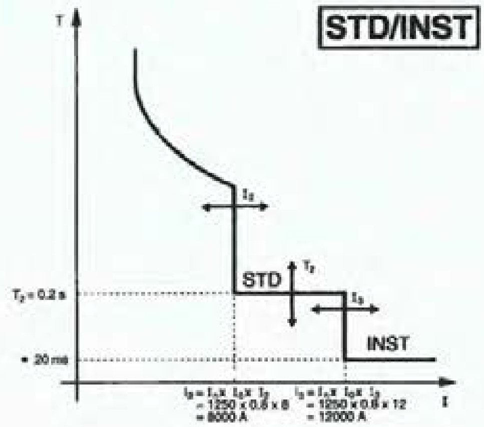
$$t = \frac{1050}{(I^2 - 1)} = \frac{1050}{(4^2 - 1)} = 70 \text{ secs}$$

The STD and INST can be constructed as follows with

$I_2 = I_n \times I_0 \times I_2$

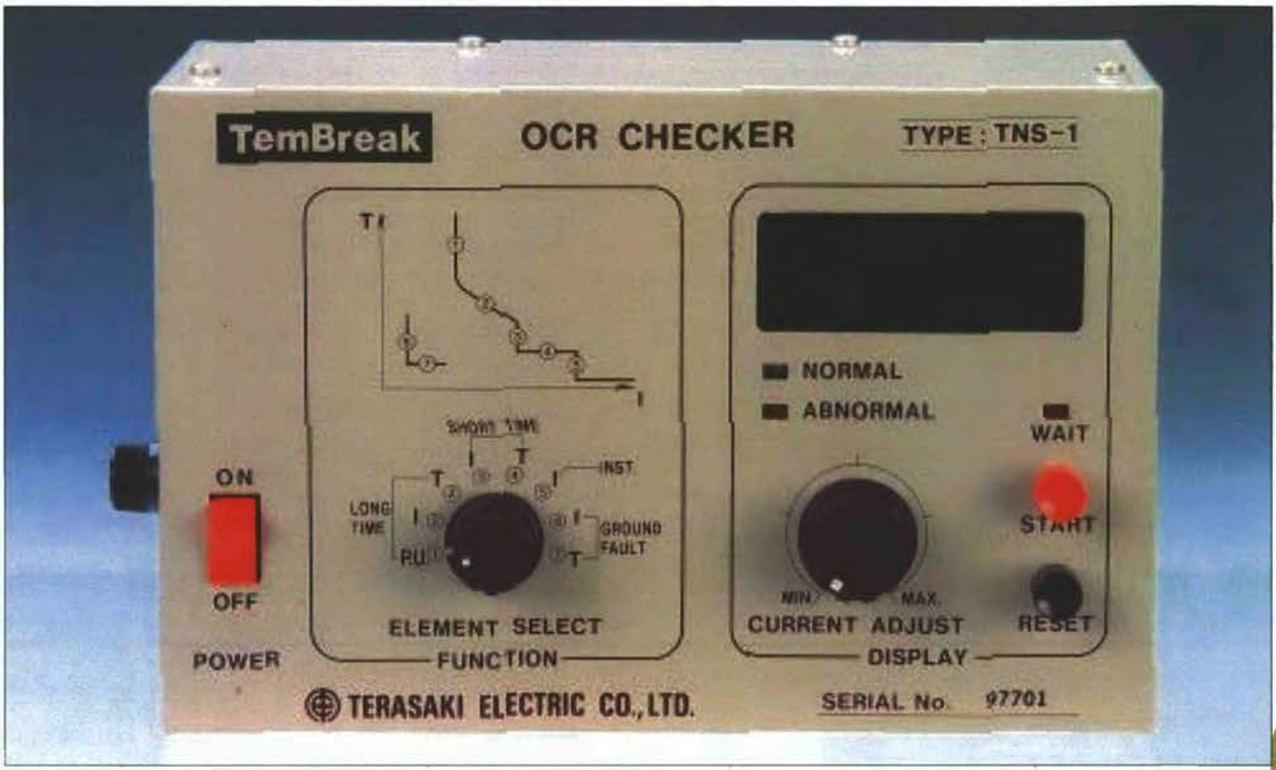
$I_3 = I_n \times I_0 \times I_3$

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.



MCCB Technical data

OCR checker, inspection and maintenance



The TemBreak (Electronic) OCR checker, Type TNS-1, is a portable easy-to-use instrument for field testing the trip functions.

It checks the pick-up current and tripping time value of the LTD, STD, INST and GFT functions.

Ratings and specifications

Power source	100~110 V, 220~240 V AC single phase 50/60 Hz
Power consumption	30 VA
Application	LTD function check (set current and trip time values) STD function check (set current and trip time values) INST function check (set current value) GFT function check (set current and trip time values)
Measurement of set current values	Display 3-digit digital display Range 0-900 mA
Measurement of tripping time values	Range 0.00-99.9 seconds
Outline dimensions (mm)	200 W x 84 H x 130 D
Weight	2.7 kg

NHP

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NOW
with AutoCAD output and complete device listing

TemCurve

Selectivity Analysis Software

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.

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.

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

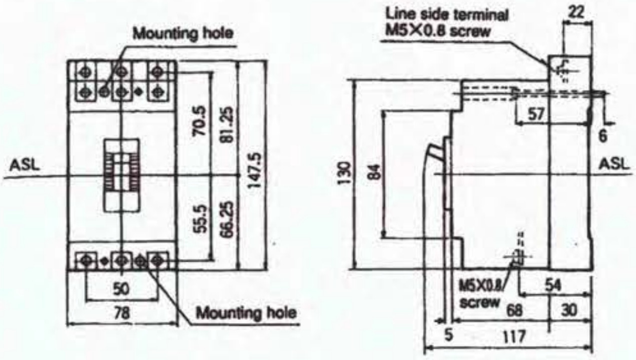
MCCB Technical data

TemBreak XM30PB

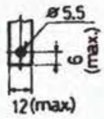
ASL: Arrangement standard line
Ⱨ: Handle frame centre line

Outline dimensions (mm)

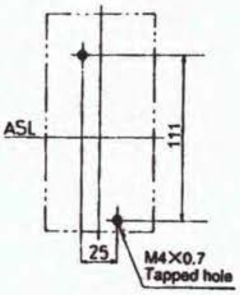
Front connected (standard)



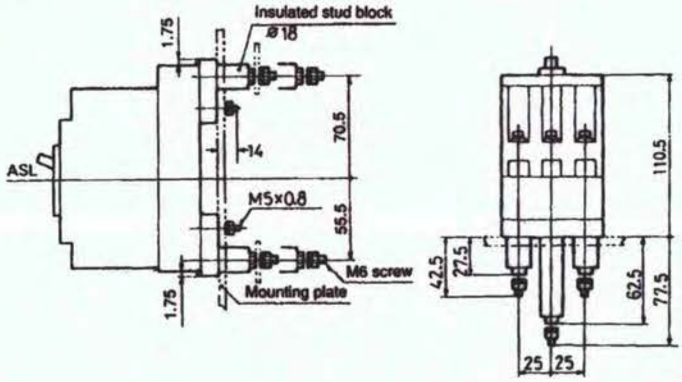
Preparation of conductor



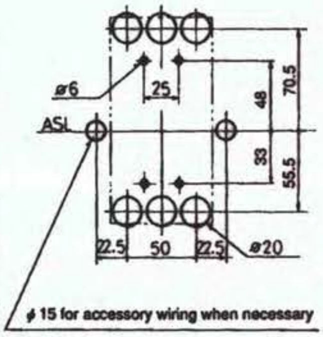
Drilling plan



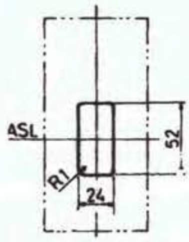
Rear connected (optional)



Drilling plan

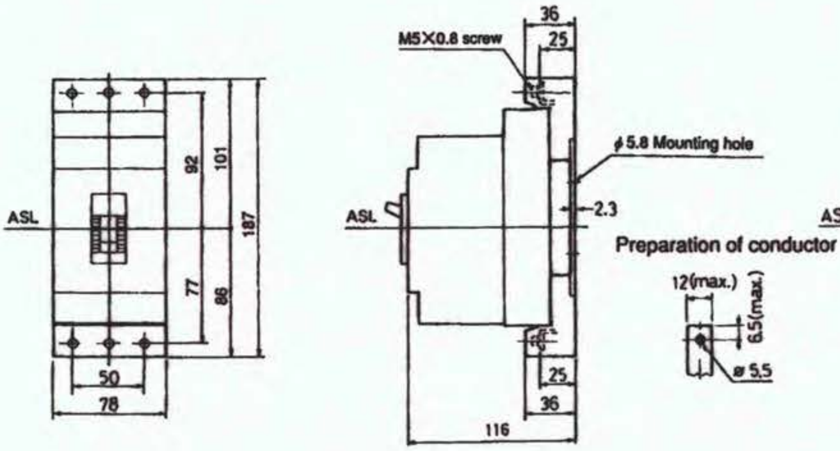


Panel cut-out

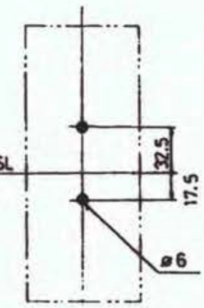


Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

Plug-in (optional)



Drilling plan



MCCB Technical data

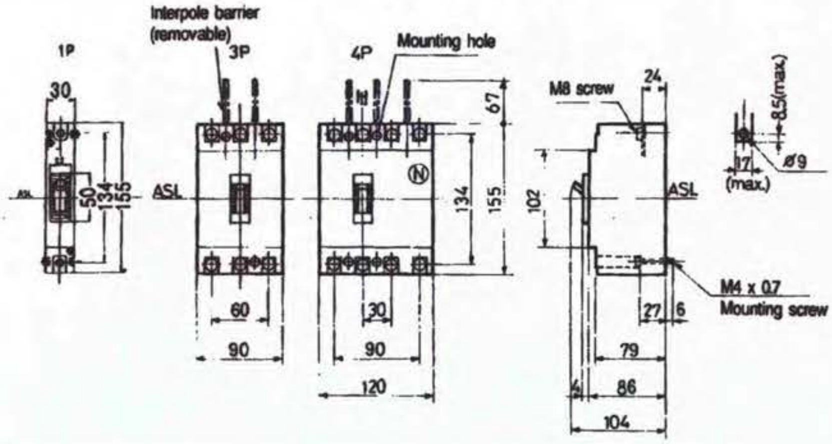
TemBreak XS125CS, CJ, NS, NJ, XH125NJ, PJ and TL30F MCCBs

ASL: Arrangement standard line
Ⅱ: Handle frame centre line

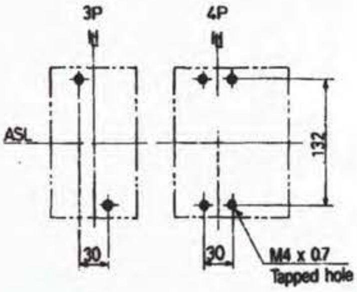
Outline dimensions (mm)

Front connected (standard)

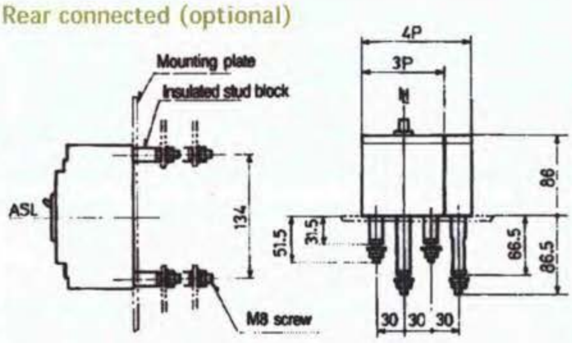
Note: XS125NS 1 pole only



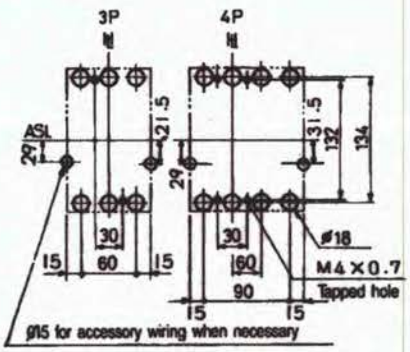
Drilling plan



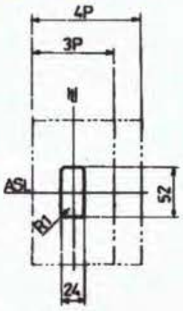
Rear connected (optional)



Drilling plan

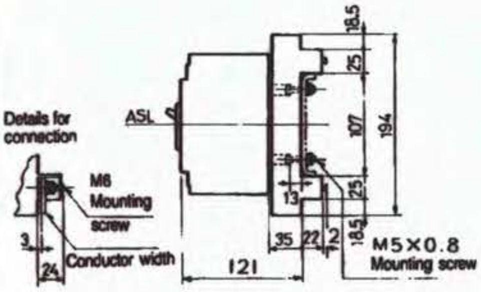


Panel cut-out

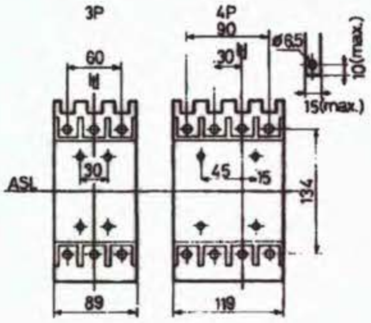


Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

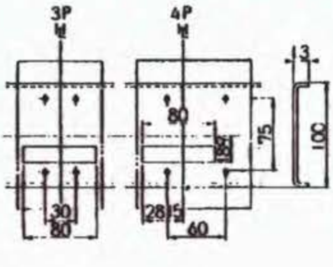
Plug-in (optional)



Mounting block



Drilling plan



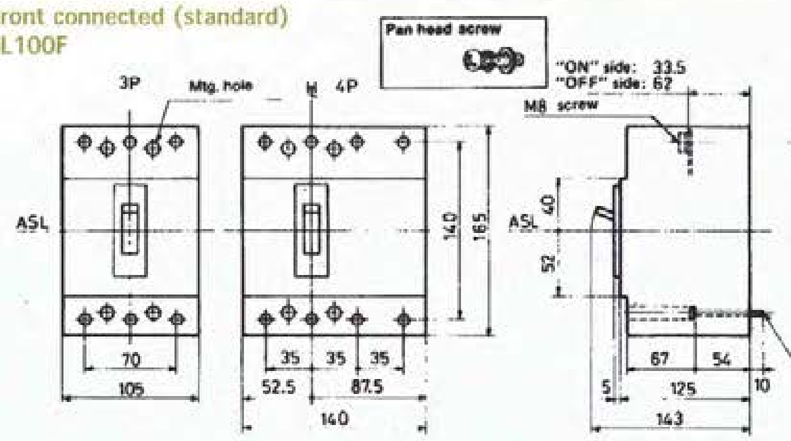
MCCB Technical data

TemBreak TL100F/TL100EM – TL100NJ

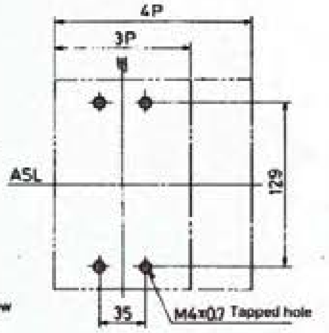
ASL: Arrangement standard line
℄: Handle frame centre line

Outline dimensions (mm)

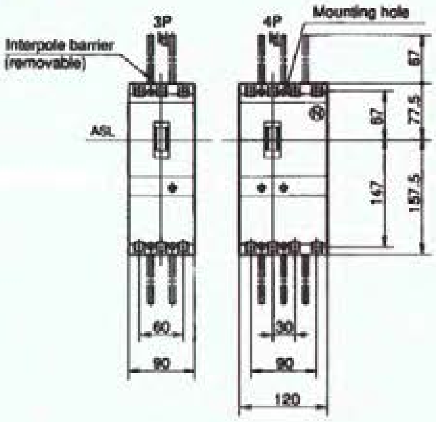
Front connected (standard)
TL100F



Drilling plan

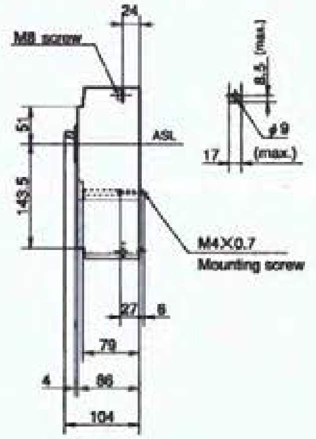


Front connected
TL100NJ

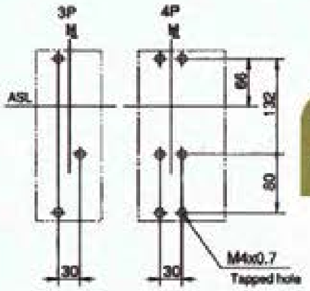


Pan head screw

Preparation of conductor

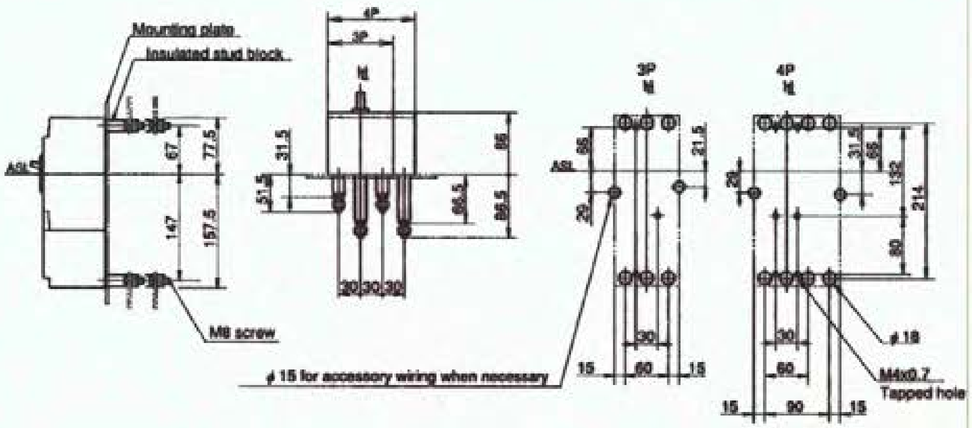


Drilling plan

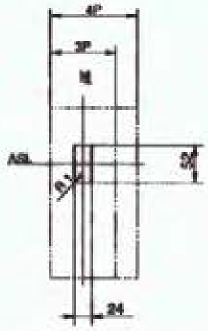


Rear connected

Bold stud type **Drilling plan**



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.

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MCCB Technical data

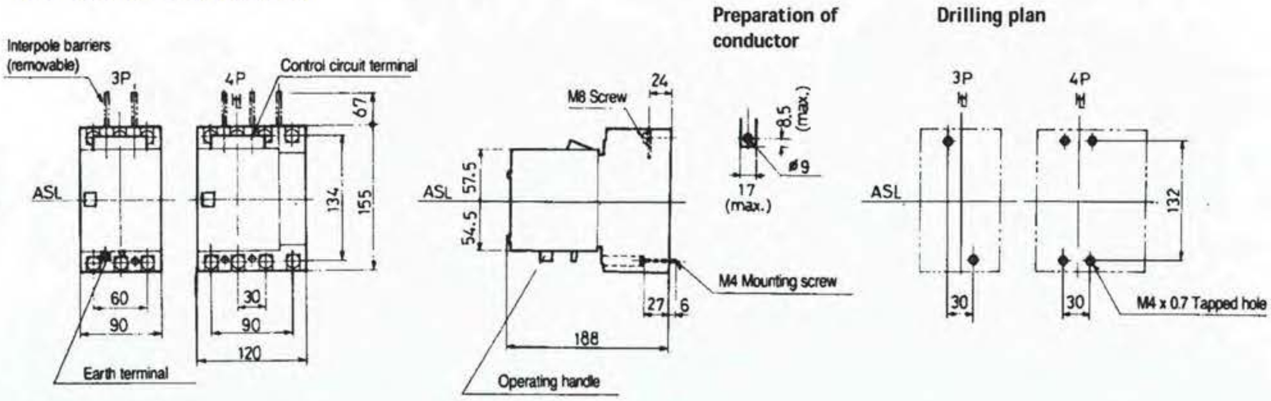
Motor operators (XMB type) for XS125, XH125, TL100NJ, TL30F [1] [2]

ASL: Arrangement standard line
℄: Handle frame centre line

Outline dimensions (mm)

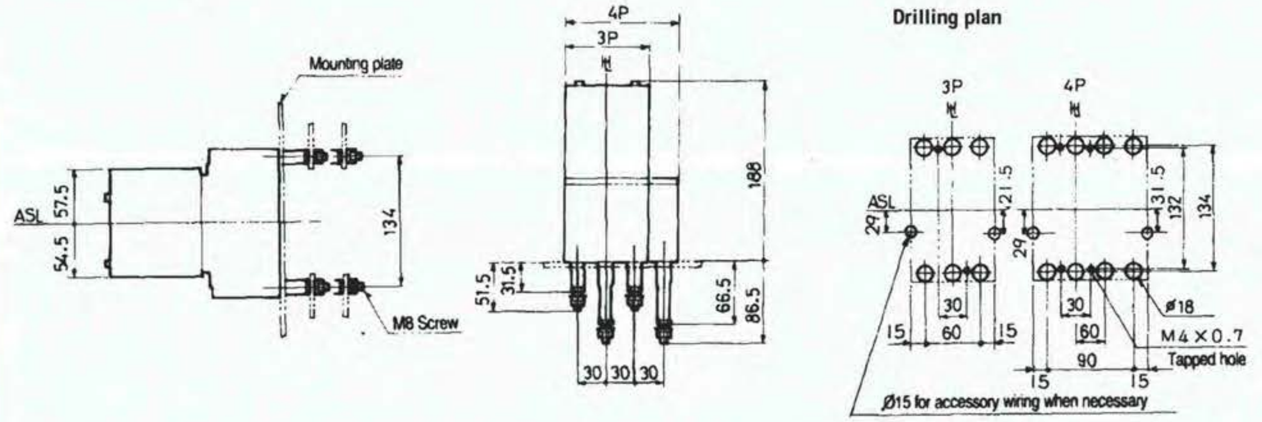
Front connected (standard)

Preparation of conductor **Drilling plan**



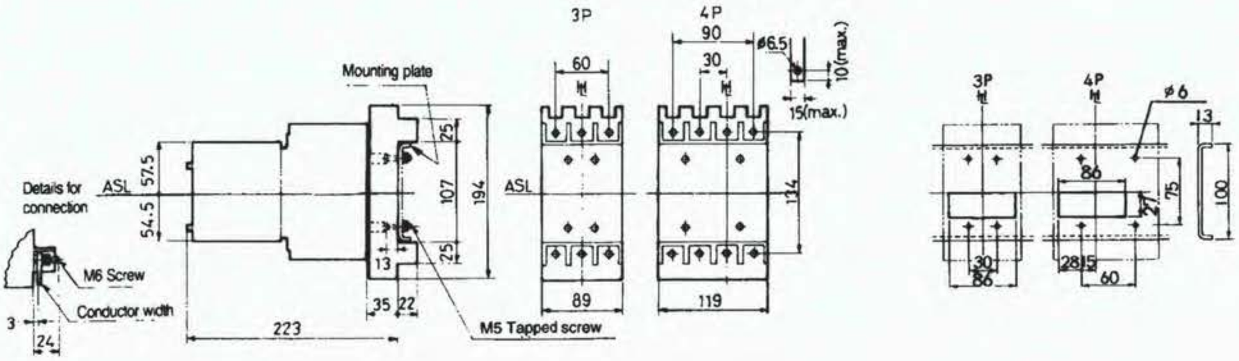
Rear connected (optional)

Drilling plan



Plug-in (optional)

Mounting block **Preparation of conductor** **Drilling plan**



Notes: [1] For dimensions of 7MB-3BA2 used for TL100F refer to NHP.
[2] 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.

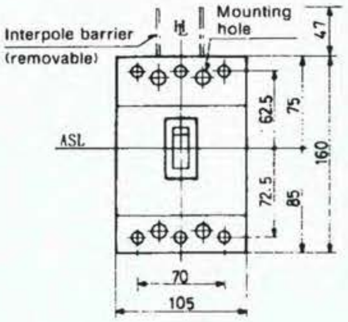
MCCB Technical data

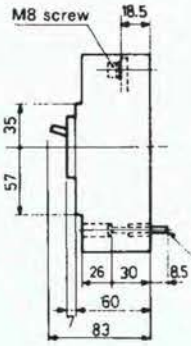
TemBreak XE225NC

ASL: Arrangement standard line
℄: Handle frame centre line

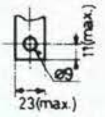
Outline dimensions (mm)

Front connected (standard)

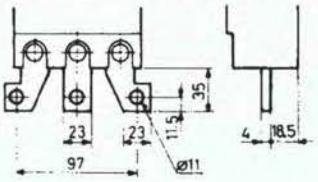




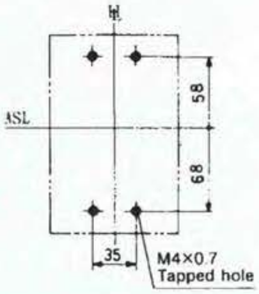
Preparation of conductor



with terminal bars (optional)

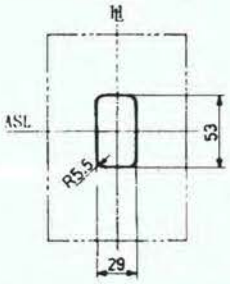


Drilling plan



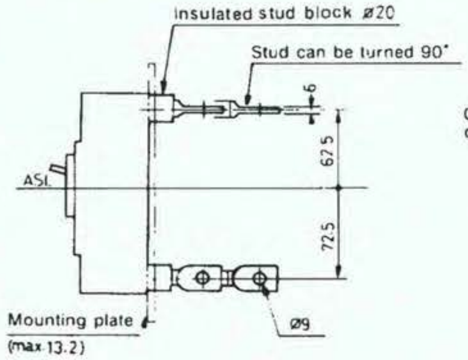
Breakers with terminal bars available on request

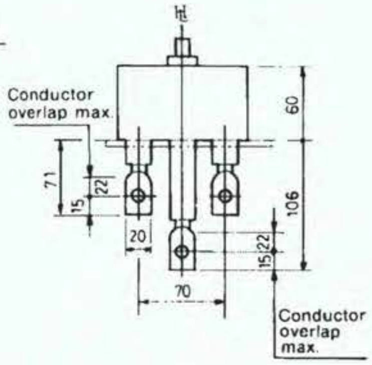
Panel cut-out



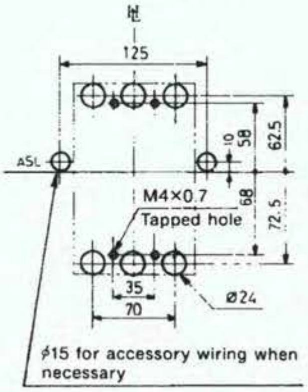
Panel cut-out dimensions shown give an allowance of 1.5 mm around the handle escutcheon.

Rear connected (optional)





Drilling plan



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

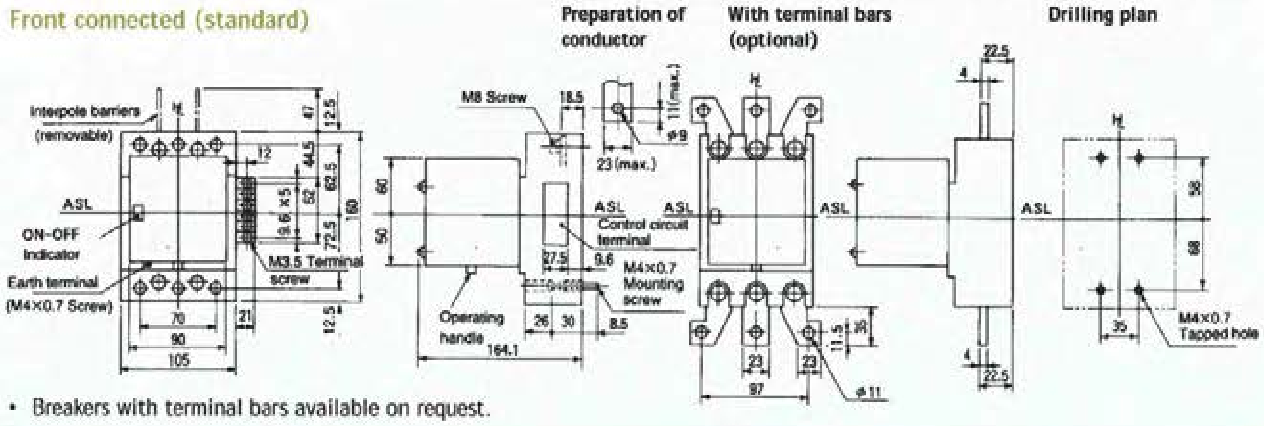
MCCB Technical data

Motor operators for XE225NC

ASL: Arrangement standard line
Ḫ: Handle frame centre line

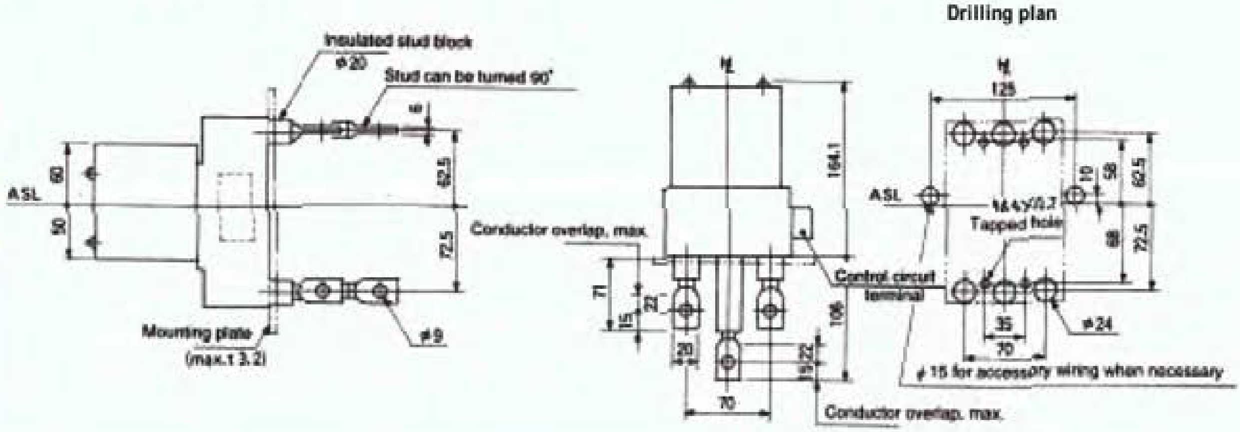
Outline dimensions (mm)

Front connected (standard)



- Breakers with terminal bars available on request.

Rear connected (optional)



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

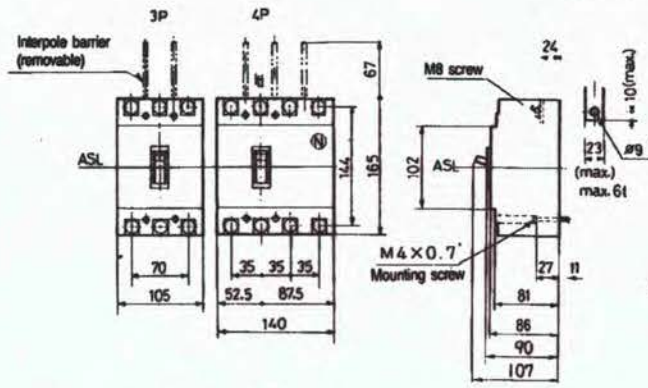
MCCB Technical data

TemBreak XS250NJ

ASL: Arrangement standard line
ℍ: Handle frame centre line

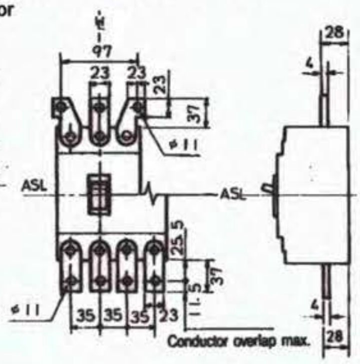
Outline dimensions (mm)

Front connected (standard)

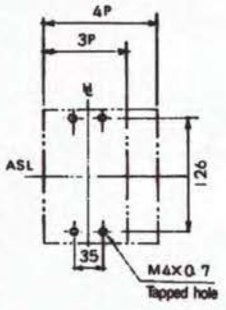


(optional)

With terminal bars

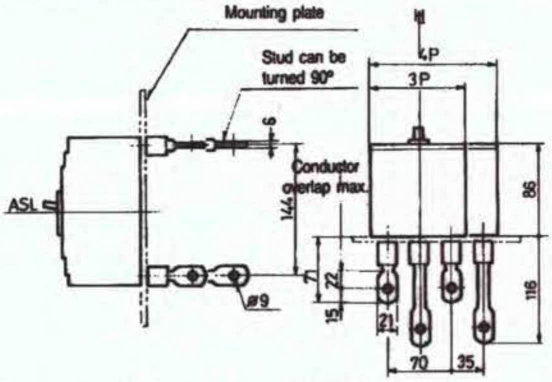


Drilling plan

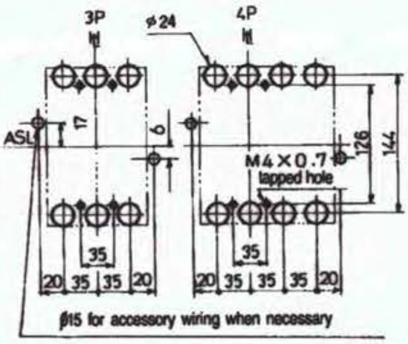


Breakers with terminal bars available on request.

Rear connected (optional)

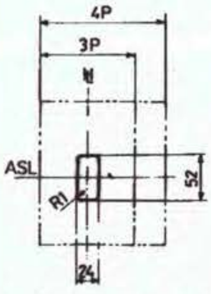


Drilling plan



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

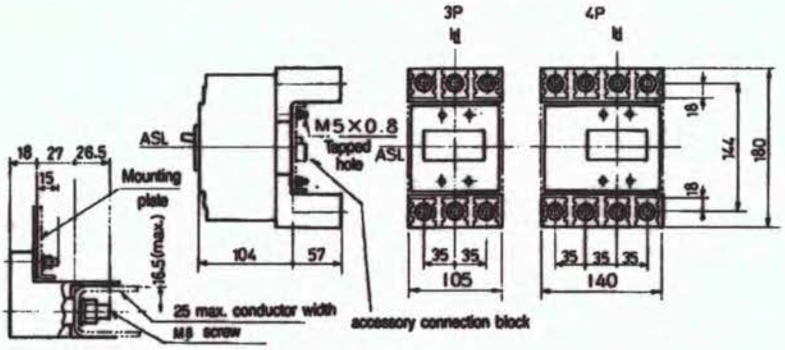
Panel cut-out



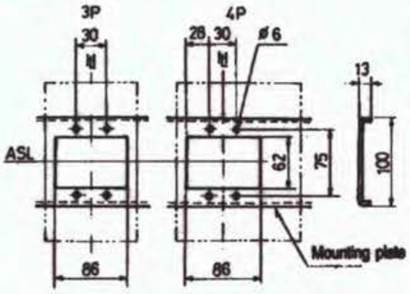
Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

Plug-in (optional)

Mounting block



Drilling plan



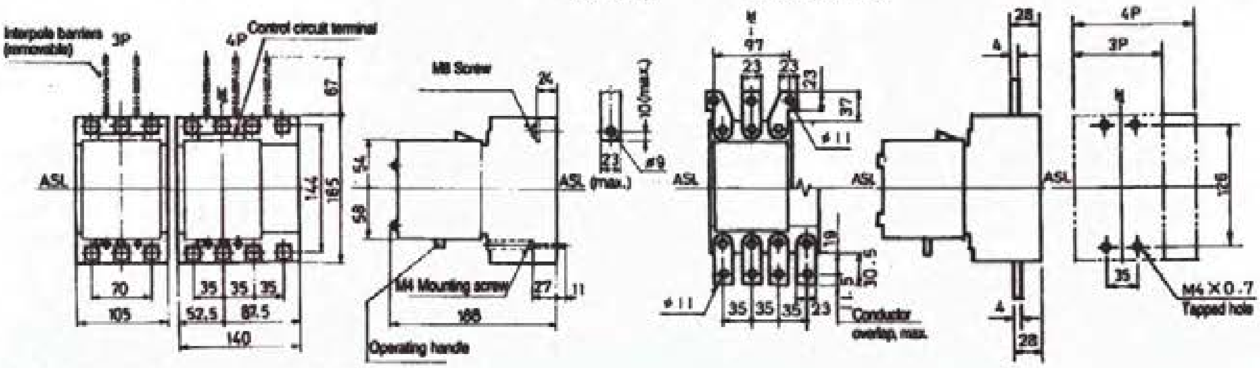
MCCB Technical data

Motor operators (XMB type) for XS250NJ

ASL: Arrangement standard line
℄: Handle frame centre line

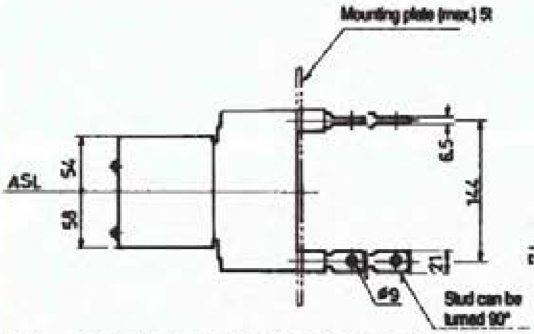
Outline dimensions (mm)

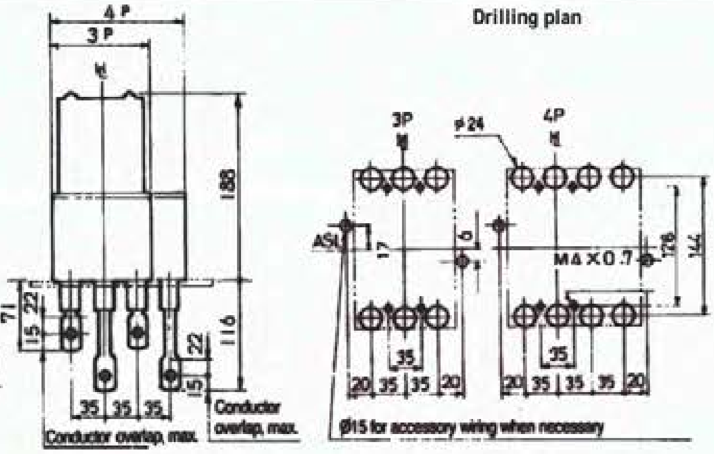
Front connected (standard)



- Breakers with terminal bars available on request.

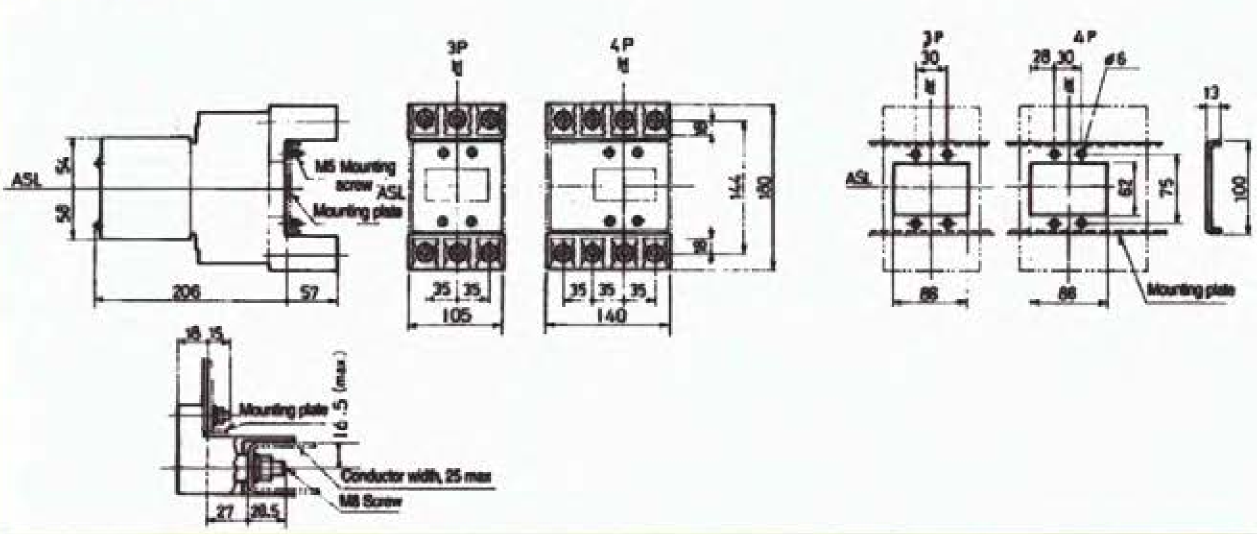
Rear connected (optional)





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

Plug-in (optional)



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

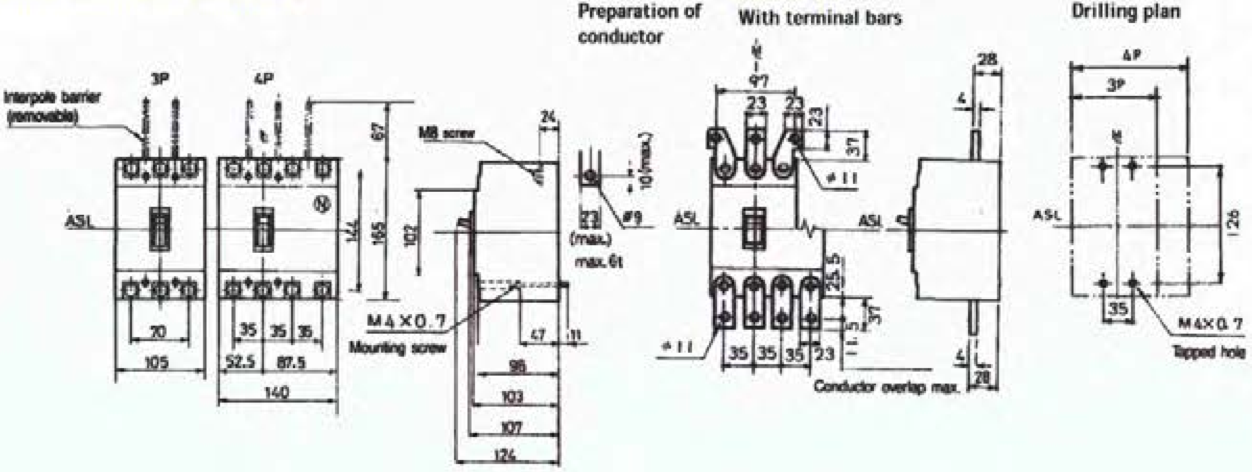
MCCB Technical data

TemBreak XH160PJ and XH250NJ

ASL: Arrangement standard line
ℍ: Handle frame centre line

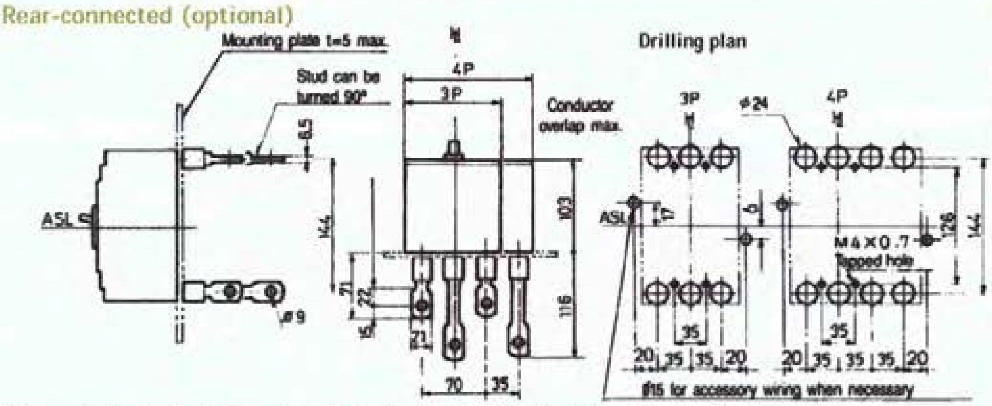
Outline dimensions (mm)

Front-connected (standard)



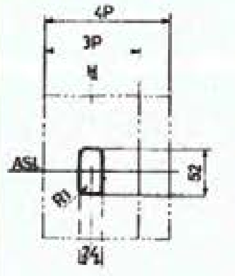
Note: Breakers with terminal bars available on request.

Rear-connected (optional)



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

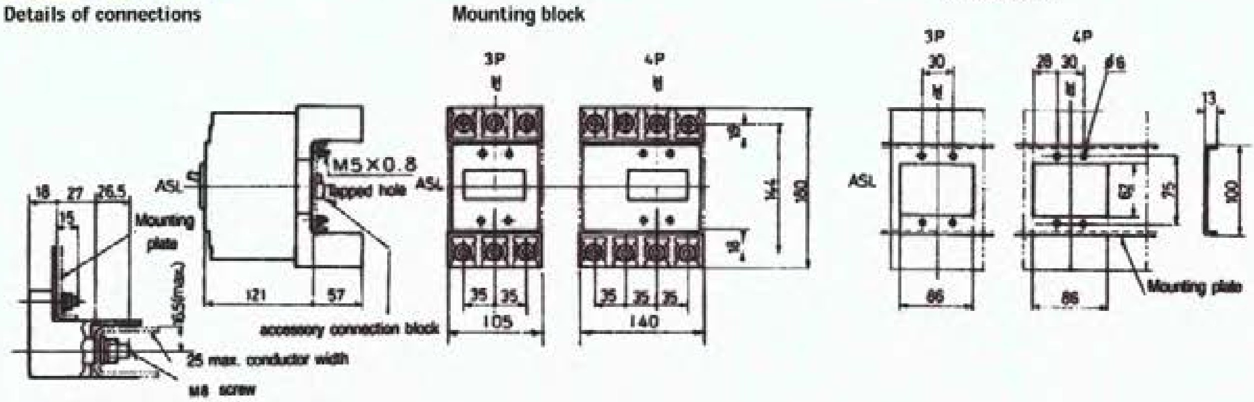
Panel cut-out



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

Plug-in (optional)

Details of connections



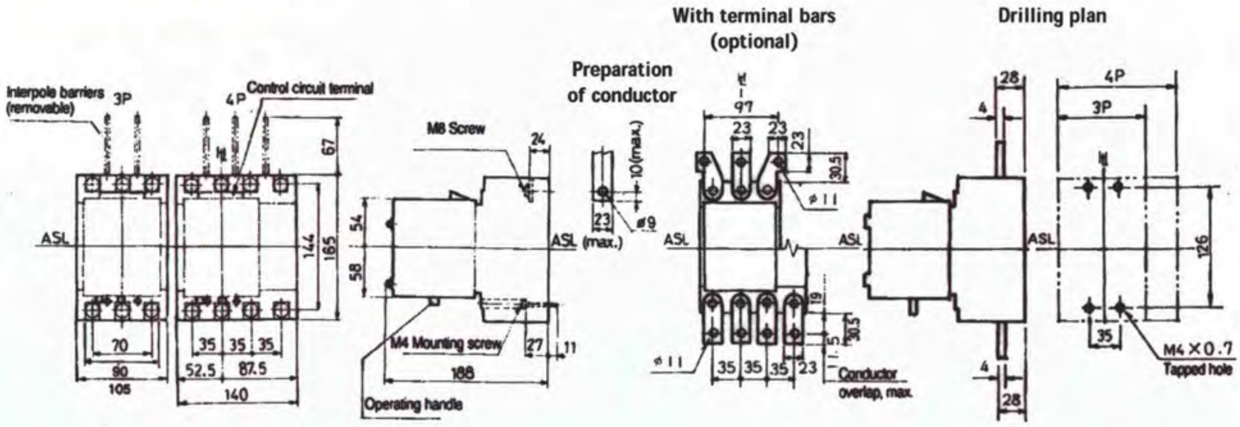
MCCB Technical data

Motor operators for XH160PJ and XH250NJ

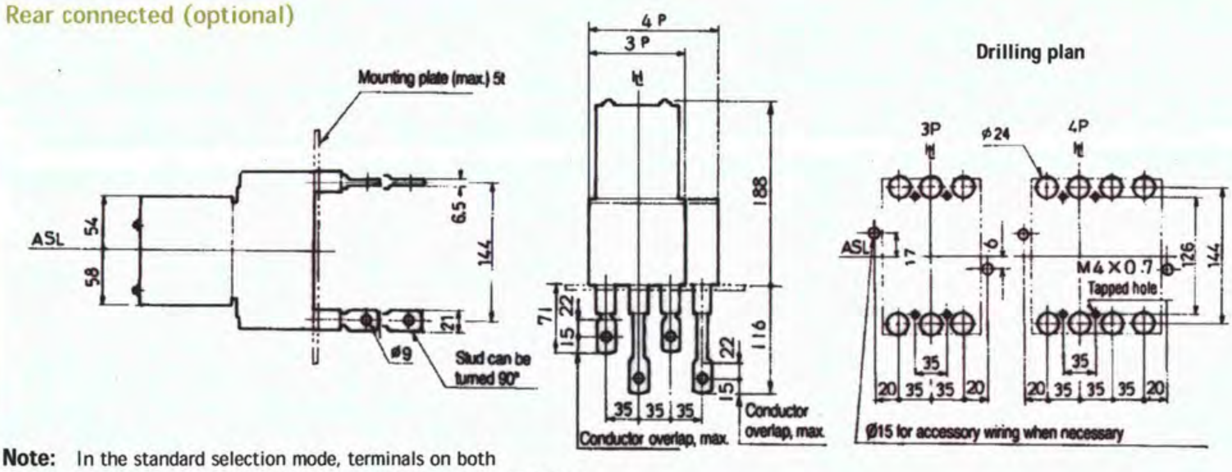
ASL: Arrangement standard line
ℍ: Handle frame centre line

Outline dimensions (mm)

Front connected (standard)

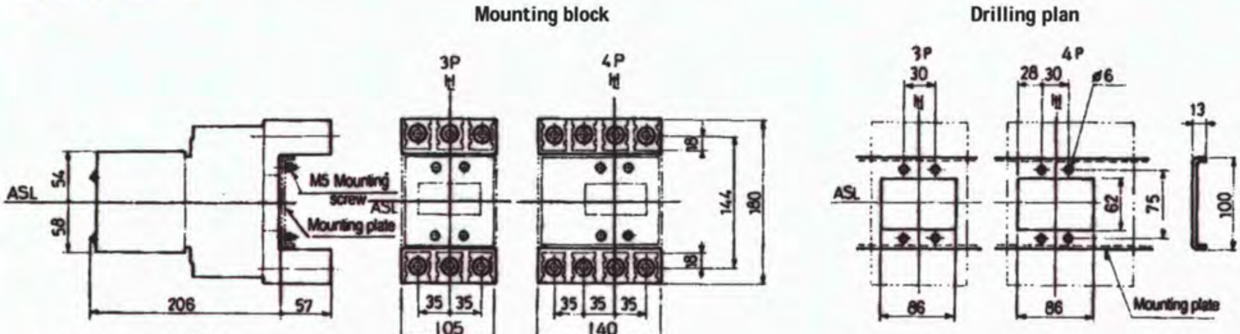


Rear connected (optional)

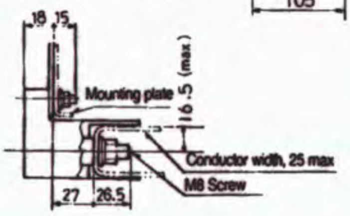


Note: In the standard selection mode, terminals on both the line side and the load side are in a horizontal orientation.

Plug-in (optional)



Details for connection



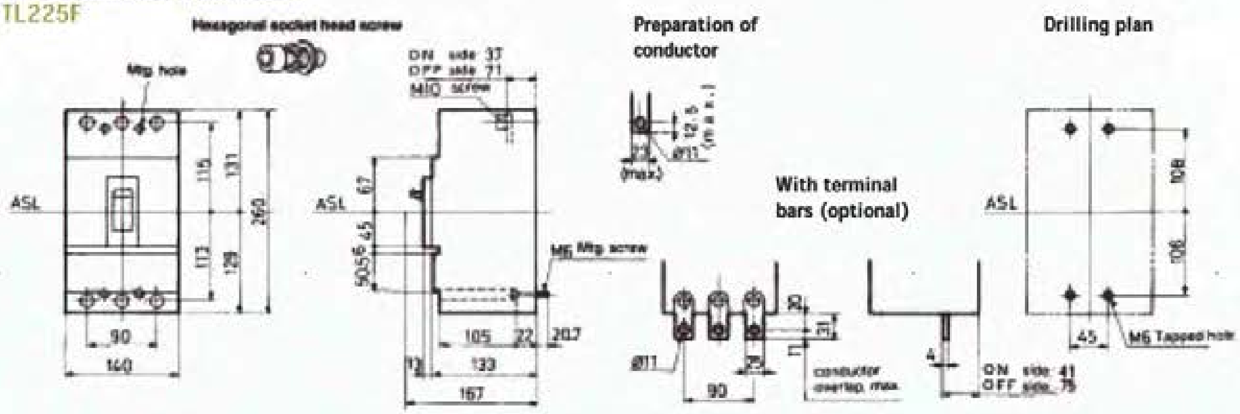
MCCB Technical data

TemBreak TL225F, TL250NJ

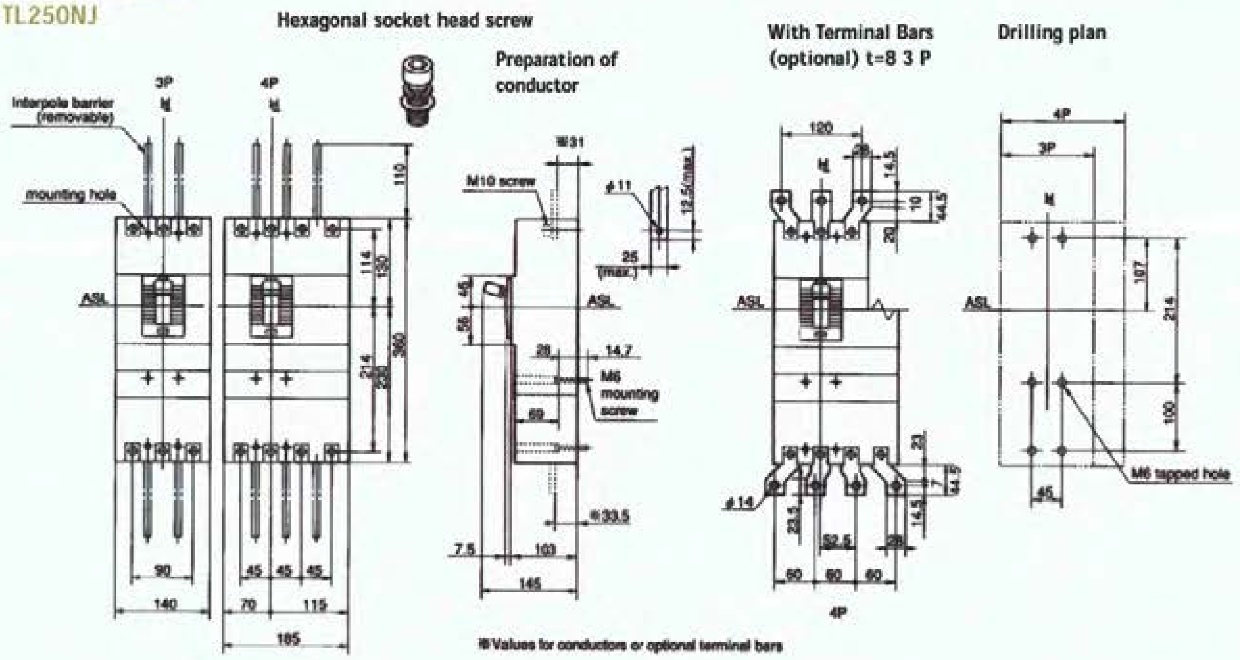
ASL: Arrangement standard line
Ⱡ: Handle frame centre line

Outline dimensions (mm)

Front connected (standard)
TL225F

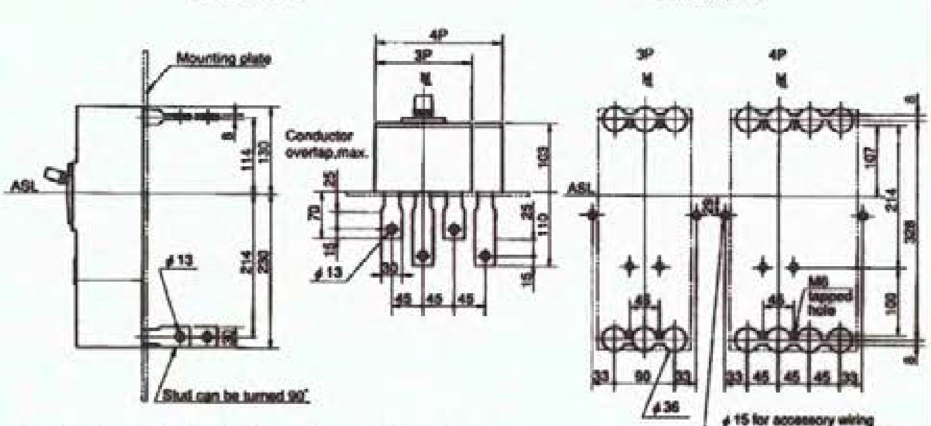


Front connected
TL250NJ



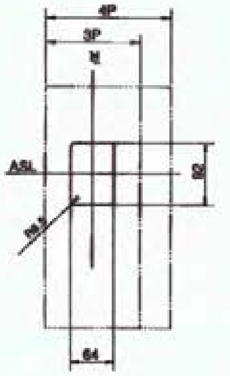
※Values for conductors or optional terminal bars

Rear connected



Note: In the standard selection 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.

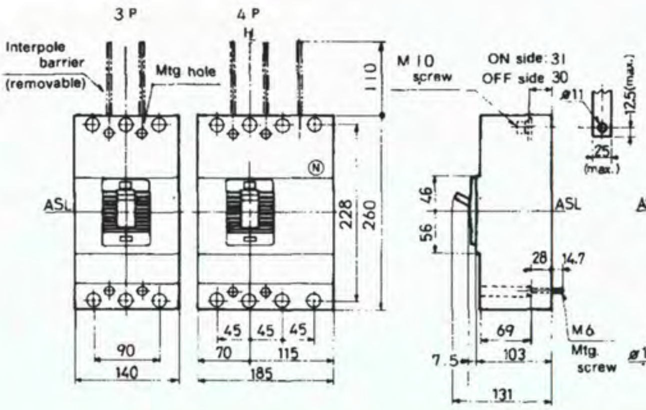
MCCB Technical data

TemBreak XS400, XH400, XH250PJ, XV400

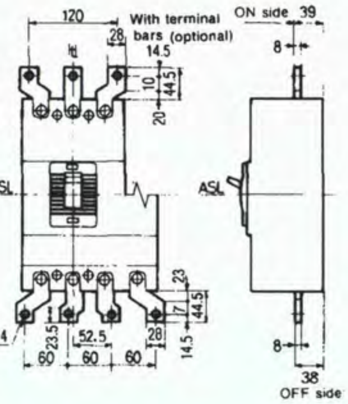
ASL: Arrangement standard line
Ḧ: Handle frame centre line

Outline dimensions (mm)

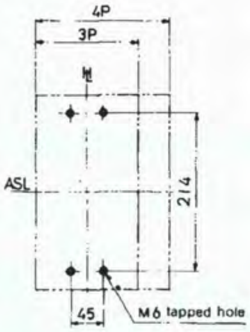
Front connected (standard)



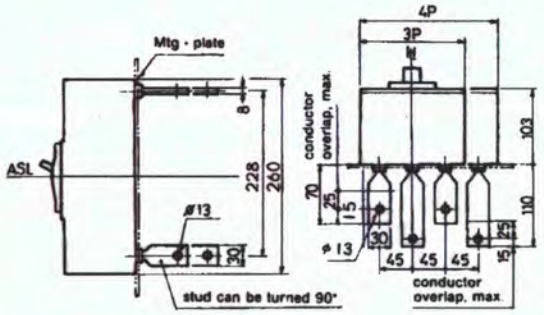
Optional extension busbars



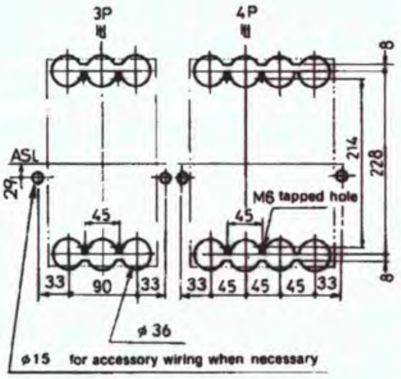
Drilling plan



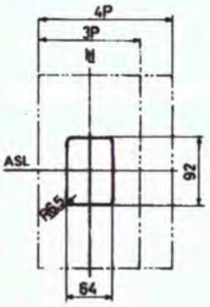
Rear connected (optional)



Drilling plan



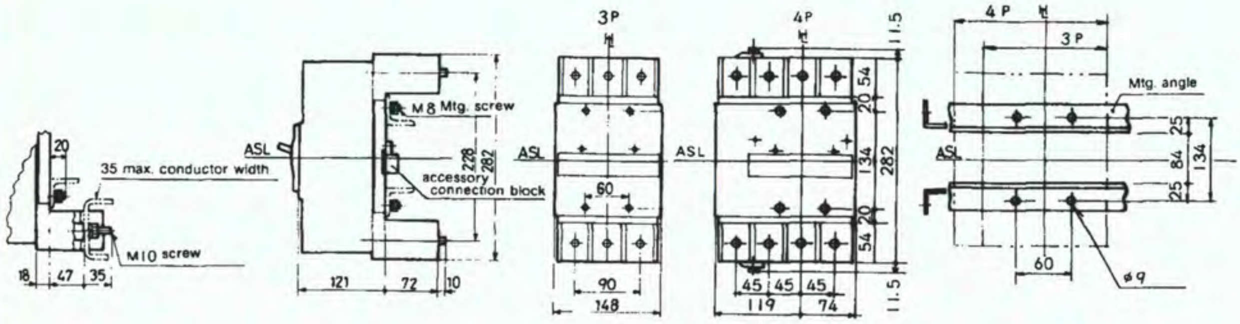
Panel cut-out



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)



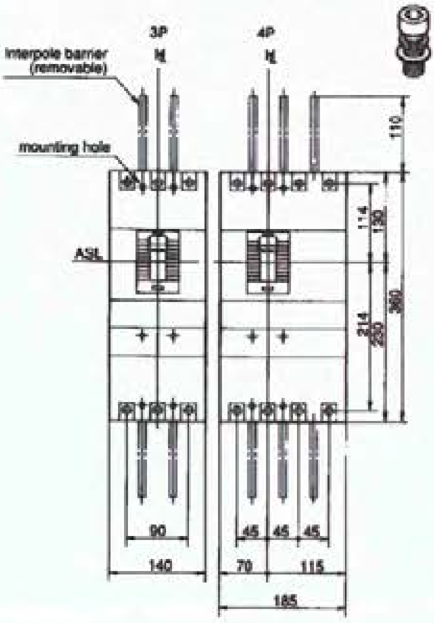
MCCB Technical data

TemBreak TL400NE

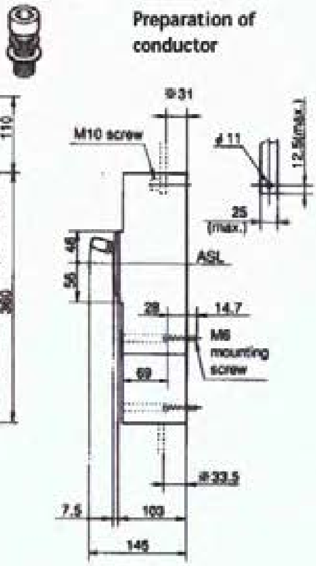
ASL: Arrangement standard line
℄: Handle frame centre line

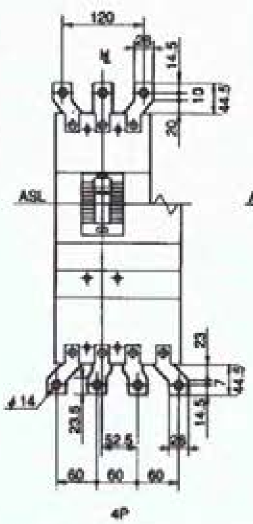
Outline dimensions (mm)

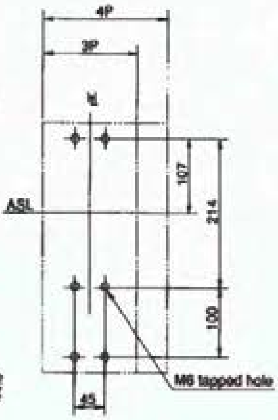
Front connected



Hexagonal socket head screw

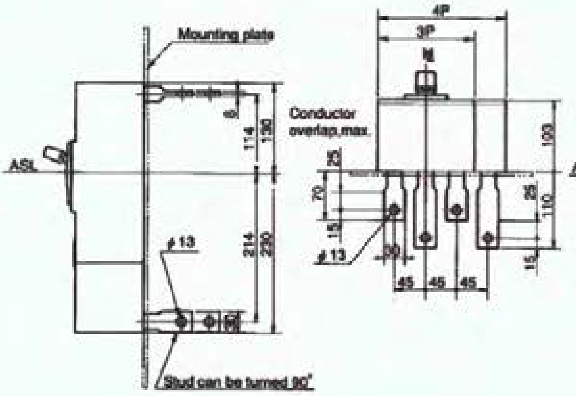


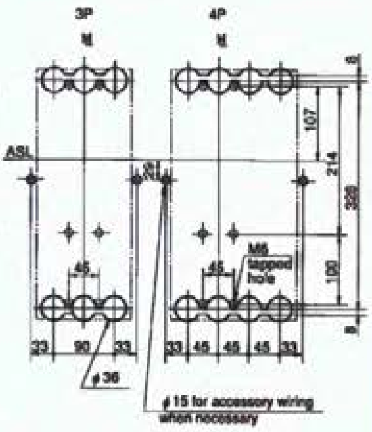




*Values for conductors or optional terminal bars

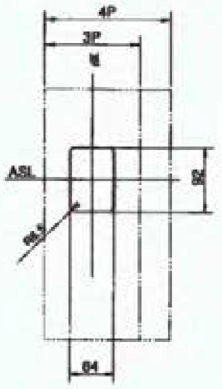
Rear connected





Note: In the standard selection 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.

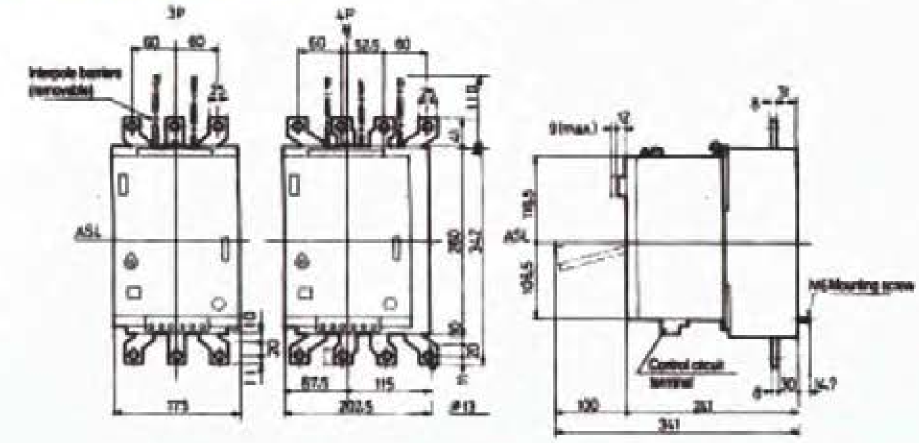
MCCB Technical data

Motor operators (XMC type) for XS400, XH400, XV400, TL250NJ, TL400NE ¹)

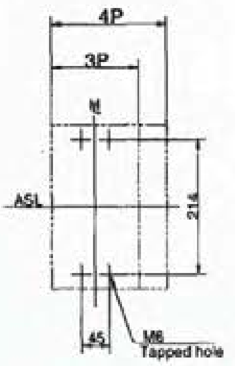
ASL: Arrangement standard line
℄: Handle frame centre line

Outline dimensions (mm)

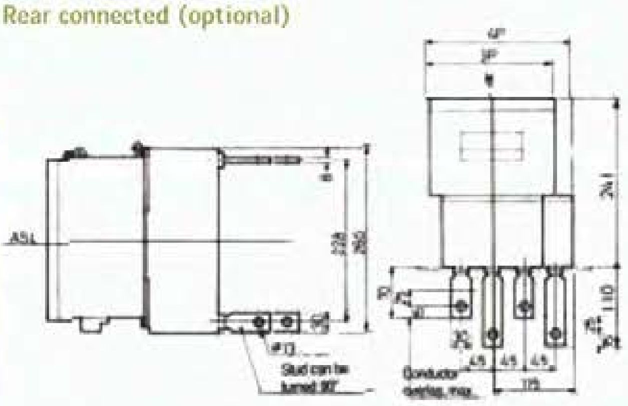
Front connected (standard)



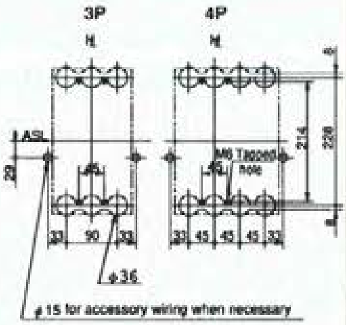
Drilling plan



Rear connected (optional)

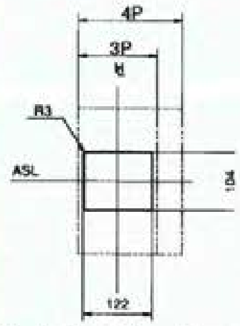


Drilling plan



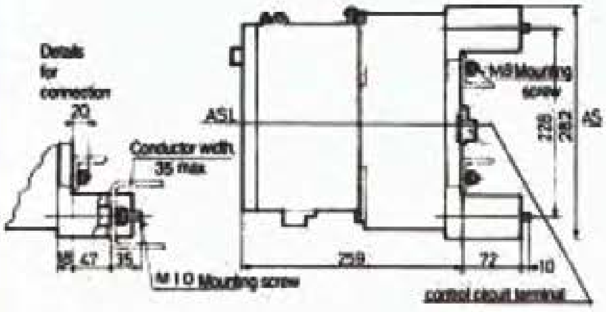
Note: In the standard selection mode, terminals on both the line side and the load side are in a horizontal orientation.

Panel cut-out

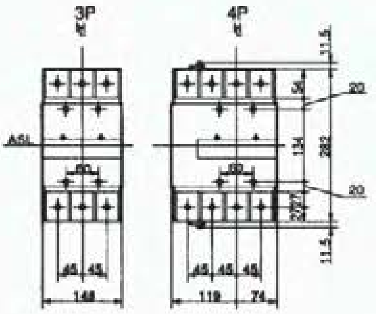


Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

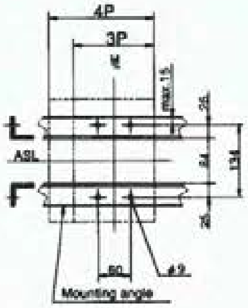
Plug-in (optional)



Mounting block



Drilling plan



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

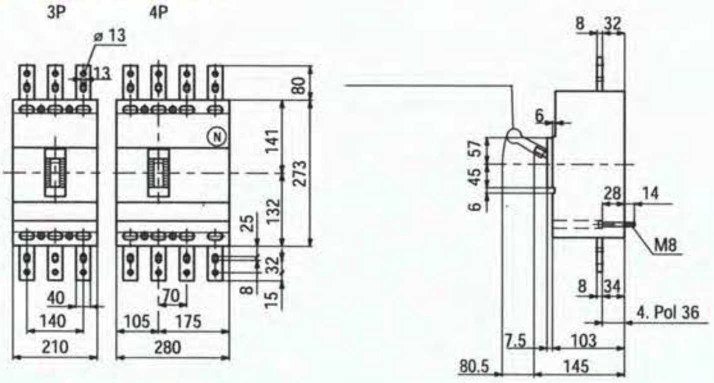
MCCB Technical data

TemBreak 630 AF XS630, XH630

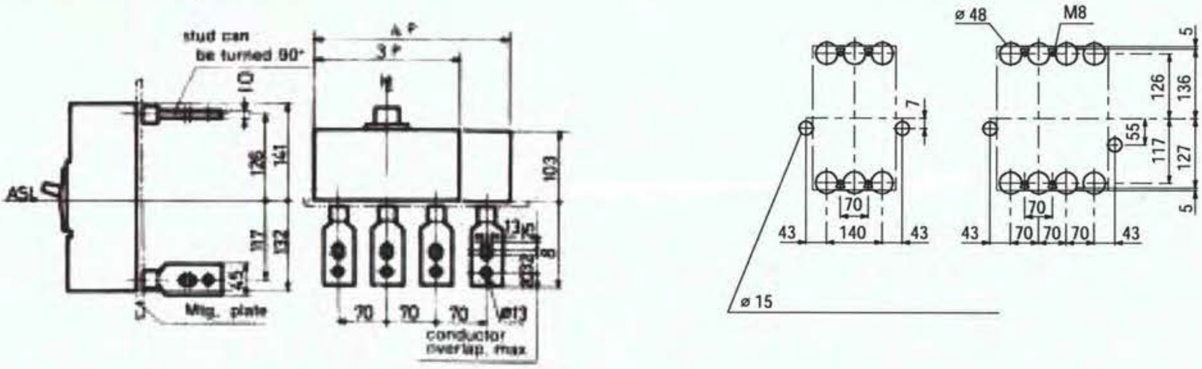
ASL: Arrangement standard line
℄: Handle frame centre line

Outline dimensions (mm)

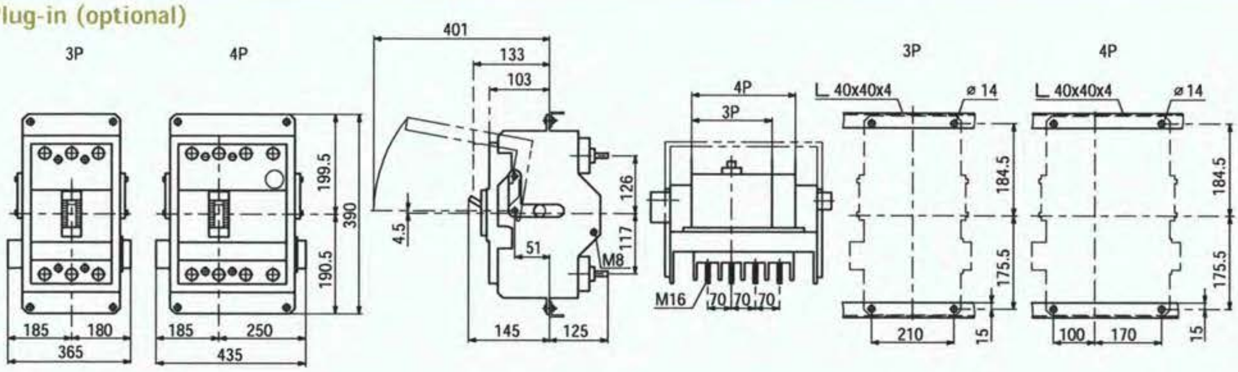
Front connected (standard)



Rear connected (optional)



Plug-in (optional)



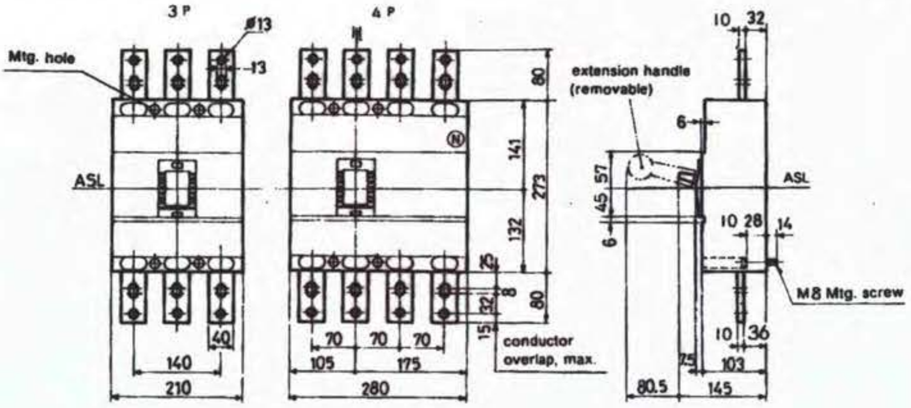
MCCB Technical data

TemBreak 800 AF XS800, XH800

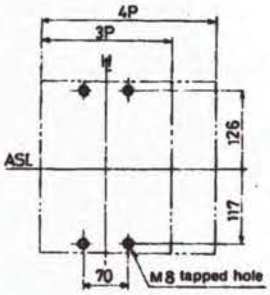
ASL: Arrangement standard line
H/L: Handle frame centre line

Outline dimensions (mm)

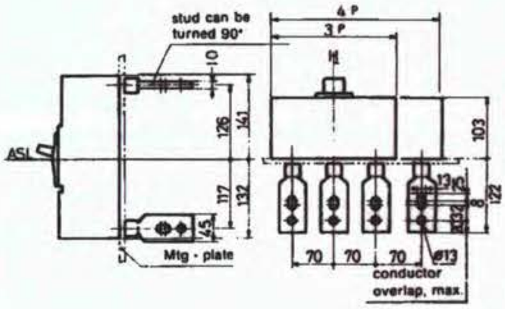
Front connected (standard)



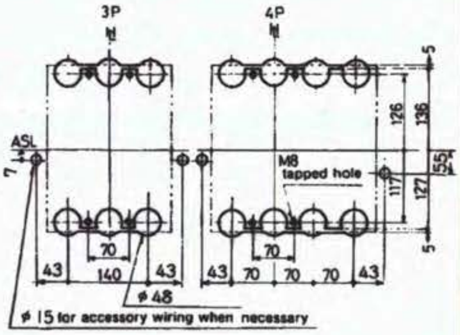
Drilling plan



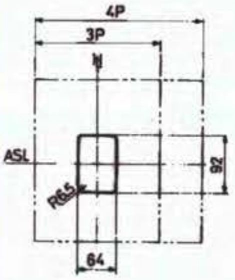
Rear connected (optional)



Drilling plan



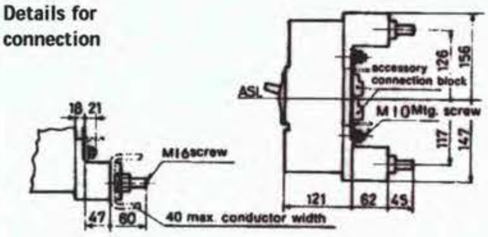
Panel cut-out



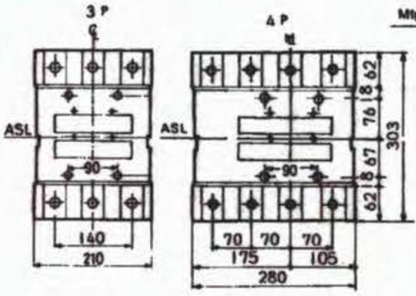
Panel cut-out dimensions shown give an allowance of 1.0 mm around the handle escutcheon.

Plug-in (optional)

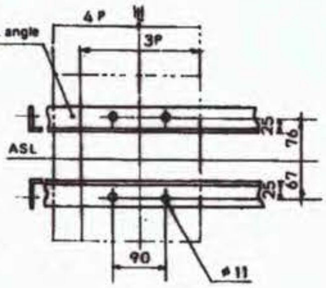
Details for connection



Mounting block



Drilling plan



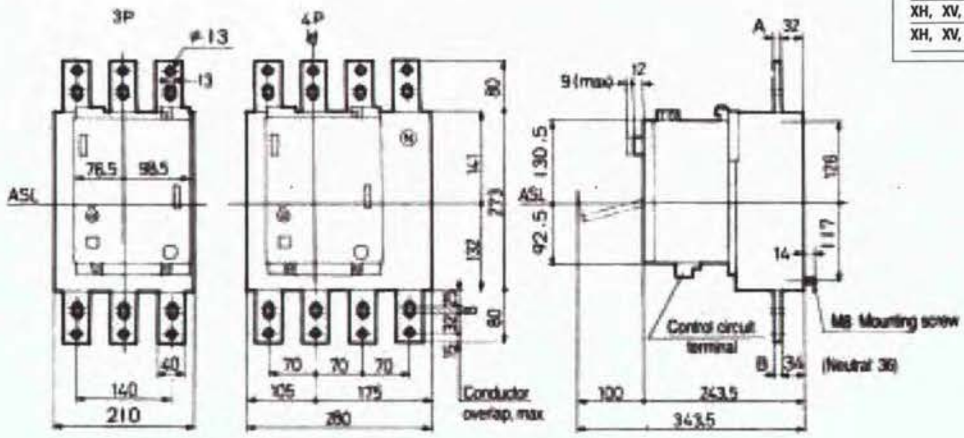
MCCB Technical data

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

ASL: Arrangement standard line
℄: Handle frame centre line

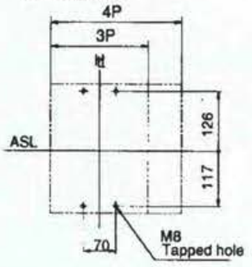
Outline dimensions (mm)

Front connected (standard)

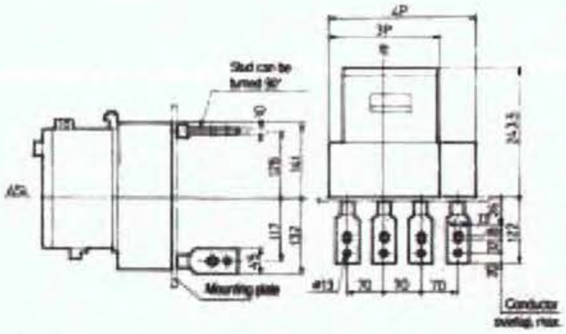


Types	A (mm)	B (mm) 3 pole	N pole
XH, XV, XS800NE	10	36	36
XH, XV, XS630NE	8	36	36

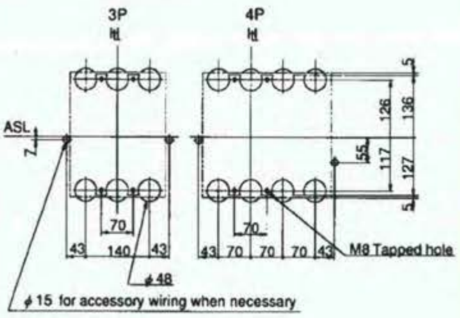
Drilling plan



Rear connected (optional)

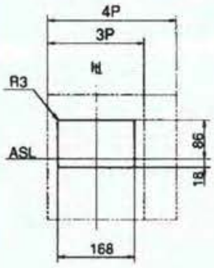


Drilling plan



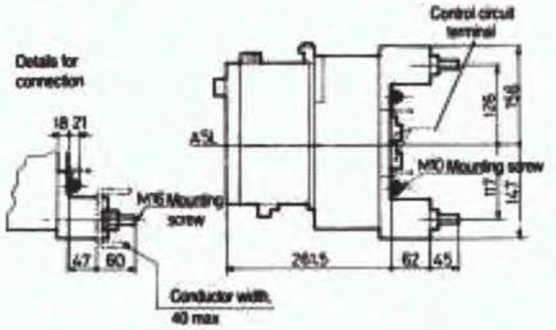
Note: In the standard selection mode, terminals on both the line side and the load side are in a horizontal orientation.

Panel cut-out

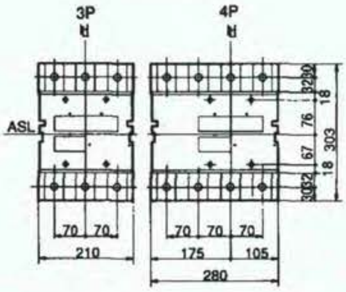


Panel cut-out dimensions shown give an allowance of 1.0 mm around the motor operator frame.

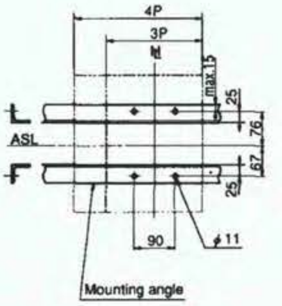
Plug-in (optional)



Mounting block



Drilling plan



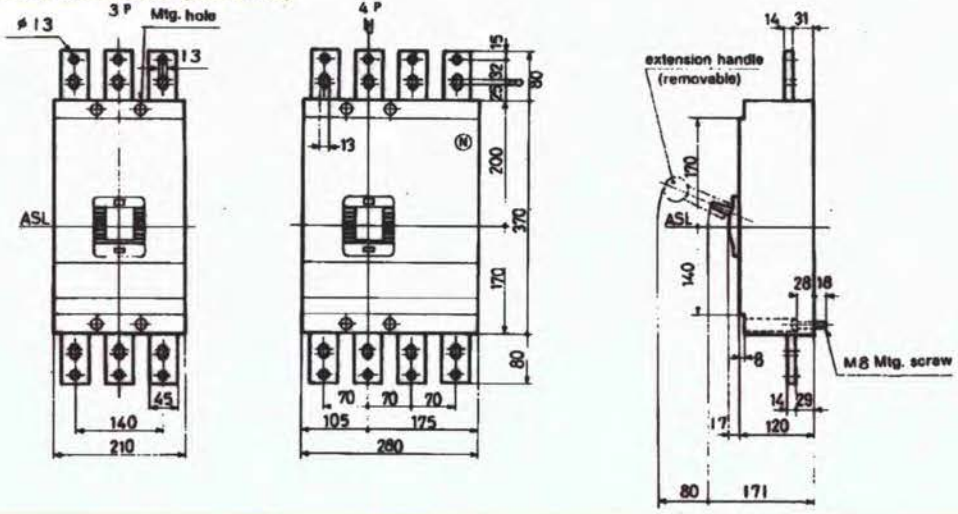
MCCB Technical data

TemBreak XS1250, XV1250

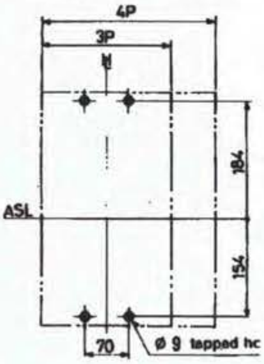
ASL: Arrangement standard line
Ⓗ: Handle frame centre line

Outline dimensions (mm)

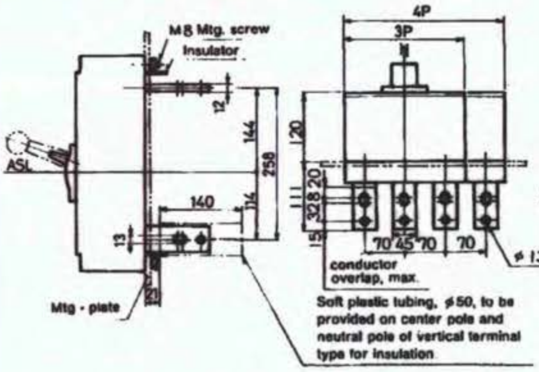
Front connected (standard)



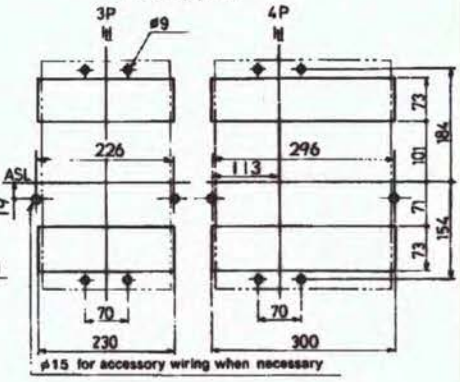
Drilling plan



Rear connected (optional)

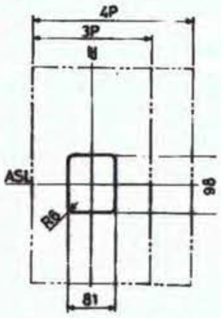


Drilling plan



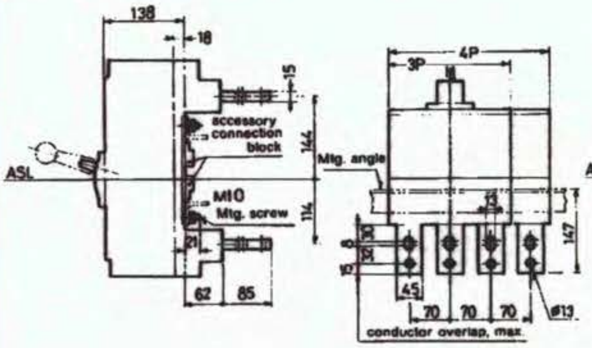
Note: In the standard shipment mode, terminals on both the line side and the load side are in a horizontal orientation.

Panel cut-out

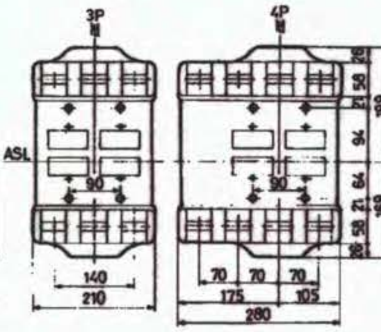


Panel cut-out dimensions shown give an allowance of 1.5 mm around the handle escutcheon.

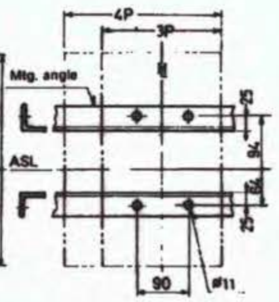
Plug-in (optional)



Mounting block



Drilling plan



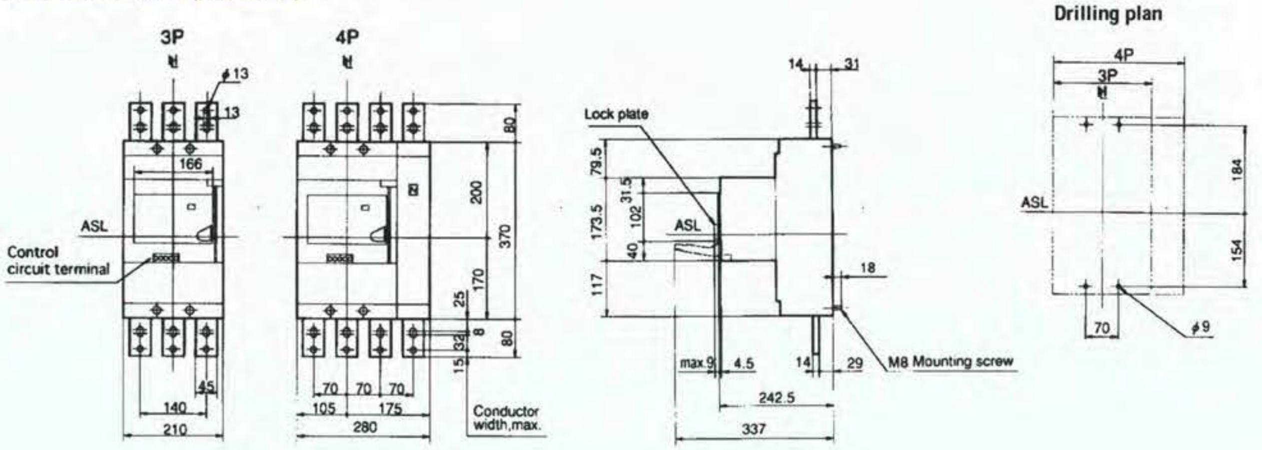
MCCB Technical data

Motor operators (XMD type) for XS1250, XV1250

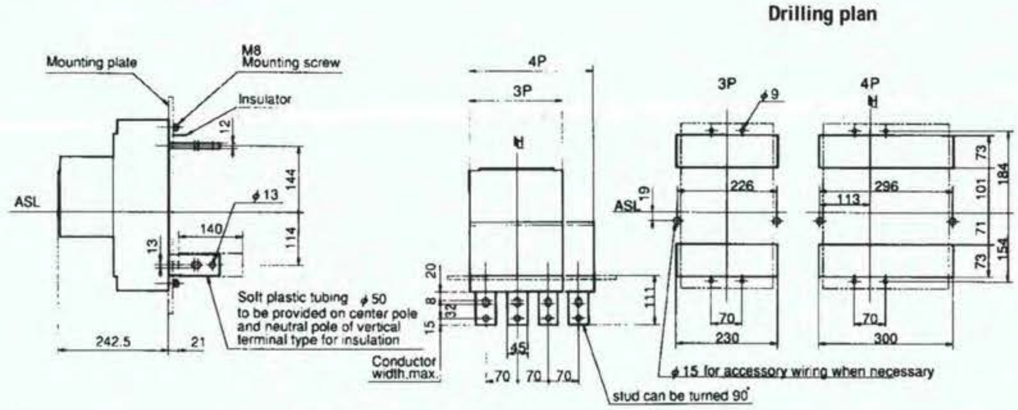
ASL: Arrangement standard line
ℍ: Handle frame centre line

Outline dimensions (mm)

Front connected (standard)

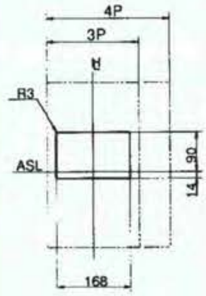


Rear connected (optional)



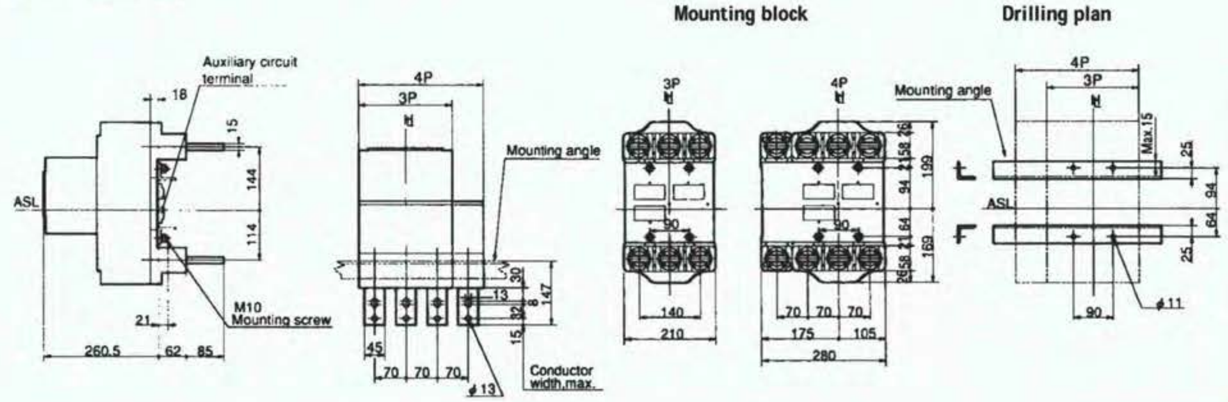
Note: In the standard selection mode, terminals on both the line side and the load side are in a horizontal orientation.

Panel cut-out



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

Plug-in (optional)



TERASAKI
Innovators in Protection Technology

MCCB Technical data

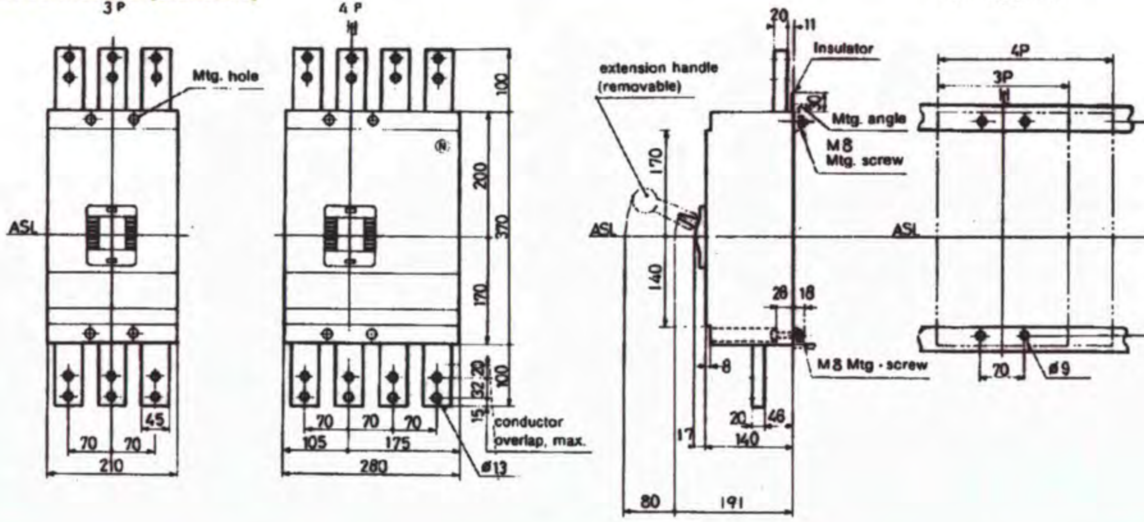
TemBreak XS1600SE, TL630, TL800, TL1250NE

ASL: Arrangement standard line
ℍ: Handle frame centre line

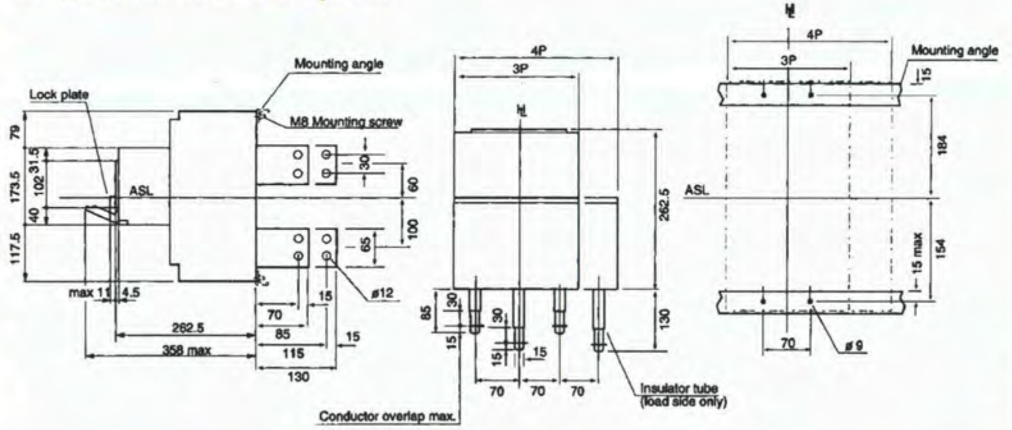
Outline dimensions (mm)

Front connected (standard)

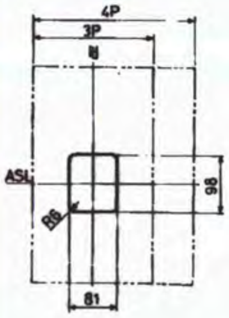
Drilling plan



Rear connected with motor operator



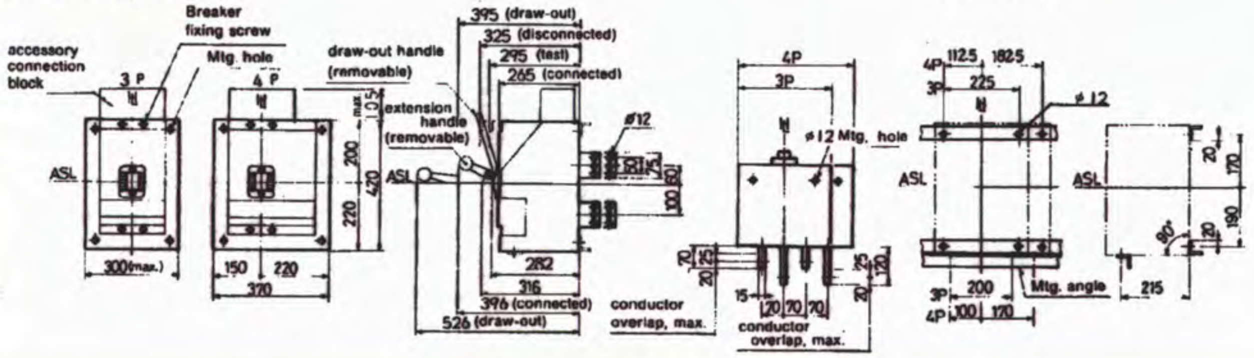
Panel cut-out



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

Draw-out (optional)

Drilling plan



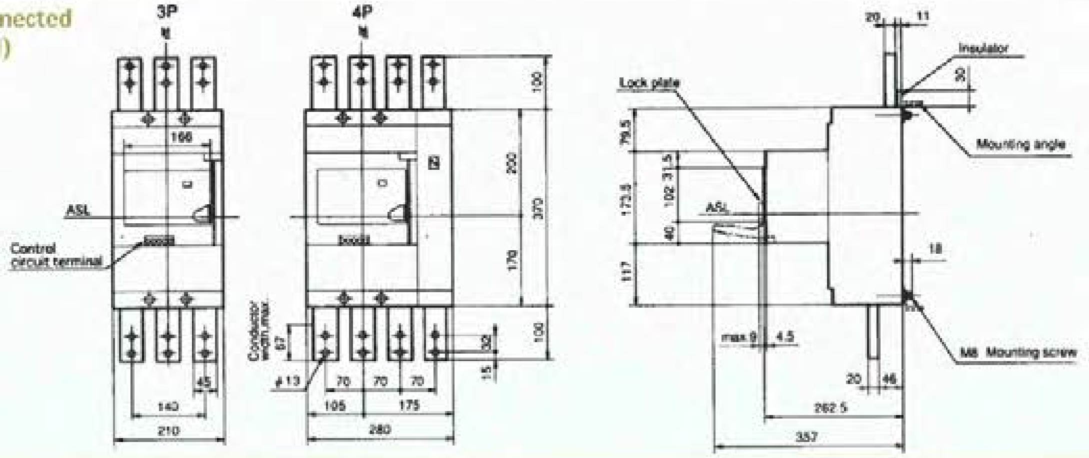
MCCB Technical data

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

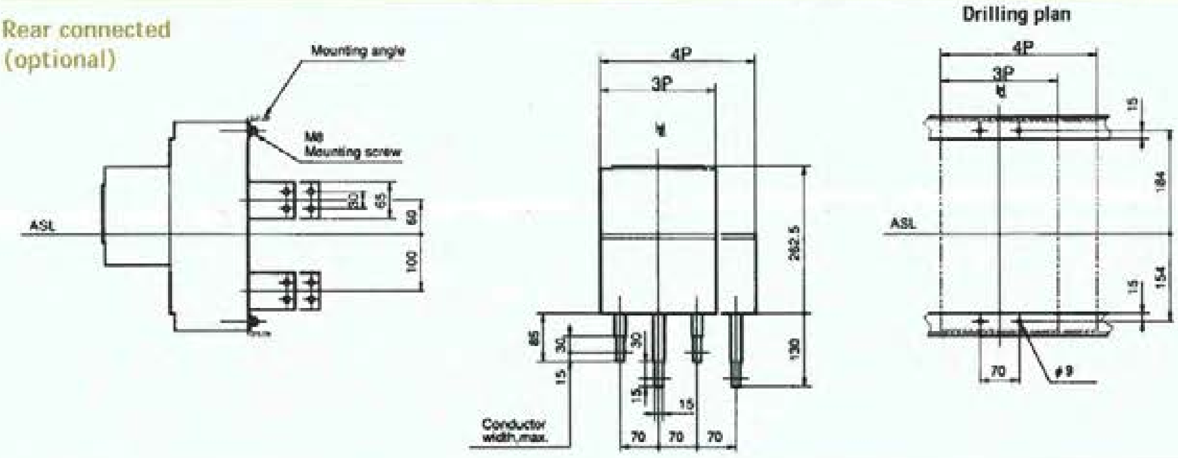
ASL: Arrangement standard line
℄: Handle frame centre line

Outline dimensions (mm)

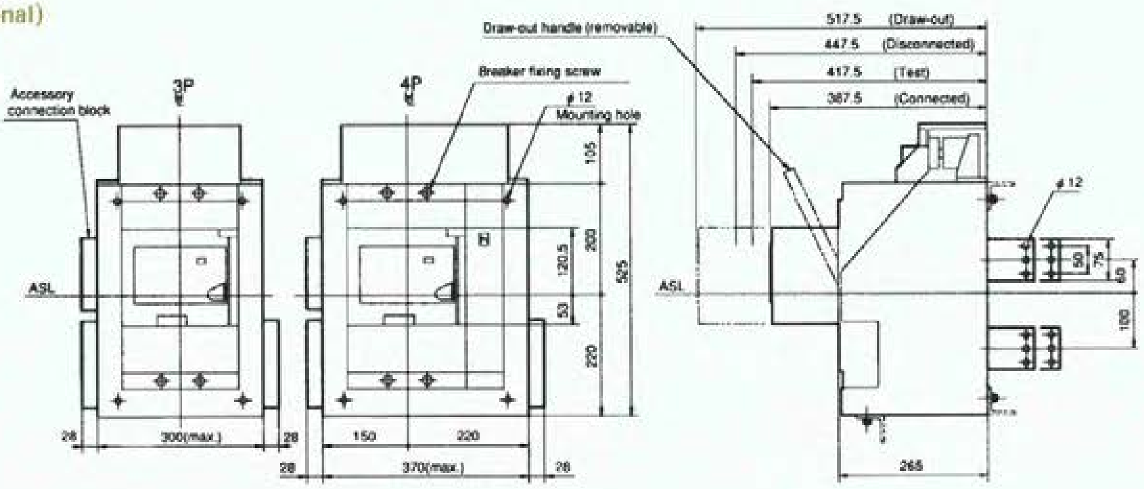
Front connected (standard)



Rear connected (optional)



Draw out (optional)



MCCB Technical data

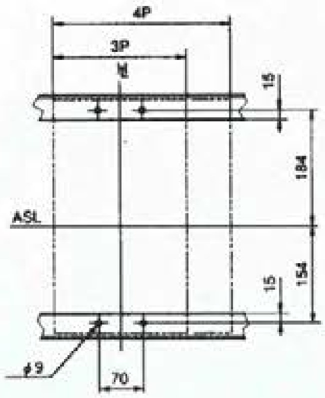
Motor operators for XS1600 TL630NE, TL800NE, TL1250NE

ASL: Arrangement standard line
℄: Handle frame centre line

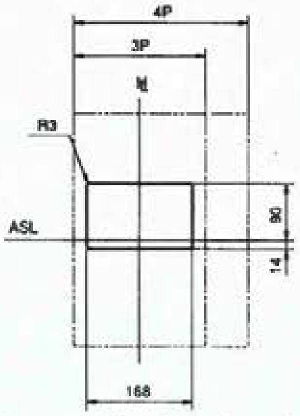
Outline dimensions (mm)

Front connected (standard)

Drilling plan



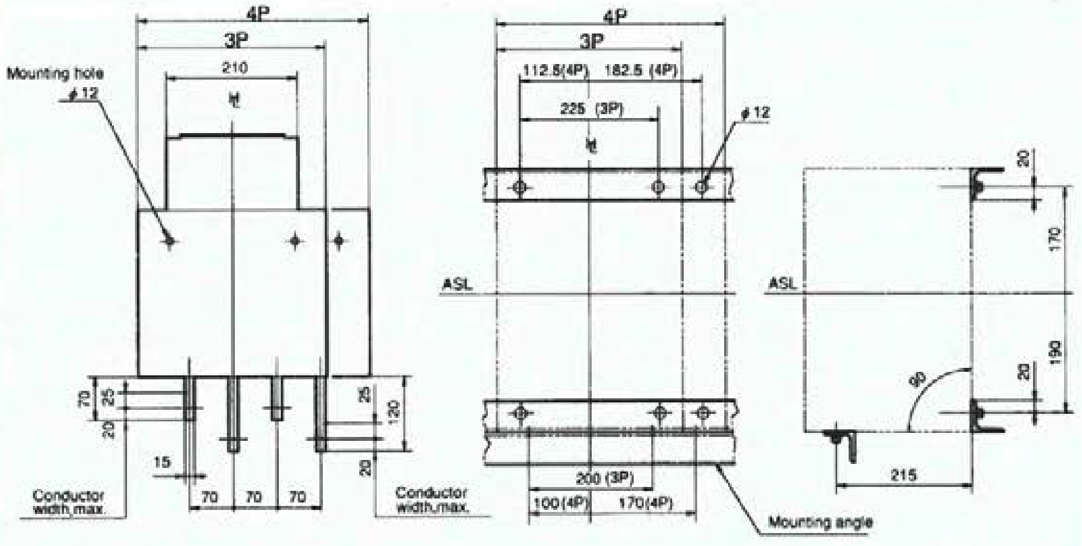
Panel cut-out



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

Draw out

Drilling plan



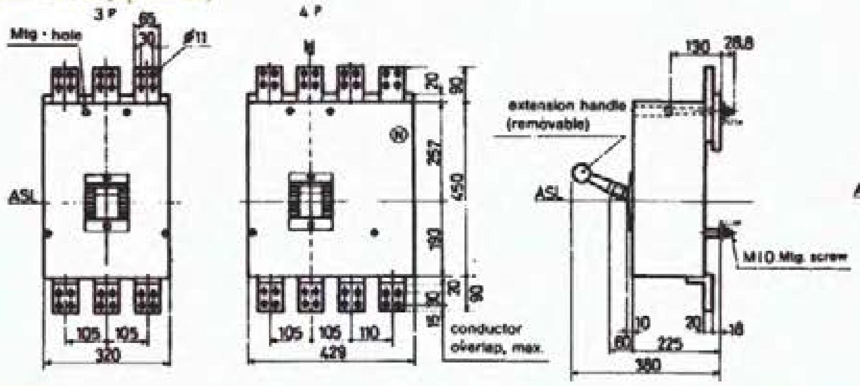
MCCB Technical data

TemBreak XS2000NE

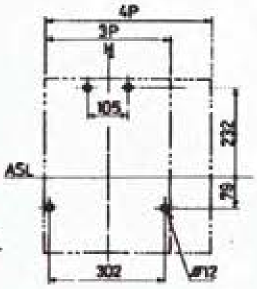
ASL: Arrangement standard line
Ħ: Handle frame centre line

Outline dimensions (mm)

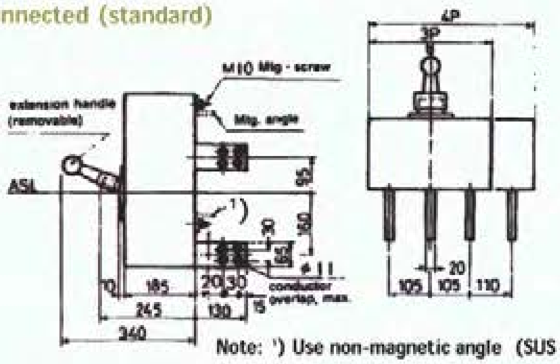
Front-connected (optional)



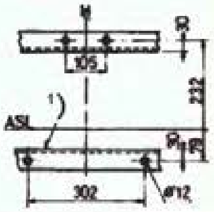
Drilling plan



Rear-connected (standard)

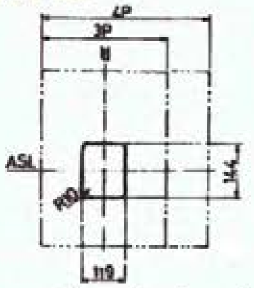


Drilling plan



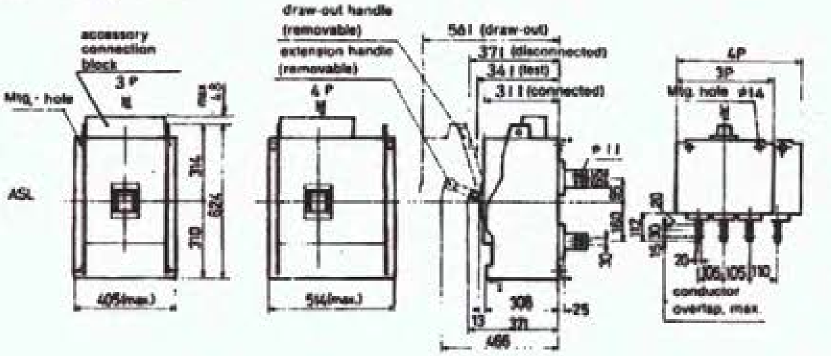
Note: ¹) Use non-magnetic angle (SUS 304 etc).

Panel cut-out

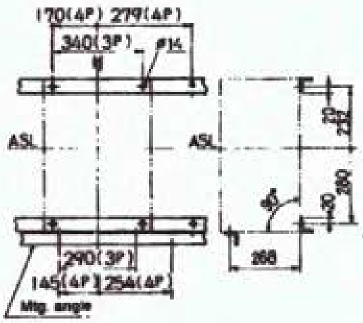


Panel cut-out dimensions shown give an allowance of 2 mm around the handle escutcheon.

Draw-out (optional)



Drilling plan



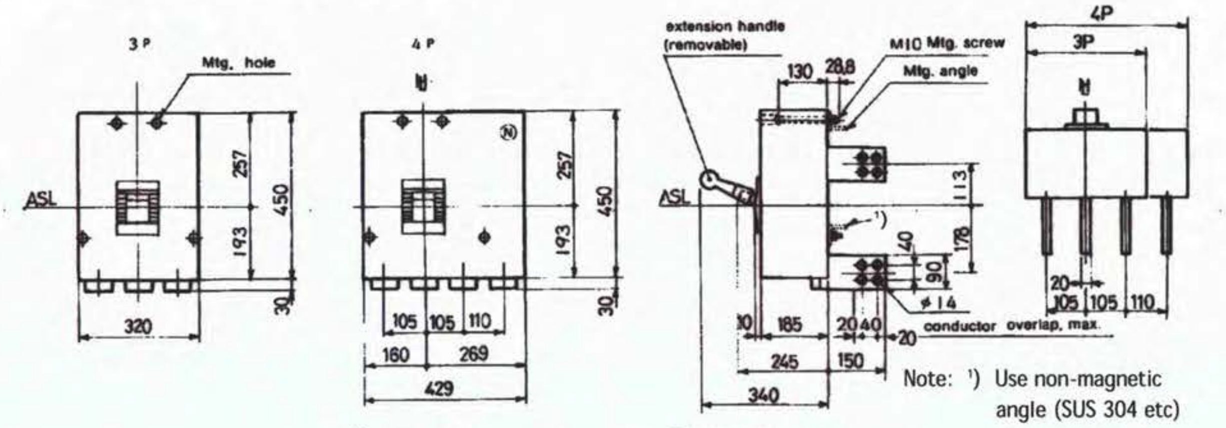
MCCB Technical data

TemBreak XS2500NE

ASL: Arrangement standard line
℄: Handle frame centre line

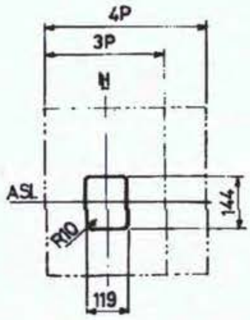
Outline dimensions (mm)

Rear-connected (RC standard, no FC version)

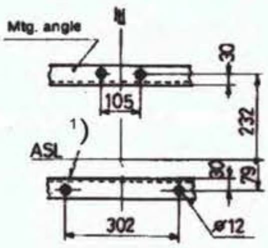


Note: 1) Use non-magnetic angle (SUS 304 etc)

Panel cut-out



Drilling plan



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

Note: 1) Use non-magnetic angle (SUS 304 etc)

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

MCCB Technical data

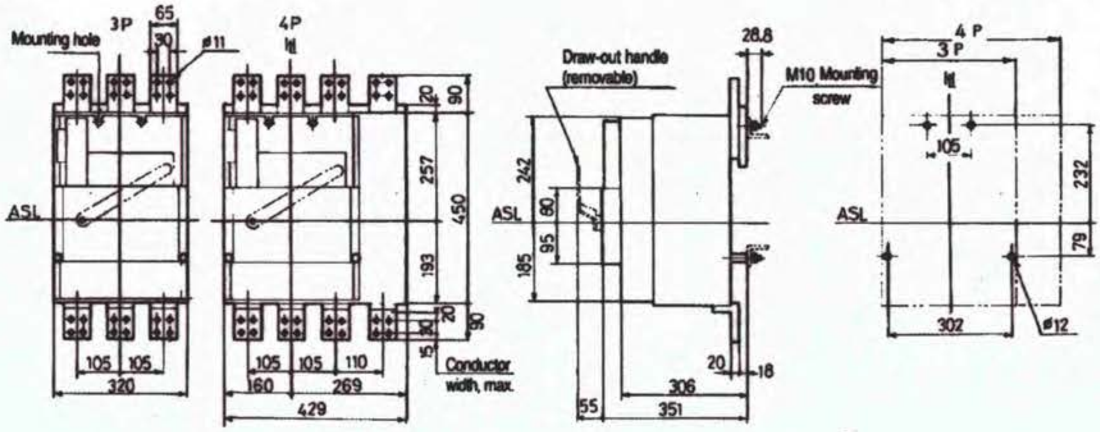
Motor operators (XMB type) for XS2000NE & XS2500NE

MCCB accessories

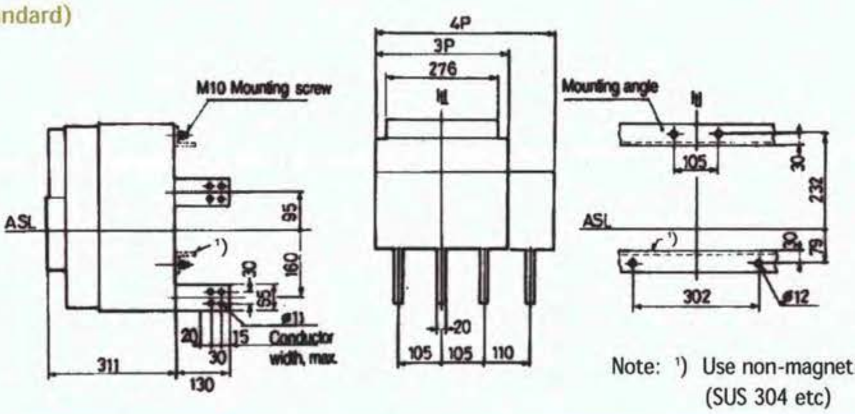
ASL: Arrangement standard line
H/L: Handle frame centre line

Outline dimensions (mm)

Front connected (optional)

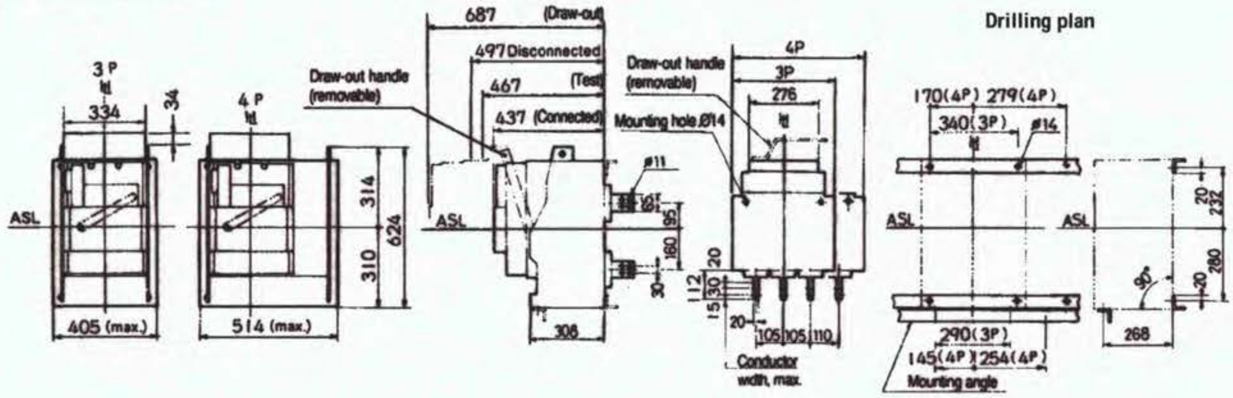


Rear connected (standard)



Note: 1) Use non-magnetic angle (SUS 304 etc)

Draw-out (optional)



MCCB Technical data

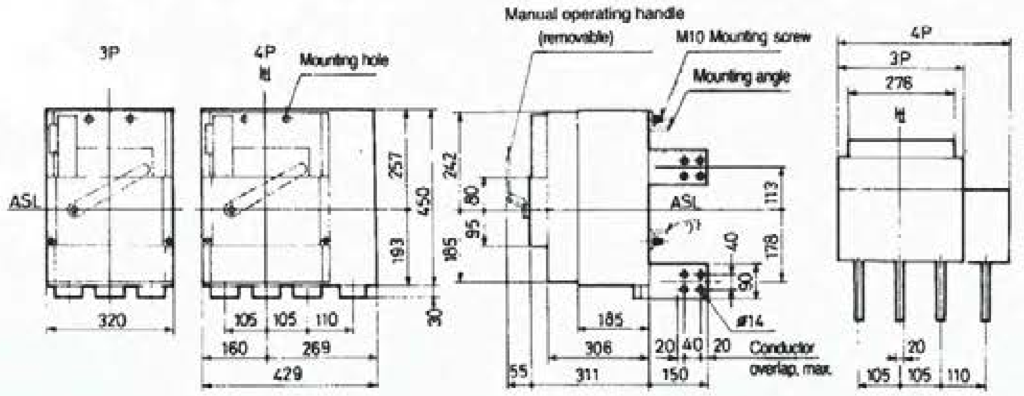
Motor operators XMB types for XS2000NE & XS2500NE

MCCB accessories

ASL: Arrangement standard line
H: Handle frame centre line

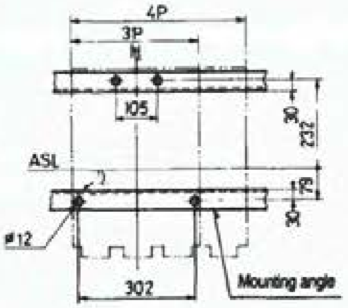
Outline dimensions (mm)

Front connected (standard)



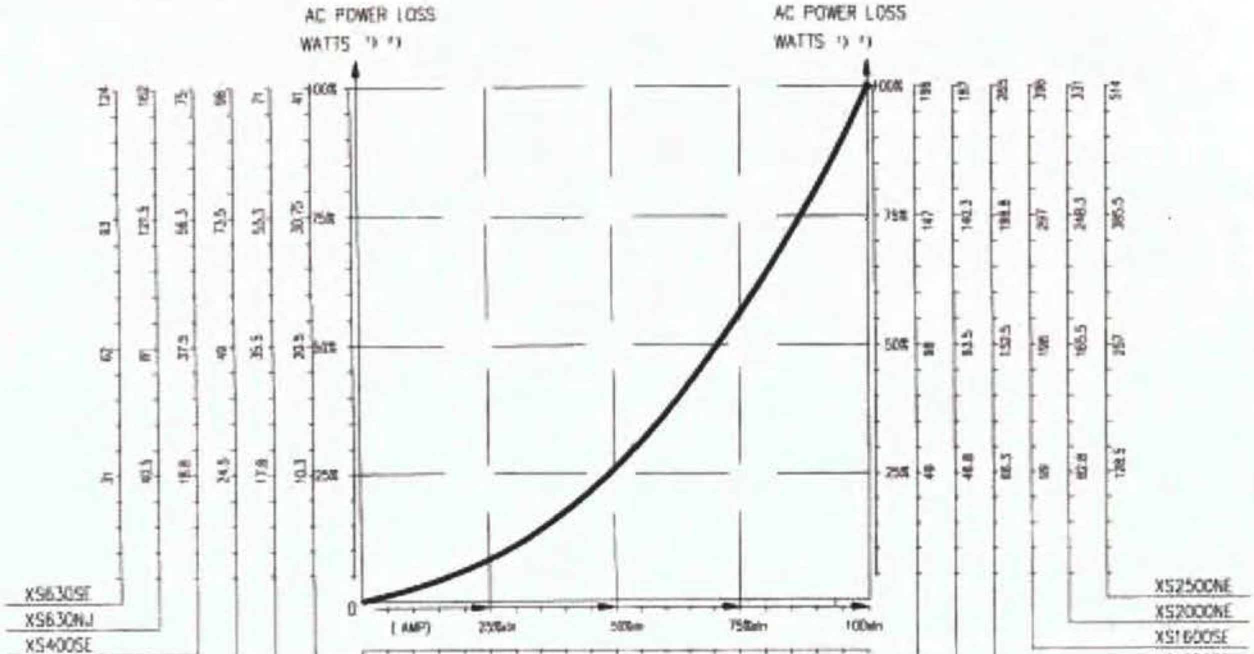
Note: ¹) Use non-magnetic angle
(SUS 304 etc)

Drilling plan



MCCB Technical data

AC power watts loss – 3 Pole MCCBs



XH125NJ	31	62.5	94	125
XH250NJ	62.5	125	187.5	250
XS400NJ/SE	100	200	300	400
XS630NJ/SE	157	315	472.5	630
XS800NJ/SE	200	400	600	800
XS1250SE	312.5	625	937.5	1250
XS1600SE	400	800	1200	1600
XS2000NE	500	1000	1500	2000
XS2500NE	625	1250	1875	2500

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.

POWERCAD™

NHP

Power Distribution

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™, QuickCable™, PowerCalc™, PowerCalc-H™, while the final and most powerful version is called PowerCad-5™.

PowerCad-5™ design software now includes Terasaki circuit breakers

The above is a typical screen representation providing a circuit schematic, along with an open window showing a protective device picture, its various device OCR settings, 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.

Note: PowerCad is a product of PowerCad Software Pty Ltd. Purchases of this software can be obtained from PowerCad. www.powercad.com.au

PowerCad 5 features:

- Maximum demand
- Cable sizing
- Conduit sizing
- Fault-loop impedance
- Cable voltage drop calculations
- Cable thermal stress
- Short circuit calculations
- Let-through energy
- Harmonic analysis
- Harmonic mitigation
- Power factor correction
- Network resonance
- L.V. Distribution Network Modelling
- Single Line diagram
- Single Line diagram export to AutoCad
- AutoCad interface for loads input
- Automatic mains & 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
- Standards AS/NZS, IEC, BS and CP5
- Generator sizing
- Harmonic active filtering
- Reactor passive filtering
- Transfer switches

NHP ELECTRICAL ENGINEERING PRODUCTS PTY LTD
A.B.N. 84 004 304 812

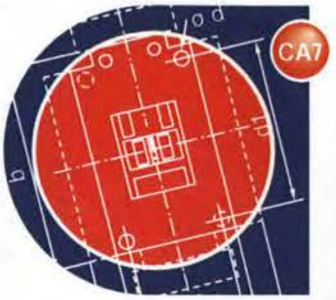
2

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

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: 07 3891 6008 Fx: 07 3891 6139



Broad current range
Compact dimensions
Maximum flexibility

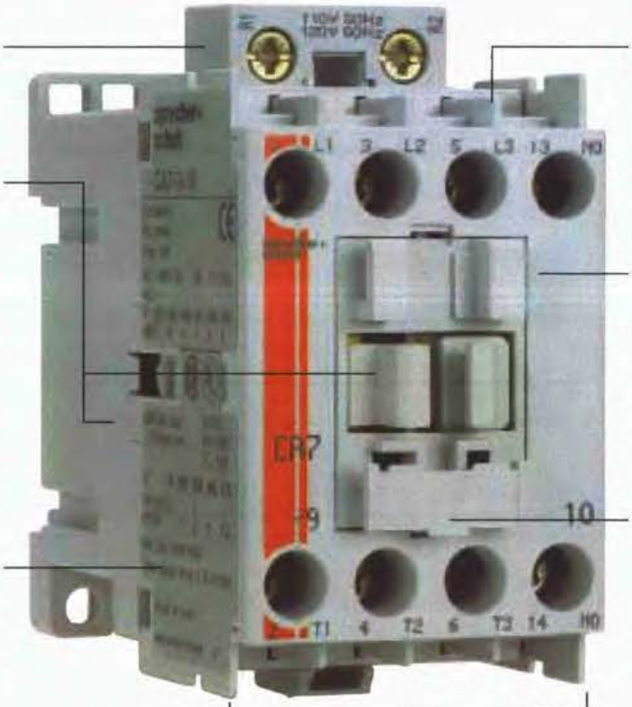
Series CA7 Contactors

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

As Little as 45mm Wide

Reduces Panel Space

Mechanically Linked Auxiliaries



Coil terminals are field-reversible! Mount a motor circuit controller on top or an overload relay on bottom

Auxiliary contacts may be mounted on front and/or sides of contactor

All CA7 contactors are designed, tested and can be selected for Type 1 and Type 2 Coordination

Auxiliary contacts are "mechanically linked" with CA7's main contacts – a requirement in safety circuits

Compact dimensions mean less panel space and lower cost

Universal accessories fit all CA7 contactors – leaving you with less inventory and more flexibility!

Dual-terminal technology maximizes wiring options and termination reliability

9-85A range covers more than 90% of all industrial applications

Protects against manual operation and accidental contact with live parts

Dimensionally compatible with KT7 motor circuit controller and CEP7 electronic overload relay

Label your contactor for easy identification

IEC design provides a more precise fit to your application – save money by buying only what you need

As little as 45mm (1-3/4") wide

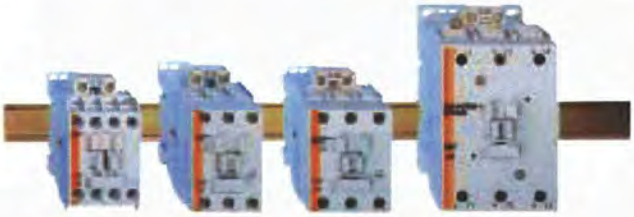
Compact dimensions with maximum performance! Our CA7 contactors control motors up to 60HP, in frame sizes ranging from 45mm (1-3/4") to a maximum of 72mm (2-3/4") wide.

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

Series CA7 Contactors



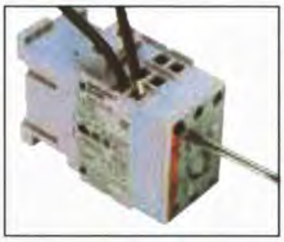
Save space, save money

The CA7 contactor series includes ten contactors within four frame sizes. The two smallest sizes house capacities up to 25HP (@460V) and 30HP (@575V). They measure only 45mm (1-3/4") in width! Even the largest of the contactors – the CA7-85, controlling motors to 60HP – measures only 72mm (2-3/4") 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 + Schuh's 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°C	Maximum Horsepower						Max. Aux. Contacts
		Single Phase		Three Phase				
		115V	230V	200V	230V	460V	575V	
CA7-9	32	1/3	1	2	2	5	7-1/2	9
CA7-12	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.

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Tel: (281) 442-9000; Fax: (800) 739-7370
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Sprecher + Schuh Canadian Division
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Tel: (905) 677-7514; Fax: (905) 677-7663
www.sscdn.cc

Publication No: F-CA7-R1 10/02

Attenti o prevent electrical shock, disconnect from power ; e before installing or servicing. Install in suitable enclosure. Keep free from contaminants.

Achtung: Vor Installations- oder Servicearbeiten Stromversorgung unterbrechen, um Unfälle zu vermeiden. Die Geräte müssen in einem passenden Gehäuse eingebaut und gegen Verschmutzung geschützt werden.

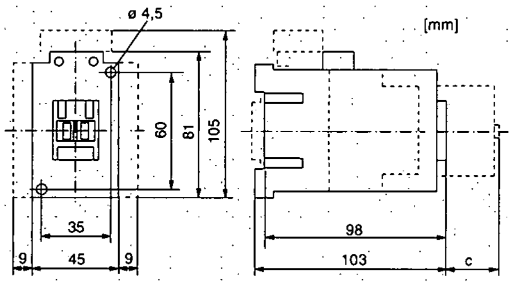
Attenzione: Per prevenire infortuni, togliere tensione prima dell'installazione o manutenzione. Installare in custodia idonea. Tenere lontano da contaminanti.

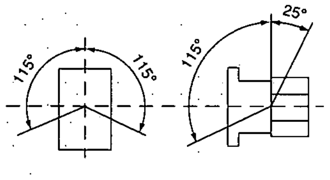
Attention: Avant le montage et la mise en service, couper l'alimentation secteur afin d'éviter tout accident. Prévoir une mise en coffret ou armoire appropriée. Protéger le produit contre les environnements agressifs.

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.

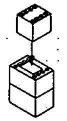
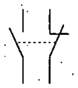
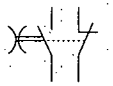
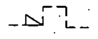
...-C30 /...-30
...-C37 /...-37

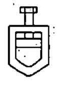
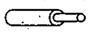
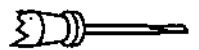
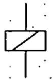
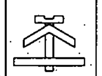
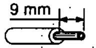
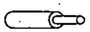
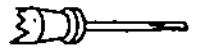
IEC 60947-1/-4-1
EN 60947-1/-4-1
UL 508; CSA 22.2 No. 14;

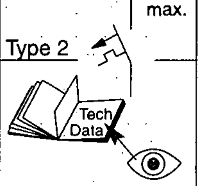




-Min. distance lateral to grounded parts or walls = 6mm
-Min. seitlicher Abstand zu geerdeten Teile oder Wände = 6mm
-Distance latéral min. enver pièces mises à terre ou parois = 6mm
-Distanza laterale min. verso pezzi a massa o pareti = 6mm
-Distancia lateral min. a chasis o paredes = 6mm

			
c [mm]	34	53	56

		11 mm  1 x 2,5...10 mm² 2 x 2,5...10 mm² No. 14...4 AWG Use 75°C Cu wire only  1 x 2,5...16 mm² 2 x 2,5...16 mm² No. 14...4 AWG	 2,5...3,5 Nm 22...31 lb-in  No 3 Pozidriv No 2
A1  A2		9 mm  1 x 1...2,5 mm² 2 x 1...2,5 mm² No. 16...12 AWG Use 75°C Cu wire only  1 x 1...4 mm² 2 x 1...4 mm² No. 16...12 AWG	 1...1,5 Nm 8,9...13 lb-in  No 3 Pozidriv No 2

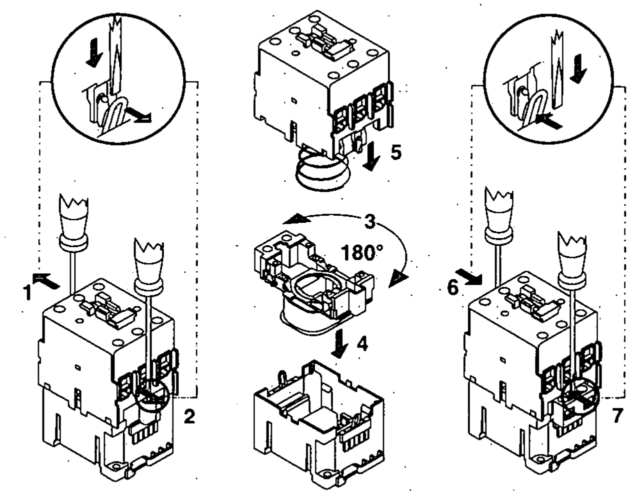
IEC 60947-4-1 **EN 60947-4-1** Ue ≤ 690 V	gG max. Type 1	Type 2	max. Type 2
 30	125 A	80 A	
37	125 A	80 A	

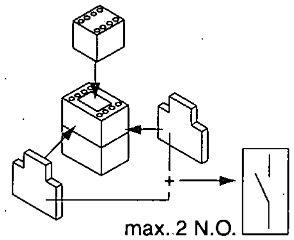
NOTICE (IEC/EN 60947-1) This product has been designed for environment A. Use of this product in environment B may cause unwanted electromagnetic disturbances in which case the user may be required to take adequate mitigation measures.
BEMERKUNG (IEC/EN 60947-1) Dieses Produkt ist für Umgebungsklasse A bestimmt. Der Gebrauch dieses Produktes in Umgebungsklasse B kann unerwünschte elektromagnetische Störungen verursachen, in diesem Fall muss der Benutzer die nötigen Massnahmen zur Verringerung ergreifen.
REMARQUE (IEC/EN 60947-1) Ce produit on l'utilise dans l'environnement A. L'utilisation de ce produit dans l'environnement B peut créer des perturbations électromagnétiques. En ce cas, l'utilisateur doit prendre des mesures pour diminuer les perturbatione électromagnétiques.
AVVERTENZA (IEC/EN 60947-1) Questo prodotto è stato progettatto per un ambiente di tipo A. L'utilizzo di questo prodotto in un ambienta B protrebbe causare disturbi elettromagnetici indesiderati, in questo caso potrebbe essere richiesto all'utilizzatore di prendere appropriate misure di mitigazione.
OBSERVACIÓN (IEC/EN 60947-1) Este producto se puede usar en el ambiente A. El uso en el ambiente B puede causar perturbaciones electromagnéticas. En ese caso de uso, el usuario debe tomar medidas de diminuir las perturbaciones electromagnéticas.

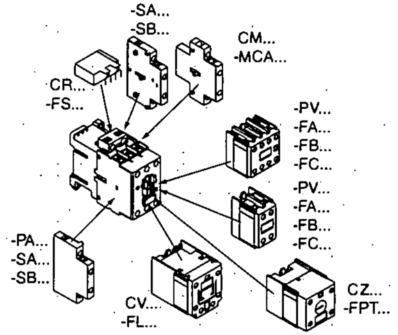
Electronically Controlled DC-Coil only!

USA/CND
Suitable for use on a circuit capable of delivering not more than 5000 rms symmetrical amperes

Size	Fuse 600 Volts Maximum	Circuit Breaker 600 Volts Maximum
30	110 A	125 A
37	125 A	125 A







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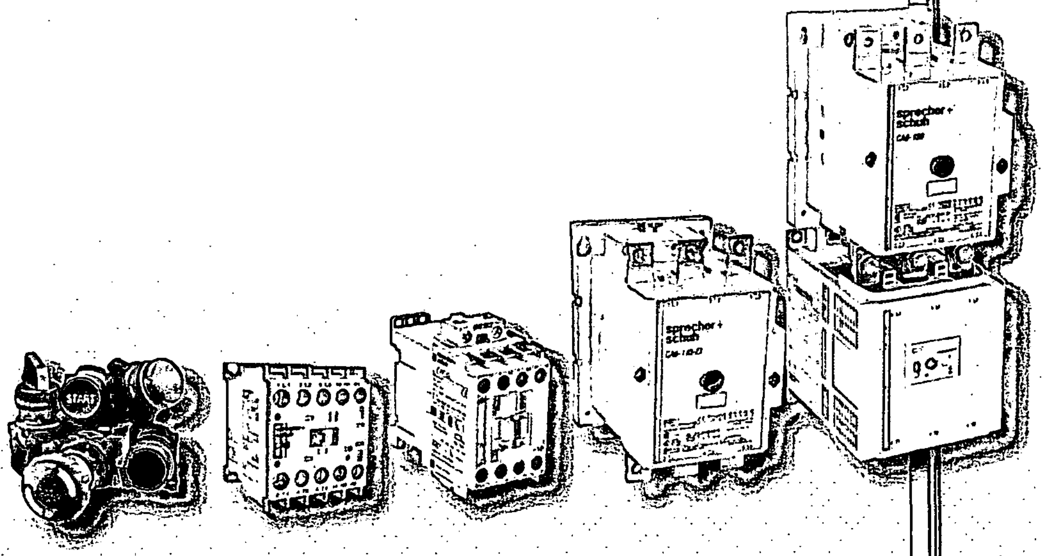
Contact Block

Performance & Selection



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Contact Block Considerations

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.

Contact Material

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.

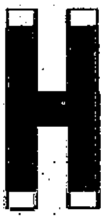
In low voltage applications (below 48V DC and 0.1 A, or below 24V AC and 0.4 A) where excess oil or dust is present, the use of more noble alloys (such as palladium, gold, and their alloys) in the contact material is recommended. These alloys are highly reliable in this type of environment.

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.

Contact Construction

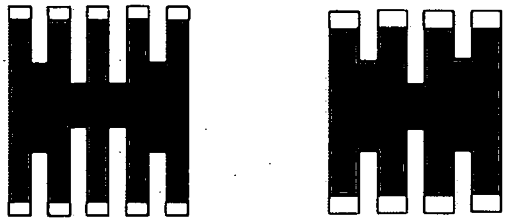
The perimeter of the contact is often shaped like a circle or rectangle and may have little effect on contact performance. The shape of the faces where the fixed and movable contacts meet is more important. This interface should not have two flat surfaces meeting. If one of the contacts has a flat surface, 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 burn 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 48V DC and 0.1 A or below 24V 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

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 be formed from gaseous contaminants that enter the switch from an external environment as well as being formed from internally generated reactants. Sealing methods have been developed to isolate the switch interior from the external 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 both fine silver contacts and noble contact materials (gold, palladium, and their alloys) is 10...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...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

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

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 external 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

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 vs. Contact Overlap

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

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

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.

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.

Mechanically Linked Contacts

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

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 external 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.

Stacking

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 external 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.

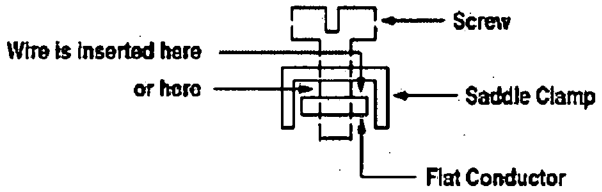
Wiring Termination

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.

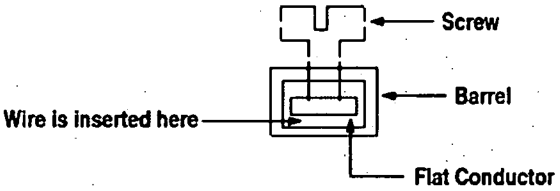
Figure 5.



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.

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 concern 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.

Special 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.

Environmental Considerations

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

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.

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

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.

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

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.

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 48V DC and 0.1 A, or below 24V 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 4/4X/13 environment, the quadfurcated/ pentafurcated blocks should be used for ultimate reliability. If the switching is within Class 1 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.

sprecher+
schuh

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TECHNICAL DATA SHEET

For

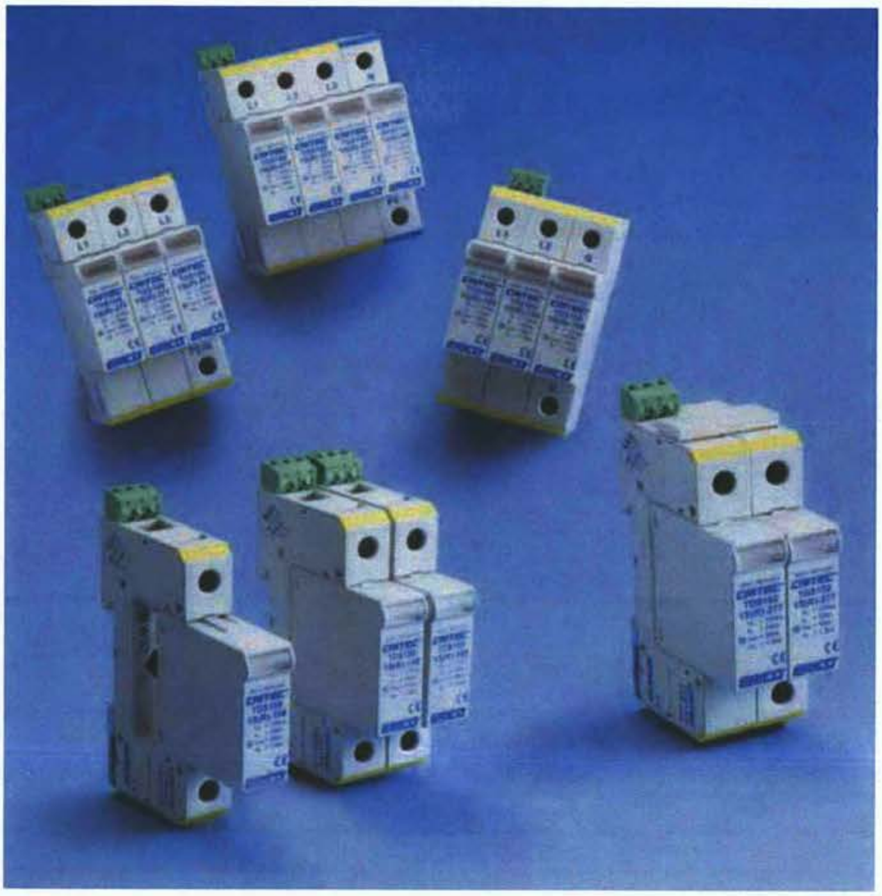
SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

Equipment Type:	Surge Diverter
Location:	Main Incomer
Model Numbers:	TDS-180-4S-277
Manufacturer:	Critec
Supplier:	Energy Correction Options PO Box 431 Kelvin Grove, QLD. 4059 Ph: 07 3356 0577 Fx: 07 3356 1432 Web: www.ecoptions.com.au

ERITECH®

TDS

CRITEC® Transient Discriminating Surge Diverters



ERICO®

Surge Protection And Surge Ratings

The stress, which an SPD will experience under surge conditions, is a function of many complex and interrelated parameters. These include:

- Location of the SPD(s) within the structure – are they located at the main distribution board or within the facility at secondary board, or even in front of the end-user equipment?
- Method of coupling the lightning strike to the facility – for example, is this via a direct strike to the structures LPS, or via induction onto building wiring due to a nearby strike?
- Distribution of lightning currents within the structure – for example, what portion of the lightning current enters the earthing system and what remaining portion seeks a path to remote grounds via the power distribution system and equipotential bonding SPDs?
- Type of power distribution system – the distribution of lightning current on a power distribution system is strongly influenced by the grounding practice for the neutral conductor. For example, in the TN-C system with its multiple earthed neutral, a more direct and lower impedance path to ground is provided for lightning currents than in a TT system.
- Additional conductive services connected to the facility – these will carry a portion of the direct lightning current and therefore reduce the portion which flows through the power distribution system via the lightning equipotential bonding SPD.
- Type of waveshape – it is not possible to simply consider the peak current which the SPD will have to conduct, one also has to consider the waveshape of this surge. It is also not possible to simply equate the areas under the current-time curves (also referred to as the action integral) for SPDs under different waveshapes.

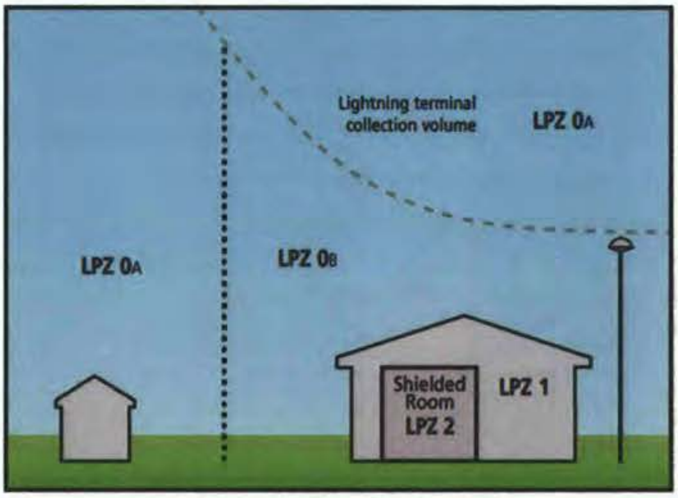
Many attempts have been made to quantify the electrical environment and "threat level" which an SPD will experience at different locations within a facility. The new IEC℠ standard on lightning protection, IEC 62305-4 "Protection against lightning - Part 4: Electrical and electronic systems within structures" 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 200kA 10/350. While this level is possible, its statistical probability of occurrence is approximately 1%. In other words, 99% of discharges will be less than this postulated 200 kA peak current level.

An assumption is made that 50% of this current is conducted via the building's earthing system, and 50% returns via the equipotential bonding SPDs connected to a three wire plus neutral power distribution system. It is also assumed that no additional conductive service exists. This implies that the portion of the initial 200 kA discharge experienced by each SPD is 25 kA.

Simplified assumptions of current dispersion are useful in considering the possible threat level, which the SPD(s) may experience, but it is important to keep in context the assumptions being made. In the example above, a lightning discharge of 200kA has been considered. It follows that the threat level to the equipotential bonding SPDs will be less than 25kA 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 10kA 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.



Protection zones defined by specific product application.

Advanced Technologies – The ERICO® 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.

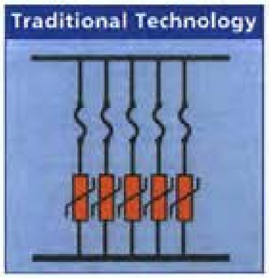
This quantum leap in technology adds a level of "intelligence" to the Surge Protection Device enabling it to discriminate between sustained abnormal over-voltage conditions and true transient or surge events. Not only does this help ensure safe operation under practical application, but it also prolongs the life of the protector since permanent disconnects are not required as a means of achieving internal over-voltage protection.

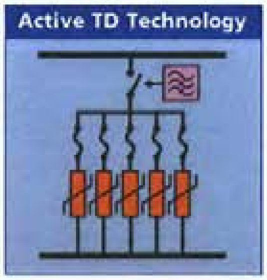
Traditional Technologies

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 50/60Hz 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 60Hz 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.

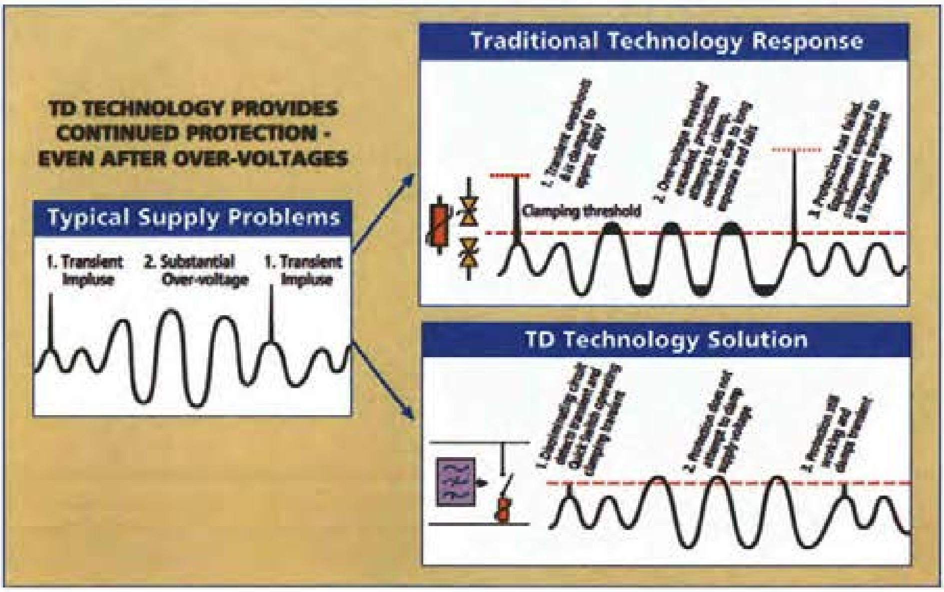




Meeting & Exceeding UL® Standards

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 over-voltage 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.



TDS130

CRITEC® TDS Surge Diverter - TDS130 Series

Features

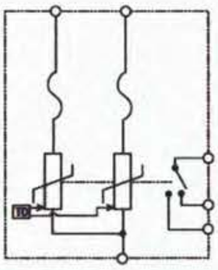
- CRITEC TD Technology with thermal disconnect protection
- Compact package, modular DIN rail mounting for limited space requirements
- Three modes of protection: L-N, L-PE & N-PE
- Indication flags and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates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

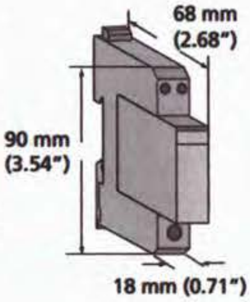
Surges and voltage transients are a major cause of expensive electronic equipment failure and business disruption. Damage may result in the loss of capital outlays, such as computers and communications equipment, as well as consequential loss of revenue and profits due to unscheduled system down-time.

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 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.





Model	TDS1301TR150	TDS1301TR240
Item Number for Europe	702421	702422
Nominal Voltage, U_n	120-150 VAC	220-240 VAC
Max Cont. Operating Voltage, U_c	170VAC	275VAC
Stand-off Voltage	230VAC	440VAC
Frequency	0-100Hz	
Nominal Discharge Current, I_n	8kA 8/20µs per mode	
Max Discharge Current, I_{max}	15kA 8/20µs L-N 15kA 8/20µs L-PE	
Protection Modes	L-G, L-N, N-G	
Technology	TD Technology with thermal disconnect	
Short Circuit Current Rating, I_{sc}	200kAIC	
Back-up Overcurrent Protection	63AgL, if supply > 63A	
Voltage Protection Level, U_p	500V @ 3kA (L+N-G) 800V @ 3kA (L-N)	800V @ 3kA (L+N-G) 1500V @ 3kA (L-N)
Status	N/O, N/C Change-over contact, 250V~/0.5A, max 1.5 mm² (#14AWG) terminals Mechanical flag / remote contacts (R model only)	
Module Width	1 M	
Dimensions H x D x W: mm (in)	90 x 68 x 18 (3.54 x 2.68 x 0.71)	
Weight: kg (lbs)	0.12 (0.26)	
Enclosure	DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1)	
Connection	1 mm² to 6 mm² (#18AWG to #10AWG) Line and Neutral Terminals ≤25 mm² (#4AWG) stranded ≤35 mm² (#2AWG) solid PE Terminal	
Mounting	35 mm top hat DIN rail	
Temperature	-40°C to 80°C (-40°F to 176°F)	
Humidity	0% to 90%	
Approvals	CE, IEC® 61643-1, UL® 1449 Ed 3 Recognized Component Type 2	
Surge Rated to Meet	ANSI®/IEEE® C62.41.2 Cat A, Cat B IEC 61643-1 Class II UL® 1449 Ed3 In 3kA mode	
Replacement Module	TDS130M150	TDS130M240
Replacement Module (Europe)	702432	702424

TDS150

CRITEC® TDS Surge Diverter - TDS150 Series

Features

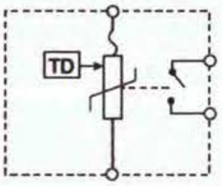
- CRITEC® TD Technology with thermal disconnect protection
- Compact design fits into DIN distribution panel boards and motor control centers
- 35 mm DIN rail mount – DIN 43 880 profile matches common circuit breakers
- Indication flags and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates replacement of a failed surge module
- 50kA 8/20µs 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

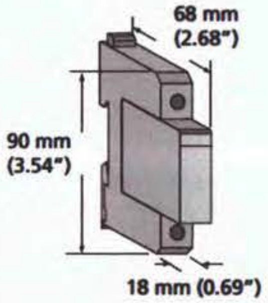
Surges and voltage transients are a major cause of expensive electronic equipment failure and business disruption. Damage may result in the loss of capital outlays, such as computers and communications equipment, as well as consequential loss of revenue and profits due to unscheduled system down-time.

The 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® 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 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.





Model	TDS1501SR150	TDS1501SR240	TDS1501SR277	TDS1501SR560
Item Number for Europe	702404	702406	702407	702408
Nominal Voltage, U_n	120-150 VAC	220-240 VAC	240-277 VAC	480-560 VAC
Max Cont. Operating Voltage, U_c	170VAC	275VAC	320VAC	610VAC
Stand-off Voltage	240VAC	440VAC	480VAC	700VAC
Frequency	0-100Hz			
Short Circuit Current Rating, I_{sc}	200kAIC			
Back-up Overcurrent Protection	125AgL, if supply > 100A			
Technology	TD with thermal disconnect			
Max Discharge Current, I_{max}	50kA 8/20µs			
Nominal Discharge Current, I_n	25kA 8/20µs	20kA 8/20		
Protection Modes	Single mode (L-G, L-N or N-G)			
Voltage Protection Level U_p	400V @ 3kA 1.0kV @ In	700V @ 3kA 1.2kV @ In	800V @ 3kA 1.6kV @ In	1.8kV @ 3kA 2.4kV @ In
Status	N/O, N/C Change-over contact, 250V~/0.5A, max 1.5 mm² (#14AWG) terminals Mechanical flag / remote contacts (R model only)			
Dimensions H x D x W: mm (in)	90 x 68 x 18 (3.54 x 2.68 x 0.69)			
Module Width	1 M			
Weight: kg (lbs)	0.12 (0.26)			
Enclosure	DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1)			
Connection	≤25 mm² (#4AWG) stranded ≤35 mm² (#2AWG) solid			
Mounting	35 mm top hat DIN rail			
Temperature	-40°C to 80°C (-40°F to 176°F)			
Humidity	0% to 90%			
Approvals	CE, IEC® 61643-1, UL® 1449 Ed 3 Recognized Component Type 2			
Surge Rated to Meet	ANSI®/IEEE® C62.41.2 Cat A, Cat B, Cat C ANSI®/IEEE® C62.41.2 Scenario II, Exposure 2, 50kA 8/20µs IEC 61643-1 Class II UL® 1449 Ed3 In 20kA mode			
Replacement Module	TDS150M150	TDS150M240	TDS150M277	TDS150M560

TDS1100

CRITEC® TDS Surge Diverter - TDS1100 Series

Features

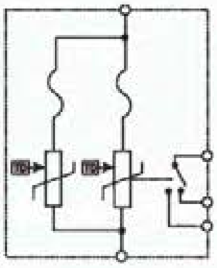
- CRITEC® TD Technology with thermal disconnect protection
- Compact design fits into DIN distribution panel boards and motor control centers
- 35 mm DIN rail mount – DIN 43 880 profile matches ommon circuit reakers
- Indication flags and voltage-free contacts provide remote status monitoring
- Separate plug and base design facilitates replacement of a failed surge module
- 100kA 8/20µs maximum surge rating provides rotection suitable or 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

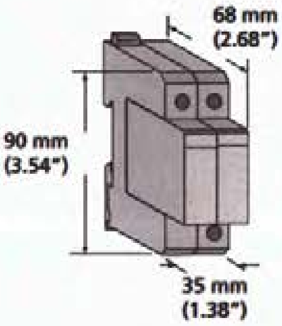
Surges and voltage transients are a major cause of expensive electronic equipment failure and business disruption. Damage may result in the loss of capital outlays, such as computers and communications equipment, as well as consequential loss of revenue and profits due to unscheduled system down-time.

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® 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 TDS1100 provides a set of voltage-free contacts for remote signaling that maintenance is due.

The convenient plug-in module and separate base design facilitates replacement of a failed surge module without needing to undo installation wiring.





Model	TDS11002SR150	TDS11002SR240	TDS11002SR277	TDS11002SR560
Item Number for Europe	702409	702411	702412	702413
Nominal Voltage, U_n	120-150 VAC	220-240 VAC	240-277 VAC	480-560 VAC
Max Cont. Operating Voltage, U_c	170VAC	275VAC	320VAC	610VAC
Stand-off Voltage	240VAC	440VAC	480VAC	700VAC
Frequency	0-100Hz			
Short Circuit Current Rating, I_{sc}	200kAIC			
Back-up Overcurrent Protection	125AgL if supply > 100A			
Technology	TD with thermal disconnect			
Max Discharge Current, I_{max}	100kA 8/20µs			
Impulse Current, I_{imp}	12.5kA 10/350µs			
Nominal Discharge Current, I_n	50kA 8/20µs	40kA 8/20µs		
Protection Modes	Single mode (L-G, L-N or N-G)			
Voltage Protection Level, U_p	400V @ 3kA 1.0kV @ 20kA	700V @ 3kA 1.2kV @ 20kA	800V @ 3kA 1.6kV @ 20kA	1.8kV @ 3kA 2.4kV @ 20kA
Status	N/O, N/C Change-over contact, 250V~/0.5A, max 1.5 mm² (#14AWG) terminals Mechanical flag / remote contacts (R model only)			
Dimensions H x D x W: mm (in)	90 x 68 x 35 (3.54 x 2.68 x 1.38)			
Module Width	2 M			
Weight: kg (lbs)	0.24 (0.53)			
Enclosure	DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1)			
Connection	≤25 mm² (#4AWG) stranded ≤35 mm² (#2AWG) solid			
Mounting	35 mm top hat DIN rail			
Temperature	-40°C to 80°C (-40°F to 176°F)			
Humidity	0% to 90%			
Approvals	CE, IEC® 61643-1, UL® 1449 Ed 3 Recognized Component Type 2			
Surge Rated to Meet	ANSI®/IEEE® C62.41.2 Cat A, Cat B, Cat C ANSI®/IEEE® C62.41.2 Scenario II, Exposure 3, 100kA 8/20µs, 10kA 10/350µs IEC 61643-1 Class I and Class II UL® 1449 Ed3 In 20kA mode			
Replacement MOV Module	TDS150M150	TDS150M240	TDS150M277	TDS150M560

TDS350

CRITEC® TDS Surge Diverter - TDS350 Series

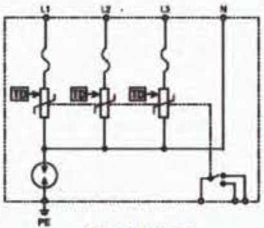
Features

- 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 43 880 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 8/20μs 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

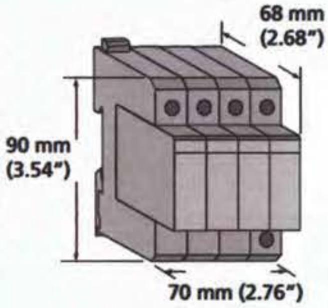
Surges and voltage transients are a major cause of expensive electronic equipment failure and business disruption. Damage may result in the loss of capital outlays, such as computers and communications equipment, as well as consequential loss of revenue and profits due to unscheduled system down-time.

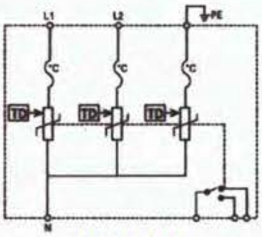
CRITEC® TD technology helps ensure reliable and continued operation during sustained and abnormal over-voltage events. Internal thermal disconnect devices help ensure safe behavior at end-of-life. A visual indicator flag provides user-feedback in the event of such operation. As standard, the TDS provides 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.

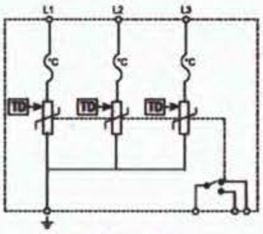


TDS350TT

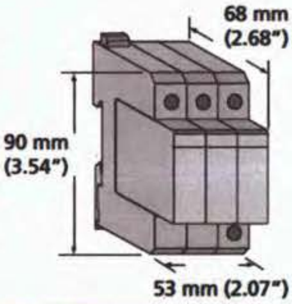




TDS50120/240



TDS350TNC



Model	TDS350TNC150	TDS50120240	TDS350TNC277	TDS350TT150	TDS350TT277
Item Number for Europe	702414	702419	702417	702416	702418
Nominal Voltage, U_n	120-150 VAC		240-277 VAC	120-150 VAC	240-277 VAC
Max Cont. Operating Voltage, U_c	170/295VAC	240/480VAC	320/536VAC	170/295VAC	320/536VAC
Stand-off Voltage	240/415VAC	240/480VAC	480/813VAC	240/415VAC	480/813VAC
Frequency	0-100Hz				
Short Circuit Current Rating, I_{sc}	200kAIC				
Back-up Overcurrent Protection	125AgL, if supply > 100A				
Technology	TD with thermal disconnect				
Max Discharge Current, I_{max}	50kA 8/20μs			12.5kA 10/350μs N-PE 50kA 8/20μs	
Nominal Discharge Current, I_n	25kA 8/20μs		20kA 8/20	25kA 8/20μs	20kA 8/20
Protection Modes	L-N	L-N, N-PE	L-N	L-N, N-PE	
Voltage Protection Level, U_p	400V @ 3kA 1.0kV @ In		800V @ 3kA 1.6kV @ In	400V @ 3kA 1.0kV @ In	800V @ 3kA 1.6kV @ In
Status	N/O, N/C Change-over contact, 250V~/0.5A, max 1.5 mm² (#14AWG) terminals Mechanical flag / remote contacts				
Dimensions H x D x W: mm (in)	90 x 68 x 53 (3.54 x 2.68 x 2.07)			90 x 68 x 70 (3.54 x 2.68 x 2.76)	
Module Width	3 M			4 M	
Weight: kg (lbs)	0.36 (0.79)			0.5 (1.10)	
Enclosure	DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1)				
Connection	≤25 mm² (#4AWG) stranded ≤35 mm² (#2AWG) solid				
Mounting	35 mm top hat DIN rail				
Temperature	-40°C to 80°C (-40°F to 176°F)				
Humidity	0% to 90%				
Approvals	CE, IEC® 61643-1, UL® 1449 Ed 3 Recognized Component Type 2				
Surge Rated to Meet	ANSI®/IEEE® C62.41.2 Cat A, Cat B, Cat C ANSI®/IEEE® C62.41.2 Scenario II, Exposure 2, 50kA 8/20μs IEC 61643-1 Class II UL® 1449 Ed3 In 20kA mode				
Replacement MOV Module	TDS150M150		TDS150M277	TDS150M150	TDS150M277
Replacement GDT Module	-			SGD112M	
Replacement GDT Module (Europe)	-			702403	

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E7128-WWEN E798LT07WWEN 01110.6M8

4

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

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: 07 3356 0577 Fx: 07 3356 1432 Web: www.ecoptions.com.au

TDF

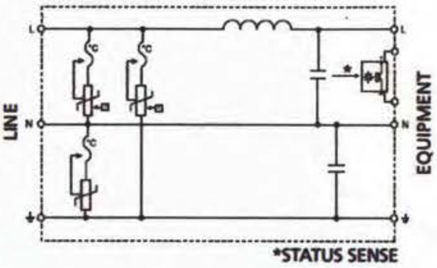
CRITEC® Transient Discriminating Filter

Features

- CRITEC® 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® 1449 Ed. 3 Listed

The TDF series has been specifically designed for process control applications to protect the switched mode power supply units on devices such as PLC controllers, SCADA systems and motor controllers. Units are UL® Recognized and available for 3A, 10A and 20A loads and suitable for 110-120V ac/dc and 220-240Vac circuits.

The TDF is a series connected, single phase surge filter providing an aggregate surge capacity of 50kA (8/20µs) across L-N, L-PE, and N-PE. The low pass filter provides up to 65dB 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	TDF3A120V	TDF3A240V	TDF10A120V	TDF10A240V	TDF20A120V	TDF20A240V
Item Number for Europe	700001	700002	700003	700004	700005	700006
Nominal Voltage, U_n	110-120 V	220-240 V	110-120 V	220-240 V	110-120 V	220-240 V
Distribution System	TN-C-S, TN-S					
Max Cont. Operating Voltage, Uc	170VAC	340VAC	170VAC	340VAC	170VAC	340VAC
Stand-off Voltage	240V	400V	240V	400V	240V	400V
Frequency	0-60Hz	50/60Hz	0-60Hz			50/60Hz
Max Line Current, I_L	3 A		10 A		20 A	
Operating Current @ U_n	135 mA	250 mA	240 mA	480 mA	240 mA	480 mA
Max Discharge Current, I_{max}	10kA 8/20µs N-PE 20kA 8/20µs L-N 20kA 8/20µs L-PE					
Protection Modes	All modes protected					
Technology	In-line series low pass sine wave filter TD Technology					
Voltage Protection Level, U_p	500V @ 500A 250V @ 3kA	700V @ 500A 600V @ 3kA	500V @ 500A 250V @ 3kA	700V @ 500A 600V @ 3kA	500V @ 500A 250V @ 3kA	700V @ 500A 600V @ 3kA
Filtering	-62dB @ 100kHz		-65dB @ 100kHz		-53dB @ 100kHz	
Status	Green LED. On=Ok. Isolated opto-coupler output					
Dimensions H x D x W: mm (in)	90 x 68 x 72 (3.54 x 2.68 x 2.83)		90 x 68 x 144 (3.54 x 2.68 x 5.67)			
Module Width	4 M		8 M			
Weight: kg (lbs)	0.7 (1.54)		1.48 (3.25)		1.57 (3.46)	
Enclosure	DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA®-1)					
Connection	1 mm² to 6 mm² (#18AWG to #10)					
Mounting	35 mm top hat DIN rail					
Back-up Overcurrent Protection	3A		10A		20A	
Temperature	-35°C to 55°C (-31°F to 131°F)					
Humidity	0% to 90%					
Approvals	C-Tick, CE (NOM 3A, 120V), CSA 22.2, UL® 1283, UL® 1449 Ed 3 Recognized Component Type 2					
Surge Rated to Meet	ANSI®/IEEE® C62.41.2 Cat A, Cat B, Cat C					

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

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ERITECH

Features

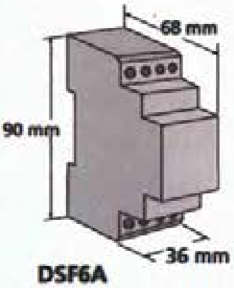
- In-line series protection
- EMI/RFI noise filtering – protects against industrial electrical noise
- Compact design – fits into motor control and equipment panels
- Three modes of protection: L-N, L-PE & N-PE
- 35 mm DIN rail mount – simple installation
- LED power indicator

DSF

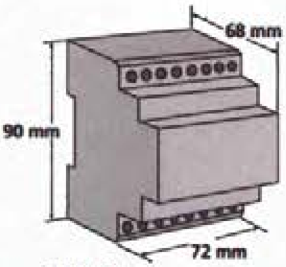
CRITEC® Dinline Surge Filter

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 30V unit is suitable for 12V and 24Vac/dc signaling and control systems.

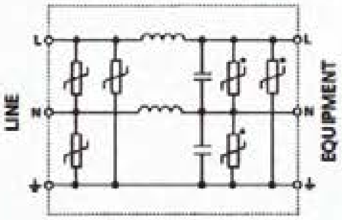
The 6A DSF series incorporates a space efficient, low pass, series filter which provides attenuation to high frequency interference. The larger 20A model provides status indication and a higher surge rating, making this ideal for the protection of higher risk equipment.



DSF6A



DSF20A



*DSF20A275V only

Model	DSF6A30V	DSF6A150V	DSF6A275V	DSF20A275V
Item Number for Europe	702090	701000	701030	701020
Nominal Voltage, U_o	24	110-120 V	220-240 V	
Distribution System	1Ph 2W+G			
System Compatibility	TN-S, TN-C-S			
Max Cont. Operating Voltage, Uc	30VAC, 38VDC	150VAC	275VAC	
Frequency	0-60Hz	50/60Hz		
Max Line Current, I_L	6 A			20 A
Operating Current @ U_c	7 mA			
Max Discharge Current, I_{max}	4kA 8/20µs	16kA 8/20µs		15kA 8/20µs L-N 15kA 8/20µs L-PE 25kA 8/20µs N-PE
Protection Modes	All modes protected			
Technology	In-line series filter MOV			
Voltage Protection Level, U_p	110V @ 3kA	400V @ 3kA	750V @ 3kA	710V @ 3kA
Filtering	-3dB @ 300kHz			-3dB @ 62kHz
Status	LED power indicator			Status indicator
Dimensions H x D x W: mm (in)	90 x 68 x 36 (3.54 x 2.68 x 1.42)			90 x 68 x 72 (3.54 x 2.68 x 2.83)
Module Width	2 M			4 M
Weight: kg (lb)	0.2 (0.441)			0.7 (1.543)
Enclosure	DIN 43 880, UL94V-0 thermoplastic, IP 20 (NEMA-1)			
Connection	1 mm² to 6 mm² (#18AWG to #10AWG)			
Mounting	35 mm top hat DIN rail			
Back-up Overcurrent Protection	6A			20A
Temperature	-35°C to 55°C (-31°F to 131°F)			
Humidity	0% to 90%			
Approvals	C-Tick, CE, NOM, UL® 1449 Ed 3 Recognized Component Type 2	C-Tick, CE		
Surge Rated to Meet	ANSI®/IEEE® C62.41.2 Cat A, Cat B			

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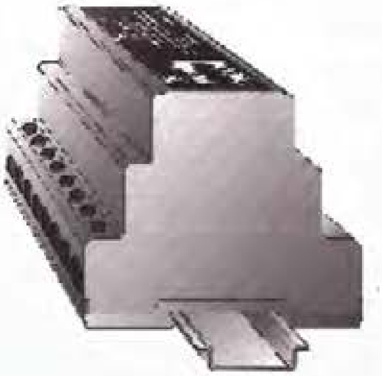
E8175-WWEN E800L707WWEN 00813.6M8

TRANSIENT DISCRIMINATING FILTER

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 35mm DIN rails. They can be selected for use on distribution systems with nominal RMS voltages of 120Vac or 240Vac at frequencies of 50/60Hz. The 120Vac unit also operates on nominal 125Vdc 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" (300mm) 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 35mm 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°F (50°C)*
- *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 (1.5mm² to 6mm²) solid or stranded conductor. The wire insulation should be stripped back 5/16" (8mm).

***NOTE:** Do not use greater than 9inlbs (1Nm) 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*
	3A	4A
	10A	10A
	20A	20A

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 output/load 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 opto-coupler. When the opto-coupler is driven on, it should be arranged to have 2mA flowing through it. For use with 24Vdc circuits, a 12kΩ current limiting burden resistor is required. For use with 12Vdc circuits, a 5.6kΩ current limit resistor is required. For use with 5Vdc circuits, a 2.2kΩ current limit resistor is required.

***NOTE:** In connecting to the TDF opto-coupler alarm output, do not reverse the +/- connections or exceed the maximum permissible ratings (30Vdc) as damage may occur.*

5

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

Equipment Type:	Surge Filter Alarm Relay
Location:	Main Incomer
Model Numbers:	DAR-275V
Manufacturer:	Critec
Supplier:	Energy Correction Options PO Box 431 Kelvin Grove, QLD. 4059 Ph: 07 3356 0577 Fx: 07 3356 1432 Web: www.ecoptions.com.au

DINLINE ALARM RELAY (DAR)

INSTALLATION INSTRUCTIONS

MODEL NUMBER
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 35mm (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°F (55°C)*
- *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 to #14 AWG (2.5mm² to 6mm²) solid or stranded conductor.
- The wire insulation should be stripped back 5/16" (8mm).
- NOTE: Do not use greater than 9inlbs (1Nm) of torque when tightening the terminals.

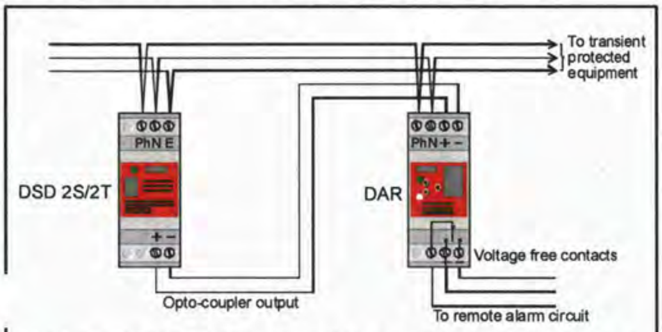
CONNECTION TO TELECOMMUNICATIONS NETWORKS

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.

INSTALLATION INSTRUCTIONS

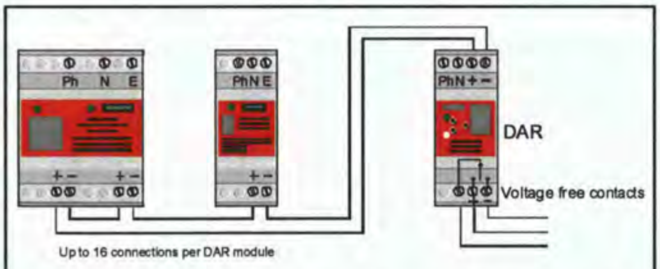
5. INTERCONNECTION

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.



+/- terminal connections are polarity sensitive. Do not reverse.

When connecting the DAR to multiple opto-couplers the opto-couplers 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.



+/- terminal connections are polarity sensitive. Do not reverse.

5. STATUS INDICATION

	✓ Protection Operational	! Protection Alarm	✗ Fault Mode
STATUS	Protection Operational	Protection Alarm	Fault Mode
DISPLAY	Normal ☼ ⑧ ④ Fault ○ ⑥	Normal ○ ⑧ ④ Fault ☼ ⑥	Normal ○ ⑧ ④ Fault ○ ⑥
EXPLANATION	Normal operation Normal (green) indicator ON Red indicator OFF Relay is energised Power is supplied	DSD in alarm mode or power to DSD has been removed Normal (green) indicator OFF Red indicator ON Relay is de-energised Power is supplied	Power to DAR removed Protection status unknown Normal (green) indicator OFF Red indicator OFF Relay is de-energised Power is OFF

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
1.5mm^2	16A	12A
2.5mm^2	20A	16A
4mm^2	25A	20A
6mm^2	32A	25A

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.*

6

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

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: 02 9603 2066 Fx: 02 9603 9335

tyco | Electronics | Energy Division **INSTALLATION INSTRUCTIONS**

Page 1 of 2

Ref: IW250PMSH – Rev 6 – March 02

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

Models Covered

252-PMM	252-PMT	252-PSF	252-PSG
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 outside these limits, the unit will initiate a trip signal via a double pole changeover relay. An illuminated green LED indicates when the thermistor temperature is within normal working limits. The unit is designed such that the alarm relay is energised when normal temperatures are reached.
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 Relay (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 monitored within settable limits. In the event of the input moving outside 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 relays should be energised. Units are factory adjusted for normal running speed = 0.75mA output. The meter adjust 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 internally. Terminals 15 and 16 give a 0/1mA signal proportional to speed.

No.1 Relay energises on rising speed
No.2 Relay energises on rising speed
No.3 Relay de-energises on rising speed

This product is designed for use only with magnetic coil inductive sensors.

Warning

- During normal operation, voltages hazardous to life may be present at some of the terminals of this unit. Installation and servicing should be performed only 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 possible, then extreme caution should be exercised.
- Terminals should not be user accessible after installation and external 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.

Installation
The Protector should be installed 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 35mm rail to DIN 46277. Alternatively they may be screw fixed; a special adaptor is supplied to mount 252 types.

To mount a protector on a DIN rail, the top edge of the cutout on the back is hooked over one edge of the rail and the bottom edge carrying the release clip clicked into place. Check that the unit is firmly fixed. Removal or repositioning may be achieved by levering down the release clip and lifting the unit up and off the rail.

Connection diagrams should be carefully followed to ensure correct polarity and phase rotation where applicable. External voltage transformers may be used on 252-PSF and 252-PSG to extend the range.

252-PMM, 252-PMT & 253-PH3
Pick up, input and output leads should be kept separate from any other wiring.

Setting Controls (252-PSF, 252-PSG)
These products have two calibration facilities that can be set to suit operating requirements and they are factory calibrated as follows:-

1. % unbalance set points
   Voltages of and below 380 volts L-L are calibrated to 1.0% class index of rated voltage. Voltages above 380 volts L-L are calibrated to 1.5% class index of rated voltage.
2. Time Delay
   For all voltage ranges 10% maximum delay.
3. Voltage Withstand
   Continuous overload = 1.35 x 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 error of the calibration marks is typically 10% of the span of the control concerned.

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 unlikely event of a repair being necessary it is recommended that the unit be returned 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 products that are, or could be, a source of interference.

Crompton INSTRUMENTS

INSTALLATION INSTRUCTIONS

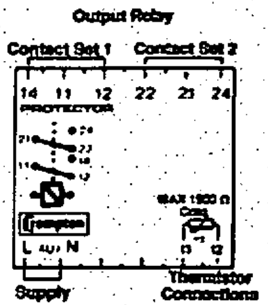
Ref: IW250PMSH – Rev 6 – March 02

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

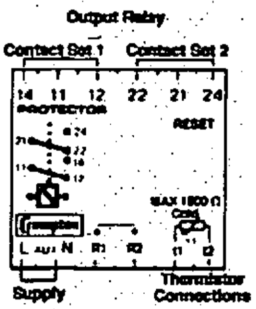
- The auxiliary supply to the unit should not be subject to excessive interference. In some cases, a supply line filter may be required.
- To protect the product against incorrect operation or permanent damage, surge transients must be controlled. It is good EMC practice to suppress differential surges to 2kV or less at the source. The unit has been designed to automatically recover from typical 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 signal 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.

It is good practice to install sensitive electronic instruments that are performing critical functions in EMC enclosures that protect against electrical interference causing a disturbance in function.

252-PMT

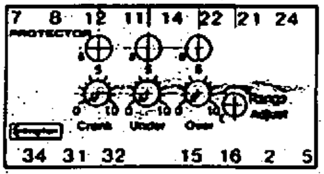


252-PMM

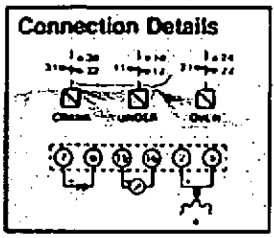


252-PMM can operate in either an automatic or a manual reset mode.
For automatic the reset link R1-R2 is to be disconnected.
For manual the reset link R1-R2 must be inserted.

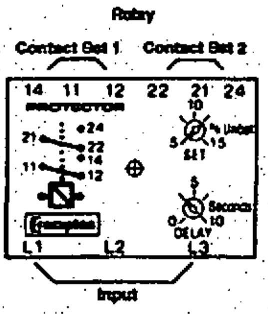
253-PH3



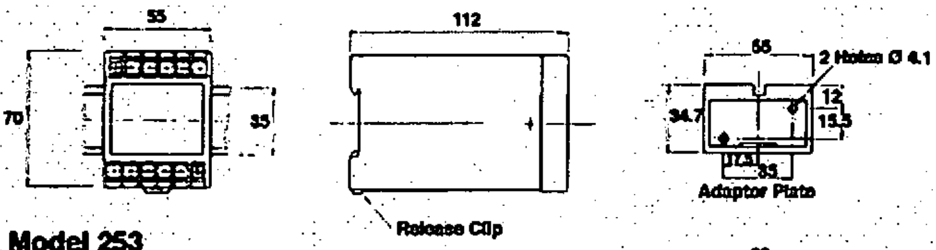
253-PH3



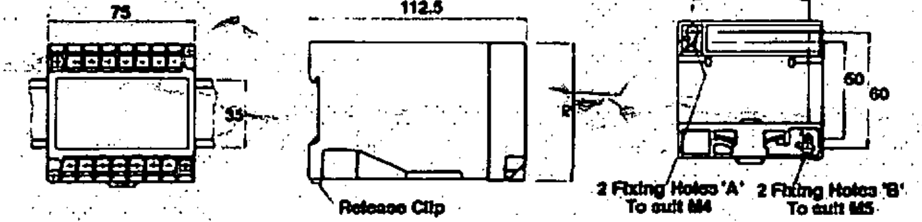
252-PSF
52-PSG



Model 252



Model 253



The information contained in these installation instructions is for use only by installers trained to make electrical power installations and is intended to describe the correct method of installation for this product. However, Tyco Electronics has no control over the field conditions, which influence product installation.
It is the user's responsibility to determine the suitability of the installation method in the user's field conditions. Tyco Electronics' only obligations are those in Tyco Electronics' standard Conditions of Sale for this product and in no case will Tyco Electronics be liable for any other incidental, indirect or consequential damages arising from the use or misuse of the products. Crompton is a trade mark.

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7

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

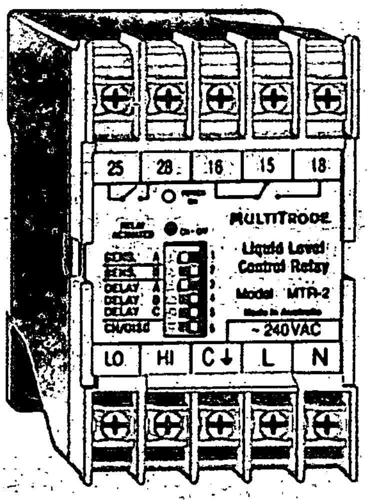
Equipment Type:	Level Relay
Location:	Common Control
Model Numbers:	MTR 240VAC
Manufacturer:	Multitrode
Supplier:	Multitrode Pty Ltd 130 Kinston Road Underwood. QLD 4119 Tel: 07 3340 7000 Fax: 07 3340 7077

1 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



There are 10 screw terminals on the unit. Facing the relay as shown, we look at the bottom terminals (left to right):

- Lo – (Charge mode). This is the point when the probe is dry 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). 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)
- " N " is "neutral" (240V AC)

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 for full 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 pump itself. 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 15 16 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 relays change state, contacts 25 and 28 close to turn on 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 or falling levels of the fluid inside the tank, they will operate to turn on a pump in discharge mode when the top sensor is wet and in charge mode turn on the pump when the bottom sensor is dry.

4 Practical Overview

4.1 Discharge Mode – DIP switch 6 set to "OFF"

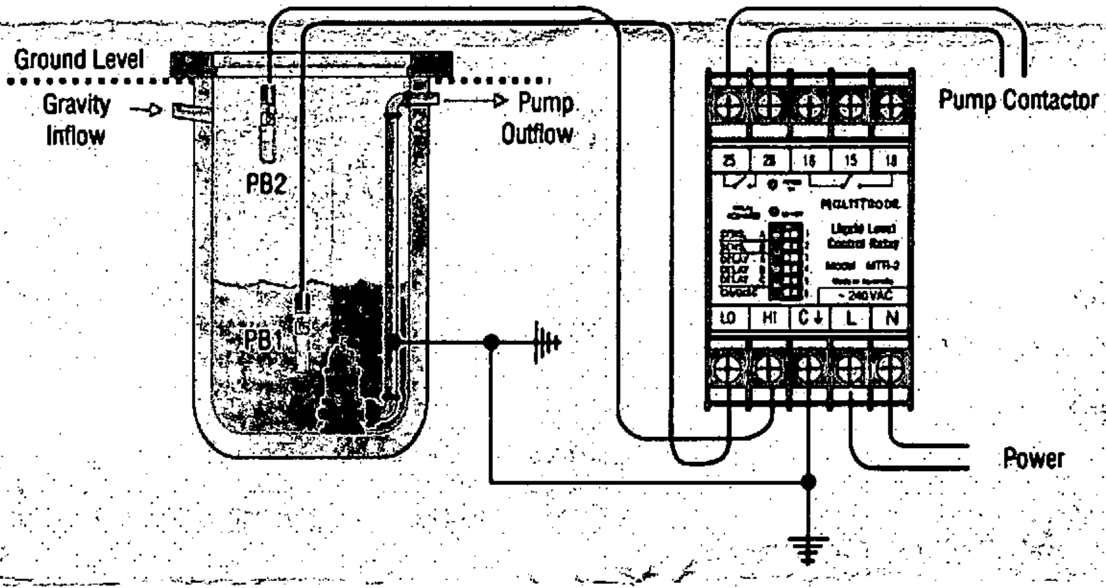
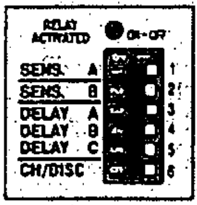


Figure 1 – Discharge Mode

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 well is full so as the water rises it reaches PB2, the relay closes and the pump starts. The level now drops below PB2 but the pump still continues to run, the level continues to drop below PB1 the relay opens the pump stops.

4.2 Charge Mode – DIP switch 6 set to "On"

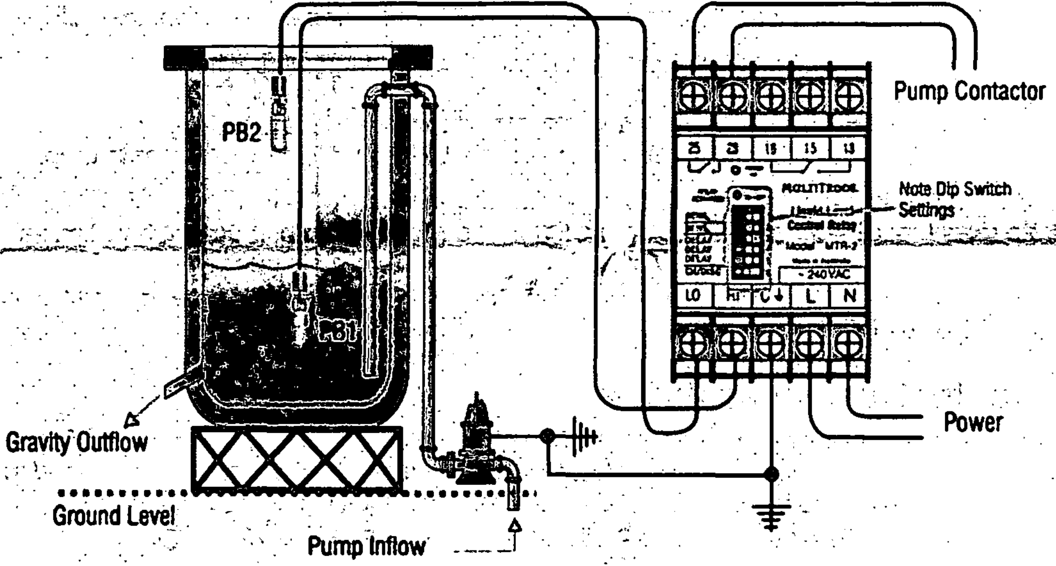
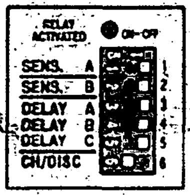


Figure 2 – Charge Mode

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 on steel 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 Applications Only)

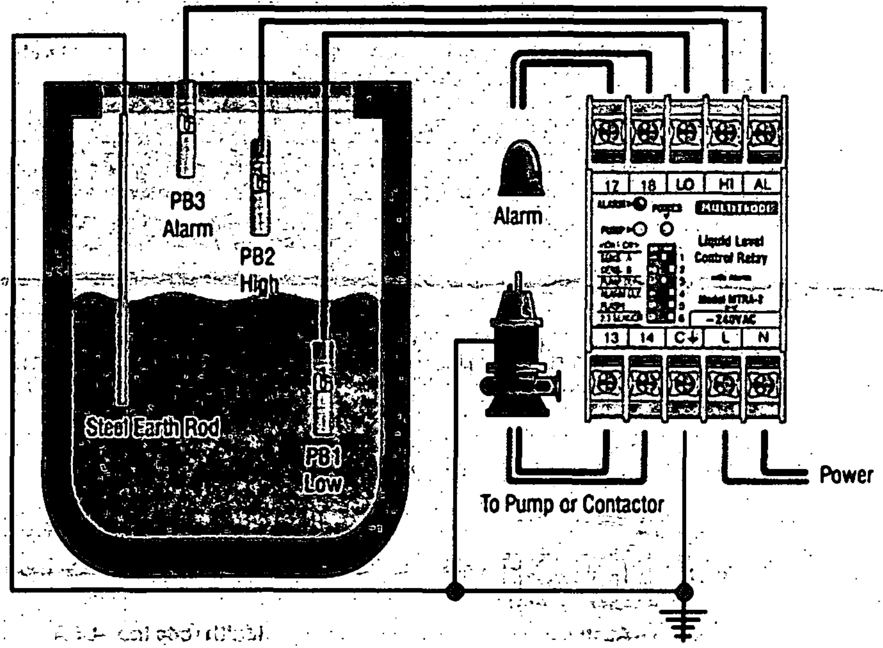


Figure 3 - MTRA Operation

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 warn 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 I 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 setting from 20KΩ to 80KΩ 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.**

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MTR_Installation_AU+US_v1-0-0.doc *13-May-2005* *Page 4 of 4*

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8

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

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

TRIO
DATACOM

TC-900DR USER GUIDE

41 Aster Avenue Carrum Downs 3201 Australia Tel: 61 3 9775 0505 Fax: 61 3 9775 0606

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/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.*

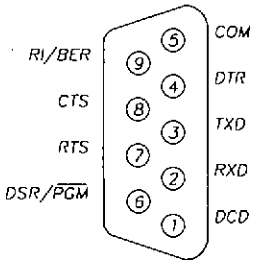
DATA CONNECTION

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

Jser 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.



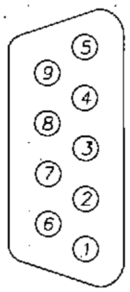
PIN NO. & FUNCTION

I. 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 ($\overline{PGM}$)
7. REQUEST TO SEND (RTS)
8. CLEAR TO SEND (CTS)
9. BIT ERROR RATE PIN (BER)

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 1.5V typically indicates -110dBm and every 0.5V increase indicates an improvement of » 10dBm.

EXTERNAL VIEW OF `**PORT B'**



PIN NO. & FUNCTION

1. DATA CARRIER DETECT (DCD)
2. RECEIVE DATA O/P (RxD)
3. TRANSMIT DATA O/P (TxD)
4. UNUSED
5. COMMON
6. DATA SET RECEIVE (DSR)
7. UNUSED
8. UNUSED
9. RECEIVE SIGNAL STRENGTH

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 13.8VDC nominal, at 600mA (Tx) nominal. If the POWER LED indicator is not illuminated once power is applied, check the internal 1Amp fuse fitted within the unit.

POWER CONNECTOR	PIN ASSIGNMENT
TOP PIN	***+VE SUPPLY (13.8vdc)***
BOTTOM PIN	***GROUND***

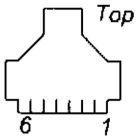
Ext. view of socket

AUXILIARY CONNECTOR

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
1	***8 VOLTS***
2	***AUDIO OUT***
3	***GROUND***
4	***MIC INPUT/SENSE***
5	***GROUND***
6	***MANUAL PTT***

External view of socket



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-900DR 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 (●). 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.

Tx PWR Err		NVRAM Err		SYNTH Err	
RXSIG	SYNC	RXSIG	SYNC	RXSIG	SYNC
☼	●	☼	●	☼	●
●	☼	●	●	●	☼
☼	●	☼	●	●	●
●	☼	●	●	●	☼
☼	●	●	☼	☼	●
●	☼	●	●	●	●
☼	●	●	☼		repeat
●	☼	●	●		
continue			repeat		

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

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TRIO

DATACOM

TC-900DR

900 MHz
Full Duplex Data Transceiver

User Manual

Issue 13 : February 2001

TABLE OF CONTENTS

IMPORTANT NOTICE

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This handbook is for the installation, operation and maintenance of the TC-900DR. The specifications described are typical only, and are subject to normal manufacturing and service tolerances.

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

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Modifications

Issue 1	February 1993 (Preliminary)
Issue 2	May 1993 Major Changes to Section 3
Issue 3	September 1993
	Minor Changes to sections, 3.1, 3.2.1, 3.2.2.1, 3.2.7, 3.4.3, 3.4.4, 4.4, 4.5, 4.7, 4.7.2, 4.7.3
	Major Changes; Inserted new section 3.2.6 KISS/SLIP Deleted section 4 Programming Deleted section 5.7.5, 5.7.6, 5.7.7 AFC Alignment
	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
	Revised figure on page 75
Issue 6	September 1994
	Addition to Section 3.2.5, 4.7.1, 4.7.2, 4.7.3, 4.7.4
	Addition of Sections 3.3.11.1, 3.3.11.2, 4.5.1,
Issue 7	April 1995
	Addition to Sections 3.8.11.2 and 3.8.12.5 Rev D Sync LED
Issue 8	September 1995
	Insertion of new Section 3.2
Issue 9	June 1998
	Section 3.3.6 replaced
Issue 10	February 1999

Modifications (cont.)

Issue 11	February 1999 Minor changes to Sections 1.5, 3.3.1, Deleted Section 1.6, 4.5.1 Replaced Section 5
Issue 12	July 2000 Minor Change to Section 7
Issue 13	February 2001 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 12.5kHz, 15kHz, 25kHz or 30kHz 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°C to +65°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 1ppm.

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 +30dBm (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 channel
- 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 : 923MHz to 933MHz (see note 1)

Tx frequency range : 847MHz to 857MHz (see note 2)

Channel spacing : Fully synthesized 12.5kHz / 25kHz, [opt 15/30]
with programmable 1/2 channel raster offset

Frequency stability : 1 ppm (-10°C to 65°C amb), [opt -30°C to 70°C],
aging <= 1ppm/Annum

Power output at Antenna connector : +30 dBm ±1dBm (1W nom)
switchable under software control 200mW/1W

Duty cycle : Continuous

Output impedance : 50 Ohms

Timeout timer : Programmable from 1 sec. to 28 minutes (max)

Tx key up time : <= to 1mS (output _ 1dB of power).

Rx sensitivity : 0.5uV at antenna input for 12 dB SINAD
at "delayed Rx signal" test point.

Rx intermodulation : >= 70 dB spurious free dynamic range.

Rx spurious responses : <= -65 dB.

Tx spurious emissions : <=-65 dBc (ref unmodulated carrier).

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 847MHz to 857 MHz.*
- *Tx frequency range 923MHz 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 asynchronous, 300..19k2 baud, 7/8 bit, 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, using Trio DataCom's DFM4-9 digital modem chipset, including Trio's unique supervisory signalling channel 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	:	±1.5 kHz (4800bps), ±2.75 kHz (9600bps)
Power requirements	:	14 Volts AC 10VA or 13.8Volts DC (11 to 16V Max).
Transmit current	:	<= to 600 mA.
Receive current	:	175 mA.
Size	:	241mm x 161mm x 65mm.
Weight	:	1.3Kg.

1.4.4 CONNECTORS

User RS-232 Connection : DB9 female wired as DCE (modem).
(AMP Part # 747844-5)

Mating connectors : DB9 male solder type.
(AMP Part # 747983-3)
Backshell to suit.
(AMP Part # 205729-1).
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).
(PCB SOCKET MOLEX Part # M5569-2A2)

Mating connector : (RECEPTACLE MOLEX Part# M5557-2R)
(RECEPT PINS MOLEX Part # M5556-TL).
Supplied with standard unit.

Supervisory Audio
Handset Connector : 6 pin modular jack.
(AMP Part # 520250-3)

Mating connector : 6 pin modular jack plug.
(AMP Part # 5-641337-3).
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 193mm x 152mm x 1.6mm.

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 20dB.

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 45MHz 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 Q3.

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 RF_{in} and RF_{bypass} pins (U2-p1,p2).

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

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 455kHz 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 dB(uv). C10 and C11 provide IF amplifier decoupling.

The output is available at IF AMP OUT (U1-p16). This is applied to a 455kHz 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 2V. The AC level of the signal is set to about **1** V_{p-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 60dB.

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 U1: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-p13, from the modem section. It is biased via R68 and R75 to a DC level of about 0.86V. 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 X3-p4, 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 100Hz. 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 U8 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 "I" 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 30dB. 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 800MHz 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 X4, 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, "/TX 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 200mW, and high power is 1W.

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 X1-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 (200mW).

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 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 returned 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 X1. Attached permanently to this connector is a 90mm 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 X1/JX3 PIN NUMBERS	SIGNAL DESCRIPTION	
1	13V8 POWER SUPPLY RAIL	
2	13V8 POWER SUPPLY RAIL	
3	13V8 POWER SUPPLY RAIL	
4	GROUND	
5	GROUND	
6	GROUND	
7	8V POWER SUPPLY	
8	8V POWER SUPPLY	
9	TXPWR SENSE	(o/p- TRANSMIT POWER SENSE)
10	TXPWR	(i/p - TRANSMIT POWER LEVEL)
11	/TX EN	(i/p - TRANSMIT ENABLE)
12	/PTT	(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 X4 and X2, and low loss coaxial cables.

CONNECTOR	SIGNAL DESCRIPTION
X4	TRANSMITTER OUTPUT
X2	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 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" 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 MHz range)*

DIPLEXER CONNECTOR	SIGNAL DESCRIPTION AND DESTINATION
850 MHz port	RF RECEIVE - RADIO SECTION X2
930 MHz port	RF TRANSMIT - RADIO SECTION X4
ANT port	ANTENNA

TYPE-B CONNECTIONS *(Transmit frequency = 850 MHz range)*

DIPLEXER CONNECTOR	SIGNAL DESCRIPTION AND DESTINATION
850 MHz port	RF TRANSMIT - RADIO SECTION X4
930 MHz port	RF RECEIVE - RADIO SECTION X2
ANT port	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 CONNECTOR	X3 PIN NUMBER	RADIO SECTION CONNECTOR X3
1	LED CLK	-	UNUSED
2	LED DATA	-	UNUSED
3	13V2	1	8V 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 165mm x 152mm x 18mm.

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^2C, 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 6264-8K or 62256-32K byte IC (U9). The standard TC-900DR is supplied with an 8K 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 74HC573 latches (U8 and U10), 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 32K RAM package will not be compatible with a modem containing an 8K 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 +10V and -10V 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, X4.

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 +13.8V and +8V power supplies.

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

The transmit signal output, TXSIG, has a signal level of 1Vp-p for 4800BPS, and 2Vp-p for 9600BPS, with a nominal DC offset of 2.0V. This offset may vary by ±1v 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 20.1666MHz XTAL and VCXO synthesiser reference oscillator, and is fed into the modem section via connector X4-p14, 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 X4-p9, 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 X4-p24, ADC3. This 4th 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 1W, or to a LOW level of 200mW. 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 74HC4066 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 (U12:A,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 (U7: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 (U12:A,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 DC 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.

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 74HC4066 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 13V8 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 +13V8, +8V and +5V.

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 AC inputs.

This is then applied to an LT1086 low dropout regulator (REG1). The output of this is set to 13V8 and feeds the RF final amplifier, and the following two regulators.

The 8V regulator (REG2) takes it's input directly from the 13V8 rail, its output is routed to the radio section, and provides supply for one of the amplifier devices.

The 5V regulator (REG3) provides the supply rail for the modem section logic circuits. It takes it's input from the 13V8 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 90mm length of 26 way ribbon cable.

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

CONNECTOR JX3 PIN NUMBER	SIGNAL DESCRIPTION	
1	13V8 POWER SUPPLY RAIL	
2	13V8 POWER SUPPLY RAIL	
3	13V8 POWER SUPPLY RAIL	
4	GROUND	
5	GROUND	
6	GROUND	
7	8V POWER SUPPLY	
8	8V POWER SUPPLY	
9	ADC2	(i/p - TRANSMIT POWER SENSE)
10	TXPWR	(o/p - TRANSMIT POWER LEVEL)
11	/TX EN	(o/p - 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	AFC CTL	(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 PIN NUMBER	SIGNAL DESCRIPTION	
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 PIN NUMBER	SIGNAL DESCRIPTION	
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 50K ohms and loading will decrease accuracy of the recorded measurement.

2.5.8.4 POWER

Power is supplied to the modem section via connector X1. Typically +13.8V 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 9600bps.

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 19K2, 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 19.2K 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 (TxCtrl1 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 0.5mS) 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 1mS, 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 10mS, 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'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:- 12,34,56,00,00,00,"B"

Response:- 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:- 00,00,00,12,34,56,"c",tt,rr,pp,ff,ss

Where:-

tt = Temperature calibration code

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:- 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:- 12,34,56,00,00,00,"F",nn

Response:- 00,00,00,12,34,56,"f"

Where:-

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:- 12,34,56,00,00,00,"H"

Response:- 00,00,00,12,34,56,"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:- 12,34,56,00,00,00,"M",xx

Response:- 00,00,00,12,34,56,"m"

Where:-

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:- 12,34,56,00,00,00,"P",nn,aa,bb,cc,...

Response:- 00,00,00,12,34,56,"p",nn,aa,bb,cc,...

Where:-

nn = parameter identifier

aa, bb, cc,... 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:- 12,34,56,00,00,00,"R",nn

Response:- 00,00,00,12,34,56,"r",nn,aa,bb,...hh

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:- 00,00,00,12,34,56,"s",tt,rr,pp,ff,ss

Where:-

tt = Temperature conversion code

rr = RSSI conversion code

pp = Transmit Power conversion code

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:- 00,00,00,12,34,56,"t"

Where:-

nnnn = timer reset value (16 bit value)

V 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:- 12,34,56,00,00,00,"V"

Response:- 00,00,00,12,34,56,"v","A2.2.0"

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:- 12,34,56,00,00,00,"W",nn,aa,bb,cc,...

Response:- 00,00,00,12,34,56,"w",nn,aa,bb,cc,...

Where:-

nn = parameter identifier

aa, bb, cc,... 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 (^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 (^H)	byte	Slot_Time
09 (^I)	word	SIDA1 and SIDA2
0A (^J)	word	SIDB1 and SIDB2
0B (^K)	word	SIDD1 and SIDD2
0C (^L)	byte	KISS_adrA
0D (^M)	byte	KISS_adrB
0E (^N)	byte	EOMA_code
0F (^O)	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
1A (^Z)	bit	RTS/CTS_interlock portA
1B (^[)	bit *	PORTB_enable
1C (^\)	bit *	Repeat_Enable portA
1D (^])	bit *	Repeat_Enable portB

1E (^^)	bit *	(Not defined, reserved for Error Recovery Enable)
1F (^_)	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 (&)	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	TxCtrl1
2E (.)	bit	TxCtrl0
2F (/)	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
3A (:)	byte	DCD_timeA
3B (;)	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 X3, or SLIP*[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.

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[1] * SLIP ®™ KISS ®™

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 1/8th of the bit rate, while on the asynchronous user port, the character rate is 1/10th 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 2.5mS. 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 ±5mS. 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 ±5mS, 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 C0 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:-

<FEND>,DA,C4,<FESC>,<TFEND>,C5,<FESC>,<TFESC>,20,BD,DC,DD,<FEND>

==> C0,DA,C4,DB,DC,C5,DB,DD,20,BD,DC,DD,C0

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	COMMENTS
0	**Data Frame**	The rest of the frame is data to be transmitted.
1	**TxDelay**	The next byte is the RF transmitter key-up delay in octets.
2	**Slotnum**	The next byte is the Slotnum parameter.
3	**Slot-Time**	The next byte is the "Slot" interval in "ticker clocks".
4	**TxTail**	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.
5	**FullDuplex**	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.
6	**SetHardware**	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.
F	**ExitKISS**	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 2.5mS), 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. 2K/2K/2K/2K for Port_A transmit, Port_A receive, Port_B transmit, Port_B receive). If Port_B is disabled, then 4K 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" (2.5mS) 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 8K CMOS RAM, of which half (4096 bytes) is allocated to the receiver. The modem can be fitted with an external memory up to 32K 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 8K CMOS RAM, of which half (4096 bytes) is allocated to the transmitter. The modem can be fitted with an external memory up to 32K 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.

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[2] "Data and Computer Communications" William Stallings

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 12MHz 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 +65C. 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.*

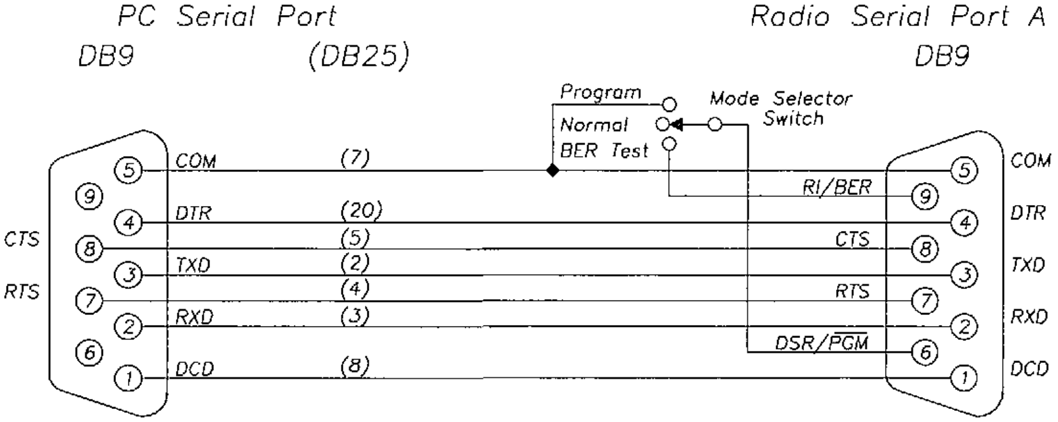
- Programmer mode.
- Bit error rate test mode.
- Handset mode.

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 +13.8v, 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 2V, but if it isn't installed, then the voltage will be about 4V. The measured voltage is compared to 3V 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 (☼), 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
☼	●	☼	●	☼	●
●	☼	●	●	●	☼
☼	●	☼	●	●	●
●	☼	●	●	●	☼
☼	●	●	☼	☼	●
●	☼	●	●	●	●
☼	●	●	☼		repeat
●	☼	●	●		
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 4800BPS unit, use 2400Hz 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 +13.8volt rail via a 4K7 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, TCI (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 2.5mS 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 20mS 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 +13.8v, 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 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
☼	●	☼	●	☼	●
●	☼	●	●	●	☼
☼	●	☼	●	●	●
●	☼	●	●	●	☼
☼	●	●	☼	☼	●
●	☼	●	●	●	●
☼	●	●	☼		repeat
●	☼	●	●		
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 GHz. -120 dBm to +10dbm. Synthesised in 100 Hz steps.
- Spectrum analyser 10 MHz to 1GHz. Dispersion down to 2kHz/cm. 80+ dB dynamic range. IF b/w down to 1 kHz.
- RF Power meter to 1GHz. -20 to +30 dbm. Accuracy ± 0.25 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	TXPWR-2	Bias to Q8
TP25	TXPWR-3	Bias to Q8
TP27	TXPWR-4	Bias to Q9
TP14	+8v	Power Supply
TP15	TXEN	Transmit enable
TP20	RxMIXOUT	Rx mixer bias
TP28	TXPA-1	Bias to Q10
TP29	TXPA-2	Bias to Q11
TP26	+13V8	Power supply
TP33	PWR CONT	Power control supply
TP30	PTT+8V	Press to talk
121 MHz SECTION		
TP13	DATA	Tx data input
TP17	60.5 MHz	Modulated 60.5MHz
TP16	121 MHz	Output of doubler
TP18	121 MHz	Modulated 121 MHz
TP32	MIC	Tx Mic audio input
NE615 IF SECTION		
TP6	415kHz I/P	455 filter input/second mixer output
TP9	QUAD	Quad detector
TP8	DATA	Rx data out
TP10	AUDIO	Rx audio out
TP7	RSSI	RSSI output
TP4	MUTE	Mute control output
TP1	2nd L.O	Second Xtal oscillator
TP2	2nd L.O	Second Xtal oscillator
TP3	IF Input	45 MHz IF filter input
TP5	IF Output	45 MHz IF filter output
TP19	VCO	VCO oscillator injection
SYNTHESISER/VCO SECTION		
TP12	LOCK DET	Synthesiser lock detect
TP11	+5V	Synthesiser +5v supply
AUXILIARY HANDSET INTERFACE SECTION		
TP21	MIC	Tx mic audio input
TP22	PTT	Manual press to talk
TP23	+8V	Handset +8V supply
TP24	AUDIO OUT	Rx audio 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 (121MHz 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	
LK2	IN	AFC option disabled	
	OUT	AFC option enabled	(factory standard)
LK4	IN	PWR control disable	
	OUT	PWR control enabled	

4.6 HOUSING

The TC-900DR 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 30db 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" i/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 (5V) 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 786MHz VCO = 907MHz Tx or 831MHz Rx
Minimum 814MHz VCO = 935MHz Tx or 859MHz Rx
VCO TYPE: MQC-978
Maximum 996MHz VCO = 875MHz Tx or 951MHz Rx
Minimum 960MHz VCO = 839MHz Tx or 915MHz 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 MHz (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 (±1500Hz), 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 -60dBc in the adjacent channel.

8 Check VTCXO Reference frequency is F(tx) +121 MHz for 853 remote units or F(tx) -121 MHz for master units. If Reference is out by more than ±1.5kHz, 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 L7 through L10 for peak o/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 75mV 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 mV RF = 0.06 VDC on HP11960 probe.
TP18	550 mV RF = 1.0 VDC on HP11960 probe.
121 MHz i/p to mixer	75 mV RF = 0.13 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	DEVIATION LEVEL
4800 bps	± 1.5 kHz peak
9600 bps	± 2.75 kHz peak

4. Note that temperature compensation is applied to the 121MHz 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 >±500Hz 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 X4.

4 With full drive, Q9 driver collector current as seen across TP26//TP27 should be approximately 45 mA (100mVDC), and NOT MORE THAN 55mA (120mVDC).

5 With full drive at Q9 each final transistor should be drawing around 175 mA(385mVDC) 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 +5VDC, set VR4 for +32 dbm+/- 0.25 dB at the tx o/p socket X4. Check that the current in EACH final collector does NOT EXCEED 225 mA.

7 Check with the spectrum analyser that the Tx 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 MHz) must be greater than 65db 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 X4 (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 = 45.455MHz)

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 ±1.5KHz

Consult factory for alignment or service information.

SECTION 5

INSTALLATION AND COMMISSIONING

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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 (Tx) at 13.8VDC, is typically 2.0 Amps. As the Tx 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 3dB 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 900MHz 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 400MHz and 900MHz over distance, please consider this when installing the unit.

CABLE TYPE	***LOSS RELATIVE TO DISTANCE***							
	1 dB		***3 dB***		***6 dB***		***9 dB***	
	450MHz	900MHz	450MHz	900MHz	450MHz	900MHz	450MHz	900MHz
RG58C/U	2.3m	1.6m	7m	5m	14m	10m	20m	15m
RG223/U	3.1m	2.3m	9m	7m	18m	14m	28m	21m
RG213/U	6.1m	4m	18m	12m	37m	24m	55m	37m
HELIAX LDF4-50A	19m	14m	57m	43m	114m	87m	171m	130m
HELIAX LDF5-50A	38m	25m	114m	75m	229m	150m	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 9dB 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 14dB 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 360^0 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 20dB 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 25dB 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 30dB 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

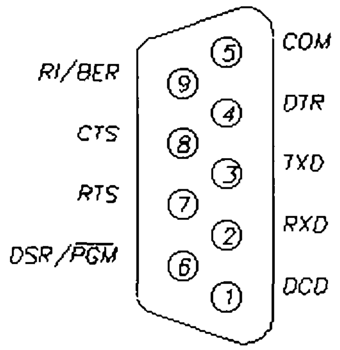
The data connection is via a DB9 connector labelled 'Port A', which is wired as a DCE as shown below. The port labelled 'Port B' is not used for the standard configuration but can be enabled by the programmer for use as a totally independent second data channel. In industrial environments connection 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)
9. BIT ERROR RATE PIN (BER)

EXTERNAL VIEW OF `PORT A'



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.

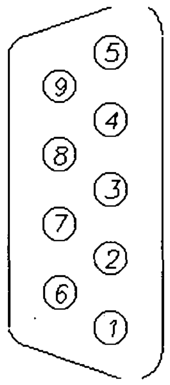
Port B of the TC450DR is essentially unused in its standard configuration but can be enabled by the Programmer for use as a totally independent second data channel. This port is essentially used for specific applications and only has one connection that may be of use for installation purposes. This connection (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 10K 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 O/P (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		Line of Site to Base	
Tx Power at Antenna		DC volts at Radio (Tx)	
Site QA Inspection:			
Notes:			
Signed		Date	

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 P\S PCB (1 Amp SLO-BLOW).
    c) Check supply volts:

Modem P\S	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 ± 250 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 1nF 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 4VDC, 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 1nF	-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 ± 910kHz. - IF detector signal (2x455) modulating or mixing with carrier. - Check 1n bypass on reference i/p to power control op-amp. Check bypasses on collectors and supply lines of low level transmitter stages, and L.O. buffer.

Carrier ± 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 ± 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 Tx 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 (2x4.7 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 V_{p-p}
Base band	Audio signal to modulator TP32	0.84 VD.C 60 mV_{p-p} for VR3 set for maximum value 400 mV_{p-p} for VR3 set for minimum value
Base band	Audio signal to modulator U7- pin 4	1.3 VD.C 0.5 V_{p-p}
121 MHz	Signal level at TP18:A	-5 dBm
Final Tx frequency	Output to diplexer connector X1	3W 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	900MHz Radio Block Diagram
	RSSI Level cf 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 900MHz 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

9

TECHNICAL DATA SHEET

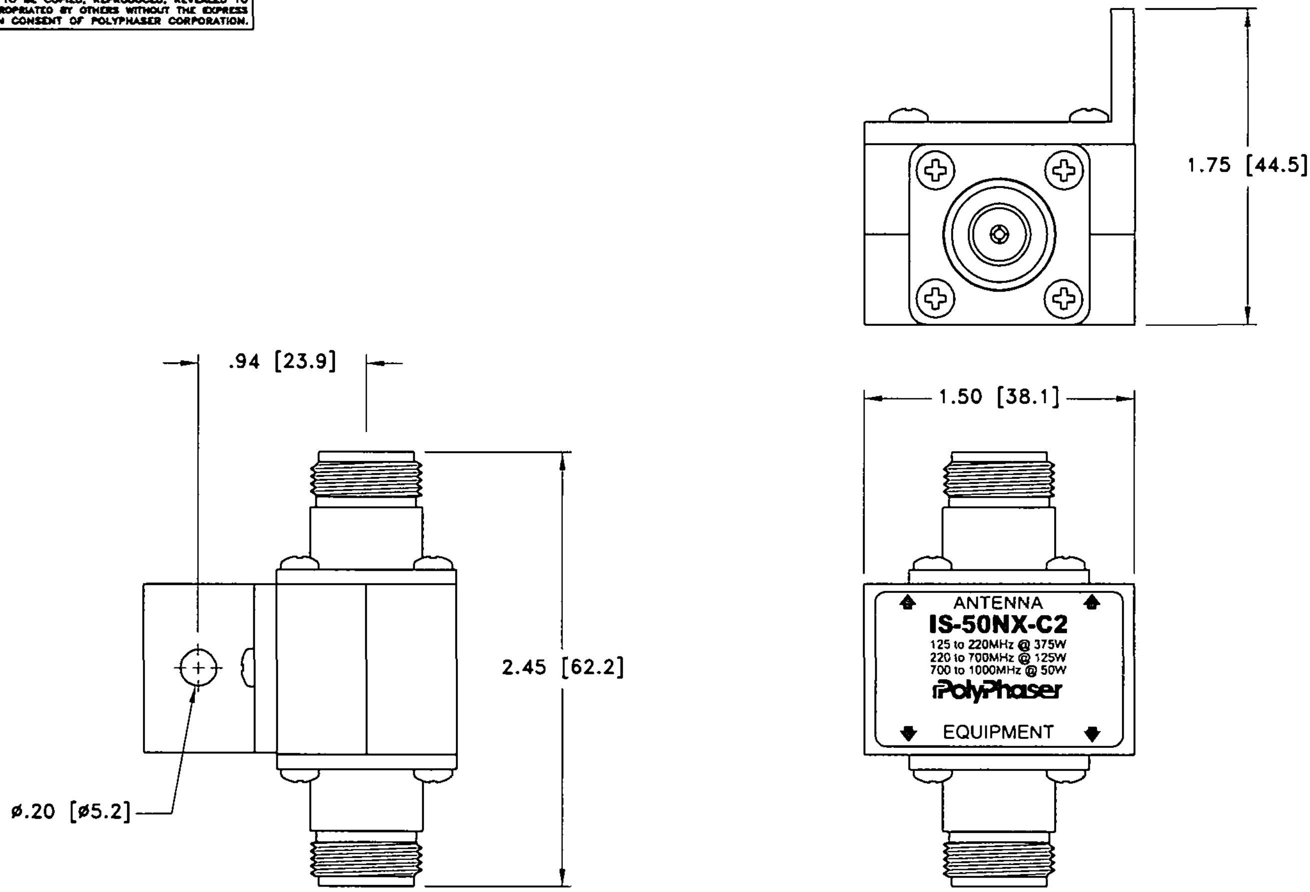
For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

Equipment Type:	Impulse Suppressor
Location:	RTU Section
Model Numbers:	IS-50NX-C2
Manufacturer:	Polyphaser
Supplier:	Brisbane Water

REVISIONS

REV LTR	DATE	ENG	MKTG	Q.A.
A	01/30/96 PJP	T. K.	– –	R. M.
B	06/30/99 JCG	K.C.B.	T.G.F.	R. M.
C	01/16/01 SH	KCB	PH	RM
D	11/18/02 SH	LC	SD	LJ



MAXIMUM CHARACTERISTICS

SURGE:
50kA IEC 1000-4-5 8/20μs WAVEFORM 500 JOULES

TURN ON:
600Vdc ±20%

TURN ON TIME:
2.5ns FOR 2kV/ns

FREQUENCY RANGE:
125MHz TO 1GHz

VSWR:
≤1.1:1 OVER FREQUENCY RANGE

INSERTION LOSS:
≤0.1dB OVER FREQUENCY RANGE

TEMPERATURE:
-45°C TO +85°C STORAGE/OPERATING +50°C

CUSTOMER APPROVAL: ____________________ DATE: ____________

ALL DIMENSIONS SHOWN ABOVE ARE FOR REFERENCE ONLY.

DRAFTER J. CALLISTER	DATE 09/21/93
MECH ENGINEER – – – –	DATE – – –
ELEC ENGINEER J. JONES	DATE 04/12/95
MARKETING – – – –	DATE – – –
QUALITY DEPT R. MATHEUS	DATE 04/12/95

PolyPhaser
CORPORATION
P.O. BOX 9000, MINDEN, NV 89423-9000 (775) 782-2511 FAX (775) 782-4476

DWG NO/PART NO/DESCRIPTION
IS-50NX-C2
CUSTOMER PRINT

CAGE CODE	FILE NAME	SCALE	SHEET
61114	-C1	1/1	1 OF 1

10

TECHNICAL DATA SHEET

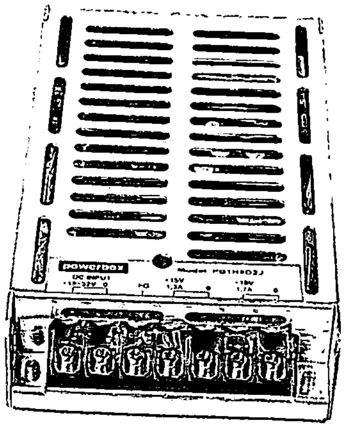
For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

Equipment Type:	Radio/DC Converter
Location:	RTU Section
Model Numbers:	PB1H-2412G-CC
Manufacturer:	Powerbox
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) 24VDC (19–32) 48VDC (38–63) 110VDC (85–140)
Inrush current	20A max. for 110V only

OUTPUT

Output voltage	See table
Voltage adjustment	±10%, ±5% for PBIH-F
Output current	See table
Ripple & noise	Output Volts x 1% + 50mV to -100mV pk-pk
Line regulation	0.8% over input range
Load regulation	0.9%, 0%–100% load
Temperature coefficient	0°C to 50°C, 0.03% per °C
Overvoltage protection	O.V. clamp, PBIH-F Output shutdown, PBIH-G, J, M, R – input must be switched off for at least 30S to reactivate
Overcurrent protection	Fold back – PBIH-F Current limiting, PBIH-G, J, M, R (PBIH-R series is adjustable); PBIH110xxR models are not adjustable
Drift	Output V x 0.5% + 15(mV) per 8 hrs after 1 hr warm-up
Rise Time	200mS max. – PBIH-F, M, R 100mS max. – PBIH-G, J (at 25°C)
Holdup time	10mS (only 110V input)
Remote sense	P8IH-R Series only

OPERATING

Efficiency	70%–89%
Safety isolation (1 minute)	Type – 12, 24, 48V input Input – Output: 1500VAC Input– Case: 1500VAC Output– Case: 500VAC Type– 110V 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°C to 50°C full load
Cooling	Convection cooled
Storage temperature	-20°C to +85°C
Humidity	85%
Shock	30G, PBIH-F, G and J
Vibration	(5Hz–10Hz, 10mm), (10Hz–50Hz) 2G, PBIH-F, G and J

STANDARDS AND APPROVALS

Safety	Designed to UL1950
C-tick	AS/NZS CISPR11 Group 1, Class A

MECHANICAL

Weight	PBIH-F : 250g PBIH-G : 380g PBIH-J : 410g PBIH-M : 800g PBIH-R : 1.4kg

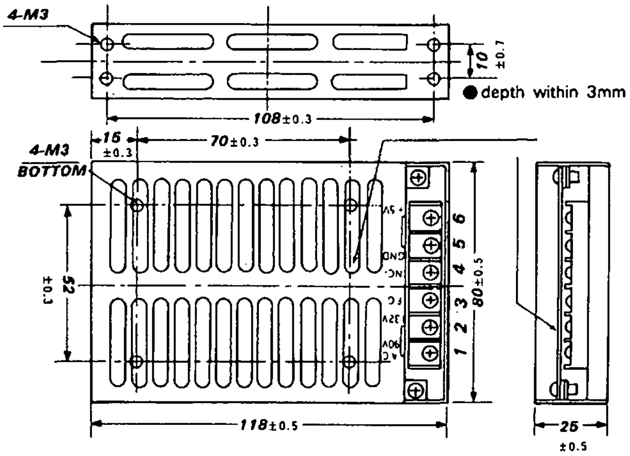
PBIH Series

15-150 WATTS DC/DC SINGLE OUTPUT

Selection Table

MODEL NUMBER	INPUT	OUTPUT		OUTPUT POWER
PBIH-1205F	9.2-16V	5V	3A	15W
PBIH-1212F	9.2-16V	12V	1.2A	15W
PBIH-1215F	9.2-16V	15V	1A	15W
PBIH-1224F	9.2-16V	24V	0.62A	15W
PBIH-2405F	19-32V	5V	3A	15W
PBIH-2412F	19-32V	12V	1.2A	15W
PBIH-2415F	19-32V	15V	1A	15W
PBIH-2424F	19-32V	24V	0.62A	15W
PBIH-4805F	38-63V	5V	3A	15W
PBIH-4812F	38-63V	12V	1.2A	15W
PBIH-4815F	38-63V	15V	1A	15W
PBIH-4824F	38-63V	24V	0.62A	15W
PBIH-11005F	85-140V	5V	3A	15W
PBIH-11012F	85-140V	12V	1.2A	15W
PBIH-11015F	85-140V	15V	1A	15W
PBIH-11024F	85-140V	24V	0.62A	15W
PBIH-1205G	9.2-16V	5V	5A	25W
PBIH-1212G	9.2-16V	12V	2.1A	25W
PBIH-1215G	9.2-16V	15V	1.7A	25W
PBIH-1224G	9.2-16V	24V	1.1A	25W
PBIH-1248G	9.2-16V	48V	0.5A	25W
PBIH-2405G	19-32V	5V	5A	25W
PBIH-2412G	19-32V	12V	2.1A	25W
PBIH-2415G	19-32V	15V	1.7A	25W
PBIH-2424G	19-32V	24V	1.1A	25W
PBIH-2448G	19-32V	48V	0.5A	25W
PBIH-4805G	38-63V	5V	5A	25W
PBIH-4812G	38-63V	12V	2.1A	25W
PBIH-4B15G	38-63V	15V	1.7A	25W
PBIH-4B24G	38-63V	24V	1.1A	25W
PBIH-484BG	38-63V	48V	0.5A	25W
PBIH-11005G	85-140V	5V	5A	25W
PBIH-11012G	85-140V	12V	2.1A	25W
PBIH-11015G	85-140V	15V	1.7A	25W
P8IH-11024G	85-140V	24V	1.1A	25W
PBIH-11048G	85-140V	48V	0.5A	25W
PBIH-1205J	9.2-16V	5V	8A	50W
PBIH-1212J	9.2-16V	12V	3.3A	50W
PBIH-1215J	9.2-16V	15V	2.7A	50W
PBIH-1224J	9.2-16V	24V	1.7A	50W
PBIH-1248J	9.2-16V	48V	0.8A	50W
PBIH-2405J	19-32V	5V	10A	50W
PBIH-2412J	19-32V	12V	4.3A	50W
PBIH-2415J	19-32V	15V	3.4A	50W
PBIH-2424J	19-32V	24V	2.5A	50W
PBIH-2448J	19-32V	48V	1A	50W
PBIH-4805J	38-63V	5V	10A	50W
PBIH-4812J	38-63V	12V	4.3A	50W
PBIH-4815J	38-63V	15V	3.4A	50W
PBIH-4824J	38-63V	24V	2.5A	50W
PBIH-4848J	38-63V	48V	1A	50W
PBIH-11005J	85-140V	5V	10A	50W
PBIH-11012J	85-140V	12V	4.3A	50W
PBIH-11015J	85-140V	15V	3.4A	50W
PBIH-11024J	85-140V	24V	2.5A	50W
PBIH-11048J	85-140V	48V	1A	50W
PBIH-1205M	9.2-16V	5V	18A	100W
PBIH-1212M	9.2-16V	12V	9A	100W
PBIH-1215M	9.2-16V	15V	7A	100W
PBIH-1224M	9.2-16V	24V	4.5A	100W
PBIH-1248M	9.2-16V	48V	2A	100W
PBIH-2405M	19-32V	5V	20A	100W
PBIH-2412M	19-32V	12V	9A	100W
PBIH-2415M	19-32V	15V	7A	100W
PBIH-2424M	19-32V	24V	5A	100W
PBIH-2448M	19-32V	48V	2A	100W
P8IH-4805M	38-63V	5V	20A	100W
P8IH-4812M	38-63V	12V	9A	100W
PBIH-4815M	38-63V	15V	7A	100W
PBIH-4824M	38-63V	24V	5A	100W
PBIH-4848M	38-63V	48V	2A	100W
PBIH-11005M	85-140V	5V	20A	100W
PBIH-11012M	85-140V	12V	9A	100W
PBIH-11015M	B5-140V	15V	7A	100W
PBIH-11024M	85-140V	24V	5A	100W
PBIH-11048M	85-140V	48V	2A	100W
PBIH-1205R	9.2-16V	5V	27A	150W
PBIH-1212R	9.2-16V	12V	13A	150W
P8IH-1215R	9.2-16V	15V	10A	150W
P8IH-1224R	9.2-16V	24V	6.5A	150W
PBIH-1248R	9.2-16V	48V	3.3A	150W
PBIH-2405R	19-32V	5V	30A	150W
PBIH-2412R	19-32V	12V	14A	150W
PBIH-2415R	19-32V	15V	11A	150W
PBIH-2424R	19-32V	24V	7A	150W
PBIH-2448R	19-32V	48V	3.5A	150W
PBIH-4805R	38-63V	5V	30A	150W
PBIH-4812R	38-63V	12V	14A	150W
PBIH-4815R	38-63V	15V	11A	150W
PBIH-4824R	38-63V	24V	7A	150W
PBIH-4848R	38-63V	48V	3.5A	150W
PBIH-11005R	85-140V	5V	30A	150W
PBIH-11012R	85-140V	12V	14A	150W
PBIH-11015R	85-140V	15V	11A	150W
PBIH-11024R	85-140V	24V	7A	150W
PBIH-11048R	85-140V	48V	3.5A	150W

PBIH-F



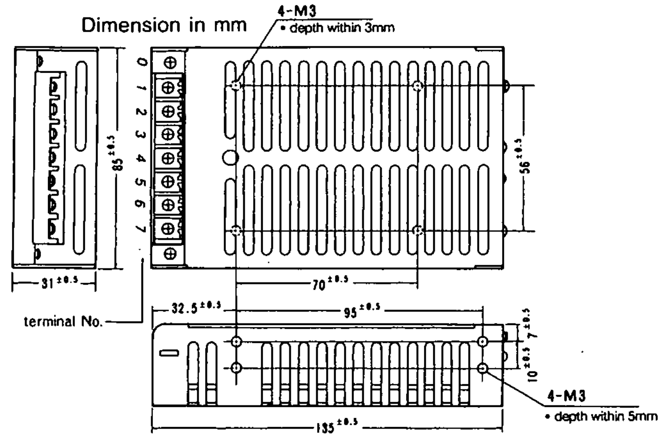
• Dimensions in mm

terminal No.	
1	0 V (DC in)
2	+V (DC in)
3	FG
4	NO Connection
5	−V out
6	+V out

PBIH Series

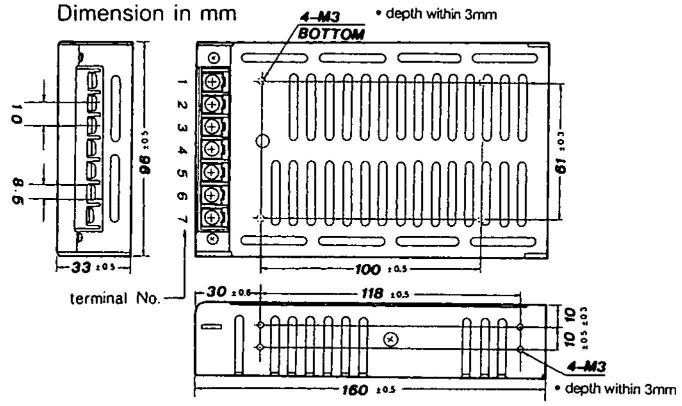
15-150 WATTS SINGLE OUTPUT

PBIH-G



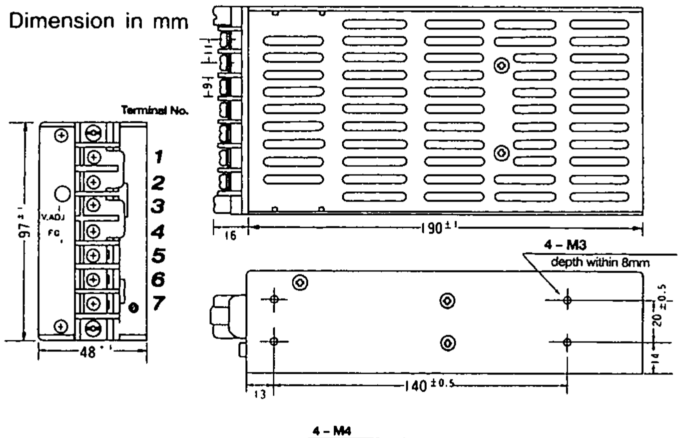
Terminal	Connection
0	FG
1	DC +V in
2	0V in
3	LFG
4	NO
5	NO
6	-V out
7	+V out

PBIH-J



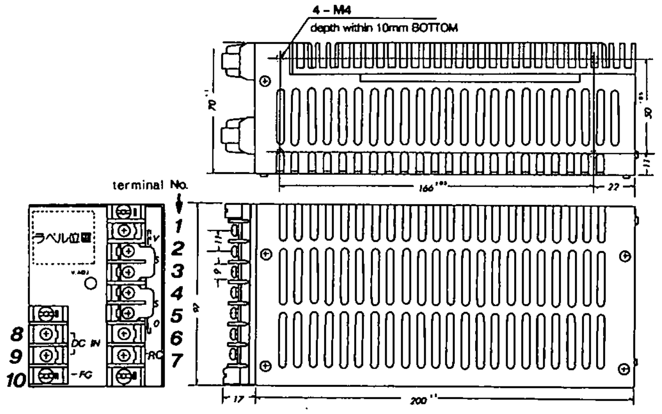
Terminal	Connection
1	FG
2	DC +V in
3	0V in
4	LFG
5	-V out
6	+V out
7	NC

PBIH-M



Terminal	Connection
1	+V out
2	+V out
3	-V out
4	-V out
5	FG
6	-V in
7	+V in

PBIH-R



Terminal	Connection
1, 2	+V out
3	+S
4	-S
5, 6	-V out
7	Remote Control
8	DC +V in
9	DC 0V in
10	FG

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TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

Equipment Type: Modem/Power Supply

Location: RTU Section

Model Numbers: PB251-24CM-CC-TT

Manufacturer: Powerbox

Supplier: 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 400VDC
Line regulation:	0.2%typical
Current:	1.4A maximum
Inrush current:	10A 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	Indefinite, auto-resetting
Over-voltage protection	17.5 to 20V latching (13.8Vdc output) 31.5 to 39V latching (27.6Vdc output)
Ripple & noise 100 MHz bandwidth	28mVp-p (13.8Vdc output) 55mVp-p (27.6Vdc output)
ENVIRONMENTAL	
Operating temperature	0 to 70°C ambient with derating, 5...90% relative humidity (non-condensing)
Over-temperature protection	Automatic & auto-resetting
Cooling requirement	Natural convection
Efficiency	80% minimum

STANDARDS & APPROVALS	
Safety	Complies with AS/NZS 60950, class 1, 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 i/p-ground o/p-ground	4242VDC for 1 minute 2121VDC for 1 minute 707VDC for 1 minute
ALARMS & BATTERY FUNCTIONS	
Converter ON/OK alarm	Indicated by voltage-free changeover relay contacts &
green LED	ON=PSU OK
Battery low (& fuse) alarm	10.2 to 12.6V for 12V battery, adjustable 20.4 to 25.2V for 24V battery, adjustable Indicated by voltage-free changeover relay contacts & green LED: ON=BATT OK
Low voltage disconnect	9.6 to 12V for 12V battery, adjustable 19.2 to 24V2 for 4V 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. 0.25V typical
MECHANICAL	
Case size	264 L x 172 W x 67 H mm
Case size with heatsink	264 L x 186 W x 67 H mm
Rack size	232 D x 19" W x 2RU H
Weight	1.9 kg
Weight with heatsink	2.1 kg
Weight (rack mounted version)	5.5 kg

Selection Table

MODEL NUMBER	**OUTPUT** **VDC**	 **I_{LOAD}**	 **I_{BATT}**	**OUTPUT POWER**
PB251-12CM	13.8V	16A	2A	220W
PB251-12CM-H	13.8V	20A	2A	275W
PB251-24CM	27.6V	11A	2A	300W
PB251-24CM-H	27.6V	12A	2A	330W
PB251-12RML	13.8V	20A	4A	275W
PB251-12B	13.8V	20A	4A	275W
PB251-24RML	27.6V	12A	2A	330W

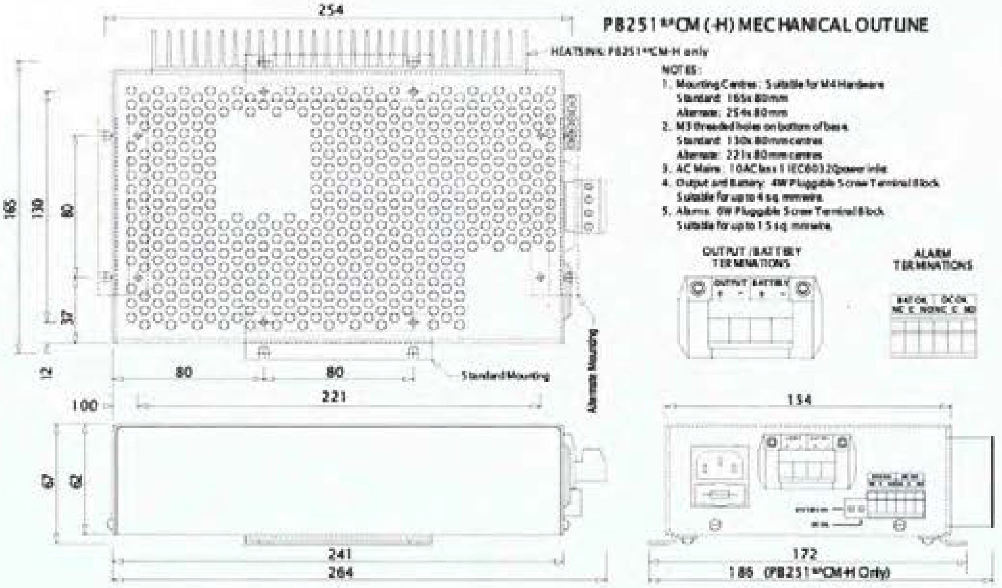
Note: Non standard battery charging current available on request. ie PB251-12CM-H-10 for 10A.

powerbox.

PB251 Series

275-330 WATTS DC UPS

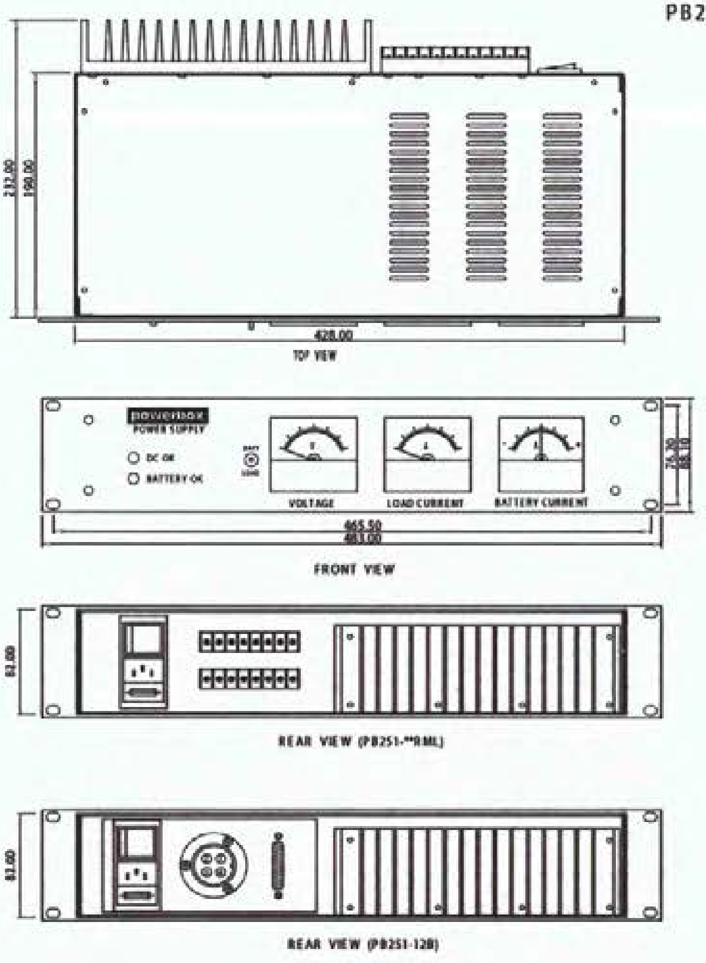
Technical Illustrations



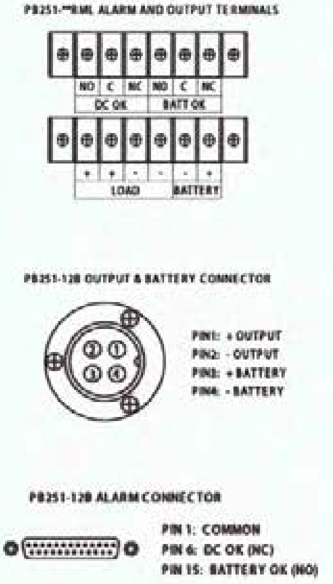
PB251CM (-H) MECHANICAL OUTLINE**

NOTES:
1. Mounting Centres: Suitable for M4 Hardware
   Standard: 165x 80mm
   Alternate: 254x 80mm
2. M3 threaded holes on bottom of base.
   Standard: 130x 80mm centres
   Alternate: 221x 80mm centres
3. AC Mains: 10A Class 1 IEC60320 power inlet
4. Output and Battery: 4W Pluggable Screw Terminal Block
   Suitable for up to 4 sq. mm wire.
5. Alarms: 6W Pluggable Screw Terminal Block
   Suitable for up to 1.5 sq. mm wire.

PB251-RML & -12B MECHANICAL OUTLINE**



NOTES:
1. 2RU x 19" rack enclosure per IEC297
2. Mounting slots are suitable for M6 hardware.
3. Input connector is a 10A Class 1 IEC60320 inlet.
4. 2 meter IEC mains cord with Australian plug is supplied with unit.
5. PB251-12B alarm terminal is DB25 female.
6. PB251-12B output and battery connector is Hirose pn. HS28R-4A. Mating connector is Hirose pn. HS28P-4A (not supplied).
7. PB251-**RML alarm and output terminals are M3.5 screws suitable for ring or fork lugs up to 8 mm wide.



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TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

Equipment Type:	Level Probe
Location:	Common Control
Model Numbers:	020130FSP
Manufacturer:	Multitrode
Supplier:	Multitrode Pty Ltd 130 Kinston Road Underwood. QLD 4119 Tel: 07 3340 7000 Fax: 07 3340 7077

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 (200mm) to a ten-sensor probe (1000mm increasing to a maximum of nine metres). Custom probes can be manufactured to suit your requirements.

Installation

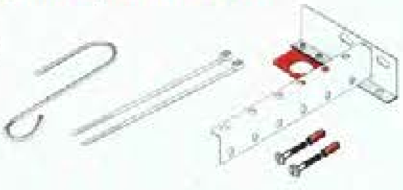
Installation is straightforward. Probes are easy to install without entering the wet area. The probe is simply lowered in from the top and suspended by its own cable, using the mounting kit supplied.

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 300mm extra wall clearance. This bracket is not included as standard with probes.

Ordering Examples and Information

Model Code	Probe Length (m/in)	Sensor Separation (mm/in)	Cable Length* (m/ft)	Number of Sensors
0.2/1-10	0.2/8	N/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 10m/33ft or 30m/100ft

Probe Length (meters)	Sensor Points	Cable Length (meters)
2.5	10	10

MULTITRODE www.multitrode.com

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Tel: +61 7 3340 7000 Fax: +61 7 3340 7077
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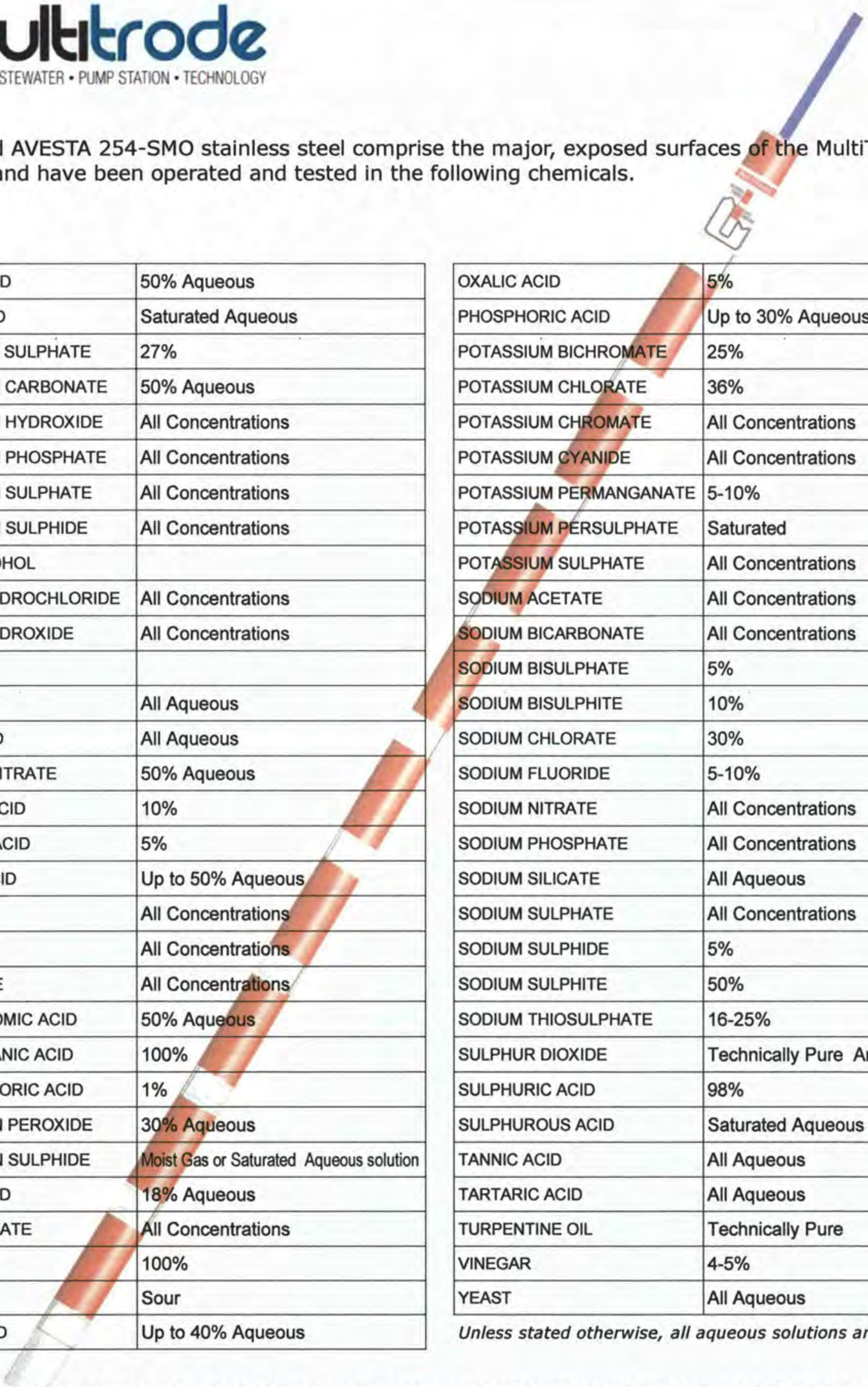
6560 East Rogers Circle
Boca Raton Florida 33487
Tel: +1 561 994 8090 Fax: +1 561 994 6282
sales@multitrode.net

MultiTrode Probe Immersion Table

multitrode
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
ADIPIC ACID	Saturated Aqueous
ALUMINIUM SULPHATE	27%
AMMONIUM CARBONATE	50% Aqueous
AMMONIUM HYDROXIDE	All Concentrations
AMMONIUM PHOSPHATE	All Concentrations
AMMONIUM SULPHATE	All Concentrations
AMMONIUM SULPHIDE	All Concentrations
AMYL ALCOHOL	
ANILINE HYDROCHLORIDE	All Concentrations
BARIUM HYDROXIDE	All Concentrations
BEER	
BORAX	All Aqueous
BORIC ACID	All Aqueous
CALCIUM NITRATE	50% Aqueous
CHLORIC ACID	10%
CHROMIC ACID	5%
FORMIC ACID	Up to 50% Aqueous
GELATINE	All Concentrations
GLUCOSE	All Concentrations
GLYCERINE	All Concentrations
HYDROBROMIC ACID	50% Aqueous
HYDROCYANIC ACID	100%
HYDROFLUORIC ACID	1%
HYDROGEN PEROXIDE	30% Aqueous
HYDROGEN SULPHIDE	Moist Gas or Saturated Aqueous solution
LACTIC ACID	18% Aqueous
LEAD ACETATE	All Concentrations
MERCURY	100%
MILK	Sour
NITRIC ACID	Up to 40% Aqueous

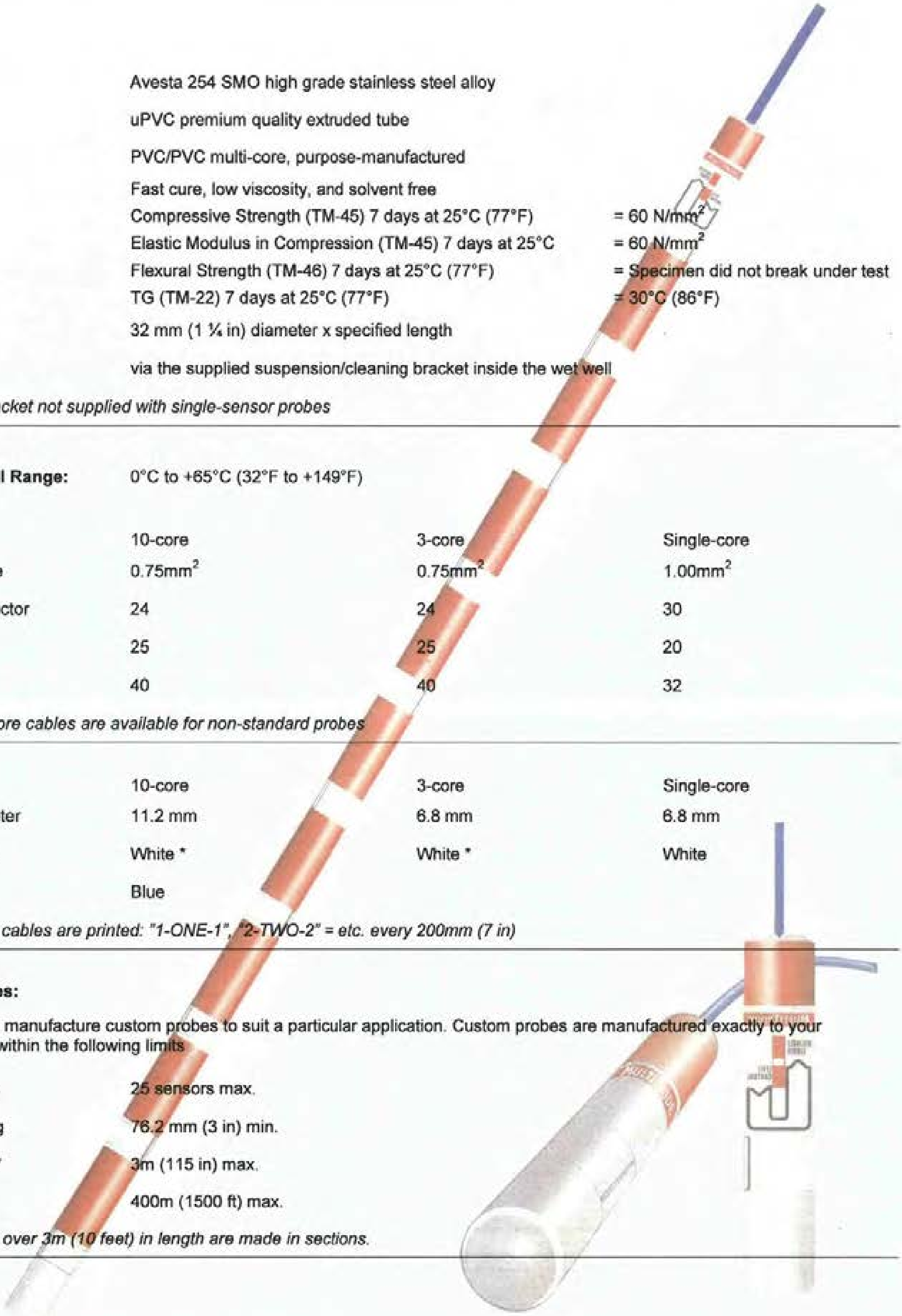
OXALIC ACID	5%
PHOSPHORIC ACID	Up to 30% Aqueous
POTASSIUM BICHROMATE	25%
POTASSIUM CHLORATE	36%
POTASSIUM CHROMATE	All Concentrations
POTASSIUM CYANIDE	All Concentrations
POTASSIUM PERMANGANATE	5-10%
POTASSIUM PERSULPHATE	Saturated
POTASSIUM SULPHATE	All Concentrations
SODIUM ACETATE	All Concentrations
SODIUM BICARBONATE	All Concentrations
SODIUM BISULPHATE	5%
SODIUM BISULPHITE	10%
SODIUM CHLORATE	30%
SODIUM FLUORIDE	5-10%
SODIUM NITRATE	All Concentrations
SODIUM PHOSPHATE	All Concentrations
SODIUM SILICATE	All Aqueous
SODIUM SULPHATE	All Concentrations
SODIUM SULPHIDE	5%
SODIUM SULPHITE	50%
SODIUM THIOSULPHATE	16-25%
SULPHUR DIOXIDE	Technically Pure Anhydrous
SULPHURIC ACID	98%
SULPHUROUS ACID	Saturated Aqueous
TANNIC ACID	All Aqueous
TARTARIC ACID	All Aqueous
TURPENTINE OIL	Technically Pure
VINEGAR	4-5%
YEAST	All Aqueous

Unless stated otherwise, all aqueous solutions are 100%.

Note: *MultiTrode probes can be used in many other aggressive applications and the list above is by no means complete.*

Leaders in Pump Station Management Technology **www.multitrode.com**

MultiTrode Probe Specifications



Materials:

Sensors:	Avesta 254 SMO high grade stainless steel alloy	
Casing:	uPVC premium quality extruded tube	
Cable:	PVC/PVC multi-core, purpose-manufactured	
Resin:	Fast cure, low viscosity, and solvent free	
	Compressive Strength (TM-45) 7 days at 25°C (77°F)	= 60 N/mm^2
	Elastic Modulus in Compression (TM-45) 7 days at 25°C	= 60 N/mm^2
	Flexural Strength (TM-46) 7 days at 25°C (77°F)	= Specimen did not break under test
	TG (TM-22) 7 days at 25°C (77°F)	= 30°C (86°F)
Dimensions:	32 mm (1 ¼ in) diameter x specified length	
Mounting:	via the supplied suspension/cleaning bracket inside the wet well	

** Mounting bracket not supplied with single-sensor probes*

Environmental Range: 0°C to +65°C (32°F to +149°F)

Cable:	10-core	3-core	Single-core
Conductor Size	0.75mm^2	0.75mm^2	1.00mm^2
Strands/Conductor	24	24	30
Ohms/km	25	25	20
Ohms/mile	40	40	32

** Other multi-core cables are available for non-standard probes*

Oversheath:	10-core	3-core	Single-core
Nominal diameter	11.2 mm	6.8 mm	6.8 mm
Core Colours:	White *	White *	White
Oversheath:	Blue		

** All multi-core cables are printed: "1-ONE-1", "2-TWO-2" = etc. every 200mm (7 in)*

Custom Probes:

MultiTrode can manufacture custom probes to suit a particular application. Custom probes are manufactured exactly to your requirements, within the following limits

No. of Sensors	25 sensors max.
Sensor spacing	76.2 mm (3 in) min.
Section length*	3m (115 in) max.
Cable length	400m (1500 ft) max.

** Note: Probes over 3m (10 feet) in length are made in sections.*

13

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

Equipment Type:	Soft Starter
Location:	Drive section
Model Numbers:	MSF-017
Manufacturer:	Emotron
Supplier:	Siemens Ltd. 885 Mountain Highway Bayswater Vic 3153 Tel: 137 222 Fax: 1300 360 222

Valid for the following Soft starter Models:
MSF-017 to MSF-1400

MSF
SOFT STARTER

INSTRUCTION MANUAL

Document number: 01-1363-01
Edition: r2
Date of release: 2001-04-20

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Safety

The soft starter should be installed in a cabinet or in an electrical control room.

- The device must be installed by trained personnel.
- Disconnect all power sources before servicing.
- Always use standard commercial fuses, slow blow e.g. type gl, gG, to protect the wiring and prevent short circuiting. To protect the thyristors against short-circuit currents, superfast semiconductor fuses can be used if preferred. The normal guarantee is valid even if superfast semiconductor fuses are not used.

Operating and maintenance personnel

1. Read the whole Instruction Manual before installing and putting the equipment into operation.
2. During all work (operation, maintenance, repairs, etc.) observe the switch-off procedures given in this instruction as well as any other operating instruction for the driven machine or system. See Emergency below.
3. The operator must avoid any working methods which reduce the safety of the device.
4. The operator must do what he can to ensure that no unauthorised person is working on the device.
5. The operator must immediately report any changes to the device which reduce its safety to the user.
6. The user must undertake all necessary measures to operate the device in perfect condition only.

Installation of spare parts

We expressly point out that any spare parts and accessories not supplied by us have also not been tested or approved by us.

Installing and/or using such products can have a negative effect on the characteristics designed for your device. The manufacturer is not liable for damage arising as a result of using non-original parts and accessories.

Emergency

You can switch the device off at any time with the mains switch connected in front of the soft starter (both motor and control voltage must be switched off).

Dismantling and scrapping

The enclosure of the soft starter is made of recyclable material as aluminium, iron and plastic. Legal requirements for disposal and recycling of these materials must be complied with.

The soft starter contains a number of components demanding special treatment, as for example thyristors. The circuit board contain small amounts of tin and lead. Legal requirements for disposal and recycling of these materials must be complied with.

CONTENTS

List of tables

List of figures

1. GENERAL INFORMATION

1.1 Integrated safety systems

The device is fitted with a protection system which reacts to:

- Over temperature.
- Voltage unbalance.
- Over- and under voltage.
- Phase reversal
- Phase loss
- Motor overload protection thermal and PTC.
- Motor load monitor, protecting machine or process max or min alarm
- Starts per hour limitation

The soft starter is fitted with a connection for protective earth ⏚ (PE).

MSF soft starters are all enclosed IP 20, except MSF-1000 and MSF-1400 which are delivered as open chassi IP00.

1.2 Safety measures

These instructions are a constituent part of the device and must be:

- Available to competent personnel at all times.
- Read prior to installation of the device.
- Observed with regard to safety, warnings and information given.

The tasks in these instructions are described so that they can be understood by people trained in electrical engineering. Such personnel must have appropriate tools and testing instruments available. Such personnel must have been trained in safe working methods.

The safety measures laid down in DIN norm VDE 0100 must be guaranteed.

The user must obtain any general and local operating permits and meet any requirements regarding:

- Safety of personnel.
- Product disposal.
- Environmental protection.

NOTE! The safety measures must remain in force at all times. Should questions or uncertainties arise, please contact your local sales outlet.

1.3 Notes to the Instruction Manual

⚠ **WARNING! Warnings are marked with a warning triangle.**

Serial number

The information given in these instructions only applies to the device with the serial number given on the label on the front page. A plate with the serial number is fixed to the device.

Important

For all enquiries and spare parts orders, please quote the correct name of the device and serial number to ensure that your inquiry or order is dealt with correctly and swiftly.

NOTE! These instructions only apply to the soft starters having the serial number given on the front page, and not for all models.

1.4 How to use the Instruction Manual

This instruction manual tells you how to install and operate the MSF soft starter. Read the whole Instruction Manual before installing and putting the unit into operation. For simple start-up, read chapter 2. page 8 to chapter 3. page 10.

Once you are familiar with the soft starter, you can operate it from the keyboard by referring to the chapter 13. page 79. This chapter describes all the functions and possible setting.

1.5 Standards

The device is manufactured in accordance with these regulations.

- IEC 947-4-2
- EN 60204-1 Electrical equipment of machines, part 1, General requirements and VDE 0113.
- EN 50081-2, EMC Emission
- EN 50081-1, EMC Emission with bypass
- EN 50082-2, EMC Immunity
- GOST
- UL508

1.6 Tests in accordance with norm EN60204

Before leaving the factory, the device was subjected to the following tests:

- Through connection of earthing system;
  - a) visual inspection.
  - b) check that earthing wire is firmly connected.
- Insulation
- Voltage
- Function

1.7 Inspection at delivery

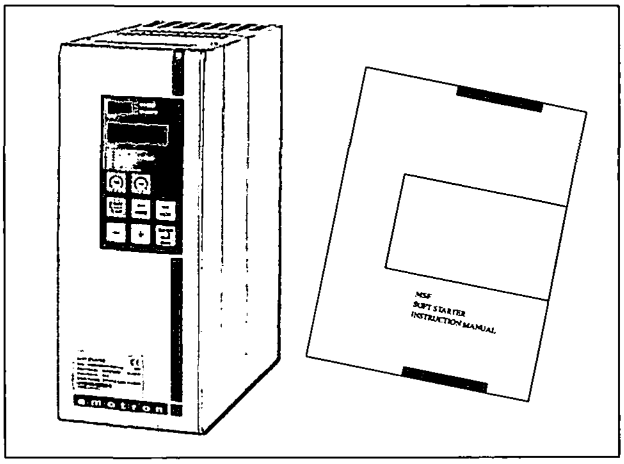


Fig. 1 Scope of delivery.

1.7.1 Transport and packing

The device is packed in a carton or plywood box for delivery. The outer packaging can be returned. The devices are carefully checked and packed before dispatch, but transport damage cannot be ruled out.

Check on receipt:

- Check that the goods are complete as listed on the delivery note, see type no. etc. on the rating plate.

Is the packaging damaged?

- Check the goods for damage (visual check).

If you have cause for complaint

If the goods have been damaged in transport:

- Contact the transport company or the supplier immediately.
- Keep the packaging (for inspection by the transport company or for returning the device).

Packaging for returning the device

- Pack the device so that it is shock-resistant.

Intermediate storage

After delivery or after it has been dismounted, the device can be stored before further use in a dry room.

1.8 Unpacking of MSF-310 and larger types

The soft starter is attached to the plywood box/loading stool by screws, and the soft starter must be unpacked as follows:

1. Open only the securing plates at the bottom of the box (bend downwards). Then lift up the box from the loading stool, both top and sides in one piece.
2. Loosen the three (3 pcs) screws on the front cover of the soft starter, down by the lower logo.
3. Push up the front cover about 20 mm so that the front cover can be removed.
4. Remove the two (2 pcs) mounting screws at the bottom of the soft starter.
5. Lift up the soft starter at the bottom about 10 mm and then push backwards about 20 mm so that the soft starter can be removed from the mounting hooks* at the top. The hooks are placed under the bottom plate and cannot be removed until the soft starter is pulled out.
6. Loosen the screws (2 pcs) for the mounting hooks and remove the hooks.
7. The hooks are used as an upper support for mounting the soft starter.

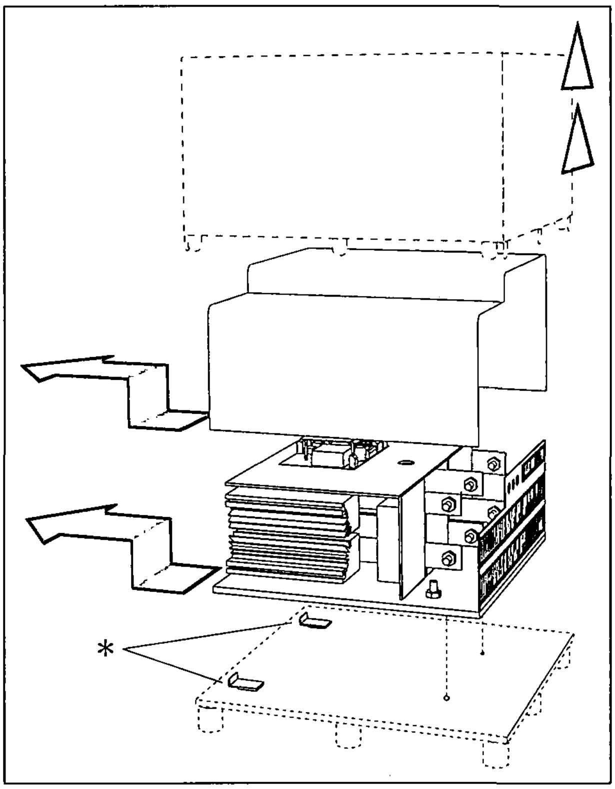
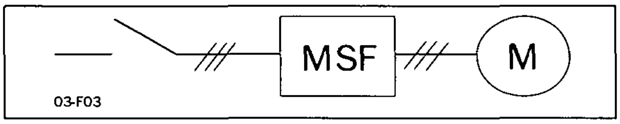


Fig. 2 Unpacking of MSF-310 and larger models.

2. DESCRIPTION

2.1 General

The MSF is installed directly between the mains and the supply cable to the motor. If a mains contactor is used it can be activated by the integrated K1 relay.



The MSF is developed for soft starting, stopping and braking three-phase motors.

There are 3 different kinds of soft starting control methods:

- **Control method 1-Phase**
  The single phase controlled soft starters provide only a reduction in starting torque no control of current or torque. These starters need a main and bypass contactor as well as external motor protections. This is a open loop voltage controller. These starters are mainly in the power up to 7.5 kW.
- **Control method 2-Phase**
  The two phase starters can start a motor without a mains contactor, but in that case voltage still is present at the motor when it´s stopped. These starters are mainly in the power up to 22 kW.
- **Control method 3-Phase**
  In the three phase Soft Starters there are different technologies:
  - Voltage control
  - Current control
  - Torque control

Voltage control

This method is the most used control method. The starter gives a smooth start but doesn't get any feedback on current or torque. The typical settings to optimize a voltage ramp are: Initial voltage, ramp time, dual ramp time.

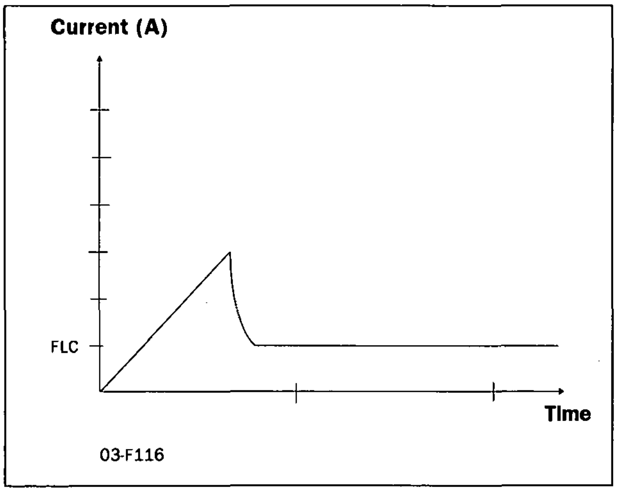


Fig. 3 Voltage control

Current control

The voltage ramp can be used with a current limit which stops the voltage ramp when the set maximum current level is reached. The maximum current level is the main setting and must be set by the user depending the maximum current allowed for the application.

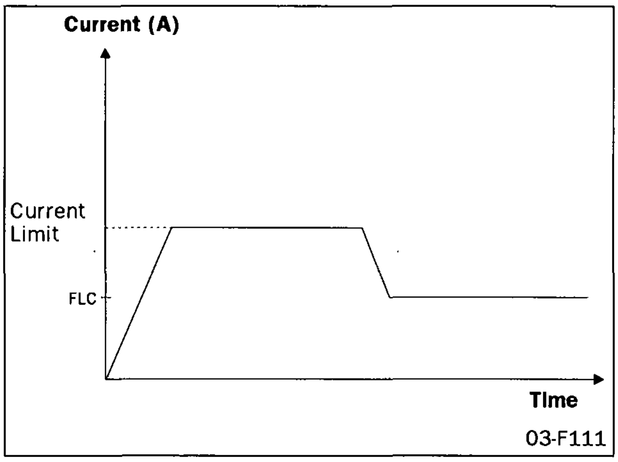


Fig. 4 Current control

Torque control

Is the most sufficient way of starting motors. Unlike voltage and current based systems the soft starter monitors the torque need and allows to start with the lowest possible current. Using a closed loop torque controller also linear ramps are possible. The voltage ramp can not hold back the motor starting torque this results in a current peak and unlinear ramps. In the current ramp there will be no peak current, but a higher current for a longer period of time during the start compared to torque control. Current starting doesn't give linear ramps. The linear ramps are very important in many applications. For an example, to stop a pump with an unlinear ramp will give water hammer. Soft starters which doesn't monitor the torque, will start and stop to fast if the load is lighter than the setting of current or ramp time.

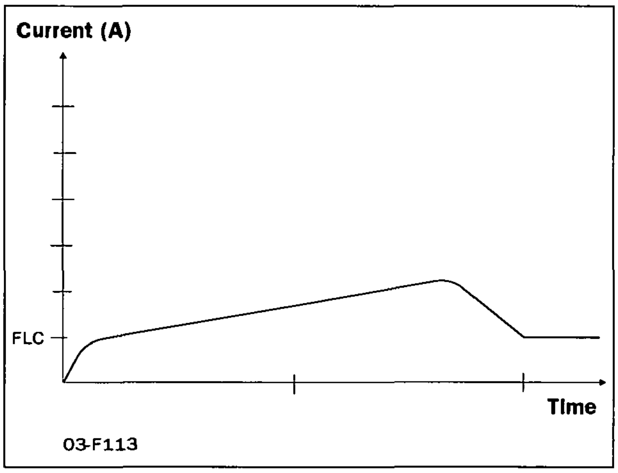


Fig. 5 Torque control

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2.2 MSF control methods

MSF Soft Starters control all three phases supplied to the motor. It manages all the 3 possible starting methods where the closed loop Torque control is the most efficient way of starting and stopping motors.

2.2.1 General features

As mentioned above soft starters offer you several features and the following functions are available:

- Torque controlled start and stop
- Current limit control at start
- Application "Pump"
- External analogue input control
- Torque booster at start
- Full voltage start (D.O.L)
- Dual voltage ramp at start and stop
- Bypass
- Dynamic DC-brake or Softbrake
- Slow speed at start and stop
- Jogging forward and reverse
- Four parameter sets
- Analogue output indicating current, power or voltage
- Viewing of current, voltage, power, torque, power consumption, elapsed time etc.
- Integrated safety system acc. to § 1.1, page 6, with an alarm list.

3. HOW TO GET STARTED

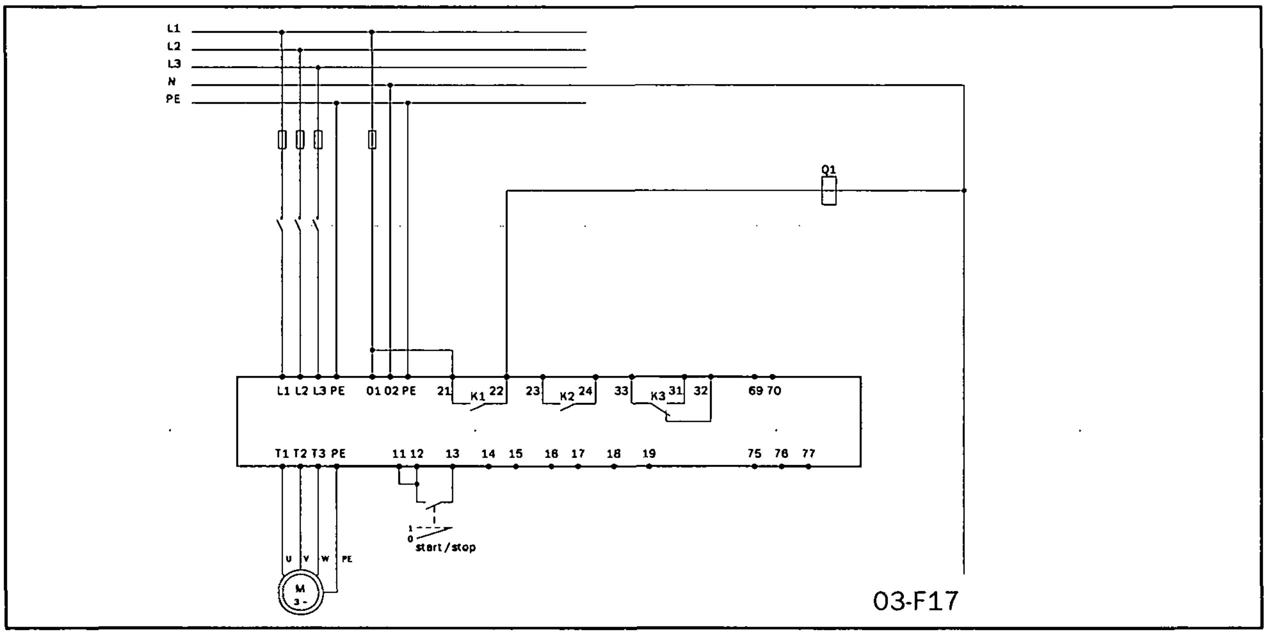

Fig. 6 Standard wiring.

This chapter describes briefly the set-up for basic soft start and soft stop by using the default "Voltage Ramp" function.

WARNING! Mounting, wiring and setting the device into operation must be carried out by properly trained personnel. Before set-up, make sure that the installation is according to chapter 6. page 24 and the Checklist below.

3.1 Checklist

- Mount the soft starter in accordance with chapter 6. page 24.
- Consider the power loss at rated current when dimensioning a cabinet, max. ambient temperature is 40°C (see chapter 12. page 74).
- Connect the motor circuit according to Fig. 6.
- Connect the protective earth.
- Connect the control voltage to terminals 01 and 02 (100 - 240 VAC or 380-500 VAC).
- Connect relay K1 (PCB terminals 21 and 22) to the contactor - the soft starter then controls the contactor.
- Connect PCB terminals 12 and 13 to, e.g., a 2-way switch (closing non-return) or a PLC, etc., to obtain control of soft start/soft stop.1)
- Check that the motor and supply voltage corresponds to values on the soft starter's rating plate.
- Ensure the installation complies with the appropriate local regulations.

1) The menu 006 must be put to 01 for start/stop command from keyboard.

3.2 Main functions/Applications

WARNING! Make sure that all safety measures have been taken before switching on the supply.

Switch on the control voltage (normally 1 x 230 V), all segments in the display and the two LED's will be illuminated for a few seconds. Then the display will show menu 001. An illuminated display indicates there is supply voltage on the PCB. Check that you have mains voltage on the mains contactor or on the thyristors. The settings are carried out according to following:

The first step in the settings is to set menu 007 and 008 to "ON" to reach the main functions 020-025 and motor data 041-046.

NOTE! The main function is chosen according to the application. The tables in the applications and functions selection (table 1, page 15), gives the information to choose the proper main function.

3.3 Motor Data

Set the data, according to the motor type plate to obtain optimal settings for starting, stopping and motor protection.

NOTE! The default settings are for a standard 4-pole motor acc. to the nominal power of the soft-starter. The soft starter will run even if no specific motor data is selected, but the performance will not be optimal.

041

400

Nominal motor voltage

Default:	400 V
Range:	200-700 V

042

45

Nominal motor current

Default:	Nominal current soft starter
Range:	25% - 150% of In_{soft} in Amp

043

22

Nominal motor power

Default:	Nominal power soft starter
Range:	25% - 300% of Pn_{soft} in kW

044

1450

Nominal motor speed

Default:	Nominal speed soft starter
Range:	500-3600 rpm

045

.86

Nominal motor cos phi

Default:	0.86
Range:	0.50-1.00

046

50

Nominal frequency

Default:	50 Hz
Range:	50/60 Hz

NOTE! Now go back to menu 007 and set it to “oFF” and then to menu 001.

3.4 Setting of the start and stop ramps

The menu´s 002 and 003 can now be set to adjust the start ramp up time and the stop ramp down time.

002

10

Start time ramp 1

Default:	10 sec
Range:	1-60 sec

Estimate the starting-time for the motor/machine. Set ”ramp up time” at start (1-60 sec).
Key “ENTER ↵ ” to confirm new value.
Key “NEXT → “, “PREV ← ” to change menu.

004

oFF

Stop time ramp 1

Default:	oFF
Range:	oFF, 2-120 sec

Set ”ramp down time” at stop (2-120 s).
“oFF” if only soft start requires.

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3.5 Setting the start command

As default the start command is set for remote operation via terminal 11, 12 and 13. For easy commissioning it is possible to set the start command on the start key on the keyboards. This is set with menu 006.

006	
2	**Selection of control mode**
Default:	2
Range:	1,2,3

Menu 006 must be set to 1 to be able to operate from keyboard.

NOTE! Factory default setting is remote control (2).

To start and stop from the keyboard, the "START/ STOP" key is used.

To reset from the keyboard, the "ENTER ↵ / RESET" key is used. A reset can be given both when the motor is running and when the motor is stopped. A reset by the keyboard will not start or stop the motor.

3.6 Viewing the motor current

Set the display to menu 005. Now the Motor current can be viewed on the display.

005	
0.0	**RMS current read-out**
Default:	-
Range:	0.0-9999 Amp.

NOTE! The menu 005 can be selected at any time when the motor is running.

3.7 Starting

WARNING! Make sure that all safety measures have been taken before starting the motor in order to avoid personal injury.

Start the motor by pressing the "START/STOP" key on the keyboard or through the remote control, PCB terminal 11, 12 and 13. When the start command is given, the mains contactor will be activated by relay K1 (PCB terminal 21 and 22), and the motor then starts softly.

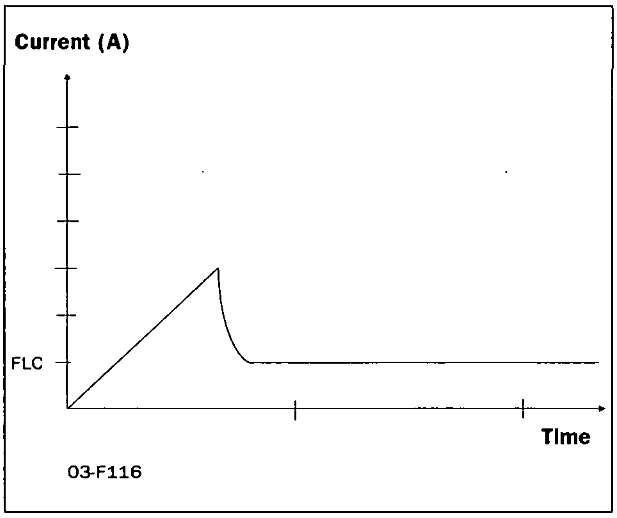

Fig. 7 Example of start ramp with main function voltage ramp.

4. APPLICATIONS AND FUNCTIONS SELECTION

This chapter is a guide to select the correct soft starter rating and the selection of the Main function and additional functions for each different application.

To make the right choice the following tools are used:

- **The norm AC53a.**
  This norm helps selecting the soft starter rating with regard to duty cycle, starts per hour and maximum starting current.
- **The Application Rating List.**
  With this list the soft starter rating can be selected depending on the kind of application used. The list use 2 levels of the AC53a norm. See table 1, page 15.
- **The Application Function List.**
  This table gives an complete overview of most common applications and duties. For each applications the menu's that can be used are given. See table 2, page 17.
- **Function and Combination matrix.**
  With these tables it is easy to see which combinations of Main and additional functions are possible, see table 3, page 19 and table 4, page 19.

4.1 Soft starter rating according to AC53a

The IEC947-4-2 standard for electronic starters defines AC53a as a norm for dimensioning of a soft starter.

The MSF soft starter is designed for continuous running. In the Applications table (table 1, page 15) two levels of AC53a are given. This is also given in the technical data tables (see chapter 12. page 74).

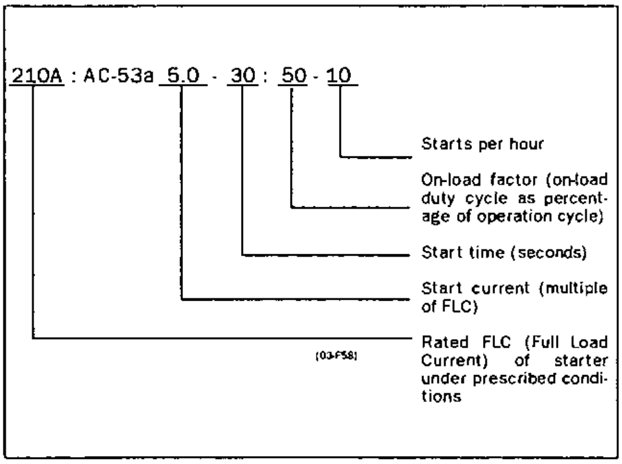

Fig. 8 Rating example AC53a.

The above example indicates a current rating of 210 Amps with a start current ratio of 5.0 x FLC (1050A) for 30 seconds with a 50% duty cycle and 10 starts per hour.

NOTE! If more than 10 starts/hour or other duty cycles are needed, please contact your supplier.

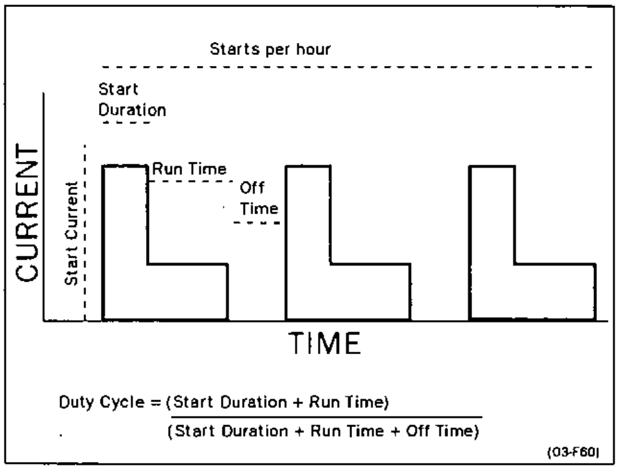

Fig. 9 Duty cycle, non bypass.

4.2 Soft starter rating according to AC53b

This norm is made for Bypass operation. Because the MSF soft starter is designed for continuous operation this norm is not used in the selection tables in this chapter.

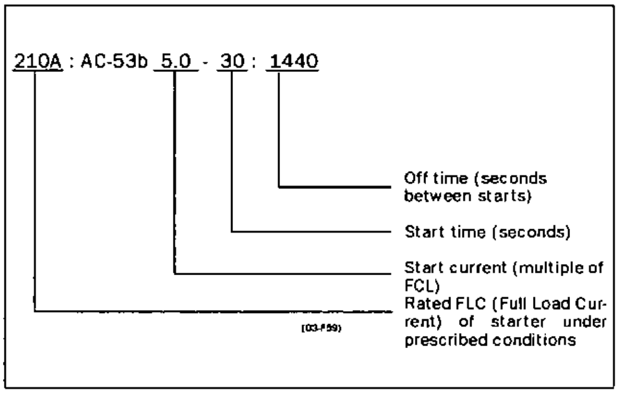

Fig. 10 Rating example AC53b.

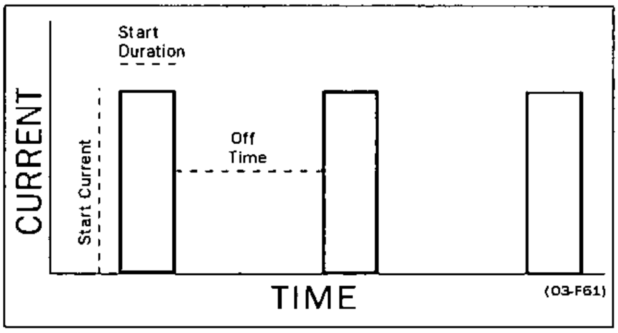

Fig. 11 Duty cycle, bypassed

The above example indicates a current rating of 210 Amps with a start current ratio of 5.0 x FLC (1050A) for 30 seconds with a 24-minute period between starts.

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4.3 MSF Soft starter ratings

According to the norms AC53a and AC53b a soft starter can have many current ratings.

NOTE! Because the MSF soft starter is designed for continuous operation the norm AC53b is not used in the application rating list.

With help of the Application Rating List with typical starting currents and categories in the AC53a level (see table 1, page 15 and table 2, page 17) it is easy to select the proper soft starter rating with the application.

The Application Rating List uses two levels for the AC53a norm:

- **AC53a 5.0-30:50-10 (heavy duty)**
  This level will be able to start all applications and follows directly the type number of the soft starter.
  Example: MSF 370 is 370 Amps FLC and then 5 time this current in starting.
- **AC 53a 3.0-30:50-10 (normal/light duty)**
  This level is for a bit lighter applications and here the MSF can manage a higher FLC.
  Example: MSF 370 in this norm manage 450 Amps FLC and the 3 times this current in starting

NOTE! To compare Soft Starters it's important to ensure that not only FLC (Full Load Current) is compared but also that the operating parameters are identical.

4.4 The Application Ratings List

Table 1 gives the Application Ratings List. With this list the rating for the soft starter and Main Function menu can be selected.

Description and use of the table:

- **Applications.**
  This column gives the various applications. If the machine or application is not in this list, try to identify a similar machine or application. If in doubt pleas contact your supplier.
- **AC53a ratings.**
  The rating according to AC53a norm is here classified in 2 ratings. The first for normal/light duty (3.0-30:50-10) and the second for heavy duty (5.0-30:50-10)
- **Typical Starting current.**
  Gives the typical starting current for each application
- **Main Function menu.**
  The Main Function menu is advised here.
  "25;=1", means: program selection 1 in menu 25.
- **Stop function.**
  Gives a possible Stop function if applicable.
  "36;=1 / 38-40", means: program selection 1 in menu 36, also menus 38 to 40 can be selected.

EXAMPLE:

Roller Mill:

- This is an application for heavy duty,
- Typical starting current of 350%.
- Main function Torque ramp start (menu 25) will give the best results.
- Stop function Dynamic Brake (menu 36, selection 1) can be used.
- As well as the Slow Speed at start and stop (menu 38-40) can be used for better start and stop performance.

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Table 1 Applications Rating List

Applications	AC53a 3.0-30:50-10 (normal/light)	AC 53a 5.0-30:50-10 (heavy)	Typical starting current %	Main function Menu nr.	Stop function Menu nr.
General & Water					
Centrifugal Pump	x		300	22	22
Submersible Pump	x		300	22	22
Conveyor		x	300-400	25;=1	36;=1 / 38-40
Compressor: Screw	x		300	25	-
Compressor, Reciprocating	x		400	25;=1	-
Fan	x		300	25;=2	-
Mixer		x	400-450	25;=1	-
Agitator		x	400	25;=1	-
Metals & Mining					
Belt Conveyor		x	400	25;=1	36;=1 / 38-40
Dust Collector	x		350		-
Grinder	x		300	25;=1	36;=1
Hammer Mill		x	450	25;=1	36;=2
Rock Crusher		x	400	25;=1	-
Roller Conveyor	x	x	350	25;=1	36;=1 / 38-40
Roller Mill		x	450	25;=1	36;=1 or 2
Tumbler		x	400	25;=1	-
Wire Draw Machine		x	450	25;=1	36;=1 or 2
Food Processing					
Bottle Washer	x		300	25;=2	
Centrifuge		x	400	25;=1	36;=1 or 2
Dryer		x	400	25;=2	
Mill		x	450	25;=1	36;=1 or 2
Palletiser		x	450	25;=1	
Separator		x	450	25;=1	36;=1 or 2
Slicer	x		300	25;=1	
Pulp and Paper					
Re-Pulper		x	450	25;=1	
Shredder		x	450	25;=1	
Trolley		x	450	25;=1	
Petrochemical					
Ball Mill		x	450	25;=1	
Centrifuge		x	400	25;=1	36;=1 or 2
Extruder		x	500	25;=1	
Screw Conveyor		x	400	25;=1	
Transport & Machine Tool					
Ball Mill		x	450	25;=1	
Grinder		x	350	25;=1	36;=1
Material Conveyor		x	400	25;=1	36;=1 / 38-40
Palletiser		x	450	25;=1	
Press		x	350	25;=1	
Roller Mill		x	450	25;=1	
Rotary Table		x	400	25;=1	36;=1 / 38-40
Trolley		x	450	25;=1	
Escalator		x	300-400	25;=1	
Lumber & Wood Products					
Bandsaw		x	450	25;=1	36;=1 or 2
Chipper		x	450	25;=1	36;=1 or 2
Circular Saw		x	350	25;=1	36;=1 or 2
Debarker		x	350	25;=1	36;=1 or 2
Planer		x	350	25;=1	36;=1 or 2
Sander		x	400	25;=1	36;=1 or 2

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4.5 The Application Functions List

This list gives an overview of many different applications/duties and a possible solution with one of the many MSF functions.

Description and use of the table:

- **Application /Duty.**
  This column gives the various applications and level of duty. If the machine or application is not in this list, try to identify a similar machine or application. If in doubt pleas contact your supplier.
- **Problem.**
  This column describes possible problems that are familiar for this kind of application.
- **Solution MSF.**
  Gives the possible solution for the problem using one the MSF function.
- **Menus.**
  Gives the menu numbers and selection for the MSF function.
  "25;=1", means: program selection 1 in menu 25.
  "36;=1 / 34,35", means: program selection 1 in menu 36, menus 34 and 35 are related to this function.

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Table 2 Application Function List

Application/ Duty	Problem	Solution MSF	Menus
PUMP Normal	Too fast start and stops	MSF Pump application with following start/stop features:	22
	Non linear ramps	Linear ramps without tacho.	
	Water hammer	Torque ramps for quadratic load	
	High current and peaks during starts.		
	Pump is going in wrong direction	Phase reversal alarm	88
	Dry running	Shaft power underload	96-99
	High load due to dirt in pump	Shaft power overload	92-95
COMPRESSOR Normal	Mechanical shock for compressor, motor and transmissions	Linear Torque ramp or current limit start.	25;=1 or 20,21
	Small fuses and low current available.		
	Screw compressor going in wrong direction	Phase sequence alarm	88
	Damaged compressor if liquid ammonia enters the compressor screw.	Shaft power overload	92-95
	Energy consumption due to compressor is running unloaded	Shaft power underload	96-99
CONVEYOR Normal/Heavy	Mechanical shocks for transmissions and transported goods.	Linear Torque ramp	25;=1
	Filling or unloading conveyors	Slow speed and accurate position control.	37-40,57,58
	Conveyor jammed	Shaft power overload	92-95
	Conveyor belt or chain is off but the motor is still running	Shaft power underload	96-99
	Starting after screw conveyor have stopped due to overload.	Jogging in reverse direction and then starting in forward.	
	Conveyor blocked when starting	Locked rotor function	75
FAN Normal	High starting current in end of ramps	Torque ramp for quadratic need	25;=2
	Slivering belts.		
	Fan is going in wrong direction when starting.	Catches the motor and going easy to zero speed and then starting in right direction.	
	Belt or coupling broken	Shaft power underload	96-99
	Blocked filter or closed damper.		
PLANER Heavy	High inertia load with high demands on torque and current control.	Linear Torque ramp gives linear acceleration and lowest possible starting current.	25;=1
	Need to stop quick both by emergency and production efficiency reasons.	Dynamic DC brake without Contactor for medium loads and controlled sensor less soft brake with reversing contactor for heavy loads.	36;=1,34,35 36;=2,34,35
	High speed lines	Conveyor speed set from planer shaft power analog output.	54-56
	Worn out tool	Shaft power overload	92-95
	Broken coupling	Shaft power underload	96-99
ROCK CRUSHER Heavy	High enertia	Linear Torque ramp gives linear acceleration and lowest possible starting current.	25;=1
	Heavy load when starting with material	Torque boost	30,31
	Low power if a diesel powered generator is used.		
	Wrong material in crusher	Shaft power overload	92-95
	Vibrations during stop	Dynamic DC brake without Contactor	36;=1,34,35
BANDSAW Heavy	High inertia load with high demands on torque and current control.	Linear Torque ramp gives linear acceleration and lowest possible starting current.	25;=1
	Need to stop quick both by emergency and production efficiency reasons.	Dynamic DC brake without Contactor for medium loads and controlled sensor less soft brake with reversing contactor for heavy loads.	36;=1,34,35 36;=2,34,35
	High speed lines	Conveyor speed set from band saw shaft power analog output.	54-56
	Worn out saw blade	Shaft power overload	
	Broken coupling, saw blade or belt	Shaft power underload	
CENTRIFUGE Heavy	High inertia load	Linear Torque ramp gives linear acceleration and lowest possible starting current.	25;=1
	To high load or unbalanced centrifuge	Shaft power overload	
	Controlled stop	Dynamic DC brake without Contactor for medium loads and controlled sensor less soft brake with reversing contactor for heavy loads.	36;=1,34,35 36;=2,34,35
	Need to open centrifuge in a certain position.	Braking down to slow speed and then positioning control.	37-40,57,58

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Table 2 Application Function List

Application/ Duty	Problem	Solution MSF	Menus
MIXER Heavy	Different materials	Linear Torque ramp gives linear acceleration and lowest possible starting current.	25;=1
	Need to control material viscosity	Shaft power analog output	54-56
	Broken or damaged blades	Shaft power overload	92-95
		Shaft power underload	96-99
HAMMER MILL Heavy	Heavy load with high breakaway torque	Linear Torque ramp gives linear acceleration and lowest possible starting current.	25;=1
		Torque boost in beginning of ramp.	30,31
	Jamming	Shaft power overload	92-95
	Fast stop	Controlled sensor less soft brake with reversing contactor for heavy loads.	36;=2,34,35
	Motor blocked	Locked rotor function	75

EXAMPLE:

Hammer Mill:

- This is an application for heavy duty,
- Main function Torque ramp start (menu 25) will give the best results.
- Torque boost to overcome high breakaway torque (menu 30 and 31)
- Overload alarm function for jamming protection (menu 92 and 95)
- Stop function Soft Brake (menu 36, selection 2) can be used. Menu 34 and 35 to set the brake time and strength.

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4.6 Function and combination matrix

Table 3 gives an overview of all possible functions and combination of functions.

1. Select function in the horizontal "Main Function" column. Only one function can be selected in this column, at a time.
2. In the vertical column "Additional Functions" you will find all possible function that can be used together with your selected main function.

Table 3 Combination matrix

Main Functions **Additional functions**	Dual ramp start	Dual ramp stop	Bypass (032)	Power factor control (033)	Torque boost (030)	Jogging with keyboard/terminal	Timer controlled slow speed	External controlled slow speed	Complete protection	Parameter sets (061)	Dynamic Vector Brake (036-1)	Softbrake (036-2)
Voltage ramp start/stop (default)	X	X	X	X	X	X	X	X	X	X	X	
Torque control start/stop (menu 025)			X	X	X	X	X	X	X	X	X	
Voltage ramp with current limit (menu 020)		X	X	X	X	X	X	X	X	X	X	X
Current limit start (menu 021)		X	X	X	X	X	X	X	X	X	X	X
Pump control (menu 022)			X						X	X		
Analog input (menu 023)									X	X		
Direct on line start (menu 024)			X						X	X		

By using one parameter set, the following start/stop table is given.

NOTE! Voltage and torque ramp for starting only with softbrake.

Table 4 Start/stop combination.

START FUNCTION **STOP FUNCTION**	Voltage ramp stop	Torque control stop	Pump control	Analog input	Direct on line stop	Dynamic Vector Brake	Softbrake
Voltage ramp start	X				X	X	X
Torque control start		X			X	X	X
Current limit start	X				X	X	X
Voltage ramp with current limit	X				X	X	X
Pump control			X		X		
Analog input				X	X		
Direct on line start					X		

By using different parameter sets for start and stop, it is possible to combine all start and stop functions.

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4.7 Special condition

4.7.1 Small motor or low load

The minimum load current for the soft starter is 10% of the rated current of the soft starter. Except for the MSE-017 there the min. current is 2 A. Example MSE-210, rated current = 210 A. Min. Current 21 A. Please note that this is "min. load current" and not min. rated motor current.

4.7.2 Ambient temperature below 0°C

For ambient temperatures below 0°C e.g. an electrical heater must be installed in the cabinet. The soft starter can also be mounted in some other place, due to that the distance between the motor and the soft starter is not critical.

4.7.3 Phase compensation capacitor

If a phase compensation capacitor is to be used, it must be connected at the inlet of the soft starter, not between the motor and the soft starter.

4.7.4 Pole-changing contactor and two speed motor

The switching device must be connected between the output of the soft starter and the motor.

4.7.5 Shielded motor cable

It is not necessary to use shielded wires together with soft starters. This is due to the very low radiated emissions.

NOTE! The soft starter should be wired with shielded control cable to fulfill EMC regulations acc. to § 1.5, page 6.

4.7.6 Slip ring motors

Slip ring motors can not be used together with the soft starter. Unless the motor is rewinded (as a squirrel cage motor). Or keep the resistors in, please contact your supplier.

4.7.7 Pump control with soft starter and frequency inverter together

It is possible e.g. in a pump station with two or more pumps to use one frequency inverter on one pump and soft starters on each of the other pumps. The flow of the pumps can then be controlled by one common control unit.

4.7.8 Starting with counter clockwise rotating loads

It is possible to start a motor clockwise, even if the load and motor is rotating counter clockwise e.g. fans. Depending on the speed and the load "in the wrong direction" the current can be very high.

4.7.9 Running motors in parallel

When starting and running motors in parallel the total amount of the motor current must be equal or lower than the connected soft starter. Please note that it is not possible to make individual settings for each motor. The start ramp can only be set for an average starting ramp for all the connected motors. This applies that the start time may differ from motor to motor. This is also even if the motors are mechanically linked, depending on the load etc.

4.7.10 How to calculate heat dissipation in cabinets

See chapter 12. page 74 "Technical Data", "Power loss at rated motor load (I_N)", "Power consumption control card" and "Power consumption fan". For further calculations please contact your local supplier of cabinets, e.g. Rittal.

4.7.11 Insulation test on motor

When testing the motor with high voltage e.g. insulation test the soft starter must be disconnected from the motor. This is due to the fact that the thyristors will be seriously damage by the high peak voltage.

4.7.12 Operation above 1000 m

All ratings are stated at 1000 m over sea level.

If a MSF is placed for example at 3000 m it must be derated unless that the ambient temperature is lower than 40 C and compensate for this higher pressure.

To get information about motors and drives at higher altitudes please contact your supplier to get technical information nr 151.

4.7.13 Reversing

Motor reversing is always possible. See Fig. 31 on page 34 for the advised connection of the reverse contactors.

At the moment that the mains voltage is switched on, the phase sequence is monitored by the control board. This information is used for the Phase Reverse Alarm (menu 88, see § 7.22, page 56).

However if this alarm is not used (factory default), it is also possible to have the phase reversal contactors in the input of the soft starter.

5. OPERATION OF THE SOFT STARTER

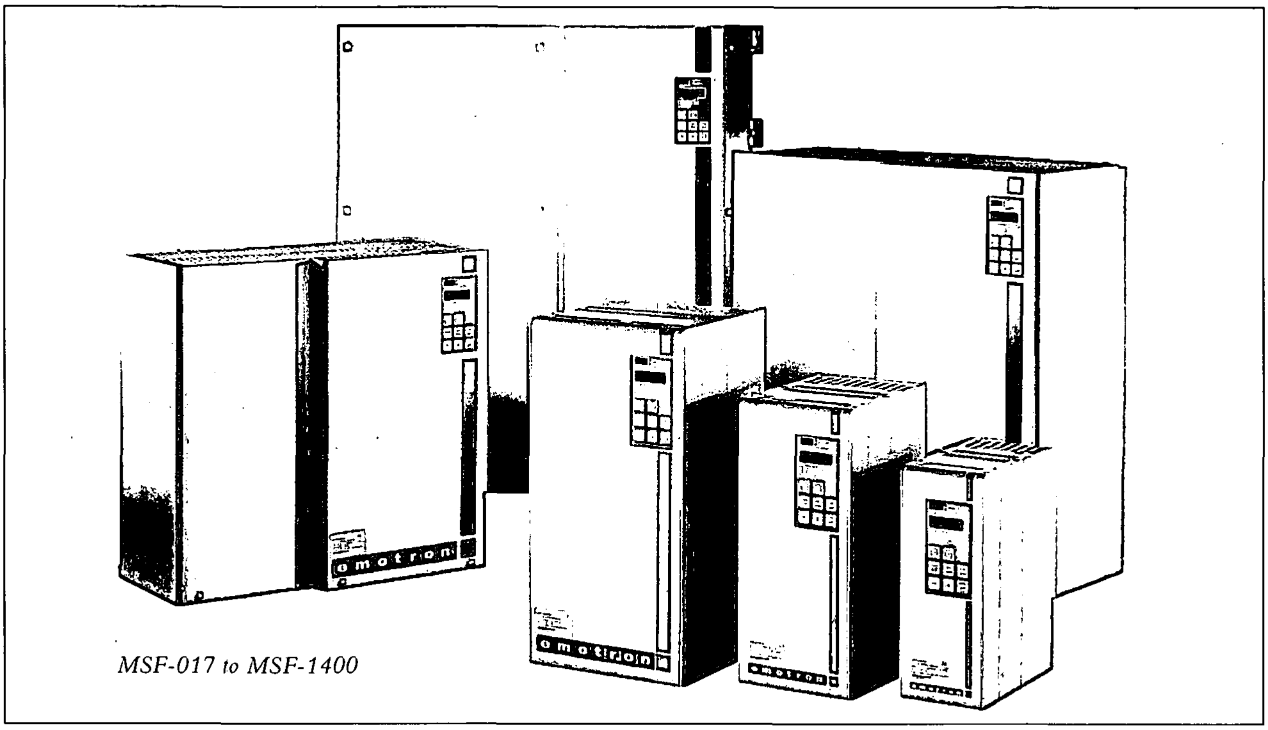

Fig. 12 MSF soft starter models.

5.1 General description of user interface

WARNING! Never operate the soft starter with removed front cover.

To obtain the required operation, a number of parameters must be set in the soft starter.

Setting/configuration is done either from the built-in keyboard or by a computer/control system through the serial interface or bus (option). Controlling the motor i.e. start/stop, selection of parameter set, is done either from the keyboard, through the remote control inputs or through the serial interface (option).

Setting

WARNING! Make sure that all safety measures have been taken before switching on the supply.

Switch on the supply (normally 1 x 230 V), all segments in the display will light up for a few seconds. Then the display will show menu 001. An illuminated display indicates there is supply voltage on the PCB.

Check that you have voltage on the mains contactor or on the thyristors. To be able to use all extended functions and optimize of the performance, program the motor data.

5.2 PPU unit

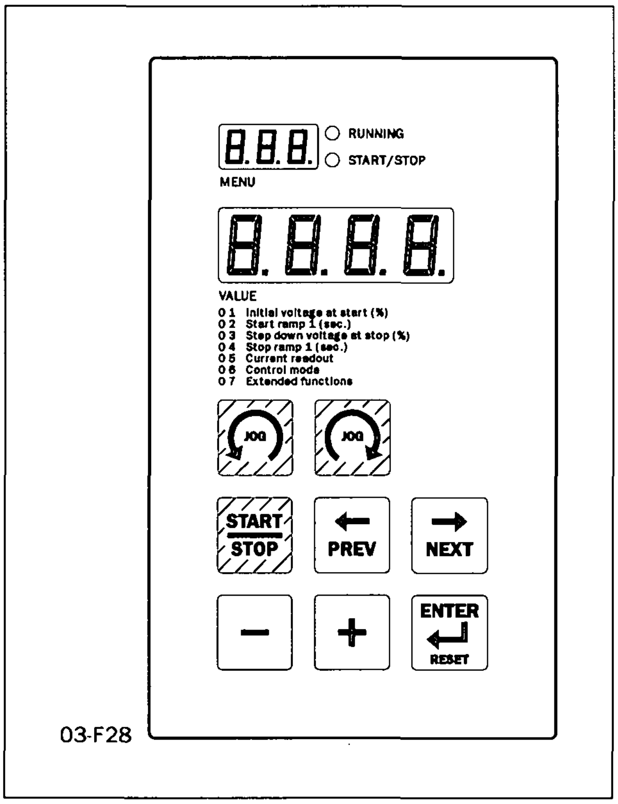

Fig. 13 PPU unit.

The programming and presentation unit (PPU) is a build-in operator panel with two light emitting diodes, three + four seven-segment LED-displays and a keyboard.

5.3 LED display

The two light emitting diodes indicates start/stop and running motor/machine. When a start command is given either from the PPU, through the serial interface (option) or through the remote control inputs, the start/stop-LED will be illuminated.

At a stop command the start/stop-LED will switch off. When the motor is running, the running-LED is flashing during ramp up and down and is illuminated continuously at full motor voltage.

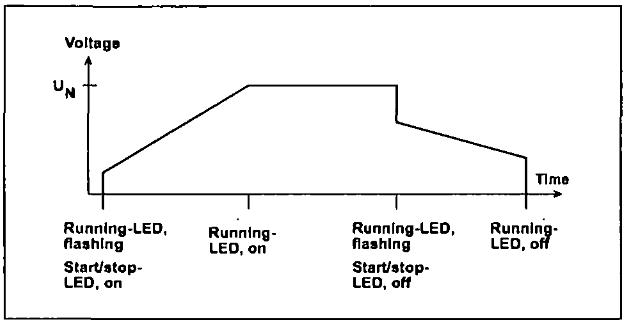

Fig. 14 LED indication at different operation situation.

5.4 The Menu Structure

The menus are organised in a simple one level structure with the possibility to limit the number of menus that are reachable by setting the value in menu 007 to "oFF" (factory setting). With this setting only the basic menus 001, 002, 003, 004, 005, 006 and 007 can be reached.

This to simplify the setting when only voltage start/stop ramps are used.

If menu 007 is in "on" and menu 008 "oFF" it is possible to reach all viewing menus and alarm lists as well.

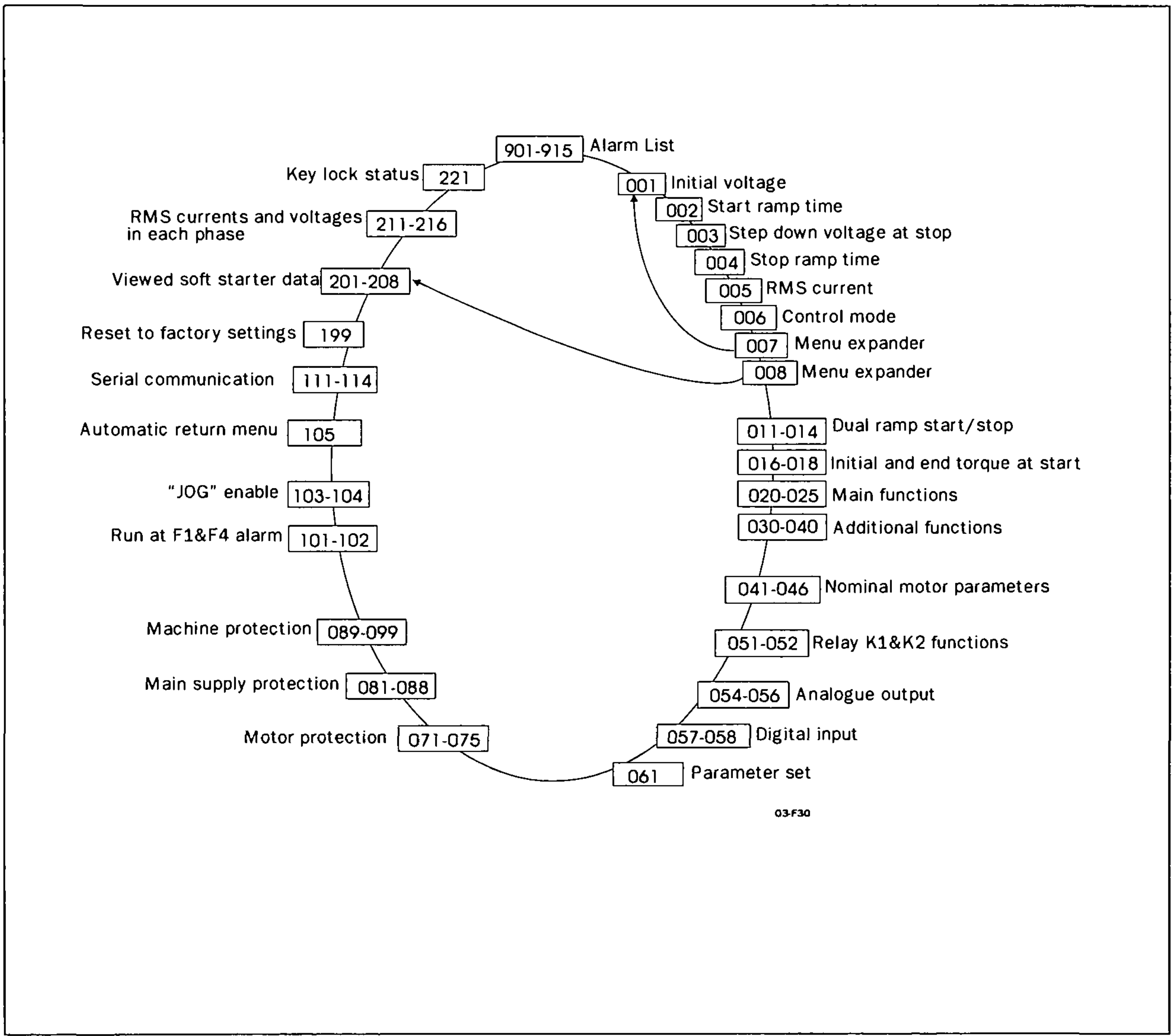

Fig. 15 Menu structure.

5.5 The keys

The function of the keyboard are based on a few simple rules. At power up menu 001 is shown automatically. Use the "NEXT →" and "PREV ←" keys to move between menus. To scroll through menu numbers, press and hold either the "NEXT →" or the "PREV ←" key. The "+" and "–" keys are used to increase respectively decrease the value of setting. The value is flashing during setting. The "ENTER ↵" key confirms the setting just made, and the value will go from flashing to stable. The "START/STOP" key is only used to start and stop the motor/machine.

The JOG and JOG keys are only used for JOG from the keyboard. Please note one has to select enable in menu 103 or 104, see § 7.25, page 61.

Table 5 The keys

Start/stop motor operation.	START STOP
Display previous menu.	← PREV
Display next menu.	→ NEXT
Decrease value of setting.	—
Increase value of setting.	+
Confirm setting just made. Alarm reset.	ENTER ↵ RESET
JOG Reverse	JOG
JOG Forward	JOG

5.6 Keyboard lock

The keyboard can be locked to prohibit operation and parameter setting by an unauthorised. Lock keyboard by pressing both keys "NEXT →" and "ENTER ↵" for at least 2 sec. The message '- Loc' will display when locked. To unlock keyboard press the same 2 keys "NEXT →" and "ENTER ↵" for at least 2 sec. The message 'unlo' will display when unlocked.

In locked mode it is possible to view all parameters and read-out, but it is forbidden to set parameters and to operate the soft starter from the keyboard.

The message '-Loc' will display if trying to set a parameter or operate the soft starter in locked mode.

The key lock status can be read out in menu 221.

221	**Locked keyboard info**
no	
Default:	no
Range:	no, YES
no	Keyboard is not locked
YES	Keyboard is locked

5.7 Overview of soft starter operation and parameter set-up.

Table with the possibilities to operate and set parameters in soft starter.

Control mode is selected in menu 006 and Parameter set is selected in menu 061. For the keyboard lock function, see § 7.30, page 65.

Table 6 Control modes

Control mode	Operation/ Set-up	Start/Stop	JOG fwd/rev	Alarm reset	Setting of parameters	
					Parameter set with external selection Menu 061=0	**Parameter set with internal selection Menu 061=1-4**
Keyboard Menu 006=1	Unlocked keyboard	Keyboard	Keyboard	Keyboard	———	Keyboard
	Locked keyboard	———	———	———	———	———
Remote Menu 006=2	Unlocked keyboard	Remote	Remote	Remote and keyboard	Remote	Keyboard
	Locked keyboard	Remote	Remote	Remote	Remote	———
Serial comm. Menu 006=3	Unlocked keyboard	Serial comm	Serial comm	Serial comm. and keyboard	———	Serial comm
	Locked keyboard	Serial comm	Serial comm	Serial comm	———	Serial comm

6. INSTALLATION AND CONNECTION

Mounting, wiring and setting the device into operation must be carried out by trained personnel (electricians specialised in heavy current technology):

- In accordance with the local safety regulations of the electricity supply company.
- In accordance with DIN VDE 0100 for setting up heavy current plants.

Care must be taken to ensure that personnel do not come into contact with live circuit components.

⚠ **WARNING! Never operate the soft starter with removed front cover.**

6.1 Installation of the soft starter in a cabinet

When installing the soft starter:

- Ensure that the cabinet will be sufficiently ventilated, after the installation.
- Keep the minimum free space, see the tables on page 25.
- Ensure that air can flow freely from the bottom to the top.

NOTE! When installing the soft starter, make sure it does not come into contact with live components. The heat generated must be dispersed via the cooling fins to prevent damage to the thyristors (free circulation of air).

MSF-017 to MSF-835 soft starters are all delivered as enclosed versions with front opening. The units have bottom entry for cables etc. see Fig. 25 on page 29 and Fig. 27 on page 31. MSF-1000 and MSF-1400 are delivered as open chassis.

NOTE! The soft starter should be wired with shielded control cable to fulfill EMC regulations acc. to § 1.5, page 6.

NOTE! For UL-approval use 75°C Copper wire only.

MSF-017 to MSF-250

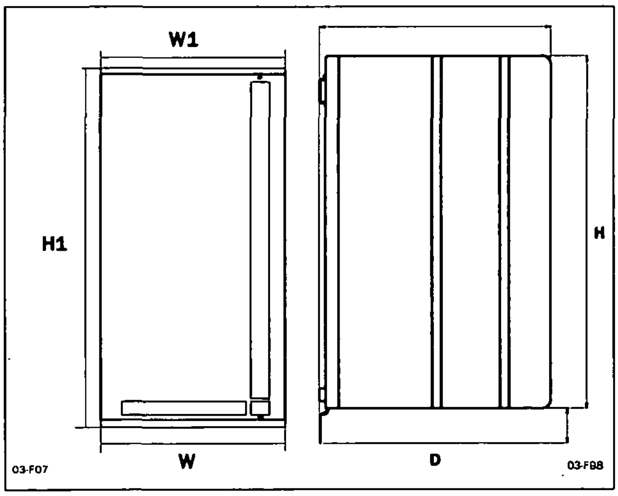

Fig. 16 MSF-017 to MSF-250 dimensions.

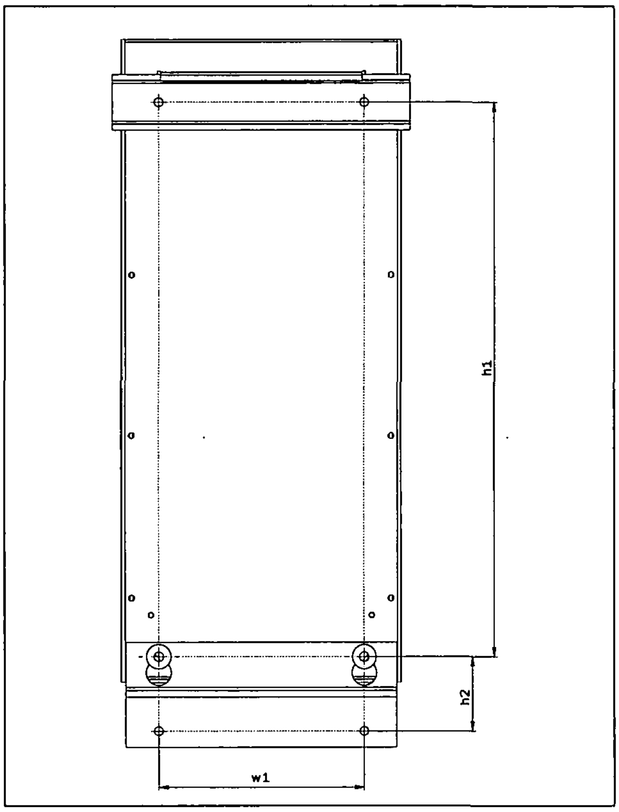

Fig. 17 Hole pattern for MSF-017 to MSF-250 (backside view).

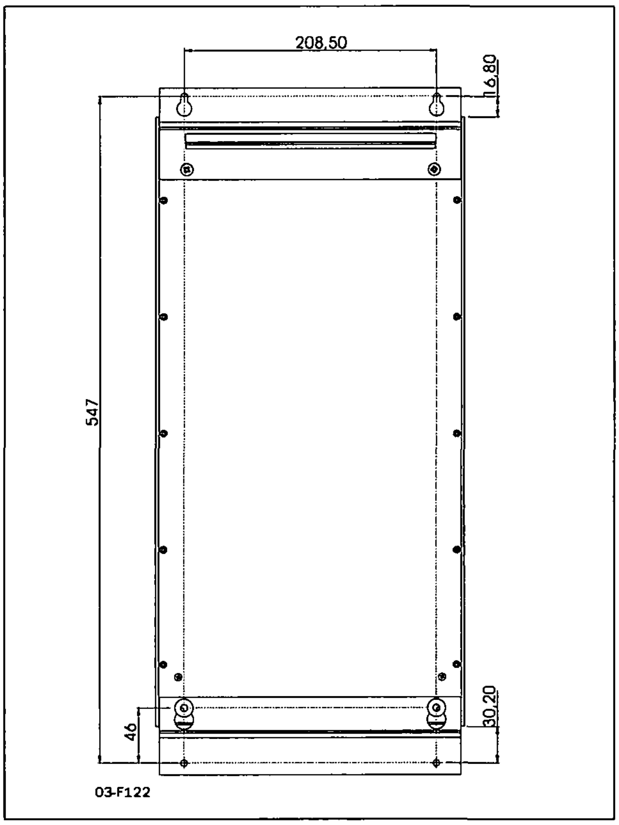

Fig. 18 Hole pattern for MSF-170 to MSF-250 with upper mounting bracket instead of DIN-rail.

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MSF-017 to MSF-250

Table 7 MSF-017 to MSF-250.

MSF model	Class	Connection	Conv./ Fan	Dimension HxWxD (mm)	Hole dist. w1 (mm)	Hole dist. h1 (mm)	Diam./ screw	Weight (kg)
-017, -030	IP 20	Busbars	Convection	320x126x260	78.5	265	5.5/M5	6.7
-045, -060, -075, -085	IP 20	Busbars	Fan	320x126x260	78.5	265	5.5/M5	6.9
-110, -145	IP 20	Busbars	Fan	400x176x260	128.5	345	5.5/M5	12.0
-170, -210, -250	IP 20	Busbars	Fan	500x260x260	208.5	445	5.5/M5	20

Table 8 MSF-017 to MSF-250

MSF model	Minimum free space (mm):			Dimension Connection busbars Cu	Tightening torque for bolt (Nm)		
	above 1)	below	at side		Cable	PE-cable	Supply and PE
-017, -030, -045	100	100	0	15x4 (M6), PE (M6)	8	8	0.6
-060, -075, -085	100	100	0	15x4 (M8), PE (M6)	12	8	0.6
-110,-145	100	100	0	20x4 (M10), PE (M8)	20	12	0.6
-170, -210, -250	100	100	0	30x4 (M10), PE (M8)	20	12	0.6
1) Above: wall-soft starter or soft starter-soft starter							

MSF-310 to MSF-1400

Table 9 MSF-310 to MSF-1400 see Fig. 20 on page 26.

MSF model	Class	Connection	Conv./ Fan	Dimension HxWxD (mm)	Hole dist. w1 (mm)	Hole dist. h1 (mm)	Diam./ screw	Weight (kg)
-310	IP 20	Busbars	Fan	532x547x278	460	450	8.5/M8	42
-370, -450	IP 20	Busbars	Fan	532x547x278	460	450	8.5/M8	46
-570	IP 20	Busbars	Fan	687x640x302	550	600	8.5/M8	64
-710	IP 20	Busbars	Fan	687x640x302	550	600	8.5/M8	78
-835	IP 20	Busbars	Fan	687x640x302	550	600	8.5/M8	80
-1000, -1400	IP00	Busbar	Fan	900x875x336	Fig. 23		8.5/M8	175

Table 10 MSF-310 to MSF-1400.

MSF model	Minimum free space (mm):			Dimension Connection, busbars Al	Tightening torque for bolt (Nm)		
	above 1)	below	at side		Cable	PE-cable	Supply and PE
-310, -370, -450	100	100	0	40x8 (M12)	50	12	0.6
-570, -710, -835	100	100	0	40x10 (M12)	50	12	0.6
-1000, -1400	100	100	100	75x10 (M12)	50	12	0.6
1) Above: Wall-soft starter or soft starter-soft starter							

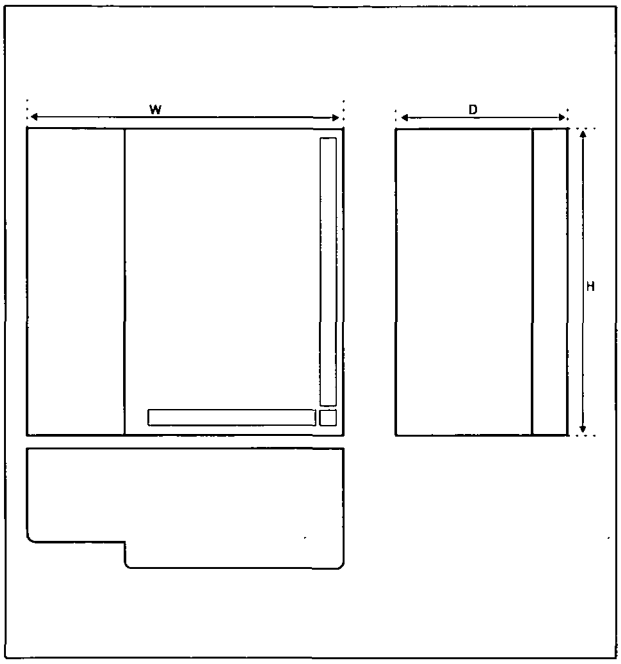


Fig. 19 MSF -310 to MSF -835.

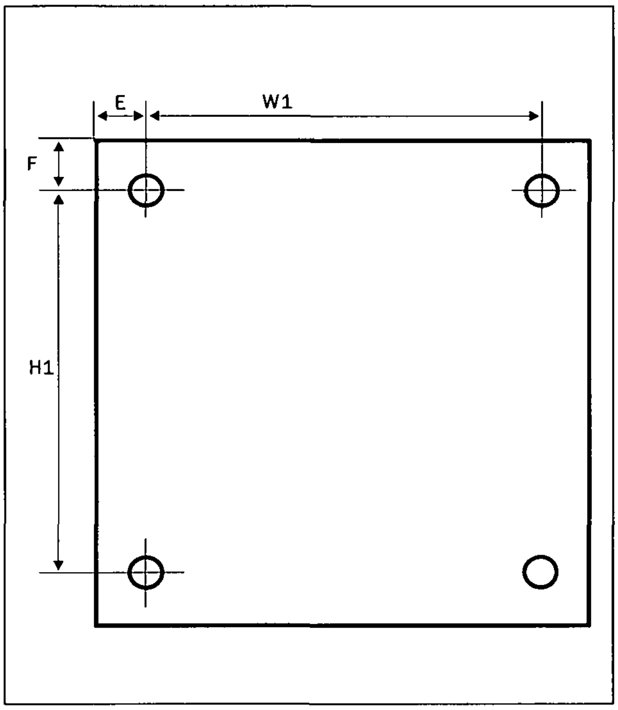


Fig. 20 Hole pattern for screw attachment, MSF-310 to MSF-835. Hole distance (mm).

MSF	e	f
-310 to -450	44	39
-570 to -835	45.5	39

Observe that the two supplied mounting hooks (see § 1.8, page 7 and Fig. 2 on page 7 must be used for mounting the soft starter as upper support (only MSF-310 to MSF-835).

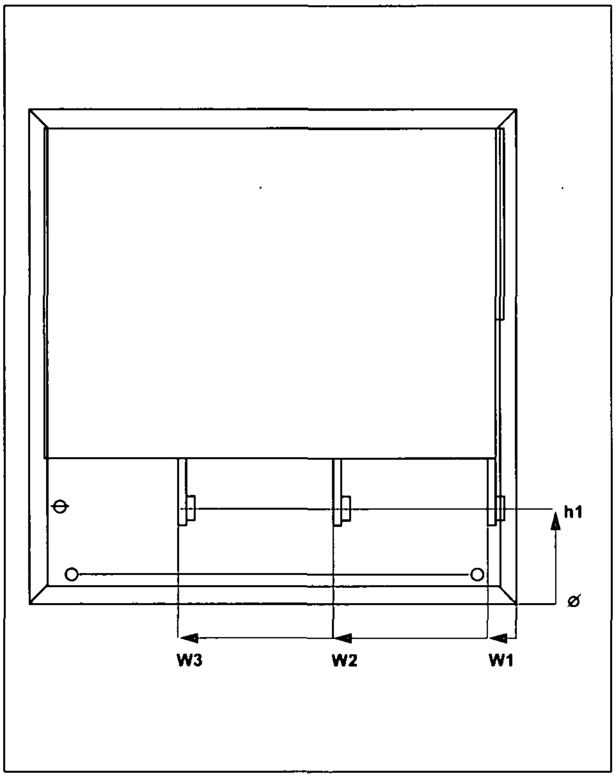


Fig. 21 Busbar distances MSF -310 to MSF -835.

Table 11 Busbar distances

MSF model	Dist. h1 (mm)	Dist. w1 (mm)	Dist. w2 (mm)	Dist. w3 (mm)
-310 to -450	104	33	206	379
-570 to -835	129	35	239.5	444
-1000 -1400		55	322.5	590.5

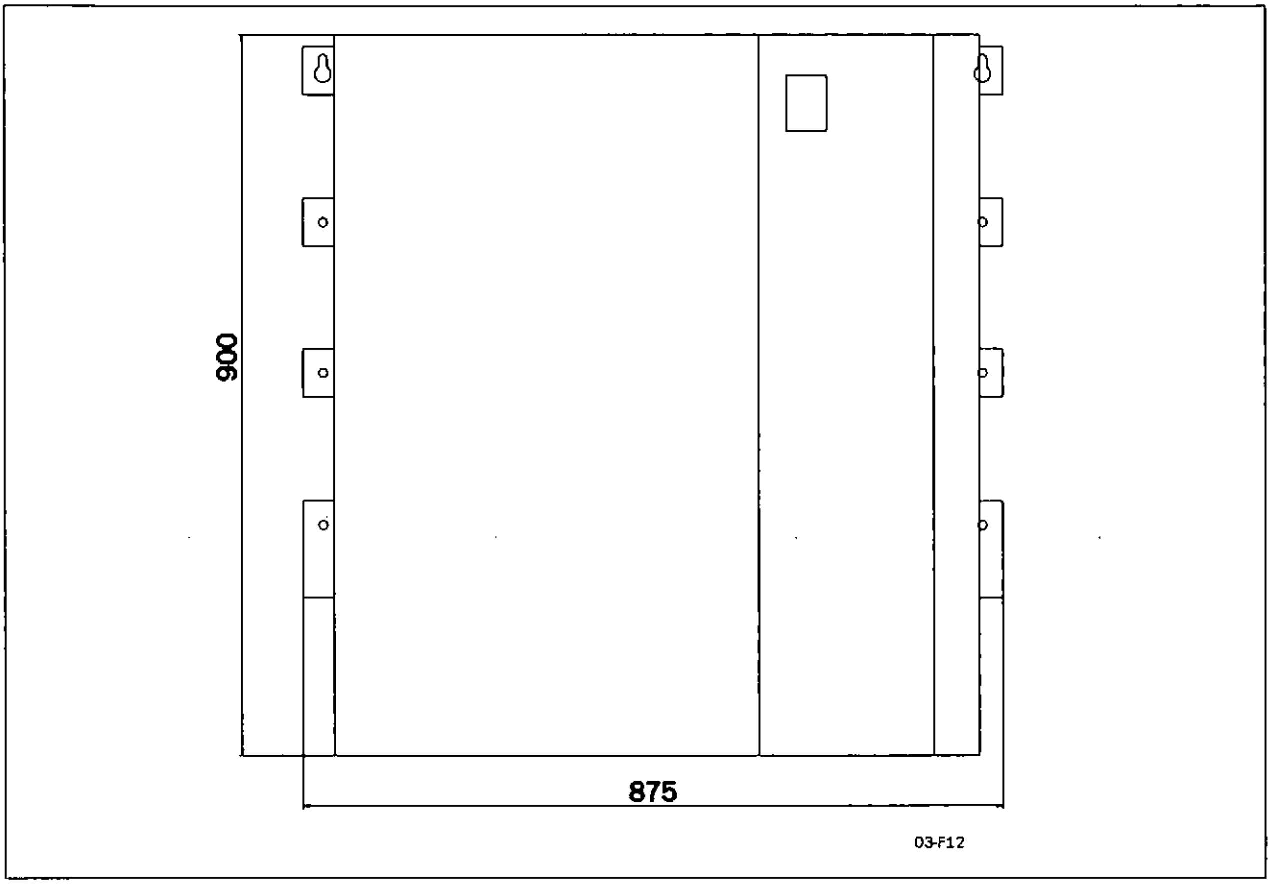


Fig. 22 MSF -1000 to -1400

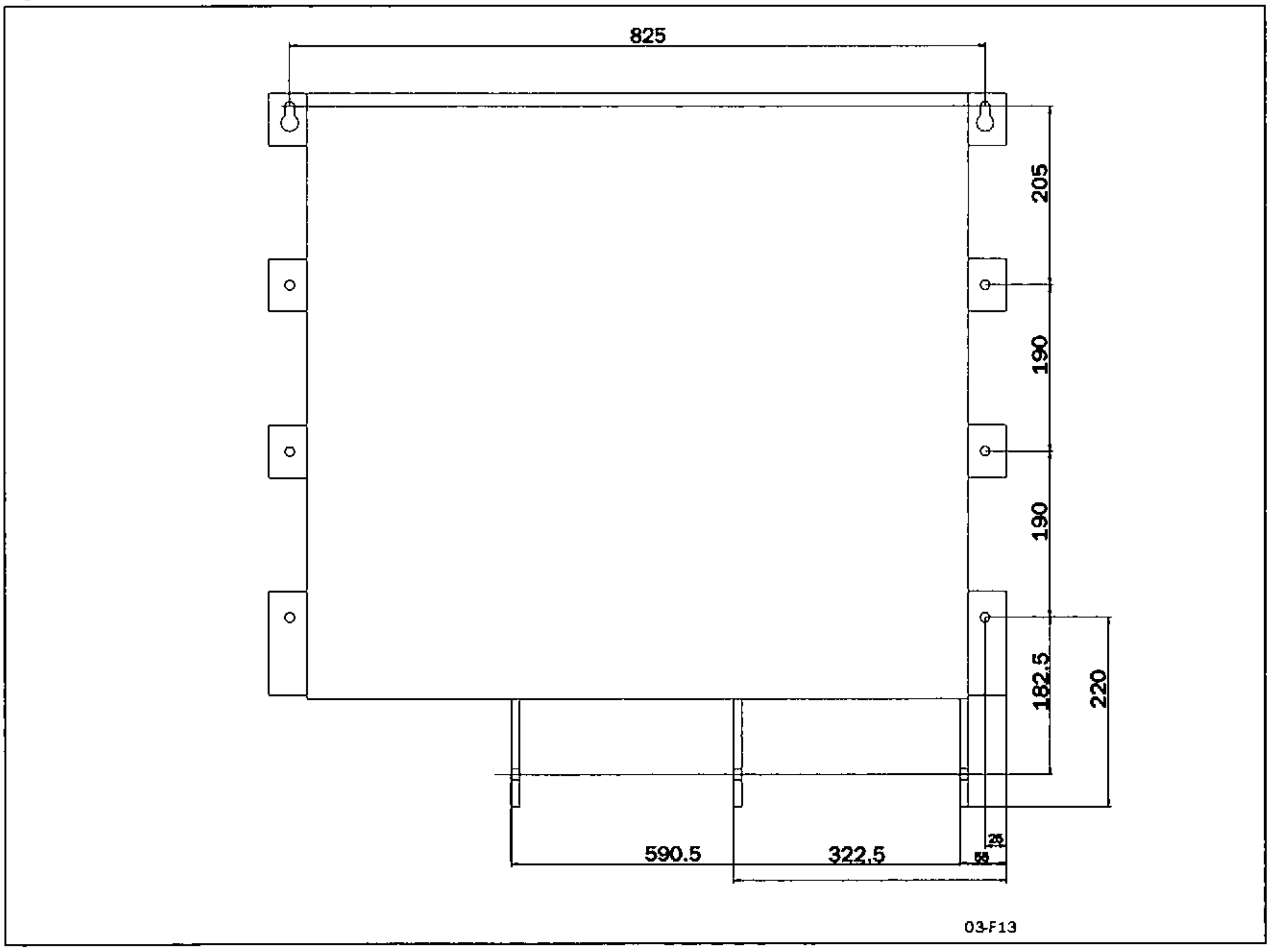


Fig. 23 Hole pattern busbar MSF -1000 to -1400.

6.2 Connections

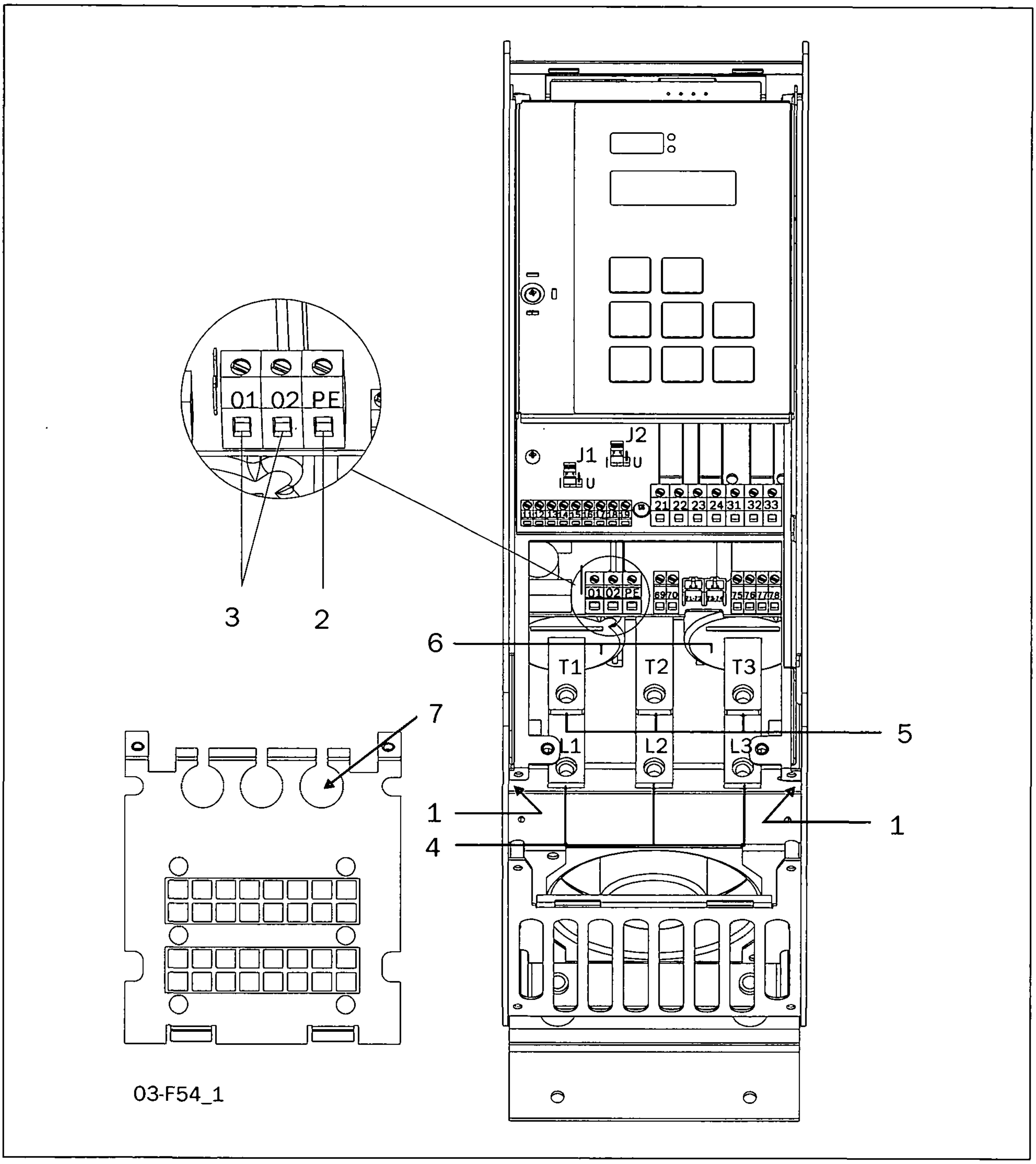


Fig. 24 Connection of MSF-017 to MSF -085.

Connection of MSF-017 to MSF-085

Device connections

1. Protective earth, ⏚ **(PE)**, Mains supply, Motor (on the right and left inside of the cabinet)
2. Protective earth, ⏚ **(PE)**, Control voltage
3. Control voltage connection **01, 02**
4. Mains supply **L1, L2, L3**
5. Motor power supply **T1, T2, T3**
6. Current transformers (possible to mount outside for bypass see § 7.12, page 43)
7. Mounting of EMC gland for control cables

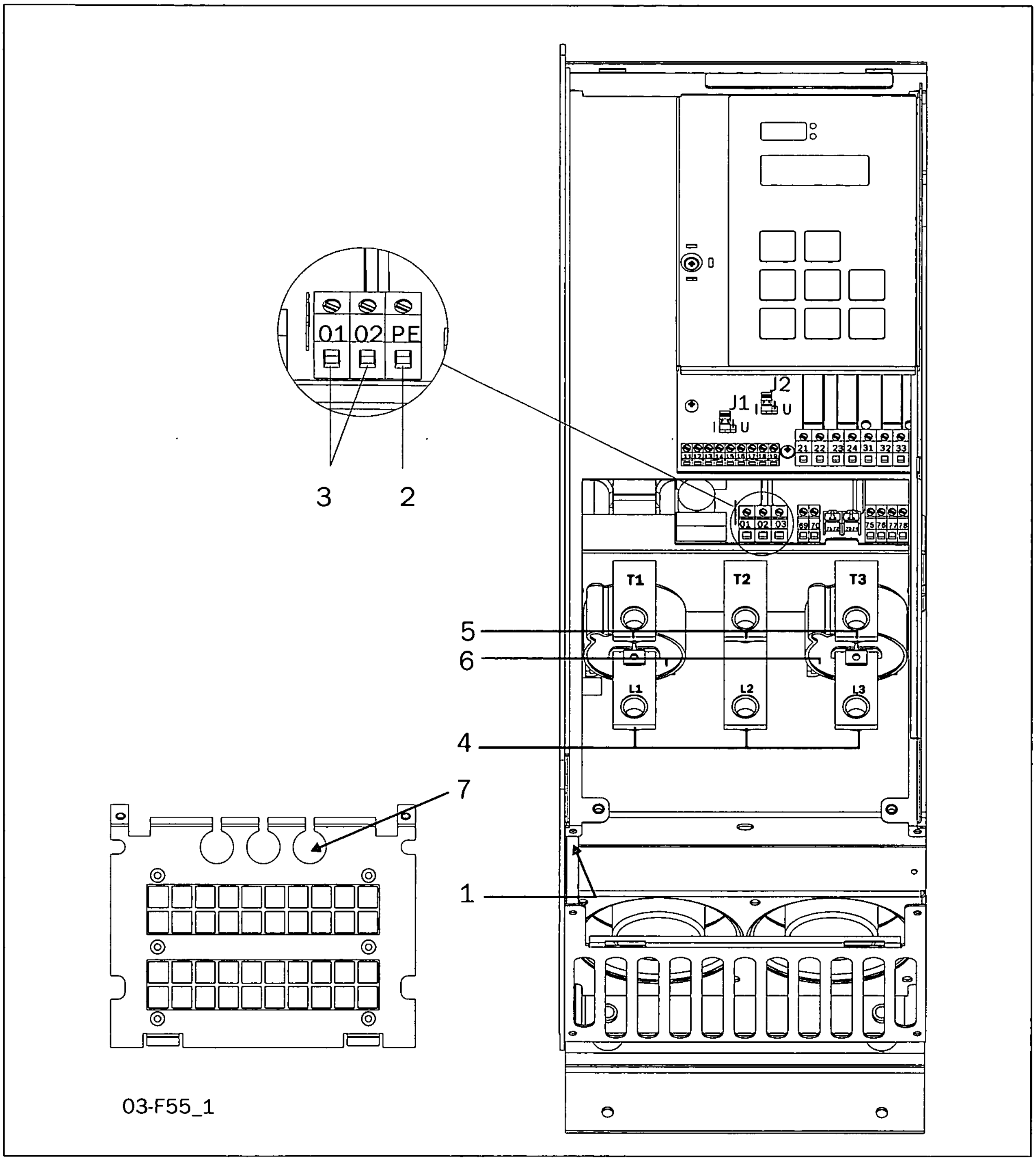


Fig. 25 Connection of MSF-110 to MSF-145.

Connection of MSF-110 to MSF-145

Device connections

1. Protective earth, ⏚ **(PE)**, Mains supply, Motor (on the left inside of the cabinet)
2. Protective earth ⏚ **(PE)**, Control voltage
3. Control voltage connection **01, 02**
4. Mains supply **L1, L2, L3**
5. Motor power supply **T1, T2, T3**
6. Current transformers (possible to mount outside for bypass see § 7.12, page 43)
7. Mounting of EMC gland for control cables

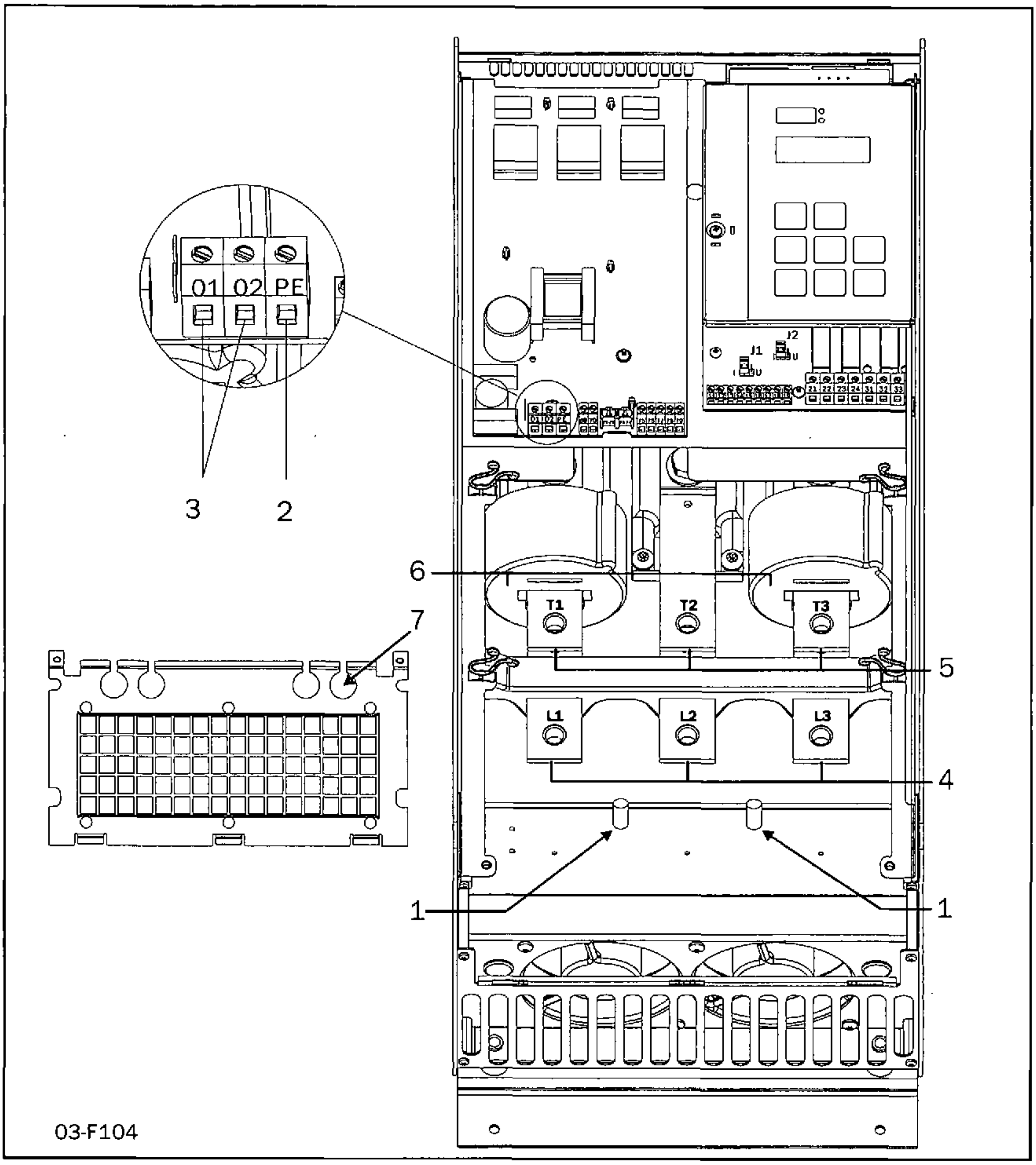


Fig. 26 Connection of MSF-170 to MSF-250

Connection of MSF-170 to MSF-250

Device connections

1. Protective earth, ⏚ **(PE)**, Mains supply, Motor (on the left inside of the cabinet)
2. Protective earth ⏚ **(PE)**, Control voltage
3. Control voltage connection **01, 02**
4. Mains supply **L1, L2, L3**
5. Motor power supply **T1, T2, T3**
6. Current transformers (possible to mount outside for bypass see § 7.12, page 43)
7. Mounting of EMC gland for control cables

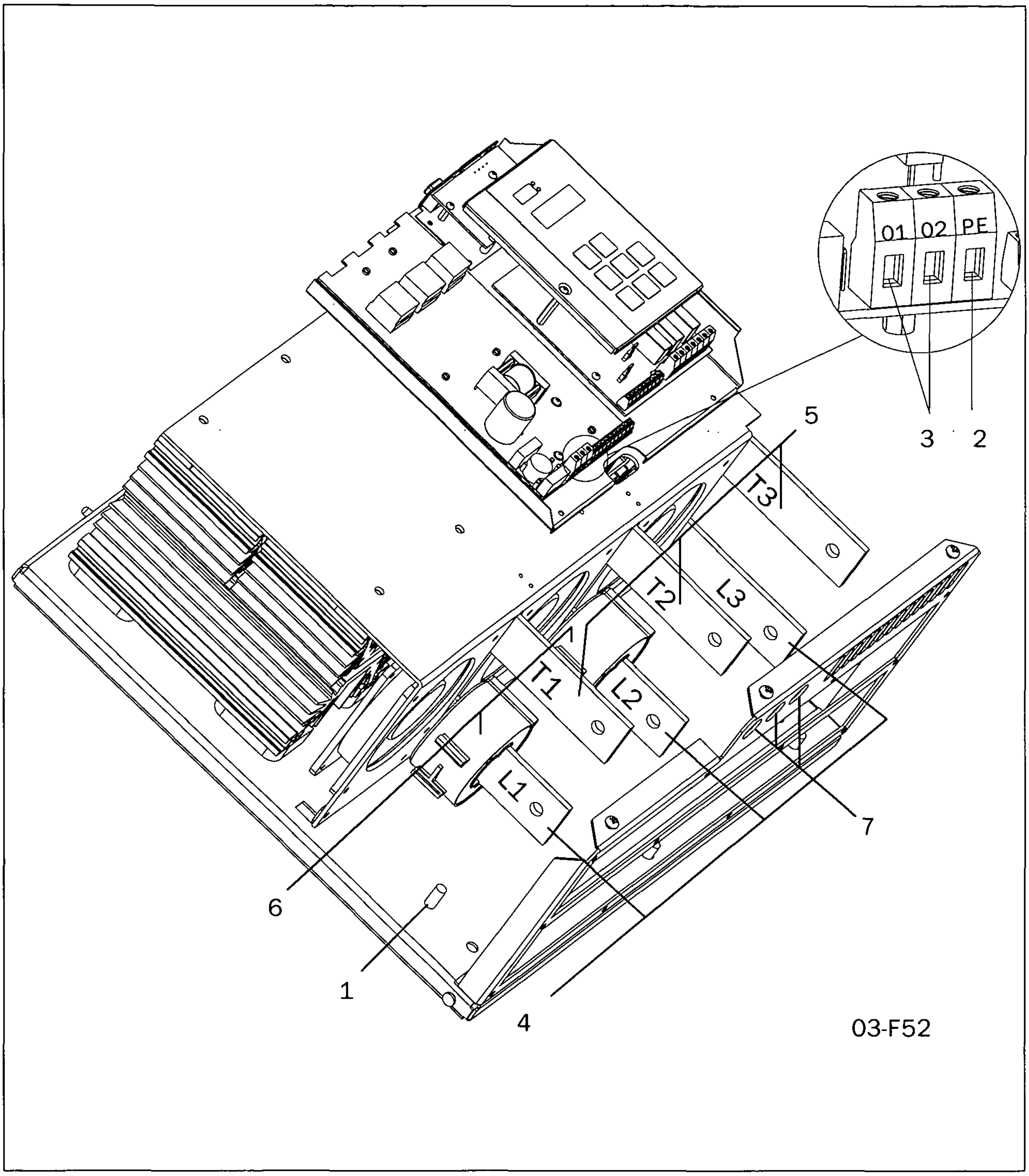


Fig. 27 Connection of MSF-170 to MSF-1400.

Connection of MSF-310 to MSF-1400

Device connections

1. Protective earth, ⏚ **(PE)**, Mains supply and Motor
2. Protective earth, ⏚ **(PE)**, Control voltage
3. Control voltage connection **01, 02**
4. Mains supply **L1, L2, L3**
5. Motor power supply **T1, T2, T3**
6. Current transformers (possible to mount outside for bypass see § 7.12, page 43)
7. Mounting of EMC gland for control cables

6.3 Connection and setting on the PCB control card

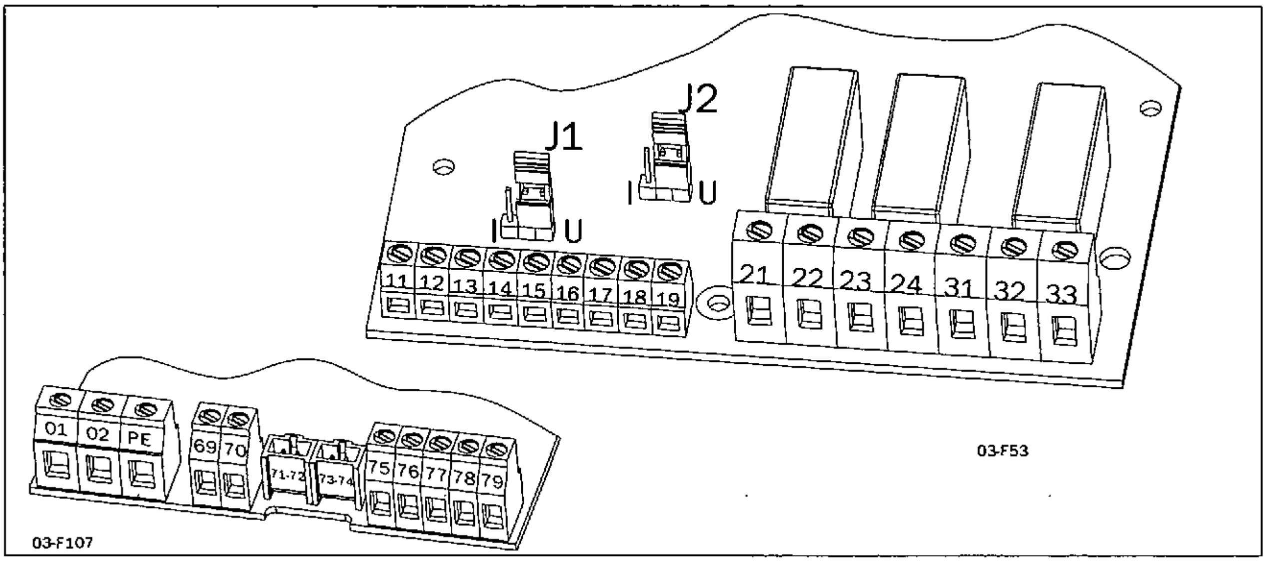


Fig. 28 Connections on the PCB, control card.

Table 12 PCB Terminals

Terminal	Function	Electrical characteristics
01	Supply voltage	100-240 VAC ±10%/380-500 VAC ± 10%
02		
PE	Gnd	⏚
11	Digital inputs for start/stop and reset.	0-3 V -> 0; 8-27 V-> 1. Max. 37 V for 10 sec. Impedance to 0 VDC: 2.2 kΩ.
12		
13	Supply/control voltage to PCB terminal 11 and 12, 10 kΩ potentiometer, etc.	+12 VDC ±5%. Max. current from +12 VDC: 50mA. Short circuit proof.
14	Remote analogue input control, 0-10 V, 2-10 V, 0-20 mA and 4-20 mA/digital input.	Impedance to terminal 15 (0 VDC) voltage signal: 125 kΩ, current signal: 100 Ω.
15	GND (common)	0 VDC
16	Digital inputs for selection of parameter set.	0-3 V --> 0; 8-27 V--> 1. Max. 37 V for 10 sec. Impedance to 0 VDC: 2.2 kΩ.
17		
18	Supply/control voltage to PCB terminal 16 and 17, 10 kΩ potentiometer, etc.	+12 VDC ±5%. Max. current from +12 VDC = 50mA. Short circuit proof.
19	Remote analogue output control	Analogue Output contact: 0-10V, 2-10V; min load impedance 700Ω 0-20mA and 4-20mA;max load impedance 750Ω
21	Programmable relay K1. Factory setting is "Operation" indication by closing terminal 21 - 22.	1-pole closing contact, 250 VAC 8A or 24 VDC 8A resistive, 250 VAC, 3A inductive.
22		
23	Programmable relay K2. Factory setting is "Full voltage" indication by closing terminal 23-24.	1-pole closing contact, 250 VAC 8A or 24 VDC 8A resistive, 250 VAC, 3A inductive.
24		
31	Alarm relay K3, closed to 33 at alarm.	1-pole change over contact, 250 VAC 8A or 24 VDC 8A resistive, 250 VAC, 3A inductive.
32	Alarm relay K3, opened at alarm.	
33	Alarm relay K3, common terminal.	
69-70	PTC Thermistor input	Alarm level 2.4 kΩ Switch back level 2.2 kΩ.
71-72*	Clickson thermistor	Controlling soft starter cooling fine temperature MSF-310 - MSF-1400
73-74*	NTC thermistor	Temperature measuring of soft starter cooling fine
75	Current transformer input, cable S1 (blue)	Connection of L1 or T1 phase current transformer
76	Current transformer input, cable S1 (blue)	Connection of L3, T3 phase (MSF 017 - MSF 250) or L2, T2 phase (MSF 310 - MSF 1400)
77	Current transformer input, cable S2 (brown)	Common connection for terminal 75 and 76
78*	Fan connection	24 VDC
79*	Fan connection	0 VDC

*Internal connection, no customer use.

6.4 Minimum wiring

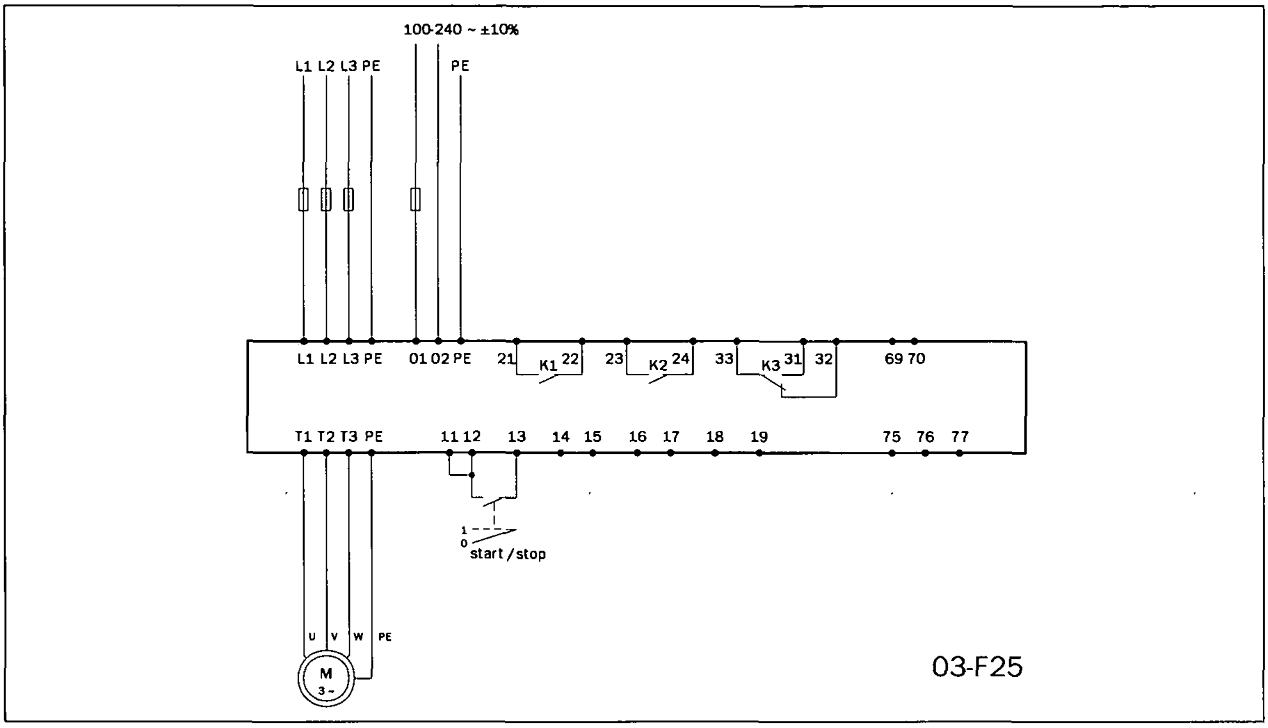


Fig. 29 Wiring circuit, "Minimum wiring".

The figure above shows the "minimum wiring". See § 6.1, page 24, for tightening torque for bolts etc.

1. Connect Protective Earth (PE) to earth screw marked ⏚ (PE).
2. Connect the soft starter between the 3-phase mains supply and the motor. On the soft starter the mains side is marked L1, L2 and L3 and the motor side with T1, T2 and T3.
3. Connect the control voltage (100-240 VAC) for the control card at terminal 01 and 02.
4. Connect relay K1 (terminals 21 and 22) to the control circuit.
5. Connect PCB terminal 12 and 13 (PCB terminal 11-12 must be linked) to, e.g. a 2-position switch (on/oFF) or a PLC, etc., to obtain control of soft start/stop. (For start/stop command from keyboard menu 006 must be set to 01).
6. Ensure the installation complies with the appropriate local regulations.

NOTE! The soft starter should be wired with shielded control cable to fulfill EMC regulations acc. to § 1.5, page 6.

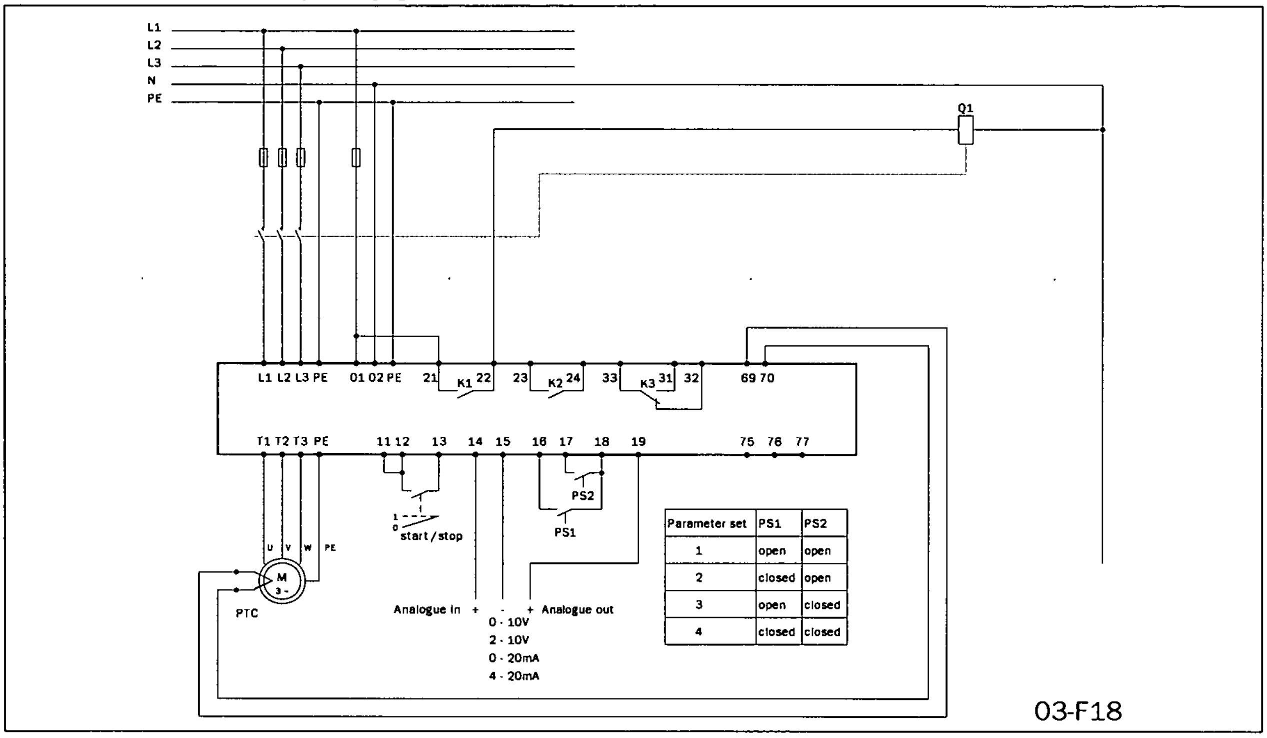
NOTE! If local regulations say that a mains contactor should be used, the K1 then controls it. Always use standard commercial, slow blow fuses, e.g. type gl, gG to protect the wiring and prevent short circuiting. To protect the thyristors against short-circuit currents, superfast semiconductor fuses can be used if preferred. The normal guarantee is valid even if superfast semiconductor fuses are not used. All signal inputs and outputs are galvanically insulated from the mains supply.

6.5 Wiring examples

Fig. 30 gives an wiring example with the following functions.

- Analogue input control, see § 7.7, page 40
- Parameter set selection, see § 7.20, page 54
- Analogue output, see § 7.18, page 52
- PTC input, see § 7.21, page 55

For more information see § 6.3, page 32.



Parameter set	PS1	PS2
1	open	open
2	closed	open
3	open	closed
4	closed	closed

Fig. 30 Analogue input control, parameter set, analogue output and PTC input.

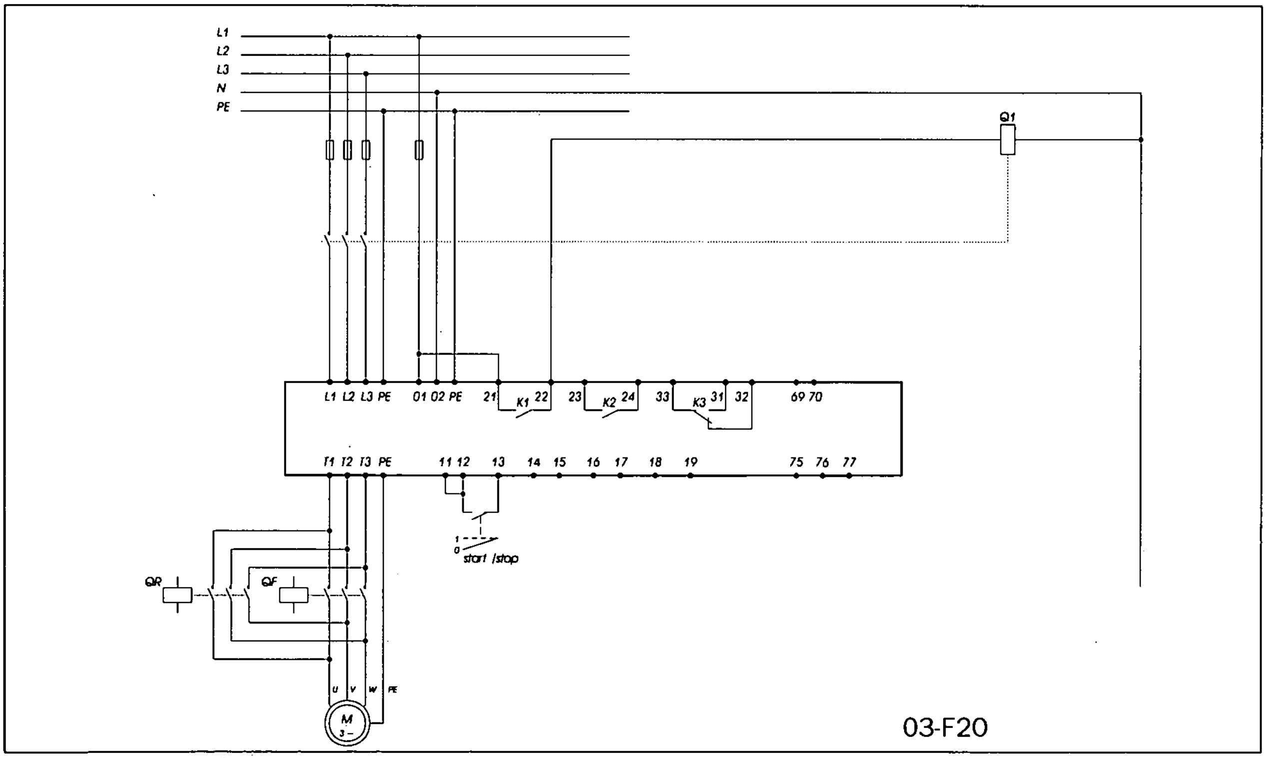


Fig. 31 Forward/reverse wiring circuit.

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7. FUNCTIONAL DESCRIPTION SET-UP MENU

This chapter describes all the parameters and functions in numerical order as they appear in the MSF. Table 13 gives an overview of the menus, see also Chapter 13. page 79 (set-up menu list).

Table 13 Set-up Menu overview

	Menu number	Parameter group		Menu numbers	See §
Basic functions	001-008	Basic	Ramp up/down parameters	001-005	7.1
			Start/Stop/Reset command	006	7.2
			Menu Expansion	007-008	7.3
Extended functions	011-199	Voltage control dual ramp		011-014	7.4
		Torque control parameters		016-018	7.5
		Main functions		020-025	7.6 - 7.10
		Additional functions		030-036	7.11 - 7.14
		Slow speed and Jog functions		037-040, 57-58, 103-104	7.15, 7.19, 7.25
		Motor Data Setting		041-046	7.16
		Outputs	Relays	051-052	7.17
			Analogue output	054-056	7.18
		Input	Digital input	057-058	7.19
		Parameter set selection		061	7.20
			Motor protection	071-075	7.21
			Main protection	081-088	7.22
			Application protection	089-099	7.23
			Resume alarms	101, 102	7.24
		Auto return menu		105	7.26
		Factory defaults		199	7.28
View functions	201-915	Main view		201-208	7.29
		RMS current per phase		211-213	7.29
		RMS voltage per phase		214-216	7.29
		Keyboard lock status		221	7.30
		Alarm list		901-915	7.31

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7.1 Ramp up/down parameters

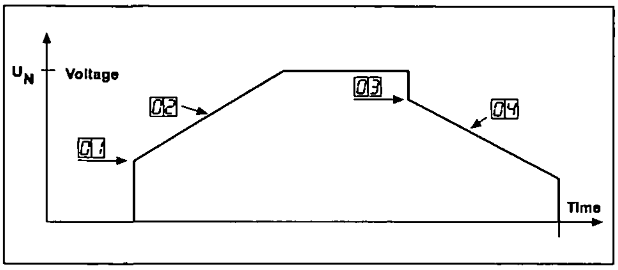


Fig. 32 Menu numbers for start/stop ramps, initial voltage at start and step down voltage at stop.

Determine the starting time for the motor/machine. When setting the ramp times for starting and stopping, initial voltage at start and step down voltage at stop, proceed as follow:

001

30

Setting the initial voltage at start ramp 1

Default:	30%
Range:	25 - 90% U_n
Set the initial voltage. Normally the factory setting, 30% of U_n, is a suitable choice.	

002

10

Setting of start ramp 1

Default:	10 sec
Range:	1-60 sec
Set "Ramp up time" at start.	

003

100

Setting of step down voltage stop ramp 1

Default:	100%
Range:	100-40% of U_n
Step down voltage at stop can be used to stop smoothly.	

004

oFF

Setting of stop ramp 1

Default:	oFF
Range:	oFF, 2-120 sec
oFF	Stop ramp disabled
2-120	Set "Ramp down time" at stop

7.1.1 RMS current [005]

005

0.0

RMS current

Default:	—
Range:	0.0-9999Amp
Read-out of the RMS motor current.	

NOTE! This is the same read-out as function 201, see § 7.28, page 63.

7.2 Start/stop/reset command

Start/stop of the motor and reset of alarm is done either from the keyboard, through the remote control inputs or through the serial interface (option). The remote control inputs start/stop/reset (PCB terminals 11, 12 and 13) can be connected for 2-wire or 3-wire control.

006 2	**Selection of control mode**
Default:	2
Range:	1,2,3
1	START/STOP/RESET command via the keyboard. - Press the "START/STOP" key on the keyboard to start and stop the soft starter. - Press "ENTER/RESET" key to reset a trip condition.
2	Via Remote control. START/STOP/ RESET commands. The following control methods are possible: - 2-wire start/stop with automatic reset, see § 7.2.1, page 37. - 2-wire start/stop with separate reset, see § 7.2.2, page 37. - 3-wire start/stop with automatic reset at start, see § 7.2.3, page 37. **WARNING! The motor will start if terminals 11, 12, 13 is in start position.**
3	START/STOP/RESET commands via serial interface option. Read the operating instruction supplied with this option.

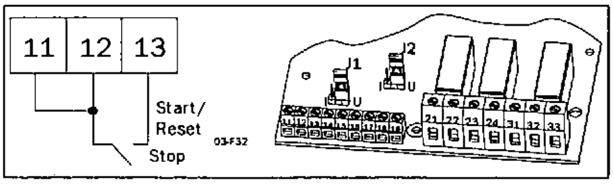
NOTE! A reset via the keyboard will not start or stop the motor.

NOTE! Factory default setting is 2, remote control.

To start and stop from the keyboard, the "START/ STOP" key is used.

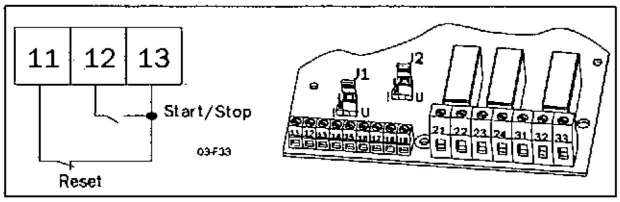
To reset from the keyboard, the "ENTER ↵ / RESET" key is used. A reset can be given both when the motor is running and when the motor is stopped. A reset from the keyboard will not start or stop the motor.

7.2.1 2-wire start/stop with automatic reset at start



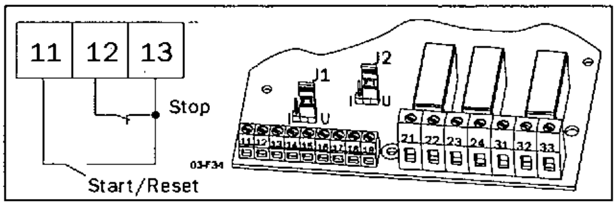
Closing PCB terminals 12 and 13, and a jumper between terminal 11 and 12, will give a start command. Opening the terminals will give a stop. If PCB terminals 12 and 13 is closed at power up a start command is given (automatic start at power up). When a start command is given there will automatically be a reset.

7.2.2 2-wire start/stop with separate reset



Closing PCB terminals 11, 12 and 13 will give a start and opening the terminals 12 and 13 will give a stop. If PCB terminals 12 and 13 are closed at power up a start command is given (automatic start at power up). When PCB terminals 11 and 13 are opened and closed again a reset is given. A reset can be given both when the motor is running and stopped and doesn't affect the start/stop.

7.2.3 3-wire start/stop with automatic reset at start.



PCB terminal 12 and 13 are normally closed and PCB terminal 11 and 13 are normally open. A start command is given by momentarily closing PCB terminal 11 and 13. To stop, PCB terminal 12 and 13 are momentarily opened.

When a start command is given there will automatically be a reset. There will not be an automatic start at power up.

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7.3 Menu expansion setting.

In order to use the viewing menus and/or the extended functions menu 007 must be set to "On", then one reach read out of the viewing menus 201-915. To be able to set any extended functions in the menus 011-199 menu 008 must be set to "on" as well.

007

oFF

Selecting of extended functions and viewing functions

Default:	oFF
Range:	oFF, on
oFF	Only function 1-7 are visible
on	- View functions 201-915 are visible - Extended functions (menu 008) selectable

008

oFF

Selecting of extended functions

Default:	oFF
Range:	oFF, on
oFF	Only view function 201-915 are visible.
on	All the function menus are visible

NOTE! Menu 007 must be "on".

7.4 Voltage control dual ramp

To achieve even smoother ramps at start and or stop, a dual ramp can be used.

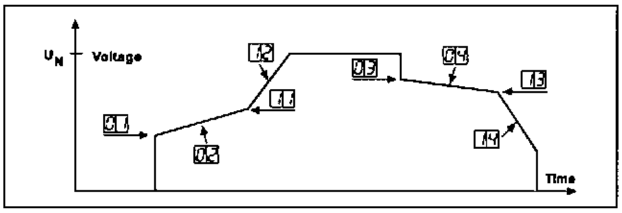

Fig. 33 Menu numbers for dual voltage ramp at start/stop, initial voltage at start and step down-voltage at stop.

The settings are carried out by beginning with the settings in menus 001-004 and 007-008 and proceed with the following steps:

011

90

Setting the initial voltage at start ramp 2

Default:	90%
Range:	30-90% U_n

Set the start voltage for start ramp 2. The initial voltage for start ramp 2 is limited to the initial voltage at start (menu 001), see § 7.1, page 36.

012

oFF

Setting of start ramp 2

Default:	oFF
Range:	oFF, 1-60 sec
oFF	Start ramp 2 disabled
1-60	Set the start ramp 2 time. A dual voltage ramp is active.

013

40

Setting of step down voltage in stop ramp 2

Default:	40%
Range:	100-40% U_n

Set the step down voltage for stop ramp 2. The step down voltage for stop ramp 2 is limited to the step down voltage at stop (menu 003).

014

oFF

Setting of stop ramp time 2

Default:	oFF
Range:	oFF, 2-120 sec
oFF	Stop ramp 2 disabled
1-60	Set the stop ramp 2 time. A dual voltage stop ramp is active.

7.5 Torque control parameters

See also § 7.10, page 42 and chapter 4. page 13 for more information on the Torque control setting.

016	
10	**Initial torque at start**
Default:	10
Range:	0 - 250% of Tn
Insert initial torque at start in percent of nominal shaft torque (Tn), see chapter 13. page 79.	

017	
150	**End torque at start**
Default:	150
Range:	50 - 250% of Tn
Insert end torque at start in percent of nominal shaft torque.	

018	
0	**End torque at stop**
Default:	0
Range:	0 - 100% of Tn
Insert end torque at stop in percent of the nominal motor torque.	

7.6 Current limit (Main Function)

The Current Limit function is used to limit the current drawn when starting (150 - 500% of In). This means that current limit is only achieved during set start-up time.

Two kinds of current limit starts are available.

- **Voltage ramp with a limited current.**
  If current is below set current limit, this start will act exactly as a voltage ramp start.
- **Current limit start.**
  The soft starter will control the current up to set current limit immediately at start, and keep it there until the start is completed or the set start-up time expires.

See Fig. 34 Current limit.

NOTE! Make sure that nominal motor current In menu 042 is correctly inserted.

7.6.1 Voltage ramp with current limit

The settings are carried out in three steps:

1. Estimate starting-time for the motor/machine and select that time in menu 002 (see § 7.1, page 36).
2. Estimate the initial voltage and select this voltage in menu 001 (see § 7.1, page 36).
3. Set the current limit to a suitable value e.g. 300% of In in menu 020.

020	
oFF	**Voltage ramp with current limit at start**
Default:	oFF
Range:	oFF, 150 - 500% In
oFF	Voltage Ramp mode with current limit disabled. Voltage Ramp enabled.
150-500	Current limit level in Voltage ramp mode.

NOTE! Only possible when Voltage Ramp mode is enabled. Menus 021-025 must be "oFF".

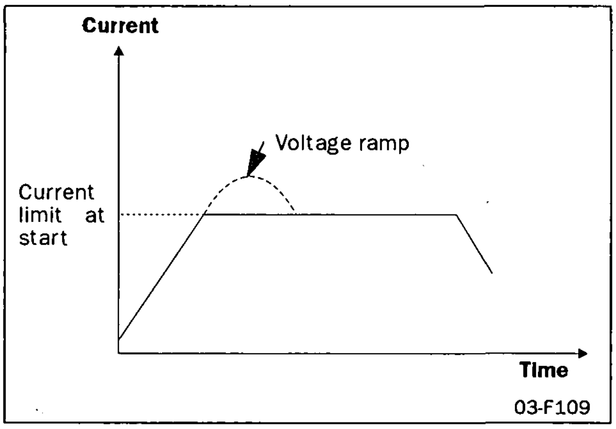

Fig. 34 Current limit

7.6.2 Current limit

The settings are carried out in two steps:

1. Estimate starting time for the motor/machine and select that time in menu 002 (see § 7.1, page 36).
2. Set the current limit to a suitable value e.g. 300% of In in menu 021.

021

oFF **Current limit at start**

Default:	oFF
Range:	oFF, 150 - 500% In
oFF	Current limit mode disabled. Voltage Ramp enabled.
150-500	Current limit level in current limit mode.

NOTE! Only possible when Voltage Ramp mode is enabled. Menus 020, 022-025 must be "oFF".

NOTE! Even though the current limit can be set as low as 150% of the nominal motor current value, this minimum value cannot be used generally. Considerations must be given to the starting torque and the motor before setting the appropriate current limit. "Real start time" can be longer or shorter than the set values depending on the load conditions. This applies to both current limit methods.

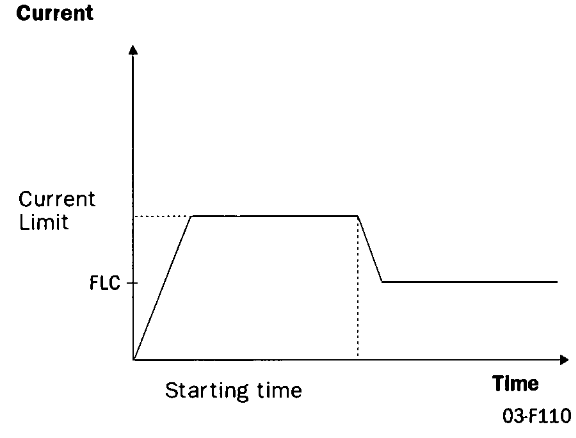

Fig. 35 Current limit

If the starting time is exceeded and the soft starter is still operating at current level, an alarm will be activated. It is possible to let the soft starter to either stop operation or to continue. Note that the current will rise uncontrolled if the operation continues (see § 7.24.2, page 61).

7.7 Pump control (Main Function)

By choosing pump control you will automatically get a stop ramp set to 15 sec. The optimising parameters for this main function are start and stop time; initial torque at start and end torque at start and stop. End torque at stop is used to let go of the pump when it´s no longer producing pressure/flow, which can vary on different pumps. See Fig. 36.

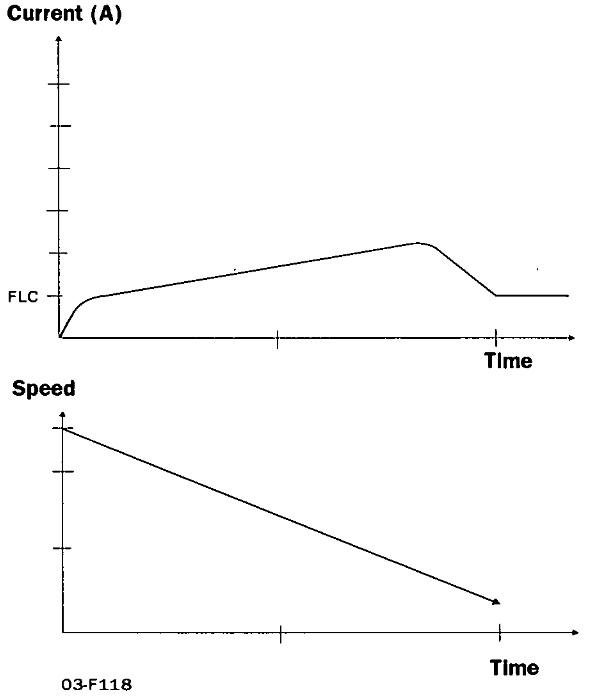

Fig. 36 Pump control

Pump application

The pump application is using Torque ramps for quadratic load. This gives lowest possible current and linear start and stop ramps. Related menus are 2, 4 (see § 7.1, page 36), 16, 17 and 18 (see § 7.5, page 39).

022

oFF **Setting of pump control**

Default:	oFF
Range:	oFF, on
oFF	Pump control disabled. Voltage Ramp enabled.
on	Pump control application is enabled.

NOTE! Only possible when Voltage Ramp mode is enabled. Menu 020-021, 023-025 must be "oFF".

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7.8 Analogue Input Control (Main Function)

Soft starting and soft stopping can also be controlled via the Analogue Input Control (0-10 V, 2-10 V, 0-20 mA and 4-20 mA). This control makes it possible to connect optional ramp generators or regulators.

After the start command, the motor voltage is controlled through the remote analogue input.

⚠ **WARNING! The remote analogue control may not be used for continuous speed regulation of standard motors. With this type of operation the increase in the temperature of the motor must be taken into consideration.**

To install the analogue input control, proceed by:

1. Connect the ramp generator or regulator to terminal 14 (+) and 15 (–).

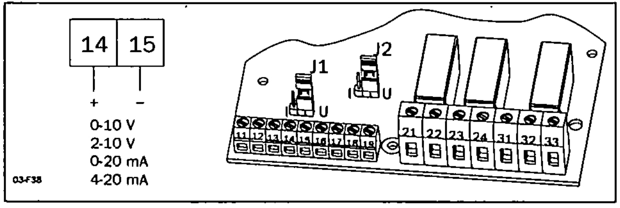

Fig. 37 Wiring for analogue input.

2. Set Jumper J1 on the PCB control card to voltage (U) or current control (I) signal position, see Fig. 38 and Fig. 24 on page 28. Factory setting is voltage (U).

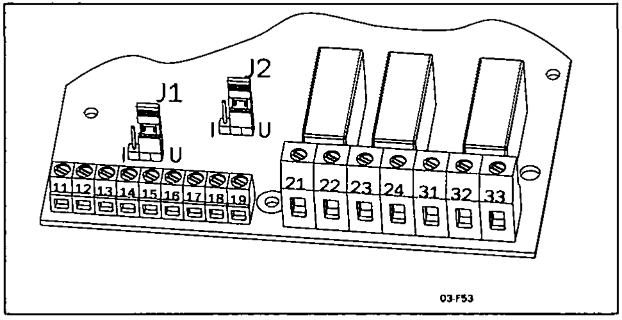

Fig. 38 Setting voltage or current for analogue input.

023

oFF

Selection of Analogue input control

Default:	oFF
Range:	oFF, 1, 2
oFF	Analogue input disabled. Voltage Ramp enabled.
1	Analogue input is set for 0-10V/ 0-20mA control signal
2	Analogue input is set for 2-10V/ 4-20mA control signal.

NOTE! Only possible when Voltage Ramp mode is enabled. Menu 020-022, 024, 025 must be "oFF"

7.9 Full voltage start, D.O.L. (Main Function)

The motor can be accelerated as if it was connected directly to the mains. For this type of operation:

Check whether the motor can accelerate the required load (D.O.L.-start, Direct On Line start). This function can be used even with shorted thyristors.

024

oFF

Setting of D.O.L start

Default:	oFF
Range:	oFF, on
oFF	D.O.L. start disabled. Voltage Ramp enabled.
on	D.O.L. start enabled

NOTE! Only possible when Voltage Ramp mode is enabled. Menu 020-023, 025 must be "oFF".

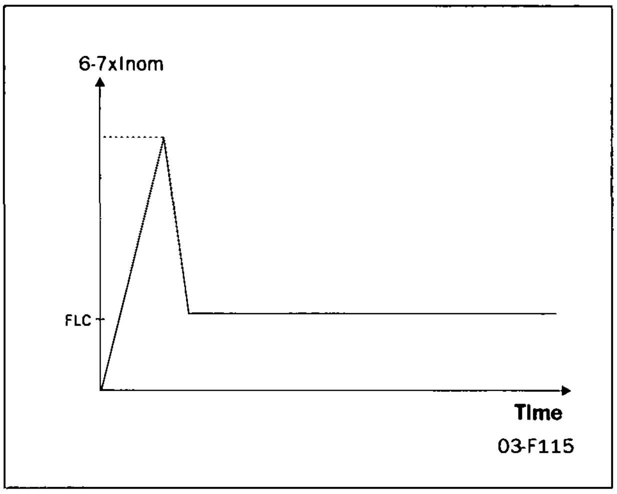

Fig. 39 Full voltage start.

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7.10 Torque control (Main function)

This main function can be used to make a start according to a pre-defined torque reference curve. Two different load characteristics, linear and square, are possible to select.

At start/stop the torque controller will follow the selected characteristic.

A torque start/stop behaviour can be seen in Fig. 40.

A perfect start and stop with torque ramps have a good linearity of current. To optimise this, use the setting of initial torque (menu 16) and end torque (menu 18). See also § 7.5, page 39.

Example:

Default for initial torque is 10% so if starting a more heavy load this will result in a small current peak in beginning of ramp. By increasing this value to 30/70% the current peak will not appear.

The end torque is increased mainly if the application has a high inertial load, like planers, saws and centrifuges. A current peak will appear in the end of ramp because the load is pushing the speed more or less by itself. By increasing this level to 150-250% the current will be linear and low.

025

oFF

Torque control at start/stop

Default:	oFF
Range:	oFF, 1, 2
oFF	Torque control is disabled Voltage Ramp enabled.
1	Torque control with linear torque characteristic
2	Torque control with square torque characteristic

NOTE! Torque control mode is only possible when Voltage Ramp mode is enabled (menu 020-024 are "oFF").

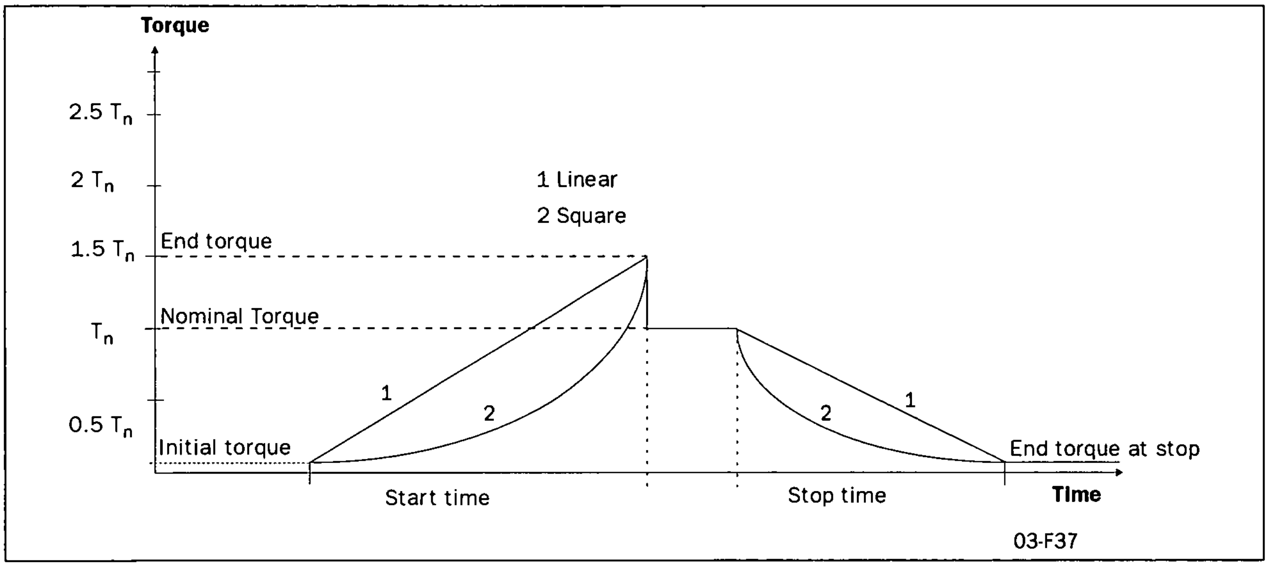

Fig. 40 Torque control at start/stop.

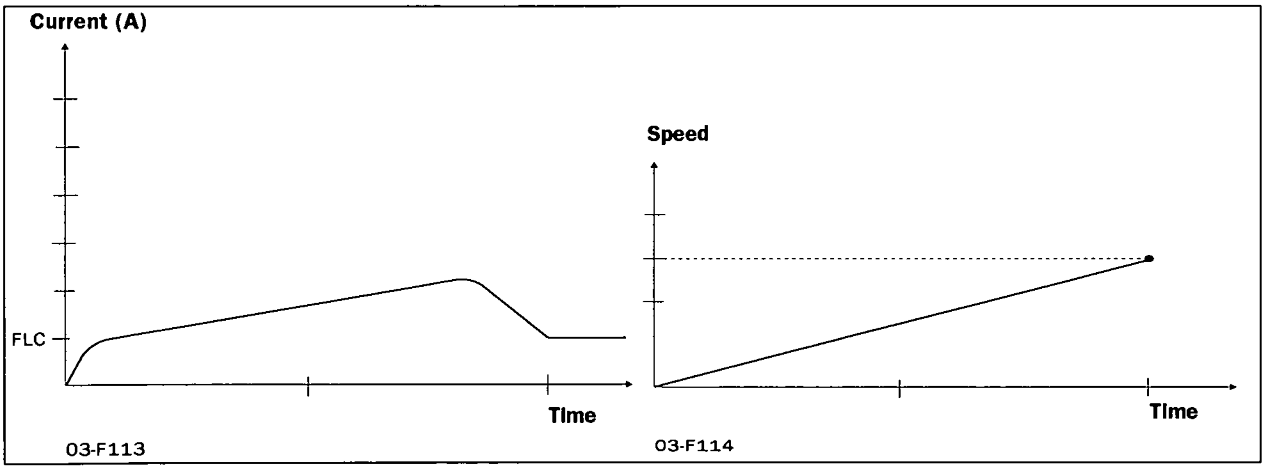

Fig. 41 Current and speed in torque control.

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7.11 Torque boost

The Torque Booster enables a high torque to be obtained by providing a high current during 0.1 - 2 sec at start. This enables a soft start of the motor even if the break away torque is high at start. For example in crushing mills applications etc.

When the torque booster function has finished, starting continues according to the selected start mode.

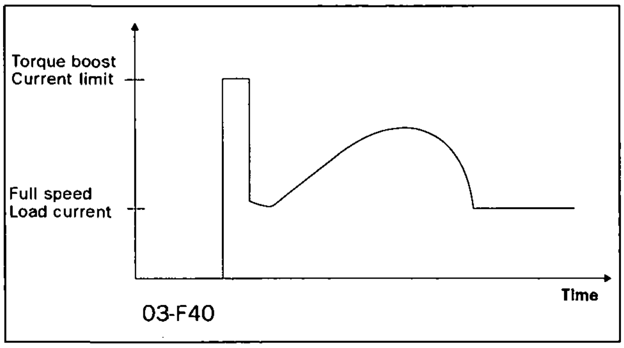

Fig. 42 The principle of the Torque Booster when starting the motor in voltage ramp mode.

See § 4.6, page 19, which main function that can be used with the torque boost.

030 oFF	**Torque boost active time**
Default:	oFF
Range:	oFF, 0.1 - 2 sec
oFF	Torque boost disabled
0.1-2.0	Set the Torque boost time.

031 300	**Torque boost current limit**
Default:	300
Range:	300 - 700% of In
The Torque boost current controller use selected value as the motor current reference.	

NOTE! Check whether the motor can accelerate the load with "Torque booster", without any harmful mechanical stress.

7.12 Bypass

In cases of high ambient temperatures or other reason it may sometimes be necessary to use a by-pass contactor to minimize the power loss at nominal speed (see Technical Data). By using the built-in Full Voltage Relay function an external contactor can be used to Bypass the soft starter when operating at nominal speed.

Bypass contactor can also be used if soft stop is required. Normally a Bypass contactor is not necessary as the device is designed for continues running conditions, see Fig. 29 on page 33 for wiring example.

NOTE! If one like to use the alarm functions, the extended functions or the viewing functions the 2-pcs current transformers must be mounted outside the soft start as shown in Fig. 44 and Fig. 45 on page 45. For this purpose an optional extension cable for the current transformers is available. Code No 01-2020-00.

032 oFF	**Setting of Bypass**
Default:	oFF
Range:	oFF, on
oFF	Bypass disabled
on	Bypass enabled. Program either relay K1 or K2 to function 2 to control the bypass contactor, see menu 51/52.

⚠ **CAUTION! If the current transformers are not mounted as in Fig. 43 on page 44 and § 6.2, page 28, the alarm and viewing functions will not work. Do not forget to set menu 032 to ON, otherwise there will be an F12 alarm and at the stop command will be a freewheeling stop.**

For further information see chapter 6.2 page 28.

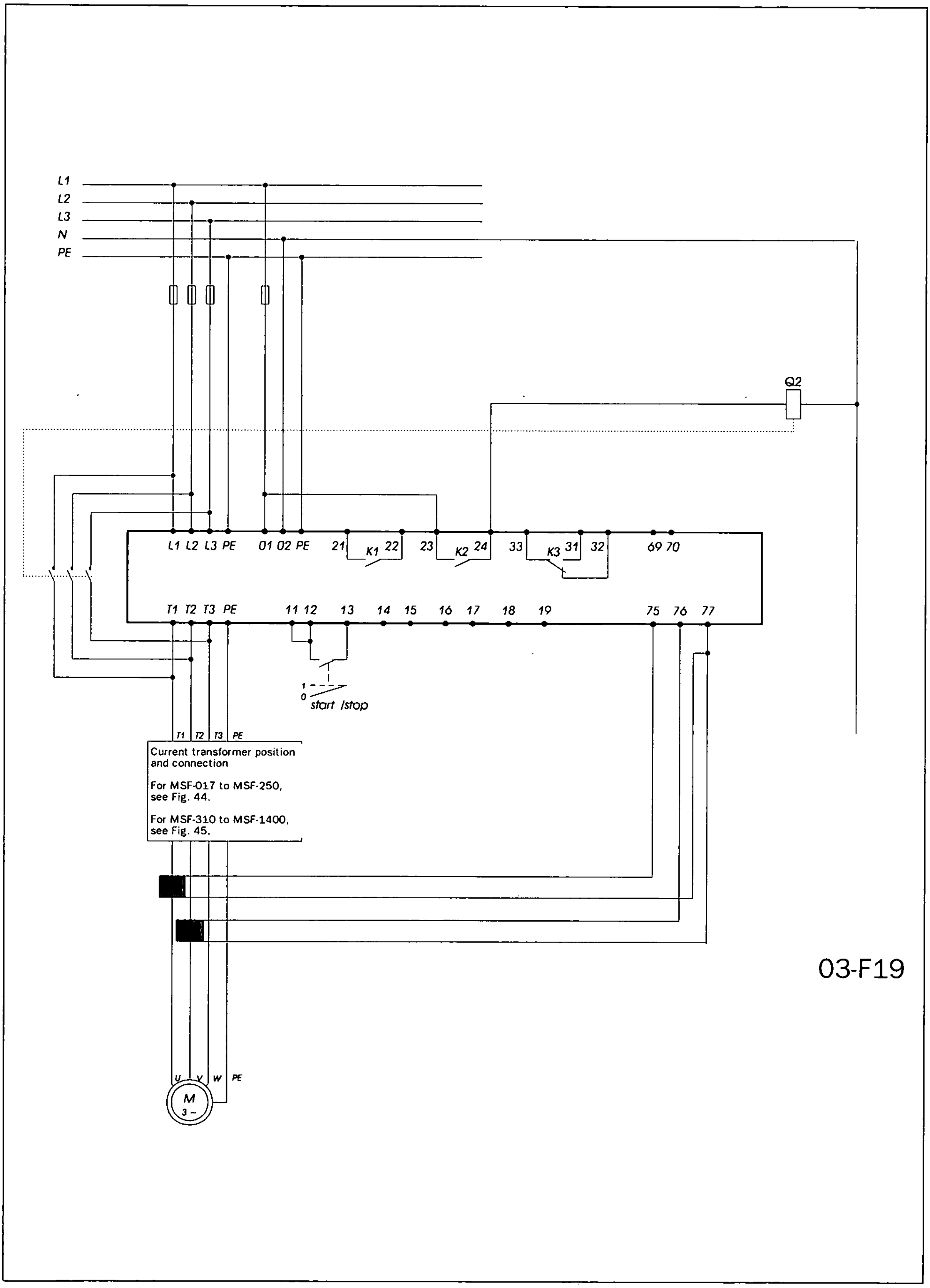

Fig. 43 Bypass wiring example MSF 310-1400.

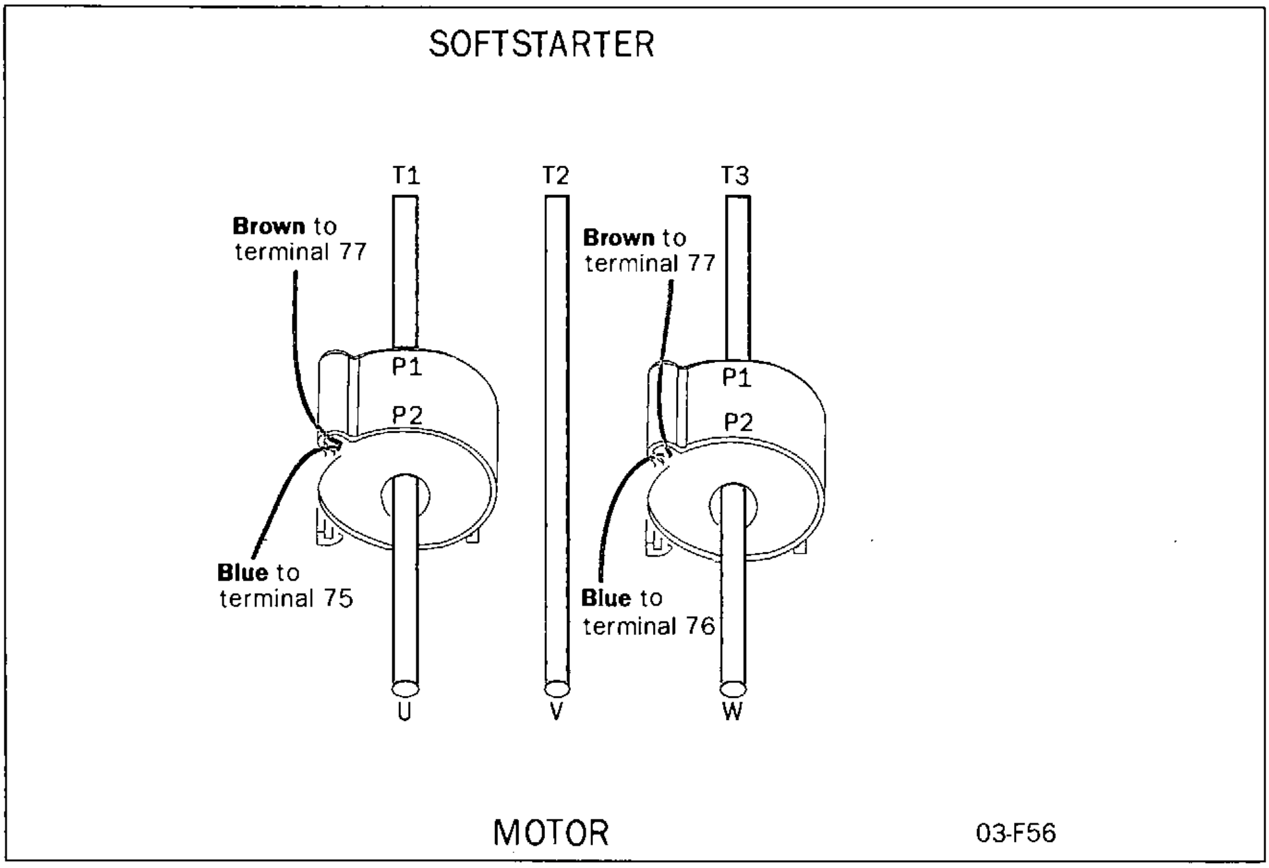

Fig. 44 Current transformer position when Bypass MSF-017 to MSF-250.

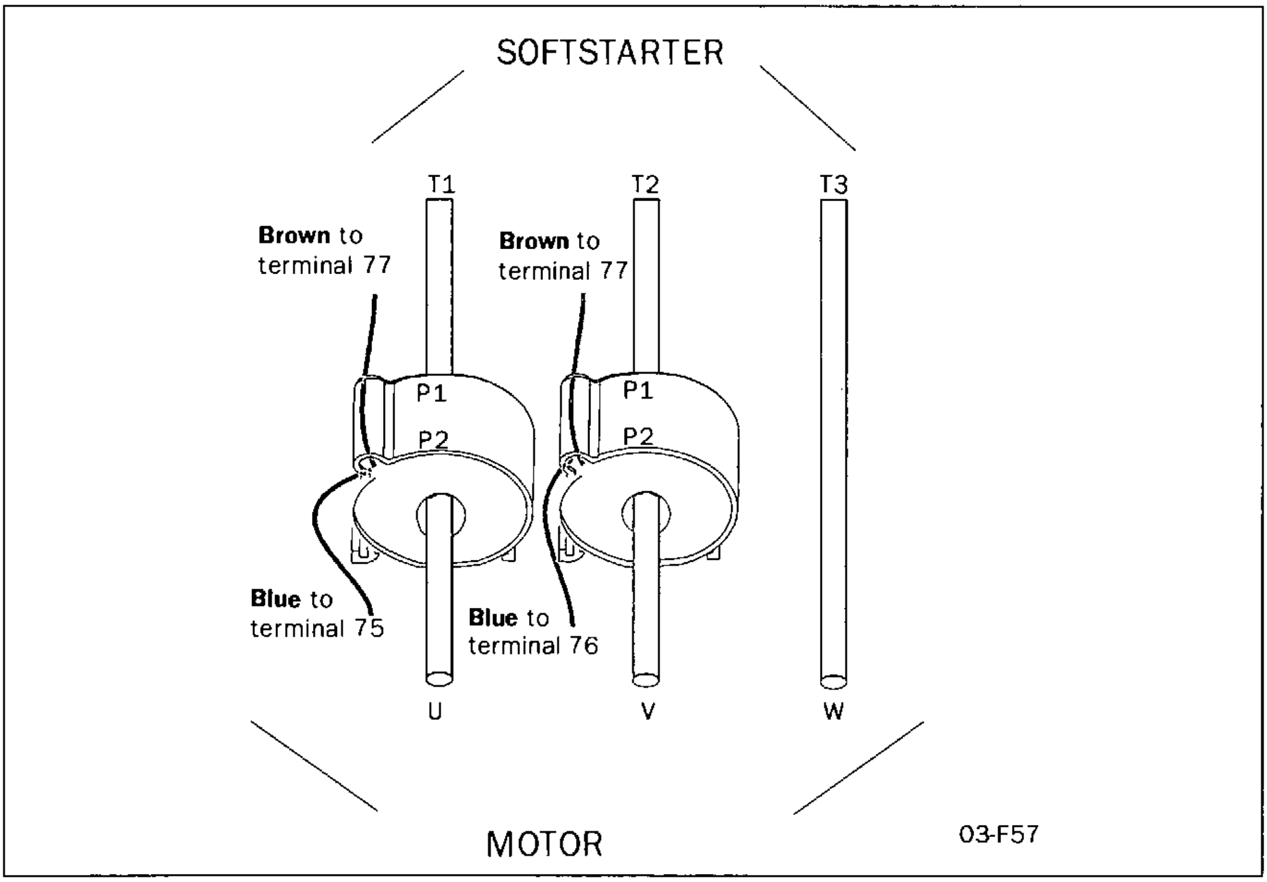

Fig. 45 Current transformer position when Bypass MSF-310 to MSF-1400.

BACK NEXT

7.13 Power Factor Control

During operation, the soft starter continuously monitors the load on the motor. Particularly when idling or when only partially loaded, it is sometimes desirable to improve the power factor. If Power factor control (PFC) is selected, the soft starter reduces the motor voltage when the load is lower. Power consumption is reduced and the degree of efficiency improved.

033 oFF	**Setting of PFC**
Default:	oFF
Range:	oFF, on
oFF	PFC disabled
on	PFC enabled. The Full voltage relay function does not work.

NOTE! If the PFC is used the EMC-directive is not fulfilled.

7.14 Brake functions

There are two built in braking methods for applications were the normal stop ramp is not enough.

- **Dynamic DC-brake**
  Increases the braking torque by decreasing speed.
- **Soft brake**
  Gives a high torque at the start of the braking and then also increasing torque by decreasing speed.

In both methods the MSF detects when the motor is standing still, so rotating in wrong direction is avoided.

Dynamic Vector Brake

- Possible to stop motors with high inertia loads from close to synchronous speed.
- At 70% of the nominal speed a DC-brake is activated until the motor is standing still or the selected Braking Time has expired (see menu 34, next page).
- No contactor needed.
- For extra safety, the soft starter has a digital input signal for monitoring standstill so that at real motor standstill will stop the output voltage immediately (see § 7.19, page 53).

Soft brake

- Even very high inertia loads can be stopped
- The Soft brake is a controlled reversing of the motor as the MSF measures the speed during braking.
- Two contactors are needed which can be placed on the in- or output of the soft starter. On the input the first contactor is connected to relay K1 which is also used as a mains contactor.
- At 30% of the nominal speed a DC-brake is activated until the motor is standing still or the selected Braking Time has expired (menu 34, next page).
- For extra safety, the soft starter has a digital input signal for monitoring standstill. So that the output voltage is stopped immediately (see menu 57-58, § 7.19, page 53).

See Fig. 47 on page 47 for the following set-up sequence:

- Soft brake is activated if menu 36=2 and menu 34 has a time selected (see next page).
- Menu 51 and 52 are automatically set to 5 and 4 to get the correct relay functions on K1 and K2 (see § 7.17, page 51).
- Relay K1 should be used to connect a contactor for supply L1, L2, L3 to MSF or motor.
- Relay K2 is used to connect phase shifting contactor to change L1, L2 and L3 to MSF or motor.
- At start K1 is activated and connects L1, L2, L3 then the motor starts. At stop K1 opens and disconnects L1, L2, and L3 and after 1s K2 connects with the other phase sequence and the braking of the motor is active.

NOTE! Soft brake uses both programmable relays. For other functions, see also the function table in chapter 7. page 35.

NOTE! For several start/stops it is recommend to use the PTC input.

⚠ **WARNING! If the Soft Brake function has been selected once and after that the Bypass function is selected, then the relay functions on K1 and K2 remain in the Soft Brake functionality. Therefore it is necessary to change the relay functions in menu 51-52 manually to the Bypass functions (see § 7.17, page 51) or reset to default in menu 199 (see § 7.28, page 63) and select the Bypass function again.**

034 oFF	**Braking time**
Default:	oFF
Range:	oFF, 1 - 120 sec
oFF	Brake function disabled
1-120	Brake time

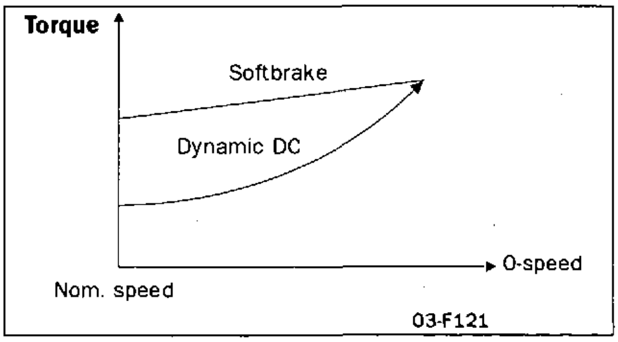

Fig. 46 Braking time

035

Braking Strength

100

Default:	100
Range:	100 - 500%

036

Brake method

1

Default:	1
Range:	1, 2
1	Dynamic vector brake, active
2	Soft brake active

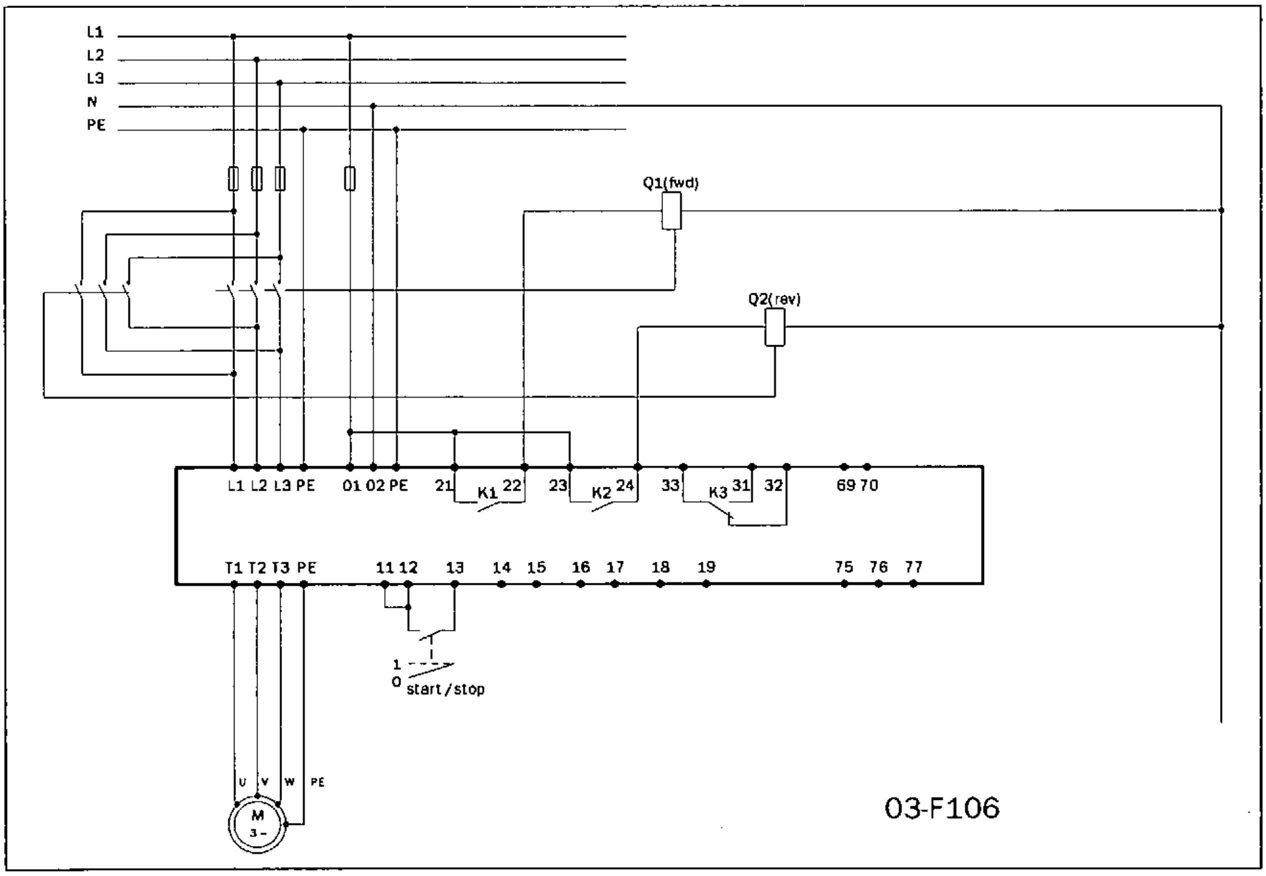

Fig. 47 Soft brake wiring example.

7.15 Slow speed and Jog functions

The soft starter is able to run the motor at a fixed slow speed for a limited period of time.

The slow speed will be about 14% of the full speed in the forward direction and 9% in the reverse direction.

The following functions are possible:

- **Slow speed controlled by an external signal.** The digital input is used to run at slow speed at a start or stop command for a selected number of pulses (edges) generated by an external sensor (photo cell, micro switch, etc.). See § 7.19, page 53 for more instructions.
- **Slow Speed during a selected time period.** The slow speed will be active after a stop command for a selected time period. See § 7.19, page 53 for more instructions.
- **Slow Speed using the "JOG"-commands.** The slow Speed can be activated via the JOG keys on the keyboard or externally via the analogue input. See § 7.25, page 61 for more instructions.

7.15.1 Slow speed controlled by an external signal.

With these setting it is possible to have an external pulse or edge signal controlling the time that the Slow Speed is active either after a Start command or a Stop command or at both commands. The following menu's are involved:

Menu	Function	See page
57	Digital input selection	page 53
58	Pulse selection	page 53
37	Slow speed torque	page 49
38	Slow speed time at start	page 49
39	Slow speed time at stop	page 49
40	DC-Brake at slow speed	page 49

Installation is as follows:

1. Set the analogue input selection for Slow Speed operation. Menu 57=2. See § 7.19, page 53. See Fig. 37 on page 41 for a wiring example.
2. Select in menu 38 (see § 7.15.2, page 49) the Slow Speed at Start time. This time will now be the absolute maximum time for Slow Speed to be active after a start command, in case the external signal will not appear.
3. Select in menu 39 (see § 7.15.2, page 49) the Slow Speed at Stop time. This time will now be the absolute maximum time for Slow Speed to be active after a stop command, in case the external signal will not appear.
4. Select in menu 57 (see § 7.19, page 53) the number of edges to be ignored by the Slow Speed input, before a start or stop is executed at slow speed. The edges are generated by an external sensor (photo cell, micro switch, etc.).

The Slow Speed torque (menu 37) and DC-Brake after Slow Speed (menu 40) can be selected if needed. (see § 7.15.4, page 49).

When the number of edges exceeds or the time expire, a start according to selected main function is made.

At stop, the motor will ramp down (if selected) and DC brake (if selected) before a slow speed forward at stop will begin. Slow speed will last as long as the number of edges on the external input is below parameter value in menu 036 and the max duration time doesn't expires. When the number of edges exceeds or the time expire, a stop is made.

In Fig. 48 on page 48 the selected number of edges are 4. It is recommended to select DC-brake (se § 7.14, page 46) before a slow speed at stop if it is a high inertia load. See Fig. 29 on page 33 for wiring diagram. In case one use DC-brake, see § 7.15.4, page 49.

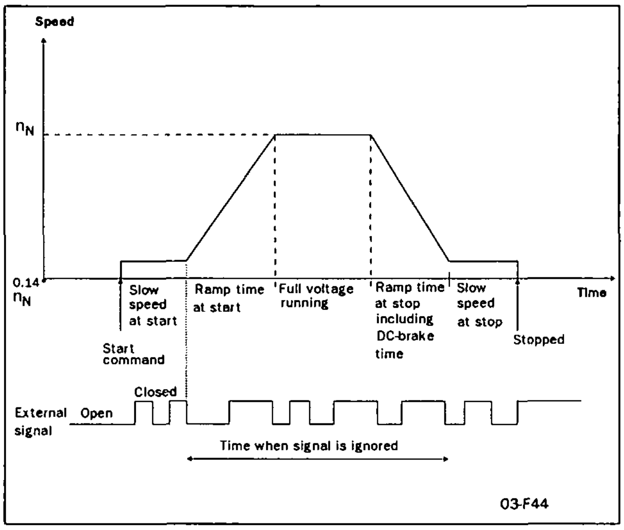

Fig. 48 Slow speed controlled by an external signal.

This additional function can be used together with most of the main functions (see § 4.6, page 19).

037

Slow speed torque

10

Default:	10
Range:	10-100

Select the magnitude of the slow speed torque.

7.15.2 Slow speed during a selected time

It is possible to have a slow speed in forward direction before a start and after a stop. The duration of the slow speed is selectable in menus 038 and 039.

It is recommended to select DC brake (see § 7.14, page 46) before a slow speed at stop if it is a high inertia load. This slow speed function is possible in all control modes, keyboard, remote and serial communication.

038

oFF

Slow speed time at start

Default:	oFF
Range:	oFF, 1 - 60 sec
oFF	Slow speed at start is disabled
1-60	Set slow speed time at start.

039

oFF

Slow speed time at stop

Default:	oFF
Range:	oFF, 1 - 60 sec
oFF	Slow speed at stop is disabled
1-60	Set slow speed time at stop.

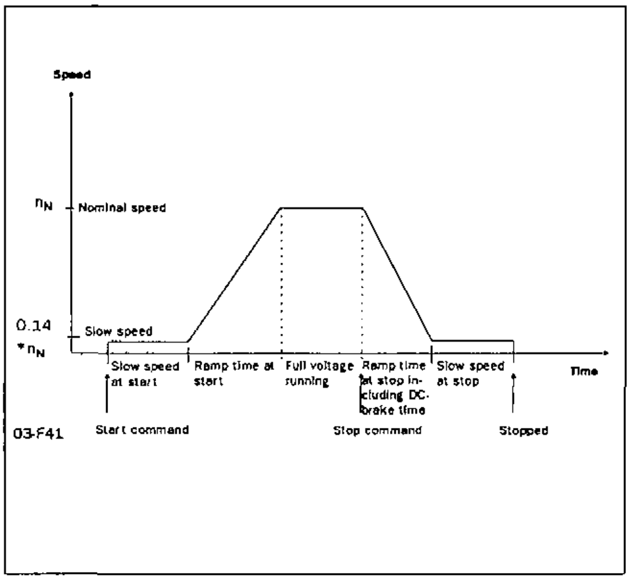

Fig. 49 Slow speed at start/stop during a selected time.

The Slow speed torque (menu 37) and the DC-Brake after Slow speed (menu 40, § 7.15.4, page 49) can be selected if needed.

7.15.3 Jog Functions

The Jog commands can be used to let the motor run at a Slow speed (forward or reverse) as long as the Jog command is active.

The Jog commands can be activated in 2 different ways:

- **Jog keys**
  The Jog-Forward and Jog-reverse keys on the control panel. The keys can be programmed separate for each function. See § 7.25, page 61 for more instructions
- **External Jog command**
  The external command is given via terminal 14 at the digital input. Only 1 function (forward or reverse) can be programmed to the digital input at the time. See § 7.19, page 53 for more instructions.

7.15.4 DC-brake after slow speed at stop [040]

A DC-brake after a slow speed at stop is possible to have, i.e. for a high inertia load or for a precise stop.

The current is controlled and the reference value for the normal DC-brake function is used (see § 7.15.4, page 49).

The duration for the DC-brake is possible to select.

This DC-brake function is not applied when the "JOG ⟲ " and "JOG ⟳" keys are used.

040

oFF

DC-Brake at slow speed

Default:	oFF
Range:	oFF, 1-60
oFF	DC-brake after slow speed at stop disabled.
1-60	DC-brake duration time after slow speed at stop.

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7.16 Motor data setting

The first step in the settings is to set menu 007 and 008 to "on" to be able to reach the menus 041-046 and enter the motor data.

NOTE! The default factory settings are for a standard 4-pole motor acc. to the nominal current and power of the soft starter. The soft starter will run even if no specific motor data is selected, but the performance will not be optimal.

041 ○ ○

400

Nominal motor voltage

Default:	400 V
Range:	200-700 V
Make sure the soft starters maximum voltage rating is suitable for chosen motor voltage.	

042 ○ ○

17

Nominal motor current

Default:	Nominal soft starter current
Range:	25% - 150% of Insoft in Amp.

043 ○ ○

7.5

Nominal motor power

Default:	Nominal soft starter power
Range:	25% - 300% of Pnsoft in kW

044 ○ ○

1450

Nominal motor speed

Default:	Nnsoft in rpm
Range:	500-3600 rpm

045 ○ ○

0.86

Nominal motor cos phi

Default:	0.86
Range:	0.50-1.00

046 ○ ○

50

Nominal frequency

Default:	50 Hz
Range:	50/60 Hz

NOTE! Now go back to menu 007, 008 and set it to "oFF" and then to menu 001.

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7.17 Programmable relay K1 and K2

The soft starter has three built-in auxiliary relays, K3 (change over contacts), is always used as an alarm relay. The other two relays, K1 and K2 (closing contacts), are programmable.

K1 and K2 can be set to either "Operation", "Full Voltage" or "Pre-alarm" indication. If DC-brake is chosen the relay K2 will be dedicated to this function.

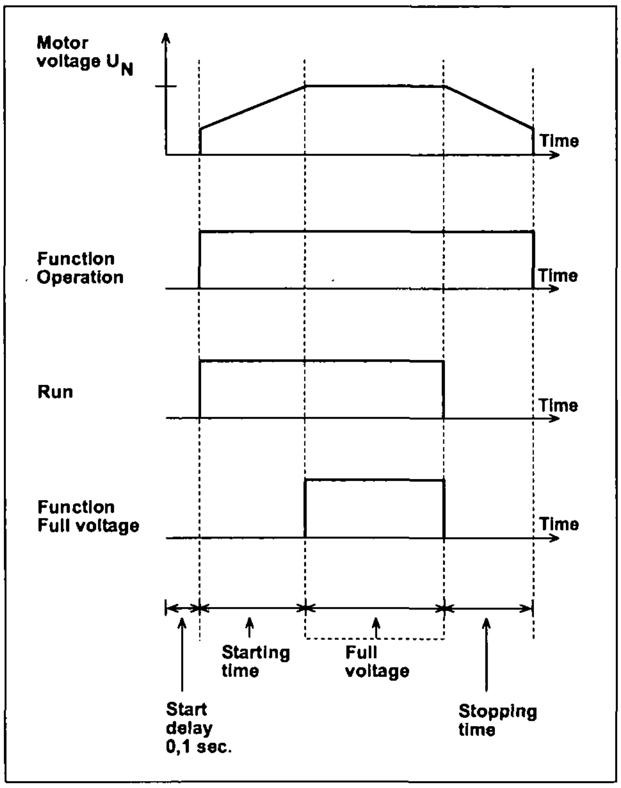

Fig. 50 Start/stop sequence and relay function "Operation" and "Full voltage".

051

Setting of K1 indication

1

Default:	1
Range:	1, 2, 3, 4, 5
1	K1 is set for "Operation"
2	K1 is set for "Full Voltage"
3	K1 is set for "Power pre-alarm"
4	No function
5	K1 is set for "Run"

052

Setting of K2 indication

2

Default:	2
Range:	1, 2, 3, 4, 5
1	K2 is set for "Operation"
2	K2 is set for "Full Voltage"
3	K2 is set for "Power pre-alarm"
4	K2 is set for "Softbrake"
5	K2 is set for "Run"

WARNING! If the Soft Brake function has been selected once and after that the Bypass function is selected, then the relay functions on K1 and K2 remain in the Soft Brake functionality. Therefore it is necessary to change the relay functions in menu 51-52 manually to the Bypass functions (see § 7.12, page 43) or reset to default in menu 199 (see § 7.28, page 63) and select the Bypass function again.

7.18 Analogue output

The soft starter can present current, voltage and power on an analogue output terminal, for connection to a recording instrument or a PLC. The output can be configured in 4 different ways, 0-10V, 2-10V, 0-20mA or 4-20 mA. To install the instrument proceed as follows:

1. Connect the instrument to terminal 19 (+) and 15 (-).

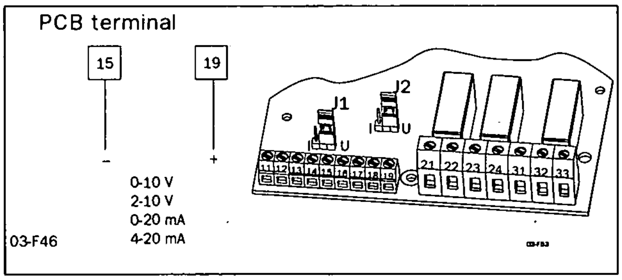

Fig. 51 Wiring for analogue output.

2. Set Jumper J2 on the PCB board to voltage (U) or current (I) signal position. Factory setting is voltage (U). See Fig. 52 on page 52 and Fig. 24 on page 28.

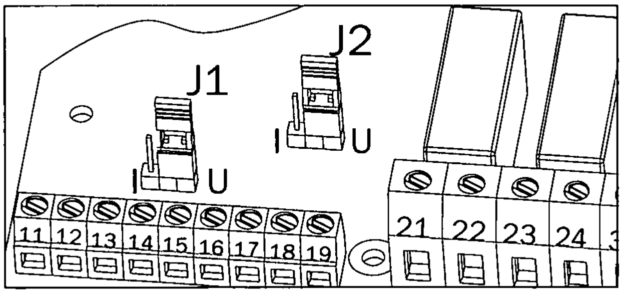

Fig. 52 Setting of current or voltage output.

3. Set the parameter in menu 054.

054 oFF	**Analogue output**
Default:	oFF
Range:	oFF, 1, 2
oFF	Analogue ouput is disabled
1	Analogue output is set to 0-10V/0-20mA
2	Analogue output is set to 0-10V/4-20mA

4. Choose a read-out value in menu 055

055 1	**Analogue output value**
Default:	1
Range:	1, 2, 3
1	RMS current, default range 0-5xIn
2	Line input RMS voltage, default range 0-720V
3	Output shaft power, default range 0-2xPn

5. Set analogue output gain to adjust the range of chosen analogue output value in menu 056.

056 100	**Analogue output gain**
Default:	100%
Range:	5-150%

Example on settings:

Set value	I_{scale}	U_{scale}	P_{scale}
100%	0-5xI_n	0-720V	0-2xP_n
50%	0-2.5xI_n	0-360V	0-P_n

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7.19 Digital input selection

The analogue input can be used as a digital input. This is programmed in Menu 57. There are 4 different functions:

- Rotation sensor input for braking functions. See § 7.14, page 46.
- Slow speed external controlled. See § 7.15.1, page 48.
- Jog functions forward or reverse enabled. See § 7.25, page 61.

Fig. 53 shows how to set the input for voltage or current control, with jumper J1 the control board. The default setting for J1 is voltage control.

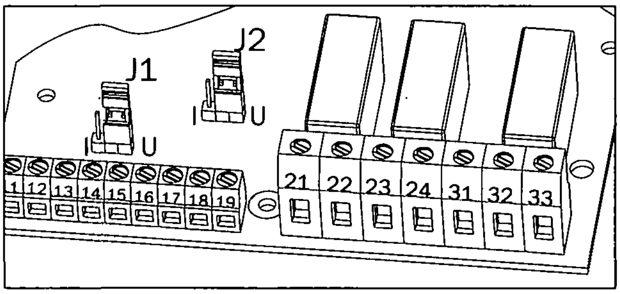

Fig. 53 Setting of J1 for current or voltage control.

Fig. 54 shows a wiring example for the analogue input as it is used for digital input.

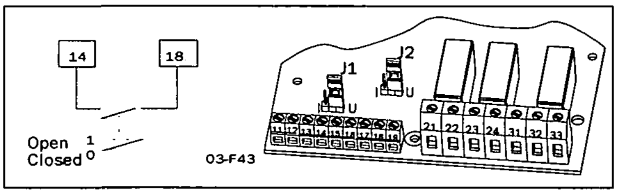

Fig. 54 Wiring for slow speed external input.

NOTE! If the Main Function Analogue control is programmed (see § 7.8, page 41) the analogue input can not be used for digital signal input. The menu 57 is then automatically set to OFF.

057

Digital input selection

oFF

Default:	oFF
Range:	oFF, 1-4
oFF	No digital input control
1	Rotation sensor for brake functions
2	Slow speed function
3	Jog forward command
4	Jog reverse command

NOTE! Jog forward, reverse has to be enabled, see § 7.25, page 61.

Depending on the selection made in menu 57, menu 58 is used to program the number of the edges. The edges can be generated by an external sensor (photo cell, micro switch etc.).

058

Digital input pulses

1

Default:	1
Range:	1-100

If Menu 57=1.
A positive or negative edge at analogue input from a rotation sensor will give a signal to stop the braking voltage.
If Menu 57=2
The number of edges to be ignored by the slow speed input, before a start or stop is executed at slow speed.

7.20 Parameter Set

Parameter Set, an important function which can be handy when using one soft starter to switch in and start different motors, or working under variable load conditions. For example; starting and stopping conveyor belts with different weight on the goods from time to time.

For sets of parameters can be controlled either from the keyboard, the external control inputs or the serial interface (option). Up to 51 different parameters can be set for each Parameter Set.

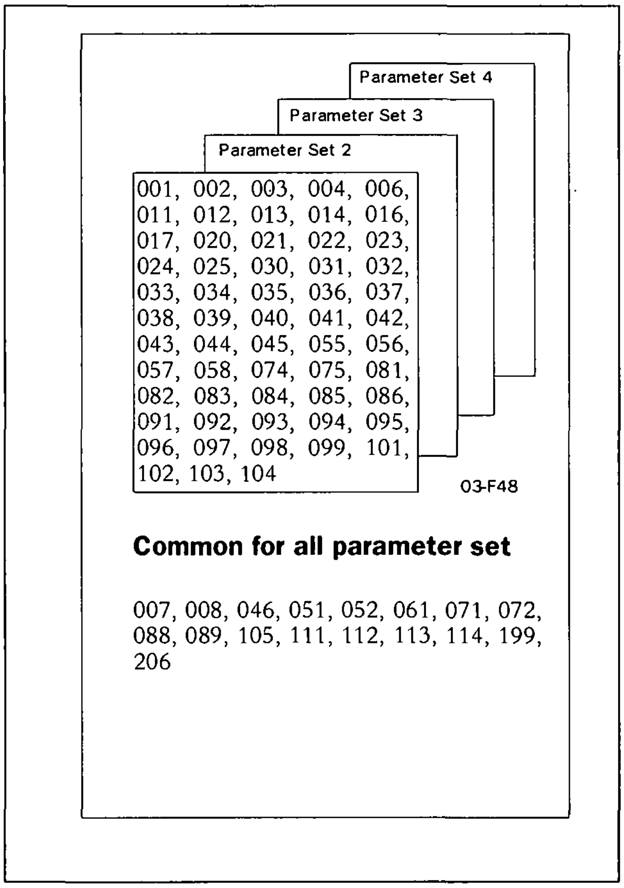

Fig. 55 Parameter overview

When 'Parameter set' in menu 061 is set to 0 (external selection), only parameters in menu 006 (Control mode) and 061 (Parameter set) can be changed. All other parameters are not allowed to change.

It is possible to change parameter set at stop and at full voltage running.

061

Parameter set

1

Default:	1
Range:	0, 1, 2, 3, 4
0	Parameter set are selected by the external input 16 and 17 (see below).
1, 2, 3, 4	Selection of parameter set 1-4.

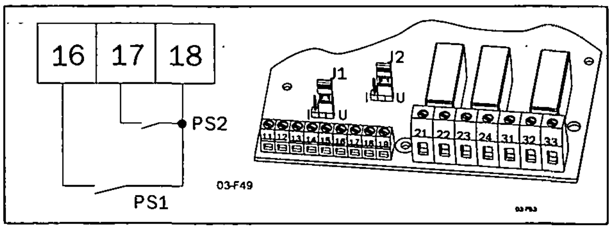

Fig. 56 Connection of external control inputs.

Parameter Set	PS1 (16-18)	PS2 (17-18)
1	Open	Open
2	Closed	Open
3	Open	Closed
4	Closed	Closed

BACK NEXT

7.21 Motor protection, overload (F2 alarm)

In many cases it is convenient to have a complete starter. The soft starter have a possibility to use either an input PTC signal from the motor, an internal thermal model of the motor for thermal protection or both together at the same time. Slight overload for long time and several overloads of short duration will be detected with both methods.

071 no	**Motor PTC input**
Default:	no
Range:	no, YES
no	Motor PTC input is disabled
YES	Motor PTC input is activated: - Connect the PTC to terminals 69 and 70, see table 12, page 32 and § Fig. 30, page 34. - A to hot motor will give an F2 alarm. The alarm can only be reseted after cooling down of the motor.

NOTE! Open terminals will give an F2 alarm immediately. Make sure the PTC is always connected or the terminals are shorted.

NOTE! The internal motor thermal protection will still generate an alarm if it is not selected oFF.

072 10	**Internal motor thermal protection**
Default:	10
Range:	oFF, 2-40 sec
oFF	Internal motor protection is disabled.
2-40	Selection of the thermal curve according to Fig. 57 - Check that menu 042 is set to the proper motor current (see § 7.16, page 50). - If the current exceeds the 100% level an F2 alarm is activated. - The motor model thermal capacity must cool down to 95% before reset can be accepted. - Used thermal capacity in menu 073 in § 7.21, page 55.

NOTE! If 'Bypass' is used check that the current transformers are placed and connected correctly (see Fig. 43 on page 44).

⚠ **CAUTION! Used thermal capacity is set to 0 if the control board loses its supply (terminal 01 and 02). This means that the internal thermal model starts with a 'cold' motor, which perhaps in reality is not the case. This means that the motor can be overheated.**

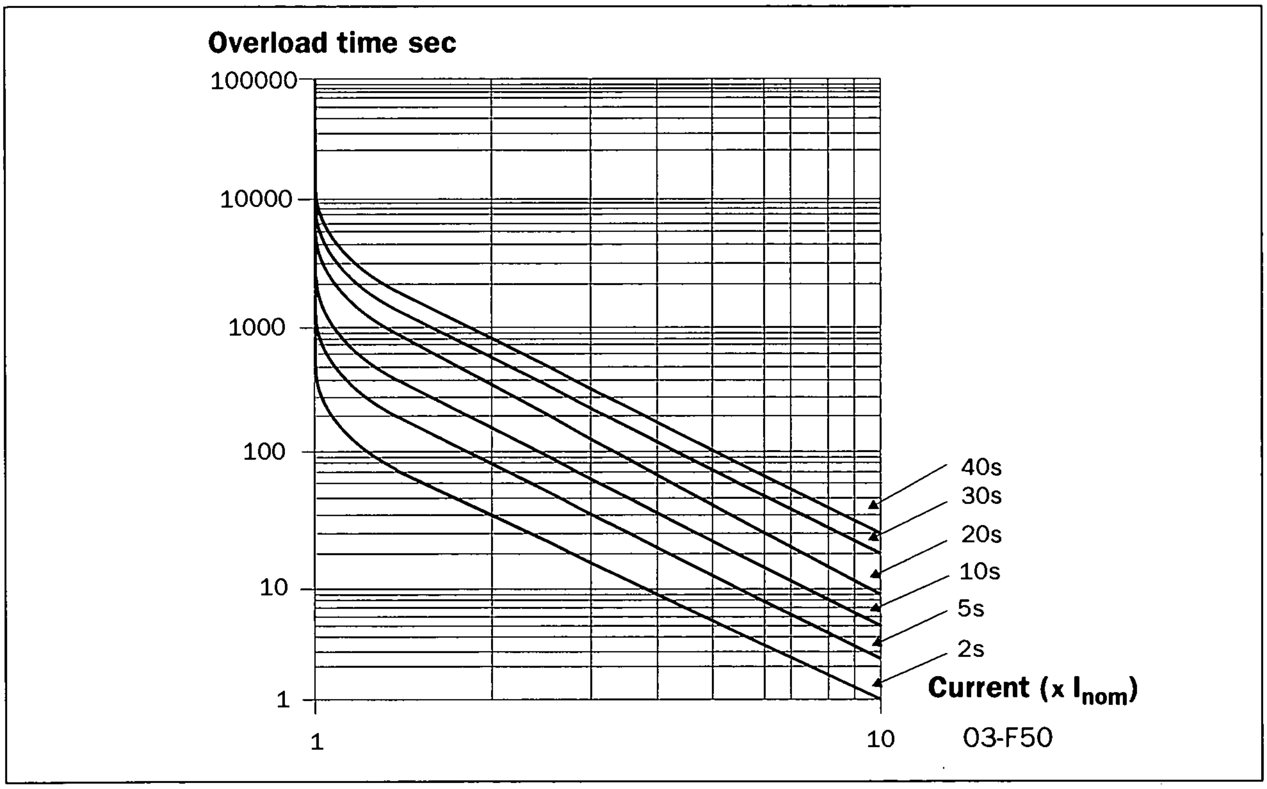

Fig. 57 The thermal curve

BACK NEXT

073

0

Used thermal capacity

Default:	-
Range:	0-150%

Read-out of the used thermal capacity. If menu 072 'Internal motor thermal protection' is selected oFF, the capacity is shown as if the default class 10 was selected.

074

oFF

Starts per hour limitation

Default:	oFF
Range:	oFF, 1-99/hour
oFF	Starts per hour limitation is disabled.
1-99	Sets the start per hour limitation alarm. If the selected number is exceeded, alarm F11 occurs.

075

oFF

Locked rotor alarm

Default:	oFF
Range:	oFF, 1.0-10.0 sec
oFF	Locked rotor alarm is disabled
1.0-10.0	An F5 alarm is given when the rotor locks. The alarm is active during starting and running.

7.22 Mains protection

081

10

Voltage unbalance alarm

Default:	10
Range:	2 -25% U_n

Insert limit in % of nominal motor voltage. Max unbalance in voltage between the 3 input phases is compared with the selected value. This is a category 2 alarm.

082

oFF

Response delay voltage unbalance alarm

Default:	oFF
Range:	oFF, 1-60 sec
oFF	Unbalance voltage alarm is disabled
1-60	Set the response delay time for unbalanced voltage alarm F8.

083

115

Over voltage alarm

Default:	115
Range:	100 -150% U_n

Insert limit in % of nominal motor voltage. Max voltage of the 3 input phases is compared with the selected value. This is a category 2 alarm.

084

oFF

Response delay over voltage alarm

Default:	oFF
Range:	oFF, 1-60 sec
oFF	Overvoltage alarm is disabled
1-60	Set the response delay time for over voltage alarm F9.

BACK NEXT

085

oFF

Under voltage alarm

Default:	85
Range:	75-100 U_n
Insert limit in % of nominal motor voltage. Min voltage of the 3 input phases is compared with the selected value. This is a category 2 alarm.	

086

oFF

Response delay under voltage alarm

Default:	oFF
Range:	oFF, 1-60 sec
oFF	Under voltage alarm is disabled
1-60	Set the response delay time for under voltage alarm F10

087

- - - -

Phase sequence

Default:	-
Range:	L123, L321
L123 is the direct phase sequence. L321 is the reverse phase sequence.	

088

oFF

Phase reversal alarm

Default:	oFF
Range:	oFF, on
oFF	Phase reversal alarm is disabled
on	Sets the phase reversal Alarm. - Switch on the power supply first. The phase sequence is stored as the correct sequence. - Sets the menu 088 to "on". - Any reversal of phase sequence will cause alarm F16.

NOTE! The actual phase sequence can be viewed in menu 87.

7.23 Application protection (load monitor)

7.23.1 Load monitor max and min/protection (F6 and F7 alarms)

MSF has a built in load monitor based on the output shaftpower. This is a unique and important function which enables protection of machines and processes driven by the motor connected to the soft starter. Both a Min and Max limit is possible to select.

In combination with the pre-alarm function, see § 7.23.2, page 58, this create a powerful protection. An auto set function is also included for an automatic setting of the alarm limits. A start-up delay time can be selected to avoid undesired alarms at start-up, see Fig. 58 on page 60.

NOTE! The load monitor alarms are all disabled during a stop ramp.

089

no

Auto set power limits

Default:	no
Range:	no, YES
no	Auto set is disabled
YES	Auto set is activated if ENTER is pressed.

090

0

Output shaftpower in %

Default:	-
Range:	0-200%
Measured output shaftpower in % of nominal motor power.	

NOTE! System must be in full voltage running before an auto set is permitted.

The actual power is regarded as 1.00xPact.
The set levels are:

Power max alarm limit[092]:	1.15xP actual
Power max pre-alarm limit[094]:	1.10xP actual
Power min pre-alarm limit[096]:	0.90xP actual
Power min alarm limit[098]:	0.85xP actual

A successful auto set shows a message 'Set' for 3 s and if something goes wrong a message 'no' will be showed.

BACK NEXT

091

10

Start delay power limits

Default:	10 sec
Range:	1-250 sec

From start command during selected delay time, all power load monitor alarms and pre-alarms are disabled.

092

115

Max power alarm limit

Default:	115
Range:	5-200% Pn

Insert limit in % of nominal motor power. The actual power in % of nominal motor power, could be read out in menu 090. If output shaft power exceeds selected limit, an F6-alarm occurs after the response delay time. The 'Auto set' function in menu 089, affect this limit even if the alarm is set "oFF" in menu 093. This is a category 1 alarm.

093

oFF

Response delay max alarm

Default:	oFF
Range:	oFF, 0.1-25.0 sec
oFF	Max Alarm is disabled.
0.1-25.0	Sets the response delay of the Max Alarm level.

7.23.2 Pre-alarm

It could be useful to know if the load is changing towards a load alarm limit. It is possible to insert both a Max and Min pre-alarm limit based on the motor output shaft power. If the load exceeds one of these limits, a pre-alarm condition occurs.

It should be noted that it is not normal alarms. They will not be inserted in the alarm list, not activating the alarm relay output, not displayed on the display and they will not stop operation. But it is possible to activate relay K1 or K2 if a pre-alarm condition occurs. To have pre-alarm status on any of these relays, select value 3 in menu 051 or 052 (see § 7.17, page 51).

A start-up delay time can be selected in menu 091 to avoid undesired pre-alarms at start-up. Note that this time is also shared with power Max and Min alarms.

NOTE! The pre-alarm status is always available on the serial communication.

094

110

Max power pre-alarm limit

Default:	110
Range:	5 -200% Pn

Insert limit in % of nominal motor power. The actual power in % of nominal motor power, could be read out in menu 090. If output shaft power exceeds selected limit, a pre-alarm occurs after the response delay time. The 'Auto set' function in menu 089, affect selected limit even if the pre-alarm is set "oFF" in menu 095.

095

oFF

Max pre-alarm response delay

Default:	oFF
Range:	oFF, 0.1 - 25.0 sec
oFF	Max Pre-Alarm is disabled.
0.1-25.0	Sets the response delay of the Max Pre-Alarm level.

096

Min power pre-alarm limit

90

Default:	90%
Range:	5 -200% Pn

Insert limit in % of nominal motor power. The actual power in % of nominal motor power, could be read out in menu 090. If output shaft power goes below selected limit, a pre-alarm occurs after the response delay time. The 'Auto set' function in menu 089, affect selected limit even if the pre-alarm is set "oFF" in menu 097.

097

Min pre-alarm response delay

oFF

Default:	oFF
Range:	oFF, 0.1 - 25.0 sec
oFF	Min Pre-Alarm is disabled.
0.1-25.0	Sets the response delay of the Min Pre-Alarm level. The Min Pre-alarm is disabled during a stop ramp down.

098

Min power alarm limit

85

Default:	85
Range:	5-200% Pn

Insert limit in % of nominal motor power. The actual power in % of nominal motor power, could be read out in menu 090. If output shaft power goes below selected limit, an F7-alarm occurs after the response delay time. The 'Auto set' function in menu 089, affect this limit even if the alarm is set 'oFF' in menu 099. This is a category 1 alarm.

099

Min alarm response delay

oFF

Default:	oFF
Range:	oFF, 0.1-25.0 sec
oFF	Min Alarm is disabled
0.1-25.0	Sets the response delay of the Min Alarm level. The Min alarm is disabled during a stop ramp down.

BACK NEXT

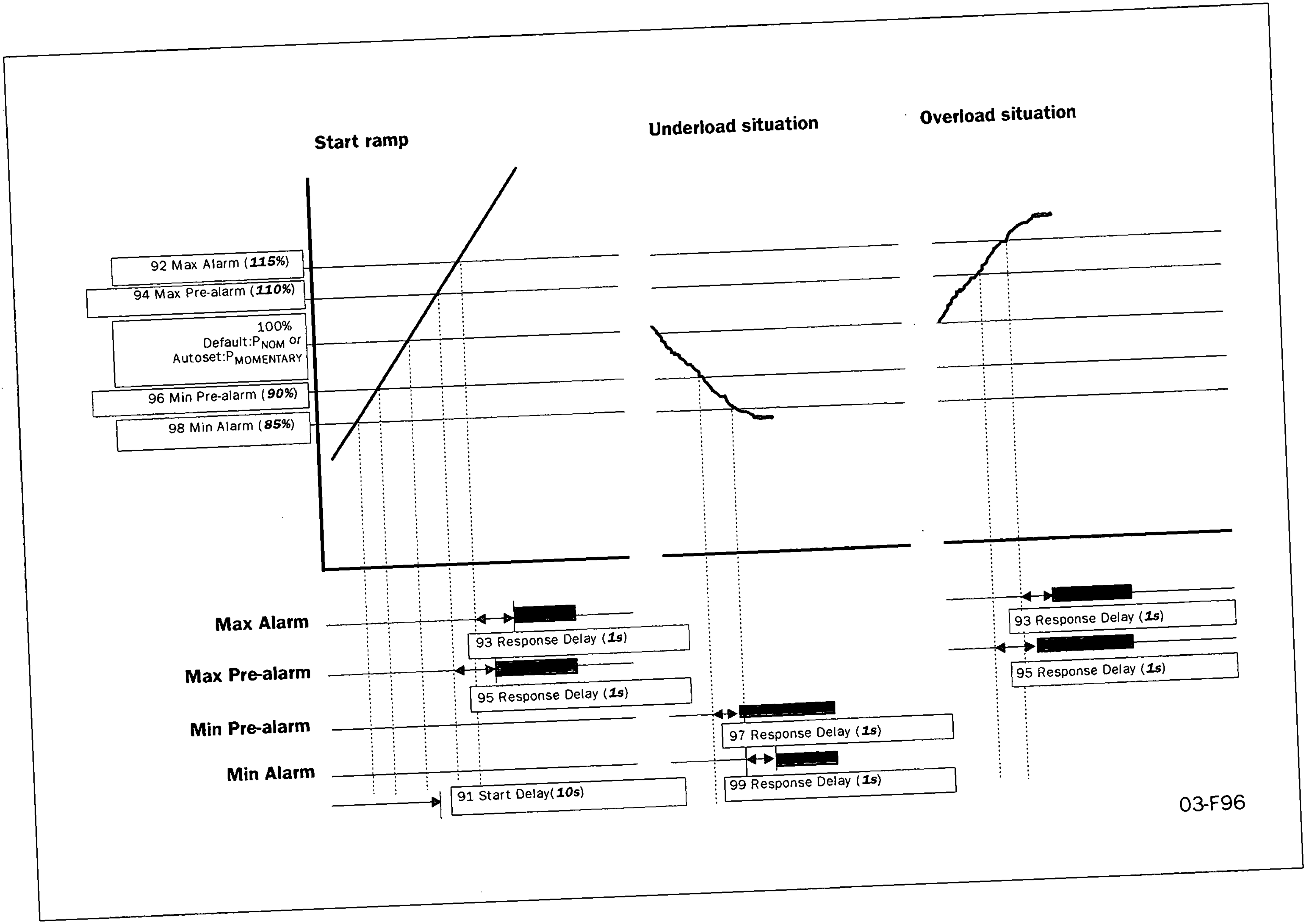

Fig. 58 Load monitor alarm functions.

7.24 Resume alarms

7.24.1 Phase input failure F1

- **Multiple phase failure.**
  Shorter failure than 100ms is ignored. If failure duration time is between 100 ms and 2 s, operation is temporary stopped and a soft start is made if the failure disappears before 2 s. If failure duration time is longer than 2 s, an F1 alarm is given in cat. 2.
- **Single phase failure.**
  During start up (acceleration) the behaviour is like multiple phase failure below. When full voltage running there is a possibility to select the behaviour.

101

no

Run at single phase loss

Default:	no
Range:	no, YES
no	Soft starter trips if a single phase loss is detected. Alarm F1 (category 2) will appear after 2 sec.
YES	Soft starter continues to run after a single phase loss. - Alarm F1 appears after 2 sec. - If the loose phase is reconnect the alarm is reset automatically. - If running on 2 phases, a stop command will give a Direct on line stop (freewheel)

7.24.2 Run at current limit time-out F4

In modes 'Current limit at start' and 'Voltage ramp with current limit at start' an alarm is activated if still operating at current limit level when selected ramp time exceeds. If an alarm occurs there is a possibility to select the behaviour.

102

no

Run at current limit time-out

Default:	no
Range:	no, YES
no	Soft starter trips if the current limit time-out is exceeded. Alarm F4 (category 2) appears.
YES	Soft starter continues to run after the current limit time-out has exceeded: - Alarm F4 appears - The current is no longer controlled and the soft starters ramps up to full voltage with a 6s ramp time. - Reset the alarm with either ENTER/ RESET key or by giving a stop command.

7.25 Slow speed with JOG

Slow speed with "JOG" is possible from the "JOG" keys, but also from terminals, see menu 57 page 53 and serial comm. The "JOG" is ignored if the soft starter is running. The slow speed "JOG" function has to be enabled for both forward and reverse directions in menus 103 and 104, see below.

NOTE! The enable functions is for all control modes.

103

oFF

JOG forward enable

Default:	oFF
Range:	oFF, on
oFF	JOG forward disabled
on	JOG forward enabled

104

oFF

JOG reverse enable

Default:	oFF
Range:	oFF, on
oFF	JOG reverse disabled
on	JOG reverse enabled

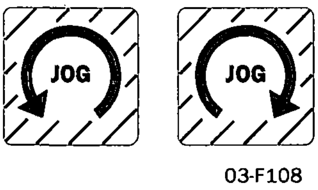

Fig. 59 The 2 Jog keys.

7.26 Automatic return menu

Often it is desirable to have a specific menu on the display during operation, i.e. RMS current or power consumption. The Automatic return menu function gives the possibility to select any menu in the menu system.

The menu selected will come up on the display after 60 sec. if no keyboard activity. The alarm messages (F1-F16) have a priority over menu 105 (as they have for all menus).

105

oFF **Automatic return menu**

Default:	oFF
Range:	oFF., 1-999
1-999	Pressing "+"/"-" will lead through the menu system.

7.27 Communication option, related Parameters

The following parameters have to be set-up:

- Unit address.
- Baud rate.
- Parity
- Behaviour when contact broken.

Setting up the communication parameter must be made in local 'Keyboard control' mode. See § 7.2, page 37.

111

1 **Serial comm unit address**

Default:	1
Range:	1-247

This parameter will select the unit address.

112

9.6 **Serial comm baudrate**

Default:	9.6
Range:	2.4, 4.8, 9.6, 19.2, 38.4 kBaud

This parameter will select the baudrate.

113

0 **Serial comm parity**

Default:	0
Range:	0.1

This parameter will select the parity.
0 No parity.
1 Even parity.

Serial comm. broken alarm

If control mode is 'Serial comm. control' and no contact is established or contact is broken the Soft starter consider the contact to be broken after 15 sec, the soft starter can act in three different ways:

1 Continue without any action at all.
2 Stop and alarm after 15 sec.
3 Continue and alarm after 15 sec.

If an alarm occurs, it is automatically reset if the communication is re-established. It is also possible to reset the alarm from the soft starter keyboard.

114

1 **Serial comm. contact interrupted**

Default:	1
Range:	oFF, 1, 2

This parameter will control the behaviour in the soft starter when the serial comm. is interrupted.
oFF No alarm and continue operation.
1 Alarm and stop operation.
2 Alarm and continue operation.

7.28 Reset to factory setting [199]

When selecting reset to factory settings:

- All parameters in all parameter sets will have default factory settings.
- Menu 001 will appear on the display.
- Note that the alarm list, the power consumption and the operation time will **not** have default settings.

199

no

Reset to factory settings

Default:	no
Range:	no, YES
no	No reset
YES	Reset all functions to the factory defaults incl. all 4 Parameter Sets.

NOTE! Reset to factory settings is not allowed at run.

7.29 View operation

General

The soft start includes as standard a numerous metering functions which eliminates the need of additional transducers and meters.

Measured values

- Current RMS 3-phase current and per phase
- Voltage RMS 3-phase voltage and per phase
- Output shaft power /torque kW/Nm
- Power factor
- Power consumption in kWh
- Operation time in hours

Viewing of the measured values

After setting motor data and extended functions one can set menu 008 in oFF and will then automatically move to menu 201, the first menu viewing the measured values and thus eliminate to scroll through menu 011 to menu 199.

201

0.0

RMS current

Default:	-
Range:	0.0 - 9999Amp
Read-out of the RMS motor current.	

NOTE! This is the same read-out as menu 005 see § 7.1.1, page 36.

202

0.0

RMS main voltage

Default:	-
Range:	0-720V
The RMS input main voltage.	

203

0.0

Output motor shaftpower

Default:	-
Range:	-9999 -+9999kW
Viewing will show negative value if generator mode.	

204

0.0

Power factor

Default:	-
Range:	0.00-1
View the actual power factor.	

NOTE! The power factor viewing will not work at bypass even if the current transformers are mounted outside the soft start.

205

0.000

Total power consumption

Default:	-
Range:	0.000 -2000MWh
View the total power consumption.	

206

n o

Reset of power consumption

Default:	no
Range:	no, YES
no	No reset of power consumtion.
YES	Reset power consumption in menu 205 to 0.000.

207

0.0

Motor shaft torque

Default:	-
Range:	-9999 - + 9999Nm
Viewing will show negative value if generator mode.	

208

0.0

Operation time

Default:	-
Range:	Hours

Operation time is calculated when the soft starter is in RUN mode. After 9999 hours the display will show two values.

Example: 12467 hours shows	1	1 sec
	2467	5sec

211

0.0

RMS current in phase L1

Default:	-
Range:	0.0 - 9999Amp
View the current in phase L1.	

212

0.0

RMS current in phase L2

Default:	-
Range:	0.0 - 9999Amp
View the current in phase L2.	

213

0.0

RMS current in phase L3

Default:	-
Range:	0.0 - 9999Amp
View the current in phase L3.	

214

0

Main voltage L1-L2

Default:	-
Range:	0-720V
View main voltage L1-L2.	

215

0

Main voltage L1-L3

Default:	-
Range:	0 - 720V
View main voltage L1-L3.	

216

0

Main voltage L2-L3

Default:	-
Range:	0 - 720V
View main voltage L2-L3.	

BACK NEXT

7.30 Keyboard lock

The keyboard can be locked to prohibit operation and parameter setting by an unauthorised. Lock keyboard by pressing both keys "NEXT → " and "ENTER ↵ " for at least 2 sec. The message '- Loc' will display when locked. To unlock keyboard press the same 2 keys "NEXT → " and "ENTER ↵ " for at least 2 sec. The message 'unlo' will display when unlocked.

In locked mode it is possible to view all parameters and read-out, but it is forbidden to set parameters and to operate the soft starter from the keyboard.

The message '-Loc' will display if trying to set a parameter or operate the soft starter in locked mode.

The key lock status can be read out in menu 221.

221 no	**Locked keyboard info**
Default:	no
Range:	no, YES
no	Keyboard is not locked
YES	Keyboard is locked

7.31 Alarm list

The alarm list is generated automatically. It shows the latest 15 alarms (F1 - F16). The alarm list can be useful when tracing a failure in the soft starter or its control circuit. Press key "NEXT → " or "PREV ← " to reach the alarm list in menus 901-915 (menu 007 has to be ON).

901 F1	**Alarm**
Default:	-
Range:	F1-F16
View actual alarm	

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8. PROTECTION AND ALARM

The soft starter is equipped with a protection system for the motor, the machine and for the soft starter itself.
Three categories of alarm are available:

Category 1
Alarm that stops the motor and need a separate reset before a new start can be accepted.
Category 2
Alarm that stops the motor and accepts a new start command without any separate reset.
Category 3
Alarm that continues to run the motor.

All alarm, except pre-alarm, will activate the alarm relay output K3, flash a red fault number on the display and it will also be placed in the alarm list. As long as the alarm is active, the display is locked in the alarm indication.

The relay output K3 can be used in the control circuit for actions needed when alarm occurs.

If more than one alarm is active, it is the last alarm that is presented on the display.

8.1 Alarm description

8.1.1 Alarm with stop and requiring a separate reset

Operation will stop for a category 1 alarm. A separate reset is needed before a new start command is accepted. It is possible to reset from keyboard (pushing "ENTER/RESET") regardless of selected control mode. It is also possible to reset the alarm from the actual control mode (i.e. if control mode is serial communication, a reset is possible to do from serial communication).

A reset is accepted first when the alarm source goes back to normal.

When a reset is made, the alarm relay output K3 is deactivated, the alarm indication on the display disappear and the original menu shows.

After a reset is made the system is ready for a new start command.

8.1.2 Alarm with stop and requiring only a new start command

Operation will stop for a category 2 alarm. A restart can be done and at the same time the alarm relay output K3 is deactivated, the alarm indication on the display disappear and the original menu shows.

It is still possible to reset the alarm in the same way as for category 1 alarms (see 8.1.1), if a start is not required at the time.

8.1.3 Alarm with continue run

Operation will continue run for a category 3 alarm. Some different reset behaviour is possible (see remarks for the specific alarms in § 8.2, page 67).

- Automatic reset when the alarm source goes back to normal.
- Automatic reset when a stop command is given.
- Manual reset during run.

When the reset occurs, the alarm relay output K3 is deactivated, the alarm indication on the display disappear and the original menu shows.

8.2 Alarm overview

Display indication	Protective function	Alarm category	Remark
F1	Phase input failure.	Cat 3. Run with auto reset.	Single phase failure when full voltage running if menu 101 'Run at phase loss' = YES. If the fault phase comes back, an automatic reset is made.
		Cat 2. Stop with reset in start.	Multiple phase failure or single phase failure when not full voltage running or if menu 101 ' Run at phase loss' = no.
F2	Motor protection, overload.	Cat 1. Stop with manual reset.	If menu 071 'Motor PTC input' = YES, cool down the motor. If menu 071 'Motor PTC input' = no, the internal model has to 'cool' down.
F3	Soft start overheated	Cat 1. Stop with manual reset.	If not cooled down, a reset will not be accepted.
F4	Full speed not reached at set current limit and start time.	If menu 102 'Run at current limit time-out' = no. Cat 2. Stop with reset in start.	The current limit start is not completed.
		If menu 102 'Run at current limit time-out' = YES. Cat 3. Run with manual reset.	When start time expired, a 6 sec ramp is used to reach full voltage, without control of the current. Reset the alarm with either a manual reset or a stop command.
F5	Locked rotor.	Cat 1. Stop with manual reset.	Motor and/or machine protection.
F6	Above max power limit.	Cat 1. Stop with manual reset.	Machine protection.
F7	Below min power limit.	Cat 1. Stop with manual reset.	Machine protection.
F8	Voltage unbalance.	Cat 2. Stop with reset in start.	Motor protection.
F9	Over voltage.	Cat 2. Stop with reset in start.	Motor protection.
F10	Under voltage.	Cat 2. Stop with reset in start.	Motor protection.
F11	Starts / hour exceeded.	Cat 2. Stop with reset in start.	Motor and/or machine protection.
F12	Shorted thyristor.	Cat 3. Run with manual reset.	When stop command comes, the stop will be a 'Direct On Line' stop, and the soft starter will be resetted. After this fault it is possible to start only in 'Direct On Line' mode. One or more thyristors probably damaged.
F13	Open thyristor.	Cat 1. Stop with manual reset.	One or more thyristors probably damaged.
F14	Motor terminal open.	Cat 1. Stop with manual reset.	Motor not correctly connected.
F15	Serial communication broken.	If menu 114 Serial comm. contact broken = 1. Cat 2. Stop with reset in start.	Serial communication broken will stop operation. Run from keyboard if necessary.
		If menu 114 Serial comm. contact broken = 2. Cat 3. Run with auto reset.	Serial communication broken will not stop operation. Stop from keyboard if necessary.
F16	Phase reversal alarm.	Cat 1. Stop with manual reset.	Incorrect phase order on main voltage input.

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9. TROUBLE SHOOTING

9.1 Fault, cause and solution

Observation	Fault indication	Cause	Solution
The display is not illuminated.	None	No control voltage.	Switch on the control voltage.
The motor does not run.	F1 (Phase input failure)	Fuse defective.	Renew the fuse.
		No mains supply.	Switch the main supply on.
	F2 (Motor protection, overload)	Perhaps PTC connection. Perhaps incorrect nominal motor current inserted (menu 042).	Check the PTC input if PTC protection is used. If internal protection is used, perhaps an other class could be used (menu 072). Cool down the motor and make a reset.
	F3 (Soft start overheated)	Ambient temperature to high. soft starter duty cycle exceeded. Perhaps fan failure.	Check ventilation of cabinet. Check the size of the cabinet. Clean the cooling fins. If the fan(s) is not working correct, contact your local MSF sales outlet.
	F4 (Full speed not reached at set current limit and start time)	Current limit parameters are perhaps not matched to the load and motor.	Increase the starting time and/or the current limit level.
	F5 (Locked rotor)	Something stuck in the machine or perhaps motor bearing failure.	Check the machine and motor bearings. Perhaps the alarm delay time can be set longer (menu 075).
	F6 (Above max power limit)	Overload	Over load. Check the machine. Perhaps the alarm delay time can be set longer (menu 093).
	F7 (Below min power limit)	Underload	Under load. Check the machine. Perhaps the alarm delay time can be set longer (menu 099).
	F8 (Voltage unbalance)	Main supply voltage unbalance.	Check mains supply.
	F9 (Over voltage)	Main supply over voltage.	Check mains supply.
	F10 (Under voltage)	Main supply under voltage.	Check mains supply.
	F11 (Starts / hour exceeded)	Number of starts exceeded according to menu 074.	Wait and make a new start. Perhaps the number of starts / hour could be increased in menu 074.
	F13 (Open thyristor)	Perhaps a damaged thyristor.	Make a reset and a restart. If the same alarm appears immediately, contact your local MSF sales outlet.
	F14 (Motor terminal open)	Open motor contact, cable or motor winding.	If the fault is not found, reset the alarm and inspect the alarm list. If alarm F12 is found, a thyristor is probably shorted. Make a restart. If alarm F14 appears immediately, contact your local MSF sales outlet.

Observation	Fault indication	Cause	Solution
The motor does not run.	F15 (Serial communication broken)	Serial communication broken.	Make a reset and try to establish contact. Check contacts, cables and option board. Verify - System address (menu 111). - Baudrate (menu 112). - Parity (menu 113). If the fault is not found, run the motor with keyboard control if urgent (set menu 006 to "1"). See also manual for serial communication.
	F16 (Phase reversal)	Incorrect phase sequence on main supply.	Switch L2 and L3 input phases.
	- - - -	Start command comes perhaps from incorrect control source. (I.e. start from keyboard when remote control is selected).	Give start command from correct source (menu 006).
	-Loc	System in keyboard lock.	Unlock keyboard by pressing the keys 'NEXT' and 'ENTER' for at least 3 sec.
The motor is running but an alarm is given.	F1 (Phase input failure)	Failure in one phase. Perhaps fuse defective.	Check fuses and mains supply. Deselect 'Run at single phase input failure' in menu 101, if stop is desired at single phase loss.
	F4 (Full speed not reached at set current limit and start time)	Current limit parameters are perhaps not matched to the load and motor.	Increase the starting time and/or the current limit level. Deselect 'Run at current limit time-out' in menu 102, if stop is desired at current limit time-out.
	F12 (Shorted thyristor)	Perhaps a damaged thyristor.	When stop command is given, a free wheel stop is made. Make a reset and a restart. If alarm F14 appears immediately, contact your local MSF sales outlet. If it is urgent to start the motor, set soft starter in 'Direct On Line' (menu 024). It is possible to start in this mode.
		By pass contactor is used but menu 032 'Bypass' is not set to "on".	Set menu 032 'Bypass' to "on".
	F15 (Serial communication broken)	Serial communication broken.	Make a reset and try to establish contact. Check contacts, cables and option board. Verify - System address (menu 111). - Baudrate (menu 112). - Parity (menu 113). If the fault is not found, run the motor with keyboard control if urgent, see also manual for serial communication.

BACK NEXT

Observation	Fault indication	Cause	Solution
The motor jerks etc.	When starting, motor reaches full speed but it jerks or vibrates.	If 'Torque control' or 'Pump control' is selected, it is necessary to input motor data into the system.	Input nominal motor data in menus 041-046. Select the proper load characteristic in menu 025. Select a correct initial- and end torque at start in menus 016 and 017. If 'Bypass' is selected, check that the current transformers are correct connected.
		Starting time too short.	Increase starting time.
		Starting voltage incorrectly set.	Adjust starting voltage.
		Motor too small in relation to rated current of soft starter.	Use a smaller model of the soft starter.
		Motor too large in relation to load of soft starter.	Use larger model of soft starter.
		Starting voltage not set correctly	Readjust the start ramp.
			Select the current limit function.
	Starting or stopping time too long, soft does not work.	Ramp times not set correctly.	Readjust the start and/or stop ramp time.
		Motor too large or too small in relation to load.	Change to another motor size.
The monitor function does not work.	No alarm or pre-alarm	It is necessary to input nominal motor data for this function. Incorrect alarm levels.	Input nominal motor data in menus 041-046. Adjust alarm levels in menus 091 - 099. If 'Bypass' is selected, check that the current transformers are correct connected.
Unexplainable alarm.	F5, F6, F7, F8, F9, F10	Alarm delay time is to short.	Adjust the response delay times for the alarms in menus 075, 082, 084, 086, 093 and 099.
The system seems locked in an alarm.	F2 (Motor protection, overload)	PTC input terminal could be open. Motor could still be to warm. If internal motor protection is used, the cooling in the internal model take some time.	PTC input terminal should be short circuit if not used. Wait until motor PTC gives an OK (not overheated) signal. Wait until the internal cooling is done. Try to reset the alarm after a while.
	F3 (Soft start overheated)	Ambient temperature to high. Perhaps fan failure.	Check that cables from power part are connected in terminals 073, 074, 071 and 072. MSF-017 to MSF-145 should have a short circuit between 071 and 072. Check also that the fan(s) is rotating.
Parameter will not be accepted.	- - - -	If the menu number is one of 020 - 025, only one can bee selected. In other words only one main mode is possible at a time.	Deselect the other main mode before selecting the new one.
		If menu 061, 'Parameter set' is set to "0", the system is in a remote parameter selection mode. It is now impossible to change most of the parameters.	Set the menu 061, 'Parameter set' to a value between "1" - "4" and then it is possible to change any parameter.
		During acceleration, deceleration, slow speed, DC brake and Power factor control mode, it is impossible to change parameters.	Set parameters during stop or full voltage running.
		If control source is serial comm., it is impossible to change parameters from keyboard and vice versa.	Change parameters from the actual control source.
		Some menus include only read out values and not parameters.	Read-out values can not be altered. In table 13, page 35, read-out menus has '—' in the factory setting column.
	-Loc	Keyboard is locked.	Unlock keyboard by pressing the keys 'NEXT' and 'ENTER' for at least 3 sec.

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10. MAINTENANCE

In general the soft starter is maintenance free. There are however some things which should be checked regularly. Especially if the surroundings are dusty the unit should be cleaned regularly.

⚠ **WARNING! Do not touch parts inside the enclosure of the unit when the control and motor voltage is switched on.**

Regular maintenance

- Check that nothing in the soft starter has been damaged by vibration (loose screws or connections).
- Check external wiring, connections and control signals. Tighten terminal screws and busbar bolts if necessary.
- Check that PCB boards, thyristors and cooling fin are free from dust. Clean with compressed air if necessary. Make sure the PCB boards and thyristors are undamaged.
- Check for signs of overheating (changes in colour on PCB boards, oxidation of solder points etc.). Check that the temperature is within permissible limits.
- Check that the cooling fan/s permit free air flow. Clean any external air filters if necessary.

In the event of fault or if a fault cannot be cured by using the fault-tracing table in chapter 9. page 68.

11. OPTIONS

The following option are available. Please contact your supplier for more detailed information.

11.1 Serial communication

For serial communication the MODBUS RTU (RS232/RS485) option card is available order number: 01-1733-00.

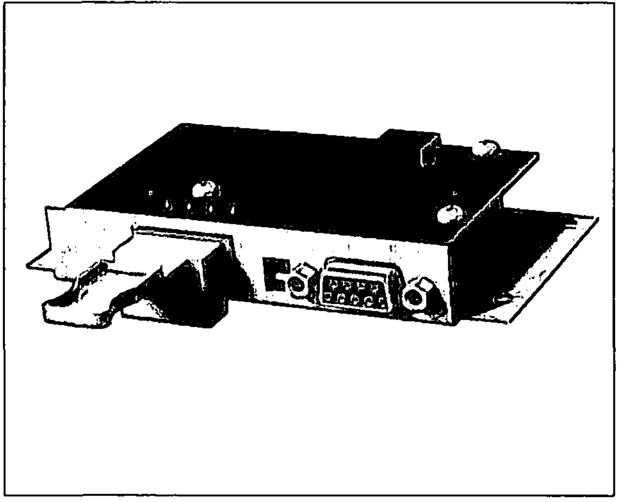

Fig. 60 Option RS232/485

11.2 Field bus systems

Various option cards are available for the following bus systems:

• PROFIBUS DP order number:	01-1734-01
• Device NET, order number:	01-1736-01
• LONWORKS:	01-1737-01
• FIP IO:	01-1738-01
• INTERBUS-S:	01-1735-01

Each system has his own card. The option is delivered with an instruction manual containing the all details for the set-up of the card and the protocol for programming.

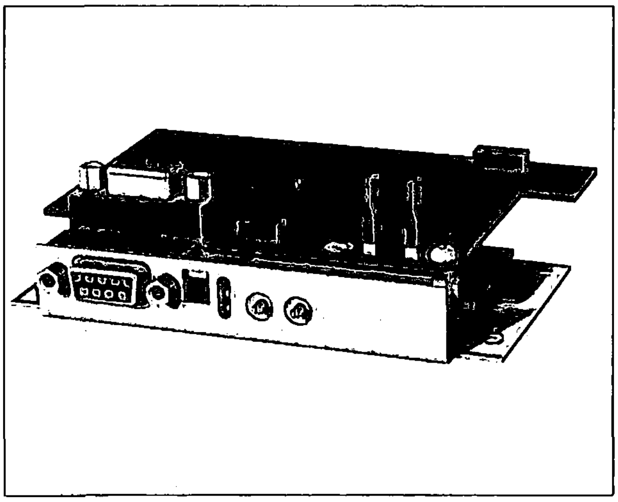

Fig. 61 Option Profibus

11.3 External PPU.

The external PPU option is used to move the PPU (keyboard) from the soft starter to the front of a panel door or control cabinet.

The maximum distance between the soft starter and the external PPU is 3 m.

The option can be factory mounted (01-2138-01) or it can be built in later (01-2138-00). For both versions instruction /data sheet are available.

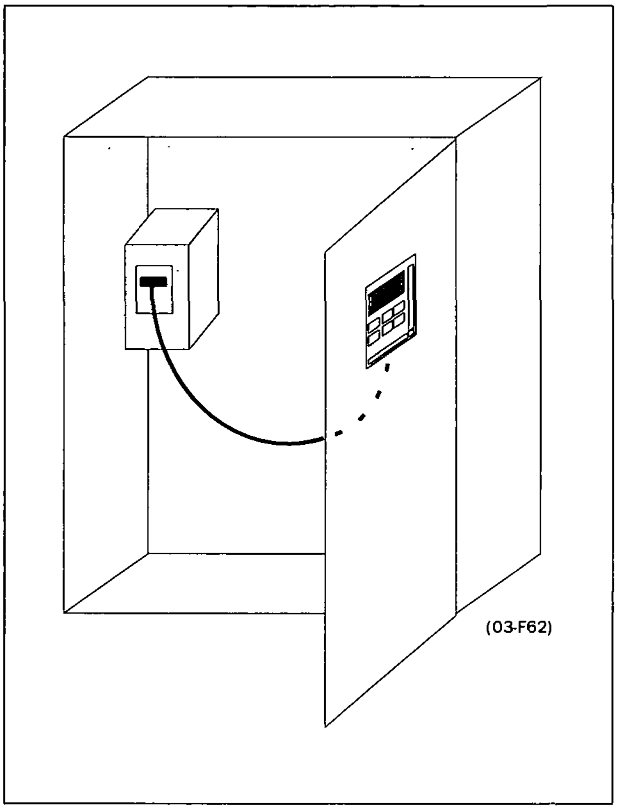

Fig. 62 Shows an example of the External PPU after it has been built in.

11.3.1 Cable kit for external current transformers

This kit is used for the bypass function, to connect the external current transformers more easy. order number: 01-2020-00.

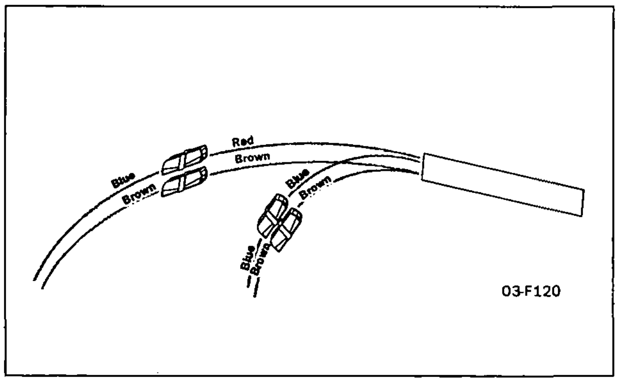

Fig. 63 Cable kit

11.4 Terminal clamp

Data: Single cables, Cu or Al	
Cables	95-300 mm^2
MSF type Cu Cable	310
Bolt for connection to busbar	M10
Dimensions in mm	33x84x47 mm
Order No. single	9350
Data: Parallel cables, Cu or Al	
Cables	2x95-300 mm^2
MSF type and Cu Cable	310 to -835
Bolt for connection to busbar	M10
Dimensions in mm	35x87x65
Order No. parallel	9351

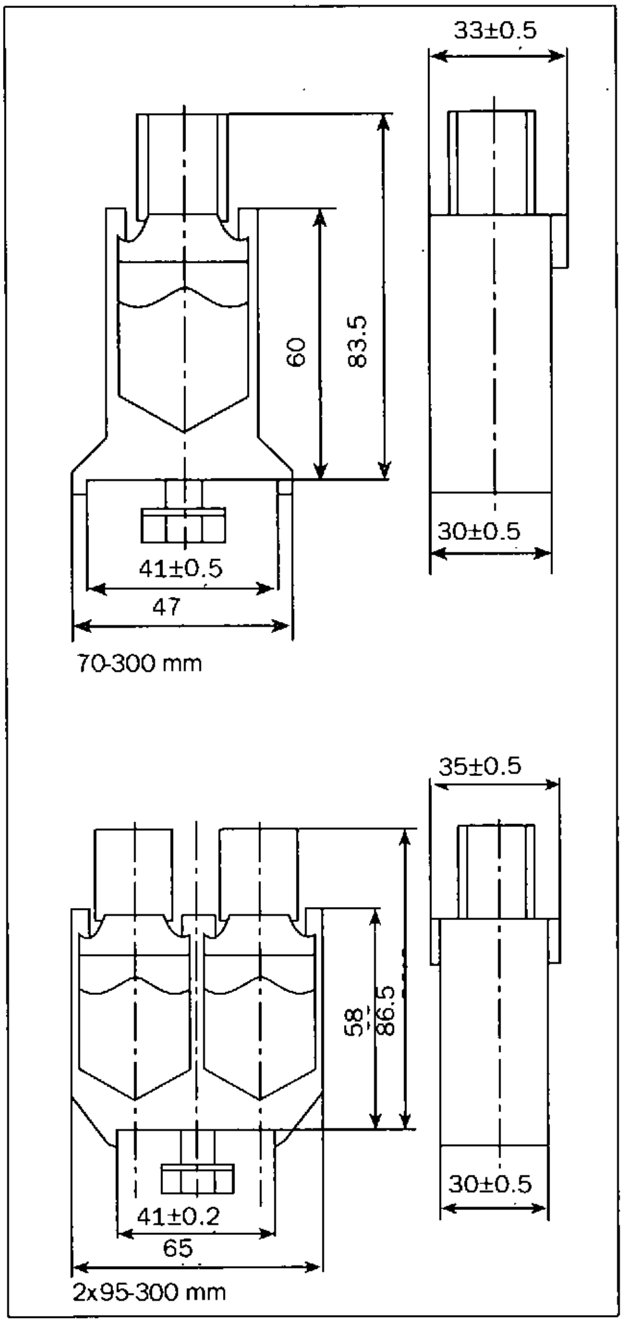

Fig. 64 The terminal clamp.

12. TECHNICAL DATA

3x200–525 V 50/60 Hz Model	**MSF-017**		**MSF-030**		**MSF-045**		**MSF-060**	
Soft starter rating according to AC35a, see chapter 4. page 13	**5.0-30:50-10 heavy**	**3.0-30:50-10 normal/light**	**5.0-30:50-10 heavy**	**3.0-30:50-10 normal/light**	**5.0-30:50-10 heavy**	**3.0-30:50-10 normal/light**	**5.0-30:50-10 heavy**	**3.0-30:50-10 normal/light**
Rated current of soft starter (A)	17	22	30	37	45	60	60	72
Recommended motor size (kW) for 400 V	7.5	11	15	18.5	22	30	30	37
Recommended motor size (kW) for 525 V	11	15	18.5	22	30	37	37	45
Order number: supply voltage (100-240V)	01-1301-01		01-1302-01		01-1303-01		01-1304-01	
Order number: supply voltage (380-500V)	01-1301-02		01-1302-02		01-1303-02		01-1304-02	
3x200-690V 50/60Hz Model	**MSF-017**		**MSF-030**		**MSF-045**		**MSF-060**	
Rated current of soft starter (A)	17	22	30	37	45	60	60	72
Motor power for 690V	15	18.5	22	30	37	55	55	75*
Order number: supply voltage (100-240V)	01-1321-01		01-1322-01		01-1323-01		01-1324-01	
Order number: supply voltage (380-500V)	01-1321-02		01-1322-02		01-1323-02		01-1324-02	
Electrical Data								
Recommended wiring fuse (A) 1)	25/50	32	35/80	50	50/125	80	63/160	100
Semi-conductor fuses, if required	80 A		125 A		160 A		200 A	
Power loss at rated motor load (W)	50	70	90	120	140	180	180	215
Power consumption control card	20 VA		20 VA		25 VA		25 VA	
Mechanical Data								
Dimensions in mm HxWxD	320x126x260		320x126x260		320x126x260		320x126x260	
Mounting position (Vertical/Horizontal)	Vertical		Vertical		Vert. or Horiz.		Vert. or Horiz.	
Weight (kg)	6.7		6.7		6.9		6.9	
Connection busbars Cu, (bolt)	15x4 (M6)		15x4 (M6)		15x4 (M6)		15x4 (M8)	
Cooling system	Convection		Convection		Fan		Fan	
General Electrical Data								
Number of fully controlled phases	3							
Voltage tolerance control	Control +/- 10%							
Voltage tolerance motor	Motor 200-525 +/- 10%/200-690 + 5%, -10%							
Recommended fuse for control card (A)	Max 10 A							
Frequency	50/60 Hz							
Frequency tolerance	+/- 10%							
Relay contacts	3 x 8A, 250 V resistive load, 3A 250VAC inductive (PF=0.4)							
Type of protection/insulation								
Type of casing protection	IP 20							
Other General Data								
Ambient temperatures								
In operation	0 - 40 °C							
Max. e.g. at 80% IN	50 °C							
In storage	(-25) - (+70) °C							
Relative air humidity	95%, non-condensing							
Max. altitude without derating	(See separate: Technical information 151) 1000 m							
Norms/Standards, Conform to:	IEC 947-4-2, EN 292, EN 60204-1, UL508							
EMC, Emission	EN 50081-2, (EN 50081-1 with bypass contactor)							
EMC, Immunity	EN 50082-2							
1) Recommended wiring fuses for: **Heavy** (first column): ramp/direct start **Normal/Light** (second column): ramp start								
NOTE! Short circuit withstand MSF017-060 5000 rms A when used with K5 or RK5 fuses.								

* 2-pole motor

3x200–525 V 50/60 Hz Model	**MSF-075**		**MSF-085**		**MSF-110**		**MSF-145**	
Soft starter rating according to AC35a, see chapter 4. page 13	**5.0-30:50-10 heavy**	**3.0-30:50-10 normal/light**	**5.0-30:50-10 heavy**	**3.0-30:50-10 normal/light**	**5.0-30:50-10 heavy**	**3.0-30:50-10 normal/light**	**5.0-30:50-10 heavy**	**3.0-30:50-10 normal/light**
Rated current of soft starter (A)	75	85	85	96	110	134	145	156
Recommended motor size (kW) for 400 V	37	45	45	55*	55	75	75	
Recommended motor size (kW) for 525 V	45	55	55	75*	75	90	90	110
Order number for supply voltage (100-240 V)	01-1305-01		01-1306-01		01-1307-01		01-1308-01	
Order number for supply voltage (380-550 V)	01-1305-02		01-1306-02		01-1307-02		01-1308-02	
3x200–690 V 50/60 Hz Model	**MSF-075**		**MSF-085**		**MSF-110**		**MSF-145**	
Rated current of soft starter (A)	75	85	85	90	110	134	145	156
Motor power for 690V	55	75	75	90	90	110	132	160*
Order number for supply voltage (100-240 V)	01-1325-01		01-1326-01		01-1327-01		01-1328-01	
Order number for supply voltage (380-550 V)	01-1325-02		01-1326-02		01-1327-02		01-1328-02	
Electrical Data								
Recommended wiring fuse (A) 1)	80/200	100	100/250	125	125/315	180	160/400	200
Semi-conductor fuses, if required	250 A		315 A		350 A		450 A	
Power loss at rated motor load (W)	230	260	260	290	330	400	440	470
Power consumption control card	25 VA		25 VA		25 VA		25 VA	
Mechanical Data								
Dimensions in mm HxWxD	320x126x260		320x126x260		400x176x260		400x176x260	
Mounting position (Vertical/Horizontal)	Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.	
Weight (kg)	6.9		6.9		12		12	
Connection, busbars Cu, (bolt)	15x4 (M8)		15x4 (M8)		20x4 (M10)		20x4 (M10)	
Cooling system	Fan		Fan		Fan		Fan	
General Electrical Data								
Number of fully controlled phases	3							
Voltage tolerance control	Control +/- 10%							
Voltage tolerance motor	Motor 200-525 +/- 10%/200-690 + 5%, -10%							
Recommended fuse for control card (A)	Max 10 A							
Frequency	50/60 Hz							
Frequency tolerance	+/- 10%							
Relay contacts	8A, 250 V resistive load, 3A, 250 V inductive load (PF=0.4)							
Type of protection/insulation								
Type of casing protection	IP 20							
Other General Data								
Ambient temperatures in operation	0 - 40 °C							
Max. e.g. at 80% I_N	50 °C							
In storage	(-25) - (+70) °C							
Relative air humidity	95%, non-condensing							
Max. altitude without derating	(See separate: Technical information 151) 1000 m							
Norms/Standards, Conform to:	IEC 947-4-2, EN 292, EN 60204-1, UL508							
EMC, Emission	EN 50081-2, (EN 50081-1 with bypass contactor)							
EMC, Immunity	EN 50082-2							
1) Recommended wiring fuses for:	**Heavy** (first column): ramp/direct start **Normal/Light** (second column): ramp start							
NOTE! Short circuit withstand MSF075-145 10000 rms A when used with K5 or RK5 fuses.								

* 2-pole motor

BACK NEXT

3x200–525 V 50/60 Hz Model	**MSF-170**		**MSF-210**		**MSF-250**		**MSF-310**		**MSF-370**	
Soft starter rating according to AC35a, see chapter 4, page 13	**6.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/light**
Rated current of soft starter (A)	170	210	210	250	250	262	310	370	370	450
Recommended motor size (kW) for 400 V	90	110	110	132	132	160*	160	200	200	250
Recommended motor size (kW) for 525 V	110	132	132	160	160	200*	200	250	250	315
Order no. for supply voltage (100-240V)	01-1309-11		01-1310-11		01-1311-11		01-1312-01		01-1313-01	
Order no. for supply voltage (380-550V)	01-1309-12		01-1310-12		01-1311-12		01-1312-02		01-1313-02	
3x200–690 V 50/60 Hz Model	**MSF-170**		**MSF-210**		**MSF-250**		**MSF-310**		**MSF-370**	
Rated current of soft starter (A)	170	210	210	250	250	262	310	370	370	450
Motor power for 690 V	160	200	200	250	250	250	315	355	355	400
Order no. for supply voltage (100-240V)	01-1329-01		01-1330-01		01-1331-01		01-1332-01		01-1333-01	
Order no. for supply voltage (380-550V)	01-1329-02		01-1330-02		01-1331-02		01-1332-02		01-1333-02	
Electrical Data										
Recommended wiring fuse (A) 1)	200/400	200	250/400	315	250/500	315	315/630	400	400/800	500
Semi-conductor fuses, if required	700 A		700 A		700 A		800 A		1000 A	
Power loss at rated motor load (W)	510	630	630	750	750 W		930	1100	1100	1535
Power consumption control card	35 VA		35 VA		35 VA		35 VA		35 VA	
Mechanical Data										
Dimensions mm HxWxD incl. brackets	500x260x260		500x260x260		500x260x260		532x547x278		532x547x278	
Mounting position (Vertical/Horizontal)	Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.	
Weight (kg)	20		20		20		42		46	
Connection, Busbars Al/Cu (bolt)	30x4 (M10)		30x4 (M10)		30x4 (M10)		40x8 (M12)		40x8 (M12)	
Cooling system	Fan		Fan		Fan		Fan		Fan	
General Electrical Data										
Number of fully controlled phases	3									
Voltage tolerance control	Control +/- 10%									
Voltage tolerance motor	Motor 200-525 +/- 10%/200-690 + 5%, -10%									
Recommended fuse for control card (A)	Max 10 A									
Frequency	50/60 Hz									
Frequency tolerance	+/- 10%									
Relay contacts	8A, 250 V resistive load, 3A, 250 V inductive load (PF=0.4)									
Type of protection/Insulation										
Type of casing protection	IP 20									
Other General Data										
Ambient temperatures in operation	0 - 40 °C									
Max. e.g. at 80% I_N	50 °C									
In storage	(-25) - (+70) °C									
Relative air humidity	95%, non-condensing									
Max. altitude without derating	(See separate: Technical information 151) 1000 m									
Norms/Standards, Conform to:	IEC 947-4-2, EN 292, EN 60204-1, (UL508, only MSF-170 to MSF-250)									
EMC, Emission	EN 50081-2, (EN 50081-1 with bypass contactor)									
EMC, Immunity	EN 50082-2									

1) Recommended wiring fuses for: **Heavy** (first column): ramp/direct start
Normal/Light (second column): ramp start

NOTE! Short circuit withstand MSF170-250 18000 rms A when used with K5 or RK5 fuses.

* 2-pole motor

3x200–525V 50/60Hz Model	MSF-450		MSF-570		MSF-710		MSF-835		MSF-1000		MSF-1400	
Soft starter rating according to AC53a, see chapter 4, page 13	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/ light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/ light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/ light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/ light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/ light**	**5.0-30: 50-10 heavy**	**3.0-30: 50-10 normal/ light**
Rated current of soft starter (A)	450	549	570	710	710	835	835	960	1000	1125	1400	1650
Recommended motor size (kW) for 400 V	250	315	315	400	400	450	450	560	560	630	800	930
Recommended motor size (kW) for 525 V	315	400	400	500	500	560	600	630	660	710	1000	250
Order no. for supply voltage (100-240V)	01-1341-01		01-1315-01		01-1316-01		01-1317-01		01-1318-01		01-1319-01	
Order no. for supply voltage (380-550V)	01-1314-02		01-1315-02		01-1316-02		01-1317-02		01-1318-02		01-1319-02	
3x200–690V 50/60Hz Model	**MSF-450**		**MSF-570**		**MSF-710**		**MSF-835**		**MSF-1000**		**MSF-1400**	
Rated current of soft starter (A)	450	549	570	640	710	835	835	880	1000	1125	1400	1524
Motor power for 690 V	400	560	560	630	710	800	800		1000	1120	1400	1600
Order no. for supply voltage (100-240V)	01-1334-01		01-1335-01		01-1336-01		01-1337-01		01-1338-01		01-1339-01	
Order no. for supply voltage (380-550V)	01-1334-02		01-1335-02		01-1336-02		01-1337-02		01-1338-02		01-1339-02	
Electrical Data												
Recommended wiring fuse (A 1)	500/1 k	630	630/1 k	800	800/1 k	1 k	1 k/1.2 k	1 k	1k/1.4 k	1.2 k	1.4 k/1.8 k	1.8 k
Semi-conductor fuses, if required	1250 A		1250 A		1800 A		2500 A		3200 A		4000 A	
Power loss at rated motor load (W)	1400	1730	1700	2100	2100	2500	2500	2875	3000	3375	4200	4950
Power consumption control card	35 VA		35 VA		35 VA		35 VA		35 VA		35 VA	
Mechanical Data												
Dimensions mm HxWxD incl. brackets	532x547x278		687x640x302		687x640x302		687x640x302		900x875x336		900x875x336	
Mounting position (Vertical/Horizontal)	Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.		Vert. or Horiz.	
Weight (kg)	46		64		78		80		175		175	
Connection, Busbars Al (bolt)	40x8 (M12)		40x10 (M12)		40x10 (M12)		40x10 (M12)		75x10 (M12)		75x10 (M12)	
Cooling system	Fan		Fan		Fan		Fan		Fan		Fan	
General Electrical Data												
Number of fully controlled phases	3											
Voltage tolerance control	Control +/- 10%											
Voltage tolerance motor	Motor 200-525 +/- 10%/200-690 + 5%, -10%											
Recommended fuse for control card (A)	Max 10 A											
Frequency	50/60 Hz											
Frequency tolerance	+/- 10%											
Relay contacts	8A, 250 V resistive load, 3A, 250 V inductive load (PF=0.4)											
Type of protection/insulation												
Type of casing protection	IP 20								IP00			
Other General Data												
Ambient temperatures in operation	0 - 40 °C											
Max. e.g. at 80% I_N	50 °C											
In storage	(-25) - (+70) °C											
Relative air humidity	95%, non-condensing											
Max. altitude without derating	(See separate: Technical information 151) 1000 m											
Norms/Standards, Conform to:	IEC 947-4-2, EN 292, EN 60204-1											
EMC, Emission	EN 50081-2, (EN 50081-1 with bypass contactor)											
EMC, Immunity	EN 50082-2											
1) Recommended wiring fuses for:	**Heavy** (first column): ramp/direct start **Normal/Light** (second column): ramp start											

BACK NEXT

Semi-conductor fuses

Always use standard commercial fuses to protect the wiring and prevent short circuiting. To protect the thyristors against short-circuit currents, superfast semiconductor fuses can be used if preferred (e.g. Bussmann type FWP or similar, see table below).

The normal guarantee is valid even if superfast semiconductor fuses are not used.

Type	FWP Bussmann fuse	
	A	I^2t (fuse) x 1000
MSF-017	80	2.4
MSF-030	125	7.3
MSF-045	150	11.7
MSF-060	200	22
MSF-075	250	42.5
MSF-085	300	71.2
MSF-110	350	95.6
MSF-145	450	137
MSF-170B	700	300
MSF-210B	700	300
MSF-250B	800	450
MSF-310	800	450
MSF-370	1000	600
MSF-450	1200	2100
MSF-570	1400	2700
MSF-710	1800	5300
MSF-835	2000	
MSF-1000	2500	
MSF-1400	3500	

13. SET-UP MENU LIST

Menu number	Function/Parameter	Range	Par.set	Factory setting	Value	Page
001	Initial voltage at start	25 - 90% of U	1 - 4	30		page 36
002	Start time ramp 1	1 - 60 sec	1 - 4	10		page 36
003	Step down voltage at stop	100 - 40% U	1 - 4	100		page 36
004	Stop time ramp 1	oFF, 2 - 120 sec	1 - 4	oFF		page 36
005	Current	0.0 - 9999 Amp	——	——		page 36
006	Control mode	1, 2, 3	1 - 4	2		page 37
007	Extended functions & metering	oFF, on	——	oFF		page 38
008	Extended functions	oFF, on	——	oFF		page 38
011	Initial voltage start ramp 2	30 - 90% U	1 - 4	90		page 38
012	Start time ramp 2	oFF, 1 - 60 sec	1 - 4	oFF		page 38
013	Step down voltage stop ramp 2	100 - 40% U	1 - 4	40		page 38
014	Stop time ramp 2	oFF, 2 - 120 sec	1 - 4	oFF		page 38
016	Initial torque at start	0 - 250% Tn	1 - 4	10		page 39
017	End torque at start	50 - 250% Tn	1 - 4	150		page 39
018	End torque at stop	0-100% Tn	1 - 4	0		page 39
020	Voltage ramp with current limit at start	oFF, 150 - 500% I_n	1 - 4	oFF		page 39
021	Current limit at start	oFF, 150 - 500% I_n	1 - 4	oFF		page 40
022	Pump control	oFF, on	1 - 4	oFF		page 40
023	Remote analogue control	oFF, 1, 2	1 - 4	oFF		page 41
024	Full voltage start D.O.L	oFF, on	1 - 4	oFF		page 41
025	Torque control	oFF, 1, 2	1 - 4	oFF		page 42
030	Torque boost active time	oFF, 0.1 - 2.0 sec	1 - 4	oFF		page 43
031	Torque boost current limit	300 - 700% I_n	1 - 4	300		page 43
032	Bypass	oFF, on	1 - 4	oFF		page 43
033	Power Factor Control PFC	oFF, on	1 - 4	oFF		page 46
034	Brake active time	oFF, 1 - 120 sec	1 - 4	oFF		page 47
035	Braking strength	100 - 500%	1 - 4	100		page 47
036	Braking methods	1, 2	1 - 4	1		page 47
037	Slow speed torque	10 - 100	1 - 4	10		page 49
038	Slow speed time at start	oFF, 1 - 60 sec	1 - 4	oFF		page 49
039	Slow speed time at stop	oFF, 1 - 60 sec	1 - 4	oFF		page 49
040	DC-Brake at slow speed	oFF, 1-60 sec	1 - 4	oFF		page 49
041	Nominal motor voltage	200 - 700 V	1 - 4	400		page 50
042	Nominal motor current	25-150% I_{nsoft} in Amp	1 - 4	I_{nsoft} in Amp		page 50
043	Nominal motor power	25 - 300% of P_{nsoft} in kW	1 - 4	P_{nsoft} in kW		page 50
044	Nominal speed	500 - 3600 rpm	1 - 4	N_{nsoft} in rpm		page 50
045	Nominal power factor	0.50 - 1.00	1 - 4	0.86		page 50
046	Nominal frequency	50, 60 Hz	——	50		page 50

BACK NEXT

Menu number	Function/Parameter	Range	Par.set	Factory setting	Value	Page
051	Programmable relay K1	1, 2, 3, (4), 5		1		page 51
052	Programmable relay K2	1, 2, 3, 4, 5	———	2		page 51
054	Analogue output	oFF, 1, 2	1 - 4	oFF		page 52
055	Analogue output value	1, 2, 3	1 - 4	1		page 52
056	Scaling analogue output	5 - 150%	1 - 4	100		page 52
057	Digital input selection	oFF, 1, 2, 3, 4	1 - 4	oFF		page 53
058	Digital input pulses	1-100	1 - 4	1		page 53
061	Parameter set	0, 1, 2, 3, 4	———	1		page 54
071	Motor PTC input	no, YES	———	no		page 55
072	Internal motor thermal protection class	oFF, 2 - 40 sec	———	10		page 55
073	Used thermal capacity	0 - 150%	———	———		page 55
074	Starts per hour limitation	oFF, 1 - 99/hour	1 - 4	oFF		page 55
075	Locked rotor alarm	oFF, 1.0 - 10.0 sec	1 - 4	oFF		page 55
081	Voltage unbalance alarm	2 - 25% U_n	1 - 4	10		page 56
082	Response delay voltage unbalance alarm	oFF, 1 - 60 sec	1 - 4	oFF		page 56
083	Over voltage alarm	100 - 150% U_n	1 - 4	115		page 56
084	Response delay over voltage alarm	oFF, 1 - 60 sec	1 - 4	oFF		page 56
085	Under voltage alarm	75 - 100% U_n	1 - 4	85		page 57
086	Response delay under voltage alarm	oFF, 1 - 60 sec	1 - 4	oFF		page 57
087	Phase sequence	L123, L321	———	———		page 57
088	Phase reversal alarm	oFF, on	———	oFF		page 57
089	Auto set power limits	no, YES	———	no		page 57
090	Output shaft power	0.0 - 200.0% Pn	———	———		page 57
091	Start delay power limits	1 - 250 sec	1 - 4	10		page 58
092	Max power alarm limit	5 - 200% Pn	1 - 4	115		page 58
093	Max alarm response delay	oFF, 0.1 - 25.0 sec	1 - 4	oFF		page 58
094	Max power pre-alarm limit	5 - 200% Pn	1 - 4	110		page 58
095	Max pre-alarm response delay	oFF, 0.1 - 25.0 sec	1 - 4	oFF		page 58
096	Min pre-alarm power limit	5 - 200% Pn	1 - 4	90		page 58
097	Min pre-alarm response delay	oFF, 0.1 - 25.0 sec	1 - 4	oFF		page 59
098	Min power alarm limit	5 - 200%Pn	1 - 4	85		page 59
099	Min alarm response delay	oFF, 0.1 - 25.0 sec	1 - 4	oFF		page 59
101	Run at single phase input failure	no, YES	1 - 4	no		page 61
102	Run at current limit time-out	no, YES	1 - 4	no		page 61
103	Jog forward enable	oFF, on	1 - 4	oFF		page 61
104	Jog reverse enable	oFF, on	1 - 4	oFF		page 61
105	Automatic return menu	oFF, 1-999	———	oFF		page 62
111	Serial comm. unit address	1 - 247	———	1		page 62
112	Serial comm. baudrate	2.4 - 38.4 kBaud	———	9.6		page 62

Menu number	Function/Parameter	Range	Par.set	Factory setting	Value	Page
113	Serial comm. parity	0, 1	———	0		page 62
114	Serial comm. contact broken	oFF, 1, 2	———	1		page 62
199	Reset to factory settings	no, YES	———	no		page 63
201	Current	0.0 - 9999 Amp	———	———		page 63
202	Line main voltage	0 - 720 V	———	———		page 63
203	Output shaft power	-9999 - 9999 kW	———	———		page 63
204	Power factor	0.00 - 1.00	———	———		page 63
205	Power consumption	0.000 - 2000 MWh	———	———		page 63
206	Reset power consumption	no, YES	———	no		page 64
207	Shaft torque	-9999 - 9999 Nm	———	———		page 64
208	Operation time	Hours	———	———		page 64
211	Current phase L1	0.0 - 9999 Amp	———	———		page 64
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Explanation of units:

U	Input line voltage
Un	Nominal motor voltage.
In	Nominal motor current.
Pn	Nominal motor power.
Nn	Nominal motor speed.
Tn	Nominal shaft torque.
Insoft	Nominal current soft starter.
Pnsoft	Nominal power soft starter.
Nnsoft	Nominal speed soft starter.

Calculation shaft torque

$$T_n = \frac{P_n}{\left(\frac{N_n}{60} x 2\pi\right)}$$

NOTE! The six main functions for motor control, menus 020–025, can only be selected one at a time.

14. INDEX

BACK NEXT

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BACK

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MAXIMIZING UPTIME

Article number 01-1363-01 r.2

14

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

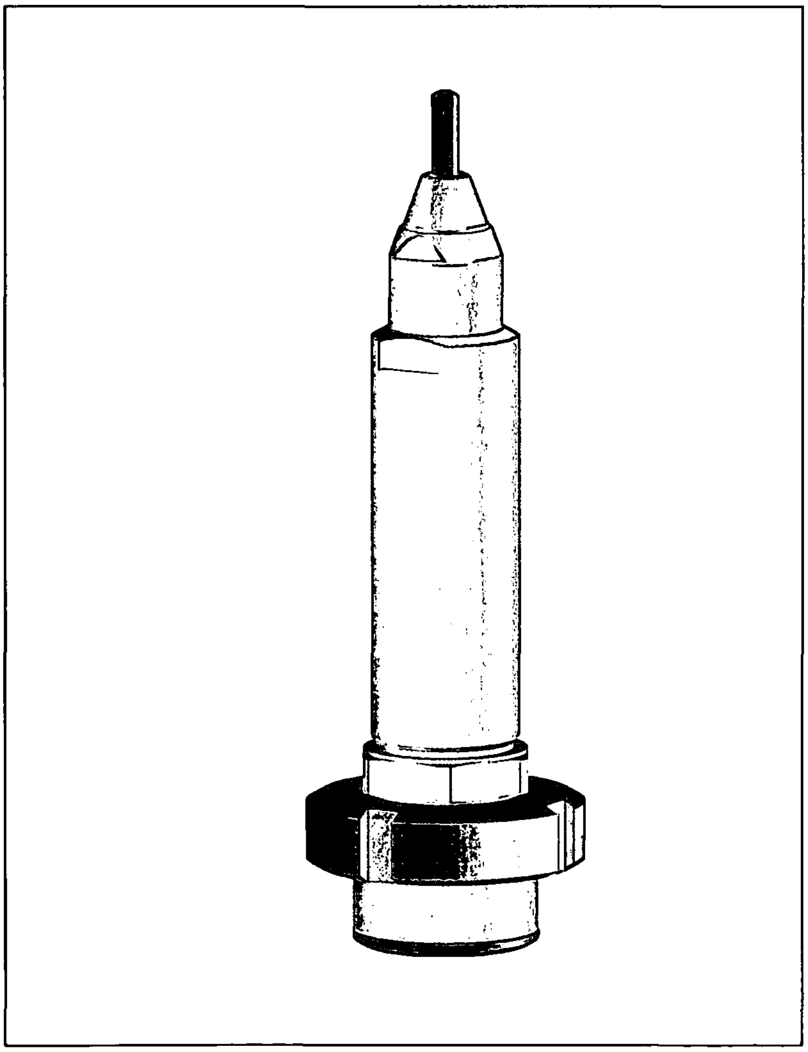
Equipment Type:	Delivery Pressure Transmitter
Location:	Common Control
Model Numbers:	BR74XXGG1FHA2X (SP119 50m Range & SP175 100m Range)
Manufacturer:	Vega
Supplier:	Vega 398 The Boulevard Kirrawee NSW 2232

VEGA

Operating Instructions

VEGABAR 74

4 ... 20 mA/HART



Process pressure/
Hydrostatic

Contents

Supplementary documentation

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

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

ℹ **Information, tip, note**
This symbol indicates helpful additional information.

⚠ **Caution:** If this warning is ignored, faults or malfunctions 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 **Ex applications**
This symbol indicates special instructions for Ex applications.

● **List**
The dot set in front indicates a list with no implied sequence.

→ **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 trouble-free 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™

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™.

---

[1] Due to the flush diaphragm, no own pressure compartment is formed.

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 Ex-approved 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

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

Components

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.

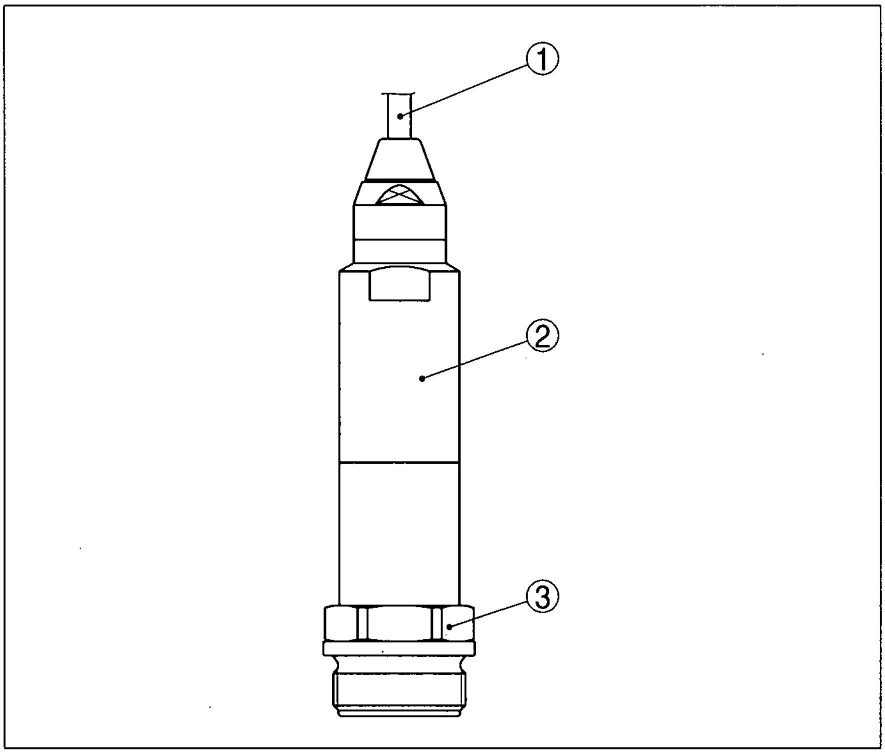


Fig. 1: Example of a VEGABAR 74 with process fitting G1½ A
1 Connection cable
2 Housing with electronics
3 Process fitting with measuring cell

3.2 Principle of operation

Area of application

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.

Functional principle

The sensor element is the CERTEC® 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® measuring cell is also equipped with a temperature sensor. The temperature value can be processed via the signal output.

Supply

Two-wire electronics 4 ... 20 mA/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 74 4 ... 20 mA/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™ 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™ and PC optionally also in the PC.

3.4 Packaging, transport and storage

Packaging

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 environment-friendly, recyclable cardboard. For special versions, PE foam or PE foil is also used. Dispose of the packaging material via specialised recycling companies.

Transport

Transport must be carried out under consideration of the notes on the transport packaging. Nonobservance of these instructions can cause damage to the device.

Transport inspection

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.

Storage

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

- Storage and transport temperature see "*Supplement - Technical data - Ambient conditions*"
- Relative humidity 20 … 85 %

4 Mounting

4.1 General instructions

Materials, wetted parts

Make sure that the wetted parts of VEGABAR 74, especially the seal and process fitting, are suitable for the existing process conditions such as pressure, temperature etc. as well as the chemical properties of the medium.

You can find the specifications in chapter "*Technical data*" in the "*Supplement*".

Temperature limits

Higher process temperatures often mean also higher ambient temperatures. Make sure that the upper temperature limits stated in chapter "*Technical data*" for the environment of the electronics housing and connection cable are not exceeded.

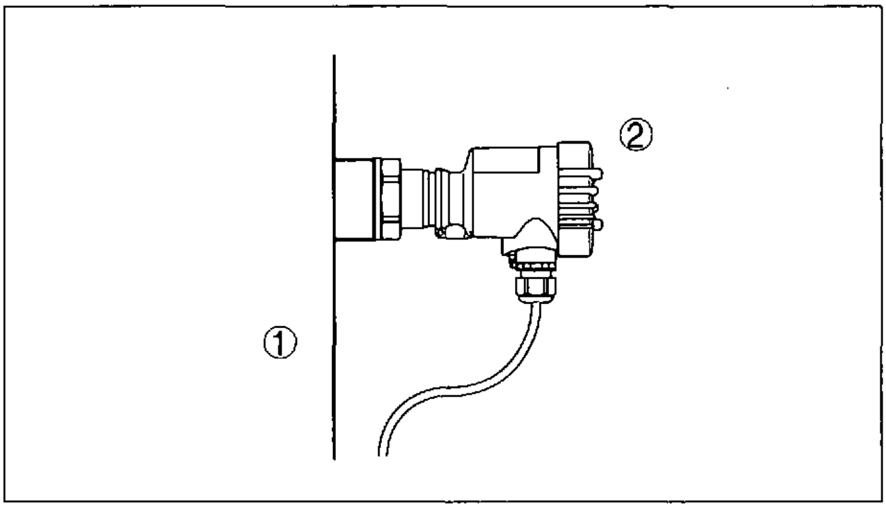


Fig. 2: Temperature ranges
1 Process temperature
2 Ambient temperature

Connection

- The connection cable has a capillary for atmospheric pressure compensation

→ Lead the cable end into a dry space or into a suitable terminal housing.

Information:
VEGA recommends the breather housing VEGABOX 02 or the indication/adjustment VEGADIS 12. Both contain terminals and a ventilation filter for pressure compensation. For mounting outdoors, a suitable protective cover is available.

4.2 Mounting steps

Sealing/Screwing in threaded versions

Seal the thread with teflon, hemp or a similar resistant seal material on the process fitting thread 1½ NPT.

→ Screw VEGABAR 74 into the welded socket. Tighten the hexagon on the process fitting with a suitable wrench. Wrench size, see chapter "*Dimensions*".

Sealing/Screwing in flange versions

Seal the flange connections according to DIN/ANSI with a suitable, resistant seal and mount VEGABAR 74 with suitable screws.

Sealing/Screwing in hygienic fittings

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*".

5 Connecting to power supply

5.1 Preparing the connection

Note safety instructions

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.

Take note of safety instructions for Ex applications

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

Select power supply

Power supply and current signal are carried on the same two-wire 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*")

Selecting connection cable

VEGABAR 74 is connected with standard two-wire cable without screen. An outer cable diameter of 5 … 9 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.

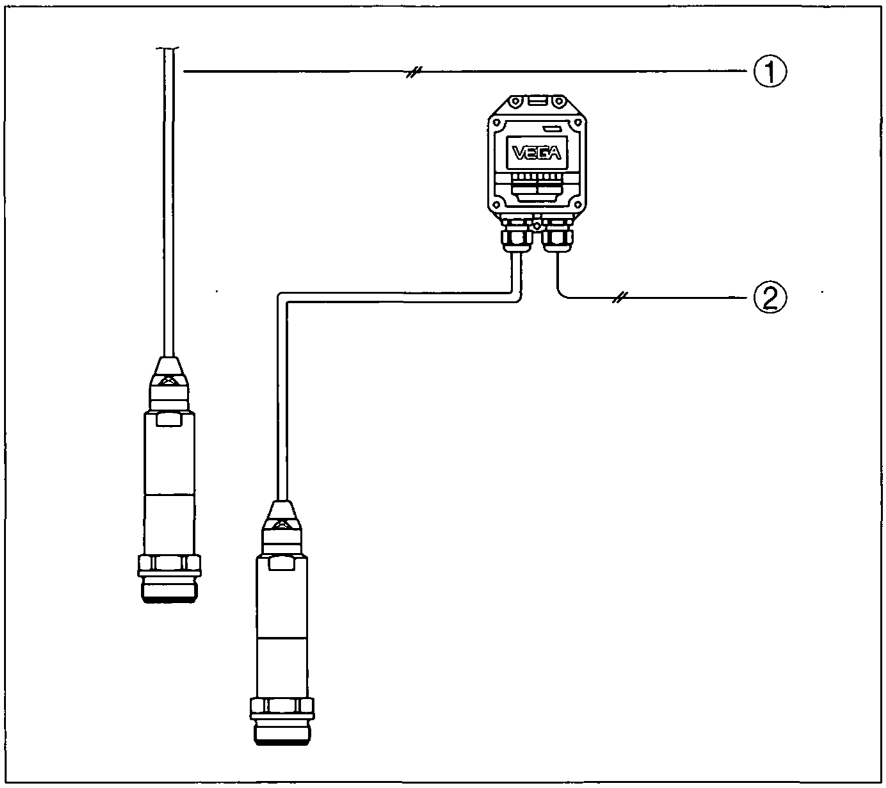


Fig. 3: Connection of VEGABAR 74
1 Direct connection
2 Connection via VEGABOX 02 or VEGADIS 12

Cable screening and grounding

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 nF, 1500 V). The low frequency potential equalisation currents are thus suppressed, but the protective effect against high frequency interference signals remains.

Select connection cable for Ex applications Ex

Take note of the corresponding installation regulations for Ex applications. In particular, make sure that no potential equalisation 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

Proceed as follows:

1 Wire the connection cable up to the connection compartment. The bending radius must be at least 25 mm.[2]

2 Connect the wire ends to the screw terminals according to the wiring plan

Via VEGABOX 01 or VEGADIS 12

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.

---

[2] The connection cable is already preconfectioned. After shortening the cable, fasten the type plate with support again to the cable.

5.3 Wiring plan

Direct connection

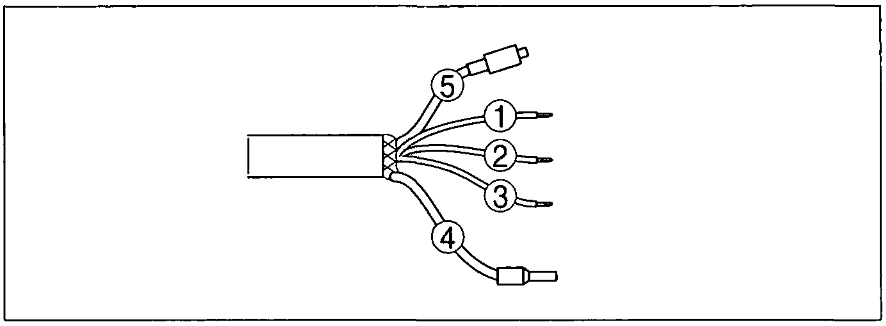


Fig. 4: Wire assignment, connection cable

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*[3]

4 *Screen*

5 *Breather capillaries with filter element*

Connection via VEGABOX 02

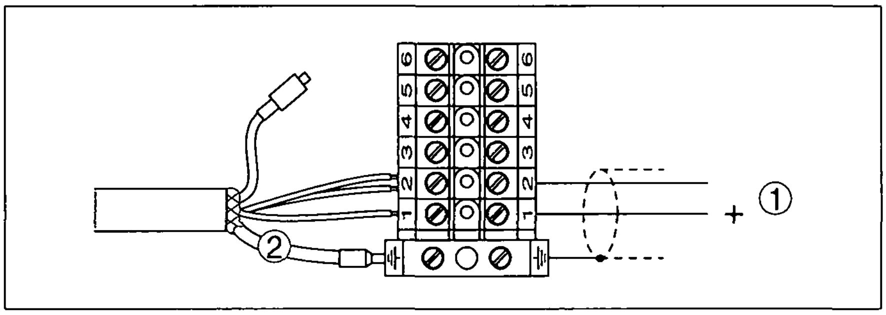


Fig. 5: Terminal assignment VEGABAR 74

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

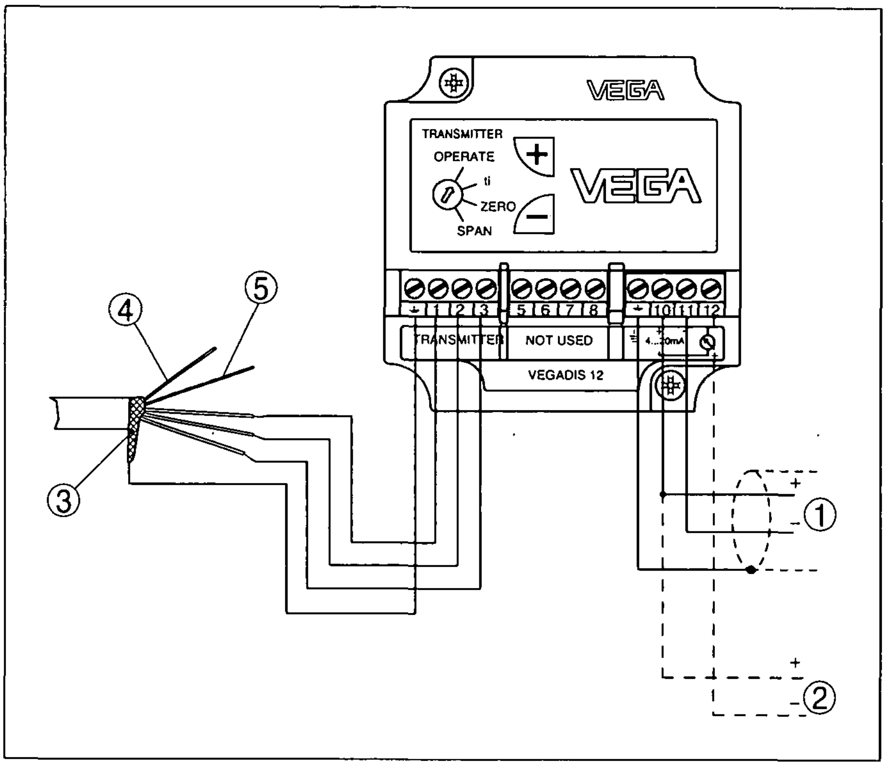


Fig. 6: Terminal assignment, VEGADIS 12
1 To power supply or the processing system
2 Control instrument (4 … 20 mA measurement)
3 Screen[5]
4 Breather capillaries
5 Suspension cable

Wire number	Wire colour/Polarity	Terminal VEGADIS 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.

→ Switch on voltage

The electronics now carries out a self-check for approx. 2 seconds. Then VEGABAR 74 delivers a current of 4 … 20 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

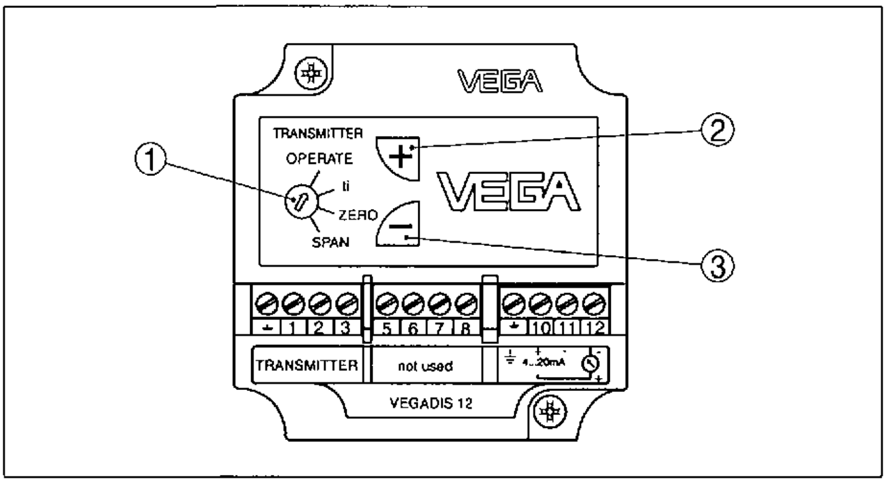


Fig. 7: Adjustment elements of VEGADIS 12
1 Rotary switch: choose the requested function
2 [+] key, change value (rising)
3 [-] key, change value (falling)

- With the rotary switch the requested function is selected
- With the *[+]* and *[-]* keys, the signal current or the integration time are adjusted
- Finally the rotary switch is set to position "*OPERATE*"

The set values are transmitted to the EEPROM memory and remain there even in case of voltage loss.

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 … 20 mA corresponds to the actual level.

Adjustment steps, integration time

Proceed as follows for the adjustment of the integration time with VEGADIS 12:

1 Open housing cover
2 Set rotary switch to "*ti*"
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

Adjustment steps, scaling

The display outputs the current 4 … 20 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 … 20 mA corresponds to the actual level.

7 Setup with PACTware™

7.1 Connect the PC with VEGACONNECT 3

Connecting the PC to the signal cable

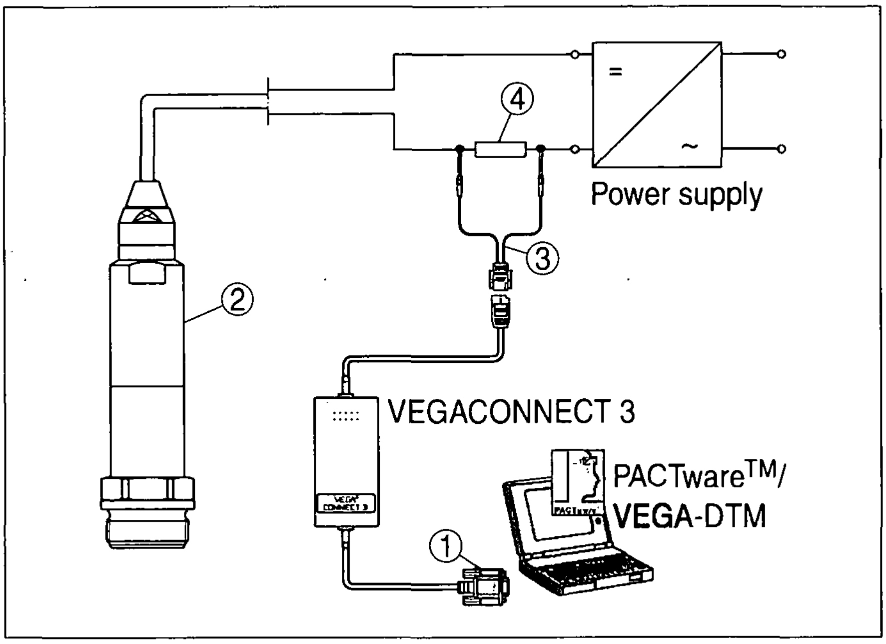


Fig. 8: Connecting the PC to the signal cable

1 *RS232 connection (with VEGACONNECT 3) or USB connection (with VEGACONNECT 4)*
2 *VEGABAR 74*
3 *HART adapter cable*
4 *HART resistance 250 Ohm (optional depending on the processing)*

Necessary components:

- VEGABAR 74
- PC with PACTware™ and suitable VEGA DTM
- VEGACONNECT 3 or 4 with HART adapter cable (art. no. 2.25397)
- HART resistance approx. 250 Ohm
- Power supply unit

Note:
With power supply units with integrated HART resistance (internal resistance approx. 250 Ohm), an additional external resistance is not necessary (e.g. VEGATRENN 149A, VEGADIS 371, VEGAMET 381/624/625, VEGASCAN 693). In such cases, VEGACONNECT 3 can be connected parallel to the 4 … 20 mA cable.

7.2 Connect the PC with VEGACONNECT 4

Connection via HART

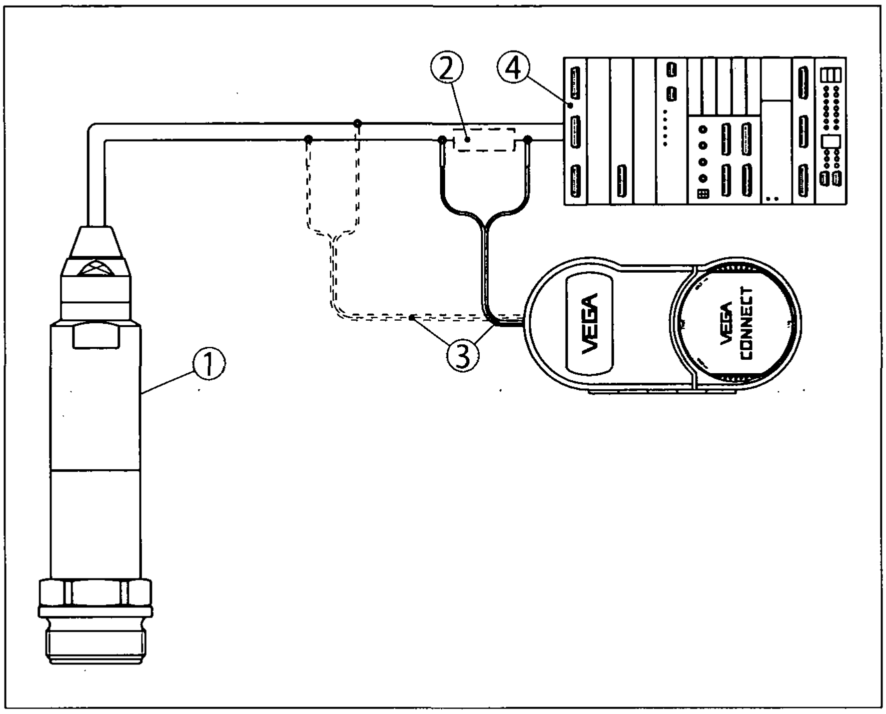


Fig. 9: Connecting the PC via HART to the signal cable
1 VEGABAR 74
2 HART resistance 250 Ohm (optional depending on the processing)
3 Connection cable with 2 mm pins and terminals
4 Processing system/PLC/Voltage supply

Necessary components:

- VEGABAR 74
- PC with PACTware™ 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 ... 20 mA cable.

7.3 Parameter adjustment with PACTware™

Further setup steps are described in the operating instructions manual "*DTM Collection/PACTware™*" attached to each CD and which can also be downloaded from our homepage. A detailed description is available in the online help of PACTware™ 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-to-date PACTware™ version. The basic version of this DTM Collection incl. PACTware™ is also available as a free-of-charge download from the Internet.

Go via www.vega.com and "*Downloads*" to the item "*Software*".

7.4 Parameter adjustment with AMS™ and PDM

For VEGA sensors, instrument descriptions for the adjustment programs AMS™ and PDM are available as DD or EDD. The instrument descriptions are already implemented in the current versions of AMS™ and PDM. For older versions of AMS™ 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™ 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

The operator of the system is responsible for taken suitable measures to remove interferences.

Causes of malfunction

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

Fault rectification

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™ and the suitable DTM. In many cases, the causes can be determined in this way and faults can be rectified.

24 hour service hotline

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.

Checking the 4 … 20 mA signal

Connect a handheld multimeter in the suitable measuring range according to the wiring plan.

? 4 … 20 mA signal not stable
  - Level fluctuations
  → Adjust integration time via PACTware™
  - no atmospheric pressure compensation
  → Check the capillaries and cut them clean

- → Check the pressure compensation in the housing and clean the filter element, if necessary

? 4 ... 20 mA signal missing

- Wrong connection to power supply
- → Check connection according to chapter "*Connection steps*" and if necessary, correct according to chapter "*Wiring plan*"
- No voltage supply
- → Check cables for breaks; repair if necessary
- supply voltage too low or load resistance too high
- → Check, adapt if necessary

? Current signal 3.6 mA; 22 mA

- electronics module or measuring cell defective
- → 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

Depending on the failure reason and measures taken, the steps described in chapter "*Set up*" must be carried out again, if necessary.

8.3 Instrument repair

If a repair is necessary, please proceed as follows:

You can download a return form (23 KB) from the Internet on our homepage www.vega.com under: "*Downloads - Forms and certificates - Repair form*".

By doing this you help us carry out the repair quickly and without having to call back for needed information.

- Print and fill out one form per instrument
- Clean the instrument and pack it damage-proof
- Attach the completed form and, if need be, also a safety data sheet outside on the packaging
- Please ask the agency serving you for the address of your return shipment. You can find the respective agency on our website www.vega.com under: "*Company - VEGA worldwide*"

9 Dismounting

9.1 Dismounting steps

⚠ **Warning:**
Before dismounting, be aware of dangerous process conditions 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/EG 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	VEGA Grieshaber KG, D-77761 Schiltach
Type name	VEGABAR 74
Parameter, pressure	Gauge pressure, absolute pressure, vacuum
Measuring principle	Ceramic-capacitive, dry measuring cell
Communication interface	None

Materials and weights

Material 316L corresponds to 1.4404 or 1.4435

Materials, wetted parts	
– Process fitting	316L
– Diaphragm	sapphire ceramic® (99.9 % oxide ceramic)
– Seal	FKM (e.g. Viton), Kalrez 6375, EPDM, Chemraz 535
– Seal process fitting thread G½ A, G1½ A	Klingersil C-4400
Materials, non-wetted parts	
– Housing	316L
– Ground terminal	316Ti/316L
– Connection cable	PUR, FEP, PE
– type label support on cable	PE-HART
Weight	0.8 … 8 kg (1.8 … 17.6 lbs), depending on process fitting

Output variable

Output signal	4 … 20 mA/HART
Failure signal	22 mA (3.6 mA), adjustable
Max. output current	22.5 mA
Damping (63 % of the input variable)	0 … 10 s, adjustable
Step response or adjustment time	70 ms (ti: 0 s, 0 … 63 %)
Fulfilled NAMUR recommendations	NE 43

Additional output parameter - temperature

Processing is made via HART-Multidrop

Range	-50 … +150 °C (-58 … +302 °F)
Resolution	1 °C (1.8 °F)
Accuracy	
– in the range of 0 … +100°C (+32 … +212 °F)	±3 K
– in the range of -50 … 0 °C (-58 … +32 °F) and +100 … +150 °C (+212 … +302 °F)	typ. ±4 K

Input variable

Adjustment

Zero adjustable	-20 … +95 % of the nominal measuring range
Span adjustable	3.3 … +120 % of the nominal measuring range
Recommended max. turn down	10:1

Nominal measuring ranges and overload resistance

Nominal range	Overload, max. pressure[6]	Overload, min. pressure
Gauge pressure		
0 … 0.1 bar/0 … 10 kPa	15 bar/1500 kPa	-0.2 bar/-20 kPa
0 … 0.2 bar/0 … 20 kPa	20 bar/2000 kPa	-0.4 bar/-40 kPa
0 … 0.4 bar/0 … 40 kPa	30 bar/3000 kPa	-0.8 bar/-80 kPa
0 … 1 bar/0 … 100 kPa	35 bar/3500 kPa	-1 bar/-100 kPa
0 … 2.5 bar/0 … 250 kPa	50 bar/5000 kPa	-1 bar/-100 kPa
0 … 5 bar/0 … 500 kPa	65 bar/6500 kPa	-1 bar/-100 kPa
0 … 10 bar/0 … 1000 kPa	90 bar/9000 kPa	-1 bar/-100 kPa
0 … 25 bar/0 … 2500 kPa	130 bar/13000 kPa	-1 bar/-100 kPa
0 … 60 bar/0 … 6000 kPa	200 bar/20000 kPa	-1 bar/-100 kPa
-1 … 0 bar/-100 … 0 kPa	35 bar/3500 kPa	-1 bar/-100 kPa
-1 … 1.5 bar/-100 … 150 kPa	50 bar/5000 kPa	-1 bar/-100 kPa
-1 … 5 bar/-100 … 500 kPa	65 bar/6500 kPa	-1 bar/-100 kPa
-1 … 10 bar/-100 … 1000 kPa	90 bar/9000 kPa	-1 bar/-100 kPa
-1 … 25 bar/-100 … 2500 kPa	130 bar/13000 kPa	-1 bar/-100 kPa
-1 … 60 bar/-100 … 6000 kPa	300 bar/30000 kPa	-1 bar/-100 kPa
-0.05 … 0.05 bar/-5 … 5 kPa	15 bar/1500 kPa	-0.2 bar/-20 kPa
-0.1 … 0.1 bar/-10 … 10 kPa	20 bar/2000 kPa	-0.4 bar/-40 kPa

---

[6] Limited to 200 bar according to the pressure device directive.

Nominal range	Overload, max. pressure6)	Overload, min. pressure
-0.2 … 0.2 bar/-20 … 20 kPa	30 bar/3000 kPa	-0.8 bar/-80 kPa
-0.5 … 0.5 bar/-50 … 50 kPa	35 bar/3500 kPa	-1 bar/-100 kPa
Absolute pressure		
0 … 0.1 bar/0 … 10 kPa	15 bar/1500 kPa	
0 … 1 bar/0 … 100 kPa	35 bar/3500 kPa	
0 … 2.5 bar/0 … 250 kPa	50 bar/5000 kPa	
0 … 5 bar/0 … 500 kPa	65 bar/6500 kPa	
0 … 10 bar/0 … 1000 kPa	90 bar/9000 kPa	
0 … 25 bar/0 … 2500 kPa	130 bar/13000 kPa	
0 … 60 bar/0 … 6000 kPa	200 bar/20000 kPa	

Reference conditions and influencing variables (similar to DIN EN 60770-1)

Reference conditions according to DIN EN 61298-1

– Temperature	+15 … +25 °C (+59 … +77 °F)
– Relative humidity	45 … 75 %
– Air pressure	860 … 1060 mbar/86 … 106 kPa (12.5 … 15.4 psi)
Determination of characteristics	Limit point adjustment according to IEC 61298-2
Characteristics	linear
Reference installation position	upright, diaphragm points downward
Influence of the installation position	<0.2 mbar/20 Pa (0.003 psi)

Deviation determined according to the limit point method according to IEC 60770[7]

Applies to **digital** HART interface as well as to **analogue** current output 4 … 20 mA. Specifications refer to the set span. Turn down (TD) = nominal measuring range/set span.

Deviation

– Turn down 1:1 up to 5:1	<0.075 %
– Turn down up to 10:1	<0.015 % x 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 % x TD

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[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 % x TD
– Turn down up to 10:1	<0.05 % x TD

Influence of the product or ambient temperature

Applies to **digital** HART interface as well as to **analogue** current output 4 … 20 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 … +100 °C (+212 °F), reference temperature 20 °C (68 °F):

Average temperature coefficient of the zero signal

– Turn down 1:1	<0.05 %/10 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 K

Thermal change of the current output

Applies also to the **analogue** 4 … 20 mA current output and refers to the set span.

Thermal change, current output	<0.15 % at -40 … +80 °C (-40 … +176 °F)

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 … 20 mA. Specifications refer to the set span. Turn down (TD) = nominal measuring range/set span.

Long-term drift of the zero signal	<(0.1 % x 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:

$F_{total} = F_{perf} + F_{stab}$

$F_{perf} = \sqrt{((F_T)^2 + (F_{Kl})^2)}$

With

- F_{total}: Total deviation
- F_{perf}: Basic accuracy
- F_{stab}: Long-term drift

- F_T: Temperature coefficient (influence of medium or ambient temperature)
- F_{Kl}: Deviation

Ambient conditions

Ambient, storage and transport temperature

– Connection cable PE	-40 … +60 °C (-40 … +140 °F)
– Connection cable PUR, FEP	-40 … +85 °C (-40 … +185 °F)

Process conditions

The specifications of the pressure stage are used as an overview. The specifications on the type 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 lbs, 300 lbs
Product temperature depending on the measuring cell seal	
– FKM (e.g. Viton)	-20 … +100 °C (-4 … +212 °F)
– EPDM	-40 … +100 °C (-40 … +212 °F), 1 h: 140 °C/ 284 °F cleaning temperature
– Kalrez 6375 (FFKM)	-10 … +100 °C (+14 … +212 °F)
– Chemraz 535	-30 … +100 °C (-22 … +212 °F)
Vibration resistance	mechanical vibrations with 4 g and 5 … 100 Hz[8]
Shock resistance	Acceleration 100 g/6 ms[9]

Electromechanical data

Connection cable	
– Configuration	four wires, one suspension cable, one breather capillary, screen braiding, metal foil, mantle
– Wire cross-section	0.5 mm² (AWG no. 20)
– wire resistance	<0.036 Ohm/m (0.011 Ohm/ft)
– Standard length	6 m (19.685 ft)
– max. length with VEGADIS 12	200 m (656.168 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 °C/77 °F	25 mm (0.985 in)
– Diameter	approx. 8 mm (0.315 in)
– Colour - standard PE	Black
– Colour - standard PUR	Blue
– Colour - Ex-version	Blue

Voltage supply

Supply voltage	
– Non-Ex instrument	12 … 36 V DC
– EEx ia instrument	12 … 29 V DC
Permissible residual ripple	
– <100 Hz	U_{ss} <1 V
– 100 Hz … 10 kHz	U_{ss} <10 mV
Load	see diagram

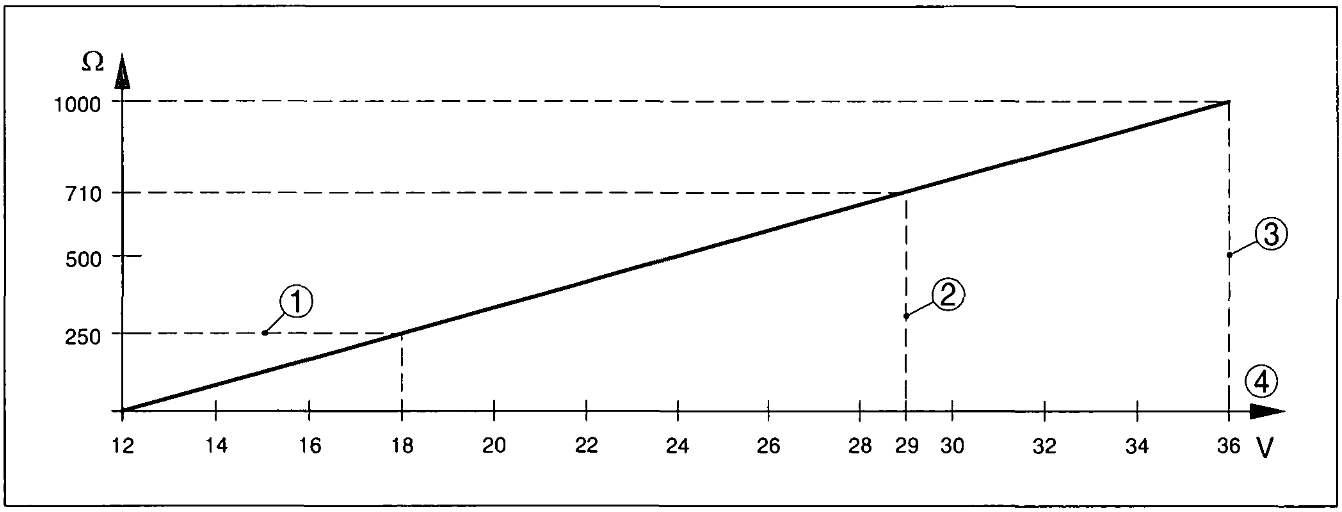

Fig. 10: Voltage diagram VEGABAR 74
1 HART load
2 Voltage limit Ex instrument
3 Voltage limit non-Ex instrument
4 Voltage supply

Load in conjunction with VEGADIS 12	see diagram

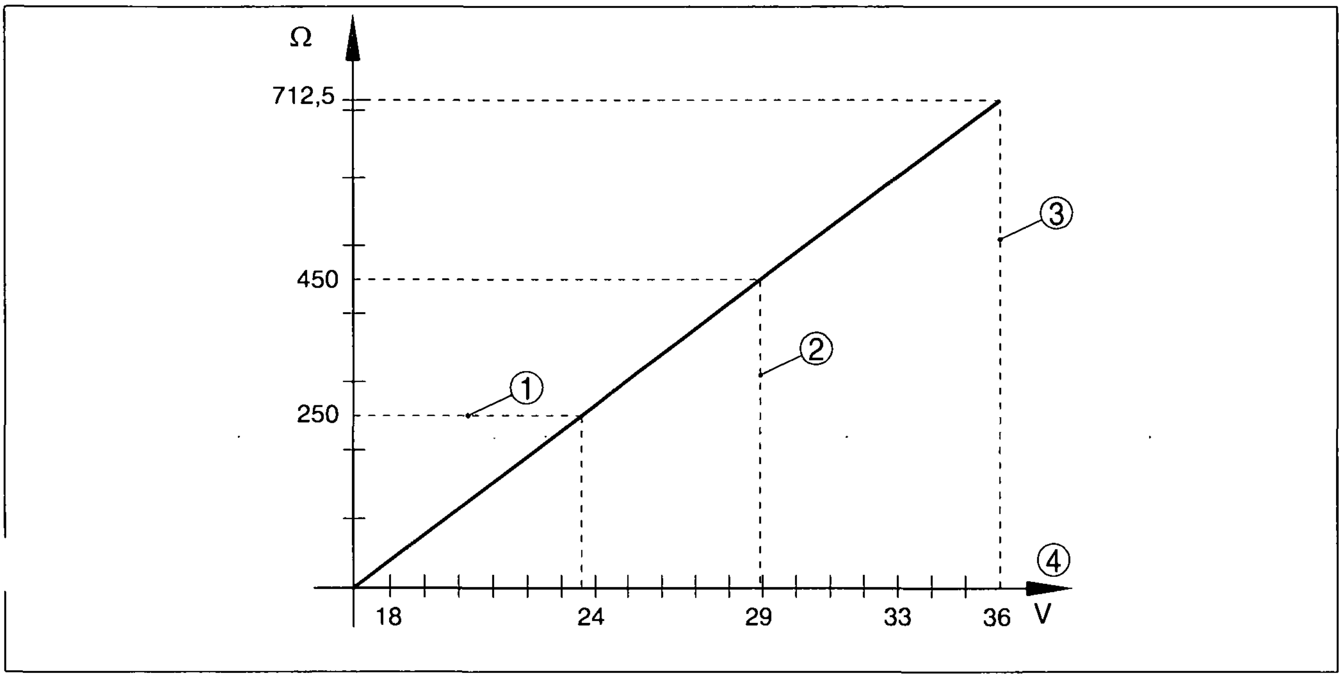

Fig. 11: Voltage diagram VEGABAR 74 with VEGADIS 12
1 *HART load*
2 *Voltage limit Ex instrument*
3 *Voltage limit non-Ex instrument*
4 *Voltage supply*

Integrated overvoltage protection	
Nominal leakage current (8/20 µs)	10 kA
Min. response time	<25 ns

Electrical protective measures	
Protection	IP 68 (25 bar)/IP 69K
Overvoltage category	III
Protection class	III

Approvals[10]	
ATEX ia	ATEX II 1G EEx ia IIC T6; ATEX II 2G EEx ia IIC T6
Ship approvals	GL, LRS, ABS, CCS, RINA, DNV
Others	WHG

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[10] Deviating data in Ex applications: see separate safety instructions.

10.2 Dimensions

VEGABAR 74 - threaded fitting

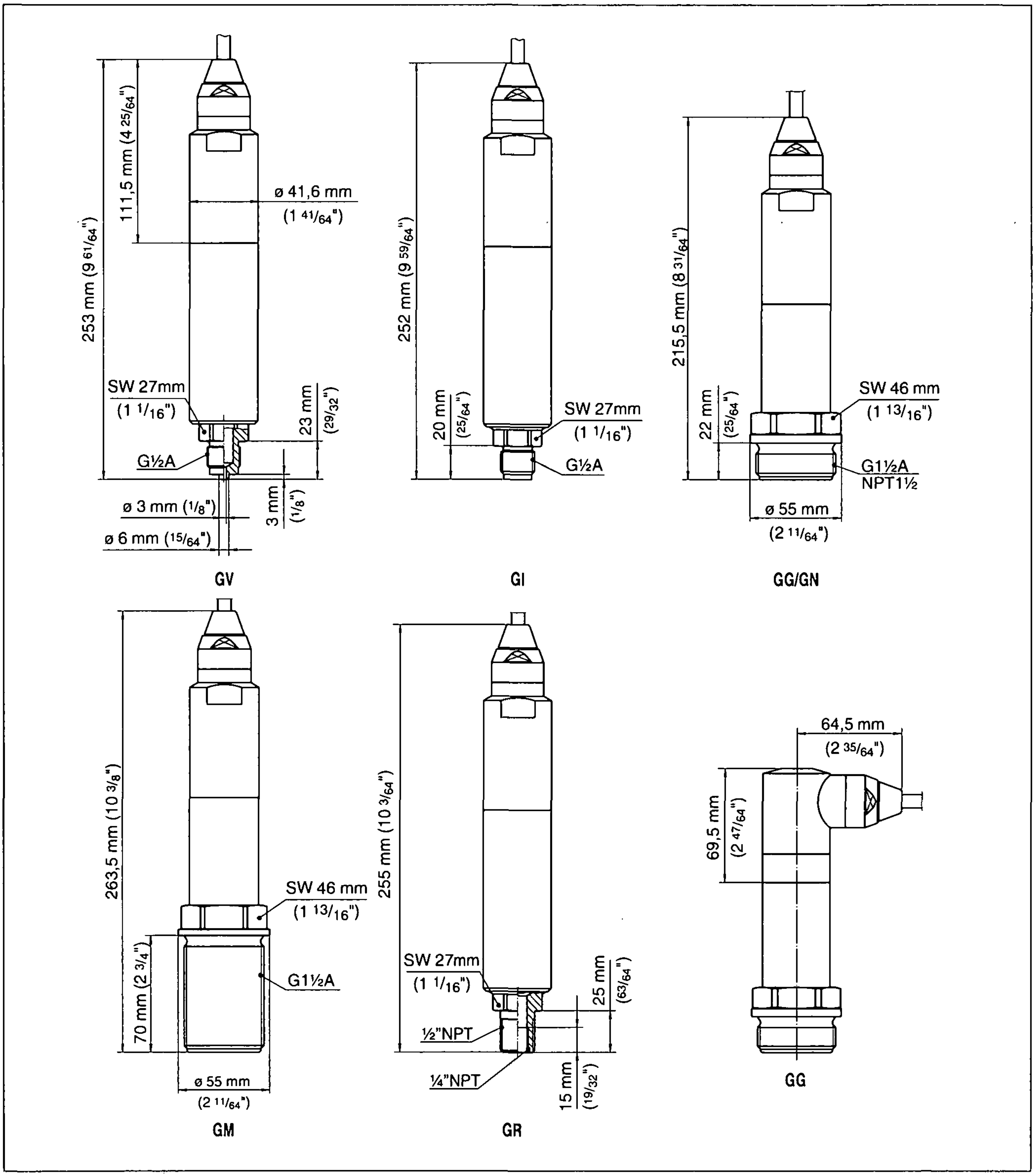


Fig. 12: VEGABAR 74 threaded fitting: GV = G½ A manometer connection EN 837, GI = G½ A inner G¼ A, GG = G1½ A, GN = 1½ NPT, GM = G1½ A 70 mm, GR = ½ NPT inner ¼ NPT

VEGABAR 74 - hygienic fitting 1

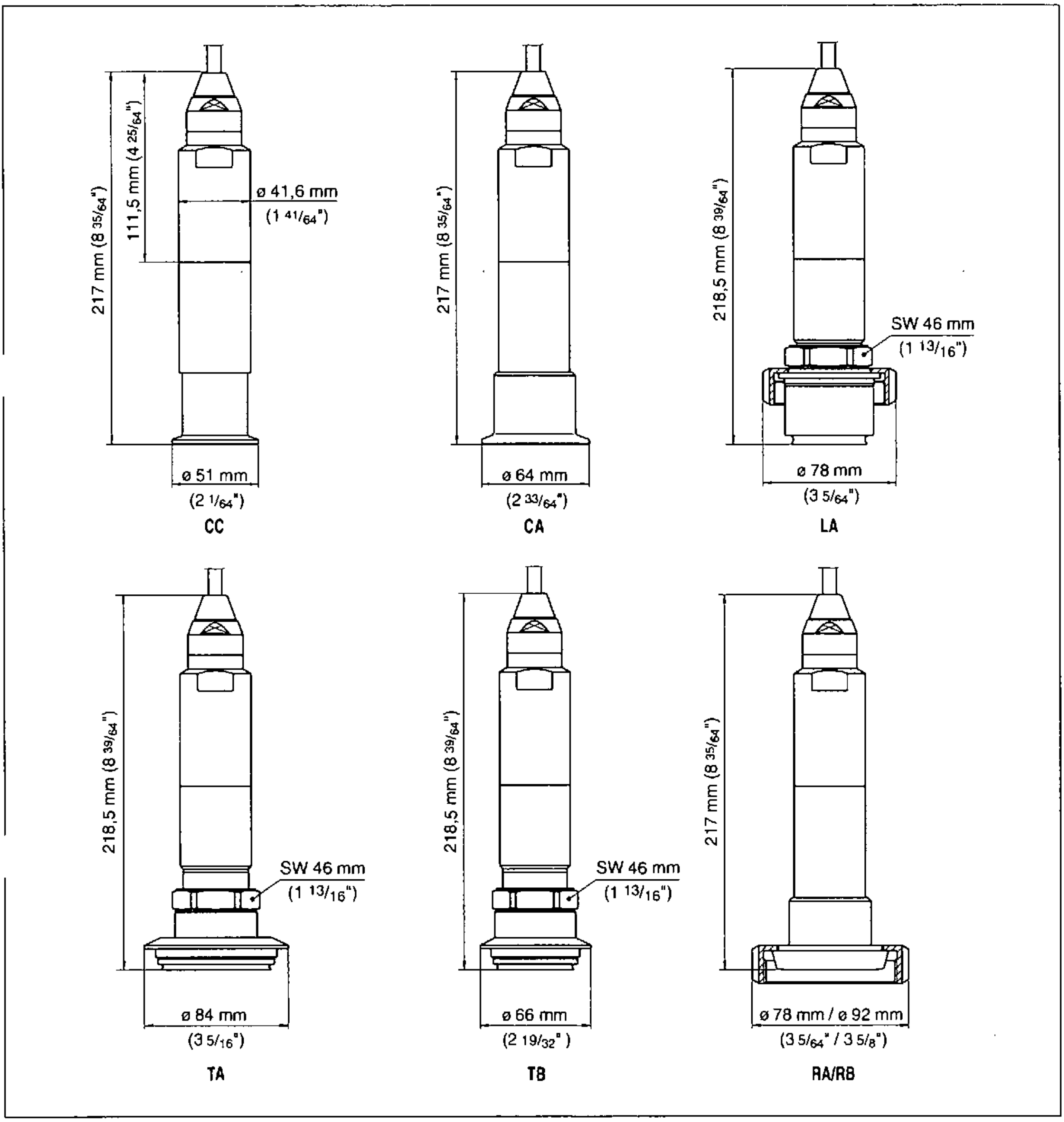


Fig. 13: VEGABAR 74 hygienic fitting: CC = Tri-Clamp 1½", CA = Tri-Clamp 2", LA = hygienic fitting with compression nut F40, TA = Tuchenhagen Varivent DN 32, TB = Tuchenhagen Varivent DN 25, RA/RB = bolting DN 40/DN 50 according to DIN 11851

VEGABAR 74 - hygienic fitting 2

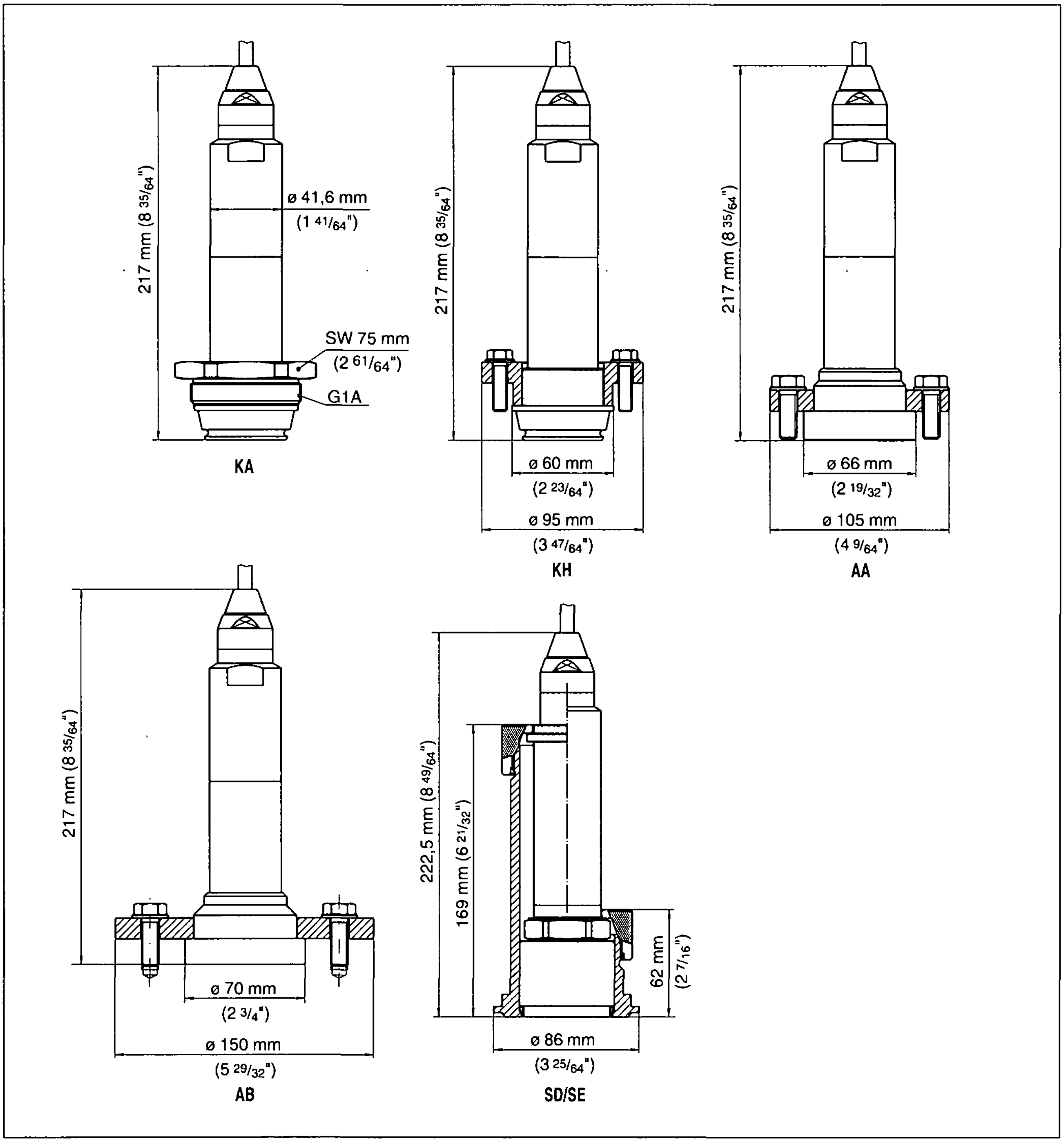
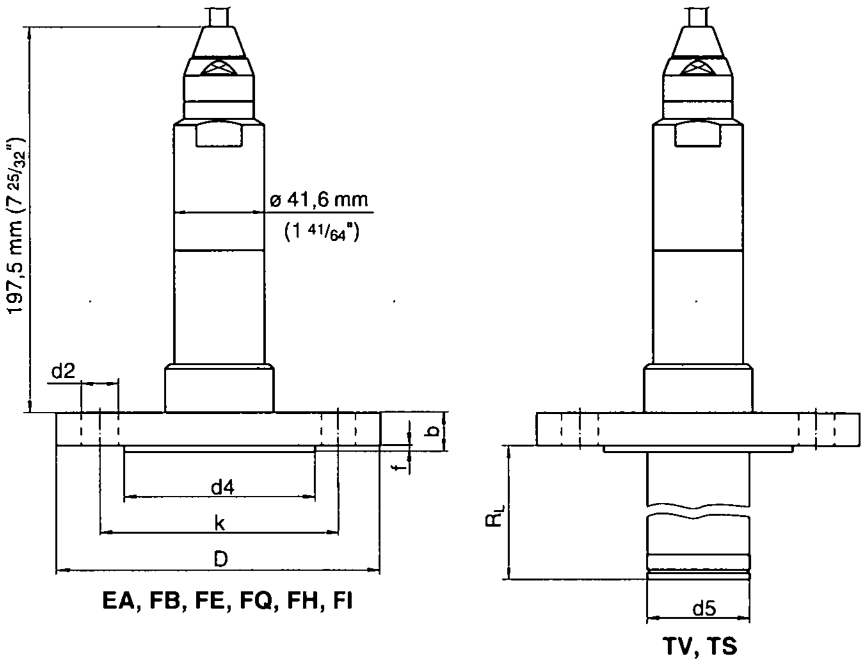


Fig. 14: VEGABAR 74 KA/KH = cone DN 40, AA = DRD, SD/SE = Anderson 3" long/short fitting

VEGABAR 74 - flange connection



①	DN	PN	D	b	k	d2	d4	f	RL	d5
EA	40	40	5 29/32"	45/64"	4 21/64"	4xø 45/64"	3 15/32"	1/8"	-	-
FB	50	40	6 1/2"	25/32"	4 59/64"	4xø 45/64"	4 1/64"	1/8"	-	-
FE	80	40	7 7/8"	15/16"	6 19/64"	8xø 45/64"	5 7/16"	1/8"	-	-

②	"	lbs	D	b	k	d2	d4	f	RL	d5
FQ	1 ½"	150	5"	11/16"	3 14/16"	4xø 5/8"	2 7/8"	1/8"	-	-
FH	2"	150	6"	3/4"	4 3/4"	4xø 5/8"	3 5/8"	1/8"	-	-
FI	3"	150	7 1/2"	3/4"	6	4xø 5/8"	6	1/8"	-	-

③	DN	PN	D	b	k	d2	d4	f	RL	d5
TV	50	40	6 1/2"	25/32"	4 59/64"	4xø 45/64"	4 1/64"	1/8"	④	1 1/2"
TS	80	40	7 7/8"	15/16"	6 19/64"	8xø 45/64"	5 7/16"	1/8"		1 1/2"

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

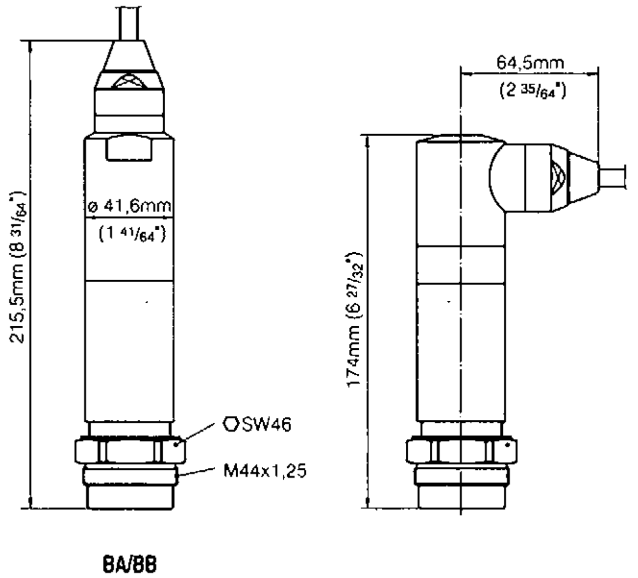


Fig. 16: VEGABAR 74 - connection for paper industry: BA/BB = M44x1.25

VEGABAR 74 - extension fitting for paper industry

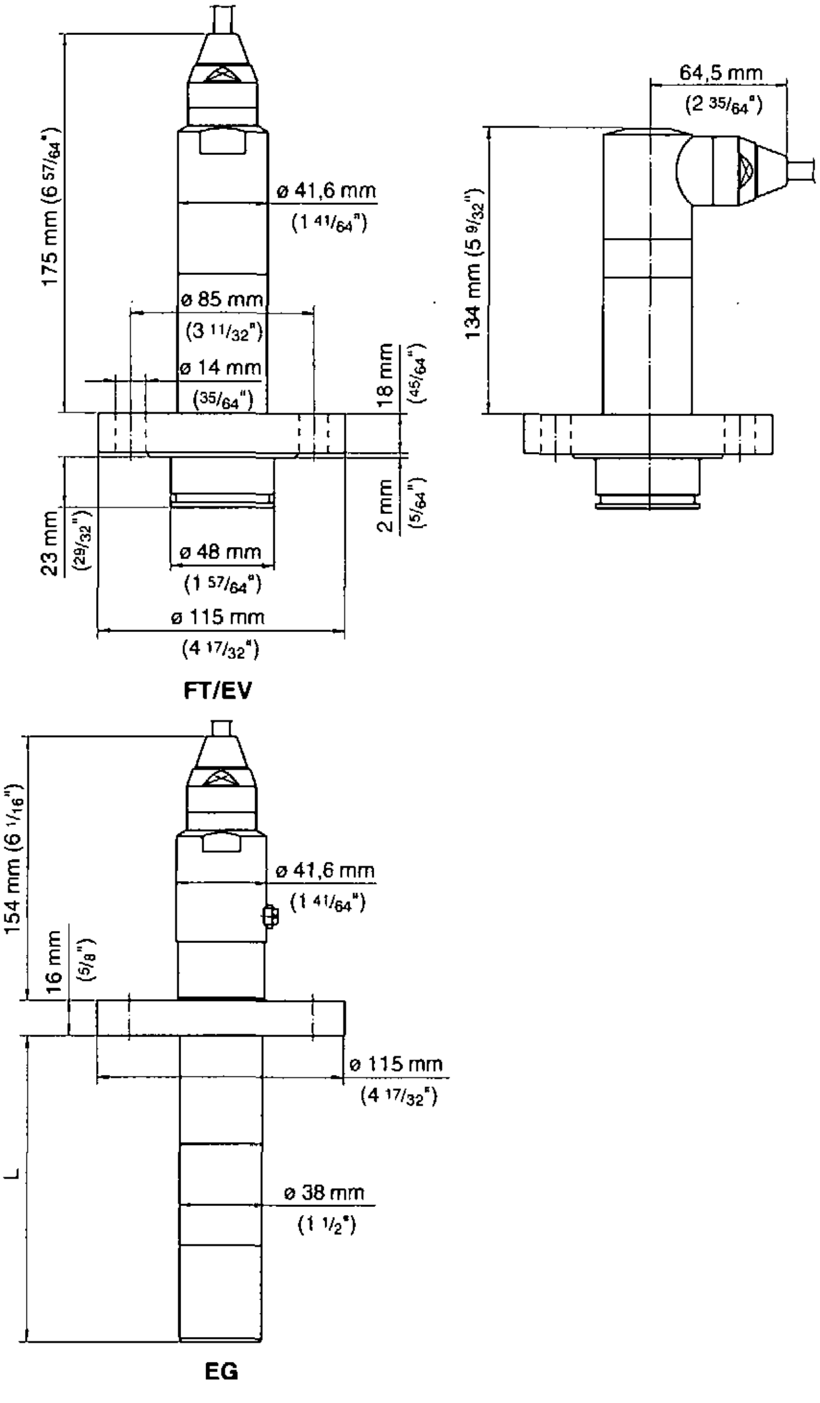


Fig. 17: VEGABAR 74 - extension fitting for paper industry: EV/FT = absolutely flush for pulper (EV 2-times flattened), EG = extension for ball valve fitting (L = order-specific)

10.3 Industrial property rights

VEGA product lines are global protected by industrial property rights.
Further information see http://www.vega.com.
Only in U.S.A.: Further information see patent label at the sensor housing.

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Para mayor información revise la pagina web http://www.vega.com.

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进一步信息请参见网站<http://www.vega.com>。

10.4 Trademark

All brands used as well as trade and company names are property of their lawful proprietor/originator.

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Fax +49 7836 50-201
E-mail: info@de.vega.com
www.vega.com

Subject to change without prior notice 28432-EN-070718

15

TECHNICAL DATA SHEET

For

SEWERAGE PUMP STATION SP144
Lavarack Av #1 Eagle Farm

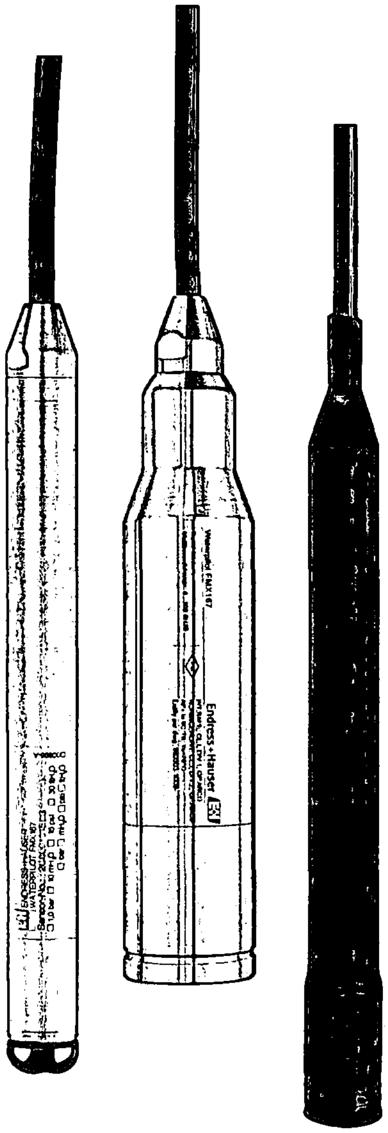
Equipment Type:	Wet Well Level Transmitter
Location:	Common Control
Model Numbers:	FM167-A2BMD1A3
Manufacturer:	Endress & Hauser
Supplier:	Unit 8/277 Lane Cove Rd North Ryde NSW 2113 Tel: 02 8877 7000 Fax: 02 8877 7099

Level Pressure Flow Temperature Liquid Analysis Registration Systems Components Services Solutions

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 FMX167 are available at Endress+Hauser:

- FMX167 with an outer diameter = 22 mm (0.87 inch): Version very suitable for drinking water applications and for use in probe tubes with small diameters
- FMX167 with an outer diameter = 42 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 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-filter pressure compensation system
- 4...20 mA output signal with integrated overvoltage protection
- Simultaneous level and temperature measurement by optional integrated temperature sensor Pt 100
- Drinking water approval: KTW, NSF, ACS
- Certified to ATEX, FM and CSA
- Marine approval: GL, ABS
- Complete measuring point solutions through comprehensive accessories

TI351P/00/en/02.08

Endress+Hauser
People for Process Automation

Table of contents

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 – Extension cable mounting screw with G1 1/2 A or 1 1/2 NPT thread		
Outer diameter d_O	22 mm (0.87 inch)	42 mm (1.66 inch)	Max. 29 mm (1.15 inch)
Seals	– FKM Viton – EPDM[1]	– FKM Viton	– FKM Viton – EPDM
Measuring ranges	– Nine fixed pressure measuring ranges in bar, mH_2O, psi and ftH_2O, from 0...0.1 bar to 0...20 bar (0...1 mH_2O to 0...200 mH_2O/ 0...1.5 psi to 0...300 psi/0...3 ftH_2O to 0...600 ftH_2O) – Customer-specific measuring ranges; factory-calibrated		– Seven fixed pressure measuring ranges in bar, mH_2O, psi and ftH_2O, from 0...0.1 bar to 0...4 bar (0...1 mH_2O to 0...40 mH_2O/ 0...1.5 psi to 0...60 psi/ 0...3 ftH_2O to 0...150 ftH_2O) – Customer-specific measuring ranges; factory-calibrated
Overload	Up to 40 bar (580 psi)		Up to 25 bar (362 psi)
Process temperature	–10...+70°C (-14...+158°F)		0...+50°C (+32...+122°F)
Ambient temperature range	–10...+70°C (-14...+158°F)		0...+50°C (+32...+122°F)
Maximum measured error	±0.2 % of upper range value (URV)		
Supply voltage	10...30 V DC		
Output	4...20 mA		
Options	– Drinking water approval – Integrated Pt 100 temperature sensor – Integrated Pt 100 temperature sensor and temperature transmitter TMT181 (4...20 mA) – Marine approval	– Integrated Pt 100 temperature sensor – Integrated Pt 100 temperature sensor and temperature transmitter TMT181 (4...20 mA) – Marine approval	– Integrated Pt 100 temperature sensor – Integrated Pt 100 temperature sensor and temperature transmitter TMT181 (4...20 mA) – Marine approval
Specialties	– Integrated overvoltage protection – Large selection of approvals, including ATEX II 2 G, FM and CSA – High-precision, long-term stable and rugged ceramic measuring cell		

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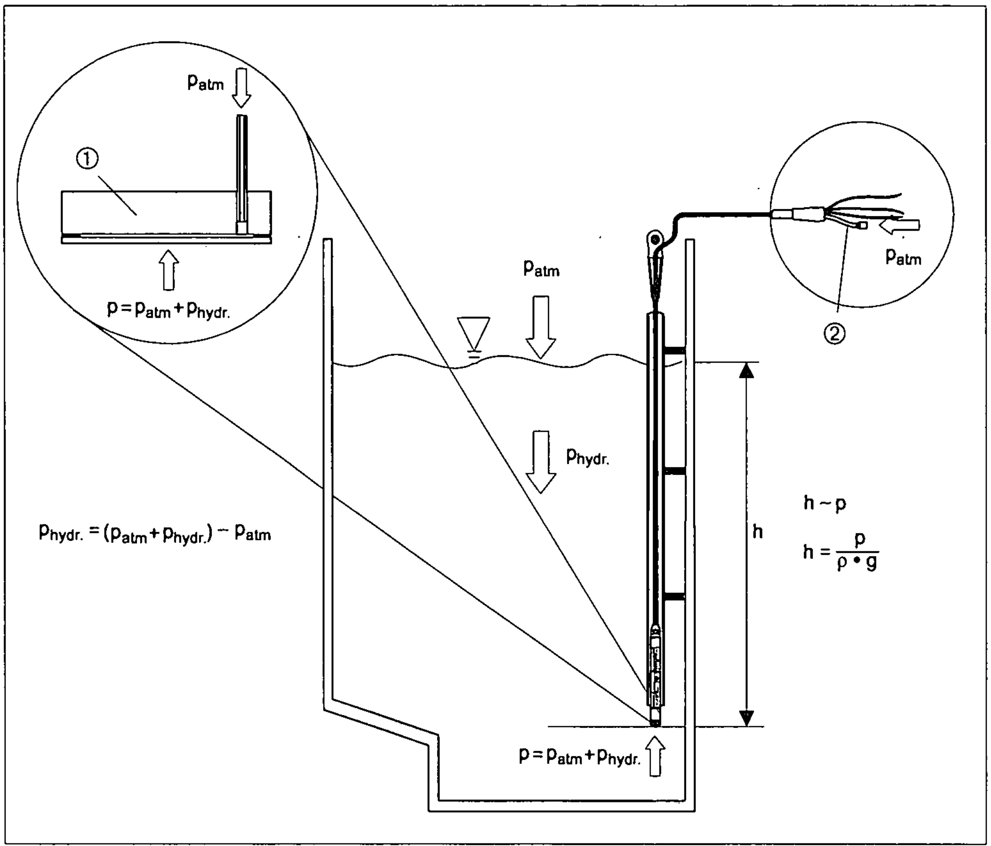
[1] Recommended for drinking water applications, not suitable for use in hazardous areas

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.



P01-FMX167xx-15-xx-xx-002

FMX167 measuring principle

1	*Ceramic measuring cell*
2	*Pressure compensation tube*
h	*Level height*
p	*Total pressure = hydrostatic pressure + atmospheric pressure*
ρ	*Medium density*
g	*Gravitational acceleration*
$p_{hydr.}$	*Hydrostatic pressure*
p_{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.

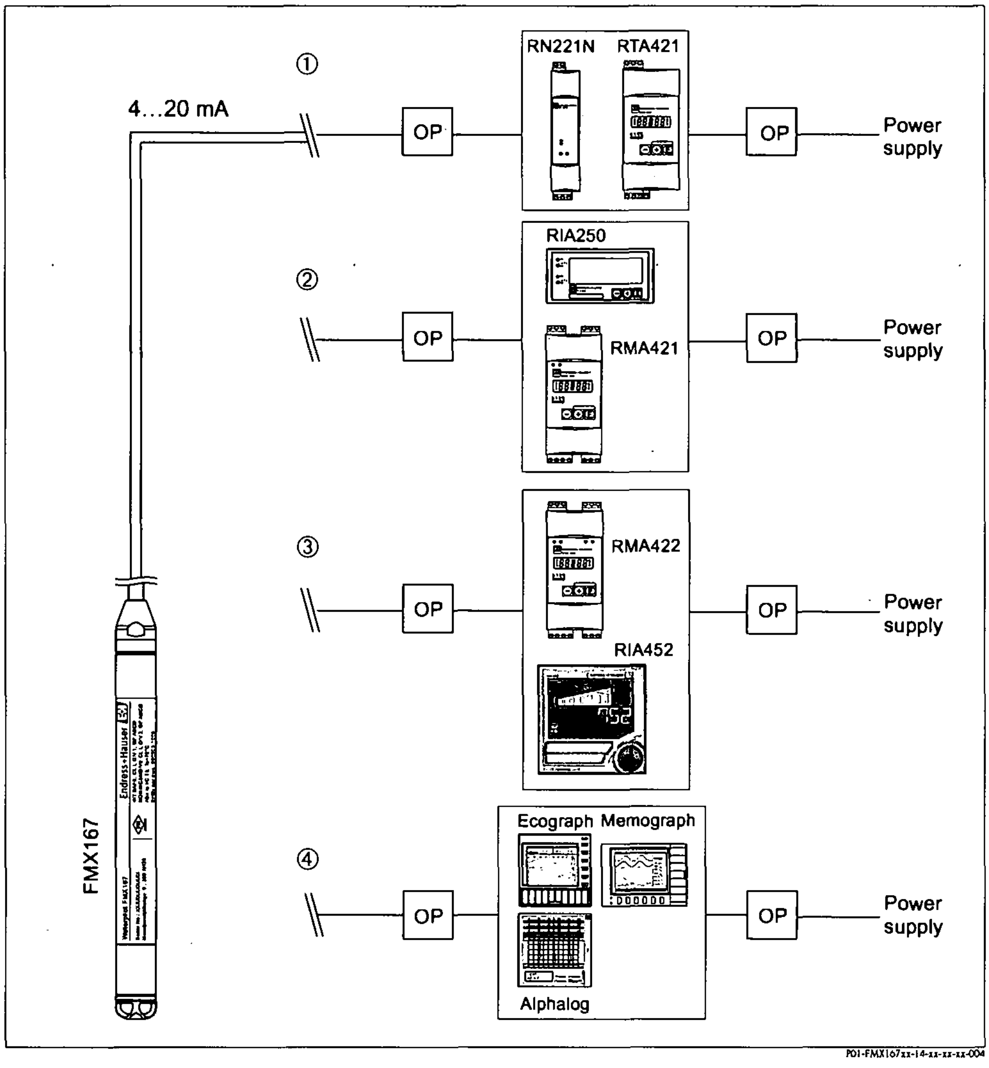
Temperature measurement with optional Pt 100 and temperature transmitter TMT181

To convert the Pt 100 signal to a 4...20 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...30 V DC.

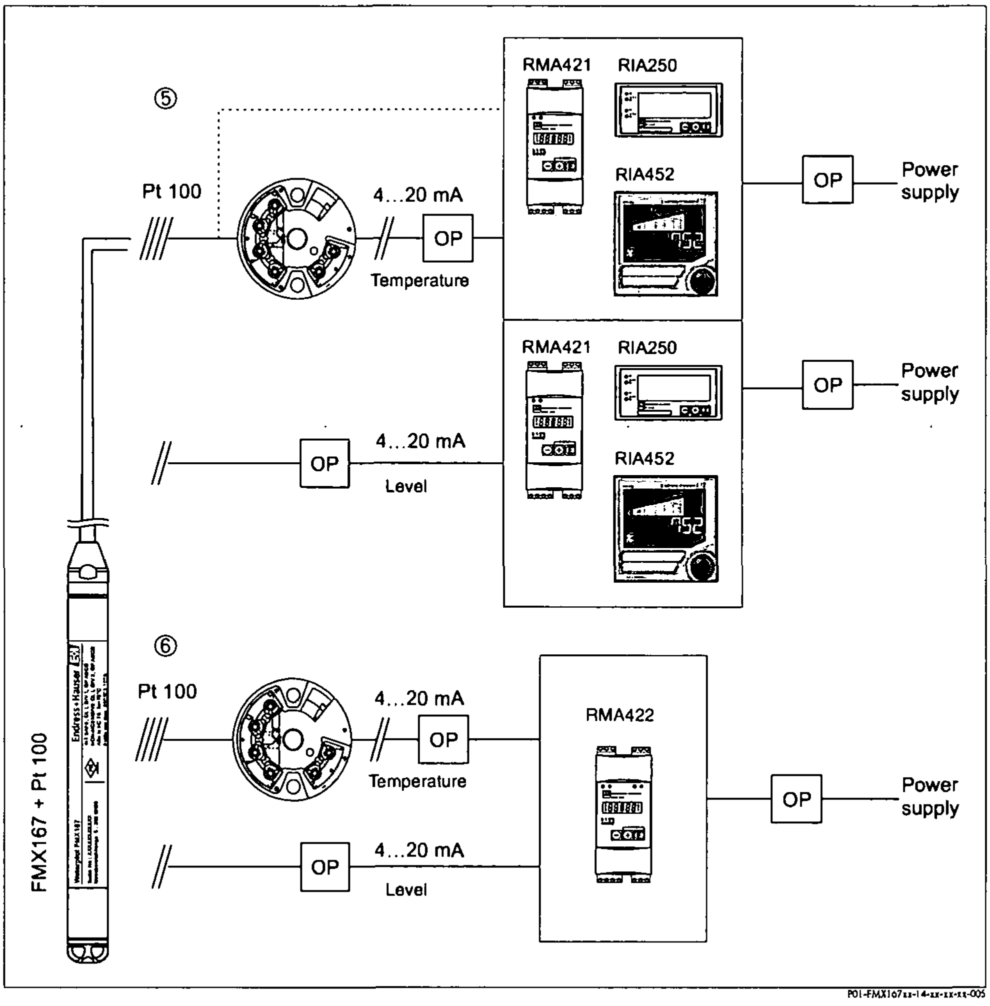
Example for other measuring point solutions with transmitter and possible evaluation units from Endress+Hauser:



Application examples with FMX167

OP Overvoltage protection e.g. HAW from Endress+Hauser

1. Simple cost-effective measuring point solution: Power supply of Waterpilot in hazardous and non-hazardous 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 overflow 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...20 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)

- Hydrostatic pressure of a liquid
- Pt 100: Temperature of a liquid

Temperature transmitter (optional)

- Temperature

Measuring range

- Nine fixed pressure measuring ranges in bar, mH_2O, psi and ftH_2O;
  → Page 18, "Ordering information" Section
- Customer-specific measuring ranges; factory-calibrated
- Temperature measurement from −10...+70°C (+14...+158°F) (optional with Pt 100)

Input signal

FMX167 + Pt 100 (optional)

- Change in capacitance
- Pt 100: Change in resistance

Temperature transmitter (optional)

- Pt 100 resistance signal, 4-wire

Output

Output signal

FMX167 + Pt 100 (optional)

- FMX167: 4...20 mA for hydrostatic pressure measured value, two-wire
- Pt 100: Temperature-dependent resistance of Pt 100

Temperature transmitter (optional)

- 4...20 mA for temperature measured value, two-wire

Load

FMX167 + Pt 100 (optional)

$$R_{tot} \le \frac{U_b - 10\ V}{0.0225\ A} - 2 \cdot 0.09 \frac{\Omega}{m} \cdot l - R_{add}$$

P01-FMX167xx-16-xx-xx-xx-000

Temperature transmitter (optional)

$$R_{tot} \le \frac{U_b - 8\ V}{0.025\ A} - R_{add}$$

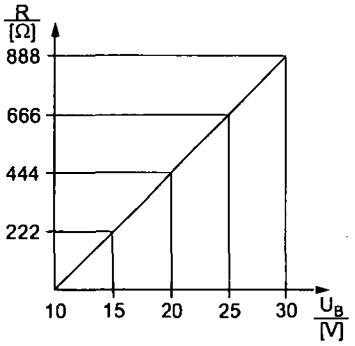
P01-FMX167xx-16-xx-xx-xx-001

R_{tot} = Max. load resistance [Ω]

R_{add} = Additional resistances such as resistance of evaluating device and/or display instrument, line resistance [Ω]

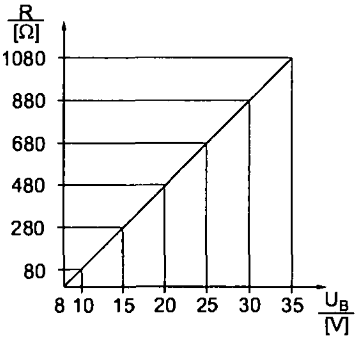
U_b = Supply voltage [V]

l = Simple length of extension cable [m] (cable resistance per wire ≤ 0.09 /Ωm)



P01-FMX167xx-05-xx-xx-xx-001

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.



P01-FMX167xx-05-xx-xx-xx-003

Load chart temperature transmitter for estimating load resistance. Subtract the additional resistances from the calculated value as shown in the equation.

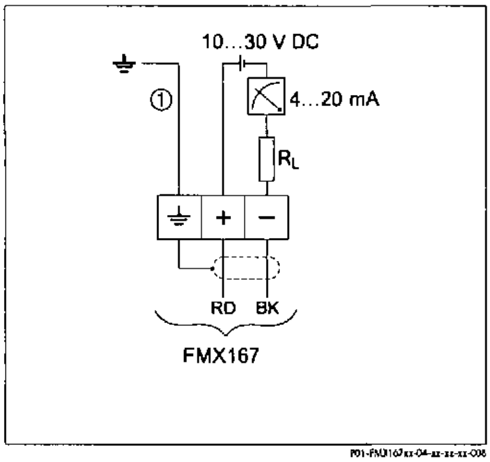
Power supply

Electrical connection

Note!

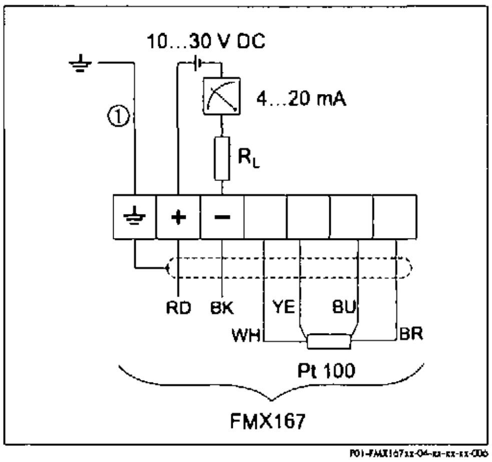
- When using the measuring device in hazardous areas, national standards and regulations as well as the Safety Instructions (XAs) or Installation or Control Drawings (ZDs) have to be observed. → See also Page 20, "Safety Instructions" and "Installation/Control Drawings" Sections.
- Reverse polarity protection 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® filter from Endress+Hauser. The terminal box can be ordered using the order code of FMX167 (→ see Page 18, "Ordering information" Section) or an accessory (order number: 52006252).

Waterpilot FMX167, standard



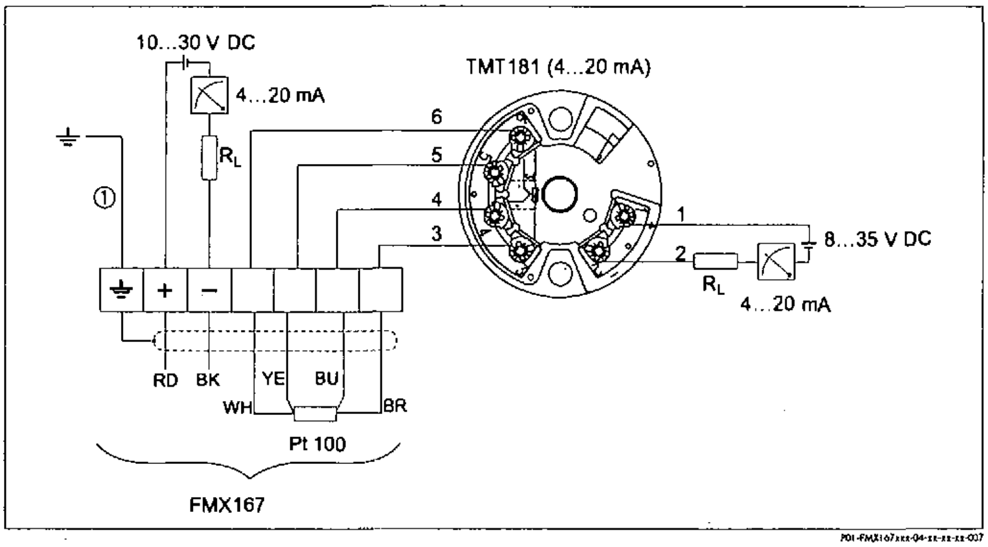
FMX167 electrical connection, versions "7" or "3" for Feature 70 "Additional options" in the order code (→ see Page 18).

Waterpilot FMX167 with Pt 100



FMX167 electrical connection with Pt 100, versions "1" or "4" for Feature 70 "Additional options" in the order code (→ see Page 18).

Waterpilot FMX167 with Pt 100 and TMT181 temperature transmitter (4...20 mA)



FMX167 with Pt 100 and TMT181 temperature transmitter (4...20 mA), version "5" for Feature 70 in the order code (→ see Page 18).

1 Not for FMX167 with outer diameter = 29 mm (1.15 inch)

Wire colors: RD = red, BK = black, WH = white, YE = yellow, BU = blue, BR = brown

Supply voltage

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. → See also Page 20, "Safety Instructions" and "Installation/Control Drawings" Sections.

FMX167 + Pt 100 (optional)	Temperature transmitter (optional)
▪ FMX167: 10...30 V DC ▪ Pt 100: 10...30 V DC	▪ 8...35 V DC

Cable specifications

FMX167 + Pt 100 (optional)	Temperature transmitter (optional)
▪ Commercially available instrument cable ▪ Terminals, terminal housing FMX167: 0.08...2.5 mm^2 ▪ If the Pt 100 signal is directly connected to a display and/or evaluation unit, we recommend the use of a shielded cable.	▪ Commercially available instrument cable ▪ Terminals, terminal housing FMX167: 0.08...2.5 mm^2 ▪ Connection, transmitter: Max. 1.75 mm^2

Power consumption

FMX167 + Pt 100 (optional)	Temperature transmitter (optional)
≤ 0.675 W at 30 V DC	≤ 0.875 W at 35 V DC

Current consumption

FMX167 + Pt 100 (optional)	Temperature transmitter (optional)
▪ Max. current consumption: ≤ 22.5 mA Min. current consumption: ≥ 3.5 mA ▪ Pt 100: ≤ 0.6 mA	▪ Max. current consumption: ≤ 25 mA Min. current consumption: ≥ 3.5 mA ▪ Pt 100 via temperature transmitter: ≤ 0.6 mA

Residual ripple

FMX167 + Pt 100 (optional)	Temperature transmitter (optional)
No effect for 4...20 mA signal up to ±5 % residual ripple within permissible range	$U_{ss} \geq 5$ V at $U_B \geq 13$ V, $f_{max.} = 1$ kHz

Performance characteristics

Reference operating conditions

FMX167 + Pt 100 (optional)

DIN EN 60770 T_U = 25°C (77°F)

Temperature transmitter (optional)

Calibration temperature 23°C ± 5 K (73°F ± 5 K)

Maximum measured error

FMX167 + Pt 100 (optional)

- Non-linearity including hysteresis and non-repeatability as per DIN EN 60770: ±0.2% of upper range value (URV)
- Pt 100: Max. ±0.7 K (Class B to DIN EN 60751)

Temperature transmitter (optional)

- ±0.2 K
- With Pt 100: Max. ±0.9 K

Long-term stability

FMX167 + Pt 100 (optional)

±0.1% of upper range value (URL) per year

Temperature transmitter (optional)

≤ 0.1 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...+30°C (+32...+86°F): ±0.4% (±0.5%)* of the upper range limit (URL)
- Thermal change in zero signal and output span for the entire medium temperature range –10...+70°C (+14...+158°F): ±1.0% (±1.5%)* of the upper range limit (URL)
- Temperature coefficient (T_K) of zero signal and output span: 0.15%/10 K (0.3%/10 K)* of the upper range limit (URL)

* Specifications for sensors 0.1 bar (1 mH_2O, 1.5 psi, 3 ftH_2O) and 0.6 bar (6 mH_2O, 10 psi, 20 ftH_2O)

Warm-up period

FMX167 + Pt 100 (optional)

20 ms

Temperature transmitter (optional)

4 s

Rise time

FMX167 + Pt 100 (optional)

- FMX167: 80 ms
- Pt 100: 160 s

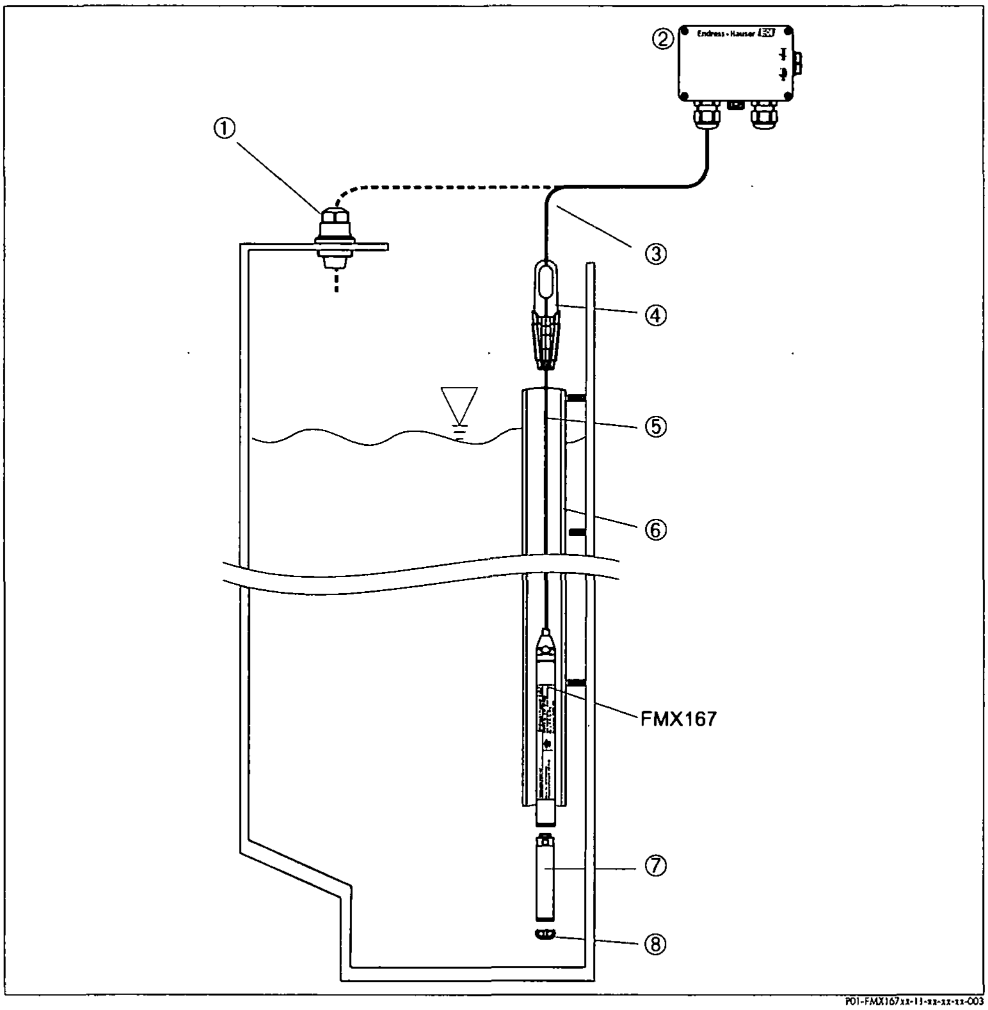
Settling time

FMX167 + Pt 100 (optional)

- FMX167: 150 ms
- Pt 100: 300 s

Installation

Installation instructions



Installation examples, here shown with FMX167 with an outer diameter = 22 mm (0.87 inch)

1	*Extension cable mounting screw can be ordered via order code or as an accessory, → see Page 14 and 19*
2	*Terminal housing can be ordered via order code or as an accessory, → see Page 15 and 19*
3	*Extension cable bending radius > 120 mm (4.72 inch)*
4	*Suspension clamp can be ordered via order code or as an accessory, → see Page 14 and 19*
5	*Extension cable up to 300 m (384 ft), for max. length → see Page 16, "Extension cable" Section*
6	*Guide tube for FMX167 with outer diameter = 22 mm (0.87 inch) internal diameter > 23 mm (0.91 inch)*
7	*Additional weight can be ordered as an accessory for FMX167 with outer diameter = 22 mm (0.87 inch) and 29 mm (1.15 inch), → 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 mm (0.04 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)

- FMX167 with outer diameter = 22 mm (0.87 inch) and 42 mm (1.66 inch): –10...+70°C (+14...+158°F) (= medium temperature)
- FMX167 with outer diameter = 29 mm (1.15 inch): 0...+50°C (+32...+122°F) (= medium temperature)

Temperature transmitter (optional)

–40...+85°C (–40...+185°F)

Storage temperature

FMX167 + Pt 100 (optional)

–40...+80°C (–40...+185°F)

Temperature transmitter (optional)

–40...+100°C (–40...+212°F)

gree of protection

FMX167 + Pt 100 (optional)

- IP 68, permanently hermetically sealed
- Optional terminal box: IP 66/IP 67

Temperature transmitter (optional)

- IP 00, moisture condensation permissible
- When mounted in the optional terminal boxes: IP 66/IP67

Electromagnetic compatibility (EMC)

FMX167 + Pt 100 (optional)

- Interference emission to EN 61326 Class B equipment, interference immunity to EN 61326 Appendix A (Industrial)
- Maximum deviation: < 0.5% of span

Temperature transmitter (optional)

- Interference emission to EN 61326 Class B equipment, interference immunity to EN 61326 Appendix A (Industrial)

Overvoltage protection

FMX167 + Pt 100 (optional)

Integrated overvoltage protection to EN 61000-4-5 ≤ 1.2kV
Install overvoltage protection ≥ 1.2 kV, external if necessary

Temperature transmitter (optional)

Install overvoltage protection, external if necessary.

Process

Medium temperature range

FMX167 + Pt 100 (optional)

- FMX167 with outer diameter = 22 mm (0.87 inch) and 42 mm (1.66 inch): –10...+70°C (+14...+158°F)
- FMX167 with outer diameter = 29 mm (1.15 inch): 0...+50°C (+32...+122°F)

Temperature transmitter (optional)

–40...+85°C (–40...+185°C) (= ambient temperature), install temperature transmitter outside medium.

Medium temperature limits

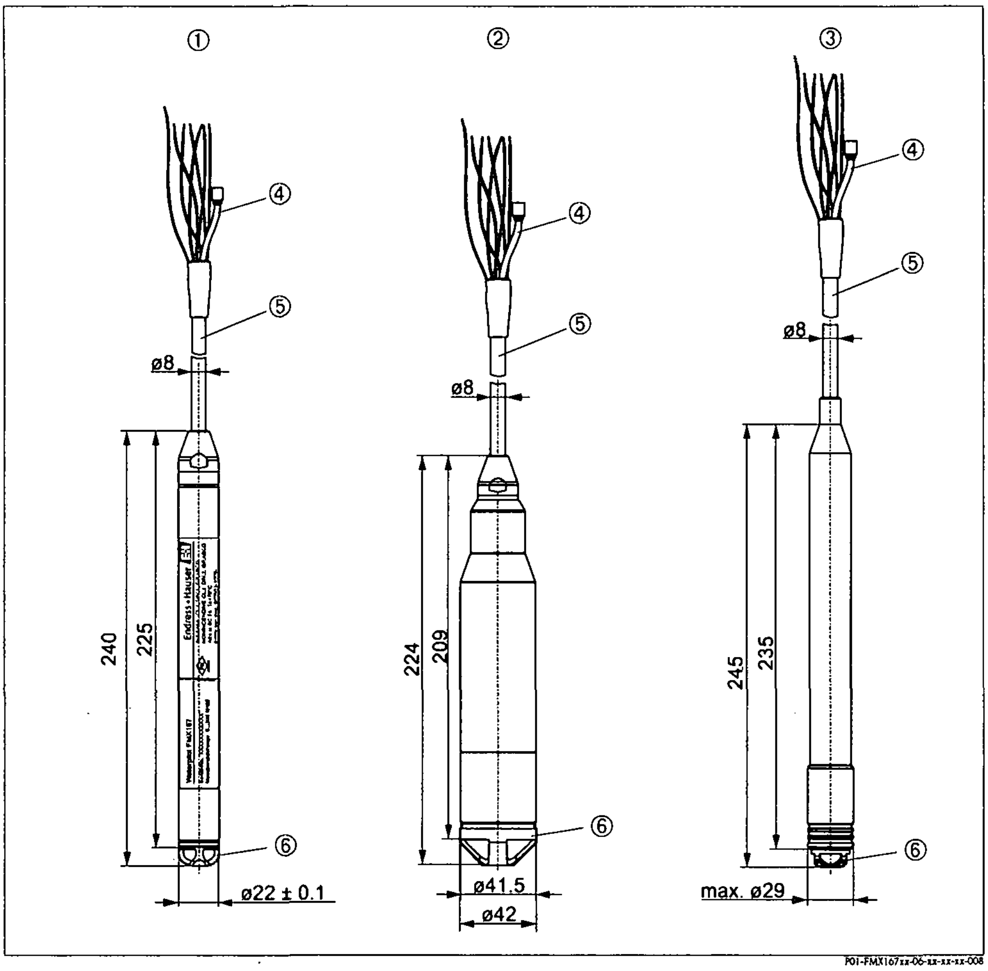
FMX167 + Pt 100 (optional)

- FMX167 with outer diameter
  = 22 mm (0.87 inch) and 42 mm (1.66 inch):
  –20...+70°C (–4...+158°F)
- FMX167 with outer diameter
  = 29 mm (1.15 inch): 0...+50°C (+32...+122°F)

(You may operate the FMX167 in this temperature range. The specification can then be exceeded, e.g. measuring accuracy).

Mechanical construction

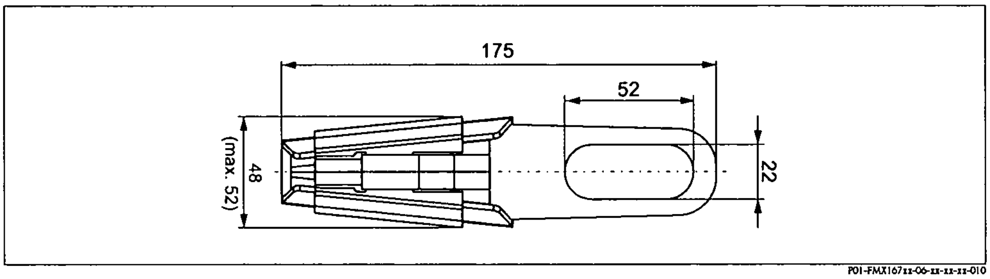
Dimensions of level probe



Versions of FMX167

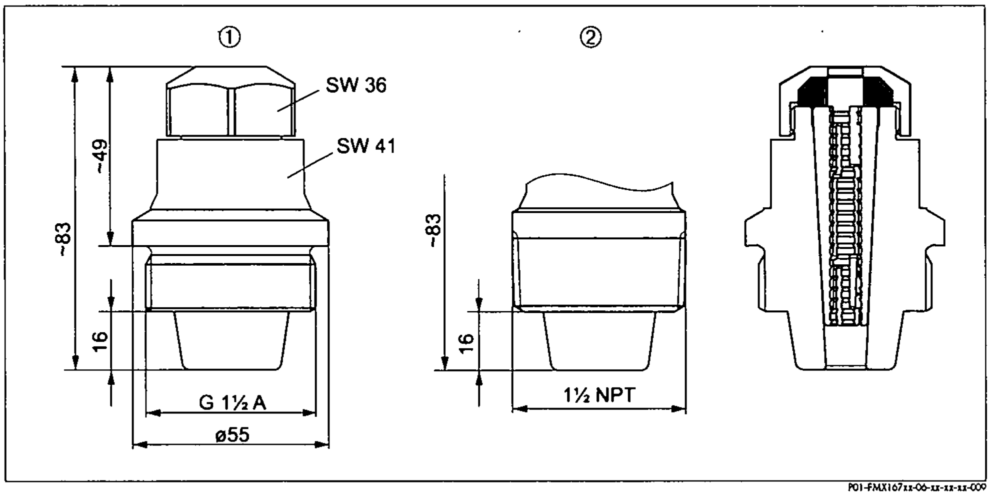
1 FMX167, version "A" or "D" for Feature 30 "Probe tube" in the order code (→ see Page 18)
2 FMX167, version "B" for Feature 30 "Probe tube" in the order code (→ see Page 18)
3 FMX167, version "C" for Feature 30 "Probe tube" in the order code (→ see Page 18)
4 Pressure compensation tube
5 Extension cable
6 Protection cap

Dimensions of suspension clamp



Suspension clamp, version 2 for Feature 20 "Connection" in the order code (→ see Page 18)

Dimensions of extension cable mounting screws

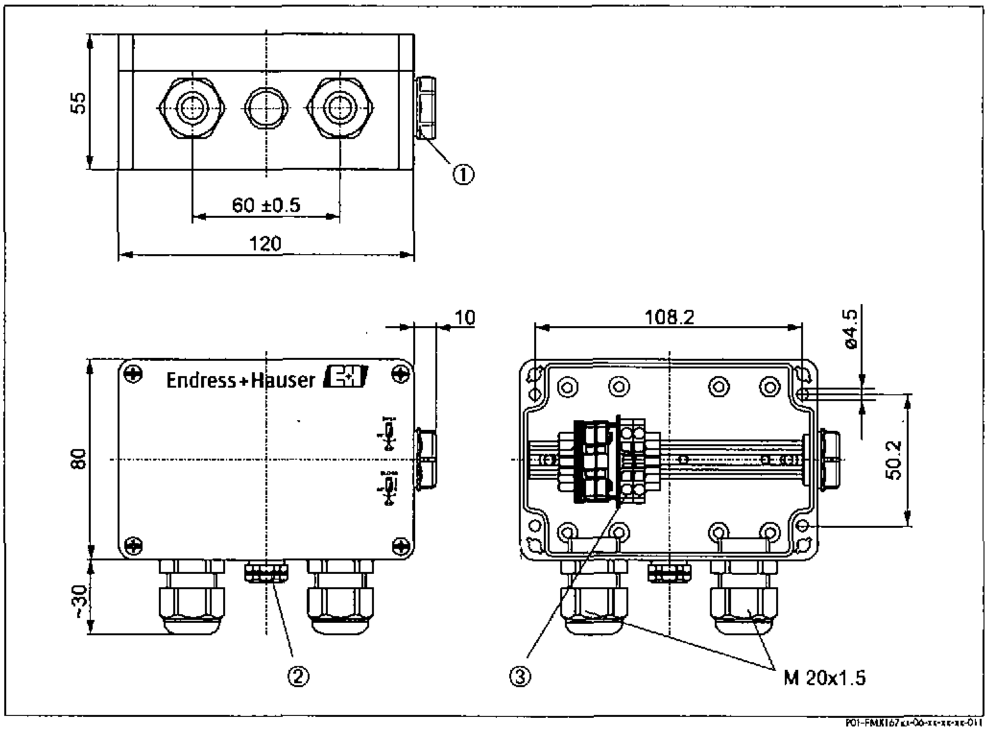


Extension cable mounting screws

1 *Extension cable mounting screw G 1 1/2 A, version "3" for Feature 20 "Connection" in the order code (→ see Page 18)*

2 *Extension cable mounting screw 1 1/2 NPT, version "4" for Feature 20 "Connection" in the order code (→ see Page 18)*

Dimensions of the terminal box IP 66/IP 67 with filter

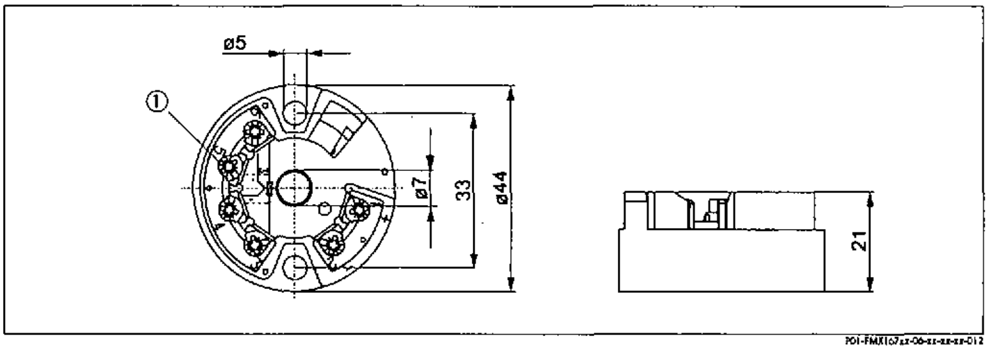


Terminal box

Version "3", "4" or "5" for Feature 70 "Additional options" in the order code (→ see Page 18)

1 Dummy plug M 20x1.5
2 GORE-TEX® filter
3 Terminals for 0.08...2.5 mm²

Dimensions of temperature transmitter TMT181



Temperature transmitter TMT181 (4...20 mA)

Version "5" for Feature 70 "Additional options" in the order code (→ see Page 18). The temperature transmitter can be used in non-hazardous areas and for EEx nA.

Weight

- Level probe, outer diameter = 22 mm (0.87 inch): 290 g
- Level probe, outer diameter = 42 mm (1.66 inch): 1150 g
- Level probe, outer diameter = 29 mm (1.15 inch): 340 g
- Extension cable PE: 52 g/m
- Extension cable FEP: 108 g/m
- Suspension clamp: 170 g
- Extension cable mounting screw G 1 1/2 A: 770 g
- Extension cable mounting screw 1 1/2 NPT: 724 g
- Terminal box: 235 g
- Temperature transmitter: 40 g
- Additional weight: 300 g

Material

Level probe
- Level probe, outer diameter = 22 mm (0.87 inch): 1.4435 (AISI 316L)
- Level probe, outer diameter = 42 mm (1.66 inch): 1.4435 (AISI 316L)
- Level probe, outer diameter = 29 mm (1.15 inch):
  - Level probe: 1.4435 (AISI 316L)
  - Sensor sleeve: PPS (polyphenylene sulfide)
  - Heat-shrink sleeve/cover: Polyolefin

  Metal does not come into contact with the medium.
- Process ceramic: Al_2O_3 aluminium oxide ceramic
- Seal (internal): EPDM or Viton
- Protective cap:
  - PE-HD (high-density polyethylene) for FMX167 with outer diameter = 22 mm and 29 mm (0.87 inch and 1.15 inch).
  - PFA (perfluoralkoxy) for FMX167 with outer diameter = 42 mm (1.66 inch).
- Extension cable insulation: Either PE-LD (low density polyethylene) or FEP (fluorinated ethylene propylene). For more information, see the next Section - "Extension cable"
- Suspension clamp: 1.4404 (AISI 316L) and glass fiber reinforced PA (polyamide)
- Extension cable mounting screw G 1 1/2 A: 1.4301 (AISI 304)
- Extension cable mounting screw 1 1/2 NPT: 1.4301 (AISI 304)
- Terminal box: PC (polycarbonate)
- Temperature transmitter: Housing PC (polycarbonate)

Extension cable

PE extension cable
- Slip-resistant extension cable with strain-relief members made of Dynemo; shielded using aluminium-coated film; insulated with polyethylene (PE), black; copper wires, twisted
- Pressure compensation tube with Teflon filter

FEP extension cable
- Slip-resistant extension cable; shielded using galvanized steel wire netting; insulated with fluorinated ethylene propylene (FEP), black; copper wires, twisted
- Pressure compensation tube with Teflon filter

Cross-section of PE and FEP extension cable
- Total outer diameter: 8.0 mm ± 0.25 mm (0.315 inch ± 0.0098 inch)
- FMX167: 3 x 0.227 mm^2 + pressure compensation tube with Teflon filter
- FMX167 with Pt 100 (optional): 7 x 0.227 mm^2 + pressure compensation tube with Teflon filter
- Pressure compensation tube with Teflon filter:
  Outer diameter = 2.5 mm (0.098 inch), internal diameter = 1.5 mm (0.059 inch)

Cable resistance of PE and FEP extension cable
- Cable resistance per wire: $\leq 0.09\ \Omega/m$

Cable length of PE and FEP extension cable
- Please also refer to Page 7, "Load" Section.
- 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. → See also Page 20, "Safety Instructions" and "Installation/Control Drawings" Sections.

Further technical data of PE and FEP extension cable
- Minimum bending radius: 120 mm (4.72 inch)
- Tensile strength: max. 950 N
- Cable extraction force: ≥ 450 N
  (The extension cable could be extracted from the level probe at a tensile force of ≥ 450 N.)
- Resistance to UV light
- PE: approved for use with drinking water

Terminals

- 3 standard terminals in terminal box
- 4-terminal strip can be ordered as accessory, Order No. 52008938
  Wire cross-section 0.08...2.5 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 EC directives.

Ex approval, type of protection

- ATEX II 2 G EEx ia IIC T6[1]
- ATEX II 3 G EEx nA II T6
- FM: IS, Class I, Division 1, Groups A–D[1]
- CSA: IS, Class I, Division 1, Groups A–D[1]

[1] Only for Waterpilot FMX167 without Pt 100

Waterpilot FMX167 with outer diameter = 22 mm (0.87 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. → See also Page 20, "Safety Instructions" and "Installation/Control Drawings" Sections.

Drinking water approval (for FMX167 with d_O = 22 mm (0.87 inch))

- KTW certificate
- NSF 61 approval
- ACS approval

Marine approval

- GL approval
- ABS approval

External standards and guidelines

DIN EN 60770 (IEC 60770):
Transmitters for use in industrial-control systems
Part 1: Methods for performance evaluation

DIN 16086:
Electrical pressure measuring instruments,
pressure sensors, pressure transmitters,
pressure measuring instruments, concepts, specifications on data sheets

EN 61326 (IEC 61326-1):
Electrical equipment for measurement, control and laboratory use – EMC requirements

Registered trademarks

GORE-TEX®
Registered trademark of W.L. Gore & Associates, Inc., USA

Ordering information

FMX167

10 Approval

A	Version for non-hazardous area
B	ATEX II 2 G EEx ia IIC T6
C	ATEX II 3 G EEx nA II T6
S	FM IS, Class I, Division 1, Groups A – D
E	CSA IS, Class I, Division 1, Groups A – D
F	CSA General Purpose

20 Connection

1	Probe cable
2	Suspension clamp, AISI 316L
3	Cable mounting screw G 1 1/2, AISI 304
4	Cable mounting screw NPT 1 1/2, AISI 304

30 Probe tube:

A	Outer diameter d = 22 mm (0.87 inch), AISI 316L
B	Outer diameter d = 42 mm (1.66 inch), flush mount, AISI 316L
C	Outer diameter d = 29 mm (1.15 inch), AISI 316L with heat-shrink sleeve PPS/polyolefin for saltwater applications
D	Outer diameter d = 22 mm (0.87 inch), AISI 316L + drinking water approval KTW/NSF/ACS (can only be selected in conjunction with EPDM seal and PE probe cable)

40 Measuring range:

Measuring range		Measuring range		Max. overload	Vacuum resistance
BA	0...0.1 bar	MA	0...1 mH_2O	5 bar	0 bar_{abs}
BB	0...0.2 bar	MB	0...2 mH_2O	5 bar	0 bar_{abs}
BC	0...0.4 bar	MC	0...4 mH_2O	7 bar	0 bar_{abs}
BD	0...0.6 bar	MD	0...6 mH_2O	10 bar	0 bar_{abs}
BE	0...1.0 bar	ME	0...10 mH_2O	10 bar	0 bar_{abs}
BF	0...2.0 bar	MF	0...20 mH_2O	18 bar	0 bar_{abs}
BG	0...4.0 bar	MG	0...40 mH_2O	25 bar	0 bar_{abs}
BH	0...10.0 bar	MH	0...100 mH_2O	40 bar	0 bar_{abs}
BK	0...20.0 bar	MK	0...200 mH_2O	40 bar	0 bar_{abs}
PA	0...1.5 psi	FA	0...3 ftH_2O	73 psi	0 bar_{abs}
PB	0...3 psi	FB	0...6 ftH_2O	73 psi	0 bar_{abs}
PC	0...6 psi	FC	0...15 ftH_2O	101 psi	0 bar_{abs}
PD	0...10 psi	FD	0...20 ftH_2O	145 psi	0 bar_{abs}
PE	0...15 psi	FE	0...30 ftH_2O	145 psi	0 bar_{abs}
PF	0...30 psi	FF	0...60 ftH_2O	261 psi	0 bar_{abs}
PG	0...60 psi	FG	0...150 ftH_2O	362 psi	0 bar_{abs}
PH	0...150 psi	FH	0...300 ftH_2O	580 psi	0 bar_{abs}
PK	0...300 psi	FK	0...600 ftH_2O	580 psi	0 bar_{abs}
VV	Adjusted to customer specifications from 0 to ___ (upper range value) in ___ (unit), upper range value: 0.1 bar (1 mH_2O, 1.5 psi, 3 ftH_2O) to 20 bar (200 m_2HO, 300 psi, 600 ft_2HO)				

50 Sensor seal:

1	FKM Viton
2	EPDM

60 Probe cable:

A	... m, shortable, PE
B	10 m, shortable, PE
C	20 m, shortable, PE
E	30 ft, shortable, PE
F	60 ft, shortable, PE
G	... ft, shortable, PE
I	... m, shortable, FEP
K	10 m, shortable, FEP
L	20 m, shortable, FEP
M	30 ft, shortable, FEP
N	60 ft, shortable, FEP
P	... ft, shortable, FEP

FMX167								Complete order code

→ Ordering information for FMX167 continued on next page.

FMX167 (continued)

70							**Additional option:**	
							7	Basic version
							S	GL/ABS marine certificate
							1	Pt 100, 4-wire
							3	Terminal box IP66/67
							4	Terminal box IP66/67 + Pt 100, 4-wire
							5	Pt 100 + temperature transmitter TMT181, 2-wire, 4...20 mA = –20...+80°C (–4...+176°F)
FMX167								Complete order code

Accessories

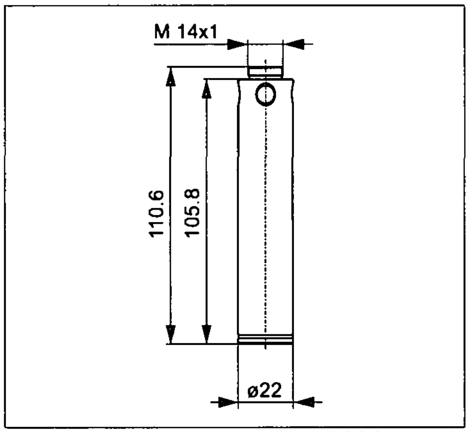
Suspension clamp

- Endress+Hauser offers a suspension clamp for simple FMX167 mounting. → See also Page 14.
- Material: 1.4404 (AISI 316L) and glass fiber reinforced PA (polyamide)
- Order number: 52006151

Terminal box

- Terminal box IP 66/IP 67 with GORE-TEX® 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). → See also Page 15.
- Order number: 52006152

Additional weight (for FMX167 with d_O = 22 mm (0.87 inch) and d_O = 29 mm (1.15 inch))



P01-FMX167xx-06-xx-xx-xx-014

- To prevent sideways movement leading to measuring errors or to ensure that the device lowers into a guide tube, Endress+Hauser provides additional weights.
  You can screw several weights together. The weights are then attached directly to the FMX167. For FMX167 with outer diameter = 29 mm (1.15 inch), a maximum of 5 weights may be screwed on to FMX167.
- Material: 1.4435 (AISI 316L)
- Weight: 300 g
- Order number: 52006153

Temperature transmitter

- Temperature transmitter, 2-wire, preset for measuring range from –20...+80°C (–4...+176°F).
  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...+70°C (+14...+158°F). → See also Page 15.
- Order number: 52008794

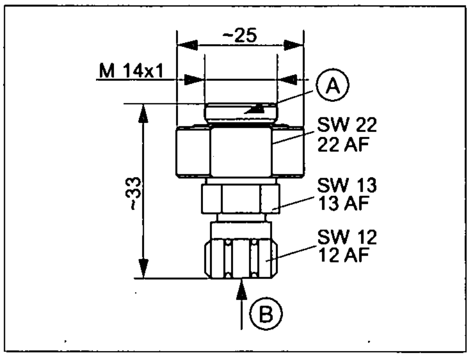
Extension cable mounting screw

- Endress+Hauser offers extension cable mounting screws to simplify the installation of the FMX167 and to close the measuring open. → See also Page 14.
- Material: 1.4301 (AISI 304)
- Order number for extension cable mounting screw with G 1 1/2 A thread: 52008264
- 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...2.5 mm²
- Order number: 52008938

Test adapter (for FMX167 with d_O = 22 mm (0.87 inch) and d_O = 29 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. → 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 ▪ Recording Technology: FA014R/09/de ▪ System Components: FA016K/09/en
Technical Information	▪ Temperature Head Transmitter iTEMP PCP TMT181: TI070R/09/en
Operating Instructions	▪ Waterpilot FMX167: BA231P/00/en
Safety Instructions	▪ ATEX II 2 G EEx ia IIC T6: XA131P/00/a3 ▪ 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 ▪ CSA IS Class I, Div. 1, Groups A – D: ZD064P/00/en
Drinking water approval	▪ SD126P/00/a3

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