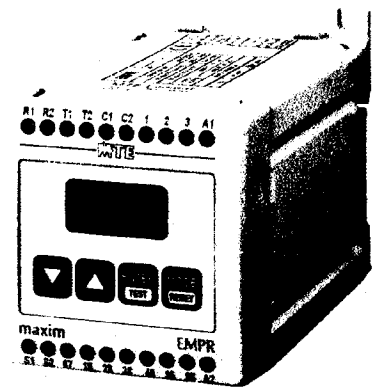
Electronic motor protection

maxim

EMPR
Technical Manual

June 1999



Contents

Introduction

The EMPR and its associated current transformers forms a complete protection system for single or three phase AC electric motors, incorporating overload, underload, earth fault and thermistor protection. In addition to the trip output relay, four individual alarm relays are provided to signal, either by means of lamps or telemetry, which type of trip has occurred. The EMPR is programmed using a four button keypad that also incorporates test and reset facilities. The programmable nature of the EMPR allows it to be set up, with adjustable trip levels and delays, to perfectly match the motor being protected. The simple step through programming menu, incorporating a three digit alphanumeric display, allows for quick and easy setup and is protected against tampering by a security access code. Another security feature is the option to prevent unauthorized reset of an earth fault trip if required.

The microcontroller based EMPR is computer tested and digitally calibrated to ensure that every unit is perfectly accurate. Dual memory storage with self checking and auto correction ensures that programmed features remain stored. Should the memory fail a trip will occur so that the motor remains protected.

Order references

EMPR	
110...120V control voltage	**EMPR115L000**
220...240V control voltage	**EMPR230L000**

Current transformers

1A / 0.5A : 25mA	**01.000158.220**
20A : 25mA	**01.000158.221**
50A : 25mA	**01.000158.222**
100A : 25mA	**01.000158.223**
200A : 5A	**01.000158.505**
500A : 5A	**01.000158.300**
1000A : 5A	**01.000158.302**
2000A : 5A	**01.000158.303**
3000A : 5A	**01.000158.304**

Core balance (earth fault) current transformers

CBCT1	**11.000587.100**
CBCT2	**11.000587.200**
CBCT3	**11.000587.300**

Technical specification

Supply voltage: **(must be specified)**

110...120V
220...240V +6% -15%
50...60Hz, 3VA

Output relays: Resistive load
5A at 250V a.c. or 30V d.c.

Inductive load
(cos Φ = 0.4) 2A at 250V a.c. or 30V d.c.

5A at 120V a.c. or 20V d.c.

Ambient temperature: -10°C... +60°C

Display:
3 digit 7 segment LED display for programming and display of percentage FLC or trip status.

Enclosure:
IP20, EN35 top hat rail or surface mounting

Terminal cable capacity: 1 x 2.5mm²

CE

Council of European Communities Directives: The products in this publication conform to relevant EEC Directives and EN Standards. Installation and use of such products must be carried out by competent, properly trained personnel, complying with any instructions supplied by MTE. Liability for improper incorporation, assembly, use, processing, storing or handling of goods remains the sole responsibility of the individual, or company carrying out such work. This publication is for information only. Whilst every care has been taken in the preparation of this publication, no liability is accepted for any consequence of its use. No licence to use any patent should be assumed. All dimensions quoted are approximate only and subject to change without notice, as are other technical features resulting from continual development and improvement.

Functional description

During normal operation the EMPR displays the "OFF" message until a current exceeding 5% of programmed motor full load current is detected. The EMPR will then display the measured current as a percentage of FLC. While the motor is running the EMPR calculates the thermal energy produced by the motor current and if the programmed maximum is exceeded then an overload trip will occur. Phase loss or large phase imbalance will also cause a trip, although the phase loss feature can be disabled with a link to allow single phase motors to be protected. A phase loss trip will occur if there is a constant loss of any one phase for at least 10 seconds.

Protection against loss of load is provided by the undercurrent feature. If the measured current falls below the programmed level for longer than the programmed undercurrent fault time then a trip will occur. The EMPR is able to distinguish between a low load condition and the motor being switched off. If not required this feature may be disabled by setting the fault level to zero.

Earth faults are measured using a core balance current transformer placed around all motor cables, excluding any earth returns. The EMPR will trip if the measured fault current exceeds the programmed level for longer than the programmed earth fault trip time. An earth fault trip will also occur if the secondary connection to the CBCT becomes open circuit. In order to assist testing the earth fault trip remains active even when the motor is stopped.

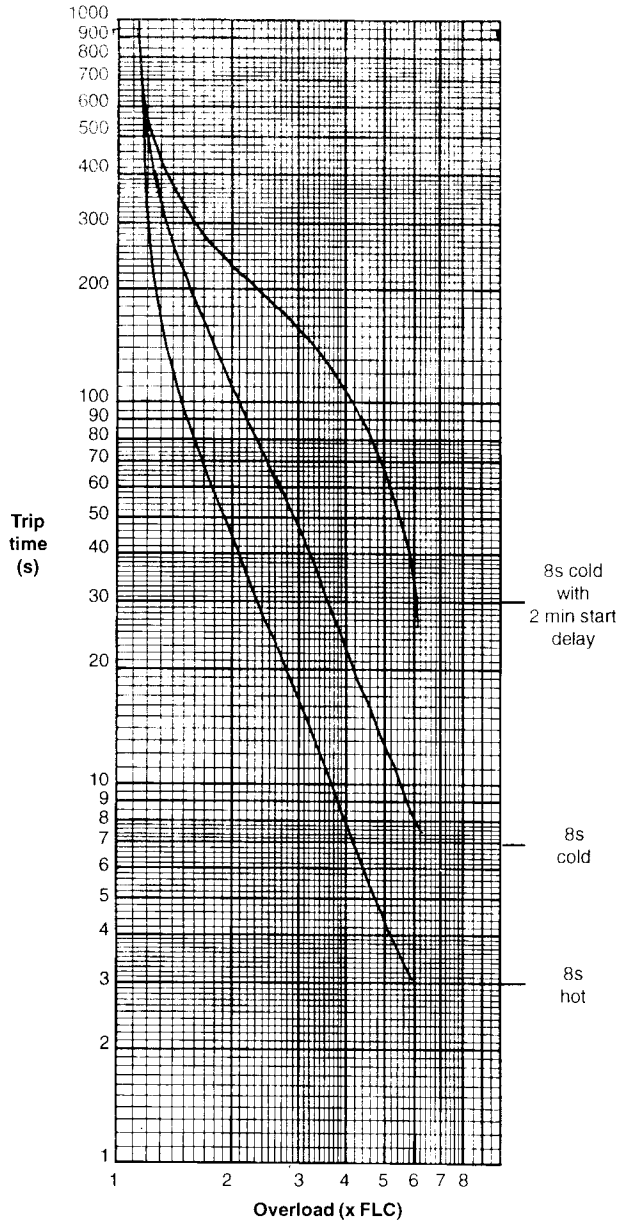
Positive temperature coefficient thermistors to BS 4999 embedded in the motor windings or a normally closed thermostat may be connected to the EMPR. A trip will occur when the measured resistance exceeds 3000Ω and this trip may be reset when the resistance falls below 900Ω. There is no separate reset delay for this feature which remains active even when the motor is stopped.

A system fault will occur if the EMPR detects a fault in the program memory which it is unable to correct automatically. In the unlikely event of this happening the EMPR will need to be reprogrammed. This fault can only be cleared by operating the in-built keypad reset. The EMPR will then automatically divert to the programming mode to allow the memory to be corrected.

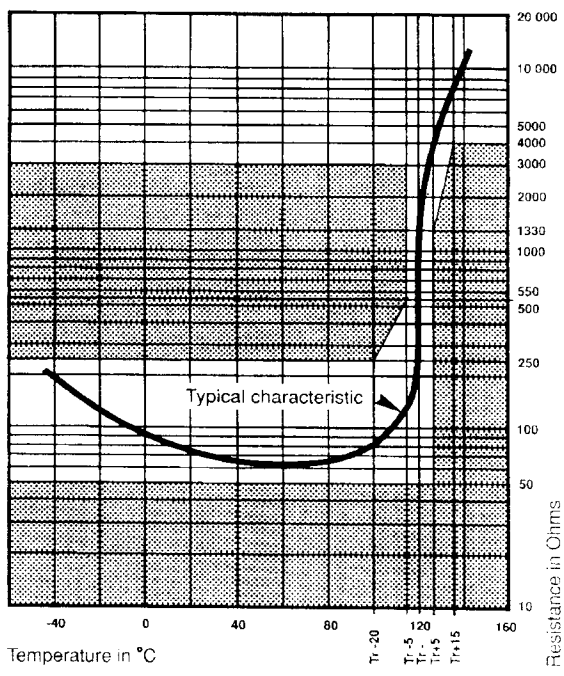
A "TEST" button is incorporated in the EMPR. If this is operated then an overload fault will be simulated and a trip will occur.

Description	Fault code		Alarm relay
Overload trip	O	F	18
Underload trip	U	F	28
Earth fault trip	E	F	48
Phase Loss trip	L	F	18
PTC thermistor trip	P	F	38
System fault	S	F	18

Typical thermal trip curves

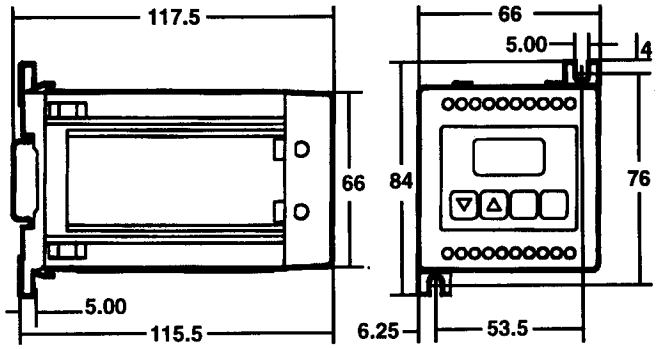


BS 4999 Thermistor characteristic



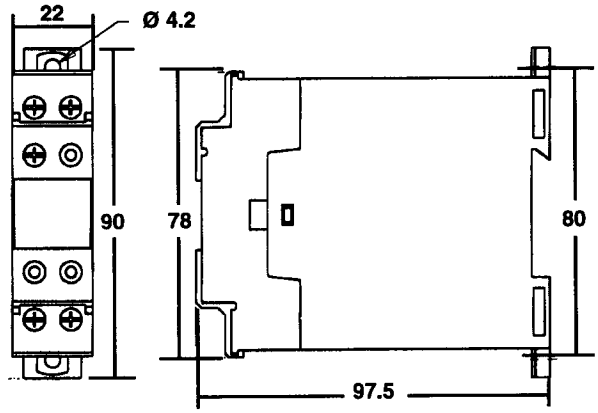
Dimensions (mm)

EMPR Weight 0.35kg

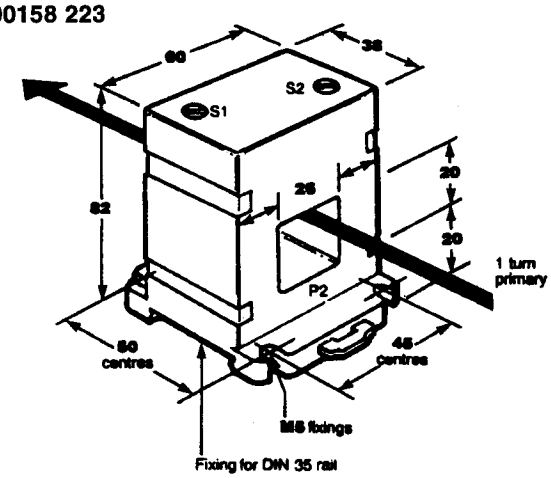


Current transformers

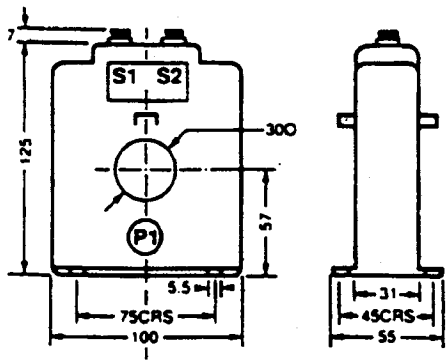
01 000158 220 Weight 0.22kg



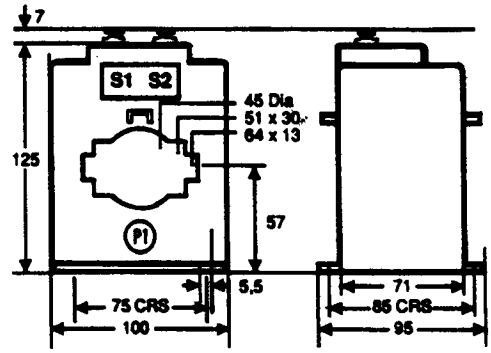
01 000158 221 Weight 0,24kg
01 000158 222
01 000158 223



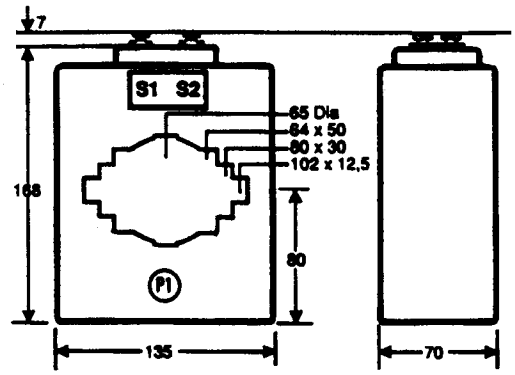
01 000158 505 Weight 0,58kg



01 000158 300 Weight 1kg

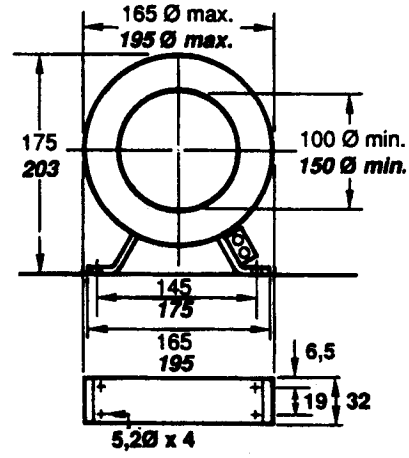


01 000158 302 Weight 2kg
01 000158 303
01 000158 304

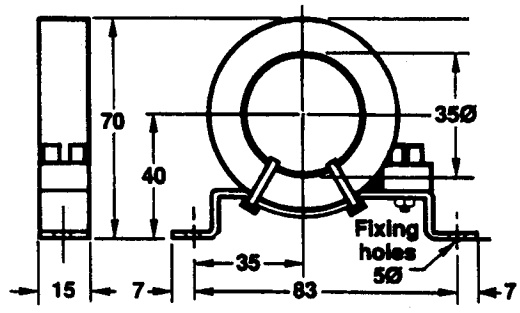


CBCT1 Weight 0,11kg
CBCT2 Weight 1,5kg
CBCT3 Weight 2,5kg

CBCT2
CBCT3



CBCT1



Terminal functions

A1, A2 } Supply voltage

R1, R2 } External reset, n/o pushbutton (link for auto reset)

T1, T2 } Thermistor input (link to disable)

C1, C2 } Core balance CT input (link to disable)

1, 2, 3 } Inputs for main current transformers

S1, S2 } Phase loss detection inhibit link

07 Common connection for all alarm relay outputs

18 Alarm relay output (n/o closed on alarm) for overload trip indication.

28 Alarm relay output (n/o closed on alarm) for underload trip indication.

38 Alarm relay output (n/o closed on alarm) for thermistor trip indication.

48 Alarm relay output (n/o closed on alarm) for earth fault trip indication.

95, 96 } Trip relay output (n/o, closed during normal operation and opens on a trip event).

Wiring information

Power supply
The power supply to the EMPR is 110...120V ac for the EMPR115L000 and 220...240V ac for the EMPR230L000. Nominal supply voltages outside this range must not be used. If required 100mA fuses may be used to protect the unit.

External reset
The EMPR has an integral reset button (combined with the MODE key on the front panel) but terminals are also provided for remote or auto reset. If auto reset is required terminals R1 and R2 should be linked. For remote manual reset a normally open reset button should be connected across the reset terminals. The contact material of the button should be suitable for switching 10V d.c. at 4mA.

Thermistor input
Terminals T1 and T2 may used for either a BS 4999 type thermistor or a normally closed (open when hot) thermostat. It may be necessary to use either twisted pair or screened cable for these connections so as to prevent pickup from other cables. When screened cable is used the screen should be connected to earth at one end only.

Earth leakage
The EMPR is designed to operate with MTE's range of core balance current transformers. Three types are available with identical electrical characteristics but with different internal diameters to accommodate changes in cable size. All phase (and neutral, if fitted) cables should pass through the centre of the CBCT. Maximum motor sizes for each CBCT type are given in the table below but fit of cables or busbars should be verified before ordering. For accurate measurements the cables should be grouped tightly together and pass through the CBCT as close to the centre of the aperture as possible, this is particularly true when a low trip level is required.

If earthing of the CBCT secondary is required then the connection to terminal C2 only should be earthed. If an earth is fitted no other connections to the EMPR may be earthed.

CBCT types

Part Number	Reference	Max motor size
11.000587.100	CBCT1	75kW
11.000587.200	CBCT2	250kW
11.000587.300	CBCT3	630kW

CT connections
Various current transformer configurations are shown in the wiring diagrams. It is important to observe the polarity of CT primary and secondary connections as nuisance tripping will otherwise occur. When applying multiple primary turns, either for low current applications or for cascading CTs, it is important to remember that one turn is a single pass through the centre of the CT. Always count the wires passing through the centre of the CT when checking primary turns as measurement errors will occur otherwise. A CT selection chart is given in the programming section. The main CTs should always be placed in the supply line, not the delta loop for delta connected motors. If it is essential to place the CTs in the delta loop then three CTs must be fitted (connect secondaries as per the 4 wire system) and reduce the programmed overload level to reflect the lower current in the delta loops. For motors rated above 100A FLC it is necessary to cascade CTs.

If earthing of the CT secondaries is required then the common point connected to terminal 1 should be earthed. For four wire applications the common of the three CTs is the preferred earthing point. In either case if there is an earth connection to the CBCT secondary then the main CT secondaries **must not** be earthed. The CBCT terminal C2 is the preferred earthing point when a choice has to be made.

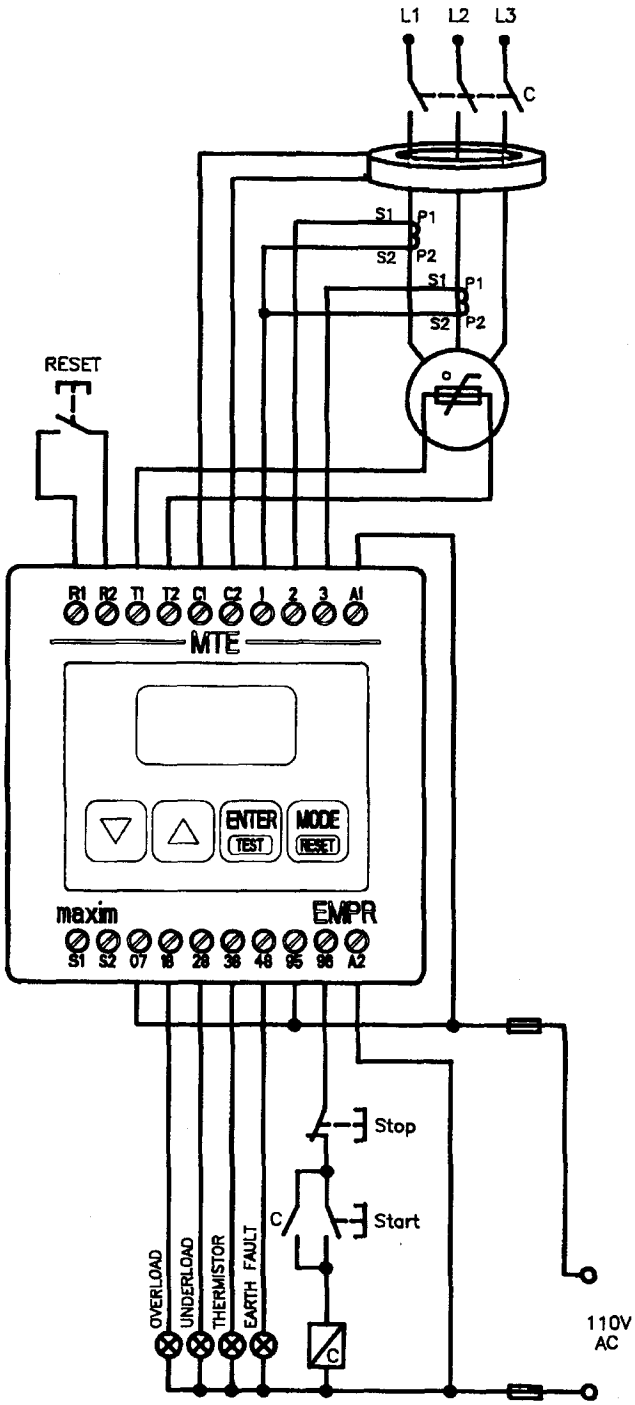
Single phase link
When the EMPR is used to protect a single phase motor a link must be fitted across terminals S1 and S2, this will disable the phase loss detection circuit. It may also be necessary to link these terminals when used with a soft-starter. Typically a contact provided by the soft starter will link these terminals during starting and stopping so as to prevent nuisance tripping. Any relay contacts used to link these terminals should be suitable for switching 10V d.c. at 4mA.

Alarm relays
Four relays are provided to indicate the type of any trip that may have occurred. These volt free relays all share one common terminal (07). The remaining terminals 18, 28, 38 and 48 can then be used either individually or combined (by linking them together to drive a single indicator) to switch warning lamps or telemetry signals. These relays are normally open and one will close to indicate the cause when a trip occurs. The relay will remain closed until a valid reset signal is received. It should be noted that these relays open on power failure but if a trip has not been reset when the power fails the EMPR will return to the trip condition when power is re-instated.

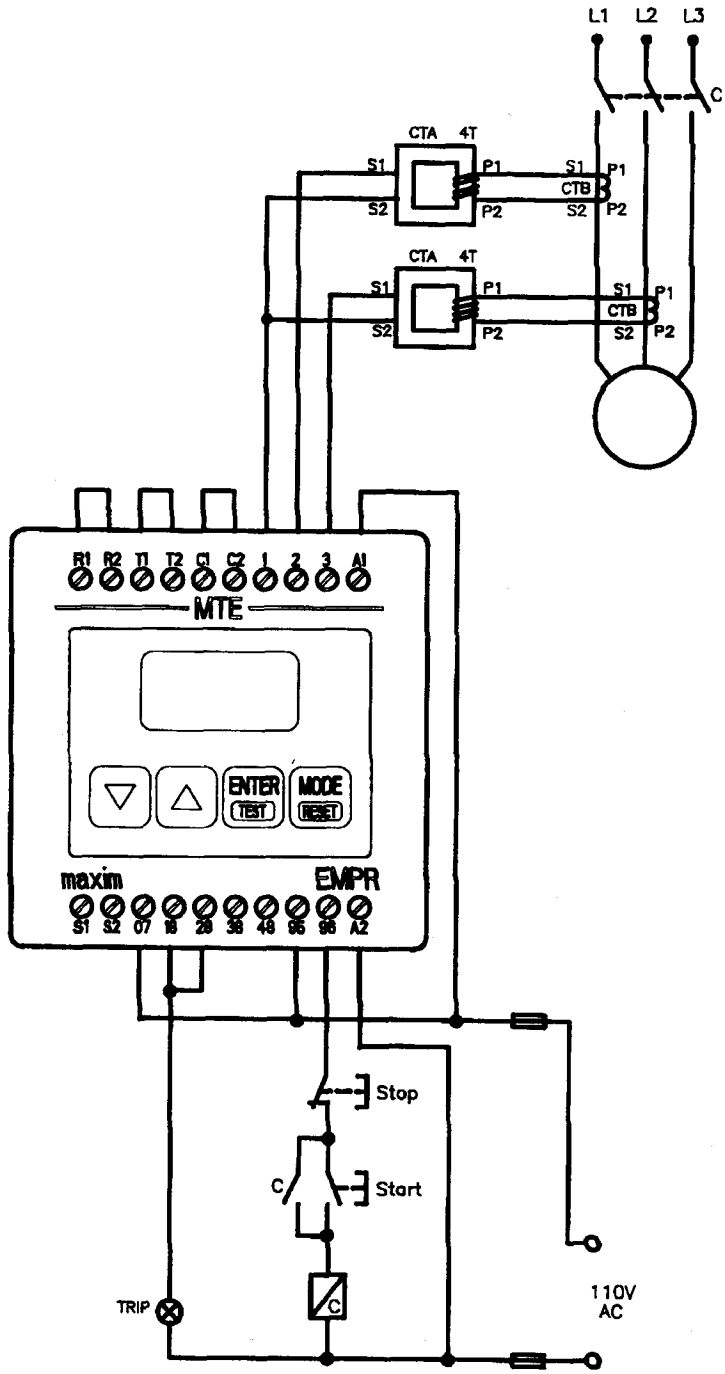
Trip relay
The trip relay is used to switch off the motor when a trip occurs. In the power down state this relay is open (as a failsafe feature) and closes, provided there are no un-cleared trip signals, approximately 0.5 seconds after the power supply is connected. The relay opens on a trip event and remains open until a valid reset signal is received.

Wiring diagrams

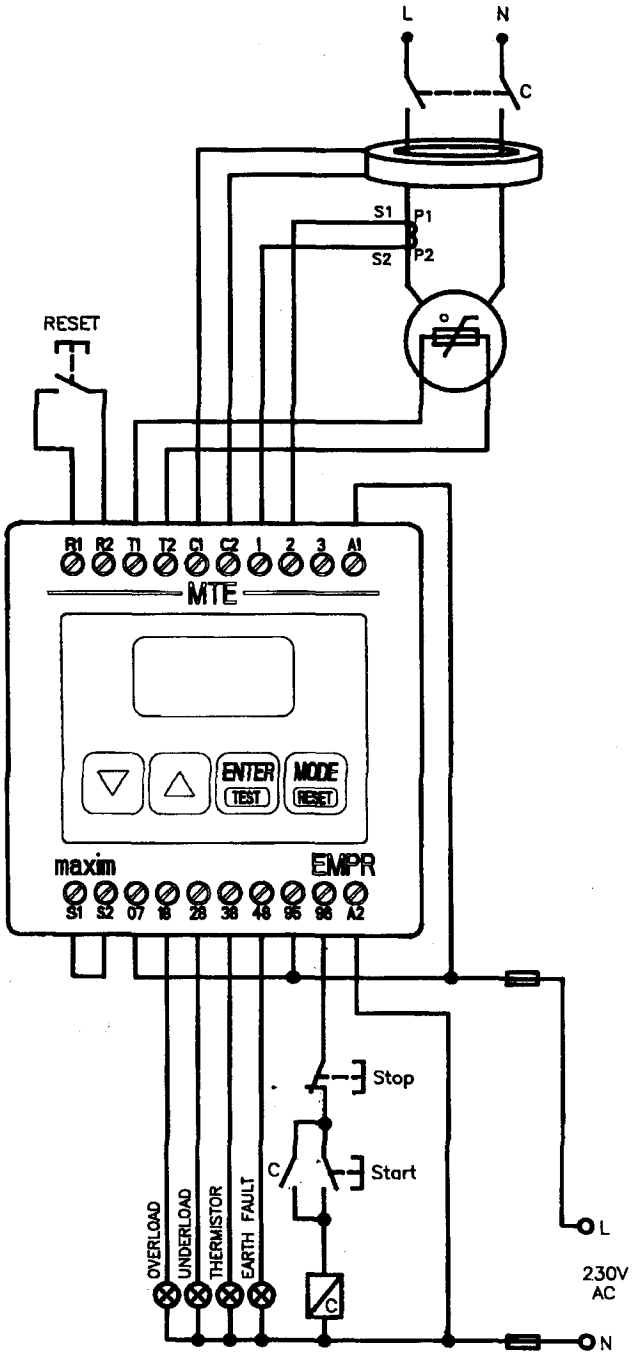
EMPR 115L000 Typical Installation



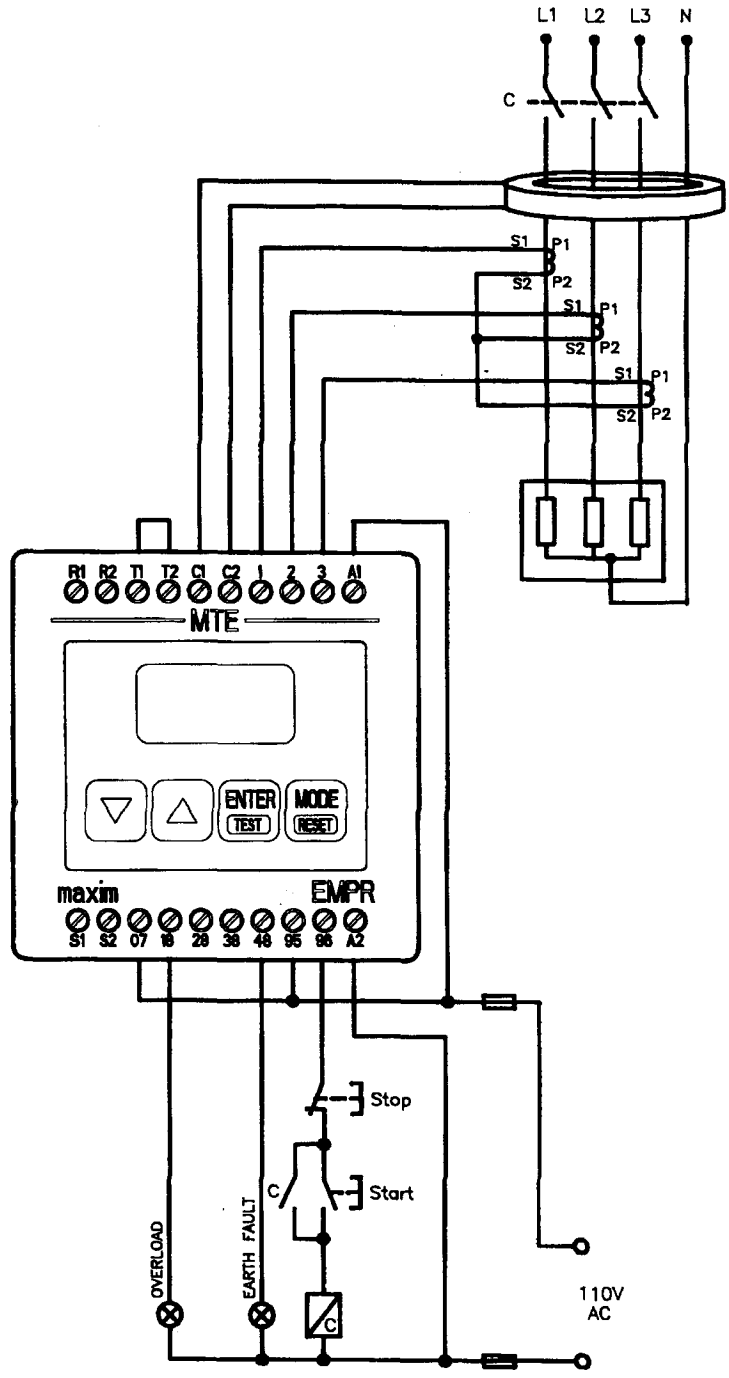
EMPR 115L000 with large (>100A) 3 phase load, combined over/ underload trip indicator lamp and auto reset.



EMPR 230L000 with single phase motor and remote reset



EMPR 115L000 with 4 wire load, overload and earth fault protection, reset via keypad



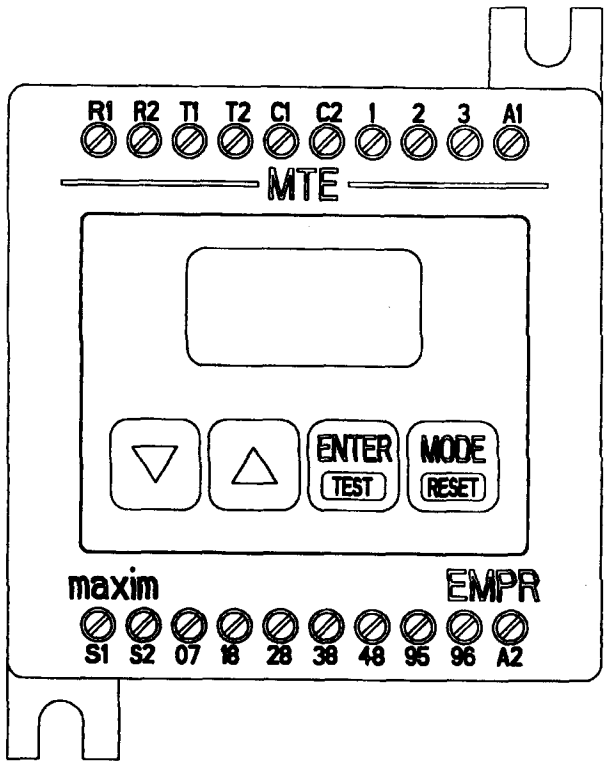
Programming

The programming mode may be entered from the stopped mode (display shows OFF) by holding down the MODE key until the display starts to flash, the DOWN key should then be momentarily operated, followed by release of the MODE key. If this sequence is not correctly completed then the device will revert to the stopped mode. When in the programming mode all relay contacts will be open, so that motor starting is not possible.

When the programming mode is entered the program jumps straight into the Access mode, and the display shows the letter A followed by zero. In order to continue with programming a correct access code must be entered. This code is fixed, the number is 81. If an incorrect code is entered the program jumps back to the stopped state. If the correct code is entered the program remains in the programming mode and the next (Start delay) option is displayed.

Once in the programming mode the program options may be stepped through by operation of the UP or DOWN keys. Scrolling is in the direction indicated by the key used and a scroll round feature allows the programmer to return to the start (or end) of the menu directly from the opposite end. As the programmer steps through the menu, option codes will be displayed on the screen. When the desired option is reached the MODE key should be pressed and the stored value associated with the option will be displayed.

Adjustments may then be made by operating either the UP or DOWN keys which will increment or decrement the value accordingly. The value being adjusted can be scrolled round at each limit of adjustment. Once the alterations have been completed the ENTER key should be pressed. The program will then step to the next set option.



Program options

Feature code	Description	Range	Increment	Default
S	**S**tart delay	0...20	1	0
O	**O**verload level	20...99	1	99
C	Protection **C**lass	1...99	1	1
E	**E**arth fault level	0.1...60	0.1 / 1*	0.1
F	Earth **F**ault delay	1...60	1	1
U	**U**nderload level	0...80	1	0
L	UnderLoad delay	1...60	1	1
P	Reset delay **P**eriod	0...20	1	0
I	**I**nhibit E/F reset	y / n	step	n
A	**A**ccess / **A**ll done	0...99 / y...n	1 / step	0 / n

* Step size is 0.1A up to 10A then 1A steps from 10A upwards

Start delay

The start delay option is only required for high inertia loads such as centrifugal fans. The delay time commences when a motor is started and continues for the set delay time which is adjustable in the range 0...20 minutes. During this period the thermal trip time will be four times the programmed value. Therefore this option should only programmed as a value other than zero if absolutely necessary to allow the motor to run up to speed without nuisance tripping. If this feature is needed try to keep the value as small as possible. Once the start delay has completed then the thermal trip time will revert to its normal value.

Overload level

In order to match the motor to the EMPR the correct current transformers must be selected from the table on page 11 and the overload level set to match the full load current of the motor. The overload range is 20...99% of the CT rating, so for a nominal adjustment range of 20...100A (for example) the actual adjustment range will be 20...99A. In practice this should not be a problem as there is plenty of overlap between ranges. Ideally choose a CT rating so that the motor FLC is just above the mid point of the adjustment range.

When setting the overload level for a single phase motor the calculated value should be reduced by 30%. For example an 8.4A single phase motor should use the 2...10A range and be set to 59% (i.e. 84% reduced by 30% or 0.7 x 84).

Current transformer selection table

Nominal adjustment Range (A)	CTA	CTA Primary turns	CTB (1 primary turn)
0.1...0.5	**01.000158.220**	*	-
0.2...1.0	**01.000158.220**	**	-
0.5...2.5	**01.000158.221**	8	-
0.8...4.0	**01.000158.221**	5	-
1.0...5.0	**01.000158.221**	4	-
2...10	**01.000158.221**	2	-
4...20	**01.000158.221**	1	-
10...50	**01.000158.222**	1	-
20...100	**01.000158.223**	1	-
40...200	**01.000158.221**	4	**01.000158.505**
100...500	**01.000158.221**	4	**01.000158.300**
200...1000	**01.000158.221**	4	**01.000158.302**
400...2000	**01.000158.221**	4	**01.000158.303**
600...3000	**01.000158.221**	4	**01.000158.304**

* Use primary terminals 1 & 3
** Use primary terminals 1 & 2

For turns ratios of current transformers listed in the table please see the Order Reference section.

Example:

A 75kW 3 phase motor with a full load current of 136A needs to be protected by an EMPR. The best adjustment range for this application is 40...200A, as 136A is just above the mid point of this range. Use the transformers recommended in the table and set the overload level to 68, as 68% of 200A is 136A.

Protection Class

The protection class may be set in the range 1...99 seconds. The class value indicates the time to trip from cold at 6 x FLC. This time can be set to match IEC 947 trip classes if required, e.g. for Class 20 set this value between 6 and 20 seconds. If IEC 947 trip classes are required the start delay must be set to zero.

Earth Fault Level

The primary earth fault current measured by the dedicated core balance current transformers may be set in the range 0.1...60A.

Earth Fault Delay

The time for an earth fault to cause a trip can be adjusted in the range 1...60s. It should be noted that during starting capacitive leakage can cause considerable earth leakage current to flow (up to 10% of FLC). Rather than setting a high trip level, a delay of a few seconds can allow this current to be ignored but smaller, continuous fault currents can then still be detected.

Underload Level

An underload level may be set to allow detection of faults such as broken drive shafts or dry pumping. This value may be adjusted in the range 0...80% of FLC, where zero is a very low level which effectively disables this feature. As a guide many motors will run at 50% of their full load current when unloaded but as this can vary greatly, the level should be carefully chosen to suit the application.

The change in current for motor gearbox combinations may not be sufficient to detect a loss of load. In such circumstances rotation sensors are best used for detecting shaft rotation.

Underload Delay

In order to prevent nuisance tripping caused by load fluctuations the underload trip delay time can be adjusted in the range 1...60s.

Reset Delay Period

After a trip event the time before a reset is allowed may be set in the range 0...20 minutes. This delay period does not apply to the thermistor trip where a reset is not possible until the thermistor has cooled to its cold (reset) resistance.

Inhibit earth fault reset

In some applications the reset of earth fault by operators needs to be either restricted or prevented. For these applications the inhibit option can be used to only allow reset of the earth fault by the EMPR's keypad reset. As the EMPR should be housed in a control cabinet access to the reset is naturally restricted. Remote reset may be inhibited by selecting the yes (y) option. All other trip modes can be reset normally either via the keypad, a remote reset button or even auto reset.

Access / All done

In the programming mode the code A changes (from the access code) to indicate "All done". Normally this option will be selected after all the other parameters have been set. In order to leave the programming mode the operator must select this mode and enter the "yes" (y) option. The program will then return to the stopped state.

MTE Limited,
Stephenson Road, Leigh-on-Sea,
Essex SS9 5LS
United Kingdom

Tel: +44 (0)1702 421 124 Fax: +44 (0)1702 420 365
E-mail: info@mte.co.uk

Visit our Web Site at: www.mte.co.uk

06012141/ 2E/ 699