MPR500 Motor Protection Relay User's Guide V1.3

Brief Overview

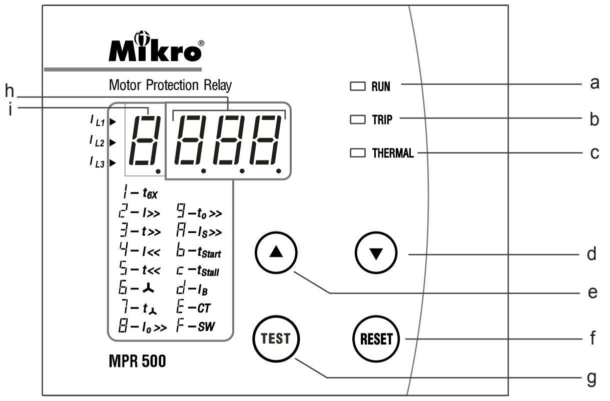


Figure 1: Front panel overview

- a – Run LED
- b – Trip/Pickup LED
- c – Thermal LED
- d – Down key
- e – Up key
- f – Reset/Mode key
- g – Test key
- h – Data LED
- i – Function LED

Symbols

- t_{6X} – Thermal overload time constant
- I>> – Short circuit/High set Overcurrent
- t>> – Short circuit/High set Overcurrent delay time
- I< – Undercurrent
- t< – Undercurrent delay time
- ⅄ – Unbalance
- $t_{⅄}$ – Unbalance delay time
- I_0> – Earth fault
- t_0> – Earth fault delay time
- I_S>> – Prolonged starting/stall rotor
- t_{Start} – Prolonged starting delay time
- t_{Stall} – Stall rotor delay time
- I_B – Base/full load current
- CT – External current transformer ratio
- SW – Soft switch

1. General Description

MPR500 is a motor protection relay that combines thermal overload, short circuit, undercurrent, unbalance, phase loss, phase sequence, lock/stall rotor and earth fault protections.

MPR500 incorporates a 4-digit LED indicator which allows direct numerical readout of set values, actual measured value and system indication.

MPR500 has 2 relay outputs (R1 and R2). R1 is On under normal operating condition to allow motor running, and off during tripping. R2 is programmable to give signal in various conditions.

A programmable binary input is provided to perform various operations upon binary input triggering.

2. Display

2.1 Current and Thermal Capacity Display

During power up, when the relay is not under tripping condition, the display shows current in ampere or thermal capacity %. The Function LED indicates which parameter is being displayed. The Data LED showing value.

Press “UP” or “DOWN” to scroll through the parameters.

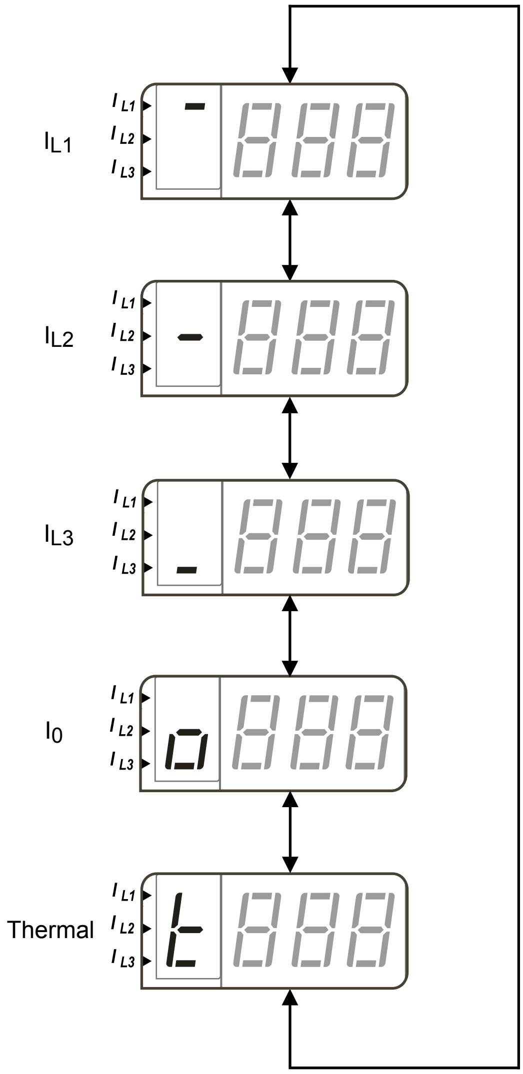


Figure 2: Current and thermal capacity display

For current more than 1000A, a dot is shown behind least significant digit. Eg: ***1.25.*** = 1.25kA

I_{L1} - Phase 1 current
I_{L2} - Phase 2 current
I_{L3} - Phase 3 current
I_0 - Zero sequence/Earth fault current
Thermal % - Thermal capacity % (Thermal overload tripping at 100%)

During Thermal capacity display, thermal capacity can be cleared to 0% by pressing "UP" and "DOWN" simultaneously for longer than 1.5 seconds.

Warning: Clearing thermal capacity effectively reset to cold start condition, user is not encouraged to clear thermal capacity unless it is sure that motor is cool enough to run/start within its thermal limit.

2.2 Auto Scroll

When auto scroll is enabled, the display scrolls between currents and thermal reading every 10 seconds. To toggle auto scroll mode, press "UP" and "DOWN" simultaneously.

2.3 LED Display

a) Run LED

Run LED shows the motor status. Refer to 3.2.1 Motor Starting.

Off	Motor stopping
Blink	Motor starting
On	Motor running

b) Trip LED

Trip LED is normally off. During tripping pickup, where tripping delay is counting down, Trip LED blinks. Trip LED on during tripping.

Off	Normal
Blink	Pickup
On	Tripping

c) Thermal LED

Thermal LED blinks when motor current is more than 105% of I_B. Thermal LED on during thermal overload tripping, and when thermal capacity is more than 40% after overload tripping (in which R1 is off, motor not allowed to start)

Off	Normal
Blink	Thermal overload warning
On	Thermal overload tripping Thermal capacity high, R1 off

3. Settings and Protection Features

3.1 Setting Display

When the relay is not under tripping condition, pressing "RESET/MODE" will scroll through various settings. Function LED showing number or alphabet to indicate which setting is being view as shown in Figure 3. Table 1 gives description of each setting.

Tip: To quickly jump back to current/thermal display during setting display, press and hold "RESET/MODE" for 1.5 second.

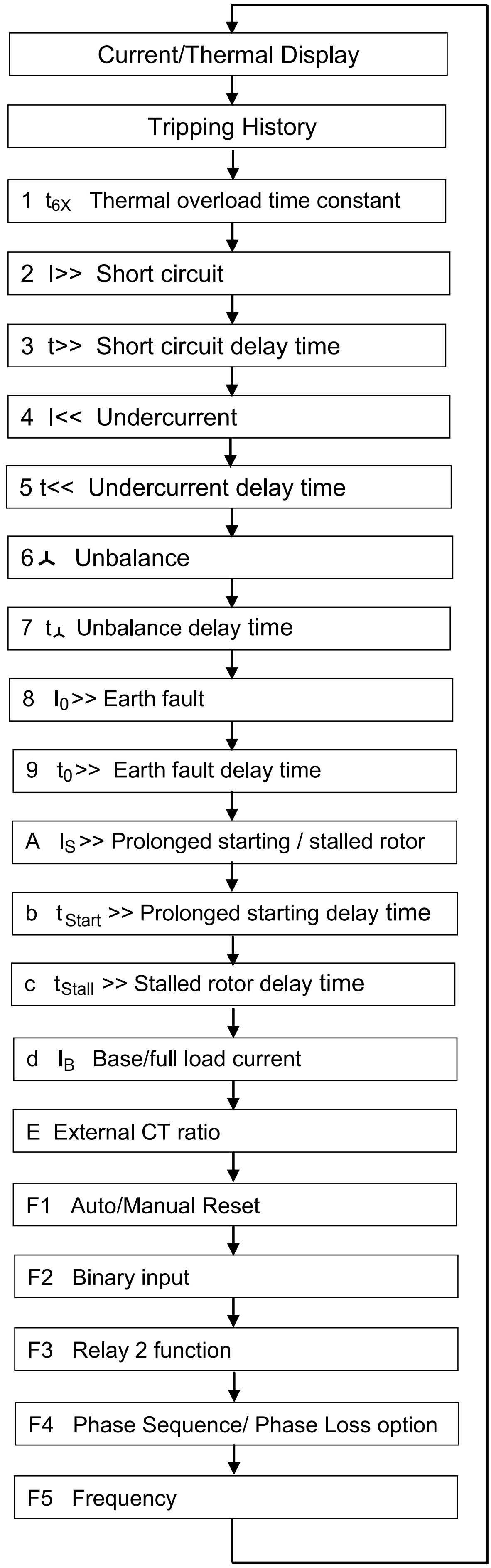


Figure 3: Display mode when pressing Reset/Mode

3.2 Programming Setting

Step 1: Press "RESET/MODE" until the Function LED shows the required setting.

Step 2: Press "UP" and "DOWN" simultaneously to enter programming mode.
The Function LED blinks to indicate the relay is in programming mode.

Step 3: Press "UP" or "DOWN" to change the value.

Step 4: To save the new value, press "UP" and "DOWN" simultaneously again. Programming mode exits, function LED stop blinking.

To exit programming mode without saving, press "RESET/MODE" once

Setting	Function	Setting Range	Description
1	t_{6X} Thermal overload time constant	1-40s. In steps of 0.1s for 1-10s, in steps of 1s for 10-40s.	Time constant for thermal overload
2	I>> Short circuit	off, 2-12 x I_B. In steps of 1 x I_B	Short circuit setting in multiples of I_B
3	t>> Short circuit delay time	0-25s. In steps of 0.1s for 0-10s, in steps of 1s for 10-25s	Delay time for short circuit
4	I<< Undercurrent	off, 20-90% of I_B. In steps of 1%	Undercurrent setting in % of I_B
5	t<< Undercurrent delay time	0-60s. In steps of 0.1s for 0-10s, in steps of 1s in 10-60s.	Delay time for undercurrent
6	⅄ Unbalance	off, 10-50%. In steps of 1%	Phase unbalance setting in %
7	$t_{⅄}$ Unbalance delay time	0-25s. In steps of 0.1s for 0-10s, in steps of 1s for 10-25s.	Delay time for phase unbalance
8	I_0>> Earth fault	off, 10-60% of I_B. In steps of 1%	Earth fault setting in % of I_B
9	t_0>> Earth fault delay time	0-25s. In steps of 0.1s for 0-10s, in steps of 1s for 10-25s.	Delay time for earth fault
A	I_S>> Prolonged starting /stalled rotor	off, 2-12 x I_B. In steps of 0.1 x I_B	Prolonged starting/stalled rotor setting in multiples of I_B
b	t_{Start}>> Prolonged starting delay time	0-60s. In steps of 0.1s for 0-10s, in steps of 1s for 10-60s.	Delay time for prolonged starting
c	t_{Stall}>> Stalled rotor delay time	0-60s. In steps of 0.1s for 0-10s, in steps of 1s for 10-60s.	Delay time for stalled rotor
d	I_B Base/full load current	2-10A	Base/full load current of motor
E	External CT ratio	1-800:1	External CT ratio. 1=direct.
F1	Auto/Manual Reset	0 - Manual reset 1- Auto reset	Manual or auto reset of tripping Thermal overload is always auto reset
F2	Binary input	0 - Block relay 1 1 - Reset tripping 2 - Instant tripping	Setting for binary input
F3	Relay 2 function	0 - On any tripping 1 - On thermal tripping 2 - On thermal warning	Relay 2 function
F4	Phase sequence (PS)/ phase loss (PL) option	0 - PS and PL off 1 - PS on 2 - PL on 3 - PL and PS on	Phase sequence and phase loss option
F5	Frequency	50 or 60Hz	Nominal value of network frequency

Table 1: Description of settings

3.2.1 Motor Status

Run LED shows the motor status. Upon power on the relay, if there is no tripping, Relay 1 turns on.

If motor current is more than 1.1 x I_B, motor is considered starting, Run LED blinks. If motor current is less than 1.05 x IB, motor is running, Run LED on. Motor is stopping when motor current drops below 0.1 x I_B.

If motor starts abnormally for longer than 60s, Run LED stops blinking and turns off, Relay 1 also turns off. This condition reset when motor current drops below 0.1 x I_B.

3.2.2 Thermal Overload

The protection is based on mathematical model of motor thermal image. The thermal capacity is calculated continuously when motor is starting, overloading or even after tripping. Tripping takes place when the thermal capacity of the motor reaches 100%. This could happen when the motor current is higher than 1.05 x I_B. After tripping a new start is not allowed until the motor cools down to less than 40% of thermal capacity. Thermal capacity can be cleared to 0% by pressing "UP" and "DOWN" simultaneously for longer than 1.5 seconds during thermal capacity display.

Warning: Clearing thermal capacity effectively reset to cold start condition, user is not encouraged to clear thermal capacity until motor is cool enough to start/run within its thermal limit.

3.2.3 t_{6X} Thermal overload Time Constant

t_{6X} sets the themal overload time constant (heating constant), which is the maximum period of time when motor current is allowed to reach a 6 x I_B. Cooling constant time is defined as 4 times of heating constant time and is applicable when motor current is less than 0.2 x I_B. Refer to the thermal tripping curve on Figure 4.

3.2.4 Short Circuit

This protection is to trip the relay quickly when high current is detected due to short circuit. I>> is normally set higher than motor starting current to avoid false tripping during motor starting and t>> is set to very short duration.

Tripping takes place when any phase of motor current is larger than I>> for longer than t>>. It can be disabled by setting t>> to 'off'.

3.2.5 Undercurrent

Undercurrent protection is activated when average motor current is larger than 0.1 x I_B. Tripping takes place when average motor current is smaller than I<< for longer than t<<. It can be disabled by setting t<< to 'off'.

3.2.6 Unbalance

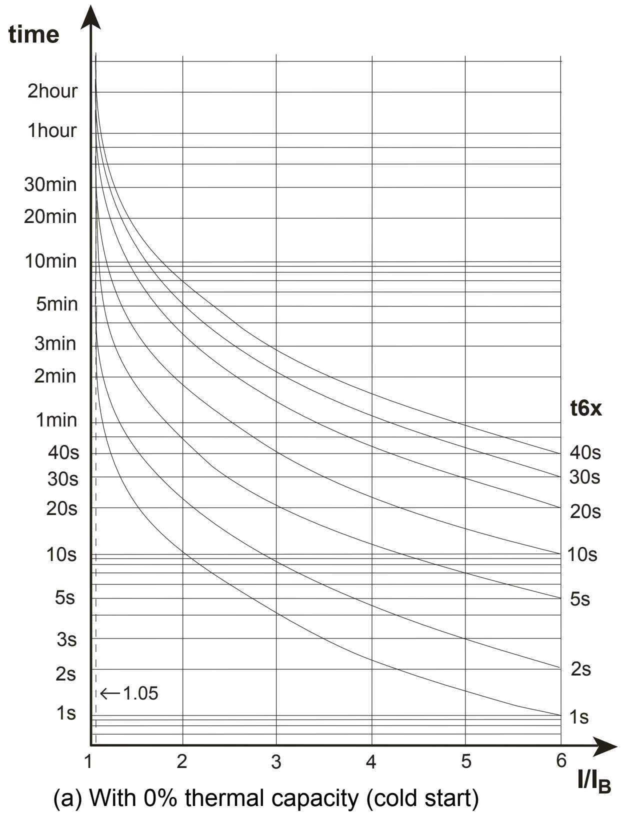
Unbalance is calculated as: $$\frac{I_{max} - I_{min}}{I_{min}} \times 100\ \%$$

where:

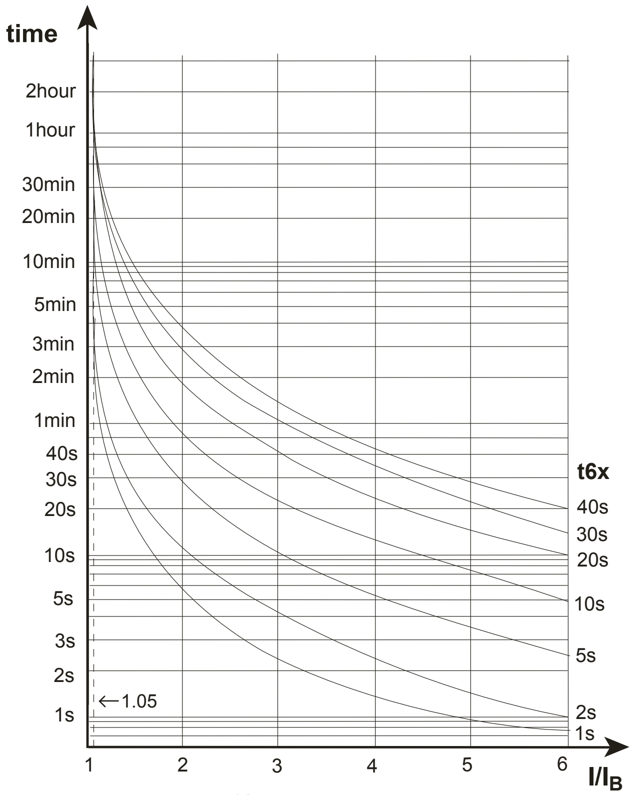
I_{max} is the maximum phase current among the 3 phases.
I_{min} is the minimum phase current among the 3 phases.

Tripping takes place when unbalance value is more than unbalance setting % for longer than unbalance delay. It can be disabled by setting unbalance delay to 'off'.

Figure 4: Thermal tripping curve



(a) With 0% thermal capacity (cold start)



(b) With prior 50% thermal capacity

3.2.7 Phase Loss

Phase loss fault is detected when average motor current is larger than 0.28 x I_B but any phase current is less than 0.1 x I_B. Tripping takes place in less than 120ms when phase loss is detected.

3.2.8 Phase Sequence

Phase sequence fault is detected when the phase sequence in any 2 or all the phases are reversed. Tripping takes place in less than 120ms when phase sequence fault is detected.

Phase loss and phase sequence protection can be enabled and disabled separately. Refer to *3.2.16 Phase sequence / phase loss option*

3.2.9 Prolonged Starting and Stalled Rotor

For prolonged starting and stalled rotor there is one I_S>> setting and separate delay time setting for each protection. I_S>> shall be set below the motor starting/ stalled current. These protections are useful when thermal overload protection is not fast enough to protect the motor during stalling.

Delay time for prolonged starting, t_{Start}>> shall be set longer than specified motor starting time. Tripping takes place when any phase current is larger than I_S> for longer than t_{Start} during motor starting.

Delay time for stalled rotor, t_{Stall}>> is activated upon completing the motor starting. Tripping occurs when any phase current is larger than I_S>> for longer than t_{Stall}>> during motor running.

Both protections can be disabled by setting I_S>> to 'off'. To disable only one of the protection, set the respective delay time for the protection to be disabled to much longer than specified.

3.2.10 Earth Fault

Earth fault protection is based on zero sequence current calculation. Tripping takes place when the current is larger than earth fault setting in % of I_B for longer than t_0>. It can be disabled by setting t_0>> to 'off'.

3.2.11 Base Current

Base current is the motor full load current. The range of setting is model dependent.

The formula is:

$$I_B = \text{Motor full load current} \times \frac{1}{\text{CT ratio}}$$

For example to use the relay with motor that has full load current of 138A, using external CT of 150/5,

$$I_B = 138 \times \frac{5}{150} = 4.6\text{A}$$

3.2.12 External CT Ratio

The CT ratio shall be set accordingly for the display to show primary current. For example when using 150/5 CT, set the value to:

$$\text{External CT ratio} = \frac{150}{5} = 30$$

3.2.13 Manual or Auto Reset

The relay can be set to manual or auto reset when the relay trips. Resetting of relay is allowed when the tripping condition cleared. Manual reset is performed by pressing the "RESET/MODE" (or using binary input if it is configured as 1 - Reset trip). Thermal overload is always auto reset.

3.2.14 Binary Input

The binary input is a dry contact input that can be configured to perform various functions.

0 - Block relay 1
The input, when triggered, will force relay 1 off.

1 - Reset tripping
The input is used to manually reset a tripping.

2 - Instant tripping
The input will generate a tripping condition. Refer to *4.4 Binary Input Tripping*.

3.2.15 Relay 2

The relay 2 output can be configured to turn on in these conditions:

0 - On any tripping
Relay 2 on during any tripping.

1 - On thermal tripping
Relay 2 on during thermal tripping only.

2 - On thermal warning
Relay 2 on when motor current is more than 1.05 x I_B.

3.2.16 Phase sequence / phase loss option

Phase sequence and phase loss detection can be on (enabled) and off (disabled) separately.

0 - Phase sequence and phase loss off
1 - Phase sequence on
2 - Phase loss on
3 - Phase sequence and phase loss on

3.2.17 Frequency

Nominal value of the network frequency. Select either 50 or 60 Hz.

4. Tripping

4.1 Tripping Display

During tripping, Trip LED on, Thermal LED also on during thermal overload tripping. Function LED and Data LED blinks showing tripping current or source as shown below:

Trip LED	Thermal LED	Function LED	Data LED	Description
On	On	t	oL	Thermal Overload tripping
On	Off	2	tripping current	Short circuit tripping
On	Off	4	tripping current	Undercurrent tripping
On	Off	6	Ub	Unbalance tripping
On	Off	6	PS	Phase sequence error tripping
On	Off	6	PL	Phase loss tripping
On	Off	8	tripping current	Earth fault tripping
On	Off	A	tripping current	Prolonged starting/Stalled rotor tripping
On	On	t	ESt	Trip Test
On	Off	t	riP	Binary input tripping

Table 2: Tripping display

4.2 Tripping Reset

During tripping condition, press "RESET/MODE" to reset, the relay will reset if condition permits. If relay is set to auto reset, the relay will reset automatically if the tripping condition is cleared with a 5% hysteresis.

4.3 Tripping Test

Press and hold "TEST" for 3.5 seconds to simulate a tripping condition, Trip LED blinks when "TEST" is pressed. During Test Tripping, "tESt" blinks, R1 off and R2 on if set to "On any tripping". Press "RESET/MODE" to reset. Tripping Test is disabled when motor is starting/running.

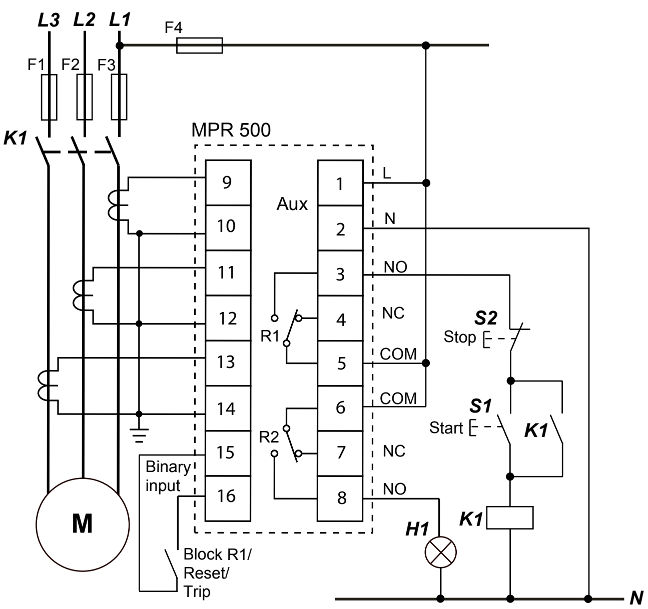
4.4 Binary Input Tripping

When Binary input is set to 2 - Instant tripping, binary input will generate a tripping condition. "triP" will blink, R1 off and R2 on if set to "On any tripping". Press "RESET/MODE" to reset. If relay is set to auto reset, the relay will reset after the input is normal for 1s.

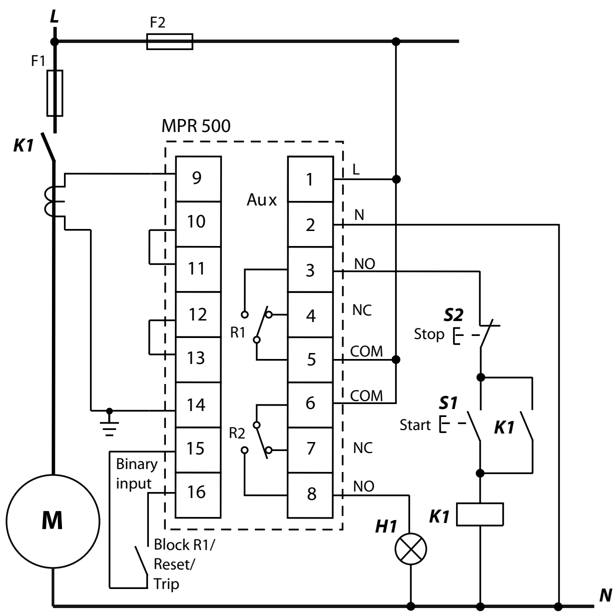
4.5 Tripping History Display

During Current/Thermal display, press "RESET/MODE" to jump to Tripping History Display. Display shows the previous tripping status with a 'dot' blinking at Function LED. To clear tripping history, press "UP" and "DOWN" simultaneously.

5. Typical Application Diagram



3-Phase Motor



Single-Phase Motor*

* To use MPR500 for single-phase protection, Io>> Earth fault, Phase sequence and phase loss protection should be set to off.

Figure 5: Example of application

6. Techinical Data

SETTING RANGES

Thermal Overload time constant, t_{6X}	:	1 – 40s. In steps of 0.1s for 1-10s, in steps of 1s for 10-40s
Short circuit, I>>	:	off, 2 – 12 x I_B. In steps of 1 x I_B
Short circuit delay time, t>>	:	0 – 25s. In steps of 0.1s for 1-10s, in steps of 1s for 10-25s
Undercurrent, I<<	:	off, 20 – 90% of I_B. In steps of 1%
Undercurrent delay time, t<<	:	0 – 60s. In steps of 0.1s for 1-10s, in steps of 1s for 10-60s
Unbalance, ⅄	:	off, 10 – 50%. In steps of 1%
Unbalance delay time, $t_{⅄}$	:	0 – 25s. In steps of 0.1s for 1-10s, in steps of 1s for 10-25s
Earth fault, I_0>>	:	off, 10 – 60% of I_B. In steps of 1%
Earth fault delay time, t_0>>	:	0 – 25s. In steps of 0.1s for 1-10s, in steps of 1s for 10-25s
Phass loss	:	<120ms
Phase sequence	:	<120ms
Prolonged starting/stalled rotor, I_S	:	off, 2 – 12 x I_B. In steps of 0.1 x I_B
Prolonged starting delay time, t_{Start}	:	0 – 60s. In steps of 0.1s for 1-10s, in steps of 1s for 10-60s
Stalled rotor delay time, t_{Stall}	:	0 – 60s. In steps of 0.1s for 1-10s, in steps of 1s for 10-60s

CT RATINGS

Rated current	:	2-10A
Rated frequency	:	50 or 60Hz
Burden	:	<0.3VA at rated current
Thermal withstand	:	Continuous: 2 x maximum rated For 30s: 6 x maximum rated For 1s: 10 x maximum rated

BINARY INPUT

Rated input voltage	:	12V (Supplied internally)

AUXILIARY SUPPLY

Model MPR 500-240A	:	85 ~ 265 V AC 110 ~ 370 V DC
Supply frequency	:	50 or 60 Hz
Maximum power consumption	:	3 VA typical

CONTACTS

Contact arrangement	:	Change-over
Contact rating	:	5A, 250V AC ($\cos\phi = 1$)
Contact material	:	Silver alloy
Operating time	:	15ms max
Expected electrical life	:	100,000 operations at rated current
Expected mechanical life	:	5 x 10^6 operations

INDICATORS

Run	:	Green indicator
Trip/Pickup	:	7-segment display and red indicators
Thermal	:	Yellow indicator

ENVIRONMENTAL CONDITIONS

Temperature	:	-5°C to +55°C
Humidity	:	56 days at 93% RH and 40°C non-condensing

MECHANICAL

Mounting	:	Panel mounting
Front panel	:	Standard DIN 96 mm x 96mm
Approximate weight	:	0.75kg

CASE DIMENSION

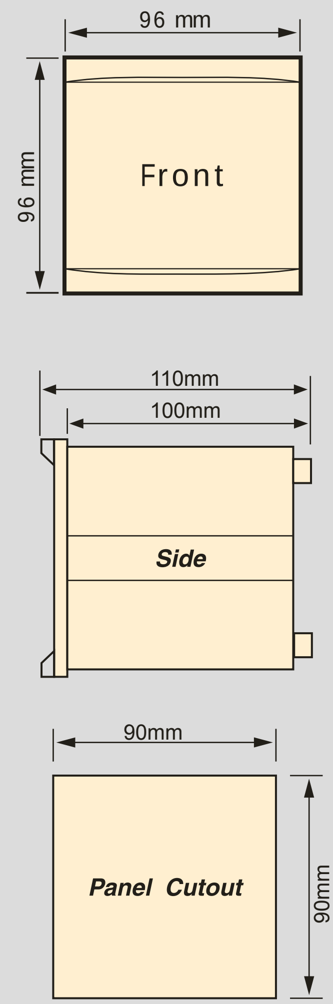


Figure 6