Motor Protective Relay

Motor Protective Relay

3E, 4E Motor Protective Relay

MPR(4E,3E)

MOTOR PROTECTIVE RELAY

Static type Motor-Relay

● MOTOR relays ranging wide in types refer to those relays purposed to protect three phase induction motors that are prime source of motive power at most industrial facilities. Motor protection by means of earlier detection of fault status to minimize overload damage is important for long motor life and avoiding damages.

● Ensuring with the trends of motors becoming compact and light-weighted, motor protection relays (MPR) being required of high performance and reliability are featuring static state a change from the conventional simple thermal relay structure.

### Phase current Vector During one phase open

Fig 1
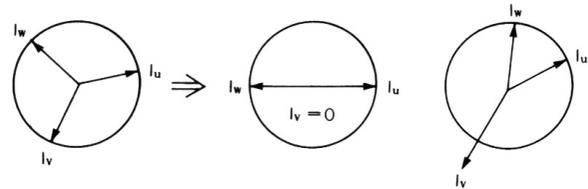
Motor relay(Function)

Element	Feature No.	Remarks
1. Overload	51	● Prevent motor burning.
2. Open phase	46	● Minnmize damages to work loads.
3. Reverse phase	47	(Careful selection is necessary for correct application.)
4. Ground fault	50G	● Offer protection against leakage damages caused by motor insulation faults.

Elements for overload

● Over loaded operation of motor will flow of over current. Long time operation of a motor in over current status would result in motor burning and that current should be cut-off immediately for protection against the burning.

● Induction motors normally require 5 to 6 times starting currents than rating current during a few seconds while starting.

● Should the relay react to such starting over current, the motor will be in operation fault status. In order to avoid such a state. precise setting of operating time will be necessary.

● Current rating is set within the range of 105% to 125% of the current setting prescribed in JEM 1357 for all motors unless otherwise specified.

● Relays are timed to operated in 40 seconds or less at 600% over current of the set level as specified in JEM 1357 and 4 minute less at 200% over current likewise.

### Phase reverse detecting mathode

Fig 2
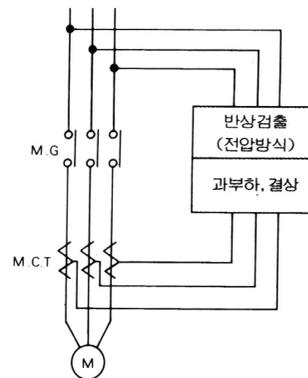
Element for open phase

● Open phase operation refers to a state of motor operation in which a three phase motor would run in single phase power because of loosened terminal connection faulty switch contact or disconnected motor coil

● Three phase motor does not start in single phase power from halt status that continous attempt to start in an open phased state will occur over current. Detection of overload status is essential to save the motor from burning.

● Should the motor is developed an open phase while the motor is in rotation the motor may rotate continuous if the load is resonably low.

Element for open phase

● Changes in phase sequence of three phase motor would reverse the direction of rotation. Revers rotation even for a short time
  would be detrimental to the lead critically.
● Reverse phase performance for immediate detection and instantaneous circuit breaking is essential whenever the phase is reversed.
● Reverse roation is preventable by three phase voltage detection.
● As shown is Flg 3. reversed phase can be detected before starting the motor if the detector is connected before the magnetic switch.
● The connection as such assures complete safety as it detects reversal factor absolutely before starting.
● When power cource is changed.
  Installation of the detector is highly desirable because wiring of motor may be misconnected very often.

Current detecting (CD) or Voltage detecting mathode(VD)

Fig 3
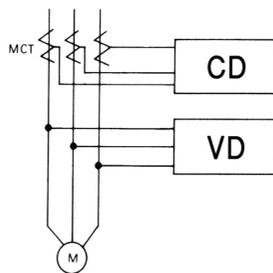
As shown in Fig. 2, open phase is detectable by voltage method without requiring use of a current transformer. The method does
not, however, offer ability to detect open phase status between detector contact point to motor. In case of line side open phase,
terminal voltage exists if the motor is running with light load that open phase may not be detectable. For this above reason, the current
detections method is desirable.
● Since over current measure alone may not always be able to prevent motor burning, consideration of open phase measure will
  be necessary.
● In case of running with light load, the current in phase fault may not be large enough to be detected as over current that status
  of open phase may not be detected.
  For this reason, application of open phase measures for prompt detection of phase fault will be necessary.
● For this reason, use of current detection method will be most advantageous although voltage detection method is available too.

Characteristics of Motor Relay

● For the purpose of improving power factor, lead factor capacitor is installed in parallel to the motor.
  Usually the motor current at light load is Var power containing harmonic waves. The capacitor is installed to absorb unnecessary
  harmonic wave. But if the capacity is too large, the open phase and reverse phase detection circuits designed with 50/60㎐ sine
  wave may operate faulty. Although such a case would rarely occur, performance of circuit needs to be protected from
  malfunctioning by determination of over current reacting point, as having the capacitor installed before the motor relay.
● In general, motor current shows unbalance by several percent.
  However, in case of power supply through long used transformer of V connection, it may swing up to 10-20 percent or even more.

MOTOR PROTECTIVE RELAY

## Features of Motor Relay

MCT(current converter for moter relay)

- MCT converts AC current into DC voltage to operate motor relays.
- By changing built–in taps. current level can be selected in steps.
- If 20A tap of MCT is selected and wounded 2 times. 10A input current will be detected as 20A that the relay can be operated at 10A current and if would 4 times, the relay can be operated even at 5A

Fig 4
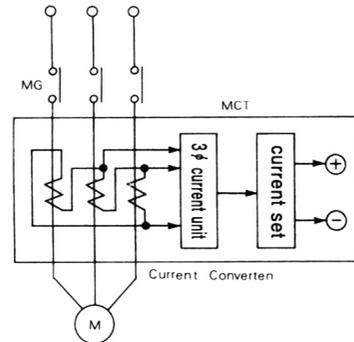
MCT output voltage characteristics

MCT TAP	Input current	Output voltage
20A	8A	8V
40A	16A	8V
80A	32A	8V

Fig 5
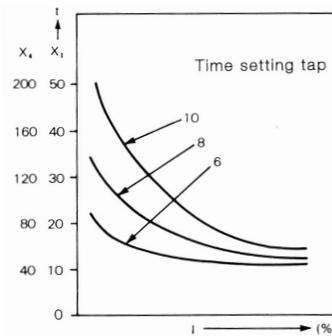
Element for over load

- Over current is detected by DC voltage obtained from input of the motor relay after conversion. Should the current exceed the level set by current regulating taps, the relay becomes activation.
- The relay operates in inverse time limit to set time when overloaded, the over current active time length can be adjusted within a range of 1 to 40 seconds when the current is greater 600 percent than the set value.
- If the relay is operated, the output relay becomes to holding status.

Open phase

Open phase relay is activated according to current and time characteristics when open phase status is detected by three phase output wave form of MCT as shown in Fig. 6 and 7.

- Motor relays are designed more as current unbalance detector than open phase detector. They are set to operate approxirmately at 35 percent or 65 percent level of current unbalance.
- Active time in open phase is approximately 1.6 seconds in an unbalance of 35% or more (for High–speed action setting.)

Fig 6
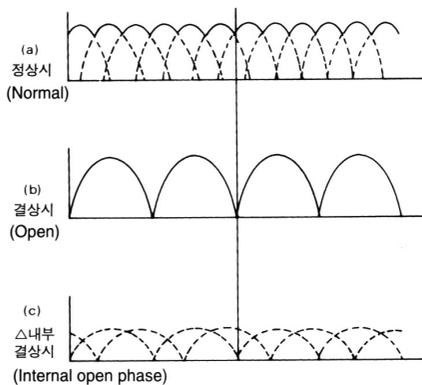
Fig 7
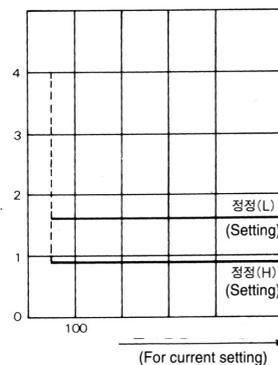
Example of 3 phase unbalance calculation

$$\text{Unbalance factor} = \frac{\text{3phase unbalance circuit reverse component}}{\text{3phase unbalance circuit normal component}} \times 100\%$$

$$\frac{\text{Reverse component}}{\text{normal component}} = \frac{1a + a^2 ib + aic}{1a + a^2 ib + a^2 ic}$$

Above formula above shall be quoted to determine unbalance ratio. For example, assume
R phase=100A, S phase=60A, T phase=70A

$$R{:}S{:}T = 1{:}0.6{:}0.7 \; (\; \frac{100}{100} = 1, \; \frac{60}{100} = 0.6, \; \frac{70}{100} = 0.7 \;)$$

that unbalance ratio in percentage can be read from the table at right. In the case of this example, unbalance ratio is 36% as read from the table.

Table for unbalance ratio

Unbalance			Ratio(%)
1.0	1.0	1.0	0
1.0	0.9	0.8	12
1.0	0.8	0.7	24
1.0	0.7	0.6	36
1.0	0.6	0.65	39
1.0	0.5	0.65	51
1.0	0.4	0.75	55
1.0	0.3	0.8	66
1.0	0.2	0.85	77
1.0	0.1	0.9	95

● Motor relays are designed more as current unbalance detector than open phase detector. They are set to operate approxirmately at 35 percent or 65 percent level of current unbalance.
● Active time in open phase is approximately 1.6 seconds in an unbalance of 35% or more (for High-speed action setting.)

Reverse phase

The relay is featured for reverse phase protection circuit and driven by line voltage(3ø)
● Driving power is supplied to motor relay through using of U-V phase of line voltage.
● In case wiring connection to W phase terminal is removed, overload and open phase elements are activated but reverse phase element does not.
● In case of over load and open phase, 3E relay is activated by the power from MCT and in case of reverse phase, it is operated by 3 phase power.

How to connect wiring

● Since 3E relay is operated by power of DC voltage detected at MCT for overload and open phase detection, connection of W phase is not necessary unless reverse phase detection is intended.
● It is perferrable for MG coil and U-V ends of relay to share same power source.
● Phase advance capacitor should be tapped on before converter (at upstream). If tapped on after (close to load end) the load, set current of 3E relay should include capacitor current.
● For connection of relay to current converter, polarity of DC current should not be reversed.
● Since three phase line voltage is connected to motor and U-V-W phase of same line voltage is connected to 3E relay, selection of relay should be carefully made to desired specifications.
● When an use of CT output for converter input is intended, MCT-31 should be used.

3E, 4E MOTOR PROTECTIVE RELAY

MPR 3E   MPR 4E   MCT

Feature

1. Protection for 3 phase motor with certain in any cases : over load, single phase operating, reverse, even earth fault.
2. Wide range of current setting and time setting in one unit.
3. Input circuit is equipped with "surge" protection circuit for no error
4. Built in semiconductor H-IC circuit : And strong against shock and vibration.
5. D4E type protects motor from earth fault with ZCT

## Products

Rated Voltage		Rated Voltage	Rated Current	Function	Installation
3E	D3E-F41	AC 110V		Over load Open phase Revers phase	Flush mounted
	D3E-F42	AC 220V			Flush mounted
	D3E-F43	AC 380V			Flush mounted
	D3E-P41	AC 110V			Socket type
	D3E-P42	AC 220V			Socket type
4E	D4E-011	AC 110V		Over load Open phase Revers phase Ground Fault	Flush mounted
	D4E-022	AC 220V			Flush mounted
MCT	MCT-31	Less than 600V	1-80A	A/V(converter)	
	MCT-32	Less than 600V	64-160A	A/V(converter)	

Specification

Deseription		3E		4E
Motor rating	Cirult voltage	Less than AC 600V(3∅) Primary voltgae		
	Rated current	AC 1–80A to 64–160A, Primary current		
	Rated voltage	AC 110V, AC 220V, Ac 380V(3∅)		
	Extent voltage	85% ~ 110% of Rated voltage		
Frequency		50/60㎐ common		
Contact capacity		AC 125V 10A, AC 250V 6A(cos∅=1.0), DC 30V 5A, AC 250V 3A(cos∅=0.4)		
Power consumption	Control power	AC 110V, 220V, 380V		AC 110V, 220V
	VA	3.5VA	7VA	10VA
Element of over load	Operating value	Operation 115% of current set value(105 ~ 125%)		
	Operating time curve	Inverse		Inverse, Definite(Ground)
	Operating time	When over load 600% of current set Operating time tapx1(1 ~ 10sec) Operating time tapx4(4 ~ 40sec)		Inverse:Same as 3E Ground Fault : More than Current set value
	Reset	More than 100% of current set value		
Element of open phase	Operating value	Less than 75% of current set value		
	Unbalance factor	H(high sensitivity set)35±10%, L(Low sensitivity)65±10%		
	Operating time	Less than 4 sec		
	Value of Operation	Less than 80% rated voltage		
	Operating time	Less than 1 sec		
Starting Lock		Starting holdtime 5sec/10sec/15sec		
SL(start lock) Ambient temperature		ON(operating) OFF(Non operating) Operating value:±10%(−10℃ ~ +50℃), operating time:±20%		
Insulation resistance		• primary−case • secondary−case ⎤ More than 10㏁		
Dielectric strength		• primary−case • secondary−case ⎤ AC 2000V 1 min • Mutually dry contact : AC 1000V 1min		
Impulse wave withstand voltage		1.2/50㎲ positive, negative polarity : 3 times Electric circuit to case : 5㎸		
		Aux power to terminal : 4.5㎸		
Over load	P'ry current circuit	Multiple 20 of current set value		
Factor	Control power circuit	Multiple 1.15 of rated voltage(3 Hours)		
Vibration strength		Viabration frequency 16:7㎐, amplitude 4㎜		
Mechanical shock resistance		500㎨ (50g)		

3E,4E MOTOR PROTECTIVE RELAY

Front plate

D3E - F41

MOTOR PROTECTIVE RELAY

D4E-022

MOTOR PROTECTIVE RELAY [4E]
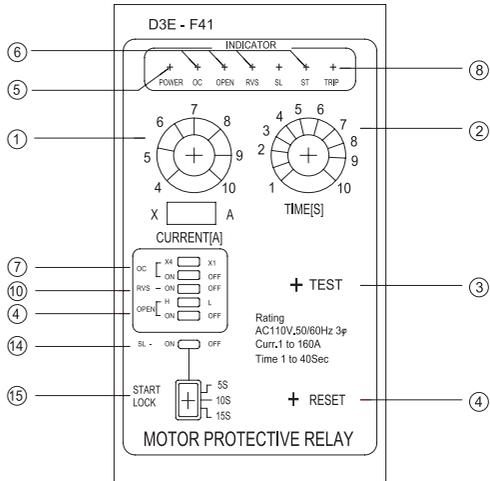
① Current setting range   ② Time setting range
⑤ Power Indicator lamp   ⑥ Operation Indicator lamp
⑧ Operation start lamp   ⑨ Open phase select switch
    Current select switch   ⑫ Operating time select switch
⑮ Starting lock time
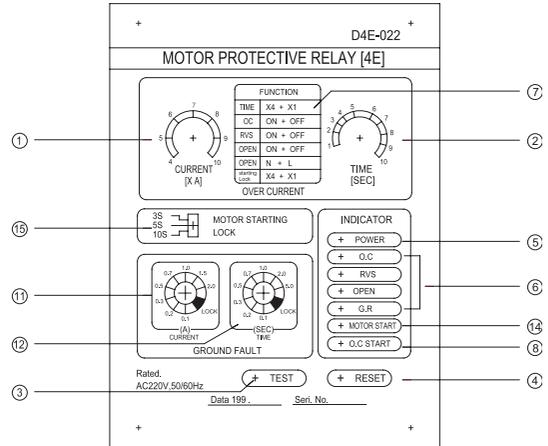
③ Test button   ④ Reset button
⑦ Operating time convert switch
⑩ Reverse select switch   ⑪ Ground fault
⑬ Ground test button   ⑭ Motor starting lock

Over load operating time characteristic

(Inverse)
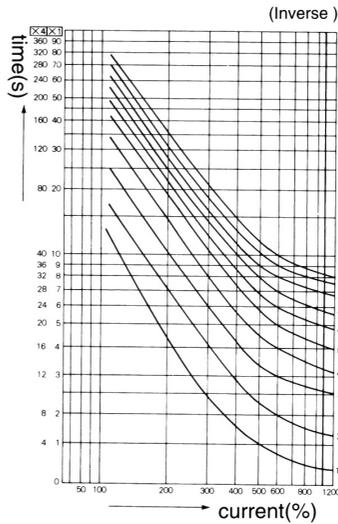
time(s)

current(%)

Single phase operating characteristic

Unblance(%)
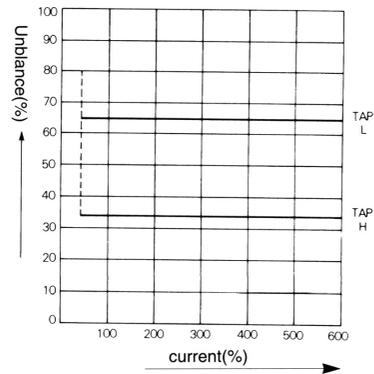
current(%)

Internal block diagram
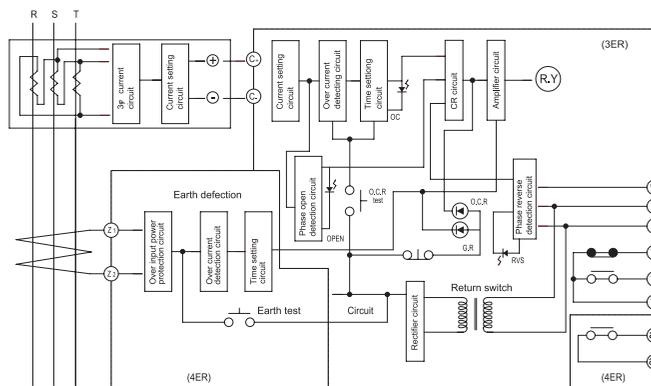
Current setting table

Model	Motor Power 220V 4P			Motor Relay		Current Converter(M.C.T)		
				Current setting (rated current × sticker no)	Current times ratio	Cable Turns	Times setting tap	tap
1	KW	HP	KW					
2	0.2	1/4	1.6	1~2.5	0.25	8	20	
3	0.4	1/2	2.5	2~5	0.5	4	20	
4	0.75	1	3.8					
5	1.5	2	6.6	4~10	1	2	20	
6	2.2	3	9.1	8~20	2	1	20	MCT −31
7	3.7	5	14.6	8~20	2	1	20	
8	5.5	7.5	21.8	16~40	4	1	40	
9	7.5	10	28.2	16~40	4	1	40	
10	11	15	40.9	32~80	8	1	80	
11	15	20	54.5	32~80	8	1	80	
12	22	30	78.2	64~160	16	1	fixed	MCT −32
13	30	40	104.5	64~160	16	1	fixed	
14	37	50	128.2	64~160	16	1	fixed	
15	In case of over 37kW using other C.T		5	2~5	0.5	4	20	MCT −31

1. Above motor power : 4 pole 1800rpm case
2. In case high voltage 3 phase induction motor, Wuse high voltage CT (2nd tated 5A, 10VA)
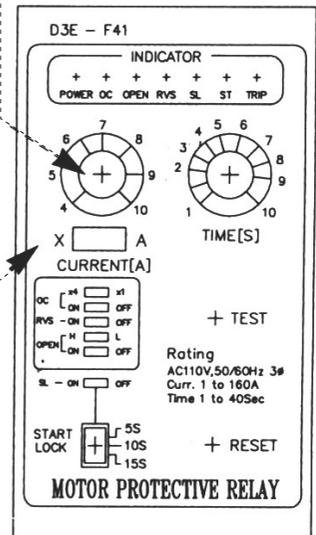
D3E − F41

Operating time setting be set from starting to normal operating time (3phase Induction motor)

Operation indication (OC, RVS, OPEN)

Operating time setting be set from starting to normal operating time (3phase Induction motor)

Item	Settting	Characteristic
Over Current	ON	Over current factor using
	OFF	Over current factor No using
	X 1	Operating time 1~10sec
	X4	Operating time 4~40sec
Open Phase	H	Operating unbalance rate 35%
	L	Operating unbalance rate 65%
	ON,OFF	ON,OFF
Reverse	ON	Reverse factor using
	OFF	Reverse factor No using

Operating current

Operating time setting be set from starting to normal operating time (3phase Induction motor)

MCT setting	Current Setting radio	4	5	6	7	8	9	10
20	X0.25	1	1.25	1.5	1.75	2	2.25	2.5
20	X0.5	2	2.5	3	3.5	4	4.5	5
20	X1	4	5	6	7	8	9	10
20	X2	8	10	12	14	16	18	20
40	X4	16	20	24	28	32	36	40
80	X8	32	40	48	56	64	72	80
fixed	X16	64	80	96	112	128	144	160
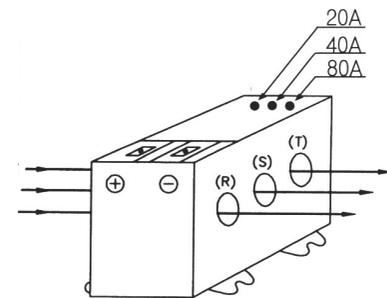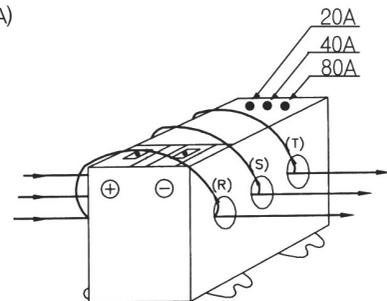
Operating time setting

According to starting current time of load, set between 1~40secs.

Time Tap		1	2	3	4	5	6	7	8	9	10
Multiple (sec)	X1	1	2	3	4	5	6	7	8	9	10
	X4	4	8	12	16	20	24	28	32	36	40

3E, 4E MOTOR PROTECTIVE RELAY

Manual (3E, 4E RELAY)

(Remark)
• Reted current and penetrating turns(table 1)

| Ampere(A)	Penetrating turns
1~2.5	8
2~5	4
4~10	2
more than 8	1
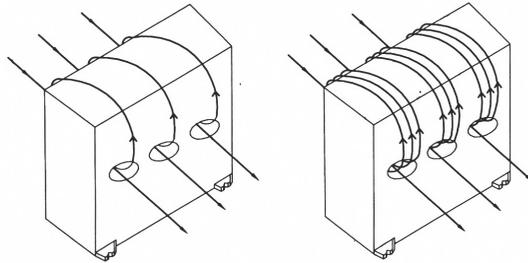
Remark

1. Refer to above table 1 and decide penetration turn according to the using ampere carafully

2. In case of rated current 1–80A, MCT–31 can be used, and in case of 64~160A, MCT–32 can be used. same direction.

4. In case high voltage and big capacity motor, normal CT'S secondary side should be penetrated through the MCT.

5. In case of 3E, 4E relay, connect all the 3 phase wire to normal phase process(U, V, W).

MCT Dimension
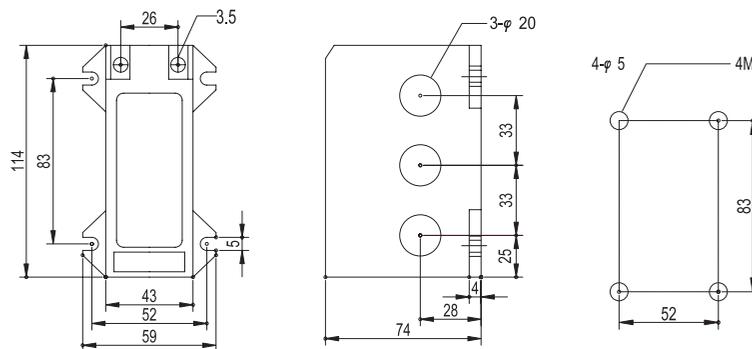
Application

1. How to set MCT

(Current setting is set 20A at factory) (MCT -31)

Select the setting tap and conductor penetrating turn according to the motor rated current.

Ex) In case rated current 4-10A, penetrating turn setting
tap will be 20 according to table 1.

2. Current setting ratio sticker

Motor relay current setting value 4~10 can cooperate with rated current sticker's

Ex) In case rated current 4~10A, setting value become 1

3. How to set current

Motor relay current setting should be decided by current times ratio setting and current setting value. At this time, operating value is 115%.

Ex) In case setting 5A ratio sticker

setting current value:(5A×0.5)→2.5A

Operating current value:(2.5A×1.15)→2.9A±10%

(table2) (unit:A)

MCT Setting Tap	Current Setting radio	4	5	6	7	8	9	10
	X0.25	1	1.25	1.5	1.75	2	2.25	2.5
	X0.5	2	2.5	3	3.5	4	4.5	5
20	X1	4	5	6	7	8	9	10
	X2	8	10	12	14	16	18	20
	X4	16	20	24	28	32	36	40
40	X8	32	40	48	56	64	72	80
80	X16	64	80	96	112	128	144	160

4. How to set time

Time setting ratio can be selected by switch position (×1, ×4)

At this time, it mean 600% over current operating time (unit:sec)

Ex) Time setting tap : 5

Ratio : ×4

Setting time 20sec (5×4)

Operating time is 20 seconds

※Note : In case of under water pump, please set less than 5
seconds. In case of normal 3 phase induction motor,
set the time from starting to normal operating.

5. Operating indication & how to reset

In case operating indicator, red LED is turned on.

At this time, output contactor become holding condition. After checking, all situation can be returned by pressing reset button.

6. How to test

Motor relay operating test can be done by pressing test button.

7. Before starting, how to confirm.

| MCT penetrating No and direction |
| ▼ |
| MCT and 3E, 4E relay polarity(+,−)confrmation |
| ▼ |
| Control power supply |
| ▼ |
| Confirmation 3 hase order(U,V,W) |
| ▼ |
| Revers test (change the phase) |
| ▼ |
| In case of instantaneous operating, it is normal |
| ▼ |
| Revers test (Return to normal positionnge the phase) |

| Press OCR test button (over setting time)(3E) | Press earth fault test butto(4E) |

| Operate |
| ▼ |
| Normal |
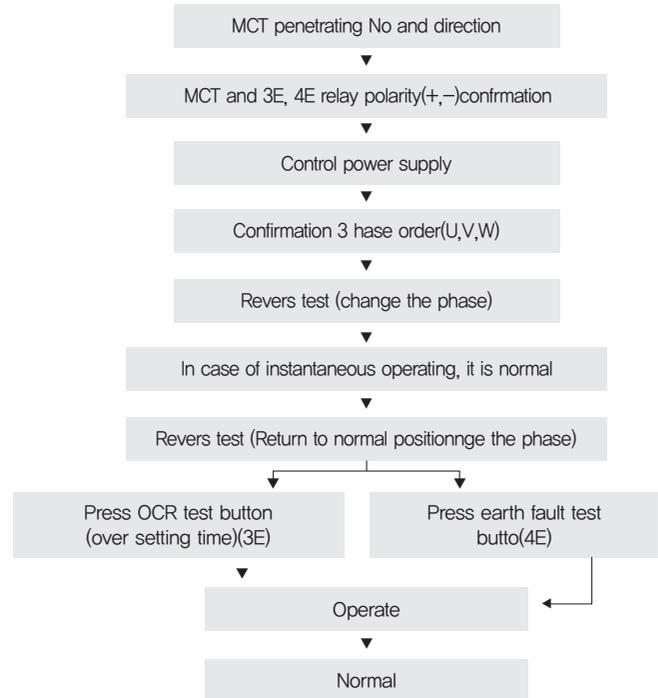
8. How to set earth fault current and test (4E relay)

(1) Sensible current is 0.1, 0.2, 0.3, 0.5, 0.7, 1.0, 1.5, 2.0, Lock(A) 9taps

(2) Time is 0.1, 0.2 0.3 0.5 0.7 1.0 1.5 2.0, 5.0 Lock(sec) 9taps

(3) After current and time setting by the pressing GR test button, it operate according to setting time.

(4) In case operating OCR, OC LED is on and in case operating GR, GR LED is on

(5) Without confirmation of normal position by pressing reset button, motor can't start.

(6) ZCT can be ordered with suitable capacity.

### Maintenance and inspection

| In case of operating at under starting	1. 3E,4E Relay is open phase itself 2. MCT penetration turn No and direction is correct or not all 3 wire 3. Power suppling voltage of relay and MCT are unbalance?
In case motor circuit tripping failure evenif relay operating indication comes out	After disconneting terminals of relay contact Ta, Tb, Tc, check whether the relay contacts are energized or not. by pressign test button

3E,4E MOTOR PROTECTIVE RELAY

External wiring diagram (3E Relay)

● Manual operating (Low voltage)
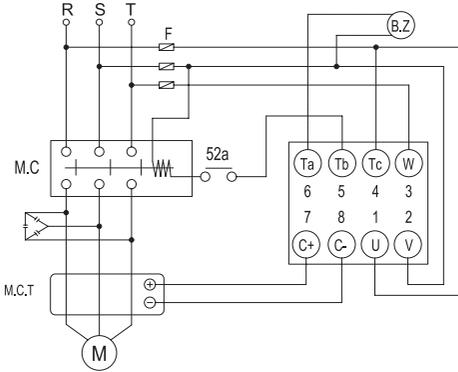
● High voltage motor

1. Installation MCT behind the condenser.
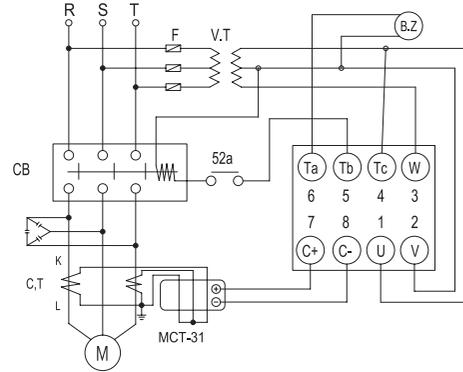
1. Installation MCT behind the condenser.
2. Use of high voltage ration C.T

External wiring diagram (4E)

External terminal

- 3E -   - 4E -

Dimension (4E)

Cutting Size : 122 x 165mm