OMRON

Measuring & Motor Protective Relays Group Catalog

Warranty and Application Considerations

Read and Understand this Catalog
Please read and understand this catalog before purchasing the products. Please consult your OMRON representative if you have any questions or comments.

■ Warranty and Limitations of Liability

Warranty and Limitations of Liability

WARRANTY

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Application Considerations

Application Considerations

BASIC CONSIDERATIONS

At OMRON, we are constantly working to improve the quality and reliability of our products. Protective Relays, however, use semiconductors, which are prone to malfunction. Be sure to use Protective Relays within their rated values. Use the Protective Relays only in systems that are designed with redundancies, flame protection, countermeasures to prevent operation errors, and other countermeasures to prevent accidents involving human life or fires.

SELECTION OF PRODUCTS

The applications, illustrations, and charts shown in this catalog are intended solely for purposes of example. Because there are many variables and requirements associated with any particular application, the final design can only be made in view of the specific parameters of each application. OMRON does not assume responsibility or liability for actual use based upon the examples shown in this catalog. Please consult one of our sales offices if you have any doubts or questions concerning your application.

In particular, the following criteria must always be considered in the selection, application, and installation of control equipment.

- Type of power supply
- Voltage rating (max. and min.)
- Current rating (max. and min.)
- Power rating (max. and min.)
- Suitability of frequency of operating controls
- Effects of component failure (mechanical and/or electrical)
- Ambient temperature of Protective Relays (Be aware that Protective Relays generate heat.)
- Mounted state

SUITABILITY FOR USE

OMRON shall not be responsible for conformity with any standards, codes, or regulations that apply to the combination of products in the customer's application or use of the products.

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The following are some examples of applications for which particular attention must be given. This is not intended to be an exhaustive list of all possible uses of the products, nor is it intended to imply that the uses listed may be suitable for the products.

- Outdoor use, uses involving potential chemical contamination or electrical interference, or conditions or uses not described in this catalog.
- Nuclear energy control systems, combustion systems, railroad systems, aviation systems, medical equipment, amusement machines, vehicles, safety equipment, and installations subject to separate industry or government regulations.
- Systems, machines, and equipment that could present a risk to life or property.

Please know and observe all prohibitions of use applicable to the products.

NEVER USE THE PRODUCTS FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE OMRON PRODUCTS ARE PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.

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Disclaimers
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Measuring and Motor Protective Relays
Selection Guide

■ List of Protective Relays

Application	Product name	Appearance	Model	Functions			Page
Overcurrent, open phase, reverse phase	Motor Protective Relay		K2CM	Motor protection	Overload, open phase, reverse phase	Inverse operation	8
			K2CM-Q			Instantaneous operation with start-up lock	
			SE-K, -KP	Motor protection	Overload, open phase, reverse phase	Inverse operation	24
			SE-KQ			Instantaneous operation with start-up lock	
			SE-K, -KP	Transformer protection		Inverse operation (Set the imbal-ance factor L to 65%.)	
Overcurrent	Current Sensor		SAO-R	Motor overcurrent protection	Inverse operation		37
			SAO-Q		Instantaneous operation with start-up lock		
			SAO-S		Instantaneous operation		
			SAO-RS	Single-phase motor overcurrent protection	Inverse operation		46
			SAO-QS		Instantaneous operation with start-up lock		
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Reverse phase	Reverse Protection Relay		APR-S	Three-phase motor reverse protection			67
Undercurrent	Current Sensor		SAO-SU	Motor/heater burnout protection	Instantaneous operation		37

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<tr><th>Application</th><th>Product name</th><th>Appearance</th><th>Model</th><th colspan="2">Functions</th><th>Page</th></tr>
<tr><td rowspan="2">Heater burnout</td><td rowspan="2">Heater Element Burnout Detector</td><td rowspan="2"></td><td>K2CU-F</td><td colspan="2">Large-capacity (4 to 80 A AC) with built-in current transformer</td><td rowspan="2">55</td></tr>
<tr><td>K2CU-P</td><td colspan="2">Small-capacity (0.5 to 4 A AC) compact, plug-in type</td></tr>
<tr><td rowspan="6">Voltage</td><td rowspan="6">Voltage Sensor</td><td rowspan="4"></td><td>SDV-FL</td><td>Single-function type</td><td>DC overvoltage/undervoltage detection, polar detection input</td><td rowspan="4">71</td></tr>
<tr><td>SDV-FM, -FM</td><td>Single-function type</td><td rowspan="2">AC/DC overvoltage/ undervoltage detection</td></tr>
<tr><td>SDV-DM, -DH</td><td>Double-function type</td></tr>
<tr><td>SDV-FH□T</td><td>Single-function type</td><td>AC/DC overvoltage/ undervoltage detection, equipped with timing function</td></tr>
<tr><td rowspan="2"></td><td>LG2-AB</td><td colspan="2">AC voltage detection (adjustable operate and release values)</td><td rowspan="2">93</td></tr>
<tr><td>LG2-DB</td><td colspan="2">DC voltage detection (adjustable operate and release values)</td></tr>
<tr><td rowspan="3">Ground faults</td><td rowspan="2">Ground Fault Relay</td><td rowspan="2"></td><td>K6EL</td><td colspan="2">Detection of ground faults due to insulation deterioration</td><td rowspan="2">97</td></tr>
<tr><td>K6EL-R</td><td colspan="2">Operates at 50 mA ±10%, conforms to standards, economical</td></tr>
<tr><td>DC Fault Detection Relay</td><td></td><td>SDG-A</td><td colspan="2">Positive and negative detection of ground faults and undervoltages</td><td>109</td></tr>
</table>

■ Zero-phase Current Transformers (ZCT)

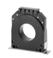
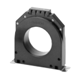
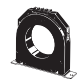
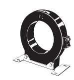
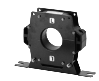
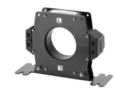
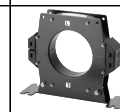
Application, installation	Indoor, through-type						Indoor, separate-type		
Model	OTG-L21	OTG-L30	OTG-L42	OTG-L68	OTG-L82	OTG-L156	OTG-CN52	OTG-CN77	OTG-CN112
Appearance									
Rated current Operating current range (200 A, 400 A, 600 A, 800 A, 1,000 A)	(50 A)	(100 A)	(200 A)	(400 A)	(600 A)	(1000 A)	(200 A)	(400 A)	(600 A)
Through-hole diameter	21 mm	30 mm	42 mm	68 mm	82 mm	156 mm	112 mm	77 mm	112 mm
Primary conductor 600-V vinyl-insulated cable (IV) 2-wire	22 mm²	60 mm²	100 mm²	400 mm²	500 mm²	500 mm²	200 mm²	500 mm²	500 mm²
Primary conductor 600-V vinyl-insulated cable (IV) 3-wire	14 mm²	38 mm²	100 mm²	325 mm²	500 mm²	500 mm²	200 mm²	400 mm²	500 mm²
Primary conductor 600-V round vinyl-insulated vinyl-sheath cable (VVR) 2-wire	8 mm²	38 mm²	100 mm²	325 mm²	400 mm²	1,000 mm²	150 mm²	400 mm²	1,000 mm²
Primary conductor 600-V round vinyl-insulated vinyl-sheath cable (VVR) 3-wire	5.5 mm²	38 mm²	60 mm²	250 mm²	400 mm²	1,000 mm²	100 mm²	325 mm²	1,000 mm²
Applicable devices K6EL 	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Secondary-side connection	Terminals (equipped with test terminals kt and lt)						Terminals, lead wire		
Weight	Approx. 80 g	Approx. 110 g	Approx. 230 g	Approx. 480 g	Approx. 700 g	Approx. 6.6 kg	Approx. 1.3 kg	Approx. 2.5 kg	Approx. 3.5 kg

TABLE OF CONTENTS

Motor Protective Relay
K2CM

Solid-state Relay Enables Choice of Three Operating Functions (Overcurrent, Open-phase, and Reverse-phase)

- Protects 3-phase induction motors and their loads from damage.
- Selection and combination of operating functions from overcurrent, open-phase, and reverse-phase.
- Circuit and output relay operation can be checked by just operating the test button.
- The set time value can be checked easily because operation time is indicated from the start of operation.
- Space-saving, integrated construction.

Model Number Structure

■ Model Number Legend

K2CU-□□□-□□
1 2 3 4 5 6

1. **Model**
   K2CM: Motor relay
2. **Mounting style**
   None: Surface-mounting, integrated type
3. **Operating time characteristics**
   None: Inverse type
   Q: Instantaneous type
4. **Supply voltage of control circuit**
   1: 100/110/120 VAC
   2: 200/220/240 VAC
   4: 400/440 VAC
5. **Current setting range**
   LS: 2 to 8 A
   L: 8 to 26 A
   M: 20 to 65 A
   H: 50 to 160 A
6. **Operating time**
   None: ×1: 2 to 10 s
   ×4: 8 to 40 s
7. **Resetting method**
   None: Manual reset
   A: Automatic reset
8. **Reverse-phase detection type**
   None: Current reverse-phase detection
   V: Voltage reverse-phase detection

Ordering Information

■ List of Models

Voltage Reverse-phase Detection Models

	Time specification	Inverse type			Instantaneous type		
	Current setting range	8 to 26 A	20 to 65 A	50 to 160 A	8 to 26 A	20 to 65 A	50 to 160 A
Resetting method	Operating voltage						
Manual	**200/220/240 VAC**	K2CM-2LV	K2CM-2MV	K2CM-2HV	K2CM-Q2LV	K2CM-Q2MV	K2CM-Q2HV
Automatic	**200/220/240 VAC**	K2CM-2LAV	K2CM-2MAV	K2CM-2HAV	K2CM-Q2LAV	K2CM-Q2MAV	K2CM-Q2HAV

Current Reverse-phase Detection Models

Resetting method	Time specification / Current setting range / Operating voltage	Inverse type				Instantaneous type			
		2 to 8 A	8 to 26 A	20 to 65 A	50 to 160 A	2 to 8 A	8 to 26 A	20 to 65 A	50 to 160 A
Manual	**100/110/120 VAC**	K2CM-1LS	K2CM-1L	K2CM-1M	K2CM-1H	K2CM-Q1LS	K2CM-Q1L	K2CM-Q1M	K2CM-Q1H
	200/220/240 VAC	K2CM-2LS	K2CM-2L	K2CM-2M	K2CM-2H	K2CM-Q2LS	K2CM-Q2L	K2CM-Q2M	K2CM-Q2H
	400/440 VAC	---	K2CM-4L	K2CM-4M	K2CM-4H	---	K2CM-Q4L	K2CM-Q4M	K2CM-Q4H
Automatic	**100/110/120 VAC**	K2CM-1LSA	K2CM-1LA	K2CM-1MA	K2CM-1HA	K2CM-Q1LSA	K2CM-Q1LA	K2CM-Q1MA	K2CM-Q1HA
	200/220/240 VAC	K2CM-2LSA	K2CM-2LA	K2CM-2MA	K2CM-2HA	K2CM-Q2LSA	K2CM-Q2LA	K2CM-Q2MA	K2CM-Q2HA
	400/440 VAC	---	K2CM-4LA	K2CM-4MA	K2CM-4HA	---	K2CM-Q4LA	K2CM-Q4MA	K2CM-Q4HA

Specifications

■ Ratings

Other features, such as 100% overcurrent capacity and flush mounting are also available. See *Model Number Legend* on page 8 for details.

Supply voltage of motor circuit	200/220, 400/440 VAC, 50/60 Hz
Supply voltage of control circuit	100/110/120, 200/220/240, 400/440 VAC, 50/60 Hz
Insulation breakdown of output contact	500 VAC
Operating voltage/current of output contact (pf = 0.4 when breaking contact)	NO contact: 120 VAC/2 A, 240 VAC/1 A, 440 VAC/0.5 A, 110 VDC/0.2 A, 220 VDC/0.1 A NC contact: 120 VAC/5 A, 240 VAC/2 A, 440 VAC/1 A, 110 VDC/0.2 A, 220 VDC/0.1 A
Contact form of output contact	Current reverse-phase detection models: SPST-NO + SPST-NC Voltage reverse-phase detection models: SPDT
Operating current range of input circuit	2 to 160 A (Number of passes: 1)
Operating voltage range of control circuit	85% to 110% of rated voltage, but operates normally at 50% of open-phase supply voltage
Operating frequency range of control circuit	95% to 105% of rated frequency
Power consumption	Approx. 3 VA (in standby state); 5 VA (in operating state)
Overcurrent function operating value	115 ±10% of the setting value
Overcurrent function operating time setting range	Inverse Type Inverse time both at starting and during operation • Time setting value (varies between 2 and 40 s) at 600% overload • Time setting value × 3 at 200% overload Instantaneous Type Fixed time at starting (start-up lock) • Time setting value (varies between 2 and 40 s) at 140% overload and starting Instantaneous during operation: 0.5 s max. (when current is increased from 100 to 140% of the set current value)

Overcurrent function operating time characteristics	Inverse type: ±10% of maximum setting value (at 600% overload) Instantaneous type: ±20% of maximum setting value (at 140% overcurrent and at starting)
Overcurrent function resetting value	100% min. of the setting value
Overcurrent function start-up operating value	Inverse type: Not applicable Instantaneous type: 30% max. of the setting value (See note.)
Open-phase operating value	85% max. of the set current value (at open-phase)
Open-phase operating time	2 s max. (at overcurrent operating value)
Reverse-phase operating value	50% max. of the current value (30% max. of the operating voltage)
Reverse-phase operating time	1 s max. (at overcurrent operating value)
Imbalance operating value	85% of the set current value
Current imbalance factor	High: 35 ±10%; Low: 60% min. (at overcurrent operating value) where $\text{Imbalance factor} = \frac{\text{Reverse phase portion}}{\text{Normal phase portion}} \times 100\ (\%)$
Imbalance operating time	2 s max.

Note: The start-up lock timer restarts when the operating value at starting becomes less than 30% of the set current value.

■ Characteristics

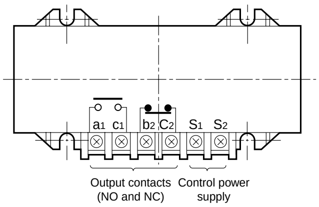
Variation due to temperature fluctuation	**At 20 ±20 °C**	Overcurrent: ±5% of operating value, ±10% of operating time Open-phase: ±10% of operating value, ±10% of operating time Reverse-phase: ±10% of operating value, ±10% of operating time
	At 20 ±30 °C	Overcurrent: ±10% of operating value, ±20% of operating time Open-phase: ±20% of operating value, ±20% of operating time Reverse-phase: ±20% of operating value, ±20% of operating time
Variation due to voltage fluctuation	**At 85% to 110% of rated voltage**	Overcurrent: ±5% of operating value, ±10% of operating time Open-phase: ±5% of operating value, ±10% of operating time Reverse-phase: ±5% of operating value, ±10% of operating time
Variation due to frequency fluctuation	**At 95% to 105% of rated frequency**	
Insulation resistance		10 MΩ min. (between current-carrying terminals and mounting panel) 5 MΩ min. (between current-carrying terminals and between contact poles)
Dielectric strength		2,500 VAC (between current-carrying terminals and mounting panel and between current-carrying terminals) 1,000 VAC (between contact poles)
Permissible impulse voltage		Current reverse-phase detection models: 6,000 V (between current-carrying terminals and mounting panel) 4,500 V (between current-carrying terminals and between control power supply terminals) Waveform: 1.2/50 μs Voltage reverse-phase detection models: 4,500 V (between current-carrying terminals and mounting panel) Waveform: 1.2/50 μs
Overcurrent strength of main circuit		No abnormality develops when 20 times the set current value is applied for 2 s, 2 times with a 1-minute interval.
Overvoltage strength of control power supply circuit		No abnormality develops when 1.15 times the relay's rated voltage is applied once for 3 hours.
Variation due to waveform distortion		No malfunction occurs when pulse containing 100% of the 2nd to 9th harmonics is applied (open-phase switch set to "Low"). (See note.)
Vibration		Malfunction: 10 to 55 Hz, 0.3-mm double amplitude (in X, Y, and Z directions for 10 minutes each) Destruction: 10 to 25 Hz, 2-mm double amplitude (in X, Y, and Z directions for 2 hours each)
Shock		Malfunction: 98 m/s^2 (approx. 10 G) in X, Y, and Z directions Destruction: 294 m/s^2 (approx. 30 G) in X, Y, and Z directions
Test current (reference only)	**Operating time**	Set time value
	Setting characteristics of operating time	Approx. ±30% of the maximum setting value
Service life		Electrical: 10,000 operations
Ambient temperature		Operating: –10 to 60 °C Storage: –25 to 65 °C
Humidity		35% to 85%
Altitude		2,000 m max.

Note: This means that no malfunction occurs with the open-phase element, but the operating value of the overload element may vary.

Connections

■ Voltage Reverse-phase Detection Models

Terminal Arrangement

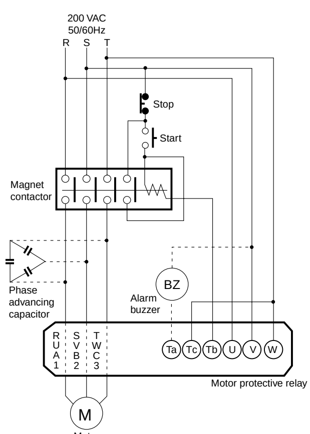


- Perform the external connections by referring to the examples given below.
- Obtain the control power supply from the same phase as the power supply to the magnet contactor coil.
- The NO and NC output contacts are independent of each other and therefore each of them can be connected to a circuit operating on a different voltage.
- Connect the phase advancing capacitors closer to the power supply than the current transformer, as shown in the examples.
- Tighten the terminal screws to a torque of 5 to 7 kg·cm (maximum torque: 10 kg·cm).
- Use of insulated solderless terminals is recommended for connection to the Relay terminals (M3.5).

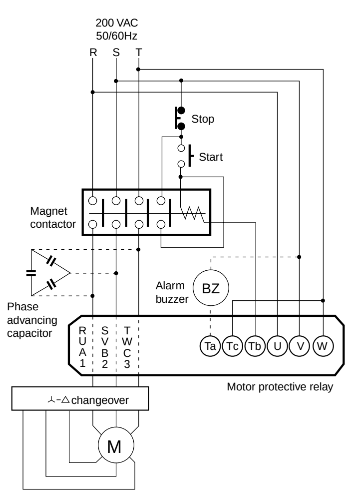
Note: **1.** In principle, the K2CM must be surface mounted with the terminal block facing downward.

2. Use M5 screws with a spring washer and a plain washer for mounting. Tighten the M5 screws to a torque of 11 to 16 kg·cm (maximum torque: 18 kg·cm).

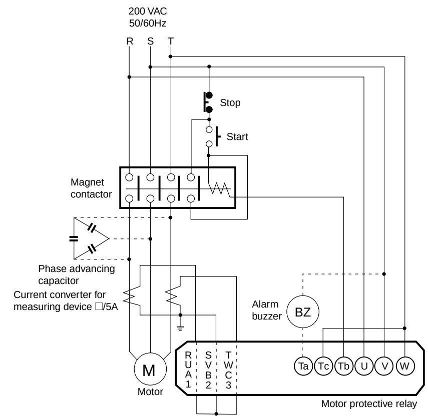
Manual Operation Low-voltage Circuit



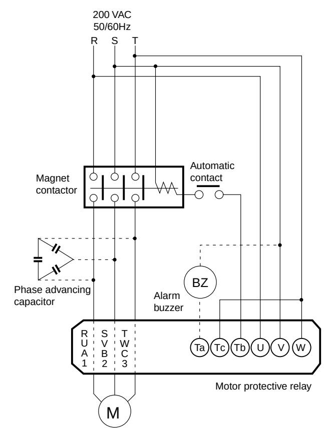
Manual Operating Low-voltage Circuit (⅄–△ Start)



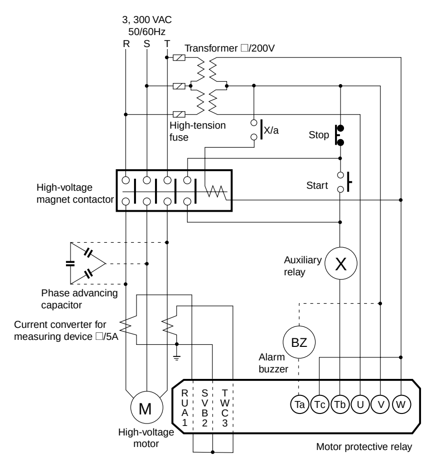
Manual Operation Low-voltage Circuit (High-capacity Motor)



Automatic Operation Low-voltage Circuit



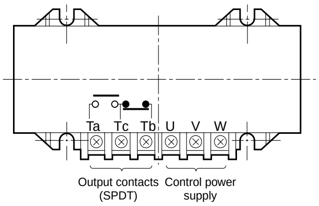
Manual Operation High-voltage Circuit



Note: Connect the phase advancing capacitor on the power supply side of the Motor Protective Relay as shown in the above diagrams.

■ Current Reverse-phase Detection Models

Terminal Arrangement

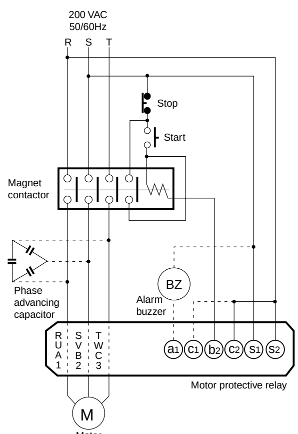


- Perform the external connections by referring to the examples given below.
- Obtain the control power supply from the same phase as the power supply to the magnet contactor coil.
- Connect the phase advancing capacitors closer to the power supply than the current transformer as shown in the examples.
- Tighten the terminal screws to a torque of 5 to 7 kg·cm (maximum torque: 10 kg·cm).
- Use of insulated solderless terminals is recommended for connection to the Relay terminals (M3.5).

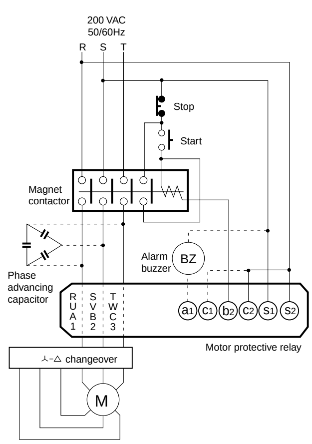
Note: 1. In principle, the K2CM must be surface mounted with the terminal block facing downward.

2. Use M5 screws with a spring washer and a plain washer for mounting. Tighten the M5 screws to a torque of 11 to 16 kg·cm (maximum torque: 18 kg·cm).

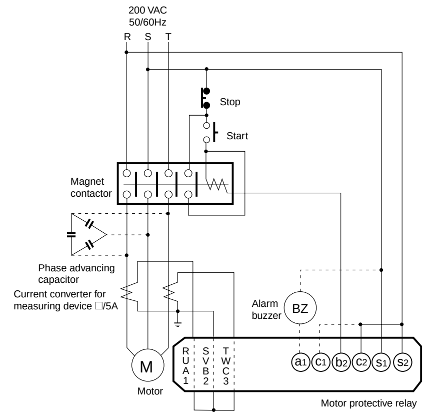
Manual Operation Low-voltage Circuit



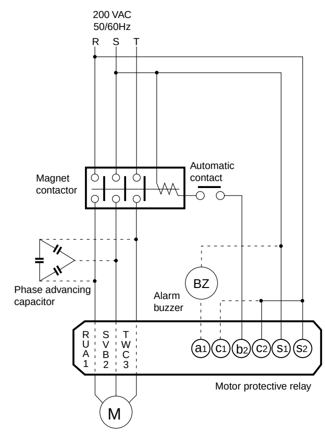
Manual Operating Low-voltage Circuit (⅄–△ Start)



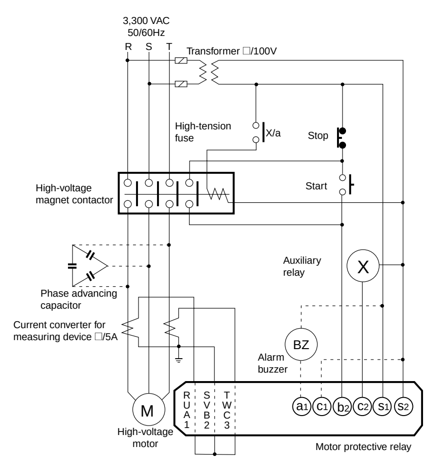
Manual Operation Low-voltage Circuit (High-capacity Motor)



Automatic Operation Low-voltage Circuit



Manual Operation High-voltage Circuit



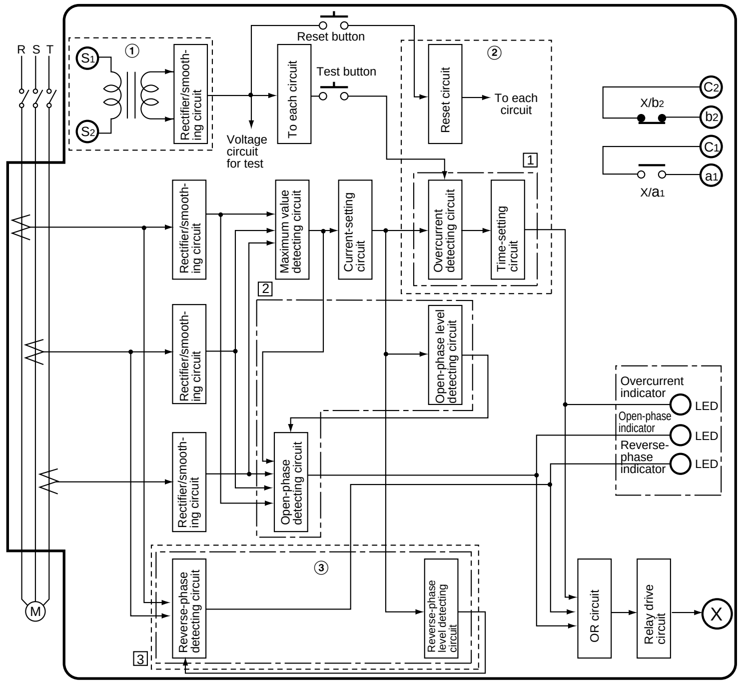
Output Circuits

■ Internal Circuit and Operation Description

Inverse and Instantaneous Types

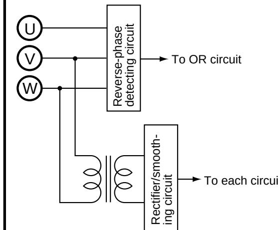
As shown on the right, the K2CM detects abnormalities in motor M by checking its line current. The motor's current signal is detected by the current transformer and is processed separately for each phase and input to the respective circuits. In each circuit, parallel judgement of failure such as overcurrent, open-phase, or reverse-phase (see note) is made based on the input signals. If a failure is detected in a circuit, the circuit's output is input to the indication circuit to illuminate the corresponding LED indicator and also input to the relay drive circuit to drive relay X, resulting in a trip signal to be externally output from it. The three major circuits are described below.

Note: Applies to current reverse-phase detection models only.



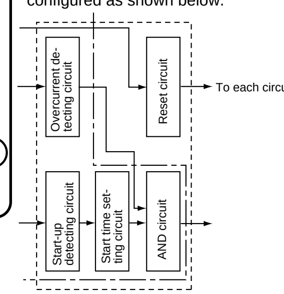
Voltage Reverse-phase Detection Models

With the voltage reverse-phase detection models, the circuit section enclosed by ① in the diagram on the left is configured as shown below. The circuit section enclosed by ③ is not used.



Instantaneous Type

With instantaneous-type models, the circuit section enclosed by ② is configured as shown below.



1) Overcurrent Circuit

Overcurrent Detecting Circuit

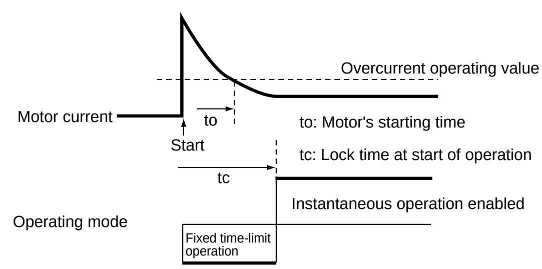
This circuit detects when the current reaches the overcurrent operating level (115% of the set current value).

Time Setting Circuit (Inverse Type)

This circuit performs time setting using the VR (variable resistor) for the operating time setting and obtains inverse-type characteristics using an RC time-limiting circuit. The operating time can be set within a range from 2 to 10 s or 8 to 40 s by operating the setting switch using a VR. The VR covers a time range 5 times the standard range.

Start-up Detecting Circuit (Instantaneous Type)

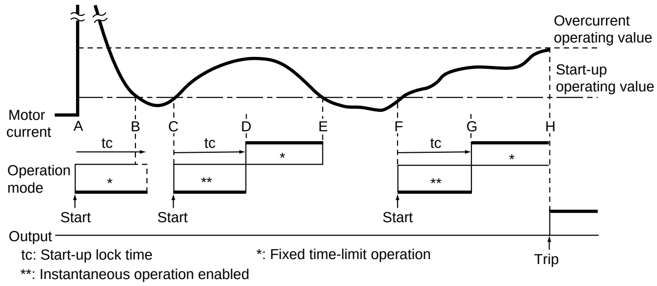
Instantaneous-type models output a trip signal instantaneously when the motor current exceeds the overcurrent operating value (115% of the set current value). At the start of motor operation, a starting current several times the rated current flows and so to prevent the motor circuit being tripped by the starting current, instantaneous operation is not enabled until a fixed time tc has elapsed, as shown in the figure. Instantaneous operation starts after tc has elapsed. Motor starting time "to" varies, depending on motor type, within a range from several seconds to several tens of seconds. There are even slight differences in starting time between the same type of motors and so be sure to set tc so that to to<tc is satisfied. If to>tc, the motor circuit will be tripped after tc has elapsed. The fixed time limit tc at the start of motor operation is called "lock time". The start-up detecting circuit detects the starting operation level (30% max. of the set current time).



Starting Time Setting Circuit (Instantaneous Type)

This circuit performs time setting using the VR for setting the start-up lock time and obtains fixed time-limit characteristics using an RC time-limiting circuit.

Operation at start-up is shown in the figure below. After the motor turns ON at point A, the motor's starting current exceeds the start-up operating value and so the RC time-limiting circuit starts charging. If, for example, the motor current descends below the start-up operating value (30% max. of the set current value) at point B before the start-up lock time, tc, has elapsed, the RC time-limiting circuit is reset immediately and when the motor current rises above the start-up operating value again at point C, the RC time-limiting circuit starts charging again. After the start-up lock time has elapsed (at point D), instantaneous operation is enabled. At the start of operation, the motor current is at its peak immediately after operation starts. It then lowers and settles at the rated current. The peak current is about 5 to 6 times the rated current and takes from several seconds to several tens of seconds to settle to the rated current. This time varies largely depending on type of motor and the nature of motor load (wt). Therefore, it is necessary to obtain the motor's starting time for operation with the load and to set a start-up lock time that allows for a margin of error. Do not set an unnecessarily long start-up lock time. If the start-up lock time is too long and an accident due to overcurrent occurs at the start of operation, the trip signal will not be output until the start-up lock time has elapsed, possibly resulting in motor burnout.



2) Open-phase Circuit

Open-phase Level Detecting Circuit

This circuit detects when the current reaches the open-phase operating level (85% max. of the set current value). Therefore, open-phase is not detected until the maximum phase of the current exceeds 85% of the set current value.

Open-phase Detecting Circuit

Output of the maximum value detecting circuit is divided and used as reference values for comparison with the output of the rectifier/smoothing circuits for the respective phases. If a phase has a value lower than the reference value, the K2CM judges it to be open-phase and outputs an open-phase signal.

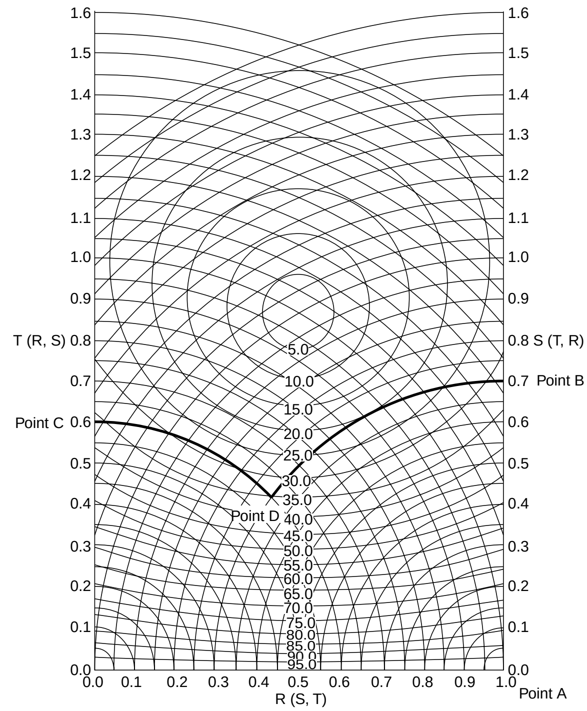
The following imbalance factors can be selected by setting the open-phase switch.

"High" . . .Operating imbalance factor: 35 ±10%

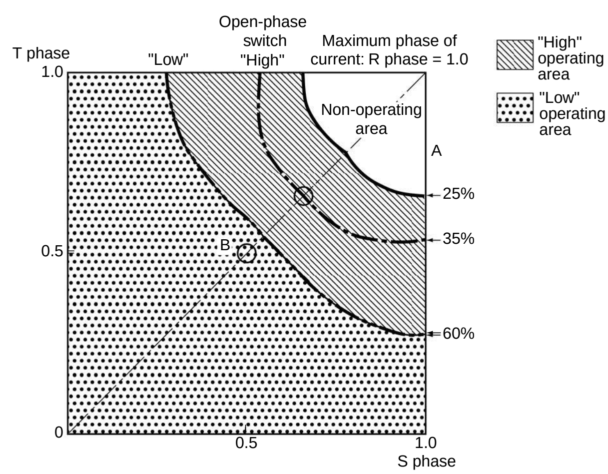
"Low" . . .Operating imbalance factor: 60% min.

The imbalance factor can be easily obtained from the following graph. In the graph, the horizontal axis indicates the maximum phase of the current whereas the two vertical axes indicate the remaining two phases. The maximum phase of the current is taken to be 1.0 as a reference point. The imbalance factor is obtained as a percentage from the curve around the center of the graph. Obtain the imbalance factor for a motor current with I_R = 100 A, I_S = 70 A, and I_T = 60 A as follows:

1. On the R axis, locate point A, where I_R = 1.0.
2. Move from point A to point B, where I_S = 0.7 on the S axis.
3. On the T axis, locate point C, where I_T = 0.6.
4. Follow the curves that pass through points B and C and locate the intersection point D.
5. Locating the point corresponding to point D on the imbalance factor curve gives an imbalance factor of 35%. Take the maximum phase of current on the horizontal axis without considering axes R, S, and T.



Generally, in open-phase detection, detecting a complete open-phase is sufficient. In such a case, set the open-phase switch to the "Low" position. If using the motor in an imbalanced condition causes problems, or when detecting internal open-phases of a delta-connected motor, set the switch to the "High" position. Depending on the motor's load condition and the imbalance of the power supply, however, special consideration may be required for the detection of internal open-phases in delta-connected motors. Consult your OMRON representative before using this method. When a transformer is connected as a load, the harmonics increase at low loads. Therefore, in such a case, set the open-phase switch to the "Low" position.



3) Reverse-phase Circuit

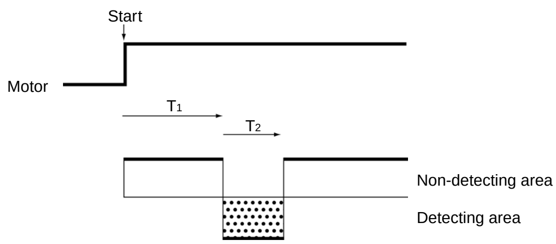
1. Current Reverse-phase Detection Models

Reverse-phase Level Detecting Circuit

This circuit detects when the current reaches the reverse-phase operating level (50% max. of the set current value). This circuit also functions as the gate of the reverse-phase signal.

Reverse-phase Detecting Circuit

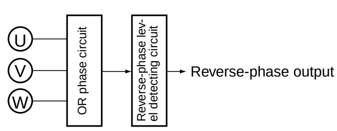
The current reverse-phase detecting method is employed for detecting reverse-phase as shown below. After the motor starts operating, the current phase becomes transiently unstable during T1 (approx. 0.1 s) and so reverse-phase detection is not performed during this period but it is performed during T2 (approx. 0.2 s). After T2 has elapsed, reverse-phase detection is not performed. For this reason, this method cannot be applied to cases where instantaneous reverse-phase is not permitted. When a reverse-phase is detected, the relay is held in the latched state even after the motor current stops (in both manual and automatic release types).



2. Voltage Reverse-phase Detection Models

Reverse-phase Detecting Circuit

Reverse-phase detecting is performed by using the voltage reverse-phase detection method.

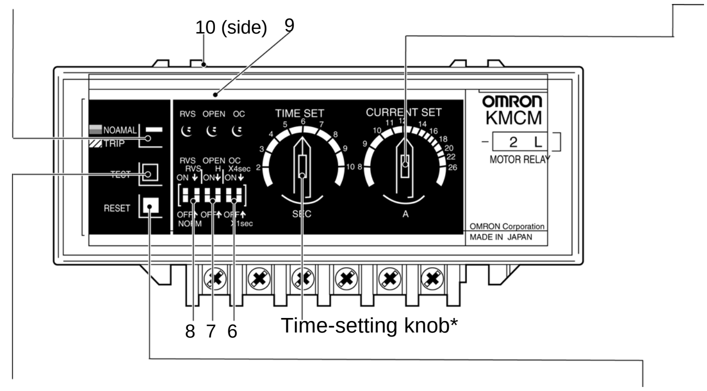


By voltage division within the above RC phase circuit, the output becomes 0 V in the normal state or 1.5 V_{uv} in the reverse-phase state. Using the output from this circuit, the reverse-phase level detecting circuit detects when the current reaches the reverse-phase operating level (80% or less of the control power supply).

Nomenclature

Trip Indicator

In normal operation, only the upper half of the display window is colored orange, whereas when the motor circuit has tripped, the entire display window becomes orange.



Current-setting Knob

- By operating the setting knob, set the current value to be equal to the rated current of the motor to be used. The current-setting knob uses the same scale as the rated current. Therefore, the operating value will be 115% of the set current value.
  Example: Operating current value
  $= 12 \times 1.15$ (115%) = 13.8 A
- The List of Current Settings shows an example. The rated current differs depending on the motor's type, construction, manufacturer, etc. Therefore, set the operating current after checking the specifications of the motor.

Test Button

Inverse Type

- Operation checks of the overcurrent function can be performed.
- Pressing the test button for the time-setting value will cause the motor circuit to trip.
- With manual resetting models, even if the test button is released after the motor circuit has tripped, the circuit remains tripped, whereas with automatic resetting models, the motor circuit continues operating and the output relay releases.
- Be sure to perform the test operation with the overcurrent switch set to ON. Set both the open-phase and reverse-phase switches to OFF. If one of these switches is set to ON, the motor circuit may trip if an open-phase or reverse-phase occurs before an overcurrent does.

Instantaneous Type

- Perform the test operation with input current at 0 and the overcurrent switch set to ON.
- Pressing the test button for the set start-up lock time will cause the motor circuit to trip.
- With manual resetting models, even if the test button is released after the motor circuit has tripped, the circuit remains tripped, whereas with automatic resetting models, the motor circuit continues operating and the output relay releases.

Time-setting Knob

- Set the required operating time by operating the time-setting knob. (With instantaneous-type models, the set operating time is used as the start-up lock time).

Note: 1. The setting scale is the operating time when 600% of the current value is input.

2. The required operating time varies depending on the type of motor, load condition, etc. You can take the time from when the motor starts to when the motor enters the steady state as a guide for setting this value. When setting the operating time for submersible motors, which require very short operating times, consult the manufacturer to obtain the correct operating time. An operating time shorter than 5 s can be used as a rough guide.

- The scale multiplying factor can be selected by the time scale multiplying factor switch.

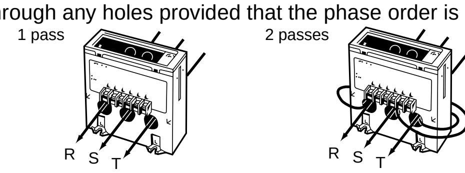
Scale multiplying factor	Time scale multiplying factor switch	
Time scale value	$\times$ **1 (s)**	$\times$ **4 (s)**
2	2	8
3	3	12
4	4	16
5	5	20
6	6	24
7	7	28
8	8	32
9	9	36
10	10	40

Reset Button

- With manual resetting models, when the motor circuit trips during normal operation or test operation, the operation indicators and the output relay can be immediately reset by pressing the reset button.
- When the motor circuit trips due to reverse-phase with automatic resetting models, the operation indicators and the output relay can be immediately reset by pressing the reset button.
- Reset button operation is ineffective when the operation power supply is OFF. When the motor circuit trips during normal operation, identify the abnormal input function by checking the LED indicators, then turn OFF the power switch of the main circuit and proceed with troubleshooting. After the abnormality is removed, turn ON the power switch of the main circuit to reset the K2CM.

Deciding the Number of Primary Conductor Passes

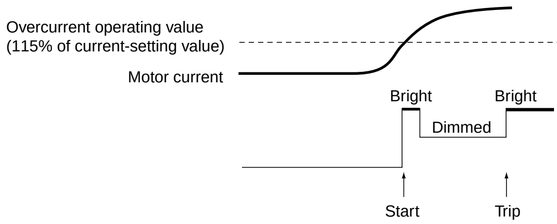
- When using a motor with a small current rating, decide the number of primary conductor passes through the current transformer holes and the tap setting by referring to the List of Current Settings.
- Pass all the three wires through the respective holes of the current transformer. Basically, the wires should be passed through the specified holes. If this is difficult, however, they can be passed through any holes provided that the phase order is R, S, and T.



- If the wires are passed through the holes only once, a current within the full scale of the current-setting knob can be set. If they are passed more than once, however, the current setting range will change according to the number of passes. The current setting range when the number of conductor passes is n can be obtained by dividing the full scale of the current-setting knob by n. For example, the current setting range of the K2CM-☐☐L☐ is 8 to 26 A when the wires are passed only once. This range is 4 to 13 A when the wires are passed twice, 2 to 6.5 A when the wires are passed four times, and 1 to 3.25 A when the wires are passed eight times.
  The wires can be passed through the holes any number of times. It is convenient for the calculation, however, if the number of passes is 2, 4, or 8.
- The signal from a high-voltage motor is input to the Motor Protective Relay via an external current transformer. In this case, the current can be set in the same manner as above by dividing the rated current of the high-voltage motor by the transformation ratio of the current transformer.

LED Indicators

When the motor circuit trips due to overcurrent, open-phase, or reverse-phase, the respective LED indicator lights (continuously). The overcurrent indicator also indicates the start of operation.



- With the inverse-type models, when the motor current exceeds the overcurrent operating value, the overcurrent indicator blinks at the bright level and then remains lit at the dimmed level. After the operating time has elapsed, with the manual resetting models, the motor circuit trips and the overcurrent indicator remains lit at the bright level, whereas with automatic resetting models, the indicator remains lit at the bright level until the motor current descends below the resetting value.
- Since the indicator status is not stored in memory when the operation power supply is turned OFF, be sure to check which indicators were illuminated when the motor circuit was tripped.

The functions of the K2CM can be used in the following seven combinations. For each function, turn ON the corresponding setting switch.

Function / Combination	Overcurrent	Open-phase	Reverse-phase
1	ON		
2		ON	
3			ON
4	ON	ON	
5		ON	ON
6	ON		ON
7	ON	ON	ON

When the setting switches for overcurrent, open-phase, or reverse-phase function are turned OFF, the following functions becomes invalid.

Function setting switch set to OFF	Invalid function
Overcurrent	Time setting and multiplication
Open-phase	“High” and “Low” imbalance factors
Reverse-phase	“Forward” and “Reverse” function

1. Overcurrent Setting Switches

These switches select the overcurrent setting and the multiplying factor linked with operating time setting.

Overcurrent detecting function	**ON**	Enabled
	OFF	Disabled
Time setting multiplying factor	$\times$ **4 (s)**	Time setting scale value $\times$ 4 = 8 to 40 s
	$\times$ **1 (s)**	Time setting scale value $\times$ 1 = 2 to 10 s

2. Open-phase Setting Switches

These switches select the open-phase detecting function and the “High” or “Low” current imbalance factor for operation.

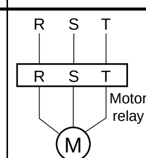
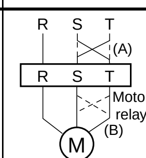
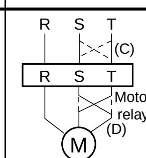
Open-phase detecting function	**ON**	Enabled
	OFF	Disabled
Imbalance factor	**High**	The motor circuit operates at an operating imbalance factor of 35 ±10%.
	Low	The motor circuit operates at an operating imbalance factor of 60%.

3. Reverse-phase Setting Switches

These switches select the reverse-phase detection function and reverse-phase polarity. By selecting the reverse-phase polarity accordingly, the K2CM can operate normally without changing the connections when wired with the order of the phases reversed.

Reverse-phase detecting function	**ON**	Enabled
	OFF	Disabled
Reverse-phase polarity	**Normal**	The motor circuit trips at reverse-phase when a reverse-phase is detected.
	Reverse	Used when a reverse-phase connection is made in the power line of the motor at a point before the current transformer (including external current transformer).

If the K2CM detects reverse-phase although the motor is rotating in the forward direction (e.g., because of incorrect wiring of power lines), set the reverse-phase polarity switch to the “Reverse” position to enable normal operation.

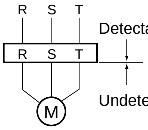
Phase condition	Normal	Reverse	Reverse
Connections			
Reverse-phase polarity switch position	Normal	Normal	Normal
Trip	None	Yes	None
Direction of motor rotation	Forward	Reverse (See below.)	Reverse

Countermeasure	**Reverse-phase polarity switch position**		Reverse	Reverse	Reverse	Reverse
	Wiring		Wiring changed at (A).	Wiring changed at (B).	Wiring changed at (C).	Wiring changed at (D).

Direction of motor rotation	Forward

Note: The K2CM detects reverse-phase at a point before the current transformer. If a reverse connection is made at the load side far from the current transformer and the motor rotates in the reverse direction, the K2CM does not detect the reverse-phase.

Reverse-detectable Range



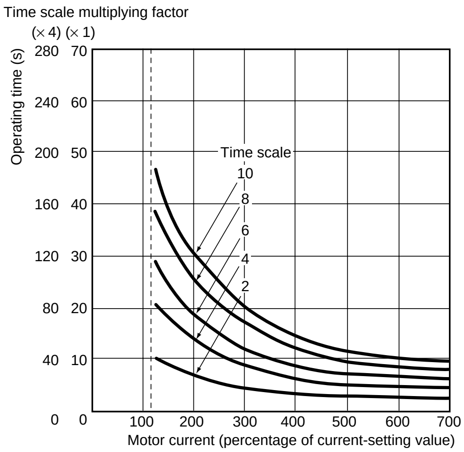
Detectable: Reverse-phase state can be detected with the motor protective relay only on the power supply side.

Undetectable: Reverse-phase state on the motor side cannot be detected with the motor protective relay.

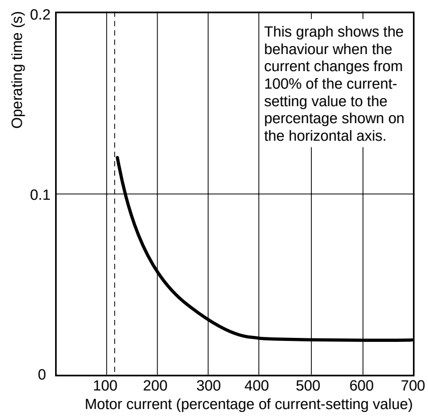
* The reverse-phase polarity switching function is applicable to current reverse-phase detection models only.

Engineering Data

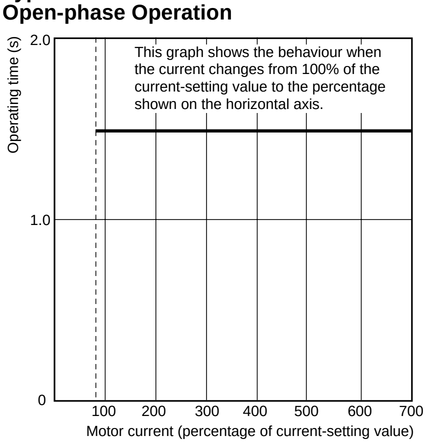
Overload Operating Time Characteristics for Inverse Type



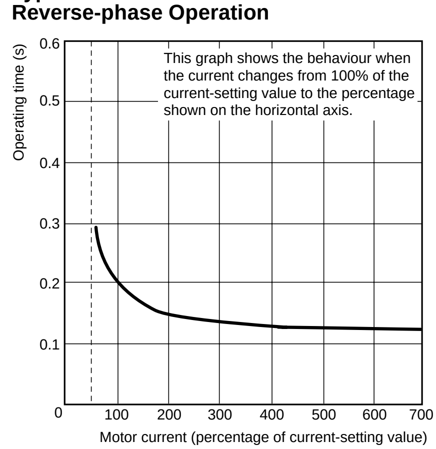
Overload Operating Time Characteristics for Instantaneous Type



Typical Characteristics of Open-phase Operation



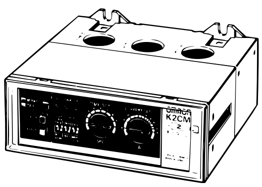
Typical Characteristics of Reverse-phase Operation

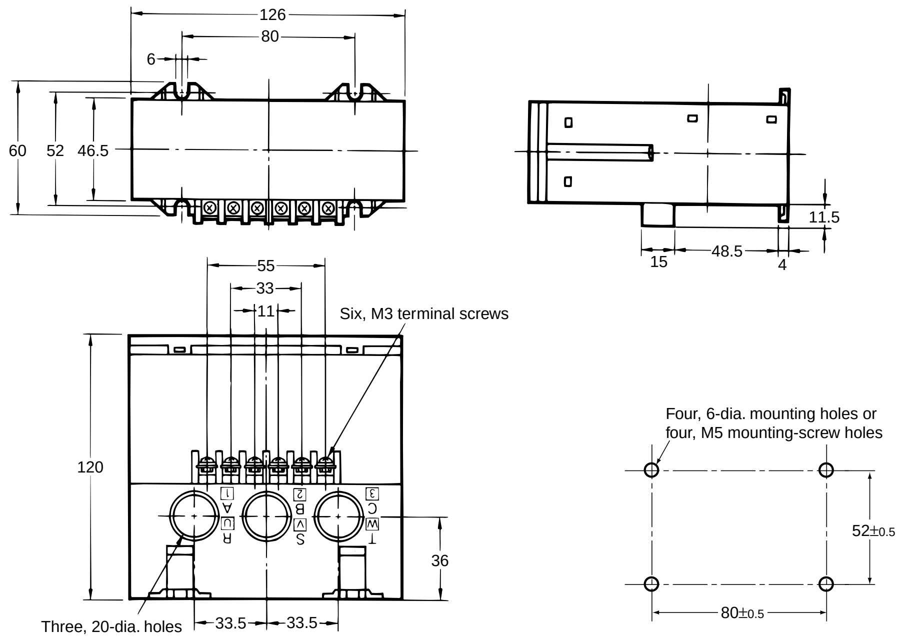


Dimensions

Note: All units are in millimeters unless otherwise indicated.

Surface-mounting Models





Operating Procedures

■ Operation, Setting, and Indication

Based on the current value of the motor to be used, perform the setting of each item of the K2CM Motor Protective Relay.

List of Current Settings (when using a 200-VAC motor)

Type*			K2CM-□□LS□	K2CM-□□L□				K2CM-□□M□	K2CM-□□H□
Number of passes			1	1	2	4	8	1	1
Setting	Time scale value		2 to 8	8 to 26				20 to 65	50 to 160
	Current setting range (A)		2 to 8	8 to 26	4 to 13	2 to 6.5	1 to 3.25	20 to 65	50 to 160
Motor***	Rated output (kW)	Rated current (A)**							
	0.2	1.8							
	0.4	2.8							
	0.75	4.2							
	1.5	7.3							
	2.2	10							
	3.7	16.1							
	5.5	24							
	7.5	32							
	11	45							
	15	61							
	18.5	74							
	22	87							
	30	117							
	37	143							

* The squares (□) represent the symbols defined under *Model Number Legend*.

** The rated current is the current at full load.

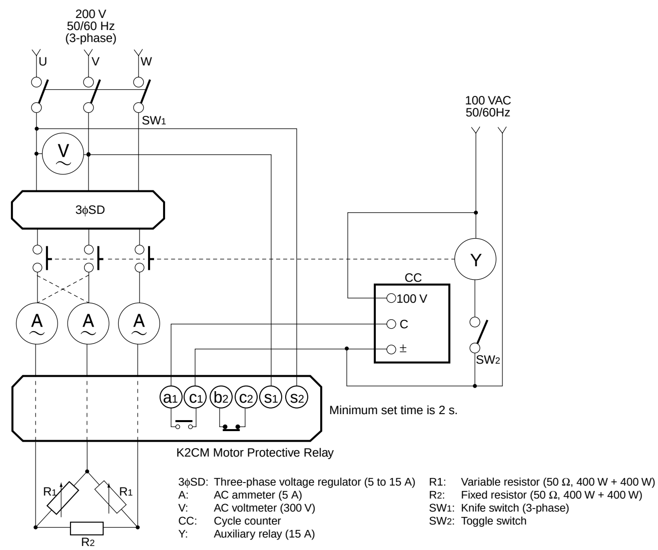
*** Supply: Low-voltage 3-phase basket type inductive motor, full-load characteristics of 200 VAC, 4-pole, totally-enclosed.

Note: When using a large-capacity or high-voltage motor whose capacity is 45 kW or more, calculate the rated current/alternating current ratio by converting with the alternating current ratio of the external current transformer.

Testing Method

■ Current Reverse-phase Detection Models

The operating characteristics listed in the table below are tested using the circuit shown on the right. Decide the number of conductor passes through the holes of the current transformer in accordance with the operating current range of the Motor Protective Relay and by referring to the current setting method described under *Operation, Setting, and Indication*.



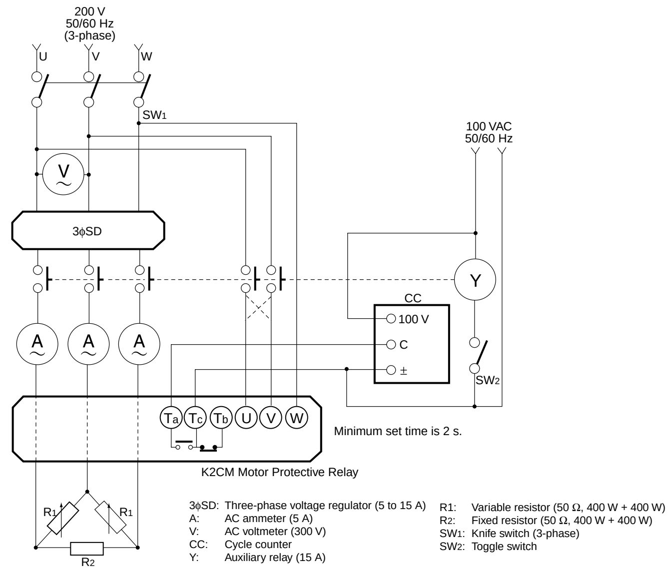
Test item		Test procedure	
		Operating value	**Operating time**
Overcurrent	Inverse type	**1.** Turn ON SW1. **2.** Turn ON SW2 to operate auxiliary relay Y. **3.** Gradually increase the current by adjusting the voltage regulator. With inverse-type models, read the value of the current when the overcurrent LED indicator blinks. With instantaneous-type models, read the value when it lights (continuously).* **4.** Turn OFF SW1 and SW2.	**1.** Turn ON SW1 and SW2. Increase the current to 600% of the set current value by adjusting the voltage regulator. Turn OFF SW1 and SW2.** **2.** Turn ON SW1. **3.** Turn ON SW2 and read the position (i.e., time) of the pointer of cycle counter CC when CC is stopped by the operation of the K2CM. The read time is the operating time for inverse-type models and the lock time of the instantaneous-type models.
	Instantaneous type		**1.** Turn ON SW1 and SW2. Increase the current to 100% of the set current value by adjusting the voltage regulator. Turn OFF SW1 and SW2. **2.** Turn ON SW1 and SW2 again and wait 2 seconds minimum. **3.** Using the voltage regulator, abruptly increase the current to 140% of the set current value. Confirm that the K2CM performs instantaneous operation. **4.** Turn OFF SW1 and SW2.
Open-phase		**1.** Open (disconnect) any one of the input phases for the current transformer. **2.** Turn ON SW1 and SW2. Gradually increase the current by adjusting the voltage regulator. **3.** Confirm that the K2CM operates at a current no greater than 85% of the set current value and that, at this current, the trip indicator is orange and the open-phase LED indicator lights. **4.** Turn OFF SW1 and SW2.	**1.** Open (disconnect) any one of the input phases for the current transformer. **2.** Turn ON SW1 and SW2. Increase the currents of the other two phases to 115% of the set current value by adjusting the voltage regulator. Turn OFF SW1 and SW2 temporarily. **3.** Turn ON SW1 and SW2 again. Read the position (i.e., time) of the pointer of cycle counter CC when CC is stopped by the operation of the K2CM. **4.** Turn OFF SW1 and SW2.
Reverse-phase		**1.** Interchange any two phases at a position closer to the power supply than the current transformer. (In the above figure, phases U and V are interchanged as shown by the dotted lines.) **2.** Turn ON SW1 and SW2. Decrease the current to 50% of the set current value by adjusting the voltage regulator. Then turn OFF SW1 and SW2 temporarily. **3.** Turn ON SW1 and SW2 again. Confirm that the K2CM operates, the trip indicator is orange, and that the reverse-phase LED lights. **4.** Turn OFF SW1 and SW2.	**1.** Interchange any two phases at a position closer to the power supply than the current transformer. (In the above figure, phases U and V are exchanged as shown by the dotted lines.) **2.** Turn ON SW1 and SW2. Increase the current to 100% of the set current value by adjusting the voltage regulator. Then turn OFF SW1 and SW2 temporarily. **3.** Turn ON SW1 and SW2 again. Read the position (i.e., time) of the pointer of cycle counter CC when CC is stopped by the operation of the K2CM. **4.** Turn OFF SW1 and SW2.

* Balance the currents between phases by adjusting variable resistor R1.

** If a current equal to 600% of the set current value cannot be attained by adjusting the voltage regulator, increase the number of conductor passes through the holes of the current transformer.

■ Voltage Reverse-phase Detection Models

The operating characteristics listed in the table below are tested using the circuit shown on the right. Decide the number of conductor passes through the holes of the current transformer in accordance with the operating current range of the Motor Protective Relay and by referring to the current setting method described under *Operation, Setting, and Indication*.



Test item		Test procedure: Operating value	Test procedure: Operating time
Overcurrent	Inverse type	**1.** Turn ON SW1. **2.** Turn ON SW2 to operate auxiliary relay Y. **3.** Gradually increase the current by adjusting the voltage regulator. With inverse-type models, read the value of the current when the overcurrent LED indicator blinks. With instantaneous-type models, read the value when it lights (continuously).* **4.** Turn OFF SW1 and SW2.	**1.** Turn ON SW1 and SW2. Increase the current by adjusting the voltage regulator to 600% of the set current value. Turn OFF SW1 and SW2.** **2.** Turn ON SW1. **3.** Turn ON SW2 and read the position (i.e., time) of the pointer of cycle counter CC when CC is stopped by the operation of the K2CM. The read time is the operating time for inverse-type models and the lock time of the instantaneous-type models.
	Instantaneous type		**1.** Turn ON SW1 and SW2. Increase the current to 100% of the set current value by adjusting the voltage regulator. Then turn OFF SW1 and SW2. **2.** Turn ON SW1 and SW2 again and wait 2 seconds minimum. **3.** Using the voltage regulator, abruptly increase the current to 140% of the set current value. Confirm that the K2CM performs the instantaneous operation. **4.** Turn OFF SW1 and SW2.
Open-phase		**1.** Open (disconnect) any one of the input phases for the current transformer. **2.** Turn ON SW1 and SW2. Gradually increase the current by adjusting the voltage regulator. **3.** Confirm that the K2CM operates at a current no greater than 85% of the set current value and that, at this current, the trip indicator is orange and the open-phase LED indicator lights. **4.** Turn OFF SW1 and SW2.	**1.** Open (disconnect) any one of the input phases for the current transformer. **2.** Turn ON SW1 and SW2. Increase the currents of the other two phases to 115% of the set current value by adjusting the voltage regulator. Turn OFF SW1 and SW2 temporarily. **3.** Turn ON SW1 and SW2 again. Read the position (i.e., time) of the pointer of cycle counter CC when CC is stopped by the operation of the K2CM. **4.** Turn OFF SW1 and SW2.
Reverse-phase		**1.** Change the phase sequence to reverse-phase by switching the U and W input terminals of the K2CM as shown by the dotted lines. **2.** Turn ON SW1 and SW2 and confirm that the K2CM operates. **3.** Add a three-phase voltage regulator to the U, V, and W terminal inputs. **4.** Adjust the voltage regulator and confirm that the K2CM operates at less than 80% of the rated supply voltage.	**1.** Put the voltage input in the reverse-phase state. **2.** Turn ON SW1 and SW2 and read the position of the pointer of cycle counter CC when CC is stopped. **3.** Turn OFF SW2.

* Balance the currents between phases by adjusting variable resistor R1.

** If a current equal to 600% of the set current value cannot be attained by adjusting the voltage regulator, increase the number of conductor passes through the holes of the current transformer.

Precautions

■ Correct Use

- The operation check using the test button is intended to check the operation of the overcurrent functions. Therefore, be sure to turn ON the overcurrent switch. Also, at this time, turn OFF the open-phase switch and reverse-phase switch to prevent unnecessary operations from being performed.
- The operating time of inverse-type models and the lock time of the instantaneous-type models depend upon the set operating time. Therefore, do not hold down the test button for more than the set operating time.
- The reverse-phase can be detected in the wiring up to the current transformer (including an external current transformer). Check the wiring between the current transformer and the motor before starting the motor.
- Current reverse-phase detection models cannot be used in applications that do not allow even momentary reversals of motor direction.
- Jogging of the motor can be performed. For details, consult your OMRON representative.
- When using the K2CM to control inching shorter than 0.5 s, the reverse-phase level detection circuit may operate. In this case, be sure to use the K2CM with the reverse-phase switch set to OFF.
- The K2CM is basically intended to protect three-phase loads. Its overcurrent function, however, can also be applied to single-phase loads. In this case, the conductors can be passed through the holes in any direction and sequence.
- When applying the K2CM to a circuit with a high imbalance factor due to the nature of the power supply or load, actually measure the imbalance factor and select the open-phase sensitivity accordingly (i.e., set the open-phase switch to either the high or low position). The K2CM cannot be used if the imbalance factor is 60% or higher.
- When applying the K2CM to the protection of three-phase transformers, give consideration to the imbalance factor due to single-phase loads.
- A power supply with a frequency other than commercial frequency cannot be used as the control power supply.
- Use of circuits containing a high percentage of harmonics, such as circuits incorporating SCR control circuits, VVVF inverters, or rectifiers, may cause errors and malfunctions. Consult your OMRON representative for details.
- When applying the K2CM to the protection of a high-voltage motor or low-voltage, high-capacity motor, use an external rectifier that does not saturate at currents up to 600% of the rated motor current and thus permits a large overcurrent; otherwise, the K2CM will output a tripping signal because of imbalanced operation when an overcurrent occurs and, with reverse-type models, the motor may be damaged by burning.
- Never tamper with the trip indicator. Use the reset switch to reset the K2CM.
- When a power failure occurs in the control power supply, the K2CM is not reset even when the reset switch is pressed. This is not an error. The K2CM can be reset only when control power is applied to it.
- Be sure to remount the front cover after detaching it for operating or setting the switches on the front panel.
- The rectifier and control circuits are combined by tightening the two screws on the right and left sides. Never loosen these screws.
- The variable resistors used to make settings are equipped with mechanisms to stop them rotating outside the valid scale range. Do not rotate the variable resistors at a torque of 1 kg·cm or more.
- When using the K2CM-Q□□A (instantaneous, automatic resetting), be sure to apply power to the Motor Protective Relay from the same power line as the magnet contactor for switching the motor.
- Be sure to provide the control power supply for the K2CM-□□□□V (voltage reverse-phase detection) from the same line as the motor.
- If current reverse-phase detection models are used in a circuit with distorted current waveforms, the reverse-phase element may perform an unwanted operation. In such circuits, use of the K2CM-□□□□V (voltage reverse-phase detection) is recommended because it is not affected at all by current waveform distortion.

Combination	Function setting switches			LED indicators			NOTE
	Overcurrent	Open-phase	Reverse-phase	Overcurrent	Open-phase	Reverse-phase	
1	ON			ON			If the inputs for combinations of two or more functions are simultaneously generated, the K2CM detects the inputs in the order reverse-phase, open-phase, overcurrent. Take combination 4 as an example. If the open-phase and overcurrent occur at the same time, there is insufficient time to detect the overcurrent because the open-phase is first detected and the K2CM outputs the tripping signal (causing the magnet contactor to turn off). Therefore, the overcurrent indicator does not light.
2		ON			ON		
3			ON	OFF		ON	
4	ON	ON			ON		
5		ON	ON		OFF	ON	
6	ON		ON	OFF		ON	
7	ON	ON	ON	OFF	OFF	ON	

■ Maintenance and Inspection

The K2CM Motor Protective Relay offers very stable characteristics. To maintain these characteristics for a long time, the following inspections are recommended.

Daily Inspection

The purpose of daily inspection is to discover causes of failure before using the Motor Protective Relay. This inspection depends somewhat on the perception of the operator as it includes visual checking, etc.

Classification	Inspection items
Connections	Loosening, damage, and dust collection at screw terminals, damage to wiring insulation sheaths, excessive force applied on wirings, adhesion of foreign objects to terminal screws
Motor Protective Relay	Adhesion of foreign objects and dust to the operation panel, shift of set value, indication status of operation indicators and trip indicator, presence/absence of front cover, loosening of screws combining rectifier and control circuits, deformation of case, abnormal temperature on housing surface
External rectifier	Loosing of terminals, unusual odor, discoloration of surface

Periodic Inspection

This inspection is performed by turning OFF the power at regular intervals to check the aging caused by long-time operation. It is recommended that periodic inspection is performed once a year.

Motor Protective Relay

Classification	Inspection item
Construction	Adhesion of dust and foreign objects to terminals, cracks in insulators around terminal block, burn damage to wirings, damage to setting knobs, selector switches, test button, and reset button, damage to insulators of solderless terminals, rust and discoloration of screw terminals
Operating characteristics	Refer to *Testing Method*.
Insulation resistance	Between terminals and mounting panel
Operation check with test button	Checking of operating time, operation indicators, and trip indicator

External Rectifier

Check for adhesion of dust and foreign objects, damage to wirings by burning, and loosening of mounting screws.

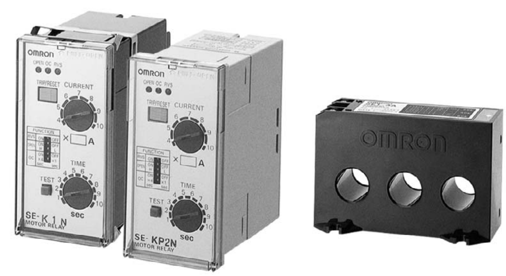
ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N121-E1-01

In the interest of product improvement, specifications are subject to change without notice.

Motor Protective Relay
SE

Solid-state Relay Provides Three Operating Functions in a Compact Package



- Prevents burnouts in 3-phase induction motors due to overcurrent, open-phase, or reverse-phase.
- LEDs indicate operation of the selected operating function.
- Wide setting ranges: current: 1 to 160 A; operating time: 1 to 40 s.
- Protects the motor from reversing without starting it.

Model Number Structure

■ Model Number Legend

SE-K□□□□□N
1 2 3 4 5 6 7 8

1. Basic model name
SE: Motor Protective Relay

2. Protective functions
K: Three possible operating functions: overcurrent, open-phase, or reverse-phase protection

3. Operating time characteristics for overload element
Q: Instantaneous type: Fixed time at starting and instantaneous during operation
None: Inverse type: Inverse operation both at starting and during operation

4. Case
P: Plug-in type
None: Flush mount type

5. Control voltage
1: 100/110/120 VAC
2: 200/220/240 VAC
4: 380/400/440 VAC

6. Reset method
None: Manual reset
A: Automatic reset

7. Operating value
None: 115% of the current SV
E: 100% of the current SV

8. Product history
N: New version

Note: A 3-phase transformer (sold separately) must be used to operate Plug-in Relays at 380, 400, 415, or 440 VAC. Drop the primary voltage (380 to 440 VAC) to a 200-VAC secondary voltage before applying it to the SE-KP2EN or SE-KQP2EN.

Ordering Information

SE-□EN

Overcurrent operating value: 100% of the current SV.

Terminal/mounting	Control voltage	Reset	Model	
			Inverse type	Instantaneous type (See note.)
Plug-in terminal/DIN rail via socket	100/110/120 VAC	Manual	SE-KP1EN	SE-KQP1EN
	200/220/240 VAC		SE-KP2EN	SE-KQP2EN
Screw terminal/flush mount	100/110/120 VAC		SE-K1EN	SE-KQ1EN
	200/220/240 VAC		SE-K2EN	SE-KQ2EN
	380/400/440 VAC		SE-K4EN	SE-KQ4EN

Note: With start-up lock: fixed time-limit on start-up, instantaneous thereafter.

SE-☐☐N

Overcurrent operating value: 115% of current SV.

Control voltage	Reset	Model	
		Inverse type	Instantaneous type (See note 1.)
100/110 120 VAC	Manual	SE-KP1N	SE-KQP1N
	Automatic	SE-KP1AN	SE-KQP1AN
200/220/240 VAC	Manual	SE-KP2N	SE-KQP2N
	Automatic	SE-KP2AN	SE-KQP2AN
100/110/120 VAC	Manual	SE-K1N	SE-KQ1N
	Automatic	SE-K1AN	SE-KQ1AN
200/220/240 VAC	Manual	SE-K2N	SE-KQ2N
	Automatic	SE-K2AN	SE-KQ2AN
380/400/440 VAC	Manual	SE-K4N	SE-KQ4N
	Automatic	---	---

Note: 1. With start-up lock: fixed time-limit on start-up, instantaneous thereafter.

2. The operating value for the overload detection function of the SE-☐☐N is 115% of the current SV.

■ Accessories (Order Separately)

Current Converters

Model	Current range
SET-3A	1 to 80 A
SET-3B	64 to 160 A

DIN rail socket
8PFA1

3-phase Transformer

Specify the primary voltage when ordering.

Only one SE relay can be connected.

Model	Primary voltage	Secondary voltage
SE-PT400	380 to 480 VAC	190 to 240 VAC

Specifications

■ Ratings

Motor circuit	Voltage: 500 VAC max. 3-phase (primary voltage at SET current converter) Current: 1 to 80 A or 64 to 160 A 3-phase (primary current at SET current converter)
Power supply circuit	Voltage: 100/110/120 VAC, 200/220/240 VAC, or 380/400/440 VAC 3-phase (treat as a single phase voltage when the reverse-phase function is not needed) Voltage fluctuation: +10/–15% max. of the rated voltage (+10/–50% max. for open-phase function) Frequency: 50/60 Hz ±5%
Current SV range	See table of *Current Converter*.
Output relay contact	Configuration: SPDT Capacity: Refer to the table below.
Power consumption	100/110/120 VAC: approx. 3.5 VA; 200/220/240 VAC: approx. 7 VA; 380/400/440 VAC: approx. 11 VA

Output Contact Capacity

Control power supply	Contact	Contact capacity
100/110/120 VAC or 200/220/240 VAC	NO	3 A (cosϕ = 1.0)/1.5 A (cosϕ = 0.3 to 0.4) at 240 VAC
	NC	3 A (cosϕ = 1.0)/2 A (cosϕ = 0.3 to 0.4) at 240 VAC
380/400/440 VAC	NO	3 A (cosϕ = 1.0)/1.5 A (cosϕ = 0.3 to 0.4) at 440 VAC
	NC	3 A (cosϕ = 1.0)/2 A (cosϕ = 0.3 to 0.4) at 440 VAC

■ Characteristics

Item		Inverse type	Instantaneous type
Overcurrent	**Operating value**	**100% of the current SV (SE-□□EN)** **115% of the current SV (SE-□□□N)**	
	Operating time characteristics	Inverse time both at starting and during operation	Fixed time at start-up and instantaneous during operation (0.5 s max. at 140% overcurrent)
	Operating time	For an overcurrent of 600%: Time scale x 1: 1 to 10 s Time scale x 4: 4 to 40 s For an overcurrent of 200%: 2.8 x t, where t is the time at 600% overcurrent. (time SV at max.)	In fixed time mode (start-up mode) with an overcurrent of 600%: Time scale x 1: 1 to 10 s Time scale x 4: 4 to 40 s In instantaneous mode: 0.5 s max. at 140% overcurrent
	Initial current in start-up mode	---	Operates when the current is about 30% of the set current
	Inertial characteristics	At the min. current SV and max. time SV, will not operate for 80% of the operating time for a 600% overcurrent.	---
Open-phase		Operating value: Less than 50% of the current SV (at open-phase) Operating unbalance: At high sensitivity (H): 35 ±10%; At low sensitivity (L): 65 ±10% (The unbalance for a max. 3-phase current equal to the current SV) Operating time: At high sensitivity (H): 2 s max.; At low sensitivity (L): 3 ±1 s (Open-phase current equal to the current SV)	
Reverse-phase		Operating value: 80% max. of the rated voltage Operating time: 0.5 s max. at the rated voltage	
Overcurrent SV accuracy		Operating value: ±10% of max. current SV Operating time: $^{+10}/_{-5}$% of max. time SV (at a time SV: 1), +10% of max. time SV (at a time SV: 2 to 10) (start-up lock)	
Influence of temperature (overcurrent)		Operating value: ±5% for 0 to 40°C; ±10% for -10 to 50°C Operating time: ±10% for 0 to 40°C; ±20% for -10 to 50°C (start-up lock)	
Influence of frequency (overcurrent)		Operating value: ±3% for a frequency fluctuation of ±5% Operating time: ±5% for a frequency fluctuation of ±5% (start-up lock)	
Influence of voltage (overcurrent)		Operating value: ±3% for a voltage fluctuation of $^{+10}/_{-15}$% Operating time: ±5% for a voltage fluctuation of $^{+10}/_{-15}$% (start-up lock)	
Insulation resistance		10 MΩ min. between the entire electric circuits and the mounting panel 5 MΩ min. between contact circuits, or between contacts of same pole	
Withstand voltage		Refer to the table below.	
Lighting impulse withstand voltage		6000 V max. between the entire circuits and the mounting panel 4500 V max. between contact circuits, or across contacts Waveform: 1.2/50 µs	
Overload capacity		Motor circuit: 20 times the current SV for 2 s, applied twice with a 1 min interval Control voltage: 1.15 times the rated control voltage for 3 hrs	
Life Expectancy		10,000 operations min. (non-conducting contacts)	
Vibration resistance		Malfunction: 10 to 55 Hz, 0.3-mm double amplitude each in 3 directions for 10 minutes Destruction: 10 to 25 Hz, 2-mm double amplitude each in 3 directions for 2 hours	
Shock resistance		Malfunction: 100 m/s^2 (approx. 10G) each in 3 directions Destruction: 300 m/s^2 (approx. 30G) each in 3 directions	
Test button operation		Operated quickly (without lighting the LED)	
Ambient temperature		Operating: –10 to 60°C (with no icing) Storage: –25 to 65°C (with no icing)	
Ambient humidity		Operating: 35% to 85%	
Altitude		2,000 m max.	
Weight		Approx. 170 to 230 g	

Dielectric Strength

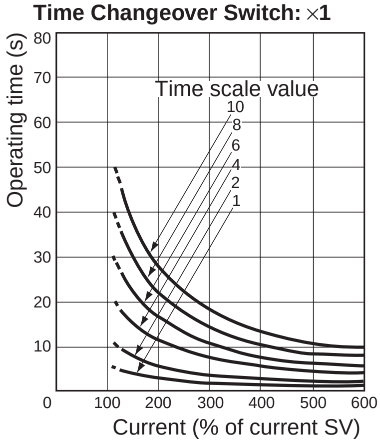
Test Area	Control voltage		
	100/110/120 VAC	**200/220/240 VAC**	**380/400/440 VAC**
Between electric circuits and the mounting panel	2,000 VAC for 1 min		2,500 VAC for 1 min
Between contact circuits and other circuits	2,000 VAC for 1 min		2,500 VAC for 1 min
Between each pair of contacts	1,000 VAC for 1 min		1,000 VAC for 1 min

Engineering Data

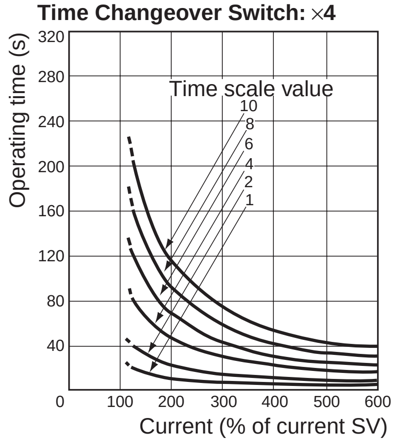
■ Operating Characteristics

Overcurrent Operating Time Characteristics (Inverse Type)

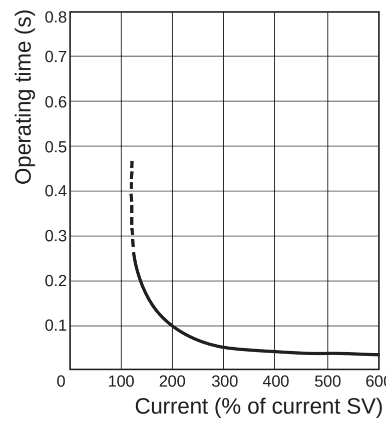
Time Changeover Switch: ×1



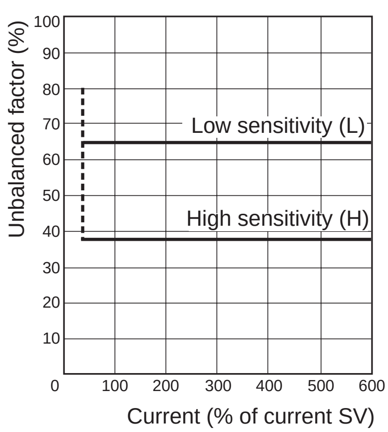
Time Changeover Switch: ×4



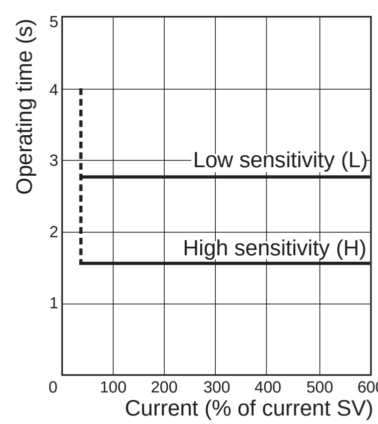
Overcurrent Operating Time Characteristics (Instantaneous Type - Start-up Lock)



Open-phase Operating Characteristics



Open-phase Operating Time Characteristics



Operation

■ Settings

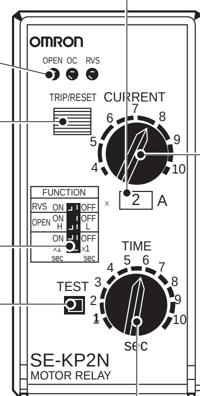
Motor Relay Switch Settings

Current Scale Multiplying Factor Decal
Determine the current scale multiplying factor corresponding to the current SV range obtained from Table 1 and paste the current scale multiplying decal to the motor protective relay. For example, when the current setting range is 8 to 20 A, the decal no. is 2.

LED Indicators
The LEDs indicate which function is in operation. OPEN refers to open-phase, OC refers to overcurrent, and RVS refers to reverse-phase.

Manual Reset
The reset button will pop out about 4 mm when the relay has been tripped. After the relay has operated, reset by pressing this button. Disconnect the power supply before resetting for reverse-phase operation.

Function Setting DIP SW
The three ON/OFF switches enable or disable the three functions. The functions can be enabled in any combination. With the open-phase function, the H/L switch sets the current imbalance factor. When set to H", the motor circuit operates at 35% of the current imbalance factor for operation. When set to L", the motor circuit operates at 65% min. of the current imbalance factor for operation.With the over-current function, the x4/x1 switch sets the time changeover value for the start-up mode. When set to x4", the operating time range is 4 to 40 s. When set to x1", the operating time range is 1 to 10 s.



Setting Operating Current
Set the current-setting knob to the required current value. The setting value is indicated by the product of the scale value and the multiplying factor as shown in the following table. The required trip current can be obtained directly by means of the current knob.

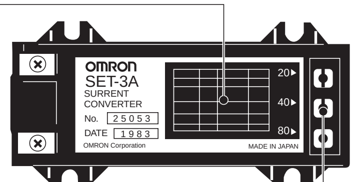
Decal No.	Current scale value (A)						
	4	5	6	7	8	9	10
0.25	1	1.25	1.5	1.75	2	2.25	2.5
0.5	2	2.5	3	3.5	4	4.5	5
1	4	5	6	7	8	9	10
2	8	10	12	14	16	18	20
4	16	20	24	28	32	36	40
8	32	40	48	56	64	72	80
16	64	80	96	112	128	144	160

Setting Operating Time
Set the time setting knob to the required time. The operating time is equal to the time scale value times the setting on the time changeover switch. For example, if the time scale value is 6 and the time changeover switch is set to 4, the operating time is 24 s.

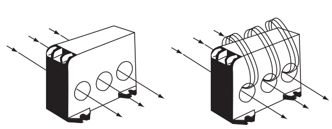
Test Button
Pushing the test button momentarily operates the trip display and the output relay.

Current Converter Settings

Determining the Number of Primary Conductor Runs
Determine the number of passes and the tap setting from the table above. For example, if the current setting range is 8 to 20 A, there is one pass and the tap setting is 20.
Pass the wires through the holes from the same direction. It doesn’t matter which wires go through which holes.



Tap Setting
In tap setting, insert the setting screw into the required tap hole with a screwdriver. After setting, be sure to replace the cover.



One conductor pass
(The conductors pass through the holes once.)

Four conductor passes
(The conductors pass through the holes four times.)

Selecting the Current Converter

The current requirements of the motor determine the current range of the Motor Protective Relay, and whether the SET-3A or SET-3B Current Converter should be used, as shown in the following table.

Motor specifications			Motor Protective Relay		Current Converter		
kW	HP	A	Current range	Decal No.	Passes	Tap settings	Model
0.2	0.25	1.4	1 to 2.5	0.25	8	20	
0.4	0.5	2.3					
0.75	1	3.8	2 to 5	0.5	4	20	
Note 1		5					
1.5	2	6.8	4 to 10	1	2	20	SET-3A
2.2	3	9.5	8 to 20	2		20	
3.7	5	15					
5.5	7.5	22	16 to 40	4		40	
7.5	10	30					
11	15	43	32 to 80	8	1	80	
15	20	57					
19	25	72					
22	30	82	64 to 160	16		Fixed	SET-3B
30	40	111					
37	50	135					

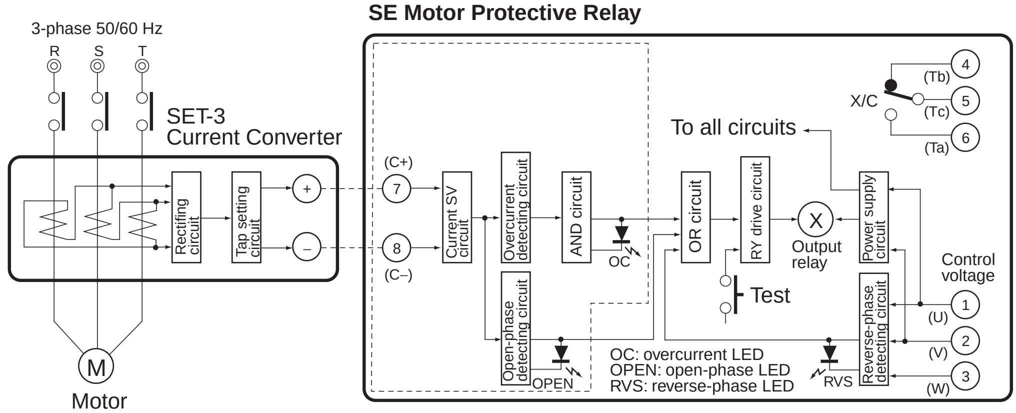
Note: 1. Connect to the secondary of a commercial current transformer for motors exceeding 37 kW.

2. Connect a commercial current transformer when using high-voltage motors or low-voltage high-capacity motors.

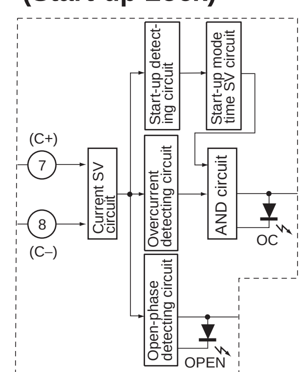
Installation

■ Internal Circuit

Inverse Type



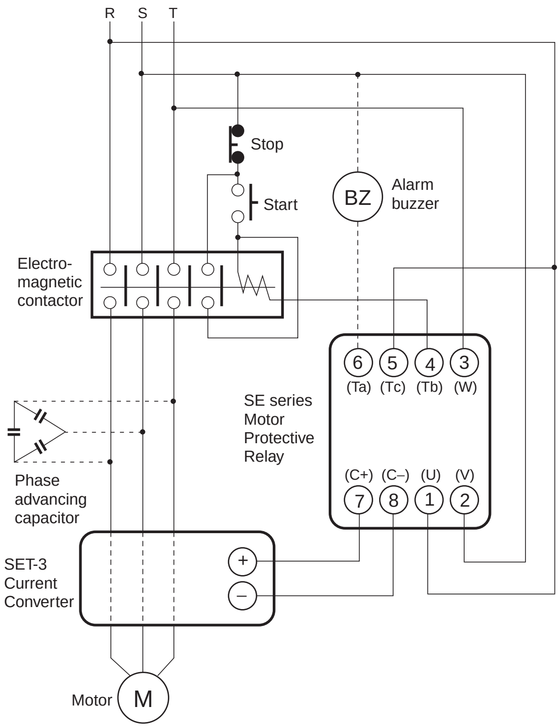
Instantaneous Type (Start-up Lock)



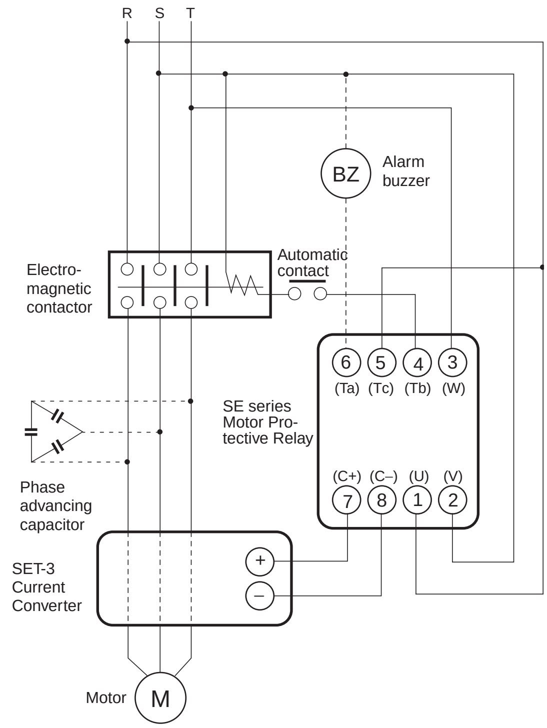
Connections

External Connections

Manual Operation Low-voltage Circuit

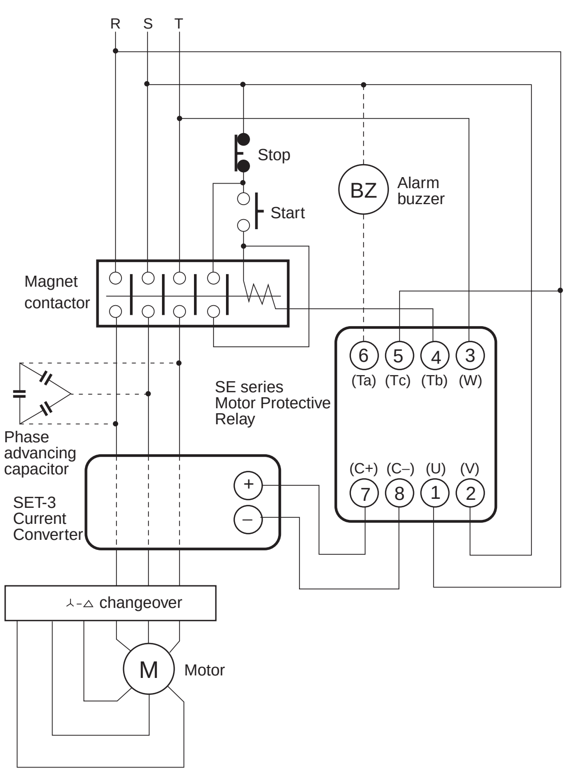


Automatic Operation Low-voltage Circuit

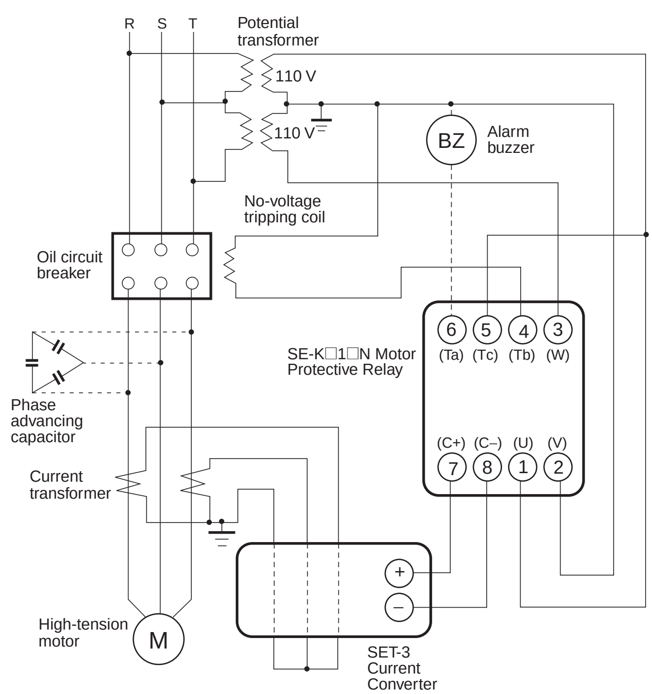


Note: When using the overcurrent and open-phase functions, it is not necessary to wire terminal 3 (W).

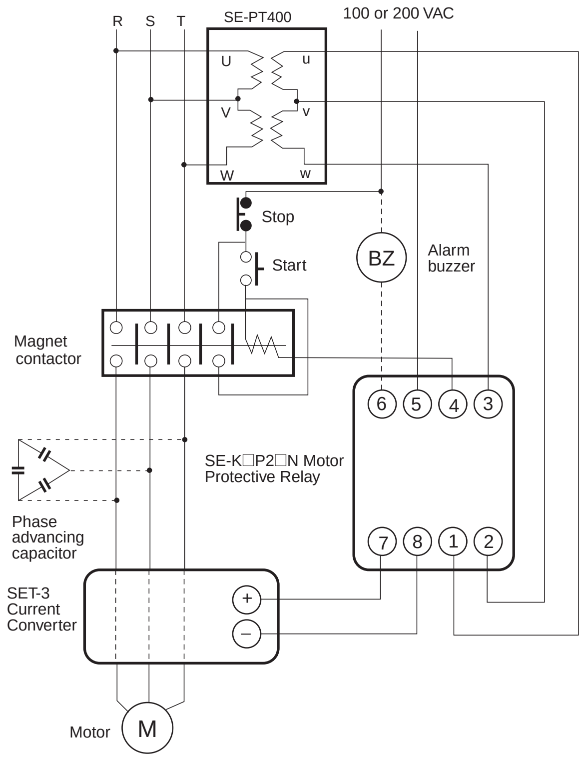
Manual Operation Low-voltage Circuit (⅄-Δ Start)



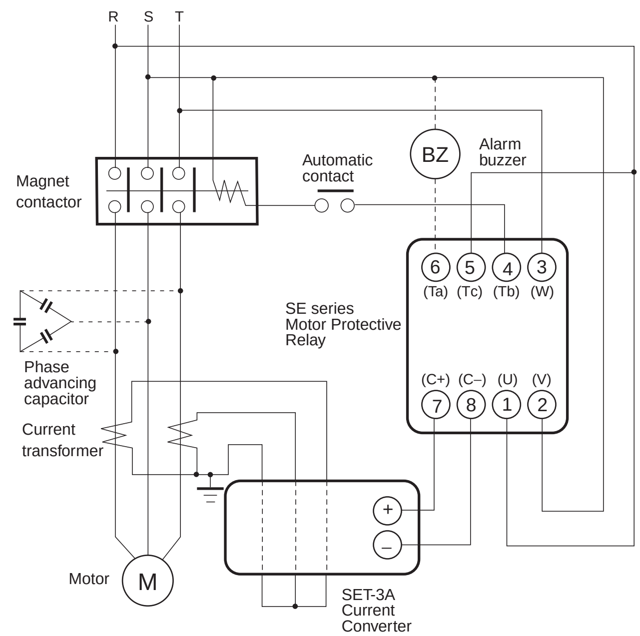
High-tension Motor No-voltage Tripping Circuit



Manual Operation Low-voltage Circuit (When using a SE-K□P2□N in a 400/440 VAC Circuit)

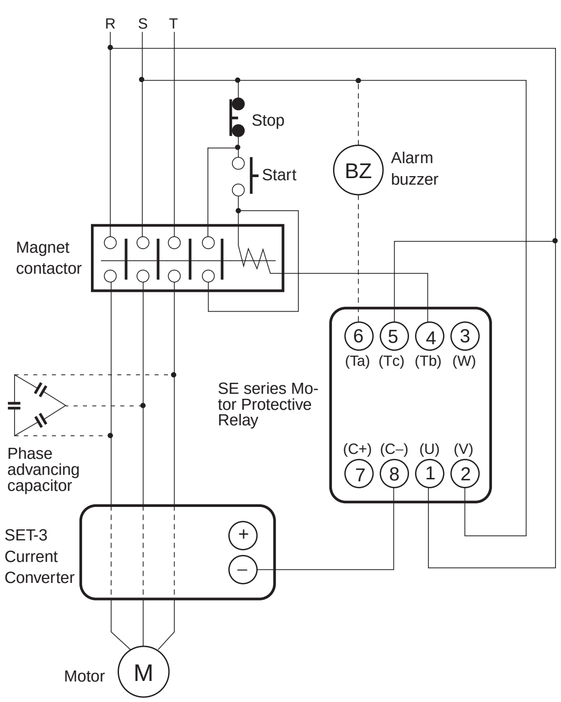


Automatic Operation Low-voltage Circuit (High-capacity Motor)

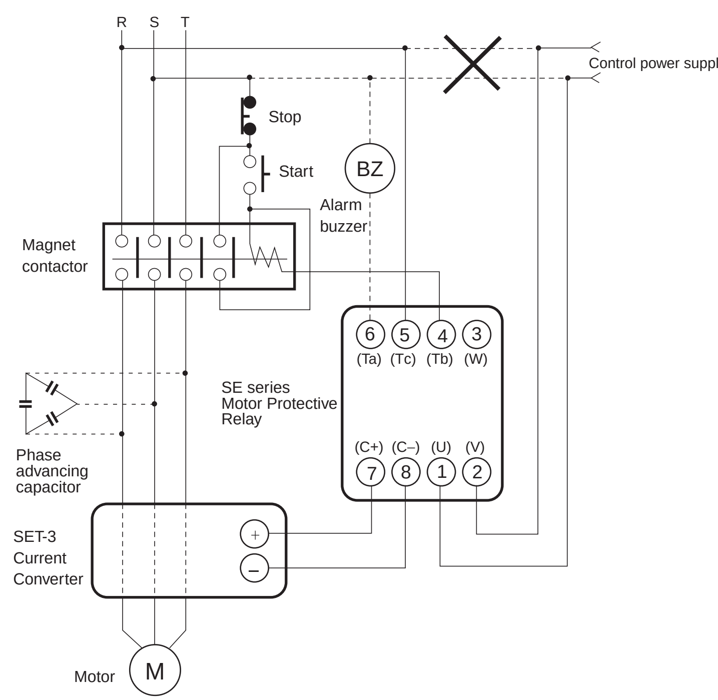


Note: When using the overcurrent and open-phase functions, it is not necessary to wire terminal 3 (W).

Manual Operation Low-voltage Circuit (Using the Overcurrent and Open-phase Functions)



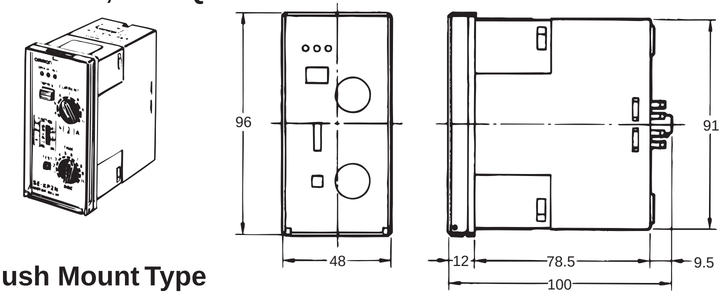
Automatic Operation



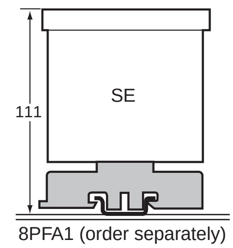
Dimensions

Note: All units are in millimeters unless otherwise indicated.

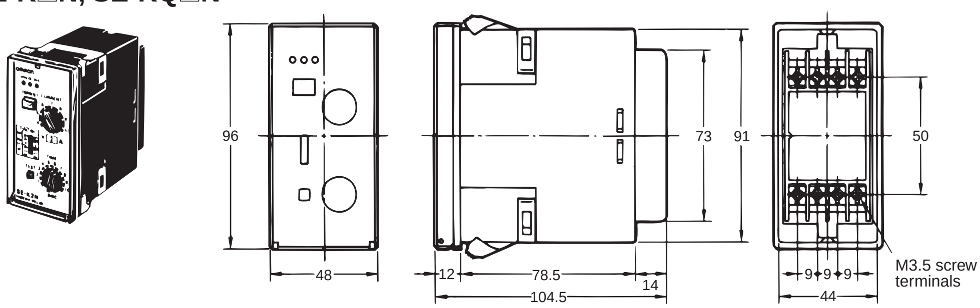
Plug-in Socket Terminal
SE-KP□N, SE-KQP□N



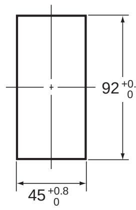
The Height of DIN Rail Mounting



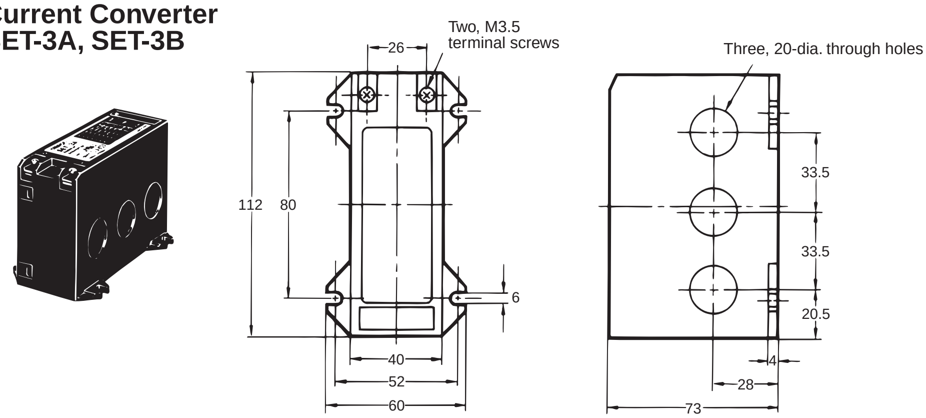
Flush Mount Type
SE-K□N, SE-KQ□N



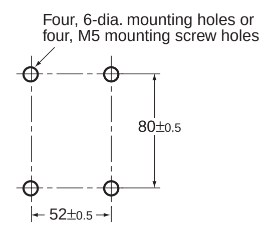
Panel Cutout



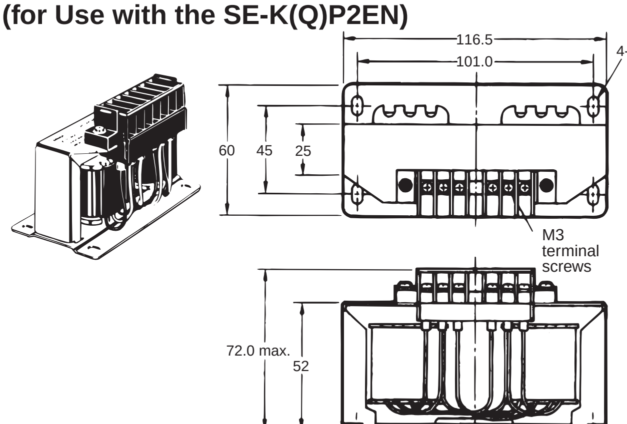
Current Converter
SET-3A, SET-3B



Mounting Holes

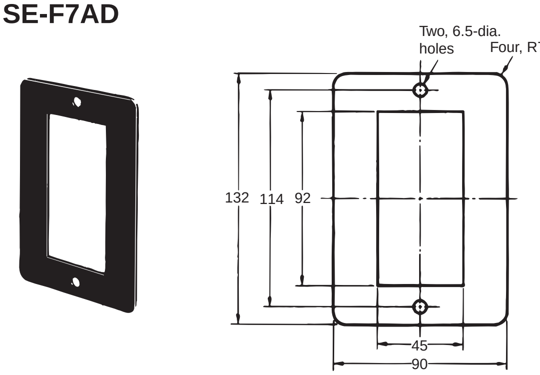


Transformer SE-PT400
(for Use with the SE-K(Q)P2EN)



Note: The SE-PT400 can be used for all 200/220/240-VAC SE Relays.
Primary voltage: 380 to 480 VAC
Secondary voltage: 190 to 240 VAC

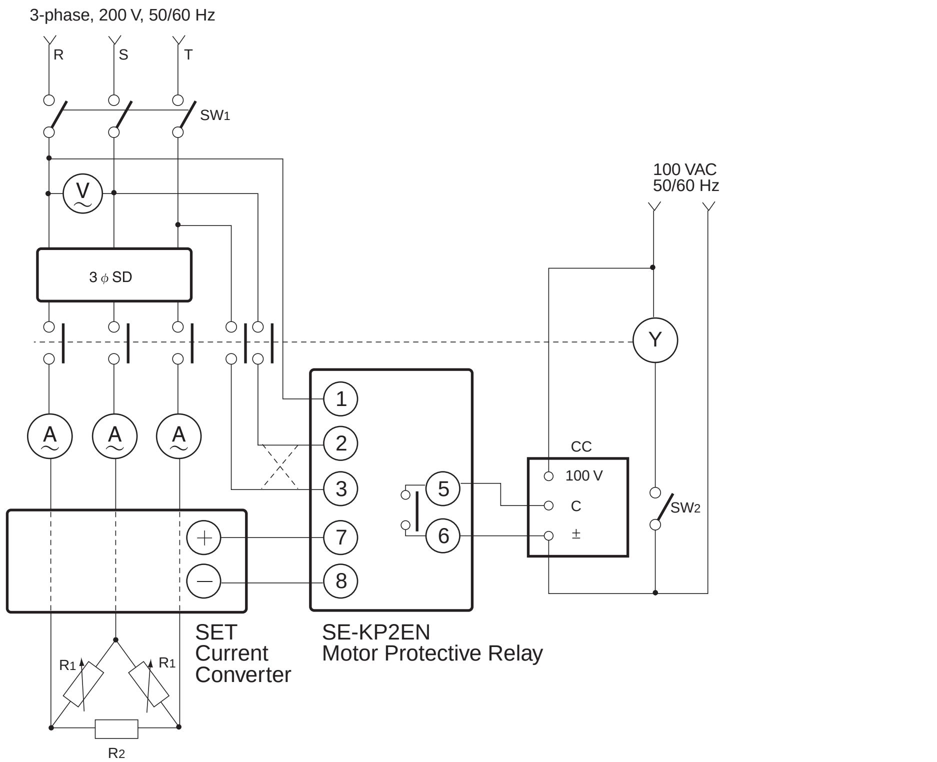
Optional Adapter
SE-F7AD



Note: This Adapter is used to replace existing flush mount models with new models.
Plate material: Steel plate (thickness: 2.0 mm)
Color: Black (Munsell N1.5)

■ Testing Method

With the circuit shown below, the characteristics listed in the following table can be tested. Determine the number of conductor runs through the holes of the current transformer in accordance with the operating current range of the Motor Protective Relay and by referring to the table in the section *Selecting the Current Converter*.



3φSD:	3-phase voltage regulator (5 to 15 A)	R_1:	variable resistor (50 Ω, 400 W + 400 W)
A:	AC ammeter	R_2:	fixed resistor (50 Ω, 400 W + 400 W)
V:	AC voltmeter (300 V)	SW_1:	knife switch (three-phase)
CC:	cycle counter	SW_2:	toggle switch
Y:	auxiliary relay (15 A)		

Test item	Test procedure	
	Operating value	**Operating time**
Overcurrent	**1.** Turn on SW_1. **2.** Turn on SW_2 to operate auxiliary relay Y. **3.** Gradually increase the current by adjusting the voltage regulator. Read the positions at which the relay operates. **4.** Turn off SW_1.	**1.** Turn on SW_1 and SW_2 and increase the current to the Current Converter to 600% of the current SV by adjusting the voltage regulator. Then turn off SW_1 and SW_2. **2.** Turn on SW_1. **3.** Turn on SW_2 and record the value of the cycle counter CC when it is stopped by the relay operation. **4.** Turn off SW_2.
Open-phase	**1.** Open (burn-out) any one of the Current Converter input phases. **2.** Turn on SW_1 and SW_2. Gradually increase the current by adjusting the voltage regulator. **3.** Confirm that the relay operates when the current is 50% or less of the current SV. **4.** Turn off SW_1.	**1.** Open (burn-out) any one of the Current Converter input phases. Adjust the voltage regulator so that the currents of the other two phases equal the current SV. **2.** Turn on SW_1 and SW_2, and record the value of the cycle counter CC when it stops. **3.** Turn off SW_2.
Reverse-phase	**1.** Reverse the leads at terminals 2 and 3 of the relay (indicated by the dashed lines) to create a reverse-phase condition. **2.** Turn on SW_1 and SW_2 and confirm that the relay operates. **3.** Connect the voltage regulator to terminals 1, 2, and 3. **4.** Increase the voltage by adjusting the voltage regulator, and confirm that the relay operates when the voltage is below 80% or less of the rated voltage.	**1.** Create a reverse-phase condition at the voltage inputs. **2.** Turn on SW_1 and SW_2, and record the value of the cycle counter CC when it stops. **3.** Turn off SW_2.

Checking Operation

Checklist After Connection and Before Starting Motor

Check the Current Converter for the proper number of conductor runs through holes and the proper direction.

↓

Check the Current Converter and Motor Protective Relay for connection with proper polarity.

↓

Check the phase-sequence of 3-phase voltage (for 3E relays).

Test Operation

Corrective action → Apply control power supply to the relay → Relay operates instantaneously: Change the phase-sequence of 3-phase voltage properly.

↓

Press the test button (for longer than the set time).

↓

Does the relay operate?

NO → Check for:
1. Loose terminal screw
2. Faulty reset of trip indicator
3. Low voltage at power supply

YES ↓

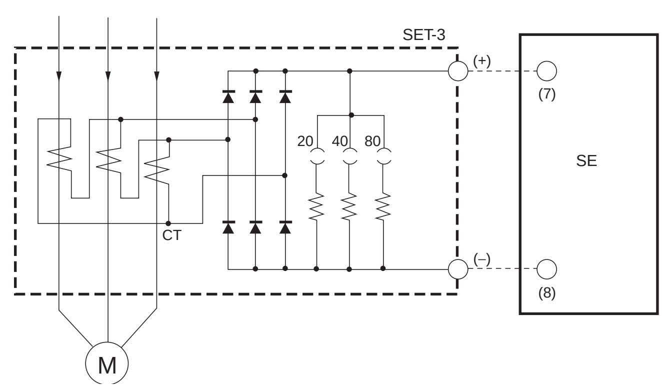
NORMAL

Troubleshooting

Trouble	Check Points
Relay operates before the motor starting time has elapsed. (OPEN indicator)	**1.** Is there any open-phase trouble in the motor or its circuit (fuses, electromagnetic contactors, wiring)? **2.** Does the Current Converter have the correct number of conductor runs through holes? Does the conductor run in the proper direction? **3.** Is the supply voltage or motor current unbalanced (unbalanced factor of more than 35%)?
Relay operates after the motor starting time has elapsed. (OC indicator)	**1.** Does the set current match the motor current? **2.** Does the set operating time match the motor starting time? **3.** Does the Current Converter have the correct number of conductor runs through the holes?
Motor circuit is not tripped when the relay operates following the depression of the test button.	**1.** Disconnect terminals 4, 5, and 6, (Ta, Tb and Tc with the flush mount type) and check the relay contacts for electrical continuity.
Relay doesn't operate properly under light loads.	**1.** Check each phase for an imbalance of more than 35%, and also check for waveform distortion. **2.** If the open-phase unbalance sensitivity switch is set to "H", then switch it to "L". **3.** If the switch is already set to "L", then the open-phase ON/OFF switch can be set to OFF, but the open-phase function will be disabled.

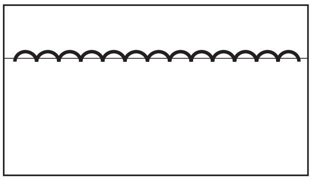
Thyristors, Rectifiers, or VVVF Inverters

An SE-series relay cannot be used with a circuit containing thyristors, rectifiers, or VVVF inverters, because these elements can change the output waveform to the point that the relay will malfunction. The diagram below shows the basic operation of an SET Current Converter.The input current is converted to a DC current suitable for the SE-series relay by 3-phase full wave rectification and the resistors.

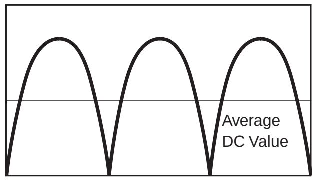


The output voltage is composed of a normal three-phase component and open-phase or imbalance components, so it is made up of both DC and AC components.

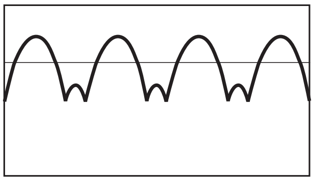
Normal Three-phase Output



Output with a Open-phase

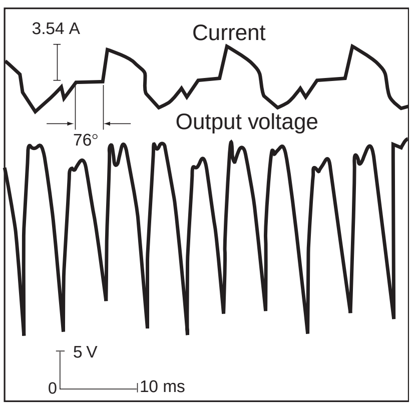


Output with an Unbalance

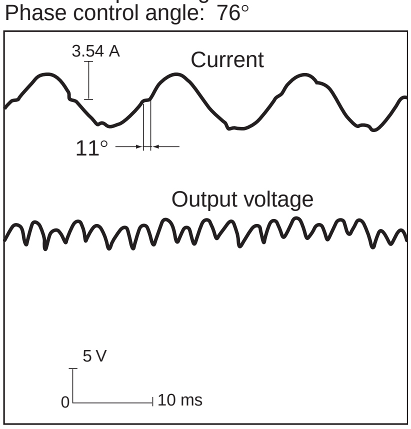


If the motor is run by thyristor phase control, the motor current waveform will be changed by the control angle, and even a small leading angle can cause malfunctions in the SE relay.

The example on the following page shows the primary current and the output waveform of the SET-3☐. When the AC component of the output is large, an SE-series relay misjudges it as open phase.



Load current: 2.50 A_{rms}
SET-3A output voltage: 21.00 VDC
Phase control angle: 76°



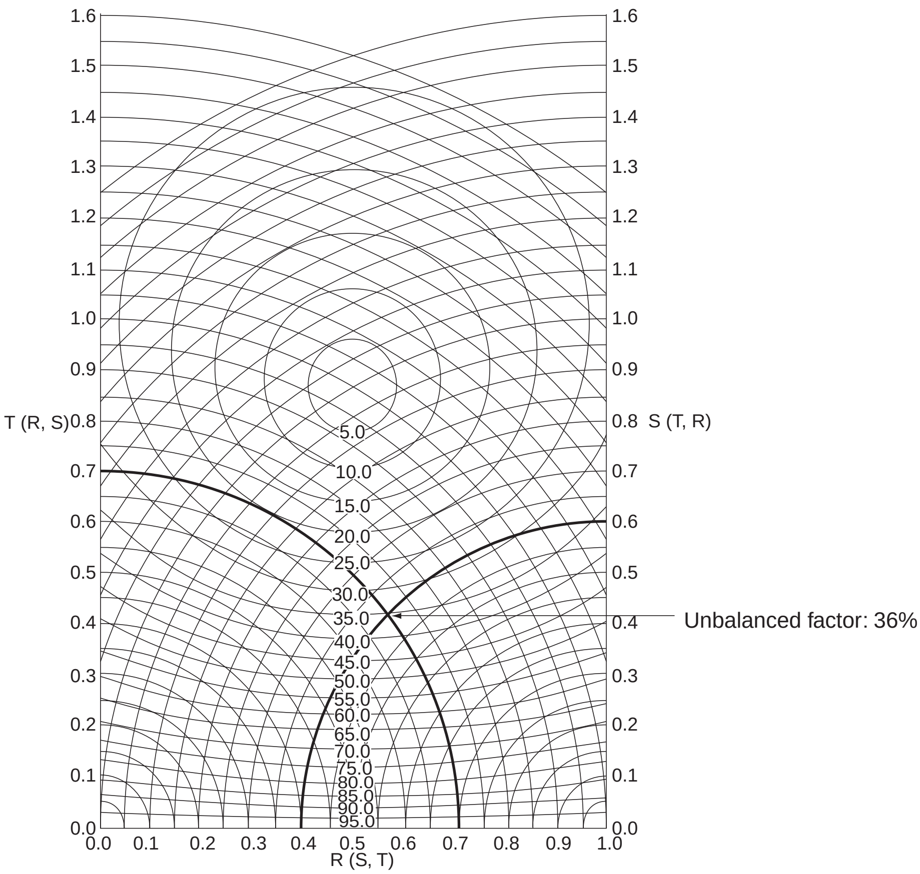
Load current: 2.50 A_{rms}
SET-3A output voltage: 21.77 VDC
Phase control angle: 11°

■ Calculating the Unbalanced Factor

The unbalanced factor can be obtained easily from the following graph. In the graph, the horizontal axis indicates the phase of the maximum current, whereas the two vertical axes indicate the remaining two phases. Taking the phase of the maximum current with a reference value of 1.0, the unbalanced factor is obtained in percentage from the curves centered in the graph.

When the motor current I_R = 100 A, I_s = 60 A, and I_T = 70 A, calculate the ratios of the currents, setting the value of the maximum current to 1. In this case the ratios are 1 : 0.6 : 0.7 (I_R : I_S : I_T).

To find the unbalanced factor, follow the arcs from the ratio values on the vertical axes, in this case 0.6 and 0.7, to their intersection point. The unbalanced factor can be estimated from the values on the graph. Here the unbalanced factor is approx. 36%.



Precautions

On Operation

Connect the phase advancing capacitor to the power supply before the Current Converter.

There are cases in which a 100/110 V power supply can be used. The main reason for using a 100/110 V power supply is to protect a high-tension motor. With a high-voltage power supply, the voltage must be reduced with a potential transformer. It is also possible to use a 100/110 V power supply with the 2E-type (two function) relays.

Use a commercial frequency power supply only for the control power supply.

The Motor Protective Relay cannot be connected to circuits containing thyristors, rectifiers, or VVVF inverters. See explanation under the heading *Use with Thyristors, Rectifiers, or VVVF Inverters*, below.

The Motor Protective Relay also cannot be used to detect an overcurrent in an inching run, because the overcurrent detection circuit is reset at every inching step.

When using an SE relay with a current requirement below 1 A, increase the number of conductor runs through the holes in the Current Converter.

Use a model SAO sensor for single-phase applications. Refer to the SAO datasheet.

Mounting

When installing with an 8PFA1 connecting socket, first fasten the socket firmly to the panel with screws, then plug in the relay and secure it with a hook. Leave at least 30 mm of space between the relays for the hooks.

Although there is no particular restriction on the mounting direction, it is best to mount horizontally.

The recommended panel thickness for panel mounting is 1 to 3.2 mm.

Connections

Make sure that the polarity is correct when connecting the Current Converter and relay.

When using a commercial current transformer with a high-tension or low -voltage, high-capacity motor, pass the external wiring of the secondary through the holes in the Current Converter.

When using as a 3E (3 function) relay, connect the three-phase voltage correctly, as with external connections.
When using as a 2E (2 function) relay, it is not necessary to connect terminal 3 (W).

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Current Sensor
SAO

Solid-state, Plug-in Current Sensor

- Applicable to motor overcurrent protection and 3-phase AC current detection.
- Inverse-type, start-up lock type, and instantaneous type overcurrent sensors available.
- Instantaneous type under current sensor available.
- Plug-in design simplifies installation, removal, and wiring.
- DIN sized (48 mm x 96 mm)

Model Number Structure

■ Model Number Legend

SAO-□□□□
1 2 3 4 5

1. **Basic model name**
   SAO: Current Sensor
2. **Operating time characteristics**
   R: Inverse type: inverse time both at starting and during operation
   Q: Instantaneous type with start-up lock
   S: Regular instantaneous type
3. **Detection function**
   U: Undercurrent detection
   None: Overcurrent detection
4. **Control voltage**
   1: 100/110/120 VAC
   2: 200/220/240 VAC
   5: 24 VDC
   6: 48 VDC
   7: 100/110 VDC
5. **Product history**
   N: New version

Ordering Information

Terminal/ mounting	Control voltage	Overcurrent detection			Under current detection
		Inverse type	Instantaneous type		Instantaneous type
			W/start-up lock*	W/o start-up lock	
Plug-in/DIN rail via socket	100/110/120 VAC	SAO-R1N	SAO-Q1N	SAO-S1N	SAO-SU1N
	200/220/240 VAC	SAO-R2N	SAO-Q2N	SAO-S2N	SAO-SU2N
	24 VDC	SAO-R5N	SAO-Q5N	SAO-S5N	SAO-SU5N
	48 VDC	SAO-R6N	SAO-Q6N	SAO-S6N	SAO-SU6N
	100/110 VDC	SAO-R7N	SAO-Q7N	SAO-S7N	SAO-SU7N

* Fixed time-limit at start-up, instantaneous thereafter.

■ Accessories (Order Separately)

Current Converters

Model	Current range
SET-3A	1 to 80 A
SET-3B	64 to 160 A

DIN rail socket
8PFA1

Specifications

■ Ratings

Motor circuit	Voltage:500 VAC max. 3-phase (primary voltage at SET Current Converter) Current:1 to 80 A or 64 to 160 A 3-phase (primary current at SET Current Converter)
Power supply circuit	Voltage: 100/110/120 VAC, 200/220/240 VAC, 24, 48 VDC, or 100/110 VDC (leveled DC) Voltage fluctuation: $^{+10}/_{-15}$% max. of the rated voltage Frequency: 50/60 Hz ±5%
Current SV range	See table of *Current Converter.*
Output contact	Configuration: SPDT Capacity: 3 A (cosϕ = 1.0)/2 A (cosϕ = 0.4) at 240 VAC; 3 A (resistive load)/2 A (L/R = 7 ms) at 24 VDC; 0.2 A (resistive load)/0.1 A (L/R = 7 ms) at 110 VDC
Power consumption	100/110/120 VAC: approx. 3.5 VA; 200/220/240 VAC: approx. 7 VA; 24 VDC: approx. 0.3 W; 48 VDC: approx. 0.5 W; 100/110 VDC: approx. 1.2 W

■ Characteristics

Item	SAO-R□N	SAO-Q□N	SAO-S□N	SAO-SU□N
Operating current	100% of the current SV (current when the relay is OFF for the SAO-SU□N)			
Operating time characteristics	Inverse type	Fixed time at start-up and instantaneous thereafter	Instantaneous type	
Operating time	For a 600% overcurrent: Time scale x 1: 1 to 10 s Time scale x 4: 4 to 40 s For a 200% overcurrent: 2.8 x t ±30%, where t is the operating time at 600% overcurrent. (time SV at max.)	In start-up lock mode with a 600% overcurrent: Time scale x 1: 1 to 10 s Time scale x 4: 4 to 40 s In instantaneous mode: 0.3 s max. at 120% overcurrent	0.3 s max. with an overcurrent of 120% the current SV	0.3 s max. when 120% the current SV drops below 80%
Initial current in start-up mode	---	Approx. 30% of the current SV	---	---
Inertial characteristics	Will not operate for 80% of operating time for a 600% overcurrent. (at min. current and max. time SV)	---		
Reset value	More than 95% of the operating current			Less than 105% of the operating current
Operating current accuracy	±10% of the current SV			
Operating time accuracy	$^{+10}/_{-5}$% of maximum time SV (at a time SV: 1) ±10% of maximum time SV (at a time SV: 2 to 10)		0.3 s max.	
Influence of temperature on operating current	±5% for 0 to 40°C; ±10% for –10 to 50°C			
Influence of temperature on operating time	±10% for 0 to 40°C; ±20% for –10 to 50°C (start-up mode)		0.3 s max. for –10 to 50°C	
Influence of frequency on operating current	±3% for a frequency fluctuation of ±5%			
Influence of frequency on operating time	±5% for a frequency fluctuation of ±5% (start-up mode)		0.3 s max. for a frequency fluctuation of ±5%	
Influence of voltage on operating current	±3% for a voltage fluctuation of $^{+10}/_{-15}$%			
Influence of voltage on operating time	±5% for a voltage fluctuation of $^{+10}/_{-15}$% (start-up mode)		0.3 s max. for a voltage fluctuation of $^{+10}/_{-15}$% (start-up mode)	

■ Characteristics (continued)

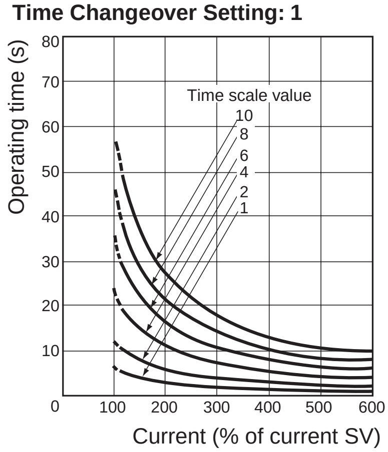
Insulation resistance	10 MΩ min. between electric circuits and the mounting panel 5 MΩ min. between contact circuits, or between contacts of same pole
Withstand voltage	2,000 VAC for 1 min between electric circuits and the mounting panel 2,000 VAC for 1 min between contact circuits and other circuits 1,000 VAC for 1 min between contacts of same pole
Lighting impulse withstand voltage	6,000 V max. between electric circuits and the mounting panel 4,500 V max. between contact circuits and other circuits 4,500 V max. between each control power circuits Waveform: 1.2 x 50 μs 3 times for each poles
Overload capacity	Motor circuit: 20 times the current SV for 2 s, applied twice with a 1 min interval Continuous current: 125% of the maximum current SV for each current range. Power supply: AC: 1.15 times the rated power supply voltage for 3 hrs, once DC: 1.3 times the rated power supply voltage for 3 hrs, once
Vibration resistance	Malfunction: 10 to 55 Hz, 0.3-mm double amplitude each in 3 directions for 10 min Destruction: 10 to 25 Hz, 2-mm double amplitude each in 3 directions for 2 hrs
Shock resistance	Malfunction: 98 m/s^2 (approx. 10G) each in 3 directions Destruction: 294 m/s^2 (approx. 30G) each in 3 directions
Test button operation	Operated quickly (without lighting the LED)
Ambient temperature	Operating: –10 to 60°C (with no icing) Storage: –25 to 65°C (with no icing)
Ambient humidity	Operating: 35% to 85%
Altitude	2,000 m max.
Weight	Approx. 170 g

Engineering Data

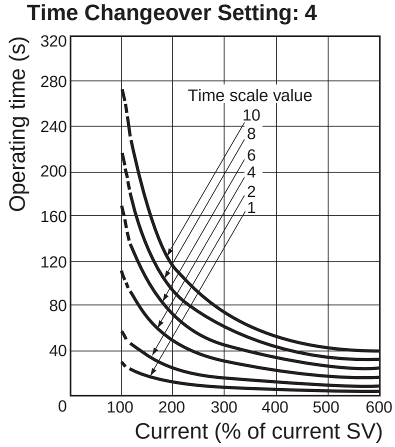
■ Operating Time Characteristics

SAO-R

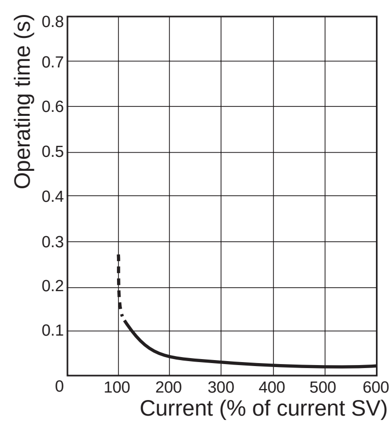
Time Changeover Setting: 1



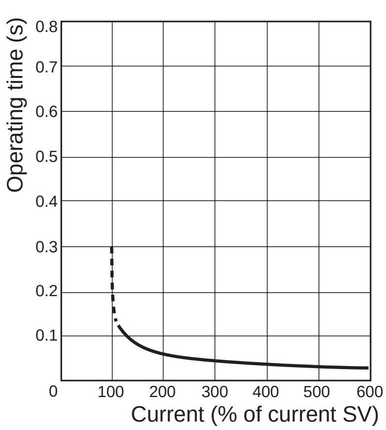
Time Changeover Setting: 4



SAO-Q

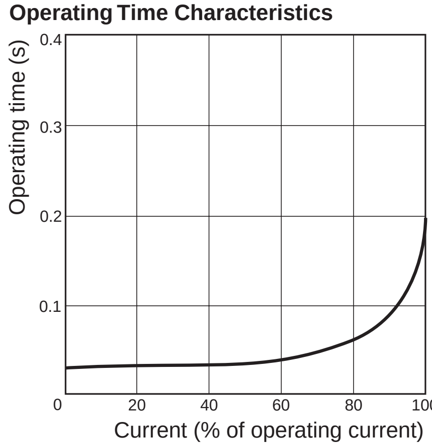


SAO-S

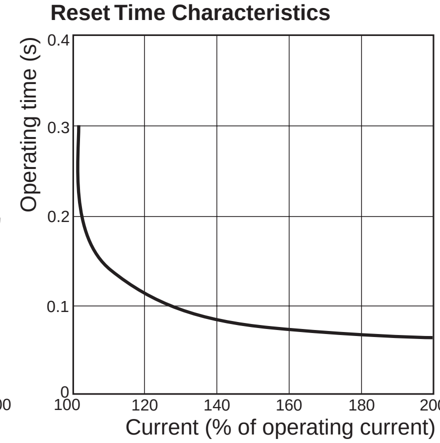


SAO-SU

Operating Time Characteristics



Reset Time Characteristics

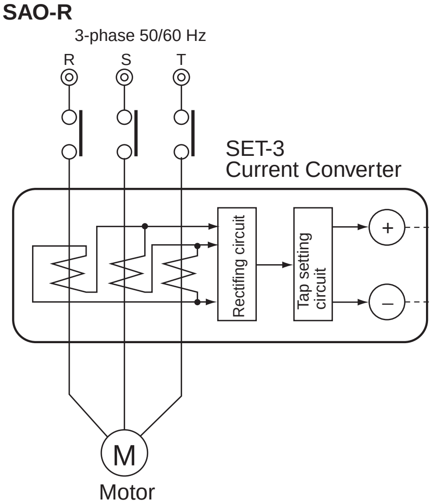


Installation

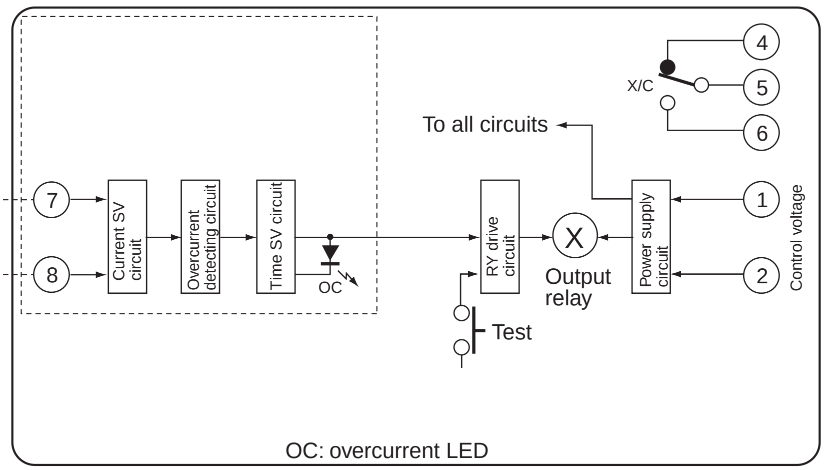
■ Connection

Internal Circuit

SAO-R

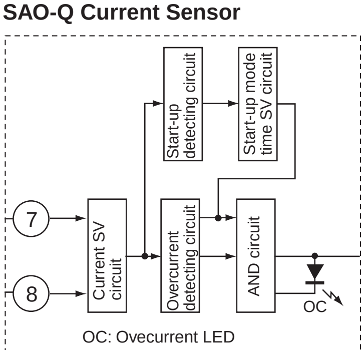


SAO-R Current Sensor

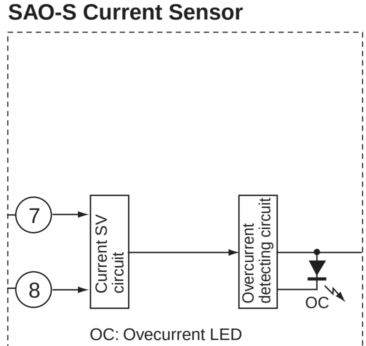


Note: There is no polarity specification when using a DC power supply.

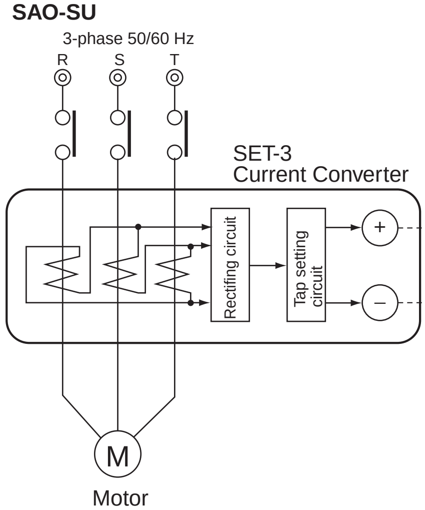
SAO-Q Current Sensor



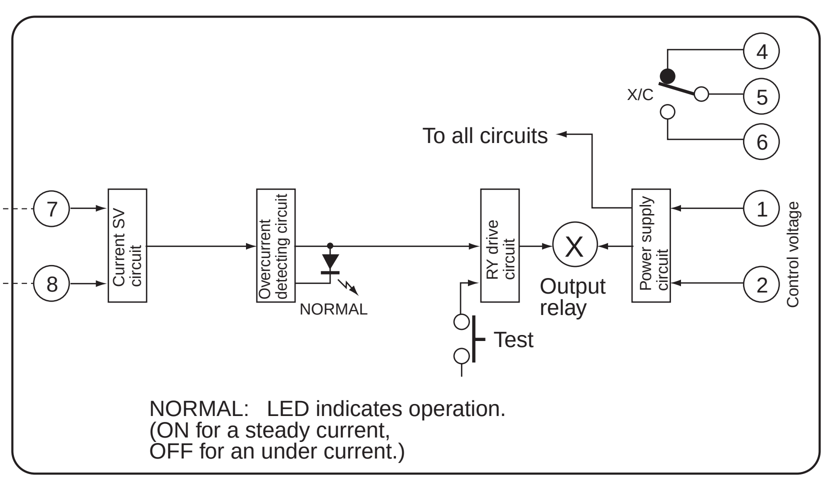
SAO-S Current Sensor



SAO-SU

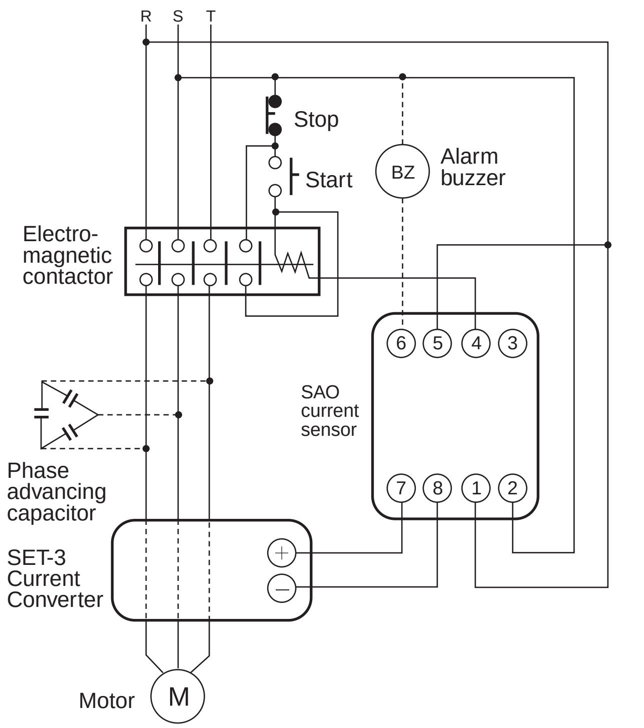


SAO-SU Current Sensor



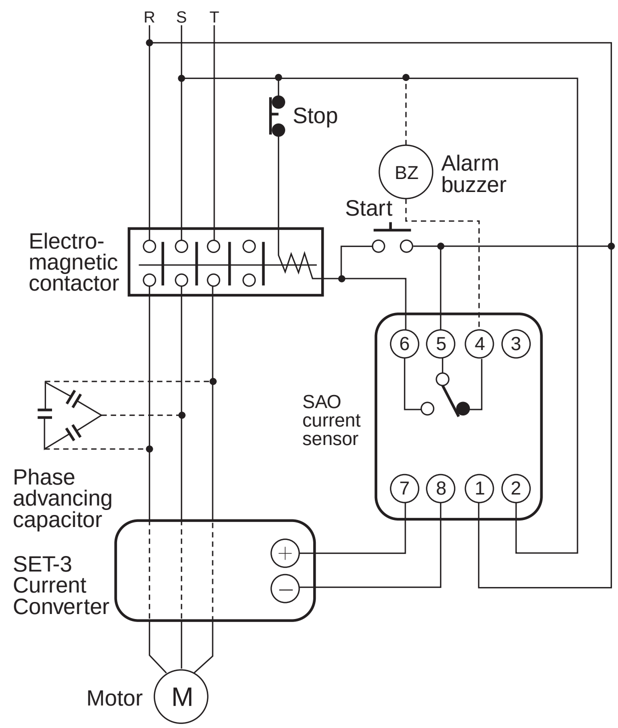
■ Connection Examples

Overcurrent Detection Circuit
SAO-R/SAO-Q/SAO-S



Note: Provide the control power supply for the SAO Current Sensor from the contactor's power supply side. If the control power supply is turned ON and the motor is started at the same time, operation inconsistent with the time SV may occur.

Undercurrent Detection Circuit
SAO-SU



Note: To prevent the buzzer sounding when power is turned ON, install a timer so that the buzzer sounds only when the timer's contacts are closed.

Operation

■ Settings

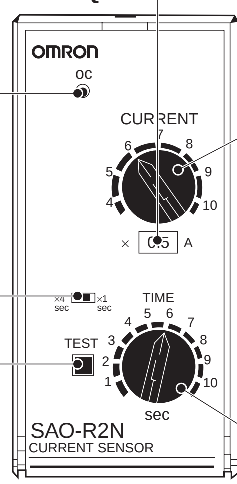
Current Sensor Switch Settings

Current Scale Multiplying Factor Decal
Determine the current scale multiplying factor corresponding to the current SV range obtained from Table 1 and paste the current scale multiplying decal to the current sensor. For example, when the current setting range is 2 to 5 A, the decal no. is 0.5.

SAO-R/Q

LED Indicator
The LED indicates that an overcurrent has occurred and the relay is operating.

Setting Operating Time
Set the time setting knob to the required time. The operating time is equal to the time scale value times the setting on the time changeover switch. For example, if the time scale value is 6, and the time changeover switch is set to 4, the operating time is 24 s. For the SAO-R, this is the operating time in the event of a 600% overcurrent. For the SAO-Q, this is the operating time in start-up mode. There is no operating time SV for the SAO-S.



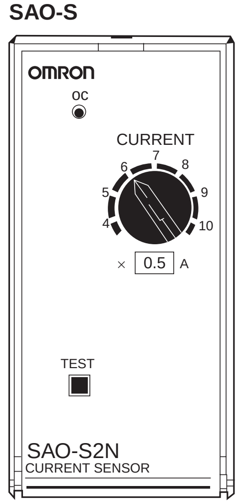
Setting Operating Current
Set the current setting knob to the required current value. The setting value is indicated by the product of the scale value and the multiplying factor as shown in the following table. The required trip current can be obtained directly by means of the current-setting knob.

Decal	Current scale value (A)						
no.	4	5	6	7	8	9	10
0.25	1	1.25	1.5	1.75	2	2.25	2.5
0.5	2	2.5	3	3.5	4	4.5	5
1	4	5	6	7	8	9	10
2	8	10	12	14	16	18	20
4	16	20	24	28	32	36	40
8	32	40	48	56	64	72	80
16	64	80	96	112	128	144	160

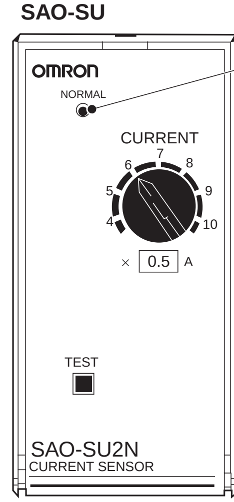
Time Setting Knob

Test Button
Pressing the test button momentarily operates the output relay. The LED indicator, however, does not light during this operation.

SAO-S



SAO-SU

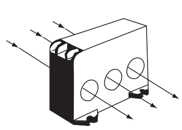


LED Indicator
The NORMAL indicator is lit for normal current; not lit for undercurrent.

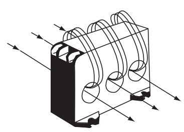
Current Converter Settings

Determining the Number of Primary Conductor Runs

Determine the number of passes and the tap setting from the table above. For example, if the current setting range is 2 to 5 A, there are four passes and the tap setting is 20.
Pass the wires through the holes from the same direction. It doesn't matter which wires go through which holes.



One conductor pass
(The conductors pass through the holes once.)

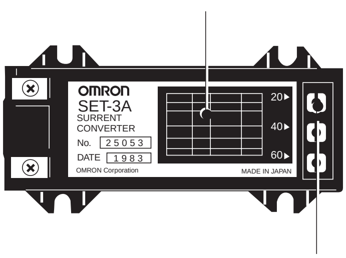


Four conductor passes
(The conductors pass through the holes four times.)

Tap Setting

In tap setting, insert the setting screw into the required tap hole with a screwdriver. After setting, be sure to replace the cover.

Primary conductor pass adjustment



Tap holes

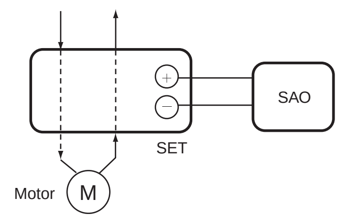
Selecting the Current Converter

The current requirements of the motor determine whether the SET-3A or SET-3B Current Converter should be used.

Current Sensor		Current Converter		
Current range	**Decal no.**	**Passes**	**Tap settings**	**Model**
1 to 2.5	0.25	8	20	SET-3A
2 to 5	0.5	4		
4 to 10	1	2		
8 to 20	2	1		
16 to 40	4		40	
32 to 80	8		80	
64 to 160	16		Fixed	SET-3B

Single-phase Motor Use

The diagram below shows how to connect an SAO-☐ Current Sensor to a single-phase motor. There is a model available for use with a single phase circuit.



Pass the required number of conductor runs through any two of the three holes in the SET-3☐ Current Converter. Even when wired as shown in the diagram, the operating current will change, so it is necessary to change the current SV as well.

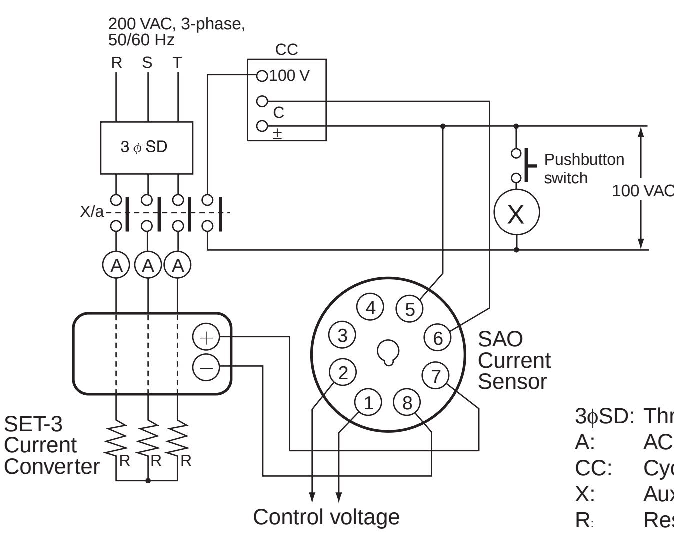
Multiply the desired operating current by 0.77 to find the appropriate current SV.

For example, if the desired operating current is 10 A, set the current SV to 0.77 x 10 A = 7.7 A.

The SAO-☐ is adjusted for 3-phase use, so verify operation in tests with the actual load before operation.

■ Checking Operation

The following circuit can be used to check SAO-☐ and SET-3☐ characteristics.

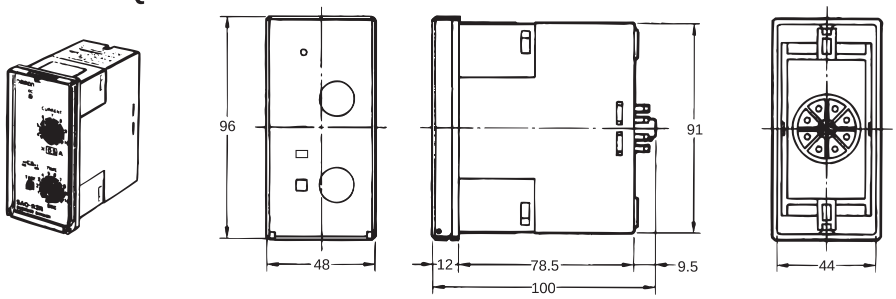


3φSD: Three-phase voltage regulator
A: AC ammeter
CC: Cycle counter
X: Auxiliary relay (15 A)
R: Resistor

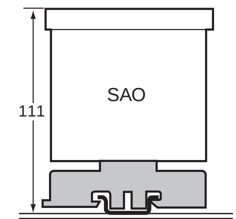
Dimensions

Note: All units are in millimeters unless otherwise indicated.

SAO-R/SAO-Q

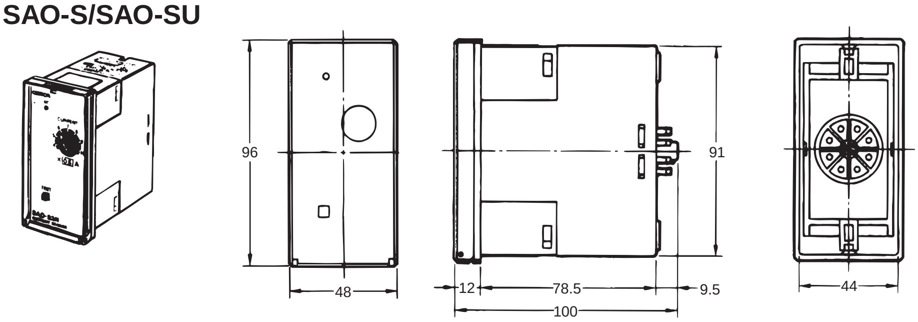


The Height of DIN Rail Mounting

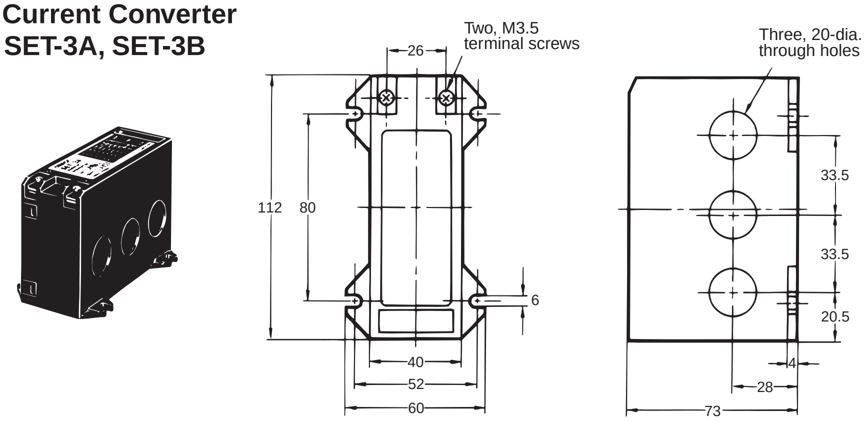


8PFA1 (order separately)

SAO-S/SAO-SU

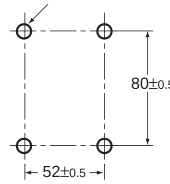


Current Converter SET-3A, SET-3B



Mounting Holes

Four, 6-dia. mounting holes or four, M5 mounting screw holes



Precautions

On Operation

Use a commercial frequency power supply only for the control power supply.

The SET-3□ Current Converter is designed for use with a single SAO Current Sensor; do not connect two units to a single SET-3□ as in figure 1 below (even if a diode is included in the circuit).

If the current transformer has sufficient capacity, the circuit in figure 2 is acceptable.

Figure 1: Never Use this Setup

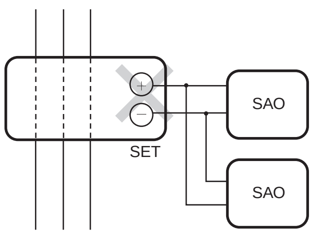
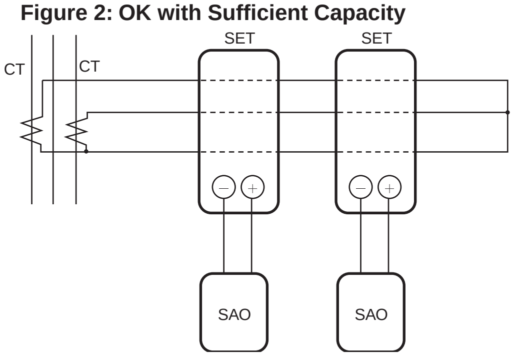


Figure 2: OK with Sufficient Capacity



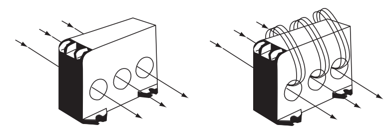
Mounting

When installing with an 8PFA1 connecting socket, first fasten the socket firmly to the panel with screws, then plug in the relay and secure it with a hook. Leave at least 30 mm of space between the relays for the hooks.

Connections

Make sure that the polarity is correct when connecting the Current Converter and Current Sensor. It is not necessary to consider polarity when using a DC control power supply.

Determine the necessary number of conductor runs from the table *Selecting the Current Converter* in the *Operation* section. Pass the wires through the holes from the same direction. It doesn't matter which wires go through which holes.



One conductor pass
(The conductors pass through the holes once.)

Four conductor passes
(The conductors pass through the holes four times.)

Testing Method

Verify operation by turning on the control voltage and pressing the test button.

It is possible to check whether SAO-□ and SET-3□ characteristics are correct or not with the test circuit shown on page 6.

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N033-E1-04

Current Sensor (Single-phase)

SAO-□S

Ideal for Single-phase Motor Overcurrent Protection

- Applicable to motor overcurrent protection and AC current detection in general single-phase circuits.
- Inverse-type, start-up lock type, and instantaneous-type overcurrent sensors are available to provide precise protection, detection, and control suited to the operating environment.
- There is no need to replace the CT or change the relay's input resistance in accordance with the size of the current, allowing ease of use.
- Plug-in design simplifies installation, removal, and wiring.

Model Number Structure

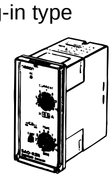
■ Model Number Legend

SAO-□S□N
1 2 3 4 5

1. **Basic model name**
   SAO: Current Sensor
2. **Operating time characteristics**
   R: Inverse type
   Q: Instantaneous type with start-up lock
   S: Regular instantaneous type
3. **Detection function**
   S: Detection for single-phase circuits
4. **Control voltage**
   1: 100/110/120 VAC
   2: 200/220/240 VAC
   5: 24 VDC
   6: 48 VDC
   7: 100/110 VDC
5. **Product history**
   N: New version

Ordering Information

■ List of Models

	Operating element	Overcurrent detection		
Appearance	Operating characteristics / Control voltage	Inverse type	Instantaneous type with start-up lock	Instantaneous type
Plug-in type 	100/110/120 VAC	SAO-RS1N	SAO-QS1N	SAO-SS1N
	200/220/240 VAC	SAO-RS2N	SAO-QS2N	SAO-SS2N
	24 VDC	SAO-RS5N	SAO-QS5N	SAO-SS5N
	48 VDC	SAO-RS6N	SAO-QS6N	SAO-SS6N
	100/110 VDC	SAO-RS7N	SAO-QS7N	SAO-SS7N

Note: The resetting method for all types is automatic reset.

Current Converters

Model	Current range
SET-3A	1 to 80 A
SET-3B	64 to 160 A

Specifications

■ Ratings

Item	Control voltage	100/110/120 VAC	200/220/240 VAC	24 VDC	48 VDC	100/110 VDC
Motor circuit	Rated voltage	500 VAC max., 3-phase (primary voltage at SET Current Converter)				
	Rated current	1 to 80 A or 64 to 160 A, 3-phase (primary current at SET Current Converter)				
Control power supply circuit	Rated voltage	100/110/120 VAC, 200/220/240 VAC, 24 VDC, 48 VDC, or 100/110 VDC (leveled DC)				
	Allowable voltage fluctuation range	$^{+10}/_{-15}$% max. of the rated voltage				
Frequency	Rated frequency	50/60 Hz				
	Allowable frequency fluctuation range	Rated frequency ±5%				
Current setting range		Refer to the *Current Settings* table.				
Output contacts	Contact configuration	SPDT				
	Contact capacity	240 VAC: 3 A (cosϕ = 1.0), 2 A (cosϕ = 0.4) 24 VDC: 3 A (resistive load), 2 A (L/R = 7 ms) 110 VDC: 0.2 A (resistive load), 0.1 A (L/R = 7 ms)				
Power consumption		Approx. 3.5 VA	Approx. 7 VA	Approx. 0.3 W	Approx. 0.5 W	Approx. 1.2 W
Weight		Approx. 170 g				
Case color		Munsell 5Y 7/1				

■ Normal Operating Conditions

Operating temperature range	–10 to 60°C (with no icing)
Operating humidity range	35% to 85%
Storage temperature range	–25 to 65°C
Altitude	2,000 m max.

■ Characteristics

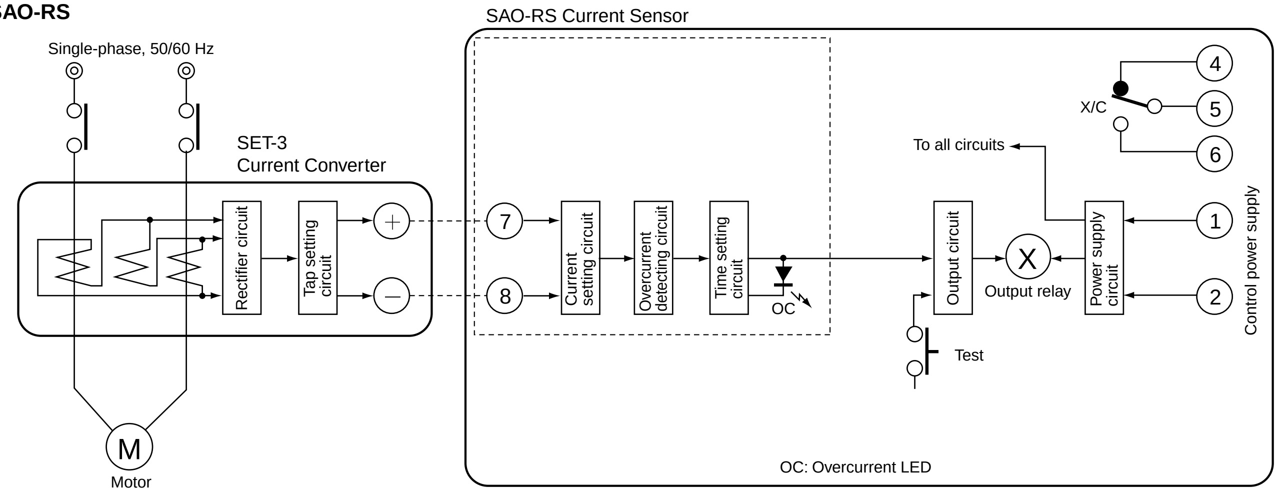
Item	SAO-RS□N	SAO-QS□N	SAO-SS□N
Operating current	100% of the current setting		
Operating time characteristics	Inverse type	Instantaneous type with start-up lock	Instantaneous type
Operating time	For a 600% overcurrent: Time scale × 1: 1 to 10 s Time scale × 4: 4 to 40 s For a 200% overcurrent: 2.8 × t ±30%, where t is the operating time at 600% overcurrent (at max. time setting).	Start-up lock time (fixed) with a 600% overcurrent: Time scale × 1: 1 to 10 s Time scale × 4: 4 to 40 s Operating time with a 120% overcurrent: 0.3 s max.	Operating time with a 120% overcurrent: 0.3 s max.
Initial current for start-up lock	---	Approx. 30% of the current setting	---
Inertial characteristics	Will not operate for 80% of the operating time for a 600% overcurrent at the minimum current setting and maximum operation time setting.	---	
Reset current	95% min. of the operating current		
Operating current accuracy	±10% of the current setting		
Operating time (start-up lock time) accuracy	At a time scale setting of 1: $^{+10}/_{-5}$% of maximum setting At a time scale setting of 2 to 10: ±10% of maximum setting		0.3 s max.
Influence of temperature on operating current	±5% for 0 to 40 °C; ±10% for –10 to 50 °C		
Influence of temperature on operating time (start-up lock time)	±10% for 0 to 40 °C; ±20% for –10 to 50 °C		0.3 s max. for –10 to 50 °C

<table>
<tr><th colspan="2">Item</th><th>SAO-RS□N</th><th>SAO-QS□N</th><th>SAO-SS□N</th></tr>
<tr><td colspan="2">Influence of frequency on operating current</td><td colspan="3">±3% for a frequency fluctuation of ±5%</td></tr>
<tr><td colspan="2">Influence of frequency on operating time (start-up lock time)</td><td colspan="2">±5% for a frequency fluctuation of ±5%</td><td>0.3 s max. for a frequency fluctuation of ±5%</td></tr>
<tr><td colspan="2">Influence of voltage on operating current</td><td colspan="3">±3% for a voltage fluctuation of $^{+10}/_{-15}$%</td></tr>
<tr><td colspan="2">Influence of voltage on operating time (start-up lock time)</td><td colspan="2">±5% for a voltage fluctuation of $^{+10}/_{-15}$%</td><td>0.3 s max. for a voltage fluctuation of $^{+10}/_{-15}$%</td></tr>
<tr><td colspan="2">Insulation resistance</td><td colspan="3">10 MΩ min. between electric circuits and the mounting panel
5 MΩ min. between contact circuits and other circuits and contact poles</td></tr>
<tr><td colspan="2">Dielectric strength</td><td colspan="3">2,000 VAC for 1 min between electric circuits and the mounting panel
2,000 VAC for 1 min between contact circuits and other circuits
1,000 VAC for 1 min between contact poles</td></tr>
<tr><td colspan="2">Lightning impulse dielectric strength</td><td colspan="3">6,000 V max. between electric circuits and the mounting panel
4,500 V max. between contact circuits and other circuits
4,500 V max. between control power supply circuit terminals
Waveform: 1.2 × 50 µs, 3 times each for positive and negative polarities</td></tr>
<tr><td rowspan="2">Overload capacity</td><td>Motor circuit</td><td colspan="3">20 times the current setting for 2 s, applied twice with a 1 min interval (primary voltage at SET Current Converter)
Continuous current: 125% of the maximum current setting for each current range.</td></tr>
<tr><td>Control power supply circuit</td><td colspan="3">AC power supply: 1.15 times the rated power supply voltage for 3 hrs, once
DC power supply: 1.3 times the rated power supply voltage for 3 hrs, once</td></tr>
<tr><td rowspan="2">Vibration resistance</td><td>Malfunction</td><td colspan="3">10 to 55 Hz, 0.3-mm double amplitude for 10 min each in X, Y, and Z directions</td></tr>
<tr><td>Destruction</td><td colspan="3">10 to 25 Hz, 2-mm double amplitude for 2 h each in X, Y, and Z directions</td></tr>
<tr><td rowspan="2">Shock resistance</td><td>Malfunction</td><td colspan="3">98 m/s^2 in X, Y, and Z directions</td></tr>
<tr><td>Destruction</td><td colspan="3">294 m/s^2 in X, Y, and Z directions</td></tr>
<tr><td colspan="2">Test button operation</td><td colspan="3">Operated quickly (without lighting the LED)</td></tr>
</table>

Connections

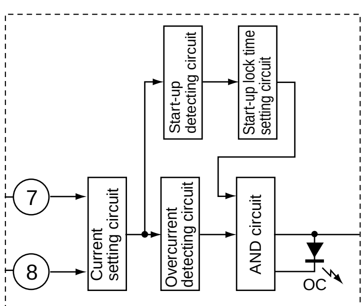
■ Terminal Arrangement

SAO-RS

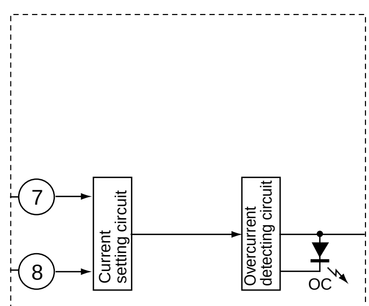


Note: There is no polarity specification when using a DC power supply.

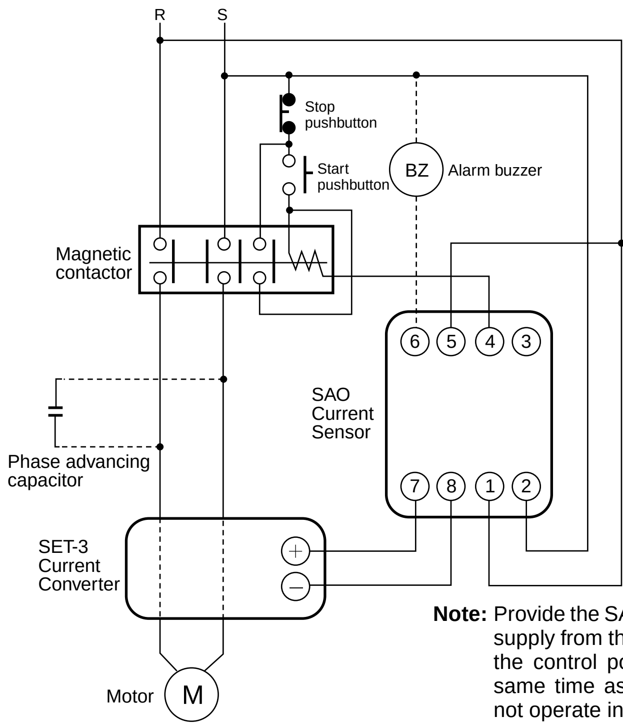
SAO-QS



SAO-SS



Output Circuits



Note: Provide the SAO Current Sensor's control power supply from the contactor's power supply side. If the control power supply is turned ON at the same time as motor start-up, the Sensor may not operate in accordance with the time setting.

Operation

Perform settings for the SAO Current Sensor and SET Current Converter in accordance with the current for the load used.

Current Settings

Rated current (current setting range)	Current scale multiplying factor decal number	Current Converter		
		Number of conductor passes	Tap setting	Model
1 to 2.5	0.25	8	20	SET-3A
2 to 5	0.5	4	20	
4 to 10	1	2	20	
8 to 20	2	1	20	
16 to 40	4	1	40	
32 to 80	8	1	80	
64 to 160	16	1	Fixed	SET-3B

Note: The current range is determined by the number of conductor passes through the SET Current Converter and the tap setting. The range of the current scale on the Sensor is from 4 to 10 A and so attach a current scale multiplying factor decal (provided with the product) to the Sensor if required.

1. Current Sensor Settings

1. Current Scale Multiplying Factor

Determine the appropriate current scale multiplying factor for the current setting range from the table, and attach the corresponding decal to the Sensor. For example, for a current setting range of 2 to 5 A, attach the 0.5 decal.

2. Setting the Operating Current

Determine the scale value for the operating current according to the required current setting and the decal number, and set the current setting knob accordingly. The relationship between the scale value and the actual operating current is shown in the following table.

Scale multiplying factor	Current scale value						
	4	**5**	**6**	**7**	**8**	**9**	**10**
×0.25	1	1.25	1.5	1.75	2	2.25	2.5
×0.5	2	2.5	3	3.5	4	4.5	5
×1	4	5	6	7	8	9	10
×2	8	10	12	14	16	18	20
×4	16	20	24	28	32	36	40
×8	32	40	48	56	64	72	80
×16	64	80	96	112	128	144	160

The figures in the above table represent the current setting values (unit: A).

3. LED Indicator

The LED indicator lights continuously when the Sensor operates in response to an overcurrent.

4. Setting the Operating Time

- Set the time setting knob to the required time. The operating time is equal to the product of the time scale value and the time scale multiplying factor.
- The time scale multiplying factor is selected with the time scale multiplying factor switch. For the SAO-RS, this is the operating time in the event of a 600% overcurrent. For the SAO-QS, this is the start-up lock time. There is no operating time setting for the SAO-SS.

Time scale value	Scale multiplying factor	
	×**1**	×**4**
1	1 s	4 s
2	2 s	8 s
3	3 s	12 s
4	4 s	16 s
5	5 s	20 s
6	6 s	24 s
7	7 s	28 s
8	8 s	32 s
9	9 s	36 s
10	10 s	40 s

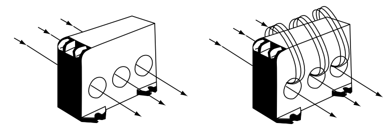
5. Test Button

Pressing the test button momentarily operates the output relay. The LED indicator, however, does not light during this operation.

2. Current Converter Settings

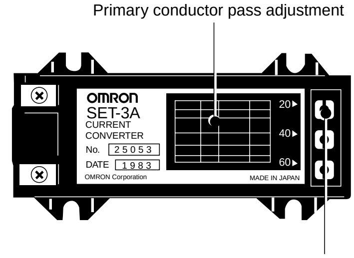
1. Deciding the Number of Primary Conductor Passes

- Decide the number of primary conductor passes and the tap setting using the *Current Settings* table. For example, if the current setting range is 2 to 5 A, use four conductor passes and a tap setting of 20.
- Pass the wires through the holes in the same direction. It does not matter which wire does through which hole.



One conductor pass
(The conductors pass through the holes once.)

Four conductor passes
(The conductors pass through the holes four times.)



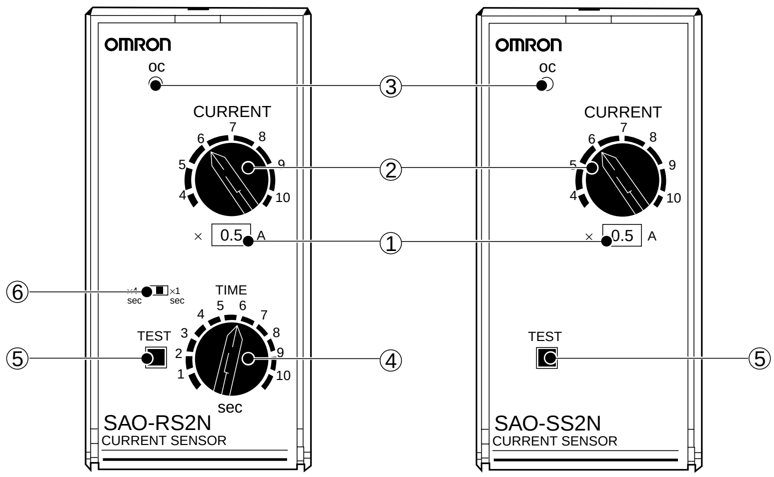
2. Tap Setting

Insert the setting screw into the required tap holes with a screwdriver. After setting, be sure to replace the cover.

Nomenclature

SAO-RS, -QS

SAO-SS



Number	Name
1	Current scale multiplying factor decal
2	Current setting knob
3	LED indicator
4	Time setting knob
5	Test button
6	Time scale multiplying factor switch

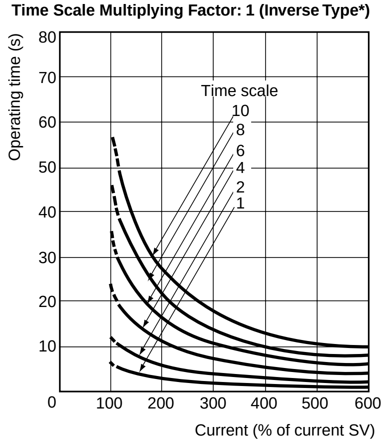
Refer to *Operation* on page 50 for details of the function of each part.

Engineering Data

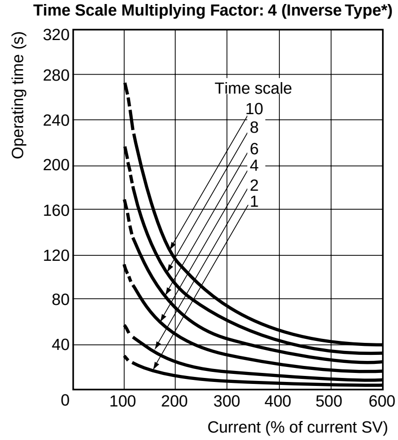
■ Operating Time Characteristics

SAO-RS

Time Scale Multiplying Factor: 1 (Inverse Type*)



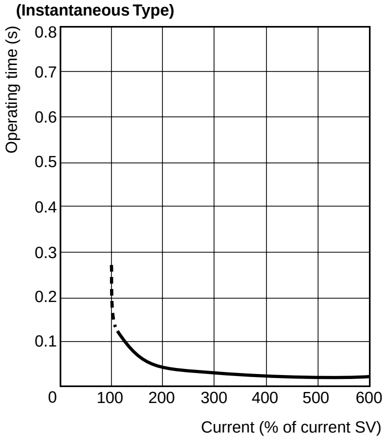
Time Scale Multiplying Factor: 4 (Inverse Type*)



Note: Inverse Type:
With inverse-type Sensors, the operating time varies with the size of the overcurrent. The larger the overcurrent, the shorter the operating time.

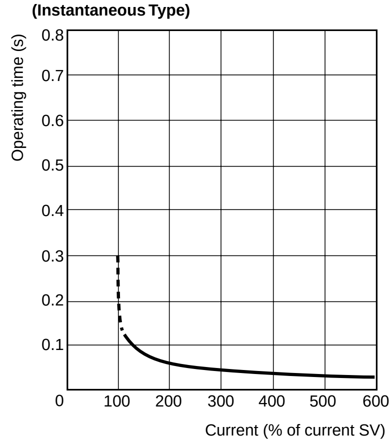
SAO-QS

(Instantaneous Type)



SAO-SS

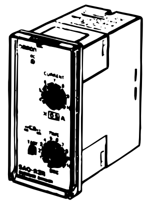
(Instantaneous Type)

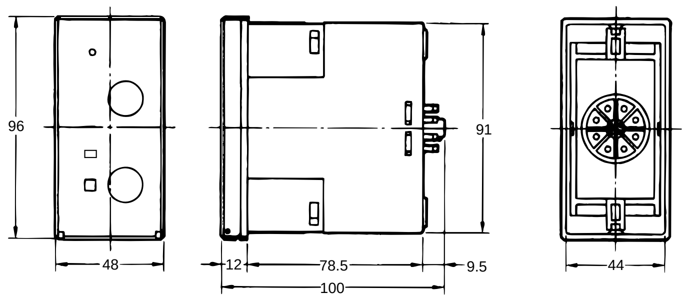


Dimensions

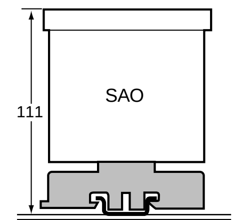
Note: All units are in millimeters unless otherwise indicated.

SAO-RS, -QS



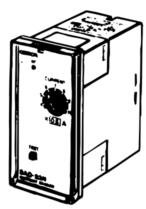


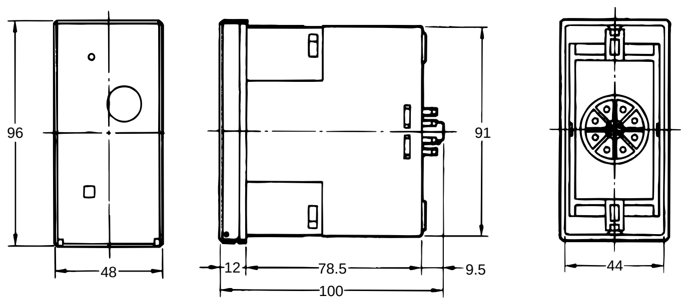
Connecting Socket



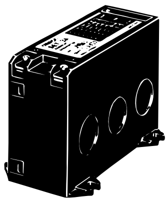
8PFA1 (sold separately)

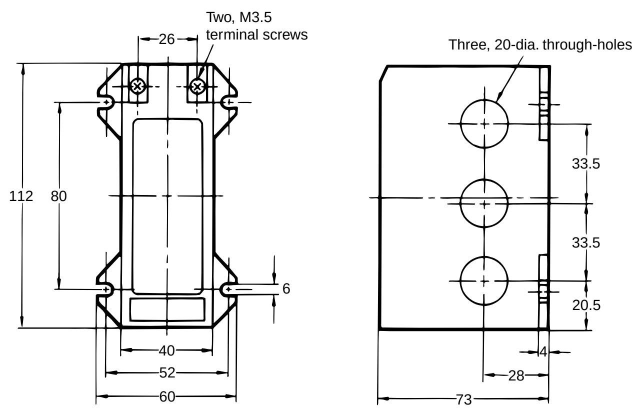
SAO-SS

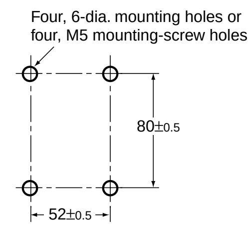




Current Converter
SET-3A
SET-3B

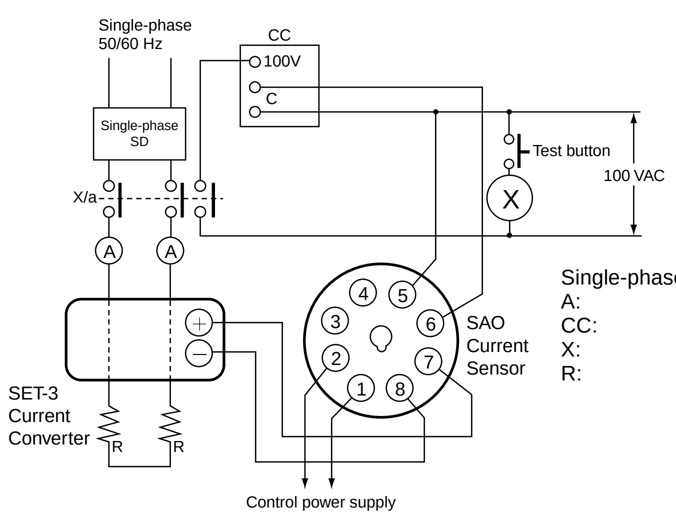






Maintenance and Inspections

- Checking Operation with the Test Button:
  Turn ON the control power supply, and test operation by pressing the test button.
- Checking Characteristics:
  Test the SAO Current Sensor and SET-3 Current Converter for changes in characteristics using the circuit on the right.



Single-phase SD:	Single-phase voltage regulator
A:	AC ammeter
CC:	Cycle counter
X:	Auxiliary relay
R:	Fixed resistor

Precautions

■ Correct Use

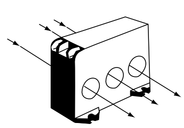
- Use a commercial frequency power supply as the AC control power supply.
- This Current Sensor cannot be used for circuits that may exhibit current waveform distortion, such as in thyristor control, circuits that incorporate inverters or rectifiers, high-frequency circuits, and capacitor loads.
- Use the K2CM for circuits incorporating inverters.
- This Current Sensor cannot be used for inching operation. The internal overcurrent detecting circuit is reset with each inching operation.
- Do not use the SET-3 Current Converter with positive and negative output terminals open. Short-circuit these terminals if they are not used.
- After the LED indicator turns ON, it will turn OFF when the control power supply voltage is turned OFF.

Mounting

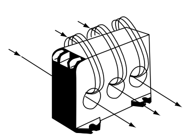
- When installing with an 8PFA1 connecting socket, first fasten the socket firmly to the panel with screws, then insert the Sensor and secure it with the hook. Leave a gap of around 30 mm between Sensors to allow for the hooks.
- There is no particular restriction regarding the mounting direction. Mount the Sensor as horizontally and securely as possible.
- When panel mounting the Sensor, obtain the mounting brackets for panel mounting SE Relays. The recommended panel thickness for panel mounting is 1 to 3.2 mm.

Connections

- Determine the necessary number of conductor passes from the *Current Settings* table and pass the all three wires through the holes in the same direction. It does not matter which wire does through which hole.



One conductor pass
(The conductors pass through the holes once.)



Four conductor passes
(The conductors pass through the holes four times.)

- Be sure to connect the Current Sensor and Current Converter with the correct polarity. Not doing so may result in malfunction.
- It is not necessary to consider polarity when using a DC control power supply.

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N123-E1-01

In the interest of product improvement, specifications are subject to change without notice.

Heater Element Burnout Detector
K2CU

Accurate Detection of Heater Element Burnout Regardless of Heater Capacities

- Accurately detects a burned heater element or elements incorporated by a molding machine or packing machine and outputs an alarm signal.
- Precisely singles out the burned element even if one heater element among several heater elements has been burned out.
- Applicable to small- to large-capacity heater elements.
- All K2CU-F large-capacity, built-in current transformer models work with both single-phase and three-phase heaters.
- Voltage fluctuation compensation function eliminates false alarms due to variations in the supply voltage.

Model Number Structure

■ Model Number Legend

K2CU-□□□-□□
1 2 3 4 5 6

1. **Heater Element Burnout Detector**
2. **Operation**
   F: Large-capacity, built-in Current Transformer model
   P: Small-capacity plug-in model
3. **Operating Current Range**
   1: 0.5 to 1 A
   2: 1 to 2 A
   4: 2 to 4 A
   10: 4 to 10 A
   20: 8 to 20 A
   40: 16 to 40 A
   80: 32 to 80 A
4. **Voltage Compensation**
   None: Not provided
   A: Provided
5. **Control Power Supply Voltage**
   A: 100/200 VAC
   B: 110/220 VAC
   C: 100 VAC
   D: 110 VAC
   E: 200 VAC
   F: 220 VAC
6. **Gate Input**
   None: Not provided
   GS: Provided

Ordering Information

K2CU-F□□A-□GS Model with Gate Input Terminals

Control supply voltage		Operating current			
		4 to 10 A	8 to 20 A	16 to 40 A	32 to 80 A
100 VAC	With voltage fluctuation compensation	K2CU-F10A-CGS	K2CU-F20A-CGS	K2CU-F40A-CGS	K2CU-F80A-CGS
110 VAC		K2CU-F10A-DGS	K2CU-F20A-DGS	K2CU-F40A-DGS	K2CU-F80A-DGS
200 VAC		K2CU-F10A-EGS	K2CU-F20A-EGS	K2CU-F40A-EGS	K2CU-F80A-EGS
220 VAC		K2CU-F10A-FGS	K2CU-F20A-FGS	K2CU-F40A-FGS	K2CU-F80A-FGS

K2CU-F Large-capacity, Built-in Current Transformer Models

Control supply voltage		Operating current			
		4 to 10 A	8 to 20 A	16 to 40 A	32 to 80 A
100 VAC	With voltage fluctuation compensation	K2CU-F10A-C	K2CU-F20A-C	K2CU-F40A-C	K2CU-F80A-C
110 VAC		K2CU-F10A-D	K2CU-F20A-D	K2CU-F40A-D	K2CU-F80A-D
200 VAC		K2CU-F10A-E	K2CU-F20A-E	K2CU-F40A-E	K2CU-F80A-E
220 VAC		K2CU-F10A-F	K2CU-F20A-F	K2CU-F40A-F	K2CU-F80A-F

K2CU-P Small-capacity, Plug-in Models

Control supply voltage		Operating current			
		0.25 to 0.5 A	0.5 to 1 A	1 to 2 A	2 to 4 A
100/ 200 VAC	With voltage fluctuation compensation	K2CU-P0.5A-A	K2CU-P1A-A	K2CU-P2A-A	K2CU-P4A-A
	Without voltage fluctuation compensation	---	K2CU-P1-A	K2CU-P2-A	K2CU-P4-A
110/ 220 VAC	With voltage fluctuation compensation	K2CU-P0.5A-B	K2CU-P1A-B	K2CU-P2A-B	K2CU-P4A-B
	Without voltage fluctuation compensation	---	K2CU-P1-B	K2CU-P2-B	K2CU-P4-B

Specifications

■ Ratings

Item	K2CU-F	K2CU-P
Control supply voltage	100, 110, 200, 220 VAC	100/200, 110/220 VAC
Rated frequency	50/60 Hz	
Carry current	1.25 times as large as each model's maximum operating current	2.5 A for K2CU-P0.5A-A/-B; 5 A
Operating voltage range	85% to 110% of control supply voltage	
Voltage fluctuation compensation range	85% to 110% of control supply voltage	85% to 110% of control supply voltage (applicable only on models with voltage fluctuation compensation)
Operating current	4 to 10 A, 8 to 20 A, 16 to 40 A, 32 to 80 A (continuously variable)	0.25 to 0.5 A, 0.5 to 1 A, 1 to 2 A, 2 to 4 A (continuously variable)
Releasing current	105% max. of operating current	110% max. of operating current
Operate time	0.5 s max. (when current changes from 150% to 0%)	
Gate input voltage range (for models with gate input terminals)	5 to 30 VDC	---
Control output	2 A at 220 VAC, SPDT (cosϕ = 0.4)	
Power consumption	Input: 0.5 VA max. Power supply: 5 VA max.	Input: 1 VA max. Power supply: 4 VA max.

■ Characteristics

Setting accuracy	±7% max.
Repeat accuracy	±3% max.
Influence of temperature	±10% max. (at 20°C±30°C)
Influence of voltage	Models without voltage fluctuation compensation: ±3% max. of the value measured at the control supply voltage, on condition that the voltage fluctuation is 85% to 110% of the control supply voltage Models with voltage fluctuation compensation: ±5% max. of the logical value, on condition that the voltage fluctuation is 85% to 110% of the control supply voltage. (see note)
Influence of frequency	±3% max. (at ±5% of rated frequency)
Insulation resistance	10 MΩ min. (at 500 VDC) between electric circuits and mounting panel
Dielectric strength	2,000 VAC, 50/60 Hz for 1 min between electric circuits and mounting panel
Overcurrent	20 times of max. set value of operating current for 2 s
Vibration resistance	Destruction: 16.7 Hz, 1-mm double amplitude for 10 min each in X, Y, and Z directions
Shock resistance	Destruction: 98 m/s^2 (approx. 10G)
Ambient temperature	Operating: –10°C to 55°C (with no icing)
Ambient humidity	Operating: 45% to 85%
Weight	K2CU-F: approx. 390 g; K2CU-P: approx. 300 g

Note: The logical value is an operating value within a range of 0.85 to 1.1 with a voltage fluctuation of 85% to 110%, based on the value at the control supply voltage measured as 1.

Operation

K2CU-F□□A-□GS Series

When power is supplied to the heater (when the SSR is ON), a current flows through the wires to the heater elements. At the same time, a voltage is imposed on the gate circuit and the K2CU-F□□A□GS begins monitoring the current flowing through the heater wires.

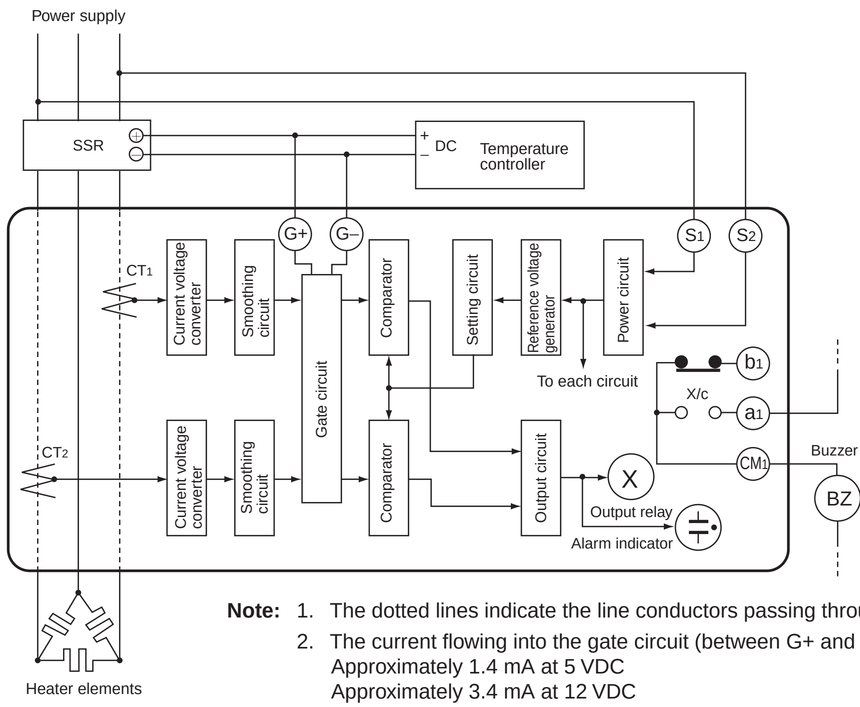
The current flowing to the heater wires is detected by the detector sections through each Current Transformer (CT) incorporated by the K2CU-F□□A-□GS.

The current signals transmitted by the two CTs are sent to the current-voltage converters, smoothing circuits, and comparators as shown in the diagram.

The signal generated by the reference voltage generator is sent to the setting circuit to provide a reference value. The reference value is sent to the comparators. Each comparator compares its heater element current input and the reference value. If the input is lower than the reference value, a signal is sent to the output circuit.

There are two detector sections operating independently. If either of the input signals from the CTs is lower than the reference value, the output relay and alarm indicator will be activated.

The K2CU-F□□A-□GS incorporates a voltage fluctuation compensation function which automatically corrects the reference value if the supply voltage fluctuates.



Note:
1. The dotted lines indicate the line conductors passing through the windows of the current transformers.
2. The current flowing into the gate circuit (between G+ and G–) is as follows:
   Approximately 1.4 mA at 5 VDC
   Approximately 3.4 mA at 12 VDC
   Approximately 6.7 mA at 24 VDC
3. When using a K2CU which has the model number suffix "GS" (a model that incorporates gate input terminals), the control output of the temperature controller must be a voltage output type.

K2CU-F Series

When power is supplied to the heater (when the contactor is ON), a current flows through the wires to the heater elements. At the same time, a voltage is imposed on the power circuit of the K2CU-F.

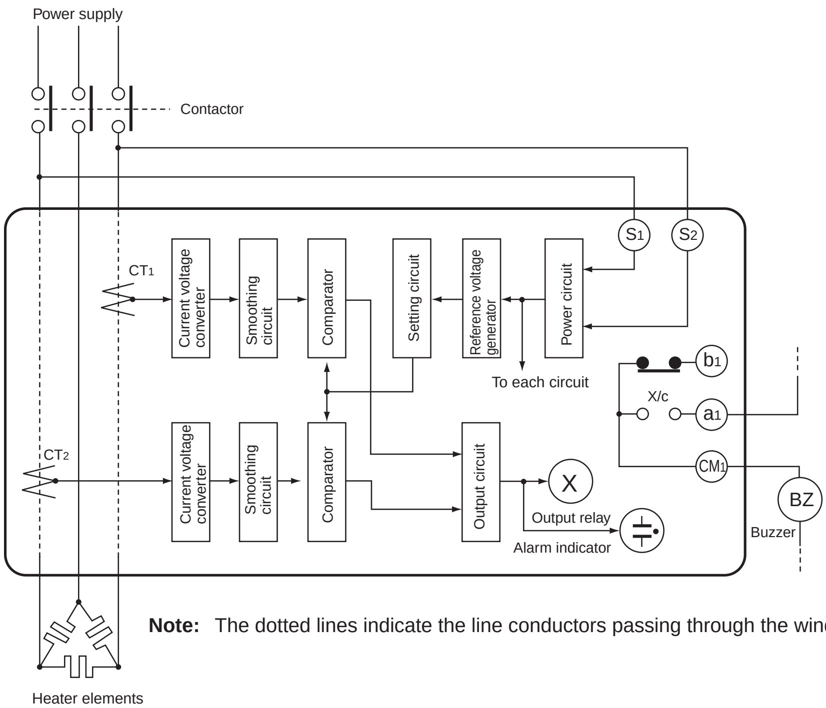
The current flowing to the heater wires is detected by the detector sections through each Current Transformer (CT) incorporated by the K2CU-F.

The current signals transmitted by the two CTs are sent to the current-voltage converters, smoothing circuits, and comparators as shown in the diagram.

The signal generated by the reference voltage generator is sent to the setting circuit to provide a reference value. The reference value is sent to the comparators. Each comparator compares its heater element current input and the reference value. If the input is lower than the reference value, a signal is sent to the output circuit.

There are two detector sections operating independently. If either of the input signals from the CTs is lower than the reference value, the output relay and alarm indicator will be activated.

The K2CU-F incorporates a voltage fluctuation compensation function which automatically corrects the reference value if the supply voltage fluctuates.

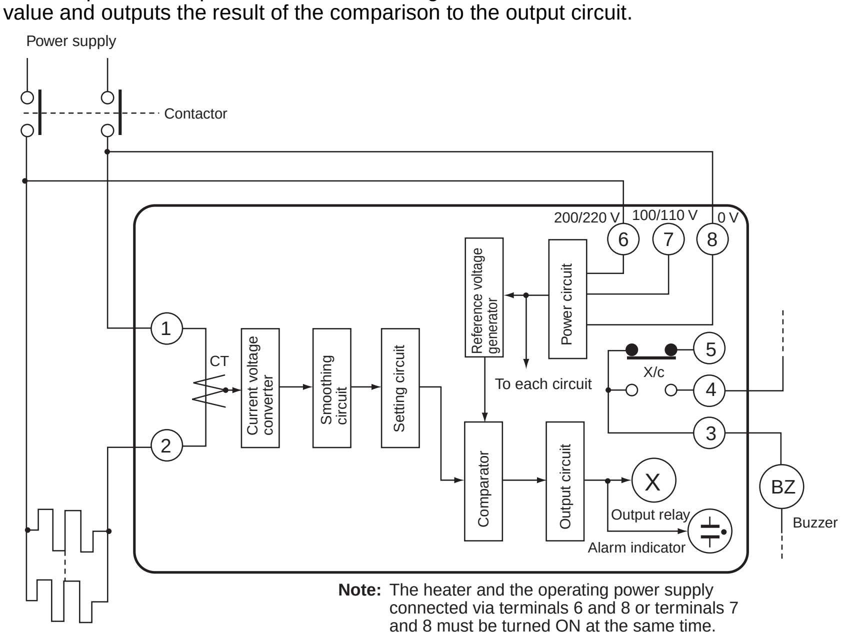


Note: The dotted lines indicate the line conductors passing through the windows of the current transformers.

K2CU-P Series

The K2CU-P operates basically in the same way as the K2CU-F.

The comparator compares external current signals and the reference value and outputs the result of the comparison to the output circuit.



Note: The heater and the operating power supply connected via terminals 6 and 8 or terminals 7 and 8 must be turned ON at the same time.

Setting of Operating Current

Use the potentiometer on the front panel to set the operating current.

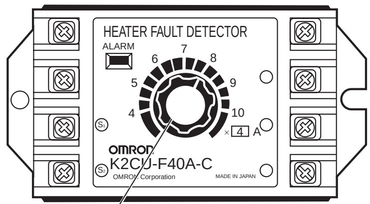
Rotate the knob to set the desired current value at which the Heater Burnout Detector should operate. Do not exceed the maximum and minimum positions.

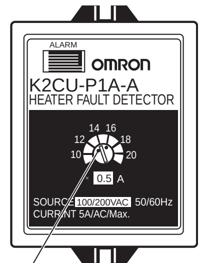
The K2CU-F's scale is divided into 12 graduations including sub-graduations and the K2CU-P's scale is divided into 5 graduations.

The knobs of the K2CU-F and K2CU-P as shown in the illustrations are set to 32 A and 0.7 A respectively.

The set operating current is defined as the mean value of the heater current under normal operating conditions and the heater current under a burnout or abnormal condition.

$$\text{Set value} = \frac{\text{Normal current + abnormal current}}{2}$$





Heater Connection and Current

The following table shows the different connections possible. The formula under each illustration indicates the electrical current value of the heater elements under normal and abnormal conditions.

Phase		Normal condition	Abnormal condition	
Single phase		5 A, 200 V, 1 kW	0 A, 200 V	
Three phase	Delta network	$(5\text{ A} \times \sqrt{3})$	$(5\text{ A} \times \sqrt{3} \times \frac{\sqrt{3}}{2})$	$(5\text{ A} \times \sqrt{3} \times \frac{1}{\sqrt{3}})$
	Star network	$(5\text{ A} \times \frac{1}{\sqrt{3}})$	$(5\text{ A} \times \frac{1}{\sqrt{3}} \times \frac{\sqrt{3}}{2})$	$(5\text{ A} \times \frac{1}{\sqrt{3}} \times \frac{\sqrt{3}}{2})$
	V network	$(5\text{ A} \times \sqrt{3} = 8.7\text{ A})$	$(5\text{ A} \times \frac{1}{2})$	$(5\text{ A} \times 1)$

Note: Values in this table are correct when a 200 VAC, 1 kW heater is used on a single-phase or three-phase current.

■ Operation Check

K2CU-F□□A-□GS

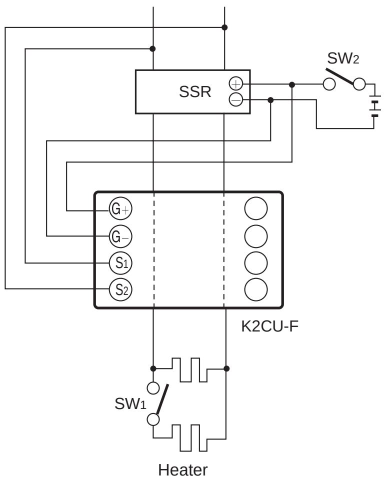
The operation of the heater burnout detector can be easily checked as follows:

In a Single-phase Circuit

Set the operating current to be 0.6 to 0.55 times the heater current.

Close the SW_2 with switch SW_1 turned on. Confirm that the alarm indicator remains off.

Turn off SW_1 and confirm that the alarm indicator comes on, and that the output relay operates.



In a Three-phase, Delta Network

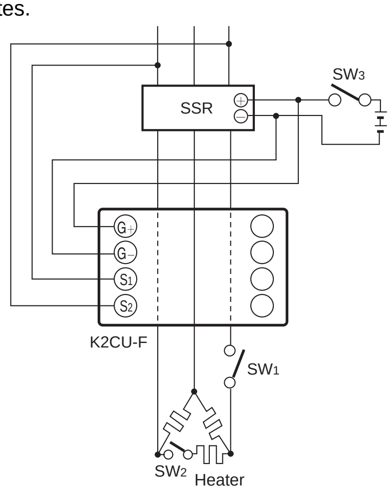
Set the operating current to be 0.6 times the heater current.

Close the SW_3 with switches SW_1 and SW_2 turned on. Confirm that the alarm indicator remains off.

Turn off SW_2 and confirm that the alarm indicator comes on, and that the output relay operates.

Turn on SW_1 set the operating current to be 0.9 times the heater current, and confirm that the alarm indicator goes off and the output relay releases.

Turn off SW_1 and confirm that the alarm indicator comes on, and that the output relay operates.

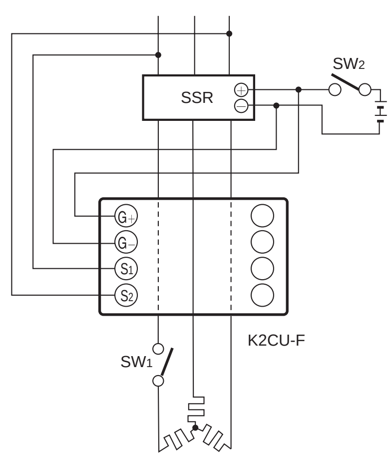


In a Three-phase, Star Network

Set the operating current to be 0.9 times the heater current.

Close the SW_2 with switch SW_1 turned on. Confirm that the alarm indicator remains off.

Turn off SW_1 and confirm that the alarm indicator comes on, and that the output relay operates.

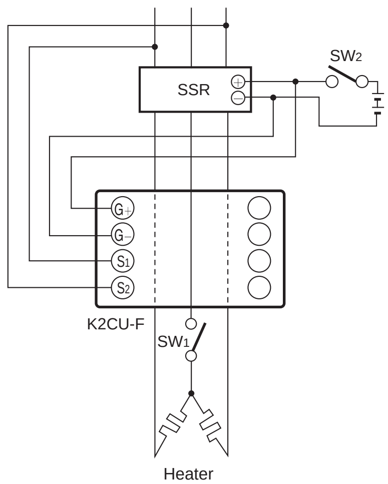


In a Three-phase, V Network 1

Set the operating current to be 0.3 to 0.35 times the heater current.

Close the SW_2 with switch SW_1 turned on. Confirm that the alarm indicator remains off.

Turn off SW1 and confirm that the alarm indicator comes on, and that the output relay operates.

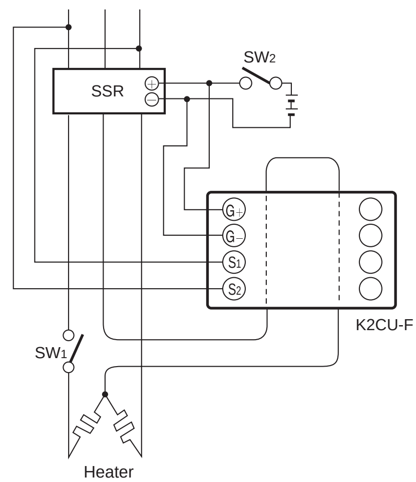


In a Three-phase, V Network 2

Set the operating current to be 0.6 times the heater current (of the phase connected between terminals 1 and 2, or the one passed through the window of the window-type Current Transformer of the heater burnout detector).

Close the SW_2 with switch SW_1 turned on. Confirm that the alarm indicator remains off.

Turn off SW1 and confirm that the alarm indicator comes on, and that the output relay operates.



K2CU-F, K2CU-P

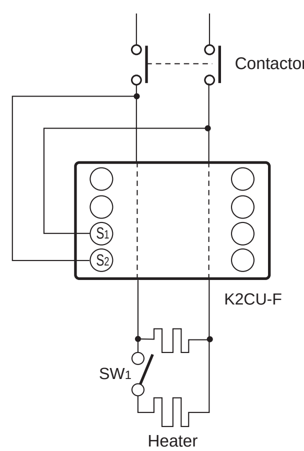
The operation of the heater burnout detector can be easily checked as follows:

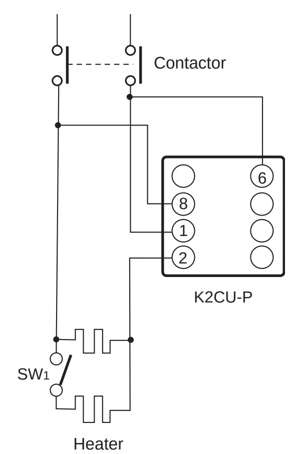
In a Single-phase Circuit

Set the operating current to be 0.55 to 0.6 times the heater current.

Close the contactor with switch SW_1 turned on. Confirm that the alarm indicator remains off.

Turn off SW_1 and confirm that the alarm indicator comes on, and that the output relay operates.





In a Three-phase, Delta Network

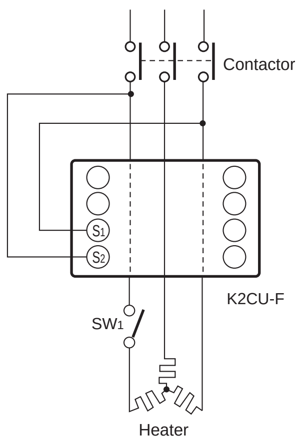
Set the operating current to be 0.6 times the heater current.

Close the contactor with switches SW_1 and SW_2 turned on. Confirm that the alarm indicator remains off.

Turn off SW_2 and confirm that the alarm indicator comes on, and that the output relay operates.

Turn on SW_1 set the operating current to be 0.9 times the heater current, and confirm that the alarm indicator goes off and the output relay releases.

Turn off SW_1 and confirm that the alarm indicator comes on, and that the output relay operates.

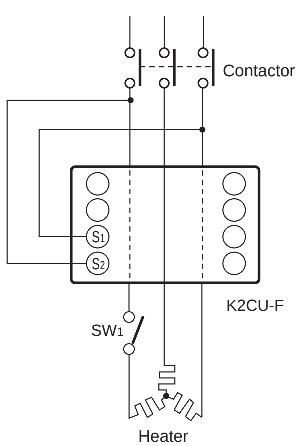


In a Three-phase, Star Network

Set the operating current to be 0.9 times the heater current.

Close the contactor with switch SW_1 turned on. Confirm that the alarm indicator remains off.

Turn off SW_1 and confirm that the alarm indicator comes on, and that the output relay operates.

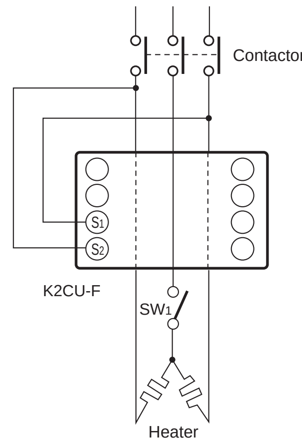


In a Three-phase, V Network 1

Set the operating current to be 0.3 to 0.35 times the heater current.

Close the contactor with switch SW_1 turned on. Confirm that the alarm indicator remains off.

Turn off SW1 and confirm that the alarm indicator comes on, and that the output relay operates.



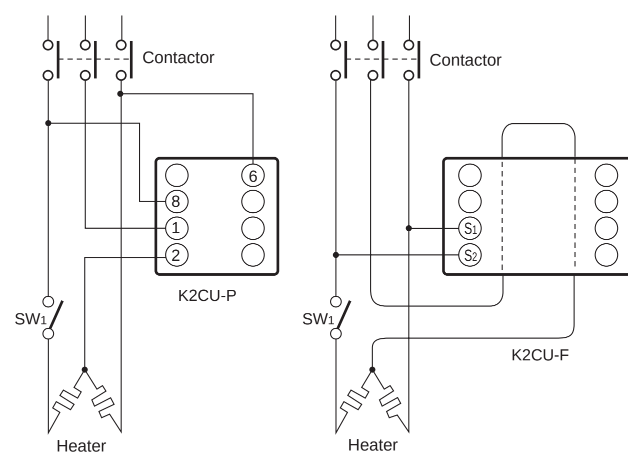
In a Three-phase, V Network 2

Set the operating current to be 0.6 times the heater current (of the phase connected between terminals 1 and 2, or the one passed through the window of the window-type Current Transformer of the heater burnout detector).

Close the contactor with switch SW_1 turned on. Confirm that the alarm indicator remains off.

Turn off SW1 and confirm that the alarm indicator comes on, and that the output relay operates.

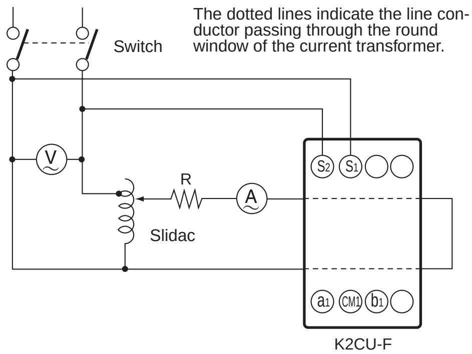
K2CU-P **K2CU-F**



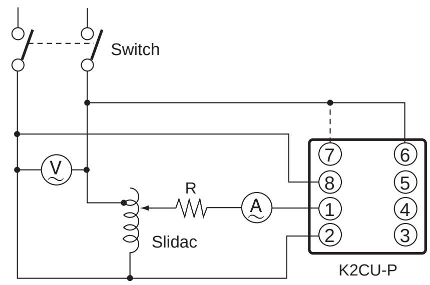
■ Test Circuit

To check the operation in detail, use the following circuit.

K2CU-F



K2CU-P

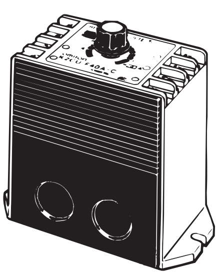


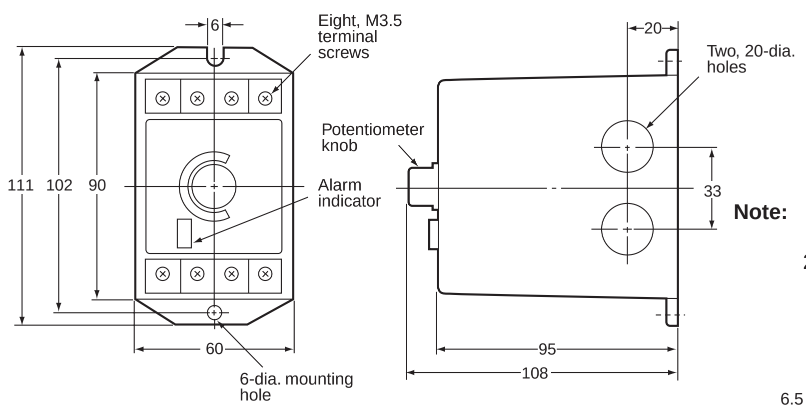
Note: Determine the value of R according to the specifications of the K2CU to be used. The dotted line indicates the connection at a supply voltage of 100 or 110 VAC.

Dimensions

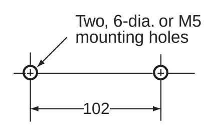
Note: All units are in millimeters unless otherwise indicated.

K2CU-F

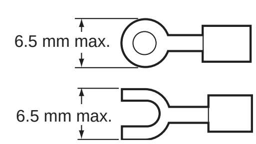




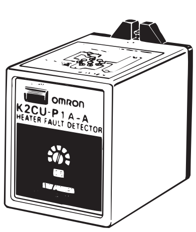
Mounting Holes

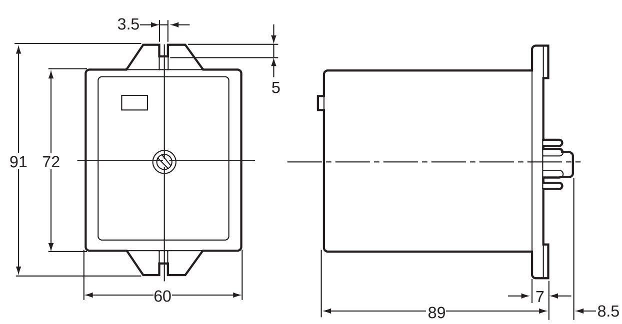


Note: 1. Install the K2CU-F on a flat surface.
2. When solderless terminal lugs are desired, use ones having an outer diameter of 6.5 mm maximum.

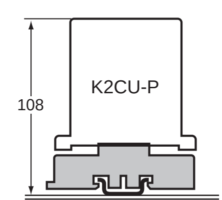


K2CU-P





Connecting Socket



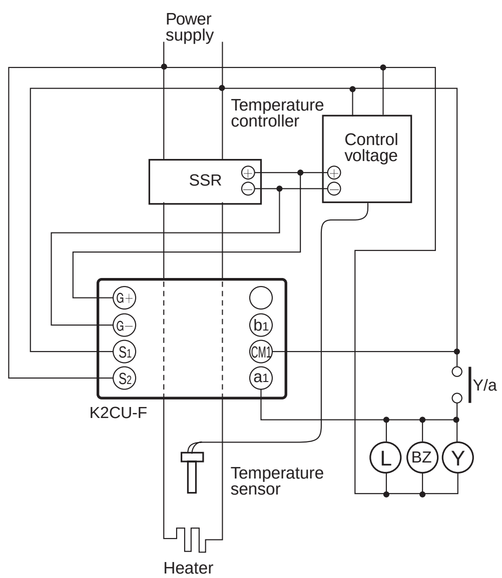
8PFA1 (order separately)

Installation

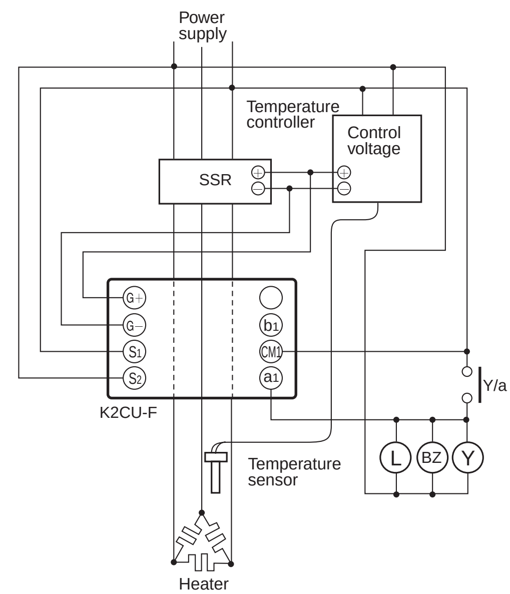
■ External Connections

K2CU-F□□A-□GS

Single-phase Heater

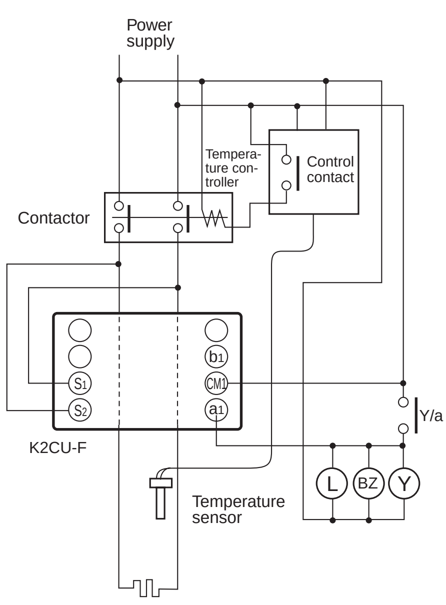


Three-phase Heater

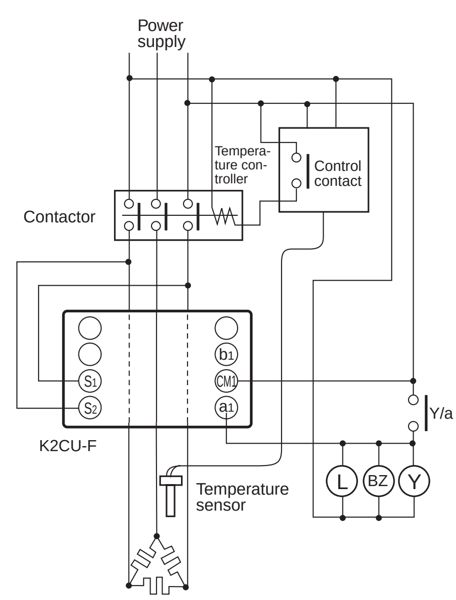


K2CU-F

Single-phase Heater



Three-phase Heater

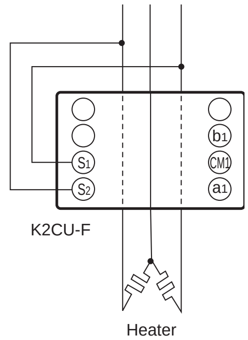


Note: 1. The dotted lines which pass through the heater burnout detector indicate the line conductor passing through the round "window" of the window-type Current Transformer.

2. Y: External relay for self-holding circuit
BZ: Alarm buzzer
L: Alarm indicator

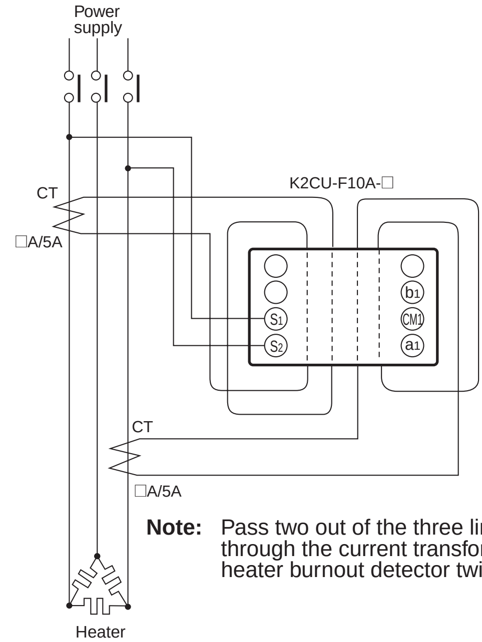
3. To use a 100 (110) VAC control power supply with K2CU-P, connect it to terminal 7 instead of 6.

Three-phase, V-connected Heater



Note: The dotted lines which pass through the heater burnout detector indicate the line conductor passing through the round “window” of the window-type Current Transformer.

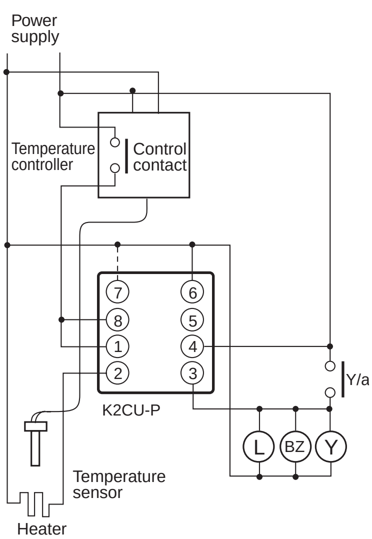
With External Current Transformer



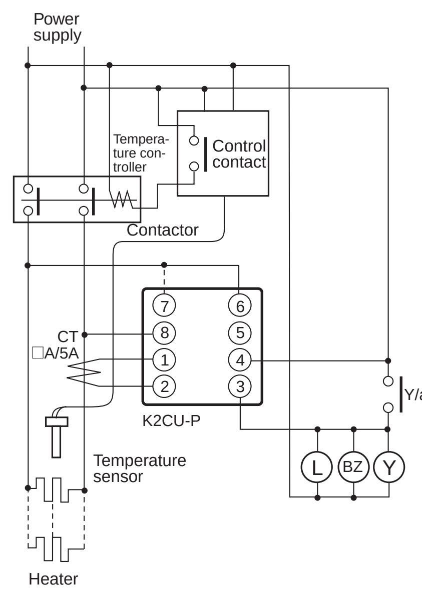
Note: Pass two out of the three line conductors through the current transformers of the heater burnout detector twice as shown.

K2CU-P Small-capacity, Plug-in Models

Small-capacity Heater



With External Current Transformer



Note: 1. The dotted lines which pass through the heater burnout detector indicate the line conductor passing through the round “window” of the window-type Current Transformer.

2. Y: External relay for self-holding circuit
BZ: Alarm buzzer
L: Alarm indicator

3. To use a 100 (110) VAC control power supply with K2CU-P, connect it to terminal 7 instead of 6.

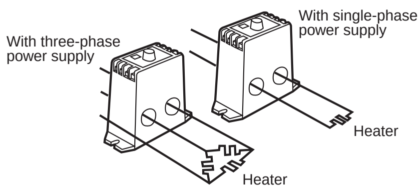
Precautions

K2CU-F□□A-□GS

Use the K2CU-F□□A-□GS (with gate input terminals) in combination with a temperature controller that has PID with feed-forward circuitry to control the heater temperature, in which case, the heater element(s) must be turned ON or OFF for 0.1 s or longer.

K2CU-F

When a single-phase heater is used, pass the two lines through the openings of the heater burnout detector. When a three-phase heater is used, pass two (phases) of the three lines through the openings. In either case, if only one line passes through, an alarm signal will always be produced.



Pass the lines through the openings only once. If they are passed more than once, the actual operating current will be less than the set current. The lines can be passed in either direction.

To use the heater burnout detector at a current less than the current range that can be set, the lines must be passed more than once. Determine the number of times the lines should be passed by the following equation:

(Operating current) x n = Current setting range

where,
n: number of times the lines loop through the window

All K2CU-F models incorporate a voltage fluctuation compensation function.

K2CU-P

The K2CU-P can be used only in single-phase circuits.

Do not pull out the K2CU-P from the socket when the K2CU-P is energized. Especially when using it in combination with a Current Transformer commercially available, this practice causes the secondary circuit of the transformer to open, which is very dangerous.

General

Refer to “*External Connections*” before using the K2CU with external CTs.

When a temperature controller is used in combination with the K2CU (except for the K2CU-F□□A-□GS), the heater element(s) must be turned ON or OFF for 1 s or longer (although the heater element(s) can be turned ON for 0.5 s according to the specifications).

The K2CU cannot be used with a phase-control circuit, inverter circuit, frequency-count circuit, cycle-control unit, or a motor load.

Mounting

Securely mount the K2CU as horizontally as possible although there is no particular limitation of mounting directions.

Connection

Solderless-type terminal must be connected to the terminals securely.

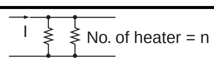
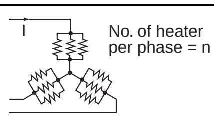
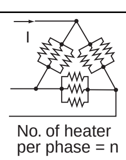
Wire the terminals correctly by referring to the external connections. The terminals have no polarity. Be sure to connect 100 (or 110) V to the 100-V (or 110-V) terminals and 200 (or 220) V to the 200-V (or 220-V) terminals of the K2CU-P or the K2CU-P may malfunction.

The control power source for the K2CU (except for the K2CU-F□□A-□GS) must be supplied from the load side via a contactor.

Be sure to impose a voltage between the 0-V terminal and 100-V (or 110-V) terminal or the 0-V terminal and 200-V (or 220-V) terminal of the K2CU-P, otherwise the K2CU-P will not operate.

Operating Current Setting when Several Heaters are Used

The following table shows relative values of changes in the current when any one of several heaters connected in parallel has burned out. The current value under normal condition is 1. Use this table as a guideline in determining the operating current.

Connection		n = 1	n = 2	n = 3	n = 4	n = 5
		0	0.5	0.67	0.75	0.8
	Current in burned-out phase	0	0.6	0.75	0.82	0.86
	Current in other phases	0.87	0.92	0.95	0.96	0.97
	Current in burned-out phase	0.58	0.77	0.84	0.88	0.91
	Current in other phases	1	1	1	1	1

Note: 1. This table shows the respective change rates in current when any one of several heaters connected in parallel has burned out.

2. The current value under the normal condition is 1.

3. The values in this table are logical values. Actually, these values may vary slightly because of influence of unbalanced loads (heaters). It is therefore recommended to test the actual current values and the load condition before determining the operating current, especially when the current under the normal condition and that under an abnormal condition do not significantly differ.

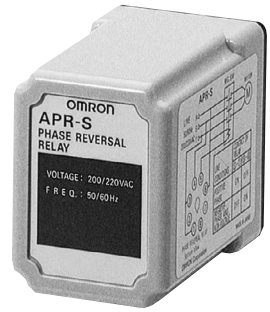
ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N039-E1-03
In the interest of product improvement, specifications are subject to change without notice.

Reverse Protection Relay
APR-S

Uses Voltage Detection to Determine Reverse Revolution of Three-phase Motor

- Detects motor reversal due to incorrect wiring.
- Direction of motor revolution is detected as soon as power is applied to the Relay. If the power is reversed, the magnetic contactor locks in the open state.
- The magnetic contactor can also be wired to protect it from being closed in open phase.
- Small, plug-in Relay that needs no adjustment.
- Uses voltage detection method to operate independently of load current.



APR-S (200 V)

APR-S380 (380/400 V)
APR-S440 (440 V)

Model Number Structure

■ Model Number Legend

APR-S□
1 2

1. **Reverse Protection Relay**

2. **Control Power Supply Voltage**
   None: 200/220 VAC
   380: 380/400 VAC
   440: 440 VAC

Ordering Information

■ List of Models

Part number	APR-S

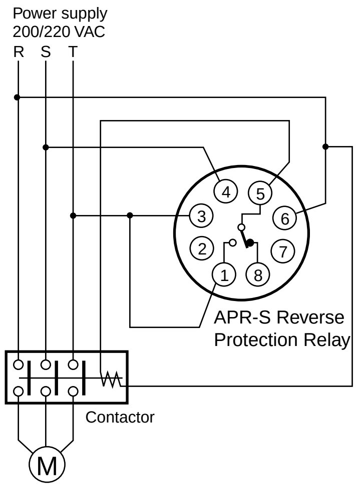
Specifications

■ Ratings/Characteristics

Type	APR-S	APR-S380	APR-S440
Supply voltage	3-phase, 200/220 VAC, 50/60 Hz	3-phase, 380/400 VAC, 50/60 Hz	3-phase, 440 VAC, 50/60 Hz
Operating voltage range	170 to 240 VAC	350 to 420 VAC	410 to 460 VAC
Operate time	100 ms max. (from power application to detection of motor direction)		
Control output	1.1 A at 200 VAC, cosϕ = 1, SPDT 2 A at 115 VAC, cosϕ = 1 0.6 A at 200 VAC, cosϕ = 0.4 1.2 A at 115 VAC, cosϕ = 0.4	1.1 A at 250 VAC, cosϕ = 1, SPDT 0.6 A at 250 VAC, cosϕ = 0.4	
Insulation resistance	100 MΩ min. (at 500 VDC)		
Dielectric strength	2,000 VAC, 50/60 Hz for 1 min		
Shock	Malfunction: 98 m/s^2 (approx. 10 G)		
Ambient temperature	–10 to 50 °C		
Life expectancy	Mechanical: 1,000,000 operations min. Electrical: 100,000 operations min.		
Weight	Approx. 100 g		

Connections

To Detect Reverse Phase or Open Phase

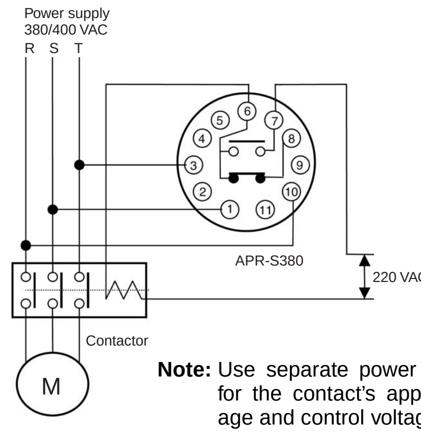


Operation

- Suppose the motor revolves in the forward direction when the input terminals ⑥, ④, and ③ of the APR-S are connected, in this sequence, to the power lines. The APR-S Relay turns ON when the phase sequence of the voltage is in the forward direction, that is, when the power lines R, S, and T are energized in this sequence. When the Relay turns ON, terminals ⑤ and ① conduct, energizing the contactor. If one of the three phases is reversed, the Relay does not turn ON and the contactor is not energized.
- To protect the motor from damage due to open phase, the wiring must be performed in exactly the same way as shown in this figure (i.e., so that the phase connecting the contactor coil is not the same as the phase connecting terminal ④ of the Relay).
  If phase R or T is open, the contactor does not operate because one side of its coil is not energized. If phase S (connected to terminal ④ of the Relay) opens, the Relay does not turn ON, allowing no current flow between terminals ⑤ and ①. The contactor therefore does not operate.
  Note, however, that the contactor is prevented from operating by preventing an open-phase voltage from flowing into the motor and not by the open-phase protection feature of the Relay.

Note: Open-phase detection is only possible when a 200/220-VAC APR-S is used with the wiring exactly the same as shown in the above diagram.

To Switch to Reverse Phase



Note: Use separate power supplies for the contact's applied voltage and control voltage.

Operation

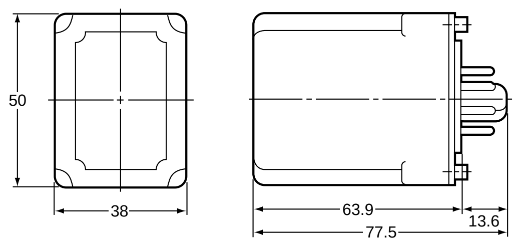
- Suppose the motor revolves in the forward direction when the input terminals ⑩, ①, and ③ of the APR-S are connected, in this sequence, to the power lines R, S, and T, respectively. The APR-S Relay turns ON when the phase sequence of the current is in the forward direction, that is, when the power lines R, S, and T are energized in this sequence. When the Relay turns ON, terminals ⑥ and ⑦ conduct, energizing the contactor. If one of the three phases is reversed, the Relay does not turn ON, and terminals ⑥ and ⑦ do not conduct, but a current flows between terminals ⑥ and ⑧, energizing the reverse-phase contactor.

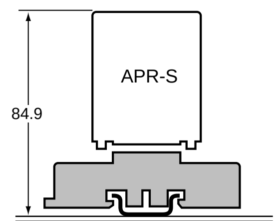
Note: Open-phase detection is not possible.

Accessories (Order Separately)

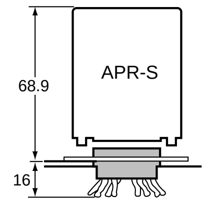
■ Dimensions

APR-S



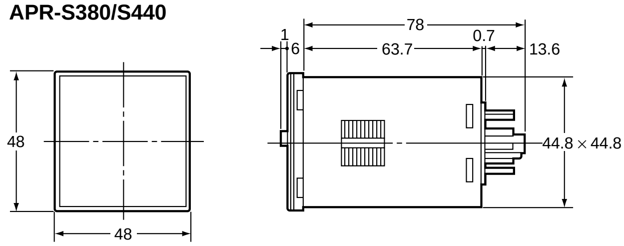


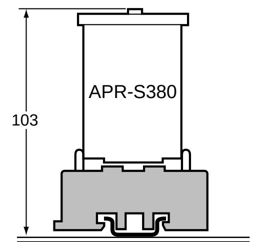
PF083A (Order separately)



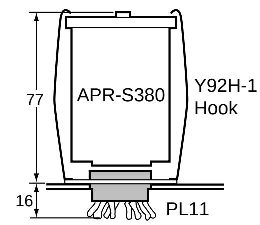
PL08 (Order separately)

APR-S380/S440





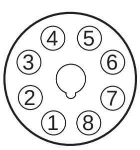
P2CF-11 (Order separately)



PL11
(Order separately)

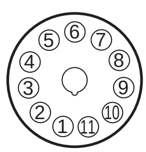
■ Terminal Arrangement

APR-S



(Bottom View)

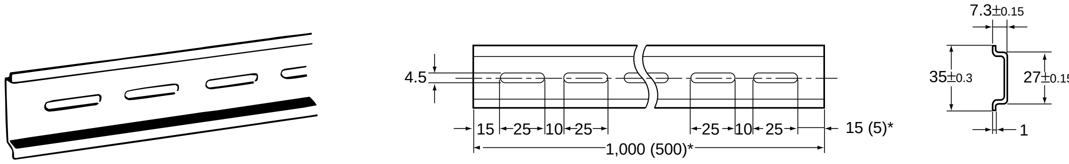
APR-S380/S440



(Bottom View)

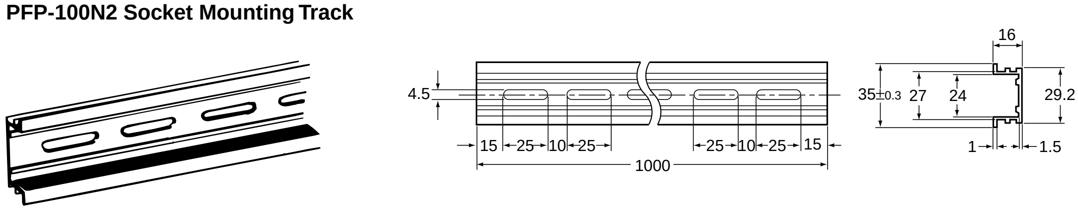
Accessories for Track Mounting

PFP-100N/PFP-50N Socket Mounting Track

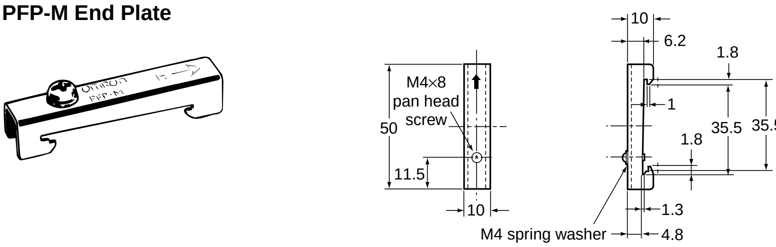


* The dimensions given in parentheses are for the PFP-50N Socket Mounting Track.

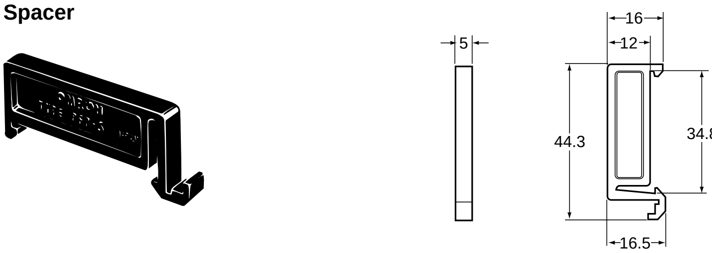
PFP-100N2 Socket Mounting Track



PFP-M End Plate



Spacer



Precautions

Correct Use

Mounting

- When using a Back Connecting Socket, mount the Socket on a panel (1 to 4 mm thick) with screws. The grooves on the Socket must face down. Then insert the Relay through the cutout on the panel into the Socket.
- When mounting the Relay with a Front Connecting Socket, first mount the Socket on a panel with screws. Then insert the Relay through the cutout on the panel into the Socket.
- Use the Holding Brackets to secure the Relay to either a Front or Back Connecting Socket.

Notes on Use

- The APR-S prevents an open-phase voltage from flowing into the motor only when the wiring shown in *To Detect Reverse Phase or Open Phase* under *Connections* is performed and then power is turned ON. It cannot detect an open phase while the motor is being driven. To detect an open phase while the motor is being driven, use the SE Motor Protective Relay.
- When power is turned ON, open-phase detection is possible only on the power supply side of the APR-S. Open-phase detection is not possible on the load side.
- The APR-S cannot detect incorrect wiring of the magnetic contactor.

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N124-E1-01

Voltage Sensor SDV

Overvoltage/Undervoltage Monitoring Relay for AC and DC Input

- Detect overvoltages or undervoltages (switch selectable) from 4 mV to 300 V.
- Detect undercurrent, reverse current, or overcurrent in DC circuits using shunt (SDV-FL).
- Detect three-phase AC current for under and/or overcurrent using current converter.
- Available in 7 supply voltage configurations.
- Single-function model with ON-delay, OFF-delay, or startup lock settings (SDV-FH☐T).
- Select either AC or DC voltage input.
- Polarity can be specified (SDV-FL) to enable easy reverse current detection.
- Selectable reset value range from 2% to 30% of operating value (SDV-F).
- LED operation indicator.
- UL/CSA approval (single-function models).

Model Number Structure

■ Model Number Legend

SDV-☐☐☐☐☐
1 2 3 4 5 6

1. **Voltage Sensor**
2. **Operation**
   F: Single-function (overvoltage or undervoltage detection)
   D: Dual-function (overvoltage and undervoltage detection)
3. **Operating Voltage Range**
   L: 4 to 240 mV (DC input only) (For SDV-F only)
   M: 0.2 to 12 V (AC or DC input)
   H: 10 to 300 V (AC or DC input)

4, 5. Control Power Supply Voltage
- 1: 12 VDC
- 2: 24 VDC
- 3: 48 VDC
- 4: 100/110 VDC
- 5: 125 VDC
- 51: 200/220 VDC (Single-function models)
- 6: 100/110 VAC
- 61: 120 VAC (Single-function models)
- 7: 200/220 VAC
- 71: 240 VAC (Single-function models)

6. **Timing Function (SDV-FH Only (See Note))**
   None: Not provided
   T: Provided

Note: SDV-FL and SDV-FM models can also be equipped with the timing function as a special specification. Ask your OMRON representative for details.

Note: Not possible for the SDV equipped with the timing function (SDV-FH☐T).

SDV-SH □□□□ (Order Separately)
1 2 3 4 5

1. Shunt (For SDV-FL Only)

2, 3, 4, 5. Rated Current

Available Models

Rated current	Rated voltage	Model	Rated current	Rated voltage	Model
5 A	60 mV	SDV-SH5	75 A	60 mV	SDV-SH75
7.5 A		SDV-SH7.5	100 A		SDV-SH100
7.5 A	100 mV	SDV-SH7.5	150 A		SDV-SH150
10 A	60 mV	SDV-SH10	200 A		SDV-SH200
15 A		SDV-SH15	300 A		SDV-SH300
20 A		SDV-SH20	500 A		SDV-SH500
30 A		SDV-SH30	750 A		SDV-SH750
50 A		SDV-SH50	1,000 A		SDV-SH1000

Note: All the above listed shunts have an accuracy in the 1.0 class.

Ordering Information

Single-function Models

Overvoltage or Undervoltage Detection (Switch Selectable)

Control power supply voltage	Input		
	DC	DC or AC (selectable)	
	Input voltage range		
	4 to 240 mV	0.2 to 12 V	10 to 300 V
12 VDC	SDV-FL1	SDV-FM1	SDV-FH1
24 VDC	SDV-FL2	SDV-FM2	SDV-FH2
48 VDC	SDV-FL3	SDV-FM3	SDV-FH3
100/110 VDC	SDV-FL4	SDV-FM4	SDV-FH4
125 VDC	SDV-FL5	SDV-FM5	SDV-FH5
200/220 VDC	---	---	SDV-FH51
100/110 VAC	SDV-FL6	SDV-FM6	SDV-FH6
120 VAC	---	---	SDV-FH61
200/220 VAC	SDV-FL7	SDV-FM7	SDV-FH7
240 VAC	---	---	SDV-FH71

Dual-function Models

Overvoltage and Undervoltage Detection

Control power supply voltage	Input: DC or AC (selectable)	
	Input voltage range	
	0.2 to 12 V	10 to 300 V
12 VDC	SDV-DM1	SDV-DH1
24 VDC	SDV-DM2	SDV-DH2
48 VDC	SDV-DM3	SDV-DH3
100/110 VDC	SDV-DM4	SDV-DH4
125 VDC	SDV-DM5	SDV-DH5
100/110 VAC	SDV-DM6	SDV-DH6
200/220 VAC	SDV-DM7	SDV-DH7
240 VAC	SDV-DM71	SDV-DH71

Note: 1. Inquire about production of models with 120- and 240-VAC control power supply.
2. Inquire about models with special processing for high-temperature, high-humidity applications.
3. The ripple factor must be 5% or less for DC power supplies.

Single-function Models with Timing Function

Control power supply voltage	Input: DC or AC (selectable); input voltage range: 10 to 300 V		
	Operating mode		
	ON-delay	OFF-delay	Startup lock
12 VDC	SDV-FH1T		
24 VDC	SDV-FH2T		
48 VDC	SDV-FH3T		
100/110 VDC	SDV-FH4T		
125 VDC	SDV-FH5T		
200/220 VDC	SDV-FH51T		
100/110 VAC	SDV-FH6T		
120 VAC	SDV-FH61T		
200/220 VAC	SDV-FH7T		
240 VAC	SDV-FH71T		

Note: SDV-FL and SDV-FM models can also be equipped with the timing function as a special specification. Ask your OMRON representative for details.

Specifications

Single-function Models

Overvoltage or Undervoltage Detection (Switch Selectable)

Model	Input voltage	Selectable operating range	Selectable reset value range	Control power supply
SDV-FL☐	DC	4 to 240 mV (4 to 12 mV, 10 to 30 mV, 20 to 60 mV, 40 to 120 mV, 80 to 240 mV)	2% to 30% (related to operating value)	12, 24, 48, 100/110, 125, 200/220 VDC (see note); 100/110, 200/220/240 VAC (50/60 Hz)
SDV-FM☐	DC or AC (selectable)	0.2 to 12 V (0.2 to 0.6 V, 0.5 to 1.5 V, 1 to 3 V, 2 to 6 V, 4 to 12 V)		
SDV-FH☐ SDV-FH☐T		10 to 300 V (10 to 30 V, 25 to 75 V, 50 to 150 V, 100 to 300 V)		

Note: Ripple is 5% max. with DC power supplies.

Dual-function Models

Overvoltage and Undervoltage Detection

Model	Input voltage	Selectable operating range			Reset value	Control power supply
		Intermediate voltage of dead band		Dead band voltage		
SDV-DM☐	DC or AC (selectable)	0.2 to 12 V	0.2 to 0.6 V	0.02 to 0.1 V	Overvoltage: (Intermediate voltage of dead band + dead band voltage) – (dead band voltage x 2/3) min. Undervoltage: (Intermediate voltage of dead band – dead band voltage) + (dead band voltage x 2/3) max.	12, 24, 48, 100/110, 125 VDC; 100/110, 200/220/240 VAC (50/60 Hz)
			0.5 to 1.5 V	0.05 to 0.25 V		
			1 to 3 V	0.1 to 0.5 V		
			2 to 6 V	0.2 to 1 V		
			4 to 12 V	0.4 to 2 V		
SDV-DH☐		10 to 300 V	10 to 30 V	1 to 5 V		
			25 to 75 V	2.5 to 12.5 V		
			50 to 150 V	5 to 25 V		
			100 to 300 V	10 to 50 V		

Note: **1.** Inquire about production of models with 120- and 240-VAC control power supply.
2. The ripple factor must be 5% or less for DC power supplies.

Ratings

Item	SDV-FL□	SDV-FM□	SDV-FH□/FH□T	SDV-DM□	SDV-DH□
Allowable continuous input overvoltage range	±10 VDC	±150 VDC 150 VAC	±350 VDC (±500 VDC for 1 min) 350 VAC (500 VAC for 1 min)	±150 VDC 150 VAC	±350 VDC (±500 VDC for 1 min) 350 VAC (500 VAC for 1 min)
Input impedance	1 kΩ	50 kΩ	2,500 kΩ	50 kΩ	2,500 kΩ
Control output	SPDT			SPST-NO and SPST-NC	
	Rated load:5 A at 220 VAC (cosϕ = 1), 5 A at 24 VDC (cosϕ = 1), 2 A at 220 VAC (cosϕ = 0.4), 2 A at 24 VDC (L/R = 7 ms) Max. contact voltage: 250 VAC, 125 VDC Max. contact current: 5 A Max. switching capacity:1,100 VA (cosϕ = 1), 120 W (cosϕ = 1), 440 VA (cosϕ = 0.4), 48 W (L/R = 7 ms)				
Power consumption	DC: 5 W max.; AC: 5 VA max.				
Ambient temperature	–10°C to 55°C (with no icing)				
Control supply voltage (see note)	12, 24, 48, 100/110, 125, 200/220 VDC; DC operating voltage range: 80% to 130% of control power supply 100/110/120, 200/220/240 VAC (50/60 Hz); AC operating voltage range: 85% to 110% of control power supply				

Note: The impedance value is a reference value; actual values may vary.

Characteristics

Item	SDV-F□□	SDV-FH□T	SDV-D□□
Operating value	100% operation for voltage setting		
Setting error	±2% of operating value		±2% of intermediate voltage of dead band, ±1% of dead band voltage
Operating time	0.5 s max. (see note)		
Influence of temperature	0°C to 40°C: ±2% max. of operating value (SDV-FL (operating value range: 4 to 12 mV) ±4% max. of operating value) –10°C to 0°C, 40°C to 55°C: ±4% max. of operating value (SDV-FL (operating value range: 4 to 12 mV) ±8% max. of operating value)		0°C to 40°C: ±2% max. of dead band voltage –10°C to 0°C, 40°C to 55°C: ±4% max. of dead band voltage
Influence of control power	±1% max. of operating value DC operating voltage range: 80% to 130% AC operating voltage range: 85% to 110%		±1% max. of dead band voltage DC operating voltage range: 80% to 130% AC operating voltage range: 85% to 110%
Influence of frequency (Input frequency changed from 10 to 500 Hz for AC input)	±1% max. of operating value		±1% max. of dead band voltage
Influence of waveform (For commercial frequency, single-phase, full-wave AC input)	±3% max. of operating value		±3% max. of dead band voltage
Insulation resistance	10 MΩ min. (at 500 VDC) between the entire electric circuitry and external case, and between the input terminal and power terminal		
Dielectric strength	2,000 VAC for 1 min between the entire electric circuitry and external case, and between the input terminal and power terminal		
Impulse withstand voltage	±1.2 x 50 µs, 4,500 V between the entire electric circuitry and external case ±1.2 x 50 µs, 3,000 V between power terminals		
Vibration resistance	Destruction: 10 to 25 Hz, 2-mm double amplitude (2G max.) for 2 hrs each in 3 directions Malfunction: 16.7 Hz, 1-mm double amplitude for 10 min each in 3 directions		
Shock resistance	Destruction: 294 m/s² (30G) Malfunction: 98 m/s² (10G)		
Weight	Approx. 290 g	Approx. 350 g	Approx. 310 g

Note: Overvoltage: Operation when voltage is changed from 80% to 120% of the operating value.
Undervoltage: Operation when voltage is changed from 120% to 80% of the operating value.

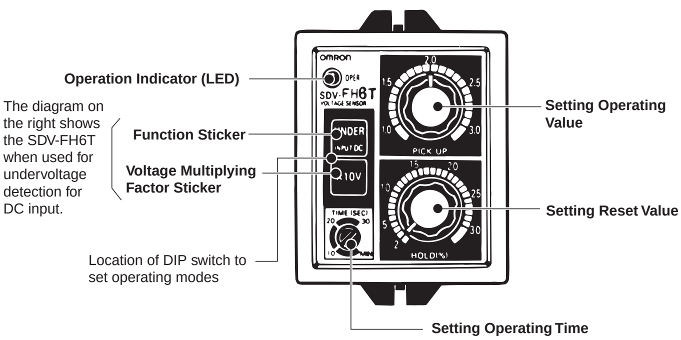
Timing Function

Item	SDV-FH☐T
Setting time	0.5 to 30.0 s (see note)
Operating time accuracy	±5% FS max.
Setting error	±15% FS max.
Reset time	5 s min.
Influence of temperature	±10% FS max.
Operating mode (set via DIP switch)	ON-delay, OFF-delay, Startup lock

Note: The time setting range when the startup lock is selected for the operating mode is approximately 1 to 30 s.

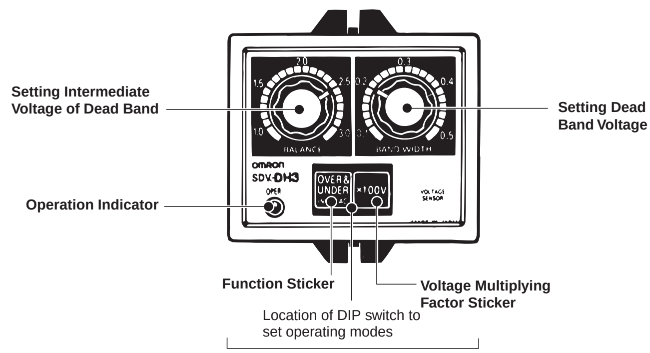
Nomenclature

SDV-F☐/-FH☐T



Note: The SDV-F☐ is not equipped with a time setting knob.

SDV-D☐



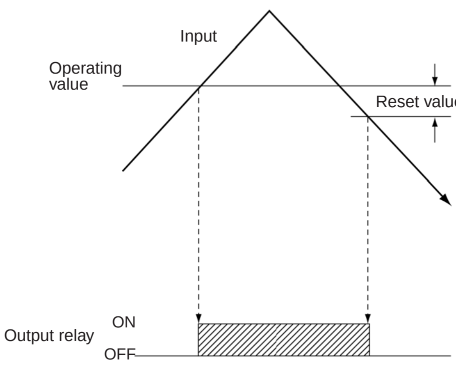
The diagram above shows the SDV-DH3 when used for AC input in the range 100 to 300 V.

Operation

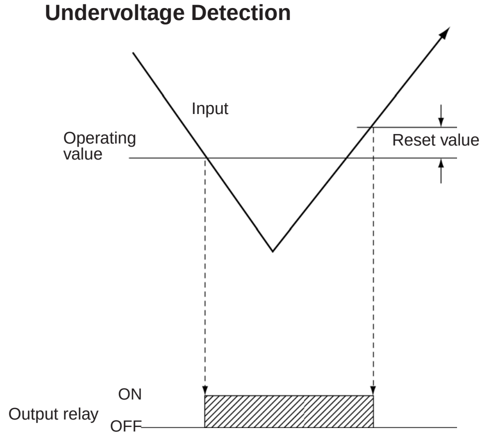
■ Timing Charts

Single-function Models

Overvoltage Detection



Undervoltage Detection



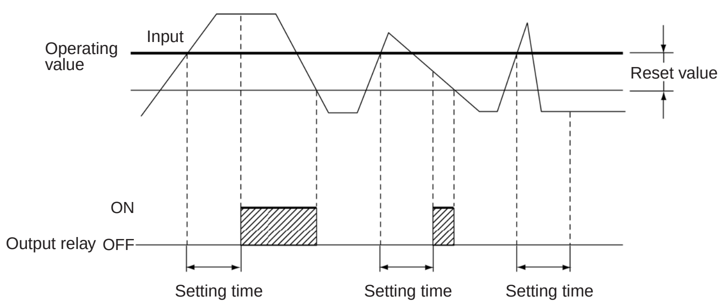
Note

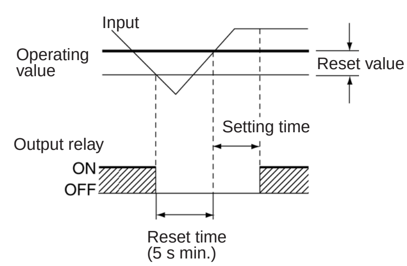
The reset time must be 5 s or longer to ensure accuracy of the timing operation.

Single-function Model with Timing Function

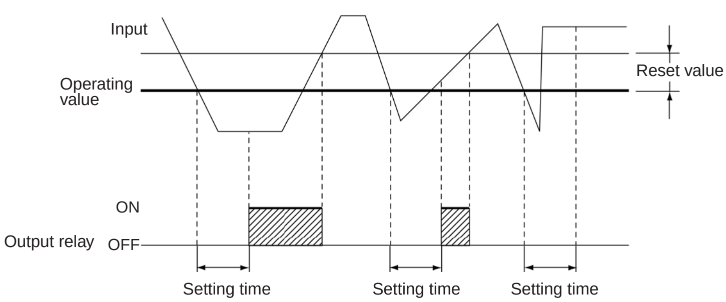
SDV-FH□T

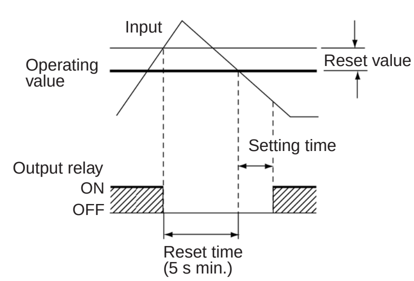
ON-delay Overvoltage Detection



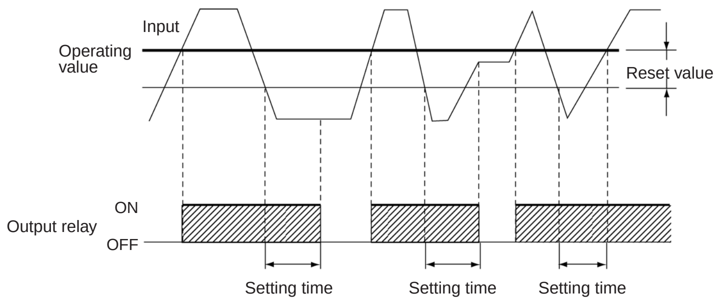


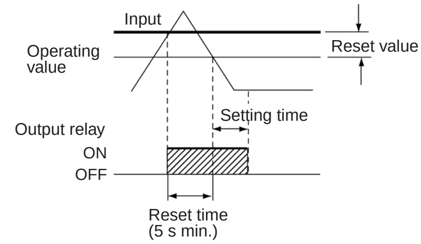
ON-delay Undervoltage Detection



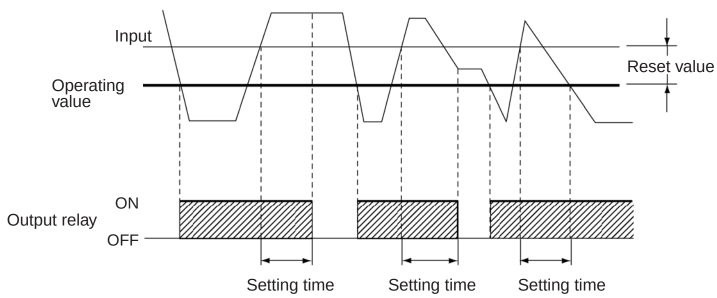


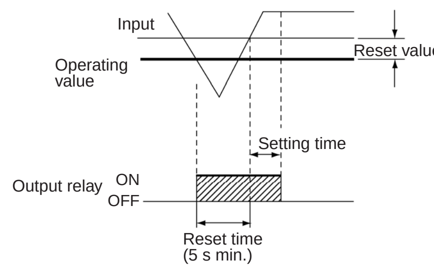
OFF-delay Overvoltage Detection



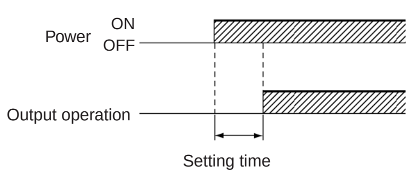


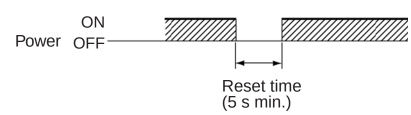
OFF-delay Undervoltage Detection





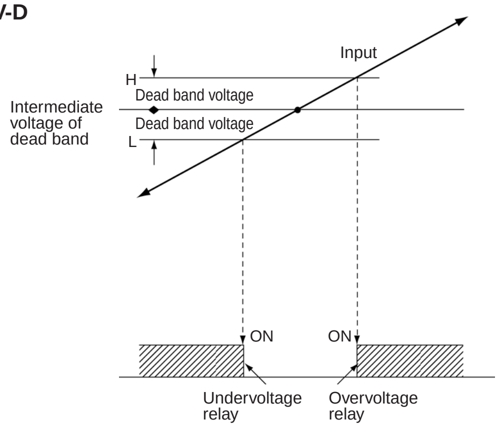
Startup Lock





Note: The output relays will be forced OFF from the control power supply is turned ON until the set time has expired.

Dual-function Models
SDV-D



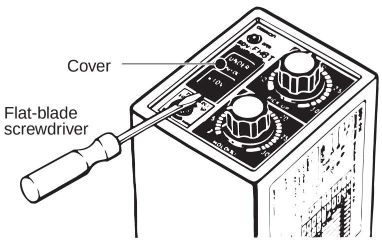
■ Setting

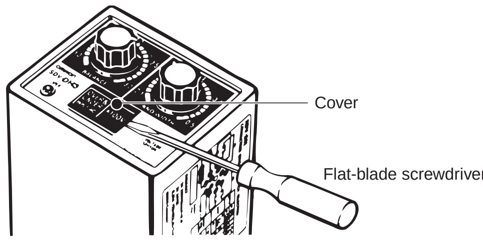
(Refer to *Examples of Mode Settings* for details on individual models.)

Set the desired values using the DIP switch and setting knobs on the front panel.

Opening the DIP Switch Cover

Remove the cover of the compartment containing the DIP switch for various mode settings, and then set the DIP switch according to the SWITCH SELECTION table affixed to the side of the voltage sensor.





Setting the DIP Switch

Set the DIP switch on the front panel for the required functions, operation inputs, and voltages. Set the switch to the top for ON settings and to the bottom for OFF settings.

- Function (SDV-F): Set to either overvoltage or undervoltage detection.
- Input: Set to either AC or DC input.
- Polarity (SDV-FL□ only): Set polarity or not to specify polarity.
  "8(+), 7(–)": Use polarity as shown for pin number.
  "FREE": Do not use polarity.
- Multiplying Factor: Set the voltage scale multiplying factor for the required operating voltage setting range.
- TIMER (SDV-FH□T): Select the timing function.
  Set ON-delay, OFF-delay, lock timer (start lock timer), or TIMER OFF.
  If TIMER OFF is set, the timing function will not be effective, and the single-function operation will be performed.

Setting of Time (SDV-FH□T Only)

Use the time setting knob to set the desired time.

Closing the DIP Switch Cover

Attach the cover to the compartment housing the DIP switch. Select the stickers for the settings that have been made and attach them to the cover.

Setting Flowchart

Select model based on operation and type of input.

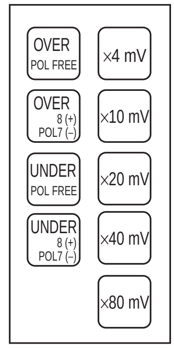
Single-function Model
↓
Determine detection method, polarity setting, operating value, and reset value.
↓
Obtain the PICK UP index scale value, HOLD index scale value, and voltage multiplying factor.
↓
Set the knob and the DIP switch, and attach stickers.
Set the desired operating mode for the SDV-FH□T.

Dual-function Model
↓
Determine intermediate voltage of dead band and dead band voltage.
Determine reset value according to dead band voltage.
↓
Obtain the BALANCE index scale value, BAND WIDTH index scale value, and voltage multiplying factor.
↓
Set the knob and the DIP switch, and attach stickers.

SDV-FL☐
Switch Selection Table

Switch		1	2	3	4	5	6
	ON ●↑						
	OFF ○↓						
Function	Under	●					
	Over	○					
Polarity	8 (+) 7 (–)		●				
	Free		○				
Multiplying factor	x 4 mV	→		○	○	○	○
	x 10 mV	→		●	○	○	○
	x 20 mV	→		○	●	○	○
	x 40 mV	→		○	○	●	○
	x 80 mV	→		○	○	○	●

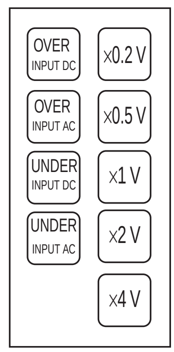
Accessory Labels



SDV-FM☐
Switch Selection Table

Switch		1	2	3	4	5	6
	ON ●↑						
	OFF ○↓						
Function	Under	●					
	Over	○					
Input	AC (20 to 500 Hz)		●				
	DC		○				
Multiplying factor	x 0.2 V	→		○	○	○	○
	x 0.5 V	→		●	○	○	○
	x 1 V	→		○	●	○	○
	x 2 V	→		○	○	●	○
	x 4 V	→		○	○	○	●

Accessory Labels

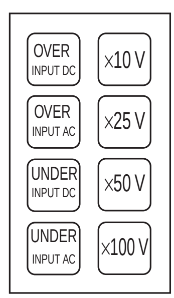


SDV-FH☐
Switch Selection Table

Switch		1	2	3	4	5	6
	ON ●↑						
	OFF ○↓						
Function	Under	●					NO USE (see note)
	Over	○					
Input	AC (20 to 500 Hz)		●				
	DC		○				
Multiplying factor	x 10 V	→		○	○	○	
	x 25 V	→		●	○	○	
	x 50 V	→		○	●	○	
	x 100 V	→		○	○	●	

Note: “NO USE” indicates that DIP switch setting is not required and the positions of these switches are irrelevant to the operation of the voltage sensor.

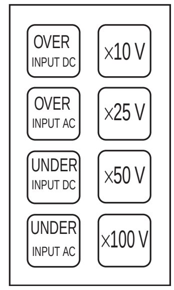
Accessory Labels



SDV-FH□T
Switch Selection Table

Switch		1	2	3	4	5	6	7	8	9	10
	ON ● ↑										
	OFF ○ ↓										
Function	Under	●					NO USE (see note)				NO USE (see note)
	Over	○									
Input	AC (20 to 500 Hz)		●								
	DC		○								
Multiplying factor	x 10 V	→		○	○	○					
	x 25 V	→		●	○	○					
	x 50 V	→		○	●	○					
	x 100 V	→		○	○	●					
Timer		ON-delay					→	●	●	●	
		OFF-delay					→	●	●	○	
		Lock timer					→	○	○	●	
		Timer OFF					→	○	○	○	

Accessory Labels

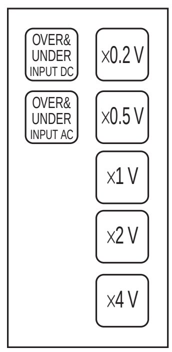


Note: "NO USE" indicates that DIP switch setting is not required and the positions of these switches are irrelevant to the operation of the voltage sensor.

SDV-DM□
Switch Selection Table

Switch		1	2	3	4	5
	ON ● ↑					
	OFF ○ ↓					
Input	AC (20 to 500 Hz)	●				
	DC	○				
Multiplying factor	x 0.2 V	→	○	○	○	○
	x 0.5 V	→	●	○	○	○
	x 1 V	→	○	●	○	○
	x 2 V	→	○	○	●	○
	x 4 V	→	○	○	○	●

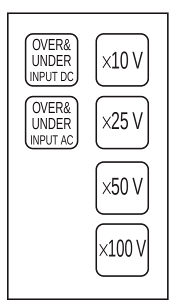
Accessory Labels



SDV-DH□
Switch Selection Table

Switch		1	2	3	4	5
	ON ● ↑					
	OFF ○ ↓					
Input	AC (20 to 500 Hz)	●				NO USE (see note)
	DC	○				
Multiplying factor	x 10 V	→	○	○	○	
	x 25 V	→	●	○	○	
	x 50 V	→	○	●	○	
	x 100 V	→	○	○	●	

Accessory Labels



Note: "NO USE" indicates that DIP switch setting is not required and the positions of these switches are irrelevant to the operation of the voltage sensor.

Examples of Mode Setting

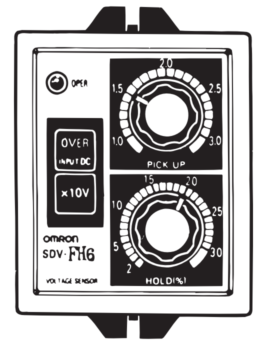
Example 1

For the single-function SDV-FH6, the setting method given below would be used to detect overvoltages with a DC voltage input. The operating value is 15 V and the reset value is 12 V.

Step 1. To set the detection method and type of input on the DIP switch.

Turn OFF pin 1 (function) to specify overvoltage detection.
Turn OFF pin 2 (input) to specify a DC input.
Attach the OVER INPUT DC stickers.

SDV-F□□



Step 2. To set the operating value according to the voltage multiplying factor and the PICK UP index scale value.

Voltage multiplying factor setting: The voltage multiplying factor is selected according to the maximum and minimum factors and a sticker is attached.
The calculation method is as follows:

The PICK UP index scale value is between 1.0 and 3.0, so calculate the voltage multiplying factor for both 1.0 and 3.0.

15 V (Operating value)/1 (PICK UP index scale value) = 15 (Maximum multiplying factor)

15 V (Operating value)/3 (PICK UP index scale value) = 5 (Minimum multiplying factor)

In this example, pins 3 to 5 are turned OFF and the x10V sticker is attached.

PICK UP index scale value setting: The calculation method is as follows (X = index scale):
10 (Voltage multiplying factor) x X = 15 V (Operating value)
Therefore, X = 1.5
Turn the PICK UP knob to 1.5.

Step 3. To set the reset value (Y = HOLD index scale value): Calculate the HOLD percentage as follows:

12 V (reset value) = 15 V (operating value) x (1 – Y)   Therefore, Y = 0.2

Set the HOLD knob to 20 (%).

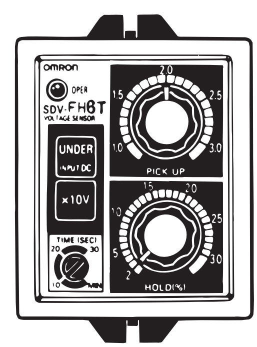
Example 2

For the single-function SDV-FH6T, the setting method given below would be used to detect undervoltages with a DC voltage input. The operating value is 20 V and the reset value is 20.4 V. An ON-delay operation is specified and the setting time is 30 s.

Step 1. To set the detection method and type of input on the DIP switch.

Turn ON pin 1 (function) to specify undervoltage detection.
Turn OFF pin 2 (input) to specify a DC input.
Attach the UNDER INPUT DC stickers.

SDV-FH□T



Step 2. To set the operating value according to the voltage multiplying factor and the PICK UP index scale value.

Voltage multiplying factor setting: The multiplying factor is selected according to the maximum and minimum factors and a sticker is attached. The calculation method is as follows:

The PICK UP index scale value is between 1.0 and 3.0, so calculate the voltage multiplying factor for both 1.0 and 3.0.

20 V (Operating value)/1 (PICK UP index scale value) = 20 (Maximum multiplying factor)

20 V (Operating value)/3 (PICK UP index scale value) = 6.7 (Minimum multiplying factor)

In this example, pins 3 to 5 are turned OFF and the x10V sticker is attached.

PICK UP index scale value setting: The calculation method is as follows (X = index scale):
10 (Voltage multiplying factor) x X = 20 V (Operating value)
Therefore, X = 2
Turn the PICK UP knob to 2.0.

Step 3. To set the reset value (Y = HOLD index scale value): Calculate the HOLD percentage as follows:

20.4 V (reset value) = 20 V (operating value) x (1 + Y)   Therefore, Y = 0.02

Set the HOLD knob to 2 (%).

Step 4. To set setting time and operating mode.

Set the time setting knob to 30 s and turn the pins 7 to 9 ON to specify ON-delay operation.

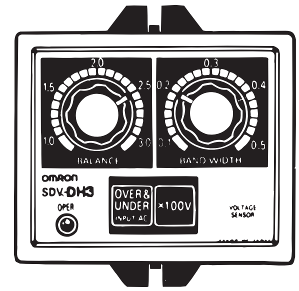
Example 3

For the dual-function SDV-DH3, the setting method given below would be used to detect over and undervoltage with an AC voltage input. The intermediate voltage of dead band is 250 V and the dead band voltage is 20 V.

Step 1. To set the detection method and type of input on the DIP switch.

Turn ON pin 1 (input) to specify a AC input.
Attach the OVER and UNDER INPUT AC stickers.

SDV-D□□



Step 2. To set the intermediate voltage of dead band according to the BALANCE index scale value and the voltage multiplying factor.

Voltage multiplying factor setting: The voltage multiplying factor is selected according to the maximum and minimum factors and a sticker is attached. The calculation method is as follows:

The BALANCE index scale value is between 1.0 and 3.0, so calculate the voltage multiply ing factor for both 1.0 and 3.0.

250 V (Intermediate voltage of dead band)/1 (BALANCE index scale value)
= 250 (maximum multiplying factor)

250 V (Intermediate voltage of dead band)/3 (BALANCE index scale value)
= 83.3 (maximum multiplying factor)

In this example, pins 2 and 3 are turned OFF and pins 4 is turned ON, and the x100V sticker is attached.

BALANCE index scale value setting: The calculation method is as follows for the BALANCE index scale value (X = index scale):

100 (Voltage multiplying factor) x X = 250 V (intermediate voltage of dead band)

Therefore, X = 2.5

Turn the BALANCE knob to 2.5.

Step 3. To set dead band voltage according to the voltage multiplying factor and BAND WIDTH index scale value.

BAND WIDTH index scale value setting:

Z (BAND WIDTH index scale value) x 100 V (voltage multiplying factor) = 20 V (dead band voltage) Therefore, Z = 0.2

Set the DEAD WIDTH knob to 0.2.

Step 4. Reset value for each detection setting: Automatically set according to the dead band voltage setting.

Reset values are calculated for overvoltage detection and undervoltage detection.

Overvoltage detection: Reset value = (250 V + 20 V) – (20 V x 2/3) = 256.7 min.

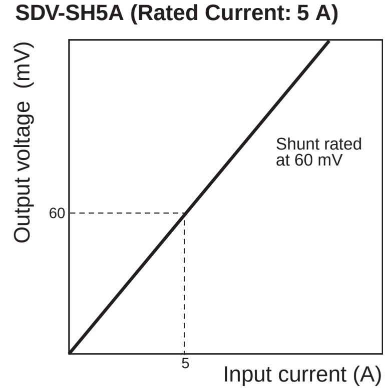
Undervoltage detection: Reset value = (250 V – 20 V) + (20 V x 2/3) = 243.3 max.

■ Shunts (Order Separately)

A shunt is a resistor to convert a DC current into a DC voltage. Use the shunt in combination with SDV-FL to detect undercurrent, reverse current and overcurrent in DC circuits.

Note: Select a shunt whose rated current is more than 120% of the current normally flowing in a circuit. The characteristics of the shunt may change or fusing of a resistor element may occur if an overload that is 1,000% of the rated current is applied. Therefore, determine the rated current of the shunt to be used, by taking the circuit conditions into account.

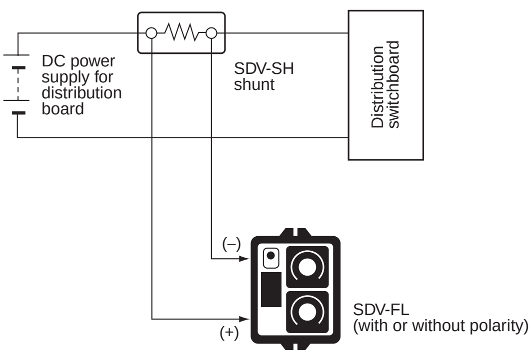
Characteristics
SDV-SH5A (Rated Current: 5 A)



■ Application Example

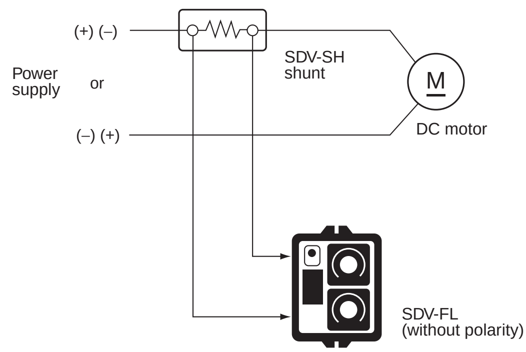
Current Detection Using the Shunt (SDV-FL)

Overload Detection (A)



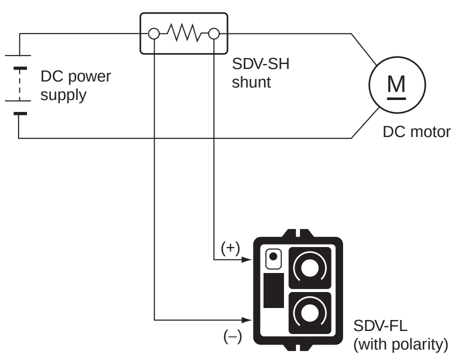
Example: Overload detection in a distribution switch board installed in a power substation.

Overload Detection (B)



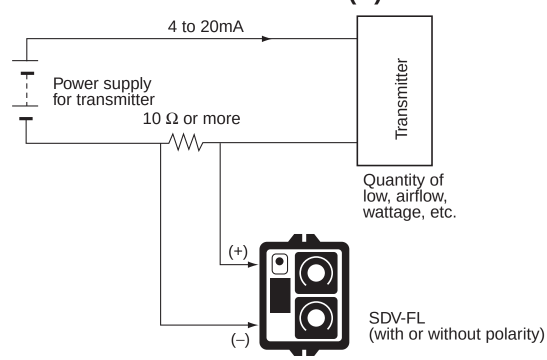
Example: Overload detection in equipment such as a motor in a rolling mill when the polarity of the applied voltage to the motor is reversed.

Reverse Current Detection (A)



Example: Detection when a DC motor is used as a generator (or a generator is used as a motor).

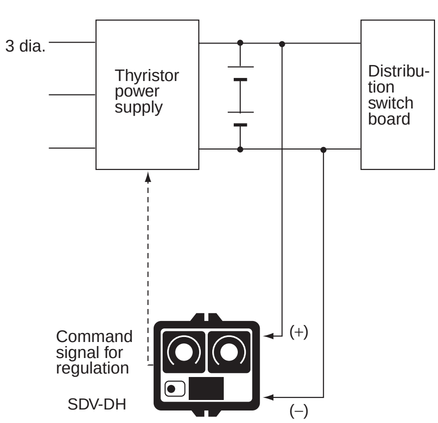
Reverse Current Detection (B)



Example: Detection of an output current from a transmitter on a control panel.

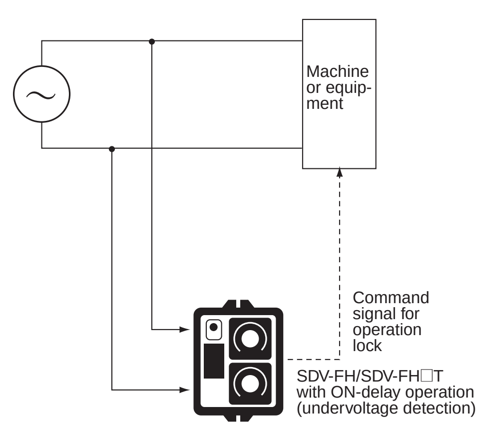
Voltage Detection (SDV-FM/FH/FH☐T/-DM/-DH)

Voltage Regulation



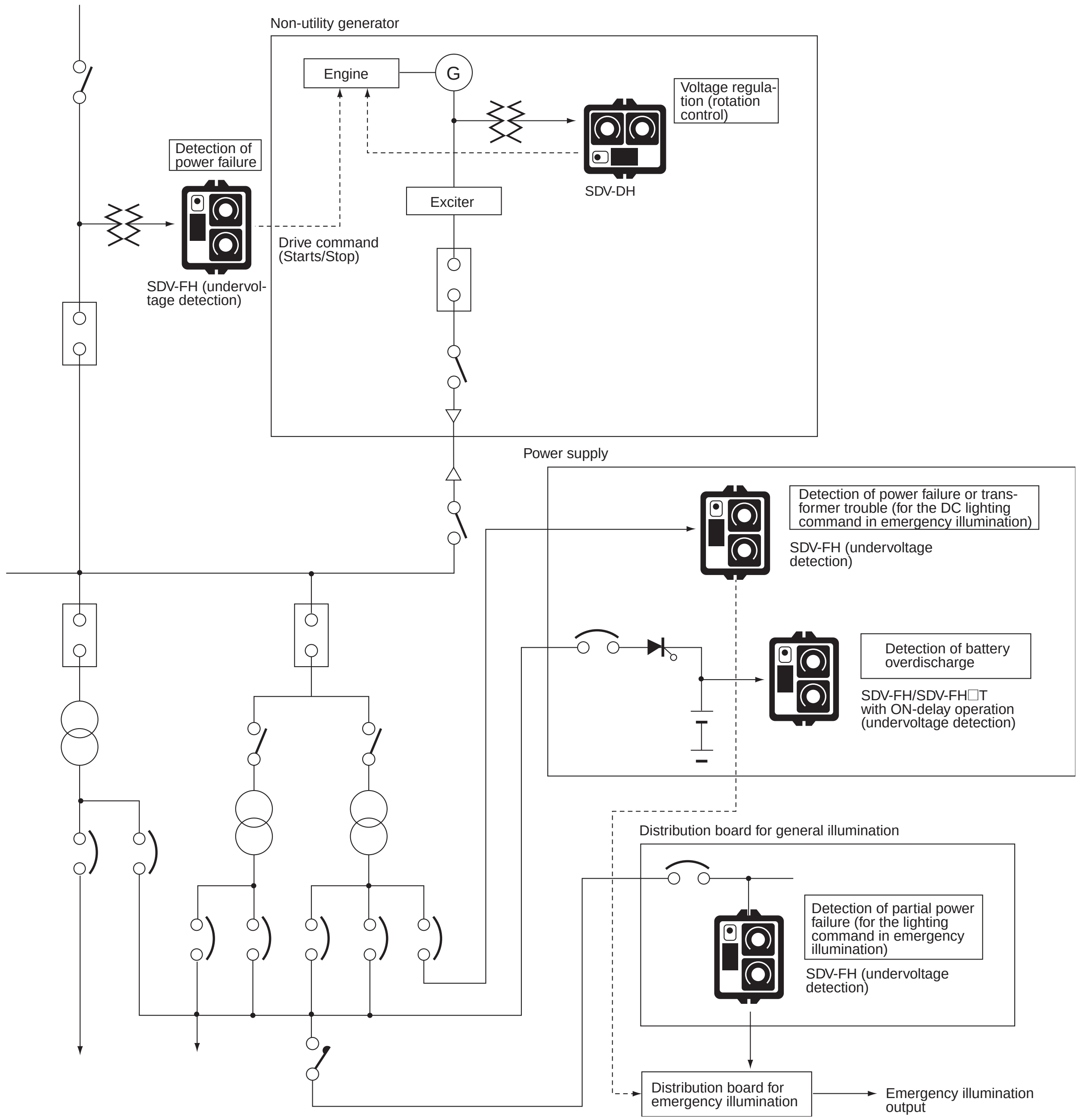
Example: Voltage regulation of a power supply unit in the distribution switchboard installed in a power substation.

Operation Lock Due to Voltage Drop (Alarm)

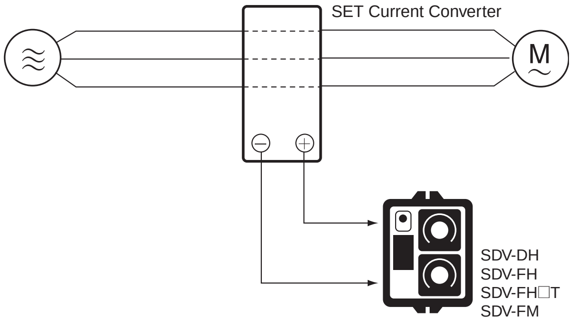


Example: Function lock due to voltage drop in a machine or equipment (alarm).

Emergency Power Supply (e.g. Standard Power Receiving/Distributing Facility)



Three-phase AC Current Detection Using Current Converter

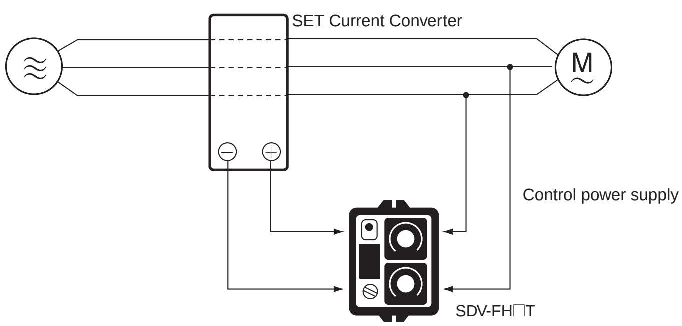


Example: Machine motor control, overload detection, undercurrent detection.

Current Converters (Order Separately)

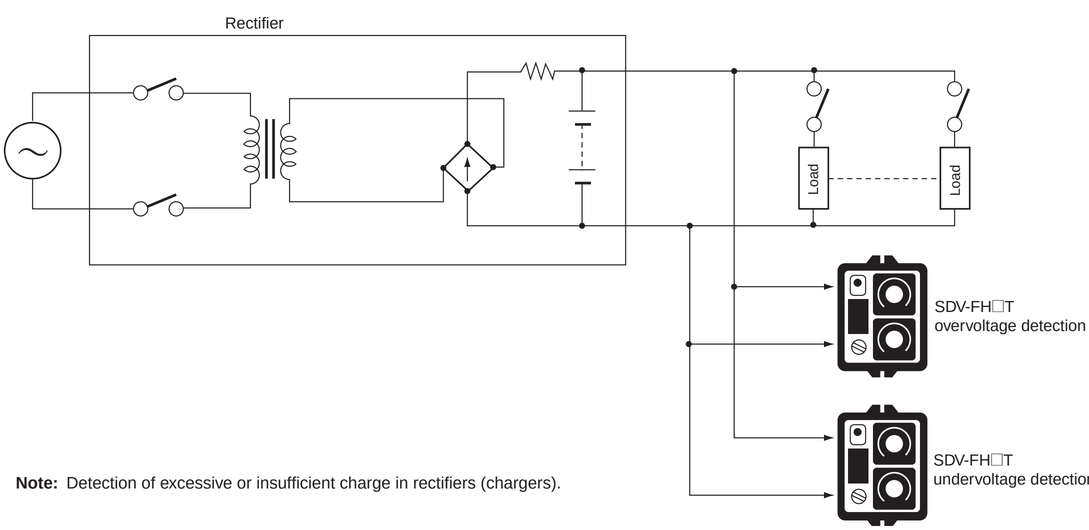
Model	Current range
SET-3A	1 to 80 A
SET-3B	64 to 160 A

Three-phase AC Current Detection with Startup Lock Operation (When Using Same Power Supply for Motor and Control Power Supply)



Voltage Monitoring in Rectifiers (Chargers) with ON-delay Operation

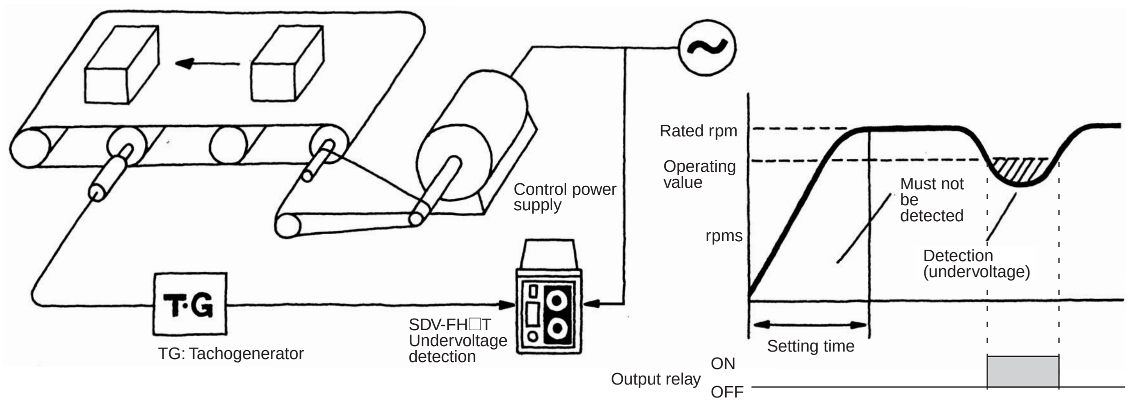
Example: To detect only overvoltage and not detect voltages for instantaneous load changes (ON/OFF).



Note: Detection of excessive or insufficient charge in rectifiers (chargers).

Rotational Speed (rpm) Monitoring with Startup Lock Operation

Example: Low speeds are detected only after the rotational speed has been reached to the rated rpm and not during startup.

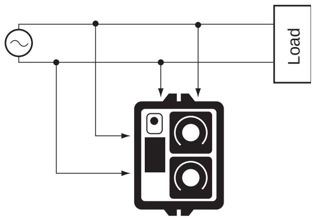


OFF-delay Operation

With OFF-delay operation, an alarm buzzer, indicator, etc., can be output for a set period of time.

■ Q&A

Q: What is necessary to detect undervoltages when using the same power supply for the input voltage and the control power supply?



SDV-F (undervoltage detection)

A: The NO contact of the output relay is used for undervoltage detection. Even if the control voltage drops to 85% of the rated voltage (AC power), the operation of the relay can be maintained. Set the mode setting on the DIP switch to overvoltage detection and set the reset value to the value to be detected. Set the operating value of the SDV to a value higher than the reset value.

Q: Will the SDV be damaged if the input setting (AC/DC) is incorrect. If not, what will happen?

A: The SDV will not be damaged, but the operating value and reset value will not be accurate. These values will be about 10% less than the set values if DC is input for an AC setting and about 10% off to the positive side if AC is input for a DC setting.

Q: Can the negative pole of a DC voltage be input to the SDV?

A: Yes. An absolute rectifier circuit is used in the SDV-F to enable negative pole input. The SDV-FL has a polarity setting, which can be set to (+)(–) to disable operation with negative voltages. Positive/Negative settings cannot be used for the dual-function SDV-D even if the intermediate voltage of dead band is set to 0. Negative inputs cannot be used for the SDV-D.

Q: Are models available with special processing for high-temperature, high-humidity?

A: Yes. The model numbers for special processing for high-temperature, high-humidity end in “TC.”
SDV-F☐☐-TC or SDV-D☐☐-TC. Special processing for high-temperature and high-humidity is not possible for the SDV equipped with the timing function (SDV-FH☐T).

Q: Is instantaneous detection faster than 0.5 s possible?

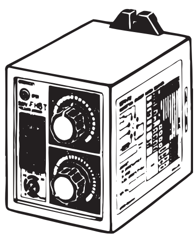
A: Use the S87A Power Interruption Detector for instantaneous detection (10 ms or 20 ms).

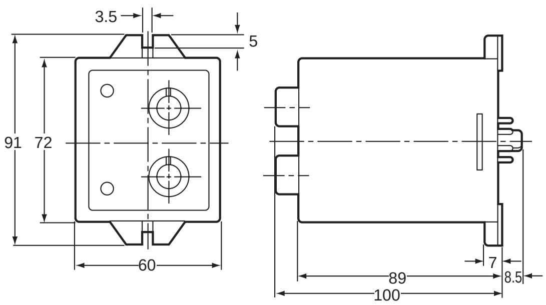
Dimensions

Note: All units are in millimeters unless otherwise indicated.

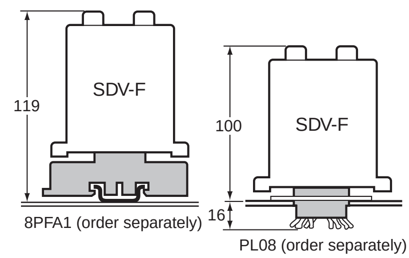
■ Main Body

SDV-F☐☐/SDV-FH☐T

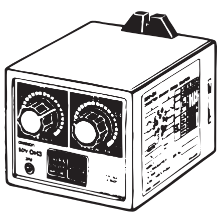


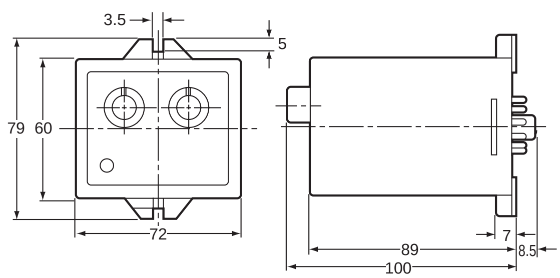


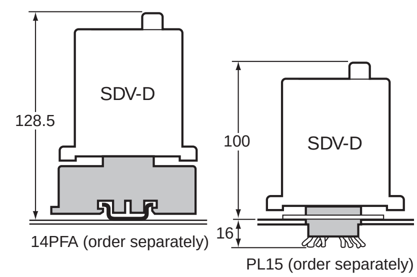
Connecting Socket



SDV-D☐☐

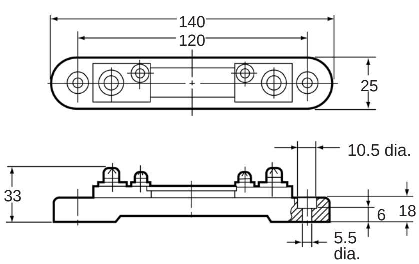






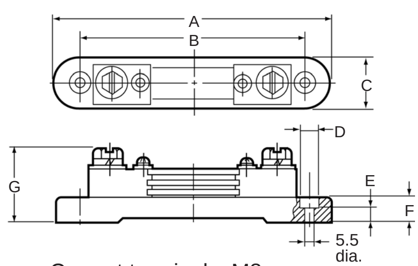
■ Shunts

SDV-SH5 to SDV-SH50 (60-mV Rating)



Current terminal: M6 screw
Voltage terminal: M4 screw

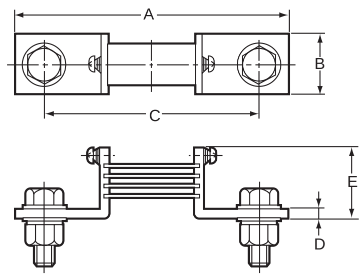
SDV-SH75 to SDV-SH200 (60-mV Rating)



Current terminal: M8 screw
Voltage terminal: M4 screw

Model	A	B	C	D	E	F	G
SDV-SH75	140	120	25	10.5	6	18	36
SDV-SH100	140	120	25	10.5	6	18	36
SDV-SH150	140	120	25	10.5	6	18	43
SDV-SH200	140	120	25	10.5	6	18	43

SDV-SH300/-SH500 (60-mV Rating)

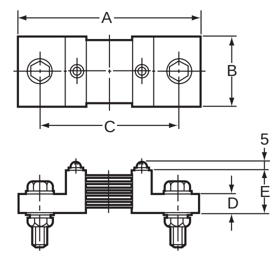


Current terminal: M10 screw (SDV-SH300), M12 screw (SDV-SH500)
Voltage terminal: M4 screw

Model	A	B	C	D	E	Resistor
SDV-SH300	130	30	110	4	36	4
SDV-SH500	160	40	120	6	41	5

Note: Inquire about models with a rated current of 1,500 A or larger.

SDV-SH750/-SH1000 (60-mV Rating)



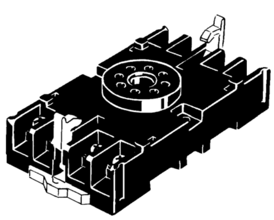
Current terminal: M12 screw
Voltage terminal: M5 screw

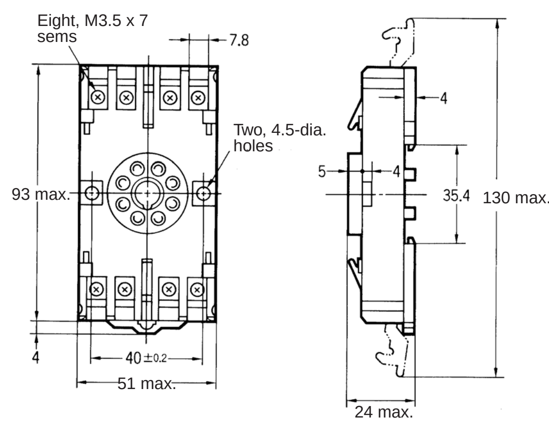
Model	A	B	C	D	E
SDV-SH750	175	45	130	15	30
SDV-SH1000	175	60	135	18	30

■ Accessories (Order Separately)

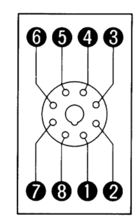
Front Connecting Socket

8PFA1

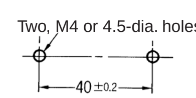




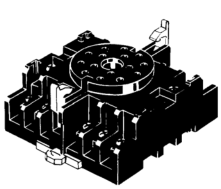
Terminal Arrangement (Top View)

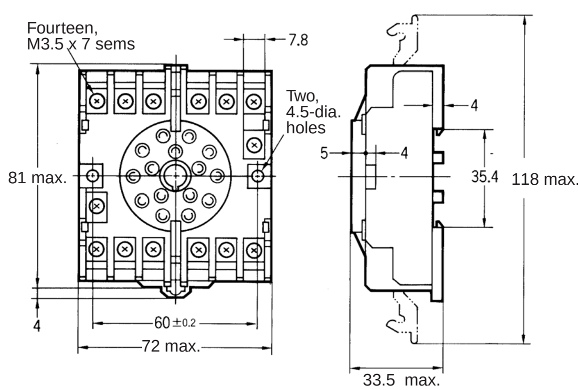


Mounting Holes

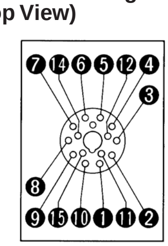


14PFA

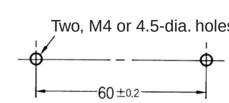




Terminal Arrangement (Top View)

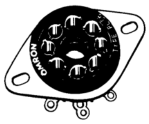


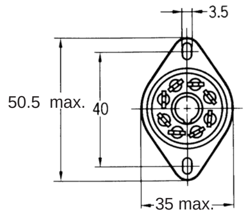
Mounting Holes

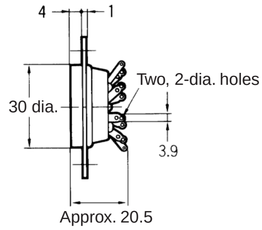


Back Connecting Socket (Solder Terminal)

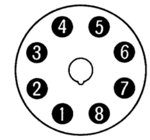
PL08



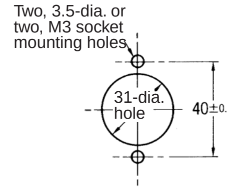




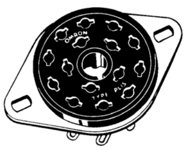
Terminal Arrangement (Bottom View)

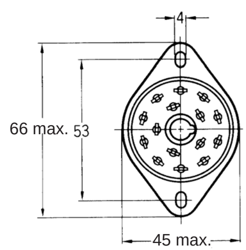


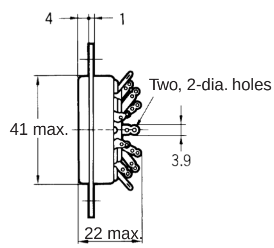
Mounting Holes



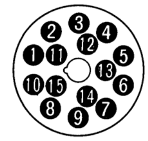
PL15



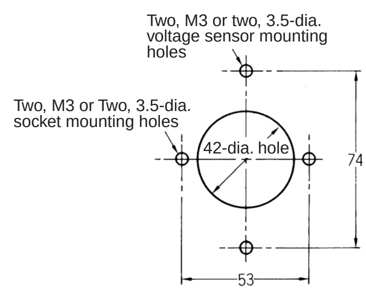




Terminal Arrangement (Bottom View)

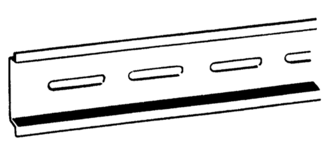


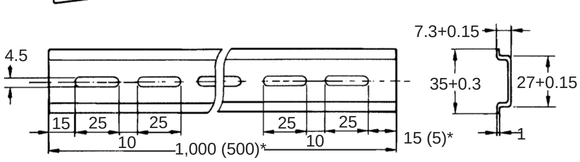
Mounting Holes



Mounting Track

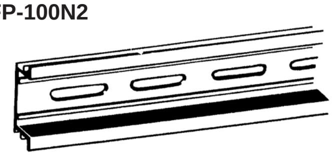
PFP-100N
PFP-50N

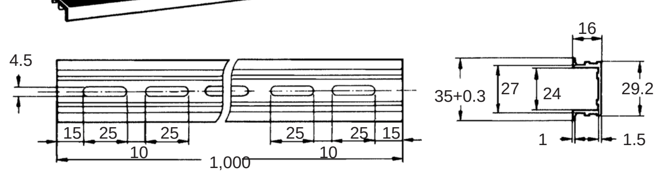




*PFP-50N

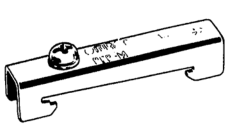
PFP-100N2

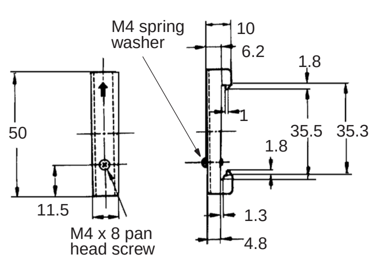




End Plates

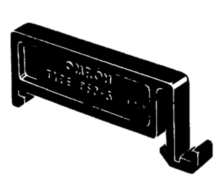
PFP-M

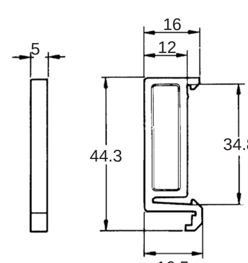




Spacers

PFP-S



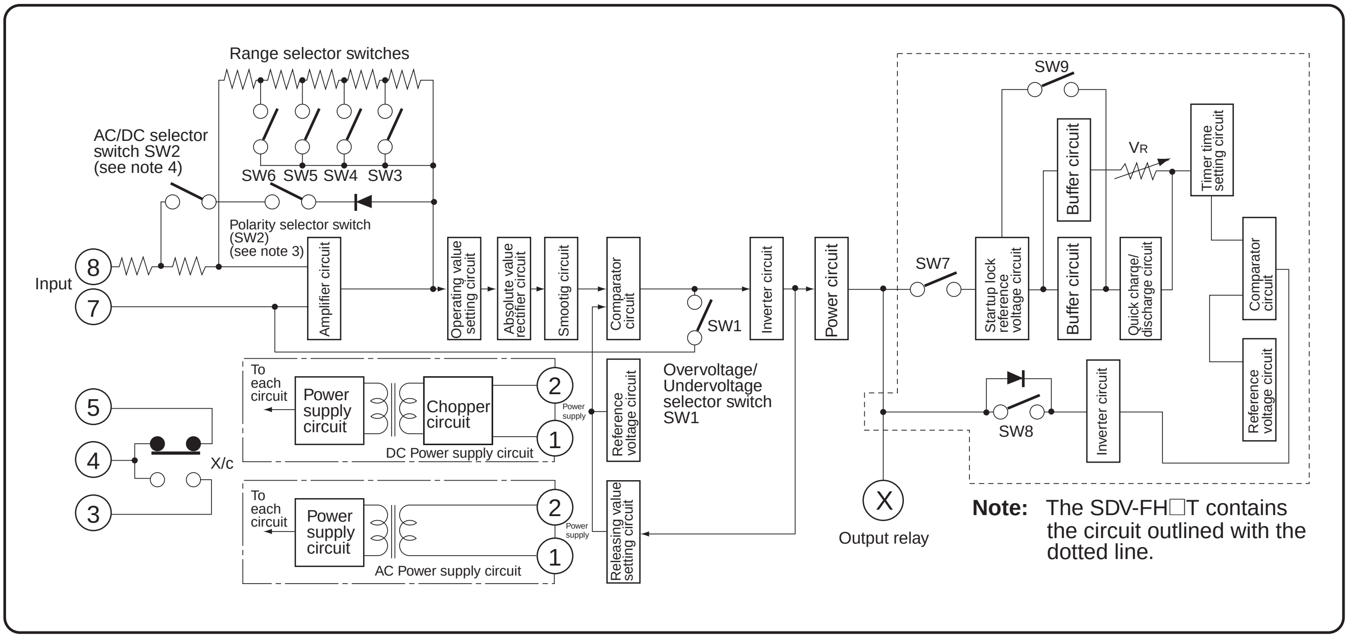


Installation

■ Internal Circuit

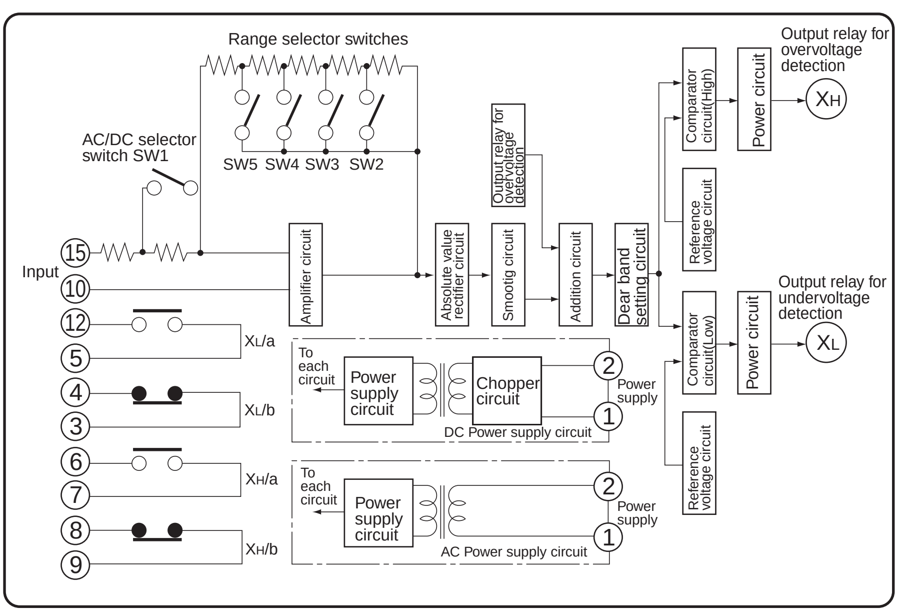
Input and power supply circuits are electrically isolated as protection against mutual interference.

SDV-F□□/SDV-FH□T



Note: 1. There is no polarity setting for the SDV-FM or SDV-FH/-FH□T.
2. There is no power supply polarity setting when using a DC control power supply for the SDV.
3. The polarity selection switch (SW2) is on the SDV-FL.
4. The AC/DC switch (SW2) is on the SDV-FM and SDV-FH/-FH□T.

SDV-D



Note: 1. There is no power supply polarity setting when using a DC control power supply for the SDV.
2. There is no polarity setting for DC inputs.

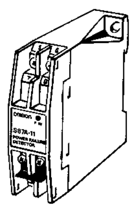
Precautions

Approximately 0.5 s is required for operation. When confirming the operating value, gradually change the input voltage while checking the value.

Power supply voltage fluctuations and the ambient operating temperature must be maintained within the allowable ranges. Be particularly careful not to apply an overvoltage beyond the specified range for the voltage detection.

Do not use the SDV in locations subject to corrosive or explosive gases.

The SDV cannot be used to detect momentary power interruptions because of its response time. Use the S87A to detect momentary power interruptions.



S87A Power Interruption Detector

An SDV cannot be used with a circuit containing thyristors, or VVVF inverters, because these elements can change the output waveform to the point that the SDV will malfunction.

Mounting

When mounting with the PL08 or PL15 Back Connection Socket, insert the Socket into a 1- to 4-mm panel from the back and secure it with screws. Do not mount the SDV until the Socket has been mounted firmly. Be sure that the key groove on the Socket is mounted on the bottom, and also secure the SDV to the panel with screws.

When mounting with the 8PFA or 14PFA Back Connection Socket, insert the SDV into the Socket and secure it with the hooks. Leave approximately 30 mm or more between Sockets to allow enough space for the hooks.

When mounting more than one SDV, allow at least 30 mm or more between them.

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.

To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N036-E1-05 In the interest of product improvement, specifications are subject to change without notice.

Voltage Sensor

LG2

Compact, Economical Plug-in Type Voltage Sensing Relay

- DPDT output contacts expand the application of the Sensor to wide-ranging fields including control, alarms, and indication.
- Voltage control is possible in the same easy manner as electro-magnetic relays, as the output relay of the sensor can be driven directly with a detection signal.
- Wide voltage setting range with fine setting capability.

Model Number Structure

■ Model Number Legend

LG2-□□
1 2 3

1. **Voltage sensor**

2, 3. **Operating Voltage**

AB: 100, 110, 200 VAC
DB: 12, 24, 48, 100 VDC

Ordering Information

■ List of Models

Detected voltage	Model
AC	LG2-AB (100 VAC) LG2-AB (200 VAC) LG2-AB (110 VAC)
DC	LG2-DB (12 VDC) LG2-DB (24 VDC) LG2-DB (48 VDC) LG2-DB (100 VDC)

Specifications

■ Ratings

Item / Model	Detected voltage	Load	Setting range		Control output			
	Rated voltage	Power/VA consumption	Must-operate (SET) voltage (percentage of rated value)	Must-release (RESET) voltage (percentage of rated value)	Rated carry current	Switching capacity		
						Rated operating voltage	Rated operating current	
							Resistive load (cosϕ = 1)	Inductive load (cosϕ = 0.4, L/R = 7 ms)
LG2-AB	100 VAC 200 VAC 50/60 Hz	5 VA max.	75% to 120%	70% to 115%	5 A	100 VAC 200 VAC 28 VDC 110 VDC	5 A 2 A 5 A 0.2 A	3 A 1.2 A 2 A 0.1 A
	110 VAC 50/60 Hz		80% to 110%	75% to 105%				
LG2-DB	12 VDC 24 VDC 48 VDC 100 VDC	3 W max.	75% to 120%	70% to 115%				

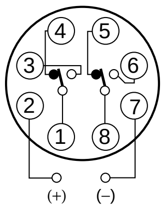
Note: 1. Set the must-operate voltage higher than the must-release voltage by at least 5% of the rated value.
2. Smoothing is required for the detected DC voltage.
3. The maximum applied voltage is 120% of the rated value.
4. Special models enabling a rated voltage of 220 V are available. The setting range for these models is 80% to 110%.

■ Characteristics

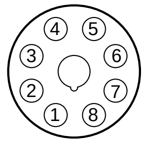
Repeat accuracy	±3% max. (with voltage fluctuations at the rate of 1 V/s)
Variation due to temperature change	±5% max. (within the range 20 °C +20/–30 °C)
Operate time	0.5 s max. (when input changes from 0 V to 120% must-operate voltage)
Release time	0.5 s max. (when input changes from 120% of the must-release voltage to 0 V)
Insulation resistance	10 MΩ min. at 500 VDC (between electric circuitry and mounting panel)
Dielectric strength	2,000 VAC, 50/60 Hz for 1 min (between electric circuitry and mounting panel)
Vibration	Malfunction: 16.7 Hz, 1-mm double amplitude
Shock	Destruction: 294 m/s^2 (approx. 30 G)
Service life	Mechanically: 10,000,000 operations min. Electrically: 50,000 operations min. (at max. applicable load)
Weight	Approx. 100 g

Connections

■ Terminal Arrangement



The polarity indication for terminals②and⑦applies to the DC model (LG2-DB). (The above diagram shows the rear side of the Relay.)

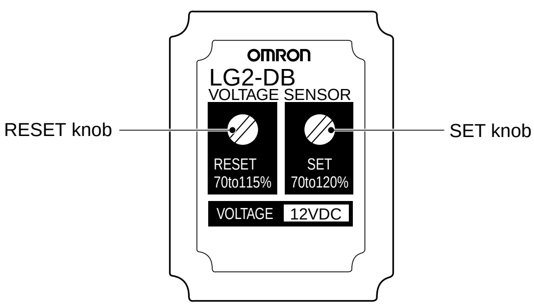


(The above diagram shows the rear side of the Relay.)

Note: 1. *Type LG2-DB is not equipped with the rectifier circuit.

2. With type LG2-DB, care should be taken to the polarity of the power supply.

Nomenclature



Setting Method

Operate Value

Input the actual voltage to be set, and set the SET knob to the point at which the Relay operates.

Release Value

• With the Relay operating, turn the RESET knob counterclockwise as far as it will go, and adjust the voltage to the value to be set. Then, gradually turn the RESET knob clockwise until it reaches the point where the Relay is released.

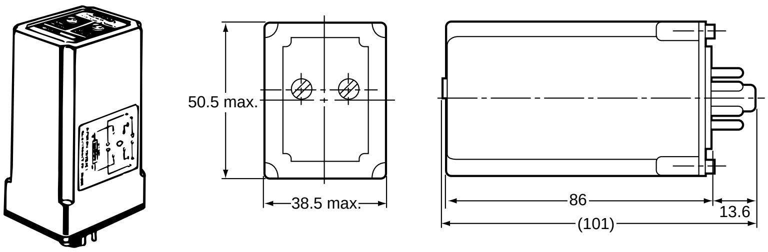
Note: After completing the settings, check the settings for the operate and release values by increasing/decreasing the input voltage.

• The LG2 can be used for undervoltage detection by using the RESET knob for the operate value and the SET knob for the release value. The Relay will normally be ON, however, and so the internal temperature will rise, and this will affect the product service life.

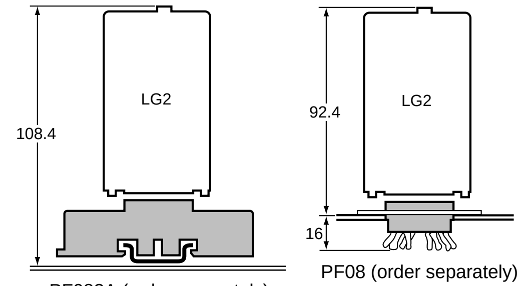
Dimensions

Note: All units are in millimeters unless otherwise indicated.

LG2-AB, LG2-DB



Mounting Height of Sensor with Socket



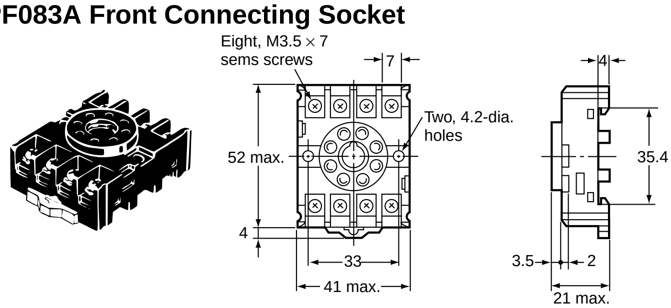
PF083A (order separately)

PF08 (order separately)

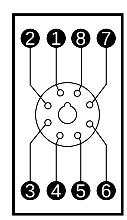
Accessories (Order Separately)

Connecting Socket

PF083A Front Connecting Socket

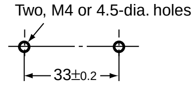


Terminal Arrangement



(Top View)

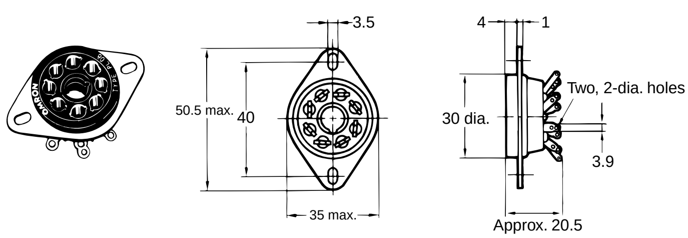
Mounting Holes



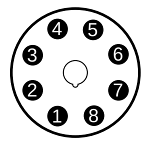
Note: Mount sockets to applicable models so that ◯ points downwards.

Applicable Models
APR-S
LG2

PL08 Back Connecting Socket (Solder Terminals)

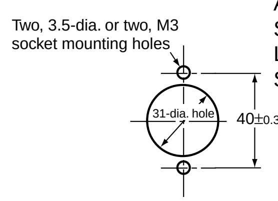


Terminal Arrangement



(Top View)

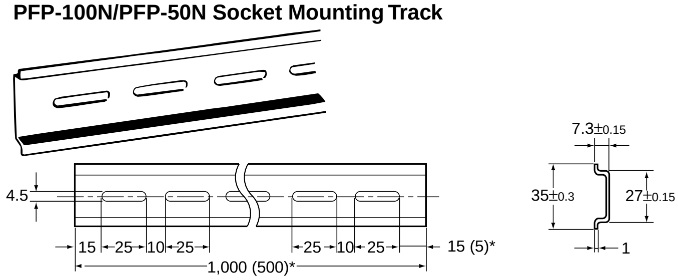
Mounting Holes



Applicable Models
SE
APR-S
SDV
LG2
SAO

Socket Mounting Track (for PF083A)

PFP-100N/PFP-50N Socket Mounting Track



* The dimensions given in parentheses are for the PFP-50N Socket Mounting Track.

Hold-down Clip

Use the Hold-down Clip to secure the Voltage Sensor on the Connecting Socket, as well as to prevent faulty contact.

Type of Socket	Applicable type of Hold-down Clip
PF083A	PFC-A7
PL08	PLC-8

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N125-E1-01 In the interest of product improvement, specifications are subject to change without notice.

Ground Fault Relay

K6EL

Economical, Compact, High-performance, DIN 48 × 48-mm Ground Fault Relay for Low Voltages (Conforms to JIS C8374)

- Performs continuous monitoring and detection of ground faults in low-voltage circuits due to the deterioration of insulation in electrical devices.
- Higher reliability ensured with improved resistance to high-frequency noise when used for inverter loads.
- Remote monitoring of cubicles is possible with automatic-reset models.
- Ground Fault Relays and through-type ZCTs (zero-phase current transformers) are mutually compatible.
- The through-type ZCTs are equipped with test terminals, allowing operation tests for Ground Fault Relays to be performed with ease.
- Series now includes K6EL-R50, which operates at 50 mA ±10%.

Model Number Structure

■ Model Number Legend

K6EL-□□
1 2 3

1. **Ground Fault Relay**
2. **Operating Time and Reset Method**
   None: 0.1 s manual reset
   A: 0.3/0.8 s (switchable) manual reset
   R: 0.5 s automatic reset
3. **Sensed Current**
   30: 30 mA (fixed)
   50: 50 mA/150 mA (switchable)
   100: 100 mA/200 mA (switchable)
   200: 200 mA/500 mA (switchable)
   500: 500 mA/1,000 mA (switchable)

Ordering Information

■ List of Models

Manual-reset Ground Fault Relays

	Type	High-sensitivity models	Medium-sensitivity models		
Type	**Operating time** / **Sensed current**	**30 mA (fixed)**	**100 mA/200 mA (switchable)**	**200 mA/500 mA (switchable)**	**500 mA/1,000 mA (switchable)**
High-speed models	Less than 0.1 s	K6EL-30	K6EL-100	K6EL-200	K6EL-500
Delayed models	0.3/0.8 s (switchable)	---	K6EL-A100	K6EL-A200	K6EL-A500

Automatic-reset Ground Fault Relays

	Type	High-sensitivity models	Medium-sensitivity models
Type	**Operating time** / **Sensed current**	**50 mA/150 mA (switchable)**	**500 mA/1,000 mA (switchable)**
Delayed models	Less than 0.5 s	---	K6EL-R500
		K6EL-R50 (See note.)	---

Note: Operating Error
50-mA tap: ±10%
150-mA tap: ±20%

ZCTs (Zero-phase Current Transformers)

Type / Rated current / Sensed current	Indoor through-type models		Indoor separate-type models	
	Model	**Diameter of through-hole**	**Model**	**Diameter of through-hole**
50 A	OTG-L21	21 mm	---	---
100 A	OTG-L30	30 mm	---	---
200 A	OTG-L42	42 mm	OTG-CN52	52 mm
400 A	OTG-L68	68 mm	OTG-CN77	77 mm
600 A	OTG-L82	82 mm	OTG-CN112	112 mm
1,000 A	OTG-L156	156 mm	---	---

■ Ground Fault Relay and ZCT Combinations

(OK: Compatible)

Ground Fault Relay / ZCT	K6EL-30 K6EL-R50	K6EL-100, -200, -500, -R500 K6EL-A100, -A200, -A500
OTG-L21 (50 A)	OK	OK
OTG-L30 (100 A)	OK	OK
OTG-L42 (200 A)	OK	OK
OTG-L68 (400 A)	---	OK
OTG-L82 (600 A)	---	OK
OTG-L156 (1,000 A)	---	OK
OTG-CN52 (200 A)	---	OK
OTG-CN77 (400 A)	---	OK
OTG-CN112 (600 A)	---	OK

Note: 1. “OK” indicates groupings that can be combined freely.

2. Combinations with the OTG-LA☐☐ are also possible.

Specifications

■ Ground Fault Relay Ratings

Type / Item		High-speed models		Delayed models	Delayed high-sensitivity models
Control power supply		100/110 VAC or 200/220 VAC, 50/60 Hz (same for all) (See note 1.)			100 VAC
Rated current		Depends on the ZCT			
Sensed current		50% to 100% of the rated sensed current (50 mA ±10%, 150 mA ±20%) (See note 2.)			
Non-operating current		0% to 50% of the rated sensed current			
Rated short-time current		2,500 A			
Ground fault indication method		LED (red)			
Test method		Relay operation confirmed using a test button. (Independent of ZCT connection.)			
Reset method	**Manual**	Either press the reset button or turn the control power supply OFF and ON again.			
	Automatic	Automatically resets when the ground fault is cleared.			
Built-in contacts	**Contact form**	SPDT+SPST-NO			SPDT
	Carrying current	5 A			3 A
	Rated load		cosϕ = 1	cosϕ = 0.4 (L/R = 7 ms)	cosϕ = 1
		240 VAC	5 A	2 A	220 VAC, 3 A
		110 VDC	0.3 A	0.2 A	
		30 VDC	5 A	3 A	
Power (VA) consumption		3 VA max.			
Weight		Approx. 110 g			

Note: 1. The K6EL-R50 requires a 100-VAC control power supply.

2. Only the K6EL-R50 can be switched between 50 mA ±10% and 150 mA ±20%.

■ Ground Fault Relay Characteristics

Item / Type	High-speed models	Delayed models	Delayed high-sensitivity models
Operating time	Less than 0.1 s	0.3 s/0.8 s (switchable)	Less than 0.5 s
Inertial non-operating time	---	0.1 s when set to 0.3 s 0.5 s when set to 0.8 s	
Control power supply range	80% to 110% of the control power supply voltage		
Operating temperature range	–10 to 55 °C (with no icing)		
Operating humidity range	45% to 85% (with no condensation)		
Insulation resistance	5 MΩ min. at 500 VDC (between charged parts and the mounting panel)		
Dielectric strength	1,500 VAC, 50/60 Hz for 1 min (between charged parts and the mounting panel)		
Lightning impulse dielectric strength	1.2/50 μs, 7,000 V (between control power supply terminals)		
Lightning impulse operation failure	1.2/50 μs, 7,000 V (primary side of ZCT)		
Vibration resistance	Destruction: 16.7 Hz, 4-mm double amplitude for 1 min		
Shock resistance	98 m/s^2		

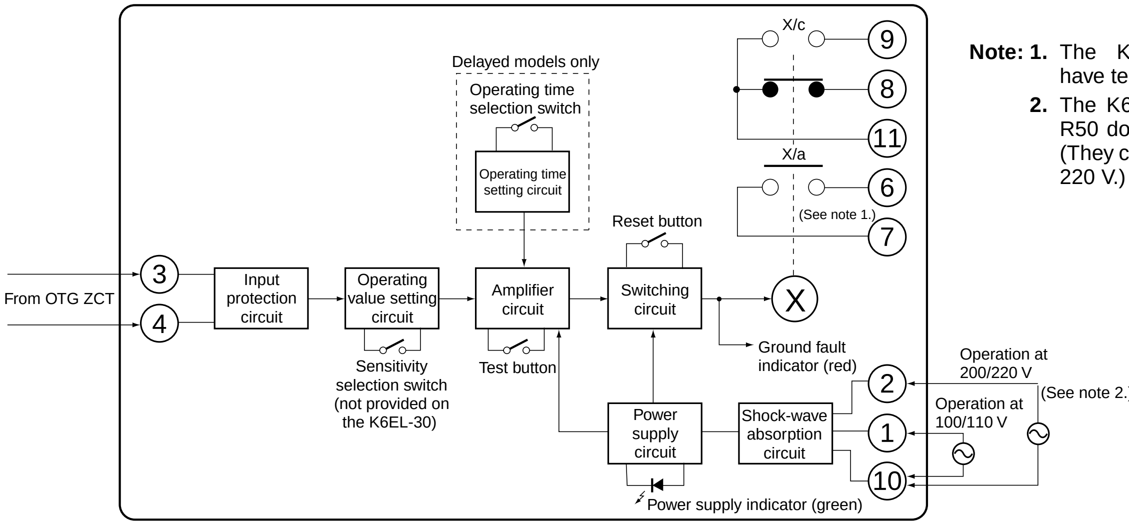
Note: The range for an operating time of 0.3 s is 0.15 to 0.45 s and the range for an operating time of 0.8 s is 0.6 to 1.2 s.

■ ZCT (Zero-phase Current Transformer)

Item / Structure	Indoor through-type models						Indoor separate-type models		
Model	OTG-L21	OTG-L30	OTG-L42	OTG-L68	OTG-L82	OTG-L156	OTG-CN52	OTG-CN77	OTG-CN112
Rated current	50 A	100 A	200 A	400 A	600 A	1,000 A	200 A	400 A	600 A
Diameter of through-hole	21 mm	30 mm	42 mm	68 mm	82 mm	156 mm	52 mm	77 mm	112 mm
Rated voltage	600 VAC max., 50/60 Hz, single-phase/three-phase								
Output terminal polarity	None (The ZCT’s output terminals k and l can be connected to either input terminals 3 or 4 of the Relay.) (See note.)								
Insulation resistance	100 MΩ min. (between charged metal parts and ground)								
Dielectric strength	2,200 VAC, 50/60 Hz for 1 min (between charged metal parts and ground)								
Ambient operating temperature	–10 to 60 °C (with no icing)								
Weight	Approx. 90 g	Approx. 130 g	Approx. 230 g	Approx. 480 g	Approx. 700 g	Approx. 6.6 kg	Approx. 1.3 kg	Approx. 2.5 kg	Approx. 3.5 kg

Note: Do not connect ZCT output terminals k and l to ground. Doing so may result in damage to the Relay.

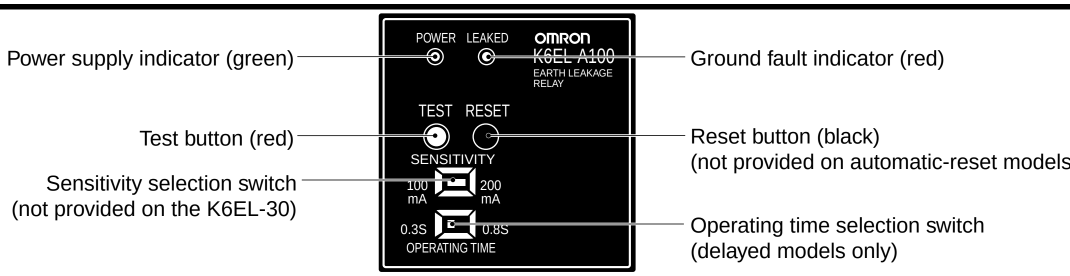
Internal Block Diagram



Note: 1. The K6EL-R50 does not have terminals 6 and 7.

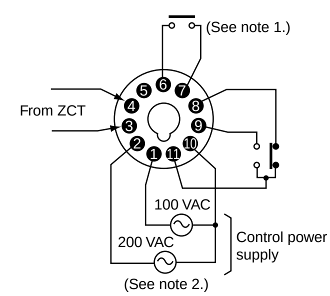
2. The K6EL-R500 and K6EL-R50 do not have terminal 2. (They cannot be used at 200/220 V.)

Nomenclature

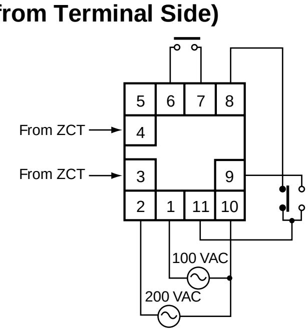


Connections

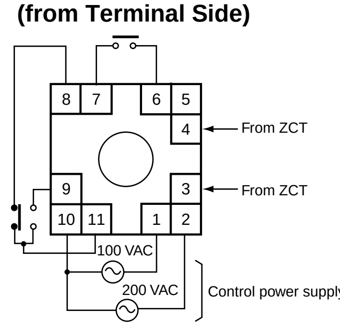
Ground Fault Relay (from Pin Side)



Ground Fault Relay with P3GA-11 (from Terminal Side)



Ground Fault Relay with P2CF-11 (from Terminal Side)

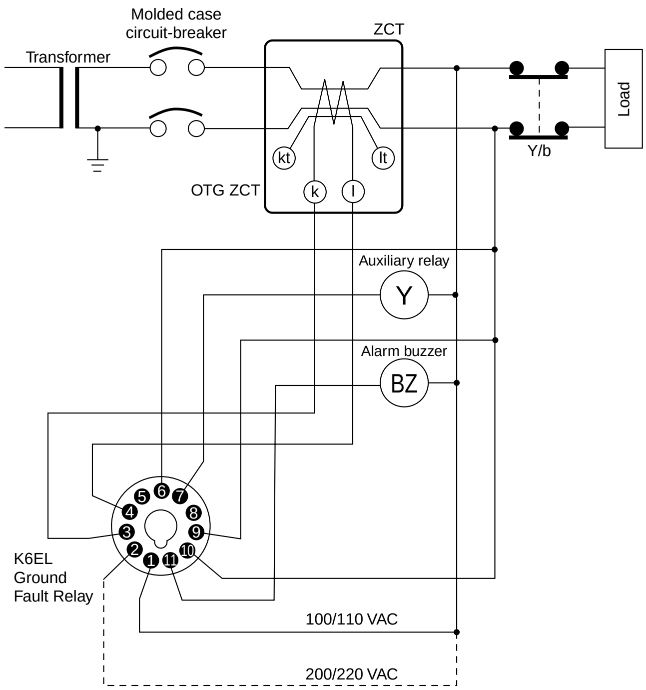


Note: 1. The K6EL-R50 does not have terminals 6 and 7.

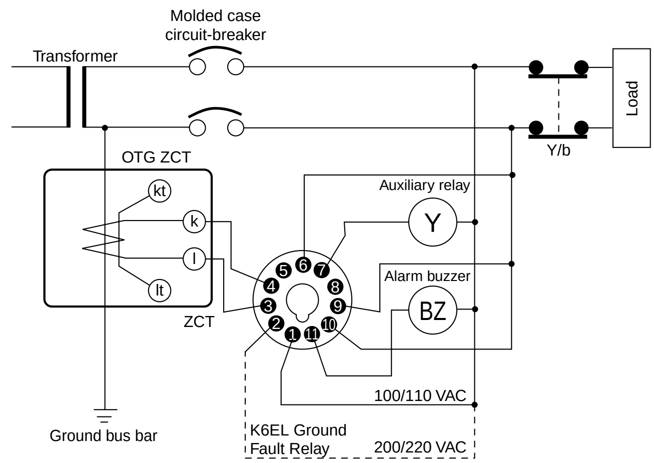
2. The K6EL-R500 and K6EL-R50 do not have terminal 2. (They cannot be used at 200/220 V.)

Connection Examples

Installation on the Electrical Path



Installation on a Ground Bus Bar



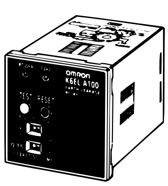
Note: 1. Do not, under any circumstances, connect the k and l lines to ground.

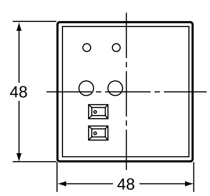
2. When not using the kt and lt terminals (test terminals), leave them unconnected. The Relay may not be able to attain its performance characteristics if used with the kt and lt terminals connected.

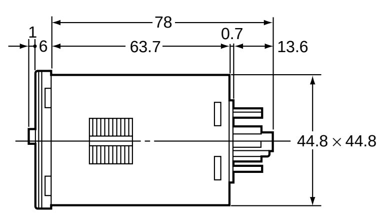
Dimensions

Note: All units are in millimeters unless otherwise indicated.

Ground Fault Relay



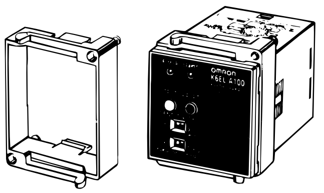


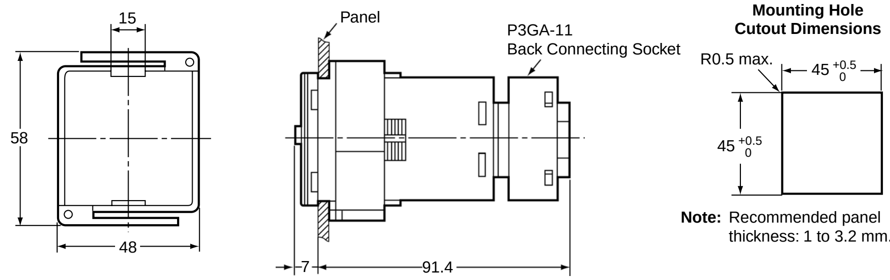


Applicable Connecting Sockets
P2CF-11 Front Connecting Socket
P3GA-11 Back Connecting Socket
PL11 Back Connecting Socket

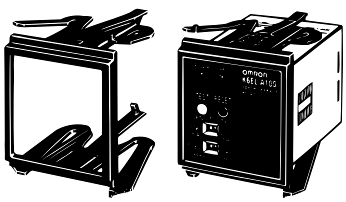
Dimensions with Adapter Mounted

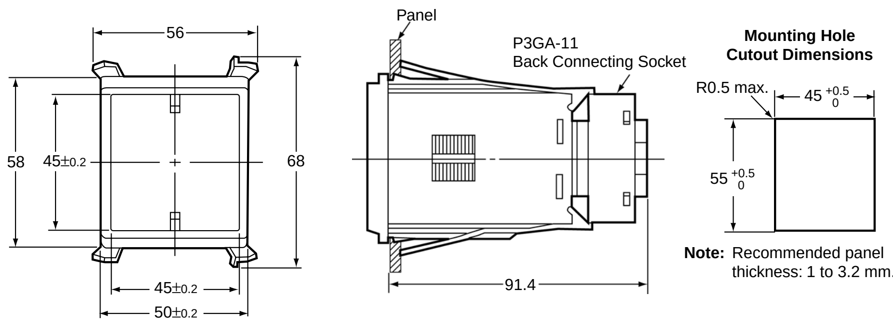
Y92F-30 Flush Mounting Adapter (Sold Separately)



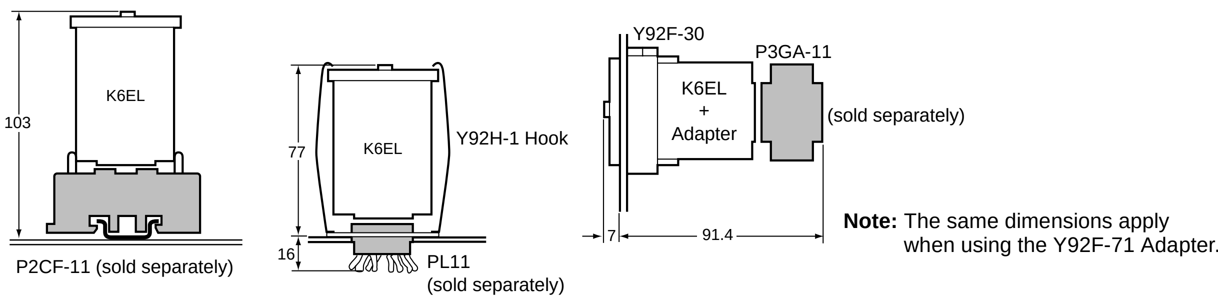


Y92F-71 Flush Mounting Adapter (Sold Separately)



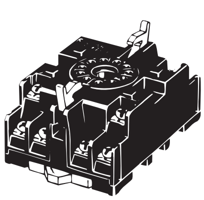


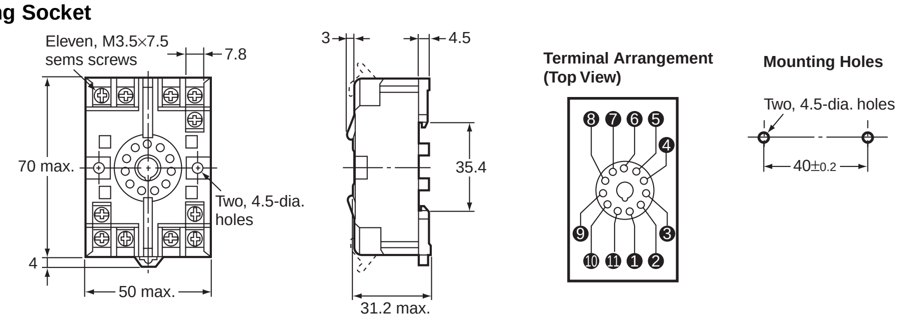
Dimensions for Socket Mounting



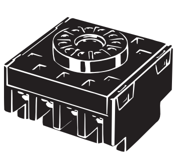
Connecting Sockets

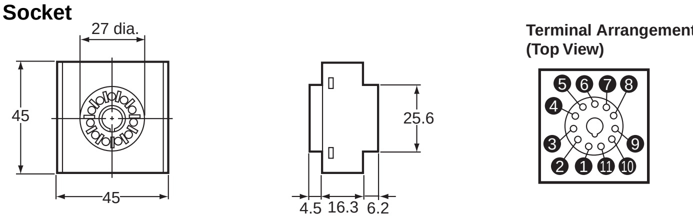
P2CF-11 Front Connecting Socket



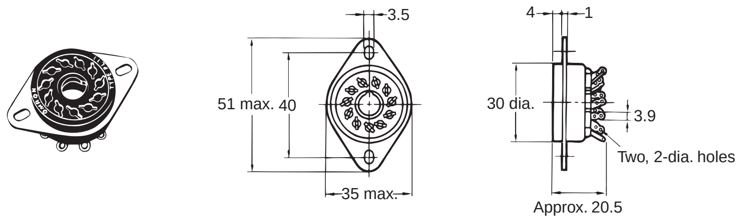


P3GA-11 Back Connecting Socket

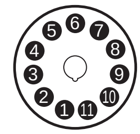




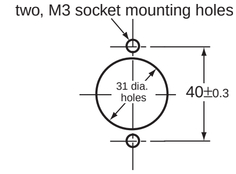
PL11 Back Connecting Socket



Terminal Arrangement (Bottom View)



Mounting Holes



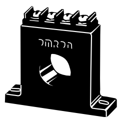
Front Cover

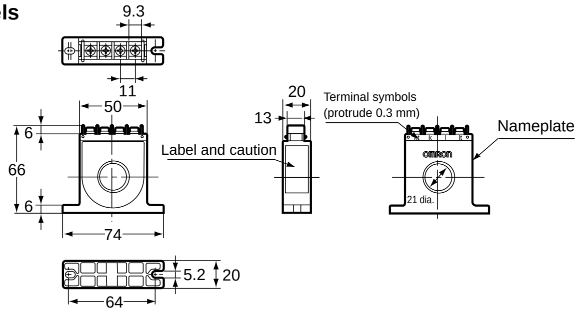
Model
Y92A-48B (Hard Cover)
Y92A-48D (Soft Cover)

ZCT

Indoor Through-type Models

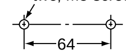
OTG-L21 (50 A)



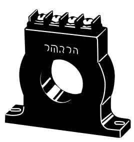


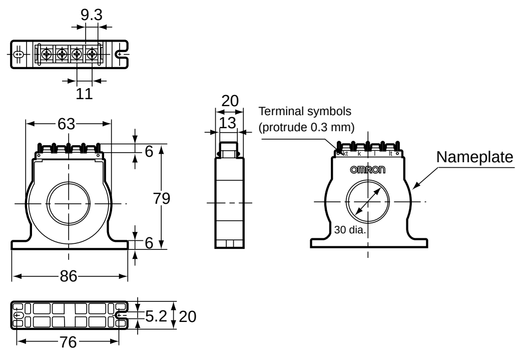
Mounting Hole Cutout Dimensions

Two, 5.5-dia. holes or two, M5 screw holes



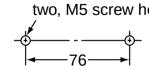
OTG-L30 (100 A)



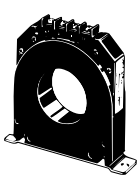


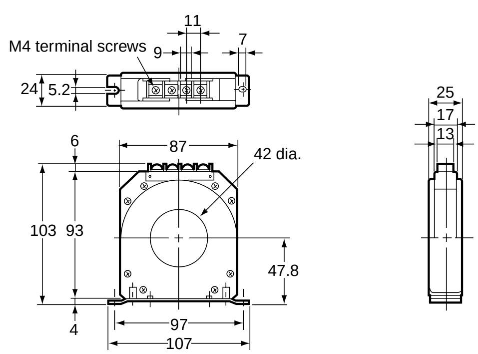
Mounting Hole Cutout Dimensions

Two, 5.5-dia. holes or two, M5 screw holes



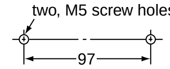
OTG-L42 (200 A)



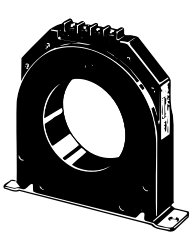


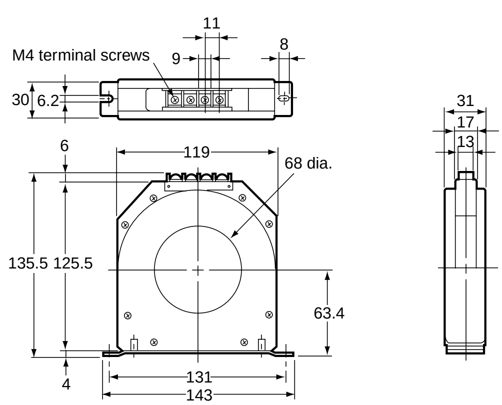
Mounting Hole Cutout Dimensions

Two, 5.5-dia. holes or two, M5 screw holes



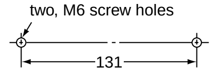
OTG-L68 (400 A)



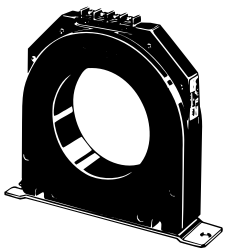


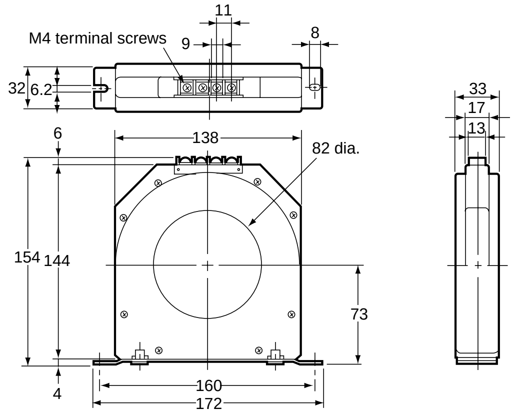
Mounting Hole Cutout Dimensions

Two, 6.5-dia. holes or two, M6 screw holes



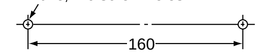
OTG-L82 (600 A)



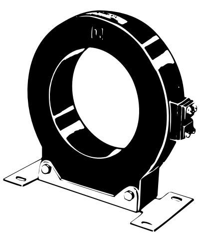


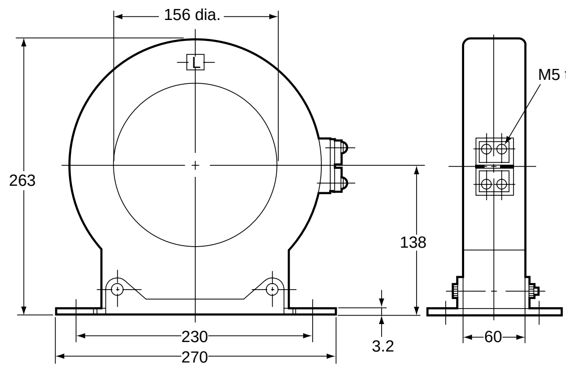
Mounting Hole Cutout Dimensions

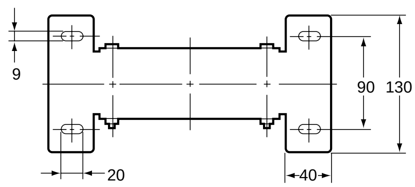
Two, 6.5-dia. holes or
two, M6 screw holes



OTG-L156 (1,000 A)

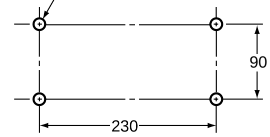




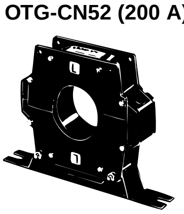


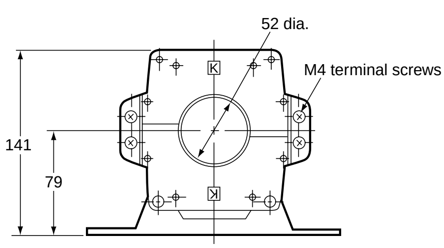
Mounting Hole Cutout Dimensions

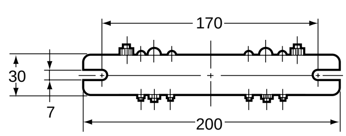
Four, 8.5-dia. holes or
four, M8 screw holes



Indoor Separate-type Models
OTG-CN52 (200 A)

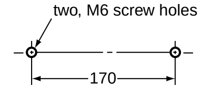




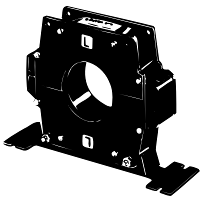


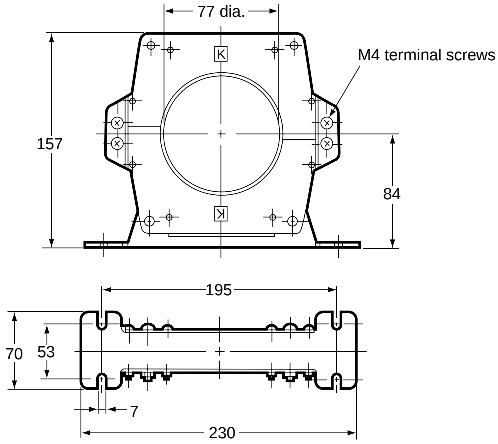
Mounting Hole Cutout Dimensions

Two, 6.5-dia. holes or
two, M6 screw holes



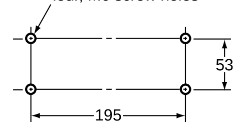
OTG-CN77 (400 A)



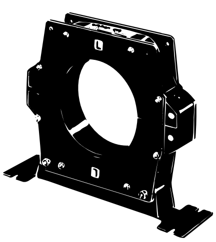


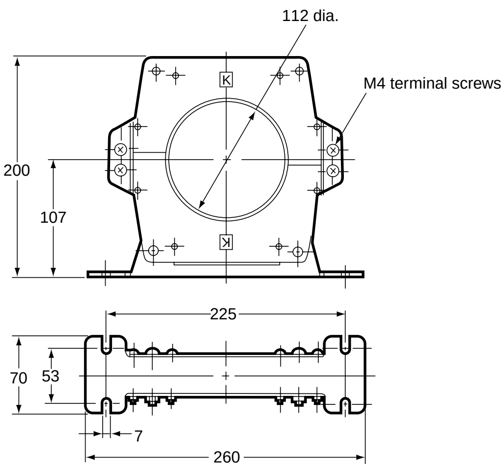
Mounting Hole Cutout Dimensions

Four, 6.5-dia. holes or four, M6 screw holes



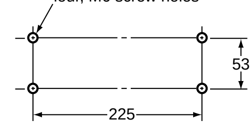
OTG-CN112 (600 A)





Mounting Hole Cutout Dimensions

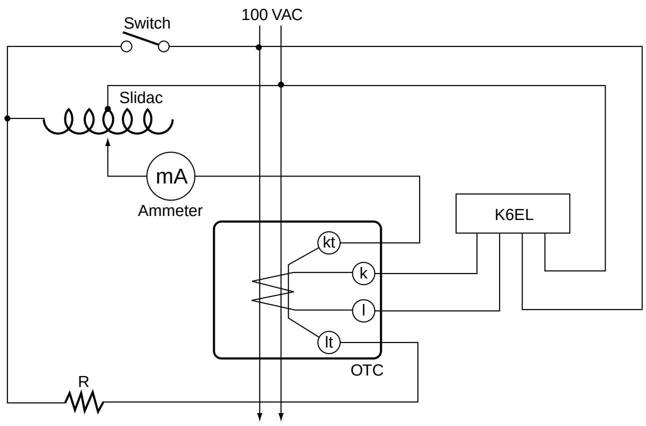
Four, 6.5-dia. holes or four, M6 screw holes



■ Maximum Wire Sizes for ZCTs

Model	Rated current	Wire/cable Through-hole diameter	600-V vinyl-insulated wire (IV) 2-wire	600-V vinyl-insulated wire (IV) 3-wire	Cable (VVR) 2-wire	Cable (VVR) 3-wire
OTG-L21	50 A	21 dia.	22 mm^2	14 mm^2	8 mm^2	5.5 mm^2
OTG-L30	100 A	30 dia.	60 mm^2	38 mm^2	38 mm^2	38 mm^2
OTG-L42	200 A	42 dia.	100 mm^2	100 mm^2	100 mm^2	60 mm^2
OTG-L68	400 A	68 dia.	400 mm^2	325 mm^2	325 mm^2	250 mm^2
OTG-L82	600 A	82 dia.	500 mm^2	500 mm^2	400 mm^2	400 mm^2
OTG-L156	1,000 A	156 dia.	500 mm^2	500 mm^2	1,000 mm^2	1,000 mm^2
OTG-CN52	200 A	52 dia.	200 mm^2	200 mm^2	150 mm^2	100 mm^2
OTG-CN77	400 A	77 dia.	500 mm^2	400 mm^2	400 mm^2	325 mm^2
OTG-CN112	600 A	112 dia.	500 mm^2	500 mm^2	1,000 mm^2	1,000 mm^2

Test Circuit



Select the resistance R shown in the test circuit diagram according to the K6EL's rated sensed current. Change the current using the slidac and ascertain the K6EL's operating value each time by reading the ammeter.

For example, R could take the values shown below:
30 mA: 3.3 kΩ, 6 W
100 mA: 1 kΩ, 20 W
200 mA: 500 Ω, 50 W
500 mA, 200 Ω, 100 W
1,000 mA: 100 Ω, 200 W

Precautions

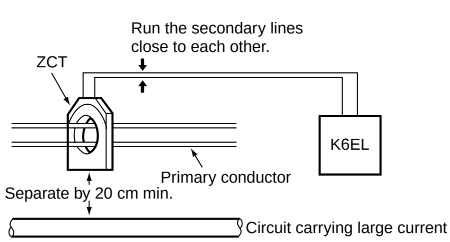
■ Correct Use

Installation and Wiring

- Do not, under any circumstances, connect the ZCT's output terminals k and l to ground. Doing so may result in damage to the Relay's internal circuits.
- Pass the primary conductor through the ZCT once.
- The Relay detects ground faults in internal wiring of devices due to insulation deterioration and so install the ZCT as close to the power supply side as possible.

ZCT Installation

- Install the ZCT at an outdoor cable inlet or on a ground bus bar at a location allowing easy inspection.
- When installing on the electrical path, use a ZCT with a value greater than the electrical path's rated current.
- If the secondary lines run in parallel to a circuit carrying a large current, either separate the lines as far as possible or use a shield line.



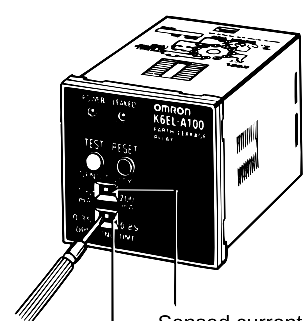
- When installing a separate-type ZCT with current flowing along the primary conductors, short the secondary terminals using clips or some other method.

Switching the Sensed Current

1. With the K6EL-□100, 200, 500, R50, and R500, the sensed current can be switched using a flat-bladed screwdriver.
2. The sensed current for the K6EL-30 is fixed and hence cannot be switched.

Switching the Operating Time

1. With the K6EL-A100, A200, and A500, the operating time can be switched using a flat-bladed screwdriver.
2. The operating time for the K6EL-30, 100, 200, 500, R50, and R500 is fixed and hence cannot be switched.



Testing

- If the ground fault indicator (red) lights when the Relay's test button is pressed, it means that the internal circuits are operating normally.
- To make an overall test, run a simulated ground fault current.

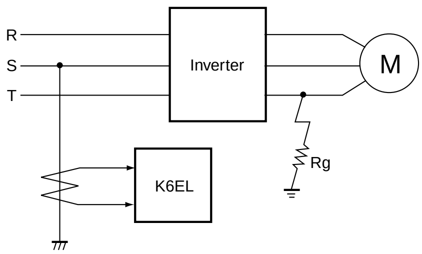
Resetting

- Once manual-reset models operate, they continue to operate until they are reset. Reset them either by pressing the reset button (black) or by turning the control power supply OFF and ON again.
- Automatic-reset models reset automatically when the ground fault is cleared (i.e., the current drops below the sensed current).

Q&A

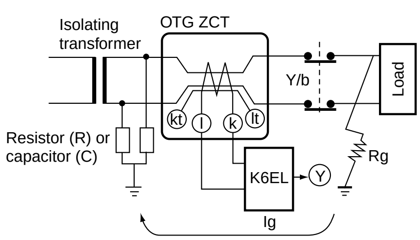
Q: How does the K6EL operate when used for inverter loads (e.g., inverter motors and inverter air conditioners)?

A: The influence of high-frequency noise generated by the inverter has been reduced by combining a special ground fault relay IC and a capacitor for cutting out high-frequencies. The possibility of malfunctions due to the influence of the inverter is much less than with the existing ESA Ground Fault Relay.



Q: What connection method should be used for ungrounded electrical paths?

A: With ungrounded electrical paths, connect the capacitor or resistor for detection in the way shown in the diagram. The table shows the formulas for calculating the resistance or capacitance as well as the formulas for calculating ground currents for complete ground faults. (Depending on the location, the allowable ground fault current may be restricted. In this case, use values of R and C that do not exceed the restrictions.)

	Connection method	Formula for resistor or capacitor		Formula for ground current	Formula for safety ground fault
Single-phase electrical path		Resistor: $R=\frac{V}{2It}$ (Ω) $P=\frac{5V^2}{R}$ (W)	It: Ground Fault Relay's set value V: Line voltage f: Frequency P: Allowable power for the resistor used (A tolerance is included in the formulas on the left.)	$Ig=\frac{V}{2Rg + R}$ (A)	$Ig=\frac{V}{R}$ (A)
		Capacitor: $C=\frac{2It}{2\pi fV}$ (F) Dielectric strength > 2 V (V)		$Ig=\frac{V}{\sqrt{(2Rg)^2+(\frac{1}{2\pi fC})^2}}$ (A)	$Ig = 2\pi fCV$ (A)

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.

To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N126-E1-01

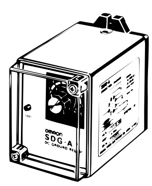
DC Fault Detection Relay
SDG

Detects Ground Faults in DC Control Circuits and DC Bus Lines

- The Relay is self-resetting and so resumes detection when the fault is cleared.
- Cannot be used for grounded DC circuits.

Ordering Information

■ List of Models

Function	Ground fault detection
Model	SDG-A
Appearance	Plug-in type 

Specifications

■ Ratings

Item \ Model / Rated input voltage		SDG-A 24 VDC	SDG-A 110 VDC
Allowable input voltage range		85% to 110% of the rated voltage	
Rated control power supply voltage		24 VDC, 110 VDC (specific types for each voltage)	
Allowable control power supply voltage		85% to 110% of the rated voltage	
Ground fault section		Operation resistance: 1 to 10 kΩ (continuously variable) Reset resistance: 115% max. of the operating value	
Operating time		1 s max. (for a sudden ground fault with resistance dropping from infinity to 0 Ω)	
Power consumption		5 W max.	
Reset method		Self-resetting	
Control output	Ground fault section	SPDT	
	Undervoltage section	---	
Contact capacity		200 VAC, 2 A (cosϕ = 0.4) 30 VDC, 2 A (L/R = 7 ms)	
Exterior		Munsell 5Y 7/1	
Weight		Approx. 330 g	

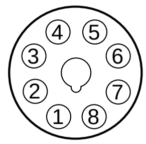
■ Characteristics

Item \ Model	SDG-A
Setting error (See note.)	Within ±5%
Influence of input voltage (See note.)	Within ±5% (at voltages between 80% and 120% of the rated voltage)
Influence of control power supply voltage (See note.)	Within ±2% (at voltages between 85% and 110% of the rated voltage)
Influence of temperature (See note.)	Within ±5% (at temperatures between –10 to 60 °C)
Insulation resistance	10 MΩ min. at 500 VDC (between electric circuits and outer casing)
Dielectric strength	2,000 VAC, 50/60 Hz for 1 min (between electric circuits and outer casing)
Lightning impulse dielectric strength	1.2/50 μs, 4,500 V between electric circuits and outer casing
Vibration (destruction)	16.7 Hz, 1.0-mm double amplitude in 3 directions for 10 min each
Shock (destruction)	294 m/s^2

Note: These figures are percentages of the maximum scale.

Terminal Arrangement

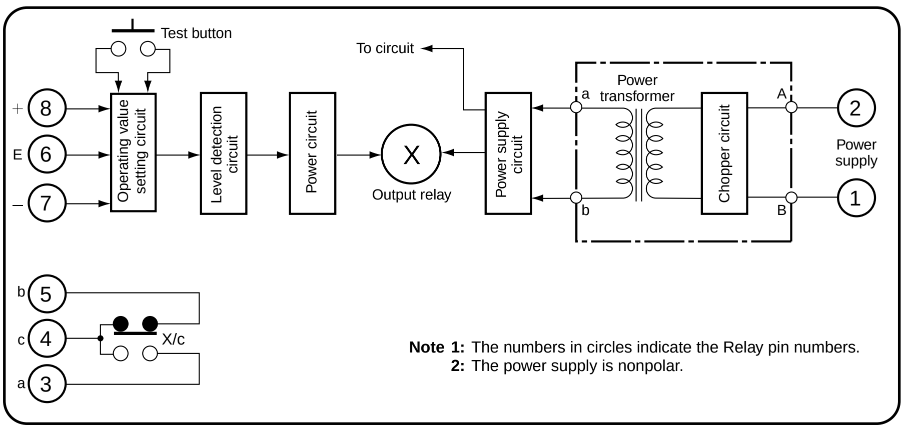
SDG-A



Terminal arrangement on rear side

Internal Block Diagram

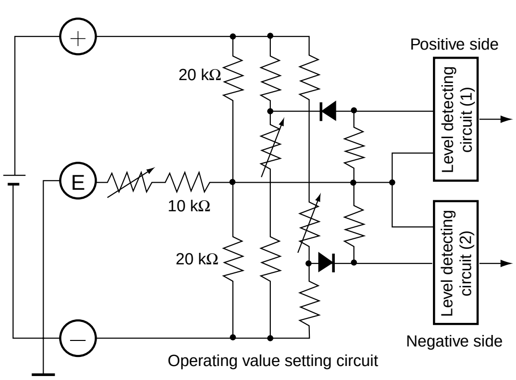
SDG-A



Note 1: The numbers in circles indicate the Relay pin numbers.
2: The power supply is nonpolar.

Operation

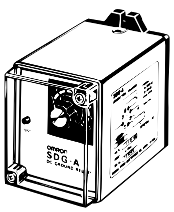
- The SDG's internal connections and the ground fault section's operating value setting circuit are shown in the diagram.
- The setting circuit is a resistance bridge circuit. When a ground fault occurs, the bridge becomes unbalanced and output turns ON. Level detecting circuits 1 and 2 detect the incidence level and an output signal is sent via the positive and negative sides of the judgement output.
- In the undervoltage section, voltage input is compared with the internal reference voltage and output is turned ON if it drops.
- When the operating resistance is set to 1 kΩ, the Relay operates if the ground fault resistance drops below 1 kΩ.

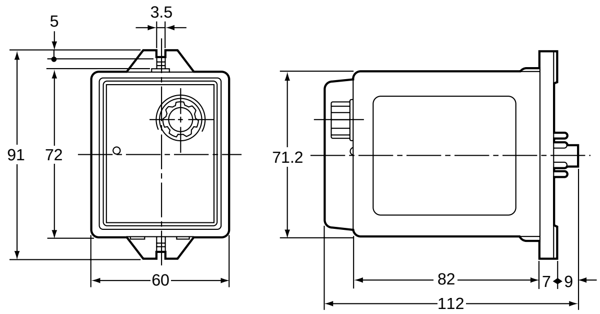


Dimensions

Note: All units are in millimeters unless otherwise indicated.

Plug-in Type





Applicable Connecting Sockets
Use an 8PFA1 Front Connecting Socket.

Precautions

■ Correct Use

Do not install this Relay in the following places.

- Grounded circuits
- Locations where inflammable gases may be present
- Locations subject to high humidity levels
- Locations subject to extreme changes in temperature
- Locations where there is a danger of mechanical damage due to severe vibrations

Mounting

- When installing with an 8PFA1 Front Connecting Socket, first fasten the socket firmly to the panel with screws, then plug in the Relay and secure it with a hook. Leave at least 30 mm of space between the Relays for the hooks.
- Although there is no particular restriction on the mounting direction, it is best to mount horizontally.

■ Ordering

Specify the following items when ordering.

- Model
- Rated input voltage
- Rated control power supply voltage

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

Cat. No. N127-E1-01

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Note: Specifications are subject to change.

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