THREE-PHASE POWER CONTROLLER

PA-3000-H3

INSTRUCTION MANUAL

Shinko

- Contents -

INTRODUCTION

Thank you for purchasing the PA-3000-H3 series power controller.
This manual contains instructions for the mounting, functions, operations and notes when operating the PA-3000-H3 series power controller.
To prevent accidents arising from the misuse of this power controller, please ensure the operator receives this manual.

The PA-3000-H3 series 3-phase angle control power controllers feature a compact size/lightweight construction and are for high-density instrumentation. They are designed for exclusive use in 3-phase angle control, and are power regulators to control the power applied to an electric furnace heater, etc. by receiving signals from a controller or a manual setting unit.

CAUTION

(1) The information given in this manual may be subject to change without notice.
(2) Every possible care was taken in compiling this manual. However, if you find a question, error or mistake in it, please contact your nearest distributor.
(3) In spite of (2) above, SHINKO does not assume any liabilities concerning the results of this instrument's operation.

1 FOR SAFE USE OF THIS INSTRUMENT (⚠Warning)

This chapter describes how to use this instrument correctly and to avoid injuries to you or others and property damage. Be sure to understand the following information thoroughly and observe the warnings and cautions given.

1. Checking the product

This instrument has passed our strict shipment inspections. After delivery, be sure to check the following items before use.

(1) Check if the delivered instrument is the one you ordered.
Ensure the specifications including the model number, rated voltage and rated current are correct.

(2) Check if this instrument was damaged during transportation, etc.
Thoroughly ensure that this instrument is not damaged.
If you notice any problem, please contact your nearest distributor.

2. Preconditions for use

This instrument is a component type designed for the installation inside an indoor instrumentation panel. Do not use it otherwise.
Before using this instrument, ensure safety by confirming the functioning of the fail-safe design, periodical inspection, etc. before shipping. In addition, for connection/operation of this instrument, use a professional with instrumentation knowledge.
Furthermore, it is necessary for an operator of this instrument to read this instruction manual for the proper understanding of fundamental operation, various precautions, etc. of this instrument.

3. Labels attached to this instrument

The following labels are attached to this instrument to ensure its safe use.

Label	Name	Description
	Alert symbol mark	This label is attached to places requiring care in handling where there is a risk of electric shock or injury.
	Protective conductor terminal	To prevent an electric shock, connect the protective conductor terminal to the protective conductor (grounding) of the facility.
	Caution: Moving parts	Keep your hands away from the mobile part (top panel fan) to prevent from injuries.
	Caution: High temperature surface	To prevent burns, keep your hands away from the top and side panels.

4. Symbols used in this manual

The safety precautions are classified into categories: “Warning” and “Caution”.
Depending on the circumstances, procedures indicated by ⚠ Caution may be linked to serious results, so be sure to follow the directions for usage.

Symbol	Scope
⚠WARNING	Procedures which may lead to dangerous conditions and cause death or serious injury, if not carried out properly.
⚠CAUTION	Procedures which may lead to dangerous conditions and cause superficial to medium injury or physical damage or may degrade or damage the products, if not carried out properly.

⚠WARNING

The following information is critical for safety. Be sure to read and understand the following warnings thoroughly before reading this instruction manual. Remember that every warning is critical for preventing injuries and other accidents.

1. Installation on an instrument panel

Make sure to install this instrument inside an indoor instrument panel. Never use it on a desktop. As some of the main circuit terminals of this instrument are exposed, protect them against human contact by using a safety measure such as protective covers.

2. Over-current protection device

This instrument does not have a power switch. As a consequence, the power supply to this instrument should be protected with an over-current protection device (such as a circuit breaker) matching the power rating.

3. Installation safety devices

When this instrument is installed in or near other equipment, whereby the failure of this instrument or peripheral instruments may lead to damage or fiscal loss, make sure to attach all safety devices to the equipment and perform a final check of its fail-safe design at the final product side. Also, never use this instrument in important equipment affecting human lives, nuclear power, aviation or space.

4. Before turning this instrument on

Confirm that the protective conductor terminal of this instrument is connected to the protective conductor (grounding) of the facility. Also, to prevent malfunction, make sure to connect a load to this instrument before turning the power on.

5. During operation

Do not touch this instrument during operation (as well as when it is turned on). High-voltage and high-temperature parts are very hazardous. Particularly, never touch the top panel, side panels, cooling fan, terminals and their surrounding area.

6. Modification or repair

To avoid an electric shock, fire or malfunction, this instrument must not be repaired, modified or disassembled by any person other than our authorized service personnel.

7. Compliance with the instruction manual

To use this instrument correctly and safely, use it in accordance with this instruction manual. We will not assume any liabilities for claims based on injuries, damage, loss of profit incurred due to abuse or misuse of this instrument.

8. Stop supplying power immediately if any abnormal event occurs.

Turn off the power immediately and contact your nearest distributor if there is any unusual odor, noise, smoke or abnormal heat.

9. Caution when lifting heavy products.

Products heavier than 18kg need more than one person when handling. The weight(s) of the products are shown in the [General Specifications] of this instruction manual.

2 CHECKING THE MODEL NUMBER

Control system	Rated current				
	30A	50A	75A	100A	150A
Phase control, Voltage feedback	PA-3030-VH3	PA-3050-VH3	PA-3075-VH3	PA-3100-VH3	PA-3150-VH3
Phase control, Current feedback	PA-3030-AH3	PA-3050-AH3	PA-3075-AH3	PA-3100-AH3	PA-3150-AH3
Phase control, Power feedback	PA-3030-PH3	PA-3050-PH3	PA-3075-PH3	PA-3100-PH3	PA-3150-PH3
Phase control, No feedback	PA-3030-H3	PA-3050-H3	PA-3075-H3	PA-3100-H3	PA-3150-H3

Control system	Rated current				
	200A	250A	300A	400A	500A
Phase control, Voltage feedback	PA-3200-VH3	PA-3250-VH3	PA-3300-VH3	PA-3400-VH3	PA-3500-VH3
Phase control, Current feedback	PA-3200-AH3	PA-3250-AH3	PA-3300-AH3	PA-3400-AH3	PA-3500-AH3
Phase control, Power feedback	PA-3200-PH3	PA-3250-PH3	PA-3300-PH3	PA-3400-PH3	PA-3500-PH3
Phase control, No feedback	PA-3200-H3	PA-3250-H3	PA-3300-H3	PA-3400-H3	PA-3500-H3

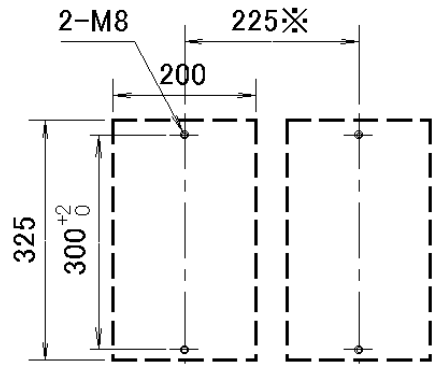
For a feedback type, 3 pieces of CT (Current transformer) are required for detection of load current and over-current.

3 INSTALLATION

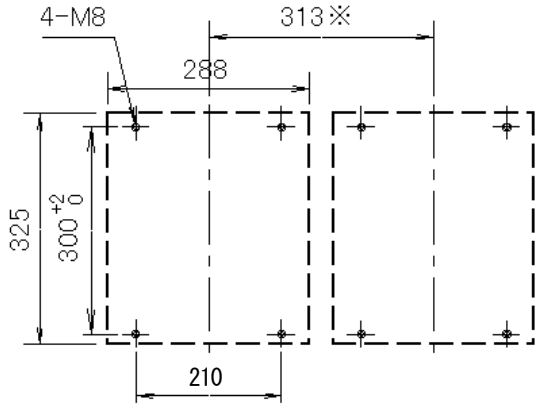
3.1 Installation Dimensions (Scale: mm)

For the dimensions of this instrument itself, see chapter 4, “Dimensions and Name of sections.”

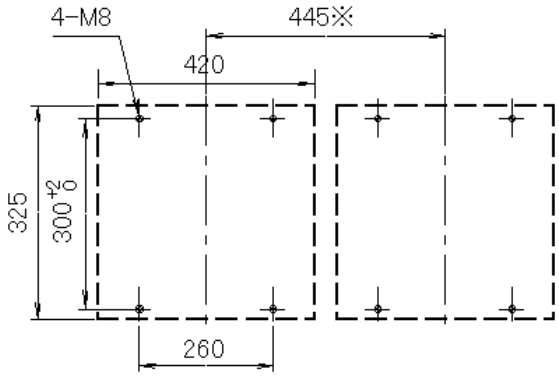
Rated current: 30A/50A



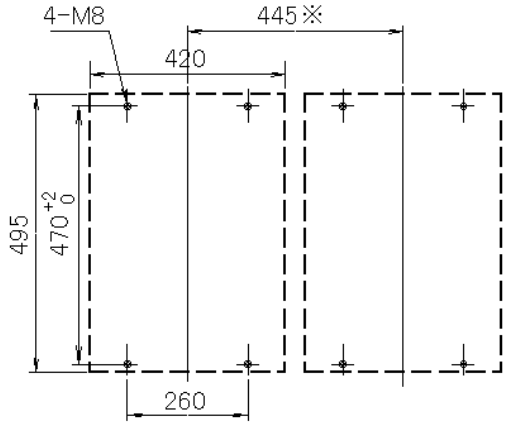
Rated current: 75A/100A



Rated current: 150A/200A/250A



Rated current: 300A/400A/500A



※ Caution: Minimum distance when plural instruments are installed side by side

3.2 Installation Precautions

WARNING	To prevent accidents, make sure to turn this instrument off before proceeding to the following operations.

Except for the accessories of the setting units, this instrument has been designed as a back -paneled unit to be installed inside an instrumentation panel.

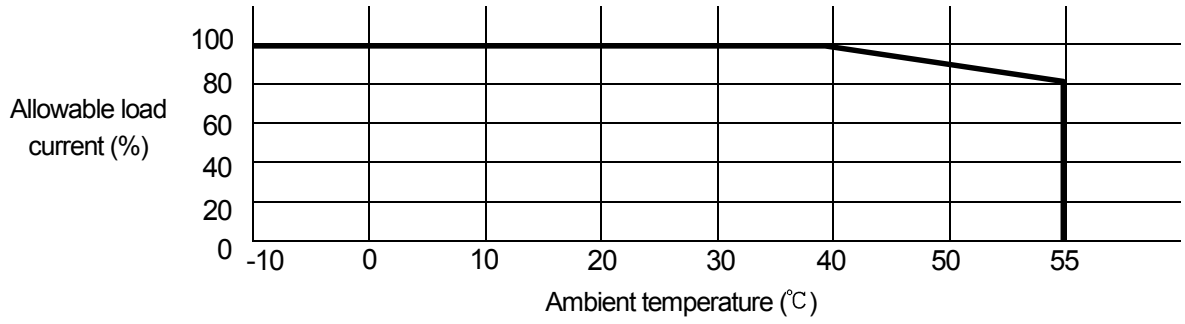
CAUTION

Environment

- Inside an instrumentation panel indoors
- Out of direct sunlight
- Avoiding mechanical oscillations or impact
- Clear of water splashes
- Unaffected by strong noise, static, electric or magnetic fields
- Ambient temperature -10 to 55℃ (When the ambient temperature exceeds 40℃, reduce the load current.)
- Ambient humidity 30 to 90%RH (No condensation)
- Free from corrosive, explosive, flammable, or combustible gases, salt, high iron content, steam, oil, chemicals, conductive materials, mine dust or other unusual substances (metal powder, cut glass, iron or carbon)
- Free from dust or dirt

Other

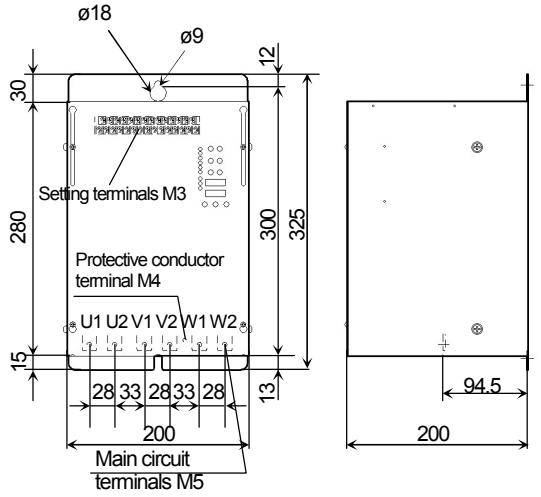
- Installation location altitude should be 2,000 meters or less.
- This instrument has high-voltage and high-temperature parts exposed externally. When installing this instrument, take proper measures to avoid contact with those parts.
- To allow the ventilation/cooling effect to achieve full performance, be sure to install this instrument with the UP mark (↑) facing upward. Reserve a space of 200 mm or more above the top of this instrument and a space of 100 mm or more below
- Keep the ambient temperature specified by placing a cooling fan, an air conditioner, etc. inside the panel, if necessary.
- Ensure that the panel on which this instrument is installed is strong enough to support it.
- To protect the system, be sure to install an external rapid-break fuse when the instrument does not have a built-in rapid-break fuse.
- Separate this instrument from equipment (electro-magnetic switch, motor, inverter, etc.) generating strong noise.
- The output waveform of this instrument contains harmonic components, which may become a source of power wave distortion or harmonic noise to other equipment. To prevent such problems, be sure to take countermeasures when installing peripheral equipment.
- Do not connect anything to the terminals that are not used. Otherwise, a malfunction may result.
- To prevent malfunction of this instrument due to environment, be sure to take the following dust measures at the control panel side. (especially in the case where this instrument is used under a special atmospheric condition such as using a carbon heater, etc.)
  1. Design the control panel with a sealed structure and take heat radiation measures.
  2. Apply the air purge to the control panel.
  3. Perform periodical cleaning.
- Working ambient temperature is between -10 and +55℃, but the rated current is specified for an ambient temperature of up to 40℃ as a reference. If the temperature exceeds 40℃, be sure to lower the load current by referring to the following graph.



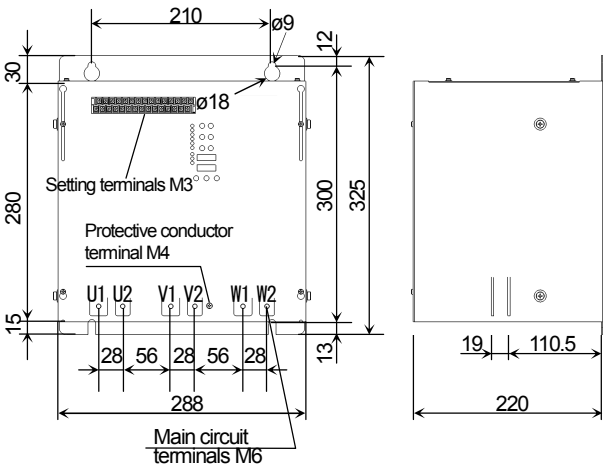
4 DIMENSIONS AND NAME OF SECTIONS

4.1 External Dimensions (Scale: mm)

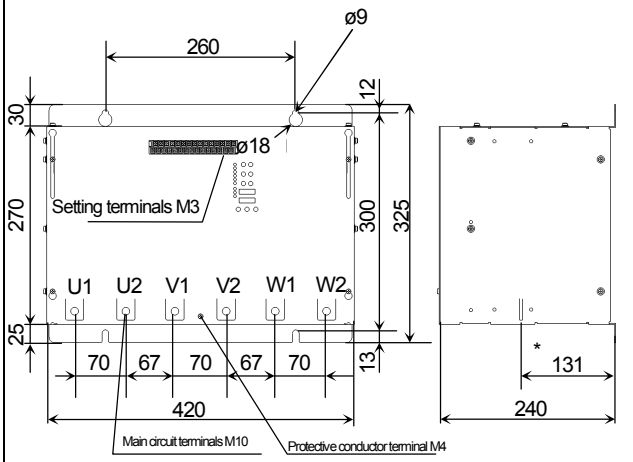
Rated current: 30A/50A



Rated current: 75A/100A

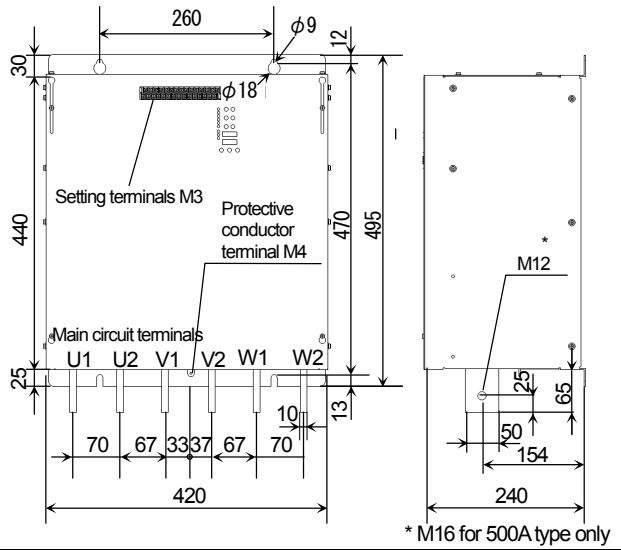


Rated current:150A/200A/250A



*141 for 250A type only

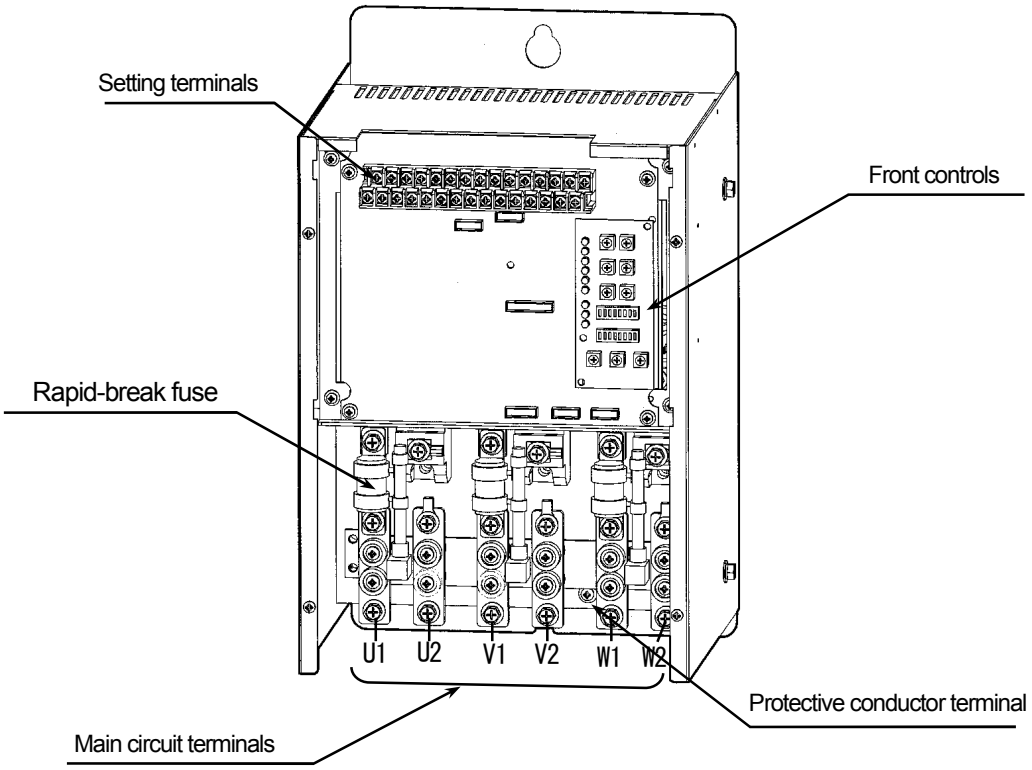
Rated current: 300A/400A/500A



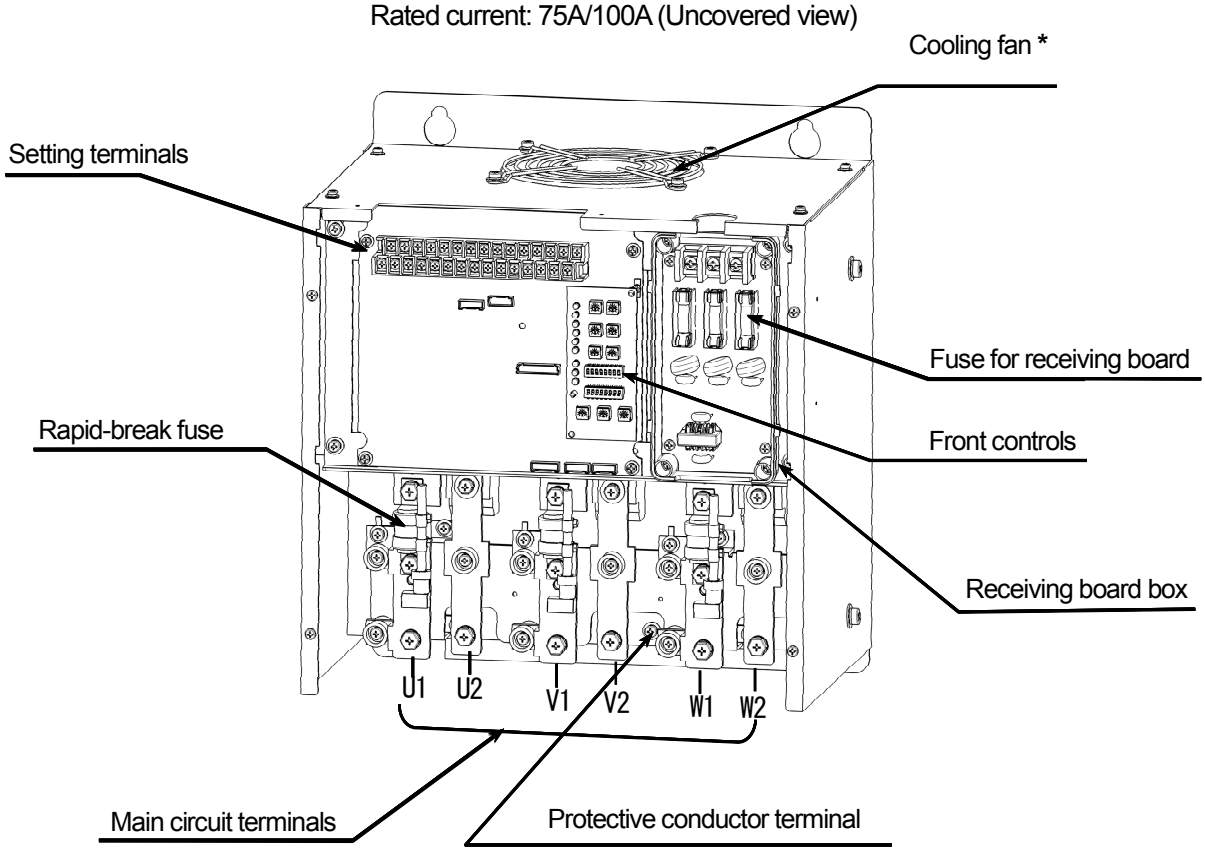
* M16 for 500A type only

4.2 Name of sections

Rated current: 30A/50A (Uncovered view)

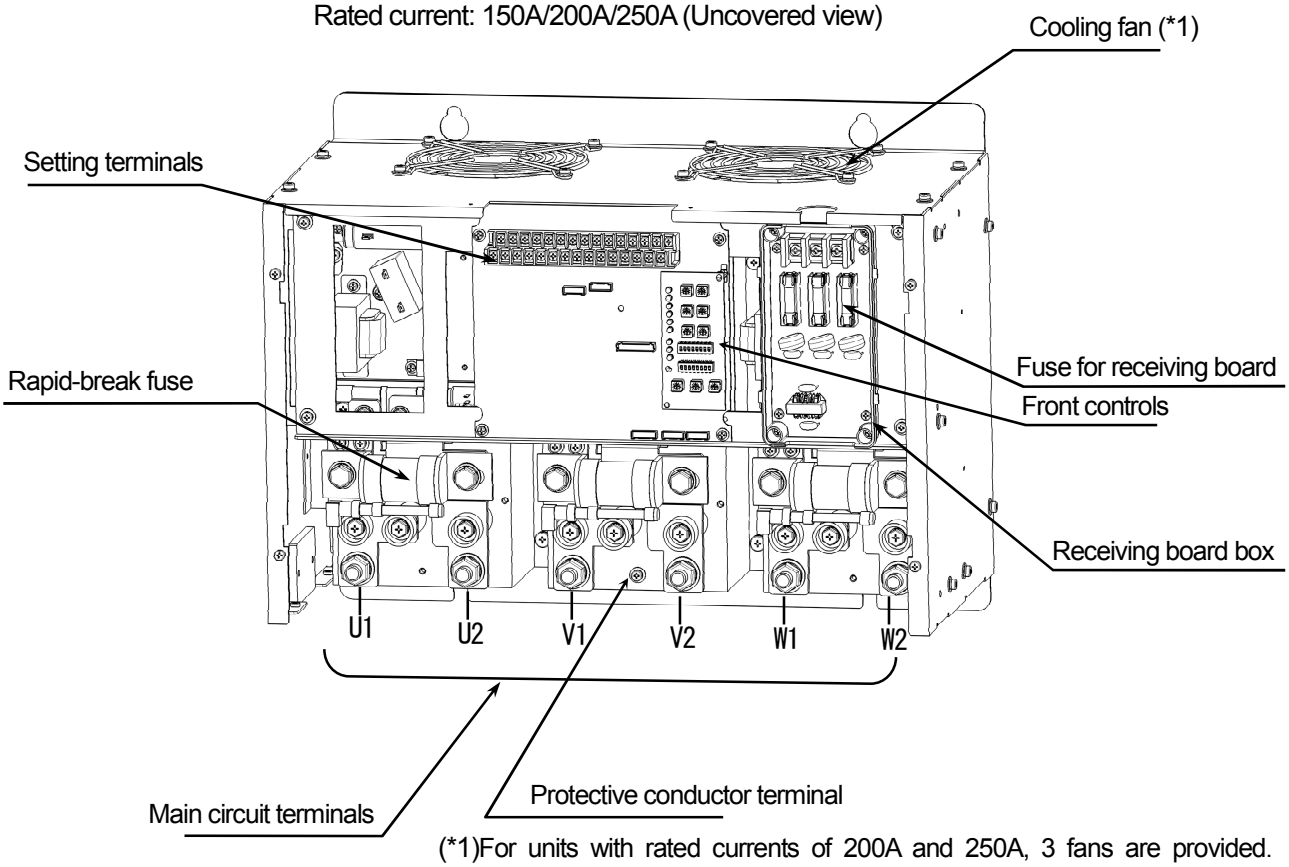


Rated current: 75A/100A (Uncovered view)



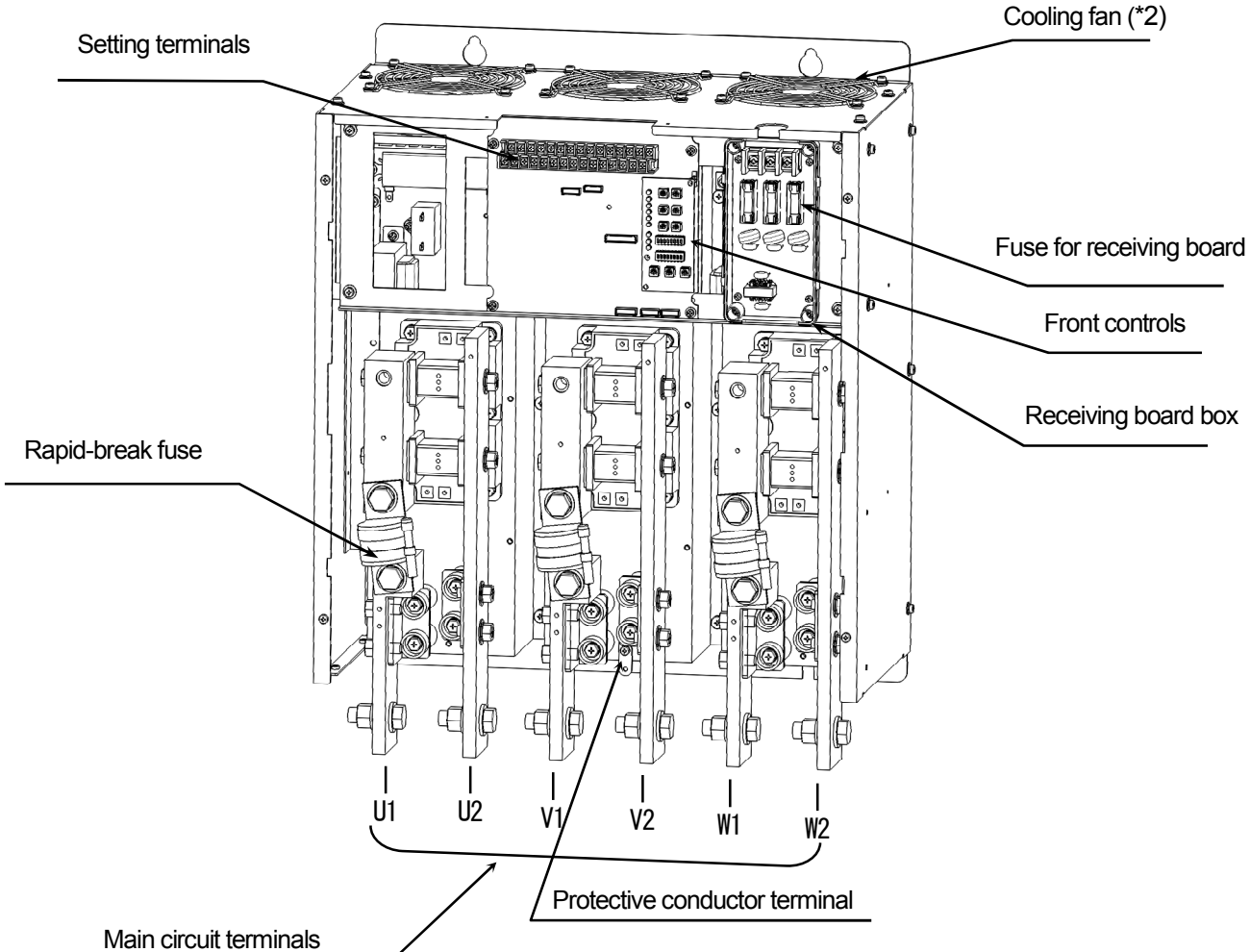
* Cooling fans not mounted for a rated current of 75A units

Rated current: 150A/200A/250A (Uncovered view)



(*1)For units with rated currents of 200A and 250A, 3 fans are provided.

Rated current: 300A/400A/500A (Uncovered view)



(*2) For units with rated currents of 300A, 2 cooling fans are provided.

5 CONNECTIONS

5.1 Connection Precautions

⚠ WARNING

(1) To prevent accidents, make sure to turn this instrument off before proceeding to the following operations.
(2) For safety, make sure to connect the protective conductor terminal to the protective conductor of the facility.
(3) For the main circuit wiring, connect the power supply side to the terminals U1, V1 and W1, and the load side to the terminals U2, V2 and W2.
(4) Make sure to coat the conductive parts with insulating materials (tube, tape, etc.) in the power supply connection sections. Any exposed connection part may result in a fire due to an electric shock or short-circuiting.

⚠ CAUTION

(1) Ensure that the rated voltage of this instrument matches the supply voltage.
(2) Check the size of each screw/bolt and tighten it with a force within ±10% of the specified securing torque.

Screw securing torque							
M3	M4	M5	M6	M8	M10	M12	M16
0.5 N•m	1.2 N•m	3 N•m	5 N•m	12 N•m	25 N•m	40 N•m	100 N•m

(3) Select wires with a gauge matching this instrument. Using a too thin wire may result in heat generation or a fire. The dielectric strength of the wires should be high enough to withstand the circuit voltage. Otherwise, an electric shock may result.
(4) Use crimp type terminals for connection to the setting terminals. Imperfect connection may result in an electric shock or malfunction.

(1) To prevent noise, distribute the wires to the setting terminals apart from the main circuit terminals (U1, V1, W1, U2, V2, W2) and do not put them in the same duct as the wires for the main circuit.
(2) The crimp type terminals for use with the setting terminals should be the R1.25-3S (small diameter for M3 screws).
(3) Even when this instrument is not operating with output, its output terminals generate a voltage from the internal snubber circuit. So it is necessary to install an over-current protection device (a breaker, etc.) to prevent an electric shock during maintenance and inspection.
(4) Due to the performance of this instrument, its wires may cause noise interference with external equipment. Be sure to distribute the wires of this instrument away from those of the peripheral equipment.
Also take noise countermeasures, such as the insertion of noise filters, as required.
(5) Equipment that are sources of noise (magnetic switch, motor, inverter, etc.) in the surroundings may affect the operation of this instrument. Distribute the wires of this instrument away from such peripheral equipment, and also take noise countermeasures, such as the insertion of noise filters, as required.
(6) After connecting, be sure to attach the cover to its original position to ensure safety.

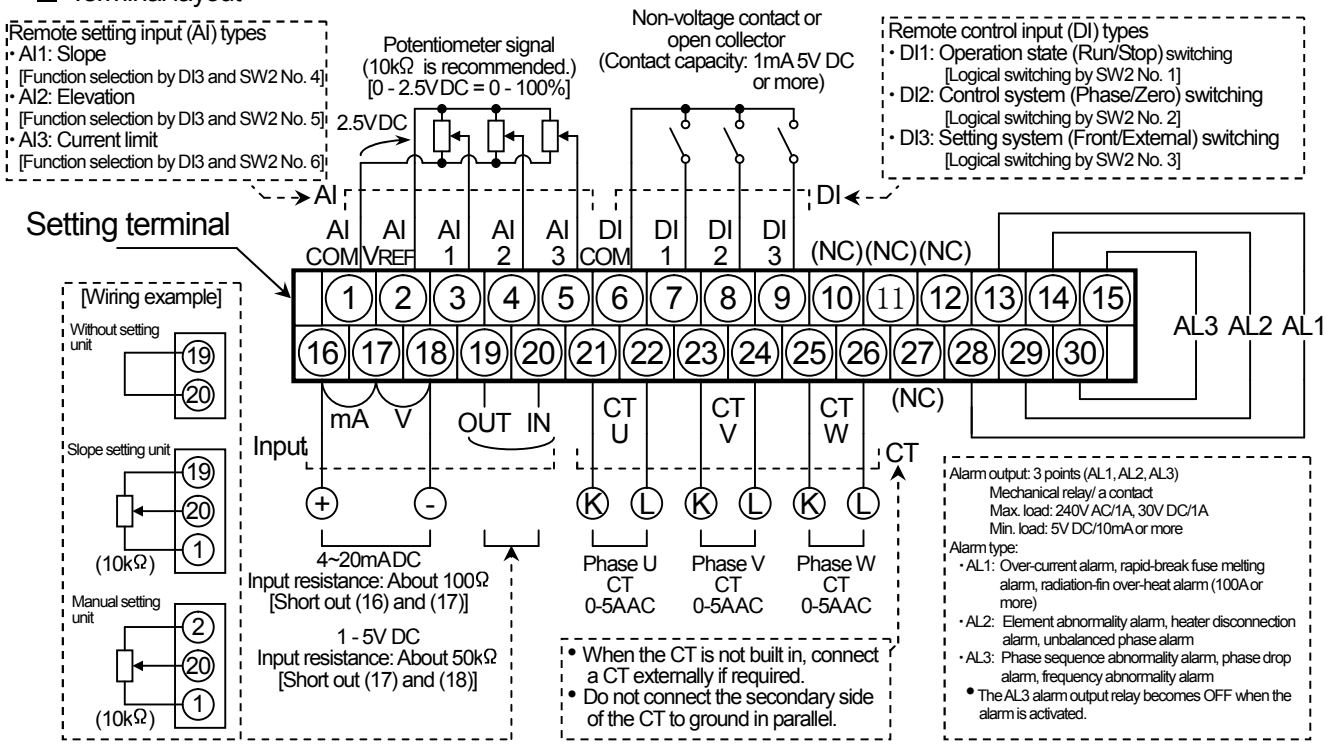
5.2 Functions of Setting Terminals

⚠ CAUTION	If settings are performed immediately after turning this instrument on, sudden changes in the output may affect the load or peripheral equipment. Perform the setting change gradually after the output stabilizes.

This instrument has setting terminals in addition to the main circuit terminals. Use them as required.

5.2.1 Layout and names of setting terminals

■ Terminal layout



- The actual layout is either horizontal or vertical depending on model.

■ Terminal list

(1)	Remote setting input common (AI COM)	(16)	Control input signal (+)
(2)	Remote setting input ref. voltage (AI VREF)	(17)	Control input signal selection (mA/ V)
(3)	Remote setting input 1 (AI1)	(18)	Control input signal (-)
(4)	Remote setting input 2 (AI2)	(19)	Control signal output (OUT)
(5)	Remote setting input 3 (AI3)	(20)	Control signal output (IN)
(6)	Remote contact input common (DI COM)	(21)	CT•U (K)
(7)	Remote contact input 1 (DI1)	(22)	CT•U (L)
(8)	Remote contact input 2 (DI2)	(23)	CT•V (K)
(9)	Remote contact input 3 (DI3)	(24)	CT•V (L)
(10)	N•C	(25)	CT•W (K)
(11)	N•C	(26)	CT•W (L)
(12)	N•C	(27)	N•C
(13)	Alarm output 1 (AL1)	(28)	Alarm output 1 (AL1)
(14)	Alarm output 2 (AL2)	(29)	Alarm output 2 (AL2)
(15)	Alarm output 3 (AL3)	(30)	Alarm output 3 (AL3)

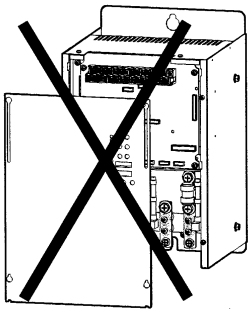
- The “N•C” terminals are not used, so do not connect anything to them. Otherwise, malfunction may result.
- Be careful that the control signal [(16) - (20)] and the remote setting input signal [(1) - (5)] are not isolated in the internal circuitry of this instrument.

5.2.2 Details of setting terminals

Pin No.	Name	Function
(1)	Remote setting input common (AI COM)	Common (reference ground) terminal for the remote setting input (AI)
(2)	Remote setting input ref. voltage (AI VREF)	Outputs 2.5V DC reference voltage for the remote setting input (AI)
(3)	Remote setting input 1 (AI1)	Inputs analog signal for the slope setting 0 to 2.5V DC of analog signal corresponds to the slope 0% to 100%.
(4)	Remote setting input 2 (AI2)	Inputs the analog signal for the elevation setting 0 to 2.5 V DC of analog signal corresponds to the elevation 0% to 100%.
(5)	Remote I setting input 3 (AI3)	Inputs the analog signal for the current limit settings 0 to 2.5 V DC of analog signal corresponds to the current limit 0 to 100%.
(6)	Remote contact input common (DI COM)	Common (reference ground) terminal for the remote contact input (DI).
(7)	Remote contact input 1 (DI1)	Inputs the remote contact for operation status (Run/Stop) switching. When “Stop” is switched to “Run”, the internal SV (control SV used in computational processing) starts from 0%.
(8)	Remote contact input 2 (DI2)	Input the remote contact for the control system (Phase angle/Zero-cross) switching. When switched during operation, the internal SV (control SV used in computational processing) starts from 0%.
(9)	Remote contact input 3 (DI3)	Input the remote contact for the setting type (Front setting [SET potentiometer]/Remote setting input [AI]) switching.
(13) (28)	Alarm output 1 (AL1)	The alarm output relay is turned ON when an over-current, rapid-break fuse meltdown or heat radiation fin overheat, or their combination, occurs. To avoid noise and protect contacts, be sure to connect a contact protection device and connect the load to it via a buffer relay. (Ref. 5.4.3)
(14) (29)	Alarm output 2 (AL2)	The alarm output relay is turned ON when the heater disconnection, thyristor element abnormality or unbalanced phase, or their combination occurs. To avoid noise and protect contacts, be sure to connect a contact protection device and connect the load to it via a buffer relay. (Ref. 5.4.3)
(15) (30)	Alarm output 3 (AL3)	The alarm output relay is turned ON after the initialization operation (mainly frequency assessment operation based on the synchronizing signal) is completed normally at start-up or reset. The relay is turned OFF when a phase sequence abnormality, phase drop, frequency abnormality, or their combination occurs. To avoid noise and protect contacts, be sure to connect a contact protection device and connect the load to it via a buffer relay. (Ref. 5.4.3)
(16)	Control input signal (+)	Connect the (+) signal of the control input signal.
(17)	Control input signal selection (mA / V)	Terminal to select whether 4 to 20mA DC or 1 to 5V DC control input signal is used. To use 4 to 20mA DC control signal, short terminals (16) and (17). To use 1 to 5V DC control signal, short terminals (18) and (17). Use the provided short-circuit plate for the short circuit.
(18)	Control input signal (-)	Connect the (-) signal of the control input signal.
(19)	Control signal output (OUT)	Outputs 0 to 2.5V DC of control signal, which corresponds to 0 to 100% of control input signal, from the internal circuitry. Usually, connect this terminal (19) directly to the control signal input (IN) terminal (20). Use the provided short circuit plate for connection between (19) and (20).
(20)	Control signal input (IN)	Inputs 0 to 2.5V DC corresponding to 0% to 100% of control signal. Usually, connect the control signal output (OUT) terminal (19) directly to this input terminal (20).
(21)	CT•U (K)	CT input (K) terminal for the U-phase.
(22)	CT•U (L)	CT input (L) terminal for the U-phase.
(23)	CT•V (K)	CT input (K) terminal for the V-phase.
(24)	CT•V (L)	CT input (L) terminal for the V-phase.
(25)	CT•W (K)	CT input (K) terminal for the W-phase.
(26)	CT•W (L)	CT input (L) terminal for the W-phase.

5.3 Preparation for Connection

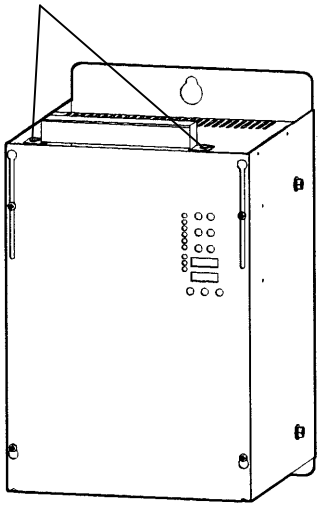
The locations of the main circuit and setting terminals differ depending on model.

⚠ CAUTION	Do not remove the cover for wiring, except when wiring to terminals for an external transformer connection. Otherwise, malfunction of this instrument, including damage to the internal electronic circuitry, may result. 

(30A – 500A type)

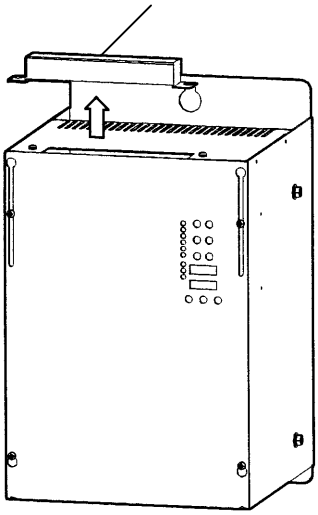
Step 1

Loosen screws.



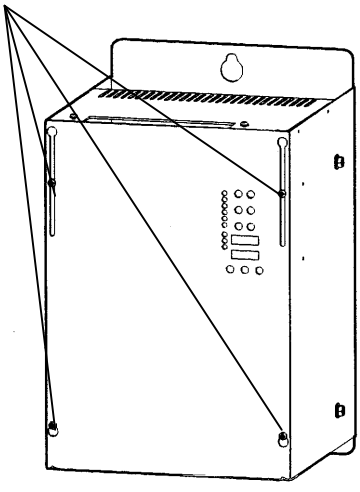
Step 2

Remove the setting terminal cover.

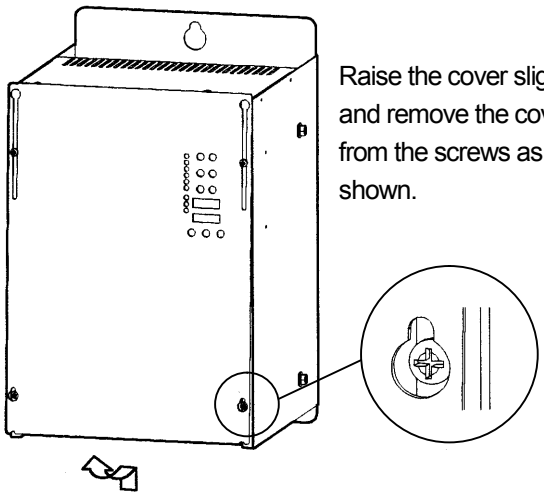


Step 3

Loosen screws.



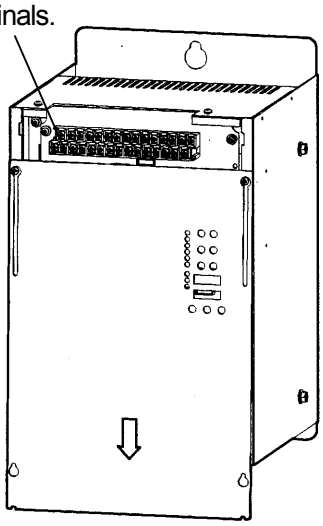
Step 4



Raise the cover slightly and remove the cover from the screws as shown.

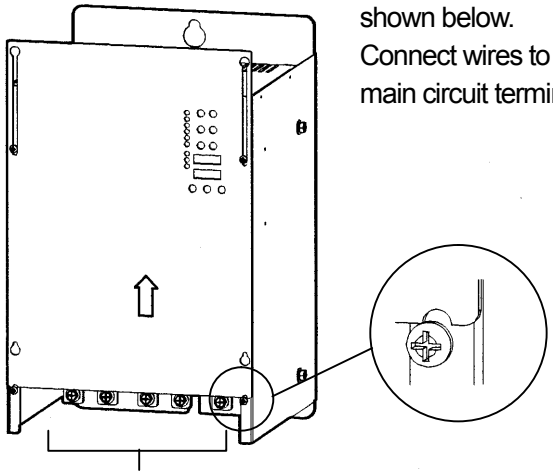
Step 5

Lower the cover and connect wires to the setting terminals.



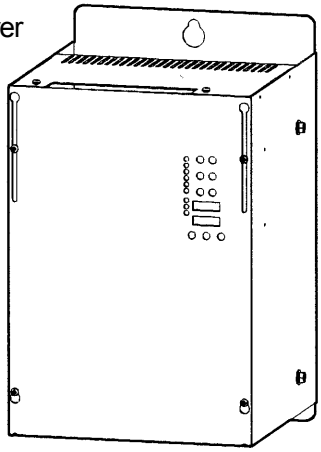
Step 6

Raise the cover and place the notch of the cover on the screw as shown below.
Connect wires to the main circuit terminals.

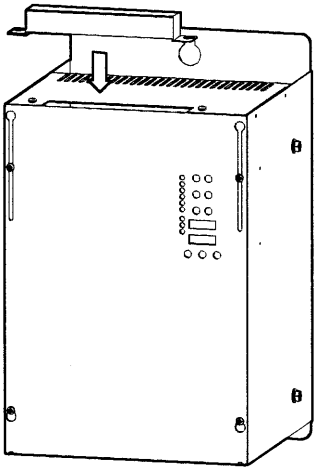


Step 7

Reattach the cover and tighten the screws.



Step 8

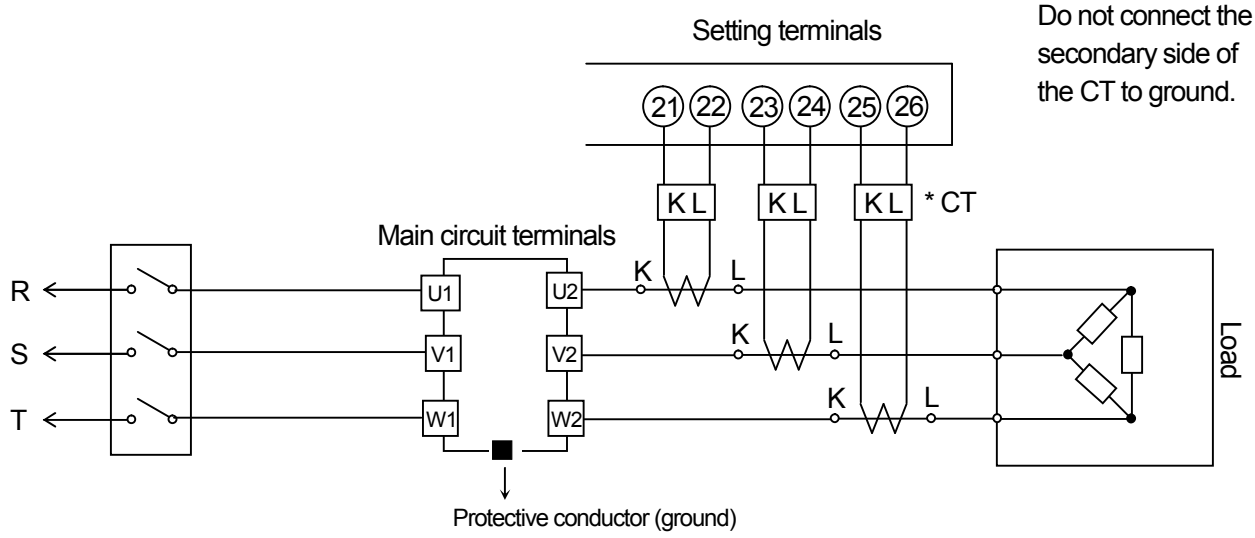


Reattach the setting terminal cover and tighten the screws.

5.4 Connection of Main Circuit Terminals

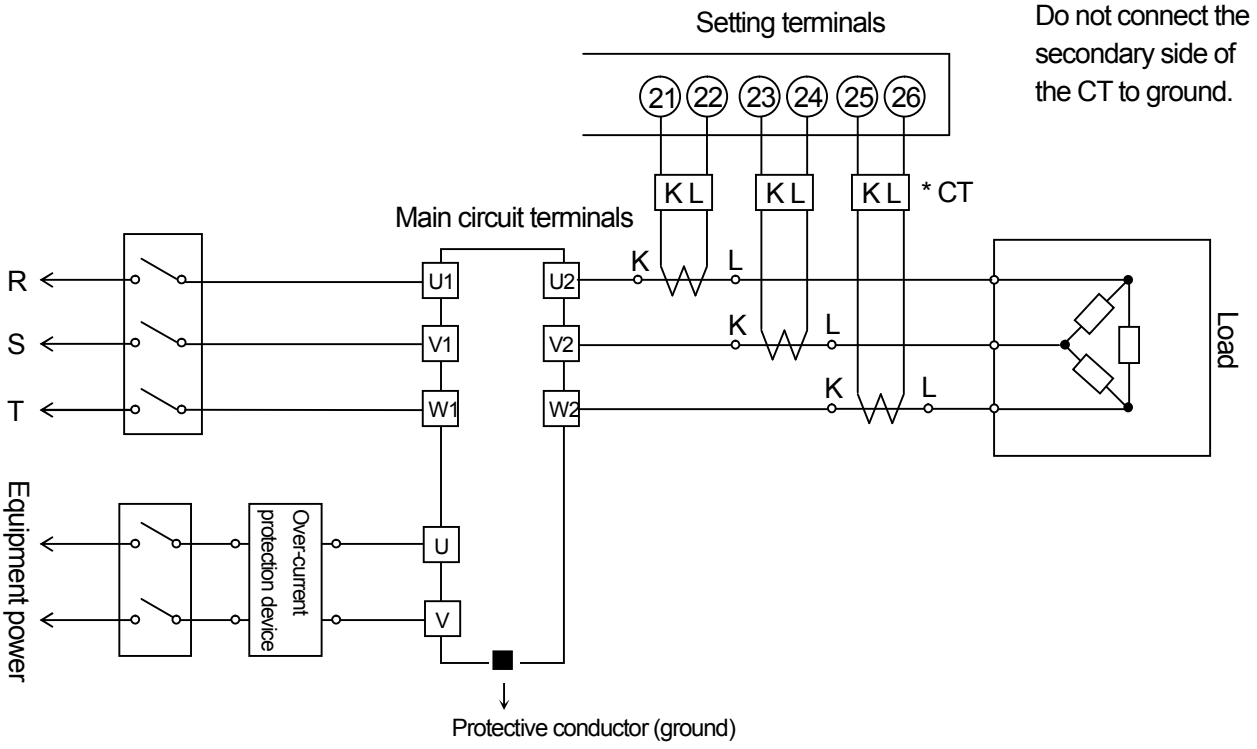
⚠ WARNING	(1) To prevent accidents, be sure to turn this instrument off before proceeding to the following operations. (2) The connection should be performed by personnel with sufficient knowledge and practical experience of wiring work.

5.4.1 Basic connection



* When the CT is not built in, externally connect a CT as required.

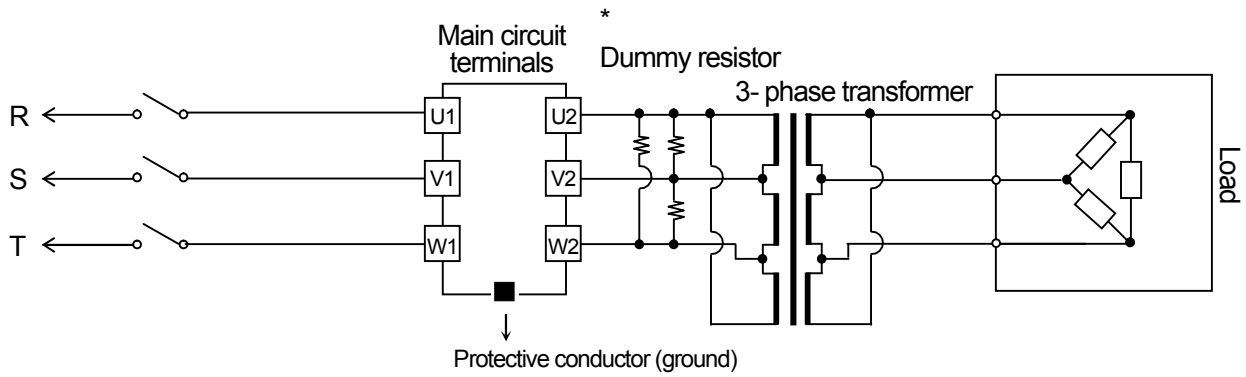
Standard type (Main circuit power and control circuit power utilize common terminals.)



* When the CT is not built in, connect a CT externally as required.

Special type (Main circuit power terminals are separated from those of control circuit power.)

5.4.2 Connection of the transformer load

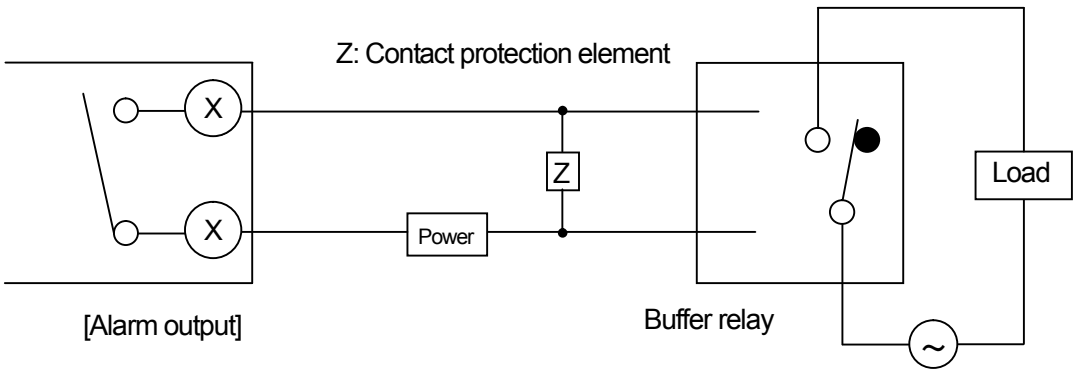


* A non-load running, in the case of the transformer load, may cause damage to this instrument and/or peripheral equipment (including the transformer). To prevent such damage, connect dummy resistors across the phases on the primary side of the transformer.
Use dummy resistors with resistance that can set currents between phases to 0.5A or more. For example, when the power voltage is 200V, the resistance should be 400Ω. In addition, the resistors should have a higher power value, being three or more times the calculated value: For example, for the 400Ω resistor, select a resistor with 300W or more as the calculated power value is 100W. Also, take necessary countermeasures such as cooling fans, depending on heat generation.
Never touch the dummy resistors because they are dangerous due to generated heat.

⚠ **CAUTION**	(1) Be sure to match the power phase on the power supply side and load side. (2) Use a high-quality power supply. If the waveform is distorted or includes noise, normal control will not be performed. This caution is particularly important when using a private electric generator.

5.4.3 Connection of the alarm output

Connect the alarm output terminals to the load via a buffer relay and contact protection element.

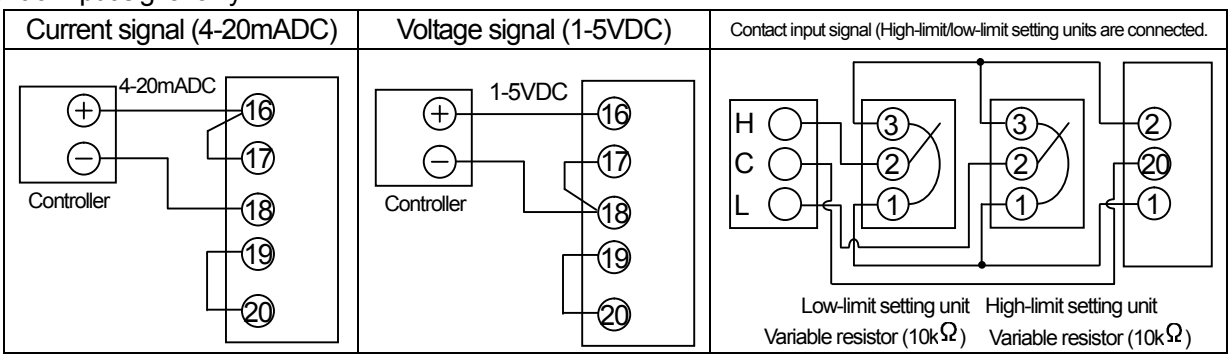


Generally, as a contact protection element, a CR combined element is used for AC power, and a diode is used for DC power.

5.5 Connection of Setting Terminals

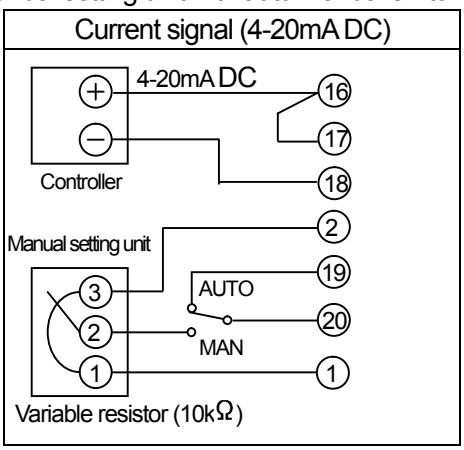
⚠ WARNING	(1) To prevent accidents, be sure to turn this instrument off before proceeding to the following operations. (2) The connection should be performed by personnel with sufficient knowledge and practical experience of wiring work.

1) Control input signal only

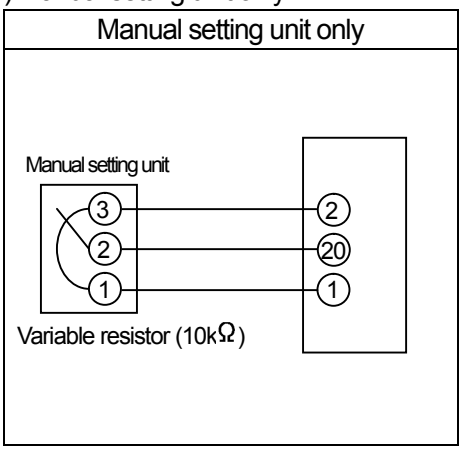


• Setting units: Low-limit value<High-limit value

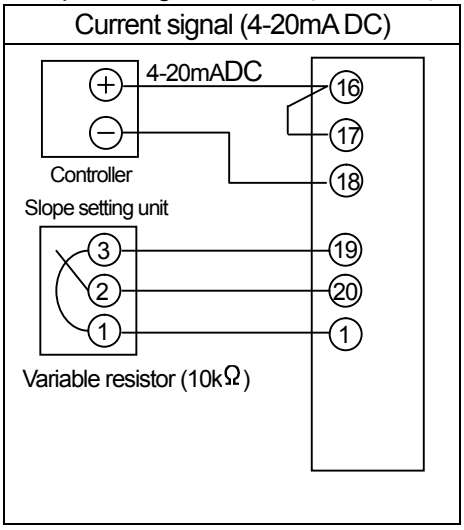
2) Manual setting unit with auto/manual switching



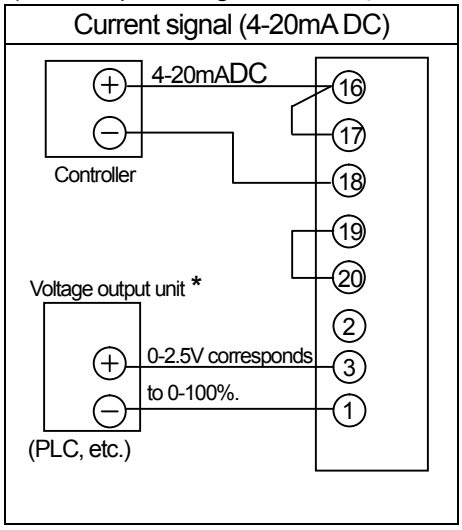
3) Manual setting unit only



4) With slope setting unit (Slope using control input signal)



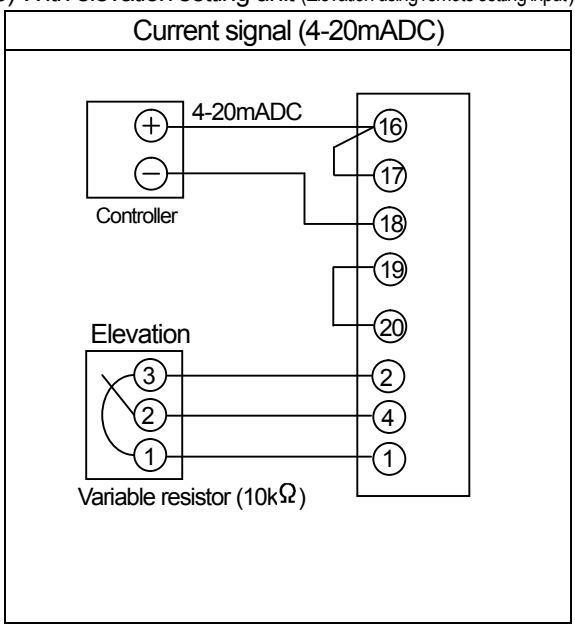
5) With slope setting unit [Slope using remote setting input (AI1)]



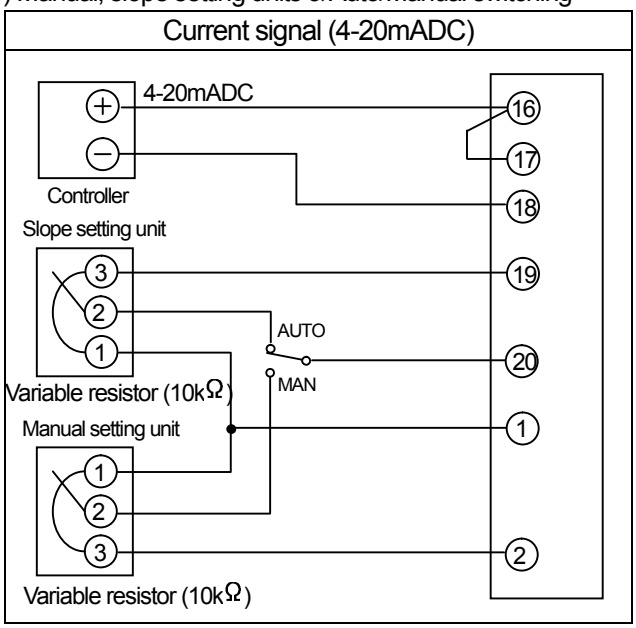
Use the two short circuit plates provided for connections between (16) and (17) (or between 17 and 18), and between (19) and (20), as required. Be sure to check the terminal numbers when connecting them.

* When connecting voltage output units to the remote setting inputs (AI1 to AI3), it is necessary to isolate each output from the voltage output units when plural PA-3000-H3 units are connected.
In addition, the output from one voltage output unit cannot be connected to plural PA-3000-H3 units in parallel.

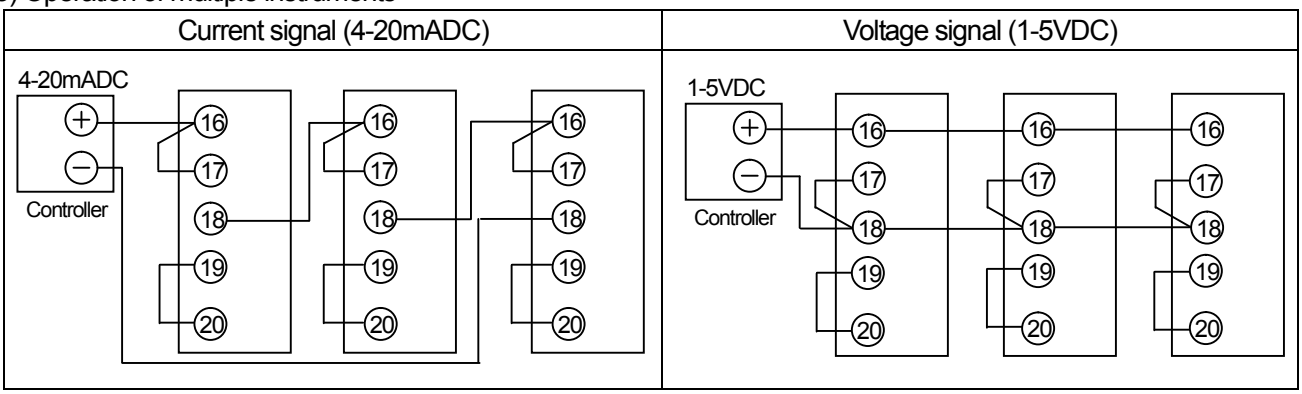
6) With elevation setting unit (Elevation using remote setting input)



7) Manual, slope setting units & Auto/Manual switching



8) Operation of multiple instruments

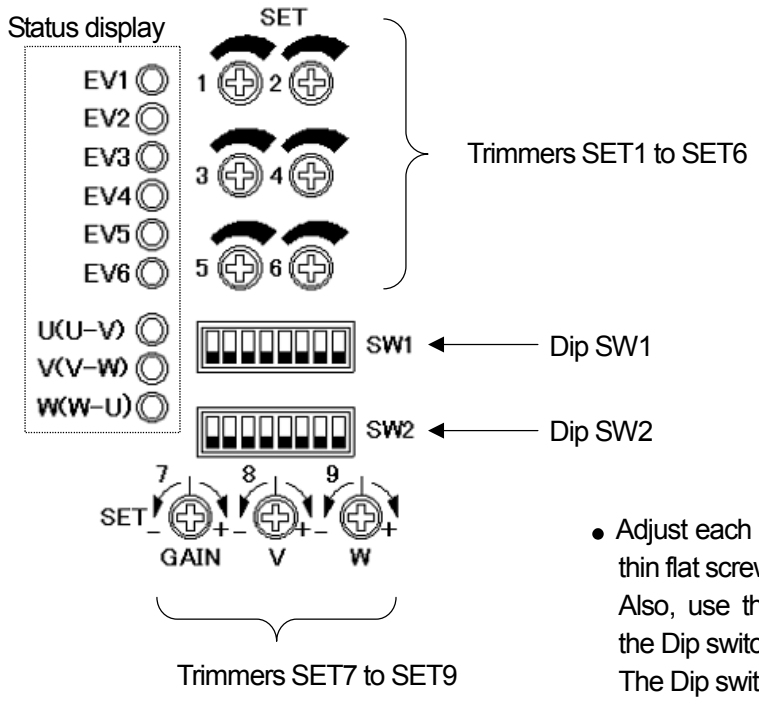


Connectable numbers of the PA-3000-H3 units for plural-unit operation are limited depending on the output capacity of a controller.

CAUTION	(1) After completing all connections, be sure to reattach the setting terminal cover. (2) The internal circuitry may be destroyed if an over-current or over-voltage is applied to the control input signal terminal. Be careful when applying a signal to this terminal.

6 PARAMETER SETTING

6.1 Front Panel



- Adjust each trimmer by turning it slowly using a thin flat screwdriver.
  Also, use the same screwdriver for switching the Dip switches.
  The Dip switch is ON in an up position and OFF in the down position.

[Functions of the SET trimmers]

SET trimmers	Function	Setting range	Default (Factory set)
SET1 trimmer	Slope	0 to 100%	100% (Full clockwise)
SET2 trimmer	Elevation	0 to 100%	0% (Full counterclockwise)
SET3 trimmer	Soft Start	Approx. 1 to 20 sec.	Approx. 1 sec. (Full counterclockwise)
SET4 trimmer	Current Limit	0 to 100%	100% (Full clockwise)
SET5 trimmer	Ratio of heater disconnection alarm	10 to 100%	100% (Full clockwise)
SET6 trimmer	Imbalance ratio of imbalance alarm	1 to 40%	40% (Full clockwise)
SET7 trimmer	Output gain of imbalance adjustment	60 to 140%	Approx. 100% (Center)
SET8 trimmer	V phase output of imbalance adjustment	-40 to +40%	Approx. 0% (Center)
SET9 trimmer	W phase output of imbalance adjustment	-40 to +40%	Approx. 0% (Center)

- The scales of the trimmers are given as approximate references. Even when a trimmer is set to the center position, the set value is not always the center value of the setting range (it is nevertheless approximately the center value).
  Each trimmer has a dead band near the fully counterclockwise and fully clockwise positions. A position slightly before the fully counterclockwise or fully clockwise position becomes the low or high limit value of the setting range.

6.2 Slope

(1) Selecting the setting method

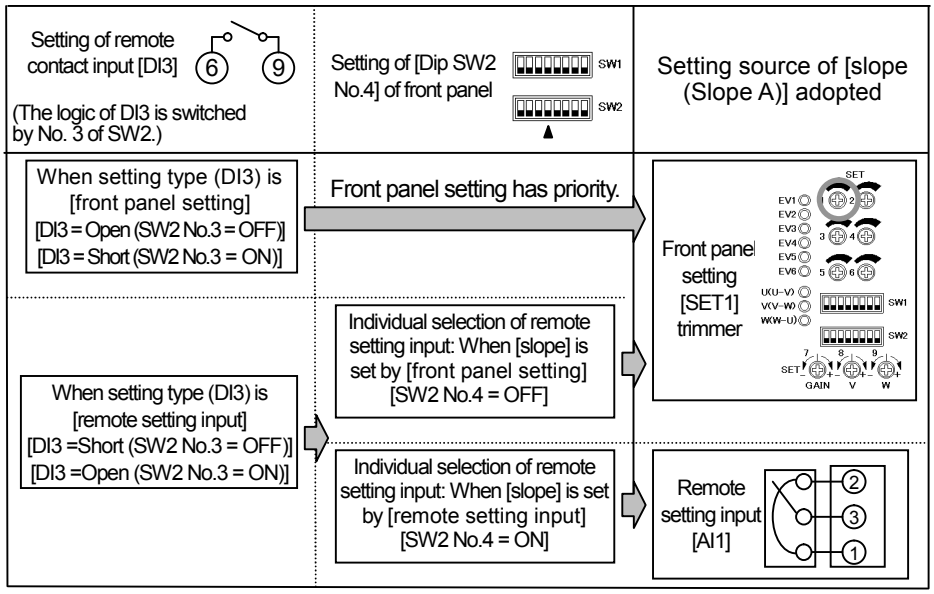
・The slope (Slope A) can be set either with the front panel setting (SET1 trimmer) or the remote setting input (AI1) as shown in the following table.

・When the slope setting (Slope B) [Setting terminals (19), (20) and (1)] using the control input signal is used, it is not necessary to set this item.

Setting method	Setting terminals (6) to (9) (DI3) setting [Setting type (front/ remote) switching]	Dip SW2 No. 3 [DI3 logical switching]	Dip SW2 No. 4 [AI1 individual selection]
When the front panel setting is used (SET1 trimmer)	Open	OFF	Any position
	Short	ON	Any position
When the remote setting input is used (AI1)	Open	ON	ON
	Short	OFF	ON

(Example) To use the front panel setting (SET1 trimmer) only when the setting terminals (6) and (9) (DI3) are short-circuited, turn on the No. 3 and No. 4 of the Dip SW2.

[Reference] Flowchart for the slope (Slope A) setting method selection



(2) Setting (SET1 trimmer) on the front panel

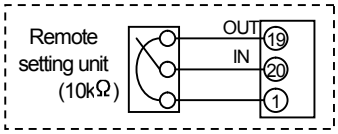
- The setting values on the front panel setting (SET1 trimmer) become 0% at the fully counterclockwise position and 100% at the fully clockwise position.
- Turn the trimmer with a thin flat screwdriver while monitoring the output to adjust to the desired value.
- The default value of the front panel setting (SET1 trimmer) is 100%.

(3) Setting (AI1) using the remote setting input

- Adjust the remote setting unit while monitoring the output to adjust to the desired setting value.
- The setting value becomes 0% at 0V of the voltage applied between the setting terminals (3) and (1) and becomes 100% at 2.5V.

(4) Alternative setting method (Slope using the control input signal = Slope B)

- The slope (Slope B) using the control input signal can also be set by inserting a remote setting unit between the control signal output (OUT) terminal (19) and control signal input (IN) terminal (20). (Right diagram)



- The slope (Slope B) using the control input signal becomes effective despite the slope setting selection [Ref. (1)].
- When the slope (Slope B) using the control input signal is not used, short-circuit terminals (19) and (20).

The final slope setting value is the product of the slope setting (Slope A) set by either [Front panel setting (SET1 trimmer)] or [Remote setting input (AI1)] and [Slope using the control input signal (Slope B)].

(Example) Final slope setting value =Slope A X Slope B = 0.50 (50%) X 0.80 (80%) = 0.40 (40%)

6.3 Elevation

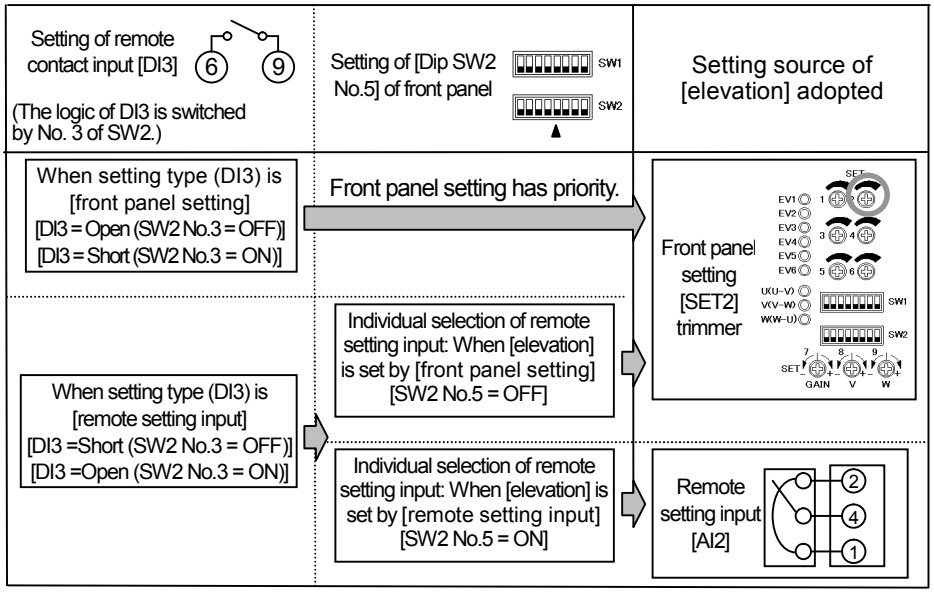
(1) Selecting the setting method

• The elevation can be set either with the front panel setting (SET2 trimmer) or the remote setting input (AI2) as shown in the following table.

Setting method	Setting terminals (6) to (9) (DI3) setting [Setting type (front/ remote) switching]	Dip SW2 No. 3 [DI3 logical switching]	Dip SW2 No. 5 [AI2 individual selection]
When the front panel setting is used (SET2 trimmer)	Open	OFF	Any position
	Short	ON	Any position
When the remote setting input is used (AI2)	Open	ON	ON
	Short	OFF	ON

(Example) **To use the front panel setting (SET2 trimmer) only when the setting terminals (6) and (9) (DI3) are short-circuited, turn on No. 3 and No. 5 of the Dip SW2.**

[Reference] Flowchart for the elevation setting method selection



(2) Setting (SET2 trimmer) on the front panel

- The setting values on the front panel setting (SET2 trimmer) become 0% at the fully counterclockwise position and 100% at the fully clockwise position.
- Turn the trimmer with a thin flat screwdriver while monitoring the output to adjust to the desired value.
- The default value of the front panel setting (SET2 trimmer) is 0%.

(3) Setting (AI2) using the remote setting input

- Adjust the remote setting unit while monitoring the output to adjust to the desired value.
- The setting value becomes 0% at 0V, and 100% at 2.5V of the voltage applied between setting terminals (4) and (1).

6.4 Soft Start

(1) Setting value

- The setting values on the front panel setting (SET3 trimmer) become approx. 1 second at the fully counterclockwise position, and approx. 20 seconds at the fully clockwise position.
- The default value of the front panel setting (SET3 trimmer) is approx. 1 second.

(2) Note

- When all control SVs are changed, the output (actually the internal SV used in computational processing) is changed gradually according to this setting.

6.5 Current Limit

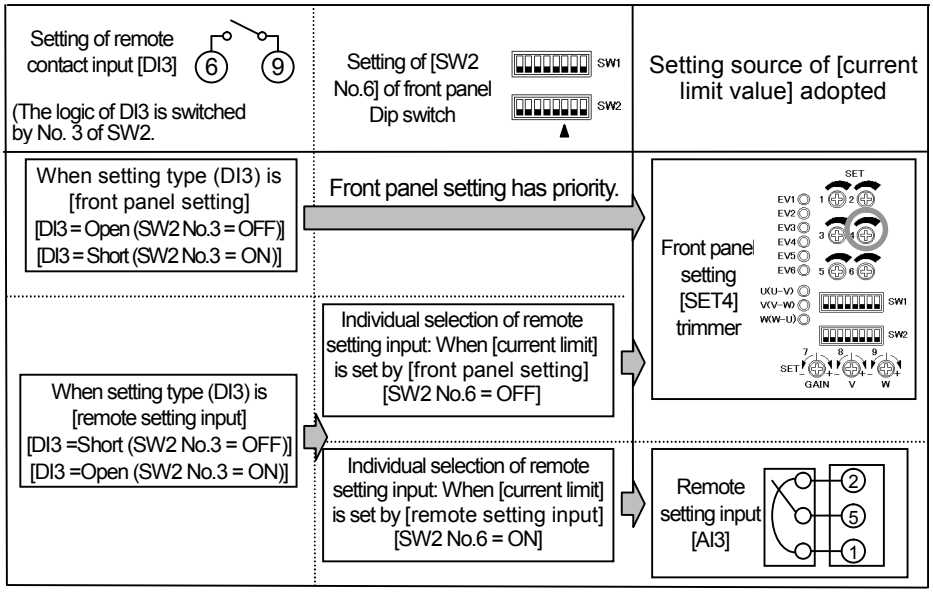
(1) Selecting the setting method

- The current limit can be set either with the front panel setting (SET4 trimmer) or the remote setting input (AI3) as shown in the following table.

Setting method	Setting terminals (6) to (9) Setting of (DI3) [Setting type (front/ remote) switching	Dip SW2 No. 3 [DI3 logical switching]	Dip SW2 No. 6 [AI3 individual selection]
When the front panel setting is used (SET4 trimmer)	Open	OFF	Any position
	Short	ON	Any position
When the remote setting input is used (AI3)	Open	ON	ON
	Short	OFF	ON

(Example) To use the front panel setting (SET4 trimmer) only when the setting terminals (6) and (9) (DI3) are short-circuited, turn on No. 3 and No. 6 of the Dip SW2.

[Reference] Flowchart for the current limit value setting method selection



(2) Setting (SET4 trimmer) on the front panel

- The setting values of the front panel setting (SET4 trimmer) become 0% at the fully counterclockwise position and 100% at the fully clockwise position.
- Turn the trimmer with a thin flat screwdriver while monitoring the output to adjust to the desired value.
- The default value of the front panel setting (SET4 trimmer) is 100%.

(3) Setting (AI3) using the remote setting input

- Adjust the remote setting unit while monitoring the output to adjust to the desired value.
- The setting value becomes 0% at 0V, and 100% at 2.5V of the voltage applied between setting terminals (5) and (1).

(4) Activating the function

- After completing the setting, turn on the front panel setting (Dip SW1 No. 1) to activate the current limit.

(5) Note

- This function cannot be used with the zero-cross control.
- A CT is needed for using the current limit. Connect a CT matching the rated current.
- The current value used for assessment is the average value of the three-phase load current values. This function cannot be applied to an individual phase.

6.6 Heater Disconnection Alarm

(1) Preparation

- Enter the SV (desired value) used in normal control and run this instrument until the control stabilizes. The load current must be 10% or more of the rated current.

(2) Storing the initial resistance

- When the load current is stabilized, set the front panel setting (Dip SW1 No. 3) to ON to store the initial resistance value in memory.
- When the initial resistance value is stored normally, "EV1" in the status display on the front panel flashes for a few seconds.
  If "EV1" does not flash, the load current is too low to calculate the resistance value. Be sure to set the load current in the normal control range before retrying the storage operation.
- When "EV1" flashes after the switch is set to ON, immediately set the switch to OFF. Make sure to set it to OFF.

(3) Ratio setting

- Set the disconnection ratio using the following formula.
  Ratio = { (Disconnection detection target resistance – Initial resistance) ÷ Initial resistance } × 100
- The setting values on the front panel setting (SET5 trimmer) become 10% at the fully counterclockwise position and 100% at the fully clockwise position.
- The default value of the front panel setting (SET5 trimmer) is 100%.

(4) Activating the function

- After completing the setting, set the front panel setting (Dip SW1 No. 2) to ON to activate the heater disconnection alarm.

(5) Note

- The load resistance value is not the resistance of the heater alone, but represents the approximate synthesized resistance between phases. This means that it does not allow the user to identify deterioration or disconnection of the heater, and it can be used only as reference information.
- Do not apply this function to a heater, of which heater resistance varies significantly (such as a silicone carbide SiC heater). Otherwise, erroneous alarms may activate.
- A CT is needed for assessment of heater disconnection. Connect a CT matching the rated current.
- A dead band (a delay time of approx. 2 min.) is provided for alarm OFF assessment.
- The initial resistance value should be stored while the load current is within the normal control range.
- After storing the initial resistance value, be sure to return the Dip switch to OFF.
- Activation of the heater disconnection alarm is started by totalizing the period in which the output (actually the internal SV used in computational processing) exceeds 10% or more and when the total period exceeds the detection period (Default: 1 minute).
- The alarm assessment is not performed when this instrument stops running.

6.7 Imbalance Adjustment

6.7.1 Outline

The imbalance adjustment function is used to adjust an imbalanced status to a balanced status. The adjustment is possible within a limited range based on either the voltage or current value.
First, select the voltage or current according to the control system. Then set No. 7 of the Dip SW1 to ON to activate the imbalance adjustment function, and adjust it using the following three trimmers.

- SET7 trimmer: Output gain. The adjustment range is from 60% at the fully counterclockwise (decrease direction) position to 140% at the fully clockwise (increase direction) position. The default value is 100%.
- SET8 trimmer: V phase output timing. The adjustment range is from -40% at the fully counterclockwise (decrease direction) position to 40% at the fully clockwise (increase direction) position. The default value is 0%.
- SET9 trimmer: W phase output timing. The adjustment range is from -40% at the fully counterclockwise (decrease direction) position to 40% at the fully clockwise (increase direction) position. The default value is 0%.

* The adjustment range is the output timing and differs from the adjustment ranges of the actual output voltage and current.

WARNING	To prevent an accident, turn this instrument off before connecting a voltmeter or ammeter.

CAUTION	(1) Adjust the adjustment trimmers by turning them slowly while monitoring the measured value. (2) When an adjustment trimmer is turned, the over-current alarm or rapid-break fuse meltdown alarm may activate due to the change of output. (3) After the adjustment, be careful not to turn any adjustment trimmers during normal use.

6.7.2 Imbalance adjustment with voltage

(1) Preparation
- Connect three RMS type measuring units between each phase to measure the voltage values (U2-V2, V2-W2, W2-U2) between each phase.
- Turn this instrument ON, enter the SV (desired value) used in normal control, and run this instrument until the control stabilizes.
- Set the SET7, SET8 and SET9 trimmers to the center positions.

(2) Activating the function
- Set the front panel setting (Dip SW1 No. 7) to ON to activate the imbalance adjustment.

(3) Output gain adjustment 1
- After the output has stabilized, reduce the outputs of the three phases by about 10% to ensure the safety of adjustment.
- Turn the SET7 trimmer (output gain) slowly counterclockwise while monitoring the voltage values on the measuring units so that the highest voltage values in the three phases is about –10% of the voltage value corresponding to the SV.

(4) Imbalance adjustment
- While monitoring the voltage values on the measuring units, turn the SET8 trimmer (V phase output timing) and SET9 trimmer (W phase output timing) slowly and alternately so that the voltage values of the three phases are almost the same.

(5) Output gain adjustment 2
- When the voltage values of the three phases are almost same, turn the SET7 trimmer (output gain) slowly clockwise so that the voltage value of each phase becomes the voltage value corresponding to the SV (desired value).
- Fine-adjust the SET8 trimmer (V phase output timing) and SET9 trimmer (W phase output timing) as required.

(6) Note
- Using the RMS type measuring units (3 units), adjust voltage values by monitoring the measured values they display.
- This function cannot be used with the zero-cross control.

6.7.3 Imbalance adjustment with current

(1) Preparation
- Connect three RMS type measuring units between each phase to measure the current values (U2, V2, W2) between each phase.
- Turn this instrument ON, enter the SV (desired value) used in normal control, and run this instrument until the control stabilizes.
- Set the SET7, SET8 and SET9 trimmers to the center positions.

(2) Activating the function
- Set the front panel setting (Dip SW1 No. 7) to ON to activate the imbalance adjustment.

(3) Output gain adjustment 1
- After the output has stabilized, reduce the outputs of the three phases by about 10% to ensure the safety of adjustment.
- Turn the SET7 trimmer (output gain) slowly counterclockwise while monitoring the current values on the measuring units so that the highest current values in the three phases is about –10% of the current value corresponding to the SV (desired value).

(4) Imbalance adjustment
- While monitoring the current values on the measuring units, turn the SET8 trimmer (V phase output timing) and SET9 trimmer (W phase output timing) slowly and alternately so that the current values of the three phases are almost the same.

(5) Output gain adjustment 2
- When the current values of the three phases are almost the same, turn the SET7 trimmer (output gain) slowly clockwise so that the current value of each phase becomes the current value corresponding to the SV (desired value).
- Fine-adjust the SET8 trimmer (V phase output timing) and SET9 trimmer (W phase output timing) as required.

(6) Note
- Using the RMS type measuring unit (3 units), adjust current values by monitoring the measured values they display.
- This function cannot be used with the zero-cross control.
- Connect a CT matching the rated current.

6.8 Imbalance Alarm

(1) Preparation
- Enter the SV (desired value) used in normal control, and run this instrument until the control stabilizes. The load current must be 10% or more of the rated current.
- When the load current stabilizes, perform imbalance adjustment if necessary.

(2) Rate setting
- Calculate and set the value (imbalance ratio) with the following formula.
  Imbalance rate = { (Load current max value - Load current min value) ÷ Load current max value } × 100
  * Load current max value: Maximum value among the load current values of three-phase (U-phase, V-phase, W-phase)
  * Load current min value: Minimum value among the load current values of three-phase (U-phase, V-phase, W-phase)
- The setting values on the front panel setting (SET6 trimmer) become 1% at the fully counterclockwise position and 40% at the fully clockwise position.
- The default value of the front panel setting (SET6 trimmer) is 40%.

(3) Activating the function
- After completing the setting, set the front panel setting (Dip SW1 No. 4) to ON to activate the imbalance alarm function.

(4) Note
- This function assesses the imbalance rate of the load current.
- This function cannot be used with the zero-cross control.
- A CT is needed for the assessment of the imbalance rate. Connect a CT matching the rated current.
- A dead band (a delay time of approx. 2 min.) is provided for assessment of alarm OFF.
- Activation of the imbalance alarm is started by totalizing the period in which the output (actually the internal SV used in computational processing) exceeds 10% or more and when the total period exceeds the detection period (Default: 1 minute).
- The alarm assessment is not performed when this instrument stops running.

6.9 Alarm Output Forced OFF

When the alarm activates, AL1 or AL2 is turned on as an alarm output. It is possible to turn it off manually. In addition, AL3 is turned off at the alarm activation, but it is possible to force it on.

(1) Setting
- The alarm output relays for AL1 and AL2 are set to OFF when the front panel setting (Dip SW 1 No. 5) is set to ON. In addition, the alarm output relay for AL3 is set to ON.
- The alarm output relays for AL1 and AL2 are not set to ON until the front panel setting (Dip SW 1 No. 5) is set to OFF. In addition, the alarm output relay for AL3 is not set to OFF.

(2) Note
- Even when the alarm output is forced to OFF, the status LED display on the front panel indicates the alarm activation.
- During the initial operation (period until the normal start-up is executed) at the start-up, the alarm output relay for AL3 is turned OFF even when the alarm output is forced to OFF.

6.10 Feedback Control OFF

In the case of instruments with the feedback control specification, the feedback control function can be forced to OFF.

(1) Setting
- The feedback control function is disabled when the front panel setting (Dip SW 1 No. 6) is set to ON.

(2) Note
- This function is not available with models with no-feedback specification or zero-cross control specification.
- If this function is switched during operation, the output (actually the internal SV used in computational processing) starts from 0%. (This instrument resets.)
- When this function is executed, the alarm output relay for AL3 is turned OFF temporarily. (When this instrument starts up normally after resetting, the alarm output relay for AL3 is turned ON again.)

6.11 Dip switch Functions

There are two Dip switches for various settings on the front panel. Set them as required.

1. **Dip SW1**

No.	Function	Default (Factory set)
1	Current limit ON/OFF. By switching to ON, the current limit activates.	OFF
2	Heater disconnection alarm ON/OFF. By switching to ON, the heater disconnection alarm activates.	OFF
3	Storage of the initial resistance value for heater disconnection alarm. By switching to ON, the initial resistance is stored 1 time only. • Be sure to set the switch to OFF in normal running and after value is stored.	OFF
4	Imbalance alarm ON/OFF. By switching to ON, the imbalance alarm activates.	OFF
5	Alarm output forced OFF. By switching to ON, the alarm output forced OFF activates.	OFF
6	Feedback control ON/OFF. By switching to ON, the feedback control becomes “disabled”.	OFF
7	Imbalance adjustment ON/OFF. By switching to ON, the imbalance adjustment activates.	OFF
8	Initialization. When the power is supplied to this instrument, the initialization of setting values activates. (The internal memory of this instrument is reset to the factory default.) • Be sure to set the switch to OFF in normal running and after initialization.	OFF

2. **Dip SW2**

No.	Function		Default (Factory set)
1	**Logical switching of remote contact input 1 (DI1) setting terminals (6) and (7) (Run/Stop)**		OFF
	SW2 (No.1) and remote contact input 1 (DI1) status	**Operation mode**	
	SW2 (OFF), remote contact input (Open)	Run	
	SW2 (OFF), remote contact input (Short)	Stop	
	SW2 (ON), remote contact input (Open)	Stop	
	SW2 (ON), remote contact input (Short)	Run	
2	**Logical switching of remote contact input 2 (DI2) setting terminals (6) and (8) (Phase/Zero-cross)**		OFF
	SW2 (No.2) and remote contact input 2 (DI2) status	**Operation mode**	
	SW2 (OFF), remote contact input (Open)	Phase angle control	
	SW2 (OFF), remote contact input (Short)	Zero-cross control	
	SW2 (ON), remote contact input (Open)	Zero-cross control	
	SW2 (ON), remote contact input (Short)	Phase angle control	
	* The control system cannot be switched with the zero-cross control type.		
3	**Logical switching of remote contact input 3 (DI3) setting terminals (6) and (9) (Front panel/Remote setting input)**		OFF
	SW2 (No.3) and remote contact input 3 (DI3) status	**Selection ***	
	SW2 (OFF), remote contact input (Open)	Front panel setting (SET trimmer)	
	SW2 (OFF), remote contact input (Short)	Remote setting input (AI)	
	SW2 (ON), remote contact input (Open)	Remote setting input (AI)	
	SW2 (ON), remote contact input (Short)	Front panel setting (SET trimmer)	
4	**Individual selection of remote setting input (AI1): Slope**		OFF
	SW2 (No.4) status	**Selection**	
	SW2 (ON)	Remote setting input (AI1)	
	SW2 (OFF)	Front panel setting (SET1 trimmer)	
5	**Individual selection of remote setting input (AI2): Elevation**		OFF
	SW2 (No. 5) status	**Selection**	
	SW2 (ON)	Remote setting input (AI2)	
	SW2 (OFF)	Front panel setting (SET2 trimmer)	
6	**Individual selection of remote setting input (AI3): Current limit**		OFF
	SW2 (No. 6) status	**Selection**	
	SW2 (ON)	Remote setting input (AI3)	
	SW2 (OFF)	Front panel setting (SET4 trimmer)	
7 8	**Selection of supply voltage for actual use**		No.7: OFF No.8: ON 200V line: 200V 400V line: 400V
	SW2 (No.7, No.8) status	**Selection** To prevent malfunction, do not select the switch status of “Not used.”	
	No.7 (ON), No.8 (ON)	240V/Not used	
	No.7 (ON), No.8 (OFF)	220V/440V	
	No.7 (OFF),No.8 (ON)	200V/400V	
	No.7 (OFF), No.8 (OFF)	Not used/380V	

***** When the selection state of SW2 No. 3 and the remote contact input 3 (DI3) is by [Front panel setting (SET trimmer)], the slope, elevation and current limit are set by the front panel setting regardless of No.4, No.5 and No.6 settings of SW2.

7 Running

7.1 Check before Running

⚠ **WARNING**	(1) To prevent an accident, be sure to turn this instrument off before proceeding to the following operations. (2) The withstand voltage test should be performed by personnel with sufficient knowledge and practical experience of such testing.

1. Checking the installation orientation

   Check that this instrument is installed with the UP (↑) mark facing upward. Otherwise, the heat radiation effect will be hindered, and the rise in internal temperature may cause malfunction.

2. Checking the connections

   Check if wiring is correct, the short circuit plates are connected properly, the connections are secure, etc. Particularly, check if the main circuit terminals such as the power supply terminals are securely tightened.

   This instrument and peripheral equipment (such as the transformer) might be damaged in the case of non-load running. Check that the load is connected before running.

3. Checking the balanced status

   Check that the power voltages between each phase and loads between each phase are balanced. If they are too imbalanced, errors in the input/output characteristics of this instrument will increase, deteriorating control.

4. Checking the power voltage and load capacity

   Check once again that the power voltage and load capacity are appropriate for the ratings of this instrument.

5. Checking the insulation

   Check the insulation of the load circuit as required. Use a 500V megger for the measurement of insulation resistance.

   When performing the withstand voltage test, short-circuit all of “U1 and U2,” “V1 and V2” and “W1 and W2” of the main circuit terminals. As the withstand voltage test could degrade this instrument and injure the test personnel, it should be conducted with the minimum required voltage. The test voltage must be lower than 1500VAC.

6. Setting the power voltage

   Set the Dip SW2 on the front panel to set the power voltage of actual use as shown below.

Check the rated voltage of the PA-3000-H3 and the actual power voltage.		Set Nos. 7 and 8 of SW2 according to the actual power voltage.
Power voltage 200V	200 V	Set No. 7 to “OFF” and No. 8 to “ON”.
	220 V	Set No. 7 to “ON” and No. 8 to “OFF”
	240 V	Set No. 7 to “ON” and No. 8 to “ON”
Power voltage 400V	380 V	Set No. 7 to “OFF” and No. 8 to “OFF ”
	400 V	Set No. 7 to “OFF” and No. 8 to “ON”
	440 V	Set No. 7 to “ON” and No. 8 to “OFF”

7. Checking the control system and parameter settings

   Check the control system (phase angle control, zero-cross control, feedback, etc.) and the parameters set on the front panel.

8. Other checking

   Check other items by reading warnings and cautions described in this instruction manual.

7.2 Start of Operation

⚠WARNING	(1) Do not approach the terminals (main circuit terminals and setting terminals) of this instrument. Electric shock due to the high-voltage parts is hazardous to human life. (2) This instrument has high-temperature parts. Particularly, do not touch the top panel, side panels, heat radiation fins, etc. (3) Do not allow a finger, stick or any object to enter or drop into the cooling fan area. The cooling fan(s) are rotating at a high speed and may cause injury or damage.

1. Turn the system ON. If possible, set the manual run or control input signal to 0% so that this instrument maintains the 0% output when it is turned ON.

2. Check that the system components including this instrument are in working order. Also, check that all of the connected signal levels (voltages, current, ON/OFF signals, etc.) are normal.
   When your instrument comes with a built-in cooling fan, check that the cooling fan rotates normally.

3. Check that the power voltages between each phase and loads between each phase are balanced.

4. Switch to the auto run (or keep manual run), start the control and observe the operation.

5. There is no problem when the control is stable. If it is unstable, adjust the controller's parameters (particularly the PID constants) and this instrument's parameters (particularly the slope).

6. Set the parameters as required.

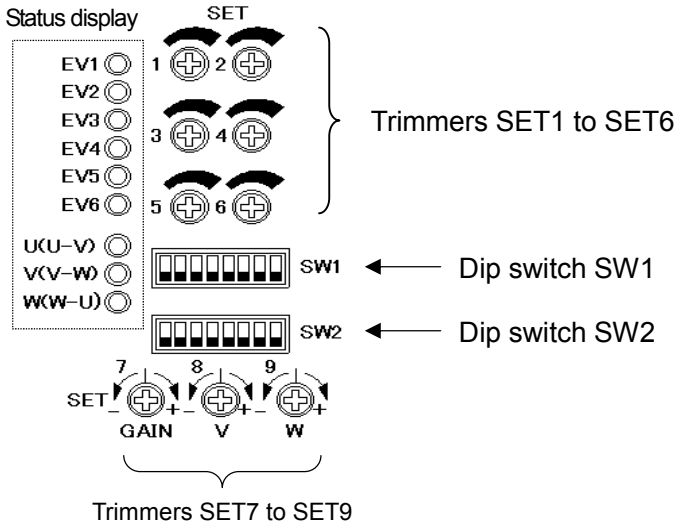
7. In a few hours after the start of operation, check again that the system components including this instrument are normal.

8. When stable control is established, it is recommended to record (save) the settings including those of this instrument.

⚠CAUTION	(1) Never run this instrument without load. Non-load running may result in damage to this instrument and/or peripheral equipment (such as the transformer). (2) Check the signals of the peripheral equipment connected to this instrument. Applying an over-voltage or over-current may damage the internal circuitry of this instrument. (3) Never switch the load (switching the load connection by a relay, a magnet, etc.). The switching of load may result in damage to this instrument and/or peripheral equipment.

7.3 Status Display

Whilst running, the EV (Event) indicators of status display on the front panel indicate various Events & other status including running status and alarm activation status.



Front panel

No.	Description
EV1 (Green)	This indicates running status. Lights for normal running, and flashes when the running becomes abnormal. The indicator also flashes in the following cases. (1) When the setting values are initialized (the internal memory is reset to the factory default); → Stops flashing after the initialization of setting values is completed. (2) If No. 8 of the Dip SW1 is set to ON when power-on (initialization of setting values); → Be sure to set the Dip switch to OFF. (3) During storage of the initial resistance value for the heater disconnection alarm; → Starts flashing after the start of storage, and stops flashing after a few seconds.
EV2 (Red)	Lights when the over-current alarm is activated, and flashes when the heater disconnection alarm is activated.
EV3 (Red)	Lights when the rapid-break fuse meltdown alarm is activated, and flashes when the abnormality alarm for the thyristor element is activated.
EV4 (Red)	Lights when the overheating abnormality alarm for the heat radiation fin is activated.
EV5 (Red)	Lights when the phase-sequence abnormality alarm is activated, and flashes when the open-phase detection alarm is activated. Note: For these 2 alarms above and frequency abnormality alarm, definite determination/discrimination of alarm status cannot be performed. Use them for your reference. When any one of these alarms is ON, check the phase-sequence abnormality, the open-phase or the frequency abnormality.
EV6 (Red)	Lights when the frequency abnormality alarm is activated, and flashes when the imbalance alarm is activated.
EV7 (Green)	Interlocks with EV2 to EV6 and provides the display-by-phase “U (U-V)” showing the applicable phase.
EV8 (Green)	Interlocks with EV2 to EV6 and provides the display-by-phase “V (V-W)” showing the applicable phase.
EV9 (Green)	Interlocks with EV2 to EV6 and provides the display-by-phase “W (W-U)” showing the applicable phase.

⚠ CAUTION	• When multiple alarms activate simultaneously, the alarm types may not be determined due to overlapped lighting of the EV indicators. The display-by-phase may also not be performed. Furthermore, when the display-by-phase is performed, certain display-by-phase indications may not be discernible. • All status display indicators light temporarily when this instrument is turned ON or the control system is switched.

8 ALARM

8.1 Alarm Activation and Alarm Output

Alarm name	Status display	Alarm output
Over-current alarm	• EV2 lights and one of EV7 to EV9 lights to indicate the phase in alarm. • In case of the over-current alarm, even when the current value has returned within the rated current range after the alarm activation, the alarm cannot be cancelled until this instrument is turned off then on. (Latched output)	AL1
Rapid-break fuse meltdown alarm	• EV3 lights and one of EV7 to EV9 lights to indicate the phase in alarm. • This alarm activates only in the instrument with the rapid-break fuse.	AL1
Radiation fin overheat alarm	• EV4 lights.	AL1
Heater disconnection alarm	• EV2 flashes and one of EV7 to EV9 lights to indicate the phase in alarm.	AL2
Thyristor element abnormality alarm	• EV3 flashes and one of EV7 to EV9 lights to indicate the phase in alarm.	AL2
Running abnormality alarm	• EV1 flashes. • This alarm is cancelled automatically in about 1 minute after the alarm activation. It can also be cancelled by turning this instrument off then on.	None
Phase-sequence abnormalities alarm	• EV5 lights.	AL3
Open-phase alarm	• EV5 flashes and one of EV7 to EV9 lights to indicate the phase in alarm.	AL3
Imbalance alarm	• EV6 flashes and one of EV7 to EV9 lights to indicate the phase in alarm.	AL2
Frequency abnormality alarm	• EV6 lights.	AL3

* Even when the alarm outputs are OFF, they may be turned ON momentarily when this instrument is turned OFF/ON. If required, take countermeasures externally against such error outputs.

* The alarm output relay for AL3 is turned OFF during the initial operation (period until the normal start-up is executed) at the start-up. The relay is turned ON after the normal start-up, and it is turned OFF when the alarm for phase-sequence abnormality, the open-phase or a frequency abnormality is activated.

8.2 Alarms and Countermeasures

Alarm name	Running status	Countermeasures
Over-current alarm	Running stops. (Thyristor gate OFF)	Turn this instrument OFF, identify the cause and take countermeasures against it, and then turn this instrument ON again. This instrument will recover.
Rapid-break fuse meltdown alarm	Running stops. (Thyristor gate OFF)	Turn this instrument OFF, identify the cause and replace the fuse, and then turn this instrument ON again. This instrument will recover.
Radiation fin overheat alarm	Running stops. (Thyristor gate OFF)	Check that the cooling fan(s) of the power controller is rotating normally and that the ambient temperature is not abnormally high, and then turn this instrument ON again. If the fan(s) is malfunctioning, turn this instrument OFF, replace the fan(s) and turn this instrument ON again. This instrument will recover.
Heater disconnection alarm	Running continues.	Turn this instrument OFF and check the heater, etc. This alarm may also activate when the CT is not connected to the power controller.
Thyristor element abnormality alarm	Running continues.	Turn this instrument OFF and check the load and connections. If it still does not recover, repair of this instrument is required.
Running abnormality alarm	Running continues.	Turn this instrument OFF then ON again. If it still does not recover, repair of this instrument is required.
Phase-sequence abnormalities alarm	Running stops. (Thyristor gate OFF)	The connections of the three phases (U, V, W) are not correct. Turn this instrument OFF and correct the connections, and then turn this instrument ON again. This instrument will recover.
Open-phase alarm	Running stops. (Thyristor gate OFF)	One of the connections of the three phases (U, V, W) is disconnected: Turn this instrument OFF and correct the connections, and then turn this instrument ON again. This instrument will recover.
Imbalance alarm	Running continues.	Turn this instrument OFF and check the power voltage, load, heater, etc.
Frequency abnormality alarm	Running stops. (Thyristor gate OFF)	Turn this instrument OFF and check the power voltage, noise, etc. Especially, in case of an abnormal voltage waveform by noise, the correct control cannot be performed. Take appropriate countermeasures against it.

9 SYSTEM PROTECTION

9.1 Power safety

To protect this instrument from abnormal voltage (surge voltage) superimposed in the power, install a lightning rod or spark killer at the power source. The following lightning rods and spark killer are recommended.

- Lightning rod 200V power line : MAK2-220 [M-system Co., Ltd.]
- Lightning rod 400V power line : MAK2-400 [M-system Co., Ltd.]
- Spark killer : 3CRH-50270 [Okaya Electric Industries Co., Ltd.]

9.2 Protection by alarm output 3

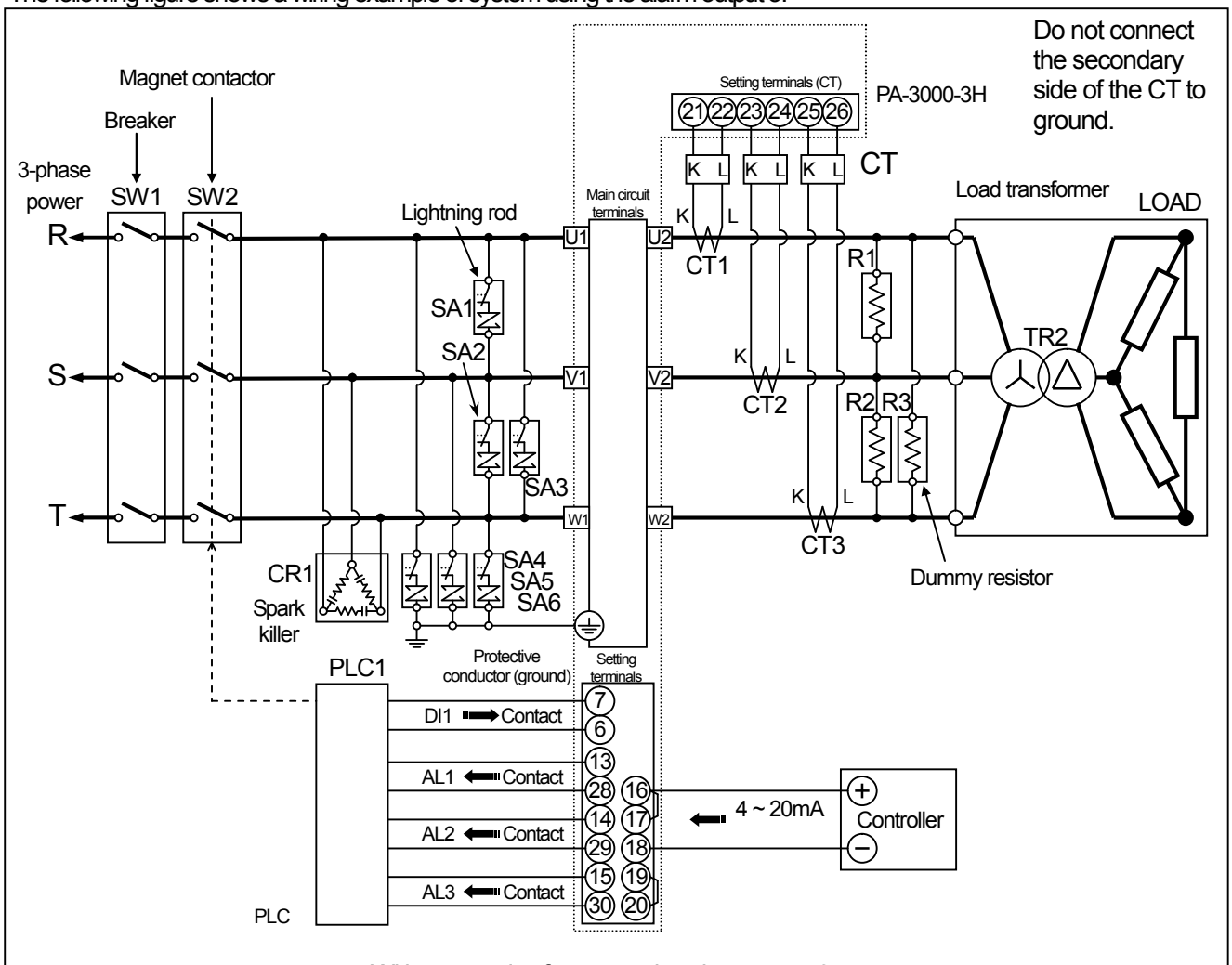
The alarm output 3 (AL3) is mainly for power related alarms. (The alarm output relay is turned OFF at the alarms activation.)

When this instrument has a fatal malfunction (burnout, etc.), alarm output 3 will usually go OFF. Specifically, alarm output 3 is turned OFF when the following problems occur in this instrument.

(1) Melting of the fuse for the receiving board of R-phase or S-phase → Control circuit power OFF → Alarm output 3 OFF
(2) Melting of the fuse for the receiving board of T-phase → W-phase open-phase occurrence → Alarm output 3 OFF
(3) Synchronizing transformer disconnection → Phase-sequence abnormality occurrence → Alarm output 3 OFF
(4) Synchronizing signal input portion burnout →Control circuit power OFF/Open-phase occurrence/phase-sequence abnormality occurrence → Alarm output 3 OFF

- Fuse for receiving board: This is for protecting the synchronizing signal input portion (control circuit power input portion), and is built -in for models with a rated current of 75A or more.
- Synchronizing transformer: For detecting the timing of the zero-cross of power.

We recommend that you will take measures, using the above, to avoid widespread system damage or serious malfunction. The following figure shows a wiring example of system using the alarm output 3.

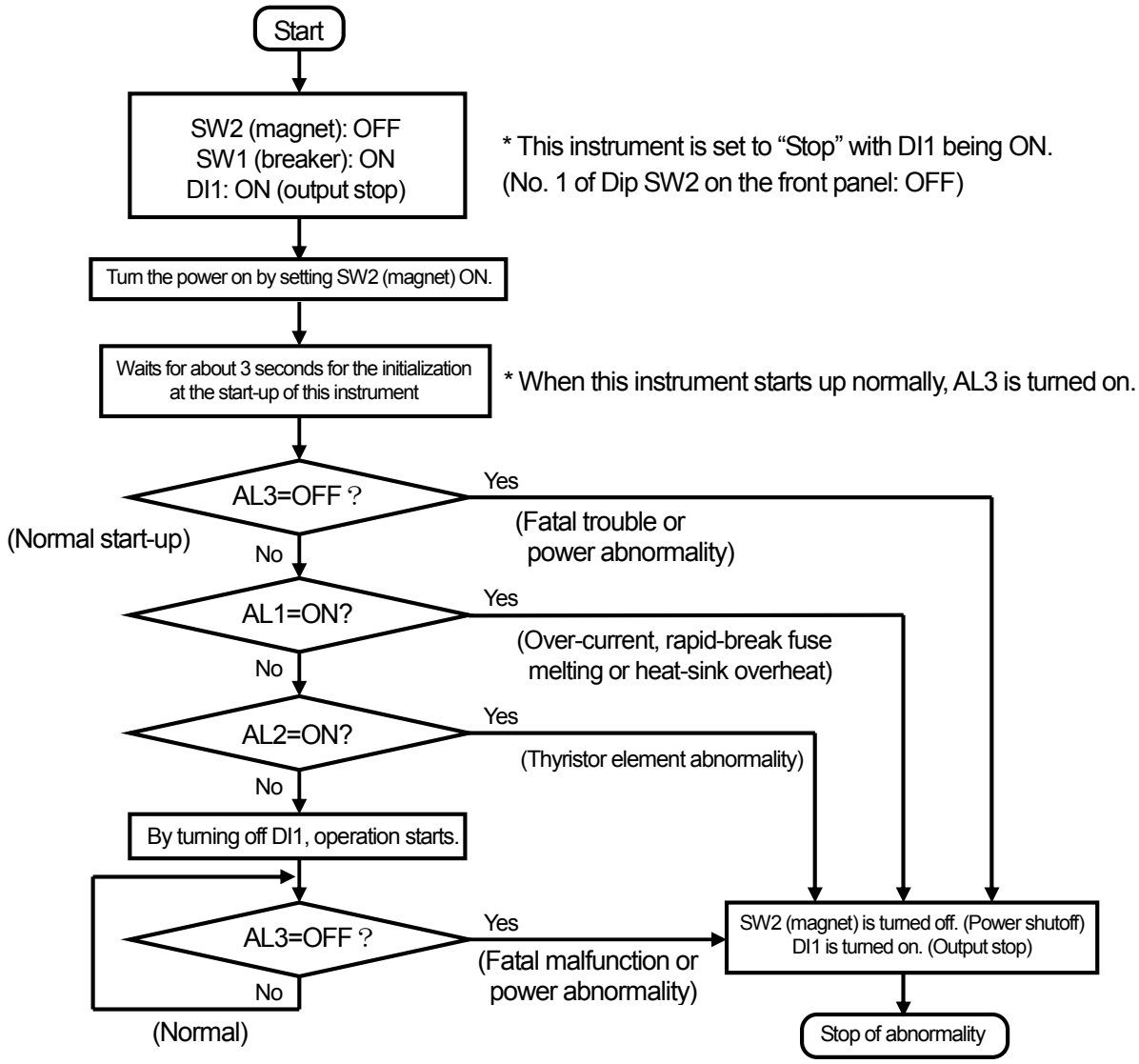


Wiring example of system using alarm output 3

The following are details of components of the wiring example shown in Sec. 9.2.

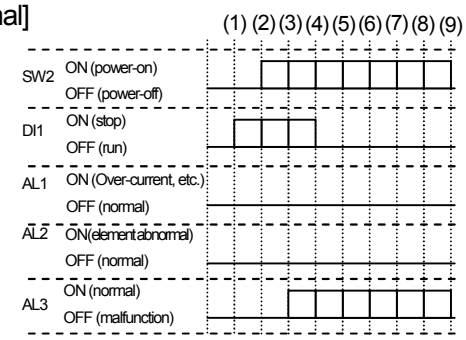
Mark	Name	Outline
PA-3000-H3	Power controller	This instrument
PLC1	PLC	Monitors any abnormality of this instrument and protects the whole system by turning off the magnet conductor when an abnormality occurs.
SW1	Breaker	This is a breaker for protecting the whole system.
SW2	Magnet conductor	Separates the system from the power source when a system abnormality occurs. Conductor ON/OFF is controlled by the PLC.
CR1	Spark killer	Protects this instrument from abnormal voltage (surge voltage) superimposed in the power.
SA1~SA3	Lightning rod	Protects this instrument from abnormal voltage (surge voltage) superimposed in the power. Make sure to install a lightning rod for external transformer specifications.
SA4~SA6	Lightning rod	Protects this instrument from an abnormal voltage (surge voltage) superimposed to the power.
CT1~CT3	Current transformer	For models without CT, connect a CT externally if required. (The over-current cannot be detected in this instrument without the CT.)
R1~R3	Dummy resistor	Make sure to install the resistor for the transformer load. Design the load so that 0.5A or more of current flows in each phase.
TR2	Load transformer	Use the transformer with a flux density of 1.2 (T) or less and with sufficient capacity.
LOAD	Load (Heater)	The secondary load of the transformer should be a three-phase balancing load (Imbalance ratio: About 10% or less).

The following flowchart is an example of the system operation sequence when alarm output 3 (AL3) is used.
The whole system is protected by separating the power from the system when an instrument abnormality occurs.



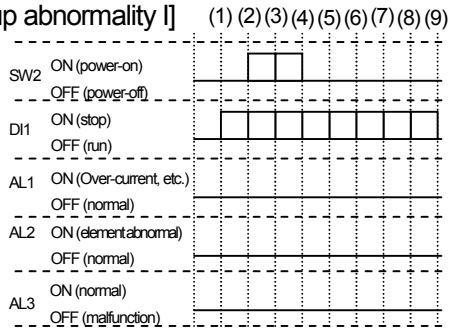
The following is an example of the operation chart when using alarm output 3 (AL3).

[Normal]



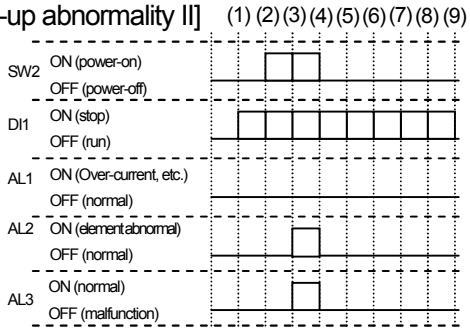
(1) : Turn on DI1 to stop this instrument.
(2) : Turn on SW2 to turn the power on.
(2)~(3) : Waiting for linearization at start-up of this instrument
(3) : When this instrument starts up normally, AL3 is turned on.
(4) : Check the states of AL1, AL2 and AL3.
(AL1 = OFF, AL2 = OFF, AL3 = ON: Normal)
When these are normal, turn off DI1 for starting operation.
(4)~ : Check the state of AL3 constantly during operation.
Normal when AL3 remains in ON status.

[Start-up abnormality I]



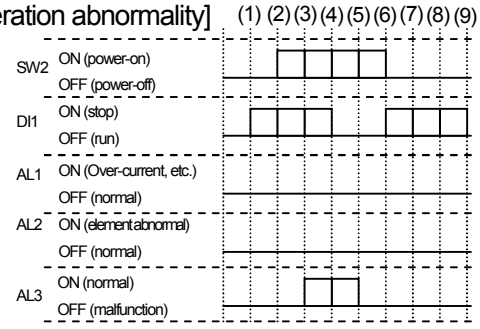
(1) : Turn on DI1 to stop this instrument.
(2) : Turn on SW2 to turn the power on.
(2)~(3) : Waiting for linearization at start-up of this instrument
(3) : AL3 remains in OFF as this instrument does not start up normally.
(4) : Check the states of AL1, AL2 and AL3.
(AL1 = OFF, AL2 = OFF, AL3 = ON: Normal)
As AL3 remains in OFF status, this instrument will assume a malfunction.
Turn off SW2 for power-off, ending abnormality.

[Start-up abnormality II]



(1) : Turn on DI1 to stop this instrument.
(2) : Turn on SW2 to turn the power on.
(2)~(3) : Waiting for linearization at start-up of this instrument
(3) : This instrument starts up and AL3 is turned on, but AL2 is turned on by malfunction of the thyristor element.
(4) : Check the states of AL1, AL2 and AL3.
(AL1 = OFF, AL2 = OFF, AL3 = ON: Normal)
As AL2 is ON, this instrument will assume a malfunction.
. Turn off SW2 for power –off, ending abnormality.

[Operation abnormality]



(1) : Turn on DI1 to stop this instrument.
(2) : Turn on SW2 to turn the power on.
(2)~(3) : Waiting for linearization at start-up of this instrument
(3) : When this instrument starts up normally, AL3 is turned on.
(4) : Check the states of AL1, AL2 and AL3.
(AL1 = OFF, AL2 = OFF, AL3 = ON: Normal)
When these are normal, turn off DI1 for starting operation.
(4)~ : Check the state of AL3 constantly during operation.
(5) : By malfunction of this instrument, AL3 is turned off.
(6)As AL3 is turned off, this instrument will assume a malfunction.

Turn off SW2 for shutting off power
Turn on DI1 to stop this instrument &to end abnormality.

9.3 Installation environment

Select a place satisfying conditions in Section 3.2 [Installation precautions] as an installation environment of this instrument. In environmental conditions exceeding the specification ranges, short-circuit/burnout accidents may occur inside this instrument. Especially, never use this instrument in an environment with conductive material, mine dust or unusual substances (metal powder, cut glass, iron or carbon).
When this instrument is used under a special environmental condition such as using a carbon heater, etc., take the following measures at the control panel.

1. Design the control panel with a sealed structure and take heat radiation measures.
2. Apply an air purge to the control panel.
3. Perform periodical cleaning.

10 TROUBLESHOOTING

Problem	Check Items
1. No output (0%).	(1) Check that the connections of the main circuit terminals are correct. • Connect U1, V1 and W1 to the 3-phase power supply (R, S and T), and connect U2, V2 and W2 to the load (such as a heater). • Confirm the phase-sequence of the 3-phase power supply with a phase detector and that the connections are in a positive-phase-sequence.
	(2) Check that the connections of the setting terminals are correct. • Confirm that the correct signal is connected to the control input signal. • Manually confirm that the output varies.
	(3) Check that the parameter settings are correct. • Confirm that the running status is not set to “Stop.” • Confirm that the slope setting is not “0%.” • Confirm that the current limit setting is not “0%.”
	(4) Check that the following alarms are not ON. • Over-current alarm • Rapid-break fuse meltdown alarm • Heat radiation fin overheat alarm • Phase-sequence abnormalities alarm • Open-phase alarm • Frequency abnormality alarm
	(5) Check that the power supply is not interfered with by noise. • When there is strong noise, a frequency abnormality is assumed and the output becomes 0%. Noise countermeasures are required in such a case.
	(6) In models with rated currents of 75A or more, the fuse for the receiving board may have melted if the following occurs. • When the power of this instrument is not turned on (The status indicator EV1 does not light even if the power is turned on.), or • When the alarm for the open-phase, phase-sequence abnormality or frequency abnormality is activated Check if the fuse for the receiving board has melted and replace it if necessary. (Refer to Section 11.4.) When the fuse for the receiving board melts, an abnormality at the power source is a possible cause. Add a protection circuit at the power source. (Refer to Section 9.1.) If this instrument is used with a melted fuse, additional damage may occur. Additionally, if the fuse has melted down though a protection circuit has already been added, do not use this instrument as this environment is not suitable for use.
2. Continuous output (100%).	(1) Check that the following connections are correct. • Confirm that the load is connected correctly. If the load is too light, the output is generated continuously. • With the current or power feedback type, confirm that the CT is connected properly. • Confirm that the correct signal is connected to the control input signal.
	(2) Check that the parameter settings are correct. • Confirm that the elevation setting is not “100%.”

Problem	Check Items
3. Output does not vary correctly.	(1) Check that the following connections are correct. • Confirm the phase-sequence of the 3-phase power supply with a phase detector and the connections are in a positive-phase-sequence. • With the current or power feedback type, confirm that the CT is connected properly. Make sure that the secondary side of the CT is not grounded. • Confirm that the correct signal is connected to the control input signal.
	(2) Check that the power waveform is normal. • If the power waveform contains noise or distortion, the output will not be proportional to the control input signal. • If a private electric generator is in use, check the power voltage and power frequency. Particularly, make sure that the power frequency is either 50 Hz or 60 Hz.
	(3) Check that the load is not imbalanced. • If it is extremely imbalanced, the output will not be proportional to the control input signal. Achieve a balanced status by correcting the power supply and/or load and performing the imbalance adjustment.
	(4) Check that the parameter settings are correct. • Confirm that the slope, elevation and soft start settings are correct.
4. This instrument malfunctions.	(1) Check all of the Check Items in 1 to 3 above.
	(2) If there is still a problem in operation of this instrument, initialize set values. (Initializing its internal memory to the default settings). • Turn this instrument OFF. • Set No. 8 of the Dip SW1 on the front panel to ON. • Turn this instrument ON. • Confirm that the EV1 status display indicator on the front panel flashes. • Set No. 8 of the Dip SW1 on the front panel to OFF. • Now initialization is complete; see if the malfunction is recovered.
5. Control output is different from the actual value on a measuring unit.	(1) Check that RMS type measuring units are used. • For the measurement of the control output of the power controller, be sure to use RMS type or armature type measuring units. A rectifier type measuring unit cannot be used.
6. Output is generated even though control input signal is 0% or less.	(1) Check the control input signal. • Check if the input signal to the control input terminals does not fluctuate or noise is not superimposed. (2) Check the length of wires. • Make wires as short as possible. Especially make the setting units and voltage signal wires short.

11 MAINTENANCE

11.1 Routine Inspection and Maintenance

⚠WARNING	(1) To prevent an accident, be sure to turn this instrument off before proceeding to the following operations. (2) To prevent burns, do not touch any hot parts, such as a heat radiation fin, immediately after turning this instrument OFF.

11.1.1 Inspection items

Inspect the following items in order to maintain this instrument in the best condition.

Item	Description
Terminal bolts and screws	If the bolts of the main circuit terminals are loose, heat will be produced due to the large current and the wiring may be burnt out. Be sure to inspect the tightness of the bolts and screws periodically.
Cooling fan(s)	Types with a rated current of 100 A or more are equipped with a cooling fan(s) on the top panel. Periodically inspect that there are no rotation irregularities or noise. Note that the cooling fan(s) is a consumable part that must be replaced periodically.
Cleaning	When this instrument is used in a dusty or dirty environment, the attached dust or dirt may degrade the insulation or cause other malfunctions. To prevent this, clean and remove dust or dirt periodically.

⚠CAUTION	Never attempt to replace parts other than the cooling fan(s) and rapid-break fuse. You may not be able to replace other parts correctly and may also risk injury if you replace them. For the replacement of parts other than the cooling fan(s) and fuse, please contact your nearest distributor.

11.1.2 Consumables

The following shows the consumables and their replacement timing.

Name of parts	Replacement interval	Operating conditions
Cooling fan(s)	2 years	• Normal working temperature • 50% or less operating rates
Printed circuit boards	5 years	

11.2 Fuse Replacement

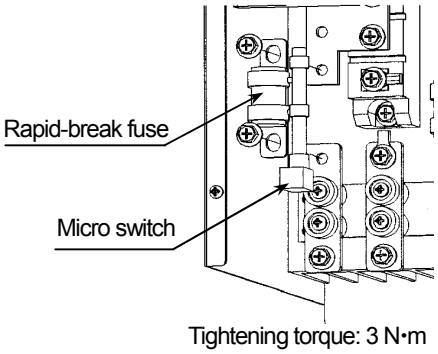
⚠WARNING	(1) To prevent an accident, be sure to turn this instrument off before proceeding to the following operations. (2) To prevent accidents, be sure to tighten the fuse with the specified torque when replacing it. Also, be sure that the new fuses are of the same specifications as the previous fuses.

When a rapid-break fuse melts, be sure to check the cause of melting and take proper countermeasures against it before replacing it. As the fuse may melt due to a malfunction of this instrument, it is necessary to check carefully.

The following shows the types of rapid-break fuses being used with this instrument. Confirm the specifications (voltage and current) of the fuse being used, and be sure to replace it with the same fuse.

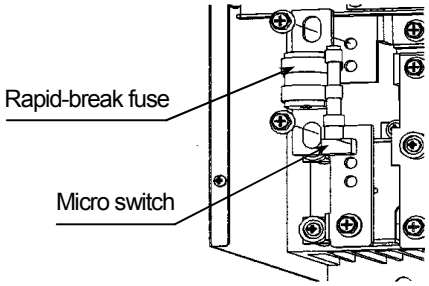
Rated voltage	Rated current	Fuse	Rated current	Fuse
200V AC	30A	Hinode Electric 250GH-50 S	200A	Hinode Electric 250GH-315 S
	50A	Hinode Electric 250GH-75 S	250A	Hinode Electric 250GH-350 S
	75A	Hinode Electric 250GH-100 S	300A	Hinode Electric 250GH-450 S
	100A	Hinode Electric 250GH-160 S	400A	Hinode Electric 250GHW-630 S
	150A	Hinode Electric 250GH-200 S	500A	Hinode Electric 250GHW-710 S
400V AC	30A	Hinode Electric 660GH-50 S	200A	Hinode Electric 660GH-315 S
	50A	Hinode Electric 660GH-80 S	250A	Hinode Electric 660GH-350 S
	75A	Hinode Electric 660GH-100 S	300A	Hinode Electric 660GH-450 S
	100A	Hinode Electric 660GH-160 S	400A	Hinode Electric 660GH-630 S
	150A	Hinode Electric 660GH-200 S	500A	Hinode Electric 660GH-710 S

Rated current: 30A/50A



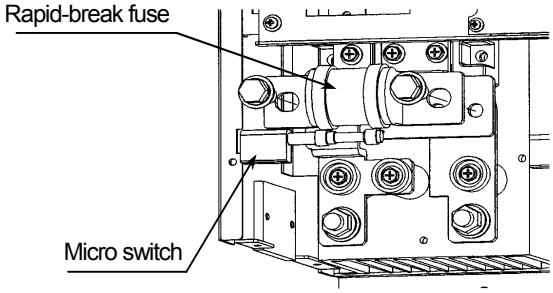
Tightening torque: 3 N•m

Rated current: 75A/100A



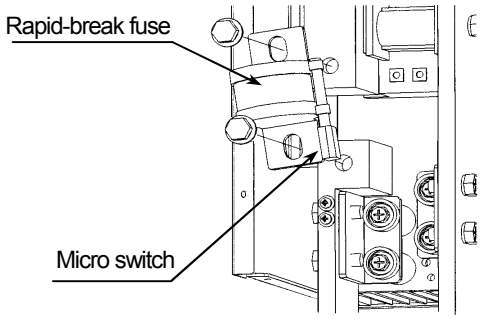
Tightening torque: 5N•m

Rated current: 150A/200A/250A



Tightening torque: 12 N•m

Rated current: 300A/400A/500A



Tightening torque: 25 N•m

• A micro switch to detect the melting-down of the rapid-break fuse is attached to the rapid-break fuse.
When replacing the rapid-break fuse, pull out the micro switch and reattach it to the rapid-break fuse after its replacement.

11.3 Cooling Fan Replacement

⚠WARNING	To prevent an accident, be sure to turn this instrument off before proceeding to the following operations.

(1) Turn the power of this instrument off.

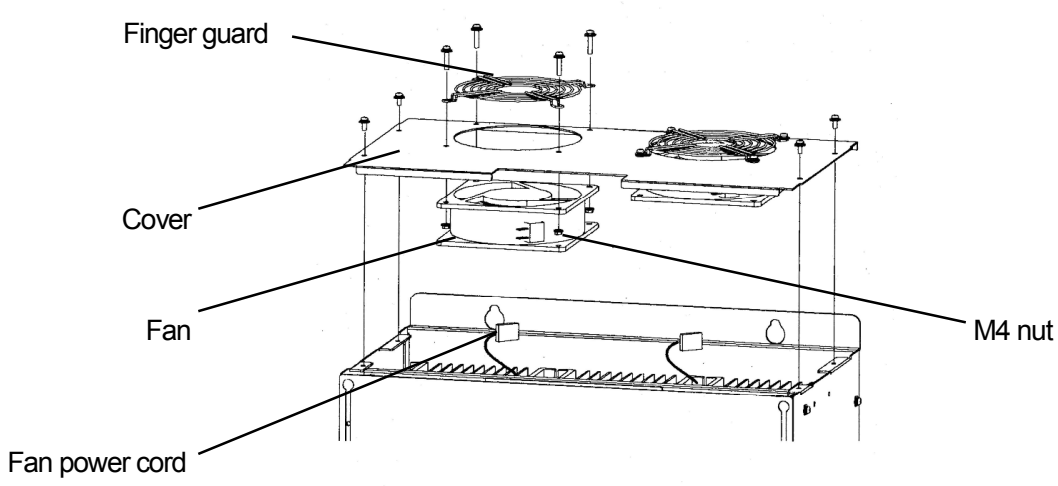
(2) Remove the cover, and unplug the fan(s) power cord connected to the fan.

(3) Replace the fan as shown below.
• Note that the type, number and installation method of cooling fans vary according to the rated current.

(4) Be sure to install the fan in the correct orientation when replacing it.
• The power cord can be connected in any position, but be sure to plug it in securely.

(5) Attach the cover by reversing the removal procedure.

(6) After replacement, turn the power of this instrument on, and ensure that all the cooling fans are rotating.



11.4 Fuse Replacement for the receiving board

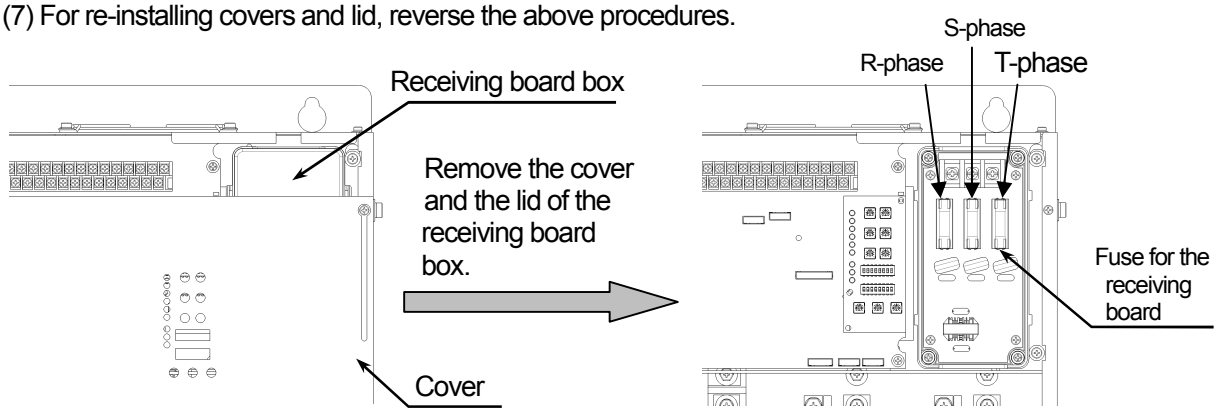
⚠ WARNING	To prevent an accident, be sure to turn this instrument off before proceeding to the following operations.

When the fuse for the receiving board has melted , make sure to check its cause and take measures before its replacement. In this case, sufficient checking is required since this instrument may be broken down.
Purchase the following fuse for the receiving board.

・Fuse for receiving board: 500SF-04　[Made by Hinode Electric S.S,]

[Replacement procedures for receiving board fuses]
Three receiving board fuses are installed in the receiving board box inside this instrument.
Replace the fuse following these procedures.

(1) Turn the power of this instrument off.
(2) Remove the cover of the instrument.
(3) Remove the lid of the receiving board box.
Since the receiving board box is fixed with 4 hooks along the sides, unhook them for removing the lid.
(4) Remove the cover of the fuse for receiving box.
(5) The cover of the fuse for the receiving box is fixed to the precut holes of the printed board with hooks.
Hold the cover of the fuse for the receiving board lightly and pull it for removal.
(6) Replace the receiving box fuse.
Since the fuse for the receiving board is fixed to the fuse clip on the printed board, pull it for removing, and then insert the replacement fuse securely.
(7) For re-installing covers and lid, reverse the above procedures.



12 GLOSSARY

12.1 Control Systems

12.1.1 Phase angle control

The phase angle control system controls the output by varying the conducting angle θ (ON timing) within 210° (3-arm operation) or 150° (6-arm operation) of the power frequency. Most power controllers employ this system.

This control is continuous compared to the zero-cross control ,and can be used in the primary side control of the transformer.

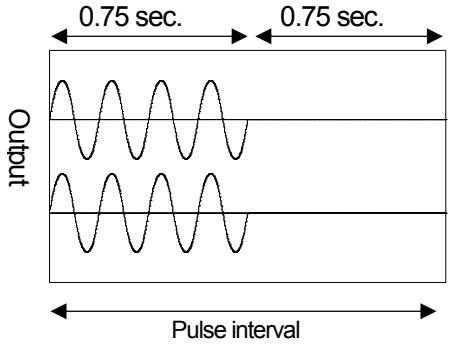
12.1.2 Zero-cross control

The zero-cross control system controls the output by defining ON/OFF for each power waveform cycle.

It generates less noise than the phase angle control. However, as the maximum current flows during the ON period and it is intermittent, the flickering phenomena (Example: Lighting flicker) may be generated.

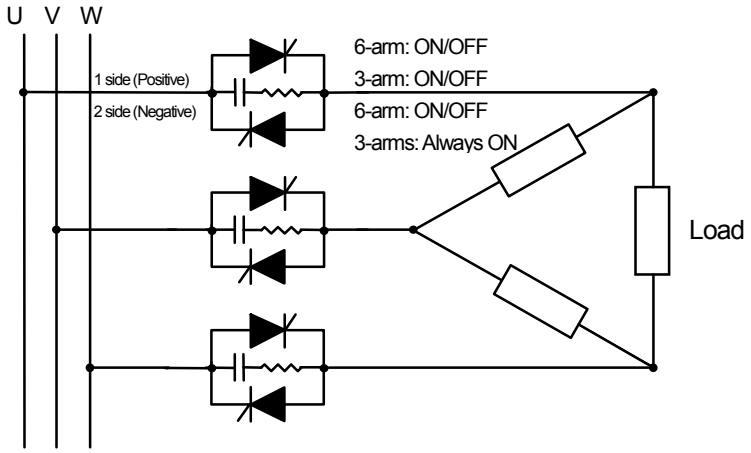
The zero-cross control can use only a Nichrome heater. Do not use it for purposes other than the primary side control of a transformer and Nichrome heater, otherwise, the over-current alarm will activate or the rapid-break fuse will be melted down.

The pulse interval corresponds to the output updating interval. For example, when the pulse interval is 1.5 sec. (default value) and the output is 50%, the ON/OFF waveform becomes as shown on the right.

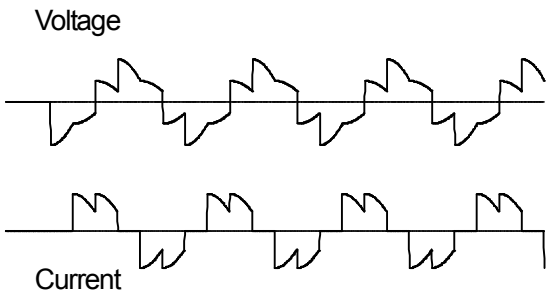


12.1.3 6-arm and 3-arm types

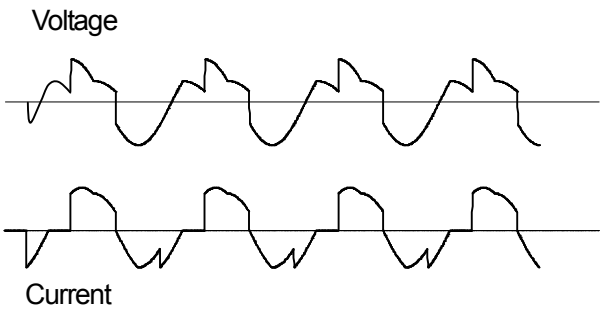
The “6-arm” type performs ON/OFF control of both the 1-side (positive) and 2-side (negative) gates of 1-power phase at the thyristor gate control. The “3-arm” type leaves the 2-side (negative) gate permanently ON. This instrument adopts the “6-arm”.



[6-arm control waveform]



[3-arm control waveform]

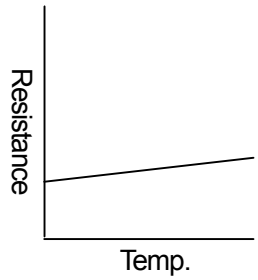


12.2 Feedback Types

12.2.1 Voltage feedback type

This type controls using the feedback of the voltage of the load, and is optimum for a heater with a low resistance-temperature characteristic as shown on the right (Nichrome heater, etc.).
Such a heater can be controlled stably by maintaining the output voltage from the power controller to a constant level.
This feedback can be used only with the phase angle control type.

Nichrome heater

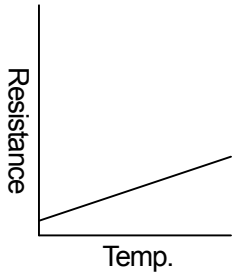


Note) The voltage feedback type controls the average value of three-phase load voltage values. This type cannot control each phase individually.

12.2.2 Current feedback type

This type controls using the feedback of the current of the load, and is optimum for a heater with a high resistance-temperature characteristic as shown on the right (Molybdenum disilicide heater, etc.).
Such a heater can be controlled stably by setting the maximum output of the power controller to the maximum rated current of the heater because this makes it possible to output the current in proportion to the control input signal regardless of changes in the resistance value.
This feedback can be used only with the phase angle control type.

Molybdenum disilicide heater

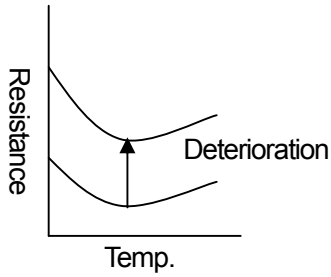


Note) ・ A CT is needed for using the current feedback type. Connect a CT matching the rated current.
・ The current feedback type controls the average value of three-phase load current values. This type cannot control each phase individually.

12.2.3 Power feedback type

This type controls using the feedback of the power of the load and is optimum for a heater, of which resistance varies according to the generated heat temperature and varies by nearly 4 times the initial resistance value over time (silicon carbide heater, etc.).
Such a heater can be controlled stably by detecting both the voltage and current applied to the load and by feeding back the power multiplying them.
This feedback can be used only with the phase angle control type.

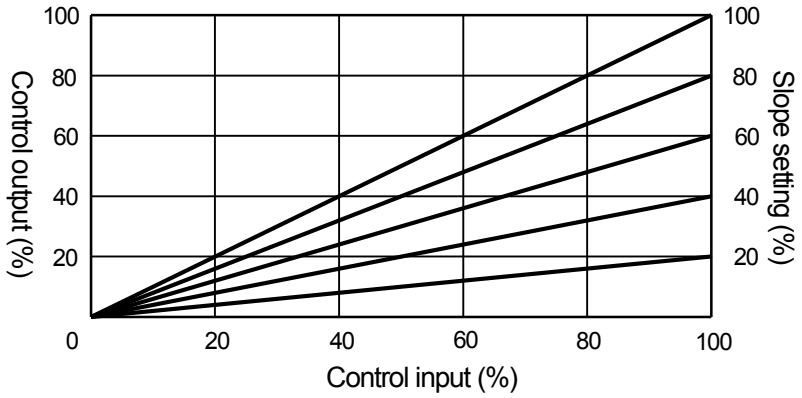
Silicon carbide (SiC) heater



Note) ・ A CT is needed for using the power feedback type. Connect a CT matching the rated current.
・ The power feedback type controls the power consumption of a load (whole power of three phases).
[$\sqrt{3}$ x Average of three-phase load voltage values x Average of three-phase load current values]
This type cannot control each phase individually

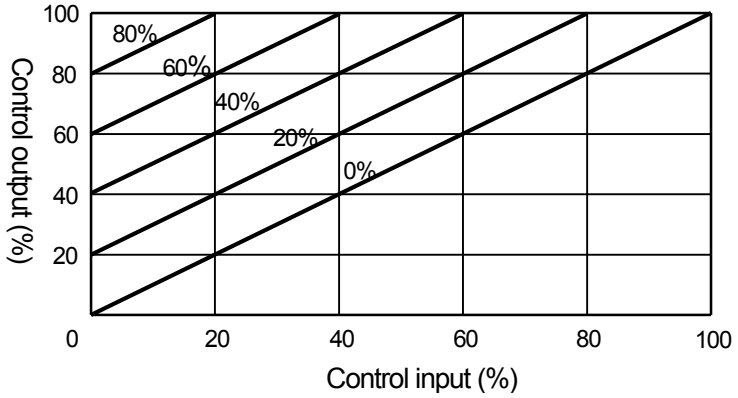
12.3 Settings

12.3.1 Slope



The slope setting provides the output (actually the internal SV used for computational processing) with a slope (inclination). It is effective for example in an electric furnace with 3-zone control where 3 units of the power controller are operated by one controller unit.

12.3.2 Elevation



The elevation setting provides the output (actually the internal SV used for computational processing) with a bias. For example, even when the controller output becomes minimum, a constant base power can be applied to an electric furnace, etc.

12.3.3 Soft start

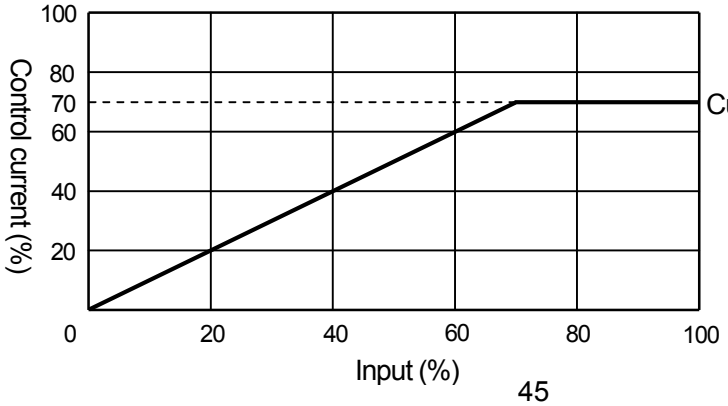
This function varies the output (actually the internal SV used for computational processing) gradually in order to prevent sudden change in the control output when this instrument is turned on or when the control input changes drastically. For example, a rush current can be suppressed in the case of a primary side control of transformer. With this instrument, the time to achieve SV from 0% to 100% can be set from approx.1 to 20 seconds.

In models without feedback, the change of output (time goal achievement of the SV from 0% to 100%) by the soft start becomes slightly faster since the actual change of output includes the operation time of the feedback control, etc.

12.3.4 Current limit

This function sets the maximum limit to the control current. For example, when the voltage feedback is used, the current flows according to the resistance of the load, and the rated current of the power controller may be exceeded if only the voltage control is used. The current limit function is used in such cases. The assessment value is the average value of three-phase load current values. This function cannot control each phase individually

The following shows an example of current limit.



(Note)

- A CT is needed for using the current limit. Connect a CT matching the rated current.

12.3.5 Imbalance adjustment

For the 3-phase control, although it is desirable that the voltage and current values of the three phases are the same values (balanced status), they are actually not the same values due to the unreliability of the power supply and an imbalanced load (imbalanced status). When the imbalanced status is serious, controllability deteriorates as well as the overall reliability of the system.

The PA-3000-H3 series incorporates the imbalance adjustment function, adjusting the output value of each phase in a limited range in the case of an imbalanced status. This function solves the imbalanced status in a simulated manner and enables stable control. The imbalance adjustment is performed based on either the voltage or current.

12.4 Alarm

12.4.1 Over-current alarm

This alarm is turned ON when a current of 120% or more of the rated current flows.

As a current above the rated current of the power controller is flowing, check if the rated current of the power controller and load specifications are met.

(Note)

- A CT is needed for judging the over-current. Connect a CT matching the rated current.

12.4.2 Rapid-break fuse meltdown alarm

This alarm is turned ON when the rapid-break fuse is melted down because a current of 150% to 200% of the rated current flowed.

The melting of the rapid-break fuse clearly indicates a system error. Check the cause and take countermeasures.

(Note)

- This alarm is available only in the specification with a rapid-break fuse.
- The fuse meltdown indicates an abnormality. Be sure to check the cause and take countermeasures, and then replace the fuse with the same type of fuse.

12.4.3 Heat radiation fin overheat alarm

For the instrument with the rated current of 100A or more, this alarm is turned ON when the heat radiation fin temperature is abnormally high.

This alarm may be caused by a malfunction of the cooling fan(s), so these should be replaced.

(Note)

- This alarm is available only with instruments with a rated current of 100 A or more.
- The cooling fan(s) should be replaced. Be sure to replace it with the same type of fan(s).

12.4.4 Heater disconnection alarm

This alarm is turned ON when the load resistance exceeds the set disconnection ratio.

- Load resistance = [Voltage] ÷ [Current]
- Disconnection ratio = [(Load resistance - Initial resistance) ÷ (Initial resistance)] ×100

(Note)

- A CT is needed for discerning heater disconnection. Connect a CT matching the rated current.

12.4.5 Thyristor element abnormality alarm

This alarm is turned ON when the feedback input value is 50% or more when the output of this instrument is 0%. In other words, an abnormality is discerned when the actual load is subjected to high power while the power controller output is 0%. However, even when this alarm is ON, the thyristor element of this instrument may not always be abnormal as there may be an abnormality somewhere else in the system (including the load).

(Note)

- Identify if the thyristor element or the system side (including the load) is abnormal. Particularly, check if the load is connected properly.
- If the thyristor element is abnormal, this instrument should be repaired.
- There is a dead band (delay time) when the alarm assessment is OFF.

12.4.6 Running the abnormality alarm

This alarm activates when the self-diagnostic function of this instrument identifies an abnormality.
This is for checking the internal memory of this instrument; this alarm informs users that the internal memory has been initialized by an unknown cause. The alarm is released about 1 minute after its activation or when this instrument is turned OFF then ON again. As the internal memory may reset at this time, check the parameter settings and perform a simulation run to confirm that the control is normal before restarting normal control operations.

(Note)

- If the settings are altered by this alarm, return them to the previous settings.
- The alarm is usually released by turning the power of this instrument OFF then ON again, but if it still doesn't release, this instrument should be repaired.

12.4.7 Phase-sequence abnormality alarm

This alarm is turned ON if there are any incorrect connections of the 3-phase power supply (U, V and W).
To release this alarm, turn this instrument OFF, connect the wires properly, and turn it ON again.

12.4.8 Open-phase alarm

This alarm is turned ON when any of the 3-phase power supply connections (U, V or W) are disconnected.
To release this alarm, turn this instrument OFF, connect the wires properly, and turn it ON again.

(Note)

- In the case of standard types (The main circuit power supply and the control circuit power supply are common.), the determination of the W phase only is enabled. If the U-phase or V-phase opens, the operation of this instrument will stop. (The power is turned OFF.)
- In the case of a light-load/serious imbalance status,/ rated voltage not used or if a special type (where the main circuit power supply and the control circuit power supply are separate) ,the open-phase determination may not perform correctly.
- Use an abnormality alarm for a three-phase power supply together with a phase-sequence abnormality alarm. (Even when the phase-sequence abnormality alarm is ON, an open-phase status or a frequency abnormality may exist. It means a definite determination of status cannot be performed on these 3 kinds of alarms.

12.4.9 Imbalance alarm

This alarm is determined by the "imbalance rate" which is the alarm set point (judgment value) and by the load currents of the three phases with the following formula.

- Imbalance rate ={(Load current max value - Load current min value) ÷ (Load current max value)} × 100(%)

(Note)

- This alarm is not available for zero-cross control types.
- A CT is needed for discerning an imbalance. Connect a CT matching the rated current.

12.4.10 Frequency abnormality alarm

This instrument detects the power frequency automatically when it is turned ON. This alarm is turned ON when the power frequency is neither 50Hz±2Hz nor 60Hz±2Hz.

The alarm can be released by checking the power frequency and by supplying power with a normal waveform. In addition, this alarm may be activated by noise in the power supply. Countermeasures against noise are required.

12.5 Load

12.5.1 Resistive load

The typical load of this kind is a heater. There are three kinds of heater according to their resistance-temperature characteristics.

(1) Nichrome heater

- This heater has a low resistant-temperature characteristic, and its current change is small. It is therefore not necessary to be controlled based on current.
  In general, it can be controlled with voltage feedback or without feedback.
- In the case of feedback types, the rated current of the thyristor should have a buffer of 10% or more of the heater rating, considering the variance in the resistance value (about ±10%).
  In the case of no-feedback types, the rated current of the thyristor should have a buffer of 20% or more of the heater rating, considering the variance in the resistance value (about ±10%) and the power voltage fluctuation (about ±10%).

(2) SiC heater

- The resistance value of this heater varies greatly as time passes and increases in the course of use.
  This means that the current flow gradually reduces and generated heat will eventually become insufficient. Therefore, power feedback types, by which the control voltage increases to maintain a constant generated heat, are the most suitable.
- The service life of this heater should be regarded as expired when the resistance value becomes about 4 times the initial resistance value. At this time, the control voltage to the heater increases to double.
- The rated current of the thyristor should have a buffer of 20% or more of the heater rating.

(3) Molybdenum disilicide heaters, metallic heaters and indicators

- The resistance value for temperatures other than the normal temperature range varies from 10 – 19 times. This heater should therefore be controlled with current feedback.
- The rated current of the thyristor should have a safe side of 20% or more of the heater rating.

12.5.2 Inductive load

The typical load of this kind is the transformer. Special care is required on the transformer's flux density. If this is too high, the iron core of the transformer is easily saturated magnetically, causing problems such as the rapid-break fuse melting-down or transformer damage due to heat. Be sure that the flux density of the transformer is 1.2 (T) or less.

The feedback type can be determined according to the resistance-temperature characteristic of the heater connected to the secondary side of the transformer.

The rated current of the thyristor should have a buffer of 30% or more of the heater rating. Such primary side control of a transformer should be performed with the phase angle control.

12.6 Other

12.6.1 Leak current

By a surge-absorbing snubber (series connected resistors and capacitors) being connected inside the power controller, the power supply and the load become connected and a very small current will flow at the output side, even when the output level is 0%. Therefore, the voltage or current at the load side can be observed even when the output is 0%, and this is not a malfunction. Control a load with a load current being large enough compared to the leak current.

12.6.2 Output voltage measurement

The output waveform (phase angle control) of the power controller is not a sine wave and is distorted.

With a rectifying type measuring unit, a correct measurement value cannot be obtained as such units are for sine waves. Use an RMS type or armature type measuring unit for the measurement of the output of the power controller.

The following shows differences between the measurements of an RMS and armature type measuring unit.

Type	Actual Voltage Measurement (V)								
RMS type	0	30	60	90	120	150	180	190	200
Rectifying type	0	12	28	50	76	107	147	166	190

12.6.3 Surge countermeasure

The power controller may be affected by a strong surge noise that may be generated during the switching (ON/OFF) of peripheral equipment such as a magnetic switch. It is recommended to attach a noise absorbing capacitor (oil capacitor or film capacitor) on the load side in order to absorb the surge noise.

13 GENERAL SPECIFICATIONS

Phases : 3 phases

Rated voltage : 200V AC (Selection with the 200V/220V/240V switch)
400V AC (Selection with the 380V/400V/440V switch), to be specified
• With the standard specifications, the power supply to the main circuit and control circuit is common. A special type using separate power supplies for the circuits can also be manufactured as an option.

Rated current : 30A, 50A, 75A, 100A, 150A, 200A, 250A, 300A, 400A, 500A To be specified

Rated frequency : 50/60 Hz (Automatic switching)

Allowable voltage fluctuation : ±10% of the rated voltage

Allowable frequency fluctuation : Rated frequency±2Hz

Control system : Phase angle control, zero-cross control

Arms : 6-arm

Feedback type : Voltage, current, power

Control input signal : 4 to 20mA DC (input resistance approx. 100Ω, max. allowable current 25mA DC)
1 to 5V DC (input resistance approx. 50kΩ, max. allowable voltage 10V DC)

Remote setting input : Trimmer signal (10kΩ recommended, 2 to 20kΩ allowable)

Remote contact input : Non-voltage contact signal or open-collector signal (External contact capacity 1mA, 5V DC or more)

Remote CT input : 0 to 5A AC of the rated current

Slope : 0 to 100% of the output range

Elevation : 0 to 100% of the output range

Soft start time : Approx. 1 to 20sec.

Current limit : 0 to 100% of the output range

Imbalance rate adjustment: Output balance adjustment in the range of approx. 40% is enabled.

Output range : 0 to 98% of the supply voltage

Output accuracy : Without feedback: ±10% of the rated voltage
With voltage feedback: ±3% of the rated voltage
(when rated voltage fluctuation is within ±10% and the load resistance fluctuation is within 1 to 10 times)
With current feedback: ±3% of the rated current
(when rated voltage fluctuation is within ±10% and the load resistance fluctuation is within 1 to 10 times)
With power feedback: ±3% of the rated power
(when rated voltage fluctuation is within ±10% and the load resistance fluctuation is within 1 to 3 times)
The accuracy is based on the reference operating condition and in the range of 10% to 90% of the ratings and is not specified under other conditions. The error of the CT is not included.

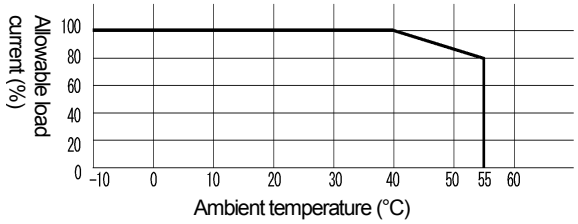
Applied load : Resistive load, inductive load
The inductive load is applicable only in the control of the primary side of a transformer in the phase angle control method. The flux density recommended for the transformer is 1.2 T or less.

Minimum load current: 0.5A or more (at 98% output at the rated voltage)

Alarm types :

Over-current alarm	(Alarm output: AL1)
Rapid-break fuse meltdown alarm	(Alarm output: AL1)
Heat radiation fin over-heat alarm	(Alarm output: AL1)
Heater disconnection alarm	(Alarm output: AL2)
Thyristor element abnormality alarm	(Alarm output: AL2)
Imbalance alarm	(Alarm output: AL2)
Running abnormality alarm	
Phase-sequence abnormality alarm	(Alarm output: AL3)
Open-phase abnormality alarm	(Alarm output: AL3)
Frequency abnormality alarm	(Alarm output: AL3)

Alarm output points : 3 points (AL1, AL2, AL3)
Alarm output AL1, AL2 ---When the alarm is activated, the output is turned on.
Alarm output AL3 ---------When the alarm is activated, the output is turned off.
Alarm output : Mechanical relay, Form A contact
Max. load 240V AC/1A, 30V DC/1A, Min. load 5V DC/10mA or more
Electrical life : 100,000 cycles or more
Contact protection element : Not built in
Over-current protection device : The Rapid-break fuse melts down when the load is short-circuited.
Output 0% (gate OFF) at approx. 120% of the rated current
The upper current limit can be set by the current limit function.
However, connect a CT matching the rated current.
Remote setting types : Slope (AI1)
Elevation (AI2)
Current limit (AI3)
Remote contact types: Running status (DI1: Run/Stop)
Control system (DI2: Phase angle control/zero-cross control)
Setting method (DI3: Front panel/Remote setting)
Cooling system : Rated current 75A or less: Natural air cooling
Rated current 100A or more: Forced air cooling
Working temperature : -10 to 55℃
The following decreasing characteristic is applicable at 40℃ or more.



Working humidity : 30 to 90%RH, No condensation.
Insulation resistance : Between power supply terminal and protective conductor (GND) terminals:
500V DC/50MΩ or more
Withstanding voltage : Between power supply terminal and protective conductor (GND) terminals:
2000V AC/1 min. (200V type)
Between power supply terminal and protective conductor (GND) terminals:
2500V AC/1 min. (400V type)
For instruments with the cooling fan(s) (i.e. rated current 100A or more), the fan power cord should be unplugged (the cooling fan has a withstanding voltage of 2000V AC and should be excluded from 2500V AC/1 min specification).

Power consumption:

	200V supply type	400V supply type
Rated current 30A, 50A, 75A	15VA	20VA
Rated current 100A	40VA	55VA
Rated current 150A, 300A	65VA	90VA
Rated current 200A, 250A, 400A, 500A	90VA	125VA

Generated heat:

Rated current	Max. heat generation	Rated current	Max. heat generation
30A	140W	250A	920W
50A	180W	300A	1100W
75A	260W	400A	1530W
100A	380W	500A	1980W

External Dimensions	: 325 (H) x 200 (W) x 200 (D) (Rated current 30A/50A types)	
	325 (H) x 288 (W) x 220 (D) (Rated current 75A/100A types)	
	325 (H) x 420 (W) x 240 (D) (Rated current 150A to 250A types	
	495 (H) x 420 (W) x 240 (D) (Rated current 300A to 500A types)	
	Excluding projections	
Weight	: Approx. 8kg (Rated current 30A/50A types)	
	Approx. 13kg (Rated current 75A/100A types)	
	Approx. 22kg (Rated current 150A to 250A types)	
	Approx. 36kg (Rated current 300A to 500A types)	
Case assembly material	: Ordinary steel sheets	
Color	: Gray	
Installation	: Panel installation	
Reference operation condition:	Ambient temperature	: 23 ±2℃
	Ambient humidity	: 55 ±5%RH (No condensation)
	Power voltage	: Rated voltage ±1%
	Power frequency	: Rated frequency
	Installation posture	: 0° Front, rear, left and right.
Normal operation condition	: Ambient temperature	: -10 to 55℃
	Ambient humidity	: 30 to 90%RH (No condensation)
	Power voltage	: Rated voltage ±10%
	Power frequency	: Rated frequency ±2Hz
	Installation posture	: 5° Front, rear, left and right
	Vibration/impact	: None.
	Altitude	: 2000m or less
Storage condition	: Ambient temperature	: -20 to 60℃
	Ambient humidity	: 5 to 90%RH (No condensation)

SHINKO TECHNOS CO., LTD.
OVERSEAS DIVISION

Reg. Office: 2-5-1, Senbahigashi, Minoo, Osaka, Japan
URL : http://www.shinko-technos.co.jp
E-mail : overseas@shinko-technos.co.jp
Tel : 81-72-727-6100
Fax: 81-72-727-7006

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