PAC28 Series

Single-Phase Thyristor Power Regulator

Instruction Manual

Thank you for purchasing a Shimaden PAC28 Series Single-Phase Thyristor Power Regulator.
After making sure the product fits the desired description, you should carefully read the instructions and get a good understanding of the contents before attempting to operate the equipment.

Request

The instruction manual should be kept in a handy place where the end user can refer to it when necessary.
Installation must be done by qualified personnel.

Preface

The instruction manual has been prepared for those involved in setup, wiring, operation or routine maintenance of PAC28 Series equipment.
This product should be used as a part to be mounted on inspection/measurement equipment.
The manual provides information concerning mounting, wiring and precautions when working with PAC28 Series equipment. You should therefore keep it in a handy place to refer to when operating and handling the equipment.
Be sure to observe all precautions and adhere to the procedures provided in the manual.
Safety rules, precautions concerning equipment damage, additional instructions and notes are written based on the following headings.

◎Matters that could result in injury or death if instructions are not followed.

⚠WARNING

◎Matters that could result in equipment damage if instructions are not followed.

⚠CAUTION

◎Additional instructions and notes

Note

⚠WARNING

PAC 28 Series is control heater power, etc., of industrial equipment. It should not be used for nuclear power generation, traffic control, communications or medical equipment.
You should either take appropriate safety measures or avoid using for control that could have a serious effect on human life. The manufacturer shall not be liable for an accident that results if used without taking appropriate safety measures.

⚠WARNING

1. The power regulator should be used so the terminal elements in the control box, etc., are not touched by human beings.
2. The power regulator should not be used as a switch.
   Even if output is zero, power is present in the capacitors and resistors of the output circuit, and could result in accident involving human life or serious bodily injury due to electrical shock.
3. Radiation fins and chassis become extremely hot. Never touch the radiation fins or chassis. Doing so could result in burn injury.
4. Do not supply power when wiring. Doing so could result in electrical shock.
5. Be sure to ground the ground terminal.
6. Do not touch terminal elements or other charged parts while conducting electricity. Also, do not introduce foreign objects or matter into the equipment.
   If a foreign object or matter accidentally gets inside, be sure to turn off the power and make sure all is safe before introducing tools or your hands.

⚠CAUTION

Be sure to observe the instruction manual when operating the device. If the content in the manual is not followed, the protectivity of the device will be impaired.
If there is danger of damage to any peripheral device or equipment due to failure of the power regulator, you should take appropriate safety measures such as mounting a rapid fuse, overcurrent circuit breaker or overheating prevention device.
We recommend you mount an electromagnetic contactor on the power supply for the device and automatically shut off the power supply immediately when an error occurs.
Using an electromagnetic contactor may result in malfunction due to contact bounce. Malfunctions are especially caused by circuits connected to transformers (inductive load). If so, you should either use the prescribed noise filter, or connect an X capacitor between the R and T main power terminals (0.1 – 0.5 μF), or a Y capacitor between the R and T power terminals and the ground (1000 – 3300 pF) to absorb the noise.

⚠CAUTION

1. Concerning the ⚠ alert symbol on the power regulator's plate, a ⚠ alert symbol is printed on the label applied to the outer surface of the device. The symbol is provided to prompt you to employ special care not to touch the device because doing so could result in electrical shock if parts that conduct power are touched when power is present, or could result in burn injury if touched when hot, etc.
2. Provide a switch or breaker as a means of cutting off power for external power circuit connected to the power terminal of the device.
   Mount a switch or breaker near the device where the operator can get to it easily and label it as an electrical breaker for the device.
3. Be sure to securely fasten conductor cable connections before using.
   Failure to do so could result in burning from overheating due to contact resistance.
4. Be sure power supply voltage and frequency do not exceed the rating.
5. Do not apply voltage/current other than rated input to the input terminal.
   Doing so could shorten the life of the product or result in equipment failure.
6. Voltage/current of load connected to the output terminal should not exceed the rating.
   Using voltage/current that exceeds the rating could shorten the life of the product by raising the temperature, and could result in equipment failure.
7. Be sure to mount the terminal cover that comes with the device after wiring.
8. The user should absolutely not modify or use the device in any way other than it was intended to be used. If this device must be disassembled for replacement or repair, contact your dealer.
9. To ensure safety and maintain the functions of this device, do not disassemble this device other than replacing the fuse.
   If this device must be disassembled for replacement or repair, contact your dealer.
10. Be sure to observe the notes and precautions provided in the manual to use the device safely and maintain its reliability.

Note: Shimaden shall bear no responsibility, monetarily or otherwise, for accident or damages caused by failure to observe warnings, notes and precautions contained in the instruction manual.

SHIMADEN CO., LTD.

MPA028-E10-D
May. 2023

Contents

1. Specifications code check

Make sure the product you have received matches the specifications of your order. If you have any questions, feel free to contact your nearest Shimaden agent.

1-1. Code selection table

Item	code	specifications			
1. Series	PAC28	High-performance thyristor type power regulator / Standard function: 1 Alarm output (AL1), 3 digital control inputs (DI)			
2. Control type		P1-	Phase control / constant voltage output	Equipped with feedback function	
		P2-	Phase control / constant current output		
		P3-	Phase control / constant power output (*1)		
		P4-	Phase control / square voltage output		
		P0-	Phase control / angle proportional input	Not equipped with feedback function	
		C1-	Cycle calculation zero voltage switching control		
3. Control input		6	Voltage: 0 – 1 V, 1 – 5 V, 0 – 10 V DC Input resistance: 200 kΩ		
			Contact		
			Voltage pulse: Rating: 12 V DC±2 V		
			Potentio: All resistance: 100 Ω – 10 kΩ 3-line		
		4	Current: 4 – 20 mA, 0 – 20 mA DC Receiving impedance: 100 Ω		
4. Main power supply voltage		90-	100 – 240 V AC		
5. Rated current		020-	20 A		
		030-	30 A		
		050-	50 A		
		075-	75 A		
		100-	100 A		
		150-	150 A		
		200-	200 A		
		300-	300 A		
		450-	450 A		
6. Analog auxiliary input (optional)		0	None		
		4	4 – 20 mA DC Receiving impedance: 100 Ω		
		5	1 – 5 V DC Input resistance: 500 kΩ		
		6	0 – 10 V DC Input resistance: 500 kΩ		
7. Alarm output 2 (optional)		0	None		
		1	1 contact output 1a 240 V AC 1A		
8. Digital control output (DO) (optional)		0	None		
		1	2 open collector outputs		
9. Communication / analog output (optional)		0	None		
		5	Communication: RS-485 Shimaden standard protocol / MODBUS communication protocol		
		6	0 – 10 V DC analog output load current: 2 mA		
10. Rapid fuse (optional)		0	Without		
		1	With		
11. Remarks		0	Without		
		9	With (Please consult before ordering.)		

Note: *1 Since the heating element of variable resistance type (especially silicon carbide type) has a high temperature coefficient, the resistance value during temperature rise will be significantly lower than in the normal temperature range. Therefore, if you want to obtain appropriate power in the entire temperature range, determine the current capacity using the following formula. Since the resistance ratio of the silicon carbide heater is approximately 1: 3, select a current capacity that is $\sqrt{3} \approx 1.73$ times the square root of the resistance ratio. If the heater deteriorates, the resistance ratio may increase further, so it is recommended to select one that is about twice as large.

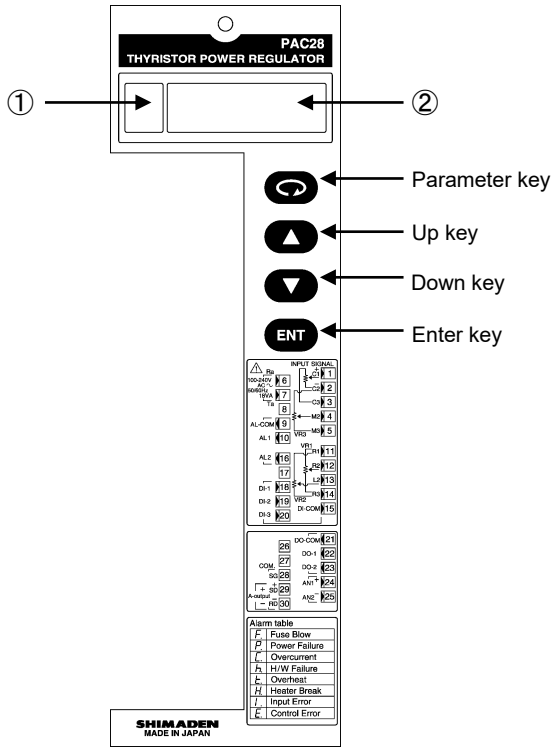
1-2. Rapid fuse selection table

Current capacity	Model
20A	QSF009
30A	
50A	QSF010
75A	
100A	QSF011
150A	QSF012
200A	QSF013
300A	QSF014
450A	

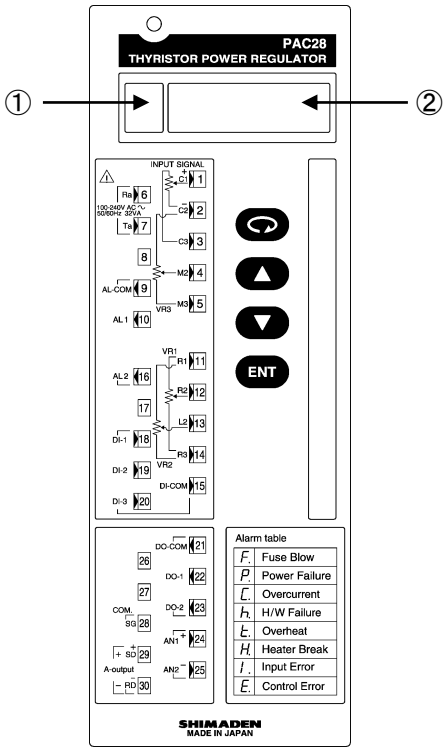
2. Panel part names and control terminals

2-1. Panel part names

20A/30A



50A/75A/100A/150A/200A/300A/450A



Display

①: Status display (red, 1 digit)・・・・・Indicates equipment status and displays parameter screens.
②: Parameter display (green, 4 digits)・・・・・Displays parameter names and related data.

Switches and their names

[P] Parameter key: Primarily used for switching screen groups. (Hereinafter referred to as [P].)
[▲] Up key: Primarily used for modifying parameter values. Increases numerical value if parameter is numbers. (Hereinafter referred to as [▲].)
[▼] Down key: Primarily used for modifying parameter values. Decreases numerical value if parameter is numbers. (Hereinafter referred to as [▼].)
[ENT] Enter key: Primarily used to register parameter settings. (Hereinafter referred to as [ENT].)

2-2. Control terminal No. and codes

Connection method of control input and external adjuster is indicted below.

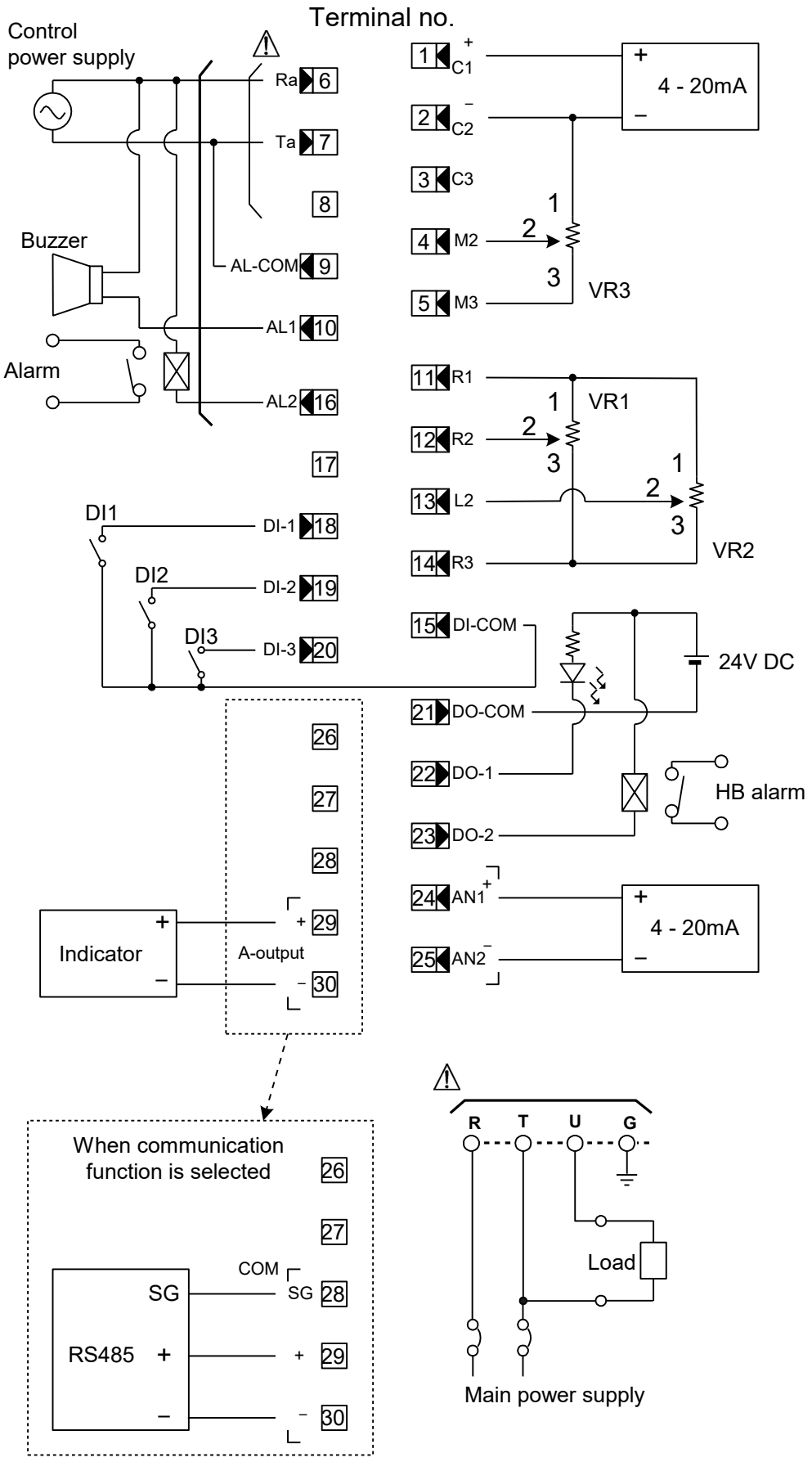
Control input

Terminal no.	Voltage/ current input	Potentio input	Contact input	Voltage pulse input
1	+	②	C1	+
2	−	①		−
3		③	C3	

Selection of ramp higher limit/lower limit and current limitation (manual setting)

Terminal no.	Codes	VR1 input	VR2 input
11	R1	①	①
12	R2	②	
13	L2		②
14	R3	③	③

2-3. Example of wiring



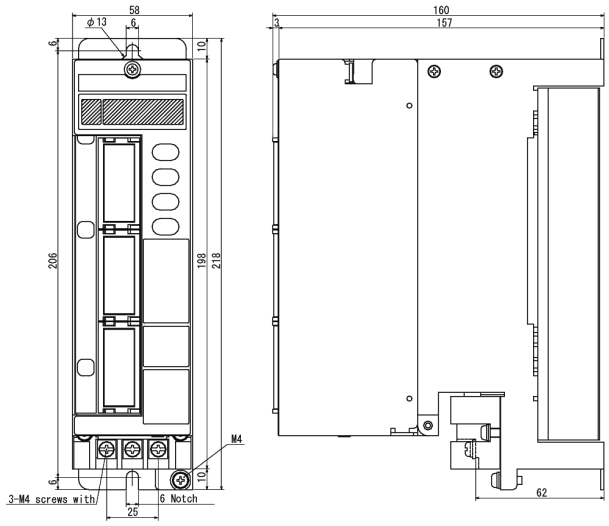
⚠ CAUTION

Power supply is applied on terminal No. 6, 7, 9, 10, 16 and R, T, U terminal. The alert symbol mark ⚠ on the power regulator's plate is to alert you that touching the terminal when power is present could result in electrical shock.

3. External dimensions and weight

Unit: mm

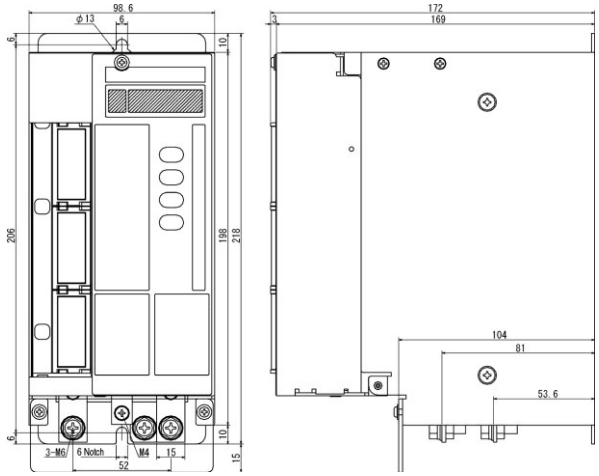
(1) 20/30A



Weight: Approx. 1.7 kg

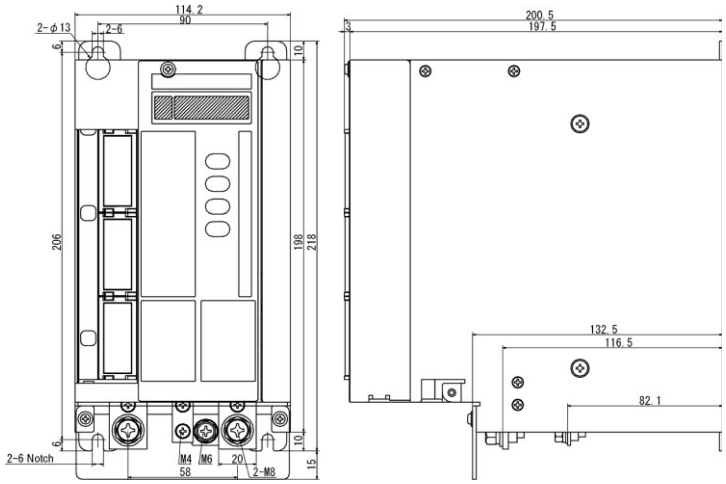
Note: Do not use M4 screws without squre washers.

(2) 50/75A



Weight: Approx. 3.3 kg

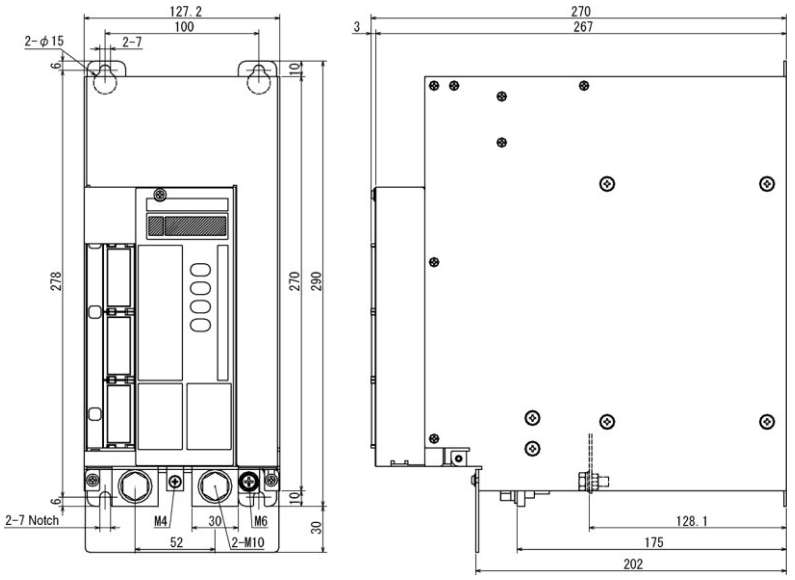
(3) 100A



Weight: Approx. 3.8 kg

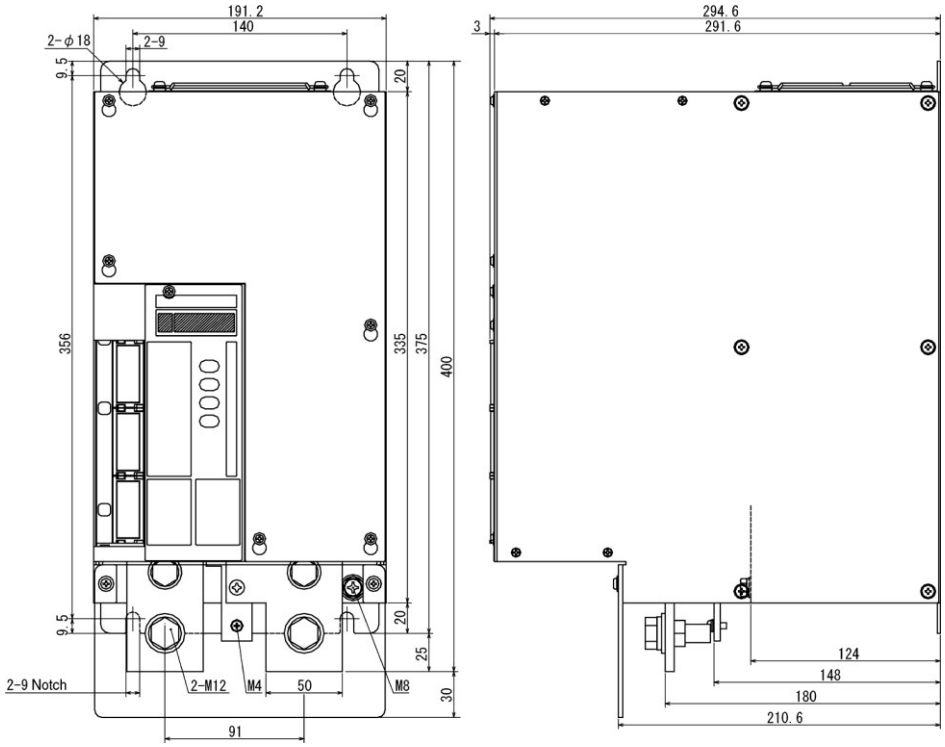
Unit: mm

(4) 150/200A



Weight: Approx. 7.2 kg

(5) 300/450A



Weight: Approx. 16 kg

Unit: mm

4. Setup location

The device is designed to be used under the following conditions. Observe the following environmental conditions when using:

1) Indoor use
2) Elevation: Max. 2000 m (see “16-2. Ambient temperature and load current”)
3) Temperature range: -10 – 55°C (see “16-2. Ambient temperature and load current”)
4) Humidity range: Max. 90% RH must be no dew condensation.
5) Over voltage category: II
6) Pollution class: 2 (IEC 60664)

⚠ CAUTION

Do not use in the following locations. Doing so could lead to equipment failure, damage or fire.

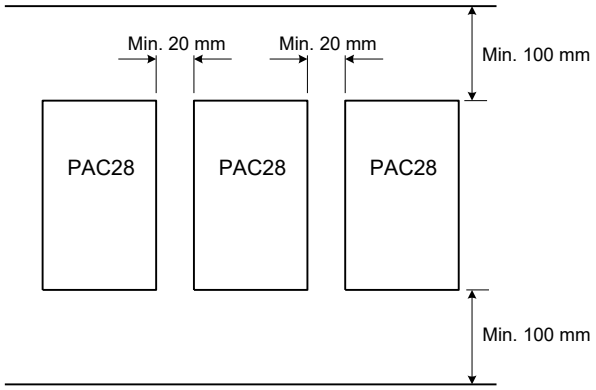
- Places exposed to flammable or corrosive gases, oil mist, or excessive dust that could cause insulation to deteriorate
- Places subject to vibration or impact
- Places exposed to water dripping or direct sunlight
- Places directly exposed to air from heater or air conditioner
- Places where maintenance cannot be performed safely

5. Mounting

Fasten to control panel, wall, rack, etc., when using. To ensure safety, arrange so that people cannot easily come into contact with the equipment.
Be sure to mount vertically to allow heat to dissipate. Provide at least 100 mm of clearance above and below the device.
If the device has to be mounted horizontally, operate at no higher than 50% of the rated current.

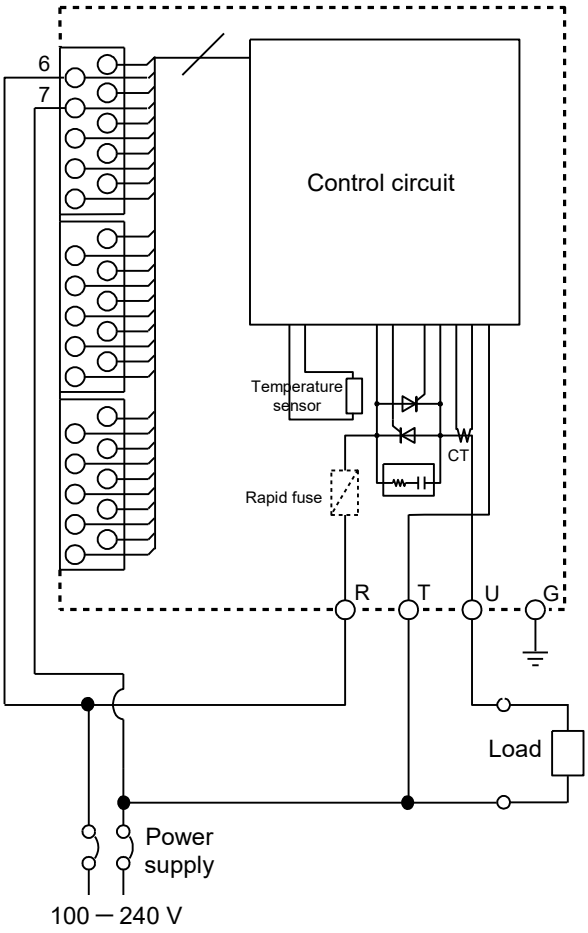
5-1. Mounting method and clearance

Provide the clearance shown in the figure.

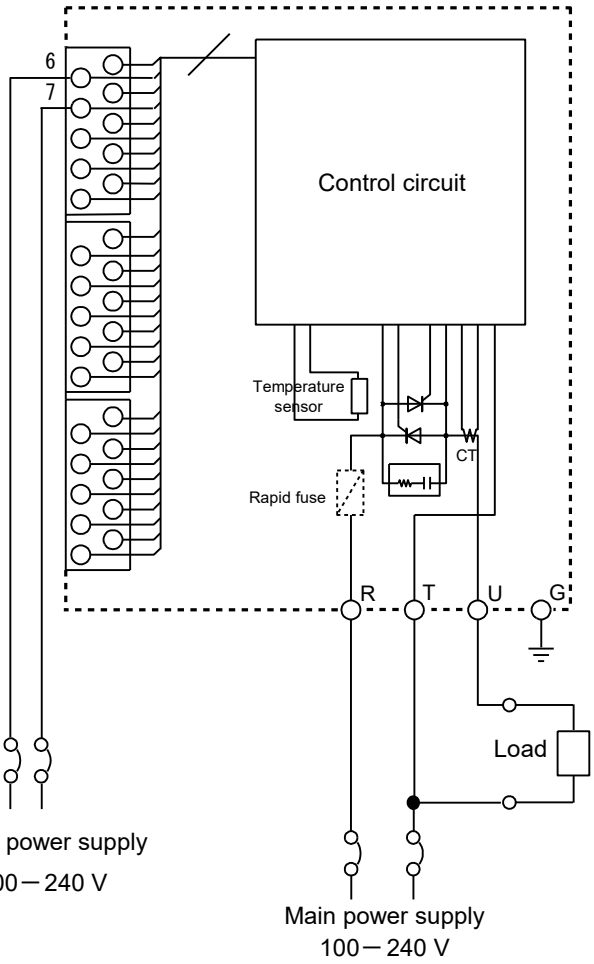


6. Circuit block diagram and terminal symbols

Shared power supply



Independent power supply



R: Power supply terminal
T: Power supply and feedback terminal
U: Output terminal
G: Protective ground terminal

7. Breaker model

Be sure to mount a breaker to operate the device safely.
Breaker model depending on rated current capacity is indicated in the following table. When using the device with reduced current, select current capacity of the breaker according to the current.

Recommended breakers

Rated current capacity	Breaker model	Breaking current	Maker
20A	BW50AAG-2P040☐☐	40A	Fuji Electric Co., Ltd.
30A	BW63EAG-2P060☐☐	60A	
50A	BW100AAG-2P100☐☐	100A	
75A	BW250EAG-2P150☐☐	150A	
100A	BW250EAG-2P200☐☐	200A	
150A	BW400EAG-2P300☐☐	300A	
200A	BW400EAG-2P400☐☐	400A	
300A	BW630EAG-2P600☐☐	600A	
450A	MF630-CW 2P600A☐☐	600A	Mitsubishi Electric Corp.

☐☐ differs depending on the shape of terminal and mounting method.

8. Ground / power supply / load (main circuit) wiring

8-1. Wiring

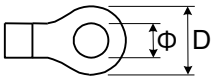
Open the terminal block cover to connect wires to the terminal block.
Loosen the fastening screws mounted on the device and wire.

8-2. Ground wiring

8-2-1. Functional grounding

The symbol mark for grounding is ⏚ (functional grounding).
If malfunction (due to noise, etc.) of equipment on which the device is mounted occurs, ground wiring decreases noise and operation becomes stable.
Using the proper terminal, securely fasten the screws; ground by maximum grounding resistance of 100Ω.
The thickness of the wire (cross-section) must be 2 mm² and over.

Ground terminal (G)	Current capacity				
	20A/30A	50A/75A	100A	150A/200A	300A/450A
Φ (mm)	Min. 4	Min. 6			Min. 8
D (mm)	Max. 10	Max. 12			Max. 22
Screws	M4	M6			M8
Fastening torque (N・m)	1.2 － 1.8	4.7 － 5.2			12.0 － 13.0



8-2-2. Protective grounding

The symbol mark for grounding is ⏚ (protective grounding).
For electrical safety, be sure to ground the device on metal plate which is connected to earth by a screw with a spring washer inserted in between.
Fasten firmly using appropriate screws.

	Current capacity				
	20A/30A	50A/75A	100A	150A/200A	300A/450A
Screws	M5	M5	M6 (2pcs)	M6 (2pcs)	M8 (2pcs)
Fastening torque(N・m)	2.8-3.2	2.8-3.2	4.7-5.2	4.7-5.2	12.0-13.0

8-3. Power supply and load wiring

The power regulator employs 3-terminal wiring. (R/U terminals) 20A/30A: M4, 50A/75A: M6, 100A: M8, 150A/200A: M10, 300A/450A: M12;
T terminal: M4. Use the proper terminal and securely fasten the screws.
For wiring of the R/U terminals, use wiring material that matches rated current. For wiring of T terminal, use wiring material of at least 0.5 mm².

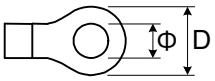
Power supply terminal (R) / output terminal (U)	Current capacity				
	20A/30A	20A/30A	20A/30A	20A/30A	20A/30A
Φ (mm)	Min. 4	Min.6	Min. 8	Min. 10	Min. 12
D (mm)	Max. 10	Max. 12	Max. 22	Max. 28.5	Max. 50.5
Screws	M4	M6	M8	M10	M12
Recommended wire thickness (cross-section)	$2mm^2$/$3.5mm^2$	$8mm^2$/$14mm^2$	$22mm^2$	$38mm^2$/$60mm^2$	$150mm^2$/$200mm^2$
Fastening torque (N・m)	0.4 – 0.6	4.7 – 5.2	12.0 – 13.0	24.0 – 25.5	40.0 – 43.0

Power supply and feedback terminal (T)	Current capacity				
	20A/30A	50A/75A	100A	150A/200A	300A/450A
Φ (mm)	Min. 4				
D (mm)	Max. 10				
Screws	M4				
Recommended wire thickness (cross-section)	0.5 mm² and over				
Fastening torque (N・m)	1.2 – 1.8				

9. Control input signal wiring

M3 screws are used for control signal terminals.
Use the proper terminal and securely fasten the screws.

Control terminal	
Φ mm	Min. 3.2
D mm	Max. 6.2
Screws	M3
Fastening torque (N・m)	0.5 ― 075

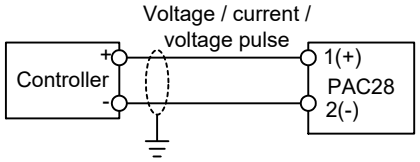


Control signal from the controller (4 – 20 mA, 1 – 5 V, 0 – 10 V, contact, etc.) enters the control input signal terminals (+ / -).
Be careful of the polarity and make sure noise from strong electric circuits does not get into the wiring.
Countermeasure against lightning surge will be required for signal line over 30m.
Use wire with thickness (cross-section) of 2.0 mm² and over for wiring to control power supply terminal (terminal No. 6, 7, 9, 10 and 16).
Use wire with thickness (cross-section) of 0.3 – 0.75 mm² for wiring to control input signal wire other than those above.

9-1. 1-to-1 connection with controller

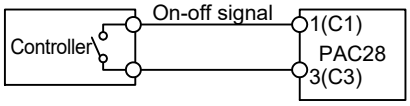
☐Connection with voltage / current / voltage pulse output controller
Adjust controller output with control signal of the device.

In the case of 1-to-1 connection, connect the positive controller output terminal (+) to terminal No. 1 and the negative terminal (-) to terminal No. 2.

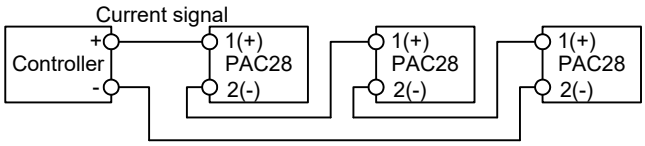


☐Connection with contact output controller

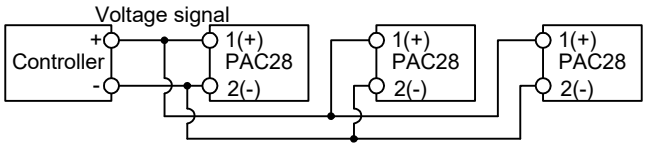
If connecting with on-off signal, connect between terminal No. 1 (C1) and terminal No. 3 (C3).



9-2. Multiple units connected to a single controller



In the case of current input type, wire control input signals in series. Input resistance for the power regulator is 100Ω, so if load resistance tolerance for a 4-20 mA output controller is 600Ω, you can connect up to 6 units.



In the case of voltage input type, wire control input signals in parallel. Input resistance for the power regulator is 200kΩ, so if maximum load current for a 0-10 V output controller is 2 mA, you can connect up to 40 units.

10. Precautions when turning on the power

10-1. Supply voltage setting

In the case of phase control / constant voltage output, phase control / constant power output, phase control / square voltage output, phase control / phase angle proportional control, set the supply voltage for the equipment to be controlled.
Set according to 'key sequence 2-1. Supply voltage.' The factory setting is 220 V (240 V specifications).

Note: There is no need to set for constant current control (current feedback), cycle calculation zero voltage switching control.

10-2. Source frequency

Source frequency should be 50/60 Hz.
Source frequency is automatically determined, but the device cannot handle sudden frequency change.
Before switching frequency, turn off the device's power.
Changing source frequency with the power on could result in output malfunction, resulting in maximum output.

10-3. Turning power on

Control power supply (for the operation of the device) and main power supply (for load) are required for the power supply of this device.
The control power supply and main power supply are independent power supplies and can be used with different voltage values. (There is no need to syncronize the two power supplies.)
Control power supply terminals are No. 6 and No. 7 and main power supply terminals are terminals R and T.
If supplying power from the same power supply, we recommend connecting terminal No. 6 with terminal R, and terminal No. 7 with terminal T.
For independent power supply, turn on the main power supply first. If the main power supply is to be turned on after the control power supply, first set control input to 0% since output is output by turning on the power supply.
Use the control power supply within the range of 100 – 240 V.
If voltage in excess of the rating is applied, internal components could be damaged. You should therefore be careful of the supply voltage.

11. Alarm function

When something is wrong with the device, you can display the status using the status indicator (red LED), then decimal point flashes, and output of an alarm. The equipment stops operating when alarms such as blown fuse, power failure, overcurrent, hardware (H/W) error, or overheating occur.

Alarm output destination allocation is set by 'key sequence 1-2. Blown fuse alarm – 1-7. Heater break alarm.'

⚠ CAUTION

When alarm 1 – 5 (indicated in the below chart) occurs, turn off the power, remove the cause, and then turn the power back on.

Alarm types	Dis-play	Conditions	Alarm output	Alarm history	Corresponding action
1. Blown fuse	"F"	Built-in fast-blow fuse (optional) has blown.	OK	Recorded	Switch to standby. (output off) You cannot return to control by communication or DI-2 input. Turn off the power, remove the cause and then return to ordinary operation by turning the power back on. Status display flashes.
2. Power failure	"P"	Frequency has exceeded the 40－70 Hz range or output voltage has exceeded the rating by 120%.			
3. Overcurrent	"C"	Output current has exceeded the rating by 130% or output current has exceeded the rating with less than 10 V of output voltage.			
4. Hardware (H/W) error	"h"	Output voltage has exceeded main circuit voltage by 75% with less than 20% of output phase angle or output cycle (output current is at least 5% of rating).			
5. Overheat	"t"	Radiator temperature has exceeded approx. 100℃.			
6. Heater break	"H"	Heater break has been detected.		Not recorded	Continue ordinary operation. Status display flashes.
7. Input error	"I"	Control input or analog auxiliary input level is too high or too low.	None		
8. Control error	"E"	No power supply syncronizing signals			

Alarm history does not disappear even if the device's power is turned off.
The alarm display is reset by key operation. (See 'key sequence 0-12. Alarm history. ')
If multiple alarms occur, alarm display is switched automatically. ("F"→"P"→"C"→……)

11-1. Blown fuse alarm (optional)

If the rapid fuse is blown by excessive current, etc., a blown fuse alarm occurs.
When the alarm occurs, device output stops, alarm output of the allocation destination is turned on.
When changing the alarm allocation destination, set by 'key sequence 1-2. Blown fuse alarm.'

For the procedure for changing the rapid fuse, see "13-1-1. Rapid fuse replacement."

11-2. Power failure

A power failure alarm occurs when source frequency exceeds the 40 – 70 Hz range or output voltage exceeds 120% of the rated voltage.
When the alarm occurs, device output stops, and output of the allocation destination is turned on.
When changing the alarm allocation destination, set by 'key sequence 1-3. Power failure alarm.'

11-3. Overcurrent

An overcurrent alarm occurs if output current exceeds 130% of the rating or output current exceeds the rating with less than 10 V of output voltage.
When the alarm occurs, device output stops, and output of the allocation destination is turned on.
If output current exceeds 130% of the rating, the overcurrent detection circuit in the device is tripped and keeps the equipment stopped. The alarm is therefore not reset unless turning the power off.
When changing the alarm allocation destination, set by 'key sequence 1-4. Overcurrent alarm.'

11-4. Hardware (H/W) error

A hardware (H/W) error alarm occurs if output voltage exceeds 75% of the main power supply voltage (output current 5% or more of rating) with less than 20% of output phase angle or output cycle. When the alarm occurs, device output stops, and output of the alarm output destination is turned on.
When changing the alarm allocation destination, set by 'key sequence 1-5. Hardware (H/W) error alarm.'

⚠ CAUTION

Avoid conducting electricity with no load. If a hardware (H/W) alarm occurs regardless of whether a load is connected, repair is required.
Contact your nearest Shimaden agent.

11-5. Overheat

If radiator temperature has exceeded approximately 100°C, a overheat alarm occurs.
For example, if the fan stops, the overheat alarm occurs. Subsequently, the thyristor device is protected to prevent the rated temperature from being exceeded and damaging the device.
When the alarm occurs, PAC28 output stops, and output of the alarm output destination is turned on.
When changing the alarm allocation destination, set by 'key sequence 1-6. Overheat alarm.'

⚠ CAUTION

If the function is activated, either improve heat dissipation conditions or decrease load current.
Output may go on/off repeatedly due to overheat. Remove the cause of the error.

11-6. Heater break

A heater break alarm occurs when heater resistance rises due to heater break or deterioration.
When the alarm occurs, output of the alarm output destination is turned on while device output continues.
When changing the alarm allocation destination, set by 'key sequence 1-7. Heater break alarm.'

11-7. Input error

An input error alarm occurs when control input or analog auxiliary input is less than -10% of the max. setting range or exceeds it by 110%.
Even if the alarm occurs, device output continues. Alarm output destination cannot be set.
HHHH is displayed on the 'key sequence 0-4. Control input' display when control input exceeds 110%.
0.0 or LLLL is displayed if less than -10% is indicated and output is at ramp lower limit value. HHHH is displayed if 110% is exceeded and output is at ramp higher limit value. (Display differs depending on type of control input.)

11-8. Control error

A control error occurs if power is not supplied to the main power supply terminals and the power supply synchronization signal cannot be detected.
Alarm output destination cannot be set.
The correlation of alarm and output are as follows:
・If control power supply and main power supply are independent and break occurs for main power supply only, output stops in this case.

⚠ CAUTION

Introduce supply voltage which matches the rating into the main power supply terminal. Introducing supply voltage other than the rating would result in equipment failure or fire.
If load error continues or becomes worse, it could result in trouble such as overcurrent, internal temperature rise, or blown rapid fuse.
Remove the location of the error as soon as possible.
Turn off the power before checking/repairing the device.

11-9. Alarm output

You can use contact output (relay a contact) as an alarm output.
Output is on when in alarm status.

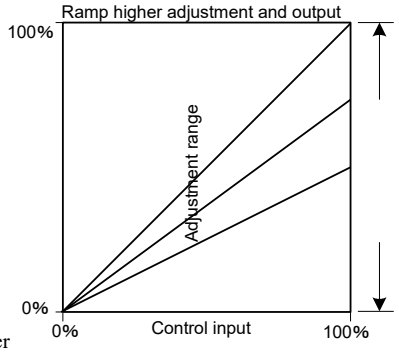
Alarm output and terminal arrangement

Output section	Signal name	Terminal No.
Alarm 1	AL1	10
	AL-COM	9
Alarm 2 (optional)	AL2	16
	AL-COM	9

12. Output adjustment function

The device operates at 0 – 100% output according to control input 0 – 100%.
The setting is enabled by key input or external adjuster or analog auxiliary input (optional) described in 'key sequence 1-10. Ramp lower limit setting.' 'key sequence 1-11. Ramp higher limit selection' and 'key sequence 1-12. Ramp higher limit setting.'
The output limit function includes output limit for start-up, current limit and slow-up function for inrush current prevention.

12-1. Ramp higher limit adjustment

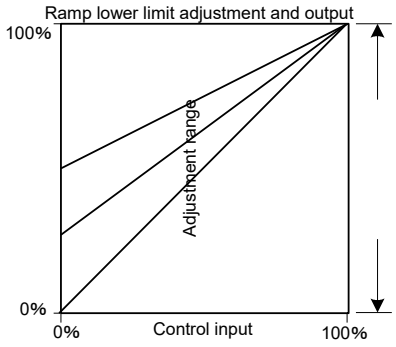


When not using external adjuster
Set to o_H by 'key sequence 1-11. Ramp higher limit selection.'
Ramp higher limit is determined by control input x (set value by '1-12. Ramp higher limit setting').
The output value for ramp higher limit can be adjusted from 0.1 to 100.0% when control input is 100%.
Because maximum output is narrowed down, output ramp of the device relative to the control input signal is changed.

12-1-1. Ramp higher limit adjustment by external adjuster

Set to $Hr\ 1$ or $Hr\ 2$ by 'key sequence 1-11. Ramp higher limit selection.'
Ramp higher limit is determined by control input x VR set value (0.1 – 100.0%) x set value by '1-12. Ramp higher limit setting.'
If allocating to external adjuster VR1, connect external adjuster 10kΩ to terminal No. 11-12-14. Ramp higher limit and lower limit adjustment cannot be allocated to the same external adjuster VR.
For terminal arrangement, see "External adjuster VR terminal arrangement."

12-2. Ramp lower limit adjustment



When not using external adjuster
Set to key input by 'key sequence 1-10. Ramp lower limit setting.'
The output value for ramp lower limit can be adjusted from 0.0 to 99.9% when control input is 0%.

12-2-1. Ramp lower limit adjustment by external adjuster

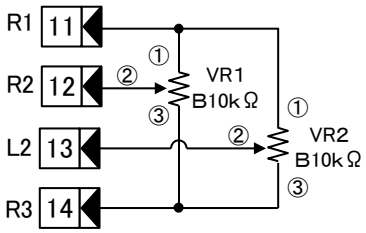
Set to $Hr\ 1$ or $Hr\ 2$ by 'key sequence 1-10. Ramp lower limit setting.'
If allocating to external adjuster VR2, connect external adjuster 10kΩ to terminal No. 11-13-14.
Ramp higher limit and lower limit adjustment cannot be allocated to the same external adjuster VR
For terminal arrangement, see "External adjuster VR terminal arrangement."

External adjuster VR terminal arrangement

Allocation	Terminal No.	VR No.
VR1	11	1
	12	2
	14	3
VR2	11	1
	13	2
	14	3

External adjuster error table

VR1, VR2		Ramp higher limit output	Ramp lower limit output
①	Break	100%	100%
②	Break	0%	0%
③	Break	0%	0%



Note
When wiring of external adjuster breaks, output becomes as indicated in "External adjuster error table."

12-3. Gain adjustment by analog auxiliary input (optional)

Output ramp can be controlled by analog auxiliary input. This can be used for feedback control by external converter.
Ramp value is obtained by multiplying multiple (0.0 – 1.0 times) of analog auxiliary input signal to control input signal. Select output ramp setting $GAin$ by 'key sequence 1-22. Analog auxiliary input.

Gain adjustment by analog auxiliary input

制御入力信号	アナログ補助入力	出力割合
0%	0%	0%
	50%	0%
	100%	0%
50%	0%	0%
	50%	25%
	100%	50%
100%	0%	0%
	50%	50%
	100%	100%

Analog auxiliary input terminal arrangement

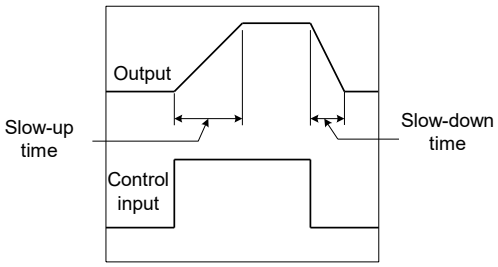
Analog auxiliary input	Terminal No.
AN1 +	24
AN2 -	25

Note
When wiring of analog auxiliary input breaks, analog auxiliary input becomes 0%.

12-4. Variation limit (slow-up / slow-down time) adjustment

Input variation is limited by setting slow-up and slow-down time. Output change of the device can be slowed down by limiting input variation.
It is effective for suppressing transient current when power is turned on, etc., and controlling heater inrush current so as not to place a burden on power equipment.
Variation limit time sets time required for output increase from 0 to 100% (slow-up) 'key sequence 1-13 Slow-up time,' or to decrease from 100 to 0% (slow-down) 'key sequence 1-14. Slow-down time.'
The longer the time is set, the slower output response is. Adjust time according to characteristics of load used.
There may be transient current if slow-up/down time is set short when using in combination with current limit function. You should therefore be careful when setting slow-up/down time.
The factory setting is approximately 1 second. If time is set shorter than this, the overcurrent protection function may be triggered depending on load conditions.

Operation diagram



⚠ CAUTION

- Variation limit may not be effective with constant current output control and constant power output control, depending on the load conditions.
- With constant voltage output control, constant current output control, constant power output control and square voltage output control, output delay may exceed preset variation limit time.
  Output starts late even if slow-up time is set to zero.

12-5. Current limit function

Function for limiting output current to within 10 – 120% of the device's rated current. The function is used to protect the thyristor by limiting inrush current when employing a large load if inrush current such as a pure metal heater or lamp heater, or to limit load current for some other objective.
Time delay is produced to control the control angle of the thyristor after detecting output voltage and output current.
Therefore, there are cases where sudden change in load while conducting power cannot be handled.

If using an external adjuster, set one of the three following VRs, **Vr 1** or **Vr2** or **Vr3**, by 'key sequence 1-15. Current limiter setting.' The same VR cannot be used.
For large inrush current load, use with variation limit time set to at least 2 seconds.
If conducting current in excess of 130% of the rated current, the overcurrent protection circuit is triggered to force output to 0% and **E** is displayed on status display.
In that case, remove the cause of the alarm and turn the power back on.
The device maintains a record of alarms (alarm history).
To clear the history, reset by 'key sequence 0-12. Alarm history.'

External adjuster terminal arrangement

Allocation	Terminal No.	VR No.
VR1	11	1
	12	2
	14	3
VR2	11	1
	13	2
	14	3
VR3	2	1
	4	2
	5	3

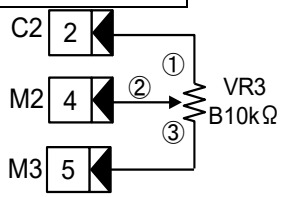
Current limit by external adjuster

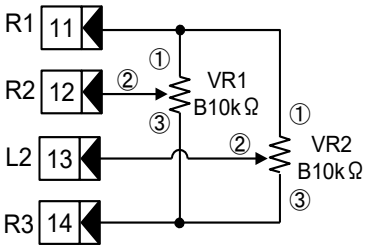
VR rotation angle	Maximum current
Max. 10%	Approx. 10%
100%	Approx. 100%

External adjuster error table

VR1,VR2,VR3		Current limit function
①	Break	100%
②	Break	0%
③	Break	0%

NOTE
- The current limit function is not activated for cycle calculation zero voltage switching control.
- When wiring of external adjuster breaks, output becomes as indicated in "External adjuster error table."

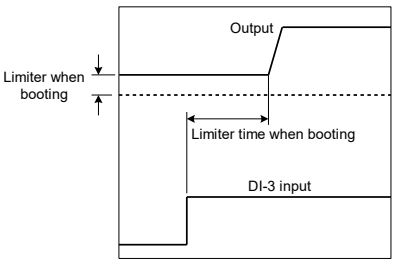




12-6. Output limit at start-up

Output limit controls inrush current at start-up if using a heater that conducts inrush current when turning on the power or switching loads (platinum, molybdenum, tungsten, halogen lamp, etc.). Due to this function, the output changes to the output set by 'Higher limit at start-up limiter' during the time set by 'Limiter time at start-up' to enable smooth operation.
The DI function (DI-3) is triggered, thus requiring DI input and setting.
See 'key sequence 1-19. Output limit at start-up setting,'
'key sequence 1-20. Higher limit at start-up limiter' and
'key sequence 1-21. Limiter time at start-up.'

Operation diagram



Setting 'key sequence 1-19. Output limit at start-up setting' to **PoS** makes the DI-3 function effective.
If the DI-3 input signal is off, output becomes limited output action, and output is kept below the output limit.
From the point in time when the DI-3 input signal becomes on until the preset limiter time at start-up, output is kept below the output limit. After limiter time at start-up elapses, output switches according to control input.

13. Rapid fuse / heater break alarm function

13-1. Rapid fuse (optional)

A rapid fuse can be selected as an option for protection of the thyristor device.

The thyristor device cannot be protected by electronic protection circuit from malfunction when using a transformer or load short circuit when conducting power. It is therefore protected by a rapid fuse.

When the rapid fuse blows, F is displayed on status display and output goes on standby.

Turn off the power and check the rapid fuse to see if it is blown.

When the rapid fuse is replaced, F display is automatically turned off and the device reverts to normal operation. However, PAC28 maintains a record of alarms (alarm history). To clear the alarm history, display 'key sequence 0-12. Alarm history' and press ENT for at least 2 seconds.

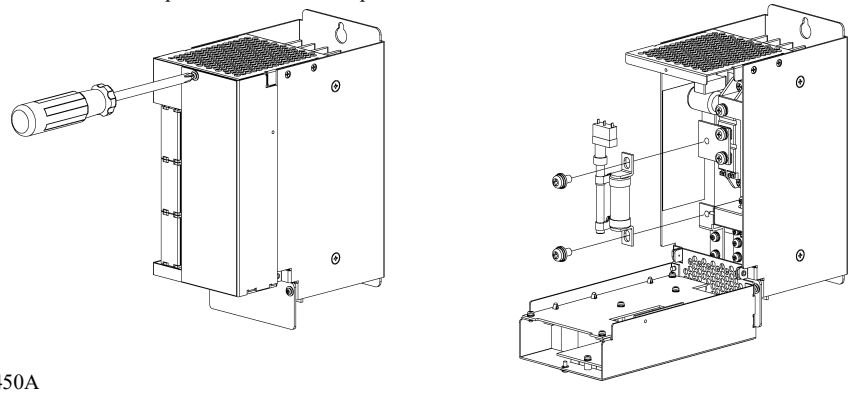
⚠CAUTION

Cut off the device's power supply before replacing the rapid fuse.

13-1-1. Rapid fuse replacement

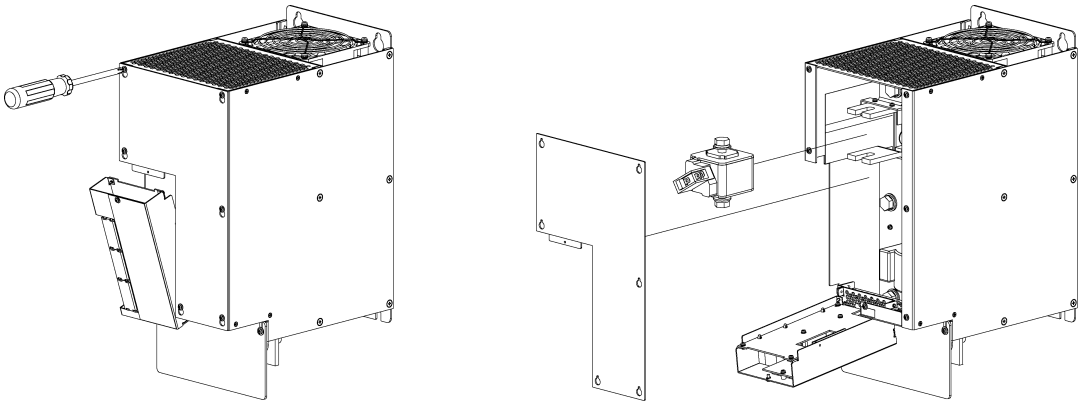
・ 20 – 200A

Loosen the screw at the top and the main cover opens.



・ 300 / 450A

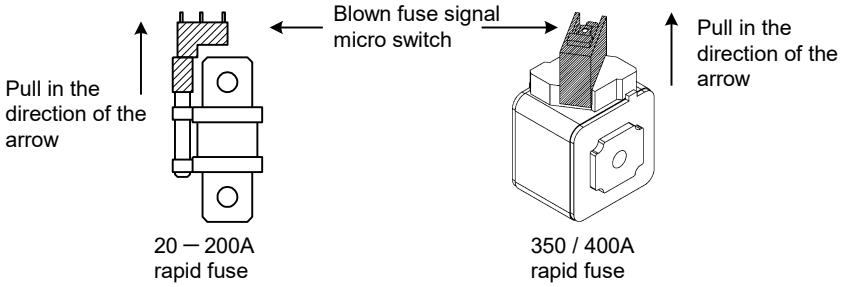
After opening the main cover, remove the front cover.



Remove the blown fuse signal micro switch before replacing the rapid fuse.

Pulling the micro switch out by the lead can break or damage the lead. Be sure to remove by gripping the micro switch body.

After the replacment, make sure to mount a micro switch on the rapid fuse.



13-1-2. Rapid fuse fastening torque

Be sure to tighten to the prescribed torque when mounting the rapid fuse.

	Rated current				
	20A/30A	50A/75A	100A	150A/200A	300A/450A
Screws	M6	M6	M8	M10	M10
Fastening torque (N•m)	4.7 – 5.2	4.7 – 5.2	12.0 – 13.0	24.0 – 25.5	24.0 – 25.5

13-2. Heater break alarm function

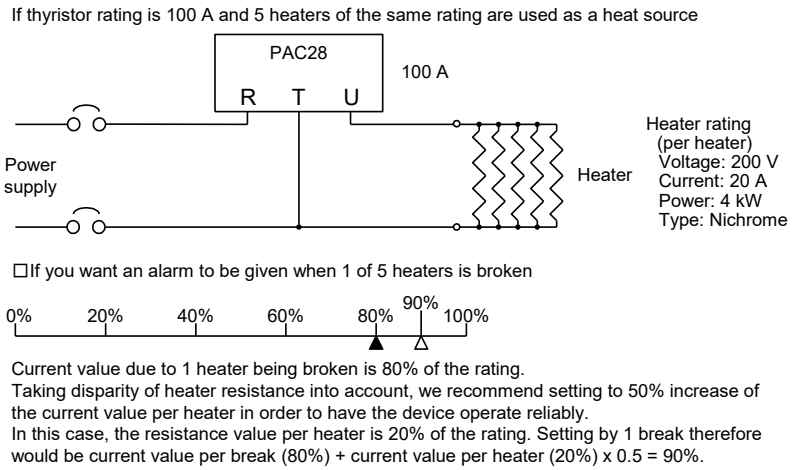
The heater break alarm is a function whereby an alarm is given to let you know when the heater is broken.

13-2-1 Operation overview

The resistance value of the heater is input with the state where temperature of the heater which is connected to the PAC 28-mounted equipment rises and load current is stable. The input value is the standard for heater break detection. Then, the resistance reduction rate is input. If the value is exceeded for 3 seconds or more, the heater is determined to be broken and the heater break alarm occurs.
When the alarm occurs, H is displayed on status display and control operation is executed as is. The alarm history is not recorded.
During the alarm output, alarm output is canceled as soon as the heater current recovers.
During the alarm output, alarm output is canceled as soon as the control input reaches the condition of 0% output.
If self-hold is required, an external self-hold circuit must be constructed.

13-2-2. Setting method

1) Preparations before setting / calculation of heater resistance
   Switch to 'key sequence 3-1. Key manual output target value setting' by the operation of 'key sequence 3-0. Manual output initial screen.'
   Normal heater voltage or current is set by 'key sequence 3-1. Key manual output target value setting.'
   Switch to r 10.0 (displays current resistance values) of 'key sequence 3-2. Basic resistance value setting.'
   The heater is powered with at least 70% device output and the heater temperature is sufficiently stabilized.
   (If the value is not the specified heater registance value, back to the 'key sequence 3-1. Key manual output target value setting' again and change heater voltage or current.)
2) Heater resistance check
   Press ENT when heater temperature stabilizes. Heater resistance value is confirmed and the value is taken as the reference value.
   *Heater resistance is calculated from the correlation of load voltage and load current values.
3) Heater break point setting: HB alarm trigger point setting
   Set current for heater break in the range of 0 – 100% by 'key sequence 1-16. Heater break alarm current.'
   Example 1: Detecting break for 1 of 5 heaters
   Current percentage for 1 break is 4/5 x 100 = 80%; set to about 90% between that and 100% current when operating normally.



Example 2: If using 1 heater
Set to about 50% between 0% current when broken and 100% when operating normally.

13-2-3. Precautions when setting

1) Set when output current of the device is as large as possible (at least 70% of the rated current).
   When output current is small (50% of rated current or lower), impact of detection error is considerable, and may result in malfunction in some cases.

2) Set heater break alarm point somewhat low.
   The function is designed so the waveforms of voltage and current are similar. Depending on the type of load, if voltage and current waveforms differ or are not proportionate, detection accuracy deteriorates and may result in malfunction in some cases.

   Even in the case of constant resistance heaters, resistance value may vary according to heater temperature in some cases. In some cases, it may be difficult to differentiate between that resistance value variation and resistance value variation due to 1 of several heaters being broken.
   If there are many heaters (5 or more), and if you set lower than the calculation value (value between 1 break and when normal), you may not be able to detect break of 1 of several heaters, but this is effective for preventing malfunction of HB alarms. (Detection accuracy deteriorates when heater current is below 30% of the rating.)

3) A load with variable resistance (large temperature coefficient) can be controlled as an applicable heater, but the heater break may not be detected correctly due to the large changes in resistance value against heat generation. When connecting a variable resistance load, the current value during operation may be higher or lower than the steady heater current value measured in advance in the key sequence "3-3. Setting the heater break judgment criteria". In such a case, it will be required to set a heater break alarm in consideration of the current change during operation to avoid false alarm.
   Example: Using 2 heaters. If heater resistance is large when starting and current when starting is 70% of the heater current for ordinary operation, set lower than 70% of the current when it drops.
   Because current when starting is 70% and 50% when 1 heater is broken, if you set to 60% between the two, you can detect 1 of 2 heaters.

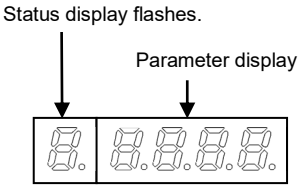
4) In the case of light loads (10% or less of the rated heater current), heater break cannot be detected.
   With transformer load, the waveform may differ for voltage and current, or voltage and current may not be proportional, resulting in lower detection precision.
   If using with light load to prevent malfunction (30% of rating or less) or transformer load, base the heater break alarm point setting on 50%.

14. Standby, manual operation, digital control input (DI) functions

The device includes operating state and standby state (STBY).
Operating state also includes automatic operation and manual operation.
Automatic operation: Output is controlled according to control input.
Manual operation: Output is controlled by key operation or external adjuster.

14-1. Standby

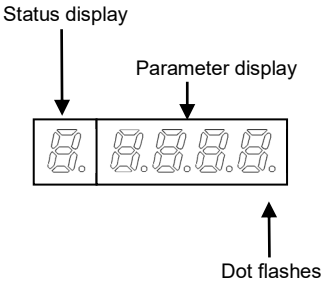
Standby state forces output to zero 0% regardless of control input.
You can control device operation by external signal using the DI function (DI-2).
Stby lights on the parameter display of the 0-0. Basic screen and the status display (red part on the far left screen) flashes.
Dot part of the status display flashes with other screens.



If any of the following conditions is satisfied, the device switches to STBY.
1) If device alarm function is triggered
Blown fuse alarm
Power failure
Overcurrent
Hardware (H/W) error
Overheat
2) With PoS setting, DI-2 of DI function turns DI input ON; with CnU setting, DI input is turned OFF.
(See 14-3. Digital control input (DI) function)
3) When switched to 'key sequence 2. Initial setting screen group'
Alarms when in stanby mode are only power supply error P, input error I , and controll error E.

14-2. Manual operation

With manual operation, operation amount is controlled manually.
Manual operation includes key operation and operation by external adjuster VR3 (DI-1 input).
(See 14-3. Digital control input (DI) function)
During manual operation, the first digit of parameter display for the monitor screen group flashes.



1) Manual operation by key:
Manual operation by key is enabled by the 'key sequence 3-1. Key manual output target value setting.'

Operation procedure:
Press and hold [ENT] on the basic screen for at least 2 seconds.

0 50.0 0-0. Basic screen

[↺] 2 seconds ↑ ↓ [ENT] 2 seconds

3 50.0 3-1. Key manual output target value setting

Output is increased by [▲] key, and decreased by [▼] key.

2) Manual operation by DI-1 input
With 'key sequence 1-17. VR3 manual operation setting,' DI input: ON by DI-1 setting: PoS or DI input: OFF by DI-1 setting: CnU enables manual operation by external adjuster VR3.
Switching from automatic operation to key manual operation switches to manual operation starting from the output value right before the switching. (Output value is carried over.)
When operation is switched from manual to automatic, the device operates automatically by the values input immediately after operation. (Output value not carried over.)
If external adjuster VR3 changes suddenly, output changes according to the set value of 'key sequence 1-13. Slow-up time' or 'key sequence 1-14. Slow-down time.'

14-3. Digital control input (DI) function

You can switch device operation conditions by switching external input signal ON/OFF.
Each DI has the following settings (valid conditions).
non・・・・: DI function invalid
PoS・・・・: Valid when DI input signal is ON
CnU・・・・: Valid when DI input signal is OFF

DI-1 switches VR3 manual operation and ordinary operation.

DI-1 function ('key sequence 1-17. VR3 manual setting')

dI_1 setting	DI-1 input	Operation state
non	Input invalid	Automatic operation
PoS	ON	VR3 manual operation
	OFF	Automatic operation
CnU	ON	
	OFF	VR3 manual operation

*Key manual has priority for key manual operation.

DI-2 switches operating state (EXE) and standby (STBY).

DI-2 function ('key sequence 1-18. STBY setting')

dI_2 setting	DI-2 input	Operation state
non	Input invalid	Operating state
PoS	ON	Standby (output standby)
	OFF	Operating state
CnU	ON	
	OFF	Standby (output standby)

DI-3 switches output limit at start-up function ON/OFF. For operation details, see "12-6. Output limit at start-up."

DI-3 function ('key sequence 1-19. Output limit when booting setting')

dI_3 setting	DI-3 input	Operation state
non	Input invalid	Output limit when booting is invalid.
PoS	ON	Slow-up after limiter time elapses
	OFF	Output limit

15. Digital control output (DO) / analog output / communication

15-1. Digital control output (DO) (optional)

DO is output to let you know when the equipment has switched to standby during operation or a heater break alarm has occurred.

Output configuration is transistor open collector output. Allocated to operation, standby or heater break alarm, the concerned DO is switched ON when in that state.

DO type and terminal arrangement

Output section	Output type	Signal name	Terminal No.
DO-1	Transistor open collector output	DO-1	22
		DO-COM	21
DO-2		DO-2	23
		DO-COM	21

15-2. Analog output (optional)

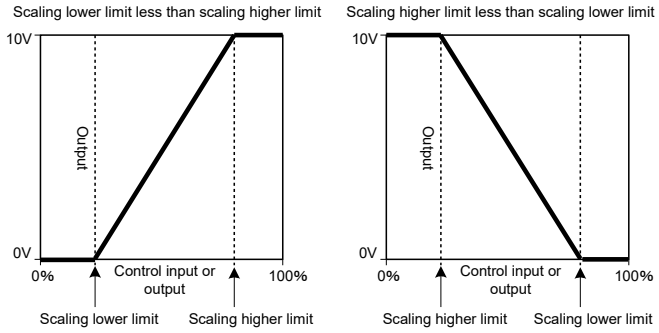
Analog output signals are used to monitor control input or output value or control other equipment.

Because it is insulated from the device input section, system power supply section and output section, it is not affected by noise.

The range of the scaling function is as follows. Inverse scaling is possible.

'key sequence 1-24. Analog output scaling lower limit' 0.0 – 100.0%

'key sequence 1-25. Analog output scaling higher limit' 0.0 – 100.0%



15-2-1. Control input transmission

Select control input transmission inPt by 'key sequence 1-23. Analog output.'

Outputs analog output 0 – 10 V according to control input 0.0 – 100.0%.

15-2-2. Control output transmission

Select control output transmission outP by 'key sequence 1-23. Analog output.'

Outputs analog output 0 – 10 V according to control output 0.0 – 100.0%.

With control output, results of limit function of 'key sequence 1-10 Ramp lower limit setting,' 'key sequence 1-11. Ramp higher limit setting,' and 'key sequence 1-15. Current limiter setting' are reflected.

15-3. Communication (optional)

Hardware conforms to RS-485.

Communication protocol is selected from among Shimaden protocol, MODBUS (ASC), and MODBUS (RTU).

Set communication conditions by 'key sequence 1-26. Communication protocol,' 'key sequence 1-27. Communication address,' 'key sequence 1-28. Communication speed,' 'key sequence 1-29. Communication parity,' 'key sequence 1-30. Stop bit' and 'key sequence 1-31. Communication delay.'

For details, see the instruction manual for the communication interface.

16. Characteristics

16-1. Rated current and heat value

Voltage (0.9 – 1.3 V) is produced between terminals by current flowing to the thyristor. Voltage between terminals and accumulation of current (W) turn into Joule heat, resulting in rise in temperature of the thyristor device. Take radiation and ventilation into account.

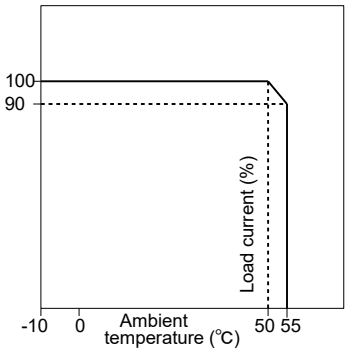
Internal heat value

Rated current	20A	30A	50A	75A	100A	150A	200A	300A	450A
Rapid fuse without heat value	32W	44W	63W	89W	109W	176W	246W	336W	476W
Rapid fuse with heat value	34W	48W	69W	102W	123W	194W	278W	354W	515W

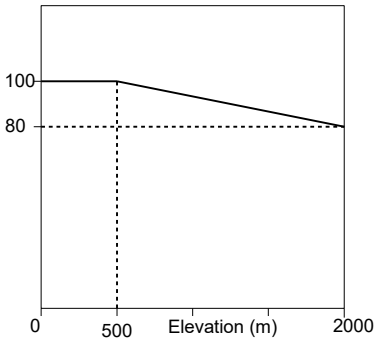
16-2. Ambient temperature, elevation and load current

Rated current of the device assumes an environment where ambient temperature does not rise above 55°C. If ambient temperature exceeds 50°C, reduce load current as shown in the figure.

Ambient temperature - load current characteristics

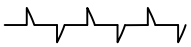
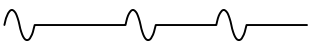
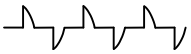
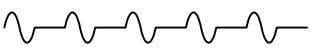
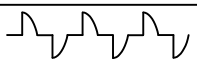
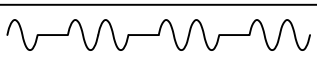


Elevation - load current characteristics



16-3. Control type and output waveform

The device includes phase control and cycle calculation zero voltage switching control types. Be sure to specify which type you want when ordering.
The customer cannot change control type.
A comparison of features is provided below.

Control type / Output	Phase control	Cycle calculation zero voltage switching control
0%		
30%		
50%		
70%		
100%		
Noise generation	Large	Small
Output	Continuous	Intermittent
Output stability	Output fluctuation within 2% (constant voltage control) relative to power supply ±10% fluctuation	Output with power supply fluctuation as is

16-4. Special heater and feedback control

With phase control, you can get more stable output control by selecting feedback control according to the purpose for which the equipment is to be used.

Heater types	Feedback control with additional function
Kanthal Super	Constant voltage control + current limit, constant power control + current limit, constant current control
Pure metal (platinum, molybdenum, tungsten, etc.).	Constant voltage control + current limit, constant power control + current limit, constant current control
Carbon	Constant voltage control (+ current limit), constant power control
Silicon carbide (SiC)	Constant voltage control (+ current limit), constant power control, constant current control

Rated current is exceeded when maximum output is applied when heater resistance is minimal in some cases. If so, current limit function is required.

16-5. Various control types

Various control functions are available for the device (constant voltage, constant current, constant power, square voltage, etc.).
Specify the desired control method when placing your order.
Feedback control is a function that detects load current and voltage in the device and controls output according to operation amount from control signal of controller, etc.
Because output fluctuation is small even if power supply voltage fluctuation or load fluctuation occurs, feedback control is the optimal function for precision control and load characteristic compensation.

Control type

Display	Control type	Feedback function
U-Fb	Phase control / constant voltage output	Voltage feedback
C-Fb	Phase control / constant current output	Current feedback
W-Fb	Phase control / constant power output	Power feedback
UUFb	Phase control / square voltage output	Voltage square feedback
PA	Phase control / phase angle proportional output	×
ZC	Cycle calculation zero voltage switching control	×

16-5-1. Phase control / constant voltage output U-Fb

You can obtain output voltage according to control input signal.
The current limit function is necessary for large inrush current loads.

16-5-2. Phase control / constant current output C-Fb

You can obtain output current according to control input signal.
The function maintains a constant output current even if load fluctuation occurs and output voltage varies.
Used for heaters with large inrush current and significant current variation. Effective for stabilizing load current as well.
When used with current limit function, output current is controlled not to exceed the limited current value.
If rated current and heat capacity do not match, adjust by 'key sequence 1-12. Ramp higher limit setting' to output rated current at control input signal 100%.

16-5-3. Phase control / constant power output W-Fb

You can obtain output power, i.e., heater heat value, according to control input signal.
Because a variable resistance load must be used as a premise, the 100% power value is calculated as half of rated voltage multiplied by rated current.
When it is applied with heaters, it enables precise temperature control.
Also, because rated power is postulated upon heater load, the correct power is not obtained for any load other than heater (motor, etc.).
If using a SiC heater, heater deterioration can be compensated for without heater transformer tap replacement.
(This may be impossible due to the correlation of supply voltage and heater voltage.)

Example: Supply voltage 200 V AC, SiC heater rated 140 V, 20 A (2.8 kW)

First calculate max. output current. Because 100% power value is calculated as half the thyristor's rated voltage multiplied by rated current, max. output current selected as follows is 30 A.

140(V) * 20(A) = 2.8(kW)
2.8(kW) / 200(V) * 2 = 28(A)

Because 100% power value in this case is 200 (V) * 30 (A) * 1/2 = 3.0 (kW), the device is set to 2.8 (kW) / 3.0 (kW) = 93% by 'key sequence 1-11. Ramp higher limit selection' and 'key sequence 1-12. Ramp higher limit setting' to adjust to heater power and output is narrowed down by VR or key (adjust while checking actual power).

By doing so, 140 V 20 A (2.8 kW) is obtained with heater initial settings when control input signal is 100%; if the heater deteriorates and resistance increases, you can raise load voltage up to 200 V 14 A (2.8 kW). During this time, work such as transformer tap replacement is completely unnecessary, so output power according to control input can constantly be obtained.

16-5-4. Phase control / square voltage output UUFb

This can handle control input signal and output voltage multiplied by themselves.
Because power relative to constant resistance is proportional to voltage squared, you can obtain power according to control signal using constant resistance heaters such as nichrome or iron-chrome.
With actual heaters, because resistance varies from several percent to ten-odd percent, controllability deteriorates compared to constant power control, but you can obtain power approximately proportional to control input signal that cannot be obtained with ordinary constant voltage control.
Unlike constant power control, you don't need to calculate device capacity and heater capacity, and set an external adjuster.

16-5-5. Phase control / phase angle proportional output PA

You can obtain phase angle output proportional to control input.
This function enables finer output control than cycle output control.

16-5-6. Cycle calculation zero voltage switching control ZC

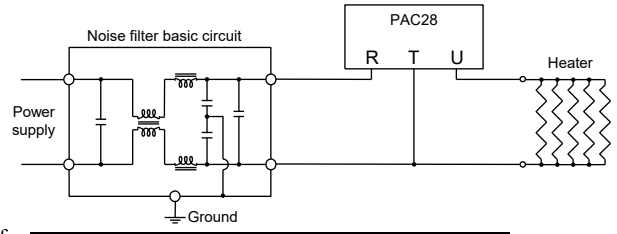
You can obtain output in synch with power supply cycle which is proportional to control input.
Not as much noise is produced as with phase angle control.

17. Noise countermeasures

With phase control, part of the power supply sine wave is dropped. This produces distortion in the sine wave if power supply impedance is high. Also, because power supply is switched each half cycle, switching noise is produced. The power supply distortion and noise may affect other equipment.
In the case of cycle calculation zero voltage switching, an extremely small amount of noise is produced compared with phase control due to switching near the zero cross point of the power supply. Because some noise is produced by switching large current, however, you should use a noise filter if necessary.
Also, if power supply impedance is high, the power supply may flicker in synch with ON/OFF of the thyristor.

17-1. Noise filter

The frequency of noise produced by the thyristor is distributed in a place below several megahertz, and the noise dampening effect of common commercially available noise filters is insufficient.
Using noise filters specified by Shimaden can dampen this noise. This noise filter is specially designed for Shimaden thyristor power regulators.

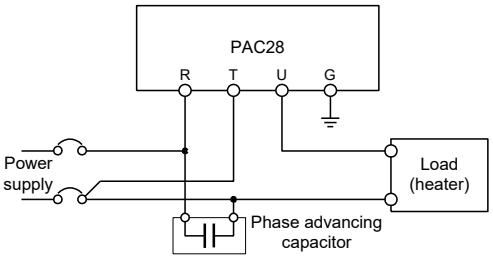


By using the noise filter, the equipment conforms to EMC standards.
The filter however can only be used for products with main power supply voltage of 100 – 240 V, 100 A and below.
For details, contact your nearest Shimaden agent.

Type	Rated current
NF2020C-SDG	20A
NF2030C-SDG	30A
NF2050C-SDG	50A
NF2080C-SDG	75A
NF2100C-SDG	100A

17-2. Improvement of power supply waveform distortion by phase advancing capacitor

It is effective to connect a phase advancing capacitor between main power supply R and T terminals to ameliorate power supply distortion (high harmonic wave) due to thyristor phase control by enhancing power factor.
Capacitor capacity of 1μF per ampere of rated current should be sufficient.
This is a very simple method, but you should take the following precautions.
1) High harmonic wave current flows into the capacitor, so pay attention to the rated current of the capacitor and watch out for temperature rise.
2) The capacitor may cause resonation with imductance of the power supply line resulting in high harmonic wave voltage; check the power supply waveform.



18. Precautions for transformer load

Transformer usage objective
1) To match voltage when heater voltage differs from supply voltage.
2) When it is necessary to insulate the heater circuit from the power supply.
3) To raise ground voltage resistance using a isolation transformer when ground insulation deteriorates like vacuum equipment.

18-1. Control method

A transformer load can be used for phase control.
A transformer load cannot be used for cycle calculation zero voltage switching control.

⚠ CAUTION

Applicable single phase transformers is as follows:
Applicable transformer: isolation transformer (double wound transformer)
Inapplicable single phase transformer: Single wound transformer (slide transformer, etc.)

Do not connect any equipment between the device and transformer.
Cut off the power supply before replacing the tap of the transformer.

18-2. Transformer magnetic flux density

Excessive current flows when the magnetic circuit becomes saturated when using the transformer (load is limited to transformer winding resistance) and could destroy the thyristor.

With cycle calculation zero voltage switching control system, the thyristor is switched (ON/OFF) each half cycle. If the load becomes heavy, the output waveform tends to become unbalanced and saturated.

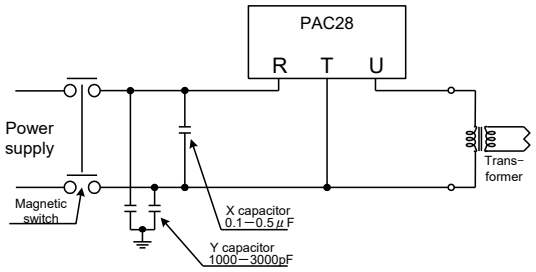
You should therefore design the system so that magnetic flux density is lower than that of a conventional transformer.

Example: When driving the primary winding of a transformer, you are recommended that the load factor should be less than 70% of rated capacity.
You are also recommended that you should keep magenetic flux density as low as possible for safe operation.

18-3. If using magnetic switch (contactor)

If using a magnetic switch (contactor) for a circuit connected to the transformer (inductive load), malfunction could result from contact bounce.

If so, you should either use the prescribed noise filter, or connect an X capacitor between the R and T main power terminals (0.1 – 0.5μF), or a Y capacitor between the R and T power terminals and the ground (1000 – 3300 pF) to absorb the noise.



18-4. Rapid fuse usage

We recommend a rapid fuse to protect the thyristor device from excessive current produced when using a transformer due to high frequency wave noise or load trouble, etc.

18-5. Prohibition of operating without load

Before conducting an operation whereby a load cannot be connected, such as test operation, disconnect the transformer wiring and connect a dummy load such as an electric heater or light bulb. Do not operate the device with the secondary side of transformer open. In order to prevent the operation without load, it is recommended that a dummy resistor be connected to primal transformer so that the current flow becomes 0.5 A or so. Do not switch loads while the device is powered. Doing so could result in excessive current and could trip the protection circuit of the device.

Example: If using a single heater and it becomes broken, then the device would be operating without a load.

19. Key sequence

Note
・The windows of the various screens are divided as follows.

Screen always displayed by key operation, etc.

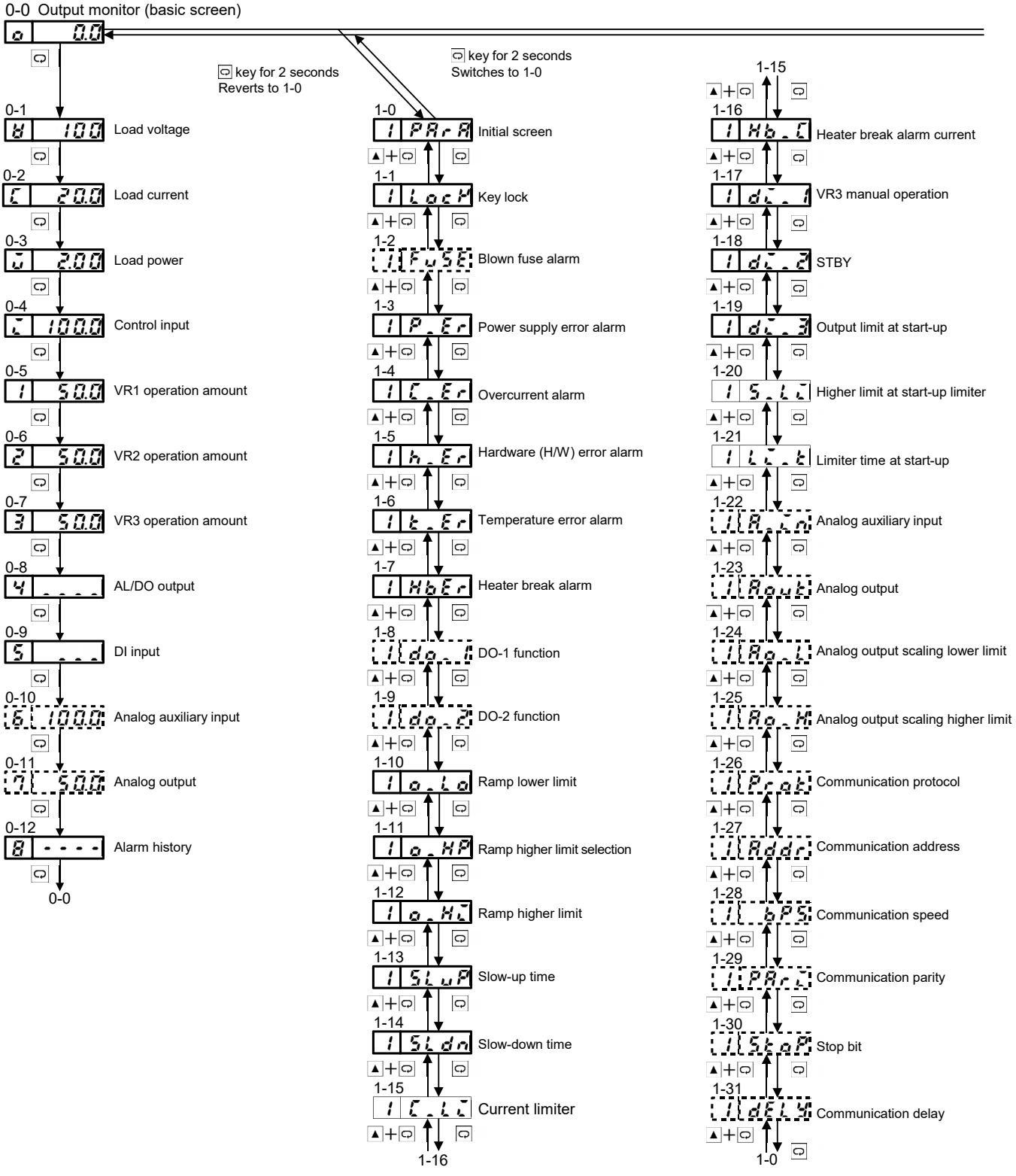
Screen skipped or displayed according to setting state of control operation or input/output type.

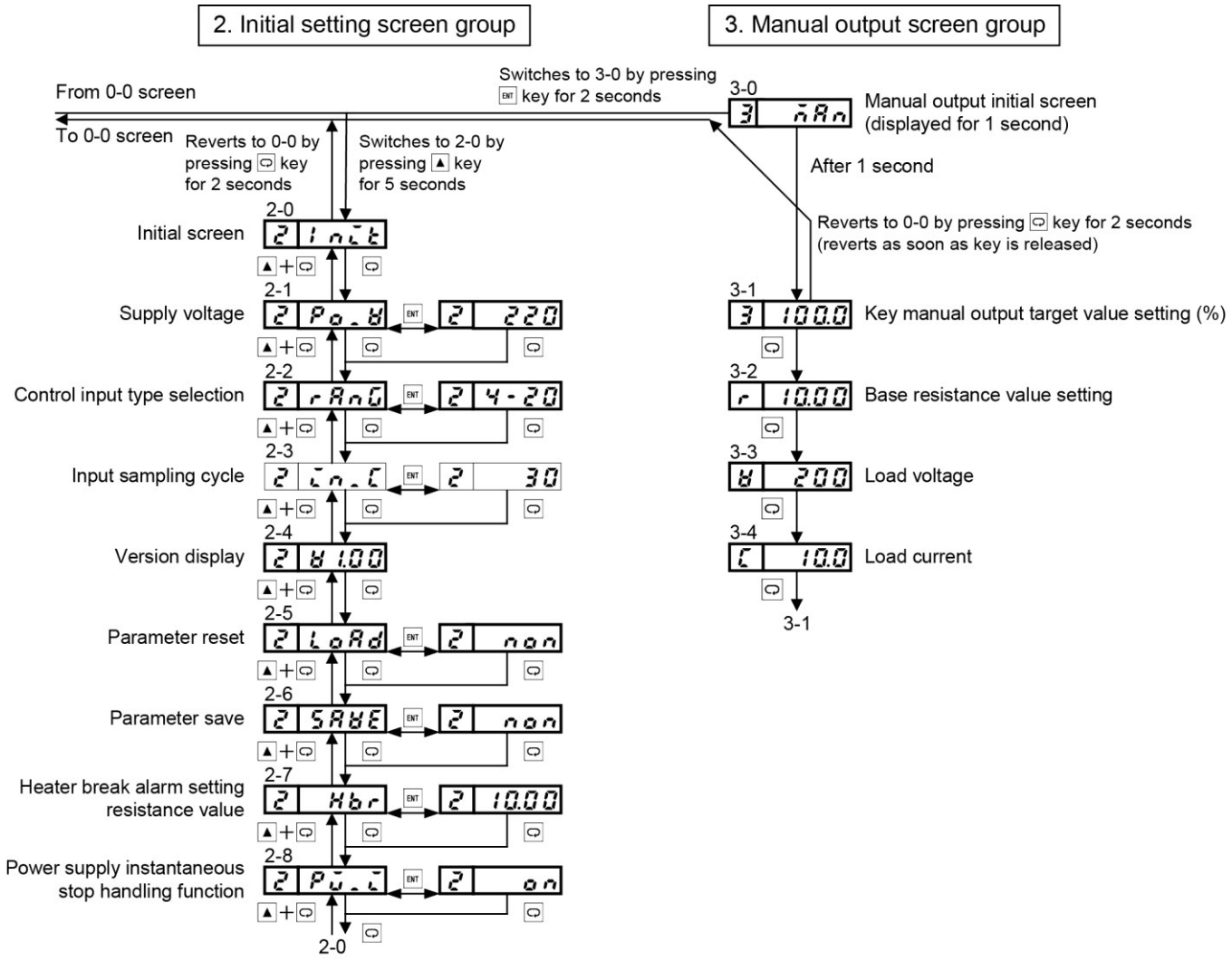
Screen displayed if applicable options are added or selected.

・Returns to 0-0 screen if there is no key action for 3 minutes while ‘1. User parameter screen group’ is displayed.

0. Monitor screen group

1. User parameter screen group




2. Initial setting screen group
3. Manual output screen group
From 0-0 screen
To 0-0 screen
Switches to 3-0 by pressing ENT key for 2 seconds
Reverts to 0-0 by pressing key for 2 seconds
Switches to 2-0 by pressing ▲ key for 5 seconds
2-0
Initial screen
2-1
Supply voltage
2-2
Control input type selection
2-3
Input sampling cycle
2-4
Version display
2-5
Parameter reset
2-6
Parameter save
2-7
Heater break alarm setting resistance value
2-8
Power supply instantaneous stop handling function
3-0
Manual output initial screen (displayed for 1 second)
After 1 second
Reverts to 0-0 by pressing key for 2 seconds (reverts as soon as key is released)
3-1
Key manual output target value setting (%)
3-2
Base resistance value setting
3-3
Load voltage
3-4
Load current

0. Monitor screen group

Screen group that displays data such as load voltage, current and input values.

0-0. Output monitor (basic screen)

Basic screen for device. Displays current output. Display unit differs according to control method. Switches from this screen to various parameter group for checking/setting various parameters.

Display unit differs according to control type.

Phase control

① Constant voltage output: Displays load voltage value. (Unit: V)
② Constant current output: Displays load current value. (Unit: A)
③ Constant power output: Displays load power value. (Unit: kVA)
④ Square voltage output:
Displays square value of load voltage as percentage. (Unit: %)
⑤ Phase angle proportional control:
Displays control phase angle as percentage. (Unit: %)

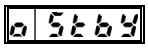
Cycle calculation zero voltage switching

⑥ Cycle calculation zero voltage switching control
Displays output operation amount as percentage. (Unit: %)

Displays  according to the following conditions:

① Constant voltage control
When load voltage is less than 10 V with 240 V specifications
② Constant current control
When load current is less than 5%
③ Constant power control
1) When load voltage is less than 10 V with 240 V specifications
2) When load current is less than 5%

The display is as follows when on standby:



[↵] Switches to subsequent screen → 'key sequence 0-1'

[↵] Pressing 2 seconds switches to user parameter group → 'key sequence 1-0.'

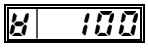
[▲] Pressing 2 seconds switches to initial setting screen group → 'key sequence 2-0.'

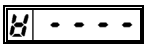
[ENT] Pressing 2 seconds switches to manual output screen group → 'key sequence 3-0.'

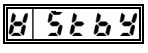
Note: In some cases, alarm content is displayed on status display (red LED 1 digit). For details, see '11. Alarm function.'

0-1. Load voltage

Displays load voltage value.

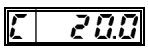
 (Unit: V)

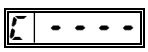
 Displayed when voltage value is less than 10 V (240 V specs.).

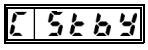
 Displayed when on standby.

0-2. Load current

Displays load current value.

 Unit: A

 Displayed when current value is less than 5% of the rating.

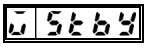
 Displayed when on standby.

0-3. Load power

Displays load power value.

 Unit: kVA

 Displayed when voltage value is less than 10 V (240 V specs.),
or when current value is less than 5% of the rating.

 Displayed when on standby.

0-4. Control input

Displays control input value. Controls according to source frequency, so it can't handle faster variation.

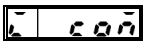
 Range: 4 – 20 mA, 1 – 5 V: -10.0 – 110.0%
0 – 20 mA: -0.3 – 110.0%
0 – 1 V, 0 – 10 V: 0.0 – 110.0%
Potentiometer, contact, voltage pulse:
0.0 – 100.0%

Displays calculation results when using analog auxiliary input.

Displays  if higher limit value is exceeded.

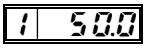
Displays  or  if less than lower limit value.

Differs according to type of control input.

 Displayed when control input is changed by communication.

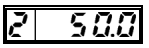
0-5. VR1 operation amount

Output amount can be changed manually by connecting external adjuster. Operation amount of the external adjuster is displayed in the range of 0 – 100%. VR1 can be allocated to either minimum output adjustment 'key sequence 1-10. Ramp lower limit setting,' maximum output adjustment 'key sequence 1-12. Ramp higher limit setting,' or current limit 'key sequence 1-15. Current limiter setting.'
VR1 is not supposed to be used when shipped from the factory.
Same function cannot be allocated to VR1/VR2/VR3.

 Setting range: 0.0 – 100.0 (%)

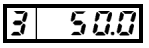
0-6. VR2 operation amount

Output amount can be changed manually by connecting external adjuster. Operation amount of the external adjuster is displayed in the range of 0 – 100%. VR2 can be allocated to either minimum output adjustment 'key sequence 1-10. Ramp lower limit setting,' maximum output adjustment 'key sequence 1-12. Ramp higher limit setting,' or current limit 'key sequence 1-15. Current limiter setting.'
VR2 is not supposed to be used when shipped from the factory.
Same function cannot be allocated to VR1/VR2/VR3.

 Setting range: 0.0 – 100.0 (%)

0-7. VR3 operation amount

Output amount can be changed manually by connecting external adjuster. Operation amount of the external adjuster is displayed in the range of 0 – 100%. VR3 can be allocated to current limiter 'key sequence 1-15. Current limiter setting' or manual operation 'key sequence 1-17. VR3 manual operation setting.'
VR3 is not supposed to be used when shipped from the factory.
Same function cannot be allocated to VR1/VR2/VR3.

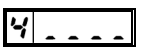
 Setting range: 0.0 – 100.0 (%)

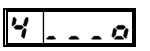
0-8. AL/DO output

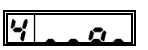
 is displayed when alarm/digital output is ON.

 is displayed when alarm/digital output is OFF.

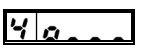
Output location set by 'key sequence 1-2 – 1-7 screens' when an error alarm occurs.
The corresponding digit doesn't light if not equipped with the option.



Display for the first digit: AL1 is on 

Display for the second digit: AL2 is on 

Display for the third digit: DO-1 is on 

Display for the fourth digit: DO-2 is on 

(The first digit is the digit on the far right.)

0-9. DI input

Displays state of DI input signal.

displayed when DI input signal ON

displayed when DI input signal OFF

DI-1, DI-2 and DI-3 settings are made by 'key sequence screens 1-17 – 1-19.'

Display for the first digit: DI-1 ON

Display for the second digit: DI-2 ON

Display for the third digit: DI-3 ON

(The first digit is the digit on the far right.)

0-10. Analog auxiliary input (optional)

This screen is displayed if you have selected analog auxiliary input specifications (optional). Displays input values for analog auxiliary input.

Range: 4 – 20 mA, 1 – 5 V: -10.0 – 110.0%

0 – 10 V: 0.0 – 110.0%

Displays if 110.0% is exceeded.

or is displayed if less than -10.0%.

Differs according to type of analog auxiliary input.

0-11. Analog output (optional)

This screen is displayed if you have selected analog output specifications (optional). Displays output values of analog output.

Range: 0.0 – 100.0 (%)

0-12. Alarm history

Displays alarm history. Even if the same alarm occurs repeatedly, it is recorded as one type of alarm.

Heater break, input error and control errors are not recorded in the history. Blown fuse, power failure, overcurrent, hardware (H/W) errors and overheating are recorded in the history.

The alarm history is maintained even if the control power is turned off.

is displayed when operating properly.

The alarm code of alarm history is displayed on this screen.

If multiple alarms occur simultaneously, they are displayed in sequence.

The alarms are displayed by ▲ ▼ in the following sequence:

F → P → C → h → t

Error code types

- F: Blown fuse
- P: Power failure
- C: Overcurrent
- h: Hardware (H/W) error
- t: Overheat

For details, see "11. Alarm function."

Alarm history clearance

To clear alarm history, press and hold ENT for at least 2 seconds on this screen.

The alarm is reset immediately, but if normal status is not recovered, the alarm will occur again.

Display for alarm

Alarm type is displayed in status display of 'key sequence 0-0.' screen.

The dot of the status display flashes on all screens other than 'key sequence 0-0.'

NOTE

Alarm code display is loaded the first time the alarm occurs only. If the alarm occurs more than once, the other times are not recorded in the history.

1. User parameter screen group

The user can modify the control operation parameters.

You can obtain safer, more reliable control characteristics by various type of alarm output settings and settings such as overcurrent limit.

The user parameter screen group is accessed by press and holding ↺ for at least 2 seconds from 'key sequence 0-0. Output monitor (basic screen).'

Concerning operation of each parameter screen, pressing ENT displays the parameters of that screen, ▼ ▲ selects the parameters, and pressing ENT enters the data.

The dot of the first digit flashes when parameters can be modified.

Pressing ENT enters the data and the dot of the first digit stops flashing.

1-0. Initial screen

Displays the initial screen of the user parameter screen group.

Switch to this screen when returning to the basic screen from the user parameter screen group.

1-1. Key lock

Limits operation of parameters screens.

Initial values: oFF

: All parameters can be modified.

: Parameters other than key lock cannot be modified.

1-2. Blown fuse alarm (optional)

This screen is displayed when rapid fuse (optional) is selected.

Allocates alarm output when the rapid fuse blows.

Can be allocated together with other alarm.

Initial value: AL 1

: Allocated to alarm output 1

: Allocated to alarm output 2

: Alarm not output

1-3. Power failure alarm

Allocates alarm output when power failure or load voltage error occurs.

Can be allocated together with other alarm.

Initial value: AL 1

: Allocated to alarm output 1

: Allocated to alarm output 2

: Alarm not output

1-4. Overcurrent alarm

Allocates alarm output when overcurrent protection circuit is triggered.

Can be allocated together with other alarm.

Initial value: AL 1

: Allocated to alarm output 1

: Allocated to alarm output 2

: Alarm not output

1-5. Hardware (H/W) error alarm

Allocates alarm output when thyristor failure or circuit error occurs.
Can be allocated together with other alarm.

1 h_Er Initial value: AL 1

1 AL 1: Allocated to alarm output 1

1 AL2: Allocated to alarm output 2

1 non: Alarm not output

1-6. Overheat alarm

Allocates alarm output when overheat occurs.
Can be allocated together with other alarm.

1 t_Er Initial value: AL 1

1 AL 1: Allocated to alarm output 1

1 AL2: Allocated to alarm output 2

1 non: Alarm not output

1-7. Heater break alarm

Allocates alarm output when heater break occurs.
Can be allocated together with other alarm.

1 HbEr Initial value: AL 1

1 AL 1: Allocated to alarm output 1

1 AL2: Allocated to alarm output 2

1 non: Alarm not output

1-8. DO-1 function (optional)

Allocates equipment status.

1 do_1 Initial value: non

1 non: No allocation

1 Sty: Standby

1 EnE: Operating

1 Hb: Heater break alarm

1-9. DO-2 function (optional)

Allocates equipment status.

1 do_2 Initial value: non

1 non: No allocation

1 Sty: Standby

1 EnE: Operating

1 Hb: Heater break alarm

1-10. Ramp lower limit

Sets allocation of output ramp limit.

1 o_Lo Initial value: 0.0

1 0.0: Key input allocation; Range: 0.0 – 99.9%

▼ Switches from 0.0 state to VR allocation.

1 Vr 1: Allocated to VR1

1 Vr2: Allocated to VR2

Note 1

Ramp lower limit, ramp higher limit and current limiter allocation cannot be overlapped for VR1 and VR2. To change allocation, you must first clear the VR allocation. Ramp lower limit cannot be set to exceed ramp higher limit.

Note 2

In the case of simultaneous setting with 'key sequence 1-22, Analog auxiliary input (optional),' ramp lower limit becomes ramp lower limit value regardless of analog auxiliary input calculation results (control input results).

1-11. Ramp higher limit selection

Sets allocation of ramp higher limit.

1 o_HP Initial value: o_H

1 o_H: Ramp higher limit is the same as the set value of 1-13.

1 Vr 1: Ramp higher limit is the set value of 1-13. x VR1 rotating angle.

1 Vr2: Ramp higher limit is the set value of 1-13. x VR2 rotating angle.

Note

Ramp lower limit and ramp higher limit allocation cannot be overlapped for VR1 and VR2. To change allocation, you must first clear the VR allocation. Ramp higher limit cannot be set below ramp lower limit.

1-12. Ramp higher limit

Sets ramp higher limit.

1 o_HL Initial value: 100.0

1 100.0: Key input allocation; Range: 0.1 – 100.0%

Note

In the case of simultaneous setting with 'key sequence 1-22. Analog auxiliary input (optional)' or if analog auxiliary input calculation results (control input results) are smaller than ramp higher limit value, priority is given to analog auxiliary input calculation results.

Priority will be given to the smaller value, [Control input results (%) (= Control input value (%) x analog auxiliary input (%))] or [ramp higher limit setting (%)].

1-13. Slow-up time

If control input varies dramatically, current value may vary precipitously, resulting in overcurrent or drop in supply voltage. To suppress this radical change, apply variation limit (slow-up time) and raise output gradually.

1 SLuP Initial value: 1.0

1 1.0 Range: 0.0 – 99.9 seconds

The setting value is the time required for output to change from 0 to 100%.

Note

Slow-up time may not be effective depending on the setting when using control method with feedback function.

1-14. Slow-down time

If control input varies dramatically, current value may vary precipitously, resulting in overcurrent or rise in supply voltage. To suppress this radical change, apply variation limit (slow-down time) and lower output gradually.

1 SLdn Initial value: 1.0

1 1.0 Range: 0.0 – 99.9 seconds

The setting value is the time required for output to change from 100 to 0%.

Note

Slow-down time may not be effective depending on the setting when using control method with feedback function.

1-15. Current limiter setting (when function selection is available)

The current limiter limits output current value to 120% of rated current. Also, where function is to be allocated is set. Lower the display to "10" when allocating to external adjuster.

1 C_LC Initial value: 100

1 100: Key input allocation

Range: 10 – 120% of rated current
Function OFF by ▼ from 10.
VR allocation by ▼ from function OFF.

1 Vr 1: Allocated to VR1

Range: 10 – 100% of rated current

1 Vr2: Allocated to VR2

Range: 10 – 100% of rated current

1 Vr3: Allocated to VR3

Range: 10 – 100% of rated current

Note

There is danger of the following duplication when conducting VR allocation of current limiter.

At this time, the currently used allocation is given precedence. To modify allocation, first clear VR allocation.

・VR1 and VR2 are ramp lower limit and ramp higher limit.
・VR3 is manual operation.

*This function is not available when cycle calculation zero voltage switching control is selected.

1-16. Heater break alarm current

Threshold value for alarm when heater break occurs is set by percentage display.

Set current value (%) for break with current at resistance confirmed by 'key sequence 3-2. Base resistance value setting' as 100%.

1 Hb_C Initial value: 0

1 0 Range: 0 – 100%

1-17. VR3 manual operation setting

Sets DI-1. Switches VR3 manual operation.

This function is temporarily unavailable while operating 'key sequence 3. Manual output screen group.'

1 dI_1 Initial value: non

1 non: No allocation (automatic operation)

1 PoS: Effective only when DI input signal ON

1 InV: Effective only when DI input signal OFF

1-18. STBY setting

Sets DI-2. Standby switch.

1 dI_2 Initial value: non

1 non: No allocation (automatic operation)

1 PoS: Effective only when DI input signal ON

1 InV: Effective only when DI input signal OFF

1-19. Output limit at start-up

Sets DI-3. Switches output limit when booting.

Set various values for 'key sequence 1-20. Higher limit at start-up limiter' and 'key sequence 1-21. Limiter time at start-up.'

1 dI_3 Initial value: non

1 non: No allocation

1 PoS: Effective only when DI input signal ON

1-20. Higher limit at start-up limiter (when function selection is available)

Displayed set to PoS by 'key sequence 1-19. Output limit at start-up setting.' Sets output limit (higher limit value) at start-up.

See "12-6. Output limit at start-up."

1 S_LC Initial value: 20.0

1 20.0 Range: 0.0 – 100%

1-21. Limiter time at start-up (when function selection is available)

Displayed set to PoS by 'key sequence 1-19. Output limit at start-up setting.' Sets time limit at start-up.

See "12-6. Output limit at start-up."

1 LC_t Initial value: 1.0

1 1.0 Range: 0.0 – 99.9 seconds

1-22. Analog auxiliary input (optional)

This screen is displayed if you have selected analog auxiliary input (optional).

If GAIn is allocated, control input result value is

control input result = control input value (%) x analog auxiliary input value (%) (0 – 1.0 times).

1 A_In Initial value: non

1 non: Not used

1 GAIn: Control input ramp

1-23. Analog output (optional)

This screen is displayed if you have selected analog output (optional).

Sets allocation of analog output.

1 Aout Initial value: outP

1 InPt: Control input value 0.0 – 100.0% is converted to 0 – 10 V.

1 outP: Output 0.0 – 100.0% is converted to 0 – 10 V.

Note

Even if allocation is changed, 'key sequence 1-24. Analog output scaling lower limit' and 'key sequence 1-25. Analog output scaling higher limit' are not initialized.

1-24. Analog output scaling lower limit (optional)

This screen is displayed if you have selected analog output (optional).

Sets scaling lower limit of analog output. Inverse scaling is possible.

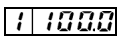
1 Ao_L Initial value: 0.0

1 0.0 Range: 0.0 – 100.0%

1-25. Analog output scaling higher limit (optional)

This screen is displayed if you have selected analog output (optional).
Sets scaling higher limit of analog output. Inverse scaling is possible.

Initial value: 100.0

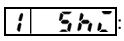


Range: 0.0 – 100.0%

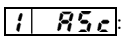
1-26. Communication protocol (optional)

This screen is displayed if you have selected communication (optional).
Sets communication protocol.

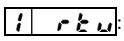
Initial value: ShC



: Shimaden protocol



: MODBUS (ASC)

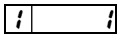


: MODBUS (RTU)

1-27. Communication address (optional)

This screen is displayed if you have selected communication (optional).
Sets communication address.

Initial value: 1

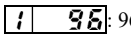


Range: 1 – 99

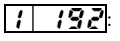
1-28. Communication speed (option)

This screen is displayed if you have selected communication (optional).
Sets communication speed.

Initial value: 96



: 9600 bps

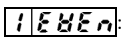


: 19200 bps

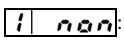
1-29. Communication parity (optional)

This screen is displayed if you have selected communication (optional).
Sets communication parity.

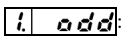
Initial value: EVEn



: Even parity



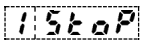
: No parity



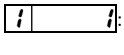
: Uneven parity

1-30. Stop bit (optional)

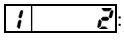
This screen is displayed if you have selected communication (optional).
Sets stop bit.



Initial value: 1



: Stop bit 1

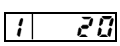


: Stop bit 2

1-31. Communication delay (optional)

This screen is displayed if you have selected communication (optional).
Sets communication delay.

Initial value: 20



: Range: 1 – 200 ms

Sets time from data reception to data transmission of the device.
Sets delay time if equipment with slow response is connected.
By doing so, you can avoid collision of data in the communication line.

Return to 'key sequence 1-0. Initial screen' by ↺.

2. Initial setting screen group

Group of screens for setting operation conditions for the device. The conditions must be set prior to operation.

The initial setting screen group is accessed by pressing and holding ▲ for at least 5 seconds from 'key sequence 0-0. Output monitor (basic screen).'
To escape from the initial setting screen, press and hold ↺ for at least 2 seconds from 'key sequence 2-0. Initial screen.' Reverts to 'key sequence 0-0. Output monitor (basic screen).'
Concerning operation of each parameter screen, pressing ENT displays the parameters of that screen, ▼ ▲ selects the parameters, and pressing ENT enters the data.
(Some screens are for display only.)
The dot of the first digit flashes when parameters can be modified.

Pressing ENT enters the data and the dot of the first digit stops flashing.

2-0. Initial screen

Initial screen for initial setting screen group
Switch to this screen when returning to the basic screen.

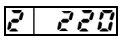
↺ Switches to subsequent screen → 'key sequence 2-1.'

↺ Pressing 2 seconds switches to monitor screen group → 'key sequence 0-0.'

2-1. Power supply voltage

Sets main power supply voltage.
This value controls operation as the rated voltage (100%).

Initial value: 220 V for 240 V specs.

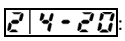


Range: Rated voltage 90 – 264 V for 240 V specs.

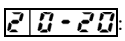
2-2. Control input type selection

Selects type of control input for the device. Displays the current range or voltage range selected in the product specifications.
① Current range selection (4 – 20 mA or 0 – 20 mA)

Initial value: 4 – 20 mA



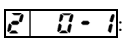
: 4 – 20 mA



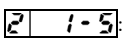
: 0 – 20 mA

② Voltage range selection (0 – 1 V, 1 – 5 V, 0 – 10 V, potentiometer, contact input, voltage pulse)

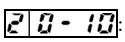
Initial value: 0 – 10 V



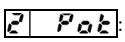
: 0 – 1 V



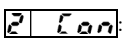
: 1 – 5 V



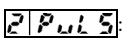
: 0 – 10 V



: Potentiometer



: Contact input



: Voltage pulse

Note
Various parameters are not changed even if control input type is changed, but input sampling cycle is reset to 30 seconds in case of contact input, and reset to 3 seconds in the case of voltage pulse.

2-3. Input sampling cycle (when function selection is available)

Displayed when control input type is selected for contact input or voltage pulse. Controller output is taken in as control input. Sets output cycle (Input sampling cycle) to get output cycle of controller, etc. If set to OFF, operates to output higher or lower limit according to input.

2 in.C Initial value: Contact input: 30, Voltage pulse: 3

2 30 Range: OFF, 1 – 120 seconds

Note

If input sampling cycle of contact input is set to 10 seconds or less, input detection accuracy diminishes and control output may not be correct.

We recommend setting input sampling cycle to at least 10 seconds.

2-4. Version display

Displays software version of the device. Cannot be modified.

2 V 1.00 The version is set to version 1.00 in this display.

2-5. Parameter initialization

Parameters are loaded by ENT. Reboot when loading parameters.

2 LoAd Initial value: non

2 non: Disabled

2 dFLt: Factory setting

2 USEr: User file

2-6. Parameter save

Parameters are saved by ENT.

2 SAvE Initial value: non

2 non: Disabled

2 USEr: User file

Note: Be sure to note that old values are lost when new ones are saved. Old values cannot be recovered once new ones are saved.

2-7. Heater break alarm setting resistance value

Displays value decided by manual output screen group 'key sequence 3-2. Base resistance value setting.' Values cannot be modified by this screen. To modify resistance, readjust by 'key sequence 3-2. Base resistance value setting.'

2 Hbr

2-8. Power supply instantaneous stop handling function

Sets whether or not conduct slow-up operation when power is restored after power is instantaneously interrupted and the device is stopped. Unlike set time of 'key sequence 1-14. Slow-up time,' slow-up time is fixed at 0.2 seconds, 10 cycles.

Slow-up operation is effective when shipped from the factory.

2 Pu.t Initial value: on

2 on: Enabled

2 oFF: Disabled

Return to 'key sequence 2-0. Initial screen' by ↺.

3. Manual output screen group

If performing manual output operation by key operation, operate by key manual target value settings. With heater break alarm, measure heater resistance value.

You cannot switch to manual output operation from standby status. With the manual output screen group, functions by DI input are temporarily not available. DI input functions begin working again when you return to an ordinary screen from the manual output screen group.

Increase/decrease output by ▼ ▲.

3-0. Manual output initial screen

Pressing and holding ENT for at least 2 seconds switches from 'key sequence 0-0. Output monitor (basic screen) to 'key sequence 3. Manual output screen group.'

When manual operation is entered, operation continues from the immediately preceding output target value.

If returning to the basic screen from manual operation, switching to output target values occurs according to control input value (including ramp lower limit setting and ramp higher limit setting).

o 100.0 0-0. Output monitor (basic screen)

↓ Press and hold ENT for at least 2 seconds.

3 mAn is displayed for approximately 1 second and then switches to 'key sequence 3-1. Key manual output target value setting.'

3-1. Key manual output target value setting

Displays the manual operation screen.

3 50.0: Sets output target value. Range: 0.0 – 100.0 (%)

Output is 50.0% for this display.

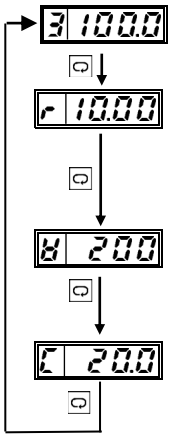
Output is variable by ▼ ▲.

Press and hold ↺ for at least 2 seconds; when the key is released, the display reverts to 'key sequence 0-0. Output monitor (basic screen).'

Note: Depending on the load, actual output may not be 100% even if set to 100%.

3-2. Base resistance value setting

Decides heater quality criteria (resistance value in normal state). Future deterioration percentage is set to determine whether heater break has occurred. Deterioration percentage is input by 'key sequence 1-16. Heater break alarm current.'



: 3-1. Key manual output target value setting

: 3-2. Base resistance value setting

Displays current heater resistance value.
Base resistance values are entered by ENT.
10.00Ω is shown in this display.

: 3-3. Load voltage

Displays current load voltage.
200 V is shown in this display.

: 3-4. Load current

Displays current load current.
20.0 A is shown in this display.

Manual output operation is possible by ▼ ▲ for any screen.

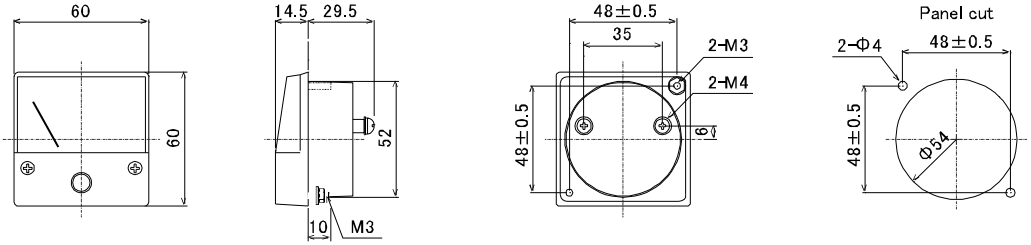
20. Accessories (optional)

20-1. Operation amount indicator

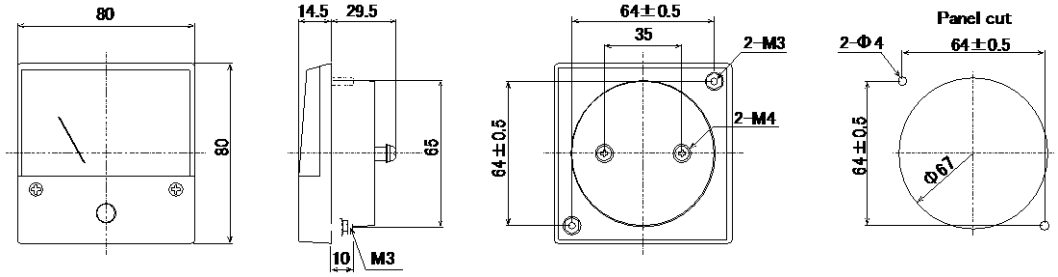
In the case of cycle calculation zero voltage switching control, because output is intermittent, a conventional gauge will be erratic if connected to the output side.
The operation amount indicator shows the analog output signal (0 – 10 V) (optional) received from the electronic circuit as a percentage.
Select a voltage meter of 0 – 10 V. Connection terminals are No. 29 (+) and No. 30 (-).

External dimensions and panel cut (unit: mm)

60 x 60 Panel cut (Type: QSM003)



80 x 80 Panel cut (Type: QSM004)

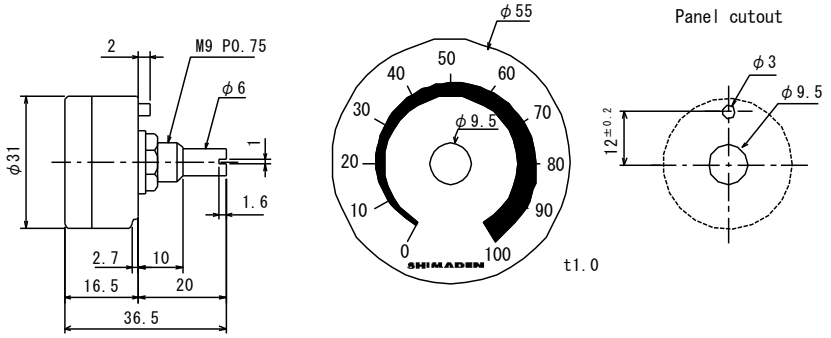


20-2. External adjuster

・Type: QSV003

・Specifications: Characteristics/resistance: B/10kΩ
Lead: Vinyl lead 1 m, M3 crimp terminal
Scale plate / knob: 1 each provided

・External dimensions and mounting dimensions



21. Spare parts

The rapid fuse can be replaced when it blows. The fuse should be replaced by a person with knowledge of electricity.
If the rapid fuse blows repeatedly, contact your nearest Shimaden agent.

Recommended rapid fuses

Model	Rated Current
QSF009	20A
	30A
QSF010	50A
	75A
QSF011	100A
QSF012	150A
QSF013	200A
QSF014	300A
	450A

22. Troubleshooting

If a problem occurs while using the equipment, check it by using the following chart and contact your nearest Shimaden agent.

	Problem	Place to inspect	Measures to take
1	No output	1) Display does not light.	Check power. If power is not supplied, check out the power supply side. If power is supplied, the device may be broken.
		2) Displays F for status display and Stby for parameter display.	The rapid fuse for protecting the thyristor has blown. Check if the load has shorted. After eliminating any abnormality, replace the rapid fuse.
		3) Displays h for status display and Stby for parameter display.	There could be something wrong with the load circuit connection. In that case, load current is zero, or open load has occurred. Check the load breakage. For other reasons, the thyristor may have shorted.
		4) Displays C for status display and Stby for parameter display.	Excessive current may have been produced for some reason. For pure metal heater or transformer load, set longer slow-up time. If the alarm is displayed again, turn the power off, set ramp higher limit to 0%, and then turn the power back on. If the alarm is no longer displayed, there might be a problem on the load side. You should therefore check the load side. If the alarm is displayed, there may be internal failure of the device.
		5) Displays t for status display and Stby for parameter display.	The thyristor may have become overheated. Turn off the power, wait for the device to cool off and then turn the power back on. If operation returns to normal but then the alarm lights again after a short time passes, the thyristor load current may be too large, or heat dissipation of the device may have become poor. If so, either lower the load current or improve heat dissipation conditions.
		6) Displays E for status display.	The main power may not be supplied. Check the power supply and wiring. If the connections and settings are correct, the device may be faulty.
		7) Is the control input signal present?	Check the level by measuring between input terminals 1 and 2 with a VOM, etc. If the control input signal is not present, check the signal supply source such as the controller. If a normal signal is present, check settings and connection with external adjusters. If the connections and settings are correct, the device may be faulty.
		8) DI operation is functioning.	When manual operation is enabled for DI-1, if the setting is “0,” output becomes “0” as well. Check the DI-1 signal and whether VR3 has been turned down.
			If standby operation is enabled for DI-2, output becomes 0% and Stby is displayed. Check the DI-2 signal and parameter setting screen.
			If output limit at start-up is “0” for DI-3, output is “0” during limiter time at start-up. Check the DI-3 signal and parameter setting screen.
		9) Output limit is functioning.	Check ramp higher limit setting and current limiter setting. Check the value of the parameter setting screen and whether the external adjuster (VR) to which the function is allocated has been turned down.
		10) Analog auxiliary input is not present or is set to "0." (Optional)	If using with analog auxiliary input selected and input is “0,” the control input result becomes “0” and output is 0%. If not using analog auxiliary input, set non.
2	Output continues as is.	1) Displays Stby for parameter display.	Find out the cause by checking alarm display and repair it.
		2) If the load circuit is open	If voltage is measured with the load circuit open, the panel meter or tester will indicate high voltage. Check the load circuit.
		3) External adjuster of ramp lower limit is connected and is effective.	The function of ramp lower limit is not to make the minimum value of output zero. Check the position of VR to which ramp lower limit is set. The position of VR can be checked on monitor screens VR1 – VR3. If set to 100.0, output will be 100.0%, so be careful.
		4) The ramp higher limit is narrowed down.	The function of ramp higher limit is to narrow down output. Check the position of VR to which ramp higher limit is set. The position of VR can be checked on monitor screens VR1 – VR3.
		5) Analog auxiliary input is 0%.	Recheck the analog auxiliary input value. If set to 0%, control input becomes 0%.
3	Maximum output has dropped.	1) Check the scale setting of the various external adjusters.	Check the scale of external adjusters (VR). Set to “100%” and check monitor output.
		2) Check control input signal.	Check if control input signal is 100%.
		3) Current control is functioning.	Check the current limit setting. Set to “100%” and check output voltage and current. If output current is at the maximum rated current, the current limit function is functioning. There may be a load in excess of the rating of the device.
		4) Constant power (power feedback) control	(Rated voltage) x (rated current) x (1/2) is proportional to the control input signal. Measure output current, and if it exceeds 1/2 of the rating, maximum output is lowered.
		5) Check the output voltage meter.	The reading may vary according to the type of meter. Be sure to use a true actual value type or moving-iron meter. If measuring voltage with a conventional digital or analog tester, the mean value is shown as the actual value conversion, which could result in significant pointing error. (In the case of a 200 V power supply, pointing error may be as much as 43 V.
4	Rapid fuse blows and overcurrent protection circuit is triggered frequently.	1) Are load capacity and device capacity appropriate?	If load rate is 100% or more, narrow down output.
		2) If inrush current from pure metal heater, etc., produces a large load	Set slow-up time longer. If this does not help, either add a current limit function or replace the device with one with a larger rated current.
		3) If using a transformer	Set slow-up time longer. Also, lighten load relative to transformer capacity. If malfunction due to noise is possible, either use a noise filter or connect a capacitor (at least 0.1 μF) between terminals R and T. A transformer load cannot be used for cycle calculation zero voltage switching control. Replace with phase control.

23. Common specifications

☐Type : PAC28
☐Control element configuration : Thyristor x 2 anti-parallel connection
☐Main power supply : 100 – 240V AC (used with full-scale voltage set to 100 – 240V; initial value: 220V)
☐Control power supply 20A – 100A: 100-240V AC 18VA 9W
150A – 450A: 100-240V AC 32VA 16W
☐Voltage fluctuation tolerance : Max. ±10% of rated voltage
☐Rated frequency : 45 – 65Hz
☐Rated current : Specify any one from among 20A, 30A, 50A, 75A, 100A, 150A, 200A, 300A, 450A
☐Minimum load : 20A/30A: 0.5A
50A/75A: 0.5A
100A/150A / 200A: 1.0A
300A/450A: 2.0A
☐Control output range: : 0 – 98% and over (does not include thyristor forward voltage drop [1 – 2V])
☐Applicable load : Resistance load or inductive load (transformer primary control: phase control)
☐Control type : Select from among phase control, cycle calculation zero voltage switching control.
Control function selection (for phase control)
・Constant voltage output : Voltage feedback by true actual value
・Constant current output : Current feedback by true actual value to handle variable resistance load
・Constant power control : Power feedback, accuracy control to handle variable resistance load
Error becomes large when there is a difference in voltage and current phases.
・Square voltage output : Voltage square feedback, control signal / output power varies linearly for constant resistance load.
☐Cooling : 20 – 100A Self cooling
150 – 450A Forced air cooling system
☐Protection : Thyristor gate cutoff, alarm output
1) Electronic overcurrent gate cutoff circuit (alarm output when in action)
2) Rapid fuse (alarm output when fuse blows) (optional)
3) Power failure detection: Detects when source frequency is below 40Hz or above 70Hz
When output voltage is 120% of the rating or more
4) Thyristor overheat detection: Detects temperature of radiator when temperature rises abnormally
5) Hardware error detection: Detects thyristor error
☐Control input : Current 4 – 20mA, 0 – 20mA DC (receiving impedance 100Ω)
Voltage 0 – 10V, 0 – 1V, 1 – 5V DC (input resistance 200kΩ or more)
Potentiometer (all resistance values 100Ω – 10kΩ, 3 line type),
Contact (sampling cycle 30 seconds)
voltage pulse (12VDC±2V) (sampling cycle 3 seconds)
Factory set to either current input or voltage input
☐Standard functions
・External adjuster : Can be allocated to ramp, current limiter, manual operation external adjuster
Up to 3 can be used; external adjuster 10kΩ, 3 line type (sold separately)
・Digital control input (DI) : 3 point input, no voltage contact or open collector can be connected, 5V 4mA Max, insulated from control input and system
Allocation fixed to: DI-1: Manual/automatic, DI-2: Standby/operating, DI-3: Output limit at start-up
When level operation and DI input signal is on, operation/non-operation selection
・Alarm output (AL1) : One a-contact 240V AC 1A, insulated from system
Blown fuse, overcurrent, power failure, hardware error, overheat selection; duplication selection possible
Heater break alarm : Heater break is detected and alarm is output. (Allocated to alarm output)
Heater break judgment 0 – 100% setting
Note: Variable resistance can be controlled as applicable heater. However, heater breakage may not be detected since the variation of resistance value is wide.
・Current limit function : Used for pure metal load, etc., inrush current limitation, response time 0.5 sec. or less (initial value: 100% of rated current)
10 – 100% of rated current setting for external adjuster
10 – 120% of rated current setting for front surface key
・Variation limit (slow-up/down) : 0.0 – 99.9 sec. variable setting (set by front surface key switch)
Time required to reach 0 – 100% output, slow-up, slow-down time independent setting, initial value: 1.0 sec.
・Error occurrence history : Leaves a record of errors when they occur.
Record of only the first time each type of error occurs is kept.
Record items
Blown fuse, power failure, overcurrent, hardware error, overheat
・Parameter save function : 2 parameter files (factory setting values and user file)
User file can save set parameters.

☐Additional functions (optional)

・Alarm output (AL2) : One point a-contact, 240V AC 1A, insulated from system
Blown fuse, overcurrent, power failure, hardware error, overheat selection; duplication selection possible

・Rapid fuse : Protects thyristor / power equipment from load shorting, etc. Alarm output for cutoff

・Analog auxiliary input : 1 point, voltage 0 – 10V, 1 – 5 V DC or current 4 – 20mA DC input, insulated from input control
Output adjustment function by analog signal. Multiplied to control input
Used for feedback control by external converter, etc.

・Analog output : 1 point, 0 – 10V DC, 2mA, insulated from control input and system
Control input value or output operation amount 0 – 100% signal output, reverse scaling possible
*Communication function and exclusive selection

・Digital control output (DO) : 2 points, open collector output (darlington output), 24V DC, 25mA ON voltage 1.5V max.
Insulated from control input and system
Standby state, operating state (including manual), from heater break, selection of output conditions

・Communication : RS-485 specs., insulated from control input and system
Communication protocol: Selection of SHIMADEN protocol or MODBUS protocol (ASC / RTU)
Communication speed: 9600/19200 bps
Parity: Selection of EVEN / NON / ODD
Stop bits: 1/2 selection
Power on/off, output control, ramp setting
Operation on/off, control input, operation amount, load voltage, current, power value, alarm status can be obtained
*Analog output and exclusive selection

☐Separately sold goods

・External adjuster : Type QSV003

・Operation amount indicator : Type 60 x 60 (QSM003)
80 x 80 (QSM004)

☐General specifications

・Service ambient temperature range : -10 – 55°C (current must be reduced for 50°C or higher.)

・Service ambient humidity range : 90% RH or lower (no dew condensation)

・Elevation : Max. 2,000 m above sea level

・Over voltage category : II

・Pollution class : 2

・Storage temperature : -20 – 65°C

・Applicable standards : Low voltage directive: IEC61010-1 and EN61010-1
(limited to product with main power supply voltage 100 – 240 V, 100 A or less)
EN IEC 61010-2-030
(limited to product with main power supply voltage 100 – 240 V, 100 A or less)
: EMC EN61326-1 (limited to product with main power supply voltage 100 – 240 V, 100 A or less)
The specified noise filter however must be used.

20A	NF2020C-SDG
30A	NF2030C-SDG
50A	NF2050C-SDG
75A	NF2080C-SDG
100A	NF2100C-SDG

・Insulation resistance
Between control power supply terminals and control input terminals
: 500V DC, 20MΩ min.
Between power terminals and ground terminals
: 500V DC, 20MΩ min.

・Dielectric strength
Between control power supply terminal and control input terminal
: 2300V AC, for 1 minute
Between power terminals and ground terminals:
: 2000V AC for 1 minute

・Material/finish : Ordinary sheet metal / paint finish

・External dimensions/weight :
20A/30A: 58 (W) x 160 (D) x 218mm (H) / approx. 1.7kg
50A/75A: 98.6 (W) x 172 (D) x 218mm (H) / approx. 3.3kg
100A: 115 (W) x 201 (D) x 218mm (H) / approx. 3.8kg
150A/200A: 128 (W) x 270 (D) x 290mm (H) / approx. 7.2kg
300A/450A: 192 (W) x 295 (D) x 400mm (H) / approx. 16kg

・Terminal cover : Standard attached

The contents of this manual are subject to change without notice.

Temperature and Humidity Control Specialists

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