PAC27 THYRISTOR TYPE SINGLE PHASE POWER REGULATOR

Instruction Manual

Thank you for purchasing this Shimaden product. Please check that the delivered product is exactly what you ordered. Please do not begin operating this product until you have read this instruction manual thoroughly and understand its contents.

"Notice"

Please ensure that this instruction manual is provided to the final user of the instrument.

Preface

This instruction manual is meant for those who will be involved in the installation, wiring, operation and routine maintenance of the PAC27 series. As this manual describes matters to be attended to concerning operation of the PAC27 series, including its installation and wiring, you are requested to keep this manual at your work site when using this equipment. In using this instrument, please follow the instructions provided herein. For matters regarding safety, potential damage to equipment and/or facilities, additional explanations and instructions are given under the following headings:

WARNING

◎This heading indicates that failure to follow instructions carefully could cause injury or even death.

CAUTION

◎This heading indicates that failure to follow instructions could cause damage to equipment and/or facilities.

NOTE

⚠WARNING

◎This heading indicates additional instructions and/or notes.
The PAC27 series is designed for controlling the power of a heater or similar equipment used in industrial facilities. It must not be used in any way that might result in injury or fatality, or must be used only after adequate safety measures are taken. We will take no responsibility for any accident resulting from the usage of this product without appropriate safety measures being in place.

⚠WARNING

1. This instrument must be housed, for example, in a control box to prevent the terminal board from coming into accidental physical contact with personnel.
2. Do not use the instrument as a switch. Even without output, the instrument is energized through a resistor, which means that it has the latent potential to create an electric shock serious enough to result in serious injury or death.
3. The temperatures of the radiation fin and the chassis rise to very high levels during operation. Never touch them. If touched, serious burns may result.
4. Wiring should be carried out without energizing the instrument. Otherwise, an electric shock is probable.
5. Before using the instrument, make sure that the earth terminal is grounded.
6. Do not touch the terminals or other charged parts by hand while they are energized. Take care to allow no foreign matter to get into the product. If something gets in by mistake and it is necessary to insert your hand or tool inside it, make sure to turn the power off and to confirm that the condition are safe enough to allow procedure.

⚠CAUTION

Should the possibility of doing harm or damage to peripheral devices, equipment or products in the event of trouble of this instrument arise, you must take appropriate safety measures such as installing the proper fuse, an overcurrent device or an overheat prevention device before you start using the instrument.

⚠CAUTION

1. The alert mark ⚠ on the plate affixed to the instrument:
   On the nameplate affixed to the outside of the instrument, the alert mark ⚠ is printed. This is to warn you of electric shock which may result if the charger is touched while it is energized. It also warns of burns which may result from the high temperature of the instrument right after power is turned off as well as while it is energized.
2. A means to turn power off, a switch or a breaker should be installed in the external power circuit to be connected to the power supply terminal of this instrument. The switch or the breaker should be installed adjacently to the instrument and in a position which allows it to be operated with ease, with an indication that it is a means of turning the power off.
3. The conductor connector should be used only after fastening it tightly. If the fastening is insufficient, overheating due to contact resistance might cause accidental burning.
4. Stick to the rated power voltage and frequency.
5. Do not apply voltage and current which are out of their rated ranges to the input terminals. Such an act may shorten the life of the product or cause trouble with the instrument.
6. Voltage/current of a load to be connected to the output terminals should be within the rated ranges. If their ratings are exceeded, a rise in temperature may shorten the life of product or cause trouble with the instrument.
7. Once wiring is completed, make sure to install the provided terminal cover.
8. Users are prohibited from remodeling the instrument or using it in a prohibited or unauthorized manner.
9. To ensure safety and maintain the functions of this device, do not disassemble this device other than "wiring to the terminal block, replacing the fuse". If this device must be disassembled for replacement or repair, contact your dealer.
10 You are requested to adhere to matters to be attended to as described in the instruction manual in order to use the instrument safely and correctly and to maintain its reliability.

Note: For accidents or damage arising from failure to observe the warnings and matters to be attended to as described in this instruction manual, we will take no responsibility nor provide compensation.

SHIMADEN CO., LTD.

PAC27F-1EE
May. 2023

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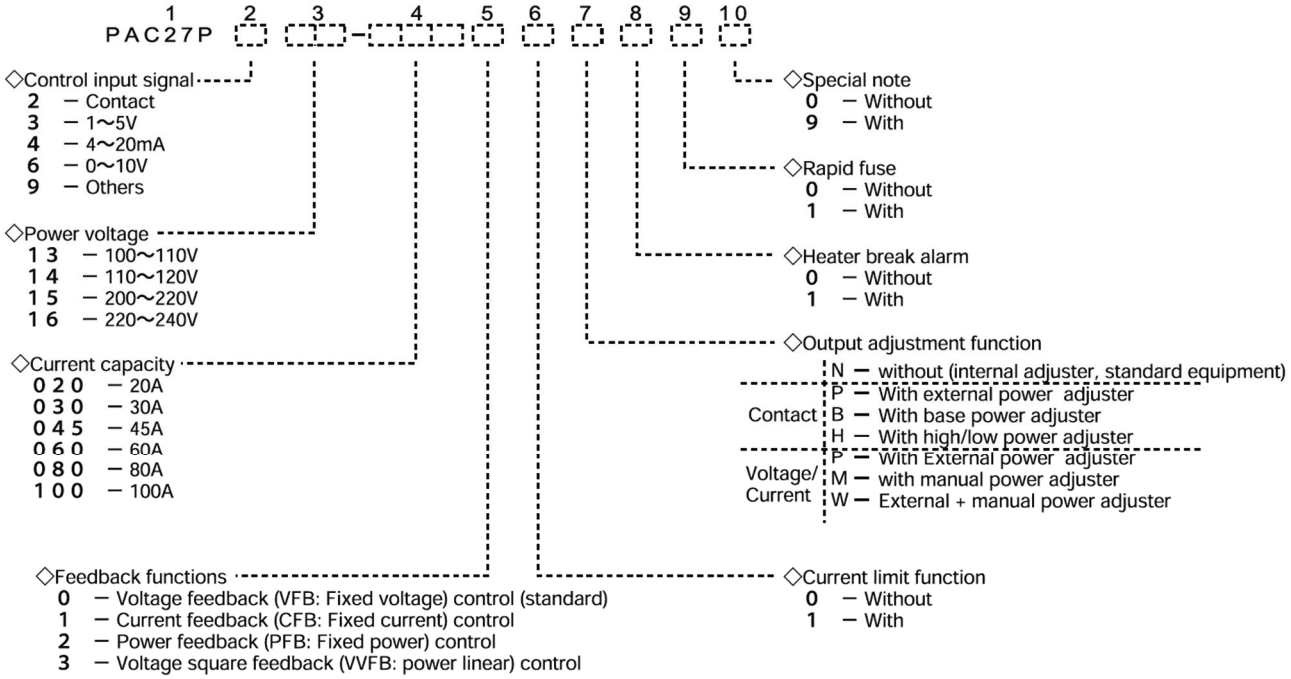
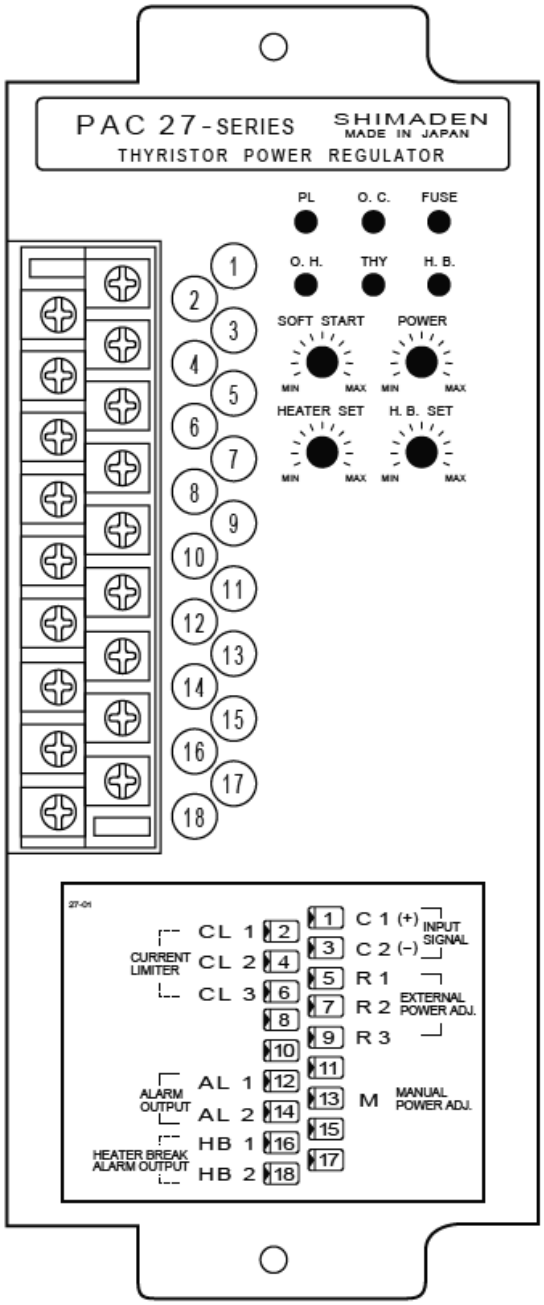
1. Confirmation of Specification Codes

Please double check that the delivered product is exactly as you specified. If you need further information, please get in touch with our nearest local office.



2. Front Panel Information and Control Terminals

2-1. Front Panel Information



☐ Names of monitor lamps

- PL : Power indicator
- O.C. : Overcurrent protection action indicator
- FUSE : Rapid fuse fusing indicator (option)
- O.H. : Thyristor overheating alarm indicator
- THY : Thyristor short circuit display/open load indicator
- H.B. : Heater break alarm action indicator (option)

☐ Names of adjusters

- POWER : Power adjuster
- SOFT START : Soft start time adjuster
- HEATER SET : Heater setting device for heater break alarm (option)
- H.B. SET : Heater break alarm setting device (option)

☐ Terminal marking and description

- C1-C2 : Control input signal
- R1-R2-R3 : External power adjuster
- M : Manual operation power (voltage/current input) adjuster
- L2-L3 : Low power (contact input) adjuster
- CL1-CL2-CL3 : Current limiting (option)
- AL1-AL2 : Alarm output
- HB1-HB2 : Heater break alarm output (option)

2-2. Control Terminal Numbers and Marking

	Code / Terminal No.	Terminal code	
		Voltage/current input	Contact input
Top terminals	1	C1 (+)	C1
	3	C2 (-)	C2
	5	R1	R1
	7	R2	R2
	9	R3	R3
	11	--	L2
	13	M	L3
	15	--	--
	17	--	--
Bottom terminals	2	CL1	
	4	CL2	
	6	CL3	
	8	--	
	10	--	
	12	AL1	
	14	AL2	
	16	HB1	
	18	HB2	

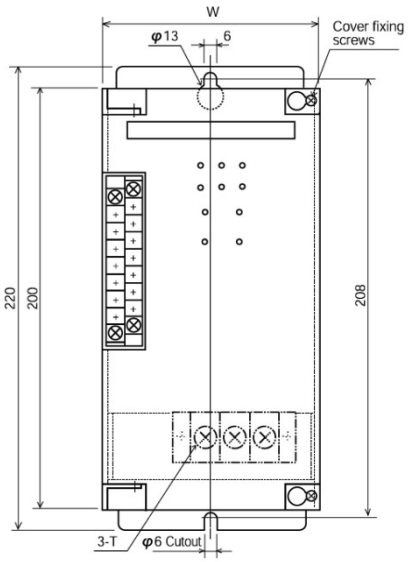
☐ The terminals have different functions depending on control input signals. Pay attention to the numbers and codes of the terminals when wiring is carried out.

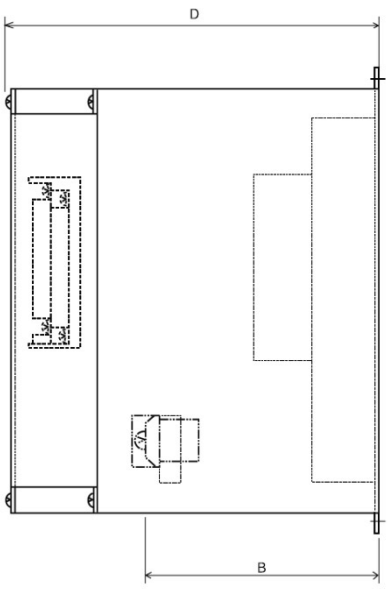
☐ The terminals with polarity are marked with (+) and (-).

☐ The alarm terminals (AL1, AL2) and (HB1, HB2) may compose a strong electric circuit in some cases. For the prevention of noise, they should be wired separately from other signal lines.

3. External Dimensions, Terminal Sizes and Masses

3-1. 20A / 30A, 45A / 60A



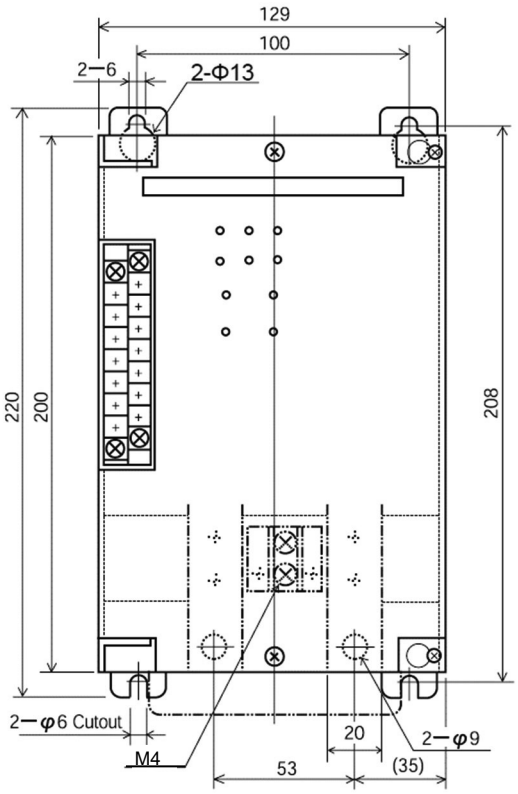


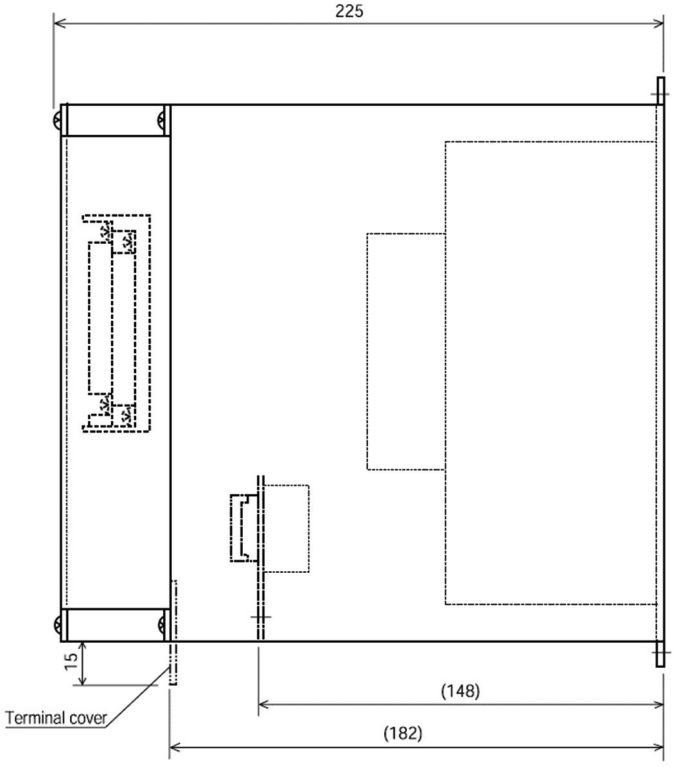
Mass
20A, 30A : About 2.2kg
45A, 60A : About 3.1kg

Code \ Current	20A / 30A	45A / 60A
W [mm]	81	102
D [mm]	160	176
B [mm]	90	108
T	M4	M5

3-2. 80A / 100A

Mass
80A, 100A : About 4.4kg





4. Installation Site

⚠CAUTION

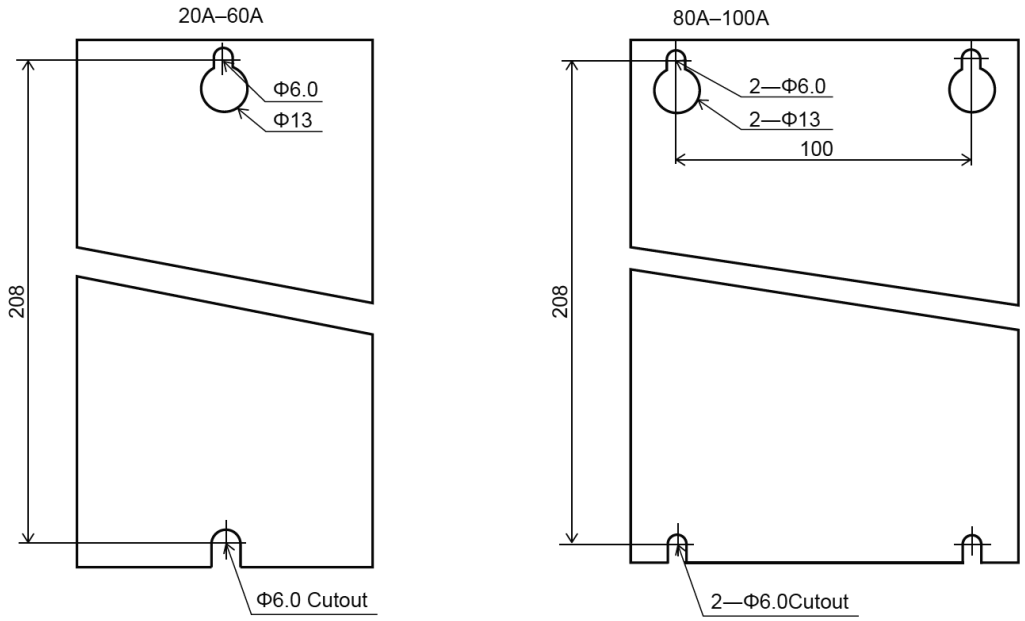
The environmental conditions of installation site affect the reliability and the life of this regulator. Avoid the following places when selecting a place for installation:

1) Ambient temperature which exceeds 40°C (Temperature allowed for this instrument is below 50°C)
2) Humidity which exceeds 90%RH
3) Flammable gas, corrosive gas, or gas or particles that can deteriorate electrical insulation is generated or is abundant.
4) Maintenance is unable to be accomplished safely.
5) Where intense vibration or impact is generated or transferred.

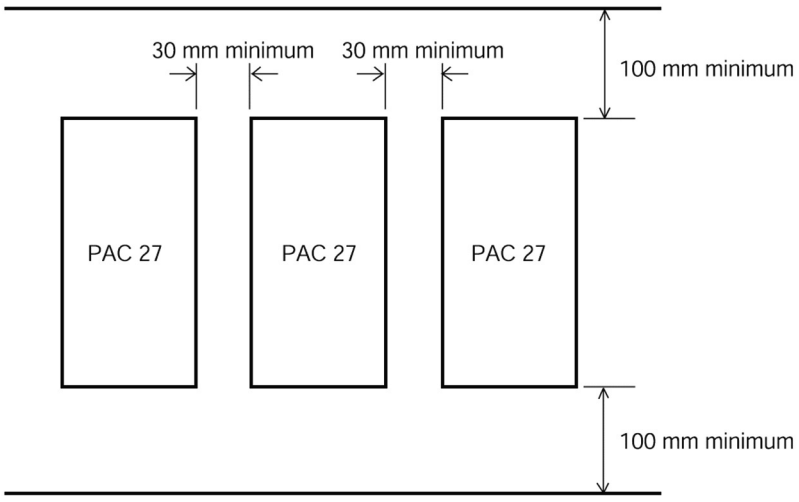
5. Mounting

Safety should be taken well into consideration in using this instrument by fixing it to a control panel, wall or rack so as to keep it from easy contact with persons.
It has to be installed vertically for heat radiation, leaving more than 100 mm spaces above and below it respectively. If it is inevitable to install the instrument horizontally, it must be used with less than 70% of the rated current.

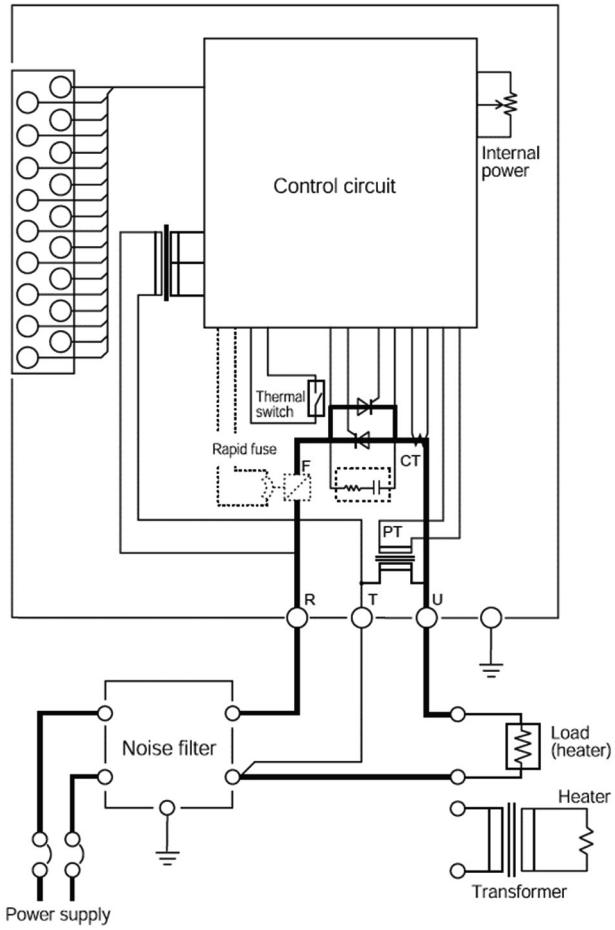
5-1. Mounting Sizes



5-2. Intervals Required for Mounting



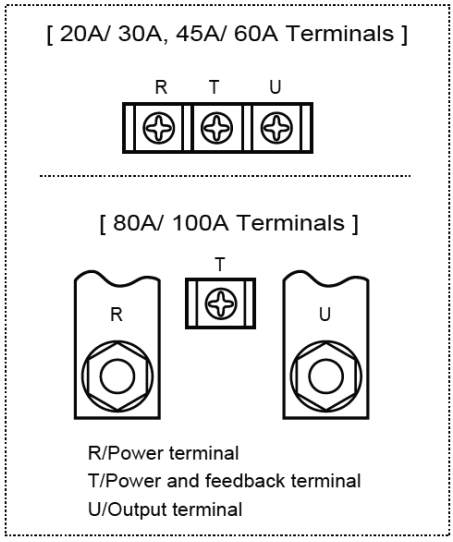
6. Circuit Block Diagram and Terminal Marking



— Terminal Marking —

☐ Control Terminal No.1–18 (See Page 4. 2-2)

☐ Power / Load Circuits



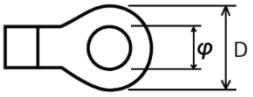
7. Earthing and Wiring for Power Supply and Load (Main Circuit)

7-1. Opening/Closing Instrument Cover

Open the cover (printed board case) of the instrument and wire the main terminal board. Loosen the fixing screws (two on the right-hand side of the instrument, M3 +) which secure the cover (printed board case) to the body by rotating them by 3 turns or so. (Refer to External Dimensions on Page 5.)
When the cover is moved to the right, the mounting portion is disengaged from the fixing screws and the cover is free to be opened. In the case of 80A or 100A, the terminal cover is attachable to the back of the cover (printed board case).

7-2. Earth Wiring

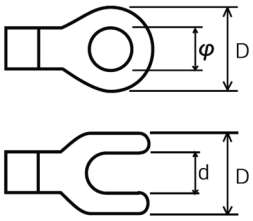
For safety's sake, make sure to use the instrument after grounding it.
The earth terminal screws of the PAC 27 are of mountings screws of M4, M5 and M6 respectively for 20A/30A, 45A/60A and 80A/100A.
Use corresponding terminals, screw tightly and ground with less than 100Ω of earthing resistance.



	Current capacity		
	20A, 30A	45A, 60A	80A, 100A
φ [mm]	4 minimum	5 minimum	6 minimum
D [mm]	10 maximum	13 maximum	16 maximum
Screw to be used	M4	M5	M6
Clamping torque	1.2～1.4 N・m	2.0～2.4 N・m	2.5～3.0 N・m

7-3. Wiring for Power Supply and Load

Three terminal wiring configurations are carried out for the PAC27; M4 for 20A-30A, 3P terminal board of M5 for 45A-60A, and bar 2 terminals of M8 & 1P terminal board of M4 for 80A-100A. Select proper terminals and tighten screws firmly.



	Current capacity			
	20A, 30A	45A, 60A	80A or 100A R and U terminals	80A or 100A T terminal
φ [mm]	4 minimum	5 minimum	8 minimum	4 minimum
D [mm]	10 maximum	13 maximum	20 maximum	9 maximum
d [mm]	4 minimum	5 minimum	8 minimum	4 minimum
Screw to be used	M4	M5	M8	M4
Clamping torque	1.2～1.4 N・m	2.0～2.4 N・m	5.5～7.0 N・m	1.2～1.4N・m

For wiring R and U terminals, use wire material suitable for current capacity. When T terminals are wired, use wire material of 0.5 mm^2 minimum.

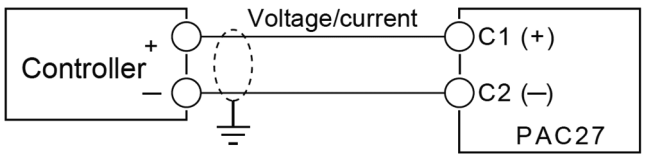
8. Wiring for Control Signals

For control signals, M3.5 terminal screws are used. Use a crimp-style terminal of more than 3.5 mm in inside diameter and less than 8 mm in outside diameter.
Tighten them with a clamping torque of 0.8 to 1.0 N • m.
Control input signal terminals (C1 and C2) receive control signals (4–20 mA, 1–5 A, 0–10 V, contact, etc.) from the controller.
Wiring should be carried out carefully so that noise from a strong electric circuit can be blocked. Pay close attention to the polarity, i.e., + and - of the terminals.
Countermeasure against lightning surge will be required for signal line over 30m.

8-1. One to One Connection to Controller

☐ Connection to Voltage/current output type controller:
Synchronize the controller output with the control signal of PAC27.

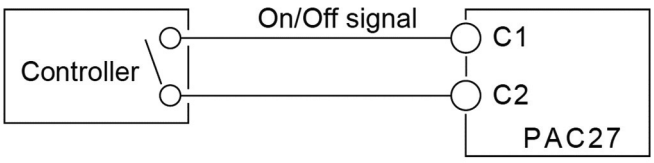
In the case of PAC27P4□□-, PAC27P3□□-, PAC27P6□□-



In the case of one to one connection, connect (+) of the output terminal of controller to C1 and (-) to C2.

□ Connection to contact output type controller:

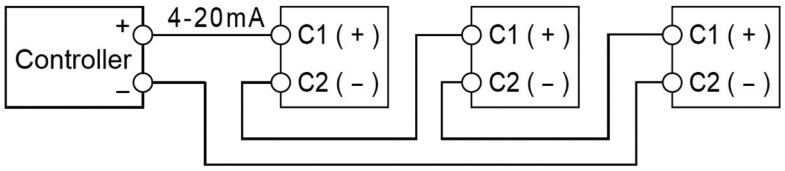
In the case of PAC27P2□□-

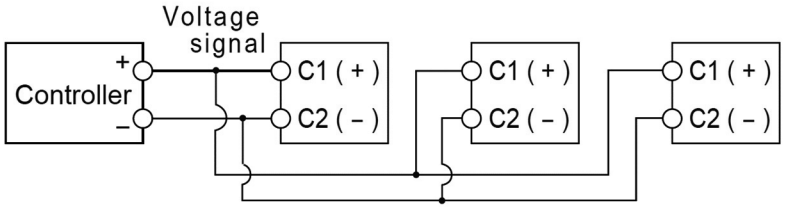


When connected to ON/OFF signal, output is produced upon shorting the C1-C2 terminals.

8-2. Connection of More Than One Unit to Controller

In case the controller is of the current input type, control input signals should be wired in series.
When the allowable range of load resistance of the 4-20mA output controller is 600Ω, maximum of six units can be connected.
Since PAC27 units have control circuits of different electric potentials, auto and manual have to be switched individually.





9. Alarm Function (standard equipment)

9-1. Overcurrent Protection Alarm

This alarm is put into action when the value of current detected by the regulator (built-in CT) exceeds approx. 130% of the rated current, blocks gate signals of thyristors and stops output, at which time current flows across the alarm output terminals AL1 and AL2. The monitor lamp [O.C.] lights. When the overcurrent protection alarm is activated, turn the power off and apply it again to reset the alarm.
Power should be turned on again after removing the cause of overcurrent.

9-2. Thyristor Overheating Alarm

This alarm is put into action when thyristor elements are heated to exceed its rated temperature, blocks the gate signal of the thyristor and stops output, at which time current flows across the alarm output terminals AL1 and AL2. The monitor lamp [O.H.] lights.
The normal state is restored automatically when the thyristor temperature falls due to absence of output.
When this function is in action, use the instrument in improved radiating conditions or with reduced load current.

9-3. Thyristor Trouble Alarm

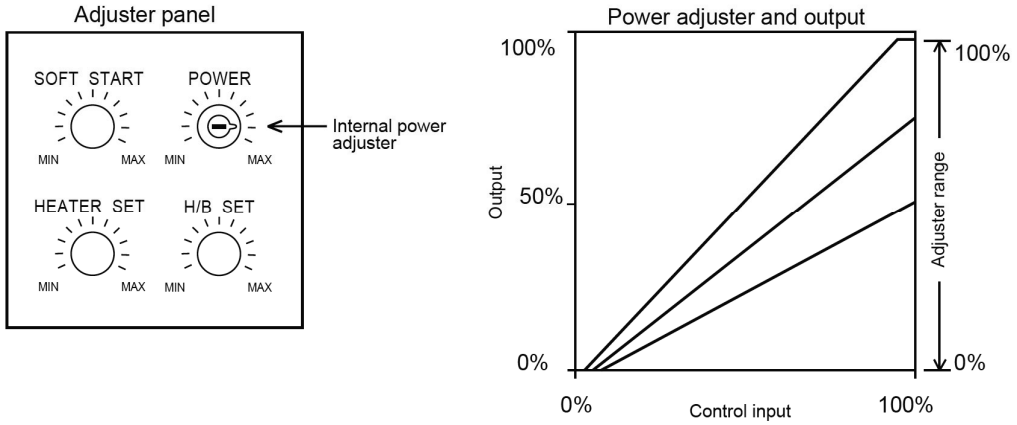
The trouble modes of thyristor element are mostly short-circuits.
This function is in action when there is output voltage without control-input signal or when it is extremely slight if any, and current flows across the alarm output terminals AL1 and AL2. The monitor lamp [THY] lights.
When the load is open, a high voltage is generated on the output side and this alarm is activated. Do not energize the instrument while the load is open. If the thyristor trouble lamp lights despite a load being connected, repair will be required.
Please call our local business office or service center nearest you.

The AL1 and AL2 are common output terminals for the 4 alarms.
1. Monitor lamp [O.C.] lights: The action of the overcurrent protection circuit - Standard
2. Monitor lamp [O.H.] lights: The action of the SCR overheating alarm - Standard
3. Monitor lamp [THY] lights: The action of the SCR trouble alarm - Standard
4. Monitor lamp [FUSE] lights: Rapid fuse break - Optional

10. Power Adjustment and Soft Start Time Adjustment

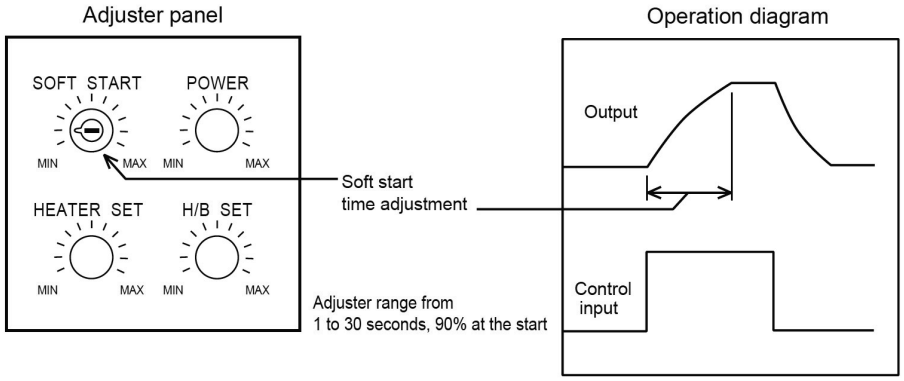
10-1. Internal Power Regulation

The power adjuster allows adjusting thyristor output in a range from 0% to 100% when the control input signal is at 100%. Power adjuster can change PAC27 output ramping with respect to control output signals.



10-2. Soft Start Time Adjustment

Soft start is the function to delay thyristor output with respect to a change in control input signal.
It can reduce the working load on equipment by suppressing transient current when power is turned on, and has the effect of suppressing the rush current of a heater.
Setting is possible from less than one second (min.) to more than 30 seconds (max.). The longer the set time, the slower the response of output. Time should be adjusted suitably for characteristics of a load to be used.
Setting a short time for soft start when the current limiting function is included, the activation of the current limiting function may be delayed relatively to the response of output of the current limiting function. In that case, a time for soft start will have to be set much longer.
In the instrument with the current limiting function, the factory setting is approx. two seconds. When the time is set shorter than that, overcurrent protection will work under certain load conditions.



11. Various Characteristics

11-1. Current Capacity and Calorific Value

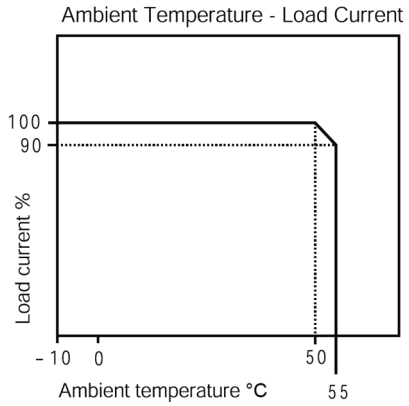
When current flows in the thyristors, voltage (0.9-1.3 V) is generated across the terminals. The product (W) of this voltage across the terminals and the current is Joule heat, which raises the temperature of the thyristor elements.
Full consideration needs to be given to radiation of heat and ventilation.

PAC 27 Internal Calorific Value

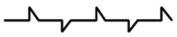
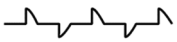
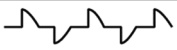
Current Capacity	20A	30A	45A	60A	80A	100A
Calorific value without fuse	23W	35W	54W	59W	79W	103W
Calorific value with fuse	25W	37W	58W	63W	85W	110W

11-2. Ambient Temperature and Load Current

The current rated for the PAC27 is at 50 ºC of ambient temperature. In case ambient temperature exceeds 50 ºC, the instrument should be used with load current as illustrated below.



11-3. Control System and Output Waveform

System / Output	Phase control system
0%	
30%	
50%	
70%	
100%	
Noise generation	Heavy
Output	Continuous
Output stability	Output fluctuation is within 2% against ±10% power fluctuation (constant voltage characteristics)

11-4. Special Heater and Feedback Control

Type of heater	Feedback control system Additional function
Supercantal	Constant voltage control + current limiting, Constant power control + current control, Constant current control
Pure metals (platinum, molybdenum, tungsten, etc.)	Constant voltage control + current limiting, Constant power control + current control, Constant current control
Carbon	Constant voltage control (+ current limiting), Constant power control
SiC (silicon carbide)	Constant voltage control (+ current limiting), Constant power control, Constant current control

If rated current is exceeded when maximum output is produced during minimum heater resistance, the current limiting function is required.

12. Countermeasure against Noise

12-1. Noise Filter & Condition for CE Marking

☐ Noise Filter

Frequency components of noise generated by the thyristors are distributed in the areas of a few megahertz or lower. Universal noise filters available on the market do not have sufficient effect to reduce such noise.
It is possible to reduce such noise when the following our designated noise filter is used.
The filter is specified for use in our thyristor power regulators.

Type	Current capacity
NF2030C-SDG	30A
NF2050C-SDG	45A
NF2060C-SDG	60A
NF2080C-SDG	80A
NF2100C-SDG	100A

Manufacturer: Soshin Denki K.K

☐ Condition for CE Marking

⚠CAUTION

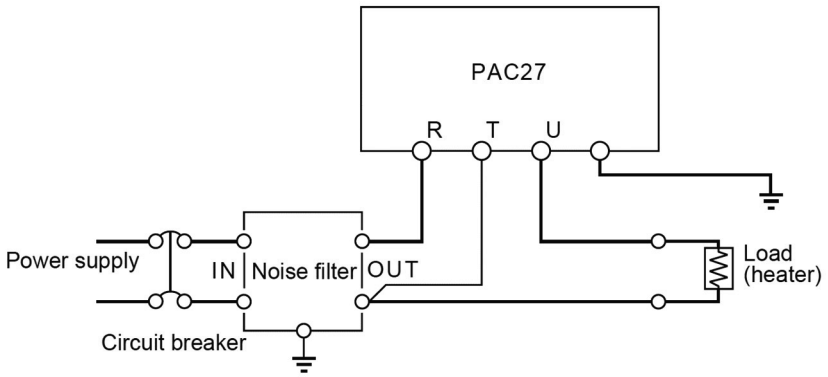
When the product is used with noise filter and wired as specified by the instruction manual, the product meets the requirement of EMC command.

1. For dealing with EMC command

Use in combination with a noise filter designed by us. Install the noise filter on the same metal plate as the PAC27. Do not forget to properly ground it.
The length of wiring between the noise filter and the PAC27 should be 0.5m or less.

2. For dealing with low-voltage command

When power line is wired, as a precaution against accidental short-circuit, make sure to install one molded case circuit breaker for each PAC27.
The current capacity of a molded case circuit breaker should be 1.3 times lower than that of the PAC27.

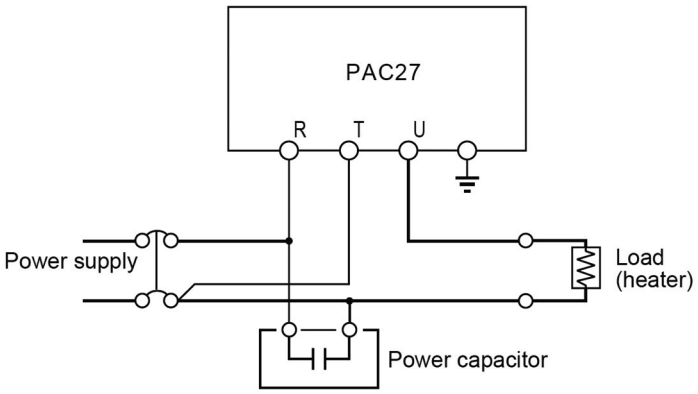


12-2. Power Waveform Distortion Improvement by Power Capacitor

To connect a power capacitor for power-factor improvement across the main terminals R and T of the PAC27 is an effective method to improve power distortion (higher harmonics).
The effect is recognized at a rate of 1μF capacitor capacity to about 1A current capacity.

Although the method is simple, attention should be paid to the following points:

1. Close attention should be paid to the rated current of the capacitor and a rise in temperature since a higher harmonic current flows into the capacitor.
2. The capacitor may produce higher harmonic voltage through its resonance with the power supply line inductance. Check the power waveforms.



13. Notes on the Use of Transformer Load

Purpose of Using Transformer
1) In case heater voltage is different from line voltage, the voltages are matched.
2) When the heater circuit needs to be insulated from the power source.
3) In case insulation to the earth lowers as experienced in vacuum devices, withstand voltage to the earth should be raised by using a compound transformer.

13-1. Transformer Flux Density

If a magnetic circuit is saturated while a transformer is being used, excessive current flows (applying a load only to transformer winding resistance) may occur and destroy the thyristor.
As thyristor control requires switching (ON-OFF) every half a cycle, a slight imbalance of output waveforms tends to cause saturation when the load increases.
Therefore, the flux density should be designed to be lower than that of an ordinary transformer.

Example: The flux density of an ordinary transformer is about 10,000 to 13,000 Gs.
It should be designed to be less than 8,000 Gs when a transformer is used together with a thyristor.
In case an ordinary transformer is used, no problem will be caused when the load rate is held below 70% of the rating for the transformer.

13-2. When Electromagnetic Switch (Contactor) Is Used

If an electromagnetic switch (contactor) is used in a circuit connected with a transformer (inductive load), a bounce of the contact may cause an erroneous movement.
In this case, use the designated noise filter or connect a capacitor (0.1–0.5μF) across the power side terminals R and T to absorb the noise.

13-3. Use of Rapid Fuse

In order to protect the thyristor elements from excessive current which is generated by high frequency noise or load trouble while a transformer is being used, we recommend that you use a Rapid fuse.

13-4. Prohibition of Open Load

In case a load is unable to be connected, for example, in a trial run, disconnect wiring for the transformer and connect a dummy load such as an electric heater or a light bulb. Do not put the transformer in operation when its load remains open.
You should not switch the load while the transformer is energized. If you do this, the soft start function will not work, resulting in generation of excessive current or activation of the protection circuit of the PAC27.

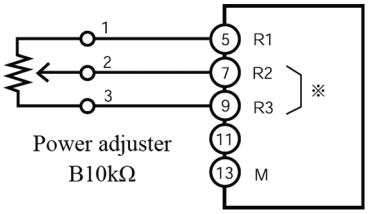
14. Wiring and Use of Additional Functions (Option)

This section applies to the instrument which has an optional function.

14-1. Output Adjusting Functions (5 types of manual adjuster)

Any of these functions can be used when an external adjuster (B 10kΩ variable resistor) is connected to a terminal. It is possible to add the functions even after the instrument has been delivered.

14-1-1. External power adjuster

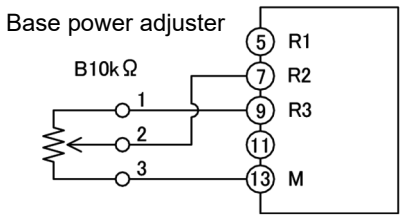


※When an external power adjuster is not used, the terminals 7 (R2) and 9 (R3) should be shorted.

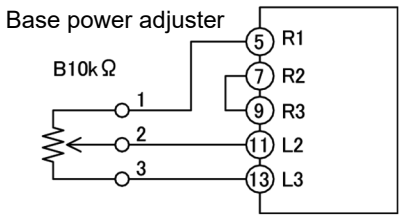
When an external power adjuster is not used, the terminals 7 (R2) and 9 (R3) should be shorted.

14-1-2. Base (residual) power adjuster

☐Voltage / Current input



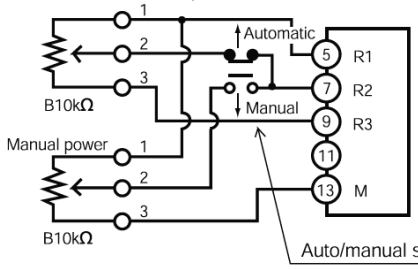
☐Contact input



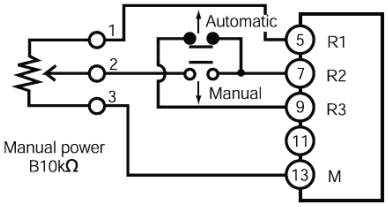
This is used to allow for output even when the control signal is at OFF.
Adjusting range is 0 - 100%.

14-1-3. When automatic operation + manual power adjuster switch is used (voltage/current input type)

• External power + manual power adjuster
Automatic/external power



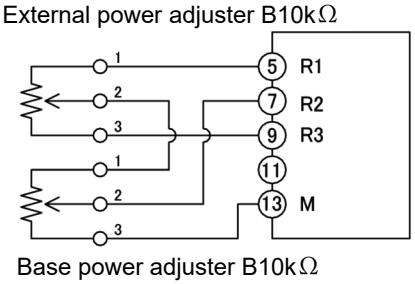
• Manual power adjuster



Provide an auto/manual switch contact externally as shown in the drawing.
It is safe to use the 'b' contact for auto and the 'a' contact for manual.

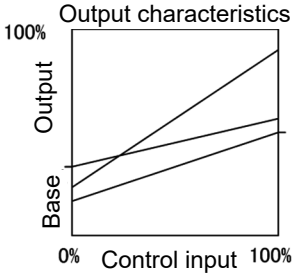
14-1-4. External power + Base (residual) power adjuster

External power adjuster B10kΩ



Base power adjuster B10kΩ

Output characteristics

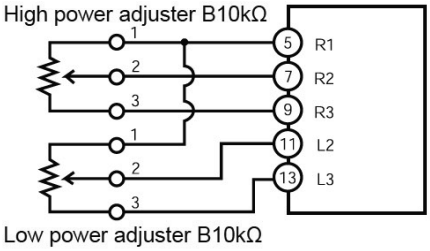


⚠CAUTION

When external power and base power are used together, they will interfere with each other. Also, even if the base power is set to 0%, the output may not be zero.

14-1-5. Contact input High-low power adjuster

High power adjuster B10kΩ



Low power adjuster B10kΩ

☐High power: When current flows across C1-C2, output can be adjuster in a range from 0 to 100%.

☐Low power: When C1-C2 are open, residual output is regulated. Residual output = (high power) x (low power)

Example: When high power = 70% and low power = 40%, residual output is 70% x 40% = 28%

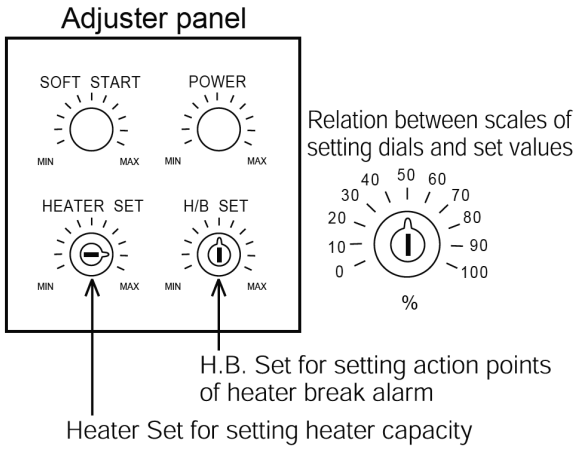
14-2. Heater Break Alarm

The heater break alarm function outputs an alarm at the time of break of one of a plurality of heaters composing the heat source. The function effectively prevents defects arising from the adverse effect of insufficient power.

14-2-1. Outline of Working

This function compares the quotient of output current of the PAC27 divided by output voltage with the set value, and outputs an alarm if the current value is lower. Even if an alarm has been output once, it will be released when current value has recovered or output voltage turns 0. In case self-hold is needed, a self-hold circuit has to be made up externally.

14-2-2. How to Set



1) Preparations before setting
   Set VR of the H.B. Set at the maximum position and VR of the Heater Set at the minimum position. Put the PAC27 in operation and energize the heater. Wait for the temperature of the heater to be fully stabilized. Confirm that the HB lamp remains off at the time.

2) Setting of Heater Set - Setting of heater capacity
   Turn VR of the Heater Set clockwise slowly and gradually while the PAC27 output voltage is at 50% or above, and set it at the position on which the HB lamp lights.
   In the event VR of the Heater Set is turned excessively, turn it counterclockwise to put off the HB lamp and then carry out the setting again.

3) Setting of H.B. ALM Set - Setting of HB alarm activation point
   After completing the setting of the Heater Set, set VR of the H.B. ALM Set at a position corresponding to the percentage of the heater current value at the time of heater breakage.
   Example 1 - When 5 heaters are used and breakage in one of them is to be detected:
   Set at a mid point between the current % at the time of breakage of one heater, 4/5 x 100 = 80% and ordinary current, 100%, at 85%.
   Example 2 - When one heater is used:
   Set at mid point between current at the time of break, 0, and ordinary current, 100%, i.e., at 50%.

14-2-3. Notes on Setting

1) Setting should be performed when the PAC27 output is as high as possible (50% or higher). Setting with a Lower output (less than 50%) will increase an adverse reading of detection error, which in turn leads to false activation.

2) For the H.B. alarm, a lower setting, less than 90%, is recommended for the following three reasons:
   It may occur that contrary to your intention of establishing a setting at 95%, an actual setting as high as nearly 100% is set due to a variation of mechanical accuracy concerning the H.B. setting device.
   This function is designed on the assumption that voltage and current have similar waveforms. Depending on the types of loads, however, voltage has a waveform which is different from or out of proportion to that of current. If this is the case, the accuracy of detection will decline and which in turn leads to false activation of the alarm.
   Even in the case of constant resistance heaters (made of nickel chrome), resistance values change according to heater temperature and the change is hard to distinguish from that change in resistance which is generated when one of the heaters burns out.
   In the event the number of heaters is large (5 or more), setting a lower than calculated level (a mean value between those at normal time and that which is generated when one of the heaters burns out) has the effect of preventing false activation of the H.B. alarm, although it may be impossible to detect a breakage of one of a plurality of heaters. (Detection is not possible when heater current falls by 10% or less.)

3) Detection of breakage in one of a plurality of heaters is possible only for constant resistance heaters. In some cases, such breakage may not be detected regarding variable resistance heaters. If current falls below a set value during operation in the case of a constant resistance heater, a lower value than the percentage of the current at the point of time when the current has fallen should be set.

   Example: Two heaters are employed. Heater resistance at the start is so high that the current at the start amounts to only 70% of its normal value. This means the current at the time of its fall is 70% and so a lower value than 70%, for example, 60% is set. Since the set value is in the middle of the starting current, 70 %, and the current at the time of breakage of one heater, 50%, detection of breakage of one of the two heaters is possible. If three similar heaters are used, the setting of a value exactly at the mid-point of current at the time of breakage of a heater, 67%, and the starting current, 70%, is not possible. Thus, breakage of one of the three heaters is undetectable.

4) A light load or a transformer load may lead to false activation of the H.B. alarm. With a light load which causes a heater current to be 10% or less of the rated value, a heater breakage may not be detected. With a transformer load, voltage waveforms may become dissimilar or out of proportion to those of the current and the accuracy of detection lowers accordingly. To prevent false activation, the H.B. alarm should be set at 50% as a standard value if the apparatus is used with a light load (less than 30% of the rated value) or a transformer load. (Detection of breakage of one of a plurality of heaters is not possible.)

14-3. Various Feedback Functions

The PAC27 has various feedback functions (constant voltage (standard), constant current, constant power, power linearity), which are so easy to operate since an external CT or PT need not be attached.
The feedback control functions detect thyristor current or voltage internally in the regulator and control it to a value set by a control signal from the controller or some other means.
If line voltage or the load varies, a change in output can be held to a minimum. The functions are most suitable for load characteristic compensation and precision control.

14-3-1. Constant voltage (VFB: voltage feedback) control (standard)

This function is equipped on a standard basis. Output voltage corresponding to a control input signal is obtained as a true effective value.
The function is usable for almost all types of loads but requires the current limiting function (option) in the case of a load with a large rush current.

14-3-2. Constant current (CFB: current feedback) control

Output current corresponding to a control input signal is obtained. When the load changes, this function works to keep output current at a constant level by changing output voltage. It is used for heaters in which rush current is large and/or current fluctuates violently. It is also effective in stabilizing load current. Even for pure metal heaters with large rush current, the use of the current control function (option) is not required. Because current corresponding to a control input signal is tried to output, a power regulator is used for regulation if the capacity of the PAC27 does not match with that of the heater.

14-3-3. Constant power (PFB: power feedback) control

Output power, i.e., a calorific value from the heater, which corresponds to a control input signal is obtained. Since it is assumed that the function is used against a load of variable resistance, rated voltage x rated current x 1/2 is set as a 100% value of power. The function is capable of being used for almost all types of heaters and allows for precision control of temperature.
As the constant power control is meant for a heater load, a correct power level is unable to be attained for other loads (such as a motor) than heaters.
Selection of this control system for an SiC heater makes compensation for heater deterioration possible without using a tap change transformer for the heater. (This may not be possible due to certain relationships between line voltage and heater voltage.)

Example: When the line voltage is 200 V AC and the rated current of an SiC heater is 140 V 20A (2.8 kW):
The rated voltage of the thyristors x rated current x 1/2 is set as a 100% power value, that is, 2.8 (kW) x 2/200 (V) = 28(A). Therefore, a PAC27 of 200-220 V 30A should be selected.
In this case the 100% power value is 220 (V) x 30 (A) x 1/2 = 3.3 (kW). In order to match with the heater power, the power regulator should be tightened to 2.8 (kW)/3.3 (kW)=85%. Owing to this, at 100% of input control signal, the initial value of the heater attains 140V 20A (2.8 kW). When the heater deteriorates to raise the resistance value, it can be used at 200 V 14A (2.8 kW) maximum. During this period, output power corresponding to control input is obtained without requiring any other operation such as tap changing by a transformer.

14-3-4. Power linearity (VVFB: voltage square feedback) control

It is arranged so that the square of output voltage corresponds to constant resistance.
Since power against constant resistance is in proportion to the square of voltage, power corresponding to control signals is obtained when used for constant resistance heaters (nickel chrome, iron chrome, etc.).
Although the controllability is lower when compared to constant power control since resistance inevitably changes between a few percent and ten percent or so in actual heaters, power which is substantially in proportion to control input signals may be obtained. It cannot be obtained by ordinary constant voltage control.
It is a type of constant voltage control. Unlike constant power control, it does not require calculation of the capacities of the PAC27 and the heater. Installation of a power regulator is also unnecessary.

14-4. Current Limiting Function

This is the function to limit output current within a range from 50 to 100% of the rated current of the PAC27. In case a pure metal heater or a lamp heater, i.e., a load with large rush current is used, this function is employed to protect thyristor by limiting rush current or to limit load current for some other purposes.
A delay in time is caused because output current is detected by a built-in CT and a phase-control angle of thyristor is controlled. Therefore, load switching while being energized is not allowed.
Besides, when a shorter time is set for soft start, current limiting may not act in time against a heavy load of rush current. This function should be used with more than 2 seconds of soft start time.
This function, working as a high limit, is different from the constant current control function which controls current. As the constant current control controls output current, however, it makes the use of the current limiting function unnecessary.

Note: Output power falls to such an extent that the load rate exceeds 100%. (Current is limited to a set value by lowering the output voltage.)

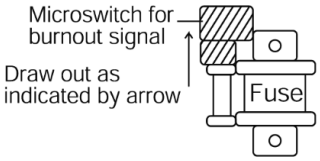
When the current limit setting device is removed, the limiting works at 0% of the rated current and no output is produced. If the instrument is used without the current limit setting device, the control terminals (CL2) and (CL3) have to be short-circuited. Then, the limiting works at 100% of the rating.

14-5. Rapid Fuse

This rapid fuse is for thyristor protection. In the case of short-circuiting of an energized load or erroneous operation while a transformer is in use, the thyristor elements are unable to be protected in an electronic protective circuit but using a rapid fuse makes protection possible.
During its use, the FUSE monitor lamp lights and the fuse fuses when there is no output.

How to Replace Fuse:

Open the cover of the body (printed board case) (See 7-1.).
A microswitch to signal for fusing is attached to the fuse. Draw out the microswitch and replace the fuse with a new one.



－Type of fuse－

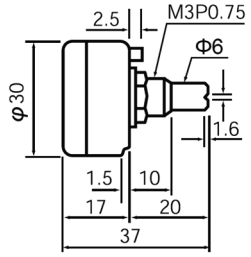
Rated current	Type of fuse	Fuse rating
20A	QSF023	32A
30A	QSF025	40A
45A	QSF035	63A
60A	QSF036	80A
80A	QSF037	160A
100A	QSF037	160A

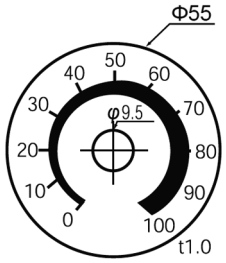
14-6. Various Power Adjusters (External Appearances and Mounting Sizes)

・Ratings

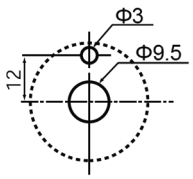
Lead wire:	1 m vinyl lead wire provided
Characteristics / resistance value:	B10kΩ
Scaled plate and knob:	One pc. each provided.

・External dimensions and mounting sizes





Panel cutout



Name and scale	/ 0 to 100%
・External power adjuster	/ same as above
・Manual power adjuster	/ same as above
・High/low power adjuster	/ same as above
・Current limit setting device	/ 50 to 100%

15. Specifications

■Control element configuration:
Thyristor (SCR) x 2 Anti-parallel connection

■Power supply
100-110V, 110-120V, 200-220V, 220-240V AC
±10% 50/60Hz

■Rated frequency: Common to 50/60 Hz

■Current capacity:
20, 30, 45, 60, 80, 100 A

■Control input signal:

Current	4-20mA DC / Receiving impedance: 100Ω
Voltage	1-5 V DC / Input impedance: 200kΩ minimum
Others	Voltage, Current signal
Contact	No-voltage contact signal

■Power Adjuster:
Voltage and current input types - Internal power adjuster is equipped on standard basis.
External power adjuster is mountable at option.

■Element protection system:
Electronic overcurrent gate breaking circuit (when in action, alarm is output.)
Rapid fuse (option) (Upon fuse breaking, alarm is output.)

■Alarm action:
When overcurrent gate breaking circuit is in action, when rapid fuse breaks, when thyristors are overheated, when shorting of thyristors is detected, when current flows across alarm output terminals (AL1 and AL2) (contact 240V AV, 1A)

■Additional functions (Common options)
Rapid fuse: with alarm output
External power
Adjustment functions: External power Manual power High/low power High power
Low power
External power + manual power
Heater break alarm: To be set at 0 to 100% of rated current

■Operating environment:

Ambient temperature range	between -10 and 50 °C
Ambient humidity range	90% RH maximum with no condensation
Storage temperature	between -20 and 65 °C

■Applicable standards:

Safety	IEC 60947-4-3, EN60947-4-3 Category: AC-51
EMC	EN60947-4-3

EMC (immunity) EN60947-4-3 on condition that designated noise filter is used.

■Insulation resistance/dielectric strength

Insulation resistance	500VDC 20MΩ minimum Between power supply terminal and chassis 500VDC 20MΩ minimum between power supply terminal and control input
Dielectric strength	200VAC/min. Between power supply terminal and chassis 3000VAC/min. between power supply terminal and control input

■Control System : Phase control
■Soft start time : Adjustable between 1 and 30 seconds
■Output voltage control range : 0 to 97% of input voltage
■Degree of output stability : Output fluctuation ±2% maximum as against input fluctuation ±10%
■Output voltage characteristics : Linear output by voltage feedback (various characteristics are selectable as designated)
■Applicable load : All heaters (additional functions to be selected suitably for characteristics)
Inductive load and transformer primary control
■Power supply indicator : Green LED lamp lights.

■Additional functions (options)

Power adjuster functions	: See appropriate item in common specifications.
Constant current control (current FB)	: Output current in proportion to control input signal
Constant power control (power FB)	: Output power in proportion to control input signal
Power linear control (voltage2 FB)	: Control and the square of output voltage are proportional to each other.
Current limiting function	: Current is limited to 50 to 100% of the rating.

16. Trouble Shooting

In the event a problem arises during operation, inspect the instrument by referring to the following table and call our office in the neighborhood.

	Problem	Point to be inspected	Remedial measure
1	Output has stopped.	1) Alarm monitor O.C. lights.	It appears that excessive current flowed for some reason. For pure metal heater or transformer load, set longer soft start time. If alarm lights again, turn power off to bring power regulator to 0%. Then, turn power on again.
		2) Alarm monitor O.H. lights.	Thyristors might be overheated. Turn power off to lower instrument temperature and turn power on again. If monitor lights again soon after situation is normalized, too large load current of thyristor or poor heat radiation is suspected. Use with reduced load current or improve radiation conditions.
		3) Alarm monitor FUSE lights.	Rapid fuse for thyristor protection might be fused. See if there is short-circuit of load or ground fault and replace with new fuse after removing cause of problem.
		4) Alarm monitor THY lights.	If load current is zero, load is open. Check for break of load.
		5) PL lamp (green) does not light.	Examine power supply and check the power source side if power is off. In case power is on, instrument trouble is suspected
		6) Are control input signals being received?	Measure input level across terminals C1 and C2 by using a tester, for example. If there is no input signal, check the supply source of signal such as a controller. In case regular signal is found, check connection and set values of power regulators. When they are correct, instrument trouble is suspected.
2	Output keeps being produced.	1) Alarm monitor THY lights.	Thyristor short-circuit or open load is assumed.
		2) Is load circuit open?	When load circuit is open, panel meter and tester will show high voltage. Examine load circuit. (This sometimes happens during trial run.)
		3) Base power or low power regulator is connected.	It is for preventing minimum value of output from being 0. Detach low power regulator and recheck.
3	Maximum output has lowered.	1) Check settings on scales of various power adjusters.	Check scales of internal and external power adjusters. Set at 100% and see how output will change.
		2) Check control input signal	Check if control input signals have been received hundred percent.
		3) Addition of current limiting circuit.	Examine scale of current limit setting device. Set at 100% and confirm output voltage/current. If output current flows fully at rated level, current limiting function is working. Load is far heavier than rated for PAC27.
		4) Constant power (power FB) control	Rated voltage x rated current x 1/2 should be in proportion to control input signal. Measure output current. If more current than 1/2 of the rating flows, maximum output will fall.
		5) Check output voltage meter.	Indicated value may change depending on types of meters. Make sure to use true RMS type or movable iron piece type meter. When voltage is measured by using general digital or analogue tester, average value is converted into true RMS for display. Hence display error increases. (In the case of 200 V power supply, display error will come to 43 V maximum.
4	Fuse breaks (FUSE lights) or excessive current protective circuit (O.C.) is activated frequently.	1) Are load capacity and PAC27 capacity suitable?	In case load rate exceeds 100%, output should be lowered by the use of power adjuster.
		2) In the case of load with large rush current such as pure metal heater.	Set longer time for soft start. If it does not work, add current limiting function (option) or replace PAC27 with one which has a larger current rating.
		3) Transformer is used.	Set longer time for soft start. Try to reduce load relatively to transformer capacity. If noise is assumed to be cause of erroneous operation, connect capacitor (250V AC 0.1 μF) across terminals R and T.

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

Temperature and Humidity Control Specialists

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PRINTED IN JAPAN