INSTRUCTION MANUAL

AUTOMATIC 3PHASE POWER-FACTOR REGULATOR

PFQ-6

PFQ-3

DAIICHI ELECTRONICS CO., LTD.

Thank you for purchasing DAIICHI ELECTRONICS product.
Please read this instruction manual carefully before using.

Safety precautions

■ Environment conditions

Please be sure to use this product in a place that meets the following conditions.
In places that do not meet this condition, malfunctions and failures, and performance and product life may be reduced.

- Within the range of ambient temperature -10 to +55 ℃, humidity 30 to 90% RH.
- Place free of dust, corrosive gas, salt and oily smoke. (Corrosive gas : SO_2 / H_2S, etc.)
- Location that is not affected by vibration and shock.
- Location that is not affected by external noise.
- If the inverter output of cycle control, SCR phase angle control and PWM control is directly measured, the error will be large.
- Altitude 1000m or less.

■ Outdoor use conditions

- These products are not a dustproof, waterproof, and splash proof construction.
  Please avoid the place with much dust. Moreover, please install in the place not exposed to rain or water drop.
- Please do not install in the place where sunlight hits directly.
  Discoloration and degradation of a name plate, and deformation of the case by the surface temperature rise may occur.

■ Mounting and wiring

Please refer to this instruction manual for mounting and the wiring.

⚠CAUTION	● Please refer to connection diagram for the wiring. ● Please avoid hot line work. ● Please use an electrical wire size suitable with the rated current. ● Please check the tightening of the screw.

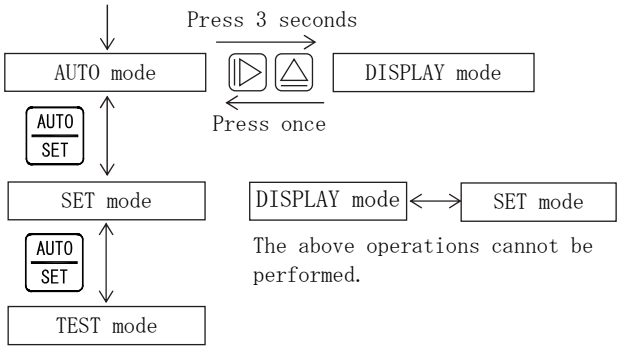
When installing this product, tighten the screws of the installation tool with a Phillips screwdriver.
The tightening torque is 0.2 to 0.29 Nm.
If torque screwdriver is not kept handy, rotate this product approximately 360 degree after contacting both screws to panel, then make sure that this product is fixed firmly.
Tighten the terminal screw with Phillips screwdriver. Tightening torque : 1.0 to 1.3N·m.

■ Preparation

This product is set to the default value when shipped from the factory.
To change the setting, refer to item 4 (pages 13 to 20).

■ Control status display

Control power supply applied (Default value)



The above operations cannot be performed.

- AUTO mode ····· The slide switch can be operated during control.
- DISPLAY mode ··· Various measured values are displayed in the same state as the automatic mode.
- SET mode ····· The set value can be changed and the control is stopped.
- TEST mode ····· Used when checking the operation of the capacitor circuit.

In the setting mode, change the DIP switch ACTION from "OPERATE" to "TEST" and press the AUTO SET switch to enter the test mode.

■ Operation

If this product is used, please be careful of the following item.

- Open the switch cover and set the slide switch of the unused capacitor circuit to "manual OFF".
- When apply the control power supply, turn off the control output contact.
- Please use an input within rated range. Keep in mind that product use beyond rated range leads to damage and malfunction.
- Close the switch cover when not in use.

⚠CAUTION	● If a terminal is touched into the power distribution, it will receive an electric shock. ● Product warranty becomes invalid when this product is disassembled or remodeled without any permission. Have a contact with us for specification change to prevent any danger caused by remodeling.

- After the control output contact is turned ON or OFF, this product does not have a disconnection detection function, so control continues even if the capacitor is not actually closing or breaking. Operation check of capacitor control circuit can be performed in a condition where this product is installed to panel as for disconnection / false electric wiring confirmation.
  Set the ACTION of the DIP switch to "TEST", and after setting (test mode), close and break in the following order every 15 seconds of delay. [C1→C2→C3→C4→C5→C6 (PFQ-3 is C1→C2→C3)]
  This operation is repeated during the test mode, so if a capacitor is connected, be sure to change the setting from "TEST" to "OPERATE" after completing the cycle. In the case of a high-voltage capacitor, it will be reclosed before the residual voltage is sufficiently discharged.
- In a circuit with AUTO / MANUAL change of capacitor switch externally, there is a possibility of simultaneous closing when external contact is changed from manual to auto.
  Therefore, please change in order of the following.
  Slide switch「OFF」→ external contact「AUTO」→ slide switch「AUTO」or control power OFF → external contact「AUTO」.

■ Maintenance and inspection

- Inspection in energized state is dangerous.
- This product does not include parts to be replaced at periodic inspection.
- Periodically check the status display, number display, LED discoloration, loose wiring, loose mounting screws, and damage to the case.
- Please wipe off lightly with the dry soft cloth. Please do not use the organic solvent, chemicals, cleaners, etc., such as an alcohol, for cleaning

■ Storage

Please store in a place that meets the following conditions.

- The ambient temperature within -20 to +70 ℃.
- Daily average temperature 40 ℃ or less.
- Location corresponding to the usage environment and use conditions.
- Location that is not affected by vibration and shock.
- Aluminum electrolytic capacitors are used in products. Please energize the power supply within one year after purchase.

■ Countermeasures against troubles

If trouble occurs within the warranty period, DAIICHI ELECTRONICS will repairs this product.

■ Disposal

Please dispose this product as industrial waste (non-combustible).
Mercury parts and a nickel-cadmium battery are not used for this product.

■ Warranty period

The warranty period of the product is one year after the date of delivery.

■ Warranty matters

We assume no responsibility for any warranty regarding the following matters.
Damage caused by reasons that cannot be attributed to our responsibility.
Loss of opportunity and lost profit for customers due to failure of our products.
Damages, secondary disasters, accident compensation resulting from special circumstances with or without our prediction. Damage to other than our products and compensation for other business.

Contents

1. Product outline

1.1 Usage of product

This product is an automatic power factor adjuster for three phases that automatically controls the input amount of power capacitors. The following effects can be obtained by using this product.

・Saving electricity charges.
・Work for power factor monitoring and adjustment can be reduced.
・Power loss can be reduced and installed capacity can be used effectively.
・The circuit voltage can be stabilized and the life of the equipment can be extended.

This product can auto closing and breaking control the power capacitor with a simple operation.

1.2 Features of product

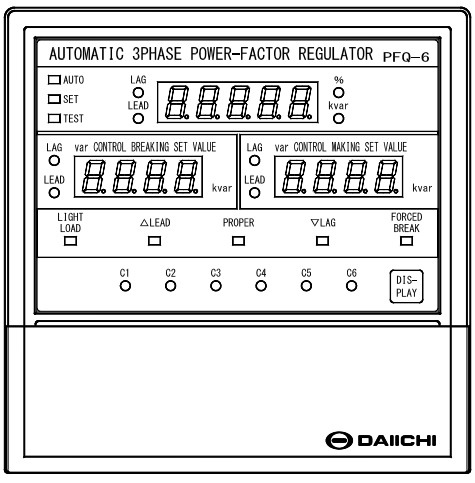
- Compact and lightweight (DIN 144 x 144).
- This product can be used for 3-phase 3-wire circuits (unbalanced load, balanced load) and 3-phase 4-wire circuit. (Switching the DIP switch)
- AC110V, AC220V, AC110/$\sqrt{3}$V are all free input.
- The control can be selected from power factor control and reactive power control.
  Power factor control : Method that sets a target power factor value and controls the power factor so that it falls within an automatically set appropriate range.
  Reactive power control : Method to control by setting reactive power value to closing or breaking.
- The light load breaking function prevents the power factor from advancing too much when the load is light.
- This product can be selected closing or breaking operation of the capacitor.
  Closing or breaking the capacitor after the delay time.
  Instantly closing or breaking the capacitor.
- With the forced breaking function, the capacitor can be breaking by an external signal.
  Operation and to sequentially breaking the capacitor every 30 seconds, the operation to breaking all at once the capacitor in an instant can be selected.
- Depending on the application and purpose, you can choose from the following control.
  Cyclic control, Optimal control, Priority control, Multi-step control
- Various types of measurements (three-phase current, three-phase voltage, active power, reactive power, apparent power, power factor) can be displayed by key operation.

1.3 Composition of type

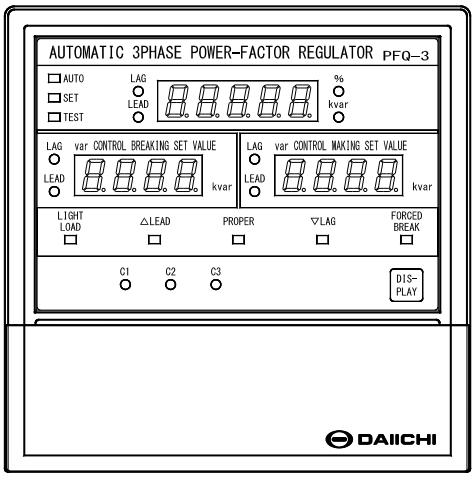
PFQ-(1) — (2) (3) (4)

Type　　Specification code

(1) Capacitor circuits	(2) Model	(3) Rated current	(4) Control power supply
6 : 6 circuits 3 : 3 circuits	B : Model B	1 : 5A 2 : 1A	1 : AC85 to 253V DC80 to 143V



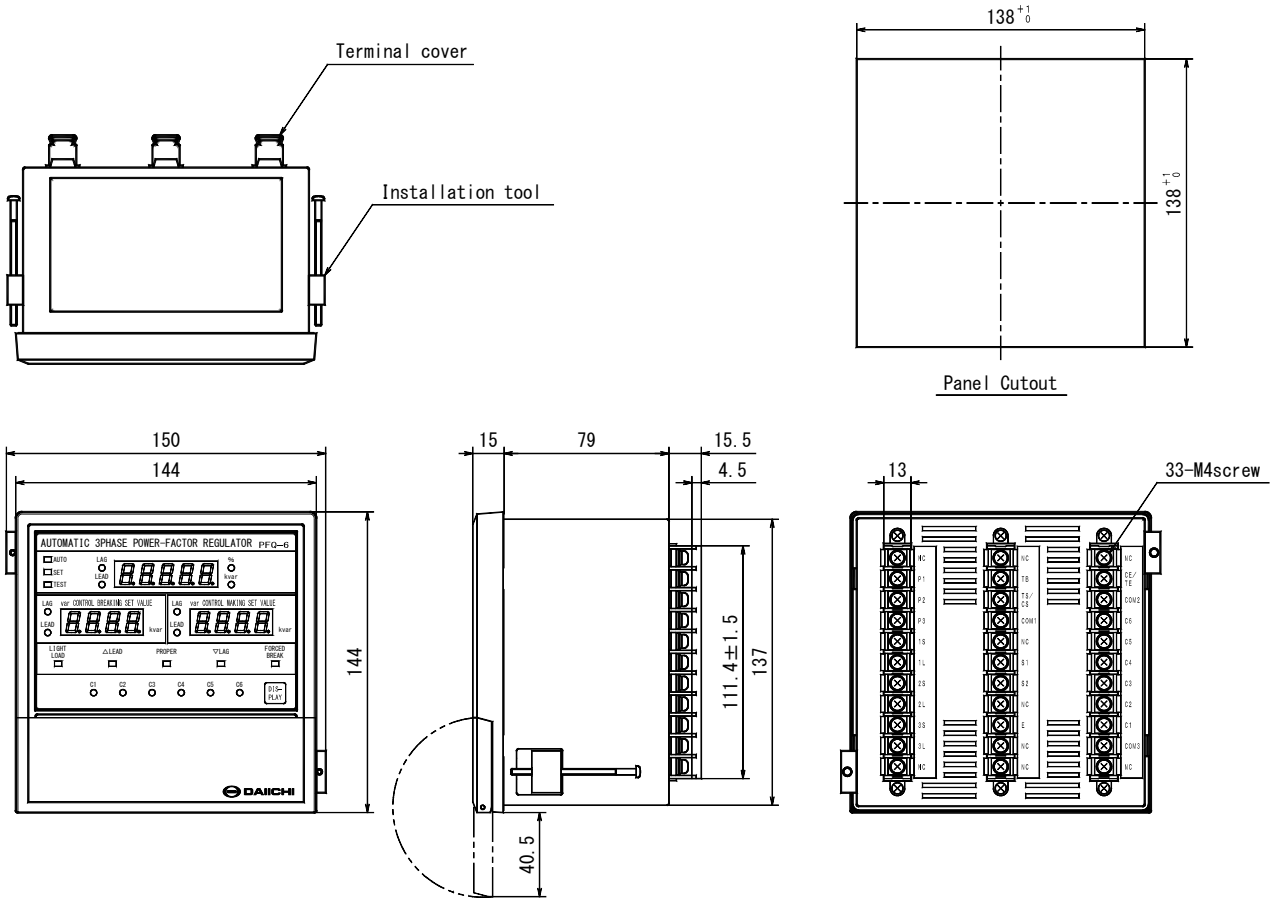
PFQ-6



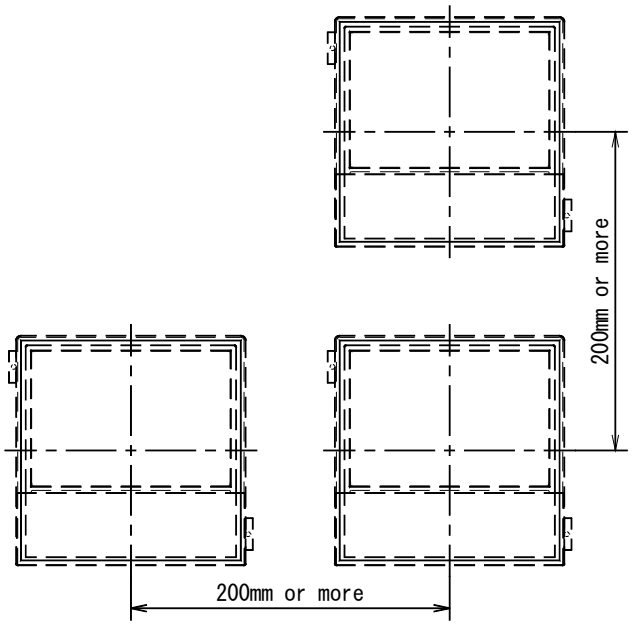
PFQ-3

2. Handling explanation

2.1 Outline dimension



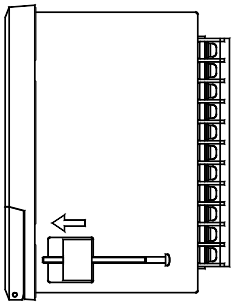
(Dimension of continuous installation)



Considering radiation of natural convection of atmosphere, keep space (200mm or more) between each equipment.
Also, secure a space of 50 mm or more on the top, bottom, left, and right of this product.

2.2 Mounting method

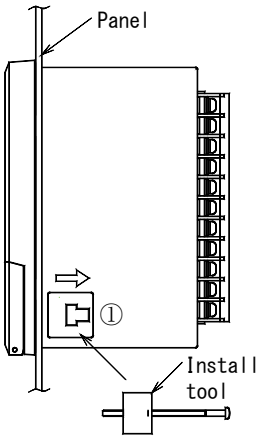
① Remove the install tool from PFQ.
Slide the install tool in the front direction to remove the install tool from the product.



② Install this PFQ in the mounting holes of a panel with a thickness of 6 mm or less.

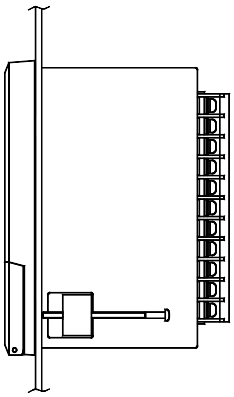
③ Attach the install tool to ① part on both sides of PFQ and slide it toward terminal direction.

<Note> The thickness of the mounting panel should be 6 mm or less.



④ Tighten the mounting screws with a phillips screwdriver.
Tightening torque 0.20 to 0.29 N·m.

Tightening when there is no torque driver.
Tighten both screws until they touch the panel, then tighten the screws about one turn to make sure the PFQ is secure.

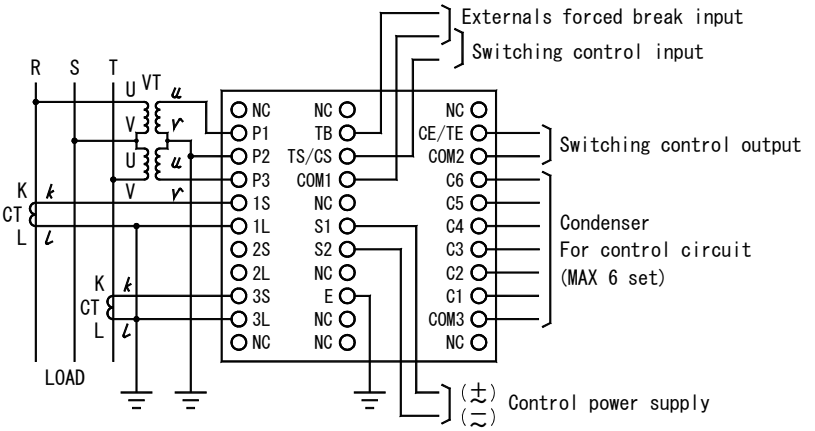


2.3 Connection

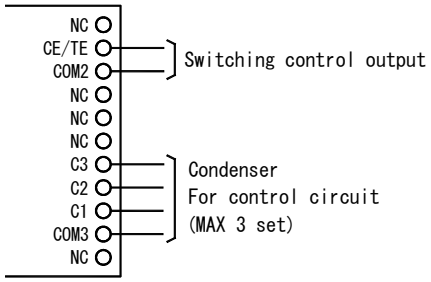
Tighten the terminal screws with a Phillips screwdriver. Tightening torque 1.0 to 1.3N·m

■ 3φ3W unbalanced load

PFQ-6

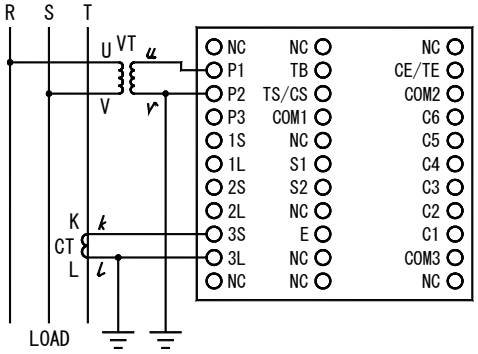


PFQ-3

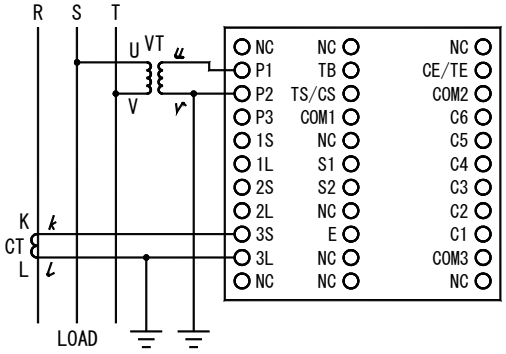


■ 3φ3W balanced load

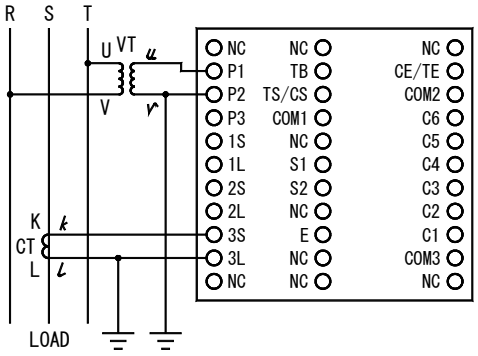
① Current T-phase connection



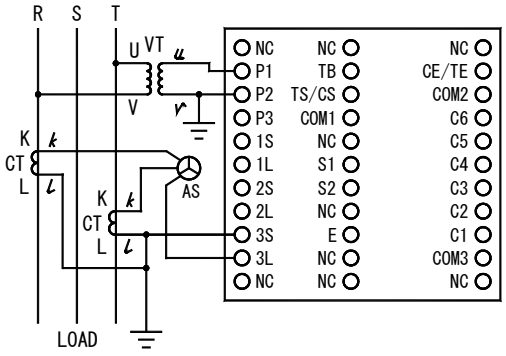
② Current R-phase connection



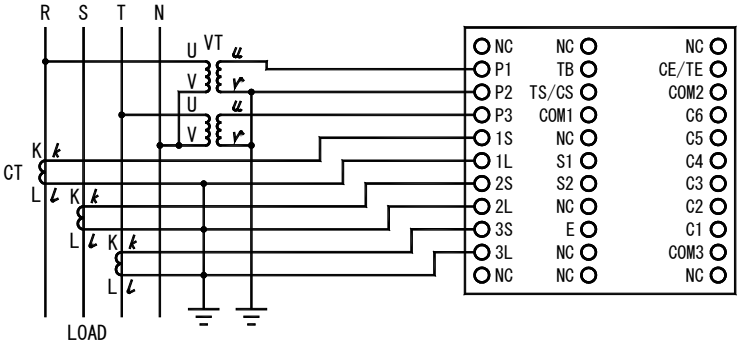
③ Current S-phase connection



④ Current S-phase connection (Synthesis of R and T-phases)

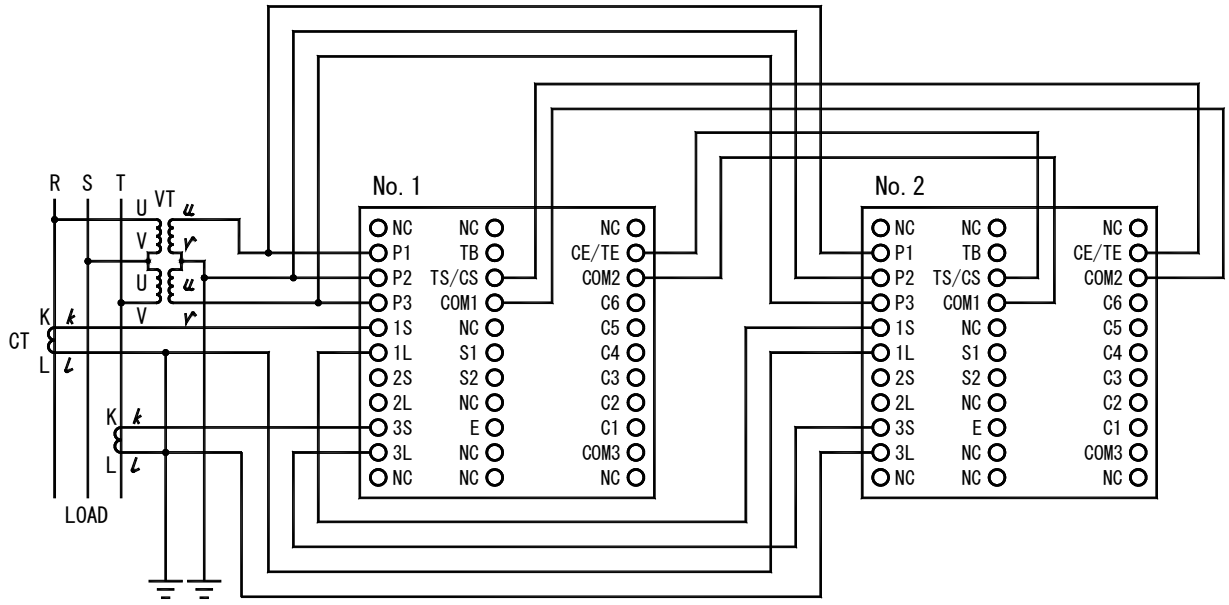


■ 3φ4W



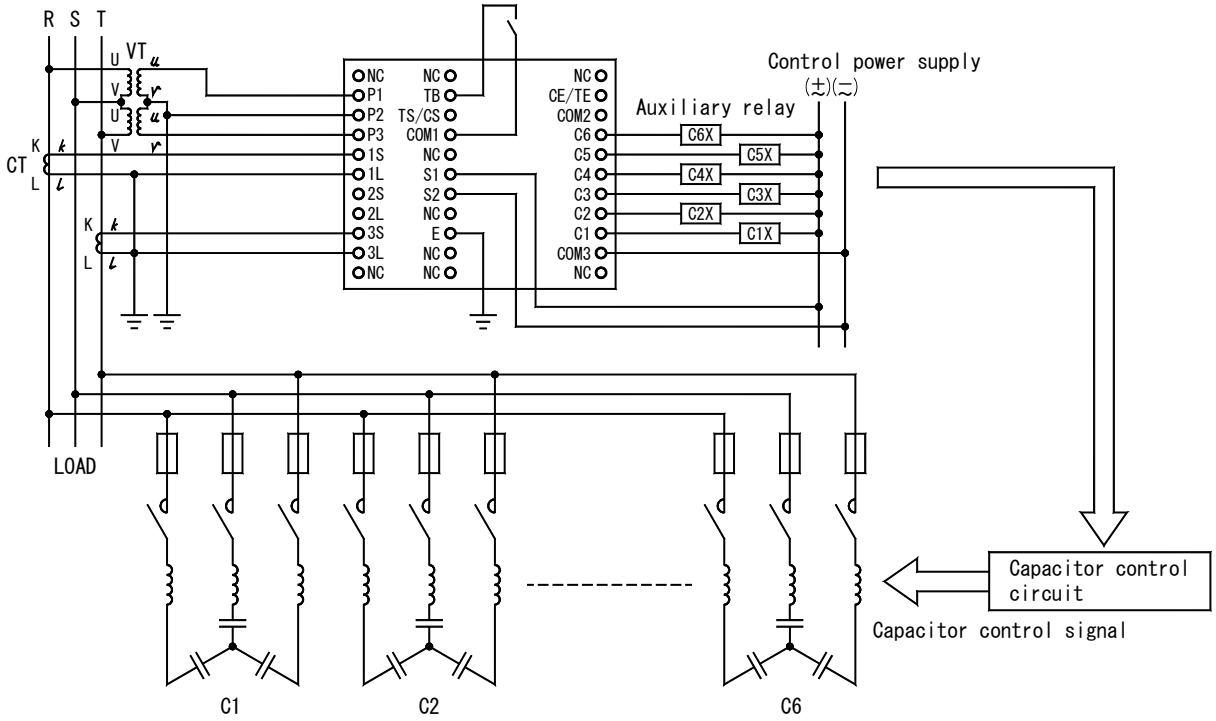
<Note> P2 terminal is N-phase.

■ Connection diagram when using two units (3φ3W unbalanced load)

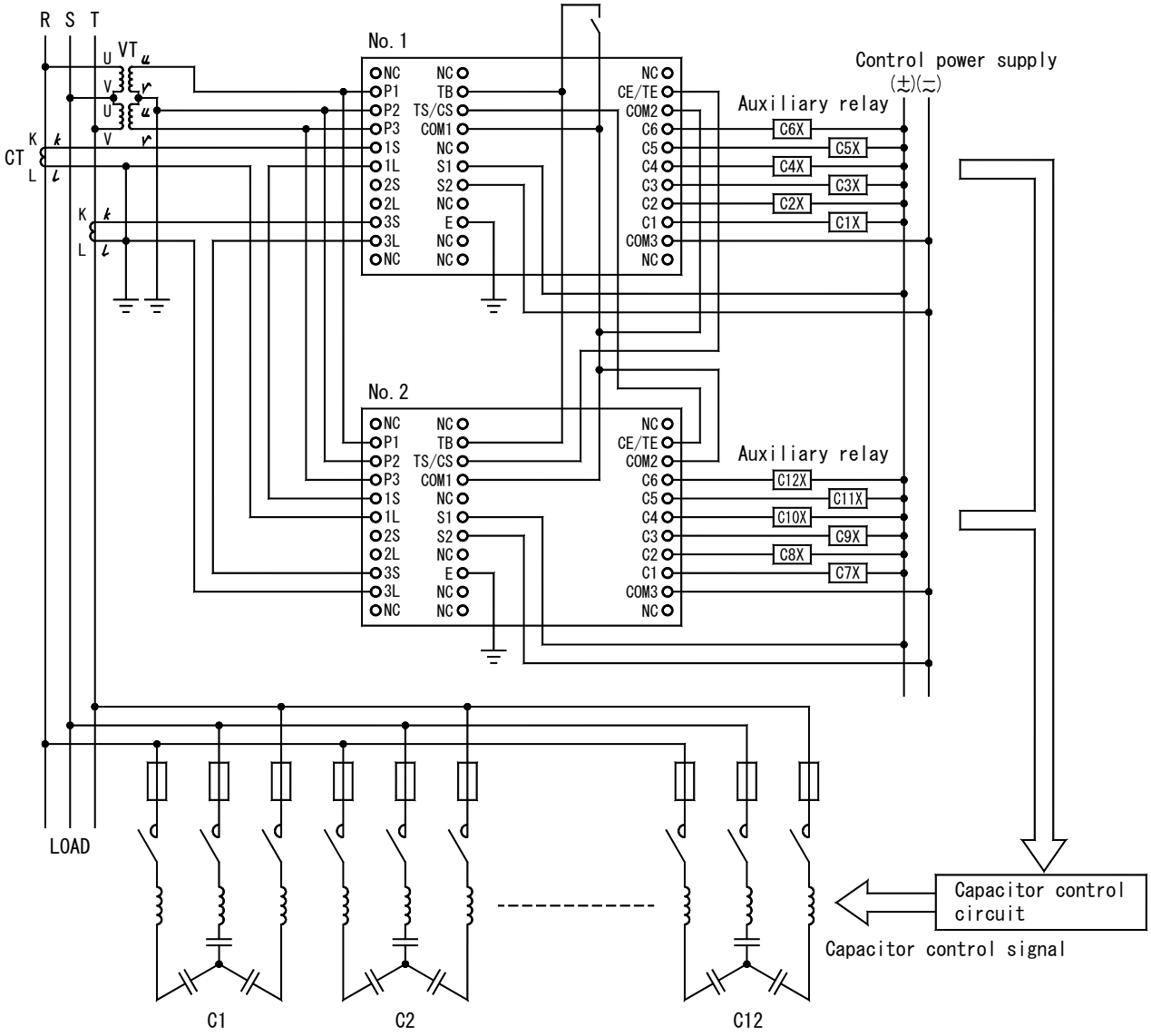


2.4 System connection example

2.4.1 3-phase 3-wire circuit unbalanced load capacitor 6 circuit example



2.4.2 3-phase 3-wire circuit unbalanced load capacitor 12 circuit example



2.5 Cautions on connections

- Please be sure to attach the terminal cover after wiring work.
- This product has noise immunity, but if a large amount of noise can be considered, separate the AC input and control power supply from the control output contact and other input/output wiring to effectively prevent malfunctions from external noise.
- Ground terminal E should be grounded to improve the shielding effect.
  Also, the ground resistance between the ground terminal and ground should be 100Ω or less.

2.6 Precautions for use

(1) Precautions when starting control

- Apply the control power after the power voltage is established.
  If the power supply voltage rises gradually, it may malfunction outside the power supply voltage range of this product.
- The DIP switch settings are read when the control power is applied. Check before applying control power. If you want to change the DIP switch settings during control, you can change the settings in "Setting mode".

(2) Precautions during control

- Close the switch cover when not changing the settings.
- When changing the setting during control, be sure to change the setting in "Setting mode".
  If the DIP switch setting is changed in "Automatic mode", "Err3" is displayed and the control stops.

(3) Precautions for control input and control output signals

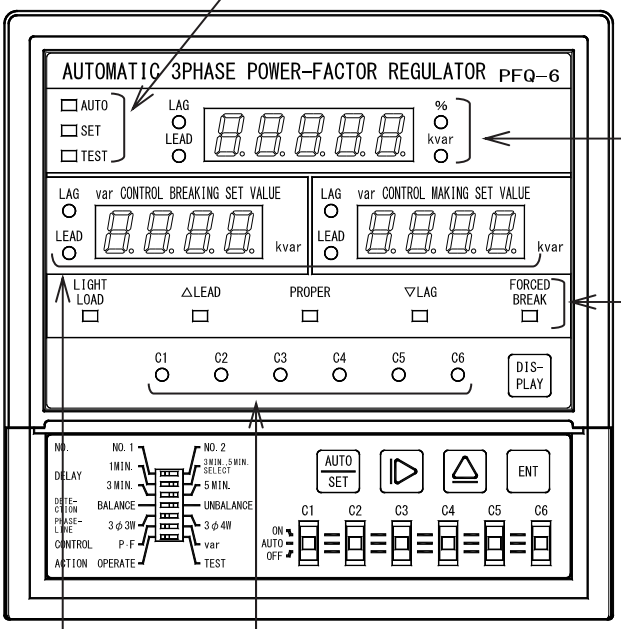
- The forced breaking input (between TB and COM1) is a non-voltage normally open contact (1a contact) input. (Circuit voltage/current 24V DC, 10mA)
  Please use the external relay whose minimum applicable load satisfies the switching voltage/current of 24V DC and 10mA.
- One side of the forced breaking input (between TB and COM1) and control switching input (between TS/CS and COM1) is common to the COM1 terminal.
- When operating the DC auxiliary relay with the control output contact (between C1 to C6-COM3 for PFQ-6, between C1 to C3-COM3 for PFQ-3), use the relay with surge suppressor.
- The control output contact (between C1 to C6-COM3 for PFQ-6, C1 to C3-COM3 for PFQ-3) is always exciting output for each capacitor, and it is C1 to C6 (PFQ-6) or C1 to C3 one side of (PFQ-3) is common to COM3 terminal.
- When connecting two units, connect the control switching output (between CE/TE-COM2) of Unit 1 to the control switching input (Between TS/CS-COM1) of Unit 2.
  Connect the control switching output (between CE/TE-COM2) of unit 2 to the control switching input (between TS/CS-COM1) of unit 1.

(4) Operation at power failure

- When a power failure occurs (control power is off), the operation stops and all the displays go out. Furthermore, all control output contacts are turned off. When the power is restored, all the control output contacts will restart from the OFF state.
- Control continues even if a power failure occurs only in the AC input circuit (control power is ON). However, if the light load breaking setting is being executed, the capacitors will be breaking in sequence.

3. Display

3.1 Names and functions of each part



① Control state display.
AUTO : LED (Green) lights in auto mode and display mode.
SET : LED (Orange) lights in setting mode.
TEST : LED (Red) lights in test mode.

② Current value display (Orange LED)
Current power factor value / current reactive power value are displayed.
Polarity is LAG, LEAD, the unit is % : Current power factor, kvar : Current reactive power.

③ Operation state display.
LIGHT LOAD : LED (Yellow) lights when the active power value falls below the set light load breaking value.
△LEAD : LED (Red) will light up when the power factor is in the forward direction relative to the proper range.
PROPER : LED (Green) lights when the power factor is within the proper range.
▽LAG : LED (Red) lights when the power factor delays against proper range.
FORCED BREAK : LED (Red) lights when forced breaking signal is input (TB-COM1 terminal short circuit) externally.

④ Control output display (Red LED)
Closing state of capacitor is displayed.
The LED (red) of each capacitor circuit lights up when the control output contact is ON (closed), and goes off when the control output contact is OFF (open). (PFQ-3 is C1, C2, C3 only)

⑤ Setting value display, data display (Green LED)

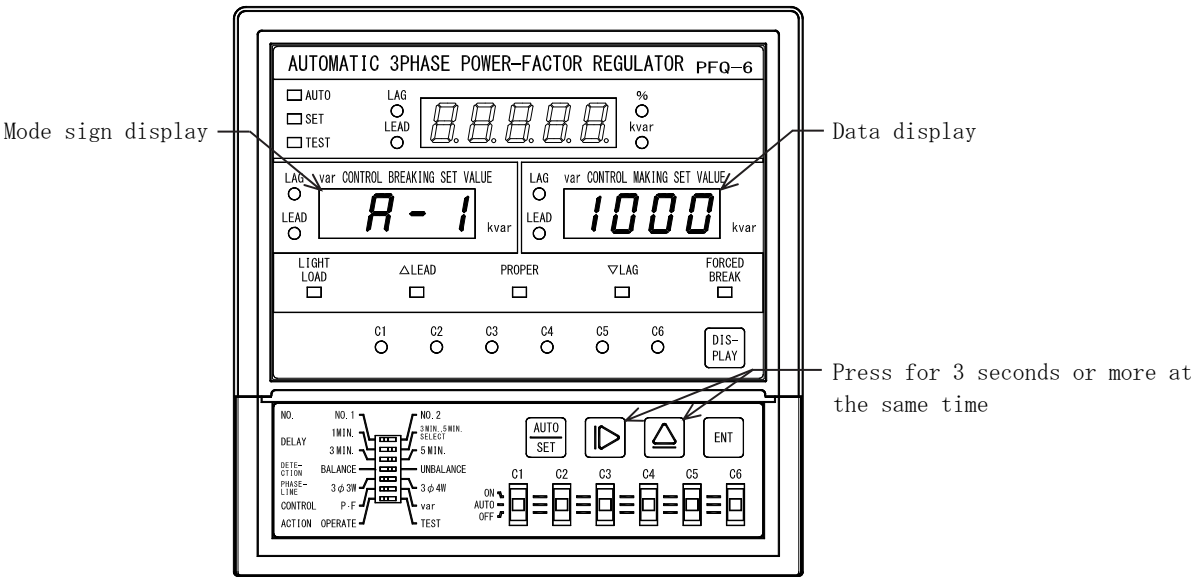
1. Setting value display
   When reactive power control is selected, the var control breaking value and var control closing value are displayed in automatic mode.
2. Data display
   Display mode appears when [▷][△] switches can be pressed simultaneously for 3 seconds or more in automatic mode.
   Mode sign is displayed in var control breaking value part and measuring data is displayed in var control closing value part.
   To cancel the display mode, press the [▷][△] switch once at the same time to return instantly.

3.2 Display of current power factor and current reactive power

In the automatic mode, the 7-segment LED on the top shows the power factor current value or reactive power current value.
The power factor or reactive power display can be switched by pressing the [DIS-PLAY] switch.

3.3 Other measurement data display (Display mode)

The measurement data can be displayed by opening the switch cover and performing the following operations.



(1) R phase current display (A-1)

Press the switches [▷] and [△] simultaneously for 3 seconds or more to enter the display mode, and the following is displayed.

The mode sign is displayed on the 7-segment LED on the lower left. (Example : A-1)

The current value of data display on the 7-segment LED on the lower right. (Example : 100.0A)

(2) Display other elements

When the [DIS-PLAY] switch is pressed in the display mode, the current values of other elements will be displayed. Furthermore, if you press the [DIS-PLAY] switch, each element will be displayed in order. (Displayed in the order shown in the table below)

Mode sign display	Display description
A-1	Current A_R (A)
A-2	Current A_S (A)
A-3	Current A_T (A)
1-2	Voltage V_{R-S} (V)
2-3	Voltage V_{S-T} (V)
3-1	Voltage V_{T-R} (V)
UW	Active power (kW)
UWr	Reactive power (kvar)
UA	Apparent power (kVA)
PF	Power factor (%)

3.4 Cautions on display

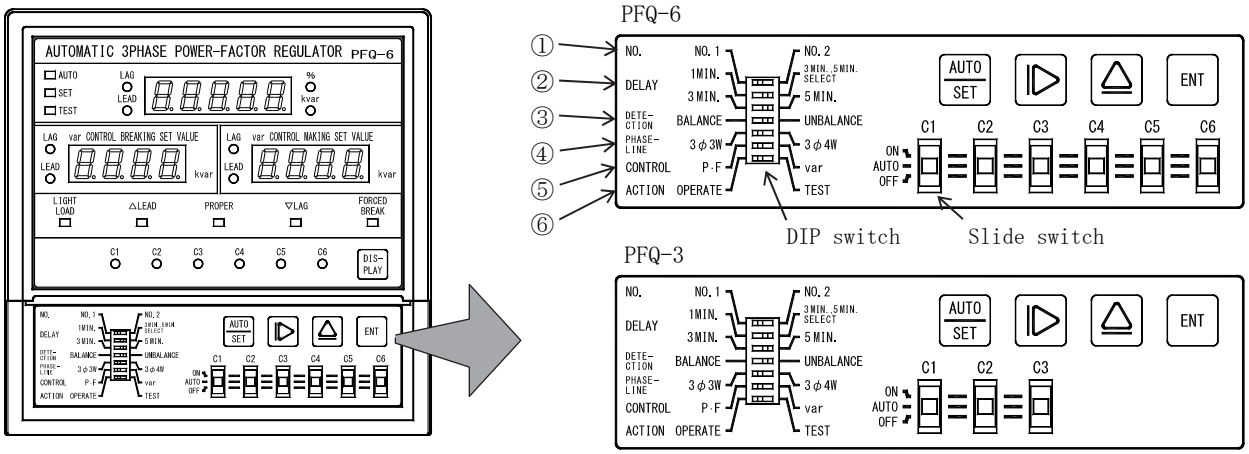
After displaying the data, be sure to return to the automatic mode.

(Press the [▷] and [△] switches at the same time to return to the automatic mode.)

Finally, close the switch cover.

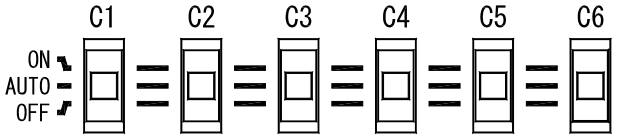
4. Setting

4.1 Arrangement of DIP switch and slide switch



4.2 Slide switch setting (AUTO mode)

This switch is a changeover switch for capacitor circuits.
Set the "Manual ON", "AUTO", and "Manual OFF" of the capacitor circuit for each capacitor circuit.
The setting can be changed during the automatic mode.



<Note> The factory setting is AUTO.

<Note> Set the switches of unused capacitor circuit No. to "Manual OFF".

⚠CAUTION	Please set the slide switch to the correct position at either ends or the center of the switch. If the switch position is incorrect, "Err4" will be displayed and the control will stop. When set to the correct position, "Err4" will be cancelled.

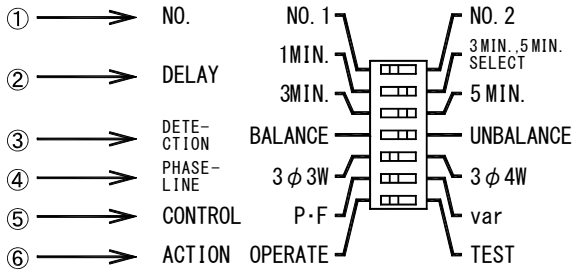
① Manual ON ····· When the delay operation setting value is "1", the capacitor is closing after the delay time has elapsed.
When the delay operation setting value is "2", the capacitor is closing instantly.
However, if the re-closing prevention timer that starts immediately after the capacitor is shut off has not passed, the capacitor is closing after the re-closing prevention timer has elapsed.

② AUTO ····· Depending on the control system, the closing and breaking of the capacitor are performed automatically.

③ Manual OFF ···· The capacitor is breaking instantly.

4.3 DIP switch settings (Setting mode)

Press switch [AUTO SET] to change to setting mode.
In the setting mode, all timers such as delay time and reclosing prevention timer are cleared.
If the DIP switch settings are changed without changing to the setting mode, "Err3" will be displayed and the control will stop. If the changed switch is returned to its original position, "Err3" will be canceled.



No.	SETTING ITEM	DEFAULT
①	NO.	NO. 1
②	DELAY	5 MIN.
③	DETECTION	UNBALANCE
④	PHASE LINE	3φ3W
⑤	CONTROL	P·F
⑥	ACTION	OPERATE

⚠CAUTION	Use the tip of screwdriver / ball-point pen for DIP switch setting change. Do not use soft tip such as pencil. Please set the slide-switch as the right position of the both ends or the center. If the switch is in the middle position, this product malfunctions.

① No. ····· Switch between NO.1 and NO.2 devices. Normally set to "No. 1".
The PFQ-6 controls up to 12 circuits and sets the devices on the C7 to C12 sides to "NO.2".
The PFQ-3 controls up to 6 circuits and sets the devices on the C4 to C6 sides to "NO.2".

② DELAY ··· Delay time setting in closing/breaking of capacitor. ● Switch direction

	Delay time "1 minute"	Delay time "3 minutes"	Delay time "5 minutes"
Setting of switch	1 MIN. ● 3 MIN. / 5 MIN. select or ● 3 MIN. ● 5 MIN. ●	● ●	● ●

Selection of delay time

Discharge device		Delay time
None	Low voltage	3 minutes or more
	High voltage	5 minutes
Discharge coil		1 minute or more
Discharge resistance		5 minutes

③ DETECTION ···· 3-phase 3-wire balanced load : Set to "BALANCE". (1VT,1CT)
3-phase 3-wire unbalanced load : Set to "UNBALANCE". (2VT,2CT)
3-phase 4-wire : No settings required. (2VT,3CT)

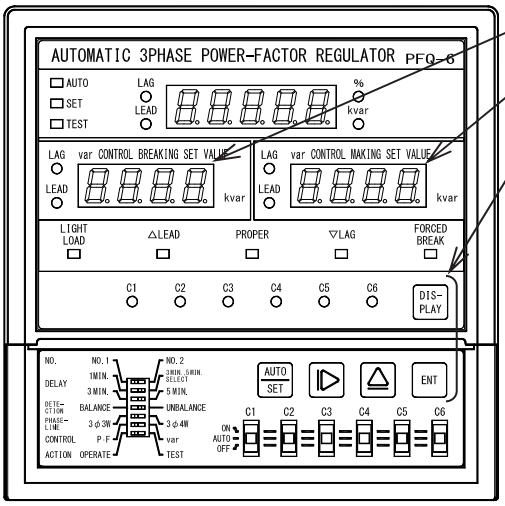
④ PHASE LINE ··· 3-phase 3-wire : Set to "3φ3W".
3-phase 4-wire : Set to "3φ4W".

⑤ CONTROL ····· Control by aimed power factor : Set to "P·F". Control by reactive power : Set to "var".

⑥ ACTION ····· Switching between OPERATE and TEST. Normally set to "OPERATE" (AUTO mode).
When set in TEST mode, closing in C1 → C2 ···→ C6 sequence, breaking in C1 → C2 ··· → C6 sequence, can be repeated (15 seconds interval). (PFQ-3 is closing in sequence of C1 → C2 → C3, and it breaking in sequence of C1 → C2 → C3.)

⚠CAUTION	This operation is repeated during the test mode. If a capacitor is connected, be sure to change the setting from "TEST" to "OPERATE" after completing the one cycle. In the case of a high-voltage capacitor, the residual voltage may be turned on again without sufficient discharge, resulting in a high transient voltage, which may cause the capacitor to malfunction.

4.4 Key switch setting (Setting mode)



Mode sign display

Setting value display

Key switch

DIS-PLAY ..... In automatic mode, switch display items.
In setting mode, switch setting items.

AUTO SET ..... Switch between automatic and setting mode.

▷ △ ... Change the setting value in setting mode.

ENT ..... Data confirmation switch after setting change.
(In setting mode)
The setting value is stored in the internal memory.

To change the setting, switch to the setting mode.
When switching from automatic mode to setting mode, control is interrupted (current status is maintained).
(While in display mode, you cannot switch from automatic to setting. Cancel the display mode and then switch to the setting mode.)

<Caution> Control is interrupted (maintained) during setting, and the 7-segment LED on the upper row lights off.

(Setting range and default setting value)

No.	Setting description	Mode sign display	Setting range	Default setting	
				Rated current 5A	Rated current 1A
①	VT ratio	U	1 to 90	60	60
②	CT ratio	C	1 to 1200	20	20
③	Target power-factor (P·F control)	P.F	LEAD 95 to 100 to LAG 85%	LAG 98%	LAG 98%
④	var control closing value (var control)	On	0 to LAG 999kvar	LAG 100kvar	LAG 20kvar
⑤	var control breaking value (var control)	OFF	LEAD 1 to LEAD 999kvar	LEAD 20kvar	LEAD 4kvar
⑥	Light-load breaking setting	Load	0 to |9999|kW	|200|kW	|40|kW
⑦	Control system	Ac 1	1 to 6	1	1
⑧	C1 to C6 capacitor capacity (PFQ-3 : C1 to C3)	c 1 to c6	1 to 9999kvar	100kvar	20kvar
⑨	Delayed operation	dEL	1 to 2	1	1
⑩	Forced breaking operation	Fb	1 to 2	1	1

<Note> If the setting is outside the setting range, the setting will not be changed even if the ENT switch is pressed, and the setting value before the setting change will be restored.

<Note> After changing the setting, be sure to press the ENT switch. (The set value is stored in the internal memory.)

① VT ratio
Ratio of primary rated voltage and secondary rated voltage of VT. (Primary rated voltage / secondary rated voltage)
(Example) For 6600/110V, the VT ratio is 60.
Please set VT=1, if it inputs direct voltage (AC220V) without using VT.

② CT ratio
Ratio of primary rated current and secondary rated current of CT. (Primary rated current / secondary rated current)
(Example) For 100/5A, the CT ratio is 20.

③ Target power-factor
The power-factor value (%) which makes a capacitor closing.
When the delay power factor occurs from the set target power factor value, the capacitor is closing.
Please set considering the power factor after closing the capacitor.
When using var control, setting is unnecessary.

④ var control closing value
The reactive power value (kvar) which makes a capacitor closing.
Please set considering the reactive power after closing the capacitor.
Set it to the same value as the capacitor capacity (for one circuit) used as a guide for the set value.
When using P･F control, setting is unnecessary.

⑤ var control breaking value
The reactive power value (kvar) which makes a capacitor breaking.
Please set considering the reactive power after breaking the capacitor.
As a guideline for the setting value, set it to the value of the capacitor capacity to be used ×0.2. (Margin is 20% to prevent hunting)
When using P･F control, setting is unnecessary.

⑥ Light-load breaking setting value
The effective power value (kW) which makes a capacitor breaking at the case of a light load.
Setting value guide
① Set to a value of minimum load ×1.2 to 1.4.
(Example) When the minimum load is 125kW, the set value is 150 to 175kW
② If the minimum load is unknown, set it to 10% of the rated power. Since the minimum load is unknown, once it is in operation, change the setting value to match the actual load.
(Example) Equipment of 6600/110V, 100/5A
Light load breaking ＝ VT ratio 60 × CT ratio 20 × 1kW (110V,5A) ×10%
＝ 120kW
(Example) Equipment of 6600/110V, 20/1A
Light load breaking ＝ VT ratio 60 × CT ratio 20 × 0.2kW (110V,1A) ×10%
＝ 24kW
When using the dip switch control with "var", there is no problem even if the light load breaking value ＝0kW. (Because it is controlled by the var control closing value and the var control breaking value)

⑦ Control system
Select the method of closing and breaking the capacitor.

Set value 1 : Cyclic control (Equal capacity control operation)
DIP switch control can be used with "P/F" and "var".

Set value 2 : Optimal control (Different capacity control operation)
DIP switch control can be used with "PF".

Set value 3 : Priority control (Different capacity control operation)
DIP switch control can be used with "PF".

Set value 4 : Multi step control ① (Capacitor capacity ratio 1 : 2 : 2 : 2 : 2 : 2)
DIP switch control can be used with "P/F" and "var".

Set value 5 : Multi step control ② (Capacitor capacity ratio 1 : 2 : 4 : 4 : 4 : 4)
DIP switch control can be used with "P/F" and "var".

Set value 6 : Multi step control ③ (Capacitor capacity ratio 1 : 2 : 4 : 8 : 8 : 8)
DIP switch control can be used with "P/F" and "var".

Refer to page 25 to 31 for operation explanation

<Note> When the control system set value 1 and 4 to 6 are selected, only the capacitor capacity of C1 can be set, and C2 to C6 (PFQ-3 C2 to C3) are automatically set.

<Note> When the control system set value 4 to 6 is selected, the setting range of the capacitor capacity C1 is set value 4 = 1 to 4999 kvar, set value 5 = 1 to 2499 kvar, set value 6 = 1 to 1249 kvar.

<Note> When the multi-step control of set value 4 to 6 of the control system is selected, the setting of ⑨ delay operation is set value 1. (Set value "2" cannot be set)

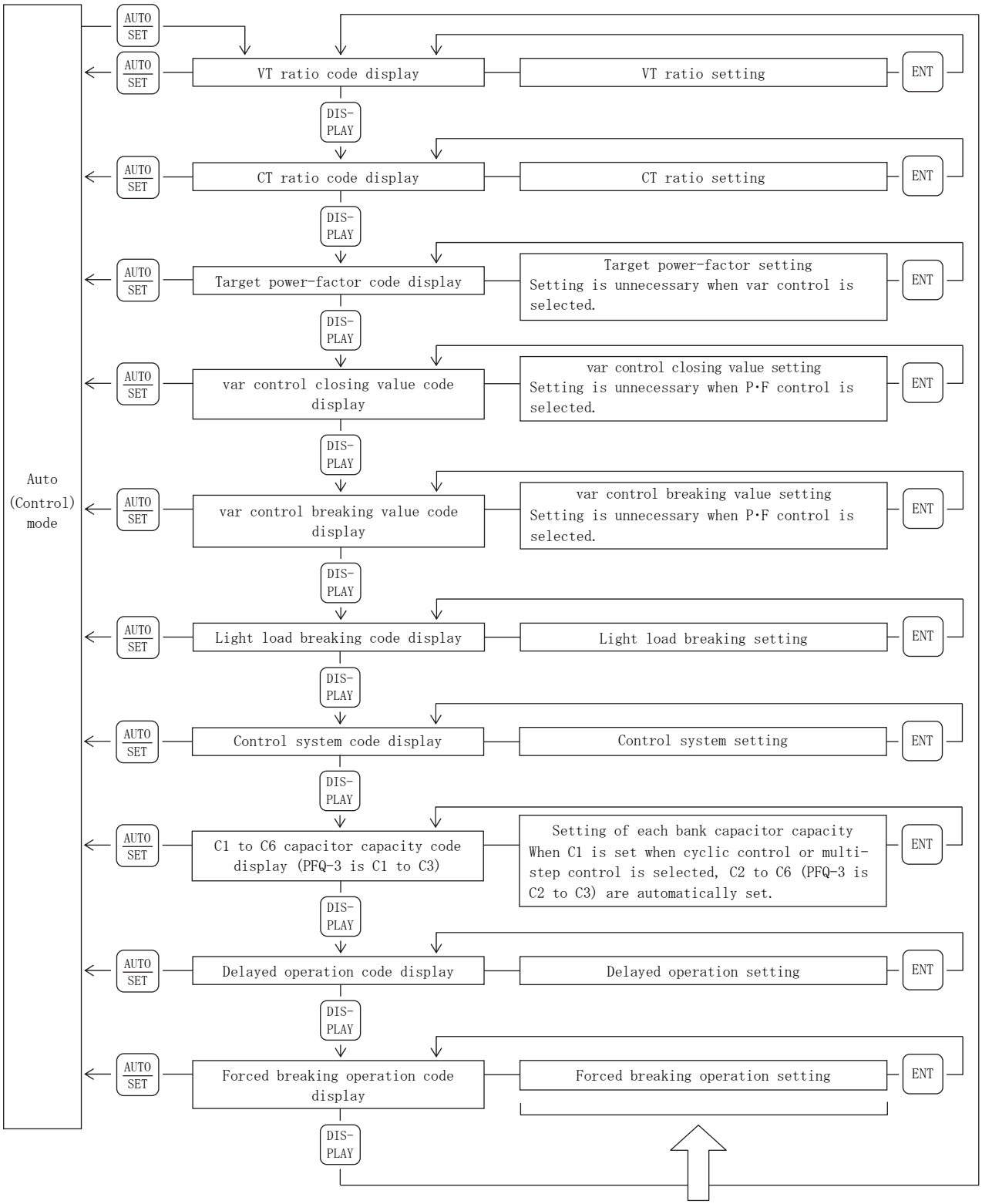
⑧ Capacitor capacity
Set each capacitor capacity of used.
Set the capacity of each capacitor to be used. (Please set the rated equipment capacity)
The capacity of the capacitor which it does not use is setting needlessness.

⑨ Delayed operation
Time to closing and breaking the capacitor.
Set value 1 : The capacitor is closing or breaking after the delay time has elapsed.
Set value 2 : Instantly closing or breaking the capacitor.
The delay time is a reclosing prevention timer that starts when the control power is applied, the capacitor is breaking, and the setting mode is released.

<Note> When multi-step control with the set value 4 to 6 of ⑦ control system is selected, the set value is 1. (Set value 2 cannot be set)

⑩ Forced breaking operation
Time to breaking the capacitor by external signal
Set value 1 : While the forced breaking input terminal is short-circuited, the capacitor is breaking every 30 seconds.
Set value 2 : When the forced breaking input terminal is short-circuited, the capacitors will be breaking instantly.

● Overview of setting operation



Each setting item moves the digit of set value with ▷ switch. And, it advances set value with △ switch. Whenever it pushes △ switch once, it repeats the values from 0 to 9, and indicates. If a setting change is made, please push an ENT switch for every setting item.

4.5 Special settings

For usage beyond the setting range, use 1/10 of the value actually used.

Set value input multiplication factor

Item / Conditions	VT ratio	CT ratio	Target power-factor	var control closing value
When the primary voltage is 1/10	1/10	1	1	1/10
	1/10	10	1	1
When the primary current is 1/10	1	1/10	1	1/10
	10	1/10	1	1
When the primary voltage and current is 1/10	1/10	1/10	1	1/100

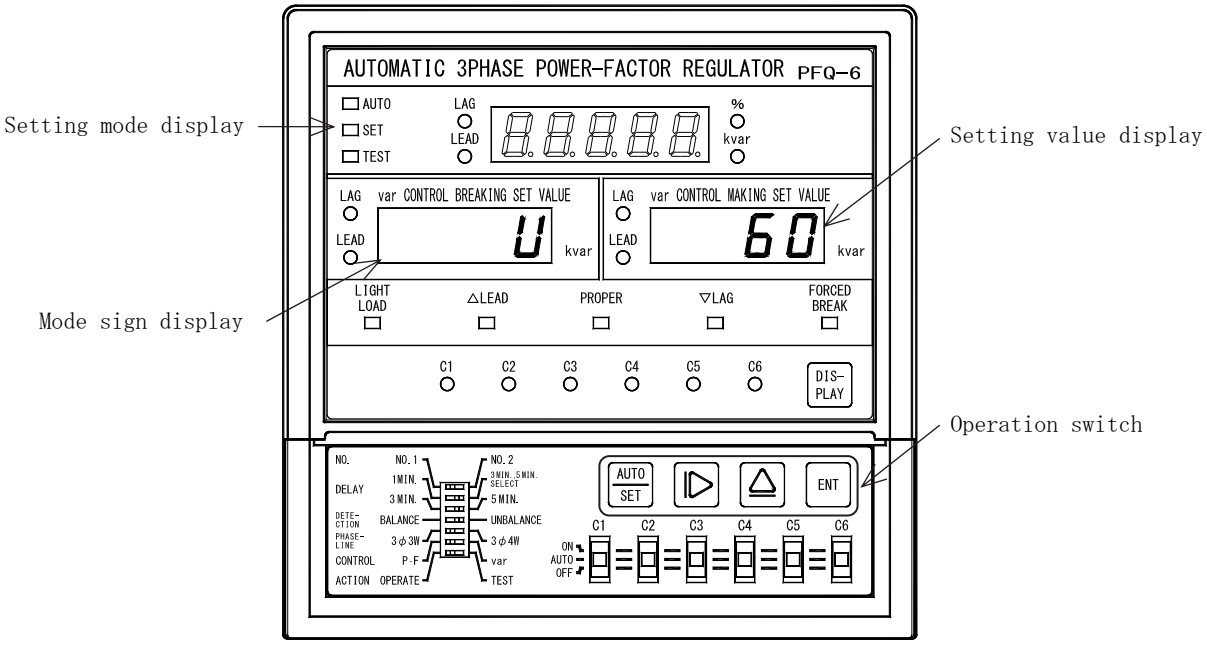
Item / Conditions	var control breaking value	Light load breaking	Capacitor capacity
When the primary voltage is 1/10	1/10	1/10	1/10
	1	1	1
When the primary current is 1/10	1/10	1/10	1/10
	1	1	1
When the primary voltage and current is 1/10	1/100	1/100	1/100

In this case, read the measured display value after multiplying it by the multiplication factor.

Measurement display multiplication factor

Item / Conditions	Voltage	Current	Three-phase active power	Power factor
When the primary voltage is 1/10	10	1	10	1
	10	1/10	1	1
When the primary current is 1/10	1	10	10	1
	1/10	10	1	1
When the primary voltage and current is 1/10	10	10	100	1

4.6 Key switch operation



(1) VT ratio setting

① Select SET mode by pressing [AUTO SET] switch (SET LED is lights).

② The mode sign display shows the VT ratio (U), and the setting value display shows the current set value (initial value 60).

③ When item excepting VT ratio is set, press [DIS-PLAY] switch and change mode sign (setting item).
Items can be changed in following sequence (CT ratio → Target power-factor ····· → Forced breaking operation → VT ratio).

④ Change VT ratio from 60 to 4 in ② state above-mentioned. As uppermost digit is blinking currently, move blinking to first digit by [▷] switch (60).
Blinking

⑤ Change the numeral of first digit by pressing [△] switch.
Whenever it pushes once, +1 (the next of 9 is 0) is taken.
Pushes 4 times and changes into 4 from 0.

⑥ Next, it pushes [▷] switch and changes the number of the digit of 10.
As 6 is blinking currently, it pushes a [△] switch 4 times and changes it into 0.

⑦ Because the set value of VT ratio was set to 04 above, it pushes and enters an [ENT] switch.

⑧ When the set value is registered, blinking will stop for 2 seconds. This completes the settings.

(2) Setting of other setting item

① Press the [DIS-PLAY] switch to change to the item display for setting the mode sign.

② Follow the same procedure of VT ratio setting for setting value change.

(3) Return to AUTO mode by pressing [AUTO SET] switch after completing setting value change. (AUTO LED is lights)

4.7 Cautions on setting

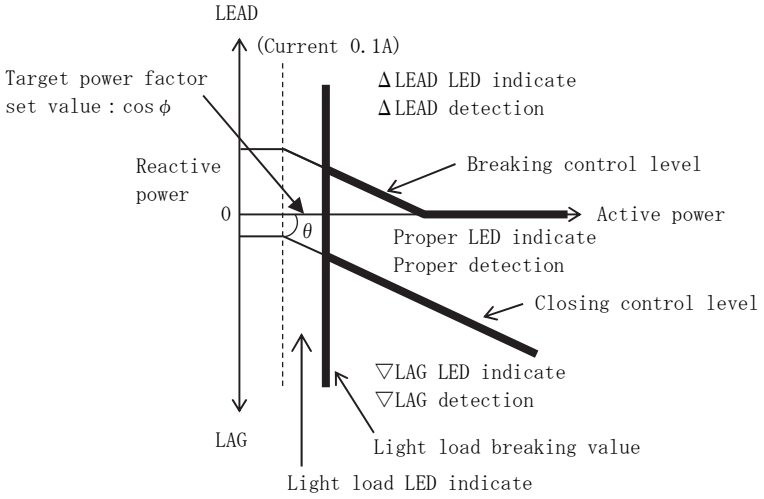
- Please after completing the setting, return to the automatic mode. Also, be sure to close the switch cover.
- If the settings are incorrect, the planned control cannot be achieved. Check the set value and carefully perform it. Also, after changing the settings, check whether the planned control has been realized.

5. Control

5.1 Power factor control

This is a control method that closing and breaking the capacitor in comparison with the set target power factor. From light load to heavy load, it is controlled within the set constant power factor.
In other words, it can be controlled with a constant power factor regardless of the load, but depending on the capacitor capacity when the load is light, the power factor may go too far.
Therefore, light load breaking is essential.
Closing and breaking of the capacitor is controlled by the following calculation method.
Closing control level : Reactive power value that the capacitor closing (▽ LAG LED lights)
Breaking control level : Reactive power value that the capacitor breaking (△ LEAD LED lights)
Capacitor capacity : C1 capacitor capacity for cyclic control. The optimum control is the minimum capacity of the already closing capacitor that is automatically closing.
The priority control is the capacity of the last capacitor that is automatically closed. Multi-step control is C1 capacitor capacity.

(1) Target power factor LAG 99% or less setting



- Closing control level (LAG kvar)
  = The reactive power value calculated from active power (kW) and target power factor.
  = Active power (kW) $\times \sqrt{\frac{1}{\cos^2\theta} - 1}$

- Breaking control level (kvar) = Closing control level − Capacitor capacity ×1.2
  If the closing control level is 1.2 times or more the capacitor capacity, 0kvar (power factor = 1) is the breaking level.

(Example) Active power : 300kW, Target power-factor : LAG 98%, Capacitor capacity : 100kvar

Closing control level (LAG kvar) = $300\text{kW} \times \sqrt{\frac{1}{0.98^2} - 1}$
= 300kW ×0.203
= 61kvar ··· Capacitor closing by LAG 61kvar.

Breaking control level (kvar) = 61kvar − 100kvar ×1.2
= 61kvar − 120kvar
=-59kvar ··· Capacitor braking by LEAD 59kvar.

(Example) Active power : 800kW, Target power-factor : LAG 98%, Capacitor capacity : 100kvar

Closing control level (LAG kvar) = $800\text{kW} \times \sqrt{\frac{1}{0.98^2} - 1}$
= 800kW ×0.203
= 162kvar ····· Capacitor closing by LAG 162kvar

Breaking control level (kvar) = 162kvar − 100kvar ×1.2
= 162kvar − 120kvar
= 42kvar ··· Capacitor breaking by 0kvar (power factor =1).

- When the secondary current is 0.5A or less, will be constant at the reactive power at the time of 0.5A. (PFQ-6, PFQ-3)

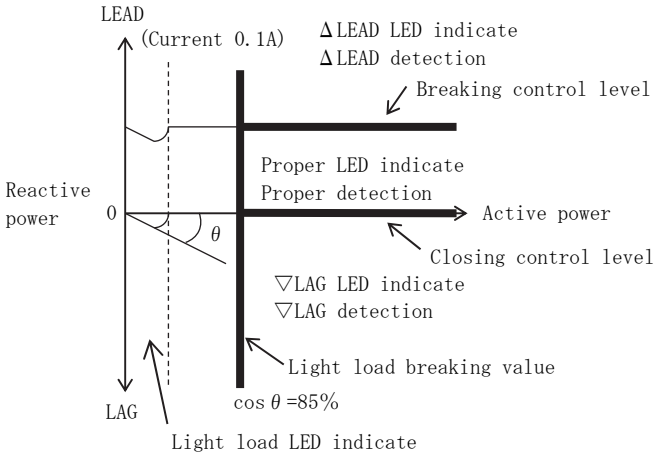
  Closing control level (kvar) $=\sqrt{3}\times$V・I (Equivalent to 0.5A)・$\cos\theta\times\sqrt{\frac{1}{\cos^2\theta}-1}$

  (Example) Active power : 90kW, Target power-factor : 98%, Capacitor capacity : 100kvar,
  VT ratio : 60 (6600/110V), CT ratio : 20 (100/5A)

  Closing control level (LAG kvar) $=\sqrt{3}\times 6600\text{V}\times 10\text{A}\times 0.98\times\sqrt{\frac{1}{0.98^2}-1}$
  $=$ 112kW $\times 0.203$
  $=$ 23kvar ・・・ Capacitor closing by LAG 23kvar
  ($\cos\theta=0.969$)

  Breaking control level (kvar) $=$ 23kvar $-$ 100kvar $\times 1.2$
  $=$ 23kvar $-$ 120kvar
  $=$-97kvar ・・・ Capacitor breaking by LEAD 97kvar
  ($\cos\theta=0.680$)

(2) The setting of the target power factor 100%



- Closing control level (kvar) = 0kvar (Power factor =1)

- Breaking control level (kvar) = Closing control level $-$ Capacitor capacity $\times$ 1.2

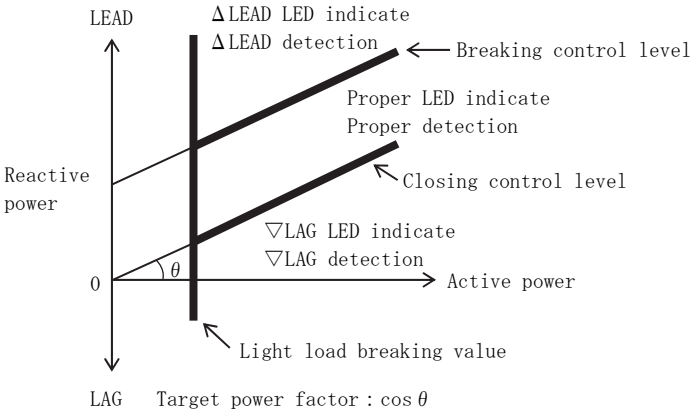
  (Example) Active power : 300kW, Target power-factor : 100%, Capacitor capacity : 100kvar,
  Closing control level (kvar) = 0kvar ・・・ Capacitor closing by 0kvar
  Breaking control level (kvar) = 0kvar $-$ 100kvar $\times$ 1.2
  = 0kvar $-$ 120kvar
  = -120kvar ・・・ Capacitor breaking by LEAD 120kvar

- When the secondary current is 0.2A or less, the target power factor is constant at 85%. (PFQ-6, PFQ-3) (Rated current 1A specification is 0.04A or less)

  Closing control level (LAG kvar)
  = Reactive power value (kvar) calculated from active power (kW) and target power factor of 85%.
  = Active power (kW) $\times\sqrt{\frac{1}{0.85^2}-1}$
  = 0.62 $\times$ Active power (kW)

  (Example) Active power : 20kW, Target power-factor : 100%, Capacitor capacity : 25kvar,
  VT ratio : 60 (6600/110V), CT ratio : 20 (100/5A)
  Closing control level (kvar) = 0.62 $\times$ 20kW
  = 12kvar ・・・・・ Capacitor closing by LAG 12kvar.
  ($\cos\theta=0.857$)
  Breaking control level (kvar) = 12kvar $-$ 25kvar $\times$ 1.2
  = 12kvar $-$ 30kvar
  = -18kvar ・・・ Capacitor breaking by LEAD 18kvar
  ($\cos\theta=0.743$)

(3) Target power factor LEAD 99% or less setting



- Closing control level (LEAD kvar) = Active power (kW) $\times \sqrt{\frac{1}{\cos^2\theta} - 1}$
- Breaking control level (LEAD kvar) = Closing control level − Capacitor capacity ×1.2

(Example) Active power : 300kW, Target power-factor : LEAD 98%, Capacitor capacity : 100kvar

Closing control level (LEAD kvar) = $300\text{kW} \times \sqrt{\frac{1}{0.98^2} - 1}$

= 300kW × 0.203

= 61kvar ····· Capacitor closing by LEAD 61kvar

Breaking control level (LEAD kvar) = 61kvar + 100kvar ×1.2

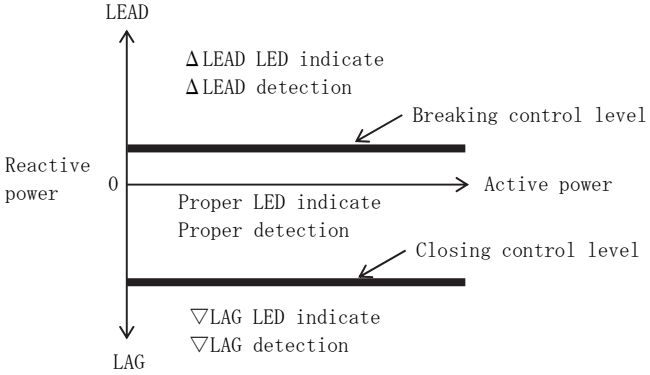
= 61kvar + 120kvar

= 181kvar ····· Capacitor braking by LEAD 181kvar

5.2 Reactive power control

This is a control system that closes and breaks the capacitor by comparing it with the set reactive power value. Controls from light load to heavy load within the set reactive power range.
Since the closing value and breaking value are set with reactive power, the power factor under light load deteriorates, but hunting can be prevented at light load. To prevent hunting after closing or breaking the capacitor, ensure that the span between the var control closing value and the var control breaking value is 1.2 times or more the capacity of the capacitor to be used.

Capacitor capacity : Cyclic control is C1 capacitor capacity
Multi-step control is C1 capacitor capacity



Closing control level (LAG kvar) = var control closing value (kvar)
Breaking control level (LEAD kvar) = var control breaking value (kvar)
} Fixation

(Example) Active power (kW) : 300kW, var control closing value : LAG 100kvar,
var control breaking value : LEAD 20kvar, Capacitor capacity : 100kvar
Closing control level (LAG kvar) = 100kvar
····· Capacitor closing by LAG 100kvar ($\cos\theta$ =0.949)
Breaking control level (LEAD kvar) = 20kvar
····· Capacitor braking by LEAD 20kvar ($\cos\theta$ =0.998)

6. Operation explanation

6.1 Features of each control system

Control	Features
Cyclic control	Suitable for equal capacity capacitor control. Since the opening and closing frequency of the vacuum magnetic contactor is made uniform, a long life can be expected. All circuits can be replaced at the same time when they reach the end of their service life.
Optimal control	suitable for a circuit with a large load fluctuation, and controlling capacitors with different capacities. However, since the vacuum magnetic contactor is opened and closed frequently and unevenly, it is necessary to perform frequent maintenance and inspection and replace it in order from the one that has reached the end of its life.
Priority control	This control is a circuit in which the load is used stably, and is suitable for capacitor control of different capacities, which uses a large-capacity capacitor for the base and adjusts the fluctuation of reactive power with a small-capacity capacitor. However, since the vacuum magnetic contactor is opened and closed frequently, it is necessary to perform maintenance and inspection frequently and replace it in order from the one that has reached the end of its life.
Multi-step control	This control operation closes or breaks the capacitor step by step in the reference capacitance unit set by C1. It is suitable for control that approaches the target power factor more finely with a small number of capacitor circuits. However, since the frequency of opening and closing the vacuum magnetic contactor is particularly high in the standard capacitance unit, it is necessary to perform frequent maintenance and inspection and replace the contactor in order from the one that has reached the end of its life.

6.2 Cyclic control operation (Control system : 1)

(1) Cyclic control is the control system by which the number of times of switching of each capacitor circuit is equalized.

(2) Closing sequence starts with C1 at the time of control power closing, and follow below-mentioned sequence.

PFQ-6

↱ C1 → C2 → C3 → C4 → C5 → C6 ┐

PFQ-3

↱ C1 → C2 → C3 ┐

(3) Breaking sequence starts from C1 when the control power is closing, and operates in the same way as the closing sequence.

PFQ-6

↱ C1 → C2 → C3 → C4 → C5 → C6 ┐

PFQ-3

↱ C1 → C2 → C3 ┐

(4) Manual ON or manual OFF capacitor circuits are excluded from cyclic control.
(This is the control of the capacitor circuit of AUTO control.)

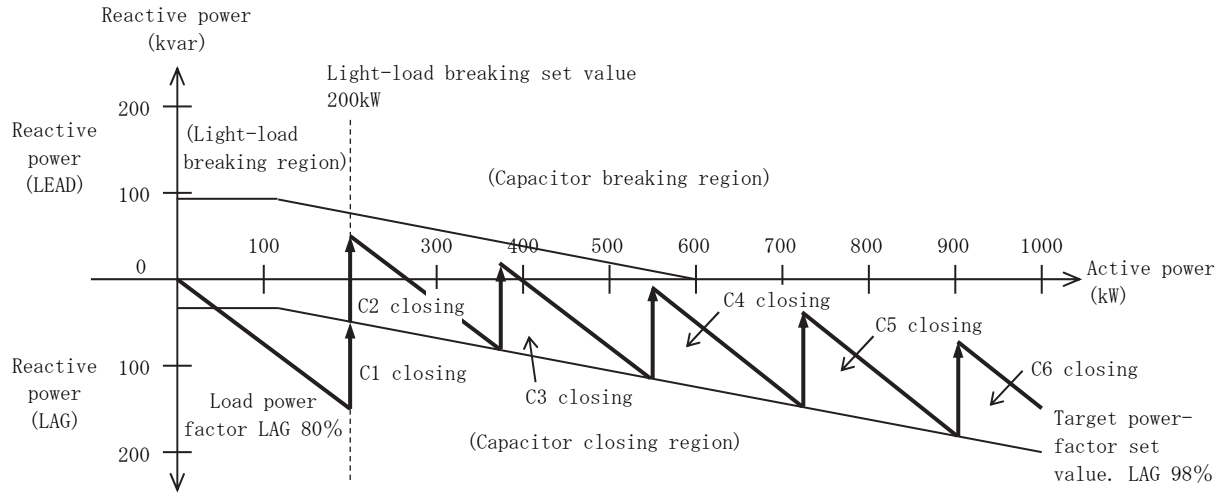
Example of cyclic control output operation

Closing / breaking		→	Closing	Closing	Closing	Closing	Closing	Closing	Breaking	Breaking	Breaking	Breaking	Closing	Closing	Closing	Breaking	Closing	Breaking	Breaking
Output state of capacitor	C1		○	○	○	○	○	○				○	○	○	○	○	○	○	
	C2			○	○	○	○	○	○					○	○	○	○	○	○
	C3				○	○	○	○	○	○					○	○	○	○	○
	C4					○	○	○	○	○	○						○	○	○
	C5						○	○	○	○	○	○	○	○	○				
	C6							○	○	○	○	○	○	○	○	○	○		

○ : Capacitor closing status.

The output action example of power-factor control, target power-factor : LAG 98%, light-load breaking : 200kW, capacitor capacity : 100kvar × 6 circuits.

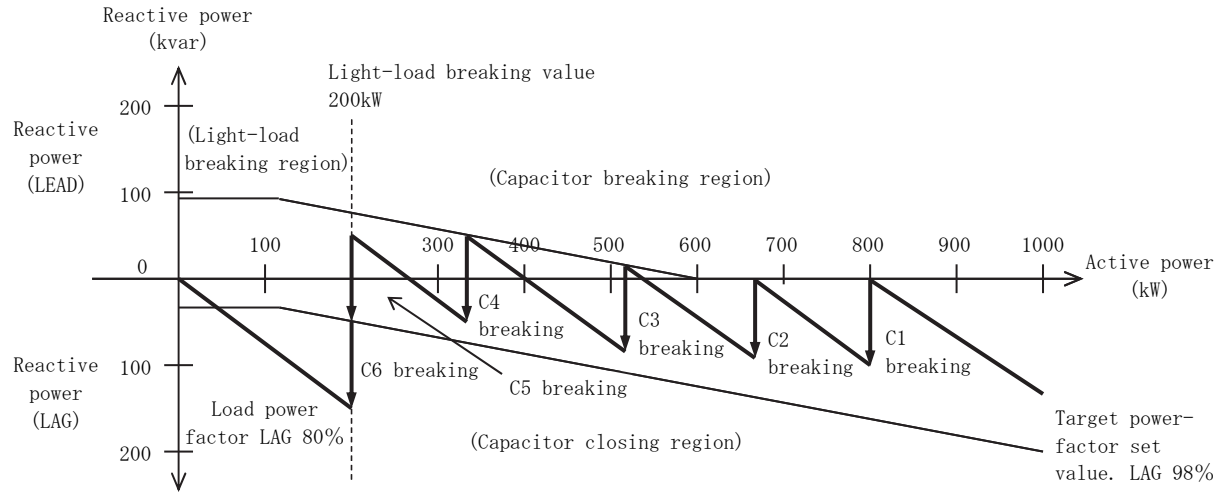
● Closing operation of capacitor (PFQ-6)



Closing order →

	C1 closing	C2 closing	C3 closing	C4 closing	C5 closing	C6 closing
Closing active power	200kW	200kW	364kW	545kW	727kW	909kW
Closing reactive power	LAG 150kvar	LAG 50kvar	LAG 74kvar	LAG 111kvar	LAG 148kvar	LAG 185kvar
Power factor after closing	LAG 97.0%	LEAD 97.0%	LEAD 99.7%	100.0%	LAG 99.7%	LAG 99.6%

● Breaking operation of capacitor (PFQ-6)



← Breaking order

	C6 breaking	C5 breaking	C4 breaking	C3 breaking	C2 breaking	C1 breaking
Breaking active power	200kW	200kW	329kW	512kW	667kW	800kW
Breaking reactive power	LAG 50kvar	LEAD 50kvar	LEAD 53kvar	LEAD 16kvar	0kvar	0kvar
Power factor after breaking	LAG 80.0%	LAG 99.5%	LAG 99.1%	LAG 98.7%	LAG 99.0%	LAG 99.3%

6.3 Optimal control operation (Control system：2)

(1) Optimal control is a control system that selects a capacitor circuit (1 circuit) with the optimum capacity in order to keep the reactive power at that time within the target power factor, and performs closing or breaking control.

(2) Closing sequence starts with the largest-capacity capacitor until aimed power factor can be approached and advance is minimum.

(3) Until a breaking sequence approaches a target power factor most after a breaking and stops becoming below a target power factor, it breaking in sequence from what has big capacity.

(4) Manual ON or manual OFF capacitors are excluded from optimal control.
(This is the control of the capacitor circuit of AUTO control.)

(5) Cyclic control is recommended for circuits with equal capacitor capacities.

Example of optimal control output operation

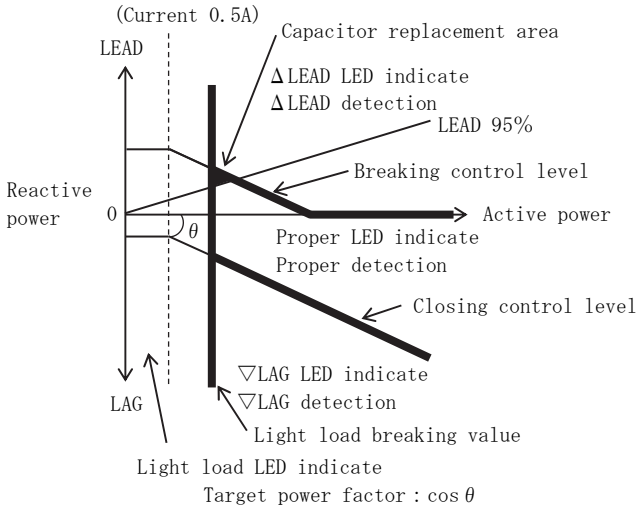
Lag reactive power value (kvar)		100	300	600	1700			600		1800		2300		1800
Output state of capacitor	C1 (100kvar)	○	○	○	○	○	○	○			○	○		
	C2 (200kvar)		○	○	○	○								
	C3 (300kvar)			○	○	○	○	○	○	○	○	○	○	○
	C4 (500kvar)					○	○	○	○	○	○	○	○	
	C5 (700kvar)											○	○	○
	C6 (900kvar)				○	○	○			○	○	○	○	○
Total capacitor closing quantity (kvar)		100	300	600	1500	2000	1800	900	800	1700	1800	2500	2400	1900

○：Capacitor closing status.
At the time of interruption, (actual capacitor capacity) ×1.2 is regarded as the capacitor capacity and controlled. (Hysteresis)

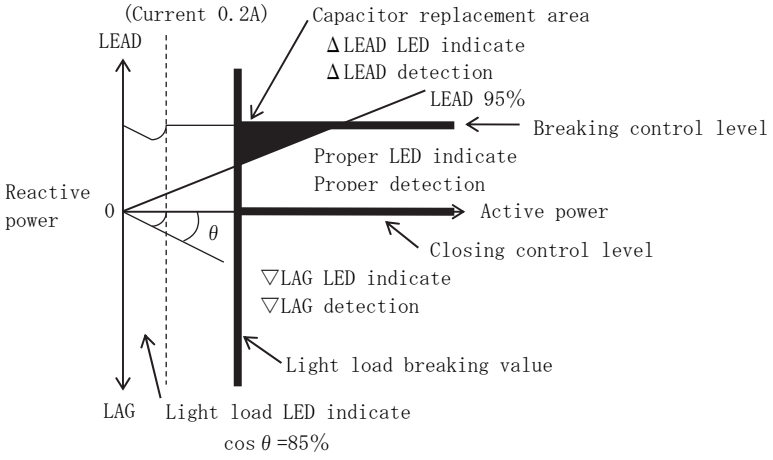
6.4 Capacitor replacement control during optimal control operation

Optimal control is suitable for circuits with large load fluctuations.
If the load gradually decreases from the state where multiple capacitors are closed, the capacitors with the smallest capacitance are broken in order, and the capacitors with the largest capacitance remain.
If the power factor advances in this state and exceeds 95%, the replacement control is performed to break the large capacitor and close the small capacitor.
After replacement, replace the capacitor with the capacitor that is closest to the target power factor and has the minimum advance.

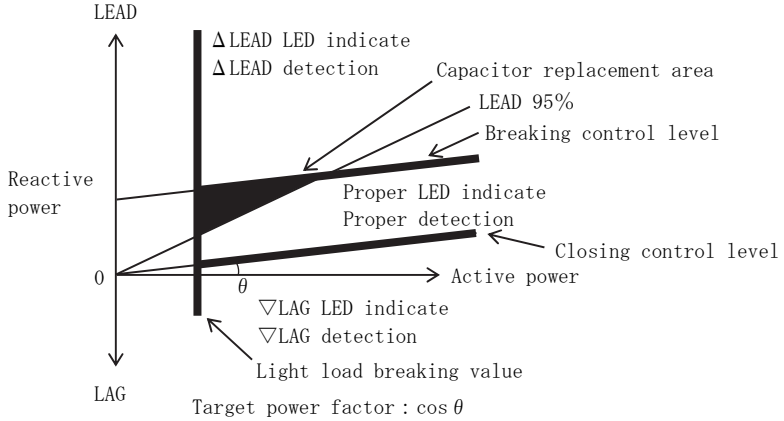
(1) Target power factor LAG 99% or less setting



(2) The setting of the target power factor 100%



(3) Target power factor LEAD 99% or less setting



6.5 Priority control operation (Control system : 3)

(1) Priority control is a circuit in which the load is used stably, and control system that gives priority to the closing or breaking of the capacitor circuit by using a large capacity capacitor for the base and adjusting the fluctuation of reactive power with a small capacity capacitor.

(2) The closing sequence, starts from C1 when the control power is applied and operates as follows.

PFQ-6
C1 → C2 → C3 → C4 → C5 → C6

PFQ-3
C1 → C2 → C3

(3) The breaking sequence is breaking sequentially from the last capacitor circuit that was closing.

PFQ-6
C1 ← C2 ← C3 ← C4 ← C5 ← C6

PFQ-3
C1 ← C2 ← C3

(4) Manual ON or manual OFF capacitors are excluded from priority control.
(This is the control of the capacitor circuit of AUTO control.)

Example of priority control output operation

Closing / breaking		Closing	Closing	Closing	Closing	Closing	Closing	Closing	Breaking	Breaking	Breaking	Breaking	Closing	Closing	Closing	Breaking	Closing	Breaking	Breaking
Output state of capacitor	C1		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	C2			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	C3				○	○	○	○	○	○	○		○	○	○	○	○	○	○
	C4					○	○	○	○	○				○	○	○	○	○	
	C5						○	○	○						○		○		
	C6							○											

○ : Capacitor closing status.

6.6 Multi step control operation (Control system : 4 to 6)

(1) Multi-step control is the control system which does closing (or breaking) of the capacitor gradually in the reference capacity unit set by C1.

(2) Manual ON or manual OFF capacitors are excluded from multi step control.
(This is the control of the capacitor circuit of AUTO control.)

(3) There are three types of control systems for multi-step control, and the number of steps can be selected according to the fluctuation range of the load.

Control system	Item	Capacity ratio (C1 : C2 : C3 : C4 : C5 : C6)
4	Multi step control ①	1 : 2 : 2 : 2 : 2 : 2
5	Multi step control ②	1 : 2 : 4 : 4 : 4 : 4
6	Multi step control ③	1 : 2 : 4 : 8 : 8 : 8

Capacity range to control is as follows.
Multi step control ① 1×C1kvar to 11×C1kvar
Multi step control ② 1×C1kvar to 19×C1kvar
Multi step control ③ 1×C1kvar to 31×C1kvar

PFQ-3 is the operation of C1, C2, C3.

<Note> When multi-step control is selected, the delay operation setting value becomes the setting value 1.

6.6.1 Multi step control ① (Capacity ratio 1 : 2 : 2 : 2 : 2 : 2)

Closing		Closing order →										
Step number		1	2	3	4	5	6	7	8	9	10	11
Output state of capacitor	C1 (10kvar)	○		○		○		○		○		○
	C2 (20kvar)		○	○	○	○	○	○	○	○	○	○
	C3 (20kvar)				○	○	○	○	○	○	○	○
	C4 (20kvar)						○	○	○	○	○	○
	C5 (20kvar)								○	○	○	○
	C6 (20kvar)										○	○
Total capacitor closing quantity (kvar)		10	20	30	40	50	60	70	80	90	100	110

○ : Capacitor closing state.

Breaking		Breaking order →										
Step number		1	2	3	4	5	6	7	8	9	10	11
Output state of capacitor	C1 (10kvar)	○		○		○		○		○		○
	C2 (20kvar)	○	○									
	C3 (20kvar)	○	○	○	○							
	C4 (20kvar)	○	○	○	○	○	○					
	C5 (20kvar)	○	○	○	○	○	○	○	○			
	C6 (20kvar)	○	○	○	○	○	○	○	○	○	○	
Total capacitor closing quantity (kvar)		110	100	90	80	70	60	50	40	30	20	10

○ : Capacitor closing state.

6.6.2 Multi step control ② (Capacity ratio 1 : 2 : 4 : 4 : 4 : 4)

Closing		Closing order →										
Step number		1	2	3	4	5	・・・	15	16	17	18	19
Output state of capacitor	C1 (10kvar)	○		○		○	・・・	○		○		○
	C2 (20kvar)		○	○				○			○	○
	C3 (40kvar)				○	○		○	○	○	○	○
	C4 (40kvar)							○	○	○	○	○
	C5 (40kvar)							○	○	○	○	○
	C6 (40kvar)								○	○	○	○
Total capacitor closing quantity (kvar)		10	20	30	40	50	・・・	150	160	170	180	190

○ : Capacitor closing state.

Breaking		Breaking order →										
Step number		1	2	3	4	5	・・・	15	16	17	18	19
Output state of capacitor	C1 (10kvar)	○		○		○	・・・	○		○		○
	C2 (20kvar)	○	○			○				○	○	
	C3 (40kvar)	○	○	○	○							
	C4 (40kvar)	○	○	○	○	○						
	C5 (40kvar)	○	○	○	○	○						
	C6 (40kvar)	○	○	○	○	○		○	○			
Total capacitor closing quantity (kvar)		190	180	170	160	150	・・・	50	40	30	20	10

○ : Capacitor closing state.

6.6.3 Multi step control ③ (Capacity ratio 1 : 2 : 4 : 8 : 8 : 8)

Closing		Closing order →										
Step number		1	2	3	4	5	・・・	27	28	29	30	31
Output state of capacitor	C1 (10kvar)	○		○		○	・・・	○		○		○
	C2 (20kvar)		○	○				○			○	○
	C3 (40kvar)				○	○			○	○	○	○
	C4 (80kvar)							○	○	○	○	○
	C5 (80kvar)							○	○	○	○	○
	C6 (80kvar)							○	○	○	○	○
Total capacitor closing quantity (kvar)		10	20	30	40	50	・・・	270	280	290	300	310

○ : Capacitor closing state.

Breaking		Breaking order →										
Step number		1	2	3	4	5	・・・	27	28	29	30	31
Output state of capacitor	C1 (10kvar)	○		○		○	・・・	○		○		○
	C2 (20kvar)	○	○			○				○	○	
	C3 (40kvar)	○	○	○	○			○	○			
	C4 (80kvar)	○	○	○	○	○						
	C5 (80kvar)	○	○	○	○	○						
	C6 (80kvar)	○	○	○	○	○						
Total capacitor closing quantity (kvar)		310	300	290	280	270	・・・	50	40	30	20	10

○ : Capacitor closing state.

7. Function

7.1 Always closing / breaking operation

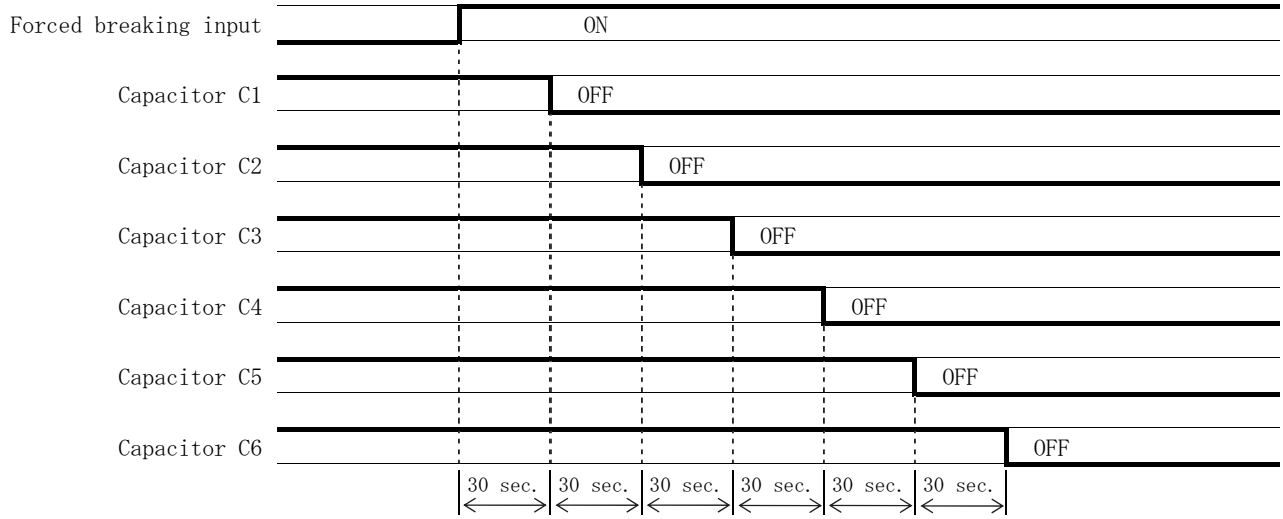
The slide switch can be used to switch between "manual ON", "automatic", and "manual OFF" for each capacitor. When set to "Manual ON", if the delay operation setting value is "1", the capacitor is closing after the delay time has elapsed. Also, if the delay operation setting value is "2", the capacitor is closing instantly.
However, if the re-closing prevention timer that starts immediately after the capacitor is breaking has not passed, the capacitor is closing after the re-closing prevention timer has elapsed.
When "Manual OFF" is set, the capacitor is breaking instantly.
Be sure to set the unused capacitor circuit to "manual OFF".

7.2 Forced breaking operation

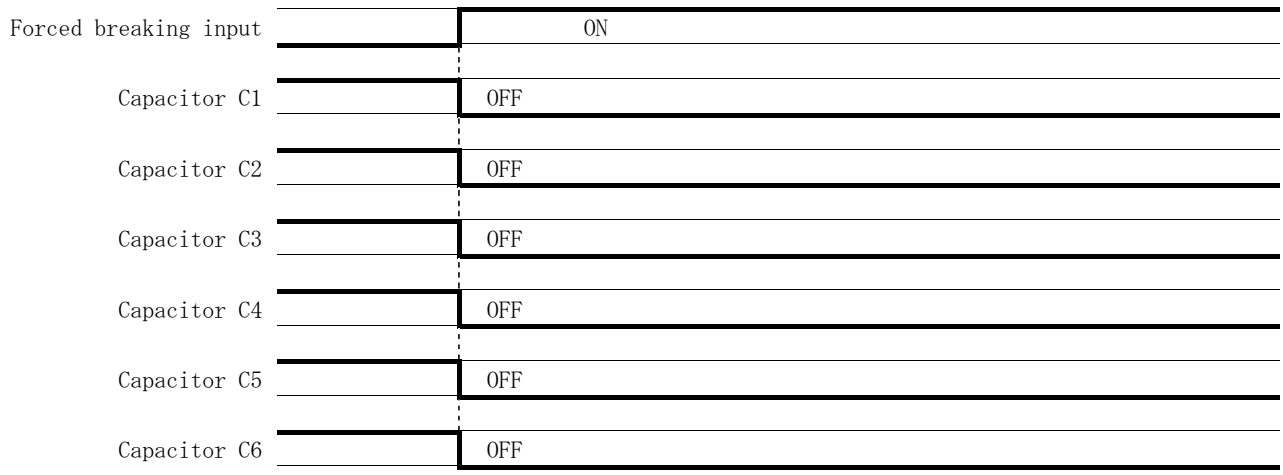
The forced breaking operation is used when the influence of harmonic interference is expected or when the capacitor circuit is opened at night.
Forced breaking While the input terminal TB-COM1 is short-circuited (Use a relay that satisfies the minimum applicable load of switching voltage and current DC24V 10mA. Reference: OMRON MY2 relay, etc.), the closed capacitor is shut off by automatic control (Excluding capacitors with manual ON setting).
Two types of operations are possible depending on the settings.

PFQ-6 operation example

① Setting value 1 : While the forced breaking input terminals are short-circuited, the capacitors are breaking sequentially every 30 seconds.



② Setting value 2 : When the forced breaking input terminal is short-circuited, the capacitors are breaking all at once.



7.3 Light load breaking operation

To prevent excessive advance power factor at light load, when the active power of the circuit becomes less than the set light load breaking set value, the capacitors that are automatically controlled are breaking in sequence.

1) Cyclic control ····· Among the capacitors that are closing, the capacitors that are closing first are breaking in order.

2) Optimal control ····· Among the capacitors that are closing, the capacitors that are largest are breaking in order.

3) Priority control ····· Among the capacitors that are closing, the capacitors that are closing last are breaking in order.

4) Multi-step control ···· Breaking in order according to the determined pattern.

7.4 Priority of closing and breaking operations

① Manual ON / Manual OFF, ② Forced breaking, ③ Light load breaking, ④ Automatic control

7.5 Closing / breaking and delay time operation

1) Closing

When the reactive power measurement value exceeds the closing control level, the lag is detected and the capacitor is closing.
When the delay operation setting value is selected to 1, the capacitors are closing sequentially every time the delay time elapses.
When the delay operation setting value is selected to 2, the capacitor is closing instantly.
If lag is detected continuously after the capacitor is closing, it is closing at 10 second intervals while the lag is detected from the second capacitor.
However, if the re-closing prevention timer that starts immediately after the capacitor is breaking has not passed, it will not be closing instantly or after 10 seconds, but will be closing-loading prevention timer has elapsed.

2) Breaking

When the reactive power measurement value exceeds the breaking control level, the lead is detected and the capacitor is breaking.
When the delay operation setting value is selected to 1, the capacitors are breaking sequentially every time the delay time elapses.
When the delay operation setting value is selected to 2, the capacitor is breaking instantly.
If lead is detected continuously after the capacitor is breaking, it is breaking at 10 second intervals while the lead is detected from the second capacitor.
The delay time of the delay time setting value 2 is measured individually for each capacitor circuit as a re-closing prevention timer immediately after the capacitor is breaking.

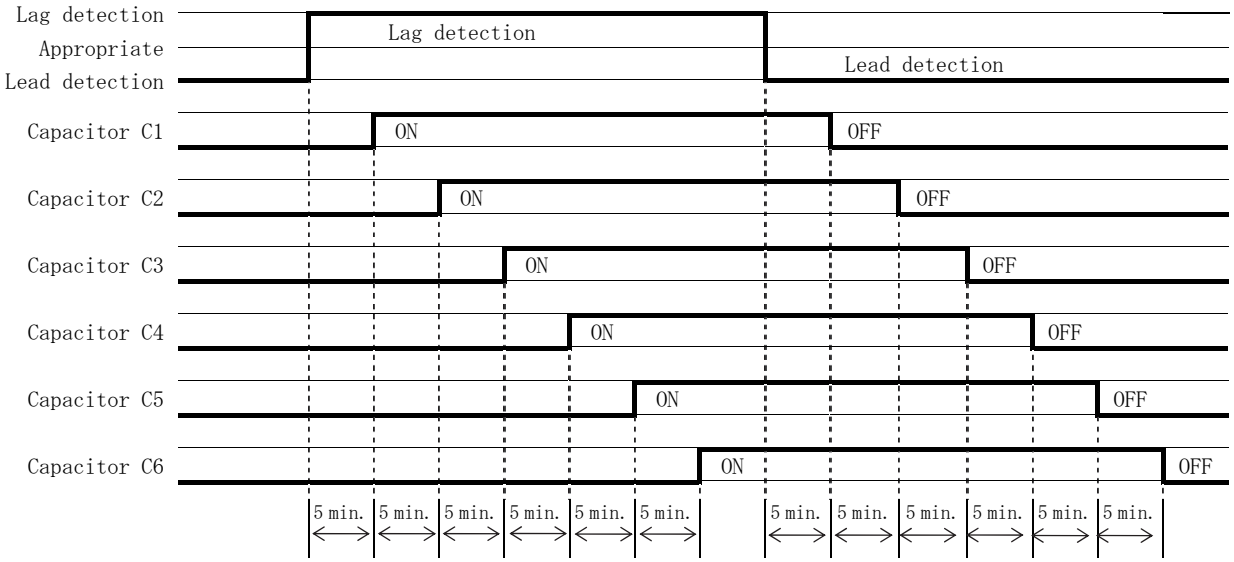
3) Operation of delay time

This is the delay time to prevent capacitor failure by providing a time until the residual voltage generated when the capacitor is breaking is discharged.
Two types of operations are possible depending on the settings.

PFQ-6 operation example

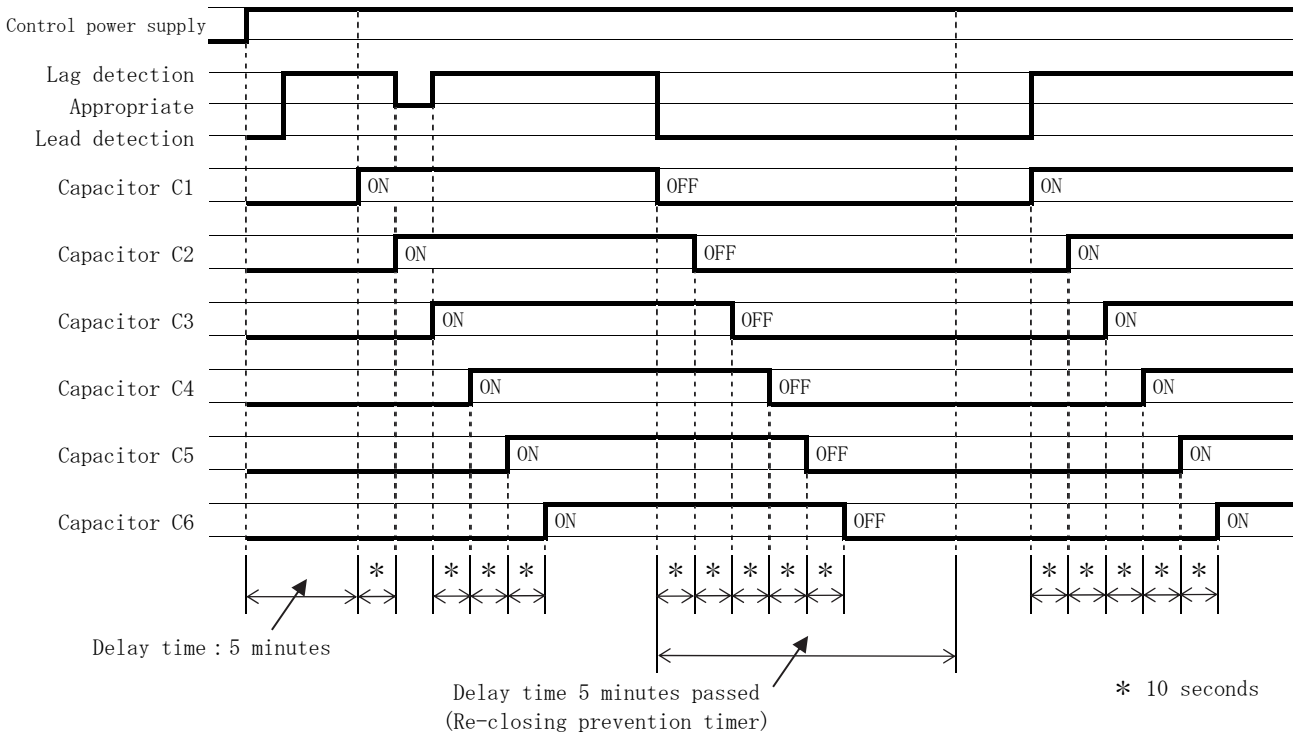
① Setting value 1 : After the delay time has elapsed, closing or breaking the capacitor.

[Operation example with a delay time of 5 minutes]



② Setting value 2 : Instantly closes or breaks the capacitor.
The delay time is a re-closing prevention timer that starts when the control power is applied, when the capacitor is breaking, or when the setting mode is released.

[Operation example with a delay time of 5 minutes]



7.6 Test

When operation check such as capacitor control circuit is performed, DIP switch is set to TEST.
When changed to test mode after setting to TEST, capacitor can be closed in following sequence (C1 → C2 → C3 → C4 → C5 → C6) at every delay time (15 seconds) passage and can be breaking in following sequence (C1 → C2 → C3 → C4 → C5 → C6). (PFQ-3 is closing by C1 → C2 → C3 and breaking by C1 → C2 → C3)
This operation is repeated during test mode. Therefore, if a capacitor circuit is connected, be sure to change the setting from TEST to OPERATE after one cycle. In the case of a high-voltage capacitor, the residual voltage will be recharged without being discharged.

7.7 Operation when connection is in reverse phase

Even if connection is a negative phase sequence, change of connection is unnecessary because it operates normally. However, connection of a 3-phase 3-wire circuit balanced load does not operate normally.

7.8 Operation when two devices are combined

Connect No.1, TS/CS-COM1 (Breaking prohibited) and No.2, CE/TE-COM2 (Breaking completed).
Connect No.2, TS/CS-COM1 (Closing prohibited) and No.1, CE/TE-COM2 (Closing completed).

1) Breaking oparation
   The breaking operation of Unit 1 is prohibited by the breaking completion signal from Unit 2.
   The breaking completion signal is released when the capacitors of Unit 2 are all broken.

2) Closing operation
   The closing operation of Unit 2 is prohibited by the closing completion signal from Unit 1.
   The closing completion signal is released when the capacitors of Unit 1 are all broken.

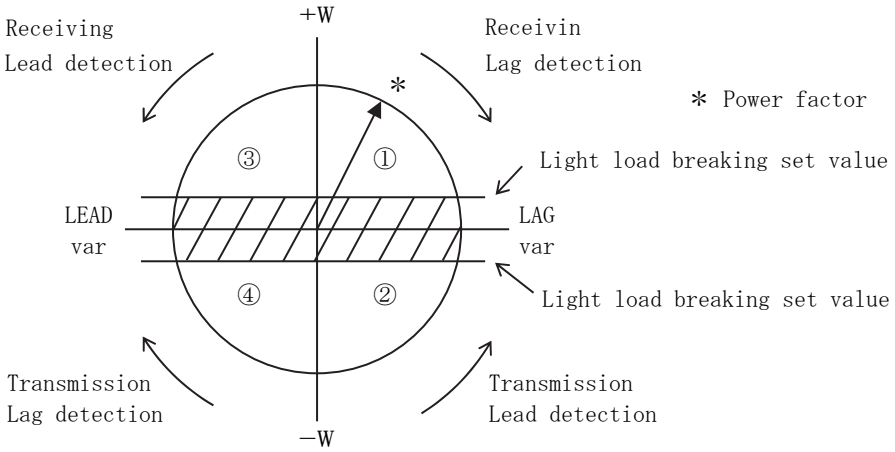
7.9 Power factor display at low input

1) Rated current 5A specifications
   When the secondary current input is approximately 0.1A or less, or the secondary voltage input is approximately 22V or less, the power factor display is set to LAG 100.0%.

2) Rated current 1A specification
   When the secondary current input is approximately 0.02A or less, or the secondary voltage input is approximately 22V or less, the power factor display is set to LAG 100.0%.

7.10 Control operation during tidal current

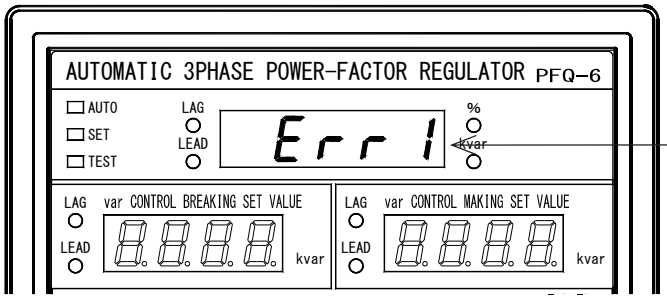
When the input is ① or ②, the lag power factor and reactive power are measured, and control is performed in the direction of closing the capacitor.
When the input is ③ and ④, lead power factor and reactive power are measured and the capacitor is controlled in the direction of breaking.
With respect to the positive direction input of the power-receiving, to determine the LAG or LEAD.



Receiving power factor	Transmission power factor	PFQ measurement	PFQ control	Output
LAG (Input ①)	−	Positive power LAG var	Lag detection	Capacitor closing
LEAD (Input ③)	−	Positive power LEAD var	Lead detection	Capacitor breaking
−	LEAD (Input ②)	Negative power LAG var	Lag detection	Capacitor closing
−	LAG (Input ④)	Negative power LEAD var	Lead detection	Capacitor breaking

8. Inspection and maintenance

8.1 Error display



Error code	Error contents	Control state	Error recovery conditions	Coping process
Err1	RAM error	Control stop	—	Product failure, replacement
Err2	A/D conversion error	Control stop	—	Product failure, replacement
Err3	Setting error (DIP switch)	Control stop	Automatic return by setting change	—
Err4	Setting error (Slide switch)	Control stop	Automatic return by setting change	—

8.2 Troubleshooting

No.	Abnormal phenomenon	Possible cause	Coping process
1	Indicator does not display.	The power supply is not supplied.	Check the power supply.
		Trouble of power supply circuit.	Replace the device.
2	Measurement display error large.	Incorrect input wiring.	Check the input wiring.
		Input circuit setting error.	Check the settings of 3-phase 3-wire, 3-phase 4-wire or balanced/unbalanced.
		VT ratio, CT ratio setting error.	Set the VT ratio and CT ratio to the correct values.
		Instrument measurement circuit failure	Replace the device
3	Error is displayed	Err1 : RAM error	Replace the device
		Err2 : A/D conversion error	
		Err3 : Setting error (DIP switch)	Check the set value. The DIP switch cannot be changed during operation.
		Err4 : Setting error (Slide switch)	Check the set value. Displayed when slide switch position is intermediate. Please set as the right position.
4	Control is hunting	Closing / breaking control level and capacitor capacity do not match.	Check the capacity of closing / breaking control level and a capacitor.
5	Capacitor does not closing	Light load LED is lights.	Set the light load breaking to the correct value. (Refer to "Setting the key switch by item 4.4")

9. Standard specifications and performance

No.	Item			Standard specifications		
1	AC input	Voltage	Rating	3φ3W	AC110V, AC220V 50/60Hz	
				3φ4W	AC110/√3V 50/60Hz	
			Consumption VA	3φ3W	AC110V : 0.25VA, AC220V : 0.5VA	
				3φ4W	AC110/√3V : 0.15VA	
		Current	Rating	AC 5 A 50/60Hz or AC 1 A 50/60Hz		
			Consumption VA	0.1VA		
2	Control switching input (Between TS/CS - COM1)			Non-voltage normally open contact (1a contact) (Common with COM1 terminal on one side of forced breaking input contact) When connecting two units, connect to the other control switching output.		
	Control switching output (Between CE/TE - COM2)			Non-voltage normally open contact (1a contact) When connecting two units, connect to the other control switching input.		
3	Forced breaking input (Between TB - COM1)			Non-voltage normally open contact (1a contact) (Common to COM1 terminal on one side of control switching input contact) Rated voltage, current DC24V, 10mA For the relay to be used externally, use a relay whose minimum applicable load satisfies the switching voltage and current of DC24V, 10mA.		
4	Control power supply		Power range	AC85 to 253V 50/60Hz DC80 to 143V AC / DC power supply		
			Consumption VA	AC110V : 15VA, AC220V : 22VA, DC110V : 13W		
			Rush current (Time constant)	AC110V : 4.2A (2ms) AC220V : 8.4A (2ms) DC110V : 3.0A (3ms)		
5	Applicable circuit			3-phase 3-wire circuit unbalanced load (2VT, 2CT) 3-phase 3-wire circuit balanced load (1VT, 1CT) 3-phase 4-wire circuit (2VT, 3CT)		
6	Control output contact		Number of capacitor circuit	6 circuits or 3 circuits		
			Contact arrangement	Non-voltage normally open contact (1a contact) (6 circuits or 3 circuits on one side are common with COM3 terminal)		
			Switching capacity	Resistive load	AC250V, 5A cosφ＝1	
					DC110V, 0.3A DC100V, 0.5A DC30V, 5A	
				Inductive load	AC250V, 2A cosφ＝0.4	
					DC110V, 0.1A DC100V, 0.15A DC30V, 2A L/R＝7ms	
			Minimum load	5V, 10mA		
			Electrical life	Inductive load	AC250V, 2A cosφ＝0.4 About 100,000 times	
					DC30V, 2A L/R＝7ms About 100,000 times	
7	Reactive power control		Closing control level (kvar)	According to var control closing value.		var control selection with DIP switch.
			Breaking control level (kvar)	According to var control breaking value.		
			Proper control width (kvar)	Span of var control closing value and var control breaking value.		
			Tolerance	±0.5% or less of rated reactive power. Range of 10 to 100% of rated current, range of LEAD 60% to LAG 60% in power factor.		
8	Power factor control		Closing control level (kvar)	Set automatically from a target power-factor. The reactive power value (kvar) calculated from effective power (kW) and target power-factor set value (cosθ)		P/F control selection with DIP switch.
			Breaking control level (kvar)	Closing control level − Capacitor capacity ×1.2 0kvar (power factor =1) if a calculation result is 0 or plus		
			Proper control width (kvar)	Set automatically by 1.2 times the capacitor capacity.		
			Tolerance	±0.5% or less of rated reactive power. Range of 10 to 100% of rated current, range of LEAD 60% to LAG 60% in power factor.		

No.	Item		Standard specifications			
9	Light load breaking control	Light load breaking value (kW)	When the active power decreases below the light load breaking value, the already closing capacitors are breaking in sequence. When the light load breaking value is set to 0, light load breaking does not work			
		Tolerance	±0.5% or less of rated active power. Power factor range from LEAD 60% to LAG 60% at 10% to 100% of rated current.			
10	Control system		1 : Cyclic control 2 : Optimal control 3 : Priority control 4 : Multi step control ① 1 : 2 : 2 : 2 : 2 : 2 5 : Multi step control ② 1 : 2 : 4 : 4 : 4 : 4 6 : Multi step control ③ 1 : 2 : 4 : 8 : 8 : 8			
11	Operation change-over (Slide switch change-over)		ON - AUTO - OFF Capacitor 6 circuits or 3 circuits individually selectable.			
12	Setting item (DIP switch change-over)		No.	NO.1 / NO.2		
			DELAY	1 MIN. / 3 MIN. / 5 MIN.		
			DETECTION	BALANCE / UNBALANCE		
			PHASE-LINE	3φ3W / 3φ4W		
			CONTROL	P·F / var		
			ACTION	OPERATE / TEST		
13	Setting item (Key switch setting)		Settings	Default value: Rated current 5A	Default value: Rated current 1A	Setting range
			VT ratio	60	60	1 to 90
			CT ratio	20	20	1 to 1200
			Target power factor	LAG 98%	LAG 98%	LEAD 95 to 100 to LAG 85%
			var control closing value	LAG 100kvar	LAG 20kvar	0 to LAG 999kvar
			var control breaking value	LEAD 20kvar	LEAD 4kvar	LEAD 1 to 999kvar
			Light load breaking	|200|kW	|40|kW	0 to |9999|kW
			Control system	1	1	1 to 6
			C1 to C6 capacitor capacity (PFQ-3 : C1 to C3)	100kvar	20kvar	1 to 9999kvar
			Delay operation	1	1	1 to 2
			Forced breaking operation	1	1	1 to 2
14	Display	7-segment LED 4 digit display	Current power factor value Current reactive power value	Display by switching with the DISPLAY switch		
		7-segment LED 3 digit display	var control closing value var control breaking value	Not displayed when power factor control is selected		
		7-segment LED 4 digit display	Current (R, S, T) Voltage (R-S, S-T, T-R) Active power Reactive power Apparent power Power factor	Can be displayed by operating a key switch		
15	Intrinsic error		For rated input Power factor : ±1.5% (20 to 100% of rated current) Current : ±0.5% Voltage : ±0.5% Active power : ±0.5% Reactive power : ±0.5% Apparent power : ±0.5%			
16	Forced breaking time error		±0.5s			
17	Delay time error		Setting value ±10% (During instantaneous operation : 0.5s or less)			
18	Control state display		AUTO / SET / TEST			

No.	Item		Standard specifications	
19	Operation state display		LEAD (Gain) / LAG (Delay) / PROPER / LIGHT LOAD / FORCED BREAK	
20	Control output display		C1 to C6 or C1 to C3 : Control output contact ON : Display is ON. Control output contact OFF : Display is OFF.	
21	Influence of temperature		Intrinsic error at 23±10℃ (tolerance)	
22	Influence of frequency		Intrinsic error at rated frequency and rated frequency ±10% (tolerance)	
23	Influence of input voltage		Intrinsic error at rated voltage and rated voltage ±15% (tolerance)	
24	Influence of control power		1/2 of the inherent error at the rated voltage and the upper and lower limits of the rated voltage (tolerance)	
25	Overload capacity	Voltage circuit	2 times 10 seconds and 1.2 times continuation of rated voltage.	
		Current circuit	40 times 1 second and 20 times 4 seconds and 10 times 16 seconds and 1.2 times continuation of rated current.	
		Control power supply	1.5 times 10 seconds and 1.2 times continuation of rated voltage. In case of DC110V, 1.5 times 10 seconds and 1.3 times continuation of rated voltage.	
26	Insulation resistance		Between input, output, control power supply, and ground.	Above 50MΩ at DC500V
27	Withstand voltage		Between input, output, control power supply, and ground.	AC2000V (50/60Hz) 1 minute
28	Lightning impulse withstand voltage		Between electric circuit and ground.	5kV 1.2/50μs. Both positive and negative polarity, for 3 times each.
			Between voltage input terminals	3kV 1.2/50μs. Both positive and negative polarity, for 3 times each.
29	Noise-capacity		(1) Damped oscillatory wave immunity When a damping vibration waveform with a peak voltage of 2.5kV and a frequency of 1MHz±10% is repeatedly applied, the measurement error is within 10%. (Control power supply, Voltage circuit, Current circuit) (2) Square wave impulse noise immunity If a noise (1μs, 100ns width) is repeated and added, measuring error is within 10%. Control power supply (Normal / Common) Over 1.0kV Voltage circuit (Normal / Common) Over 1.0kV Current circuit (Common) Over 1.0kV Control input (Inductive common) Over 1.0kV Control output (Common) Over 1.0kV (3) Electric wave noise immunity When intermittently irradiating 150MHz and 400MHz radio waves with 5W, 1m, measurement error within 10%. When touching a mobile phone or wireless LAN (2.4GHz, 5GHz), measurement error within 10%. (4) Electrostatic discharge immunity 8kV (air discharge) when power is on, measurement error within 10%. 10kV (air discharge) when power is off, no damage. Capacitor charging method	
30	Vibration		Single amplitude 0.15mm, 10 - 55Hz, Each minute octave in 5 times sweep (When mounted to panel). Direction of vibration : X, Y, Z direction.	
31	Shock		Apply a shock of 300m/s^2 3 times forward and backward in X, Y, Z direction (When mounted to panel).	
32	Operating temperature limits		-10 to +55℃	
33	Storage temperature limits		-20 to +70℃	
34	Operating humidity limits		30 to 90% RH (No condensation)	
35	Mass		Approx. 1.0kg	
36	Color (including frame)		Black (Munsell N1.5)	
37	Other		Ingress Protection code, IP30	

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