



INSTRUCTION MANUAL

Power Factor Controller RVC-L

Installation Instructions

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1. Preamble

1.1 Introduction to this User Manual

The detailed information provided in this manual is intended to help you quickly install and operate the RVC-L Power Factor Controller.

1.2 Warnings



Caution, danger warning sign.

Read the safety precautions carefully before installing and operating the RVC-L controller. This manual is for the reference of installation, maintenance and operation personnel.

1.3 Security

The RVC-L controller complies with the requirements of the EU LVD (Low Voltage) Directive 2006/95/EC.



Beware of electrocution safety tips.

The RVC-L controller must be installed, maintained and operated by a qualified electrical technician. Do not operate with electricity. To clean, wipe the dust with a dry cloth. Do not use abrasives, solvents or alcohol. Before cleaning, turn off the power and disconnect the voltage measurement circuit. Do not open the RVC-L controller housing. There are no user-ready parts inside the instrument. This RVC-L controller can be connected to a current transformer. Do not unplug the current transformer until you are sure that it is short-circuited or that it has been connected in parallel to another load with a sufficiently low impedance, otherwise dangerous high voltages will be generated. The current sampling line adopts 2.5mm² specification, the voltage sampling line adopts 1mm² specification, and the tightening torque of terminal screws is not more than 0.5Nm. External isolation devices (e.g. switches) and external overcurrent protection devices (e.g. 2A fuses) must be provided to protect the RVC-L controller. Do not use this product for any purpose other than the function for which it was designed.

1.4 Electromagnetic compatibility

The controller complies with <GB/T 9663-2013> EMC (Electromagnetic Compatibility) regulations for operation at 50Hz.

The following guidelines help to improve the EMC of a system:

1. Metal enclosures can generally improve electromagnetic compatibility.
2. Cables shall be routed away from the aperture of the housing.

3. Cables shall be placed close to a grounded metal structure.
4. Use multiple grounding busbars on door panels or other panel parts as needed. Avoid common ground impedance.

1.5 Cybersecurity disclaimer

The RVC-L controller is designed to connect and transfer information and data through a network interface. This network interface should be connected to a secure network. It is your responsibility to provide and continuously ensure a secure connection between the Products and your network or any other network, as the case may be, and to establish and maintain appropriate measures (such as, but not limited to, the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc.) to protect the RVC-L Controller Products, networks, systems and interfaces from any type of security breaches, unauthorized access, interference intrusion, leakage and/or theft of data or information. Beijing ABB Low Voltage Apparatus Co., Ltd. and its subsidiaries shall not be liable for damages and/or losses caused by such security breaches, unauthorized access, interference, intrusion, disclosure and/or theft of data or information.

While Beijing ABB Low Voltage Electric Apparatus Co., Ltd. provides functional testing for products and updates released by us, you should develop your own testing procedures for any product updates or other major system updates (including, but not limited to, code changes, configuration file changes, third-party software updates or patches, hardware replacements, etc.) to ensure that the security measures you have implemented have not been compromised and that the functionality of the systems in your environment as expected.

2. Introduction to Controllers

2.1 Overview of the contents of this chapter

This chapter provides a general description of the power factor controller RVC-L, which describes the basic structure of the controller, its main functions, and the controller's LCD screen user interface.

2.2 Introduction to the controller

This product is a reactive power compensation controller based on 32-bit ARM architecture processor, which is suitable for reactive power compensation control circuits of low-voltage power systems from 100V to 750V.

2.3 Technical characteristics

RVC-L controllers enable power factor compensation in three-phase balanced loads. This model is suitable for balancing three-phase load reactive power compensation. Single-phase current measurement, with phase or line voltage measurement, is a power factor controller that realizes co-compensation.

- As long as the wiring phase sequence is correct, no need to set parameters, can also be intelligent compensation control.
- Control of physical quantities: reactive power + target power factor, avoidance of compensation dead zones, prevention of switching oscillations.
- The display is feature-rich, showing various electrical parameters, temperature, number of days of operation, etc.
- Complete protection function, over-voltage, under-voltage, voltage harmonic over-limit, current harmonic over-limit, temperature over-limit, no-load alarm, compensation capacity insufficient alarm and so on.
- Super anti-interference ability, EMC electromagnetic compatibility test: EFT group pulse anti-interference up to 4000V class A (the highest level of IEC standard).

2.4 Outline view

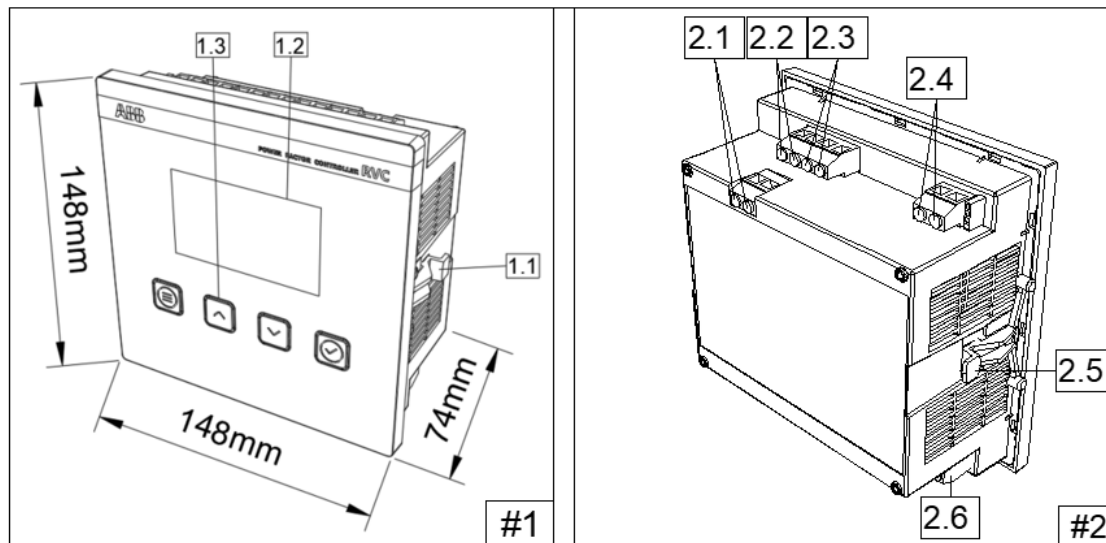


Figure 1: Front view of RVC-L

1.1 Mounting clip

1.2 LCD display

1.3 Keyboard

2.1 PS1 & PS2 operating power access terminals

2.2 L2 & L3 voltage access terminals

2.3 I11 & I12 Current transformer access terminals

2.4 RS485 communication terminal

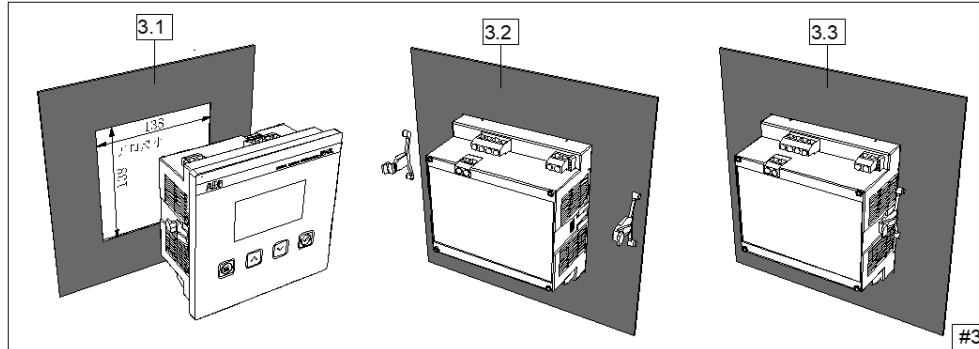
2.5 Mounting clip

2.6 Outputs for each group

3. Installation and Wiring

3.1 Installation and Dimensions

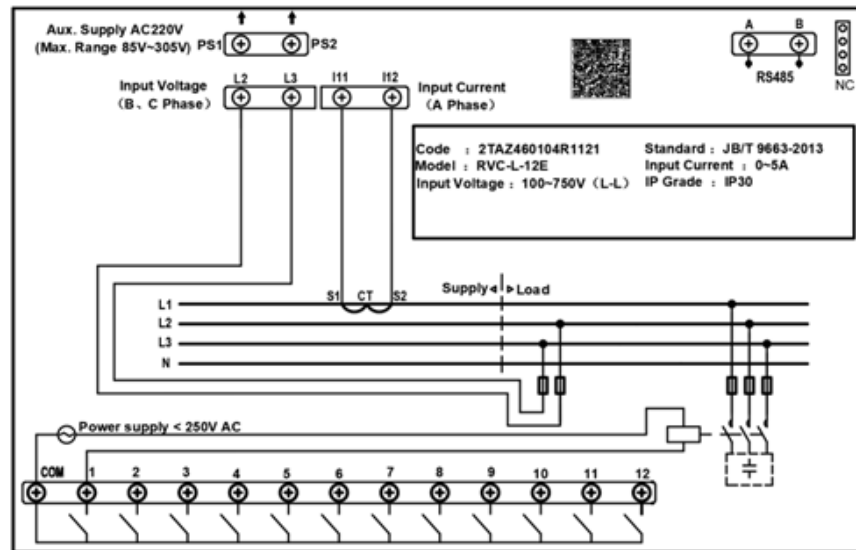
Gently push this controller into the panel of the instrument cabinet where the holes have been cut, as shown in the figure below. The fixings are then snapped into the slots on the side.



Insert hole size is 138 x 138 mm.

3.2 Wiring diagram

This wiring diagram shows how the main circuit and control circuits are connected.



Special warning:

- 1.COM terminal maximum working voltage 250V, need to connect independent power supply < 250V.
2. Do not connect the sampling voltage to the operating power terminals (PS1 and PS2), otherwise it will burn the controller.
3. After the capacitor bank is completely disconnected from the power supply, it still must wait for 5 minutes of discharging time before maintenance can be carried out.

L2, L3: Sampling voltage access terminals

I11, I12: Current transformer secondary access terminals

PS1, PS2: Operating power terminals

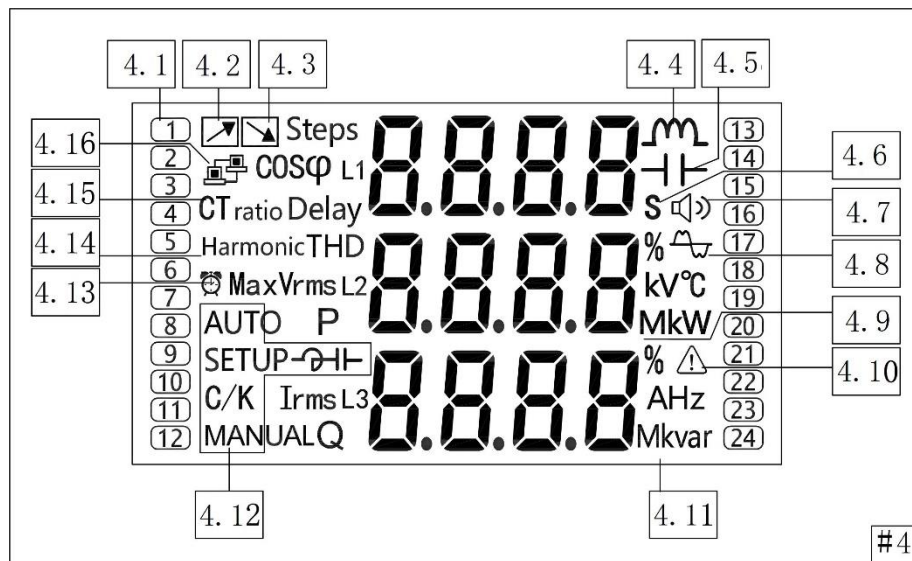
RS485 A, B: RS485 communication terminal

COM: Output relay common terminal

1-12: Output relays

4. Operation and Setup

4.1 Annotation of LCD Icons



4.1 Capacitor output state

4.2 Input action indication

4.3 Cut-off action indication

4.4 Inductive power factor

4.5 Capacitive power factor

4.6 Unit: seconds

4.7 Over-voltage and under-voltage alarm display

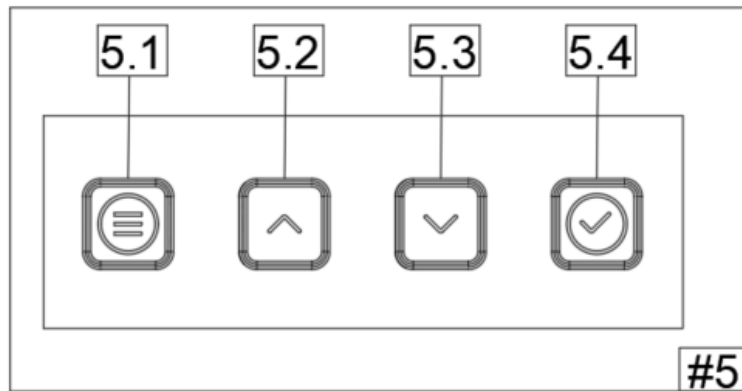
4.8 Harmonic overrun alarm display

4.9 Unit of active power kW or MW

4.10 Underload or insufficient compensation capacity

- 4.11 The unit of reactive power kvar or Mvar
- 4.12 Manual setup and setup mode selection
- 4.13 Date-related displays
- 4.14 Display of total harmonics and individual harmonics
- 4.15 CT multiplier, current sampling transformer ratio
- 4.16 Communication parameters and operating status

4.2 Keyboard



- 5.1  Home button (return)
- 5.2  Up key / digit plus 1
- 5.3  Down key / move one position to the right
- 5.4  Confirmation key

4.3 Modes of operation

There are 6 operating modes, namely "Auto", "Manual", "Setup", "Auto Setup", "Capacitance Reactance", "C/K".

To enter a mode: Press , then press  to the corresponding mode, and press  to confirm entering this mode.

To change the number: Press  to +1 at the cursor blinking position, and press  to move the cursor one place to the right.

Tip: The first time power on after leaving factory, the controller will enter the quick setup wizard mode, requesting to set the number of groups, CT multiplier, reactor reactance and capacitor rating parameters, if the parameter is still unknown, press the  key to enter the automatic mode, when all the above parameters are set up, when controller power on, will no longer enter the wizard mode, you can long press the  key for 5 seconds to operate in the automatic state and enter quick setup wizard mode again.

4.3.1 "Automatic" mode:

According to the parameters set by the user, the capacitor is automatically switched to achieve the target value of power factor.

 Key function: switch to display voltage/current, active power/reactive power, temperature/frequency. Automatically rotates the display every 10 seconds.

 Key function: switch to display voltage harmonic total distortion rate/current harmonic total distortion rate, full-wave power factor PF.

 Key Function : hr02 to hr21 indicates the 2nd to 21st harmonics, press  to ascending order,  to descending order and  to return.

4.3.2 "Manual" mode:

To manually switch capacitors; after entering, press  once to put in, then press  once to remove; press  to select the next channel, and press  to select the previous channel. Press  twice to exit manual into auto mode. If you enter the manual mode and exit directly to the automatic mode without performing the casting and cutting action or selecting the number of circuits, all capacitors that have been put in will be removed.

 Indicates that the channel has been put in, and  indicates that the channel has been removed.

Tip: When discharge delay acts in the manual mode of the RF controller, will lead to the failure of re-input, you need to wait for the end of the capacitor discharge delay.

4.3.3 "Setup" mode (manual setup):

Parameters of manual setting include 7 parts, namely parameters P0001 ~ P0004, P0006, P0007 and P0015.

4.3.3.1 Item P0001 (commonly used item):

Number of groups: Set according to the actual number of capacitor groups.

CT magnification: e.g. 1000/5, set as 200.

COS ϕ : target power factor from 0.5ind (inductive) to 0.5CAP (capacitive).

Delay time: switching delay time, 1.00~99.99 seconds.

Overvoltage: Voltage upper limit, system voltage exceeds the limit capacitor will be removed.

Harmonic overvoltage: the upper limit of the total distortion rate of voltage harmonics, and the capacitor is removed when the harmonics exceed the limit.

4.3.3.2 Item P0002 (uncommonly used item):

Delay CAP diS: Here refers to the capacitor discharge delay, CAP (Capacitor Capacitor) diS (Discharge).

Over-temperature °C: the upper limit of internal temperature of the controller, to cut off the capacitor in case of temperature exceed the limit.

SYS-Voltage: system voltage 0.40kV, 0.69kV , voltage of the power supply system.

 **Cir**: Capacitor switching mode, press  to switch **Cir** (Circular), **Line** (Linear), **FaSt** (Fast).

Cyclic mode (Cir): Transmit switching control instruction based on average reactive load during switching delay. If the capacitor capacity of each circuit is equal, the first-in-first-out cycle mode is adopted, which will prolong the service life of capacitors and contactors; if the capacitor capacity of each circuit is not the same (the difference between any two sets of capacitor capacity is more than 20%), the intelligent switching mode is adopted, which intelligently combines the optimal switching strategy.

Linear mode (Line): Transmit switching control instruction based on average reactive load during switching delay. A linear first-in, first-out model is used.

Warning: The controller controlling contactor switching cannot be set to fast mode to prevent capacitor cabinet failure caused by excessive switching inrush current.

PHS- Voltage L2-3 Current L1: "Modify Wiring Phase Sequence" is used to adjust the phasing of the wiring so that when a wrong voltage or current phase is connected, it can be corrected through this parameter without line switching.

Voltage **L2-3** indicates that the voltage signal is connected to phase BC, and current **L1** indicates that the sampling current transformer is connected to phase A.

L1-n indicates that the sampling voltage is phase voltage (L1-n indicates that phase A voltage is taken), so this product supports the sampling method of single-phase voltage (usually phase A voltage and phase A current are taken).

Shortcut: This function can be operated by long pressing the  key for 5 seconds in the automatic state.

C/K  000.0%: Percentage of the minimum single capacitor group. In case of the load is very low, when it is not enough to put in one capacitor and the power factor is lower than 0.9 (inductive), set 20%~40% of the allowable overcompensating amount.

4.3.3.3 Item P0003 (communication setting, no need to set for product without communication function):

 **id-- rS-1:** id is the address of the RS485 communication port; rS-1 is the 1st port and rS-2 is the 2nd port.

 **bPS-** RS485 communication baud rate, 4.8 kbps, 9.6 kbps, 19.2 kbps, 38.4 kbps, 57.6 kbps, 115.2 kbps.

 **PtY-** RS485 communication parity bit, even (even parity check, as even actually), odd (odd parity check), none (no parity check) .

 **AU--:** Master-Slave mode setting, A means this machine is the master, A2 means 1 master with 2 slaves, b means this machine is the slave, b2 means this machine is the 2nd slave. (1 master can take up to 4 slaves)

4.3.3.4 Item P0004 (observable only and unchangeable):

 **run day 0100:** the number of running days, indicating that the controller has been running for 100 days in total.

Pola None: CT polarity display, can display **None** (no polarity), **Pos** (Positive polarity), **Neg** (Negative polarity), set the positive and negative polarity, the controller supports the display and compensation of the four-quadrant power (such as a site with solar power generation), but current sampling shall not be reversely connected, the parameter is set by the manufacturer, the default setting is **None** no polarity.

4.3.3.5 Item P0006 (parameter of uncommonly used item):

Und-voltage: lower voltage limit, all capacitors can be cut off in case of undervoltage of system.

Harmonic overcurrent: the upper limit of the total current harmonic distortion rate, over the limit will cut off the capacitors, the default setting is 000.0%, which means that the harmonic current overcurrent alarm function is not activated.

COS ϕ  Cutting target power factor, default setting is 1.00.

Hint: If the input target power factor is 0.92 and the removal target power factor is set to 0.97:

1. If the current system power factor is lower than 0.92, the controller will put in capacitors to make the system power factor exceed 0.92 before stopping putting in capacitors;
2. After setting the cutting target power, if the current system power factor is greater than 0.97, the controller will cut the capacitor so that the system power factor is less than 0.97, and then stop cutting the capacitor.

Delay : Cutting delay setting, the default setting is 0, then it will share the same cutting delay with the input delay.

C/K group number DEC-  : Capacitance decay rate alarm reminding setting, the default is 100% means that the capacitance decay alarm is not activated, if the capacitor attenuation of one channel is smaller than this value, the automatic interface will only flash  alarm and continue to run.

C/K group number DEC- : Capacitor attenuation rate alarm setting, the default is 100% means that the capacitor attenuation alarm is not activated, a certain road capacity attenuation is less than the value, the automatic interface will flash the group number + this channel alarm, and this channel is no longer put into operation.

Tip: The Capacity Decay Alarm setting function will be activated only if already set C/K value and a measured C/K value is available.

thr - : In equal capacitance mode, single capacitor input threshold setting, default 110% means that the system demand reactive power should be greater than 1.1 times than the capacity of the capacitor before putting in this channel capacitor.

thr - : In equal capacitance mode, single capacitor removal threshold setting, default 50% means that the system oversupply reactive power has to be greater than 0.5 times than the capacity of the capacitor before this channel capacitor is removed.

PS---: Setting the parameter password, the default is 0000, then there is no need for password verification, when a non-zero password is set, then password verification is required to enter the **P0001~P0015** item parameter page from the **setup** menu.

Tip: Ask the user to keep the password in mind!

 **Number of groups**  **t** -: The upper limit of the running time (hour). The default is 000.0, then the function is not activated. When the set value has exceeded 1.0 hour, it will time each channel that have been casted, and after the running time reaches the upper limit value, it will cut off the channel, so that the controller will cast other channels which have been cut off, this function is applicable to the site of super-steady state load, and the site where the casting and cutting status has not been updated for the whole day.

 **Fan**: External fan start control temperature setting, the default is 40 °C (recommended setting value is less than 60 °C), that is, when the temperature of the controller reaches 40 °C, it will automatically start the external fan to ventilate and dissipate the heat (to realize this function, you need to set the last 1 channel of the controller as fan mode, and connect the fan).

4.3.3.6 Item P0007 (configure the output mode for each channel):

Number of Group Conf  : Set output mode for the first channel, 8 modes can be set and viewed, 1.nor: indicates normal mode (factory mode), 2.on: the channel is put in intrinsically (for transformer no-load compensation), 3.off: the channel is intrinsically cut off, 4.Fau: fault of this channel, 5.Dis: capacitor fault, 6.Abn: capacitance attenuation alarm of the capacitor, 7.Fan: indicates that the

channel is used for fan contact output (after the alarm of over-temperature, the contact is communicated), 8.Ala: indicating that the channel is for alarm junction output. Among them, modes 4, 5 and 6 can only be used for viewing but not setting.

Tip: If the 12th channel is set as temperature control contact output, then the number of controller groups can only be set to 12 channels, if only matched 9 channels capacitance, then need to set the remaining 10th/11th channel capacitive reactance parameter to 3.off mode.

4.3.3.7 Item P0015 (Clear the measured C/K value):

Clear each group of actual measured C/K value (displayed in the third line), when the controller measured C/K value is not very accurate (mainly due to load changes on the site during measurement), enter the parameter page can clear the measured C/K value, the controller then will use the set C/K value (on condition that the capacitive reactance configuration and CT multiplier is set, otherwise the controller will still automatically measure the C/K value).

4.3.4 "Automatic setting" mode:

This mode only can be operated on the site and shall not be used for commissioning in the panel builder plant.

This mode displays the set value (first line, factory default is 0) and the actual measured value (third line) of the C/K value of the capacitor currently being measured.

Tip: When performing the "Auto Setup" operation, select the time when the user's load is low or relatively stable.

The controller controls automatically when entering the mode, this process may take a few minutes to complete and when it is done , controller will operate in automatic mode.

Shortcut key: This function can be operated by long pressing the  key for 5 seconds in the automatic state

4.3.5 "Capacitive reactance" mode:

In this mode, configuration of each channel of capacitor is set: if one channel is set, following channels have the same configuration by default, with auto-following function for easy setting.

Reactance rate **P**: If there is a series reactor connected and the reactance is 7.0%, set it to P07.0; if there is no series reactor connected, set it to P00.0; the harmonic suppressor is set to P00.1.

Voltage **V**: Rated voltage 450.0V, 480.0V marked on the capacitor

Capacitor capacity **kvar**: the rated capacity of 15.0kvar, 30.0kvar, 50.0kvar marked on the capacitor

4.3.6 "C/K" mode (only for observation of C/K values):

This mode will display the C/K set value for each channel (first line) and the measured C/K value of the controller (third line); press  to select the next channel in ascending order, and press  to return to the previous channel in descending order; the parameter C/K can only be observed but not set.

The set C/K value (first line) is the results of calculations with the CT set value (CT multiplier set actual value), capacitor parameters, and reactor parameters. For example, if CT = 500/ 5, capacitor 30kvar/ 450V and reactor 6%, then C/K in a 400V power system is calculated as:

$$C/K = \frac{400 \times 400}{450 \times 450} \times \frac{30 \times 1000}{\sqrt{3} \times 400 \times 100 \times (1 - 6\%)} = 0.364$$

Tip: When the controller has both measured and set C/K values, the controller gives priority to the measured C/K value, and the measured C/K value must be cleared through the **P0015** setting if you want to use the set C/K value.

4.4 Shortcut key operation

Functions of shortcut operation are activated by long pressing each key for more than 5 seconds in the automatic state.

Shortcut key 1: Long press the  key, to enter the Quick Setup Wizard.

Shortcut key 2: Press and hold  key to enter phase sequence adjustment mode: the phase of sampled voltage and current can be changed by pressing the key; correct wiring errors without changing wiring.

Shortcut key 3: Long press  key to enter the auto setting mode: the controller automatically switch each circuit, and the CK value of the circuit is automatically acquired during the switching process. (Note: This function requires the grid environment to be relatively stable, such as no load current, or the load fluctuation does not exceed 30% of the minimum capacitance capacity during the automatic setting period.)

Shortcut key 4: Long press  key, power off the software, all outputs will be removed one by one and remain in the cut-off state, OFF is displayed on the interface, controller can be powered on again by pressing  key.

4.5 Alarms and protection

4.5.1 Protection functions

Protection 1: Overvoltage 

In case of overvoltage,  alarm flashes and all capacitors will be removed sequentially.

Protection 2: Over-temperature 

When the temperature inside the controller exceeds protection temperature, $^{\circ}\text{C}$ alarm flashes and all capacitors will be removed sequentially.

Protection 3: Harmonic overvoltage (upper limit of total harmonic voltage distortion rate) 

If the total voltage harmonic distortion rate exceeds the user-set harmonic overvoltage threshold,  alarm flashes and all capacitors will be removed.

4.5.2 Alarm functions

Alarm: Output Fault

When the capacitor corresponding to the output of the channel is open, there is a fault in switch or the fuse of the channel is burnt, the controller will flash the "group number" and the corresponding number of channel at the same time, such as: Steps  flashes at the same time, indicating that the 5th channel output has fault and this channel is no longer put into operation.

Alarm  :

Alarm 1: No-load alarm state

There is no load current or the load is too low (sampling transformer secondary side current is less than 0.02A), only alarm, do not cut off capacitance; forced to put into capacitance (such as when compensating system reactive power), the capacitance will not be removed even controller detected no load in the system.

Alarm 2: Insufficient compensation capacity alarm state

When all capacitors have been put in, the power factor is still below the inductive 0.9. This may result in the payment of interest rate electricity charges (i.e., reactive power penalties).

Alarm 3: Capacitive load alarm state (only alarm, not remove capacitor)

The controller is not putting in any set of capacitors, but the power factor is showing capacitive, which can lead to reactive power penalties.

5. technical specification

5.1 Technical parameters

- ※ Control physical quantity: reactive power and power factor.
- ※ Sensitivity: $\geq 20 \text{ mA}$.
- ※ Operating voltage: PS1, PS2 terminals, allowable voltage range is AC (85V to 305V) and independent power supply required.
- ※ Input voltage: L2, L3 terminals, AC 100V ~ 750V

Input current: I11, I12 terminals, 0 to 5A (Supports 0 to 1A on the secondary side of the current transformer).

※ Frequency range: 50 or 60 Hz +/- 5% (automatically adapts to the grid frequency).

※ Input current impedance: < 0.1 Ohm.

※ Controller energy consumption: ≤ 15VA.

※ Output point rating:

Maximum inductive load AC 250V/2.0A

※ Measurement accuracy:

- Voltage: ±1%;
- Current: ±1%;
- Power factor: ±1.5%;
- Active power: ±2.5%;
- Reactive power: ±2.5%.

※ Implementation of standards:

- 《JB/T 9663-2013》。

5.2 Functional parameters

※ Target power factor setting: from 0.5ind (inductive) to 0.5CAP (capacitive).

※ Switching delay time: 1.00~99.99 seconds.

※ Switching mode: circular(Cir), linear(Line) or fast (Fast).

※ Save function: All programmed parameters and modes are saved in a non-volatile memory.

※ Power failure protection: All capacitors will be disconnected automatically if power failure exceeds 20ms .

5.3 Installation and working environment

※ Overall dimensions: 148*148*76mm (length*width*thickness)

※ Installation hole size: 138*138mm

※ Weight: approx. 610g

※ Protection level: shell protection level IP30; panel protection level IP40

※ Operating temperature: -20°C to +55°C

※ Storage temperature: -25°C to +70°C

※ Relative humidity: Maximum 95 %; no condensation

6. Fault resolution

Fault	Resolution
The first time it is used in the field, the controller performs certain input and removal actions and then begins normal operation.	This is normal and usually only happens once.
After power on, controller display inductive, power factor is below 0.9 or less, target power factor is not reached, capacitor is not put into operation. This type of question is the most common question asked by customers	Usually caused by the load is too low, when the load is not high enough to put in the capacitance of one capacitor, the controller will not put in the capacitor, otherwise, even put in a capacitor will lead to overcompensation; Once the load increase, controller can be used normally.
After power on, controller display capacitive, and the capacitor is not put in; or the power factor drops instead of rising after the capacitor is put in.	Normally it is caused by wrong wiring, please check whether the phase sequence of voltage and current is correct or not (see #6 wiring diagram). If you suspect that the wiring is wrong, you can use the shortcut key and long press  for 5 seconds to correct the wiring phase sequence.
The power factor remains unchanged after the capacitor is put in.	The sampling current transformer is mounted in the wrong location, the current transformer should be mounted "in front" of capacitor banks and loads.
Controller display nothing after power on.	Check voltage protection settings, fuses and supply voltage, otherwise, the controller may be faulty.
 All capacitors are disconnected after the alarm icon flashes.	Check the grid voltage and maximum protection parameters, the upper limit value of the total distortion rate of the harmonic voltage, and the upper limit value of the over-temperature.
Current in the capacitor circuit increases abnormally after capacitor put in. Usually caused by large harmonic currents and harmonic voltages of system, while capacitors also can amplify harmonics, which may cause greater harm.	Install series reactor in each capacitor circuit, for the 5th and 7th harmonics, the reactance ratio is generally 7% of the iron core reactor; for the 3rd harmonic, the reactance ratio is generally 14%.

