OPERATING MANUAL

PQC
Power Quality Controller

The controller that maximizes reliability and monitors power quality

FRAKO Kondensatoren- und Anlagenbau GmbH
www.frako.com

Contents

1 About this manual

The PQC Power Quality Controller is an instrument for controlling the power factor and other power quality parameters. Throughout this manual, it will be referred to simply as the PQC.

The current version of this manual can be accessed at our website: www.frako.com.

1.1 Objective

This operating manual has been prepared for persons who install, connect, commission and operate the PQC. The manual must be read through carefully and completely before any work on or with the instrument is carried out. All actions taken must be in accordance with this manual.

1.2 Safekeeping

This operating manual contains important instructions for operating the PQC safely, correctly and cost-effectively. It is to be considered part of the instrument itself and must be held in a secure place where it can be referred to at all times.

1.3 Symbols used in this manual

Special instructions in this operating manual are marked by symbols and separated from the other text by lines.

Warning signs

In order to avoid accidents, death or injury and damage to assets, these instructions must always be followed. The warning signs consist of the appropriate key word – DANGER, WARNING, CAUTION or ATTENTION – plus a yellow symbol on the left-hand side, as shown below:

WARNING!

Type of danger!

Description of the danger and possible consequences

– Actions to avoid the danger

The symbols and key words classify the extent of the danger:

Symbol	Key word	Meaning
	DANGER	This key word indicates a hazard with a high level of risk that if not avoided can result in death or serious injury.
	WARNING	This key word indicates a hazard with an intermediate level of risk that if not avoided can result in death or serious injury.
	CAUTION	This key word indicates a hazard with a low level of risk that if not avoided can result in slight or moderate injury.
	ATTENTION	Damage to property could occur if this sign is not heeded.

Notes

Notes supplement the general text with additional information on the correct functioning and fault-free operation of the PQC. They are marked with the white-on-blue symbol on the left-hand side, as shown below:

Note

Example of a note

1.4 Reference documents

For further information on the PQC please refer to the following documents:

- “PQC Application Note”
- “Modbus Specification”
- “REST Application Note”

2 Safety

2.1 Intended use

Within the scope of the technical data (see *Section 3 "Technical data"*), the PQC Power Quality Controller is intended for the control of power factor cos φ by switching reactive power in and out. Any use of the instrument that deviates from its intended use must be expressly approved by the manufacturer.

2.2 Instrument-specific dangers

The PQC has been manufactured using state-of-the-art technology. Nevertheless, not all potential dangers can be excluded.

Failure to observe the safety instructions can result in death, serious injury or severe damage to equipment and other assets.

Danger from electricity

The PQC operates at the supply voltage. Touching live components at the instrument terminals and connecting cables can cause serious injury or may even be life-threatening.

- Installation, commissioning and decommissioning of the PQC may only be carried out by appropriately qualified technicians who are also familiar with and understand the contents of this manual.
- When the PQC is being installed or serviced, the instrument and the electrical system must be isolated from the power supply.
- The isolated electrical system must be locked out and tagged to prevent its being inadvertently switched on again.
- It must be verified that none of the terminals are live.
- All live components in the vicinity must be covered to prevent inadvertent contact.
- Current transformer circuits must be short-circuited before they are interrupted.
- Only approved installation cables must be used.
- The PQC must only be employed on duties up to the specified maximum power. Overloading the instrument can result in its destruction, create a fire hazard or cause an electrical accident. The load ratings for the various connections must not be exceeded.
- Do not open the PQC.
- When the PQC is in operation, the USB port must not be touched.

Danger from heat

The instrument terminals can become hot during operation.

– After the PQC has been operating, sufficient time must be allowed for the PQC and its terminals to cool down before work is carried out on the connections.

2.3 Management information

Personnel qualifications

The following qualifications are required for personnel working with the PQC:

– Installing, commissioning, troubleshooting (installation): electrician

– Operation, troubleshooting (faulty configuration): persons who have read and understood the operating manual.

– Troubleshooting (instrument faults): FRAKO Service + Support

User responsibility

In commercial operations in Germany, it is essential to comply with the regulations of the Social Accident Insurance Institution covering electrical installations. In other countries, the equivalent local regulations must be followed.

The safety of the system in which the PQC is incorporated is the responsibility of the persons installing and operating the system.

For safety reasons and to retain conformity with product approval requirements (CE marking), the user is not permitted to convert or otherwise modify the PQC.

The user must ensure that all operators are familiarized with this operating manual and follow it at all times.

2.4 Disclaimer

No claims under guarantee shall be valid in the event of damages caused by failure to observe the instructions in this operating manual. We shall not be held liable for consequential damages!

Incorrect operation or failure to observe the safety instructions will invalidate all claims under the guarantee, and no liability is accepted for any injuries to persons or damages to assets arising therefrom or occasioned thereby!

2.5 Relevant standards

Installation and commissioning of the instrument in industrial plant must be carried out in strict compliance with the following standards:

– EN 61508-1:2011-02; VDE 0803-1:2011-02

Any other laws, standards, regulations and safety rules (IEC, EN, VDE, etc.) relevant to this product and the protection of persons and assets must be observed. In Germany, it is essential to comply with the Equipment Safety Act (GSG) and the regulations of the German Social Accident Insurance Institutions. In other countries, the equivalent local regulations must be followed.

2.6 Repair

Should repair work be necessary, the customer or user must contact the manufacturer of the PQC: FRAKO Kondensatoren und Anlagenbau GmbH, Tscheulinstrasse 21A, D-79331 Teningen, Germany; www.frako.com.

3 Technical data

Power supply:

Type	xxx240x-xx	xxx480x-xx
Supply voltage	85–267 V AC (absolute limits), frequency 45–65 Hz, or 100–377 V DC (absolute limits)	85–530 V AC (absolute limits), frequency 45–65 Hz, or 100–750 V DC (absolute limits)
Power draw	maximum 5 VA	
Overcurrent protection	External, maximum 2 A (time delay) specified	

Inputs:

Category	Single phase	3-phase
Type	xxxxxx1-xx	xxxxx3-xx
Voltage path measurement inputs	80 V AC – maximum 760 V AC (phase–phase, absolute limits), suitable for 115–690 V AC networks, electrically interconnected via high resistances, measurement of medium voltages possible using an x/100 V transformer; In areas where UL / CSA standards apply (versions PQC xxx480x-xx): networks with nominal voltages 115–600 V AC; power failure detection after duration of a half-wave	
Current path measurement inputs	x/5 A AC or x/1 A AC (transformer secondary current ≥ 15 mA), electrically isolated, power draw maximum 1 VA per transformer connection, continuous overload rating up to 6 A AC, transient overload maximum 10 A AC for 10 seconds	
Digital inputs	Up to five digital inputs	
	5–24 V DC inputs, alternatively usable as up to 5 x 24 V DC, 100 mA outputs, electrically interconnected with each other and the temperature input	
Temperature inputs	1 x PT-100 or PT-1000 RTD, 4-wire or 2-wire configuration, automatic probe type identification; 2 x NTC thermistor type TDK/ Epcos-B57861S0502F040, FRAKO Article No. 29-20094, measuring range –50 °C to +200 °C, electrically connected with the digital outputs	

Category	Single phase	3-phase
Type	xxxxxx1-xx	xxxxx3-xx
Type	xxxxxx-4x	
Profile switching (T)	S0 pulse as per DIN 43864, common earth with FRAKO Starkstrombus (Frakobus)	

Interfaces:

Type	xxxxxx-2x	xxxxxx-3x	xxxxxx-4x
Modbus RTU interface	120 Ω terminating resistor required at the end of the bus system		
Ethernet interface (Modbus TCP, web server)		100 Mbit/s Ethernet standard 100 BASE-T	
FRAKO Starkstrombus (Frakobus)			RS-485, surge impedance 120 Ω, for connection to the FRAKO Energy Management System

Outputs:

Category	12 output relays	6 output relays	6 output relays
Type	120xxxx-xx	060xxxx-xx	061xxxx-xx
Output relays (outputs for switching stages)	NO contact with common pole P; AC - 14 250 V AC, maximum 3 A or DC - 13 30 V DC, maximum 3 A, mechanical service life 2×10^7 cycles, electrical service life AC - 14 at 3 A: 1×10^5 cycles, AC - 14 at 0.5 A: 2×10^6 cycles		AC-14 440 V AC, max. 3 A or DC-13 125 V DC, max. 3 A, mechanical service life 1×10^7 cycles, electrical service life AC-14 at 3 A:1×10^5 cycles, AC-14 at 0.5 A: 2×10^6 cycles
	Common supply conductor P to the output relays maximum 10 A; Note: utilization category AC-14/DC-13 as per IEC 60947-5-1; for all PQC types in areas where UL / CSA standards apply: 3 A 250 V AC cos φ = 1 at 85 °C, 3 A 30 V DC L/R = 0 ms at 85 °C		

Category	12 output relays	6 output relays	6 output relays
Type	120xxxx-xx	060xxxx-xx	061xxxx-xx
Alarm contact	Volt-free NO contact, AC-14 250 V AC, max. 3 A or DC-13 30 V DC, max. 3 A, mechanical service life 2 × 10^7 cycles, electrical service life AC-14 at 3 A 1.5 × 10^5 cycles, AC-14 at 0.5 A 2 × 10^6 cycles. Note: utilization category AC-14/DC-13 as per IEC 60947-5-1, in areas where UL / CSA standards apply: 3 A 250 V AC cos φ = 1 at 85 °C, 3 A 30 V DC L/R = 0 ms at 85 °C		
Type	xxxxxxx-x1		
Digital outputs	Up to 5 digital outputs 24 V DC, 100 mA, electrically interconnected with each other and the temperature input. Alternatively usable as up to 5 × 5–24 V DC digital inputs. Note: This internal interconnection gives rise to a minimum current of about 1 µA at the outputs. In the case of a relay with low power LEDs, for example, a weak glow may therefore result.		

Connections: Via pluggable screw terminals

Type	xxx240x-xx	xxx480x-xx
Instrument power AUX, Insulation rating	Conductor cross section max. 2.5 mm², min. 0.2 mm²	
	min. 250 V AC, 70 °C	500 V AC, 70 °C
Protective earth PE	Via 6.3 mm female slide connector; conductor cross section at least equal to the largest conductor cross section of the AUX phases, the voltage measurement connections, the output relays and the alarm connections; insulation colour yellow/green	
Voltage measurement inputs L1, L2, L3, N	Conductor cross section max. 2.5 mm², min. 0.2 mm² Insulation rating; Example 1: for 230 V AC, select at least 250 V AC, 70 °C; Example 2: for 690 V AC, select at least 750 V AC, 70 °C	
Current measurement inputs L1, L2, L3, terminals S1 and S2 in each case	Conductor cross section max. 2.5 mm², min. 0.2 mm² Insulation rating: min. 250 V AC, 70 °C	
Type	xx0xxxx-xx	xx1xxxx-xx
Output relays (outputs for switching stages)	Conductor cross section max. 2.5 mm², min. 0.2 mm²	
	250 V relay Insulation rating: min. 250 V AC, 70 °C	440 V relay Insulation rating: min. 500 V AC, 70 °C
Alarm contact	Conductor cross section max. 2.5 mm², min. 0.2 mm² Insulation rating: min. 250 V AC, 70 °C	

USB for updates (service interface)	USB Micro A and Micro B ports
Type	**xxxxxxx-x1**
Digital inputs and outputs	Conductor cross section max. 1.5 mm², min. 0.14 mm² Insulation rating: 50 V DC, 70 °C
Temperature inputs	Conductor cross section max. 1.5 mm², min. 0.14 mm² Insulation rating: 50 V DC, 70 °C
Type	**xxxxxxx-2x**
Modbus RTU interface	Conductor cross section max. 1.5 mm², min. 0.14 mm² Insulation rating: 50 V DC, 70 °C
Type	**xxxxxxx-3x**
Ethernet interface	Ethernet cable Cat 5 as per TIA-568A/B, S/FTP shielding, RJ45 plug
Type	**xxxxxxx-4x**
FRAKO Starkstrombus (Frakobus)	Conductor cross section max. 1.5 mm², min. 0.14 mm² Insulation rating: 50 V DC, 70 °C
Input for profile switching	Conductor cross section max. 1.5 mm², min. 0.14 mm² Insulation rating: 50 V DC, 70 °C

Note

0.14 mm² = AWG 26; 0.2 mm² ≈ AWG 25;
1.4 mm² ≈ AWG 16; 2.5 mm² = AWG 14

Design data:

Dimensions (W x H x D)	144 mm × 144 mm × 70 mm casing 144 mm × 165 mm × 70 mm casing including connectors
Mounting	Front of panel in 138 mm x 138 mm cutout to IEC 61554, held by four retaining lugs at the corners of the casing Maximum screw tightening torque 0.4 Nm
Weight	approx. 770 g without packaging
Ingress protection	Front of instrument when mounted in cabinet IP40, when mounted in cabinet with upgrade kit (Article No. 20-50015) IP54; rear of instrument and terminals IP20; all as per EN 60529 Pollution degree 2 as per EN 61010-1:2011-07.

Electrical design	Casing protection class I as per EN 61140 Working voltage up to max. 760 V AC absolute value at voltage measurement inputs. TNV1 circuits, some of which interconnected: digital inputs and outputs, optional temperature inputs, optional Modbus interface.
Casing design	Flammability rating UL 94 V-0 according to casing manufacturer Impact resistance IK06 as per EN 61010-1:2011-07, 8.2.2
Service life	At +25 °C ambient temperature 15 years
EMC	EMC as per EN 61326-1 EN 61000-4-2, electrostatic discharge: air 8 kV and contact 6 kV with horizontal and vertical coupling plane EN 61000-4-3, radiated immunity (EMS) 80 MHz – 1 GHz, horizontal and vertical, level 10 V/m = industrial environment radiation, Class A Hardware version V1.0: EN 55022A EMI 30 MHz – 1 GHz = industrial environment, Class A Being a Class A device, this version can cause radio interference in residential areas. In this case, users may be called upon to take appropriate remedial measures at their own expense. From hardware version V1.2: EN 55022A EMI 30 MHz – 1 GHz = office and residential area, Class B EN 61000-4-6, immunity to conducted disturbances, level 10 V RMS, 150 kHz – 80 MHz[1] PQC xxxxxxx-3x: EN 55022A EMI 30 MHz – 1 GHz = office and residential area, Class A EN 61000-4-4, burst immunity, 1 kV capacitive coupling, 2 kV injection into power supply cable and voltage measurement inputs EN 61000-4-5 surge immunity, 2 kV injection into power supply cable and voltage measurement inputs

1 The standard radio-frequency field test as per EN 61000-4-6 (EMC immunity) calls for amplitude modulation at a modulation frequency of 1 kHz. However, this frequency lies within the measurement range of the instrument in its intended use (20th harmonic of 50 Hz = 1 kHz). It is therefore to be expected that the measuring circuit clearly respond to the standard test. For this reason, the radio-frequency field test can only be carried out without amplitude modulation.

Ambient conditions:

Temperature range	-25 °C to +65 °C, noncondensing
Installation altitude	Maximum height above sea level 2000 m

Measuring system:

Accuracy	Voltage and current measurement ±1% at 50/60 Hz and 25 °C ambient temperature
Averaging function	Over 1 second, updated every 100 ms
Harmonics	Measured via Lx–N All even and uneven harmonics up to the 19th

4 Instrument description

4.1 Function

The PQC Power Quality Controller continuously calculates the reactive and active power components in the supply network using the measurement data from the current path (current transformer) and the voltage path (voltage measurement connection). If the reactive power component exceeds certain thresholds, which the PQC has determined during the calibration procedure or which have been set as described, switching commands are given via the instrument outputs. If the inductive reactive power is greater than the value preset during instrument configuration (target cos φ), after an adjustable time delay one or more of the PQC control contacts are closed. The PQC thus switches capacitor stages in as required in order to restore the target power factor. If the inductive reactive power component of the loads reduces again, this causes capacitor stages to be switched out. The PQC makes a variety of options possible for customizing the control settings to suit the individual application. The clear overview in the display provides effective monitoring of power factor correction. So-called ‘cyclic switching’ is a useful feature for prolonging the service life of the installation, since it ensures that all capacitor stages of the same power rating are on average switched in equally frequently.

Regeneration

The PQC has a four-quadrant control function. If active power is fed back into the supply network, for example by combined heat and power systems, the PQC continues to correct for the reactive power drawn from the supply network. When this regeneration occurs, the active power P is displayed with a minus sign before it. Regeneration mode is also indicated by a symbol appearing on the display screen.

4.2 Instrument versions

The PQC is available in various versions, identifiable by their type designation:

PQC	xx	x	xxx	x	–	x	x	Type designation
PQC PQC	12 06	0 1	240 480	1 1	– –	2 3	1 0	Example

- Measurement inputs:
1 = Temperature (I/O extension)
- Interface:
2 = Modbus RTU
3 = Ethernet
4 = FRAKO Starkstrombus (Frakobus)
- Measurement inputs:
1 = single-phase
3 = 3-phase
- Max. supply voltage:
240 V
480 V
- Output relays:
0 = 250 V
1 = 440 V
- Number of switching outputs:
12
06

4.3 User interface

The instrument is operated with the five keys located below the display:

Key	ESC	↑	↓	⇄	i
Action	PQC overview	Select	Select	Open submenu	Display information

Note

The keys are assigned different functions according to the particular menu. These specific functions are described in the appropriate section.

Icon	Key	Function
	Escape	Go back one level in the system tree.
	Up	Increase a selected parameter by an increment. Move a selected item upwards.
	Down	Decrease a selected parameter by an increment. Move a selected item downwards.
	Return/Enter	Go one level deeper in the system tree (e.g. Select a chosen parameter). Select and confirm a chosen parameter (e.g. Adopt a value).
	Info	Help text

The PQC can be operated in three languages, which are selected at **Main menu > Configuration > Service > Commissioning** (see *Section 5.3.2 “PQC initial start-up”*):

– **German**

– **English**

– **French**

4.4 Password protection

The PQC uses a password to prevent sensitive menu items being accessed by unauthorized persons.

Protected menu items:

– **Main menu > Configuration**
  Security level 1, Password: last four digits of the serial number (see label on PQC or *Section 6.4 “About PQC”*.

– **Main menu > Configuration > Service > Reset Switch. Count**

– **Main menu > Configuration > Service > Service**
  Security level 2, Password: 3725

The user is prompted to enter the password as soon as a protected menu is selected.

The ↑ and ↓ keys are used to adjust each digit, which is then confirmed with the ⇄ key. Once the 4th digit has been confirmed with this key, the menus at the security level concerned become accessible for one hour.

5 Installation

The installation of the PQC is carried out in three steps:

- Mounting at the desired location (see *Section 5.1.1 “Preparing for installation”* and *Section 5.1.4 “Mounting the instrument”*)
- Electrical connections (see *Section 5.2.1 “Electrical installation procedure”* and *Section 5.2.2 “Completing the electrical installation”)*
- Commissioning (see *Section 5.3.1 “Preparations for start-up”*)

The steps must always be taken in this order.

5.1 Mounting at the desired location

5.1.1 Preparing for installation

1. Verify that the set is complete (see *Section 5.1.2 “Scope of supply”*).
2. Inspect the instrument for any external damage.
   If any damage is apparent, for safety reasons it must **not** be put into service.
   In case of doubt, please contact FRAKO Service + Support.
3. Verify that the intended location of the PQC is suitable (see *Section 5.1.3 “Suitable location”*).

5.1.2 Scope of supply

The PQC and its accessories consist of:

- 1 PQC instrument
- 4 or more (depending on the instrument version) reverse-polarity-proof male connectors, supplied loose
- 1 operating manual
- 1 DVD

5.1.3 Suitable location

The location where the PQC is installed must comply with the following conditions (see also *Section 2.1 “Intended use”* and *Section 3 “Technical data”*):

- Only install the PQC in areas where there is no danger of gas or dust explosions.
- Do not expose the PQC to direct sunlight or high temperatures, and do not install the instrument near to devices that generate heat.
- The PQC must be mounted in an adequately ventilated area. Its rear and sidewalls must not be covered.
- Do not expose the instrument to rain, water, dampness or high levels of humidity.

Avoid direct contact with water at all cost.

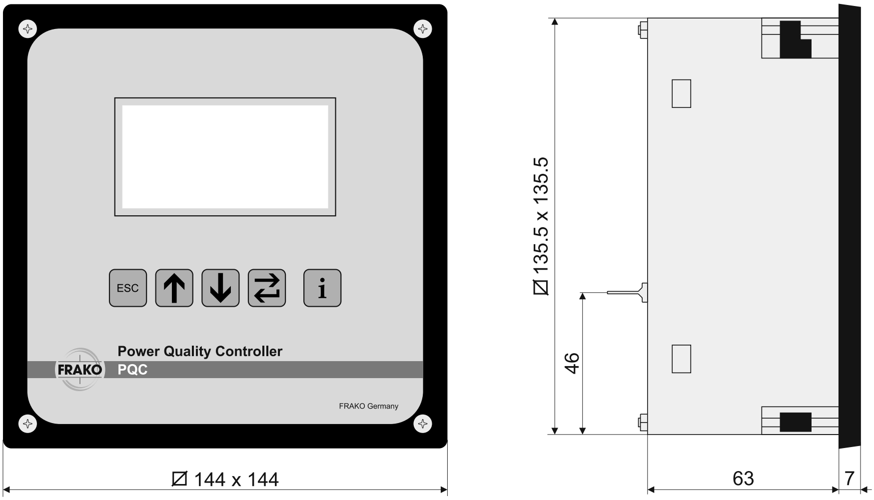
– Protect the PQC against jolting and physical blows.

The instrument is installed vertically on the outside of the control cabinet or enclosure so that the controls and display are accessible to the operator.

Hardware version V1.0: This is a Class A device. In office and residential areas, it can cause interference to radio reception. In this case, it may be necessary to take appropriate precautions with the installation.

When considered from the rear, the PQC is a panel-mounted instrument with IP20 ingress protection. Adequate protection against inadvertently touching live components must be provided, and the ingress of dust and water must be prevented by ensuring that the instrument is installed in a suitable enclosure (e.g. control cabinet or distribution panel).

5.1.4 Mounting the instrument



The PQC is designed for mounting in a 138 mm x 138 mm cutout to IEC 61554 in the front of a control cabinet. It is held in place by four retaining lugs in the corners of the instrument.

Note

The option is given of mounting the PQC in control cabinets with IP54 ingress protection. For this an additional gasket (Article No. 20-50015) is available that seals the gap between the PQC front panel and the wall of the control cabinet.

WARNING!

Danger from electricity!

Touching live components at the instrument terminals and connecting cables can cause serious injury or may even be life-threatening.

– Installation, commissioning, decommissioning and removal of the PQC may only be carried out by appropriately qualified personnel who have read and understood the content of this manual.
– When the PQC is being fitted and connected, the instrument and the electrical system must be isolated from the power supply.
– The isolated electrical system must be locked out and tagged to prevent its being inadvertently switched on again.
– It must be verified that none of the terminals are live.
– All live components in the vicinity must be covered to prevent inadvertent contact.

1. Turn the four retaining screws at the front of the PQC anticlockwise so that the four retaining lugs in the corners of the instrument are swivelled to lie flat behind its front panel.
2. Option: In the case of a cabinet with IP54 ingress protection, fit the gasket from the accessories set in the rear groove behind the PQC front panel.
3. Insert the sheet-metal rear of the PQC through the cutout provided in the control cabinet until fully home.
4. Press the PQC front panel gently against the control cabinet exterior and tighten the four retaining screws at the corners by turning them clockwise, applying a torque of ≤ 0.4 Nm. This causes the retaining lugs to swivel outwards and be drawn towards the inner side of the cabinet wall until they are held tightly up against it.

5.2 Electrical installation

5.2.1 Electrical installation procedure

WARNING!

Danger from electricity!

Touching live components at the instrument terminals and connecting cables can cause serious injury or may even be life-threatening.

– Installation, commissioning, modification and retrofitting at the PQC may only be carried out by appropriately qualified personnel who have read and understood the content of this manual.
– When the PQC is being fitted and connected, the instrument and the electrical system must be isolated from the power supply.

– The isolated electrical system must be locked out and tagged to prevent its being inadvertently switched on again.
– It must be verified that none of the terminals are live.
– All live components in the vicinity must be covered to prevent inadvertent contact.

CAUTION!

Danger from heat

The instrument terminals can become hot during operation and could cause burns.

– After the PQC has been operating, sufficient time must be allowed for the instrument and its terminals to cool down before work is carried out on the connections.

The PQC is connected as shown in the diagrams in *Section 5.2.10 "Connection diagrams for all PQC types"* and as specified in *Section 5.2.3 "Specifications for the electrical connections"*:

1. Connect the earth (see *Section 5.2.4 "Earth connection"*).
2. An external disconnecting device with a fuse must be fitted in the power supply line to the PQC (see *Section 5.2.5 "Power supply"*).
3. Connect the voltage measurement cabling (see *Section 5.2.6 "Voltage measurement"*).
4. Connect the current measurement cabling (see *Section 5.2.7 "Current measurement"*).
5. Connect the output relays (see *Section 5.2.8 "Output relays (control outputs)"*).
6. If required, connect the alarm relay to transmit an alarm signal (see *Section 5.2.9 "Alarm function"*).

5.2.2 Completing the electrical installation

WARNING!

Danger from electricity!

If there is a fault in the wiring adjacent to the PQC, there is a danger that its four retaining screws could become live and therefore a safety hazard. Touching live components at the instrument terminals and connecting cables can cause serious injury or may even be life-threatening.

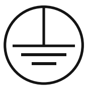
– Securely fasten the cabling at the location where the PQC is mounted (e.g. control panel, cabinet).

At the location where the PQC is installed (e.g. control cabinet, enclosure), verify that all wires and cables are securely fastened or grouped in harnesses to ensure that any stray wire or strand cannot contact one or more of the instrument's retaining screws.

5.2.3 Specifications for the electrical connections

- Only approved solid core or stranded wire cables having an adequate cross section and sufficiently high voltage withstand ratings must be used for the connecting cabling.
- If flexible stranded cables are used for the PQC connections, short ferrules 6 mm in length must be crimped onto their ends.
- Suitable clips or other fasteners must be fitted to relieve any strain on the wires and cables connected to the PQC.
- No additional connectors must be fitted in the wires and cables connected to the PQC.
- All the connectors supplied with the PQC must be plugged in, even when it is not intended to use them, and be secured to the instrument with their retaining screws, if provided.

5.2.4 Earth connection



An earthing tab is provided for the PE connection in the rear wall of the casing. It is marked with the earthing symbol as per EN 60617-2 shown at left

The PE conductor cross section must be at least equal to that of the largest conductor of the AUX phases, the voltage measurement connections, the relay outputs or the alarm connections. Its insulation colour is yellow/green. Earthing connections for network power circuits must have at least the same current-carrying capacity rating as the circuits themselves.

If the earthing tab has broken off, the PQC must not be started up. The instrument must either be repaired or replaced.

Note

The PQC may only be put into service if the earthing conductor is connected to it.

5.2.5 Power supply

External disconnector

An external disconnecting device, such as an isolator or circuit breaker, must be fitted in the power supply line to the PQC. This must be located in the vicinity of the instrument and must be able to isolate all cables connected to the AUX terminals of the PQC. This device must not disconnect the earthing conductor.

Fuses

The instrument power supply circuit AUX must be protected externally by one or two fuses, either:

– 2 A time delay, 250 V AC (PQC Type: PQC xxx240x-xx) or
– 2 A time delay, 500 V AC (PQC Type: PQC xxx480x-xx).

One such fuse is required in the phase line when the power is from a **phase–neutral** connection, but two fuses must be installed, one in each phase, if a **phase–phase** connection is used.

Please refer to the diagrams in *Section 5.2.10 "Connection diagrams for all PQC types"*, for further information.

5.2.6 Voltage measurement

Depending on the instrument type, the PQC can measure one, two or three AC voltages. The voltage measurement inputs are electrically interconnected via high resistances. See *Section 3 "Technical data"* for the measurement ranges. DC voltages cannot be measured.

The PQC voltage measurement inputs are designed for 100–690 V AC networks.

It is possible to measure medium voltages using an x/100 V transformer.

It is not necessary to provide external overcurrent protection in the voltage measurement circuits since these are safety impedance-protected. In this case, a short-circuit-proof cable (double insulated stranded wire) must be used to connect the voltage measurement inputs.

Instrument types with single-phase measurement:

For single-phase measurement, the terminals **L** and **N/L** are connected as shown in the diagrams in *Section 5.2.10 "Connection diagrams for all PQC types"*. The voltage can be measured between any two phases or between any phase and neutral.

Instrument types with 3-phase measurement:

For 3-phase measurement, the terminals **L1, L2, L3** and **N** are connected as shown in the connection diagrams in *Section 5.2.10 "Connection diagrams for all PQC types".* Phases **L1, L2** and **L3** must be connected in correct phase sequence.

For 3-phase measurement, it is advisable to connect the **N** terminal as well. This enables the high measurement accuracy of the PQC to be achieved when measuring phase–neutral voltages and the parameters derived from these. If no neutral conductor is present, the **N** terminal can be left unconnected. However, this is only advisable when the phases are symmetrically loaded.

Note

If an instrument type designed for three-phase measuring is used to measure only one phase, the terminals **L1** and **N** must be used. The terminals **L2** und **L3** must then be commoned with the terminal **N** to prevent incorrect measurements being made.

5.2.7 Current measurement

The PQC is designed for connection to x/1 A and x/5 A external current transformers electrically isolated from the power supply. Depending on the instrument type, the PQC can measure one, two or three AC currents. Attention must be paid to the allowable measurement range. See *Section 3 “Technical data”* for further information.

WARNING!

Danger from electricity!

If live current transformer circuits are interrupted, there is the danger that arcing may occur, which could cause electric shock, burns or eye injuries. In addition, red-hot metal particles could be spattered, which apart from the health hazard also constitute a fire risk.

– The retaining screws on the connectors must be tightened to prevent the connectors accidently working loose.

– The secondary-side connections of the current transformers must be short-circuited before the circuits to the PQC are interrupted or the connector removed!

Note

If an earth terminal is provided at the secondary side of the current transformer, this must be connected to an earthing conductor! We recommend in general that every current transformer circuit be earthed.

Instrument types with single-phase measurement:

The current can be measured in any desired phase, with the current transformer circuit connected to the **L** terminals **S1** and **S2** as shown in the diagram (see *Section 5.2.10.1 “Connection diagram: Type PQC 1202401-xx”*).

Instrument types with 3-phase measurement:

The current transformer circuits must be connected to the respective S1 and S2 terminals for each of the phases L1, L2 and L3, as shown in the diagram (see *Section 5.2.10.2 “Connection diagram: Type PQC 1202403-xx”*).

Unassigned current measurement inputs can be left unconnected.

Note

In networks with a nominal voltage of 1000 V and more, the regulations call for the current transformer circuits to be earthed.

If networks with a nominal voltage of 1000 V or over are left unearthed, damage may occur to the instrument.

With three-phase measurement, automatic connection identification is not possible.

5.2.8 Output relays (control outputs)

Depending on instrument type, the PQC is equipped with 6 or 12 output relays (control outputs). Relays or contactors are usually connected to these to switch the capacitor stages in and out.

The output relays **Q1–Q12** (**Q1–Q6** in the case of PQC versions with 6 output relays) receive their control voltage from a common feed **P**. The load ratings of the output relays and the common feed line **P** can be found in the connection diagrams or the technical data (see *Section 3 “Technical data”*).

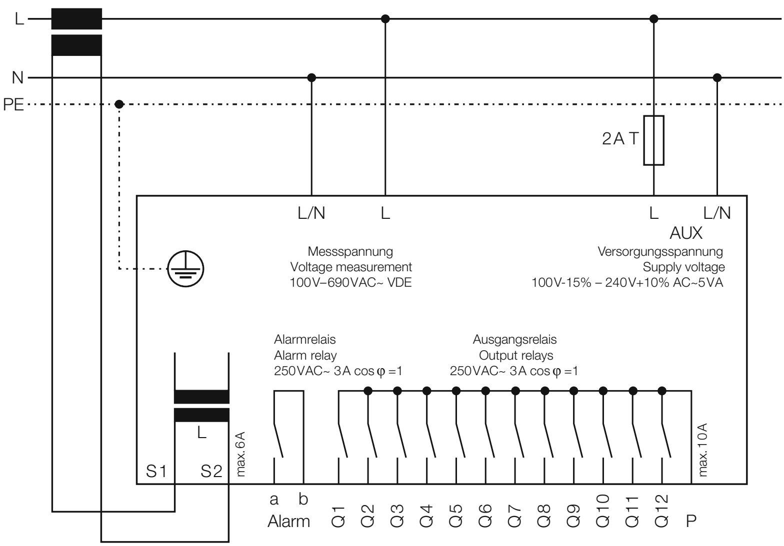
If not all of the available output relays are to be used, it is recommended to connect the output cables starting with output 1 and leaving no gaps.

5.2.9 Alarm function

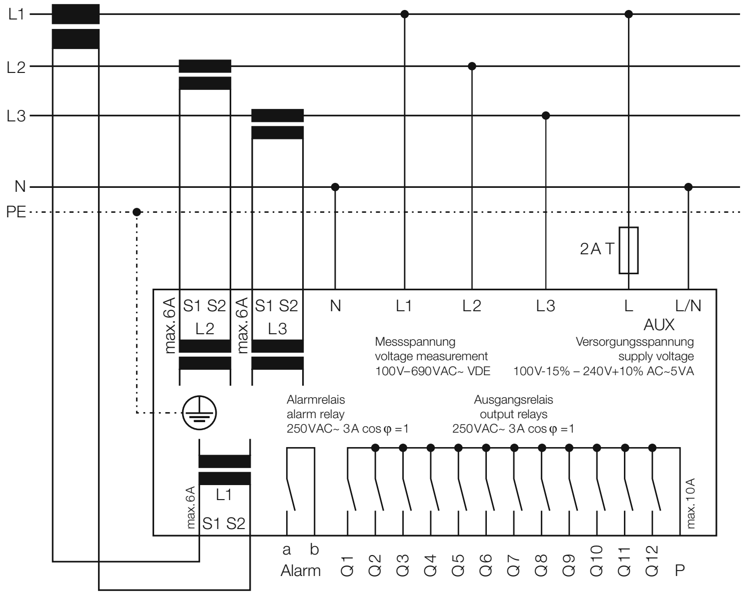
The PQC has a volt-free contact to transmit alarms externally, alarm terminals **a** and **b** being provided for this external connection as shown in the diagrams in *Section 5.2.10 “Connection diagrams for all PQC types”*. Attention must be paid to the load rating of the contact (see *Section 3 “Technical data”*).

5.2.10 Connection diagrams for all PQC types

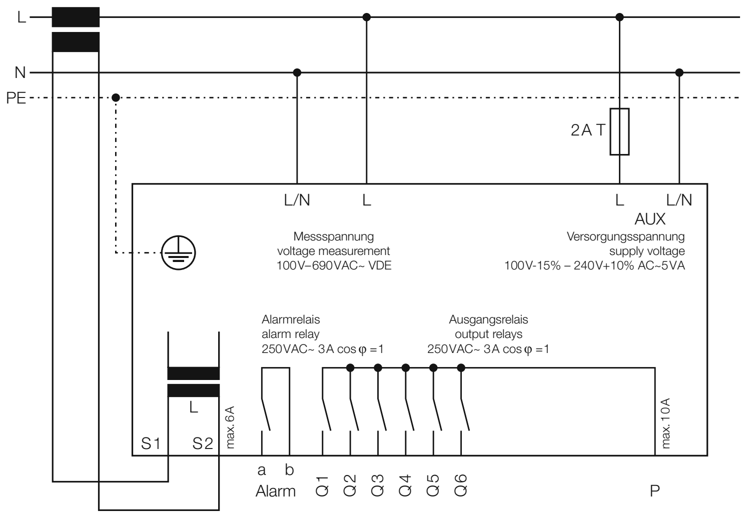
5.2.10.1 Connection diagram: Type PQC 1202401-xx



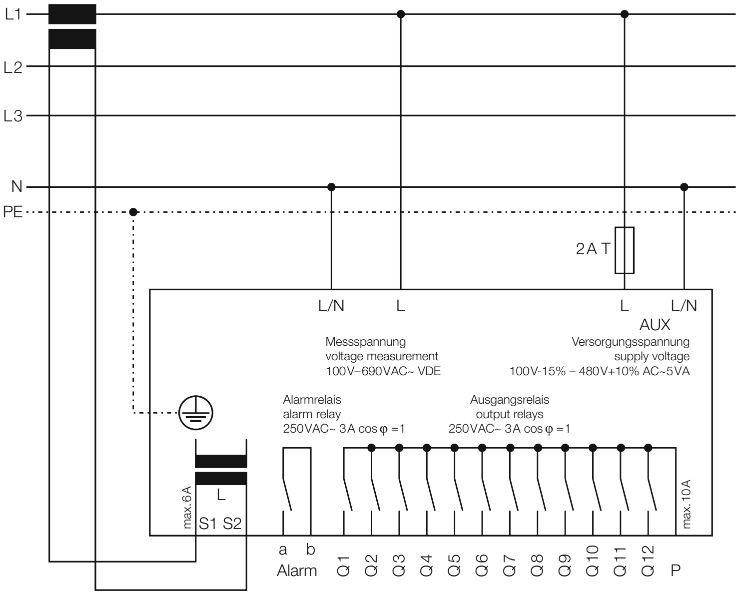
5.2.10.2 Connection diagram: Type PQC 1202403-xx



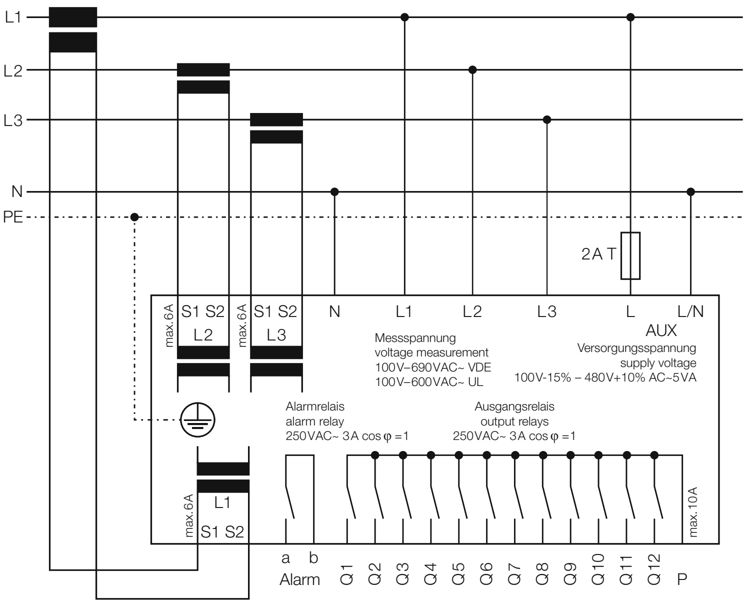
5.2.10.3 Connection diagram: Type PQC 0602401-xx



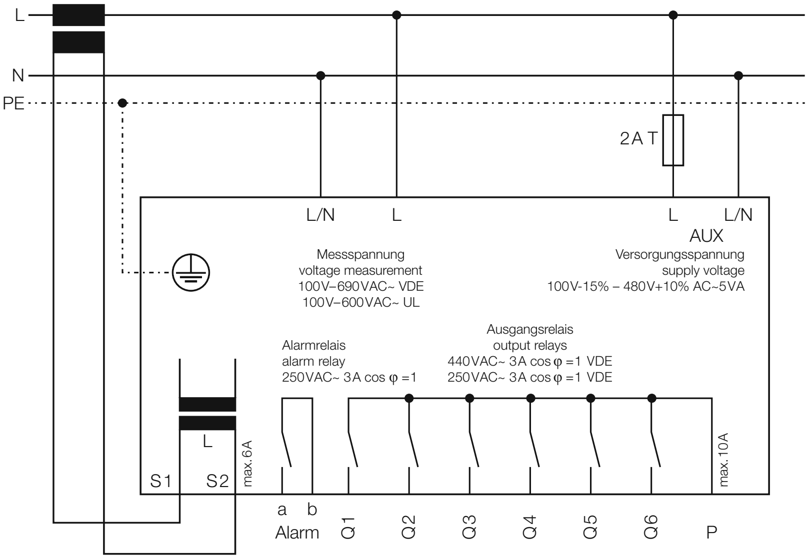
5.2.10.4 Connection diagram: Type PQC 1204801-xx



5.2.10.5 Connection diagram: Type PQC 1204803-xx



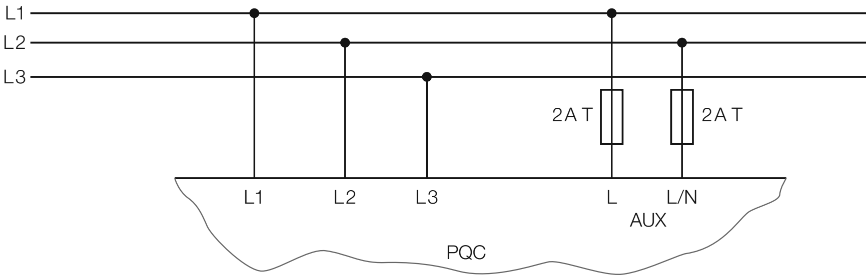
5.2.10.6 Connection diagram: Type PQC 0614801-xx



5.2.10.7 Options for connecting the AUX power supply for PQC xxx480x-xx types

Connecting the AUX terminals to a 100 to 480 V AC power supply

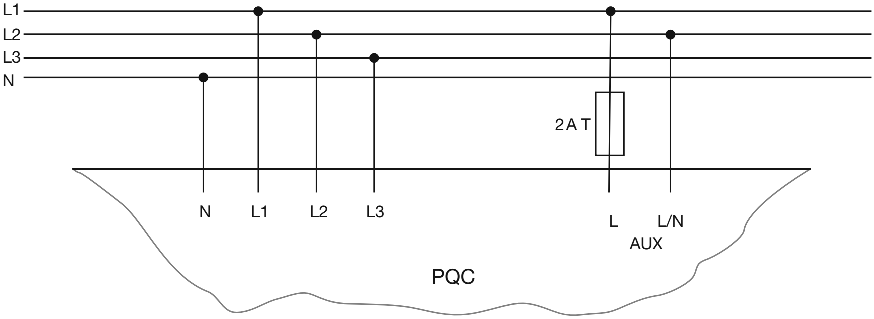
Part of connection diagram for 400/415 V networks with no neutral conductor



Instrument type: PQC 1204803-xx

400 V AC / 415 V AC – Networks with no neutral N

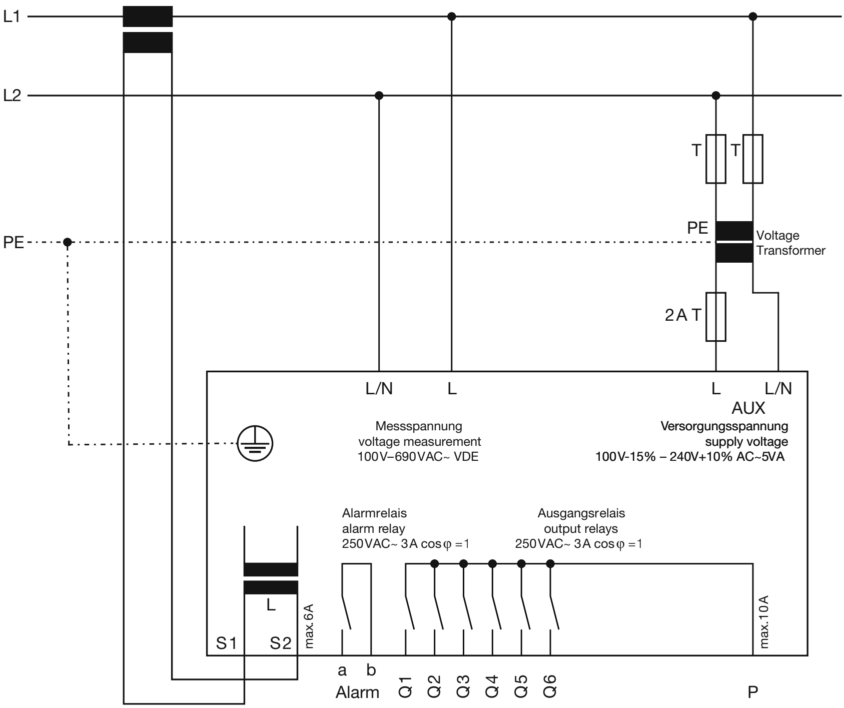
Part of connection diagram for 690 V networks with a neutral conductor



Instrument type: PQC 1204803-xx

690 V AC networks with neutral N (phase – neutral = 400 V AC)

5.2.10.8 Other connection options



5.3 Commissioning (initial start-up)

5.3.1 Preparations for start-up

WARNING!

Danger from electricity!

Touching live components at the instrument terminals and connecting cables can cause serious injury or may even be life-threatening.

– It must be verified that the PQC is installed and connected in accordance with its intended use before power is switched on.

– Cover the instrument terminals.

ATTENTION!

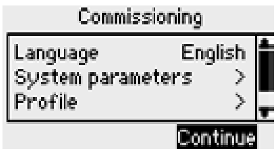
Risk to equipment!

If the PQC terminals are wrongly connected, or if the wrong voltages or signals are applied to them, this can damage the instrument itself and the installation.

– Verify that all the connections are correct before switching on the power.

1. Verify that the PQC has been correctly installed and connected as described in *Section 5.1 "Mounting at the desired location"* and *Section 5.2 "Electrical installation"* and that all the connectors supplied with the instrument have been plugged in.
2. Verify that the earth connection has been made.
3. Ensure, for example by means of a closed door or a suitable cover, that the instrument terminals can no longer be touched.
4. Switch on the instrument power.
5. Carry out the initial start-up (see *Section 5.3.2 "PQC initial start-up"*).

5.3.2 PQC initial start-up



Key	ESC	↑	↓	⇄	i
Action	Main menu	Select language dt – en – fr	Select language dt – en – fr	Confirm language and return to parameter selection	–

When the power is switched on, the PQC Start screen is displayed, showing information about the installed firmware. The initial start-up dialogue then starts automatically, in which the essential parameters for operation can then be set and the start-up mode selected.

Note

If the PQC does not start, switch off the power and check the cabling.

The following parameters must be selected or confirmed:

Language German, English (factory default), French

Network parameters **Voltage transformer ratio**

Range 1 to 300, transformer ratio: $\frac{V_{primary}}{V_{secondary}}$

Current transformer ratio

Range 1 to 7000, transformer ratio: $\frac{I_{primary}}{I_{secondary}}$

Example: current transformer $\frac{500\,A}{5\,A}$

Transformer ratio: $k = \frac{I_{primary}}{I_{secondary}} = \frac{500\,A}{5\,A} = 100$

Profile Control profile, with which the PQC is to operate after a successful start-up.

The PQC as delivered from the factory is set with the FRAKO specific kinked control characteristic curve and the target cos φ_{target} = 0.92 ind. See *Section 6.3.3 "Control parameters"*.

Communication Where relevant: settings for communication interface (Modbus RTU / Modbus TCP / Frakobus). See *Section 6.3.5 "Communication (optional)"* for further information.

Identification Automatic / manual connection and stage identification (see *Section 5.3.3 "Automatic connection and stage identification"* and *Section 5.3.4 "Manual connection and stage identification"*).

Note

For the voltage and current readings (and the values of power derived from them) to be displayed correctly, it is essential that the voltage and current transformer ratios be entered.

Regardless of the initial start-up mode, all the configuration data are saved in a non-volatile memory. In the event of power loss (intended or not) these data are not lost. When the power supply returns, the PQC starts up automatically and begins the control process after booting up.

Note

Automatic connection and capacitor stage identification is only possible with single-phase measurement.

5.3.3 Automatic connection and stage identification

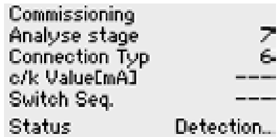
To start the automatic connection and capacitor stage identification procedure, select **Auto** in the **Detection** menu and confirm this with **Continue**.

The PQC switches the individual output relays one after the other and identifies not only the phase angle of the current and voltage measurement paths but also to which output each capacitor stage is assigned. Each output is switched several times until the PQC can verify the measured values. When identifying stages automatically, the PQC determines the capacitance value of each switching output relative to that of the smallest stage. These relative values are displayed as a switching sequence.

Relative values > 9 are represented by letters (a = 10, b = 11, ...).

This is shown in the following screenshots:

Stage capacitive power identification is being carried out; connection identification is complete, with the result connection type 6.



When the PQC has successfully completed the connection and stage identification procedure, the operator must confirm the result with the ⇄ key. The PQC then switches to operating mode and displays the **PQC overview** screen. If at this moment there is a concrete need for reactive power control, the PQC commences to switch stages in or out as necessary.

If the PQC has not been successful in completing the connection and stage identification procedure, the notifications ‘Connect detection failed’ or ‘Stage detection failed’ are displayed.

If the **ESC** key is pressed to cancel the automatic connection and stage identification procedure, the notification ‘Terminate identification’ is displayed.

5.3.4 Manual connection and stage identification

To initiate the manual start-up procedure, select **Man** in the **Detection** menu and confirm this with **Continue**.

In the manual start-up, the following parameters must be determined manually and entered:

Connection type see *Section 5.3.4.1 "Connection type"*

c/k value see *Section 5.3.4.2 "Calculation of c/k"*

Switching sequence The switching sequence must be set in terms of the relative values of the individual stages to each other:

1:1:1:1:1…	1:1:2:4:4…	1:2:3:4:4…
1:1:2:2:2…	1:1:2:4:8…	1:2:3:6:6…
1:1:2:2:4…	1:2:2:2:2…	1:2:4:4:4…
1:1:2:3:3…	1:2:3:3:3…	1:2:4:8:8…

Number of stages Indicates the number of control outputs used.

When all the necessary information has been entered, confirm this with **Continue**. The PQC then switches to operating mode and displays the **PFC – Overview** screen. If at this moment there is a concrete need for reactive power control, the PQC commences to switch stages in or out as necessary

Note

Manual start-up mode deactivates the capacitive power identification function when the PQC is operating. This can, however, be reactivated manually.

5.3.4.1 Connection type

With the connection type, the phase angle of the current and voltage measurement paths is indicated. It can be found from the table below:

Connection type	Connection to voltage path		
	L – L/N	**L – L/N**	**L – L/N**
0	L1 – N	L2 – N	L3 – N
1	L1 – L3	L2 – L1	L3 – L2
2	N – L3	N – L1	N – L2
3	L2 – L3	L3 – L1	L1 – L2
4	L2 – N	L3 – N	L1 – N
5	L2 – L1	L3 – L2	L1 – L3
6	N – L1	N – L2	N – L3
7	L3 – L1	L1 – L2	L2 – L3
8	L3 – N	L1 – N	L2 – N
9	L3 – L2	L1 – L3	L2 – L1
10	N – L2	N – L3	N – L1
11	L1 – L2	L2 – L3	L3 – L1
Current transformer in:	↑ **L1**	↑ **L2**	↑ **L3**

Example:

The current transformer is installed in phase **L2**, while the voltage is measured between the phase **L3** and **N**. It is therefore connection type 4.

If the current transformer is installed or connected the wrong way round, this can be corrected for by the choice of connection type, i.e. by adding 6 to the connection type number given by the table. In the above example, this gives the connection type 10. If the result of this addition were to be greater than 11, the rule is to subtract 6 from the connection type number instead.

5.3.4.2 Calculation of c/k

To operate the system, the value of c/k (response current) must be determined. This equals 65% of the nominal current of the smallest capacitor stage and is to be detected in the PQC current measurement path.

The c/k value can be calculated from the following formula:

$$I_A = 0.65 \cdot \frac{Q_{smallest\ stage}}{V \cdot \sqrt{3} \cdot k} \cdot 1000 \approx 0.375 \cdot \frac{Q_{smallest\ stage}}{V \cdot k} \cdot 1000\,[mA]$$

I_A = response current in mA to be set

$Q_{smallest\ stage}$ = capacitive power of smallest stage in var (not the total capacitive power of the system)

V = network voltage in V at the primary side of the voltage transformer

k = transformer ratio (primary side / secondary side)

Alternatively, for a 400 / 50 Hz network the c/k setting can also be read off from the table below:

c/k setting for 400 V 50 Hz AC network ~ in mA															
Current		Corrective power in kvar of the smallest stage (not the total corrective power) of the power factor correction system													
	k	2.5	5	6.25	7.5	10	12.5	15	20	25	30	40	50	60	100
30/5	6	401	802	1002	1203	1604									
40/5	8	301	601	752	902	1203	1504								
50/5	10	241	481	601	722	962	1203	1443							
60/5	12	200	401	501	601	802	1002	1203	1604						
75/5	15	160	321	401	481	642	802	962	1283	1604					
100/5	20	120	241	301	361	481	601	722	962	1203	1443				
150/5	30	80	160	200	241	321	401	481	642	802	962	1283			
200/5	40	60	120	150	180	241	301	361	481	601	722	962	1203		
250/5	50	48	96	120	144	192	241	289	385	481	577	770	962	1155	
300/5	60	40	80	100	120	160	200	241	321	401	481	642	802	962	1604
400/5	80	30	60	75	90	120	150	180	241	301	361	481	601	722	1203
500/5	100	24	48	60	72	96	120	144	192	241	289	385	481	577	962
600/5	120	20	40	50	60	80	100	120	160	200	241	321	401	481	802
750/5	150		32	40	48	64	80	96	128	160	192	257	321	385	642
1000/5	200		24	30	36	48	60	72	96	120	144	192	241	289	481
1500/5	300			20	24	32	40	48	64	80	96	128	160	192	321
2000/5	400					24	30	36	48	60	72	96	120	144	241
2500/5	500						24	29	38	48	58	77	96	115	192
3000/5	600						20	24	32	40	48	64	80	96	160
4000/5	800								24	30	36	48	60	72	120
5000/5	1000									24	29	38	48	58	96
6000/5	1200									20	24	32	40	48	80
7000/5	1400										21	27	34	41	69

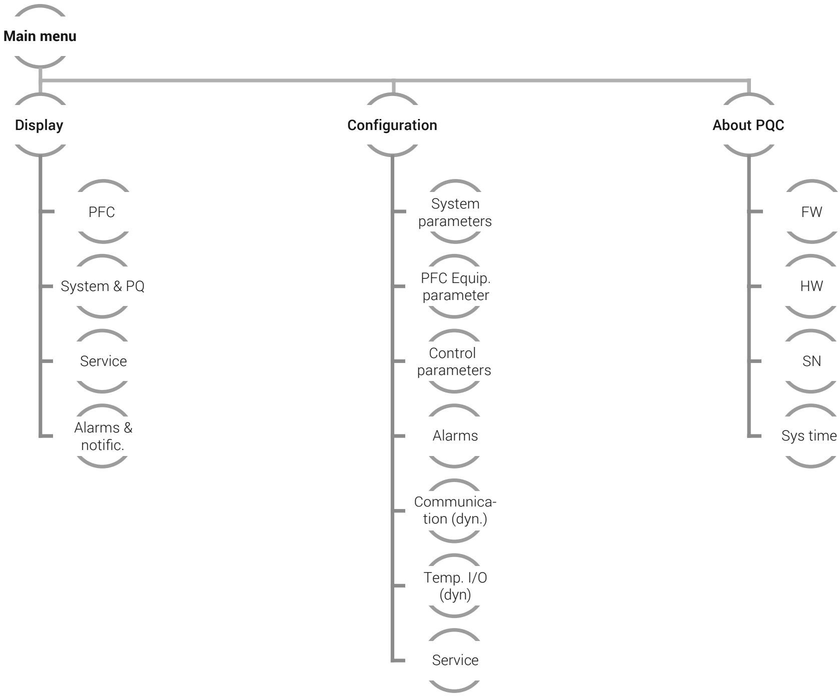
The smallest value of c/k that can be set is 20 mA. If a smaller value is determined in the calculation, either a smaller current transformer ratio or a larger stage corrective power (capacitance of the smallest stage) must be selected. In these cases FRAKO Service + Support is available to offer a customized instrument solution.

6 Description of the menu

6.1 Main menu

From the main menu, all the measurement readings and settings that the PQC makes available can be displayed and where possible changed.

The main menu is divided into three main groups: **Display**, **Configuration** and **About PQC**



6.2 Display

Main menu > Display

In the Display menu, all measurement readings and parameters relevant to power factor correction are shown. The main Display menu items are:

PFC	Measurement readings relevant to power factor correction
System and PQ	Network and power quality parameters
Service	Status display
Alarms & notifications	Display of momentary alarms and the alarm history

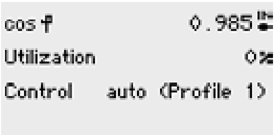
6.2.1 PFC

Main menu > Display > PFC

All measurement readings and parameters relevant to power factor correction are shown here.

6.2.1.1 Overview

Main menu > Display > PFC > Overview



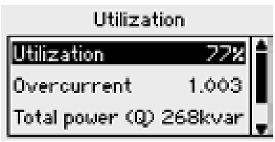
cos φ	Display of the momentary value of cos φ
Utilization	The ratio of the momentary switched-in capacitance to the total available capacitance, expressed as a percentage (0 % = no capacitors switched in, 100 % = all capacitors switched in)
Control	Auto / Man and active control profile
Alarm	Flashes if an alarm is present.
Regeneration	Flashes if power is being fed in to the supply network.

Note

If Alarm flashes, pressing the [i] key will display the list of active alarms and notifications.

6.2.1.2 Capacity utilization

Main menu > Display > PFC > Utilization



Utilization	The ratio of the momentary switched-in capacitance to the total available capacitance, expressed as a percentage.

Overcurrent This parameter is the ratio I_{rms} / $I_{50Hz,60Hz}$ i.e. the theoretically determined ratio of the momentary RMS current to the fundamental current in the capacitor. The tuning factor p of the power factor correction system is also taken into account in this calculation.

Total power (Q) This parameter is the sum of all the connected 3-phase capacitor stage corrective powers.

Available power (Q) This parameter is the 3-phase capacitor corrective power still available for switching in.

6.2.1.3 Control outputs

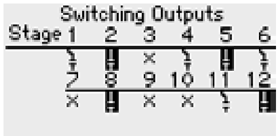
Main menu > Display > PFC > Switching outputs

The overview display shows the momentary statuses of all the capacitor stages.

Stages 1,4,5,7,10,11: switched-out active stages

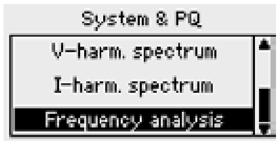
Stages 8 and 12 switched-in active stages

A permanently switched-in fixed capacitor stage is shown as a switched-in active stage with an F.



6.2.2 System & PQ

Main menu > Display > System & PQ



6.2.2.1 System data

Main menu > Display > System & PQ > System data

cos φ Display of the momentary power factor cos φ

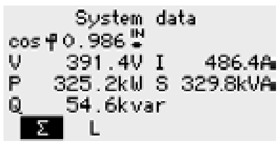
VΔ /V VΔ phase-phase voltage / V phase-neutral voltage

P Display of the momentary active power

Q Display of the momentary reactive power (if capacitive reactive power with a minus sign)

I Display of the momentary current

S Display of the momentary apparent power



Σ	Sum of all the phases (L1 to L3); if a single-phase PQC, theoretical calculation of the sum assuming a balanced load

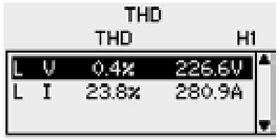
6.2.2.2 THD

Main menu > Display > System & PQ > THD

Display of THDv and THDi and their magnitudes as percentages of the fundamental H1

Single phase PQC: display of Lx and Ix

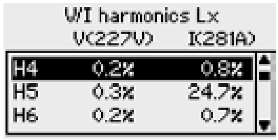
3-phase PQC: display of all three THDv and THDi values



6.2.2.3 V/I harmonics

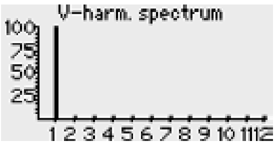
Main menu > Display > System & PQ > V/I harmonics

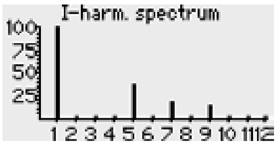
Display of percentage values of the voltage and current harmonics together with the fundamental values for voltage and current. With a 3-phase PQC, pressing the ⇄ key toggles the display through the phases L1 to L3.



6.2.2.4 V-harm. spectrum, I-harm. spectrum

Main menu > Display > System & PQ > V-harm. spectrum, I-harm. spectrum





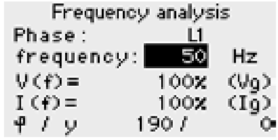
Graphical display of the harmonics spectrum up to the 19th

Key	ESC	↑	↓	⇄	i
Action	Back to Display menu	Zoom +	Zoom -	Toggle between H1–12 and H13–19	Additional info

The fundamental at 50/60 Hz is shown as 100 %. One scale division on the y-axis represents 5 %.

6.2.2.5 Frequency analysis

Main menu > Display > System & PQ > Frequency analysis



Phase Measurement on Lx [1 ≤ X ≤ 3]

Frequency 10 Hz to 2,500 Hz in steps of 10 Hz

V(f) Magnitude of voltage at the selected frequency as a percentage of the fundamental voltage $V_{(f)}$ (f = 50/60 Hz)

I(f) Magnitude of current at the selected frequency as a percentage of the fundamental $I_{(f)}$ (f = 50/60 Hz)

Angle φ Angle between $V_{(f)}$ and $I_{(f)}$ in degrees

Angle γ Angle between V (fundamental) and $I_{(f)}$ in degrees

Key	ESC	↑	↓	⇄	i
Action	Info status	Frequency +10 Hz	Frequency –10 Hz	Select phase	–

6.2.3 Service

Main menu > Display > Service

6.2.3.1 Configuration

Main menu > Display > Service > Configuration

Control status Automatic or manual control mode

Switching sequence Display of the capacitor stages detected. The relative values (switching sequence) can be distributed over the available stages as desired. The largest permitted relative value is 16, the smallest 0.

Available stages Number of capacitor stages detected

c/k value [mA] The response current is determined from the smallest capacitor stage detected

Connection type Type of connection for L1, L2 and L3 current transformers.

See Table in *Section 5.3.4 “Manual connection and stage identification”*

6.2.3.2 Stage status

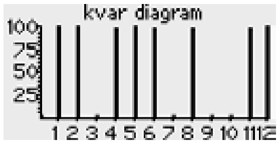
Main menu > Display > Service > Cap. stage status

No.	No. of the stage [1–12]
Stat. (status)	ON / OFF / [x seconds] ON: Switches stage in manually OFF: Switches stage out manually [x seconds]: Time remaining until the capacitor stage can be switched in again (discharge time)
Q[var]	This is the stage corrective power in var (3-phase stage corrective power).
Switching cycles	Number of stage switching cycles

6.2.3.3 kvar diagram

Main menu > Display > Service > kvar diagram

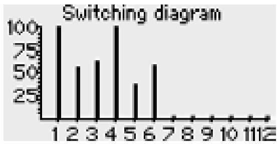
The **kvar diagram** shows the momentary corrective power of the capacitor stages as a percentage. After the instrument has been started up, this graphic shows every detected stage as 100%. With time, however, capacitor wear causes this corrective power to fall.



6.2.3.4 Switching diagram

Main menu > Display > Service > Switching diagram

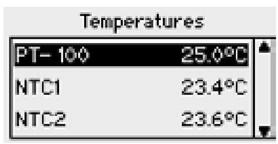
This diagram shows the switching cycle counters for all the stages as a column chart. 100% on the y-axis represents the set limit for the number of switching cycles counted.



6.2.3.5 Temperatures (optional temperature I/O extension)

Main menu > Display > Service > Temperatures

Displays the temperature from the activated PT-100/1000, NTC1 and NTC2 probes.



6.2.3.6 Temperatures (optional temperature I/O extension)

Main menu > Display > Service > I/O status

Shows the available inputs and outputs of the temperature I/O extension and indicates the status of each.

6.2.4 Alarms & notifications

Main menu > Display > Alarms & notific.

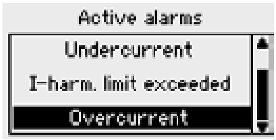
Status of the momentary alarms, display of Alarm and Min/Max history.

6.2.4.1 Alarms & notifications

Main menu > Display > Alarms & notific. > Alarms & notific.

All currently active alarms are shown in a list. If one of these is selected and the ⇄ key is pressed, details such as the momentary reading are displayed.

The limits for several alarms can be set in the Configuration menu (see *Section 6.3.4 "Alarms"*). All alarms are listed in *Section 9 "Troubleshooting"*.



Note

The **Alarms & notific.** menu can also be displayed from the menu item **Display > PFC > Overview** if the ⓘ key is pressed.

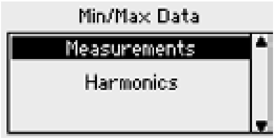
6.2.4.2 Alarm history

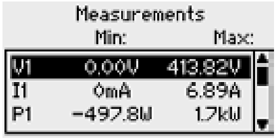
Main menu > Display > Alarms & notific. > Alarm history

The alarm storage function displays the 10 most recently occurring alarms, with the latest alarm at the top and the oldest one at the bottom of the list (sorted by time). Selecting one of the lines shown and pressing the ⓘ key causes the alarm condition to be displayed in plain language.

6.2.4.3 Min/Max data

Main menu > Display > Alarms & notific. > Min/Max data





The Min/Max storage holds the minimum and maximum values of the following measurement readings:

– Measurement data per phase:
  - Voltage
  - Current
  - Power (active, reactive and apparent)
  - System frequency
  - Overcurrent
– Harmonics:
  - Voltage harmonics
  - Current harmonics
– Temperatures: (only available with the optional temperature and I/O extension)
  - PT
  - NTC1
  - NTC2

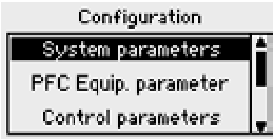
Note

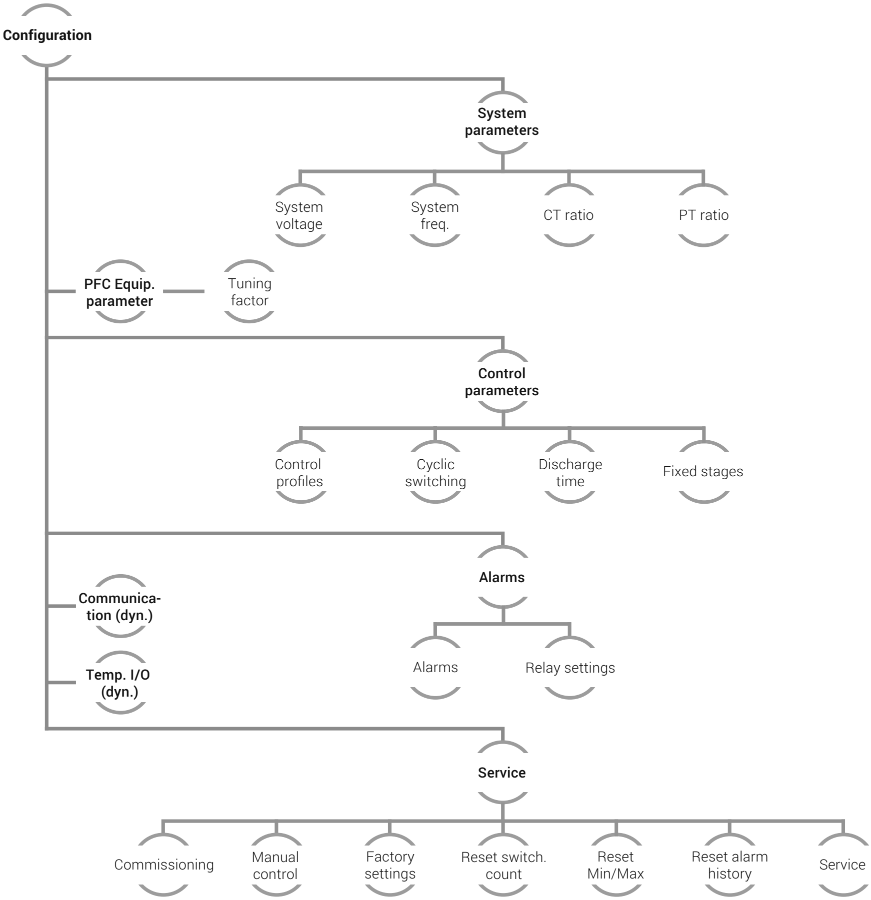
Pressing the [i] key shows the times elapsed since the minimum and maximum values displayed on the screen occurred.

6.3 Configuration

From the Configuration menu, all the parameters relevant to the operation of the power factor correction system can be changed and configured to give customer-specific control characteristics.

Main menu > Configuration





6.3.1 System parameters

Main menu > Configuration > System parameters

Setting the specific parameters for the network to be controlled:

System nominal voltage Setting range: 60 V – 60 kV

System nominal frequency 50 Hz, 60 Hz, Auto

Automatic mode: The PQC determines the network frequency automatically. In the case of networks with heavy voltage harmonics or commutation notches, it can be necessary to set the network nominal frequency manually to the appropriate value.

Voltage transformer Range 1 to 300, transformer ratio = $\frac{V_{primary}}{V_{secondary}}$

Current transformer Range 1 to 7000, transformer ratio = $\frac{I_{primary}}{I_{secondary}}$

e.g. for a current transformer 500 A / 5 A

transformer ratio K = $\frac{I_{primary}}{I_{secondary}} = \frac{500\ A}{5A} = 100$

6.3.2 PFC Equip. parameters

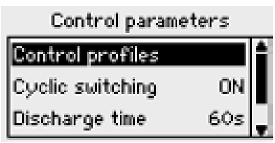
Main menu > Configuration > PFC Equip. parameters

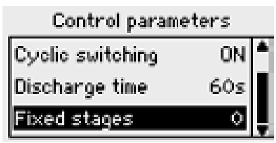
Setting the specific parameters for the power factor correction system:

Tuning factor Detuning of the power factor correction system (A value must be set for correct computation of overcurrent. If the system is not detuned, 0% must be entered.)

6.3.3 Control parameters

Main menu > Configuration > Control parameters





Setting the specific parameters for the PQC control function:

Control profiles	Profile, profile switching **Profile:** 5 control profiles, see *Section 6.3.3.1 "Control profiles"* **Profile switching:** Automatic switching of profiles to Q(V) or Q(P), digital input, see *Section 6.3.3.3 "Automatic switching over of the control profiles (profile switching)"*
Cyclic switching	ON / OFF (ON is recommended). The purpose of cyclic switching is to ensure that all capacitor stages of the same power rating are switched in equally frequently.
Discharge time	5 – 900 s (1 s increments) capacitor stage discharge time. The discharge time must be at least as long as the longest discharge time of the capacitors in use
Fixed stages	Capacitor stages permanently switched in, not under PQC control

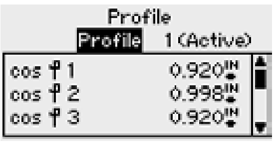
6.3.3.1 Control profiles

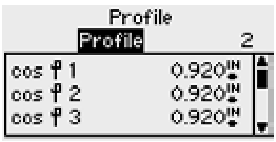
Main menu > Configuration > Control parameters > Control profiles

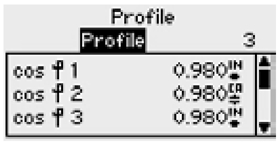
Profile	See *Section 6.3.3.2 "Settable control profiles"*
Profile switching	See *Section 6.3.3.3 "Automatic switching over of the control profiles (profile switching)"*

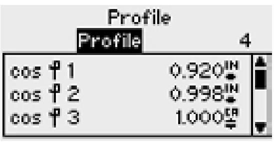
6.3.3.2 Settable control profiles

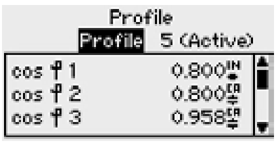
Main menu > Configuration > Control parameters > Control profiles > Profile











Five control profiles can be individually selected and edited. The instrument is supplied with the following factory settings:

	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
cos φ 1	0.920 ind	0.920 ind	0.980 ind	0.920 ind	0.958 cap
cos φ 2	0.998 ind	0.920 ind	0.980 cap	0.998 ind	0.928 cap
cos φ 3	0.920 ind	0.920 ind	0.980 ind	1,000	0.958 cap
cos φ 4	0.998 ind	0.920 ind	0.980 cap	1,000	0.928 cap
Low load	1	1	0	-1	-1
Switching delay ON	45 s	45 s	45 s	45 s	45 s
Switching delay OFF	5 s	45 s	45 s	5 s	45 s
Controlled phase	L1	L1	L1	L1	L1

Typical control profile applications

Profile 1 Optimum control curve for power-consuming applications where an inductive cos φ is called for. The 2nd target cos φ acts as the upper limit, thus reducing the number of switching cycles and avoiding overcompensation with certainty.

Profile 2 Control curve for power-consuming applications where an inductive cos φ is called for.

Profile 3 Control curve for power-consuming applications where an average cos φ of 1 is called for and both inductive and capacitive operating points are permissible.

Profile 4 Control curve for power-consuming applications where an average cos φ of 1 is called for and both inductive and capacitive operating points are permissible.

Profile 5 Control curve for applications in networks where electricity is generated, such as hydropower or wind turbine systems, and in which a capacitive cos φ is called for.

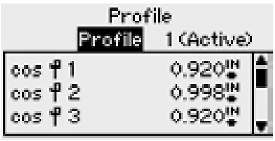
Note

Further information is given in the “PQC Application Note“.

Control profile parameters (Edit profile)

Key	ESC	↑	↓	⇄	i
Action	Profile selection (Save Yes/No)	Select parameter	Select parameter	Parameter selection Back to parameter selection	–

Configuring control profile



Key	ESC	↑	↓	⇄	i
Action	Profile selection (Save Yes/No)	Increase value +	Decrease value -	Back to parameter selection	–

cos φ 1 to cos φ 4 0.50 capacitive to 0.50 inductive (in increments of 0.01)

Low load -2.0 to +2.0 (in increments of 0.5)

Switching delay ON 5 to 500 seconds (in increments of 1 s)

Switching delay OFF 5 to 500 seconds (in increments of 1 s)

Active Activate control profile (only one profile can be active)

Phase L1, L2 or L3: select controlled phase (only with 3-phase versions)

Configuration of the control profile

Target cos φ 1 to 4:

Four values of target cos φ can be configured.

Power import quadrant ($P > 0$)	cos φ 1 must always be more inductive than cos φ 2
Power export quadrant ($P < 0$)	cos φ 3 must always be more inductive than cos φ 4

Freedom of choice for the individual cos φ target values means that the resulting control curve can be changed at will, with the sole limitation that the more capacitive cos φ options 2 and 4 cannot be more inductive than the cos φ options 1 and 3 respectively.

Special case: cos φ 1 and cos φ 2, or cos φ 3 and cos φ 4, are the same:

In this case, the more inductive cos φ (i.e. cos φ 1 or cos φ 3) is used as the upper set limit of the control curve, while the lower set limit is at 4/3 (≈ 1.333) x (power of the smallest stage) below that. The low load parameter enables the low load range to be adjusted (see below). This special case of the control curve allows the user to approximately reproduce the control characteristics of previous FRAKO reactive power control systems.

Low load:

The low load parameter defines the points where the control curve crosses the Q-axis (where active power = 0) on the P-Q diagram. The minimum width of the control curve is always 4/3 x (power of the smallest stage).

Low load = 0 ➡ No parallel shift of the control curve. The centre line of the curve is at cos φ = 1

Low load = 0.5 ➡ Parallel shift of the control curve through 0.5 x 2/3 x power of the smallest stage (= 25%) in the inductive direction.

Low load = 1 ➡ Parallel shift of the control curve through 1 x 2/3 x power of the smallest stage (= 50%) in the inductive direction.

Low load = -1 ➡ Parallel shift of the control curve through 1 x 2/3 x power of the smallest stage (= 50%) in the capacitive direction.

Switching delay ON / Switching delay OFF

The switching delays, i.e. the times between one switching action and the next, can be set between the values of 5 and 500 seconds in 1-second increments. ‘Delay ON’ specifies the time during which the PQC integrates the calculated control deviation before switching the appropriate capacitance in. ‘Delay OFF’ is similar, except that here the time to elapse before the appropriate capacitance is switched out is specified directly.

If more stages are required, the switching time delays are shortened in accordance with the number of stages concerned (e.g. 2 stages required = switching delay time ÷ 2, or 3 stages required = switching delay time ÷ 3).

Note

- In order to keep the wear of the contacts to a minimum, the 'Delay ON' time should only be set to less than 45 seconds in exceptional cases.
- The discharge time, which ensures that the capacitors are fully discharged before they are switched in again, takes precedence over, i.e. overrides, the switching delay times.

Selecting the controlled phase

The **Control profiles** menu also includes the **Phase** setting. This is used to select the phase used by the PQC for control purposes (can only be edited on 3-phase PQCs).

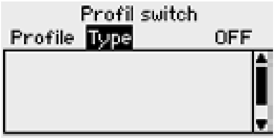
Any one of the three phases **L1, L2** and **L3** may be selected.

Note

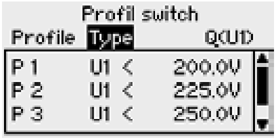
With single-phase PQCs, it is always the connected phase that is controlled.

6.3.3.3 Automatic switching over of the control profiles (profile switching)

Main menu > Configuration > Control parameters > Control profiles > Profile switch



Automatic profile switching off



Automatic profile switching Q(V)

Key	ESC	↑	↓	⇄	i
Action	Control setting	–	Profile switching settings	Switching type (Q(V1) etc.)	–

The automatic profile switching function enables the PQC control profiles to be changed automatically. With this, a Q(V) or Q(P) control curve with 5 points on it can be set up (see “PQC Application Note”).

The following parameters can be used to prompt switching:

- Voltage (L–N) and (L–L)
- Active power (phase power, total power)
- Digital inputs of the Temp. I/O option
- Frakobus tariff input (optional); only Profiles 1 and 2 can be switched over

6.3.4 Alarms

Main menu > Configuration > Alarms

Alarms see *Section 6.3.4.1 “Alarms”*

Relay function With this option, the action of the alarm relay can be inverted:

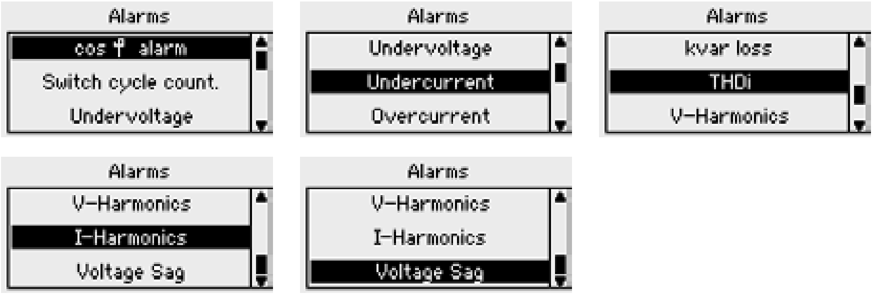
NO mode: contact closes when an active alarm occurs.

NC mode: contact opens when an active alarm occurs.

Note

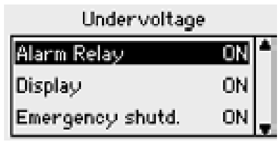
A list of the current and historical alarms is displayed at **Main menu > Display > Alarms & notific**. See Section 6.2.4 for further information.

6.3.4.1 Alarms



Key	ESC	↑	↓	⇄	i
Action	PQC setting	Select alarm limit	Select alarm limit	Edit alarm limit	–

Alarm management



When an alarm condition occurs, the PQC offers various actions for signalling or processing the alarm. These can be configured individually for each alarm type.

- Transmission via **Alarm Relay**
  If the alarm relay function is assigned to an alarm, the alarm relay incorporated in the PQC switches when the alarm occurs (connections: Alarm a, b) and remains in that state as long as the alarm is active.
- Alarm **Warning in Display**
  If the alarm display function is assigned to an alarm, an information window pops up in the PQC display. This message can be acknowledged by pressing the ⇄ key, regardless of whether the alarm condition is still present or not.
- **Emergency shutdown** of the power factor correction system
  Under critical alarm conditions, such as overcurrent, the PQC can initiate an emergency trip in response to the alarm in order to protect the power factor correction system. This interrupts the automatic control function and deactivates (switches off) all the control outputs. Automatic control remains deactivated for the duration of the alarm plus a further 240 seconds. After this time, the PQC automatically begins to control the system to achieve cos φ_{target} again.
- Alarm signal via **Temp-I/O output**
  If the PQC has the Temperature I/O option, the alarms can also be connected to separate outputs. The assigned output remains switched on for the duration of the alarm concerned (NO mode only).
- Alarm signal via **Modbus**
  If the PQC has the Modbus communications interface (RTU or TCP), the alarm

register can be read for all existing alarms. Please refer to the Modbus Specification for further information

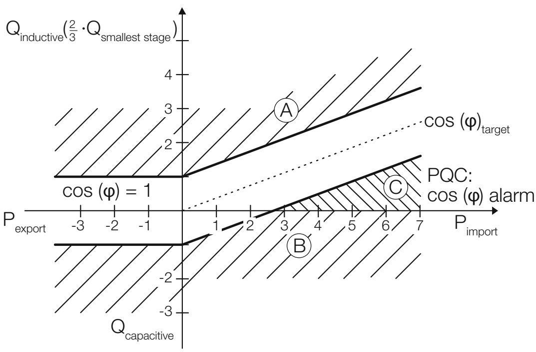
Note

The alarm setting options are described in detail in the following sections. All Alarm messages are listed in *Section 9 “Troubleshooting”*.

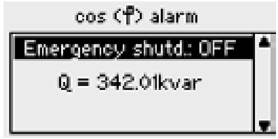
6.3.4.2 Cos φ alarm

The PQC gives a cos φ alarm under the following conditions:

1. The measured cos φ is more inductive than the control band and all the capacitance is already switched in. The PQC cannot therefore switch in any more capacitance to make cos φ more capacitive (see area A in the diagram below).
2. Control band alarm ON:
   The measured cos φ is more capacitive than the control band and all the capacitance is already switched out. The PQC cannot therefore switch out any more capacitance to make cos φ more inductive (see areas B and C in the diagram below).
   Control band alarm OFF:
   The measured cos φ is more capacitive than the control band but not inductive and all the capacitance is already switched out. The PQC cannot therefore switch out any more capacitance to make cos φ more inductive (see area B in the diagram below).



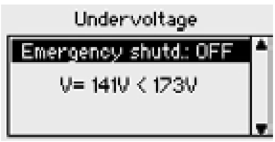
The notification ‘cos φ alarm’ indicates the amount of corrective power still lacking – or, in the case of a negative value, needing to be switched out – that would enable the PQC to adjust cos φ to the middle of the specified control band.

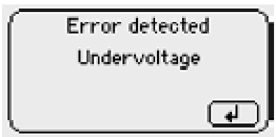


6.3.4.3 Switching cycle counter

Alarm limit 10 k to 500 k (increments of: 1k), default value = 80 k

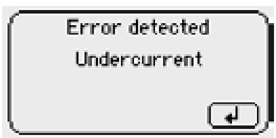
6.3.4.4 Undervoltage





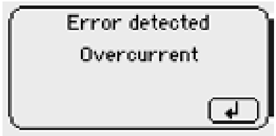
Alarm limit 50% to 100% (in increments of 1%), default setting = 85%
The alarm is given if the measured voltage falls below the limit set as a percentage of the nominal supply voltage.

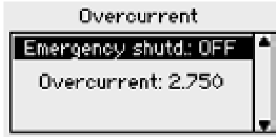
6.3.4.5 Undercurrent



Alarm limit Cannot be adjusted. Triggered when the measured secondary current drops below 10 mA.

6.3.4.6 Overcurrent





Overcurrent is the theoretically determined ratio of the momentary RMS current to the fundamental current in the capacitor (I_{rms} / $I_{50Hz,60Hz}$). It therefore indicates how great the proportion of harmonic currents is compared to the fundamental current.

The tuning factor p of the power factor correction system is also taken into account in this theoretical calculation.

The overcurrent in the capacitor can only be computed correctly when the exact system tuning factor is entered. If the system is not detuned, 0% must be entered.

Alarm limit 1 to 2.00 (increments of 0.01)

6.3.4.7 Overvoltage

Alarm limit 100% to 130% (in increments of 1%), default setting = 110%
The alarm is given if the measured voltage exceeds the limit set as a percentage of the nominal supply voltage.

6.3.4.8 kvar loss

Alarm for detecting the fall in corrective power of a capacitor stage from its calibrated value. If the measured corrective power drops below the set limit, the stage is excluded from the power factor control process.

Setting range: OFF to 95% (OFF: In the power factor correction process, there is no monitoring of stage corrective power.)

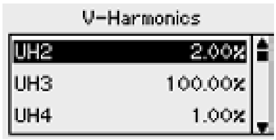
Note

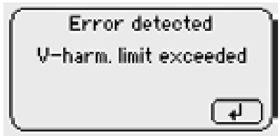
If the PQC is calibrated manually, this alarm is automatically deactivated and the alarm limit set at OFF.
The alarm can, however, be reactivated manually.

6.3.4.9 THDi

Alarm limit 5% to 500% (increments of 1 %)

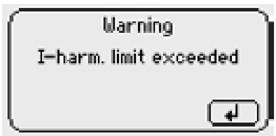
6.3.4.10 V Harmonics





Alarm limit 0% to 100% (increments of 0.01%)

6.3.4.11 I Harmonics



Alarm limit 0% to 100%
(increments of 0.01 %)

6.3.4.12 Short-term voltage blackout (voltage sag)

The voltage sag alarm is designed to protect the capacitors and their contactors against power cuts that are short enough (10 ms) to make the capacitor contactors open and immediately close again.

Sensitivity 50% to 93% (in increments of 1%)

(voltage sag value) as % (100% corresponds to V_{nom})

50% = not sensitive, 93% = highly sensitive

The instrument has a factory default setting of 85% for the sensitivity factor, corresponding to 85% of the nominal supply voltage. This is based on the method described in EN 61000-4-30 (2009): Class A, $V_{rms\ (1/2)}$, V_{rest}.

For the correct functioning of the alarm, and the protection this affords the system, it is essential that the measured voltage and the control voltage for the switching outputs are connected to the same phase.

If the PQC is provided with the optional Modbus (RTU/TCP) interface, the associated event counter readings (L1–L2–L3) and thus the number of short-term voltage sags (10 ms) can be acquired and analysed.

6.3.4.13 Temperature PT-100 / 1000 / NTC1 / NTC2 (optional temperature I/O extension)

Alarm limit –50 to 200 °C (increments of 1 K)

6.3.4.14 Inputs I/O 1–I/O 5 (optional temperature I/O extension)

An activated input of the temperature and I/O extension can allow the PQC to process logic signals.

Example: Interruption of the control function when a logic 1 is received. The possibilities here are extremely diverse.

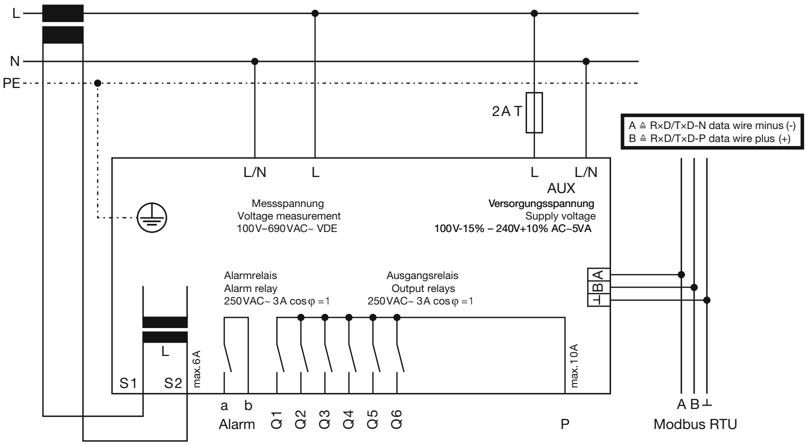
6.3.5 Communication (optional)

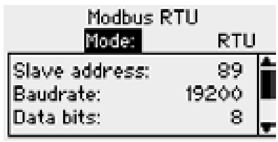
Main menu > Configuration > Communication (dyn.)

The PQC has several optional means of communication. The existence of this menu depends on whether the PQC is equipped with a communication option, and if so, what type.

6.3.5.1 Modbus RTU

Modbus RTU connection





The following parameters can be set in the Modbus configuration menu:

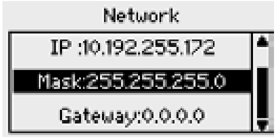
Bus address	The PQC is accessed at the set bus address
Baud rate	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
Data bits	5 to 8
Stop bits	1 or 2
Parity	even, odd or none

Note

Further details are described in the Modbus Specification.

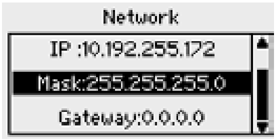
6.3.5.2 Modbus TCP (IoT)

DHCP ON



To operate the PQC in DHCP mode, DHCP ON must be selected. The data displayed in this menu (IP, Mask, Gateway) indicate the network settings assigned by the server, meaning that the available services (Modbus TCP, web server) are accessible in the network.

DHCP OFF



To use the Ethernet interface with manual network configuration, the following settings must be made in the PQC:

- IP address
- Subnet mask
- Gateway (optional)

When these settings have been made, the available services (Modbus TCP, web server) can be accessed in the network.

The PQC is accessible via the Modbus TCP/IP protocol and port 502 at the set IP address. The data that can be retrieved are listed in the FRAKO Modbus Specification.

Note

The web server is only fully functional with the following browsers:

- Mozilla Firefox version 60.0.1 or later
- Google Chrome version 66.0.3359.181 or later.

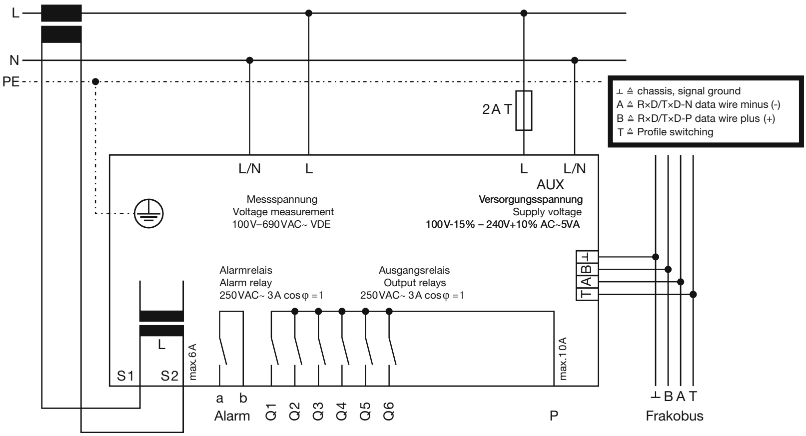
The PQC allows a maximum of 2 simultaneous connections.

Note

For additional information on the optional Ethernet interface please refer to the "PQC Application Note".

6.3.5.3 FRAKO Starkstrombus (Frakobus)

Frakobus connections



The PQC bus address can only be changed at the instrument itself.

6.3.6 Temperature I/O (optional)

Typical circuits for the passive digital inputs and outputs, plus the temperature measurement inputs, are shown in the following diagram:

Temperature measurement inputs

The configuration of the temperature measurement inputs can be carried out at the PQC: **Main menu > Configuration > Temp-I/O (dyn.**).

The possible temperature units are:

– C (degrees Celsius)

– K (Kelvin)

– F (degrees Fahrenheit)

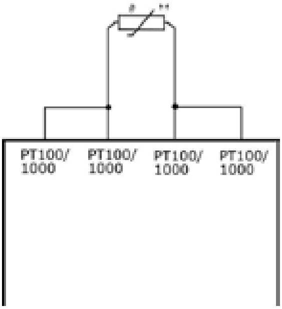
Here the temperature probes actually used are configured as active/inactive.

The temperatures measured by active probes connected to the inputs are displayed in the PQC **Temperatures** menu.

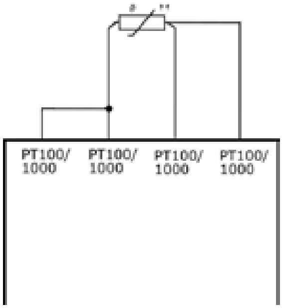
See *Section 6.2.3.5 “Temperatures (optional temperature I/O extension)”*.

If a defined alarm limit is to be monitored with each temperature measurement input, these can be set in the PQC **Alarms** menu (see *Section 6.3.4 “Alarms”*). A fixed hysteresis of 1.5 K is programmed.

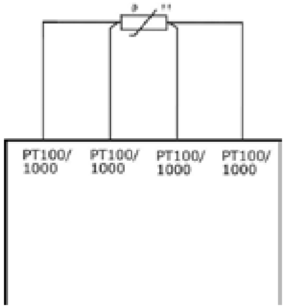
Connections for a PT-100 / 1000 temperature measurement input are provided:



2-wire connection

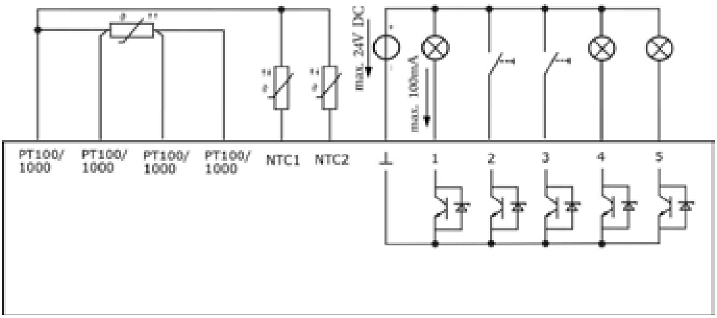


3-wire connection



4-wire connection

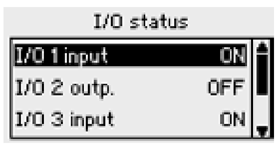
In addition, one or two 2-wire NTC probes (Article No. 29-20094, 7-metre cable) can be connected as shown below:



Passive digital inputs and outputs

The terminals 1 to 5 can be configured for the particular application as inputs or outputs in the PQC: **Main menu > Configuration > Temp-I/O (dyn.)**. If the configured inputs or outputs as used as alarms, the alarm routes can be set in the **Alarms** menu (see *Section 6.3.4 “Alarms”*).

The momentary statuses of the inputs and outputs are shown in the **I/O status** menu (see *Section 6.2.3.6 “Temperatures (optional temperature I/O extension)”*).



One input can be used to switch between control profiles 1 and 2. This is configured in the PQC by navigating as follows: **Main menu > Configuration > Temp-I/O (dyn.)**. When this option is active, profile switching takes place exclusively via this input (no profile switching is then possible from the PQC menu or optional Modbus RTU interface) and only between the stored control profiles 1 (input 1: low level) and 2 (input 1: high level).

The digital inputs are suitable for electrical signals from 5 V DC up to a maximum of 24 V DC.

The digital outputs (open collector type) are suitable for an externally applied voltage up to a maximum of 24 V DC and a maximum current of 100 mA.

6.3.7 Service

Main menu > Configuration > Service (password protected)

6.3.7.1 Start-up

Main menu > Configuration > Service > Commissioning

See *Section 5.3.2 "PQC initial start-up".*

6.3.7.2 Manual control

Main menu > Configuration > Service > Manual Control

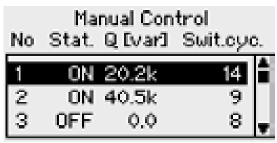
ATTENTION!

Risk to equipment!

Switching in capacitor stages manually can result in overcorrection of the system. This can cause other problems, such as resonance-induced overvoltage in the supply network and/or damage to the capacitor stages or other loads connected to the network.

– The supply network must be monitored for resonant conditions and overvoltage whenever stages are switched in manually.

This menu shows the numbers of the stages (1 to 12), the status of each stage (ON/OFF), its corrective power (determined automatically or set manually) and its switching cycles.



No. No. of the stage [1–12]

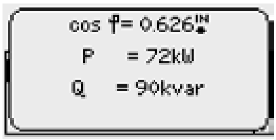
Stat. (status) ON / OFF / [x seconds]
ON: switches stage in manually
OFF: switches stage out manually
[x seconds]: Time remaining until the capacitor stage can be switched in again (discharge time)

Q(var) Momentary stage corrective power in var
(This is the 3-phase stage corrective power.)

Switching cycles Number of stage switching cycles

When a stage is switched out again, this is done immediately. Before this stage can be switched in again, it is necessary to wait until the capacitor‘s set discharge time has elapsed. A countdown of the remaining discharge time is displayed in the Status column. Not until this time has elapsed can the stage be switched in again. If it is attempted to switch in the stage before the countdown is finished, the message ‘Not possible’ is displayed. (The stage is then not switched in automatically after the discharge time has elapsed.)

Pressing the [i] key displays the momentary values of cos φ, P and Q.



6.3.7.3 Factory default settings

Main menu > Configuration > Service > Factory settings

Resets the PQC at its factory default settings (without affecting the switching cycle counter).

6.3.7.4 Clear switching cycles counters

Main menu > Configuration > Service > Reset Switch. Count

Reset switching cycle counters for all stages to zero (singly or individually, service password necessary); see *Section 4.4 “Password protection”.*

> **Note**
> A switching cycle counter may only be reset after the corresponding contactor has been replaced.

6.3.7.5 Reset Min/Max

Main menu > Configuration > Service > Reset Min/Max

Reset all Min/Max values.

6.3.7.6 Reset alarm history

Main menu > Configuration > Service > Reset Alarm history

Reset all alarms saved until now.

6.3.7.7 Service

Main menu > Configuration > Service > Service

Optional service functions

T-I/O Update	Software update mode for Temp.
T-I/O CLI	for FRAKO Service
IoT Update	Software update mode for IoT
IoT CLI	for FRAKO Service
Frakobus Update	Software update mode for Frakobus

6.4 About PQC

Main menu > About PQC

This item gives information about the instrument:

FW	Firmware version number
HW	Hardware version number
SN	Serial number
Sys Time	Operating hours

6.5 Factory settings

Main menu > Configuration

Menu	Parameter	Setting
System parameters *(Section 6.3.1 "System parameters")*		
System parameters	Nominal voltage	400 V
	Nominal frequency	Auto
	Transformer ratio (I)	1
	Transformer ratio (V)	1
PFC parameters *(Section 6.3.2 "PFC Equip. parameter")*		
PFC parameters	Tuning factor	7%
Control parameters *(Section 6.3.3 "Control parameters")*		

Menu	Parameter	Setting
Control parameters	Cyclic switching	ON
	Discharge time	60 s
	Fixed stages	0
Settings for control profile 1	cos φ 1	0.920 ind
	cos φ 2	0.998 ind
	cos φ 3	0.920 ind
	cos φ 4	0.998 ind
	Low load	1
	Switching delay ON	45 s
	Switching delay OFF	5 s
	Active	ON
	Phase	L1
Settings for control profile 2	cos φ 1	0.920 ind
	cos φ 2	0.920 ind
	cos φ 3	0.920 ind
	cos φ 4	0.920 ind
	Low load	1
	Switching delay ON	45 s
	Switching delay OFF	45 s
	Active	OFF
	Phase	L1
Settings for control profile 3	cos φ 1	0.980 ind
	cos φ 2	0.980 cap
	cos φ 3	0.920 ind
	cos φ 4	0.980 cap
	Low load	0
	Switching delay ON	45 s
	Switching delay OFF	45 s
	Active	OFF
	Phase	L1

Menu	Parameter	Setting
Settings for control profile 4	cos φ 1	0.920 ind
	cos φ 2	0.998 ind
	cos φ 3	1.000
	cos φ 4	1.000
	Low load	-1
	Switching delay ON	45 s
	Switching delay OFF	5 s
	Active	OFF
	Phase	L1
Settings for control profile 5	cos φ 1	0.958 cap
	cos φ 2	0.928 cap
	cos φ 3	0.958 cap
	cos φ 4	0.928 cap
	Low load	-1
	Switching delay ON	45 s
	Switching delay OFF	45 s
	Active	OFF
	Phase	L1
Alarms *(Section 6.3.4 "Alarms")*		
Alarms	Relay function	NO (normally open)
cos φ alarm	Control band alarm	OFF
	Alarm relay	ON
	Display	ON
	Emergency trip	OFF
Switching cycle counters	Alarm limit	80 k
	Alarm relay	ON
	Display	ON
	Emergency trip	OFF
Undervoltage	Alarm limit	85%
	Alarm relay	ON
	Display	ON
	Emergency trip	ON
Undercurrent	Alarm relay	OFF
	Display	ON
	Emergency trip	ON

Menu	Parameter	Setting	
Overcurrent	Alarm limit	1.20	
	Alarm relay	ON	
	Display	ON	
	Emergency trip	ON	
Zero stage detection	Alarm limit	80%	
	Alarm relay	ON	
	Display	ON	
	Emergency trip	OFF	
THDi	Alarm limit	50%	
	Alarm relay	OFF	
	Display	OFF	
	Emergency trip	OFF	
Overvoltage	Alarm limit	110%	
	Alarm relay	ON	
	Display	ON	
	Emergency trip	ON	
V Harmonics	Alarm limit	**Harmonic**	**Alarm limit %**
		2	2
		3	100
		4	1
		5	6
		6	100
		7	5
		8	0.5
		9	100
		10	0.5
		11	3.5
		12	100
		13	3
		14	0.43
		15	100
		16	0.41
		17	2
		18	100
		19	1.76
	Alarm relay	OFF	
	Display	ON	
	Emergency trip	OFF	

Menu	Parameter	Setting
I Harmonics	Alarm limit	100% all (IH2 – IH19)
	Alarm relay	OFF
	Display	OFF
	Emergency trip	OFF
Voltage sag	Sensitivity	85%
	Alarm relay	ON
	Display	ON
	Emergency trip	ON
Communication *(Section 6.3.5 "Communication (optional)")*		
Modbus RTU	Slave address	0
	Baud rate	19200
	Data bits	8
	Parity	None
	Stop bits	1
Modbus TCP	DHCP	ON
	IP	192.168.0.61
	Subnet	255.255.255.0
	Gateway	192.168.0.1
Frakobus	Frakobus address	0
Temp. I/O *(Section 6.3.6 "Temperature I/O (optional)")*		
Temp. I/O	Temperature units	°C
	PT	OFF
	NTC1	OFF
	NTC2	OFF
	I/O 1	Input
	I/O 2	Input
	I/O 3	Input
	I/O 4	Input
	I/O 5	Input

6.6 Service interface

The PQC has a service interface in the form of a Micro USB port. This is used for servicing tasks such as firmware updates.

Note

This interface is solely for the use of trained FRAKO Service + Support personnel.

For further information concerning firmware updates please contact FRAKO Service + Support by telephone at +49 7641 453 544 or by e-mail at service@frako.de.

7 General operation

The following points must be observed when the PQC is operated:

- The instrument must always be operated in a closed control cabinet.
- All voltages applied to the instrument must never exceed the limits specified in the technical data.
- The ambient temperatures must always be within the range specified in the technical data.

8 Cleaning and maintenance

8.1 Safety during cleaning and maintenance

WARNING!

Danger from electricity!

There are dangerous voltages present inside the PQC. Touching live components in the PQC or at the instrument terminals and connecting cables can cause serious injury or may even be life-threatening.

– Do not open the PQC casing.
– During cleaning and maintenance, the PQC and the connecting cables must be isolated from the power supply.
– The isolated electrical system must be locked out and tagged to prevent its being inadvertently switched on again.
– All connections must be checked to verify that they are no longer live.
– All live components in the immediate vicinity must be covered.

8.2 Cleaning

The PQC may only be cleaned with a dry cloth. Do not use aggressive or abrasive cleaning agents or solvents.

8.3 Maintenance

The PQC does not contain any components that need maintenance.

9 Troubleshooting

If alarms occur during operation of the PQC, the following table provides assistance in identifying and remedying the faults.

Alarm message	Fault	Possible cause	Remedial action
	PQC not working; no display at front of instrument	No power – or the wrong voltage – connected	Check that the correct instrument power supply is connected and that the fuse in the circuit has not blown.
cos (phi) alarm	PQC gives a cos φ alarm although the momentary cos φ is better (nearer to 1) than the target value. More capacitive than the control band but still inductive	See *Section 6.3.4.2 "Cos φ Alarm"* for control band alarm settings.	See *Section 6.3.4.2 "Cos φ Alarm"* for control band alarm settings.
Undervoltage	PQC indicates or states that voltage is less than set alarm limit, although a voltage is shown on the screen.	The alarm limit has not been adjusted for the network nominal voltage.	Set the correct alarm limit for the network nominal voltage (see *Section 6.3.1 "System parameters")*
Undercurrent	No value for current shown in the display (0 A)	Break or short-circuit in the current transformer cable	Use an ammeter to check current in current path ($I_{min} \geq 0.015$ A). Danger: see *Section 5.2.7 "Current measurement"*
		The current in the current path is too low.	($I_{min} \geq 0.015$ A) Install a smaller current transformer.
		Defective current transformer	Check the current transformer.
Undervoltage + Undercurrent	PQC shows no meas-ured voltage and no current, although it has been verified that power is connected and a current is flowing.	Multiple zero-voltage crossings in measured voltage.	Settings for the Network nominal parameters –> Change setting from Auto to the appropri-ate network frequency (50 Hz or 60 Hz).
Overcurrent	Voltage harmonics in network too high	Triggered when ratio $I_{rms}/I_{50Hz,60Hz}$ exceeds alarm limit.	

Alarm message	Fault	Possible cause	Remedial action
Switching counter	Number of switching cycles of one or more contactors exceeds set maximum		Replace the contactors concerned and reset their switching cycle counters.
V-harm. limit exceeded	Voltage harmonics in network too high		
kvar loss	The PQC has detected one or more stages whose nominal power has fallen.	Capacitor stage(s) has/have lost capacitance.	Replace capacitor(s)
		Because of an unstable network, the PQC has mistakenly detected a loss of capacitance.	Deactivate the kvar loss detection function.
Voltage sag		Short-time voltage black-out (voltage sag) Triggered if a voltage sag causes the RMS voltage to fall below the set limit within the duration of a half-wave	
Connect detection failed Stage detection failed	During the automatic connection and stage identification procedure the PQC cannot determine the type of connection or the relative value of the stage capacitance.	Fault in control circuit (contactors not switching)	Check the control circuit against the connection diagram and check the fuse.
		Fuses for the capacitor stages missing or defective	Check whether capacitors are energized after switching.
		Current transformer installed in the wrong location	Check whether the current transformer has been installed as per the connection diagram.
		Severe reactive power fluctuations	Wait for power supply to stabilize; set c/k value and connection type manually.

Alarm message	Fault	Possible cause	Remedial action
	Despite inductive load, no stages are switched in when PQC is in automatic mode.	When the PQC was programmed, c/k, switching time delay or discharge time have been set too high.	Check the PQC programming and change if necessary.
		In automatic operation, the response current c/k was not correctly identified.	Check the control circuit against the connection diagram and repeat the calibration procedure.
		Another current measuring instrument (e.g. an ammeter) has been connected in parallel with the current path.	All measuring instruments in the current path must always be connected in series.
	In automatic mode, one stage is continually being switched in and out (hunting).	The value of c/k was set too low when the PQC was programmed.	Set c/k value correctly according to the table.
		Severe load fluctuations; the delay time was set too low.	Set higher delay time.
	The displayed cos φ is less than cos φ_{target} although the PQC has switched in all stages.	Type of connection incorrectly entered.	Select type of connection again.
		Fault in control circuit.	Check whether the capacitor contactors have been activated.
		Fault in capacitor circuit	Check the fuses and contacts of the capacitor contactors and possibly also measure the currents of each capacitor stage with a tong tester.
		Severe reactive power fluctuations	Read off the corrective power still lacking from the menus.
		Faulty calibration	Repeat the calibration procedure.

Alarm message	Fault	Possible cause	Remedial action
	PQC does not switch out all stages under low load conditions or during plant shutdown.	c/k set too high	Set c/k according to table.
		PQC is in manual mode.	Deactivate manual control.
		Wrong control profile selected	Adjust the control profile to suit system requirements.
	The LCD backlighting comes on briefly then goes off again, while the LCDs display nothing or only the starting logo – the instrument restarts repeatedly.	Instrument power supply voltage is too low.	Check whether the correct voltage is reaching the PQC. Is there is a high contact resistance in the power supply circuit?
	Capacitor stage statuses display appears on screen but capacitor contactors are not activated.	Control circuit is not connected properly or there is no control voltage.	Check the control circuit against the connection diagram and check the fuse.
		Neutral not connected to contactors.	

Note

Additional error messages are described in the “PQC Application Note”.

10 Decommissioning and removal, storage and disposal

10.1 Decommissioning the PQC

WARNING!

Danger from electricity!

Touching live components at the instrument terminals and connecting cables can cause serious injury or may even be life-threatening.

– Installation, commissioning and decommissioning of the PQC may only be carried out by appropriately qualified personnel who have read and understood the content of this manual.

– Isolate the PQC and the system from the power supply before decommissioning it.
– The isolated electrical system must be locked out and tagged to prevent its being inadvertently switched on again.
– It must be verified that none of the terminals are live.
– All live components in the vicinity must be covered to prevent inadvertent contact.

CAUTION!

Danger from heat

The instrument terminals can become hot during operation and could cause burns.

– After the PQC has been operating, sufficient time must be allowed for the instrument and its terminals to cool down before work is carried out on the connections.

ATTENTION!

Risk to equipment!

If the exposed ends of disconnected cables come into contact with each other, this can result in short-circuits and overloading of the installation conductors, resulting in damage to equipment.

– All disconnected cables must be individually isolated and insulated, and measures must be taken to prevent their inadvertent contact with live components or electrically conducting parts.

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1. Current transformers must be short-circuited.
2. Remove all cables from the PQC.
3. Individually isolate and insulate all disconnected cables and take measures to prevent their inadvertent contact with live components or electrically conducting parts.

10.2 PQC removal

The PQC is held in place against the rear of the cabinet front wall by four retaining lugs in the corners of the instrument. These can be released by undoing the retaining screws.

1. Turn all four screws anticlockwise with a screwdriver. This slackens the four retaining lugs and swivels them to lie flush behind the PQC front panel.
2. Withdraw the PQC from the front of the cabinet.

10.3 Storage

– The PQC must be stored in a clean, dry and dust-free location.
– The storage temperature must be within the range -20 °C to +80 °C.

10.4 Disposal

Any electronic instrument that is no longer required must be disposed of in an environmentally sound manner.

ATTENTION!

Risk of pollution!

Incorrect disposal can cause environmental pollution.

– Dispose of the instrument in compliance with the regulations of the country concerned.

In the European Union, electrical scrap and electronic components are subject to the WEEE (Waste Electrical and Electronic Equipment) Directive. These components must not be disposed of as normal domestic or commercial waste. In other countries, the equivalent local regulations must be followed when electronic instruments are disposed of. They must be handed in at special recycling centres.

One way of ensuring environmentally sound disposal is to return the instruments to FRAKO Kondensatoren- und Anlagenbau GmbH in Teningen, Germany, or the company‘s local representatives. Alternatively, the instruments can be given to a firm specializing in the recycling of electronic equipment.

Power capacitors

Reactive power controllers

Power factor correction systems

Modules

EMS components

Measuring instruments and network analysers

Power quality

EMS ISO 50001

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