Reference Manual

MPFC-PF

Multi-Use Power Factor Controller

and grid monitor

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Revision	Date	Name	Comment
01.0	December 18, 2025	AJ	Creation of the MPFC-PF Reference Manual
01.1	May 12, 2026	AJ	Basic Setup of the Network System
01.2	August 10, 2026	AJ	Phase Angle Tables pp. 17, 18, 19, 40
01.3	August 19, 2026	AJ	Modbus Register 14.4 in a separate manual
01.4	August 19, 2026	AJ	Hunting Alarm (Pendulum Protection)
01.5	August 19, 2026	AJ	14.3.1.1 Fast (rapid control with thyristor controllers)

Subject to technical changes

The contents of our documentation have been compiled with the utmost care and reflect our current state of knowledge. However, please note that updates to this document may not always be made simultaneously with technical advancements to our products. Information and specifications are subject to change at any time.

Please check for the latest version at www.beluk.de

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1. Safety Instructions

IMPORTANT SAFETY NOTICES AND INSTRUCTIONS– PLEASE READ THESE INSTRUCTIONS CAREFULLY BEFORE INSTALLING AND OPERATING THE DEVICE!

The following symbols are used in the manual and on the back of the device to highlight hazards or provide special instructions.

! DANGER	
	indicates an imminent hazardous situation. If this situation is not avoided, it will result in death or serious injury.

! WARNING	
	indicates a potentially imminent hazardous situation. If this situation is not avoided, it will also result in death or very serious injuries.

! CAUTION	
	indicates a potential hazardous situation, which—if not avoided—could result in minor or moderate injury.

! NOTE
NOTICE indicates a situation that could result in property damage to the product or other property if not avoided.

Note: Our devices must not be subjected to a high-voltage test (1000 V according to VDE 0113)!

When testing the entire system, the MPFC-PF must be excluded from the measurement!

The MPFC-PF has been tested in accordance with IEC/EN/UL/CSA 61010-1.

2. Product Description

The **MPFC-PF** is a measurement and control device designed to optimize your power quality.

It is designed for both single-phase and three-phase systems in power distribution facilities and industrial distribution networks.

The voltage harmonic limits (THD-U) according to EN 50160 serve as the benchmark for alarm configuration.

Integration into your energy management system is facilitated by the Modbus RTU protocol via the RS-485 interface and, optionally, by the IEC 61850 protocol via the Ethernet interface.

2.1 Product Configuration

		PF12R1DLI				Options				
PF	12	R	T	1	D	L	I	Q	T	C
Family Power Factor / Reactive Power Controller	Number of Outputs 6 / 12 / 18 / 24	Output Type Relay	Output Type Transistors	Number Current Inputs 1/4	Power Supply AC / DC	Data logger + event recorder + 8 GB microSD card	IEC 81850	Q - Algorithms	DTC	I4 Current

Standard configuration:
- AC Power Supply
- 2 AC digital inputs
- 6 relay outputs
- 1 current measurement input
- 1 voltage measurement input
- RS485 interface
- Input for external NTC22K temperature sensor

2.2 List of Options

Hardware Option	Description	Software Option
-D	DC Power Supply	
-L	Data Logger / Event Logger	
-I	IEC 61850 protocol via Ethernet interface	
	Q-Algorithms	-Q
	Dynamic Transformer Compensation	-T
	I4 Current Measurement	-C

2.3 Features of the

Hardware:
Front-panel mount, 144 x 144 mm
Connection: Screw terminals, max. 2.5 mm²
Optional software tool for configuration via Modbus RTU
3 voltage measurement inputs (L1-L2-L3-N)
1 / 4 current measurement inputs (via external x/1A and x/5A current transformers for energy monitoring)
2 digital inputs
1/2 potential-free changeover contacts
1 or 2 dry make contacts
6, 12, 18, 24 potential-free output relays (AC) / transistor outputs (DC)
Data storage up to 8 GB µSD
RS485 interface (Modbus RTU, slave, up to 115,200 baud)
NTC22K temperature sensor
Measurement:
True RMS measurement
Calculation of cos phi relative to the fundamental wave
Harmonics up to the 63rd harmonic
Overvoltage category: AC: IEC/EN/UL/CSA 61010-1 (VDE 0411-1)
CAT III: <300 V LN / <519 V LL
CAT II: 300–317 V LN / 519–550 V LL
Surge Voltage Category: DC: IEC/EN/UL/CSA 61010-1 (VDE 0411-1)
CAT III: 40–240 V
Sampling rate: 6.4 kHz (128 samples per period)
Measurement category: IEC/EN/UL/CSA 61010-2-030 (VDE 0411-2-030)
CAT IV: ≤ 300 V
CAT III: > 300 V to 600 V

2.4 Intended Use

The device is intended for industrial use in indoor, stationary electrical compensation systems. Select an environment free of harmful oils, acids, gases, vapors, dust, radiation, etc. Ambient temperature: -20°C to 45°C. The MPFC-PF may only be operated by qualified personnel who are familiar with the use of the device.

For current measurement, external, listed current transformers for energy monitoring with reinforced insulation in accordance with IEC 61010 and a secondary current of X/1A or X/5A must be used.

For use in low-voltage applications (phase-to-phase 400 V / phase-to-neutral 230 V) and, under certain conditions (use of current and voltage transformers!), for use in medium-voltage compensation systems.

Installation of the device requires an external all-pole disconnecting device (10 A fuse).
For controlling 250 V AC/5 A switching devices in accordance with UL/VDE

2.5 Certificates

CE, cTÜVus

The product meets the requirements of:
EN 61010-1:2010/A1:2019
UL 61010-1:2012/R:2023-06
CSA C22.2 No. 61010-1:2012/U3:2023-06
EN IEC 61010-2-030:2021/A11:2021
UL 61010-2-030:2018
CSA C22.2 No. 61010-2-030:2018

2.6 Scope of Delivery

1x	MPFC-PF unit
2x	Mounting Clamps
1x	Installation instructions
1x	Test report
Terminal blocks: Screw-type terminal blocks, max. 2.5 mm²	

Standard terminal blocks:

Quantity	Part Number	Description	Application	Terminal designation
1x	1231078	SK ST2Z	Supply Voltage	L (+); N (-) Power supply
1x	1231148	SK MST4Z	Digital inputs	DI 1.1, DI 1.2; DI 2.1, DI 2.2
1x	1231150	SK ST4Z	Voltage measurement inputs	UN, UL1, UL2, UL3
1x	1260730	SK ST8Z	Current measurement inputs	K1, L1…K4, L4
1x	1232297	SK MCST3Z	Modbus	A (+) / GND / (-) B
1x	1231410	SK MCST2Z	External Temperature Sensor	External Temp

Optional **Digital Output Card 1**

Quantity	Order Number	Description	Application	Connection Designation
1x	1230881	SK MST3Z	Changeover contact	12,14,11
1x	1231280	SK MST2Z	Normally open contact	23,24
1x	1231080	SK MST7Z	Relay outputs	C1, S1–S6
1x	1230533	SK MST6Z	Relay outputs	S7–S12

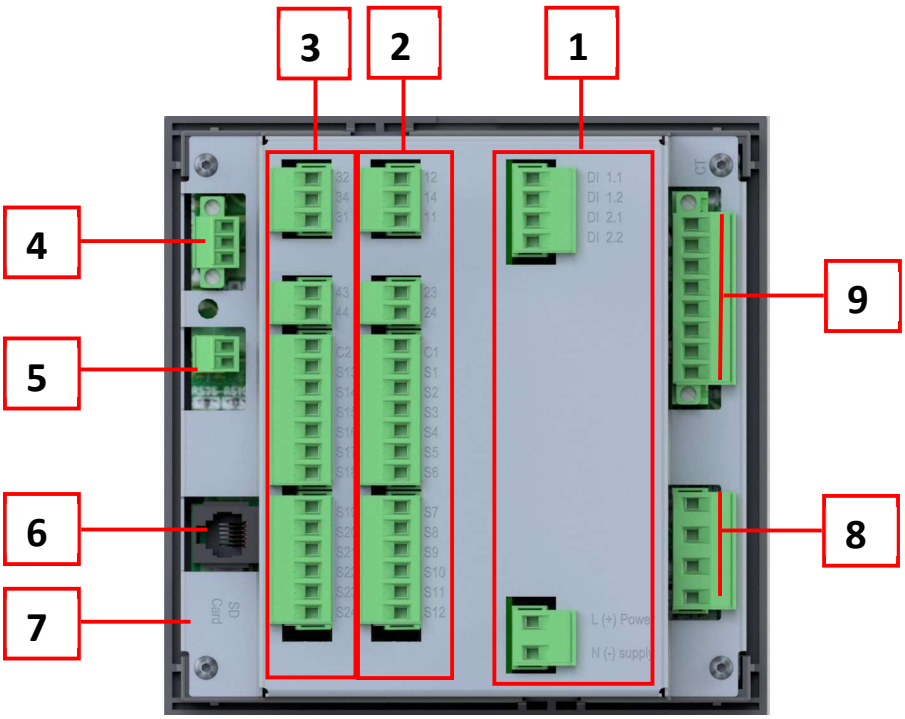
Optional **digital output card 2**

Quantity	Order number	Description	Application	Connection Designation
1x	1230881	SK MST3Z	Changeover contact	32, 34, 31
1x	1231280	SK MST2Z	Normally open contact	43,44
1x	1231080	SK MST7Z	Relay outputs	C2, S13–S18
1x	1230533	SK MST6Z	Relay outputs	S19–S24

Optional **communication card**

Quantity	Order number	Description	Application	Connector designation
1x	1230881	SK MST3Z	Changeover contact	32, 34, 31
1x	1231280	SK MST2Z	Normally open contact	43,44

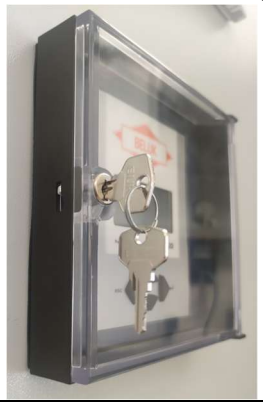
2.7 Device Rear Panel



1	**Power supply board** 4-pin terminal DI 1.1 DI 1.2 DI 2.1 DI 2.2 2-pole terminal L (+) N (-)	2 programmable digital inputs (DI) Variant 1 AC: Phase – Neutral: 90 – 317 V AC Phase – Phase: 155 – 550 V AC Variant 2 DC: 40 – 240 V DC	Fine-strand conductors with wire end ferrules: 0.2–2.5 mm², AWG 24–12 Strip length: 7 mm Tightening torque: 0.5 Nm
2	**Digital output card** **Module Slot 2** 3-pin terminal 12, 14, 11, (NO) / (NC) 2-pin terminal 23, 24 (NC) 7-pin terminal C1 S1–S6 **Option** 6-pin terminal S7–S12	1 x changeover contact 1 x signal contact 13 x programmable signal contacts (NO)	Fine-strand conductors with ferrule: 0.2–2.5 mm², AWG 24–12 Strip length: 7 mm Tightening torque: 0.5 Nm

3	**Option** **Digital output card** **Module Slot 1** 3-pin terminal 32, 34, 31, (NO) / (NC) 2-pin terminal 43, 44 (NC) 7-pin terminal C2 S13–S18 6-pin terminal S19–S24	1 x changeover contact 1 x signal contact 13 x programmable signal contacts (NO)	Fine-strand conductors with ferrule: 0.2–2.5 mm², AWG 24–12 Strip length: 7 mm Tightening torque: 0.5 Nm
4	**Interface** Modbus RS485 3-pin terminal A (+) ⊥ B (-)	Use shielded cable Connect the cable shield to ground potential to reduce external interference.	Fine-stranded conductors with ferrule: 0.2–1.0 mm², AWG 30–16 Strip length: 5 mm Tightening torque: 0.3 Nm
5	**External temperature sensor** 2-pole terminal Ext1 / Ext2	NTC22K	Fine-strand conductors with ferrule: 0.2–2.5 mm², AWG 24–12 Strip length: 7 mm Tightening torque: 0.5 Nm
6	**System interface**	for firmware updates via a special programming cable and tool	
7	**µSD card slot**	8 GB, 32 GB	
8	**Voltage measurement inputs** 4-pole terminal UN UL1 UL2 UL3	40–600 V AC	Fine-stranded conductors with ferrule: 0.2–2.5 mm², AWG 24–12 Strip length: 7 mm Tightening torque: 0.5 Nm
9	**Current measurement inputs** 2-pole terminal K1 L1 Optional 8-pole terminal K1 L1 K2 L2 K3 L3 K4 L4	10 mA – 6 A (Continuous overload 10 A)	Fine-stranded conductors with ferrule: 0.2 – 2.5 mm², AWG 24–12 Strip length: 7 mm Tightening torque: 0.5 Nm

2.8 Accessories

Order number:	Description	Product Specification:
1258828	Modbus-USB Converter	Modbus-USB converter consisting of a hardware unit, a 1.5-meter-long RS485/USB cable, and the software. To enable communication with a computer
1265305	TTL-USB converter with cable	Programmer for firmware updates
1264602	8 GB micro SD card	Compatibility tested by BELUK Requires data storage / event recorder function
1252603	DC-DC Converter	Input voltage: 16.8–33.6 V DC, output voltage: 48 V DC
1262015	AC-DC Converter	Input voltage: 230 V AC Output voltage: 24 V DC
1230538 1260390	Clear-view door VT + gasket 	Clear-view door, complete with lock, lockable, with dimensions 144 x 144 mm. This is adhered to the front of our device. The gasket goes between the control cabinet and the clear-view door. This ensures protection class IP54 on the front side ; the rear side, which is located inside the control cabinet, remains at IP20.

3. Installation

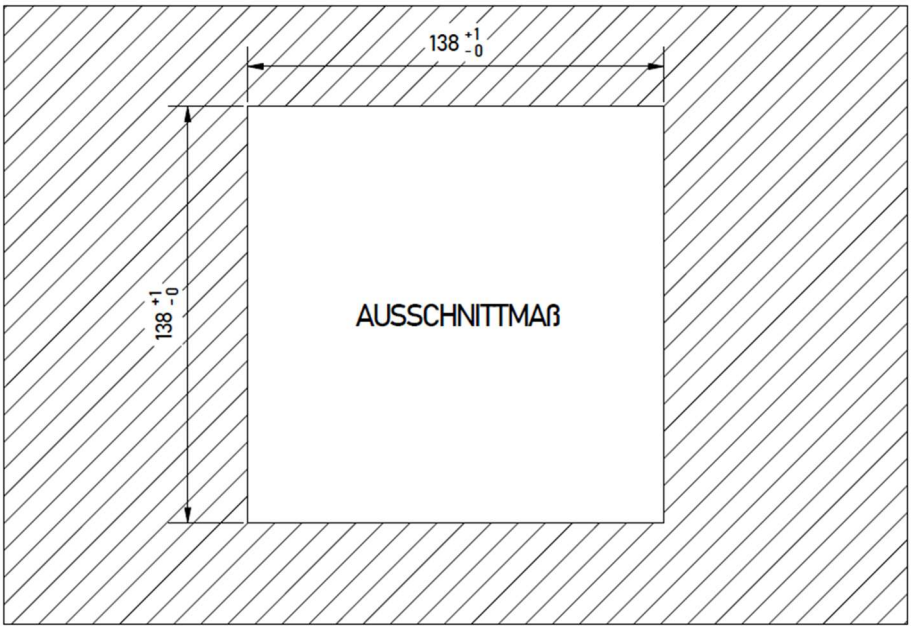
Installation location:	in the control cabinet door
Installation orientation:	Vertical
IP Rating	Front: IP50 / Rear: IP20
Mounting type:	2x mounting clamps

To ensure adequate ventilation, the following clearances must be maintained:

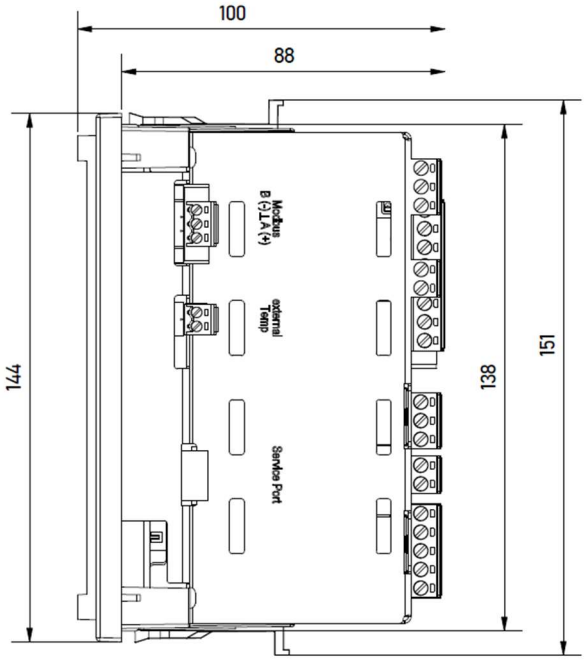
Top / bottom: min. 50 mm

Left / right: min. 20 mm

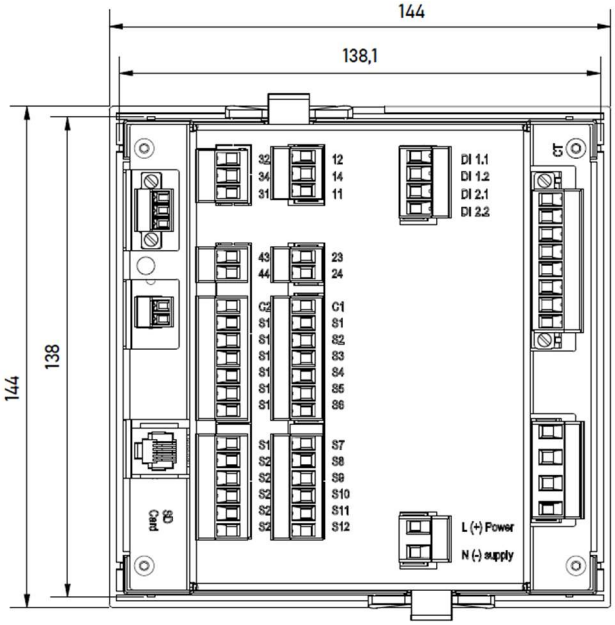
Cutout
138x138 (+0.5) mm



Side view



Rear view



4. Installation

! DANGER	
	RISK OF ELECTRIC SHOCK, EXPLOSION, OR ELECTRIC ARC (FR) **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH (EN)** **RISK OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH (DE)**
Installation, **commissioning**, and **maintenance** may only be performed by a qualified electrician who possesses the necessary qualifications. A **qualified electrician** is a person who possesses the skills, experience, and necessary knowledge for the construction, installation, and operation of electrical equipment and systems, and who has been trained in the identification and prevention of potential hazards. During installation, the applicable regulations governing the construction of switchgear and accident prevention must be observed. Devices with damaged or open enclosures or terminal blocks must not be operated on the power supply and must be immediately de-energized and disconnected. Before disconnecting the current measurement path at the device or at **the current transformer**, the current transformer must be short-circuited. To prevent electric shock, current transformers must always be disconnected from the power distribution system or the building's power supply before performing installation or maintenance work. Failure to do so can result in life-threatening voltage at the connections of the current measurement path or the transformer. The transformer will be destroyed by a sustained high voltage.	
After disconnecting the device, wait **75 seconds** until the capacitors have discharged. **Check that the device is de-energized!** Only then may doors or covers be removed.	
BELUK GmbH assumes no responsibility or liability for injury to persons or damage to equipment resulting from installation that is not performed properly and in accordance with the intended use.	

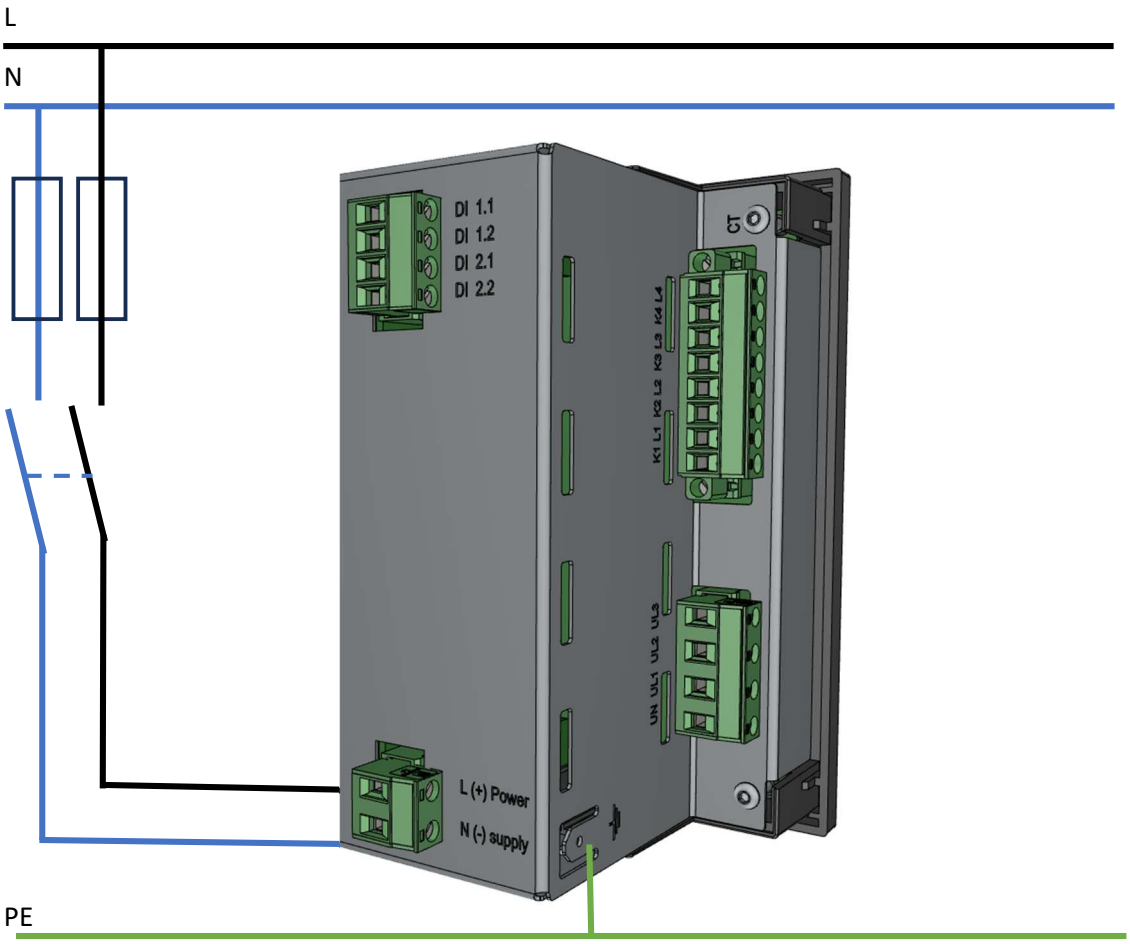
! WARNING	
	If the voltage exceeds the voltage specified on the nameplate, a voltage transformer must be used! Otherwise, the device may be damaged.

4.1. Supply voltage

The supply voltage must match the specifications on the nameplate!

Mains voltage:	**Range:**	**Connection:**
High voltage:	110,000 V – 35,000 V AC	Via voltage transformers
Medium voltage:	35,000 V – 10,000 V AC	Via voltage transformers
Low voltage:	1,000 V AC / 690 V	Via voltage transformers
	400 V / 230 V AC	Directly for the **AC** version
Extra-low voltage:	50 V AC	/
	120 V DC	Directly on the **DC** version

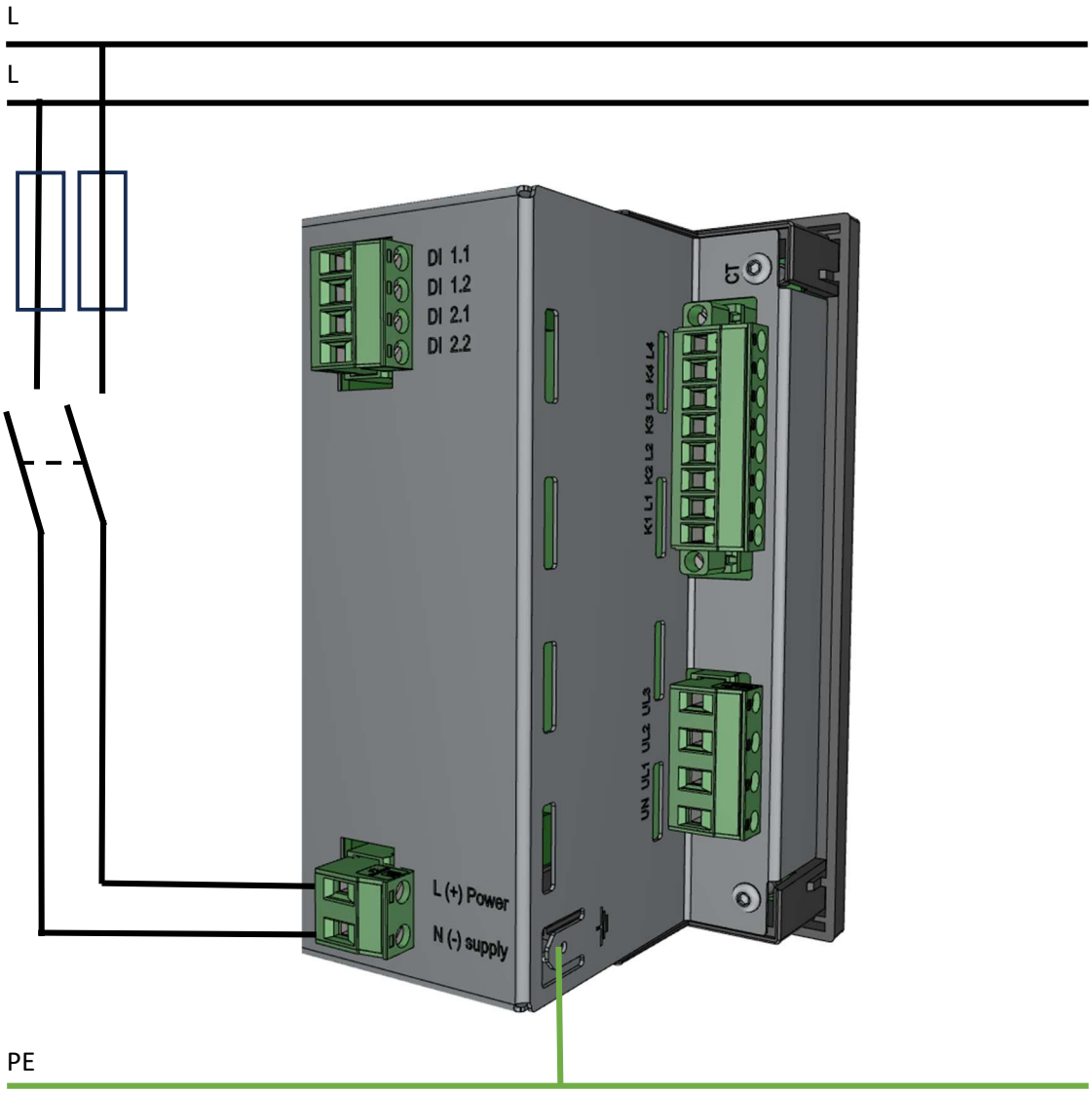
Installation of the device requires an external all-pole disconnect device (10 A fuse).



For housing grounding: 6.3 x 0.8 mm flat plug

! WARNING	
	If the voltage exceeds the voltage specified on the nameplate, a voltage transformer must be used! Otherwise, the device may be damaged.

Installation of the device requires an external all-pole disconnect device (10 A fuse).



For housing grounding: 6.3 x 0.8 mm flat plug

! WARNING	
	If the voltage exceeds the voltage specified on the nameplate, a voltage transformer must be used! Otherwise, the device may be damaged.

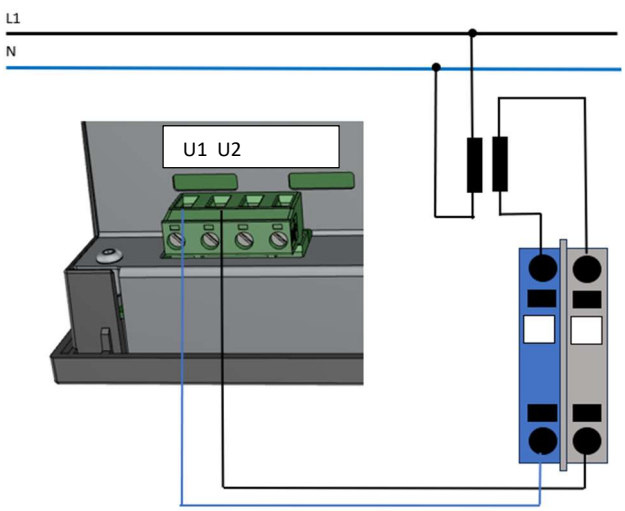
4.2. Measuring voltage

! NOTE
At least 35 VAC TRMS must be present at **the voltage measurement input**. Use a circuit breaker (10 A) as an overcurrent protection device. In **MV switchgear**, a voltage transformer (VT) a voltage transformer (VT) must be used! A VT ratio of 1.00–5000.0 can be set in the software. For a **3-phase measurement,** the neutral conductor is not strictly required Without an external neutral conductor, a virtual neutral conductor is generated within the device. If the device is connected directly to the measurement voltage <u>without</u> a voltage transformer, the VT value must be set to 1!

Measurement range: 40–600 V AC RMS directly or via a voltage transformer -> VT ratio adjustable up to 5000

Mains voltage:	**Range:**	**Connection:**
High voltage:	110,000 V – 35,000 V AC	Via voltage transformers
Medium voltage:	35,000 V – 10,000 V AC	Via voltage transformers
Low voltage:	1,000 V AC / 690 V	Via voltage transformers
	400 V / 230 V AC	Direct
Extra-low voltage:	50 V AC	Direct

4.2.1. Connection to a single-phase (L1) power system

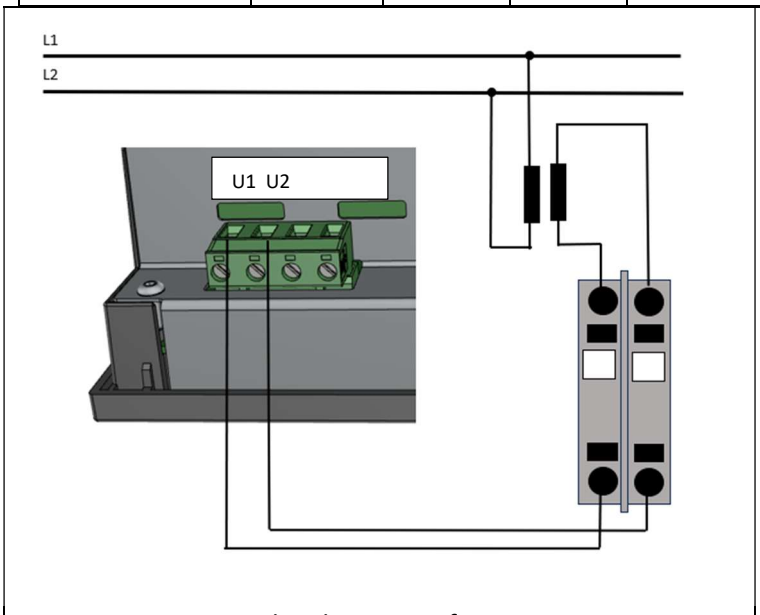


NOTE: For single-phase measurements, the neutral conductor must also be connected for phase synchronization and as a reference potential!

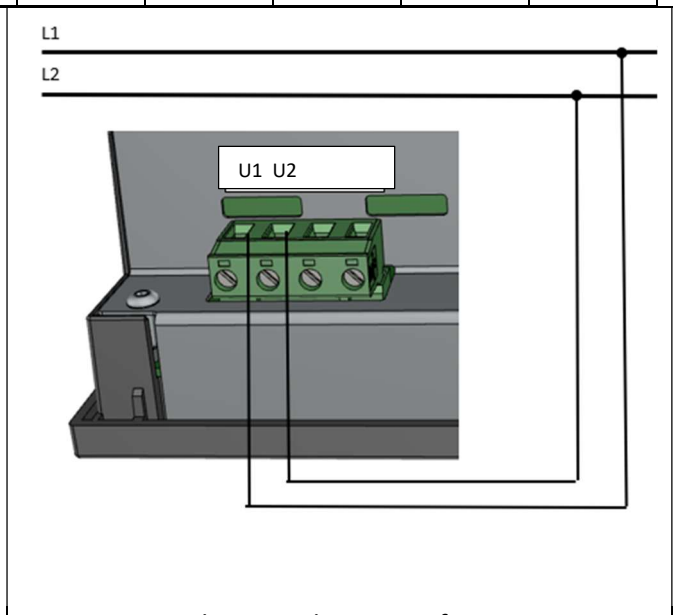
1-Phase – Neutral

Voltage measurement	L1-LN	L2-N	L3-N	L2-N	L3-N	L1-N	L3-N	L1-N	L3-N
Connection	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1
Current Transformer measurement	L1	L2	L3	L2	L3	L1	L3	L1	L2
CT Connection	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1

Correction angle	0°	0°	0°	120°	120°	120°	240°	240°	240°



With voltage transformer

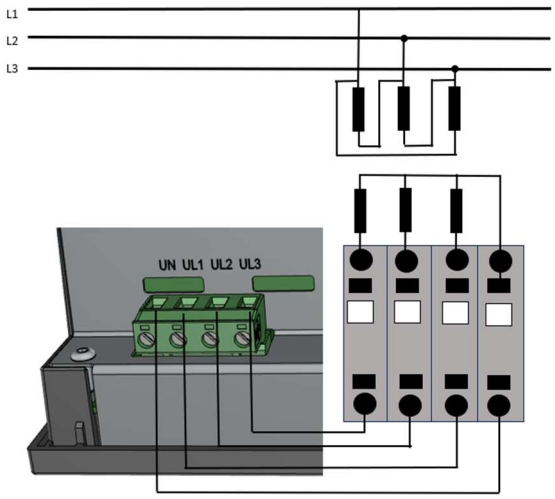


Without a voltage transformer

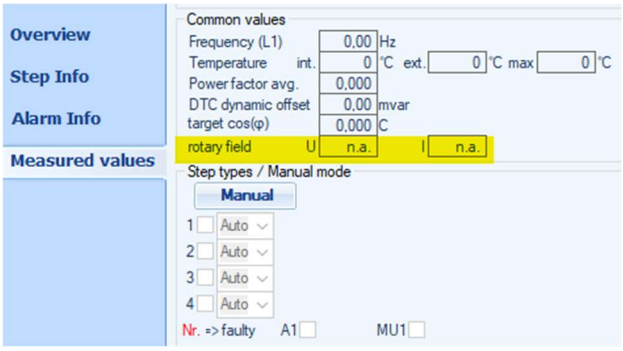
1-phase - phase

Voltage measurement	L2-L3	L3-L1	L1-L2	L2-L3	L3-L1	L1-L2	L2-L3	L3-L1	L1-L2
Connection	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1
Current Transformer measurement	L1	L2	L3	L2	L3	L1	L3	L1	L2
CT Connection	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1
Correction angle	90°	90°	90°	210°	210°	210°	330°	330°	330°

4.2.2. Connection to a 3-phase power system



Rotating field monitoring via the configuration tool on the computer.



3-phase – (neutral conductor)

Voltage measurement	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)
Connection	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)
Current Transformer measurement	L1	L2	L3	L2	L3	L1	L3	L1	L2
CT Connection	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1
Correction angle	0°	0°	0°	120°	120°	120°	240°	240°	240°

NOTE: The direction of rotation is displayed on the home screen and in the configuration wizard!

4.3 Measurement current

! NOTE

For **current measurement,** external, listed current transformers for energy monitoring with reinforced insulation in accordance with IEC 61010 and a secondary current of X/1A or X/5A must be used.

At least 10 mA TRMS must be present at the current measurement input.

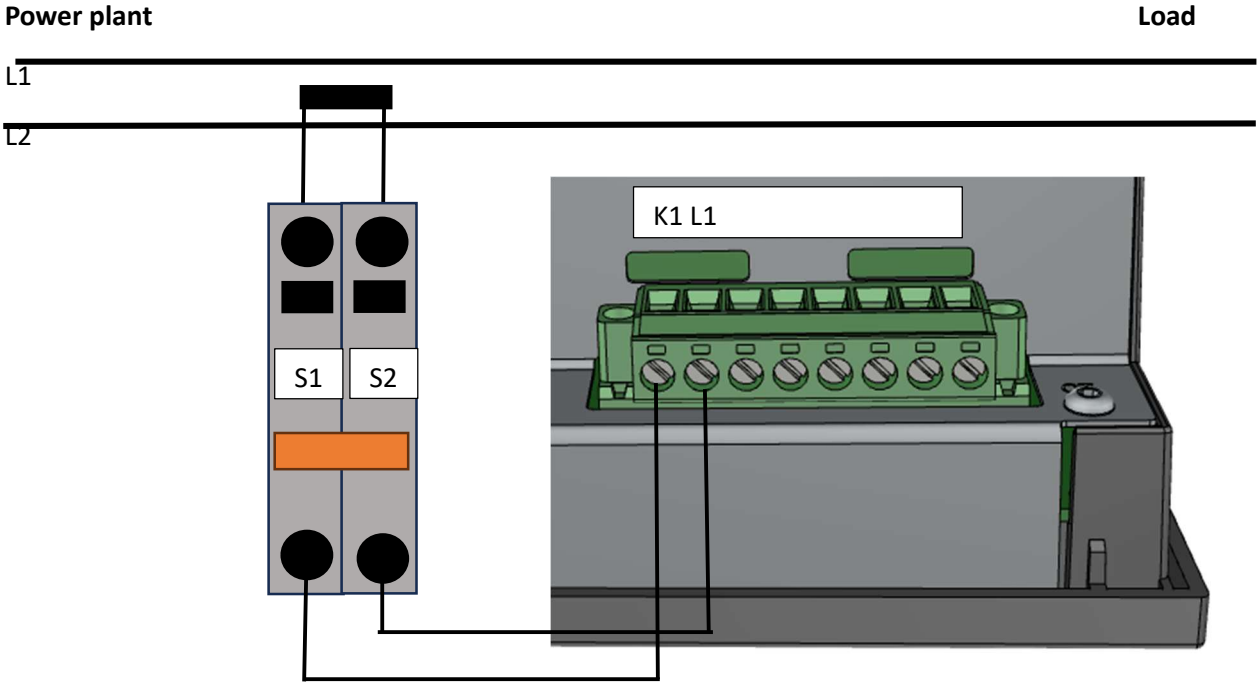
Current transformers must always be used with isolating terminals!

An open current transformer generates a very high voltage that poses a danger to people and equipment.
This can result in the destruction of the current transformer.

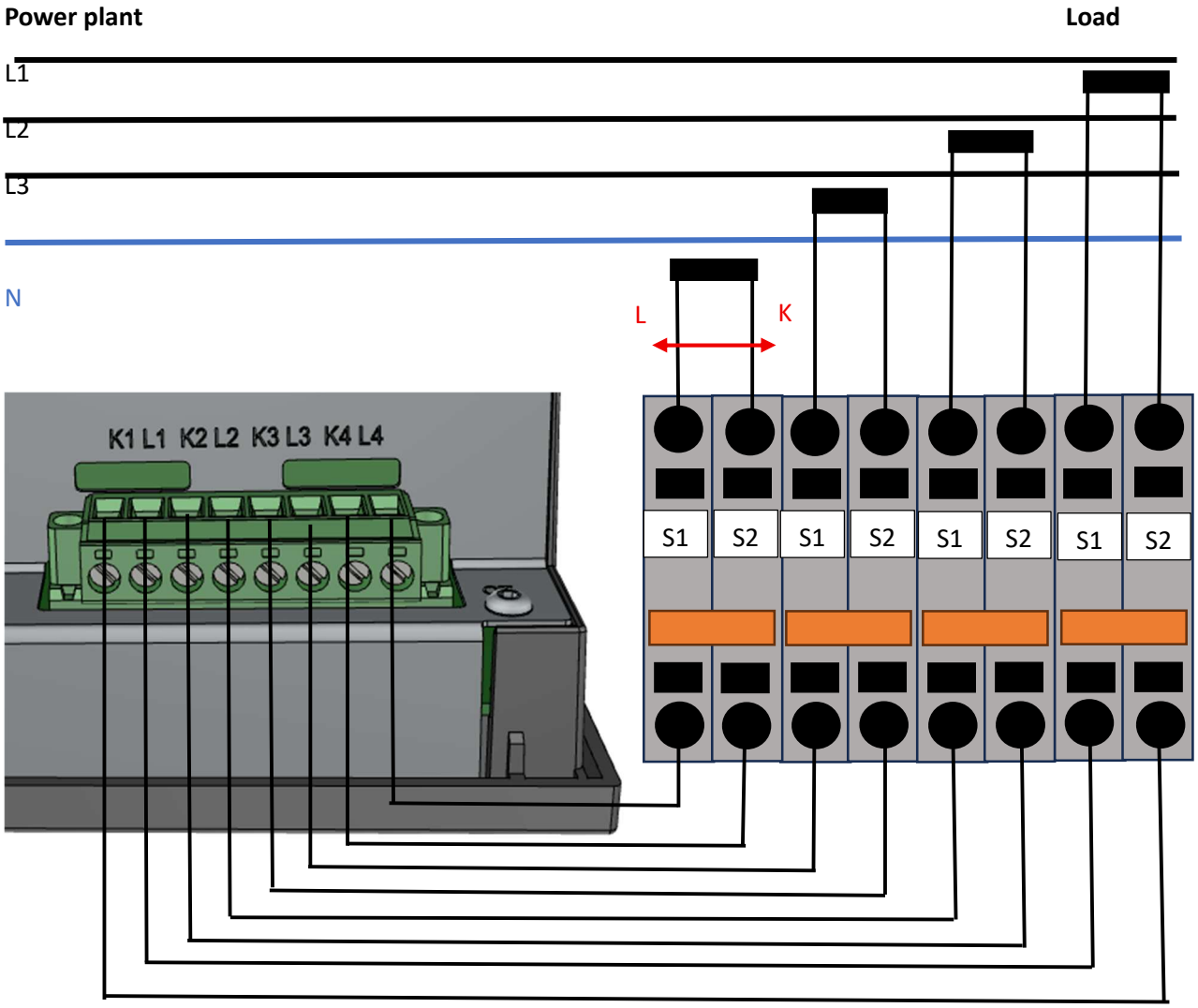
Direction-of-rotation indication is only possible via the Modbus-USB converter!

! WARNING	
Property damage may result from failure to observe the connection requirements.	Voltages and currents outside the permissible measurement range can damage the device. Observe the measurement range specifications listed in the technical data.

4.3.1 Single-phase current measurement

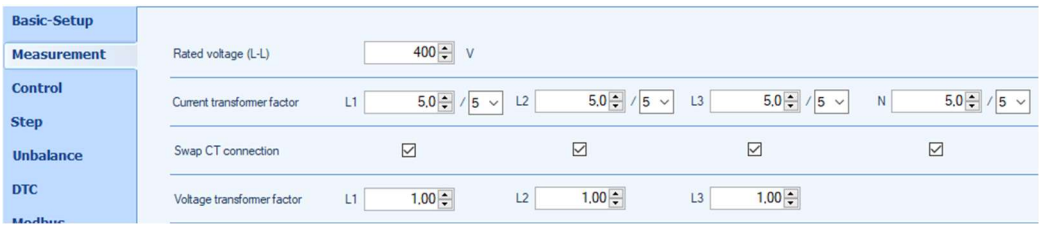


4.3.2 3-phase current measurement



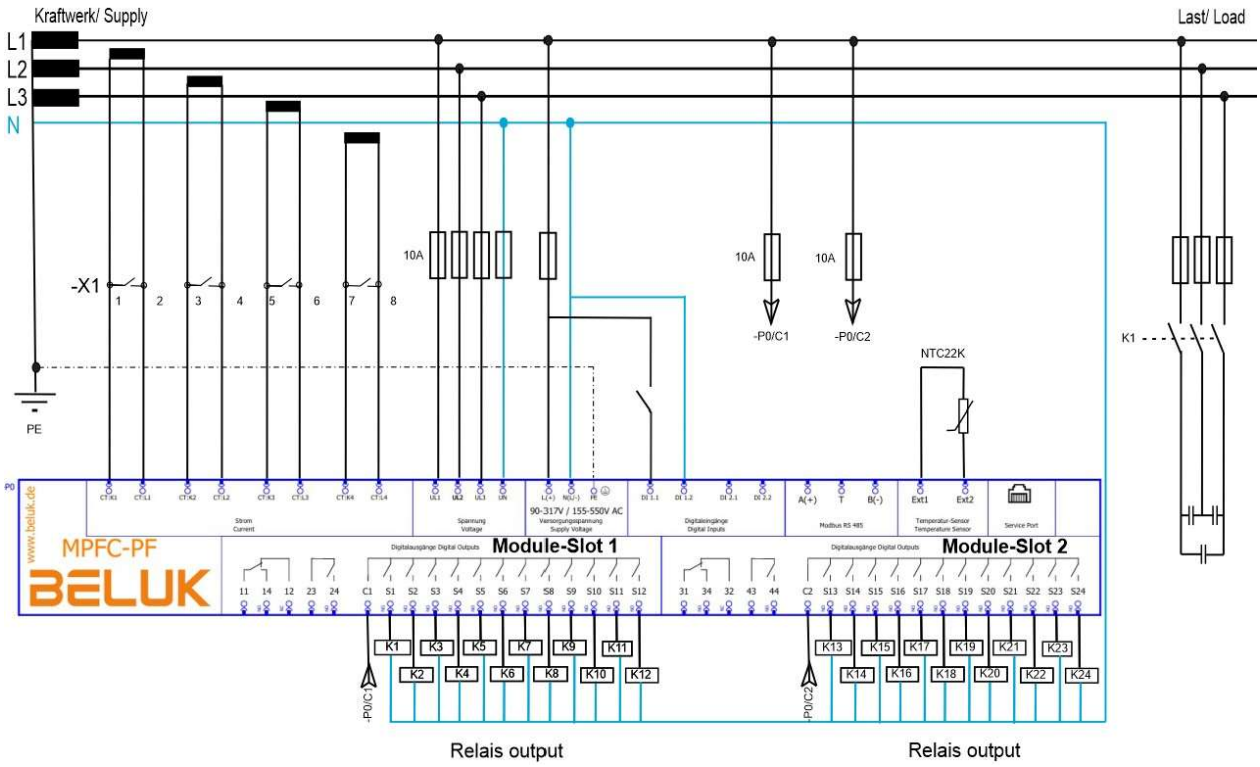
Wiring error!

K and L must be swapped!

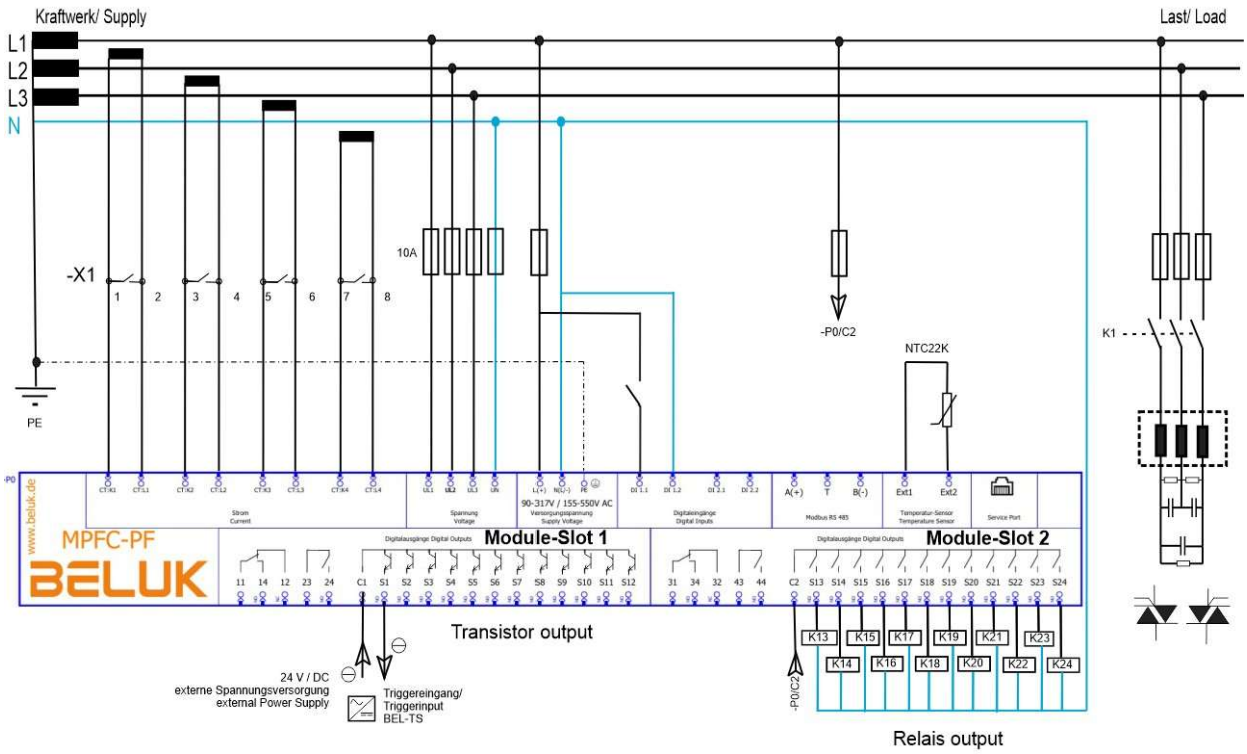


5. Wiring Examples

5.1. Wiring Diagram MPFC – PF 3-Phase Measurement with Relay Outputs



5.2. Wiring diagram MPFC – PF 3-phase measurement with relay and transistor outputs



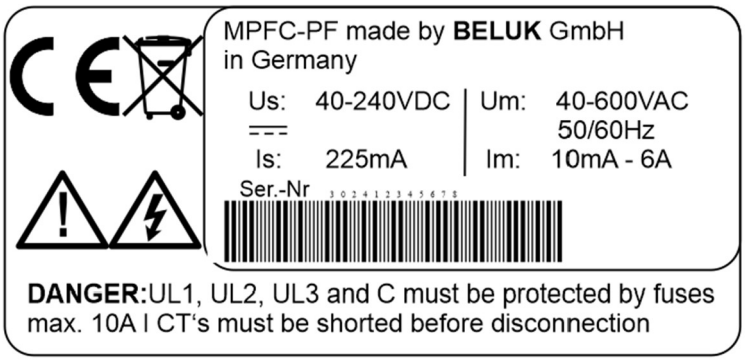
! WARNING	
Caution – Risk of death from electric shock!	Touching bare or stripped wires that are live can result in serious injury or even death. 1. Disconnect the system from the power source! 2. Secure against accidental re-energization! 3. Verify that all poles are de-energized! 4. Properly ground the system! Use only grounding points marked with the grounding symbol!

! CAUTION	
Malfunction, damage to the device, or risk of injury due to improper connection.	Improperly connected devices may • provide incorrect readings, • damage the device, or • pose a risk of injury to people. <u>Note:</u> **Measurement currents must come from the same power source.** **Do not use the meter to measure direct current!** **Ground the device cover!**

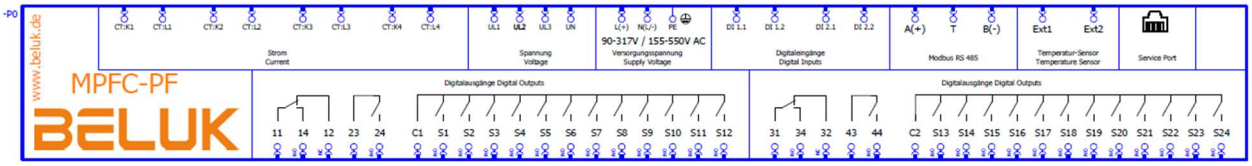
5.3. Nameplate

AC Power Supply	Series:	MPFC-PF
	Manufacturer:	BELUK GmbH
	Supply Voltage:	Us
	Max. current consumption	Is
	Measuring voltage:	Um
	Measuring current:	In
	Serial number:	Barcode
	Declaration of Conformity:	CE
	Disposal:	Electronic waste
	Hazard symbols:	Chapter 1 Safety Instructions

DC Power Supply	Series:	MPFC-PF
	Manufacturer:	BELUK GmbH
	Supply Voltage:	Us
	Max. current consumption	Is
	Measuring voltage:	To
	Measurement current:	In the
	Serial number:	Barcode
	Declaration of Conformity:	CE

	Disposal:	Electronic waste
	Hazard symbols:	Chapter 1 Safety Instructions

5.4. Eplan Macro



6. Commissioning

- Supply Voltage
- Measuring Voltage
- Measuring Current

Match the data on the nameplate.
Remove the current transformer bridge.
➔ Switch on the voltage.
When the device starts up, the display turns orange .
The capacitor symbols flash, indicating that the
75-second discharge period is being completed.
You can now begin the configuration.

! Note on system configuration

If the device is connected to a **single-phase system**, **the display turns red** and the **"U-Limit" alarm message** flashes.
This is because the device is set to a **3-phase system** by default.
To prevent the alarm, the system setting must be adjusted:
Menu path:
Basic Setup → 8.5.8 System (Outer Conductor)
Action:
Change the setting from **"3-phase"** to **"1-phase**."

7. Home Screen

I1	Digital Input 1 - When triggered, the circle turns black Functions: Alarm / Alarm Suppression / Cosphi 2 / Disable Q-Offset / Rate Switching
I2	Digital Input 2 - When triggered, the circle turns black Functions: Alarm / Alarm suppression / Cosphi 2 / Disable Q-offset / Tariff switching
A	Alarm relay 1 or 2—When triggered, the circle turns black
M	Multi-use Output 1 or 2 - When triggered, the circle turns black
	Memory card present Flashes when logging/saving data
	Rotation direction (L = left; R = right)
01:00:26	Time (hour / minute / second)
01/01/00	Date (day / month / year)
1.00	Current cos ϕ
i 0.95	Target Cos ϕ
	Measured values for **L1, L2, L3,** and the **∑**
 	Measurements **Un:** Phase-to-neutral voltage (V) **ULL:** Phase-to-phase voltage (V) **P** Active power (W) **△ Q** Capacitance required to achieve the target cos ϕ **Q** Reactive power (var) **S** Apparent power (VA) **THDU:** Voltage harmonics in % **THDI:** Current harmonics in %

<table>
<tr><td> </td><td>The capacitor symbol indicates the following states:
<table>
<tr><th rowspan="6">State</th><th>flashing</th><td>Capacitor is discharging
(discharge time 75 seconds)</td></tr>
<tr><th>Not illuminated</th><td>Ready for use</td></tr>
<tr><th>Black background</th><td>Level activated by control</td></tr>
<tr><th>x on a black background</th><td>Stage permanently ON</td></tr>
<tr><th>X</th><td>Level permanently OFF</td></tr>
<tr><th>F</th><td>Level defective “Faulty”</td></tr>
</table></td></tr>
</table>

8. Operation

The MPFC is operated using 4 buttons.

NOTE: After 5 minutes without pressing a button, the device returns to the main display.

If no button is pressed within 5 minutes, the backlight dims. Pressing any button turns the backlight back on. The backlight contrast can be adjusted as follows:

via the **menu -> Settings -> System -> Contrast and Brightness**

1

- Exit menu item
- Move cursor to the left
- Reset alarm (press and hold for 3 seconds)

2

- Decrease values
- Select the next measurement value, menu item, or step number

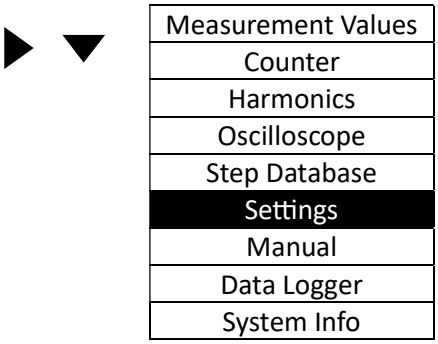
3

- Increase values
- Select the previous measurement value, menu item, or step number

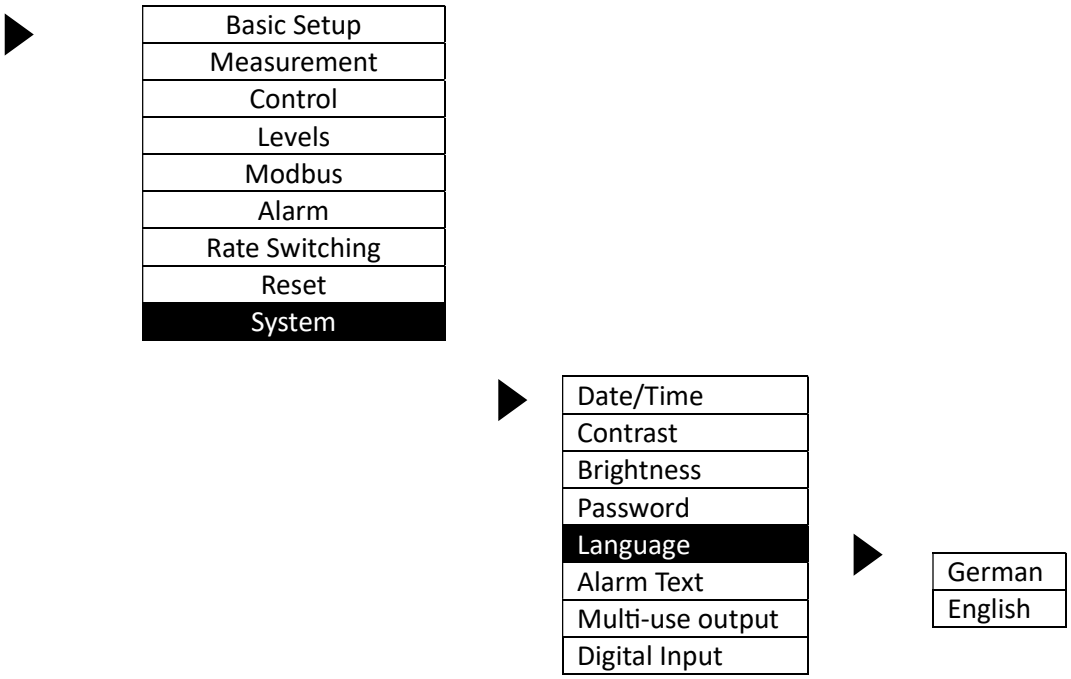
4

- Open menu item
- Move the cursor to the right
- Accept value

8.1 Menu

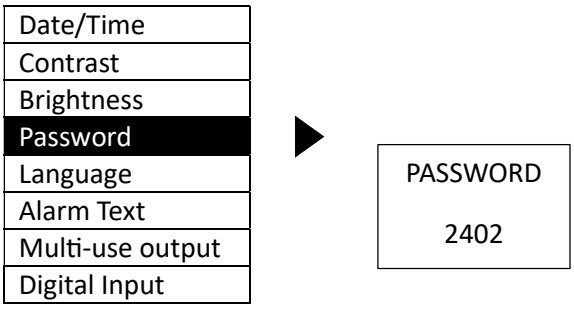


8.2 Language Settings



8.3 Password

All settings, except for the basic setup are password-protected.



8.4 Basic Setup

Contains all settings necessary for commissioning.

No password required

Overview with default, minimum, and maximum values.

	Rated voltage (L-L)	**Current Transformer Factor**	**Voltage transformer factor**	**Switching time**	**Discharge time Transistor**	**Discharge time Relay**
Standard	400.0 V	5.0/5	1.00	5.0 s	75.0 s	75.0 s
Min.	100 V	1/1 A 1/5 A	1.00	0.1 s	0.0 sec	0.0 sec
Max.	242,000 V	50,000/1 A 50,000/5 A	5,000	999.9 s	999.9 sec	999.9 sec

	Target Cos ϕ 1	**Control**	**Power System**	**Measurement**
Standard	1.00 i	OFF	I: 1-phase V: 1-phase S: 3-phase	PF6R1A
Min.	0.7 c	ON	I: 1-phase V: 1-phase S: 1-phase	1-phase and N
Max.	0.7 i	OFF	I: 1-phase V: 3-phase S: 3-phase	
		HOLD	I: 3-phase V: 3-phase S: 3-phase	PF6R4A

8.4.1 Rated Voltage (L-L)

The rated voltage is the specified value for the power grid during normal operation.

! NOTE
This reference value is one of the most important setting values! The upper and lower limits of **the voltage monitoring.** The **step sizes** are also based on the set nominal voltage.

Category	**L-L Voltage**	**Min. -10%**	**Max. +10%**
NV	400 V	360 V	440 V
MV	10 kV | 20 kV | 30 kV	9 kV | 18 kV | 27 kV	11 kV | 22 kV | 33 kV
HV	60 kV | 110 kV	54 kV | 99 kV	66 kV | 121 kV

! WARNING	
Risk of injury from electrical voltage!	If the device is exposed to surge voltages exceeding the permissible overvoltage category, safety-critical insulation within the device may be damaged. As a result, the safety of the product can no longer be guaranteed. Use the device only in environments where the permissible overvoltage category is not exceeded.

! WARNING	
Property damage due to failure to observe the connection requirements.	Voltages and currents outside the permissible measurement range can destroy the device. Adhere to the measurement range specifications listed in the technical specifications.

8.4.2 Current transformers Factor

Use an external current transformer for each phase with a ratio of x/1 or x/5.

Ratio of the primary to the secondary side of the current transformer, e.g., 1000/5

In the default setup, the value is applied to all 3 phases.

! NOTE
Select the transformer so that a measurement resolution of **at least 10 mA** is achieved (the controller's response threshold is 10 mA) Cable length and accuracy class must be taken into account when selecting the transformer! x/1 A transformer for long measurement lead lengths x/5A transducer for a higher accuracy class **Shielded cables are recommended!**

8.4.3 Voltage transformer ratio

Enter the voltage transformer ratio. The ratio must be entered as a value

(e.g., 1000/100 = 10).

The voltage transformer factor can be entered with one decimal place.

NOTE: If the device is connected directly to the measurement voltage without a voltage transformer, use the value 1.

8.4.4 Switching time

Switching time is the delay between switching the individual stages. This time is used during measurement to determine the power requirement.

Fast control is available as an option; for this, thyristor controllers should be used for switching.

! NOTE

Failure to follow this note may result in property damage to the product or other property!

When setting the switching time, the following factors must be taken into account:

a) The switching time should protect the power contactors from an unnecessarily high number of switching cycles and thus from excessive wear.

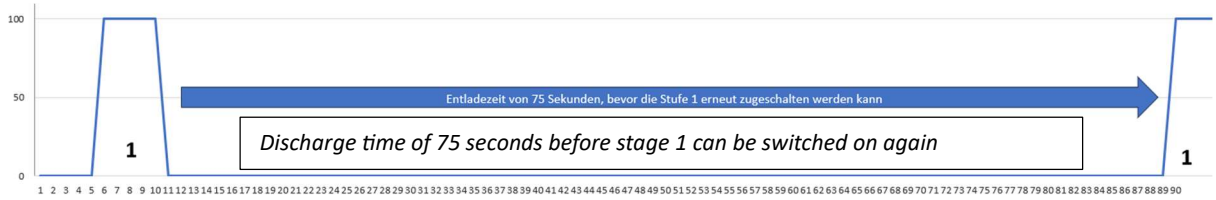
b) Reactive power demand is averaged over the switching time. Rapid fluctuations in reactive power are smoothed out.

8.4.5 Discharge time

The discharge time is a blocking period that elapses after a stage is switched off.

It ensures that the capacitors are fully discharged before the stage is switched on again.

As long as this hold time has not elapsed, the corresponding stage of the control system is not available. The discharge time hold must be adjusted to the discharge duration of the capacitors.



A stage that is in the discharge state is displayed as blinking in the main menu.

! WARNING

Danger from undischarged capacitors!	Connecting a capacitor bank that has not been discharged can result in **damage to the capacitor** or the **entire system**! **Make sure that all capacitor banks are completely discharged before switching them on.** This can result in injury.

8.4.6 Target Cos phi 1

Setting the target cos phi 1 defines the active power factor to be achieved through reactive power compensation (control target).

8.4.7 Control

ON	To start control operation Control is enabled and operates using the selected algorithm.
OFF	For maintenance work on the capacitor bank or when manually entering the phase angle of the measured voltage. Control is off, and active stages are switched off one after another at 3-second intervals.
HOLD	Control is paused, and active stages remain active.

8.4.8 System (neutral conductor)

Installation in a **3-phase power system** (L1, L2, L3)—see **wiring diagram 5**

Or **in a single-phase power system** (L1).

With this setting, the stage size detection and other parameters are adjusted.

I: Single-phase V: Single-phase S: Single-phase	Single-phase current measurement (1 CT) Single-phase voltage measurement (1 VT) Calculation Apparent power / Reactive power / Active power **Single-phase grid -> L-N**
I: Single-phase V: Single-phase S: Three-phase	Single-phase current measurement (1 CT) Single-phase voltage measurement (1 VT) Calculation Reactive power / Apparent power / Active power based on the measured single-phase voltage and current. It is assumed that the current is the same for all three phases
I: single-phase V: 3-phase S: 3-phase	Single-phase current measurement (1 CT) 3-phase voltage measurement (3 VT) Calculation Apparent power / reactive power / active power based on the individual phase voltages. It is assumed that the current is the same for all three phases
I: 3-phase V: 3-phase S: 3-phase	Complete individual measurement for all three phases (hardware: 3 CTs and 3 VTs required)

8.4.9 Measurement

When configured for a single-phase power system, menu **14.1.7 "Measurement"** is not applicable**,** since the system assumes by default a **three-phase capacitor connection**— —with **a symmetrical load**.

For a **3-phase measurement**, the
connection type can be selected in the Measurement menu.

Here, current and voltage are measured separately for each phase.

! NOTE
External current and voltage transformers are required for the measurement.

8.4.10 Auto Initialization

Basic Setup
Measurement
Control
Stages
Unbalance
Fault Current
Modbus
Alarm
Rate Switching
Reset
System

14.1.5 Auto Init.

Current and voltage must be within the set tolerances.

Measurement + Phase Detection	Detects whether a 1-phase or 3-phase measurement is connected. For a single-phase voltage connection, detects whether it is connected to L-N or L-L. Detects whether a single-phase or three-phase capacitor is connected. The phase angle is determined and, if necessary, automatically corrected by a phase correction angle. All outputs are switched through sequentially to determine the step size. Two cycles are performed.
CT factor	The step size must be entered as a reference value.
Step size detection	Step size detection depends on the transmission ratio of the converters. Formula: **Qc/PT*CT** Step size in var Voltage transformer ratio* Current transformer ratio Example: when using a current transformer CT: 4000/5 Voltage transformer PT: 690/100 Step size 50 kvar $\frac{50{,}000 \text{ var}}{6.9 \times 800}$ = 9.06 If the result is greater than 10, there is a high probability that the step size has been correctly identified. If the value is less than 10, a different converter is recommended.

		To determine the step size, the outputs are switched through one after another, being turned on and off 5 times each.

! NOTE

Automatic initialization…

- can ONLY be used when detecting inductive OR capacitive steps!
- Switches only steps with the step type AUTO!
- is aborted if the mains fluctuation is too high.
- Does not detect steps if the measurement current is too low (min. 15 mA)
- Displays the message “No Steps” if no steps are connected.

9. Measurement Values

NOTE: After 5 minutes without pressing a button, the controller returns to the main display.

Single-phase measurement

VLN	TRMS Voltage [V] Phase - Neutral
VLL	Phase to Phase
I	TRMS current [A]
Vf	TRMS fundamental voltage [V]
If	TRMS fundamental current [A]
P Sum	Active power [W]
Q total	Reactive power [var]
S Total	Apparent power [VA]
Cos ϕ Sum	Total cos ϕ
PF Sum	Total power factor
Tan ϕ total	Total tan ϕ
Delta Q total	Missing reactive power to compensation target [var]
ϕ	°
THDU	Harmonic THD-U [%]
THDI	Harmonics THD-I [%]

F	Frequency [Hz]
V max	Maximum TRMS Voltage [V]
THDU max	THD-U (Maximum) [%]
THDI max	Maximum THD-I [%]
T int	Internal Temperature [°C]
T ext	External temperature [°C]
T max	Maximum temperature [°C]
OPH	Device operating hours [h]
PFavg	Average power factor
CO2	g
I4	TRMS Current [A]
I4f	TRMS fundamental current [A]
THDI4	Harmonic THD-I [%]
IUBC1	Asymmetry current, capacitor 1
IUBC2	Asymmetry current, capacitor 2
IUBC3	Asymmetry current, capacitor 3
IUBC4	Asymmetry current, capacitor 4

3-phase measurement

V1	TRMS Voltage [V]
V2	Phase – Neutral
V3	
V12	TRMS Voltage [V]
V23	Phase – Phase
V31	
V1f	TRMS fundamental voltage [A]
V2f	
V3f	
I1	TRMS current [A]
I2	
I3	
I1f	TRMS fundamental current [A]
I2f	
I3f	
P Total	Total active power [W]
Q total	Total reactive power [var]
S Total	Total apparent power [VA]
P1	Active power [W]
P2	
P3	
Q1	Reactive power [var]
Q2	
Q3	
S1	Reactive power [VA]
S2	
S3	
Delta Q1	Missing Reactive Power
Delta Q2	to the compensation target [var]
Delta Q3	
Delta Q total	
Cos ϕ 1	Cos ϕ
Cos ϕ 2	
Cos ϕ 3	
PF1	Power Factor
PF2	
PF3	
Tan ϕ 1	Tan ϕ
tan ϕ 2	
tan ϕ 3	

Cos ϕ total	Cos ϕ total
PF Sum	Total Power Factor
tan ϕ sum	tan ϕ total
ϕ 1	°
ϕ 2	
ϕ 3	
THDU1	Harmonics THD-U [%]
THDU2	
THDU3	
THDI1	Harmonics THD-I [%]
THDI2	
THDI3	
F	Frequency [Hz]
V1max	TRMS Voltage [V]
V2max	Maximum values
V3max	
THDU1 max	THD-U Maximum Values [%]
THDU2 max	
THDU3 max	
THDI1 max	THD-I Maximum Values [%]
THDI2 max	
THDI3 max	
T int	Internal temperature [°C]
T ext	External temperature [°C]
Tmax	Maximum temperature [°C]
OPH	Device operating hours [h]
PFavg	Average power factor
CO2	g
I4	TRMS Current [A]
I4f	TRMS fundamental current [A]
THDI4	Harmonics THD-I [%]
IUBC1	Asymmetry current, capacitor 21
IUBC2	Asymmetry current, capacitor 2
IUBC3	Asymmetry current, capacitor 3
IUBC4	Asymmetry Current Capacitor 4

10. Counter

W PI	**Active power imported**		
W PE	**Active power exported**		
WP I1	Active power import L1	WP E1	Active power export L1
WP I2	Active power import L2	WP E2	Active power export L2
WP I3	Active power import L3	WP E3	Active power export L3
W Qi	**Inductive reactive power**		
W Qc	**Capacitive reactive power**		
WQ i1	Inductive reactive power L1	WQ c1	Capacitive reactive power L1
WQ i2	Inductive reactive power L2	WQ c2	Capacitive reactive power L2
WQ i3	Inductive reactive power L3	WQ c3	Capacitive reactive power L3
WP I T2	**Active power imported, Tariff 2**		
WP E T2	**Active power export, Tariff 2**		
WP I1 T2	Active power import L1	WP E1 T2	Active power export L1
WP I2 T2	Active power import L2	WP E2 T2	Active power export L2
WP I3 T2	Active power import L3	WP E3 T2	Active power export L3
WQ i T2	**Inductive reactive power, rate 2**		
WQ c T2	**Capacitive reactive power, Tariff 2**		
WQ i1 T2	Inductive reactive power L1	WQ c1 T2	Capacitive reactive power L1
WQ i2 T2	Inductive reactive power L2	WQ c2 T2	Capacitive reactive power L2
WQ i3 T2	Inductive reactive power L3	WQ c3 T2	Capacitive reactive power L3

11. Harmonic

11.1. Table

The table provides an overview of the measured values, showing the ratio in %, relative to the specified limit values of the EN 50160 standard.

U1 2-63
U2 2-63
U3 2-63
I1 2-63
I2 2-63
I3 2-63

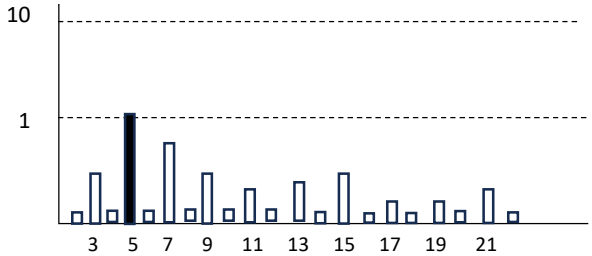
2:	0.0%
4:	0.0%
6:	0.0%
8:	0.0%
10:	0.0%

3:	0.5%
5:	1.7%
7:	0.8%
9:	0.7%
11:	0.3%

U1

11.2. Bar Chart

If the permitted limit is exceeded, the bar turns completely solid.

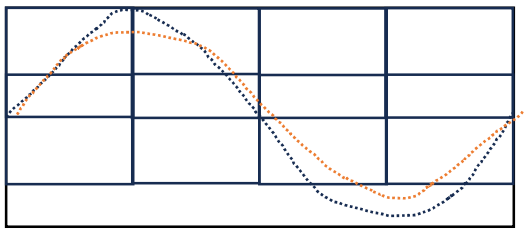


U1

U2 2-63
U1 2-63
U3 2-63

12. Oscilloscope

Visual representation of the rms values of voltage V and current A for the 3 phases L1, L2, L3, L4



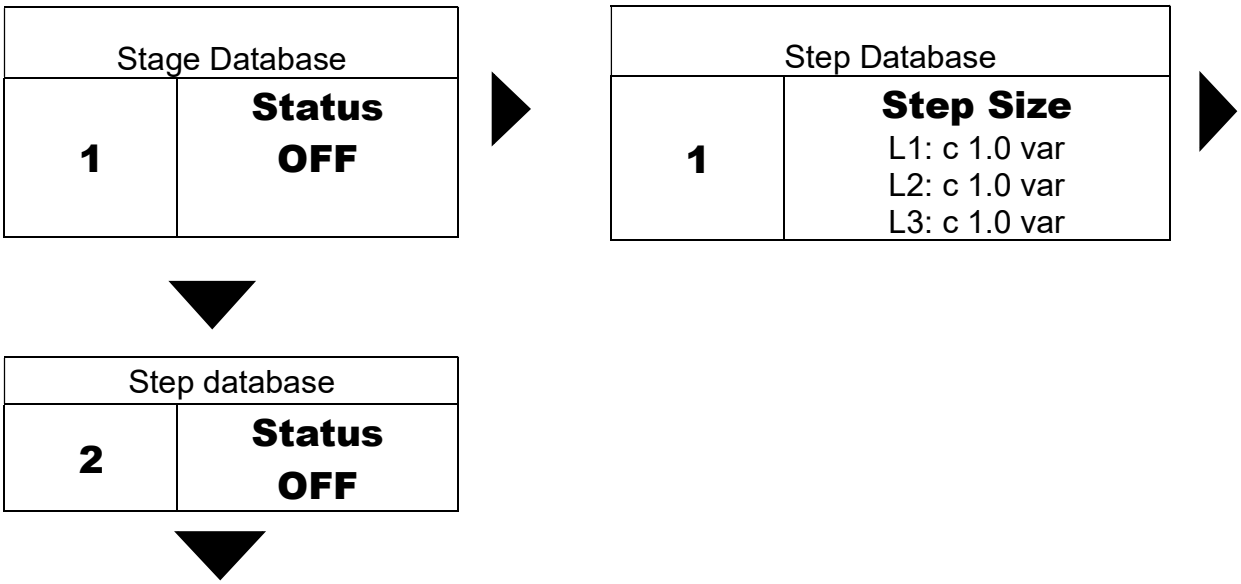
L1 … 230.8 V – 16.0 A

13. Step Database

The step database displays 5 values as information.

Status	Step size (var)	Step size (%)	Cycles (0)	Hours (h)

Status **OFF**	This is recommended when **no** stage is connected to prevent unnecessary switching attempts.
Status **ON**	is recommended to compensate for a constantly present load.
Status **AUTO**	is recommended when the control algorithm is to take over control.



! NOTE
If the step size in percent shows more than 100 percent—for example, 138 percent—this is because the manually set step value exceeds the actual power output. This occurs, for example, when the compensation stage has been replaced, but the step size has not been reset, or in the event of significant grid fluctuations.

14. Settings

14.1. Measurement

No password is required for the basic setup; this is explained in section 8.4

NOTE: A password is required to access the following menu!

Basic Setup
Measurement
Control
Levels
Unbalance
Fault Current
Modbus
Alarm
Rate Switching
Reset
System

▶ Menu Measurement

14.1.1. Rated Voltage — 100 – 242,000 V

The value set in the Basic Setup is applied.

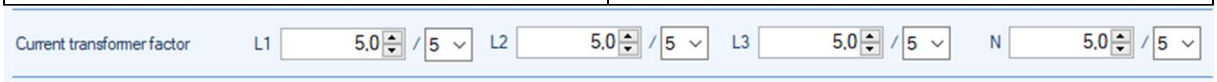
14.1.2. CT Factor — 1.0 – 9,600.0

The value is taken from the default setup.
Here, the value can be entered individually.

CT1:	**5.0/5**
CT2:	**5.0/5**
CT3:	**5.0/5**

or

Via the configuration wizard on the computer

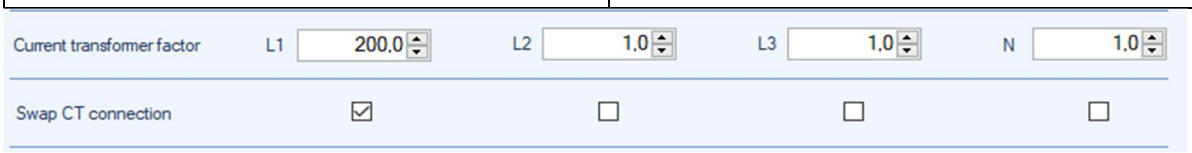


14.1.3. Change CT connection

The value is taken from the basic setup.
Here, the value can be entered individually.

CT1:	☐
CT2:	☐
CT3:	☐

or
using the configuration wizard on the computer



14.1.4. VT Factor 1.00 – 5,000.00

The value can be entered manually here.

Value is taken from the base setup

VT1:	**1.0**
VT2:	**1.0**
VT3:	**1.0**

14.1.5. Automatic Initialization

Measurement + Step Detection
CT Factor
Step Size Detection

14.1.6. System (Power System) 3-phase

Single-phase

3-phase

14.1.7. Measurement 3-phase

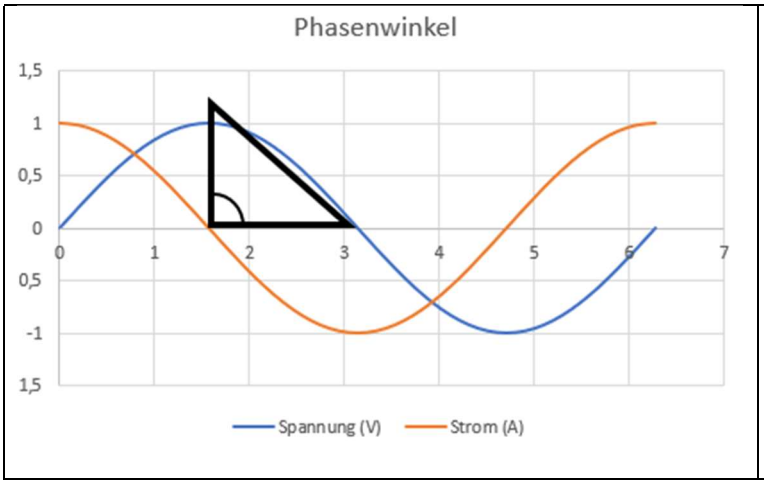
Current and voltage are measured separately for each phase.

Single-phase

3-phase

14.1.8. Phase correction angle 0 – 359°

	Depending on how the **measurement voltage** and **current** are connected, the phase angle is determined, which affects the calculation of power, cos ϕ, power factor, and step sizes.



Single-phase – neutral conductor

Voltage measurement	L1-LN	L2-N	L3-N	L1-N	L2-N	L3-N	L1-N	L2-N	L3-N
Connection	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1
Current Transformer measurement	L1	L2	L3	L2	L3	L1	L3	L1	L2
CT Connection	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1
Correction angle	0°	0°	0°	120 °	120 °	120 °	240 °	240 °	240 °

1-Phase - Phase

Voltage measurement	L2-L3	L3-L1	L1-L2	L2-L3	L3-L1	L1-L2	L2-L3	L3-L1	L1-L2
Connection	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1	UN-UL1
Current Transformer measurement	L1	L2	L3	L2	L3	L1	L3	L1	L2
CT Connection	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1
Correction angle	90°	90°	90°	210 °	210 °	210 °	330 °	330 °	330 °

3-phase – (neutral conductor)

Voltage measurement	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)	L1-L2-L3 (-N)
Connection	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)	UL1-UL2-UL3-(UN)
Current Transformer measurement	L1	L2	L3	L2	L3	L1	L3	L1	L2
CT Connection	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1	K1-L1
Correction angle	0°	0°	0°	120°	120°	120°	240°	240°	240°

The phase correction angle can be detected automatically by performing the **automatic initialization** or entered manually.

- If **the AI** correctly detects the phase correction angle for current and voltage measurement, this value should not be changed.
- If the **AI** fails due to unfavorable network conditions, the phase correction angle can be entered manually, or an incorrectly detected phase angle can be corrected.

NOTE: It is recommended to disable the control during manual entry.
Control: OFF (Main Menu 8.4)

The **AI** starts only if the current and voltage are within the specified tolerances.

Outputs set to the ON or OFF step type are not taken into account by the AI.

NOTE: The **AI** correctly detects the phase angle only if capacitors are connected to the switching outputs. However, if the controller compensates for reactive power using choke coils, this may lead to malfunctions.

NOTE: Constant load conditions are a prerequisite for successful AI!
The presence of constant load conditions facilitates successful **AI** operation**.**

14.1.9. Frequency AUTO

To ensure maximum accuracy in current and voltage measurement, it is necessary to synchronize the sampling rate with the line frequency. Although the line voltage is filtered internally, severe commutation dips can disrupt automatic synchronization, which in turn leads to measurement errors. To avoid such disruptions, the following settings can be configured.

AUTO:	Automatic synchronization ensures the highest measurement accuracy for line voltage without commutation dips.
50 Hz:	For reliable operation on a 50 Hz grid with extremely poor power quality.
60 Hz:	For safe operation in a 60 Hz grid with extremely poor grid quality.

14.1.10. Internal temperature offset -10 … 10 °C

Used to correct the temperature measurement within the device.

14.1.11. External temperature offset -10 … 10 °C

Used to correct the external temperature measurement.

14.1.12. CO2 emission factor (reactive) 0.0 – 999.0 g/kvarh

This “Emission factor reactive” parameter is used to enter the amount of CO2 required for generate 1 kvarh [g/kvarh].
-> The default value is 8.5 g/kvarh
CO2 reading display -> CO2 saved in kg.
(Calculated using step sizes/run time/reactive emission factor)
The counter can be reset via the “Reset Menu” for the CO2 counter.

! NOTE

The value is only approximate, since the reactive emission factor for supply of 1 kvarh cannot be determined exactly. The factor depends on a wide variety of factors and the location, and it also changes constantly over time
.
Therefore, it is the customer’s responsibility to enter an

appropriate value in parameter 210. The current default value of 8.5 g/karh corresponds approximately to the European standard for 2022.

14.2. Control

14.2.1. Control ON / OFF / Hold

Turn the control on or off. When the control is turned off, all active stages are switched off one after another at the specified switching interval. When the control is turned back on, the discharge time of the capacitors is always taken into account ( ). If “Hold” is selected, the control remains in its current state.

ON	Control is enabled and operates using the selected algorithm.
OFF	The control system is off, and active stages are switched off one after another at 3-second intervals.
HOLD	Control is paused, and active stages remain on.

14.2.2. Control Algorithm Best-Fit

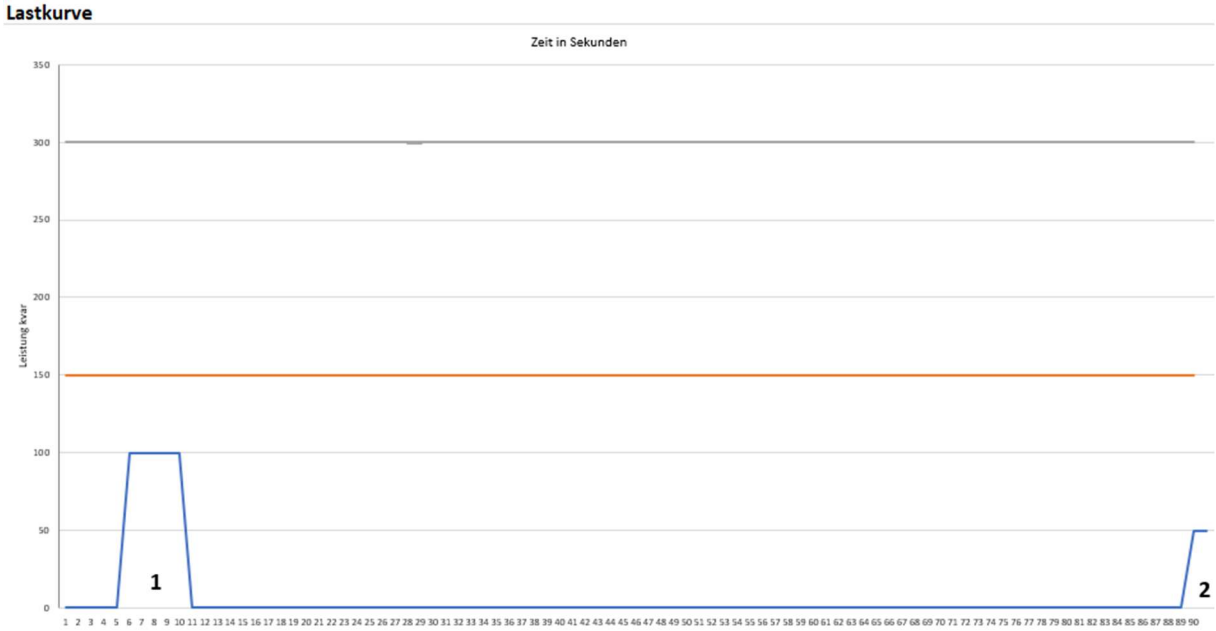
5 Standard Algorithms

Best Fit	Protect capacitor stages, extend service life	Balances operating hours and switching cycles. Applies to 90% of use cases.
FIFO	When using stages of equal size. The switching sequence is maintained according to	First in, first out. The stage that was switched on first is switched off first.
LIFO Up	When using steps of equal size. The switching sequence follows	Last in, First out. Starts with stage 1
LIFO Down	When using steps of equal size. Adherence to the switching sequence	Last in, first out. Starts with the last stage
Progressive	Fast control, faster measurement	For large and rapidly changing loads

14.2.2.1 Best-Fit

The controller operates according to the BEST-FIT principle to achieve the best compensation result. Before each switching operation, the controller compares all stage values stored in the stage database with the determined reactive power requirement **(Delta Q)** and always selects the stage that comes closest to the set control target (cos phi 1).

If identical stages are connected to the controller, the number of switching operations is automatically distributed across the affected stages, either based on **switching cycles** or **operating hours**.



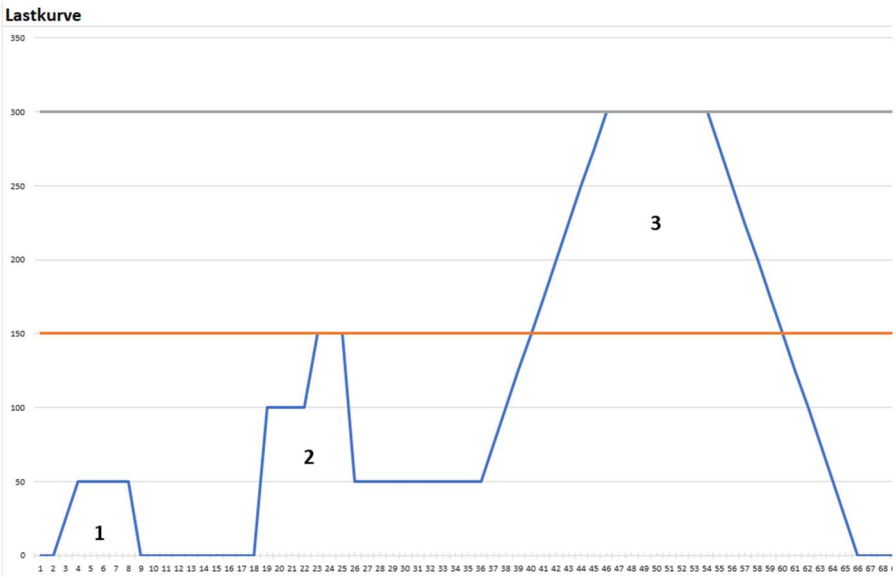
Compensation system with 300 kvar

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Level 6	Level 7	Level 8
		25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar
		50 kvar		50 kvar		50 kvar		50 kvar	
	Switching time (activation)	5 sec	5 sec	5 sec	5 sec				
	Switch-off time	5 sec	5 sec	5 sec	5 sec				
	Best-Fit Algorithm								
	Switching sequence ON	1	2	3	4				
1	Switching sequence OFF	1	2	3	4				
	Discharge time	75 sec	75 sec	75 sec	75 sec				
	Operating hours (h)	25	25	26	26	20	20	27	27
	Switching sequence ON					1	2		
2	Switching sequence OFF								

14.2.2.2 FIFO

First in, first out. The best compensation is achieved by using steps of equal size.
To ensure control stability, faulty steps are automatically disabled and skipped by the control algorithm. Therefore, the corresponding setting cannot be changed.

NOTE: The settings in the "Step Swap" and "Switching Distribution" menus are not taken into account.



The controller <u>starts at stage **1**</u> and automatically switches to the next higher stage as needed.

When <u>switching off,</u> the controller starts at <u>stage 1</u> and, if necessary, always switches off the stage with the next higher number.

For example, if stages 3 through 7 are still active, the control system starts at stage 8 when switching on. If stage 12 has been activated and stage 1 has not yet been activated, the control system starts again at stage 1. When switching off, the control system starts at stage 3.
If stage 12 has been switched off and stage 1 is still active, the next stage to be activated is stage 1.
For each stage, the system checks separately whether switching is appropriate.

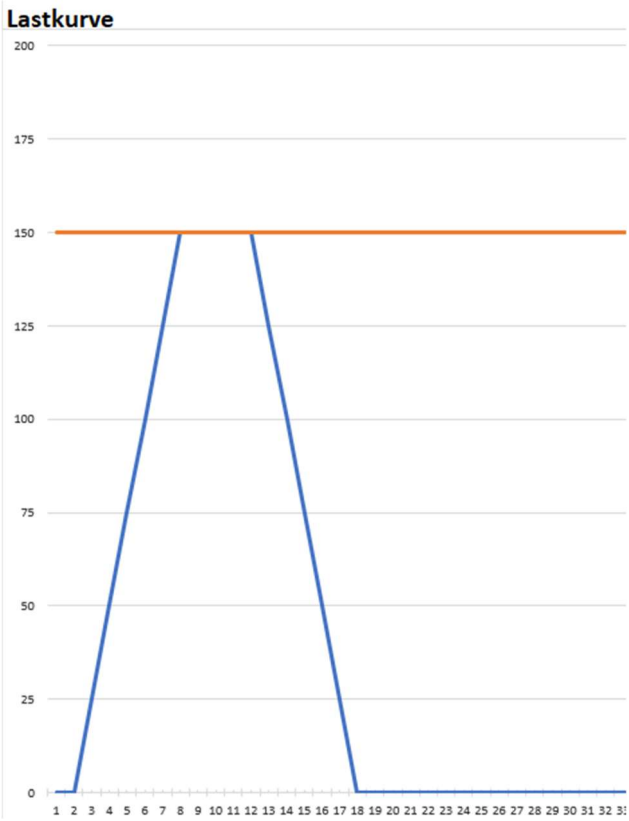
<u>Compensation system with 300 kvar</u>

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Level 6	Level 7	Level 8	Level 9	Level 10	Level 11	Level 12
		25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar
		50 kvar		50 kvar		50 kvar		50 kvar		50 kvar		50 kvar	
1	Switching time (on and off)	1 sec	1 sec										
	FIFO algorithm												
	Switching sequence ON	1	2										
	Switching sequence OFF	1	2										
	Discharge time	10 sec	10 sec										
2	Switching sequence ON	1	2	3	4	5	6	7					
	Switching sequence OFF	1	2	3	4								
3	Switching sequence ON								8	9	10	11	12
	Switching sequence OFF					1	2	3	4	5	6	7	8
3		1	2	3	4								
		9	10	11	12								

14.2.2.3 LIFO Up

The best compensation result is achieved by using steps of equal size.

NOTE: The settings in the "Step Swap" and "Switching Distribution" menus are not taken into account.



Starting with stage 1, the controller always switches to the next higher stage **as needed**.

The stages are deactivated in reverse order.

For each stage, the system checks whether a switching action is appropriate.

To ensure control stability, faulty stages are disabled and skipped by the control algorithm.

The corresponding setting cannot be modified.

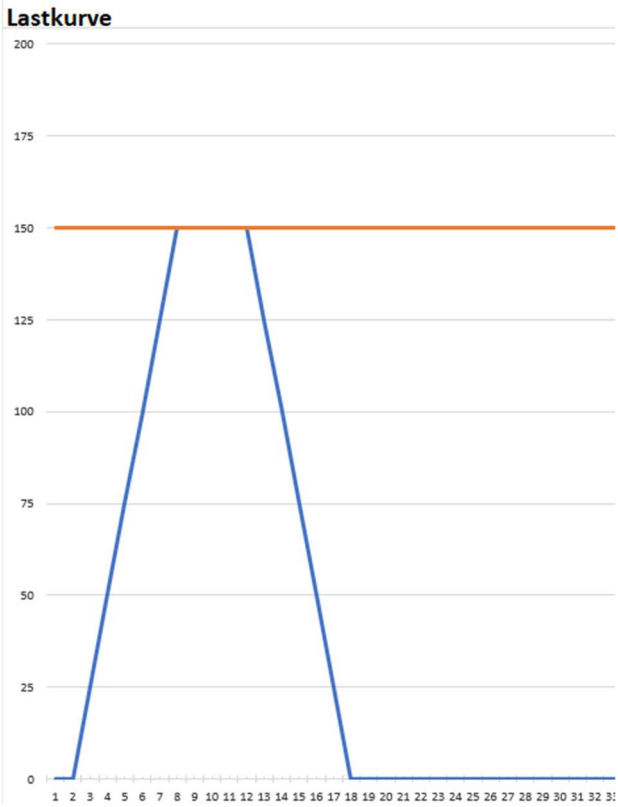
Compensation system with 200 kvar

	Stage 1	Stage 2	Stage 3
	50 kvar	50 kvar	50 kvar
	50 kvar	50 kvar	50 kvar
Switching time (on and off)	1 sec	1 sec	1 sec
FIFO algorithm			
Switching sequence ON	1	2	3
Switching sequence OFF	3	2	1
Discharge time	10 sec	10 sec	10 sec

14.2.2.4 LIFO Down

The best compensation result is achieved by using steps of equal size.

NOTE: The settings in the "Step Swap" and "Switching Distribution" menus are not taken into account.



Starting with the **last stage**, the controller always switches to the next lower stage as needed.

The stages are deactivated in reverse order. For each stage, the system checks whether a switching action is appropriate.

To ensure control stability, faulty stages are disabled and skipped by the control algorithm. The corresponding setting cannot be modified.

Compensation system with 200 kvar

	Stage 1	Stage 2	Stage 3
	50 kvar	50 kvar	50 kvar
	50 kvar	50 kvar	50 kvar
Switching time (on and off)	1 sec	1 sec	1 sec
FIFO algorithm			
Switching sequence ON	3	2	1
Switching sequence OFF	1	2	3
Discharge time	10 sec	10 sec	10 sec

14.2.2.5 Progressive

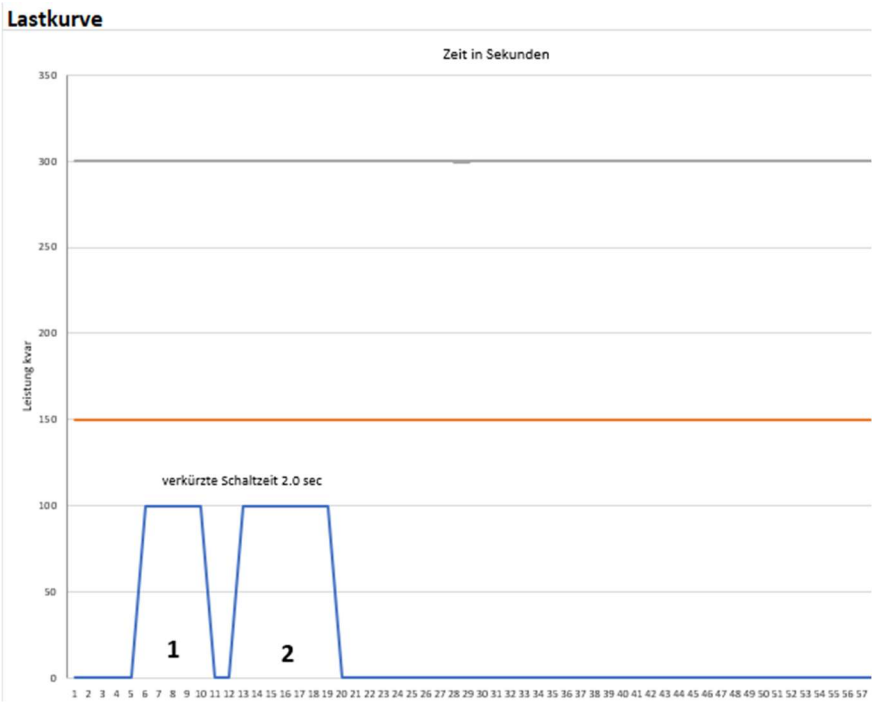
Control is based on the BEST-FIT principle and, when necessary, switches multiple stages on and off in succession with a **shortened switching time**.

Switching time	0.1…999.9 s	Default: 2.0 seconds

The set switching time is ignored in order to achieve faster switching behavior and a shorter response time.

The stage sizes must be entered manually, as stage detection is disabled in this control algorithm. This results in the disadvantage that the control system does not support defective stage detection or power loss detection.

NOTE: The settings in the “Tap Change” and “Switching Distribution” menus are not taken into account.



Compensation system with 300 kvar

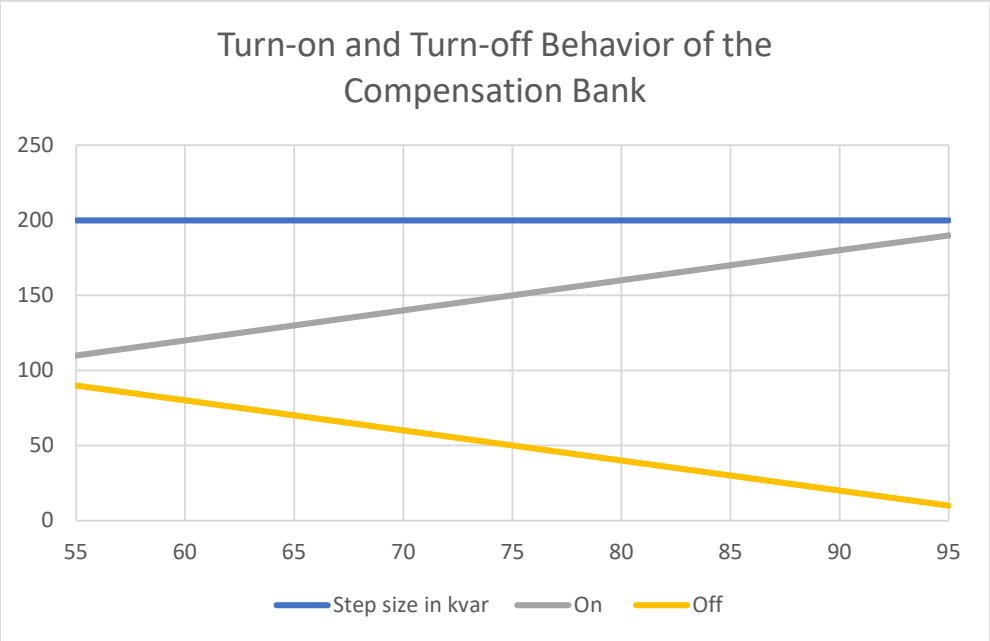
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Level 6	Level 7	Level 8
		25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar	25 kvar
		50 kvar		50 kvar		50 kvar		50 kvar	
	Switching time (activation)	5 sec	5 sec	5 sec	5 sec				
	Switch-off time	5 sec	5 sec	5 sec	5 sec				
	Algorithm: Progressive								
1	Switching sequence ON	1	2	3	4				
1	Switching sequence OFF	1	2	3	4				
	Discharge time	75 sec	75 sec	75 sec	75 sec				
	Operating hours (h)	25	25	26	26	20	20	27	27
2	Switching sequence ON					5	6	7	8
2	Switching sequence OFF					1	2	3	4

14.2.3. Control hysteresis 55…100%

The control sensitivity determines the switching threshold for turning the stages on and off (hysteresis). A lower value allows for a more precise compensation result but increases the number of switching cycles.

The factory setting for this parameter is 55%. If the difference between the reactive power and the control target exceeds 55% of a stage's power rating, the stage may be switched on or off. In this case, 45% overcompensation after switching on or 45% undercompensation after switching off is permitted.

Stage size in kvar	Control sensitivity in %	On (kvar)	Off (kvar)
200	55	110	90
200	60	120	80
200	65	130	70
200	70	140	60
200	75	150	50
200	80	160	40
200	85	170	30
200	90	180	20
200	95	190	10
200	100	200	0



14.2.4. Target Cos phi 1 0.70 c ... 0.70 i

Setting the target cos phi 1 determines the active power factor to be achieved through reactive power compensation (control target).

14.2.5. Target Cos phi 2 0.70 c ... 0.70 i

Setting the target cos ϕ 2 defines the active power factor to be achieved through reactive power compensation (control target).

The target cos ϕ 2 can be used as a control target for **P-export** or when switching to the off-peak rate via the **digital input (DI)**.

Settings for the DI can be found in the System 14.8 menu

P-Export = Active power feed-in to the grid

14.2.6. On-time 0.1…6500.0 s

The "ON" switching time is the time that is waited between the activation of the individual stages in the normal control algorithm.

If a switching time is set in the main menu under the "Switching Time" menu item, this value is used for both switching on and off.

Individual settings for switching on and off are applied only in this menu.

14.2.7. OFF switching time 0.1…6500.0 s

The "OFF" switching time is the time that elapses between the deactivation of the individual stages.

If a switching time is set in the main menu under the "Switching Time" menu item, this time is used for both turning the system on and off.

Custom settings for power-on and power-off are only applied in this menu.

14.2.8. Shutdown interval when control is off 0…100,000 ms

When control is switched OFF, the stages are switched off in accordance with the algorithm and the switch-off time.

! WARNING	
Risk of injury from electrical voltage!	Capacitor stages may still be live even after being switched off!

14.2.9. Shutdown interval during an alarm 0...100,000 ms

This time defines the interval at which the individual stages are shut down in the event of various alarms and/or events.

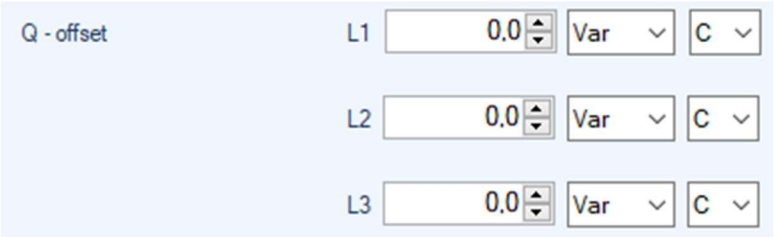
! WARNING	
Risk of injury from electrical voltage!	Capacitor stages may still be live even after they have been shut down!

14.2.10. Q – Offset 9.9 MVAr ... 9.9 MVAr

The reactive power offset is used to correct the measurement
An offset is added to the measured reactive power to compensate for a permanent reactive load that cannot be measured (e.g., the inductance of the upstream feed-in transformer or, in the case of capacitive loads, those caused by long cable runs).

NOTE: The reactive power offset also affects the following measured values:
Current, reactive power, control deviation, apparent power, power factor, cosφ , and tanφ .

Can be set for phases L1 | L2 | L3



14.2.11. Step Detection ON / OFF

ON	During operation, the sizes of the steps are automatically determined and continuously adjusted as the steps are turned on and off. Therefore, it is not necessary to enter the default value of 3 var during commissioning. As soon as step detection for a step is complete (after 20 switching operations), its original size is set to the current step size value. Stage detection can be terminated early by manually entering the stage size.
OFF	Stage detection is disabled, so the stage sizes must be entered manually . <u>Manual entry may be necessary:</u> When there are significant load fluctuations and the step size is detected incorrectly.

NOTE: Once step detection for a step is complete or the step size has been entered manually, the <u>step database (INFO)</u> displays the current step size for that step as a percentage of the original step size.

14.2.12. Measurement Pause for Step Detection 5 – 100 cycles

After the power-on pulse, the device waits for the set measurement pause to elapse before beginning step detection.

1 cycle is one power line period, i.e., 20 ms for a 50 Hz power line and 16.7 ms for a 60 Hz power line

10 cycles at 50 Hz correspond to 0.2 seconds

NOTE: For MV applications, the measurement pause should be adjusted according to the step size, e.g., to 40 cycles (equivalent to 800 ms)

14.2.13. Fault Level Detection ON / OFF

ON	Defective stages are detected during normal operation and displayed as "**F" (**faulty). A step detected as faulty upon startup is immediately shut down and is no longer taken into account by the control algorithm.
OFF	The controller does not detect faulty stages.

14.2.14. Disable faulty stages ON / OFF

ON	If a stage is identified as faulty, it is excluded from the control system.
OFF	Stages identified as faulty can still be used for control.

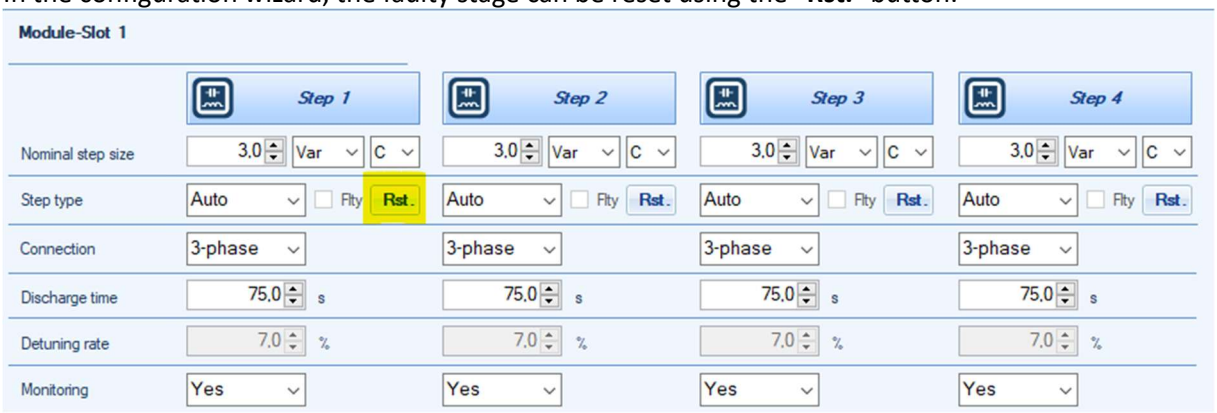
! NOTE

A stage is considered “faulty”
if there is no grid response after 3 consecutive switching operations.

Manual switching of this step is not possible!

If a defective capacitor has been replaced, the step type must be manually reset in the “Settings Steps” menu.
After repair, the stage can be reintegrated into the control system and is also ready for use in manual mode.

In the configuration wizard, the faulty stage can be reset using the **“Rst.”** button.



If a faulty power contactor was responsible for the defective step, the switching cycle counter for the corresponding step must be manually reset to 0 after replacing the contactor in order to restart the contactor's switching cycle monitoring. Menu **14.3.5** Resetting the Switching Cycles

14.2.15. Blockout Time for Faulty Stages 0 – 48 h

After X hours, the controller automatically resets the stage type of the affected stage to AUTO and tests it again.

If set to 0, the stage is permanently disabled.

14.2.16. Distribute switching cycles ON / OFF

ON	When using steps of the same size
OFF	When using steps of different sizes

14.2.17. Basis for the switching cycle distribution Hours / Cycles

Takes into account the wear on the stage capacity based on operating hours or switching cycles.

! NOTE
<u>Distribution based on switching cycles</u> If power contactors are used to control the capacitor stages, it is recommended to distribute them evenly based on the number of switching operations. This ensures an even load on the power contactors and prevents excessive wear on individual contactors. <u>Distribution Based on Operating Hours</u> To ensure uniform aging of the installed capacitors, distribution based on the number of operating hours must be selected.

14.2.18. Tolerance for switching cycle distribution 5–50%

For steps of equal size, the tolerance is set once for all of them.
All steps that fall within the set tolerance are considered for the distribution.
Example: If a 50 kVar step is to be switched, then with a 10% tolerance, all steps between 45 and 55 kVar are considered for distribution.

14.2.19. Q-Capacitive-> Step Disconnection ON / OFF

Depending on the load and the available compensation stages, the controller may overcompensate.
An example: Power demand Delta Q = 125 kvar, target cos phi 1, control hysteresis 100%. Only 50kvar stages are available. Result: 25kvar overcompensation

ON	Overcompensation is permitted
OFF	Overcompensation is not permitted.

14.2.20. Step Swap ON / OFF

ON	The controller attempts to better achieve the control target by switching stages.

OFF	The function is disabled.

NOTE: To avoid unnecessary switching cycles, this function should be disabled when using stages of the same size.

14.2.21. Step-Switching Time 0.1 – 6500.0 s

This is the waiting time between switching off an active stage and switching on another stage that more closely matches the determined reactive power demand. During stage switching, the normal switching time is not observed.

14.2.22. Tolerance for stage switching 5 – 99%

The goal is to avoid oscillation (frequent switching on and off).
For stage switching, only stages whose stage size deviates by this tolerance value are considered.
Example: A 50 kVar stage is switched on, and the algorithm continuously checks whether the target cos phi (with a tolerance setting of 10%) can be better achieved with stages >55 kVar or <45 kVar, and then switches these with a shortened switching time.

14.2.23. Step Tracking ON / OFF

ON	The step size adjusts during operation. Step losses are compensated for. If a value greater than 100% is displayed, this is because the manually set value was higher than the actual value. Another possible cause is significant power grid fluctuations, during which the controller detected a value higher than the actual value.
OFF	The value remains as initially set

14.2.24. Cos ϕ2 for grid injection (P-export) ON / OFF

ON	If active power is being fed back into the grid, control is performed according to the set target cos ϕ 2.
OFF	The target cos ϕ 1 remains the control target even when active power is being fed back into the grid.

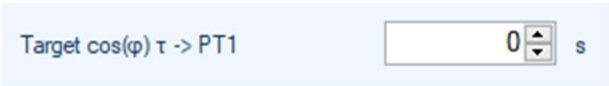
14.2.25. Time-Constant Control 0–900 s

The target cos phi is reached with a delay.

Set this to avoid a sudden change between cos phi 1 and cos phi 2.

When using the **Q algorithms**, since the target cos phi is calculated continuously.

The control value is specified by the utility operator.

With a PT-1 element (**first-order delay element), 2/3 of the target cos phi** is applied after a time tau (adjustable value) the target cos phi is set to 2/3. After 5 tau, approximately 100% of the target cos phi is set.	

(Comparable to the charging curve of a capacitor).	

14.3. Stages

Stages			
L123	AUTO		
1	C 3 var		
	75 s		
ESC	PREV	NEXT	ENTER

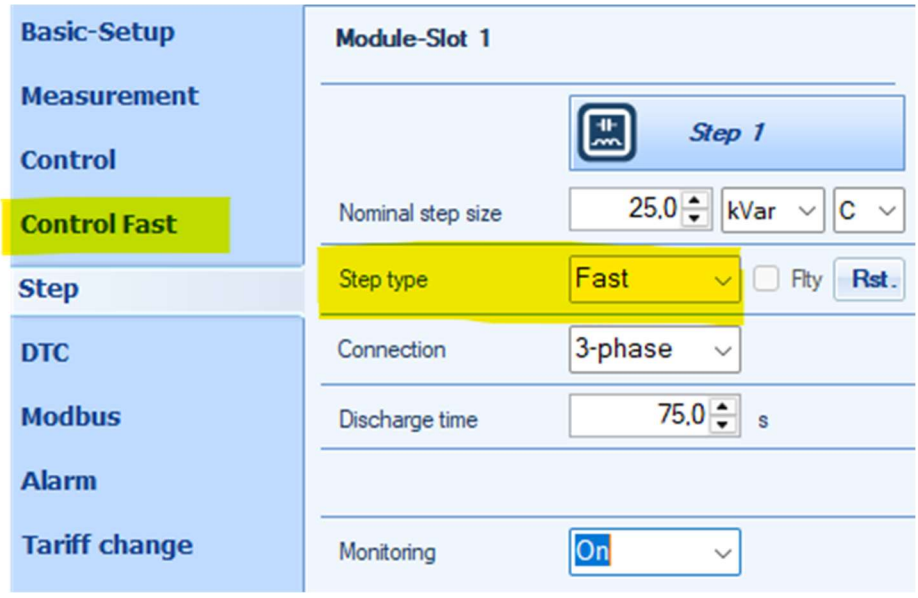
14.3.1. Step Type AUTO

Auto	The control system automatically selects the stage.
On	The stage is permanently on (The stage is still monitored and will be shut down in critical situations).
Off	The stage is permanently turned off or deactivated. Unused stages should be set to this stage type to avoid unnecessary switching operations and alarms.
Fast	can only be selected for thyristor stages; these switch at zero-crossing --> therefore, no discharge time is required

14.3.1.1. Stage Type :(Fast fast control with thyristor controllers)

The stage type “Fast”can only be used when a thyristor controller is connected.

In addition, the **“Control** Fast” menu (fast control) is available



Control Fast

The following parameters must be set

	Min./Max.	**Default**

Cycles Measurement Pause	0…255	5
Max. capacitive compensation power	0…9.9 Mvar	0 var
Max. inductive compensation power	0…9.9 Mvar	0 var
Cycle average	0…255	10

1 cycle is 1 mains period (20 ms at 50 Hz)
1/50 Hz = 0.02 sec
1/60 Hz = 0.0166666 sec

14.3.2. Step size 0–9.9 Mvar

If **automatic step detection** is **disabled**, the step size (nominal step value) must be entered manually for each step.

The entered step nominal value refers to the set <u>nominal voltage.</u>

<u>Here is an example:</u> when using a capacitor CN = 3 × 138 µF

35.9 kvar at 525 volts / 50 Hz

20.8 kvar at 400 volts / 50 Hz

$Qc = 3*C*U^2*2*\pi*f$

$Qc = 3 \times 0.000138 \times 400^2 \times 2 \times \pi \times 50$ Hz

<u>Qc = 20.8 kvar</u>

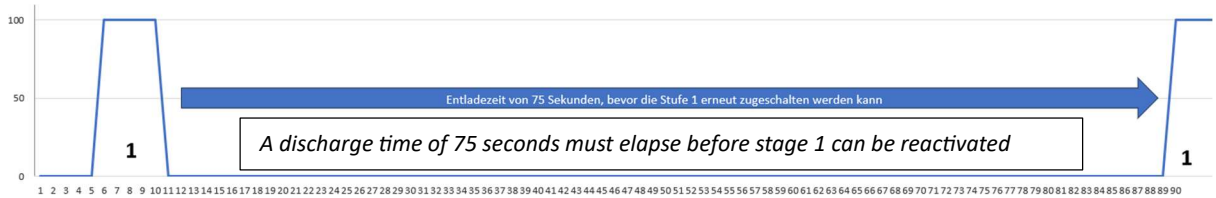
14.3.3. Discharge time 0–1,000 s

The discharge time is a delay period that elapses after a stage is switched off.

It ensures that the capacitors are fully discharged before the stage is switched on again.

Until this delay period has elapsed, the corresponding control stage is not available. The discharge delay must be adjusted to the discharge time of the capacitors.

The default setting is 75 seconds.



A stage that is in the discharge state is displayed as blinking in the main menu.

! WARNING

Danger from undischarged capacitors!	Switching on an undischarged capacitor stage can result in the destruction of the capacitor or the entire system! Ensure that all capacitor stages are fully discharged before switching them on.

14.3.4. Monitoring ON / OFF

The monitoring functions for the individual stages can be disabled.

ON	Set monitoring functions are active.
OFF	Stage monitoring, stage tracking, defective stage detection, and power loss detection are deactivated for the selected stage.

14.3.5. Cycles Reset

Resets the switching cycles for the selected stage.

14.3.6. Operating Hours Reset

Resets the operating hours counter for the selected stage.

14.3.7. Stage Size Reset

Resets the initial value to the default value of 3 var capacitive.

14.3.8. Connection Type

Can be selected for each stage if a 3-phase power system was selected under **"System"** and 3-phase measurement was selected under **"Measurement"** in the Basic Setup. Otherwise, this value is locked to "3-phase."

L3-N
L2-N
L1-N
3-phase

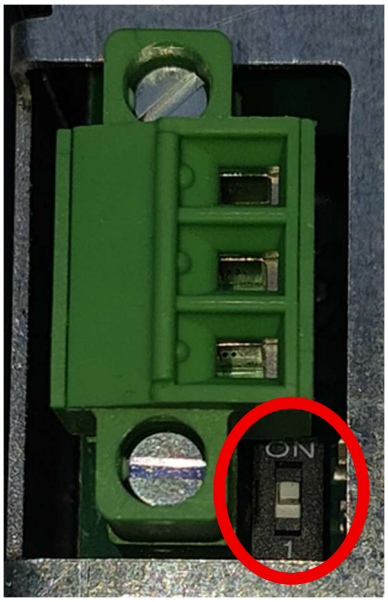
14.4. Modbus

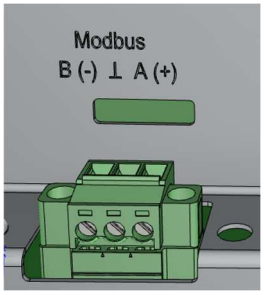
The device features a standard
RS-485 communication interface.

Connection via a 3-wire screw terminal
+ / GND / -

A **120-ohm** terminating resistor must be installed at the end of the line.
To activate it, the single-pole switch must be set to **ON**.

The MPFC operates as a slave device.



Rated values for the Modbus interface		Wire gauge:
3-pole terminal A (+) / GND / (-) B	Fine-strand conductors with ferrule: Solid-wire conductors with ferrule: Stripping length: Tightening torque:	0.2 – 1.0 mm², AWG 30–16 0.2–1.0 mm², AWG 30–16 5 mm 0.3 Nm
	The cable shield must be connected to ground to reduce external interference. Up to 32 devices can be connected in parallel	
Address:	**1–247**	
Baud rate:	200; 2400; 4800; 19200; 38400; 57600; and 115200 baud	
Parity	8E1, 8N2, 801, 8N1	
Access rights:	Read access, read/write access	

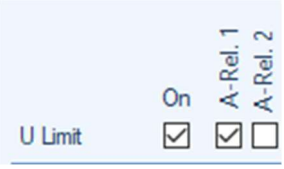
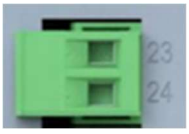
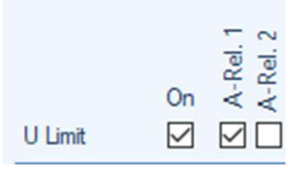
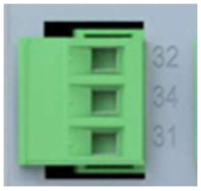
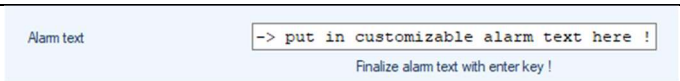
14.5.
14.5. Alarm

There are 23 alarms to choose from that can be activated.

Default Settings

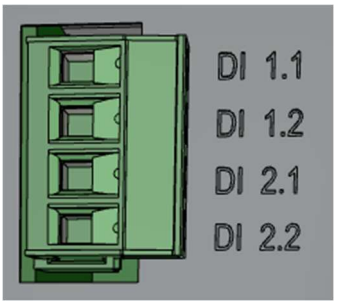
Alarm	Overview	ON	Alarm Response	Min.	Max.	Delay	Reset
							Auto Reset Delay 5.0 s
1	U-Limit			-10%	10%	60 s	Manual
2	I High limit				1,000 A	60 s	Manual
3	I Low limit				0.0 A	60 s	Manual
4	THD U				8.00%	60 s	Manual
5	Harmonics			Standard EN50160	Reduction 0%	0.0 s	Manual
6	THD I				20%	60 s	Manual
7	Frequency			49.5 Hz	50.5 Hz	10 s	Manual
8	Temperature INT			Fan 30 °C	50°C	4°C	Manual
9	EXT Temperature			Fan 30 °C	50°C	4°C	Manual
10	DI Input 1				Rising	0.0 s	Manual
11	DI Input 2				Rising	0.0 s	Manual
12	P Overload				10,000 kW	60 s	Manual
13	Q Overload			Capacitance -10,000 kvar	10,000 kvar	60 s	Manual
14	S Overload				10,000 kVA	60 s	Manual
15	P export					60 s	Manual
16	Alarm Control					60 s	Manual
17	's step is defective “Faulty Step”					Nominal value 50%	Manual
18	Step warning					Nominal value 70%	Manual
19	Tiered service				Hours 1,000 h	Cycles 1,000	Manual
20	cos phi			Capacitance -0.80	Ind. 0.80	60 s	Manual
21	Manipulation						
22	Current Input 4				0.1 A	60 s	Manual
23	Hunting Alarm (Oscillation Protection)			Cycles: 1	Hours: 48 h		Manual

Alarm Response Settings	
Software	Hardware
Activation of a selected alarm	**Alarm Relay 1** Change Relay 12

	14 11 	
Multi-purpose output 1 Signal contact (23/24) Assignment 8.15 System Normally open Stage External fan Internal fan Normally Open	**Multi-purpose output 1** 23 24 	
Activation of a selected alarm 	**Alarm Relay 2** Changeover relay 32 34 31 	
Multi-purpose output 2 Signal contact (43/44) Assignment **8.15 System** Normally open Stage External fan Internal fan Normally Open	**Multi-purpose relay 2** 43 44 	
An alarm message can be entered under the **System 8.20 menu**		
The control can be turned off.	Control Off	
Control can be paused.	Ctrl. Hold	
Use cos phi 2.	Cos phi 2	
	Blocked by	

<table>
<tr><td>Digital input 1 / 2 can be used, for example, for maintenance purposes to disable the alarm.

System Setting **8.15**
Set to “Block Alarm,” for example

<table><tr><td>Alarm</td></tr><tr><td>Rate Switching</td></tr><tr><td>Target cos phi 2</td></tr><tr><td>Disable Q-Offset</td></tr><tr><td>Block alarm</td></tr></table></td><td>Digital Input 1
Digital Input 2
 

Option to use a maintenance switch</td><td></td></tr>
<tr><td colspan="2">Option available only with IEC 61850</td><td></td></tr>
<tr><td></td><td>GOOSE 1</td><td></td></tr>
<tr><td></td><td>GOOSE 2</td><td></td></tr>
<tr><td></td><td>GOOSE 3</td><td></td></tr>
</table>

14.5.1 Hunting Alarm (Hunting Protection)

Hunting monitoring protects the hardware from excessive wear caused by too frequent switching operations.

How it works:
Within a **rolling time window** (1–48 hours), the number of switching operations per stage is recorded.

If a stage exceeds the set **switching limit** (1–9,999), it is automatically set to the **“Faulty”** status

and excluded from control for the set **lockout duration**.

Status & Reset:

- **Automatic:** Once the lockout period has elapsed, the stage is reintegrated into normal control operation.
- **Manual:** The user can reset the “Faulty” status at any time to immediately reactivate the stage.

NOTE: The “Faulty” stages can also be reset by pressing the up and down buttons simultaneously.

14.6. Rate Switching

Default setting: Off -> OFF

Rate switching -> ON at a specified time or via

digital input 1 or 2, which can be used as a trigger.

Setting **8.15 System**

Function:	Alarm
	Rate Switching
	Target cos phi 2

	Disable Q-Offset
	Block alarm

Trigger	ON	Digital INPUT
Time, e.g.,	10:00 PM – 6:00 AM	

14.7. Reset

Settings
Steps
Faulty Steps
Counter
Operating Hours
Power Factor
Max. Values
CO2 counter
Data memory
Factory settings

NOTE: You can also reset the "Faulty" levels by pressing the up and down buttons simultaneously.

14.8. System

Date/Time
Contrast
Brightness
Password
Language
Alarm Text
Multi-use output
Digital Input

14.8.1. Multi-purpose output 1 / 2

Function:	Normally open
	Stage
	External fan
	Internal fan
	Normally open

14.8.2. Digital Input 1/2

Function:	Alarm
	Rate switching
	Target cos phi 2
	Disable Q-offset
	Block alarm

15. Manual

NOTE: A password is required to access the following menu!

Manual Activate?	
No	YES

When you exit manual mode, the controller returns to the set control mode.

ON	Control takes over control mode
OFF	All active stages are turned off, except for the FIX ON stages.
HOLD	The current status of the stages is maintained.

1 stage	Toggling the stage immediately displays the change in Delta Q
2nd stage	Toggling the stage immediately displays the change in Delta Q
Level 3	Toggling the stage immediately displays the change in Delta Q
Level 4	Toggling the stage immediately displays the change in Delta Q
MU1	
AL1	
MU2	
AL2	

16. Data Logger

Setup History	Default
Alarm History	Default
Level database	Option L
Measurement Values	Option L
Event Logger	Option L
Export	Option L
Eject Card	Option L

16.1. Setup History

Up to 64 settings are stored on the device

Date	01/02/25
Time	05:16:05
Setting	Measurement

16.2. Alarm History

Up to 64 alarm events are stored on the device

Alarm	U LIMIT
Date	01/02/25
Time	03:20:09
Limit	207.0
Measurements	0.0

These values are saved to the memory card as a CSV file

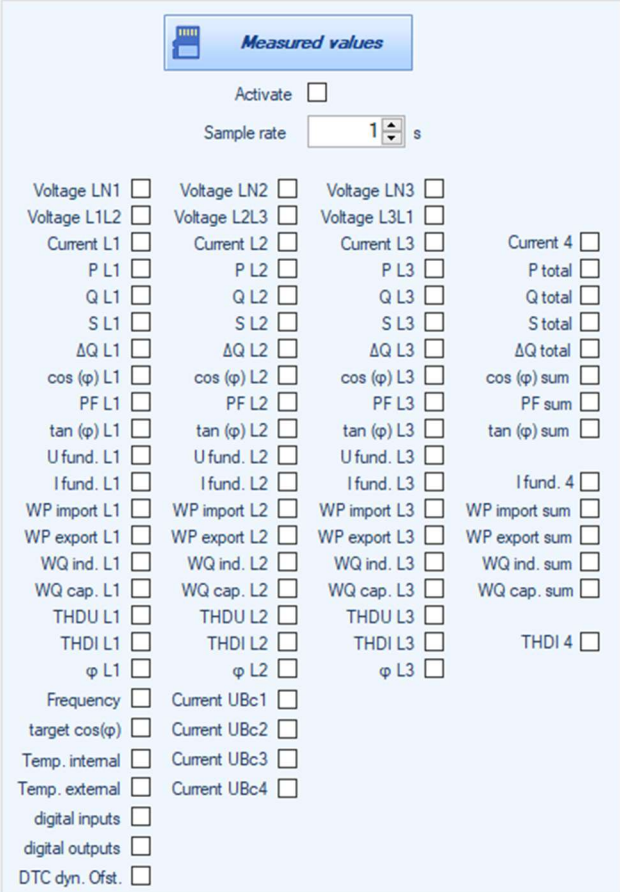
16.3. Step database

STEP INFO

Module-Slot 1

	Step1	Step2	Step3	Step4
Step type	Auto	Auto	Auto	Auto
Step faulty				
Connection	3-phase	3-phase	3-phase	3-phase
Nominal step size	3,0	3,0	3,0	3,0
	Var C	Var C	Var C	Var C
Actual step size L1	1,0	1,0	1,0	1,0
	var C	var C	var C	var C
Actual step size L2	1,0	1,0	1,0	1,0
	var C	var C	var C	var C
Actual step size L3	1,0	1,0	1,0	1,0
	var C	var C	var C	var C
Operation cycles	0	0	0	0
Operation hours [h]	0	0	0	0
Discharge time [s]	75,0	75,0	75,0	75,0
Detuning rate [%]	7,0	7,0	7,0	7,0
Monitoring	Yes	Yes	Yes	Yes

16.4. Measurement values



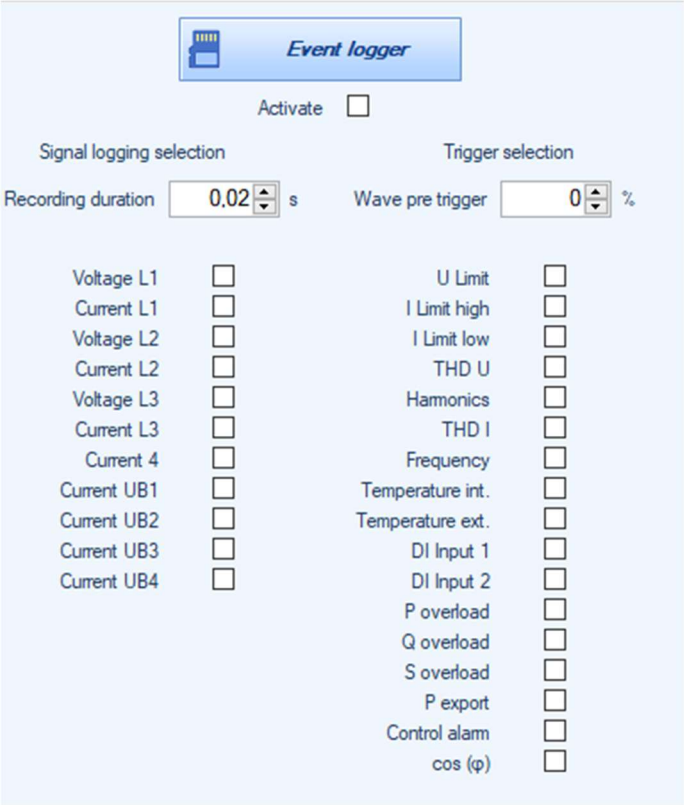
Depending on the number of measured values and the
"sample rate,"
the duration of the stored values.
Examples:

Input parameters		
Number of values per interval	15	Measured values
Storage interval (seconds)	1	seconds
Maximum file size (GB)	8	GB
Storage duration in years	3.0	years

Input Parameters		
Number of values per interval	20	Measured values
Storage interval (seconds)	5	seconds
Maximum file size (GB)	8	GB
Storage duration in years	11.3	years

Input parameters		
Number of values per interval	82	Measured values
Storage interval (seconds)	1	seconds
Maximum file size (GB)	8	GB
Storage duration in years	0.6	years

16.5. Event Logger



16.6. Export

Setup History: All settings that have been changed are saved as a CSV file on the SD card.

Alarm History: All alarm events are saved as a CSV file on the SD card, including the time and date.

Example of the CSV file

Date	Time	Frequency	V LN1	V L1L2	I 1	P total
September 24, 2025	1:23:52 PM	50.00	229.92	398.23	0.11	70.5
September 24, 2025	1:23:57 PM	49.99	229.64	397.75	0.11	70.4
September 24, 2025	1:24:02 p.m.	50.00	229.59	397.66	0.11	70.3
September 24, 2025	1:24:07 p.m.	50.01	229.57	397.63	0.11	70.3

16.7. Eject card

Before removing -> Eject card

Eject card?	
No	YES

17. System Info

APP:	MPFC -PF	Application
SW:	V01.00.00	Software Version Base
HW:	V00.00.01	Hardware Revision Base
Serial Number:	102200000001	Serial Number
OPT:	UB LOG Q	Options
M 1:	4R LP	Module Slot 1
HW:	V01.00.02	Hardware Revision
M 2:	IEC 61850	Module Slot 2
HW:	V01.01.02	
SW:	V03.00.03	
M 3:	UB	
HW:	V02.00.04	

18. Configuration

The latest software is available for download on our website.

https://beluk.de/Downloads/

http://www.beluk-qr.de/download/MPFC_Configuration_Tool_V2_1.zip

For data transmission, please request our Modbus USB converter to connect the computer and the control unit via the Modbus interface.

After installation, the configuration software is saved in the following file:

C:\ProgramData\Beluk

Name	Änderungsdatum	Typ	Größe
MPFC	01.04.2025 08:43	Progress .CFG File	1 KB

The software has two access permission levels.

	“Limited”:	Read access. Write access only to basic parameters	
	"Advanced":	Read and write access to all parameters	Initial password: 0000

A cybersecurity-compliant password must be at least eight characters long and contain one uppercase letter, one lowercase letter, and one number.

NOTE: The device is shipped with “read” access rights.
If the device is to be configured using the configuration tool, the “**Write/Read** Access” permission must be set on the device.

NOTE: If the password has been forgotten, you must delete the file and reinstall the software.

19. Technical Specifications MPFC-PF

Device Type: MPFC-PF			
AC Supply Voltage		OPTION: DC supply voltage	
L N	Phase - Neutral: 90 – 317 V AC (+/- 10%) Phase to Phase: 155 – 550 V AC (±10%)	+ -	40–240 V DC (±10%)
Overvoltage category IEC/EN/UL/CSA 61010-1 (VDE 0411-1)	CAT III Phase to neutral: < 300 V AC Phase to phase: < 519 V AC CAT II Phase–neutral: 300–317 V AC Phase–Phase: 519–550 V AC	Overvoltage Category IEC/EN/UL/CSA 61010-1 (VDE 0411-1)	CAT III 40–240 V DC
Rated surge voltage	CAT III 4 kV CAT II 2.5 kV	Rated surge voltage	CAT III 4 kV
Max. power consumption	9 VA (90 V AC LN) to 55 VA (550 V AC LL)	Max. power consumption	9 VA

Max. current consumption	100 mA	Max. current consumption	225 mA
Circuit protection	6 A (Class B)	Circuit protection	6 A (Class B)
Frequency range	45–65 Hz	Internal fuse	Type T3.15 A / 400 DC in accordance with IEC 60127-2
Digital Input 2 x DI		Digital Input 2 x DI	
DI 1.1 / 1.2 DI 2.1 / 2.2	90 – 250 V AC LN	DI 1.1 / 1.2 DI 2.1 / 2.2	40 – 240 V DC
Voltage measurement:			
Measurement range:	40 – 600 V AC RMS		
UL3 UL2 UL1 UN	Direct measurement: 40–600 V AC RMS or via voltage transformer -> VT ratio adjustable up to 5000		
Response threshold	35 V AC RMS		
Fuse rating	10 A		
Sampling frequency	6.4 kHz (128 samples per period)		
Power consumption	0.2 VA		
Impedance	3 MΩ per phase		
Current measurement CT:	Only via external current transformers for energy monitoring with reinforced insulation in accordance with IEC 61010		
Measurement range	10.0 mA – 6.0 A		
Continuous overload	10 A		
Overload for 1 second	120 A (sinusoidal)		
Sampling frequency	6.4 kHz (128 samples per period)		
Power consumption	1 VA		
4-phase current measurement L4 K4 L3 K3 L2 K2 L1 K1	Only via external current transformers! (x/1A); (x/5A)		
Measurement accuracy	Measured voltage: +/- 1% Measured current: +/- 1%		
Measurement category IEC/EN/UL/CSA 61010-2-030 (VDE 0411-2-030)	CAT IV: <= 300 V AC CAT III: > 300 V AC to 600 V AC		
Alarm Outputs		Multi-purpose outputs	

12 14 11 32 34 31	1 or 2 dry contacts changeover contacts (depending on configuration) Switching capacity (resistive load): 250 V AC/5 A per UL/VDE Duty cycle 100%	23 24 43 44	1 or 2 dry N/O normally open contacts (depending on configuration) Switching capacity (resistive load): 250 V AC/5 A per VDE 400 V AC/1 A per VDE 48 V DC/1 A per VDE 110 V DC/0.2 A per VDE Duty cycle 100%
Relay Outputs		**OPTION T**	Transistor outputs
Power supply C1 C2	max. 10 A Common power supply Per output card	Power supply C1 C2	max. 1.2 A Shared power supply Per output card
S1-6 S1-12	Up to 24 (12 relay outputs per card): Switching capacity (resistive load): 250 V AC/5 A per VDE 400 V AC/1 A per VDE 48 V DC/1 A per VDE 110 V DC/0.2 A per VDE Switching capacity (resistive load): 250 V AC/5 A per UL 30 V DC/5 A per UL Duty cycle **100%** up to **45°C** ambient temperature **50%** duty cycle up to **50°C** ambient temperature	S1-6 S1-12	Up to 24 (12 transistor outputs per card): Switching capacity per transistor: 8–48 V DC/100 mA Duty cycle 100%
OPTION I	IEC 61850		
ETH1 ETH2	Data rate: 100 Mbit/sec		
Modbus RTU interface		Analog input	
A (+) / GND / (-) B	Modbus RS485 (standard) Slave Baud rates: 1200; 2400; 4800; 9600; 19200; 38400; 57600; 115200 baud	External Temp	For 22k NTC only External temperature sensor
Internal temperature measurement			
under the housing cover	Type: NTC 22k Accuracy: ±3 °C		

General:			
Ambient temperature	Operating: -20 °C – 45 °C Storage: -40 °C – 85 °C	Cutout	138x138 (+0.5) mm
Humidity	Range: 0% – 95% Condensation: Not permitted	Dimensions	144 x 144 x 90 mm
Altitude	up to 2,000 m above sea level	Weight	approx. 0. 85 kg
Dirt resistance	2		
Protection rating	Front: IP50 Front with clear-view door and seal: IP54 Rear: IP20	Enclosure	Front: Plastic enclosure (UL94-VO), Rear: Metal
Protection class	1		
OPTIONS D	Data Storage / Event Recorder	HS Code	90328900

Rated values: Screw terminals, pluggable, max. 2.5 mm²		Cross-sectional area:
2-pole terminal 4-pole terminal	Fine-strand conductors with ferrule:	0.2–2.5 mm², AWG 24–12
4-pole terminal 8-pole terminal	2 flexible conductors of the same cross-section with TWIN ferrule and plastic sleeve:	0.5–1.0 mm², AWG 30–16
3-pole terminal 2-pole terminal 7-pin terminal 6-pin terminal	Solid-wire conductors with ferrule:	0.2–2.5 mm², AWG 24–12
3-pin terminal 2-pin terminal 7-pin terminal 6-pin terminal	Stripping length:	7 mm
	Tightening torque:	0.5 – 0.6 Nm

Connection specifications for external temperature sensor interface		Cross-section:
2-pole terminal Ext. 1 Ext. 2	Fine-strand conductors with ferrule:	0.2–1.0 mm², AWG 30–16
	Solid-wire conductors with ferrule:	0.2–1.0 mm², AWG 30–16
	Strip length:	5 mm
	Tightening torque:	0.3 Nm

Modbus Interface Specifications		Cross-sectional area:
3-pin terminal A (+) / GND / (-) B	Fine-strand conductors with ferrule:	0.2 – 1.0 mm², AWG 30–16
	Solid-wire conductors with ferrule:	0.2–1.0 mm², AWG 30–16
	Strip length:	5 mm
	Tightening torque:	0.3 Nm

Measured values	
The following measured values are available for each phase individually and as a total: Phase-to-neutral voltage, Phase-to-phase voltage, Fundamental voltage, Current, Fundamental-wave current, Active power, Reactive power, Apparent power, Shortfall in reactive power relative to the control target, Cos phi, Power factor, tan phi, Phase shift, THD U, THD I,	Individual harmonics as a bar chart and table in %, Frequency, device operating hours, Operating hours of compensation stages, switching cycles Compensation stages, Internal temperature, External temperature, Average power factor, Maximum values: Voltage, Current, Temperature, THDU, TDUI, Reactive power (inductive/capacitive) Active power import / export CO2 savings

20. Service and Maintenance

The device undergoes various safety tests prior to shipment and is marked with a seal. If a device is opened, the safety tests must be repeated. A warranty is provided only for unopened devices.

For questions not answered or described in this manual, please contact the manufacturer. To ensure your inquiry is processed, please have the following information ready:

- Device name (see nameplate) ·
- Serial number (see nameplate) ·
- Software release (see system display) ·
- Measurement voltage and supply voltage ·
- Detailed description of the error.

20.1. Defective device

Before you send defective measuring instruments back to the manufacturer for inspection.

Contact the manufacturer's support team.

Please include the RMA number assigned to you and send the device for inspection to:

BELUK GmbH | Taubenstraße 1 | 86956 Schongau

20.2. Maintenance

! WARNING	
Warning regarding unauthorized tampering or improper use of the device.	Opening, disassembling, or tampering with the device in an unauthorized manner, or operating it beyond the specified mechanical, electrical, or other operating limits, can result in property damage or injury, including death. Only qualified electrical personnel may work on devices and their components, assemblies, systems, and circuits! Always use your device or component as described in the accompanying documentation.

! NOTE
Care and Cleaning of the Display: The use of water or other solvents, such as denatured alcohol, acids, or acidic cleaning agents on the front film or the display, can damage or destroy the device during cleaning. Water, for example, can penetrate the device housing and destroy the device. Clean the device, the front film, or the display with a soft cloth. If the surface is heavily soiled, use a cloth dampened with clean water. Clean the front film and the display—for example, to remove fingerprints—with a special LCD cleaner and a lint-free cloth. **Do not use acids or acidic cleaning agents to clean the device.**

20.3. Disposal

Please observe national regulations when disposing of the meter!

If necessary, dispose of individual parts according to their nature and applicable country-specific regulations, e.g., as

- electronic waste
- plastics
- metals

If necessary, hire a certified disposal company to dispose of the device