REFERENCE MANUAL

REACTIVE POWER CONTROLLER

CX plus

1   Safety notes

Read these **safety notes and instructions** attentively and carefully first. Familiarise yourself with the device prior to installation, commissioning and operation. The following symbols are used in the manual and on the device label on the back of the device in order to indicate dangers and problems or to give specific instructions.

⚠ **DANGER**
DANGER indicates a dangerous situation which, if not avoided, may cause death or severe injuries.

⚠ **WARNING**
WARNING indicates a dangerous situation which, if not avoided, may cause death or severe injuries.

⚠ **CAUTION**
CAUTION indicates circumstances which may damage or destroy the device in case of non-observance, but do not cause injuries.

NOTE: Further information in order to describe special technical features in a more detailed way.

⚠ **DANGER**
During the installation of the CX plus, there is a risk of electric shock. For this reason, installation, commissioning and maintenance may exclusively be performed by a skilled electrician with the necessary qualification. A skilled electrician is a person who has the ability, experience and knowledge necessary for the construction, installation and operation of electrical equipment and systems and who is trained in the detection and prevention of potential hazards. During installation, the relevant regulations for the installation of switchgear and for the prevention of accidents must be observed and complied with. Devices with damaged or open housing or terminals may not be connected to the mains and must be disconnected immediately. The current transformer must be short-circuited prior to disconnecting the current measurement path at the device resp. at the current transformer. Otherwise, there may be a life-threatening voltage at the connections of the current measurement path resp. of the transformer. In the long run, the transformer will be destroyed by the high voltage.

2 Installation and commissioning

1)   Before installation, the connection data of the CX plus must be compared with the data of the supply network and of the installation.

2)   The working area must be disconnected from voltage and secured against unauthorised and unintentional restart. The absence of voltage must be verified with a standardised instrument / testing device. The voltage-free system must be grounded and short-circuited. Adjacent live parts must be covered and / or placed behind barriers.

3)   The current transformer must be short-circuited. A current transformer that has NOT been short-circuited generates very high voltages posing a danger to persons and equipment. The current transformer can thereby be destroyed.

4)   Disconnect and remove the old reactive power controller.

5)   Plug the CX plus into the switch panel section and fix it with the two mounting brackets. (Section 138 x 138 mm)

6)   Connect the protective conductor at the PE terminal of the metal back of the CX plus.

7)   Connect the connecting lines as per the wiring diagram (current transformer: K to power plant, L to load).

8)   Remove the current transformer jumper.

9)   Switch on voltage.

10) With a proper connection and correct connection data, the display lights and all symbols are visualised on the LCD in the course of a display test for 1 second.

11) The current transformer factor must be entered.

12) If necessary, also enter the correct nominal voltage and the voltage transformer factor.

13) Execute the "Automatic initialisation" (AI).

14) If the "Automatic initialisation" was successfully finished, the message AUTO appears on the display. Control starts after the discharge time lock (default: 75 s).

3   Wiring diagrams

CX plus-12R
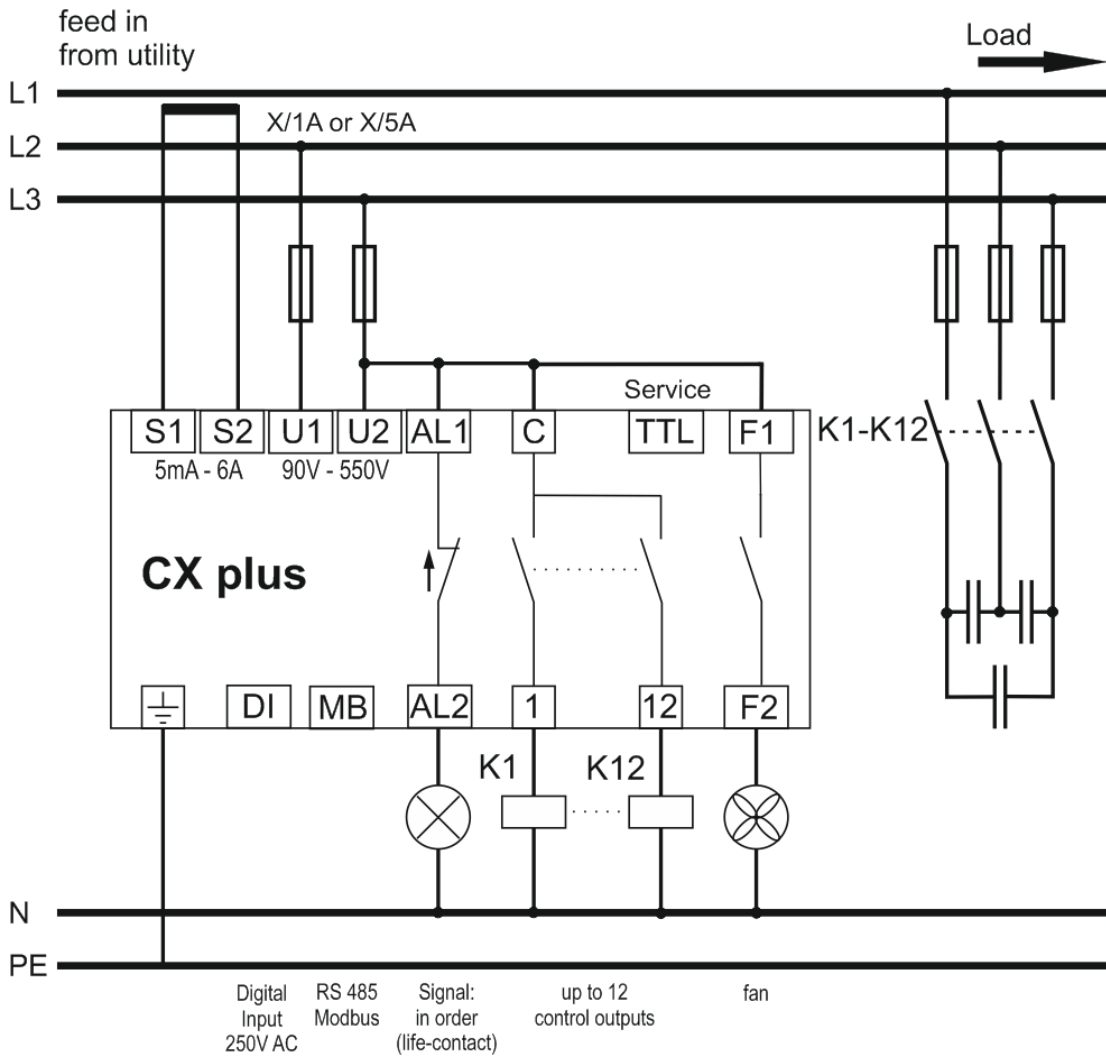
3.1   List of options

Designation		Explanation
CX plus	-06R	6 output / step relay
	-12R	12 output / step relay
	-MB	Modbus RTU – Connection via RS485 3-wire bus
	-m	Signalling / alarm relay with break contact

4 Connection data

Measuring and supply voltage

Combined voltage measurement and supply
Range: 90 – 550 V AC, 45 – 65 Hz
Terminals: U1 / U2
A transformer factor can be set when using voltage transformers.
Range 1.0 – 350.0

Current measurement

Current measurement
Range: 5 mA – 6 A AC, 45 – 65 Hz.
The use of x/1 and x/5 transformers is possible.
Terminals: S1 (K) / S2 (L)
Transformer factor adjustable from 1 – 9600

Switching outputs relay
only option -xxR

Equipment with 6 (**option: -06R**) or 12 switching outputs (**option: -12R**)
Switching outputs potential-free with common root
Terminals: C / 1 – 12
Switching capacity 5 A / 250 V AC

Fan relay

Closes the contact when exceeding the pre-set temperature limit 1.
Terminals: F1 / F2
Switching capacity 5 A/ 250 V AC
The fan relay may be used alternatively as 7th or 13th switching output for a step.
This function is described in more detail in the chapter "APPLICATIONS", paragraph "Additional switching output for a step".

Alarm relay

Normally open contact, closed in normal operating condition.
Opens in case of alarm and in case of a failure of the supply voltage (life contact).
Terminals: AL1 / AL2
Switching capacity 5 A / 250 V AC

Digital input

Digital input either for switching to the second target cos φ or for supressing the I-LOW alarm.
Adjustable logic: HIGH or LOW active
Terminals: I1 / I2
Input signal: 90 – 250 V AC

Temperature measurement

internal NTC (under the housing cover)

MODBUS interface
only option: -MB

Protocol: MODBUS-RTU
Interface: RS485
Terminals: + / GND / -

TTL interface

Service interface. For service purposes only.

⚠ **CAUTION**
Exception: The current transformer factor (SETUP/Ct) must be entered in order to correctly calculate the measurement values and to correctly identify the step sizes.

5 Commissioning

The CX plus is pre-programmed with default values, which enable an operation almost without further settings, if connected to a 400 V supply network according to the wiring diagram.

⚠ **CAUTION**
Exception: The current transformer factor (SETUP/Ct) must be entered in order to correctly calculate the measurement values and to correctly identify the step sizes.

The measurement values of current and power are only displayed, if the current transformer factor has been set.

NOTE: If the connection of measuring voltage and current results in a phase between voltage and current not equal to 0° resp. 90°, execute the AUTO INITIALISATION (AI) first or manually set the phase correction angle (setup menu: 206) correctly. The table with the phase correction angles depending on the connection of measuring voltage and current can be found in the annex, paragraph Setting of phase correction angles.

NOTE: The "Automatic initialisation" only identifies the correct phase between measuring voltage and current. Furthermore, the AI determines which switching outputs are occupied and which not. Switching outputs which are not occupied are set to the step type "FOFF". The step sizes are determined at first via the control in the normal control mode.

After applying the mains voltage, the message **"AUTO"** appears on the display and the currently measured COS φ is displayed, if measuring voltage and current are within the tolerance. Normally, the COS φ should be inductive (display of a small **i** behind the first line). From this moment on, the discharge time lock of the capacitors is active (factory setting: 75 sec.). After the discharge time lock, the CX plus starts controlling. In the process, the step sizes are determined automatically. Step outputs which are not occupied are set to the step type "FOFF" (Fix-Off), if the first three switching processes have been unsuccessful. I.e. the control ignores these steps.

6 Questions during commissioning

1)   **"AUTO"** is not displayed ➔ control stopped or switched off.

Possible causes:

Manual operation, control has been stopped or switched off in the setup menu.

Current is less than 5 mA, voltage of THD of voltage or current are out of tolerance, temperature is too high, "Automatic initialisation (AI)" was cancelled with error.
➔ Control is switched off

2)   Display **"U ALARM"** ➔ measuring voltage out of tolerance

Possible causes:

Over- or under-voltage in the system, the set nominal voltage and the voltage transformer factor do not correspond to the system.

> Solution:

> Check the settings for nominal voltage (SETUP/100/Un) and voltage transformer (SETUP/100/Pt). The set voltage tolerance range is too small.

> Solution:

> Check the settings of the tolerance range (SETUP/204).

3)   Display **"I Lo ALARM"**   ➔ no current

Possible causes:

Connection from the current transformer to the controller is not correct; current transformer jumper is not removed; transformation ratio of the transformer is too large ➔ current is less than 5 mA ➔ no current

4)   Display **"EXPORT"**   ➔ feeding back of active power

There is no real feeding back, please check the connection of measuring voltage and current (phase, polarity).

Possible causes:

The set phase correction angle does not correspond to the connection of measuring voltage and current

> Solution:

> Correct the connection, execute the "Automatic initialisation (AI)" or manually set the phase correction angle correctly.

Measuring voltage or current has been connected at a twisted angle of 180° from the direction of connection (U2 / U1 instead of U1 / U2 resp. S2 / S1 instead of S1 / S2).

Solution:

Correct the connection, execute the "Automatic initialisation (AI)" or add 180° to resp. subtract 180° from the set phase correction angle (SETUP/206) (new angle < 360°).

Please observe the separate notes at the end of the chapter for the setting of the phase correction angle.

Also see chapter "**Automatic initialisation**"

5)   Incorrect "**COS PHI**" is displayed ➔ incorrect connection

Incorrect phase between measuring voltage and current. Please check the connection of measuring voltage and current (phase, polarity).

Possible causes:

The set phase correction angle does not correspond to the connection of measuring voltage and current.

Solution:

Correct the connection, execute the "Automatic initialisation (AI)" or manually set the phase correction angle correctly.

Measuring voltage or current has been connected at a twisted angle of 180° from the direction of connection (U2 / U1 instead of U1 / U2 resp. S2 / S1 instead of S1 / S2).

Solution:

Correct the connection, execute the "Automatic initialisation (AI)" or add 180° to resp. subtract 180° from the set phase correction angle (SETUP/206) (new angle < 360°).

Please observe the separate notes at the end of the chapter for the setting of the phase correction angle.

Also see chapter "**Automatic initialisation**"

6)   Display "**AI Abrt**" ➔ The "Automatic initialisation" (AI) was cancelled with error.

Possible causes:

Heavy load fluctuations during the "Automatic initialisation (AI)"

Solution:

Restart the "Automatic initialisation (AI)", when the mains is steadier. The measuring current was too small.

The current transformer ratio may be too large.

Solution:

Check if the selected current transformer corresponds to the system and change it, if necessary. Restart the "Automatic initialisation (AI)".

The step sizes may be too small.

Solution:

Enter the phase correction angle (SETUP/206) manually and switch on the control again (SETUP/100/PFC or SETUP/310).

If the "Automatic initialisation" (AI) is not successful after several attempts, it is alternatively possible to manually set the correct phase correction angle (SETUP/206). The step outputs which are not occupied can be set manually (SETUP/100/OUt) to the step type "**FOFF**".

The control must be manually switched on again (SETUP/100/PFC or SETUP/310).

7)   Step outputs are immediately switched off again.

Possible causes:

The nominal value of a step saved in the step database is not correct anymore (after changing a capacitor, the value must be entered manually again or the entire step database must be reset).

Step is defective ➔ no step power identified during switching

Solution:

Check the fuses and power contactors.

(see chapter Step identification / defective steps)

8)   One or several steps were identified as defective.

No step power identified during switching.

Possible causes:

Steps are defective

Solution:

Change the capacitors

Fuses are defective

Solution:

Change the fuses

Power contactor does not switch anymore or contacts are defective.

Solution:

Change the power contactor

(see chapter **"Identification / resetting defective steps")**

9)   Frequent switching of the outputs

Possible causes:

The initial values of the step power of the individual steps are still saved in the step database. By switching the steps, the step powers of the individual capacitors are identified and saved in the step database.

10)   Identified step sizes are incorrect

Possible causes:

The set current transformer factor is incorrect

Solution:

Enter the current transformer factor correctly (SETUP/100/Ct), enter the step sizes manually (SETUP/402) or reset the step database (SETUP/602).

Heavy load fluctuations during the step identification

Solution:

Enter the step sizes manually (SETUP/402) or reset the step database (SETUP/602).

The set phase correction angle does not correspond to the connection of measuring voltage and current.

Solution:

Correct the connection, execute the automatic initialisation or manually set the phase correction angle correctly.

11)   Measurement values of current and power are not displayed.

Possible causes:

The current transformer factor was not set.

Solution:

Enter the current transformer factor correctly (SETUP/100/Ct).

12)   Measurement values of current, power and step sizes are incorrect.

Possible causes:

The set current transformer factor is incorrect.

Solution:

Enter the current transformer factor correctly (SETUP/100/Ct), enter the step sizes manually (SETUP/402) or reset the step database (SETUP/602).

⚠ **WARNING**

Prior to disconnecting the current measurement path at the device resp. at the current transformer, the current transformer must be short-circuited. Otherwise, there may be a life-threatening voltage at the connections of the current measurement path resp. of the transformer. In the long run, the transformer will be destroyed by the high voltage.

NOTE: In order to set the phase correction angle:

A table with the phase correction angles depending on the connection of measuring voltage and current can be found in the **annex, paragraph <u>Setting of phase correction angles</u>**.

If the adding of 180° results in a phase angle equal to or greater than 360°, subtract 180° instead.

<u>Example:</u>

Previously set phase correction angle = 270°

270° + 180° = 450° ➜ greater than 360°

➜ 270° - 180° = 90° ➜ **phase correction angle to be set**

7 Indications on the display

The currently selected main menu is shown on the right side of the display.

INFO: Step database

AUTO: Control is active: Steps are switched on and off automatically.

MANUAL: Manual operation: Steps can be switched on and off manually.

SETUP: Setup menu

ALARM: Alarm memory: The last 10 alarms can be shown here.
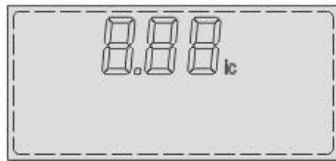
The current COS PHI is shown in the top menu level in the first line of the display. The small **i** resp. **c** indicates, if the COS PHI is inductive or capacitive. The codes for the individual sub-points are shown in the submenus.
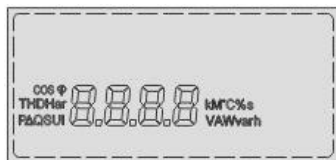
The settings and measurement values (in the middle) with the respective abbreviation (on the left) and the units (on the right) are shown in the second line of the display. In case of an alarm, a message will be shown here. All possible messages are listed and explained in the table on the next page.

Active switching outputs are shown in the bottom line. If one step was identified as defective (three unsuccessful switching operations), the respective step symbol starts to flash. The step symbol of the selected step is flashing in the step database and in the setup menu.
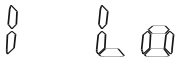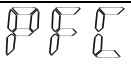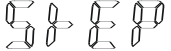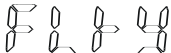
NT: 2nd target COS-PHI is active

EXPORT: Export (feeding back) of active power

ALARM: Flashes when there is an alarm message
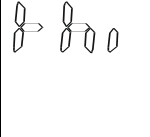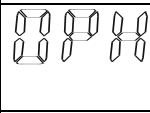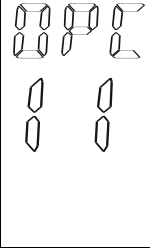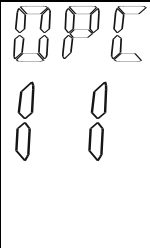
In case of an alarm, an alarm message is flashing on the display in addition to the display "ALARM" at the CX plus. The table below offers an overview of all possible alarm messages.

In order to reset the active alarms, keep the ◄(ESC) key pressed for 3 s.

Alarm messages:

U0 ALARM	Measuring voltage is out of the set tolerance.
I Lo ALARM	Measuring current is less than 5 mA (short-circuit jumper may still be present at the current transformer (K – L) or interruption in the current path or current transformer ratio is too large).
I IIo ALARM	Measuring current is too high.
PFC ALARM	The controller cannot reach the compensation target.
HArU ALARM	The set limit for the THD of the voltage has been exceeded. Steps will be or were already switched off one by one.
HArI ALARM	The set limit for the THD of the current has been exceeded. Steps will be or were already switched off one by one.
StEP ALARM / FLty ALARM	One or several steps are defective. The step symbols of the defective steps are flashing with the alarm message. The error codes **Step** and **FLty** are flashing alternatingly.
SPL ALARM / 0 0 ALARM	The step power of one or several steps has dropped below 75% of the initial power. Error code and step number are flashing alternatingly. The affected steps are switched off, set to the step type "**FOFF**" and are locked for the control. Only the smallest affected step number is displayed.
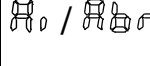
ϑ ϑ₀₀	ALARM	The second temperature limit has been exceeded. Steps will be or were already switched off one by one.
ϴϴϷϴϴ	ALARM	Set limit value of the operating hours has been exceeded.
ϴϴϷℭ ϴ ϴ	ALARM / ALARM	Set limit of the maximum permissible switching cycles of one or several steps has been exceeded. Error code and step number are flashing alternatingly. Only the smallest affected step number is displayed.
ϴϴϷℭ ϴ ϴ	ALARM / ALARM	Set limit of the maximum permissible operating hours of one or several steps has been exceeded. Error code and step number are flashing alternatingly. Only the smallest affected step number is displayed.

If several alarms are active, the alarm messages are exchanged cyclically.

Example: U and I-Low alarm are active, the alarm messages are displayed as follows: 3 times error code "**U**", then 3 times "**I**", then again 3 times starting with "**U**" etc.

In addition to the alarm messages, the following error and status messages are displayed.

Error messages:

Aᵢ / Abrt	The automatic initialisation (AI) was cancelled due to an error. The control was switched off.

An active error message can be reset by pressing the ◄(ESC) key for 3 s.

Status messages:

$F\ A\Pi\Pi$	Temperature limit 1 has been exceeded; switching output fan is switched on.
	NOTE: The activation of the switching output fan and the display of the fan message only occur, if the function Use switching output FAN as step switching output (SETUP/406) is deactivated (NO).
PFC OFF	The control is switched off.
PFC Hold	The control is stopped.

NOTE: Status messages <u>cannot</u> be reset by pressing the ◄(ESC) key.

NOTE: Alarm messages are only displayed in the main menu. The menu items INFO, MANUAL, SETUP or ALARM must not be selected.
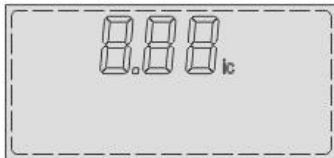
NOTE: If the menus INFO, MANUAL, SETUP or ALARM are selected in the main menu, only error and status messages are displayed.

NOTE: If the submenus INFO, MANUAL, SETUP or ALARM are active, no alarm, error or status messages are displayed.

NOTE: The messages Ao / $Abrt$, $PFC\ OFF$ and $PFC\ Hold$ are only displayed in the main menu, when no alarm is signalled.

NOTE: Only one active error resp. status message is displayed.

The error message Ao / $Abrt$ has priority over the status messages $F\ A\Pi\Pi$ and $PFC\ OFF$ resp. $PFC\ Hold$.

The status message $F\ A\Pi\Pi$ has priority over the status messages $PFC\ OFF$ resp. $PFC\ Hold$.

8 Operation:

The CX plus is operated using 4 keys.

NOTE: If no key is pressed within 60 s, the backlighting is switched off. If the backlighting is switched off, the backlighting is first switched on by pressing one of the 4 keys.

There is only a reaction in the user menu when you press a key again.

Increase values, select the previous measurement value, menu item and step number

Exit menus,
moves the cursor to the left,
reset alarms (keep the key pressed for approx. 3 s in order to reset the alarm)

Open menus,
moves the cursor to the right,
accept the set value

Reduce values, select the next measurement value, menu item and step number

Entering numerical values:

As the procedure for entering the numerical values is always the same, the input mask is described beforehand:

The current value is shown on the display, while the first digit is flashing. By pressing the keys "▲" and "▼", this digit can be increased or decreased. With the key "▶", you can switch to the next digit in order to set the desired value with the keys "▲" and "▼". With the key "◀", you can switch to the previous digit in order to set the desired value with the keys "▲" and "▼". If you selected the last digit (on the right) and you press the key "▶", you can set the multiplier k (kilo) or m (mega) with the keys "▲" and "▼" in case of higher values, if necessary. In order to accept the value and to finish entry, please press the key "▶" again.

If a set value was not accepted or if another value is displayed after the entry, it is possible that the set value exceeded resp. fell below the limit of the setting range.

You may cancel the entry of a value at any time with the key "◄": Press the key "◄" until the first digit (on the left) is selected. The entry is cancelled without accepting the new value by pressing the key "◄" again.

9 Menu CX plus

9.1 Measurement value menu

All measurement values with a grey background are hidden in factory setting and are only displayed, if the current transformer factor is set in the menu "SETUP/100/Ct".

NOTE: If the device is reset to factory settings (SETUP/602), the current transformer factor must be entered again so that all measurement values are displayed again.

Display	Display	Description
1.00 i	1.00 i / U 400 V	Voltage L - L
1.00 i INFO	1.00 i / U 230 V	Voltage L - N
1.00 i MANUAL	1.00 i / I 40.45 A	Current in the measurement phase
1.00 i SETUP	1.00 i / P 30.37 kW	Active power 3 phase
1.00 i ALARM	1.00 i / Q 82.89 Var	Reactive power 3 phase
	1.00 i / ΔQ 80.08 Var	Missing reactive power for the target COS-PHI 3 phase
	1.00 i / S 30.68 kVA	Apparent power 3 phase

1.00 i THD 1.41 % U	Harmonic distortion U total
U 3 Har 0.40 % U	Odd harmonic U 3 - 19
1.00 i THD 1.67 % I	Harmonic distortion I total
I 3 Har 0.74 % I	Odd harmonic I 3 - 19
1.00 i cosφ 0.999	Cos φ three-digit
PF 0.888	Power factor ratio P/S
APF 1.000	Average power factor
F 50	Frequency
t 58 °C	Temperature

Display	Description
thl **88** °C	Highest measured temperature
▲▼	
OPh **188.9** h	Operating hours counter
▲▼	
tAn **0.99**	tan φ
▲▼	
hl U **405** V	Highest measured voltage L - L
▲▼	
hl THD U **2.66** %	Highest measured harmonic distortion U total
▲▼	

Jump upwards to:
Voltage L - L

9.2 INFO (step database)

The switching cycles, the operating hours, the step type / status, the current step power and the step power with regard to the initial power (in %) are displayed in the "INFO" menu for each step. With these data it is possible to draw conclusions about the condition of the system and the condition of the individual steps.

NOTE: The current step size (in kVar) is only displayed, if the current transformer factor has been set in the "SETUP" menu.

The step power with regard to the initial power (in %) is only displayed, if the step identification has been completed or if the step size was entered manually (see chapter Step identification)

Select the step number with ▼ ▲.
Select the step with ▶.

Select the values with ▼▲.

1.00 i INFO → INFO → **CC 25** kVar

Display of the step size is only active, if the CT has been set, otherwise ----

1.00 i MANUAL → INFO → **98** %

Current step value in % with regard to the initial value. Is only displayed, if the step identification has been completed or if the step size was entered manually. Otherwise, only ---- is displayed.

1.00 i SETUP → INFO → **OC 808**

Switching cycles of the step

1.00 i ALARM → **Auto**

Step type / status:

AUTO: Step is active
FOFF: Step is deactivated
FON: Step is always on
Flty: Step is defective

OPh 342 h

Operating hours of the step

Jump upwards to:

Display of the step size

INFO

| 1 | 2 | 3 | 4 | max |

CC
25   kVar

| 1 | 2 | 3 | 4 | max |
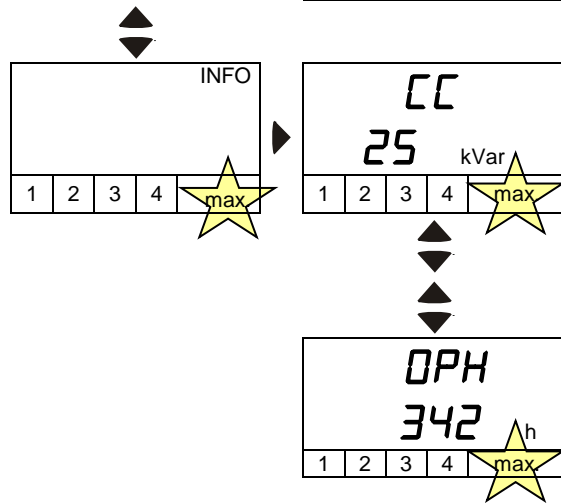
Display of the step size is only active, if the CT has been set, otherwise ----

OPH
342   h

| 1 | 2 | 3 | 4 | max |

Operating hours
of the step

9.3   MANUAL (manual operation: Manually switch steps on and off)

It is possible to manually switch the step outputs of the CX plus for test purposes. The automatic control is stopped in the "MANUAL" menu. In order to prevent an unintentional stopping of the control, this menu item is provided with a key lock (keep the key "▶" pressed for 3 s in order to enter the MANUAL menu). As soon as you leave the menu, the control restarts automatically and switches off those steps which are not necessary, as the case may be.

NOTE: The discharge time lock is observed when manually switching steps. After manually switching off a step, the discharge time lock for this step is active. The affected step can only be switched on again after the discharge time lock.

NOTE: Deactivated steps (FOFF), steps which are permanently switched on (FON) and locked steps (FAULTY, FOFF due to step-power-lost-alarm) cannot be switched manually.

NOTE: A manual operation of the steps is not possible, when the control algorithms "LIFO", "FIFO" or "COMBI-FILTER" are set. The MANUAL menu is locked.

NOTE: If the step database was switched off by U-ALARM, TEMP2, THD-U or THD-I alarm, it is not possible to switch the steps manually anymore, while the alarm is still active. When the step database has been restarted again, the discharge time lock for all steps runs out first. The MANUAL menu is locked if the automatic initialisation was activated in the SETUP/100/Ai or SETUP/207 resp. for as long as the setting is activated (AI has not been started yet) or for as long as the AI is executed (🔠 ₀ is shown in the top line on the display in the main menu). It is not possible to switch the steps manually.

1.00 i

↕

1.00 i INFO

Select the step with ▼ ▲. Switch a step on or off with ▶.

The current COS φ is displayed for each switching operation.

Observe the discharge times!

↕

1.00 i MANUAL ▶ **0.95** i MANUAL
1
▶ **1.00** i MANUAL
1
1
▶ **1.00** i MANUAL
1
▶

↕ ↕

1.00 i

SETUP

0.95 i MANUAL
2
▶ **1.00** i MANUAL
2
2
▶ **1.00** i MANUAL
2
▶

↕ ↕

1.00 i

ALARM

↕

↕

0.95 i MANUAL
12
▶ **1.00** i MANUAL
12
12
▶ **1.00** i MANUAL
12
▶
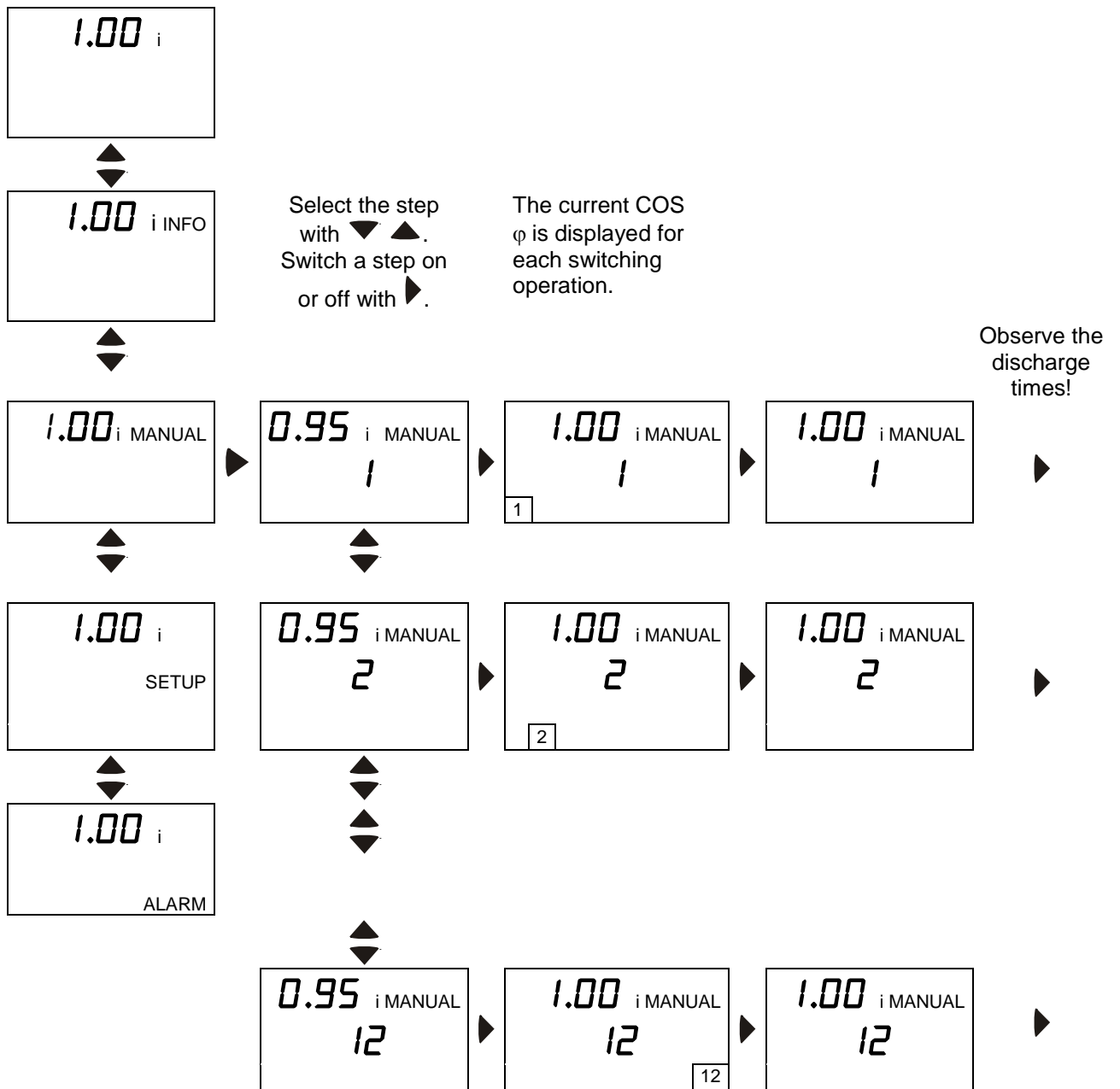
9.4   SETUP (setup menu)

100 Quick START setup

Contains all the important settings for commissioning from the setup menus 200 to 400. This menu is always visible. No further settings are necessary for the commissioning of the control in case of a connection to a 400 V mains and in case of a connection of measuring voltage and current, where a phase of 0° (connection voltage = L-N) or 90° (connection voltage = L-L) results.

NOTE: At first, however, the current transformer factor must be set in order to correctly calculate and display the current, the powers and the step sizes.

We recommend executing the **automatic initialisation (AI)** for commissioning. This identifies the connection of the controller (phase between voltage and current) and <u>automatically</u> determines the correct phase correction angle (SETUP/206).

The CX plus performs a connection type identification of the measuring voltage (L-L / L-N) depending on the set nominal voltage. With the aid of these data, the control starts automatically.

The nominal voltage and, if necessary, the current transformer factor must also be entered for other mains voltages.

⚠ **CAUTION**
If the connection of measuring voltage and current results in a phase not equal to 0° (connection voltage = L-N) or not equal to 90° (connection voltage = L-L), execute the automatic initialisation (AI) first or manually set the phase correction angle (SETUP/206) correctly. Otherwise, the calculation of the powers, of the COS-PHI and of the step sizes is incorrect and the control does not work correctly or not at all.

The CX plus can be adjusted to the system conditions and be optimised in the setup menu at any time.

NOTE: The menus 200 to 700 are hidden in the quick START menu. In order to show these menus, change to the EXPERT setup.

1.00 i

▲
▼

1.00 i INFO

▲
▼

1.00 i

MANUAL

▲
▼

1.00 i

SETUP ▶ **100** SETUP ▶ **Un**
400 V SETUP

Setting of the nominal voltage **Un = phase voltage**. This value is required for the monitoring of the voltage tolerance. The step sizes saved in the step database also refer to the nominal voltage.

▲
▼

1.00 i

ALARM

▲
▼

Ct
50 SETUP

Entry of current transformer factor e.g. 250/5 = 50

▲
▼

Pt
1 SETUP

Entry of voltage transformer factor (if no transformer is used, value = 1)

▲
▼

AI
no SETUP

"Yes": The controller performs an identification of the phase (connection of measuring voltage and current) and of the occupied and non-occupied switching outputs (AUTO-INIT).

▲
▼

PFC
On SETUP

"ON" control ON,
"OFF" control OFF,
"HOLD" control is stopped

▲
▼

CP1
1 SETUP

Target COS φ 1 of the control

▲
▼

29

Rev. 02

```
  5t
 10   S SETUP
```

Switching time, waiting time between switching the individual steps on and off

▲
▼

```
 Out

      SETUP
```

Setting of the step type for each individual step:

Select the step number with ▼ ▲.

Select the step with ▶.

AUTO: Step is active.
FOFF: Step is deactivated.
FON: Step is always on.
Flty: Step is defective (cannot be set)

9.5 Expert SETUP menu CX plus

In order to change from the quick START SETUP menu to the EXPERT SETUP menu of the CX plus, press the key ▼ or ▲. You are now requested to enter a PIN. The standard PIN is **242**.

NOTE: The PIN can be changed in the SETUP menu 608. No matter which PIN was set, you can always enter the EXPERT SETUP menu with the master PIN "242". If the PIN has been set to "000", the EXPERT SETUP menu is not protected by a PIN anymore. All SETUP menus are unlocked without entering a PIN.

Enter the PIN (**242**) and confirm with the key ►(↵). The previously hidden menus 200 to 700 can now be selected with the keys ▼ ▲.

You can enter these submenus with the key ►(↵).

The EXPERT SETUP menu of the CX plus is divided into seven groups. The menu items in these groups are grouped logically. The following groups exist:

100 Quick START setup

Contains all the important settings for commissioning from the setup menus 200 to 400. This menu is always visible.

200 Settings MEASUREMENT

Contains settings in order to adjust the measurement of the CX plus to the network conditions.

300 Settings CONTROL

Contains settings in order to adjust the control to the system requirements and to optimise it.

400 Settings STEP DATABASE

The step parameters are set in the step database. When the step identification is switched off, the step size must be entered manually here for each individual step.

500 Settings ALARM

Almost all alarms and monitoring functions can be activated / deactivated and limit values can be set in the alarm menu.

600 Reset menu

Allows resetting all made settings, values saved by the controller and counters. Additionally, it is possible to call up the software version of the device and to set the password (PIN) for the expert setup menu.

700 Settings MODBUS (only option -MB)

Contains settings in order to parametrise the MODBUS-RTU communication interface (RS485).

NOTE: This submenu is only available with the option -MB.

9.6　100 Quick START setup

Contains all settings important for commissioning.

100 Quick START setup

MENU	FUNCTION	AREA
Un	Nominal voltage measurement = **phase voltage**	100...242000 V

It is necessary to correctly enter the nominal voltage, because the upper and lower limit of the voltage monitoring are calculated from the nominal voltage (see tolerance range nominal voltage). The step sizes saved in the step database also refer to the set nominal voltage.

Ct	Current transformer factor	1...9600

Entry of the current transformer factor: The ratio must be entered as value (e. g. 1000/5 = 200).

NOTE: If the current transformer factor is entered
- and the automatic step identification is <u>deactivated</u>, the current step size of all steps is reset to the original value (entered value).
- and the automatic step identification is <u>activated</u>, the current and the original step size (the value which was accepted after the completion of the step identification) of all steps is reset to the initial value of 3 var capacitive. The step identification restarts again.

Pt	Voltage transformer factor	1.0...350.0

Entry of the voltage transformer factor: The ratio must be entered as value (e. g. 1000/100 = 10).
If the device is directly connected to the measuring voltage without transformer, the value 1 must be used.

The voltage transformer factor can be entered with one decimal place. As only 3 characters are available for the display of the saved value, the value is rounded up or down for the display.

NOTE: If the voltage transformer factor is entered
- and the automatic step identification is <u>deactivated</u>, the current step size of all steps is reset to the original value (entered value).
- and the automatic step identification is <u>activated</u>, the current and the original step size (the value which was accepted after the completion of the step identification) of all steps is reset to the initial value of 3 var capacitive. The step identification restarts again.

AI	Start "Automatic initialisation"	Yes/No

"YES": Starts the "Automatic initialisation (AI)".
Starts the "Automatic initialisation" after activating the AI ("YES"), the setting is immediately set back to "NO" then. The setting remains on "YES" until the AI is started (U alarm, I-Low alarm).

The **automatic initialisation** switches all outputs one by one. In this way, the controller can identify the used switching outputs.
In addition to this, the phase (connection of measuring voltage and current) is identified.
In this way, a potentially incorrect connection of the current resp. voltage input can be identified and corrected by setting the phase correction angle.
The **automatic initialisation** only starts, if current and voltage are within the set tolerances.

Outputs which are set to the step type "FON" or "Flty" are not considered during the **automatic initialisation**.

NOTE: The automatic initialisation (AI) can only identify the phase, if capacitors are connected to the switching outputs. If the CX plus compensates the reactive power by means of reactors, this function will cause errors. AI works best when there are constant load conditions.

PFC	Control	ON/OFF/Hold

Starting, stopping and switching off the automatic control. The following settings are available:
ON: Control is ON and works in normal operation.
OFF: Control is OFF and active steps are switched off one by one at 3 second intervals.
Hold: Control is stopped and the active steps remain switched on.

If the control is set to "OFF", "PFC" and "OFF" appear alternatingly on the display.
If the control is set to "Hold", "PFC" and "Hold" appear alternatingly on the display.
In order to start the control, set the setting to "ON".

NOTE: If the step identification was switched off and if the current transformer factor and no step size has been entered manually yet, the control is switched off ("OFF") and the setting is locked. The setting remains locked until the current transformer factor is entered once and at least one step size is entered manually. Then, the control can be switched on again.

CP1	Target COS φ 1	0.70 c ...0.70 i

The active power factor, which shall be reached by the reactive power compensation (control target), is determined by setting the target Cos φ 1.

St	Switching time	1...6500 s

The switching time refers to the waiting time between switching individual steps in the normal control algorithm. This value should be adjusted respectively.

The switching time should be set based on the following aspects:
1. The switching time shall protect the contactors against an unnecessary amount of switching operations and thus against a too rapid wear.
2. The need for reactive power is determined via the switching time. Fast fluctuations of the reactive power are compensated in the process.

OUt	Switching outputs (step 1…max)	

The following step types except for the step type "**Flty**" can be set for each individual step:

- **AUTO** = Step is active and is used by the control.
- **FON** = Step is permanently switched on (step is monitored nevertheless and is switched off in critical situations).
- **FOFF** = Step is permanently switched off / deactivated. Steps which are not used should be set to this step type in order to prevent unnecessary switching operations and alarms.
- **Flty** = Step was switched three times without success and identified as defective. This is not used for the control anymore.

Defective steps are flashing in the step display.

Steps which are set to the step type "**Flty**" can be switched back to the desired step type in this menu.

9.7   200 Settings Measurement

Contains settings in order to adjust the measurement of the CX plus to the network conditions.

200 Settings Measurement

MENU	FUNCTION	AREA
201	Nominal voltage measurement = **phase voltage**	100...242000 V

It is necessary to correctly enter the nominal voltage, because the upper and the lower limit of the voltage monitoring are calculated from the nominal voltage (see tolerance range nominal voltage). The step sizes saved in the step database also refer to the set nominal voltage.

202	Current transformer factor	1...9600

Entry of the current transformer factor: The ratio must be entered as value (e. g. 1000/5 = 200).

NOTE: If the current transformer factor is entered
- and the automatic step identification is <u>deactivated</u>, the current step size of all steps is reset to the original value (entered value).
- and the automatic step identification is <u>activated</u>, the current and the original step size (the value which was accepted after the completion of the step identification) of all steps is reset to the initial value of 3 var capacitive. The step identification restarts again.

203	Voltage transformer factor	1...350

Entry of the current transformer factor: The ratio must be entered as value (e. g. 1000/100 = 10).
If the device is directly connected to the measuring voltage without transformer, the value 1 must be used.

The voltage transformer factor can be entered with one decimal place. As only 3 characters are available for the display of the saved value, the value is rounded up or down for the display.

NOTE: If the voltage transformer factor is entered
- and the automatic step identification is <u>deactivated</u>, the current step size of all steps is reset to the original value (entered value).
- and the automatic step identification is <u>activated</u>, the current and the original step size (the value which was accepted after the completion of the step identification) of all steps is reset to the initial value of 3 var capacitive. The step identification restarts again.

204	Tolerance range nominal voltage	0...100 %

The value is set in percent with regard to the nominal voltage. If the measuring voltage is out of the set tolerance, the control is switched off and all active steps are immediately switched off.

205	Connection type voltage measurement	Yes/No

"YES" = voltage measurement L-L
"NO" = voltage measurement L-N

Automatic connection identification voltage measurement:
By means of the set nominal voltage, the controller calculates the voltages for both connection types (L-L and L-N) from the measured voltage. If these are within the set voltage tolerance (factory setting +/- 10%), the controller automatically determines the connection type of the voltage measurement. This cannot be changed manually.

If the measured voltage is out of this tolerance, the connection type of voltage measurement can be set manually.

206	Phase correction angle	0...345

Depending on the connection of measuring voltage and current, a phase to one another results ➔ phase correction angle. The phase correction angle must be set respectively, **because otherwise, the calculations of the powers, of the COS-PHI, of the power factor and of the step sizes are incorrect. The control does not work correctly or not at all.**

The phase correction angle can be identified automatically by executing the automatic initialisation or it can be entered manually in **15° steps**.

If the AI correctly identified the phase correction angle for current and voltage measurement, this value should not be changed, because otherwise, the control does not work correctly anymore.

In case the **automatic initialisation** failed due to unfavourable network conditions, the phase correction angle can be entered manually, or an incorrectly identified phase angle can be corrected. The table "**Setting of phase correction angle depending on the connection**" in the ANNEX offers an overview of the connection possibilities and the phase correction angles to be set.

207	Start automatic initialisation	Yes/No

"YES": Starts the "Automatic initialisation (AI)".
Starts the "Automatic initialisation" after activating the AI ("YES"), the setting is immediately set back to "NO" then. The setting remains on "YES" until the AI is started (U alarm, I-Low alarm).

The **automatic initialisation** switches all outputs one by one. In this way, the controller can identify the used switching outputs. In addition to this, the phase (connection of measuring voltage and current) is identified. In this way, a potentially incorrect connection of the current resp. voltage input can be identified and corrected by setting the phase correction angle.
The **automatic initialisation** only starts, if current and voltage are within the set tolerances.
Outputs which are set to the step type "FON" or "Flty", are not considered during the **automatic initialisation**.

NOTE: The automatic initialisation (AI) can only identify phases, if capacitors are connected to the switching outputs. If the CX plus compensates the reactive power by means of reactors, this function will cause errors. AI works best when there are constant load conditions.

208	Synchronisation frequency	Auto/Fix50/Fix60

For highest accuracy of the measurement of voltage and current, it is necessary to synchronise the sample values to the mains frequency. An automatic synchronisation may be disturbed due to strong commutation notches of the mains voltage despite internal filtering. This leads to huge, striking measurement errors.
Therefore, the following settings are possible:

AUTO: Automatic synchronisation for highest measurement accuracy at mains voltage without commutation notches.
50: **FIX-50 HZ** for a safe operation in 50 Hz mains with extremely poor mains quality.
60: FIX-60 HZ for a safe operation in 60 Hz mains with extremely poor mains quality.

209	Temperature offset	-10…10 °C

A temperature offset for the temperature measurement can be set here, in order to correct possible component-dependent deviations.

9.8   300 Settings control

Contains settings in order to adjust the control to the system requirements and to optimise it.

300 Settings control

MENU	FUNCTION	AREA
301	Control sensitivity	55…100 %

The control sensitivity indicates the switching threshold for switching steps on and off. A low value allows a more exact compensation result. As a result, however, the possibility increases that the control tends to hunt.
The value can be set in the range of 55% - 100%. The factory setting is 60%. This means, if the missing reactive power for the control target is greater than 60% of the step power, the step may be switched on resp. off. In this case, 40% of overcompensation is allowed after switching on resp. 40% of under-compensation is allowed after switching off.

302	Target COS φ 1	0.70 c...0.70 i

The active power factor, which shall be reached by the reactive power compensation (control target), is determined by setting the target COS φ 1.

303	Target COS φ 2	0.70 c...0.70 i

The active power factor, which shall be used as control target, is determined by setting the target COS φ 2, if P export (SETUP/304 = YES) was identified or if the digital input switches to low rate.

304	Target COS φ 2 in case of P export	Yes/No

"**YES**" the controller uses the target COS φ 2 as control target in case of P export.
"**NO**" the controller works with the target COS φ1 in case of P export.

305	Switching time	1…6500 s

The switching time refers to the waiting time between switching individual steps in the normal control algorithm. This value should be adjusted respectively.
The switching time should be set based on the following aspects:

1. The switching time shall protect the contactors against an unnecessary amount of switching operations and thus against a too rapid wear.
2. The need for reactive power is determined via the switching time. Fast fluctuations of the reactive power are compensated in the process.

306	Switching time step exchange	1…6500 s

This refers to the waiting time between switching off an active step and

switching on a step which fits more precisely to the determined need for reactive power. The normal switching time is not observed for the step exchange.

307	Activate step exchange	Yes/No

"**YES**": The controller tries to better reach the control target by means of step exchange.
"**NO**": The function is deactivated.

This function is useful when steps of different sizes are available. **If all available steps have the same power, this function should be deactivated, because, otherwise, unnecessary switching cycles may occur.**

NOTE: The step exchange function is always deactivated in the control algorithms "COMBI filter", "LIFO", "FIFO" and progressive.

308	Step identification	Yes/No

"**YES**": Step identification is activated. Step sizes are determined automatically during operation and are updated continuously. Defective steps and power loss of the individual steps are identified. Manually entered step sizes are overwritten by the automatic updating of the step size. If the step identification is completed for a step (50 switching operations), the original step size is set to the value of the current step size.
The step identification can also be concluded prematurely by manually entering the step size.

"**NO**": Step identification is deactivated. Step sizes must be entered manually, the updating of the step sizes, the identification of defective steps and the identification of power loss of the individual steps, however, are active. By entering the step size, the value of the original step size is set to the value of the current step size (entered step size).

It is necessary to enter the step sizes manually, if
   a) there are rapidly changing loads in the system and the step sizes are identified incorrectly due to this.
   b) the switchgears have a delay of more than 200 ms.

NOTE: If the step identification for a step has been completed or if the step size was entered manually, the current step size with regard to the original step size in % is displayed in the step database menu (INFO) for this step.

NOTE: By switching off the step identification, the control is switched off, set to "OFF" and locked. The setting remains locked until the current transformer factor is entered once and at least one step size is entered manually. Then, the control can be switched on again.

309	Lock faulty steps	Yes/No

"**YES**": If the controller cannot identify a reaction from mains after switching a step, this step is locked after three unsuccessful switching operations and is not used for the control anymore. Steps which were identified as defective are flashing in the step display and are displayed as step type "Flty" in the info and in the setup menu "100/OUt and 403".

"**NO**": Steps which are identified as faulty are not blocked and are still used by the control. This results in unnecessary switching cycles.

NOTE: Steps which are identified as faulty are set to the step type AUTO and checked again every 24 hours or after a restart of the controller.

310	Control	ON/OFF/Hold

Starting, stopping and switching off the automatic control. The following settings are available:

ON: Control is ON and works in normal operation.
OFF: Control is OFF and active steps are switched off one by one at 3 second intervals.
Hold: Control is stopped and the active steps remain switched on.

If the control is set to "OFF", "PFC" and "OFF" appear alternatingly on the display.
If the control is set to "Hold", "PFC" and "Hold" appear alternatingly on the display.
In order to start the control, set the setting to "ON".

NOTE: If the step identification was switched off and if the current transformer factor and no step size has been entered manually yet, the control is switched off ("OFF") and the setting is locked. The setting remains locked until the current transformer factor is entered once and at least one step size is entered manually. Then, the control can be switched on again.

311	Control algorithm	1/2/3/4/5

A detailed description of the control algorithms can be found in the chapter "Control algorithm".

1) **BEST-FIT (AUTO):** The controller works according to the "BEST-FIT" principle (best result). This means that, before each switching operation, the controller compares all step sizes saved in its step database with the determined need for reactive power and always selects the step which comes closest to the set control target. If the controller has connected steps of the same size, the number of switching operations is automatically distributed to these steps either via the switching cycles or via the operating hours (SETUP/315).

2) **LIFO: "Last IN, First OUT"**: The controller starts with step 1 and switches on the step of the next higher number each time, if necessary. The steps are switched off in reversed order. It is checked individually for each step, if the switching operation is useful. This may lead to an unprecise compensation in case of steps of different sizes.

⚠ **CAUTION**

If the setting "Lock faulty steps" (SETUP/309) is deactivated, steps which are identified as defective are not blocked anymore. Their step type remains set to "AUTO". Therefore, the defective step is not skipped.

The control continuously switches the defective steps on and immediately off again unnecessarily in the cycle of the switching time. The next faultless steps are ignored for switch-on, because the defective step is not blocked and thus not skipped. Therefore, it may not be possible for the control to reach the target COS-PHI. The switch-off of the steps is not affected by this.

NOTE: The step exchange function and the switching distribution (switching cycles or operating hours) are always deactivated in case of steps of the same size.

NOTE: It is not possible to switch the steps manually.

3) **COMBI FILTER:** Special algorithm for combi filter systems with two different degrees of choking. The controller works according to the "**BEST-FIT**" principle. The difference is that the controller always has switched on more or the same compensation power which is connected at the odd switching outputs than / as is connected at the even outputs. Already switched on step powers by FON steps are not considered by the control.

> ⚠ **CAUTION**
>
> The combi filter algorithm only works with capacitive steps.
>
> If the step identification is executed for the first time, more step power may be switched on at the even switching outputs than at the odd ones. Enter the step sizes manually (SETUP/402) in order to avoid this.
>
> Be careful when you define FON steps. By setting FON steps, more step power may be switched on at the even switching outputs than at the odd ones.

NOTE: The step exchange function and the switching distribution (switching cycles or operating hours) are always deactivated in case of steps of the same size.

NOTE: It is not possible to switch the steps manually.

4) **PROGRESSIVE:** Works like the "**BEST-FIT**" algorithm, with the exception that the controller switches on and off several steps one by one with a shortened switching time, if necessary. The set switching time is ignored in the process.
The step sizes must be entered manually, because the step identification is always deactivated in this algorithm.
The entry should be as precise as possible, because the control will otherwise tend to hunt.

NOTE: The step exchange function and the step identification are always deactivated. An updating of the step sizes, an identification of defective steps and an identification of power loss of the individual steps by the control are not possible.

5) **FIFO: "First IN, First OUT"** (cyclic control): The controller starts with step 1 and switches on the step of the next higher number each time, if necessary. When switching off, the controller starts with step 1 and switches off the step of the next higher number each time, if necessary. If steps 3 to 7 are still switched on, the control starts with step 8 when switching on. If step 12 has been switched on and step 1 has not yet been switched on, the control starts with step 1 next. When switching off, the control starts with step 3. If step 12 has been switched off and step 1 is still switched

on, the control starts with step 1 next. It is checked individually for each step, if the switching operation is useful. This may lead to an unprecise compensation in case of steps of different sizes.

NOTE: The step exchange function and the switching distribution (switching cycles or operating hours) are always deactivated in case of steps of the same size.

NOTE: It is not possible to switch the steps manually.

312	Offset reactive power (Q offset)	-9,9Mvar… 9,9Mvar

Reactive power OFFSET in var, which is added to the measured reactive power. This function allows the compensation of a permanently reactive load which cannot be measured (e. g. from the upstream input transformer).

NOTE: The offset of the reactive power also influences the following measurement values: current, reactive power, control deviation, apparent power and the power factors $COS\varphi$, PF and TAN φ.

313	Asymmetry factor (asymmetric switching time)	-127…127

Ratio between switch-on time and switch-off time: The switching time for the step exchange is not influenced. X is the asymmetry factor.

$X = 1$ = Switch-on and switch-off time are the same

$X = +2$ to $+127$: Switch-off delay is a multiple of the switching time
Switch-off delay = switching time multiplied by X
Switch-on delay = switching time

$X = -2$ to -127: Switch-on delay is a multiple of the switching time
Switch-on delay = switching time multiplied by X
Switch-off delay = switching time

314	Q capacitive = switch off steps	Yes/No

"**NO**" Capacitive actual value of the $COS\varphi$ is permitted.

"**YES**" Capacitive actual value of the $COS\varphi$ is **NOT** permitted. As soon as a capacitive $COS\varphi$ is measured, the controller switches off the necessary step power **without** observing the switching time in order to avoid capacitive network conditions.

NOTE: This function only has consequences in the control algorithms "Best Fit" and "Progressive".

> ### ⚠ **CAUTION**
>
> This function cannot be transferred to "inductive" steps the other way round.
>
> The values for target $COS\varphi$ 1 and target $COS\varphi$ 2 must be set to an inductive value (0.95 i or lower), because the control will otherwise tend to hunt.

315	Distribute switching operations of the steps via the operating hours of the individual steps	

"**NO**": The switching operations of steps of the same step size are distributed via the switching cycles of the individual steps.

"**YES**": The switching operations of steps of the same step size are distributed via the operating hours of the individual steps.

9.9   400 Settings step database

The step parameters are set in the step database. When the step identification is switched off, the step size must be entered manually here for each individual step.

400   Settings step database

MENU	FUNCTION	AREA
401	Discharge time lock	1...1200 s

Here, the discharge time lock is set globally for all steps. The discharge time lock is a blocking time which is started after switching off a capacitor stage and is running out. This is important, so that the capacitor is completely discharged before it is switched on again. As long as the blocking time has not run out yet, the respective step is not available for the control. The discharge time lock should be adjusted to the discharge duration of the capacitors. This depends on the discharging device.

402	Step nominal value (step 1…max)	-9.9 Mvar… 9.9 Mvar

When the automatic step identification is deactivated, the step size = step nominal value must be entered manually for each individual step. The entered step nominal value refers to the set nominal voltage. The value is entered individually for each switching output.

NOTE: If the step identification was concluded for a step or if the step size was entered manually, the current step size with regard to the original step size is displayed in % in the step database menu (INFO) for this step.

If the step identification was switched off and if the current transformer factor and no step size has been entered manually yet, the control is switched off ("OFF") and the setting is locked. The setting remains locked until the current transformer factor is entered once and at least one step size is entered manually. Then, the control can be switched on again.

If the current or voltage transformer factor is entered subsequently
- and the automatic step identification is <u>deactivated</u>, the current step size of all steps is reset to the original value (entered value).
- and the automatic step identification is <u>activated</u>, the current and the original step size (the value which was accepted after the completion of the step identification) of all steps is reset to the initial value of 3 var capacitive. The step identification restarts again.

403	Step type (step 1…max)	AUTO / FON / FOFF

The following step types except for the step type "**Flty**" can be set for each individual step:
- **AUTO** = Step is active and is used by the control.
- **FON** = Step is permanently switched on (step is monitored nevertheless and is switched off in critical situations).
- **FOFF** = Step is permanently switched off / deactivated. Steps which

are not used should be set to this step type in order to prevent unnecessary switching operations and alarms.

- **Flty** = Step was switched three times without success and identified as defective. This is not used for the control anymore. Defective steps are flashing in the step display.

Steps which are set to the step type "**Flty**" can be switched back to the desired step type in this menu.

404	Switching cycle counter (step 1…max)	0...500000

The switching cycle counter of a step is increased by 1 for each complete switching operation (switch-on and switch-off) of the affected step.
The switching cycles of the steps offer conclusions to the condition of the capacitor contactors.
If the service alarm is activated (Setup/506 = YES) and if the switching cycle counter of a step exceeds the set limit (Setup/507), the **OPC** alarm (max. switching cycles) is triggered and signalled.

If, e. g., the power contactor of a step has been changed, the switching cycle counter for this step can be set back to "**0**" in this menu in order to restart monitoring. In this way, an active **OPC** alarm is reset.

If several steps of the same size are connected and the option "**Distribute switching operations of the steps via the operating hours of the individual steps**" is deactivated (SETUP/315 = **NO**), the controller automatically distributes the switching cycles for these steps based on the switching cycle counters so that each of these steps has the same amount of switching operations (+/- 1).

405	Operating hours counter steps (step 1…max)	0...65500 h

The operating hour counter of a step is working while the affected step is switched on.
The operating hour counter of a step offers conclusions to the condition of the running time and the condition of a capacitor.
If the service alarm is activated (Setup/506 = YES) and if the operating hour counter of a step exceeds the set limit (Setup/509) by 1 h, the **OPHS** alarm (max. operating hours steps) is triggered and signalled.

If, e. g., a capacitor has been changed, the operating hour counter for this step can be set back to "**0 h**" in this menu in order to restart monitoring. In this way, an active **OPHS** alarm can be reset.

NOTE: Operating hours can only be entered as full hours.

If several steps of the same size are connected and the option "**Distribute switching operations of the steps via the operating hours of the individual steps**" is activated (SETUP/315 = **YES**), the controller automatically distributes the switching operations for these steps based on the operating hour counters of the individual steps, so that the operating hours for these steps are distributed evenly.

406	Switching output fan as further step output	Yes/No

"**NO**": The switching output fan works normally.
The fan control function via the alarm system is active.

"**YES**": Switching output fan is available as 7th resp. 13th step output.
The fan control function via the alarm system is deactivated.

⚠ CAUTION

When you switch the function, all active steps are always switched off one by one. FON steps are not switched off.

Alarms and monitoring functions can be activated / deactivated and limit values can be set in the alarm menu.

NOTE: The following alarms cannot be deactivated: U, I-HIGH, THD-U, THD-I and TEMP2 alarm. The fan control (TEMP1) can only be deactivated by activating the function SETUP/406 (switching output fan usable as 7th resp. 13th step output). The I-LOW alarm can only be suppressed via the digital input, when the function SETUP/518 is activated.

NOTE: The following alarm cannot be parametrised: I-HIGH alarm (I > 6 A, actual measuring current in the secondary circuit)

The limit values for the U alarm are determined via the settings of the nominal voltage (SETUP/100/Un or SETUP/201), the voltage tolerance range (SETUP/204) and the voltage transformer factor (SETUP/100/Pt or SETUP/203).

The alarm relay opens, when at least one ALARM is active and signalled. The alarm relay does not close again until no ALARM is active anymore.

⚠ CAUTION

In case of the option –m (alarm relay as opener), the logic is the other way round.

<div align="center">

500 Settings ALARM
</div>

MENU	FUNCTION	AREA
501	Reset alarm manually	Yes/No

"**YES**": Alarm messages (display and alarm relay) must be reset manually. In order to reset active alarms, **keep** the key ◄ **(ESC) pressed** for **approx. 3 s.**

"**NO**": As soon as the alarm condition is no longer active, the alarm messages (display and alarm relay) is reset automatically.

NOTE: An alarm can only be reset manually, if it is no longer active. The alarm relay cannot be reset again until no alarm is active anymore.

502	THD-U limit value	3...20 %

Setting of the limit value for the THD-U monitoring.
If the set THD-U limit value is exceeded, the alarm is signalled (display and alarm relay) after the set delay time (SETUP/ 504). The message "**HarU** ₐₗₐᵣₘ" appears on the display. The alarm relay opens its contact.

If the function SETUP/503 is activated, all active steps ("AUTO" & "FON") are switched off one by one with the delay time set under SETUP/504 and are locked for 30 min. The last active step is switched off first, when the delay time has run out after the signalling of the alarm. Then, the other steps are switched off one by one at the interval of the delay time. When all active steps have been switched off, the control is stopped for as long as the alarm is still active.

If the value falls below the set THD-U limit value, a still active step switch-off sequence is cancelled. The already switched-off steps, however, remain locked until the blocking time (max. 30 min) has run out. If the control has been stopped, this is restarted and the controller can switch the steps again. If the function "Manual reset" (SETUP/501 = NO) is deactivated, the alarm messages (display and alarm relay) are reset automatically after 15 s.

NOTE: The alarm relay is only reset, if no other alarm is active.

503	THD-U / THD-I / TEMP 2 alarm = switch off active steps	Yes/No

"**NO**": active steps are not switched off in case of an alarm.

"**YES**": When the set THD-U or THD-I or TEMP 2 limit value is exceeded, all active steps ("AUTO" & "FON") are switched off one by one with the delay time set under SETUP/504 and are locked for 30 min. The last active step is switched off first, when the delay time has run out after the signalling of the alarm. Then, the other steps are switched off one by one at the interval of the delay time. When all active steps have been switched off, the control is stopped for as long as one of these three alarms is still active.

NOTE: The control is stopped while the alarm is still active. The steps which have been switched off by the alarm system are locked for max. 30 min. Active "FON" steps are also switched off and blocked. Steps which have been switched on manually are NOT switched off. If you manually switch off a step, this is only locked during the discharge time.

504	Delay time THD-U, THD-I and TEMP 2 alarm / switch-off interval of the steps	1...255 s

Adjustable delay time for the THD-U, THD-I and TEMP 2 alarm. The set

time is, at the same time, also the switch-off interval of the steps in case of
an alarm, if the setting SETUP/503 is activated.

505	Stop the control if I == 0	Yes/No

**Measuring current refers to the current which is actually measured
by the controller in the secondary circuit (without considering the
current transformer factor).**

"**YES**": If the measuring current is less than 5 mA, the control is stopped.
All active steps remain switched on.
When the measuring current is greater than or equal to 5 mA again, the
control is switched on again and the controller can switch steps on and off
again.

"**NO**": If the measuring current is less than 5 mA and the I-LOW alarm is
signalled, the controller switches off all active steps one by one at an
interval of 60 s. The last active step is switched off first and **immediately**.
The other steps are switched off one by one at the interval. **Active "FON"
steps and steps which have been switched on manually are NOT
switched off.** When the measuring current is greater or equal to 5 mA
again, the still active step switch-off sequence is cancelled.

When the measuring current is greater than or equal to 5 mA again, the
control is switched on again and the controller can switch steps on and off
again.

506	Service alarm	Yes/No

"**YES**": If the set limit of the operating hours of the controller or of a step or
the switching cycles of a step are exceeded, the service alarm is signalled
immediately (display and alarm relay).

"**NO**": The service alarm is not signalled.

507	Max. switching cycles of a step	1...500000

Limit value of switching cycles for steps for the service alarm.
If the service alarm is activated (SETUP/506 = YES) and if the limit value
of the switching cycles for a step is exceeded, the service alarm is
signalled immediately. The message "**OPC ALARM**" is shown on the display
alternatingly with the step number. Only the lowest step number of the
affected steps is displayed. The alarm relay opens its contact.

In order to reset the alarm, change the power contactors of the affected
steps as a preventive maintenance measure before, if necessary. After
this, manually set the switching cycle counters of the affected steps under
SETUP/404 to "0". The alarm messages (display and alarm relay) are not
reset automatically until the switching cycle counters of all steps have
fallen below the set limit and the function "Manual reset" (SETUP/501 =
NO) is deactivated. The alarm relay is only reset, if no other alarm is
active.

508	Max. operating hours of the controller	1...65500 h

Limit value of the operating hours of the controller for the service alarm. If
the service alarm is activated (SETUP/506 = YES) and if the limit value of
the operating hours of the controller is exceeded by 1 h, the service alarm
is signalled immediately and the message "**OPH ALARM**" is shown on the
display. The alarm relay opens its contact.

In order to reset the alarm, perform maintenance works at the system

before, if necessary. After this, manually set the operating hour counter of the controller under SETUP/603 back to 0 h. The alarm messages (display and alarm relay) are not reset automatically until the switching cycle counters of all steps have fallen below the set limit and the function "Manual reset" (SETUP/501 = NO) is deactivated. The alarm relay is only reset, if no other alarm is active.

NOTE: The limit value can only be entered as full hours.

509	Max. operating hours of a step	1...65500 h

Limit value of the operating hours for the steps for the service alarm. If the service alarm is activated (SETUP/506 = YES) and if the limit value of the operating hours for the steps is exceeded by 1 h, the service alarm is signalled immediately and the message "**OPH   ALARM**" is shown on the display alternatingly with the step number. Only the lowest step number of the affected steps is displayed. The alarm relay opens its contact.

In order to reset the alarm, perform preventive maintenance works at the affected steps, if necessary. After this, manually set the operating hour counters of the affected steps under SETUP/405 back to 0 h. The alarm messages (display and alarm relay) are not reset automatically until the operating hour counters of all steps have fallen below the set limit and the function "Manual reset" (SETUP/501 = NO) is deactivated. The alarm relay is only reset, if no other alarm is still active.

NOTE: The limit value can only be entered as full hours.

510	THD-I limit value	1…200%

Setting of the limit value for the THD-I monitoring. If the set THD-I limit value is exceeded, the alarm is signalled (display and alarm relay) after the set delay time (SETUP/ 504) and the message "**HAr I   ALARM**" appears on the display. The alarm relay opens its contact.

If the function SETUP/503 is activated, all active steps ("AUTO" & "FON") are switched off one by one with the delay time set under SETUP/504 and are locked for 30 min. The last active step is switched off first, when the delay time has run out after the signalling of the alarm. Then, the other steps are switched off one by one at the interval of the delay time. When all active steps have been switched off, the control is stopped for as long as the alarm is still active.

If the value falls below the set THD-I limit value, a still active step switch-off sequence is cancelled. The already switched-off steps, however, remain locked until the blocking time (max. 30 min) has run out. If the control has been stopped, this is restarted and the controller can switch the steps again. If the function "Manual reset" (SETUP/501 = NO) is deactivated, the alarm messages (display and alarm relay) are reset automatically after 15 s. The alarm relay is only reset, if no other alarm is active.

NOTE: The control is stopped while the alarm is active. The steps which have been switched off by the alarm system are locked for max. 30 min. Active "FON" steps are also switched off and blocked. Steps which have been switched on manually are NOT switched off. If you manually switch off a step, this is only locked during the discharge time.

511	Digital input active in case of HIGH signal	Yes/No

"**YES**" = HIGH active:
No signal is applied at the digital input ➜ not active
Signal applied at the digital input ➜ active

"**NO**" = LOW active:
No signal is applied at the digital input ➜ active
Signal applied at the digital input ➜ not active

NOTE: The digital input can be used either for switching to the target COS φ 2 (low rate) or for suppressing the I-LOW alarm. Its function is set under SETUP/518.

		3…
512	Temperature limit 1 = fan	(TEMP2-5K) °C

If the temperature limit 1 is exceeded, the controller switches on the switching output for the fan. The status message "**FAN**" is flashing on the display in the bottom line of the main menu. If the temperature falls below the temperature limit 1 by 5 K, the controller switches off the switching output for the fan again after 10 s. The status message "**FAN**" is no longer shown on the display.

NOTE: If the switching output is used as an additional step output (SETUP/406) ("YES"), the fan control is activated via the alarm system.

		(TEMP1+5K)…
513	Temperature limit 2 = alarm	60 °C

Setting of the temperature limit 2 = temperature alarm.
If the temperature limit 2 is exceeded, the alarm is signalled after the set delay time (SETUP/ 504). The message "**thi** ALARM" is shown on the display and the alarm relay opens its contact. If the function SETUP/503 is activated, all active steps ("AUTO" & "FON") are switched off one by one with the delay time set under SETUP/504 and are locked for 30 min.

The last active step is switched off first, when the delay time has run out after the signalling of the alarm. Then, the other steps are switched off one by one at the interval of the delay time. When all active steps have been switched off, the control is stopped for as long as the alarm is still active.

If the temperature falls below the temperature level 2 by 5 K, the still active step switch-off sequence is cancelled. The already switched-off steps, however, remain locked until the blocking time (max. 30 min) has run out. If the control has been stopped, this is restarted and the controller can switch the steps again. If the function "Manual reset" (SETUP/501 = NO) is deactivated, the alarm messages (display and alarm relay) are reset automatically after 10 s. The alarm relay is only reset, if no other alarm is active.

NOTE: The control is stopped while the alarm is still active. The steps which have been switched off by the alarm system are locked for max. 30 min. Active "FON" steps also are switched off and blocked. Steps which have been switched on manually are NOT switched off. If you manually switch off a step, this is only locked during the discharge time.

514	Control alarm (target COS φ cannot be reached)	Yes/No

"**YES**": Control alarm is activated. If the controller could not reach the target COS-PHI after a 75-fold switching time, because no suitable step is available to be switched on resp. off (φ Q > smallest step➜ over- /under-compensation), the control alarm is signalled. The message "**PFC** ALARM" is shown on the display and the alarm relay opens its contact. When the control reaches the target COS-PHI again, the alarm messages (display and alarm relay) are automatically reset, if the function "Manual reset" (SETUP/501 = NO) is deactivated. The alarm relay is only reset if no other alarm is active.

"**NO**": Control alarm is deactivated.

515	Step alarm: Faulty steps	Yes/No

"**YES**": Alarm for faulty steps is activated. If the function SETUP/309 is activated and if a step is identified as faulty after 3 unsuccessful switching operations, the step alarm faulty steps is signalled. The message "**Step ALARM / Flty**" is shown alternatingly on the display. Steps which have been identified as defective and have been blocked are flashing on the step display. The alarm relay opens its contact. The alarm remains active while at least one step is set to the step type "**Flty**".

In order to reset the alarm, set the step type of the affected step to not equal to "**Flty**". If the function "Manual reset" (SETUP/501 = NO) is deactivated, the alarm messages (display and alarm relay) are automatically reset. The alarm relay is only reset, if no other alarm is active.

"**NO**": Alarm for faulty steps is deactivated.

516	Step alarm: Step power loss	Yes/No

"**YES**": Alarm for step power loss is activated.
If the current step size falls below 75% of the initial size, the step alarm step power loss is signalled.

The message "**SPI ALARM**" is shown on the display alternatingly with the step number. Only the lowest number of the affected steps is displayed. The alarm relay opens its contact. The step type of the affected steps is set to "FOFF" and blocked. The step is locked for the control. The step is locked for as long as the current step size is smaller than 75% of the initial size. The step type cannot be changed.

In order to reset the alarm and to activate the affected steps, these steps must be changed first. After this, manually enter the step sizes of the replaced steps in the SETUP/402, so that the current step size is correct again and is equal to the initial size ➔100%. The step type of these steps can be set again now. If the function "Manual reset" (SETUP/501 = NO) is deactivated, the alarm messages (display and alarm relay) are automatically reset. The alarm relay is only reset, if no other alarm is active.

"**NO**": Step alarm step power loss is deactivated.

517	The display is flashing when an alarm is signalled.	Yes/No

"**NO**": Display is **NOT** flashing when an alarm is signalled. This is the default setting.

"**YES**": Display is flashing when an alarm is signalled.

NOTE: This only works when the backlighting is switched off. If you press a key on the device, the backlighting is switched on again. The display is not flashing anymore. If no other key is pressed, the backlighting is switched off after 60 s. The display is flashing again.

518	Switching between functions of digital input	Yes/No

"**NO**": The digital input can be used in order to switch to the target COS $\varphi 2$ (low rate). This is the default setting.

"**YES**": Digital input can be used in order to supress the I-LOW alarm.

| 519 | Info: I-LOW alarm suppression |

For information purposes only. No settings possible.
"**YES**" = Digital input is active; I-Low alarm is suppressed.

"**NO**" = Digital input is not active; I-Low alarm is NOT suppressed.

NOTE: I-LOW alarm can only be suppressed via the digital input, if the function SETUP/518 is activated.

9.10   600 RESET menu

Enables the resetting of all settings made, of the values saved by the controller and of the counters. In addition, it is possible to request the software version of the device and to change the password (PIN) for the expert setup menu.

600 RESET menu

MENU	FUNCTION	AREA
601	RESET settings	Yes/No

„**YES**": Resets all settings made including the setting of the discharge time of the steps (SETUP/401) and the function "Use switching output FAN as step switching output" (SETUP/406) to factory settings.

Exception: The step database (SETUP/402, 403, 404 und 405) is not reset.

NOTE: The nominal voltage, the current transformer factor, the voltage transformer factor and the phase correction angle must be entered again, so that all measurement values are displayed correctly and the control is functioning. As an alternative to the entry of the phase correction angle, it is also possible to execute the automatic initialisation (AI).

602	RESET step database	Yes/No

"**YES"**: Resets the step database (SETUP/402, 403,404, 405) and the function "Use switching output FAN as step switching output" (SETUP/406) to factory settings.
EXCEPTION: The setting of the discharge time of the steps (SETUP/401) is not reset.

⚠ **CAUTION**
All active steps, including the FON steps, are immediately switched off.

NOTE: All step sizes, switching cycle counters and operating hour counters of the steps are reset. In this way, the previously recorded power loss, switching cycles and operating hours of all steps are lost. An active service alarm with regard to the switching cycles and operating hours of steps is thus also reset.

NOTE: If the step identification is switched off (SETUP/308 = NO), the control is switched off, set to "OFF" and blocked. The step sizes must be entered manually again (SETUP/402). The control must be switched on again (SETUP/100/PFC or SETUP/310). The setting of the control remains blocked until the current transformer factor is entered once and at least one step size is entered manually. Then, the control can be switch on again.

603	RESET operating hour counter	Yes/No

"**YES**": Resets the operating hour counter of the controller.
After confirming the setting with **"YES"**, the RESET takes place. The setting will automatically return to **"NO"**.

604	RESET average system power factor (SPF)	Yes/No

"**YES**": Resets the average system power factor (SPF). After confirming the setting with **"YES"**, the RESET takes place. The setting will automatically return to **"NO"**.

605	RESET maximum measured temperature	Yes/No

"**YES**": Resets the value of the maximum measured temperature. After confirming the setting with **"YES"**, the RESET takes place. The setting will automatically return to **"NO"**.

606	RESET alarm messages	Yes/No

"**YES**": Resets all active alarm messages (display and alarm relay) and the alarm memory (menu ALARM).
After confirming the setting with **"YES"**, the RESET takes place. The setting will automatically return to **"NO"**.

NOTE: The alarm messages on the display are only reset, if the respective alarms are not active anymore. The alarm relay is only reset, if no alarm is active anymore.

607	Display of the software version status of the device	-------

For information purposes only. No settings possible.
Software version of the device. This is shown as moving script: **xx.xx.xx**

608	Setting of the expert SETUP password (PIN).	0…999

Setting of the expert SETUP password (PIN) for the SETUP menus 200, 300, 400, 500, 600 and 700.

NOTE: The SETUP menu 100 is always available even without PIN. The SETUP menu 700 is only available with the option -MB.
    9.11

700 Settings MODBUS (communication interface)

Contains settings in order to parametrise the MODBUS-RTU communication interface (RS485).

NOTE: This submenu is only available with the option -MB.

700 Settings MODBUS

MENU	FUNCTION	AREA
701	Baud rate	1200,2400,4800, 9600,19200, 38400,57600, 115200
	Setting of the baud rate (transmission rate) of the communication interface.	
702	Parity and stop bit	EVEN/ODD/ NONE
	Setting of the parity and the stop bits of the communication interface. **EVEN:** Parity = **Even** Stop bits = **1** **ODD:** Parity = **Odd** Stop bits = **1** **NONE:** Parity = **None** Stop bits = **2**	
703	MODBUS slave address	1…247
	Setting of the MODBUS slave address (BUS address)	

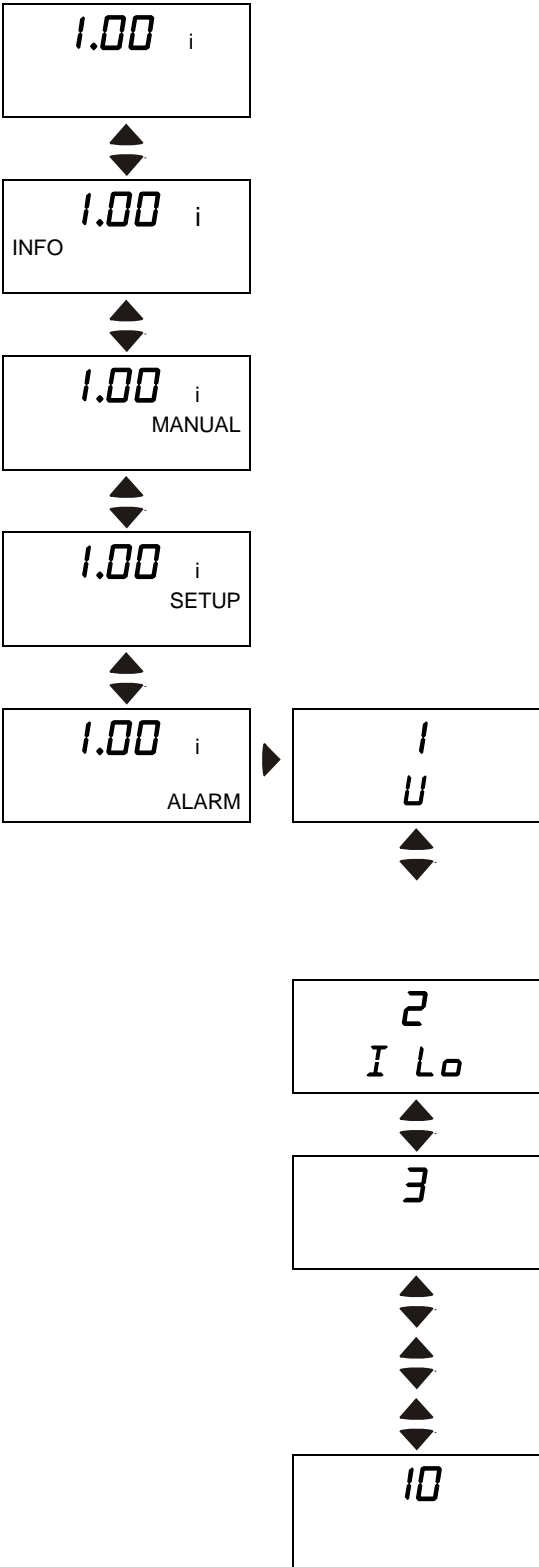**NOTE:** The BUS address may only be assigned once within the BUS.

9.12 Alarm memory menu

The last 10 occurred and signalled alarms are saved and displayed in the alarm memory. The latest alarm is on memory space 1, the oldest alarm on memory space 10. The alarm memory works as sliding buffer. If a new alarm is signalled, this is saved at the first space. In the process, all previously available entries (1-10) from memory space 1 onwards are each moved on by one memory space. As a consequence, the alarm previously saved under memory space 10 is deleted. The alarm memory is non-volatile. This may be deleted completely by simultaneously pressing the keys "▲" and "▼" for approx. 3 s in the alarm memory menu. The alarm memory may also be deleted under SETUP/606.

NOTE: As a consequence, all alarms signalled on the display and the alarm relay are also reset, if no alarm is active anymore.

```
┌─────────────────┐
│   1.00    i     │
│                 │
└─────────────────┘
         ▲
         ▼
┌─────────────────┐
│   1.00    i     │
│ INFO            │
└─────────────────┘
         ▲
         ▼
┌─────────────────┐
│   1.00    i     │
│        MANUAL   │
└─────────────────┘
         ▲
         ▼
┌─────────────────┐
│   1.00    i     │
│         SETUP   │
└─────────────────┘
         ▲
         ▼
┌─────────────────┐      ┌─────────────────┐
│   1.00    i     │  ▶   │      1          │
│         ALARM   │      │      U          │
└─────────────────┘      └─────────────────┘
                                  ▲
                                  ▼

                         ┌─────────────────┐
                         │      2          │
                         │    I Lo         │
                         └─────────────────┘
                                  ▲
                                  ▼
                         ┌─────────────────┐
                         │      3          │
                         │                 │
                         └─────────────────┘
                                  ▲
                                  ▼
                                  ▲
                                  ▼
                         ┌─────────────────┐
                         │     10          │
                         │                 │
                         └─────────────────┘
```

10 Technical specifications

Measuring and supply voltage:	90 – 550 V AC, single-phase, 45-65 HZ, 6 VA, max. protection 6 A, transformer factor adjustable from 1.0…350.0
Current measurement:	5 mA – 6 A, single-phase, transformer factor adjustable from 1…9600

Switching outputs:
 	
    Relay
 	
    or
 	
    optionally transistor outputs
	Option -06 R or 12 R:
	
	Relay:
	
	Normally open contact, common root, max. protection 10 A
	switching capacity contact: 250 V AC / 5 A
	
	                                                 400 V AC / 1 A
	
	                                                  48 V DC / 1 A
	
	                                                 110 V DC / 0.2 A
	
	Transistor outputs:
	
	Open collector, switching capacity: 8 – 48 V DC / 100 mA

Temperature measurement:	internal NTC (under the housing cover)
Switching output alarm:	Relay, potential-free, normally open contact closed in normal operating condition, opens in case of an alarm and in case of a failure of the supply voltage (life contact) max. protection 2 A, switching capacity contact: 250 V AC / 5 A
Switching output fan:	Relay, potential-free, normally open contact Can alternatively be used as 7th resp. 13th switching output for a step (function may be switched). max. protection 2 A, switching capacity contact: 250 V AC / 5 A
Digital input:	Input signal: 90 – 250 V AC Logic: HIGH- / LOW active (adjustable)
Communication interface:	Protocol: MODBUS-RTU Interface: RS485 Connection: 3-pole screw terminal, pluggable, max. 1.5 mm²
Service interface:	TTL, rear side. **For service purposes only.**
Ambient temperature:	Operation: -20° C – 70° C, storage: -40° C – 85° C
Humidity:	0% - 95%, condensing not allowed
Overvoltage category:	300 V_{LN} / 519 V_{LL} → CAT III > 519 V – 550 V → CAT II Degree of contamination → 2
Standards:	IEC 61010-1

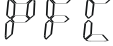|	
	IEC 61000 6- 2
	IEC 61000 6- 4: level B
	IEC 61326- 1
	UL 61010
Conformity and listing:	CE, NRTL(UL), c NRTL (cUL), EAC
Connection:	Screw terminals, pluggable, max. 4 mm²
Housing:	Front: Instrument housing made of plastic (UL 94 V-0), Back: Metal cover
Protection type:	Front: IP41 Back: IP20
Weight:	approx. 0.6 kg
Dimensions:	144 x 144 x 58 mm HxWxD, section 138 (+0.5) x 138 (+0.5) mm

11 Troubleshooting

Fault / alarm	Possible cause	Remedy
No notification on the display	• Measuring / supply voltage misses	• Check, if the connected measuring voltage is in the range of 90…550 V AC. • Check the correct connection of the measuring voltage and correct it, if necessary.
Display notification ALARM	• Measuring voltage out of tolerance •	• Check the measuring voltage. • Check the setting of the nominal voltage and the voltage tolerance and correct it, if necessary. • Check the set voltage transformer factor.
Display notification ALARM"	• Measuring current is too small: • I < 5 mA (I is the actual current which is measured by the controller on the secondary side of the transformer)	• Check the connection of the current transformer, line break possible • Remove the short-circuit jumper of the current transformer • The transmission ratio of the used current transformer is too large •
Display ALARM	• The current is greater than permitted: I > 6 A • (I is the actual current which is measured by the controller on the secondary side of the transformer)	• Overload in the system • Current transformer ratio is too small • ➔ Check the current transformer ratio of the transformer, replace by suitable transformer type, if necessary. •
Incorrect display of the voltages	• Incorrect voltage transformer ratio has been set • Connection identification voltage measurement • Identified as faulty	• Check the setting of the current transformer ratio in the SETUP menu (SETUP/100/Pt resp. • SETUP/203), correct it, if necessary. • Check the setting "Connection of voltage

		measurement" (SETUP/205), correct it, if necessary (depends on the set nominal voltage)
Incorrect display of the current	• Incorrect current transformer ratio has been set.	• Check the setting of the current transformer ratio in the SETUP menu (SETUP/100/Ct resp. • SETUP/202), correct it, if necessary. •
The active power factor, active and reactive power, missing reactive power for the control target are displayed incorrectly.	• The automatic initialisation has not been executed. • The automatic initialisation was cancelled with error. • The phase correction angle was set incorrectly or identified as incorrect by the AI. • Offset reactive power • (Q offset) is set. •	• Start the automatic initialisation "SETUP/100/AI resp. SETUP/207)" in the SETUP menu. • Or check the phase correction angle (SETUP/206) in the SETUP menu, correct it, if necessary. • A transformer is also compensated by the compensation system. The displayed COS φ corresponds to the COS φ upstream of the transformer. • If there is no reason for a set Q offset, check the setting of the • Q offset (SETUP/312), set it to 0 var, if necessary. •
The power factor does not change after switching one or several steps. Steps are switched off again.	• The current transformer is positioned incorrectly. • (Current transformer installed downstream of the exit to the compensation system ➜ the controller only sees the load, thus there is no reactive power change in the supply line.) • Steps are defective.	• Check the installation position of the current transformer according to the wiring diagram (the transformer must be installed upstream of the exit to the compensation system, so that the current of the load and of the compensation is recorded), correct it, if necessary. • Check the capacitor steps; fuse, power contactor or capacitor may be defective. • ➜ change
Alarm	• Permanent	• Check the target COS-PHI

PFC ALARM	overcompensation / under-compensation	settings.
	• (The controller could not reach the target COS-PHI after a 75-fold switching time, because no suitable step is available for switching on resp. off (φ Q > smallest step)	• Check the power contactors, the contactor contact may be stuck together or the contactor coil may be defective.
		• Check the settings of all step types (steps may be set to "FON" ➔ permanently switched on or set to "FOFF" ➔ deactivated)
		• Check the relation of the current to the original step size of the individual steps, the power loss of one or several steps may be too high ➔ change the affected steps, if necessary.
		• Check if one or several steps were identified as defective and were locked ➔ check the capacitors, fuses and power contactors. Set the step type to "AUTO", if necessary.
		• Check the dimensioning of the system. The compensation power may not be enough anymore or the gradation of the step sizes is too rough or the step sizes may be oversized.
		•
Opposite control behaviour: Controller switches on a capacitor step ➔ COS-PHI becomes more inductive instead of changing towards capacitive.	• Phases via the connection of measuring voltage and current do not correspond to the set phase correction angle • Connection of measuring voltage and current has been connected at a twisted angle of 180° (U2 / U1 instead of U1 / U2 resp. S2 / S1 instead of S1 / S2). •	• Correct the connection of current and voltage, if necessary, or adjust the phase correction angle. • If the connection of voltage or current has been mixed up, correct the connection or add 180° to resp. subtract 180° from the set phase correction angle (new angle < 360°) and enter.
EXPORT and a COS-PHI capacitive are shown on the display, even though no active power is fed back and the COS-	• Connection of measuring voltage and current has been connected at a twisted angle of 180° (U2 / U1 instead of U1 / U2 resp. S2 / S1 instead	• If the connection of voltage or current has been mixed up, correct the connection or add 180° to resp. subtract 180° from the set

PHI is inductive.	of S1 / S2).	phase correction angle (new angle < 360°) and enter.
Individual steps are neither switched on nor off	• Step types incorrect settings	• Check the settings of the step types: steps may be set to "FON" ➔ permanently switched on or set to "FOFF" ➔ deactivated)
Steps are identified as defective Steps are switched off again and locked Alarm STEP ALARM / FLTY ALARM	• Step is defective	• Check the capacitor steps; fuse, capacitor or contactor may be defective. • Set the step type back to "AUTO" after the cause has been eliminated in order to reset the alarm. The control can use the steps again for the control.
Steps are not switched on	• Steps are too big	• The necessary reactive power is less than the switching threshold of the step power of the smallest capacitor step. • Check ΔQ in the measurement value menu. • Check the dimensioning of the system. The gradation of the step sizes may be too rough or the step sizes may be oversized.
No steps may be switched in the manual mode.	• Steps are locked, because • U-Alarm is active or the discharge time of the steps is still running. • Steps have been switched off due to the THD-U, THD-I or TEMP2 alarm and have been locked for 30 min. • LIFO, combi filter or FIFO has been set as control algorithm.	• Check if the measuring voltage is within the valid range and if the U alarm is signalled, enter the set nominal voltage again, if necessary. • After a restart of the control, wait for the set discharge time lock and try again. • If steps have been switched off due to the • THD-U, THD-I or TEMP2 alarm, wait for the blocking time of 30 min. • In order to test the steps, use the control algorithm Best Fit ("AUTO") (SETUP/311). •

Alarm 𝟻𝟶𝖯𝖫 ALARM / 𝟶 𝟶 ALARM (Step Power Lost) The affected steps are not switched on anymore resp. cannot be switched on in manual operation.	• Step alarm step power loss: • The ratio of the current to the original step size has fallen below 75% (power loss). • ➔ Affected steps have been set to "FOFF" and are locked for as long as the alarm is active.	• Check the power loss of the affected steps (relation of the current to the original step size), change the affected steps, if necessary, and manually enter the step sizes again in order to reset the alarm. Then, the step type of the steps can be set back to "AUTO".
TEMP1 limit value has been exceeded, but the switching output for the fan does **NOT** switch on.	• The switching output for the fan is used as 7th resp. 13th step output.	• Check the settings for the fan switching output: • SETUP/406 may be set to "YES" ➔ switch to "NO".
Switching output for the fan switches on (step symbol 13 is displayed), even though TEMP1 limit value has **NOT** been exceeded.	• Use the switching output for the fan as 7th resp. 13th step output.	• Check the settings for the fan switching output: • SETUP/406 may be set to "YES" ➔ switch to "NO".
Switching output of step 13 is not used by the control resp. it is not possible to switch it in manual operation, because step 13 cannot be selected.	• Switching output fan is set as fan switching output (default).	• Check the settings for the fan switching output: • SETUP/406 may be set to "NO" ➔ switch to "YES". • Check the step type for the step output 13; switch to "AUTO", if necessary. • Is the root connection of the fan switching output connected to the supply voltage as illustrated on the wiring diagram (NO INTERNAL CONNECTION to the root connection of the step switching outputs)
No display notification "𝟶 𝟶 𝟶 ALARM" even though the measuring current is less than 5 mA	• I-LOW alarm is suppressed by the digital input.	• Check the INFO display under SETUP/519 ➔ "YES" == I-LOW alarm is suppressed by the digital input. Do not .trigger the digital input, should the occasion arise. • Check the setting for the switching between functions of the digital input (SETUP/518), switch to "NO", if necessary. • Check the setting of logic digital input (SETUP/511) and switch to logic, if necessary:

		• NO = LOW active • YES = HIGH active
No display notification "**NT**", control does not work with target COS-PHI, even though the digital input is activated.	• The function of the digital input is switched to "Suppression of I-LOW alarm". • Logic digital input is set incorrectly. •	• Check the setting for the switching between functions of the digital input (SETUP/518), switch to "NO", if necessary. • Check the setting of logic digital input (SETUP/511), switch to logic, if necessary: • NO = LOW active • YES = HIGH active

12 Applications

12.1   Additional switching output for a step

The controller has only 6 or 12 switching outputs. An additional switching output, however, is required for a step.

Solution:

The CX plus offers the possibility to use the switching output for the fan as additional switching output for a step.

Procedure:

- Activate the function "**Use the switching output FAN as step switching output**" (SETUP/406).

  Set the setting to "**YES**" in the SETUP menu 406.

⚠ CAUTION
When you switch between functions, all active steps must always be switched off one by one first, before the control may restart. FON steps are not switched off.

- Set the step type for the additional switching output (SETUP/100/OUt and SETUP/403).

Set the desired step type for the step output no. 7 resp. 13 in the SETUP menu 100/OUt or 403 (DEFAULT: "AUTO").

- If the step identification is switched off (SETUP/308 = **NO**), the step size for the step output no. 7 resp. 13 must be entered manually in the SETUP menu 402.

Function:

If the step type is set to "**AUTO**", the controller uses the "fan switching output" as 7th resp. 13th step. If the controller switches on the switching output, this is signalled with the step symbol "7" resp. "13" on the display. If the step type is set to "FON", this step is permanently switched on.

NOTE: If the function "Use the switching output FAN as step switching output" (SETUP/406) is activated, the fan activation by the alarm system is deactivated. If the temperature limit 1 is exceeded, the status message "FAN" is no longer displayed. The switching output fan which has been switched on by the alarm system is immediately switched off. It is now activated by the control (additional switching output).

12.2 Fan activation

The controller shall take over the fan activation depending on the temperature in the switch cabinet.

Solution:

The CX plus is equipped with a temperature sensor (NTC) integrated under the housing. The limit value, at which the switching output for the fan shall be activated, can be set in the alarm system.

Procedure:

- Deactivate the function "**Use the switching output FAN as step switching output**" (SETUP/406).

Set the setting to "**NO**" in the SETUP menu 406 (DEFAULT).

| ⚠ **CAUTION** |
|---|
| When you switch between functions, all active steps must always be switched off one by one first, before the control may restart. FON steps are not switched off. |

- Set the temperature limit 1 in the SETUP/512.

Set the temperature limit 1 in the SETUP menu 512. The temperature limit 2 (SETUP/513) may have to be increased, because the maximum setting range of the temperature limit 1 depends on the set temperature limit 2: **TEMP1$_{max}$ = TEMP2 – 5K**

Function:

Upon exceeding the temperature limit 1, the switching output fan is switched on. The status message "**FAN**" is flashing on the display in the bottom line in the main menu. If the temperature in the switch cabinet falls and if the value falls below the temperature limit 1 by 5 K, the switching output fan is switched off again after 10 s. The status message "**FAN**" is no longer shown on the display. A flapping of the fan switching output is prevented by the temperature hysteresis of 5 K.

NOTE: If the submenus "INFO", "MANUAL", "SETUP" or "ALARM" are active, the status message "FAN" is not displayed.

NOTE: An active error message Ro / $Abrt$ suppresses the status message "FAN". Reset the error message Ro / $Abrt$ by pressing the ◄(ESC) key for 3 s.

12.3   Over-temperature switch-off steps

The controller shall switch off the active steps depending on the temperature in the switch cabinet in case of over-temperature.

Solution:

The CX plus is equipped with a temperature sensor (NTC) integrated under the housing. The limit value, at which the switching outputs of the active steps shall be switched off one by one while the temperature alarm is still active, can be set in the alarm system. In this way, the steps are protected against overheating and the temperature in the switch cabinet can return to normal.

Procedure:

- Set the temperature limit 2 in the SETUP/513.

Set the temperature limit 2 in the SETUP menu. The temperature limit 1 (SETUP/512) may have to be reduced, because the minimum setting range of the temperature limit 2 depends on the set temperature limit 1: **$TEMP2_{min}$ = TEMP1 + 5K**

- Activate the function "**Switch off steps one by one in case of TEMP alarm**" (SETUP/503)

Activate the function "**Switch off steps one by one in case of TEMP alarm**" (step switch-off sequence) in the SETUP/503: SETUP/503 == **YES**

- Delay time TEMP alarm / cycle step switch-off sequence (SETUP/504)

Set the delay time for the TEMP alarm in the SETUP menu 504. At the same time, this is also the cycle for the step switch-off sequence.

Function:

Upon exceeding the temperature limit 2, the set delay time (SETUP/504) will run out first. After the delay time has run out, the message $\vartheta > \vartheta_{00}$ ALARM is signalled on the display and the contact of the alarm relay is activated. After the set delay time has run out again, the step switch-off sequence begins: In the process, the last active step (AUTO, FON) is switched off first. All active steps (AUTO, FON) are switched off one by one in the cycle of the set delay time, for as long as the temperature alarm is still active. All steps which are switched off by the alarm system are locked for 30 min. When all active steps have been switched off, the control is stopped.

NOTE: The alarm system does not switch off steps in manual operation. The step switch-off sequence does not start until you leave the MANUAL menu.

If the temperature in the switch cabinet falls and if the temperature falls below the temperature limit 2 by 5 K, a still active step switch-off sequence is cancelled. The control starts again and may switch steps on and off again. The steps which have been switched off by the alarm system, however, remain locked for the duration of the blocking time and thus are not available for the control.

If the function "Manual reset" (SETUP/501 = NO) is deactivated, the alarm messages (display and alarm relay) are automatically reset after 15 s. The alarm relay is only reset, if no other alarm is active.

12.4 THD-U / THD-I protection

The controller shall protect the active steps by switch-off in case the entire harmonic distortion on the voltage (THD-U) or on the current (THD-I) is exceeded.

Solution:

The alarm system of the CX plus can react when the set limit values of the entire harmonic distortion on the voltage (THD-U) or on the current (THD-I) is exceeded and it can switch off all active steps in order to protect the capacitors. The limit values for the THD-U and the THD-I can be set individually in the alarm system.

Procedure:

- Set the THD-U limit value in the SETUP/502.

Set the limit value for the THD-U alarm in the SETUP menu 502.

- Set the THD-I limit value in the SETUP/510.

Set the limit value for the THD-I alarm in the SETUP menu 510.

- Activate the function "**Switch off steps one by one in case of TEMP alarm**" (SETUP/503).

Activate the function "**Switch off steps one by one in case of TEMP alarm**" (step switch-off sequence) in the SETUP/503: SETUP/503 == **YES**

- Delay time TEMP alarm / cycle step switch-off sequence (SETUP/504)

Set the delay time for the TEMP alarm in the SETUP menu 504. At the same time, this is also the cycle for the step switch-off sequence.

Function:

Upon exceeding the THD-U or the THD-I limit value, the set delay time (SETUP/504) will run out first. After the delay time has run out, the message **HarU** (THD-U alarm) resp. **HarI** (THD-I alarm) is signalled on the display and the contact of the alarm relay is activated.

After the set delay time has run out again, the step switch-off sequence begins: In the process, the last active step (AUTO, FON) is switched off first. All active steps (AUTO, FON) are switched off one by one in the cycle of the set delay time, for as long as one of the two alarms is still active. All steps which have been switched off by the alarm system are locked for 30 min. When all active steps have been switched off, the control is stopped.

NOTE: The alarm system does not switch off steps in manual operation. The step switch-off sequence does not start until you leave the MANUAL menu.

If the THD-U and the THD-I fell below the set limit values, a still active step switch-off sequence is cancelled. The control starts again and may switch steps on and off again. The steps which have been switched off by the alarm system, however, remain locked for the duration of the blocking time and thus are not available for the control.

If the function "Manual reset" (SETUP/501 = NO) is deactivated, the alarm messages (display and alarm relay) are automatically reset after 15 s. The alarm relay is only reset, if no other alarm is active.

12.5   Switching to target Cos φ 2 via the digital input

The CX plus shall be switched to the second target COS φ via an external switching signal.

Solution:

The digital input of the controller may be used for switching to the set target COS φ 2.

Procedure:

- Activate the function "**Digital input switches to the target COS φ 2**" (SETUP/518).

Set the setting to "**NO**" in the SETUP menu 518 (DEFAULT).

- Set the logic of the digital input (SETUP/511).

The logic can be set in the SETUP menu 511, whether the digital input is HIGH or LOW active:

"YES" = HIGH active

"NO" = LOW active

Function:

If the digital input is activated, the notification "**NT**" appears on the display and the controller regulates towards the set **target COS φ 2**.

If the digital input is no longer activated, the notification "**NT**" disappears from the display and the controller regulates towards the set **target COS φ 1** again.

12.6   Suppression of the I-LOW alarm by the digital input

I-LOW condition during the off-peak period may be a normal operating condition. Therefore, the CX plus shall not signal an I-LOW alarm. Because of this, the I-LOW alarm shall be suppressed via an external switching signal.

Solution:

The digital input of the controller may be used for suppressing the I-LOW alarm.

Procedure:

- Activate the function "**Suppress the I-LOW alarm via the digital input**" (SETUP/518).

Set the setting to "**YES**" in the SETUP menu 518.

- Set the logic of the digital input (SETUP/511).

The logic may be set in the SETUP menu 511, whether the digital input is HIGH or LOW active:

"YES" = HIGH active

"NO" = LOW active

Function:

If the digital input is activated, an active I-LOW alarm is suppressed. "**YES**" is shown on the status display for the I-LOW alarm suppression (SETUP/519).

If the digital input is no longer activated, the suppression is deactivated. An active I-LOW alarm is signalled now (display and alarm relay).

"**NO**" is shown on the status display of the I-LOW alarm suppression (SETUP/519).

NOTE: If an active I-LOW alarm is signalled and if the digital input is activated for suppression, the alarm message is only reset after 15 s. The AUTO symbol is not displayed again until the set switching time has run out, provided that the control is not switched off.

NOTE: If an active I-LOW alarm is being suppressed at the moment and if the digital input is no longer activated, the alarm is not signalled until the delay time of 60 s has run out.

NOTE: If the delay time has not run out yet and if the digital input is activated again, an active I-LOW alarm is suppressed immediately. If the digital input is no longer activated, the delay time is restarted (60 s). The I-LOW alarm is signalled after the delay time has run out.

12.7 Detection of step power loss (Step Power Loss)

The CX plus shall detect the power loss of the individual steps and switch off and permanently lock the affected steps in case the value falls below a limit value.

Solution:

The CX plus continuously adjusts the current step size to the determined value when switching a step on and off. This function is also active when the step identification is switched off.

The alarm system of the CX plus compares the current step size of each individual step with the original step size:

Step size in % of the initial value = current step size / original step size *100%

If the current step size fell below 75% of the original step size, the alarm system may trigger a step alarm step power loss and switch off and permanently lock the affected steps.

The step alarm step power loss serves for the protection of the upstream throttle of the individual capacitor steps. The capacitor and the upstream throttle form a filter (absorption circuit). This is designed in a way that an odd harmonic is not completely absorbed. If the current step power has already fallen below 75% and if it continues to fall, there is the risk that the absorption circuit completely absorbs the odd harmonic. In this way, the throttle is overloaded and wiil finally be destroyed.

Procedure:

- Activate the function "Step alarm step power loss" (SETUP/516).

  Set the setting to "**YES**" in the SETUP menu 516.

Function:

If the current step size of a step fell below 75% of the original step size, the step alarm step power loss is triggered. The message SPL　　ALARM and the step number of the affected step are signalled alternatingly on the display and the contact of the alarm relay is activated.

If several steps are affected, only the lowest step number of the affected steps is displayed.

The affected step is switched off immediately and set to the step type "FOFF". The step is locked for the control resp. manual operation. The step type of the affected step is blocked and cannot be changed.

In order to reset the alarm and to activate the affected steps, the steps must be changed first. After this, the step size must be entered manually (SETUP/402) for each affected step. The step size for these steps may now be set back to "**AUTO**". The steps may be switched again by the control resp. in manual operation.

If no step triggers the alarm anymore, the alarm is reset, provided that the function "Manual reset" (SETUP/501 = NO) is deactivated. The alarm messages (display and alarm relay) are reset automatically. The alarm relay is only reset, if no other alarm is active.

NOTE: The monitoring of a step only works, if the step identification for this step is concluded or if the step size was entered manually.

13 Identification / manual entry of step sizes

13.1 Step identification is activated – Automatic identification of the step size

If the step identification is activated (SETUP/308 = **YES**), the CX plus automatically determines the step size after switching on and after switching off a step, respectively. This value is saved as the current step size for this step in the step database after the first switching operation. Then, the current step size is quickly adjusted to the determined value during the first 50 switching operations. The step identification for a step is completed after 50 switching operations (switching on 25 times, switching off 25 times).

The original step size is now equated with the current step size in the step database. The monitoring of the step power loss is active for this step from now on.

The step identification for a step may be concluded prematurely by manually entering the step size. From the 51st switching operation on, the CX plus continuously adjusts the current step size to the determined value when switching a step on and off. The adjustment takes place softly, so that a heavy load fluctuation during the measurement does not falsify the step size. In this way, the power loss of a step may be determined.

The updating and adjustment of the step size is even active when the step identification is switched off.

If the controller cannot identify a mains reaction during the first 3 switching operations (switching on and off = 1 switching operation), the step type of the affected step is set to "**FOFF**".

If a step has more than three switching operations and if the controller cannot identify a mains reaction during 3 consecutive switching operations, the step is considered as faulty by the control. If the function "**Lock faulty steps**" is activated (SETUP/309 = **YES**), the affected step is set to the step type "**Flty**" and is ignored by the control. It is not possible to switch this step manually. The step symbol of the faulty step is flashing in the step display on the display.

If the current transformer or the voltage transformer factor is entered, all step sizes (current and original step size) are reset to the initial value of 3 var capacitive. The step identification starts all over again.

NOTE: If inductive steps are connected, the step sizes must be entered manually, because the initial value is 3 var capacitive and thus cannot be switched on in case of a capacitive network.

13.2 Problems regarding the step identification

The step identification can be falsified due to heavy and rapid load fluctuations. In this case, the determined step sizes may extremely deviate from the actual nominal value. It is possible, that a capacitive step is identified as an inductive step. The control will not work correctly in this case.

Solution:

In this case, the step sizes = step nominal value must be entered manually.

Procedure:

- Switch off the control.

Set the setting the "**OFF**" in the SETUP menu 100/ PFC or 310.

- Switch off the step identification.

Set the setting to "**NO**" (step identification off) in the SETUP menu 308.

- Enter the step sizes manually.

Enter the respective step nominal value for all connected steps in the SETUP menu 402.

- Check the step type.

In case of problems with the step identification, it is possible that connected steps have been set to "**FOFF**" by the controller. Therefore, the step size of the individual steps should be checked in the SETUP menu 100/OUt or 403 and be switched to "AUTO", if necessary.

- Switch on the control again.

Set the setting to "**ON**" in the SETUP menu 100/ PFC or 310.

The control can now work normally. Despite the step identification being switched off, the current step sizes are updated (power loss identification) and faulty steps are identified.

13.3   Step identification is deactivated / manual entry of the step sizes

The step sizes = step nominal values must be entered manually, when the step identification is switched off (SETUP/308 = **NO**). Otherwise, the controller will switch on and immediately switch off steps again, because the initial value of the current step size deviates too much from the actual step size in the step database (3 var capacitive).

The step size = step nominal value can be entered for each individual step in the SETUP menu 402. The original step size is equated with the current step size in the step database after entering the step size for a step. The monitoring of the step power loss is active for this step from now on.

The CX plus continuously adjusts the current step size to the determined value when switching a step on and off. The adjustment takes place softly, so that a heavy load fluctuation during the measurement does not falsify the step size. In this way, the power loss of a step may be determined. The updating and adjustment of the step size is even active when the step identification is switched off.

If the controller cannot identify a mains reaction during 3 consecutive switching operations (switching on and off = 1 switching operation), the step is considered as faulty by the control. If the function "**Lock faulty steps**" is activated (SETUP/309 = **YES**), the affected step is set to the step type "**Flty**" and is ignored by the control. It is not possible to switch this step manually. The step symbol of the faulty step is flashing in the step display on the display.

If the current transformer or the voltage transformer factor is entered, the current step size of each individual step is reset to its original value (the last manually entered value).

NOTE: The control is switched off, set to "OFF" and blocked, when you switch off the step identification. This setting remains blocked until the current transformer factor is entered once and at least one step size is entered manually. The control cannot be switched on again until then.

14 Identification / resetting of defective steps

If the controller has identified a step as defective (3 consecutive switching cycles without mains reaction) and blocked this (step type = "**Flty**"), this step is blocked for the control for 24 hours. **Defective steps are only locked, if the function "Lock faulty steps" is activated (SETUP/309 = YES).** After this blocking time, the controller resets the step type of this step to "**AUTO**" and tests this step again, if necessary. If again no mains reaction is identified to 3 consecutive switching cycles, this step is locked by the control again for 24 hours (step type = "**Flty**").

Locked faulty steps are displayed with the step type "**Flty**" in the menu "**INFO**". The respective step symbol of the step is flashing in the step display.

If the defective step was changed resp. the defective fuse was replaced, the step type can be switched manually back to "**AUTO**" (SETUP/100/OUt or SETUP/403). Then, the step is available to the control for switching again resp. may be switched again in manual operation.

If a defective power contactor was responsible for the identification of the faulty step, the switching cycle counter of this step (SETUP/404) should be reset manually to 0 after changing the contactor in order to restart the switching cycle monitoring for the contactor.

15 Adding additional steps

If an existing system is extended by one or several steps, the additional steps may be added in the step database.

For this purpose, the step type of the additionally occupied switching outputs must be set to "**AUTO**" (SETUP/100/OUt or SETUP/403).

If the step identification is switched off (SETUP/308 = **NO**), the step sizes for these steps must also be entered manually (SETUP/402).

16 Automatic distribution of switching operations to steps

The CX plus automatically distributes the switching operations to all connected steps **of the same size**. This is realised either via the switching cycle counters of the individual steps (default setting) or via the operating hours of the individual steps.

16.1 Distribution of the switching operations via the switching cycles

If several steps of the same size are connected and the option "**Distribute the switching operations steps via the operating hours of the individual steps**" is deactivated (SETUP/315 = **NO**), the controller automatically distributes the switching cycles for these steps based on the switching cycle counters, so that each of these steps has the same amount of switching operations (+/- 1).

Example:

Steps 5, 6 and 7 have the same step size.

If the steps 5 and 6 have **13 switching cycles** and the step 7 only **12 switching cycles**, the controller will switch on step 7 first for the next switch-on in order to distribute the switching cycles evenly.

16.2 Distribution of the switching operations via the operating hours

If several steps of the same size are connected and the option "**Distribute the switching operations steps via the operating hours of the individual steps**" is activated (SETUP/315 = **YES**), the controller automatically distributes the switching operations for these steps based on the operating hour counters of the individual steps, so that the operating hours for these steps are distributed evenly.

Example:

Steps 5, 6 and 7 have the same step size.

If the step 5 was in operation for **2 h**, step 6 for **1 h** and step 7 for **3 h**, the controller will switch on step 6 first for the next switch-on in order to distribute the operating hours evenly.

NOTE: The distribution of the switching operations in case of steps of the same size is only active in the control algorithm "BEST-FIT".

17 Automatic initialisation

⚠ **CAUTION**
The phase correction angle must be set depending on the connection of measuring voltage and current, so that the measurement of the active and reactive power, the COS-PHI, the power factor and the automatic identification of the step sizes works perfectly. This is a condition for a perfect functioning of the control.

The automatic initialisation can identify the connection of the controller and automatically sets the phase correction angle after a successful completion. The automatic initialisation also identifies,

whether or not steps are connected at the switching outputs. Not occupied switching outputs are set to the step type "**FOFF**".

NOTE: The "Automatic initialisation" does not perform an identification of the step sizes. The identification of the step sizes only takes place via the control in normal control operation (see chapter "Identification / manual entry of step sizes").

The phase correction angle can also be set manually in the SETUP menu 206. The step types of the not occupied switching outputs can be set to "**FOFF**" manually in the SETUP menu 100/OUt or 403.

NOTE: We recommend checking the step types of the switching outputs after the successful completion of the "Automatic initialisation" with regard to whether all connected steps are still set to the step type "AUTO".

It may happen that the AI did not identify occupied switching outputs correctly and set these to the step type "**FOFF**".

17.1 Procedure of the automatic initialisation

If the automatic initialisation was activated in the SETUP menu 100/AI or 207 by setting the setting to "**YES**", the AI will start as soon as the voltage is in the valid range, the measuring current is **greater than 5 mA**. The AI switches on the first step, when the discharge time of the steps and the set switching time have run out. AI_0 is shown on the display in the top line.

NOTE: The setting remains set to "YES" in the setup menu 100/AI resp. 207 for as long as the automatic initialisation has not yet started. As soon as the AI is started, this setting is automatically set back to "NO".

The AI respectively switches on and off again the individual steps one by one. The next cycle of the AI does not start with switching on the first step until the set discharge time and switching time have run out. The AI performs **a maximum of 4 cycles**. In the process, the occupied and not occupied switching outputs are identified and the phase correction angle to be set is determined.

NOTE: Steps with the step type "FON" and "Flty" are ignored by the AI. If the control switched on steps before the start of the AI, these will be switched off one by one first, before the AI may begin.

If the measured power change was too small during a cycle, the AI will switch on all steps one by one first in the next cycle and then off again one by one.

NOTE: The duration of the automatic initialisation depends on the number of cycles, the maximum number of switching outputs, the set switching time (default setting: 10 s) and the discharge time (default setting 75 s) of the steps. The greater the set switching time and discharge time, the longer does the AI take. Therefore, the AI may take several minutes (switching time = 10 s, discharge time = 75 s, 4 cycles ➔ approx. 7 min).

If the automatic initialisation was successful after **a maximum of 4 cycles**, the determined phase correction angle is set automatically and not occupied step outputs are set to the step type "**FOFF**".

The notification **AUTO** appears on the display and the control starts switching steps on and off in the cycle of the set switching time after the set discharge time has run out in order to reach the control target.

17.2   Problems during the AI / cancellation of the AI

If the automatic initialisation cannot identify the phase angle during a maximum of 4 cycles, the AI is cancelled with error message:

The messages $\boxplus \iota$ and $\boxplus \text{b} r \text{F}$ are shown alternatingly on the display.

The control was switched off by the AI ("OFF"): The messages "PFC" and "OFF" are shown alternatingly on the display.

Possible causes:

1) The measuring current was too small. The current transformer ratio may be too large or the step sizes are too small.

   ➔ Check the current transformer ratio; select a transformer with the appropriate transmission ratio, if necessary. Start the AI gain.

2) Heavy load fluctuations during the **automatic initialisation**

   ➔ Start the AI again when the mains is steadier.

3) No steps identified at the step outputs. Check fuses and power contactors. Start the AI again.

If the AI is not successful after several attempts, the correct phase correction angle **must** be entered manually (SETUP/206). The not occupied step outputs can be set to the step type "**FOFF**" manually (SETUP/100/OUt).

Instruction regarding the setting of the phase correction angle:

A table with the phase correction angles depending on the connection of measuring voltage and current can be found in the **annex, paragraph <u>Setting of phase correction angles</u>**.

If a phase angle equal to or greater than 360° results by adding 180°, subtract 180° instead.

<u>Example:</u>

Previously set phase correction angle = 270°

270° + 180° = 450° ➔ greater than 360°

➔ 270° - 180° = 90° ➔ **phase correction angle to be set**

NOTE: If the automatic initialisation was cancelled with error once, the control is switched off. After the repeated start and the successful execution of the AI or by manually setting the phase correction angle and setting the step types of the not occupied switching outputs to "FOFF", the control (SETUP/100/PFC or SETUP/310) must <u>explicitly</u> be switched on again by switching the setting the "ON". The step types of the individual switching outputs (SETUP/100/Out or SETUP/403) should be checked after the AI with regard to whether all connected steps are still set to the step type "AUTO" and all not connected steps are set to "FOFF". These may have to be corrected manually. If the automatic initialisation was activated in the SETUP/100/AI or SETUP/207 resp. for as long as the setting is activated (AI was not started yet) or for as long as the AI is being executed ($\boxplus \iota$ is shown on the display in the top line in the main menu), the MANUAL menu remains locked. It is not possible to switch the steps manually.

18 Control algorithm

5 different control algorithms are available in the CX plus. The control algorithm used by the controller can be set in the SETUP menu 311:

1 = BEST FIT (default)

2 = LIFO

3 = COMBI FILTER

4 = PROGRESSIVE

5 = FIFO

18.1   BEST FIT (AUTO)

The controller works according to the **"BEST FIT"** principle (best result). This means that, before each switching operation, the controller compares all step sizes saved in its step database with the determined need for reactive power and always selects the step which comes closest to the set control target. If the controller has connected steps of the same size, the number of switching operations is distributed automatically to these steps either via the switching cycles or via the operating hours (SETUP/315).

Blocked defective steps (**"FAULTY"**) and steps with the step type "**FON**" and "**FOFF**" are skipped by the control. If a step is identified as defective and blocked (**"FAULTY"**) after being switched on 3 times, this step will be skipped by the control. Steps which have been switched off by the alarm system via the step switch-off sequence and have been locked for max. 30 min. are also skipped.

If steps which have been identified as defective are not locked, the function "**Lock faulty steps**" (SETUP/309) must be deactivated. Otherwise, the affected step will be switched on and off unnecessarily.

⚠ **CAUTION**

The defective step is switched on and immediately switched off again. If the control target has not been reached yet, the affected step is continuously switched on and immediately switched off again in the cycle of the switching time. The control hunts.

⚠ **CAUTION**

A faultless step may be switched on and off alternatingly with a defective step. The control hunts.

18.2   LIFO

"Last In, First Out": The controller starts with step 1 and switches on the step of the next higher number each time, if necessary. The steps are switched off in reversed order. It is checked individually for each step, if the switching operation is useful. This may lead to an unprecise compensation in case of steps of different sizes. Blocked defective steps (**"FAULTY"**) and steps with the step type "**FON**" and "**FOFF**" are skipped by the control. If a step is identified as defective and blocked (**"FAULTY"**) after being switched on 3 times, this step will be skipped by the control. Steps which have been switched off by the alarm system via the step switch-off sequence and have been locked for max. 30 min. are also not available for the control.

⚠ **CAUTION**

If the setting "Lock faulty steps" (SETUP/309) is deactivated, steps which are identified as defective are not blocked anymore. Their step type remains set to "AUTO". Therefore, the defective step is not skipped.

The control continuously switches the defective steps on and immediately off again unnecessarily in the cycle of the switching time. The control hunts. The next faultless steps are ignored for switch-on, because the defective step is not blocked and thus not skipped. Therefore, it may not be possible for the control to reach the target COS-PHI. The switch-off of the steps is not affected by this.

NOTE: The step exchange function and the switching distribution (switching cycles or operating hours) are always deactivated in case of steps of the same size.

NOTE: It is not possible to switch the steps manually.

18.3   Combi filter

Special algorithm for combi filter systems with two different degrees of choking. Like in case of the **"BEST-FIT"** algorithm, the controller works according to the **"BEST-FIT"** principle. The difference is that the controller always has switched on more or the same compensation power which is connected at the odd switching outputs than / as is connected at the even outputs. Already switched on step powers by FON steps are not considered by the control.

Blocked defective steps (**"FAULTY"**) and steps with the step type "**FON**" and "**FOFF**" are skipped by the control. If a step is identified as defective and blocked (**"FAULTY"**) after being switched on 3

times, this step will be skipped by the control. Steps which have been switched off by the alarm system via the step switch-off sequence and have been locked for max. 30 min. are also skipped.

If steps which have been identified as defective are not locked, the function "**Lock faulty steps**" (SETUP/309) must be deactivated. Otherwise, the affected step will be switched on and off unnecessarily.

⚠ CAUTION

The defective step is switched on and immediately switched off again. If the control target has not been reached yet, the affected step is continuously switched on and immediately off again in the cycle of the switching time. The control hunts.

The combi filter algorithm only works with capacitive steps.

If the step identification is executed for the first time, more step power may be switched on at the even switching outputs than at the odd ones. Enter the step sizes manually (SETUP/402) in order to avoid this.

Be careful when you define FON steps.

By setting FON steps, more step power may be switched on at the even switching outputs than at the odd ones.

NOTE: The step exchange function and the switching distribution (switching cycles or operating hours) are always deactivated in case of steps of the same size.

NOTE: It is not possible to switch the steps manually.

18.4 Progressive

Works like the **"BEST-FIT"** algorithm, with the exception that the controller switches on and off several steps one by one with a shortened switching time, if necessary. The set switching time is ignored in the process.

The step sizes must be entered manually, because the step identification is always deactivated in this algorithm. The entry should be as precise as possible, because the control will otherwise tend to hunt.

Steps with the step type "**FON**" and "**FOFF**" are skipped by the control. Steps which have been switched off by the alarm system via the step switch-off sequence and have been locked for max. 30 min. are also skipped.

NOTE: The step exchange function and the step identification are always deactivated. An updating of the step sizes, an identification of defective steps and an identification of power loss of the individual steps by the control are not possible.

18.5 FIFO

"First IN, First OUT" (cyclic control): The controller starts with step 1 and switches on the step of the next higher number each time, if necessary. When switching off, the controller starts with step 1 and switches off the step of the next higher number each time, if necessary. If steps 3 to 7 are still

switched on, the control starts with step 8 when switching on. If step 12 has been switched on and step 1 has not yet been switched on, the control starts with step 1 next. When switching off, the control starts with step 3. If step 12 has been switched off and step 1 is still switched on, the control starts with step 1 next. It is checked individually for each step, if the switching operation is useful. This may lead to an unprecise compensation in case of steps of different sizes.

Blocked defective steps (**"FAULTY"**) and steps with the step type "**FON**" and "**FOFF**" are skipped by the control. Steps which have been switched off by the alarm system via the step switch-off sequence and have been locked for max. 30 min. are also skipped.

If a step is identified as defective and blocked (**"FAULTY"**) after being switched on 3 times, this step will be skipped by the control.

If steps which have been identified as defective are not locked, the function "**Lock faulty steps**" (SETUP/309) must be deactivated. Otherwise, the affected step will be switched on and off unnecessarily.

These steps are switched on and immediately switched off again and skipped by the control. The next step is used for switch-on. When switching off, blocked defective steps are also skipped. The defective steps will again be switched on and immediately switched off again and skipped during the next cycle of the cyclic control.

Example:

Steps 12, 1, 2, 3, 4 are switched on, step 5 is defective and not switched on. When switching on, step 5 is switched on and immediately switched off again. Step 5 is skipped and and step 6 is switched on instead. Steps 7, 8, 9, 10, 11 are switched on normally one by one. When switching off, the steps 12, 1, 2, 3 and 4 are switched off. As step 5 is defective and was already switched off, this is skipped and step 6 is switched off next. Steps 7, 8, 9, 10 and 11 are switched off normally one by one. Step 5 is switched on and immediately switched off again and skipped during each cycle of the cyclic control for as long as the function "**Lock faulty steps**" (SETUP/309) is deactivated. If the function "**Lock faulty steps**" (SETUP/309) is activated, step 5 is not blocked until after the third switch-on attempt and skipped automatically during each cycle of the cyclic control.

NOTE: The step exchange function and the switching distribution via the switching cycles or the operating hours) are always deactivated in case of steps of the same size.

NOTE: It is not possible to switch the steps manually.

19 Transformer compensation

The compensation of a transformer for which no fixed step is available can be solved in two ways with the CX plus:

19.1   Setting of the offset reactive power:

The current transformer is installed at the output side of the transformer ➔ consequently, the reactive power of the transformer is not measured by the CX plus.

By setting an offset reactive power = reactive power of the transformer (SETUP/312), this is added to the measured reactive power (within the system).

Procedure:

Determine the inductive reactive power of the transformer. Enter the determined value in the SETUP menu "312" in order to also compensate the transformer.

Function:

The set offset reactive power (Q offset) is added to the measured reactive power and considered in the control deviation. Therefore, the COS φ is **always** shown before the transformer. This means, that the COS φ within the system may be capacitive, but the measurement of the electrical power supplier measures the required COS φ.

19.2 Mixed measurement:

The reactive power caused by the transformer is measured by the medium-voltage current measurement and is also controlled via the connected compensation system.
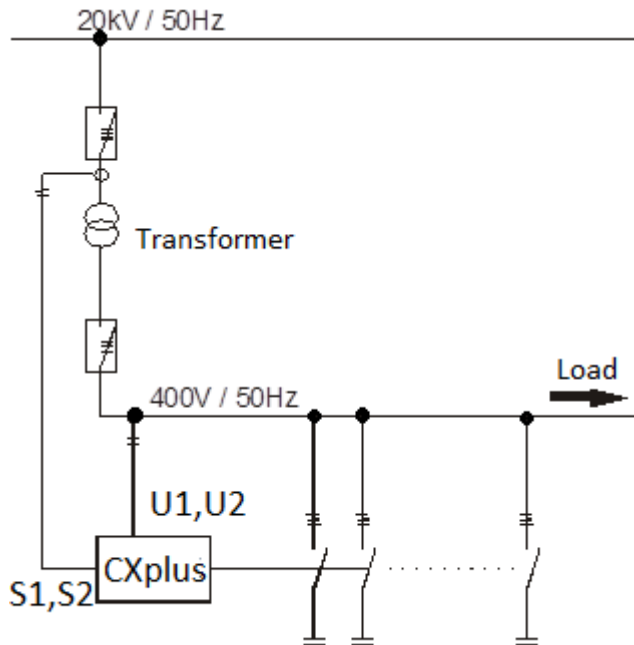
Procedure:

Connect the measurement of the controller as shown on the diagram opposite and start the **automatic initialisation (AI)** (SETUP/100/Ai or SETUP/207). The vector group of the transformer is considered automatically in the process.

NOTE: If the automatic initialisation (AI) was not successful (the messages Ai and $Abrt$ are shown alternatingly on the display), the phase correction angle must be set manually (SETUP/206).

The connection possibilities for the most common transformer vector groups and the phase correction angle to be set are listed in the ANNEX under point "**Connection for mixed measurement**". If the phase correction angle was entered, the control must be switched on (SETUP/100/OUt or SETUP/310) again, because it was switched off ("OFF") by the AI.

20 Default and customer settings

NOTE: Some settings which are important for commissioning from the SETUP menus 200, 300 and 400 are summarised again in the quick START menu 100. These are the same settings, e. g. nominal voltage: menu 100/ Un == menu 201, etc.

The fields with a grey background either cannot be changed (status displays) or are reset (RESET menu) automatically to "NO" when switching from "NO" to "YES".

Menu	Default setting	Customer setting
100		
Un	400 V	
Ct	1	
Pt	1	
AI	NO	
PFC	ON	
CP1	1	
St	10 s	
OUt	Step 1…max = AUTO	
200		
201	400 V	
202	1	
203	1	
204	10%	
205	NO	
206	Connection voltage L-N = 0° L-L = 90°	
207	NO	
208	AUTO	
209	0° C	
300		
301	60%	
302	1	
303	0.95 i	
304	NO	
305	10 s	
306	2 s	
307	YES	
308	YES	
309	YES	
310	ON	
311	1	
312	0	
313	1	
314	NO	
315	NO	

400		
401	75 s	
402	Step 1…max = 3 var c	
403	Step 1…max = AUTO	
404	Step 1…max = 0	
405	Step 1…max = 0 h	
406	NO	
500		
501	NO	
502	20%	
503	NO	
504	60 s	
505	NO	
506	NO	
507	500 k	
508	65.5 kh	
509	65.5 kh	
510	50%	
511	YES	
512	30° C	
513	55° C	
514	NO	
515	NO	
516	NO	
517	NO	
518	NO	
519	NO/YES	NO/YES
600		
601	NO	NO
602	NO	NO
603	NO	NO
604	NO	NO
605	NO	NO
606	NO	NO
607	xx.xx.xx	xx.xx.xx
700		
701	19.2 k	
702	EVEN	
703	1	

21 Revision list

Date	Name	Revision	Comment
28.06.17	ChP	01	First edition
07.07.17	ARP	02	Revision of the schematic menu screen

22 Annex

22.1 Setting of phase correction angles depending on the connection

Voltage	L1-N	L2-N	L3-N	L1-N	L2-N	L3-N	L1-N	L2-N	L3-N
Current transformer	L1	L2	L3	L2	L3	L1	L3	L1	L2
Correction angle	0°	0°	0°	240°	240°	240°	120°	120°	120°
Voltage	L2-L3	L3-L1	L1-L2	L2-L3	L3-L1	L1-L2	L2-L3	L3-L1	L1-L2
Current transformer	L1	L2	L3	L2	L3	L1	L3	L1	L2
Correction angle	90°	90°	90°	330°	330°	330°	210°	210°	210°

22.2 Connection in case of mixed measurement

Vector group	Current transformer	Voltage
Dy5	L1	L2-N
Dy5	L2	N-L3
Dy5	L3	N-L1
Yz5	L1	L2-N
Yz5	L2	N-L3
Yz5	L3	N-L1
Dx6	L1	L3-L2
Dx6	L2	L2-L1
Dx6	L3	L1-L3
Yy6	L1	L3-L2
Yy6	L2	L2-L1
Yy6	L3	L1-L3
Dy11	L1	N-L2
Dy11	L2	L3-N
Dy11	L3	L1-N
Yz11	L1	N-L2
Yz11	L2	L3-N
Yz11	L3	L1-N

Errors excepted and subject to modifications. Beluk GmbH, July 2017