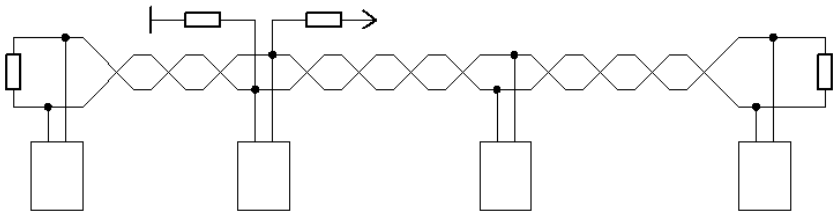
Technical Documentation



CX plus - Modbus

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Revision list

Date	Name	Revision	Comment
25.09.17	ChP	01	First edition
04.07.18	SO	02	Adaption to Firmware 1.1

Table of contents

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.

1.1 Symbols

! DANGER
DANGER indicates a dangerous situation which, if not avoided, may cause death or sever 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
The note symbol indicates further information in order to describe special technical features in a more detailed way.

1.2 Safety notes and further information

! DANGER

During the installation of the reactive power controller 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 open 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 level 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.

! WARNING

Before you change the parameter settings at the device, read this reference manual of the reactive power controller CX plus attentively and carefully in order to familiarise yourself with the individual device settings and the associated impacts.

! WARNING

Never change device settings via Modbus, if you do not know the consequences of the change beforehand or if someone is currently working at the system!

! WARNING

Never manually switch on or off compensation stages via Modbus, if you are not sure, what the switching operation will cause or if someone is currently working at the system!

! WARNING

Please observe, that the changes are immediately effective in the device after the writing process of the value!

! WARNING

Do not try to write addresses (resp. registers) via Modbus, which are not defined in this manual or are explicitly identified for writing!

! WARNING

When writing values, always observe the permissible setting range! Never write non-defined bits in bitmasks with a Boolean "1"!

! CAUTION

Modifications at the device settings made via Modbus are only saved in the “volatile memory” (RAM). All modifications at the device settings made via Modbus will be lost after a device restart (Reset)!

In order to prevent this, the device settings must be saved in the “non-volatile memory (FLASH)”.

The saving in the “non-volatile memory (FLASH)” must be activated explicitly. Information about this may be found in Paragraph 5.9 (Permanent storage of the device settings).

! CAUTION

Unnecessary writing activities in the FLASH memory will reduce its service life and thus the service life of the reactive power controller CX plus!

Consequently, frequent writing activities in the FLASH memory shall be avoided. Therefore, do not save the device settings in the “non-volatile memory (FLASH)” until you have made all settings!

2 Overview

The Modbus communication interface of the reactive power controller CX plus offers the possibility to read measurement values via a bus connection from remote computer systems in order to use these for further processing.

The present manual describes the data transmission using the Modbus protocol, which defines methods of data transport and addressing, but is not generally determined for a specific transmission medium (physical transmission level).

The reactive power controller CX plus uses the industrial standard RS485 for data transmission. This bus system additionally offers the possibility to operate several devices via the same BUS cable.

A multitude of commercial devices and programmable logic controllers (PLC) are compatible with the Modbus protocol as communication medium, which enables the user to realise a bus system with little effort.

3 MODBUS/RS485

The communication protocol Modbus RTU basically consists of two levels:

- The industrial standard RS485 is used as underlying data transmission medium. This controls the physical transmission of the data byte between the bus participants and is recognised by high-quality levels, the Modbus application protocol.

- The Modbus application protocol uses the underlying RS485 protocol for data transmission. It defines commands (so-called “Function Codes”, FC), addresses and data structures.

NOTE
Further information on the MODBUS protocol can be found at **www.Modbus.org**. The currently valid bus specifications are also available here.

3.1 Physical level - RS485 (defined in EIA485/ISO8482)

3.1.1 2-wire and 4-wire bus

The communication standard RS485 uses two wires for data transport **D(+)** and **D(-)**. The two symmetrical data wires always work with a differential voltage level of at least ± 200 mV. This results in a total of two possibilities presented by the two logical levels “low” and “high”. Due to this differential transmission technology, the standard RS485 is particularly resistant to electromagnetic interferences and wire lengths of more than 1000 metres may be reached.

The reactive power controller CX plus is compatible with the following transmission rates (baud rates, see Paragraph 3.2.3): 1200; 2400; 4800; 19200; 38400; 57600 and 115200 baud. All parity variations (even, odd and none) are compatible.

Differences between the variations of the communication standards RS485:

- 2-wire RS485: This type uses two wires for the communication, so that the same wire pair must be used for both data directions. Therefore, it is necessary to switch between sending and reception process at each device (half-duplex mode).

- 4-wire RS485: In this case, a wire pair each is used for both data directions. Switching is only necessary for the senders of the slave devices. Due to the Modbus protocol, however, it is also only possible to use the half-duplex mode in this case. Thus, it is not possible to increase the transmission capacity.

NOTE
The reactive power controller CX plus is exclusively compatible with the 2-wire mode!

Both types require another wire each, which must be connected between all bus devices: The common ground signal **GND**.

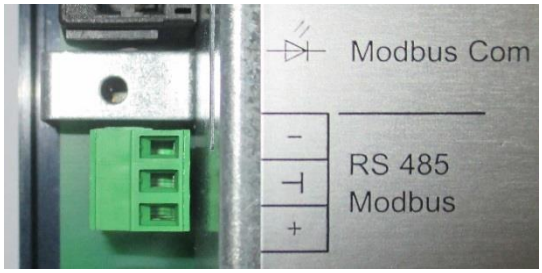
! CAUTION
The shield of the cable must not be connected for this purpose!

The cable shield shall be connected with the ground potential in order to reduce interferences from the outside.

The standard RS485 is compatible with several devices at one bus wire (usually up to 32 participants). For this purpose, all signals of the devices must be connected in parallel. Usually, this are the data wires **D(+)** and **D(-)** as well as the signal ground (**GND** or **GROUND**).

A bus wire with all connected participants is called a bus segment. The data may be exchanged between several segments by means of the so-called “repeaters”.

3.1.2 3-pole plug connection



A 3-pole plug connector is provided for the connection of the Modbus interface. The symbolism in the adjacent figure illustrates the terminal assignment.

Figure 1: Connector plug with symbolic marking of the Modbus communication interface of the reactive power controller CX plus

For commissioning, the data wires **+** with **D(+)** and **-** with **D(-)**, as well as the **signal ground (centre port)** must be connected with the signal ground of the respective bus wire.

3.1.3 Wire termination

The termination of the bus wire by a resistor is strictly necessary for a properly functioning bus system, in order to prevent interferences. For this reason, the bus wire ends must be equipped with a resistor. The value of the resistor must be adequate for the cable impedance and is generally selected with 120 Ω. Connect the termination resistor with the data wires at each end of a bus segment.

NOTE
A bus segment may only be terminated at the two ends! If a device terminates the bus segment between beginning and end of the segment, all other devices downstream of this device until the segment end are not accessible anymore, unless the master device is connected to the segment beginning!

Some devices, particularly bus converters, have integrated termination resistors. Therefore, check the operating instructions of all used bus devices. If these devices are connected within the BUS segment, their termination resistors must be switched off. In case it is not possible to switch off these integrated resistors, the respective devices must be placed at the ends of the bus! **Consequently, it is only possible to use two devices with fix termination resistors!**

3.1.4 Bias voltage (line biasing)

If no data are transmitted via the bus wire, the data wires are in an undefined state without bias voltage. Due to the installed termination resistor, both data wires would have almost the same voltage. Furthermore, external influences may lead to interferences of the signal level. For this reason, a bias voltage of the bus wires is necessary in order to prevent this case.

The resistors must be in the range of 450 Ω…650 Ω. A so-called pull-up-resistor is connected between the data wire **+** resp. **D(+)** and +5 V and a pull-down-resistor is connected with the contact **–** resp. **D(-)** and 0 V. These resistors are required once per bus segment, the position of the installation is freely selectable. However, we recommend a position in the middle of the bus wire. Please check, if there are already integrated bias resistors by means of the operating instructions of the used bus devices!

The 3-pole plug connection used in this case requires the bias voltage via an external power supply unit of the remote station.

NOTE

Caution: Different manufacturers use the connection designation A and B. An equation of the connection designation to (A = +) and (B = -) is not always true. This must be checked case by case.

3.1.5 Communication indicator

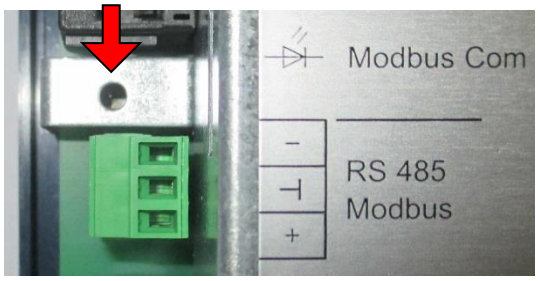


Figure 2: Communication indicator (LED) of the Modbus communication interface of the reactive power controller CX plus

The yellow light-emitting diode at the back of the device indicates the activity of the data transmission. This only lights (flashes) when the device communicates with the master device.

3.2 The Modbus protocol

3.2.1 Modbus description

The communication protocol Modbus RTU uses the RS485 interface as subordinate physical level and implements the control mechanism for the data transmission. Consequently, it is arranged at level 2 ("Link Layer") of the OSI[1] layer model for data exchange.

3.2.2 Serial data format and data frame

The data are transmitted in a fixed data frame because the individual datasets are separated from each other and the bus system remains inactive for 3.5 characters. "Protocol Data Units" (PDUs) organise the entire data, which are transmitted serially from the subordinate physical data level via the bus system.

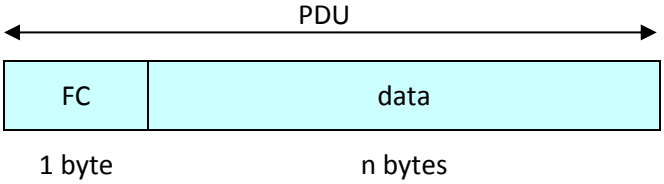


Figure 3: Schematic illustration of a "Protocol Data Unit" - PDU

PDU consist of two parts:

- The "Function Code" (FC) gives a command which defines the task of the slave device connected downstream.
- The data block consists of the respective data for a "Function Code" (FC). A FC can include pure data as well as register addresses for the data access of the slave.

The PDU defines an individual data unit, which shall reach a specific bus device in order to perform a certain function there. The transmission differs depending on the used physical level. In order to control the transmission, the PDU is equipped with further data blocks. This extension is the "Application Data Unit" (ADU) for the communication standard RS485.

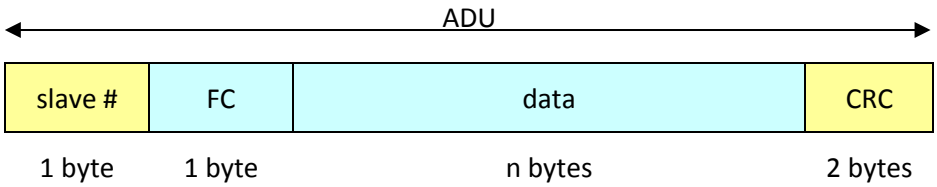


Figure 4: Schematic illustration of an "Application Data Unit" - ADU

[1] Abbreviation OSI: Open System Interconnection.

When using the ADU for the transmission via RS485, this includes two further data blocks:

- The first field specifies the target for the data set, the so-called "Slave number" (="Slave address").
- Additionally, the transmission is secured via the CRC[2]16 checksum.

3.2.3 Serial transmission types

The protocol defines two different coding systems for the structure of the data packet: RTU and ASCII[3] coding.

NOTE
The reactive power controller CX plus always uses the RTU coding. The ASCII coding is not implemented and is only mentioned here for the sake of completeness.

"Remote Terminal Unit" (RTU)

In case of this transmission mode, each 8-bits data byte includes two 4-bits hexadecimal numbers, which are transmitted as a complete byte. In this way, a maximum transmission density is achieved. The following information are transmitted with each data byte:

- 1 start bit
- 8 data bits, "Least Significant Bit" first (little Endian)
- 1 parity bit (if it is set)
- 1 stop bit for the parity "even" or "odd". 2 stop bits for the case that the parity is "none" in order to compensate a missing parity bit.

3.2.4 Function codes

As already mentioned, the data packet includes "Function Codes", which specify the commands of the bus master to the bus slaves. The slave executes the command (if possible) and then answers with the same function code as acknowledgement of receipt. The valid range for function codes is determined between 1 and 127, but only a part of this is used. We refer to the Modbus specifications for detailed information. If it is not possible for the slave to execute the command, an exception code is sent. The function code of an exception code includes the function code of the received command which caused errors. The slave modifies this command in a way, that the MSB[4] (=most significant bit) is set in order to communicate an error to the master. The content of the data set describes the error in more detail.

[2] Abbreviation CRC: Cyclic Redundancy Check.

[3] Abbreviation ASCII: American Standard Code for Information Interchange.

[4] Abbreviation MSB: Most Significant Bit.

The reactive power controller CX plus is compatible with the following function codes:

Function Code		Description
Decimal	Hexadecimal	
03	0x03	Read holding register
04	0x04	Read input register
06	0x06	Write single register
08	0x08	Diagnostic functions
16	0x10	Write multiple registers

Table 1: Compatible function codes of the reactive power controller CX plus

3.2.5 Exception codes

If a slave cannot execute a command of the master, it answers with an "Exception Code". The exception code includes the function code of the received command, which caused the error (cf. Paragraph 3.2.4).

The complete list can be looked at in the Modbus specification. At this point, only the list with the exception codes used by the reactive power controller CX plus is mentioned, as the master software handles the most exception errors automatically. If the programming of the Modbus master stack takes place automatically, the complete specifications are necessary, in which the complete list of the exception codes is included.

The reactive power controller CX plus uses the following exception codes:

Exception Code		Description
Decimal	Hexadecimal	
01	0x01	Illegal Function Code
02	0x02	Illegal Data Address
03	0x03	Illegal Data Address
04	0x04	Slave Device Failure
06	0x06	Slave Device Busy

Table 2: Used exception codes of the reactive power controller CX plus

3.2.6 Master-slave protocol

The master-slave protocol is used for communication. Only the Modbus master device can initialise a data exchange, the data exchange begins by transmitting a data set with the respective function code to the slave. Subsequently, the slave will execute this command.

☝NOTE
The Modbus specification requires exactly one master device. All other devices must be declared as slaves.

- The unicast mode is used as common mode for communication under Modbus RTU. In this case, an individual slave is addressed in the data packet of the master. The valid address range is between 1 and 247. The slave executes the command and answers by sending a data packet as acknowledgement back to the master device.

- The master device does not receive an answer to its request in every case. In the multicast mode, all slaves in the bus system are addressed in parallel. All slaves execute the same command, however, without transmitting an answer. The master device initialises a multicast data exchange by using a "0" as slave address.

3.2.7 Address space

The data of the reactive power controller CX plus are organised and made accessible by means of addresses. Each address provides the access to a data word = a register. The length of a data word is always 16 bits.

The reactive power controller CX plus does not distinguish the addresses between the function codes. A single large address space is available and each valid function code can be used in order to access the data of a specific address. Nevertheless, the data may only be used reasonably if these are interpreted correctly.

The data may be assigned to the following types:

- UINT16: 16 bits integer value without sign
- SINT16: 16 bits integer value with sign
- UINT32: 32 bits integer value without sign
- SINT32: 32 bits integer value with sign
- FLOAT (REAL): 32 bits floating point value, as defined in the IEEE standard 754.

As the data are organised in 16 bits-wide words (= registers), several successive addresses must be read for longer data fields. For this case, the base address is indicated in the respective tables. In order to read data with the format FLOAT (=REAL) (32 bits) with the base address 12, for example, two 16 bits words (= 2 registers) of the addresses 12 and 13 must be read. These two values must be interlinked adequately in order to receive the desired result with 32 bits. The most SCADA and PLC software packages manage this procedure automatically.

☝NOTE
32 bits values must always be read or written successively (2 words = 2 registers). It is not possible to read or write only one register (16 bits) of a 32 bits value resp. between two 32 bits values!

NOTE
Little Endian (Intel) coding of the data. 32 bits values are always transmitted as follows:

Double word:

LOW word (LSB) | HIGH word (MSB)

Several 32 bits values, the values are ranked:

1st double word | 2nd double word | nth double word

3.2.8 Modbus addressing

There are different addressing modes:

- **Address:**

  The MODBUS address always begins with **0** and goes up to **65535**. The address may be used with each function code.

  NOTE
  In order to determine the correct addressing mode, please read the operating instructions of the used software or of the SCADA system!

- **Register:**

  Some SCADA systems work with registers instead of addresses.

  Registers always begin with **1** and end with **65536.**

  NOTE
  Even though addresses are mentioned in some PC software (e.g. Modbus Poll) and SCADA systems (e.g. Netbiter WS100 & WS200), it is the register what is expected in reality. In this case, a 1 must always be added to the address! Register = address + 1

- **Address with function code**

  Some SCADA systems **add** an **offset** to the address for the determination of the function code. In this case, a **1 is also often added to the Modbus address ➔ register.** For example, the address **40001** would mean **"read Modbus address 0 with function code 03_{hex}", 30012** would mean **"read MODBUS address 11 with function code 04_{hex}".**

  NOTE
  Registers are often incorrectly called addresses (e.g. Modbus Poll, Netbiter WS100 & WS200)! In reality, however, the address is transmitted in the data packet!

4 Modbus settings of the reactive power controller CX plus

4.1 Reactive power controller CX plus - Modbus setup

NOTE
Menu 700 is only available in the "SETUP" settings, if the used device is compatible with the communication protocol Modbus RTU (option -MB).

The Modbus setup menu (**700**) provides the user the following setting options:

- **701 BAUD RATE**: Selection of the baud rate. The valid range is between **1.2k (1,200)** and **115k** (**115,200)**.
  - Factory setting: **19.2k (19,200)**
- **702 PARITY**: Selection of the parity as well as of the stop bits between **8E1** (**Even, 1 stop bit**), **8O1** (**Odd, 1 stop bit**) or **8N2** (**None, 2 stop bits**).
  - Factory setting: **8E1 (Even, 1 stop bit)**
- **703 ADDRESS**: Selection of the Modbus slave address (slave ID). The valid range is between **1** and **247**.
  - Factory setting: **1**

NOTE
Settings for baud rate and parity must be identical for all bus participants! The SLAVE address of a device, however, may only exist once in the bus system!

4.2 Important RS485 BUS connection parameters

Parameter	Reactive power controller CX plus
Max. number of slaves without repeater.	32 slaves
Max. length bus wire	1000m (3300ft) at 115k Baud
Max. length of stubs (tap-offs)	• 20m (66ft) for 1 tap-off • 40m (131ft) divided by the number of tap-offs
Bus bias voltage	• A pull-up resistor 450…650Ω at +5V DC • A pull-down resistor 450…650Ω at 0V
Wire termination	Termination resistor each 120Ω at both ends of the bus

Table 3: RS485 connection parameters

5 Addresses and registers

NOTE
The reactive power controller CX plus answers to the reading of a non-defined address resp. a non-defined register with the hexadecimal value 0x8000 for each read register in the data field.

5.1 Measurement values

The available measurement values begin with the address 500 with intervals of 2 data words (registers). All values may be read with the function codes 03_{hex} and 04_{hex}.

NOTE
32 bits values must always be read successively (2 words = 2 registers). It is not possible to read only one register (16 bits) of a 32 bits value or to read between two 32 bits values!

5.1.1 Modbus addresses of the measurement values

Address	Register	Value	Number words	Data type	Write access	Unit
500	501	Voltage U_{LL}	2	Float	---	V
502	503	Voltage U_{LN}	2	Float	---	V
504	505	Current (including Q_{Offset})	2	Float	---	A
506	507	Frequency	2	Float	---	Hz
508	509	Active power P (sum)	2	Float	---	W
510	511	Reactive power Q (sum)	2	Float	---	var
512	513	Apparent power S (sum)	2	Float	---	VA
514	515	Missing reactive power ΔQ for control target	2	Float	---	var
516	517	Cos ϕ	2	Float	---	---
518	519	Power factor (P/S)	2	Float	---	---
520	521	Average power factor	2	Float	---	---
522	523	tan ϕ	2	Float	---	---
524	525	Ambient temperature	2	Float	---	°C
526	527	Temperature maximum	2	Float	---	°C

Table 4: Measurement values of the reactive power controller CX plus (1)

5.1.2 Modbus addresses of the measurement values (continuation)

Address	Register	Value	Number words	Data type	Write access	Unit
528	529	THD U	2	Float	---	%
530	531	THD I	2	Float	---	%
532	533	U 3. overtone	2	Float	---	%
534	535	U 5. overtone	2	Float	---	%
536	537	U 7. overtone	2	Float	---	%
538	539	U 9. overtone	2	Float	---	%
540	541	U 11. overtone	2	Float	---	%
542	543	U 13. overtone	2	Float	---	%
544	545	U 15. overtone	2	Float	---	%
546	547	U 17. overtone	2	Float	---	%
548	549	U 19. overtone	2	Float	---	%
550	551	I 3. overtone	2	Float	---	%
552	553	I 5. overtone	2	Float	---	%
554	555	I 7. overtone	2	Float	---	%
556	557	I 9. overtone	2	Float	---	%
558	559	I 11. overtone	2	Float	---	%
560	561	I 13. overtone	2	Float	---	%
562	563	I 15. overtone	2	Float	---	%
564	565	I 17. overtone	2	Float	---	%
566	567	I 19. overtone	2	Float	---	%
568	569	Operating hours controller	2	Uint32	---	h
570	571	U_{LLmax}	2	Float	---	V
572	573	THD U_{max}	2	Float	---	%
574	575	Current (excluding Q_{Offset})	2	Float	---	A

Table 5: Measurement values of the reactive power controller CX plus (2)

5.2 Device settings (USER PARAMETERS)

Device settings (user parameters) can be read via MODBUS with the function codes 03_{hex} and 04_{hex} and written with the function codes 06_{hex} and 10_{hex}. The device settings are available as of address 100 in the UINT16, SINT16, UINT32 or SINT32 format. Table 5 shows the available device settings with corresponding address and the valid setting range.

! WARNING

Never change device settings via Modbus, if you do not know the consequences of the change beforehand or if someone is currently working at the system!

! CAUTION

Modifications at the device settings are only saved in the "volatile memory (RAM)"! All modifications at the device settings made via Modbus will be lost after a device restart! In order to prevent this, the device settings must be saved in the "non-volatile memory" (FLASH).
The saving in the "non-volatile memory (FLASH)" must be activated explicitly! Information about this may be found in Paragraph 5.9.

NOTE
With function code 06_{hex}, it is only possible to write addresses resp. registers of the data type UINT16 and SINT16!

NOTE
The reactive power controller CX plus answers to the reading of a non-defined address resp. a non-defined register with the hexadecimal value 0x8000 for each read register in the data field.

NOTE
32 bits values must always be read or written successively (2 words = 2 registers). It is not possible to read or write only one register (16 bits) of a 32 bits value resp. between two 32 bits values!

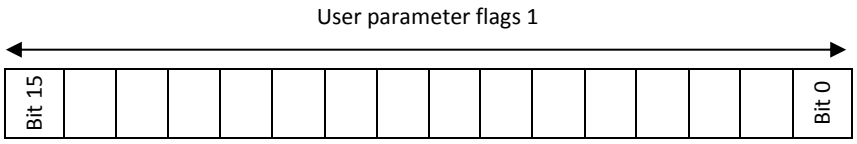
NOTE
Please observe the setting range of the user settings. If a value from outside the valid value range is written, the reactive power controller CX plus answers with the exception code 3! The incorrect value is not accepted!

Address	Register	Value	Number words	Data type	Write access	Setting range
100	101	User parameter flags 1	1	UINT16	YES	Bitmask
101	102	User parameter flags 2	1	UINT16	YES	Bitmask
102	103	Voltage transformer factor (PT)	1	UINT16	YES	10…3,500 (1.0…350.0)
103	104	Current transformer factor (CT)	2	UINT32	YES	10…96,000 (1…9,600)
105	106	$U_{nominal}$ (U_{LL})	2	UINT32	YES	1,000…2,420,000 (100.0…242,000.0)
107	108	Voltage range	1	UINT16	YES	0…1,000 (0…100%)
108	109	Phase correction angle (phase offset)	1	UINT16	YES	0…345 in 15° stages
109	110	Sensitivity control	1	UINT16	YES	550…1,000 (55…100%)
110	111	Target cos φ 1	1	UINT16	YES	70…130 (0.7ind…0.7cap)
111	112	Target cos φ 2	1	UINT16	YES	70…130 (0.7ind…0.7cap)
112	113	Discharge time	1	UINT16	YES	10…12,000 (1…1,200s)
113	114	Switching time	1	UINT16	YES	10…65,000 (1…6,500s)
114	115	Time delay during stage exchange	1	UINT16	YES	10…65,000 (1…6,500s)
115	116	Asymmetry factor	1	SINT16	YES	-127…127 without 0 and -1
116	117	Max. switching cycles	2	UINT32	YES	1…500,000
118	119	Max. operating hours	1	UINT16	YES	1…65,500 (h)
119	120	Max. THD-U value	1	UINT16	YES	30…200 (3…20%)
120	121	Time delay THD U alarm	1	UINT16	YES	10…2.550 (1…255s)
121	122	Temperature limit 1 (fan relay)	1	UINT16	YES	30…[temp2-50] (3°C…[temp2-5])
122	123	Temperature limit 2 (temperature alarm)	1	UINT16	YES	[temp1+50]…600 ([temp1+5] …60°C)
123	124	Reactive power offset	2	SINT32	YES	-9,900,000… 9,900,000 (var)
125	126	Temperature offset	1	SINT16	YES	-10…10 (°C)
126	127	Max. THD-I value	1	UINT16	YES	10…2000 (1…200%)
127	128	Max. operating hours stages	1	UINT16	YES	1…65,500 (h)
128	129	I-High-Alarm delay time	1	UINT16	YES	100…300 (10…30s)
129	130	Alarm step off sequence time	1	UINT16	YES	10…2.550 (1…255s)

Table 6: Device settings of the reactive power controller CX plus

5.2.1 User parameter flags 1

Address	Register	Value	Number words	Data type	Write access	Setting range
100	101	User parameter flags 1	1	UINT16	YES	Bitmask



Bit 0	(0) – Connection voltage L-N	(1) – Connection voltage L-L
Bit 1	If bit 1&2 are set to zero, the frequency measurement AUTO is active. If bit 1&2 are set to one, frequency FIX 50 Hz is active..	(1) – Frequency FIX 50 Hz
Bit 2		(1) – Frequency FIX 60 Hz
Bit 3	**X**	
Bit 4	(0) Faulty step recognition OFF	(1) Faulty step recognition ON
Bit 5	(0) – No switching to target cos φ 2, if EXPORT appears on the display	(1) – Switching to target cos φ 2, if EXPORT appears on the display
Bit 6	(0) – Stage exchange OFF	(1) – Stage exchange ON
Bit 7	(0) – Stage identification OFF	(1) – Stage identification ON
Bit 8	(0) – NO BLOCKING of faulty stages	(1) – BLOCKING of faulty stages
Bit 9	(0) – STOP or HOLD of the control	(1) – START of the control
Bit 10	(0) – STOP of the control	(1) – HOLD of the control if Bit 9 = 0
Bit 11	(0) – BEST-FIT algorithm	(1) – LIFO algorithm
Bit 12	(0) – BEST-FIT algorithm	(1) – PROGRESSIVE algorithm
Bit 13	(0) – NO action, if Q is capacitive	(1) – Switch off capacitive STAGES, if Q is capacitive
Bit 14	**X**	
Bit 15	(0) I-Low-Alarm OFF	(1) I-Low-Alarm ON

Table 7: User parameter flags (1)

X = Reserved

NOTE

Reserved bits must be written with a Boolean "0", otherwise the reactive power controller CX plus will answer with the exception code 3! An incorrect bitmask is not accepted!

Bit 9 & Bit 10: **Only one out of these two bits is tolerated to be activated at the same time. If both bits are activated at once, the power factor controller will answer with the exception code 3 (illegal data value).**

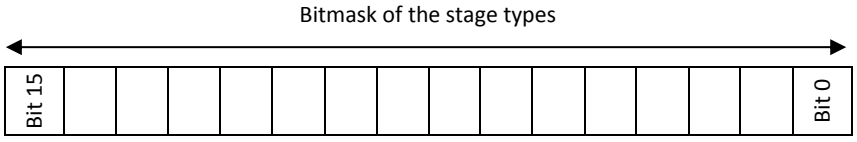
NOTE

Flags 1 – Bit 11 & Bit 12: **Only one out of these two bits is tolerated to be activated at the same time. If both bits are activated at once, the power factor controller will answer with the exception code 3 (illegal data value).**

Flags 2 – Bit 10 & Bit 12: **Only one out of these two bits is tolerated to be activated at the same time. If both bits are activated at once, the power factor controller will answer with the exception code 3 (illegal data value).**

User parameter flags 2

Address	Register	Value	Number words	Data type	Write access	Setting range
101	102	User parameter flags 2	1	UINT16	YES	Bitmask



Bit 0	(0) – AUTO resetting of the alarms	(1) – MANUAL resetting of the alarms
Bit 1	(0) – NO SWITCH-OFF of the stages in case of THD U-, THD I- and TEMP2- alarm	(1) – SWITCH-OFF of the stages in case of THD U-, THD I- and TEMP2- alarm
Bit 2	(0) – No stopping of the control at I< 5mA	(1) – Stopping of the control at I< 5mA
Bit 3	(0) – Service alarm ON	(1) – Service alarm OFF
Bit 4	(0) – Control alarm OFF	(1) – Control alarm ON
Bit 5	(0) – Faulty stage alarm OFF	(1) – Faulty stage alarm ON
Bit 6	(0) – Power loss stages alarm OFF	(1) – Power loss stages alarm ON
Bit 7	(0) – Alarm signalling by backlighting OFF	(1) – Alarm signalling by backlighting ON
Bit 8	(0) – DI-Alarm steps OFF **X**	(1) – DI-Alarm steps ON
Bit 9	(0) – DI active in case of NEGATIVE flank	(1) – DI active in case of POSITIVE flank
Bit 10	(0) – BEST-FIT algorithm	(1) – COMBI-FILTER algorithm
Bit 11	(0) – Normal function of the fan relay	(1) – Fan relay as additional stage output
Bit 12	(0) – BEST-FIT algorithm	(1) – FIFO algorithm
Bit 13	Switching distribution stages (0) – according to switching cycles of the stages	Switching distribution stages (1) – according to running time of the stages
Bit 14	(0) – I-low alarm / DI-function cannot be suppressed by digital input	(1) – I-low alarm / DI-function can be suppressed by digital input
Bit 15	(0) – Bit 14 & Bit 15= 0 : Switch to Target-COSPHI2	(1) – DI-Function: DI-Alarm

Table 8: User parameter flags (2)

X = Reserved

NOTE

Reserved bits must be written with a Boolean "0", otherwise the reactive power controller CX plus will answer with the exception code 3! An incorrect bitmask is not accepted!

Bit 14 & Bit 15: **Only one out of these two bits is tolerated to be activated at the same time. If both bits are activated at once, the power factor controller will answer with the exception code 3 (illegal data value).**

5.3 Stage database

The information on the individual stages are stored in the stage database. The stage type settings and the stage data of each stage may be read via Modbus with the function codes 03_{hex} and 04_{hex}.

☝NOTE
The reactive power controller CX plus answers to the reading of a non-defined address resp. a non-defined register with the hexadecimal value 0x8000 for each read register in the data field.

5.3.1 Stage type settings

Stage type settings are provided as of address 200 as binary bitmask in UINT16 format. The least significant bit (bit 0) represents stage output 1, the other stage outputs follow with increasing bit significance. If the fan relay is used as additional stage (SETUP / 406 = YES), this stage will be represented by bit 12.

The function **"fan relay as additional stage output"** must be activated in SETUP menu 406 (YES), so that the settings for the additional stage are taken into account.

☝NOTE
It is only possible to write the bitmasks of the stage type settings except for the mask "faulty stages" with the function codes 06_{hex} and 10_{hex}.

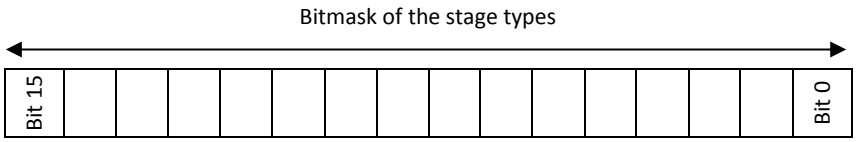
! WARNING
Never change stage type settings via Modbus, if you do not know the consequences of the change beforehand or if someone is currently working at the system!

! CAUTION
Modifications at the stage type masks via MODBUS are immediately stored in the "non-volatile memory (FLASH)". Thus, the entered stage type settings are not temporary and will be used again by the reactive power controller CX plus after a device restart!

☝NOTE
If several stages are set to the stage type "FON" at the same time, the set discharge time will run out for each individual stage first! Afterwards, these stages are switched on successively with the set switching time! The "FON" stage which was defined first is switched on immediately without observing the switching time!

☝NOTE
If several stages are set to the stage type "FOFF" at the same time, these stages will be switched off immediately without delay

Address	Register	Value	Number words	Data type	Write access	Setting range
200	201	Stage mask – auto / fix OFF	1	UINT16	YES	Bitmask
201	202	Stage mask – fix ON	1	UINT16	YES	Bitmask
202	203	Stage outputs – faulty stages	1	UINT16	---	Bitmask



Stage types:

AUTO = if corresponding bits are **set to "0"** in the FIX OFF stage mask **and** the FIX ON stage mask.

FOFF = if corresponding bits are **set to "1"** in the FIX OFF stage mask and **"0"** in the FIX ON stage mask.

FON = if corresponding bits are **set to "1"** in the FIX OFF stage mask **and** the FIX ON stage mask.

FAULTY = if corresponding bits are **set to "1"** in the stage mask "Faulty stages".

5.3.2 Bits stage type settings 6-stage controller

Bit 0	(0) – Stage type for stage 1 not activated	(1) – Stage type for stage 1 activated
Bit 1	(0) – Stage type for stage 2 not activated	(1) – Stage type for stage 2 activated
Bit 2	(0) – Stage type for stage 3 not activated	(1) – Stage type for stage 3 activated
Bit 3	(0) – Stage type for stage 4 not activated	(1) – Stage type for stage 4 activated
Bit 4	(0) – Stage type for stage 5 not activated	(1) – Stage type for stage 5 activated
Bit 5	(0) – Stage type for stage 6 not activated	(1) – Stage type for stage 6 activated
Bit 6	**X**	
Bit 7	**X**	
Bit 8	**X**	
Bit 9	**X**	
Bit 10	**X**	
Bit 11	**X**	
Bit 12	(0) – Stage type for additional stage 7 not activated	(1) – Stage type for additional stage 7 activated
Bit 13	**X**	
Bit 14	**X**	
Bit 15	**X**	

Table 9: Bitmask of the stage type setting of the 6-stage controller CX plus

X = Reserved / not occupied in the 6-stage controller

NOTE
Stage type settings for the additional stage are only taken into account, if the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES)!

5.3.3 Bits stage type settings 12-stage controller

Bit 0	(0) – Stage type for stage 1 not activated	(1) – Stage type for stage 1 activated
Bit 1	(0) – Stage type for stage 2 not activated	(1) – Stage type for stage 2 activated
Bit 2	(0) – Stage type for stage 3 not activated	(1) – Stage type for stage 3 activated
Bit 3	(0) – Stage type for stage 4 not activated	(1) – Stage type for stage 4 activated
Bit 4	(0) – Stage type for stage 5 not activated	(1) – Stage type for stage 5 activated
Bit 5	(0) – Stage type for stage 6 not activated	(1) – Stage type for stage 6 activated
Bit 6	(0) – Stage type for stage 7 not activated	(1) – Stage type for stage 7 activated
Bit 7	(0) – Stage type for stage 8 not activated	(1) – Stage type for stage 8 activated
Bit 8	(0) – Stage type for stage 9 not activated	(1) – Stage type for stage 9 activated
Bit 9	(0) – Stage type for stage 10 not activated	(1) – Stage type for stage 10 activated
Bit 10	(0) – Stage type for stage 11 not activated	(1) – Stage type for stage 11 activated
Bit 11	(0) – Stage type for stage 12 not activated	(1) – Stage type for stage 12 activated
Bit 12	(0) – Stage type for additional stage 13 not activated	(1) – Stage type for additional stage 13 activated
Bit 13	**X**	
Bit 14	**X**	
Bit 15	**X**	

Table 10: Bitmask of the stage type setting of the 12-stage controller CX plus

X = Reserved

☝NOTE
The stage type settings for the additional stage are only taken into account, if the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES)!

5.3.4 Manual switching of stages via MODBUS

! WARNING

As you purposefully intervene in the control, you should use this function only with extreme care!

Manual switching operations of the compensation stages are not permitted, unless you are absolutely sure that no one is working at the system!

! CAUTION

Modifications at the stage type masks via MODBUS are immediately stored in the "non-volatile memory (FLASH)". Thus, the entered stage type settings are not temporary and will be used again by the reactive power controller CX plus after a device restart!

! CAUTION
By manually switching the stages via Modbus, the stage types are switched to "FOFF" resp. "FON". Please ensure after the completion of the manual switching operations, that the stage types are set back to the stage type "AUTO". "FOFF" and "FON" stages would otherwise be ignored by the control!

☝NOTE
If several stages are set to the stage type "FON" at the same time, the set discharge time will run out for each individual stage first! Afterwards, these stages are switched on successively with the set switching time! The "FON" stage which was defined first is switched on immediately without observing the switching time!

☝NOTE
If several stages are set to the stage type "FOFF" at the same time, these stages will be switched off immediately without delay!

In order to manually switch on and off individual stages via MODBUS, the stage type of these stages must **first** be set to **"FOFF"**. This is realised by setting the respective bit in the FIX OFF stage type mask (address 200 / register 201).

! CAUTION
If these stages were switched on by the control, these will be switched off as a consequence!

To switch stages manually, the respective bits in the FIX ON stage type mask (address 201 / register 202) must be set to "1" or "0". Here, "1" switches the respective stage on (stage type **"FON"**) and "0" switches the respective stage off (➔ stage type **"FOFF"**).

☝NOTE
If the stages are used again by the control, the respective bits in the FIX OFF stage type mask (address 200 / register 201) must be set to "0" ➔ stage type "AUTO"!

5.3.5 Stage data

The stage data are available as of address 208 in the UINT16, UINT32 and SINT32 format.

The stage data are listed in the following tables separately for the 6- and the 12-stage controller. The values for the stage sizes refer to the nominal voltage.

☝NOTE
32 bits values must always be read successively (2 words = 2 registers). It is not possible to read only one register (16 bits) of a 32 bits value or to read between two 32 bits values!

5.3.6 Stage date of the 6-stage controller

Address	Register	Value	Number words	Data type	Write access	Unit
208	209	Current stage size stage 1	2	SINT32	---	var
210	211	Current stage size stage 2	2	SINT32	---	var
212	213	Current stage size stage 3	2	SINT32	---	var
214	215	Current stage size stage 4	2	SINT32	---	var
216	217	Current stage size stage 5	2	SINT32	---	var
218	219	Current stage size stage 6	2	SINT32	---	var
220	221	X				
222	223	X				
224	225	X				
226	227	X				
228	229	X				
230	231	X				
232	233	Current stage size additional stage 7	2	SINT32	---	var
234	235	Original stage size stage 1	2	SINT32	---	var
236	237	Original stage size stage 2	2	SINT32	---	var
238	239	Original stage size stage 3	2	SINT32	---	var
240	241	Original stage size stage 4	2	SINT32	---	var
242	243	Original stage size stage 5	2	SINT32	---	var
244	245	Original stage size stage 6	2	SINT32	---	var
246	247	X				
248	249	X				
250	251	X				
252	253	X				
254	255	X				
256	257	X				
258	259	Original stage size additional stage 7	2	SINT32	---	var

Table 11: Stage data of the 6-stage reactive power controller CX plus (1)

X = Not occupied in the 6-stage controller

NOTE
The stage data for the additional stage are only in use if the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES)!

5.3.7 Stage data of the 6-stage controller (continuation)

Address	Register	Value	Number words	Data type	Write access	Unit
260	261	Switching cycles stage 1	2	UINT32	---	---
262	263	Switching cycles stage 2	2	UINT32	---	---
264	265	Switching cycles stage 3	2	UINT32	---	---
266	267	Switching cycles stage 4	2	UINT32	---	---
268	269	Switching cycles stage 5	2	UINT32	---	---
270	271	Switching cycles stage 6	2	UINT32	---	---
272	273	**X**				
274	275	**X**				
276	277	**X**				
278	279	**X**				
280	281	**X**				
282	283	**X**				
284	285	Switching cycles additional stage 7	2	UINT32	---	---
286	287	Stage running time in hours stage 1	1	UINT16	---	h
287	288	Stage running time in hours stage 2	1	UINT16	---	h
288	289	Stage running time in hours stage 3	1	UINT16	---	h
289	290	Stage running time in hours stage 4	1	UINT16	---	h
290	291	Stage running time in hours stage 5	1	UINT16	---	h
291	292	Stage running time in hours stage 6	1	UINT16	---	h
292	293	**X**				
293	294	**X**				
294	295	**X**				
295	296	**X**				
296	297	**X**				
297	298	**X**				
298	299	Stage running time in hours additional stage 7	1	UINT16	---	h

Table 12: Stage data of the 6-stage reactive power controller CX plus (2)

X = Not occupied in the 6-stage controller

NOTE
The stage data for the additional stage are only in use if the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES)!

5.3.8 Stage data of the 12-stage controller

Address	Register	Value	Number words	Data type	Write access	Unit
208	209	Current stage size stage 1	2	SINT32	---	var
210	211	Current stage size stage 2	2	SINT32	---	var
212	213	Current stage size stage 3	2	SINT32	---	var
214	215	Current stage size stage 4	2	SINT32	---	var
216	217	Current stage size stage 5	2	SINT32	---	var
218	219	Current stage size stage 6	2	SINT32	---	var
220	221	Current stage size stage 7	2	SINT32	---	var
222	223	Current stage size stage 8	2	SINT32	---	var
224	225	Current stage size stage 9	2	SINT32	---	var
226	227	Current stage size stage 10	2	SINT32	---	var
228	229	Current stage size stage 11	2	SINT32	---	var
230	231	Current stage size stage 12	2	SINT32	---	var
232	233	Current stage size additional stage 13	2	SINT32	---	var
234	235	Original stage size stage 1	2	SINT32	---	var
236	237	Original stage size stage 2	2	SINT32	---	var
238	239	Original stage size stage 3	2	SINT32	---	var
240	241	Original stage size stage 4	2	SINT32	---	var
242	243	Original stage size stage 5	2	SINT32	---	var
244	245	Original stage size stage 6	2	SINT32	---	var
246	247	Original stage size stage 7	2	SINT32	---	var
248	249	Original stage size stage 8	2	SINT32	---	var
250	251	Original stage size stage 9	2	SINT32	---	var
252	253	Original stage size stage 10	2	SINT32	---	var
254	255	Original stage size stage 11	2	SINT32	---	var
256	257	Original stage size stage 12	2	SINT32	---	var
258	259	Original stage size additional stage 13	2	SINT32	---	var

Table 13: Stage data of the 12-stage reactive power controller CX plus (1)

NOTE
The stage data for the additional stage are only in use if the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES)!

5.3.9 Stage data of the 12-stage controller (continuation)

Address	Register	Value	Number words	Data type	Write access	Unit
260	261	Switching cycles stage 1	2	UINT32	---	---
262	263	Switching cycles stage 2	2	UINT32	---	---
264	265	Switching cycles stage 3	2	UINT32	---	---
266	267	Switching cycles stage 4	2	UINT32	---	---
268	269	Switching cycles stage 5	2	UINT32	---	---
270	271	Switching cycles stage 6	2	UINT32	---	---
272	273	Switching cycles stage 7	2	UINT32	---	---
274	275	Switching cycles stage 8	2	UINT32	---	---
276	277	Switching cycles stage 9	2	UINT32	---	---
278	279	Switching cycles stage 10	2	UINT32	---	---
280	281	Switching cycles stage 11	2	UINT32	---	---
282	283	Switching cycles stage 12	2	UINT32	---	---
284	285	Switching cycles additional stage 13	2	UINT32	---	---
286	287	Stage running time in hours stage 1	1	UINT16	---	h
287	288	Stage running time in hours stage 2	1	UINT16	---	h
288	289	Stage running time in hours stage 3	1	UINT16	---	h
289	290	Stage running time in hours stage 4	1	UINT16	---	h
290	291	Stage running time in hours stage 5	1	UINT16	---	h
291	292	Stage running time in hours stage 6	1	UINT16	---	h
292	293	Stage running time in hours stage 7	1	UINT16	---	h
293	294	Stage running time in hours stage 8	1	UINT16	---	h
294	295	Stage running time in hours stage 9	1	UINT16	---	h
295	296	Stage running time in hours stage 10	1	UINT16	---	h
296	297	Stage running time in hours stage 11	1	UINT16	---	h
297	298	Stage running time in hours stage 12	1	UINT16	---	h
298	299	Stage running time in hours additional stage 13	1	UINT16	---	h

Table 14: Stage data of the 12-stage reactive power controller CX plus (2)

NOTE
The stage data for the additional stage are only in use if the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES)!

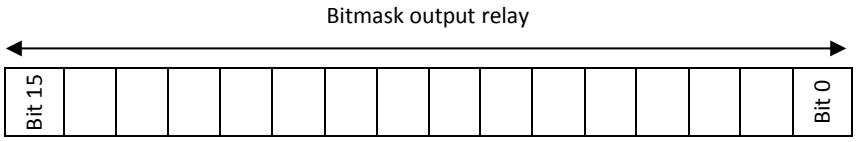
5.4 States of the switching outputs

The states of the switching outputs are available at address 300 as binary bitmasks in the format UINT16 and may be read via Modbus RTU with the function codes 03_{hex} and 04_{hex}.

The least significant bit (bit 0) represents stage output 1, the other stage outputs follow with increasing bit significance. The fan relay resp. the additional stage output is represented by bit 12, and the alarm relay is represented by bit 13.

NOTE
The reactive power controller CX plus answers to the reading of a non-defined address resp. a non-defined register with the hexadecimal value 0x8000 for each read register in the data field!

Address	Register	Value	Number words	Data type	Write access	Unit
300	301	Bitmask switching outputs	1	UINT16	---	---



5.4.1 States of the switching outputs of the 6-stage controller

Bit 0	(0) – Stage 1 not active	(1) – Stage 1 active
Bit 1	(0) – Stage 2 not active	(1) – Stage 2 active
Bit 2	(0) – Stage 3 not active	(1) – Stage 3 active
Bit 3	(0) – Stage 4 not active	(1) – Stage 4 active
Bit 4	(0) – Stage 5 not active	(1) – Stage 5 active
Bit 5	(0) – Stage 6 not active	(1) – Stage 6 active
Bit 6	**X**	
Bit 7	**X**	
Bit 8	**X**	
Bit 9	**X**	
Bit 10	**X**	
Bit 11	**X**	
Bit 12	(0) – Fan relay / additional stage output 7 not active	(1) – Fan relay / additional stage output 7 active
Bit 13	(0) – Alarm relay active	(1) – Alarm relay not active
Bit 14	**X**	
Bit 15	**X**	

Table 15: States of the switching outputs of the 6-stage controller CX plus

X = Reserved / not occupied in the 6-stage controller

NOTE
If the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES), bit 12 represents the additional stage output. Otherwise, the state of the fan control function will be signalled.

5.4.2 States of the switching outputs of the 12-stage controller

Bit 0	(0) – Stage 1 not active	(1) – Stage 1 active
Bit 1	(0) – Stage 2 not active	(1) – Stage 2 active
Bit 2	(0) – Stage 3 not active	(1) – Stage 3 active
Bit 3	(0) – Stage 4 not active	(1) – Stage 4 active
Bit 4	(0) – Stage 5 not active	(1) – Stage 5 active
Bit 5	(0) – Stage 6 not active	(1) – Stage 6 active
Bit 6	(0) – Stage 7 not active	(1) – Stage 7 active
Bit 7	(0) – Stage 8 not active	(1) – Stage 8 active
Bit 8	(0) – Stage 9 not active	(1) – Stage 9 active
Bit 9	(0) – Stage 10 not active	(1) – Stage 10 active
Bit 10	(0) – Stage 11 not active	(1) – Stage 11 active
Bit 11	(0) – Stage 12 not active	(1) – Stage 12 active
Bit 12	(0) – Fan relay / additional stage output 13 not active	(1) – Fan relay / additional stage output 13 active
Bit 13	(0) – Alarm relay active	(1) – Alarm relay not active
Bit 14	**X**	
Bit 15	**X**	

Table 16: States of the switching outputs of the 12-stage controller CX plus

X = Reserved

NOTE
If the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES), bit 12 represents the additional stage output. Otherwise, the state of the fan control function will be signalled.

5.5 Extended operating hour counter of the stages in seconds

In the address range 600 to 612, the stage running time is provided in seconds (extended operating hour counter of the stages). After 3600 seconds = 1 hour, the counter is reset to zero and starts again from zero. The operating hour counter of the stages (address range 286 to 298) is increased by 1 for each respective stage in the stage database.

NOTE
The operating hours display of a stage in the stage information menu and the SETUP menu 405 is composed of both counters. The operating hours are displayed as decimal number: 3.50 h corresponds to three and a half hours and not 3 hours and 50 minutes!

NOTE
The running time for a stage connected at the fan relay is only measured if the function "fan relay as additional stage output" is activated in the SETUP menu 406 (YES)!

The stage running time in seconds of the individual stages may be read via Modbus with the function codes 03_{hex} and 04_{hex}.

NOTE
The reactive power controller CX plus answers to the reading of a non-defined address resp. a non-defined register with the hexadecimal value 0x8000 for each read register in the data field.

Address	Register	Value	Number words	Data type	Write access	Values range
600	601	Stage running time in seconds stage 1	1	UINT16	---	0…3599s
601	602	Stage running time in seconds stage 2	1	UINT16	---	0…3599s
602	603	Stage running time in seconds stage 3	1	UINT16	---	0…3599s
603	604	Stage running time in seconds stage 4	1	UINT16	---	0…3599s
604	605	Stage running time in seconds stage 5	1	UINT16	---	0…3599s
605	606	Stage running time in seconds stage 6	1	UINT16	---	0…3599s
606	607	**X**				
607	608	**X**				
608	609	**X**				
609	610	**X**				
610	611	**X**				
611	612	**X**				
612	613	Stage running time in seconds additional stage 7	1	UINT16	---	0…3599s

Table 17: Stage running time of the 6-stage controller CX plus

X = Not occupied in the 6-stage controller

5.5.1 Stage running time 12-stage controller

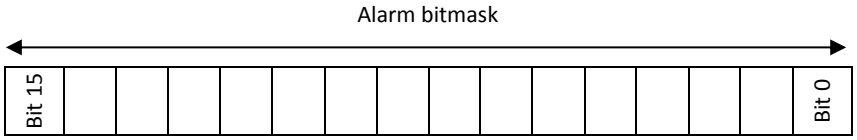
Address	Register	Value	Number words	Data type	Write access	Values range
600	601	Stage running time in seconds stage 1	1	UINT16	---	0…3599s
601	602	Stage running time in seconds stage 2	1	UINT16	---	0…3599s
602	603	Stage running time in seconds stage 3	1	UINT16	---	0…3599s
603	604	Stage running time in seconds stage 4	1	UINT16	---	0…3599s
604	605	Stage running time in seconds stage 5	1	UINT16	---	0…3599s
605	606	Stage running time in seconds stage 6	1	UINT16	---	0…3599s
606	607	Stage running time in seconds stage 7	1	UINT16	---	0…3599s
607	608	Stage running time in seconds stage 8	1	UINT16	---	0…3599s
608	609	Stage running time in seconds stage 9	1	UINT16	---	0…3599s
609	610	Stage running time in seconds stage 10	1	UINT16	---	0…3599s
610	611	Stage running time in seconds stage 11	1	UINT16	---	0…3599s
611	612	Stage running time in seconds stage 12	1	UINT16	---	0…3599s
612	613	Stage running time in seconds additional stage 13	1	UINT16	---	0…3599s

Table 18: Stage running time of the 12-stage controller CX plus

5.6 Alarm status

The alarm status of the controller is provided under the address 701 as binary bitmask in the UINT16 format and can be read via MODBUS with the function codes 03_{hex} and 04_{hex}. The assignment of the individual alarms takes place via the bitmask illustrated below. The alarm is active when the corresponding bit is = 1.

Address	Register	Value	Number words	Data type	Write access	Unit
701	702	Alarm status	1	UINT16	---	Flags



Bit0	(0) – “Alarm Max. Operation Hours Stages (OPHS)” NOT active	(1) – “Alarm Max. Operation Hours Stages (OPHS)” active
Bit1	(0) – “THD-I Alarm” NOT active	(1) – “THD-I Alarm” active
Bit2	(0) – “Alarm Max. Switching Cycles Stages (OPC)” NOT active	(1) – “Alarm Max. Switching Cycles Stages (OPC)” active
Bit3	(0) – “Alarm Max. Operation Hours PFC (OPH)” NOT active	(1) – “Alarm Max. Operation Hours PFC (OPH)” active
Bit4	(0) – “Alarm Temp. 2 limit (thi)” NOT active	(1) – “Alarm Temp. 2 limit (thi)” active
Bit5	(0) – “Temp. 1 limit (FAN)” NOT active	(1) – “Temp. 1 limit (FAN)” active
Bit6	(0) – “Stage Power Lost Alarm” NOT active	(1) – “Stage Power Lost Alarm” active
Bit7	(0) – “Faulty Stage Alarm” NOT active	(1) – “Faulty Stage Alarm” active
Bit8	(0) – “THD-U Alarm” NOT active	(1) – “THD-U Alarm” active
Bit9	(0) – “Control (PFC) Alarm” NOT active	(1) – “Control (PFC) Alarm” active
Bit10	(0) – “Over Current (I-hi) Alarm” NOT active	(1) – “Over Current (I-hi) Alarm” active
Bit11	(0) – “Under Current (I-Low) Alarm” NOT active	(1) – “Under Current (I-Low) Alarm” active
Bit12	(0) – “Voltage (U) Alarm” NOT active	(1) – “Voltage (U) Alarm” active
Bit13	(0) – Digital-Input-Alarm NOT active **X**	(1) – Digital-Input-Alarm active **X**
Bit14	**X**	
Bit15	(0) – SYSTEM-Alarm NOT active **X**	(1) – SYSTEM-Alarm active **X**

Table 19: Alarm status messages of the reactive power controller CX plus

X = Reserved

5.7 Alarm memory

The alarm memory with 10 storage places is provided as of address 800 as binary bitmask in the UINT16 format.

The masks of the alarm memory may be read via MODBUS with the function codes 03_{hex} and 04_{hex}.

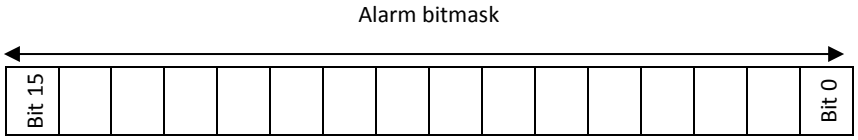
NOTE

The reactive power controller CX plus answers to the reading of a non-defined address resp. a non-defined register with the hexadecimal value 0x8000 for each read register in the data field.

Address	Register	Value	Number words	Data type	Write access	Unit
800	801	Alarm 1 (latest alarm)	1	UINT16	---	Bitmask
801	802	Alarm 2	1	UINT16	---	Bitmask
802	803	Alarm 3	1	UINT16	---	Bitmask
803	804	Alarm 4	1	UINT16	---	Bitmask
804	805	Alarm 5	1	UINT16	---	Bitmask
805	806	Alarm 6	1	UINT16	---	Bitmask
806	807	Alarm 7	1	UINT16	---	Bitmask
807	808	Alarm 8	1	UINT16	---	Bitmask
808	809	Alarm 9	1	UINT16	---	Bitmask
809	810	Alarm 10 (oldest alarm)	1	UINT16	---	Bitmask

Table 20: Alarm memory of the reactive power controller CX plus

The assignment of the saved alarms takes place via the bitmask illustrated below. The bit set to "1" represents the saved alarm.



Bit 0	(1) – “Alarm Max. Operation Hours Stages (OPHS)”
Bit 1	(1) – “THD-I Alarm”
Bit 2	(1) – “Alarm Max. Switching Cycles Stages (OPC)”
Bit 3	(1) – “Alarm Max. Operation Hours PFC (OPH)”
Bit 4	(1) – “Alarm Temp. 2 limit (thi)”
Bit 5	**X**
Bit 6	(1) – “Stage Power Lost Alarm”
Bit 7	(1) – “Faulty Stage Alarm”
Bit 8	(1) – “THD-U Alarm”
Bit 9	(1) – “Control-Alarm (PFC)”
Bit 10	(1) – “Over Current-Alarm (I-hi)”
Bit 11	(1) – “Under Current-Alarm (I-Low)”
Bit 12	(1) – “Voltage-Alarm (U)”
Bit 13	(1) – Digital-Input-Alarm
Bit 14	**X**
Bit 15	(1) – SYSTEM-Alarm

Table 21: Bit assignment alarms of the reactive power controller CX plus

X = Reserved

5.8 Device identification

The device identification is available as of address 400 as UINT16 value and can be read with the function codes 03_{hex} and 04_{hex}.

NOTE
The reactive power controller CX plus answers to the reading of a non-defined address resp. a non-defined register with the hexadecimal value 0x8000 for each read register in the data field.

The data of the individual addresses are each encoded with 2 ASCII characters. The structure of the device identification is illustrated in the following table by means of an example.

Address	Register	Value	Number words	Data type	Write access	Data (HEX)	Data (ASCII)
400	401	Software version	1	UINT16	---	0x30, 0x31	01
401	402		1	UINT16	---	0x2E, 0x30	.0
402	403		1	UINT16	---	0x30, 0x2E	0.
403	404		1	UINT16	---	0x30, 0x30	00
404	405	Serial number part 1: Date code week	1	UINT16	---	0x32, 0x31	21
405	406	Serial number part 2: Date code year	1	UINT16	---	0x31, 0x37	17
406	407	Serial number part 3: Consecutive number	1	UINT16	---	0x31, 0x30	10
407	408		1	UINT16	---	0x30, 0x33	03
408	409		1	UINT16	---	0x30, 0x38	08
409	410		1	UINT16	---	0x31, 0x35	15
410	411	Hardware version	1	UINT16	---	0x30, 0x31	01
411	412		1	UINT16	---	0x2E, 0x30	.0
412	413		1	UINT16	---	0x30, 0x2E	0.
413	414		1	UINT16	---	0x30, 0x30	00

Table 22: Device identification of the reactive power controller CX plus

5.9 Permanent storage of the device settings

If the device settings made via MODBUS shall be stored permanently by the reactive power controller CX plus, the storage of the settings in the **"non-volatile memory (FLASH)"** must be activated explicitly.

Address	Register	Value	Number words	Data type	Write access	Unit
4095	4096	Storage of the device settings in the FLASH	1	UINT16	YES	---

By writing the code "**29864**" to the address 4095 (register 4096) via the function code 10_{hex}, the storage action, saving the device settings in the **"non-volatile memory (FLASH)"**, is activated. The respective settings are available again after a device restart.

! CAUTION

Unnecessary writing activities into the FLASH memory will reduce its service life and thus the service life of the reactive power controller CX plus (approx. 100,000 writing cycles)!

Consequently, frequent writing activities in the FLASH memory shall be avoided. Therefore, do not save the device settings in the "non-volatile memory (FLASH)" until you have made all settings!

NOTE
The function code 06_{hex} cannot be used in the present case!

By reading the address **4095** (resp. register 4096) with the function codes 03_{hex} and 04_{hex}, the status of the writing activity can be requested.

0 = No active writing activity/writing activity not completed successfully.

1 = A writing activity is active and has not yet been completed.

6 Troubleshooting

In case no communication may be set up between programming device and reactive power controller, the error must be searched between reactive power controller CX plus and PC resp. SCADA system or specific customer software!

Possible causes:

1. Are the communication settings (baud rate, parity and stop bits) set correctly in the Modbus settings of the reactive power controller CX plus? Change the configuration, if necessary.

   ☝NOTE
   All participants of the Modbus communication structure must have the same communication parameters!

2. Is the SLAVE address (SLAVE ID) of the reactive power controller CX plus set correctly? The setting may have to be adjusted.

   ☝NOTE
   The slave address (slave ID) may only be assigned once in the Modbus communication structure!

3. Does the Modbus master device (PC software resp. SCADA system) use the same slave address set in the configuration of the reactive power controller CX plus? If this is not the case, these must be adjusted.

4. If the cable of the bus connection shows any damages, this must be replaced.

5. Defective clamping and plug connection must be replaced.

6. The pin assignment of the 3-pole RS485 connection (**+**, **-**, **GND**) must correspond to the terminal assignment in Figure 1: Connector plug with symbolic marking of the Modbus communication interface of the reactive power controller CX plus.

7. Is it possible, that the data wires have been connected at the pins **+** and **–** of the 3-pole RS485 terminal of the reactive power controller CX plus in mixed-up order? **+** must be connected with **D(+)** and **–** with **D(-)** of the RS485 bus system. If necessary, the connection of the data wires of the reactive power controller CX plus must be corrected.

8. Is the assignment of the data wires **D(+)** (resp. **A**) and **D(-)** (resp. **B**) generally mixed-up in the bus system?

   ☝NOTE
   In case of some devices, the data conductor "A" cannot be equated with "D(+)" and the data conductor "B" cannot be equated with "D(-)" or, otherwise, the logic of the bus system is mixed-up! Correct the connection of the data wires in this case.

9. Was the shield of the BUS wire used as **GND** wire?

   ☝NOTE
   The shield of the bus wires must not be used as GND wire! The ground signal must be wired separately!

10. Was the bus wire correctly terminated with termination resistors? If need be, termination resistors must be retrofitted resp. their position corrected.

    ☝NOTE
    The bus system may only be terminated at the first and the last participant! Some devices have integral termination resistors.

    If possible, integral termination resistors should be switched off or these devices should be placed at the beginning and at the end of the bus line.

11. In case of long bus wires an active supply of the bus line may be necessary by an external power supply unit via bias resistors, because the voltage levels on the data wires may show undefined conditions.

    ☝NOTE
    The reactive power controller CX plus cannot supply the bus system actively!

12. Provided that the bus system is supplied actively, the bias resistors must be connected correctly. Please check the proper functioning of the power supply unit as well as the key figures of the installed resistors.

13. In case a RS485/RS232 converter is used for the connection of the reactive power controller CX plus, the communication settings at the converter must be checked and correspond to the settings of the other bus participants. If necessary, check the data sheet of the converter.

14. If several PC applications access the same serial interface of the PC at the same time (multiple occupancy), to which the RS485/RS232 converter is connected, the multiple occupancy shall be removed and another free serial interface shall be used for the converter.

    ☝NOTE
    Only one application may access a serial interface at the same time!

The communication between PC and reactive power controller CX plus is set up, but there are frequent communication errors (timeouts).

Possible causes:

1. The transmission rate (baud rate) is set too high. The next lower baud rate must be selected and set in all bus participants.

2. The common ground signal (GND) is missing in the bus structure. Check if all bus participants are connected via the common ground signal (GND). If not, the common ground signal must be retrofitted.

   NOTE
   The shield of the bus wires must not be used as GND wire! (common ground signal)! The ground signal must be wired separately!

3. There are undefined voltage levels on the data wires of the bus wire, because the active supply (bias voltage) is missing. Check if an active supply is available or if a bus participant is able to actively supply the bus system. If necessary, the active supply of the bus wires must be retrofitted via an external power supply unit and additional bias resistors.

The communication is set up, but the software causes problems on the PC or the SCADA system, please check the following points:

1. Settings slave address, baud rate, parity and stop bits in the software.

2. If correct measurement values are read, the Modbus address resp. the registers must be checked and set correctly.

   NOTE
   Even though Modbus addresses are mentioned in some SCADA systems, it is the registers which are expected in reality. In this case, a 1 must always be added to the address!

   Register = address + 1.

   In order to determine the correct addressing mode, please read the manual of the software resp. of the SCADA system.

3. Provided that the data cannot be interpreted correctly, the used data format must be checked for the affected address resp. the register and set correctly, if necessary.

   NOTE
   The reactive power controller CX plus uses the Little Endian (Intel) coding of the data. This shall be observed for the interpretation of 32 bits values:

   LOW word (LSB) | HIGH word (MSB)

   Particularly in case of the Netbiter WS100 and WS200 devices, the data type with the prefix SWAPPED shall always be used as data type for UINT32, SINT32 and FLOAT!

4. If the reactive power controller CX plus answers with the **exception code 03 = Illegal Data Value** during the reading process of a 32 bits value, check if only **1 word** of the 32 bits value is read resp.

written or if it is read resp. written **between two 32 bits values**. The number of registers may probably have to be changed to 2 words or the address (or the registers) have to be corrected in a way, that the 32 bits value is read resp. written completely.

5. In case the reactive power controller CX plus returns the value **0x8000** during the reading process of one or several address(es) resp. register(s), the address (resp. register) for the returned value is not defined. The entered address resp. register or the number of words to be read must be checked and corrected, if necessary.

6. If the reactive power controller CX plus answers with the **exception code 03 = Illegal Data Value** in the course of a writing process, please check if the value to be written is within the valid value range, if undefined bits of the bitmasks are set to a Boolean **"0"**, or if the target address resp. register may be written. In this case, the value to be written, the bitmask or the target address resp. the register shall be corrected.

NOTE
Non-defined bits of the bitmasks must be written with a Boolean "0"!

7 Annex – ASCII table

Dec	Hex	ASCII
0	0x00	NUL
1	0x01	SOH
2	0x02	STX
3	0x03	ETX
4	0x04	EOT
5	0x05	ENQ
6	0x06	ACK
7	0x07	BEL
8	0x08	BS
9	0x09	HT
10	0x0A	LF
11	0x0B	VT
12	0x0C	FF
13	0x0D	CR
14	0x0E	SO
15	0x0F	SI
16	0x10	DLE
17	0x11	DC1
18	0x12	DC2
19	0x13	DC3
20	0x14	DC4
21	0x15	NAK
22	0x16	SYN
23	0x17	ETB
24	0x18	CAN
25	0x19	EM
26	0x1A	SUB
27	0x1B	ESC
28	0x1C	FS
29	0x1D	GS
30	0x1E	RS
31	0x1F	US

Dec	Hex	ASCII
32	0x20	SP
33	0x21	!
34	0x22	"
35	0x23	#
36	0x24	$
37	0x25	%
38	0x26	&
39	0x27	'
40	0x28	(
41	0x29	)
42	0x2A	*
43	0x2B	+
44	0x2C	,
45	0x2D	-
46	0x2E	.
47	0x2F	/
48	0x30	0
49	0x31	1
50	0x32	2
51	0x33	3
52	0x34	4
53	0x35	5
54	0x36	6
55	0x37	7
56	0x38	8
57	0x39	9
58	0x3A	:
59	0x3B	;
60	0x3C	<
61	0x3D	=
62	0x3E	>
63	0x3F	?

Dec	Hex	ASCII
64	0x40	@
65	0x41	A
66	0x42	B
67	0x43	C
68	0x44	D
69	0x45	E
70	0x46	F
71	0x47	G
72	0x48	H
73	0x49	I
74	0x4A	J
75	0x4B	K
76	0x4C	L
77	0x4D	M
78	0x4E	N
79	0x4F	O
80	0x50	P
81	0x51	Q
82	0x52	R
83	0x53	S
84	0x54	T
85	0x55	U
86	0x56	V
87	0x57	W
88	0x58	X
89	0x59	Y
90	0x5A	Z
91	0x5B	[
92	0x5C	\
93	0x5D	]
94	0x5E	^
95	0x5F	_

Dec	Hex	ASCII
96	0x60	`
97	0x61	a
98	0x62	b
99	0x63	c
100	0x64	d
101	0x65	e
102	0x66	f
103	0x67	g
104	0x68	h
105	0x69	i
106	0x6A	j
107	0x6B	k
108	0x6C	l
109	0x6D	m
110	0x6E	n
111	0x6F	o
112	0x70	p
113	0x71	q
114	0x72	r
115	0x73	s
116	0x74	t
117	0x75	u
118	0x76	v
119	0x77	w
120	0x78	x
121	0x79	y
122	0x7A	z
123	0x7B	{
124	0x7C	|
125	0x7D	}
126	0x7E	~
127	0x7F	DEL

Source: https://de.wikipedia.org/wiki/American_Standard_Code_for_Information_Interchange

8 Notes