

# CMC 500

## Technical Data



## Technical Data

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# 1 Specifications

## 1.1 General

This section contains the complete specifications for the CMC 500. These specifications characterize the behavior of the device under different operating and environmental conditions. The values stated in this chapter are one of the following:

- Guaranteed specifications are either verified with every CMC 500 during production or defined by design and are valid for a defined time period.
- Typical specifications are determined with an adequate number of devices during type tests under calibration conditions.

All **guaranteed specifications** are given with a confidence level of 99 % when operated under the conditions stated in section [Specification conditions](#) (page 3). To take account of component drift, most specified values are guaranteed for 1 and 2 years. If nothing is stated, the specified value is guaranteed and corresponds to a drift of 2 years. The period starts on the date of issue stated on the Certificate of Calibration and Conformance.

All **typical specifications** are determined with an adequate number of test sets during type tests by our calibration experts under the conditions stated in section [Calibration conditions](#) (page 3). Typical specifications are not tested during production and are therefore not warranted.

- ▶ For calculation examples on how to interpret the specifications, see section [Accuracy calculation examples](#) (page 31).

## 1.2 Specification conditions

Unless stated otherwise, the specifications given in this section apply at the terminals of the CMC 500 and under the following conditions:

- Warm-up period: 15 minutes
- Temperature:  $23 \pm 5$  °C
- Relative humidity: between 20 % and 90 %
- Regular adjustment: at least every 2 years

## 1.3 Calibration and adjustment conditions

- Storage: 24 h at  $23 \pm 5$  °C, at a humidity between 40 % and 60 %
- Warm-up period: 30 minutes
- Temperature:  $23 \pm 2$  °C
- Relative humidity: between 40 % and 60 %
- Additional conditions defined for each functional element (for example, calibration burden for analog output modules)

## 1.4 System clock accuracy

All signals generated or measured by the CMC 500 refer to a common internal time base that is specified as follows:

Table 1-1: System clock accuracy specification

<b>Characteristic</b>	
Clock performance	Stratum 3 (ANSI/T1.101-1987)
<b>Frequency drift (over time)</b>	
24 hours	< $\pm 0.37$ ppm ( $\pm 0.000037$ %)
20 years	< $\pm 4.60$ ppm ( $\pm 0.00046$ %)
Frequency drift (over temperature range)	< $\pm 0.28$ ppm ( $\pm 0.000028$ %)
Frequency resolution (signal generation)	< 5 $\mu$ Hz

## 1.5 Synchronization

### Synchronization of system clock

By synchronizing the system clock to an external time base, the system clock accuracy can be improved up to the level of the external time base. Synchronizing the system clock additionally makes the absolute time available in the system to tag measurement results, start distributed tests at the same time, and generate and measure synchrophasors.

The following specifications are according to the IEEE 1588-2008 (v2) and refer to the internal time base. For the absolute time accuracy of the outputs and inputs, the inherent error of the respective channel itself has to be added.

Table 1-2: System clock synchronization specification

<b>Characteristic</b>	<b>Specification</b>
Offset (UTC)	Error < $\pm 1$ $\mu$ s
Pulling range	$\pm 100$ ppm ( $\pm 0.01$ %)
Supported profiles	IEEE C37.238-2011 (Power Profile) IEC/PAS 61850-9-3: Communication Networks and Systems for Power Utility Automation – Part 9-3: Precision Time Protocol Profile for Power Utility Automation (Utility Profile)
Supported sources	OMICRON CMGPS 588 or any Precision Time Protocol source (PTP grandmaster clock)

### Synchronization of voltage and current output signals

The phase and frequency of the voltage and current outputs can be synchronized to a reference input signal of 15 to 70 Hz applied to binary input 10. In contrast to the synchronization of the system clock, this kind of synchronization influences the frequency and phase of the signal generation directly.

The possible accuracy depends on the quality of the synchronization signal because the synchronization uses the zero crossings of the signal.

## 1.6 Analog output modules U, S, and V

This chapter contains specifications for multiple modules. The following table shows the supported configurations:

Table 1-3: Analog output modules U, S, and V – Configuration overview

			U	S	V
Current	L-N / L4-N4	4 × 30 A	✓	–	–
	L-N	3 × 30 A	✓	✓	–
	L4-N4	1 × 30 A	✓	✓	✓
	LLL-N	1 × 90 A (high amplitude)	✓	✓	–
	L-L	1 × 30 A (high power)	✓	✓	–
Voltage	L-N / L4-N4	4 × 300 V	✓	–	✓
	L-N	3 × 300 V	✓	✓	✓
	LLL-N	1 × 300 V (high power)	✓	✓	✓
	L-L	2 × 600 V (high amplitude)	✓	–	✓
	L-L	1 × 600 V (high amplitude)	✓	✓	✓
Mixed	L-N / L4-N4	3 × 300 V / 1 × 30 A	✓	–	✓
	L-N / L4-N4	3 × 30 A / 1 × 300 V	✓	–	–

### 1.6.1 General

Table 1-4: Current output specification – General

Characteristic	Specification
Ranges	Range I: 0 ... 1.25 A Range II: 0 ... 6 A Range III: 0 ... 30 A
Protection	Protected against overload and overtemperature
Frequency range <sup>1</sup>	0 ... 5 kHz
<b>Configurations</b>	
L-N / L4-N4	4 × 30 A
LLL-N (parallel)	1 × 90 A (high amplitude)
L-L (series)	1 × 30 A (high power)
Max. compliance voltage (RMS)	20 V
<b>Resolution per channel (DC)</b>	
1.25 A range	< 20 µA
6 A range	< 100 µA
30 A range	< 500 µA

<sup>1</sup> For injections longer than 1 minute, the maximum fundamental frequency is limited to 587 Hz to comply with international trade restrictions for frequency-controlled signal generators. For other options, contact OMICRON Support (→ [Support](#) (page 40)).

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Table 1-5: Voltage output specification – General

Characteristic	Specification
Ranges	Range I: 0 ... 75 V Range II: 0 ... 300 V
Protection	Protected against short circuit, overload, and overtemperature
Frequency range	0 ... 5 kHz
<b>Configurations</b>	
L-N / L4-N4	4 × 300 V
LLL-N (parallel)	1 × 300 V (high power)
L-L (series)	2 × 600 V (high amplitude)
Max. output current (RMS)	1 A
<b>Resolution per channel (DC)</b>	
75 V range	< 1 mV
300 V range	< 4 mV

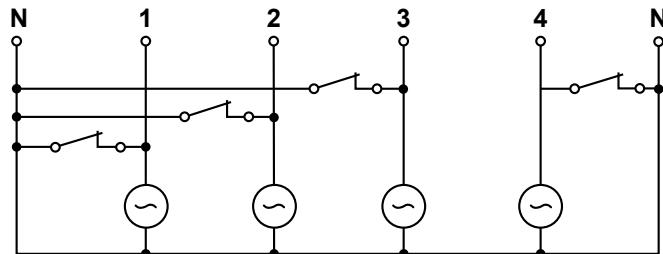
Table 1-6: Mixed configurations – General

Configuration	Specification
L-N / L4-N4 (mixed)	3 × 30 A / 1 × 300 V
L-N / L4-N4 (mixed)	3 × 300 V / 1 × 30 A

## 1.6.2 Protection

The analog output is protected against short circuit, overload, and overtemperature.

If the *CMC 500* or the analog output is off, the outputs are short-circuited.



## 1.6.3 Accuracy

The accuracy of the analog output modules is specified based on burden, amplitude accuracy and phase accuracy. Detailed information is available in the following sections.

Accuracy specifications are given either in absolute or relative values, with relative values being indicated as percentage of the set value and percentage of the range.

The accuracy specifications are given under the following conditions:

- Output configuration: Multi-phase symmetrical or single-phase
- Burden: Resistive load within burden range
- Unused analog outputs: off
- Overload or short circuit: no indication

### 1.6.3.1 Burden

The amplitude and phase accuracy of the analog output module depends on the connected burden. Unless stated otherwise, the specification is valid within the following conditions:

Table 1-7: Current output specification – Burden

Range	Adjustment burden	Burden range
1.25 A	0.35 $\Omega$	< 0.7 $\Omega$
6 A	0.25 $\Omega$	< 0.5 $\Omega$
30 A	0.15 $\Omega$	< 0.3 $\Omega$

Table 1-8: Voltage output specification – Burden

Range	Adjustment burden	Burden range
75 V	4 k $\Omega$	> 2 k $\Omega$
300 V	4 k $\Omega$	> 2 k $\Omega$

### 1.6.3.2 Amplitude accuracy

The amplitude accuracy is specified using a measurement bandwidth of 20 kHz.

Table 1-9: Current output specification – Accuracy

Range	Frequency	Typical <sup>1</sup>	Guaranteed (1 year) <sup>1</sup>	Guaranteed (2 years) <sup>1</sup>
1.25 A	$\leq$ 100 Hz	0.05 + 0.01	0.10 + 0.03	0.20 + 0.03
	$\leq$ 400 Hz	0.1 + 0.01	0.15 + 0.06	0.25 + 0.06
	$\leq$ 1 kHz	0.15 + 0.01	0.40 + 0.13	0.50 + 0.13
	$\leq$ 5 kHz	2 + 0.02	10 + 1.0	10 + 1.0
	DC offset <sup>2</sup>	0.15 mA	0.3 mA	0.3 mA
6 A <sup>3</sup>	$\leq$ 100 Hz	0.05 + 0.01	0.16 + 0.03	0.26 + 0.03
	$\leq$ 400 Hz	0.1 + 0.01	0.25 + 0.08	0.35 + 0.08
	$\leq$ 1 kHz	0.18 + 0.01	0.45 + 0.20	0.55 + 0.20
	$\leq$ 5 kHz	3 + 0.02	10 + 1.0	10 + 1.0
	DC offset <sup>2</sup>	2 mA	3 mA	3 mA
30 A	$\leq$ 100 Hz	0.1 + 0.01	0.15 + 0.03	0.25 + 0.03
	$\leq$ 400 Hz	0.14 + 0.01	0.22 + 0.06	0.32 + 0.06
	$\leq$ 1 kHz	0.18 + 0.01	0.35 + 0.13	0.45 + 0.13
	$\leq$ 5 kHz	3 + 0.02	10 + 1.0	10 + 1.0
	DC offset <sup>2</sup>	2 mA	6 mA	6 mA

<sup>1</sup> Error less than (% of set value + % of range).

<sup>2</sup> Valid over full operating temperature range (-25 ... 50 °C). Add this to the  $\leq$  100 Hz specification to get the maximum DC error.

<sup>3</sup> The specifications are valid after a cool-down period of 5 minutes if currents greater than 6 A have been output before.



If the test object evaluates AC and DC components, the offset needs to be considered in the RMS value. The effect is negligible for currents higher than 5 % of the output range.

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The typical offset specification is valid directly after activation due to an internal offset adjustment before every activation. The guaranteed specification considers potential temperature drifts while the outputs are active in addition.

In case the device is operated outside of the nominal temperature range of  $23 \pm 5$  °C, the following coefficients must be considered to calculate the accuracy:

Table 1-10: Current output specification – Temperature coefficient

Range	Temperature coefficient < 18 °C (guaranteed)	Temperature coefficient > 28 °C (guaranteed)
1.25 A	15 ppm/°C	15 ppm/°C
6 A	40 ppm/°C	15 ppm/°C
30 A	40 ppm/°C	15 ppm/°C

Table 1-11: Voltage output specification – Accuracy

Range	Frequency	Typical <sup>1</sup>	Guaranteed (1 year) <sup>1</sup>	Guaranteed (2 years) <sup>1</sup>
75 V	≤ 100 Hz	0.03 + 0.005	0.07 + 0.01	0.17 + 0.01
	≤ 400 Hz	0.05 + 0.005	0.13 + 0.02	0.23 + 0.02
	≤ 1 kHz	0.15 + 0.005	0.50 + 0.04	0.60 + 0.04
	≤ 5 kHz	3 + 0.02	10 + 1.0	10 + 1.0
	DC offset <sup>2</sup>	2 mV	5 mV	5 mV
300 V	≤ 100 Hz	0.04 + 0.006	0.09 + 0.01	0.19 + 0.01
	≤ 400 Hz	0.05 + 0.006	0.15 + 0.02	0.25 + 0.02
	≤ 1 kHz	0.2 + 0.006	0.52 + 0.04	0.62 + 0.04
	≤ 5 kHz	2 + 0.02	10 + 1.0	10 + 1.0
	DC offset <sup>2</sup>	6 mV	20 mV	20 mV

<sup>1</sup> Error less than (% of set value + % of range).

<sup>2</sup> Valid over full operating temperature range (-25 ... 50 °C). Add this to the ≤ 100 Hz specification to get the maximum DC error.

- The neutral socket of the first three channels is internally connected to the neutral socket of the 4th channel. Nevertheless, the 4th channel must be used with its dedicated neutral to reach the specified voltage accuracy.
- If the test object evaluates AC and DC components, the offset needs to be considered in the RMS value. The effect is negligible for voltages higher than 5 % of the output range.

In case the device is operated outside of the nominal temperature range of  $23 \pm 5$  °C, the following coefficients must be considered to calculate the accuracy:

Table 1-12: Voltage output specification – Temperature coefficient

Range	Temperature coefficient (guaranteed)
75 V	15 ppm/°C
300 V	15 ppm/°C

### 1.6.3.3 Phase accuracy

Table 1-13: Current output specification – Phase accuracy

Reference	Range	Frequency	Typical	Guaranteed
Internal time base	1.25 A	50/60 Hz	0.03°	0.10°
	6 A	50/60 Hz	0.04°	0.12°
	30 A	50/60 Hz	0.03°	0.12°

Table 1-14: Voltage output specification – Phase accuracy

Reference	Range	Frequency	Typical	Guaranteed
Internal time base	75 V	50/60 Hz	0.02°	0.05°
	300 V	50/60 Hz	0.02°	0.05°

### 1.6.3.4 Total harmonic distortion and noise (THD+N)

The THD+N is specified using a fundamental frequency of 55 Hz and a measurement bandwidth of 20 kHz.

Table 1-15: Current output specification – THD+N

Range	Current	THD+N (typical)	THD+N (guaranteed)
1.25 A	0.5 A	< 0.16 %	< 0.23 %
	1 A	< 0.08 %	< 0.12 %
6 A	1 A	< 0.08 %	< 0.12 %
	5 A	< 0.03 %	< 0.05 %
30 A	5 A	< 0.08 %	< 0.15 %
	30 A	< 0.03 %	< 0.05 %

Table 1-16: Voltage output specification – THD+N

Range	Voltage	THD+N (typical)	THD+N (guaranteed)
75 V	30 V	< 0.08 %	< 0.12 %
	75 V	< 0.03 %	< 0.05 %
300 V	75 V	< 0.03 %	< 0.05 %
	300 V	< 0.03 %	< 0.05 %

## 1.6.4 Output power

The output power of the CMC 500 is specified for line voltages from 100 to 240 V.

For line voltages below 220 V, follow these steps to achieve the maximum output power of the CMC 500 without restrictions:

- ▶ Set the fuse emulation to 15 A in the web interface.
- ▶ Use a power cord rated for 15 A.

### Current output

The AC output power is specified for 50/60 Hz signals. Power ratings given in W are tested with resistive loads.

Table 1-17: Current output specification – Output power

Configuration	Typical	Guaranteed
<b>4-phase symmetrical (0°, 90°, 180°, 270°)</b>		
4 × 30 A <sub>AC</sub>	4 × 200 W at 12 A	4 × 160 W at 12 A
L-N / L4-N4		
<b>3-phase symmetrical (0°, 120°, 240°)</b>		
3 × 30 A <sub>AC</sub>	3 × 250 W at 15 A	3 × 200 W at 15 A
L-N	3 × 185 W at 30 A	3 × 150 W at 30 A
<b>1-phase high amplitude (0°, 0°, 0°)</b>		
1 × 90 A <sub>AC</sub>	1 × 630 W at 39 A	1 × 510 W at 39 A
LLL-N (parallel)		
1 × 90 A <sub>DC</sub>	1 × 795 W at 36 A	1 × 630 W at 36 A
LLL-N (parallel)		
<b>1-phase high power (0°, 180°)</b>		
1 × 30 A <sub>AC</sub>	1 × 500 W at 15 A	1 × 400 W at 15 A
L-L (series)		
1 × 30 A <sub>DC</sub>	1 × 705 W at 15 A	1 × 565 W at 15 A
L-L (series)		

The charts below were determined under the following conditions:

- Frequency: 55 Hz for AC signals
- Fan speed: 100 %
- Altitude: 440 m above sea level
- Output duration
  - Continuous operation (solid line): 15 min on
  - Pulsed operation (dashed line): 2 s on/10 s off

The maximum output duration can be found in [Derating](#) (page 14).

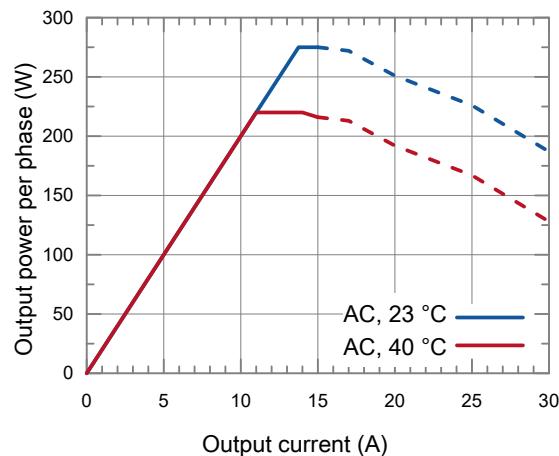


Figure 1-1: Typical output power for 3-phase symmetrical output current

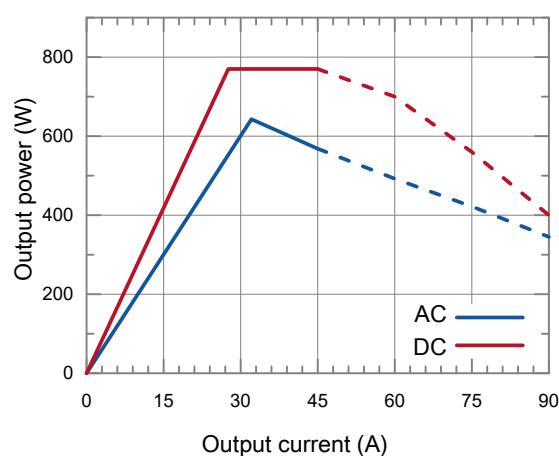


Figure 1-2: Typical output power for 1-phase high-amplitude output current

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### Voltage output

The AC output power is specified for 50/60 Hz signals. Power ratings given in W are tested with resistive loads.

Table 1-18: Voltage output specification – Output power

Configuration	Typical	Guaranteed
<b>4-phase symmetrical (0°, 90°, 180°, 270°)</b>		
4 × 300 V <sub>AC</sub> L-N / L4-N4	4 × 115 W at 300 V	4 × 90 W at 300 V
<b>3-phase symmetrical (0°, 120°, 240°)</b>		
3 × 300 V <sub>AC</sub> L-N	3 × 140 W at 300 V	3 × 115 W at 300 V
<b>1-phase high power (0°, 0°, 0°)</b>		
1 × 300 V <sub>AC</sub> LLL-N (parallel)	1 × 405 W at 300 V	1 × 315 W at 300 V
1 × 300 V <sub>DC</sub> LLL-N (parallel)	1 × 480 W at 300 V	1 × 390 W at 300 V
<b>1-phase high amplitude (0°, 180°)</b>		
1 × 600 V <sub>AC</sub> L-L (series)	1 × 280 W at 600 V	1 × 225 W at 600 V
1 × 600 V <sub>DC</sub> L-L (series)	1 × 320 W at 600 V	1 × 260 W at 600 V

The charts below were determined under the following conditions:

- Frequency: 55 Hz for AC signals
- Fan speed: 100 %
- Altitude: 440 m above sea level
- Output duration: 15 min on (continuous)

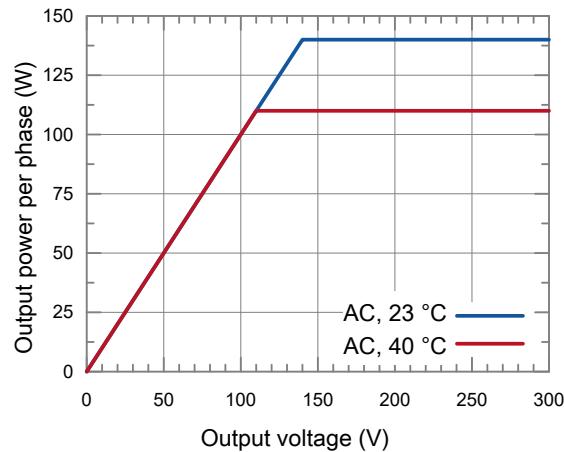


Figure 1-3: Typical output power for 3-phase symmetrical output voltage

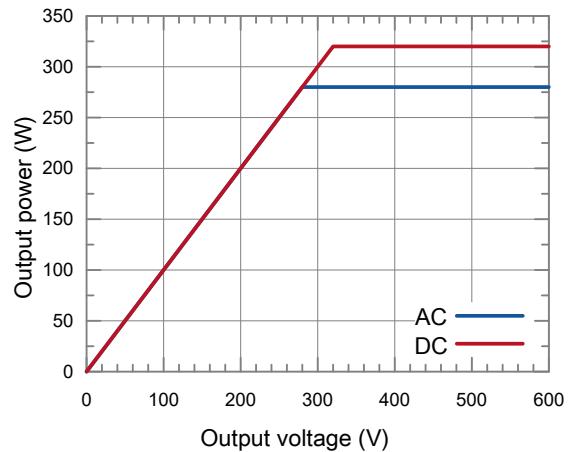


Figure 1-4: Typical output power for 1-phase high-amplitude output voltage

## 1.6.5 Derating

### Current output

The output duration, duty cycle, frequency, voltage and current amplitude are parameters for the derating of the CMC 500 operating at the specification limits.

The analog output module is protected based on a mathematical model with continuous monitoring to keep the module in the safe operating area.

Refer to section Power supply for limitations based on the maximum power consumption.

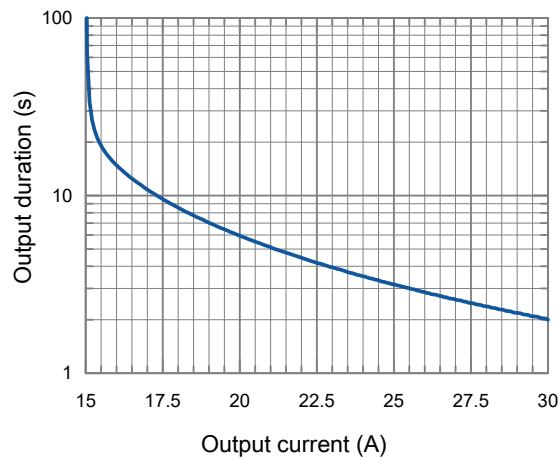


Figure 1-5: Output duration limit of the current amplitude

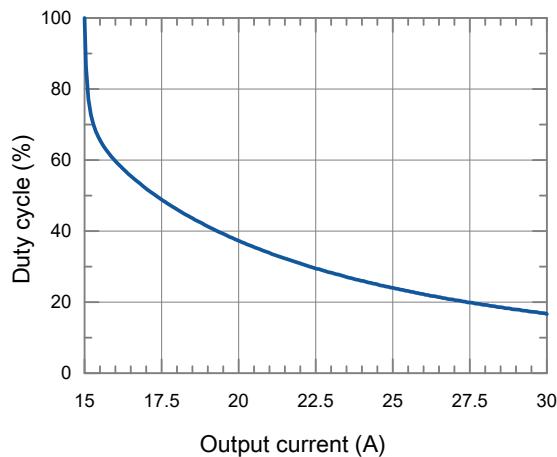


Figure 1-6: Output duty cycle limit of the current amplitude

The current output derating of the frequency chart is valid for symmetrical output configurations and a single channel, but not for 1-phase 90 A high amplitude configuration. For frequencies below 5 Hz, the pulsed output duration can be less than 2 s.

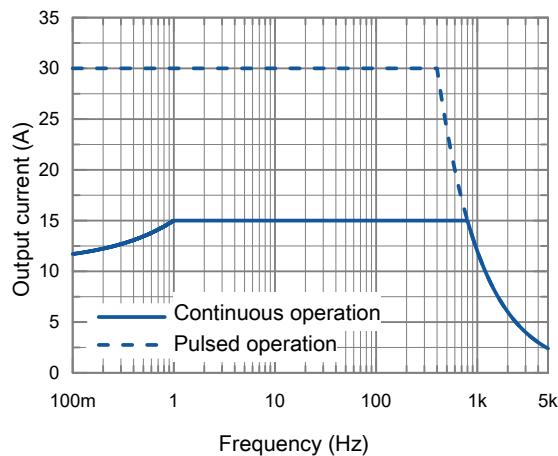


Figure 1-7: Current output derating of the frequency

## Voltage output

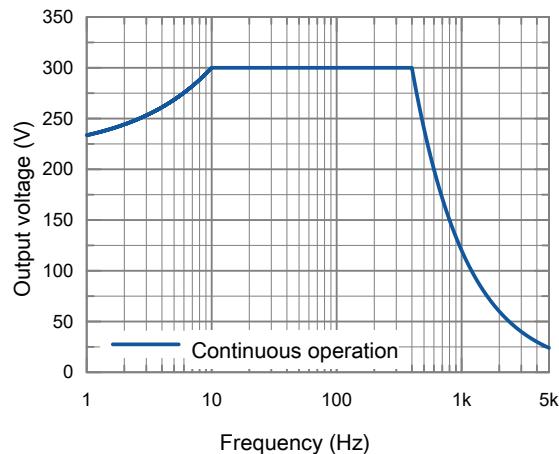


Figure 1-8: Voltage output derating of the frequency

## 1.7 Analog output module H

The following table shows the supported configurations:

Table 1-19: Analog output module H – Configuration overview

H		
Current	L-N	3 × 60 A
	LLL-N	1 × 180 A (high amplitude)
	L-L	1 × 60 A (high power)

### 1.7.1 General

Table 1-20: High-current output specification – General

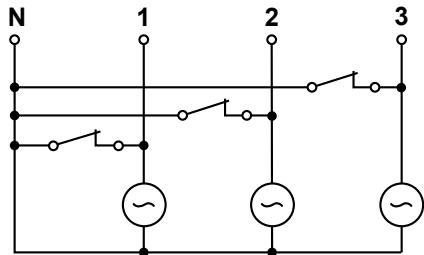
Characteristic	Specification
Ranges	Range I: 0 ... 1.25 A Range II: 0 ... 60 A
Protection	Protected against overload and overtemperature
Frequency range <sup>1</sup>	0 ... 3 kHz
<b>Configurations</b>	
L-N	3 × 60 A
LLL-N (parallel)	1 × 180 A (high amplitude)
L-L (series)	1 × 60 A (high power)
Max. compliance voltage (RMS)	25 V
<b>Resolution per channel (DC)</b>	
1.25 A range	< 20 µA
60 A range	< 1 mA

<sup>1</sup> For injections longer than 1 minute, the maximum fundamental frequency is limited to 587 Hz to comply with international trade restrictions for frequency-controlled signal generators. For other options, contact OMICRON Support (→ [Support](#) (page 40)).

## 1.7.2 Protection

The analog output is protected against overload and overtemperature.

If the *CMC 500* or the analog output is off, the outputs are short-circuited.



### 1.7.3.2 Amplitude accuracy

The amplitude accuracy is specified using a measurement bandwidth of 20 kHz.

Table 1-22: High-current output specification – Accuracy

Range	Frequency	Typical <sup>1</sup>	Guaranteed (1 year) <sup>1</sup>	Guaranteed (2 years) <sup>1</sup>
1.25 A	≤ 100 Hz	0.07 + 0.02	0.14 + 0.03	0.24 + 0.03
	≤ 400 Hz	0.2 + 0.02	0.50 + 0.06	0.60 + 0.06
	≤ 1 kHz	0.8 + 0.02	2.00 + 0.25	2.10 + 0.25
	≤ 3 kHz	3 + 0.02	10 + 1.0	10 + 1.0
	DC offset <sup>2</sup>	0.2 mA	1.0 mA	1.0 mA
60 A	≤ 100 Hz	0.07 + 0.02	0.18 + 0.03	0.28 + 0.03
	≤ 400 Hz	0.1 + 0.02	0.23 + 0.06	0.33 + 0.06
	≤ 1 kHz	0.2 + 0.02	0.75 + 0.15	0.85 + 0.15
	≤ 3 kHz	2 + 0.02	10 + 1.0	10 + 1.0
	DC offset <sup>2</sup>	5 mA	15 mA	15 mA

<sup>1</sup> Error less than (% of set value + % of range).

<sup>2</sup> Valid over full operating temperature range (−25 ... 50 °C). Add this to the ≤ 100 Hz specification to get the maximum DC error.

- If the test object evaluates AC and DC components, the offset needs to be considered in the RMS value. The effect is negligible for currents higher than 5 % of the output range.

The typical offset specification is valid directly after activation due to an internal offset adjustment before every activation. The guaranteed specification considers potential temperature drifts while the outputs are active in addition.

In case the device is operated outside of the nominal temperature range of 23 ± 5 °C, the following coefficients must be considered to calculate the accuracy:

Table 1-23: High-current output specification – Temperature coefficient

Range	Temperature coefficient < 18 °C (guaranteed)	Temperature coefficient > 28 °C (guaranteed)
1.25 A	15 ppm/°C	15 ppm/°C
60 A	40 ppm/°C	25 ppm/°C

### 1.7.3.3 Phase accuracy

Table 1-24: High-current output specification – Phase accuracy

Reference	Range	Frequency	Typical	Guaranteed
Internal time base	1.25 A	50/60 Hz	0.1°	0.25°
	60 A	50/60 Hz	0.1°	0.20°

### 1.7.3.4 Total harmonic distortion and noise (THD+N)

The THD+N is specified using a fundamental frequency of 55 Hz and a measurement bandwidth of 20 kHz.

Table 1-25: High-current output specification – THD+N

Range	Current	THD+N (typical)	THD+N (guaranteed)
1.25 A	0.5 A	< 0.1 %	< 0.20 %
	1 A	< 0.03 %	< 0.10 %
60 A	5 A	< 0.07 %	< 0.10 %
	60 A	< 0.02 %	< 0.05 %

### 1.7.4 Output power

The output power of the *CMC 500* is specified for line voltages from 100 to 240 V.

For line voltages below 220 V, follow these steps to achieve the maximum output power of the *CMC 500* without restrictions:

- ▶ Set the fuse emulation to 15 A in the web interface.
- ▶ Use a power cord rated for 15 A.

#### Current output

The AC output power is specified for 50/60 Hz signals. Power ratings given in W are tested with resistive loads.

Table 1-26: High-current output specification – Output power

Configuration	Typical	Guaranteed
<b>3-phase symmetrical (0°, 120°, 240°)</b>		
3 × 60 A <sub>AC</sub>	3 × 450 W at 30 A	3 × 350 W at 30 A
L-N	3 × 300 W at 60 A	3 × 200 W at 60 A
<b>1-phase high amplitude (0°, 0°, 0°)</b>		
1 × 180 A <sub>AC</sub>	1 × 1 200 W at 75 A	1 × 1 000 W at 75 A
LLL-N (parallel)		
1 × 180 A <sub>DC</sub>	1 × 1 300 W at 75 A	1 × 1 000 W at 75 A
LLL-N (parallel)		
<b>1-phase high power (0°, 180°)</b>		
1 × 60 A <sub>AC</sub>	1 × 900 W at 30 A	1 × 700 W at 30 A
L-L (series)		
1 × 60 A <sub>DC</sub>	1 × 1 000 W at 30 A	1 × 700 W at 30 A
L-L (series)		

The charts below were determined under the following conditions:

- Frequency: 55 Hz for AC signals
- Fan speed: 100 %
- Altitude: 440 m above sea level
- Output duration
  - Continuous operation (solid line): 15 min on
  - Pulsed operation (dashed line): 2 s on/10 s off
  - The maximum output duration can be found in [Derating](#) (page 20).

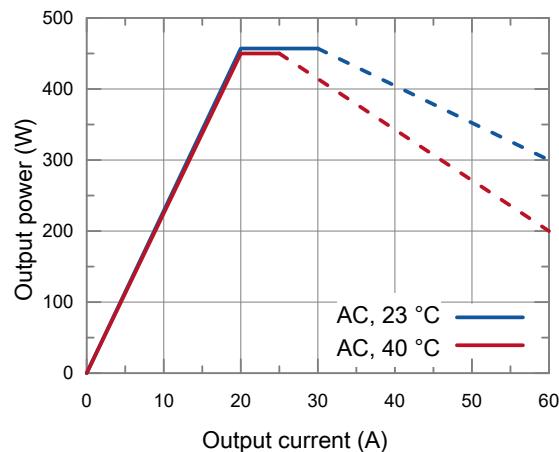


Figure 1-9: Typical output power for 3-phase symmetrical output current

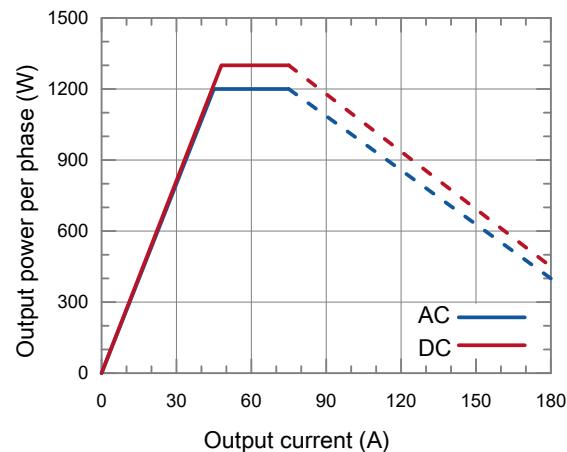


Figure 1-10: Typical output power for 1-phase high-amplitude output current

## 1.7.5 Derating

The output duration, duty cycle, frequency, voltage and current amplitude are parameters for the derating of the CMC 500 operating at the specification limits.

The analog output module is protected based on a mathematical model with continuous monitoring to keep the module in the safe operating area.

Refer to section Power supply for limitations based on the maximum power consumption.

### Current output

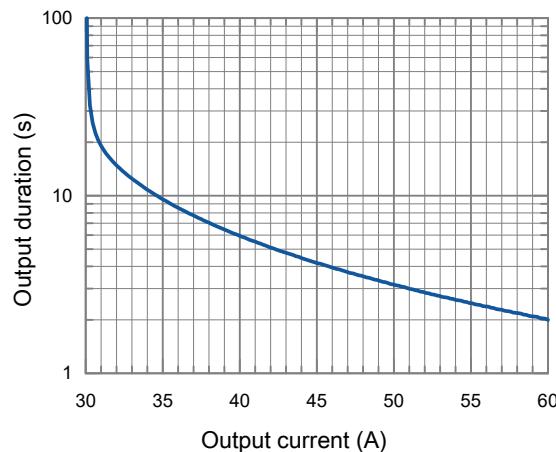


Figure 1-11: Output duration limit of the current amplitude

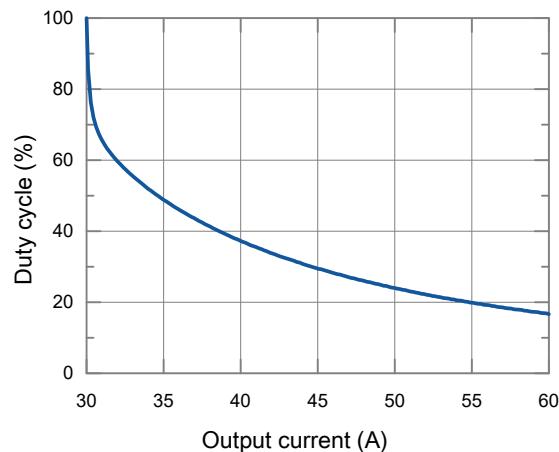


Figure 1-12: Output duty cycle limit of the current amplitude

The current output derating of the frequency chart is valid for symmetrical 3-phase and a single channel, but not for 1-phase 180 A high amplitude configuration. For frequencies below 5 Hz, the pulsed output duration can be less than 2 s.

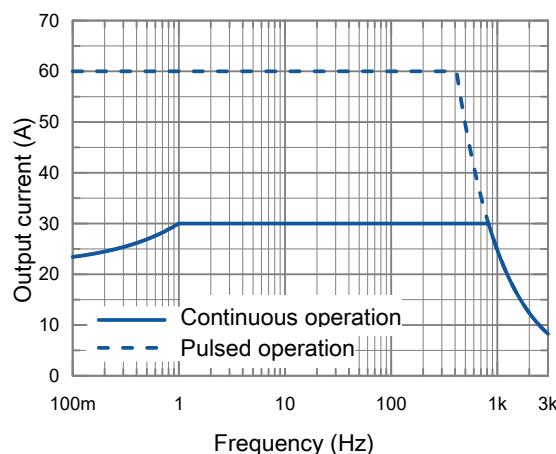


Figure 1-13: Current output derating of the frequency

## 1.8 Auxiliary DC output (AUX DC OUT)

Table 1-27: Auxiliary DC output specification

Characteristic	Specification
Voltage range	12 ... 264 V
Power	50 W/0.8 A continuous output 120 W/2 A short-term output for up to 2 s
Accuracy	Error < 5 % of set value + 0.25 V
Resolution	0.25 V
Protection	Protected against short circuit, overload, and overtemperature
Overload indication	Yes

## 1.9 Binary outputs (BINARY OUT)

Table 1-28: Binary output specification

Characteristic	Specification
Number of binary outputs	4
Type	Relay, normally open
Max. AC loading capacity	$V_{max} = 300$ V, $I_{max} = 8$ A, refer to load limit curve
Max. DC loading capacity	$V_{max} = 300$ V, $I_{max} = 8$ A, refer to load limit curve
Min. switching load	12 V or 100 mA
Electrical lifetime	50 000 switching cycles at 230 V/8 A and ohmic load (AC)
Operate time	10 ms max.
Release time	5 ms max.
Bounce time	3 ms max.

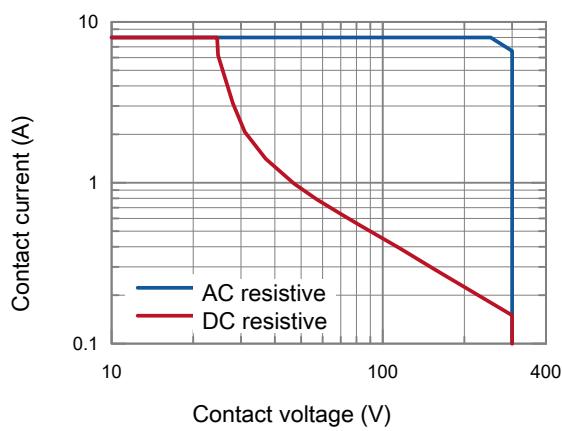


Figure 1-14: Load limit of binary outputs

## 1.10 Binary/analog inputs (BINARY/ANALOG IN)

There are different configuration options for the binary/analog inputs available (→ Test set variants).

**Note:** The inputs of the configuration option **A** can be configured as binary or analog inputs whereas the inputs of option **B** are binary inputs only.

Table 1-29: Binary/analog input specification

Characteristic	Specification
Number of inputs	10
Number of potential groups	10
Measurement category	Configuration option <b>A</b> : CAT IV/150 V; CAT III/300 V; CAT II/600 V  Configuration option <b>B</b> : CAT IV/150 V; CAT III/300 V

### 1.10.1 Binary input mode

This section is relevant for both configuration options of the binary/analog inputs (→ Test set variants).

Table 1-30: Binary input mode specification

Characteristic	Specification
Time resolution	100 µs
Max. measuring time	Unlimited
Deglitch time	0 ... 500 ms (→ Deglitching input signals)
Debounce time	0 ... 500 ms (→ Debouncing input signals)
Counting function	f ≤ 3 kHz, pulse width > 150 µs

#### 1.10.1.1 Potential-sensing mode

Table 1-31: Potential-sensing mode specification

Characteristic	Specification
Modes	AC or DC sensing
Trigger criteria for Logical 1	Threshold ≥ 0 V: Input voltage > threshold Threshold < 0 V: Input voltage < threshold
Threshold range	Configuration option <b>A</b> : ±600 V Configuration option <b>B</b> : ±212 V
Typical hysteresis	10 % of  threshold  or 250 mV, whichever is higher. Threshold ≥ 0 V: <ul style="list-style-type: none"><li>• Pick-up value is threshold</li><li>• Drop-off value is threshold minus hysteresis</li></ul> Threshold < 0 V: <ul style="list-style-type: none"><li>• Pick-up value is threshold</li><li>• Drop-off value is threshold plus hysteresis</li></ul>

Characteristic	Specification
<b>Guaranteed accuracy (configuration option A)<sup>1</sup></b>	
Threshold $\leq$ 10 V	Error $<$ 0.2 % of threshold + 20 mV
Threshold 10 V ... 100 V	Error $<$ 0.2 % of threshold + 200 mV
Threshold $\geq$ 100 V	Error $<$ 0.2 % of threshold + 1 V
<b>Guaranteed accuracy (configuration option B)</b>	
Threshold $<$ 14.1 V	Error $<$ 5 % of threshold + 100 mV
Threshold $\geq$ 14.1 V	Error $<$ 5 % of threshold + 1.5 V
Typical input impedance (10 V, 55 Hz)	Configuration option <b>A</b> : $1 \text{ M}\Omega \parallel 70 \text{ pF}$ Configuration option <b>B</b> : $985 \text{ k}\Omega \parallel 75 \text{ pF}$

<sup>1</sup> Specified over full temperature range from  $-25$  to  $50$  °C.

### 1.10.1.2 Potential-free mode

In the potential-free binary input mode, a small voltage is applied to the input for sensing the state of a connected potential-free contact. The threshold and range are programmed automatically.

Table 1-32: Potential-free mode specification

Characteristic	Specification
Trigger criteria	Logical 0: $R > 80 \text{ k}\Omega$ Logical 1: $R < 20 \text{ k}\Omega$
Typical sensing voltage	Configuration option <b>A</b> : 16 V Configuration option <b>B</b> : 17 V

### 1.10.2 Analog input mode

This section is relevant for the configuration option **A** of the binary/analog inputs (→ Test set variants). Unless stated otherwise, the following specifications are valid for the analog inputs only (without the influence of the analog output modules or other modules).

In the analog input mode, a variety of measurements are possible, such as RMS, phasor, harmonics, or power measurements. The computation of the measurement is performed in the control software based on the samples delivered by the *CMC 500*. Therefore, the following specifications only apply to the measurement hardware itself and not to the measurement algorithms. For accuracy specifications of the measurement algorithms, refer to the documentation of the concerning software.

Table 1-33: Analog input mode specification

Characteristic	Specification
Measurement ranges (max. RMS value)	10 mV, 100 mV, 1 V, 10 V, 100 V, 600 V
Maximum crest factor	1.75
Sampling rate ( $f_s$ )	10 kHz, 40 kHz
Measurement bandwidth	4 kHz @ $f_s = 10$ kHz with $> 80$ dB attenuation above 5 kHz 16 kHz @ $f_s = 40$ kHz with $> 85$ dB attenuation above 20 kHz
Typical input impedance (10 V, 55 Hz)	$1 \text{ M}\Omega \parallel 70 \text{ pF}$

### 1.10.2.1 Amplitude accuracy

The following table does not consider noise, disturbances, and crosstalk. The AC accuracy has been verified using a frequency-selective measurement.

Table 1-34: Analog input mode specification – Amplitude accuracy

Range	Frequency	Guaranteed (1 year) <sup>1</sup>	Guaranteed (2 years) <sup>1</sup>	Temperature co- efficient <sup>1,2</sup>
10 mV	DC <sup>3</sup>	0.08 + 1.20	0.11 + 1.30	0.0015 + 0.0400
	≤ 1 kHz	0.09 + 0.30	0.12 + 0.40	0.0015 + 0
100 mV	DC <sup>3</sup>	0.08 + 0.12	0.11 + 0.13	0.0015 + 0.0040
	≤ 1 kHz	0.09 + 0.03	0.12 + 0.04	0.0015 + 0
1 V, 10 V, 100 V	DC <sup>3</sup>	0.08 + 0.08	0.11 + 0.08	0.0015 + 0.0020
	≤ 1 kHz	0.09 + 0.03	0.12 + 0.04	0.0015 + 0
	≤ 4 kHz	0.12 + 0.04	0.15 + 0.04	0.0015 + 0
	≤ 10 kHz <sup>4</sup>	0.23 + 0.06	0.26 + 0.06	0.0030 + 0
600 V	DC <sup>3</sup>	0.08 + 0.07	0.10 + 0.07	0.0015 + 0.0015
	≤ 1 kHz	0.09 + 0.03	0.11 + 0.04	0.0015 + 0
	≤ 4 kHz	0.13 + 0.04	0.14 + 0.04	0.0015 + 0
	≤ 10 kHz <sup>4</sup>	0.24 + 0.06	0.25 + 0.06	0.0030 + 0

<sup>1</sup> Error less than (% of reading + % of range).

<sup>2</sup> ± (% of reading + % of range)/°C beyond 23 ± 5 °C.

<sup>3</sup> DC specifications are not valid for 30 s after switching the measurement range.

<sup>4</sup> For 40 kHz sampling rate only.

### 1.10.2.2 Phase and frequency accuracy

The phase and frequency accuracy are specified for signal levels above 10 % of the measurement range and sinusoidal signals between 15 and 70 Hz. They are not guaranteed for the 10 mV range.

Table 1-35: Analog input mode specification – Phase and frequency accuracy

Measurement type	Guaranteed (1 year)	Guaranteed (2 years)
Frequency	0.01 %	0.01 %
Phase (to internal time base)	0.02°	0.03°

### 1.10.2.3 Noise levels

Noise levels are specified with the input short-circuited by flexible jumpers.

Table 1-36: Analog input mode specification – Noise levels

Range	Typical RMS noise level	
	10 kHz sampling rate	40 kHz sampling rate
10 mV	11 $\mu$ V	22 $\mu$ V
100 mV	11 $\mu$ V	22 $\mu$ V
1 V	25 $\mu$ V	48 $\mu$ V
10 V	91 $\mu$ V	147 $\mu$ V
100 V	913 $\mu$ V	1.5 mV
600 V	8 mV	13 mV

### 1.10.2.4 Common-mode rejection

The common-mode rejection is measured with one analog input channel short-circuited and a sinusoidal signal of 600 V between the short-circuited channel and the black 4 mm sockets of all other analog inputs.

Table 1-37: Analog input mode specification – Common-mode rejection

Range	Signal frequency	Typical rejection ratio
10 mV	55 Hz	-148 dB
	500 Hz	-129 dB
100 mV	55 Hz	-148 dB
	500 Hz	-129 dB
1 V	55 Hz	-142 dB
	500 Hz	-123 dB
10 V	55 Hz	-129 dB
	500 Hz	-110 dB
100 V	55 Hz	-107 dB
	500 Hz	-88 dB
600 V	55 Hz	-91 dB
	500 Hz	-72 dB

### 1.10.2.5 Crosstalk from current outputs

The measurement results may be influenced by magnetic coupling from the current outputs inside the device. For frequencies up to 70 Hz, this influence is negligible. With increasing frequency, however, a change of the measurement values can be observed. The measurement results stated below were determined with the analog output module **U** in analog output **A** short-circuited and set to 10 A with symmetrical conditions.

Table 1-38: Analog input mode specification – Crosstalk from current outputs

Range	Current output frequency	Typical coupled RMS value
10 mV	1 kHz	31 $\mu$ V
100 mV	1 kHz	31 $\mu$ V
1 V	1 kHz	36 $\mu$ V
10 V	1 kHz	38 $\mu$ V
100 V	1 kHz	2.4 mV
600 V	1 kHz	2.2 mV

## 1.11 DC measurement input (DC IN)

### 1.11.1 General

The DC measurement input is a configuration option (→ Test set variants).

Table 1-39: DC IN current input specification – General

Characteristic	Specification
Measurement ranges	$\pm 1$ mA $\pm 20$ mA
Typical input resistance	8 $\Omega$
Typical measurement settling time	800 ms

Table 1-40: DC IN voltage input specification – General

Characteristic	Specification
Measurement ranges	$\pm 10$ V $\pm 1$ V $\pm 100$ mV $\pm 10$ mV
Typical input resistance	1 M $\Omega$
Typical measurement settling time	800 ms

## 1.11.2 Accuracy

Table 1-41: DC IN current input specification – Accuracy

Range	Guaranteed <sup>1</sup> (1 year)	Guaranteed <sup>1</sup> (2 years)	Temperature coefficient <sup>1,2</sup>
20 mA	0.04 + 0.02	0.06 + 0.02	0.0010 + 0.0003
1 mA			

<sup>1</sup> Error less than (% of reading + % of range).

<sup>2</sup>  $\pm$  (% of reading + % of range)/°C beyond 23 ± 5 °C.

Table 1-42: DC IN voltage input specification – Accuracy

Range	Guaranteed <sup>1</sup> (1 year)	Guaranteed <sup>1</sup> (2 years)	Temperature coefficient <sup>1,2</sup>
10 V	0.04 + 0.02	0.05 + 0.02	0.0010 + 0.0003
1 V	0.04 + 0.02	0.05 + 0.02	0.0010 + 0.0003
100 mV	0.04 + 0.05	0.05 + 0.06	0.0010 + 0.0010
10 mV	0.04 + 0.37	0.05 + 0.38	0.0010 + 0.0020

<sup>1</sup> Error less than (% of reading + % of range).

<sup>2</sup>  $\pm$  (% of reading + % of range)/°C beyond 23 ± 5 °C.

## 1.12 Control interface (CONTROL)

Table 1-43: Control interface – Ethernet ports

ETH1, ETH2, ETH3	
Connector	RJ-45
Link speed	10 / 100 / 1 000 Mbit/s
Power over Ethernet (PoE)	IEEE 802.3af (15.4 W max.) IEEE 802.3at (30 W max.)
Cable	Cat 5e STP (Shielded Twisted Pair) or better

Table 1-44: Control interface – USB

USB	
Connector	USB type C
Speed	USB 2.0 high speed (480 Mbit/s)
Power consumption	Self-powered
Cable	USB 2.0 high speed or better
Output power	up to 45 W

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Table 1-45: Control interface – USB-A

<b>USB-A</b>	
Connector	USB type A
Speed	USB 2.0 high speed (480 Mbit/s)
Output current	500 mA max.
Cable	USB 2.0 high speed or better

Table 1-46: Control interface – Expansion ports

<b>EXP1, EXP2, EXP3, EXP4</b>	
Connector	TE Mini I/O
Protocol	Proprietary (non-Ethernet compliant)
Power over Ethernet (PoE)	IEEE 802.3af (15.4 W max.) IEEE 802.3at (30 W max.)
Cable	Cat 5e STP (Shielded Twisted Pair)

## 1.13 Communication protocols

### 1.13.1 Power over Ethernet (PoE) power sharing

All Ethernet and expansion ports share the same power supply and are limited by a common power budget of 90 W. The two Ethernet ports have priority over the expansion ports.

### 1.13.2 IEC 61850 protocols

Table 1-47: IEC 61850 protocols specification – Sampled Values (Publishing)

IEC 61850 Sampled Values (Publishing)	
Specification	According to the "Implementation Guideline for Digital Interface to Instrument Transformers Using IEC 61850-9-2" of the UCA International Users Group and according to "IEC 61869-9:2016 Instrument transformers - Part 9: Digital interface for instrument transformers" (with configurable datasets).
Sampling rate/packing	4 000 Hz – 1 sample per packet 4 800 Hz – 1 sample per packet 12 800 Hz – 8 samples per packet 15 360 Hz – 8 samples per packet 5 760 Hz – 1 sample per packet 4 800 Hz – 2 samples per packet 14 400 Hz – 6 samples per packet
Configurable optional fields	smpCnt – sample count smpSynch – synchronization status smpRate – sampling rate smpMod – sample mode gmIdentitiy – grandmaster clock ID ConfRev – configuration revision
Number of publishing SV streams <sup>1</sup>	4 <sup>2</sup> (when 0 streams subscribed) 1 (when 1 stream subscribed) 0 (when 2 streams subscribed)
Number of attributes per dataset	max. 32
Number of mapped signals into dataset <sup>1</sup>	max. 24

<sup>1</sup> As a CMC test set has 24 signal generators, only 24 individually generated signals can be mapped to the datasets, independent of how many attributes are configured. Additional attributes can be set to constant values.

<sup>2</sup> Depending on the control software, less might be possible.

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Table 1-48: IEC 61850 protocols specification – Sampled Values (Subscription)

<b>IEC 61850 Sampled Values (Subscription)</b>	
Specification	According to the "Implementation Guideline for Digital Interface to Instrument Transformers Using IEC 61850-9-2" of the UCA International Users Group
Sampling rate/packing	4 000 Hz – 1 sample per packet 4 800 Hz – 1 sample per packet 12 800 Hz – 8 samples per packet 15 360 Hz – 8 samples per packet 5 760 Hz – 1 sample per packet 4 800 Hz – 2 samples per packet 14 400 Hz – 6 samples per packet
Max. number of subscribed SV streams	2

Table 1-49: IEC 61850 protocols specification – GOOSE/R-GOOSE

<b>IEC 61850 GOOSE/R-GOOSE</b>	
Specification	Mapping of binary outputs to data attributes in published GOOSE or R-GOOSE messages Sum of virtual binary outputs: 360 Sum of GOOSE or R-GOOSE to be published: 128
Subscription	Mapping of data attributes from subscribed GOOSE or R-GOOSE messages to binary inputs Sum of virtual binary inputs: 360 Sum of GOOSE or R-GOOSE to be subscribed: 128
Performance (GOOSE only)	Type 1A; Class P2/3 (IEC 61850-5) Typical processing time (application to network or vice versa): < 1 ms
VLAN support (GOOSE only)	Selectable priority and VLAN-ID

### 1.13.3 Other communication protocols

The integrated web interface can be accessed via HTTPS with a web browser (→ Web interface).

## 1.14 Accuracy calculation examples

### 1.14.1 Analog output amplitude accuracy at higher ambient temperature (AC)

In situations where the *CMC 500* is operated at ambient temperatures outside the range of 23 °C ± 5 °C, it is crucial to consider the temperature coefficient. This particular example involves the use of the [analog output H](#) (page 15) and incorporates specified values for amplitude accuracy in the calculation. The ambient temperature value can also represent the maximum anticipated temperature, allowing for a "worst-case scenario" calculation. This approach ensures that the system is prepared for extreme conditions and can function effectively even in less than ideal circumstances.

Set value:  $I_s = 5 \text{ A}, 50/60 \text{ Hz}$

Range:  $I_r = 60 \text{ A}$

Ambient temperature:  $T_a = 40 \text{ }^{\circ}\text{C}$

Utilizing these values, refer to the guaranteed accuracy specification for 1 year, as specified in [Amplitude accuracy](#) (page 17): error less than (% of set value + % of range).

$$0.18 + 0.03$$

Furthermore, it is necessary to take into account the temperature coefficient for temperatures exceeding 28 °C, as specified in the [Temperature coefficient table](#) (page 17).

$$\alpha_{28} = 25 \frac{\text{ppm}}{\text{ }^{\circ}\text{C}} = 0.0025 \frac{\%}{\text{ }^{\circ}\text{C}}$$

For the calculation, it is necessary to determine the difference between the maximum specified temperature (23 °C + 5 °C = 28 °C) and the ambient temperature:

$$\Delta T = T_a - 28 \text{ }^{\circ}\text{C} = 40 \text{ }^{\circ}\text{C} - 28 \text{ }^{\circ}\text{C} = 12 \text{ }^{\circ}\text{C}$$

Finally, calculate the maximum amplitude error for one year as follows:

$$\begin{aligned} I_{e,max} &= I_s \cdot (0.18\% + \Delta T \alpha_{28}) + I_r \cdot 0.03\% \\ &= 5 \text{ A} \cdot (0.18\% + 12 \cdot 0.0025\%) + 60 \text{ A} \cdot 0.03\% \\ &= 10.5 \text{ mA} + 18 \text{ mA} = 28.5 \text{ mA} \end{aligned}$$

For comparison, calculate the permissible amplitude error within a temperature range of 23 °C ± 5 °C for one year as follows:

$$\begin{aligned} I_{e,max} &= 5 \text{ A} \cdot 0.18\% + 60 \text{ A} \cdot 0.03\% \\ &= 9 \text{ mA} + 18 \text{ mA} = 27 \text{ mA} \end{aligned}$$

## 1.14.2 Analog output amplitude accuracy at low ambient temperature (AC)

The calculation for an ambient temperature of  $-10^{\circ}\text{C}$  would largely remain the same as in [Analog output amplitude accuracy at higher ambient temperature \(AC\)](#) (page 31). Hence, we will focus on the differences in this particular scenario. For temperatures falling below  $18^{\circ}\text{C}$ , it is necessary to utilize the corresponding temperature coefficient as specified in the [Temperature coefficient table](#) (page 17).

$$\alpha_{18} = 40 \frac{\text{ppm}}{\text{ }^{\circ}\text{C}} = 0.0040 \frac{\%}{\text{ }^{\circ}\text{C}}$$

For the calculation, it is necessary to determine the difference between the minimum specified temperature ( $23^{\circ}\text{C} - 5^{\circ}\text{C} = 18^{\circ}\text{C}$ ) and the ambient temperature:

$$\Delta T = 18^{\circ}\text{C} - T_a = 18^{\circ}\text{C} + 10^{\circ}\text{C} = 28^{\circ}\text{C}$$

The rest of the calculation is the same as in [Analog output amplitude accuracy at higher ambient temperature \(AC\)](#) (page 31), using  $\alpha_{18}$  instead of  $\alpha_{25}$  for the calculation:

$$\begin{aligned} I_{e,max} &= I_s \cdot (0.18\% + \Delta T \alpha_{28}) + I_r \cdot 0.03\% \\ &= 5 \text{ A} \cdot (0.18\% + 12 \cdot 0.0040\%) + 60 \text{ A} \cdot 0.03\% \\ &= 11.4 \text{ mA} + 18 \text{ mA} = 32.6 \text{ mA} \end{aligned}$$

## 1.14.3 Analog output accuracy of combined AC + DC RMS values

Set value:  $I_s = 1 \text{ A}, 50/60 \text{ Hz}$

Range:  $I_r = 60 \text{ A}$

If the test object evaluates AC and DC components in the RMS value and the set value is less than 5 % of the range, the offset has to be considered. Utilizing these values, refer to the guaranteed accuracy specification for 1 year, as specified in [Amplitude accuracy](#) (page 17), error less than (% of set value + % of range).

$$0.18 + 0.03$$

DC offset:

$$I_{os} = 15 \text{ mA}$$

With this data, the maximum AC error can be calculated as follows:

$$\begin{aligned} I_{e,max(AC)} &= I_s \cdot 0.18\% + I_r \cdot 0.03\% \\ &= 1 \text{ A} \cdot 0.18\% + 60 \text{ A} \cdot 0.03\% \\ &= 1.8 \text{ mA} + 18 \text{ mA} = 19.8 \text{ mA} \end{aligned}$$

Now, the maximum combined RMS error can be calculated as follows:

$$\begin{aligned} I_{e,max} &= \sqrt{I_{e,max(AC)}^2 + I_{os}^2} \\ &= \sqrt{19.8^2 + 15^2} \text{ mA} = 24.8 \text{ mA} \end{aligned}$$

- i** The DC error of the analog output is automatically adjusted to zero during the activation of the output. The specified DC offset is only relevant for long output durations or large temperature changes.

#### 1.14.4 Analog input accuracy at higher ambient temperature (AC)

Measured voltage:  $U_i = 70 \text{ V}, 50/60 \text{ Hz}$

Range:  $U_r = 100 \text{ V}$

Ambient temperature:  $T_a = 40 \text{ }^\circ\text{C}$

Utilizing these values, refer to the guaranteed accuracy specification for 1 year, as specified in [Amplitude accuracy](#) (page 24), error less than (% of reading + % of range).

0.09 + 0.03

Temperature coefficient:

$$\alpha = 0.0015 \frac{\%}{^\circ\text{C}}$$

For the calculation, it is necessary to determine the difference between the maximum specified temperature ( $23 \text{ }^\circ\text{C} + 5 \text{ }^\circ\text{C} = 28 \text{ }^\circ\text{C}$ ) and the ambient temperature:

$$\Delta T = T_a - 28 \text{ }^\circ\text{C} = 40 \text{ }^\circ\text{C} - 28 \text{ }^\circ\text{C} = 12 \text{ }^\circ\text{C}$$

Finally, calculate the maximum amplitude measurement error for one year as follows:

$$\begin{aligned} U_{e,max} &= U_i \cdot (0.09\% + \Delta T \alpha) + U_r \cdot 0.03\% \\ &= 70 \text{ V} \cdot (0.09\% + 12 \cdot 0.0015\%) + 100 \text{ V} \cdot 0.03\% \\ &= 75.6 \text{ mV} + 30 \text{ mV} = 105.6 \text{ mV} \end{aligned}$$

For comparison, calculate the maximum amplitude measurement error within a temperature range of  $23 \text{ }^\circ\text{C} + 5 \text{ }^\circ\text{C}$  for one year as follows:

$$\begin{aligned} U_{e,max} &= U_i \cdot 0.09\% + U_r \cdot 0.03\% \\ &= 70 \text{ V} \cdot 0.09\% + 100 \text{ V} \cdot 0.03\% \\ &= 63 \text{ mV} + 30 \text{ mV} = 93 \text{ mV} \end{aligned}$$

### 1.14.5 Analog input accuracy at higher ambient temperature (DC)

Measured voltage:  $U_i = 70 \text{ V, DC}$

Range:  $U_r = 100 \text{ V}$

Ambient temperature:  $T_a = 40 \text{ }^{\circ}\text{C}$

Utilizing these values, refer to the guaranteed accuracy specification for 1 year, as specified in [Amplitude accuracy](#) (page 24), error less than (% of reading + % of range).

0.08 + 0.08

For the DC specification, we get a temperature coefficient for the reading and a temperature coefficient of the range from the same table in %/°C of reading + %/°C of range:

0.0015 + 0.002

The temperature coefficient for the range could also be interpreted as temperature-related offset drift  $\alpha_{os}$  in addition to the temperature coefficient applied to the reading value  $\alpha_r$ :

$$\alpha_r = 0.0015 \frac{\%}{^{\circ}\text{C}}$$

$$\alpha_{os} = 0.002 \frac{\%}{^{\circ}\text{C}}$$

For the calculation, it is necessary to determine the difference between the maximum specified temperature ( $23 \text{ }^{\circ}\text{C} + 5 \text{ }^{\circ}\text{C} = 28 \text{ }^{\circ}\text{C}$ ) and the ambient temperature:

$$\Delta T = T_a - 28 \text{ }^{\circ}\text{C} = 40 \text{ }^{\circ}\text{C} - 28 \text{ }^{\circ}\text{C} = 12 \text{ }^{\circ}\text{C}$$

Finally, calculate the maximum DC measurement error for one year as follows:

$$\begin{aligned} U_{e,max} &= U_i \cdot (0.08\% + \Delta T \alpha_r) + U_r \cdot (0.08\% + \Delta T \alpha_{os}) \\ &= 70 \text{ V} \cdot (0.08\% + 12 \cdot 0.0015\%) + 100 \text{ V} \cdot (0.08\% + 12 \cdot 0.002\%) \\ &= 70 \text{ V} \cdot (0.08\% + 0.018\%) + 100 \text{ V} \cdot (0.08\% + 0.024\%) \\ &= 68.6 \text{ mV} + 104 \text{ mV} = 172.6 \text{ mV} \end{aligned}$$

For comparison, calculate the maximum DC measurement error within a temperature range of  $23 \text{ }^{\circ}\text{C} \pm 5 \text{ }^{\circ}\text{C}$  for one year as follows:

$$\begin{aligned} U_{e,max} &= U_i \cdot 0.08\% + U_r \cdot 0.08\% \\ &= 70 \text{ V} \cdot 0.08\% + 100 \text{ V} \cdot 0.08\% \\ &= 56 \text{ mV} + 80 \text{ mV} = 136 \text{ mV} \end{aligned}$$

## 2 Technical data

### 2.1 Environmental conditions

Characteristic	Specification
<b>Temperature</b> Operating Storage	–25 ... +50 °C (–13 ... +122 °F) –40 ... +70 °C (–40 ... +158 °F)
<b>Maximum altitude</b> Operating Storage	4 000 m (13 000 ft) 15 000 m (49 000 ft)
Humidity	5 % ... 95 % relative humidity; no condensation
Shock	15 g/11 ms 30 g/6 ms
Vibration (not in operation)	10 ... 500 Hz, 1 g, 20 sweep cycles
Vibration (in operation)	10 ... 500 Hz, 0.5 g, 1 sweep cycle
Drop	10 cm
<b>Standards</b>	
Europe	EN 60068-2-1, EN 60068-2-2, EN 60068-2-6, EN 60068-2-14, EN 60068-2-27, EN 60068-2-30, EN 60068-2-31, EN 60068-2-78
International	IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-6, IEC 60068-2-14, IEC 60068-2-27, IEC 60068-2-30, IEC 60068-2-31, IEC 60068-2-78

## 2.2 Mechanical data

Characteristic	Specification	
Weight	CMC 500 VHX	12.4 kg (27.3 lb)
	CMC 500 USX	12.1 kg (26.7 lb)
	CMC 500 UHX	12.9 kg (28.4 lb)
	CMC 500 USH	14.9 kg (32.8 lb)
	CMC 500 UHH	15.6 kg (34.4 lb)
Dimensions without handles (W × H × D)	364 × 263 × 225 mm (14.3 × 10.4 × 8.9 in)	
Degree of protection	IP20 according to EN/IEC 60529	
Standards		
Europe	EN 60068-2-6, 10 Hz–500 Hz, 1 g/20 sweeps not operating, 10 Hz–500 Hz, 0.5 g/20 sweeps operating EN 60068-2-27, 15g/11 ms, 30 g/6 ms EN 60068-2-31, 0.1 m EN 60721-3-7 (7M2)	
International	IEC 60068-2-6, 10 Hz–500 Hz, 1 g/20 sweeps not operating, 10 Hz–500 Hz, 0.5 g/20 sweeps operating IEC 60068-2-27, 15g/11 ms, 30 g/6 ms IEC 60068-2-31, 0.1 m IEC 60721-3-7 (7M2)	

## 2.3 Electromagnetic compatibility (EMC)

Emission	
Europe	EN IEC 61326-1, EN 55032 (Class A), EN IEC 61000-3-2, EN 61000-3-3
USA	47 CFR Part 15 Subpart B (Class A) of FCC
Canada	CAN ICES-003 (A)/NMB-003(A)
International	IEC 61326-1, IEC 55032 (Class A), IEC 61000-3-2/3
Immunity	
Europe	EN IEC 61326-1, EN IEC 61000-4-3/11/18, EN 61000-4-2/4/5/6/8/16, EN 61000-6-5, installation category II, EN IEC 61326-3-1
International	IEC 61326-1, IEC 61000-4-2/3/4/5/6/8/11, IEC 61000-6-5, installation category II, IEC 61326-3-1

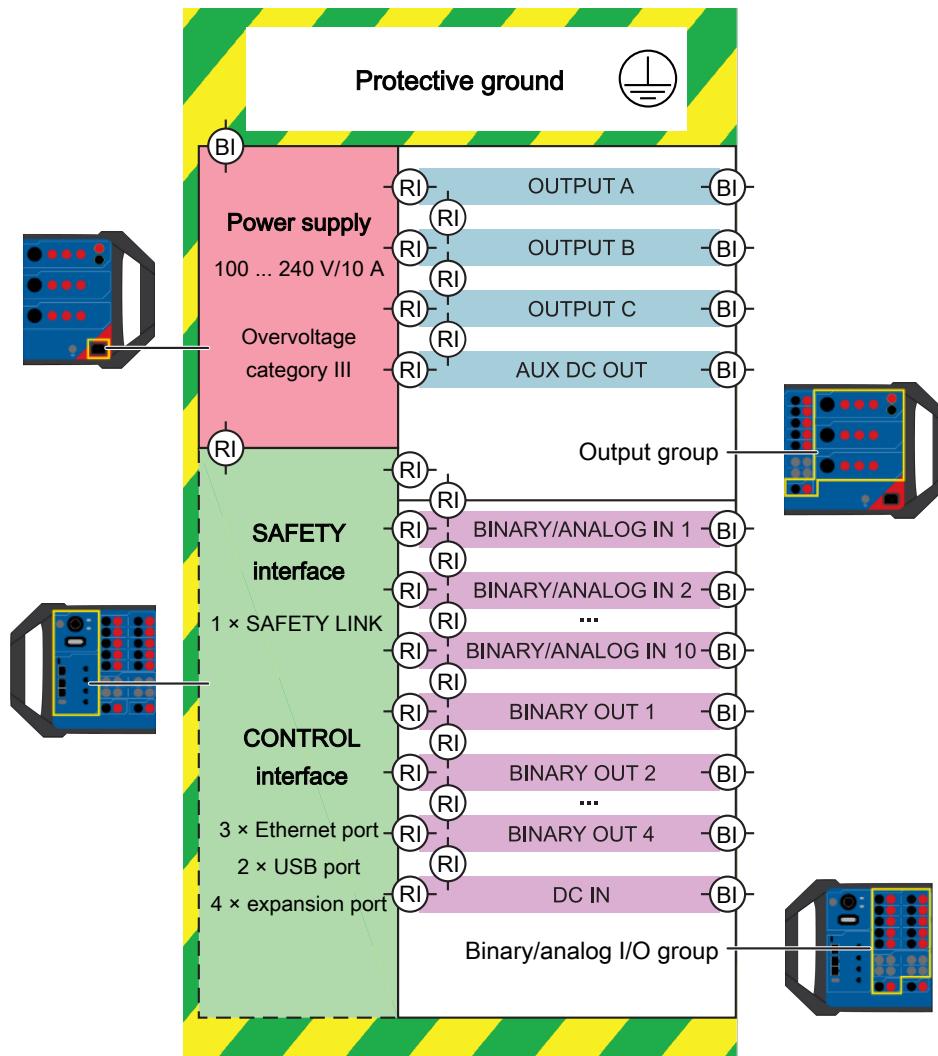
## 2.4 Safety standards

Certified standards	
Europe	EN 61010-1, EN IEC 61010-2-030, EN ISO 13849-1
International	IEC 61010-1, IEC 61010-2-030, ISO 13849-1
USA	UL 61010-1, UL 61010-2-030
Canada	CAN/CSA-C22.2 No. 61010-1, CAN/CSA-C22.2 No. 61010-2-030

## 2.5 Electrical insulation groups

The insulation of the CMC 500 is designed for pollution degree 2. The following image is a simplified representation that shows how the inputs and outputs of the CMC 500 are insulated against protective ground and each other. Each module is insulated by reinforced insulation against each other.

BI = basic insulation; RI = reinforced insulation



Compliance notice for EN 50678 and EN 50699: Impedance between power supply input and protective ground is greater than 800 kΩ.

## 2.6 Power supply

Characteristic	Specification
Connection	C14 connector according to EN IEC/IEC 60320-1
<b>Voltage (single phase)</b>	
Nominal voltage	100 ... 240 V ( $\pm 10\%$ )
Operational range	85 ... 264 V
Nominal current	10 ... 15 A (configurable, see Power supply plug types)
<b>Frequency</b>	
Nominal frequency	50/60 Hz
Operational range	47 ... 63 Hz
Overvoltage category	III

## 2.7 Battery

Characteristic	Specification
Type	Lithium iron phosphate (LiFePO <sub>4</sub> )
Nominal voltage	3.2 V <sub>DC</sub>
Maximum charge voltage	4.1 V <sub>DC</sub>
Battery nominal capacity	1 500 mAh
Nominal energy	4.8 Wh
Rechargeable	Yes
Recommended charge current	<0.7 A

The test set's battery is specified as **Dangerous Goods Class 9 (Miscellaneous Dangerous Goods)**: CMC 500 with built-in battery: **UN 3481** (lithium-ion battery contained in equipment or packed with equipment).

For more information, refer to Material Safety Data Sheet (MSDS) of the *CMC 500*.

# Support

When you are working with our products, we want to provide you with the greatest possible benefits. If you need any support, we are here to assist you.



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