

# CMS2015

## MagnetoResistive Current Sensor ( $I_{PN} = 15\text{ A}$ )

The CMS2000 current sensor family is designed for highly dynamic electronic measurement of DC, AC, pulsed and mixed currents with integrated galvanic isolation. The MagnetoResistive technology enables an excellent dynamic response without the hysteresis that is present in iron core based designs.

The CMS2000 product family offers PCB-mountable THT current sensors from 5 A up to 100 A nominal current for industrial applications.

### Product Overview

| Article description         | Package | Delivery Type |
|-----------------------------|---------|---------------|
| CMS2015-SP3 (discontinued)  | THT     | Tray          |
| CMS2015-SP10 (discontinued) | THT     | Tray          |

### Quick Reference Guide

| Symbol               | Parameter                             | Min.       | Typ.       | Max.      | Unit          |
|----------------------|---------------------------------------|------------|------------|-----------|---------------|
| $V_{CC}$             | Supply voltage                        | $\pm 12.0$ | $\pm 15.0$ | -         | V             |
| $I_{PN}$             | Primary nominal current (RMS)         | -          | -          | 15        | A             |
| $I_{PR}$             | Primary measuring range <sup>1)</sup> | -60        | -          | +60       | A             |
| $f_{co}$             | Frequency bandwidth (-3 dB)           | 200        | -          | -         | kHz           |
| $\epsilon_{z, SP3}$  | Accuracy for SP3 <sup>2)</sup>        | -          | -          | $\pm 0.8$ | % of $I_{PN}$ |
| $\epsilon_{z, SP10}$ | Accuracy for SP10 <sup>2)</sup>       | -          | -          | $\pm 0.5$ | % of $I_{PN}$ |

<sup>1)</sup> For 3 s in a 60 s interval ( $RMS \leq I_{PN}$ ) and  $V_{CC} = \pm 15\text{ V}$ .

<sup>2)</sup>  $\epsilon_z = \epsilon_G$  &  $\epsilon_{lin}$  with  $V_{CC} = \pm 15\text{ V}$ ,  $I_P = I_{PN}$ ,  $T_{amb} = 25\text{ °C}$ .

### Qualification Overview

| Standard           | Name                                                | Status   |
|--------------------|-----------------------------------------------------|----------|
| 2002/95/EC         | RoHS-conformity                                     | Approved |
| EN 61800-5-1: 2007 | Adjustable speed electrical power drive systems     | Approved |
| DIN EN 50178       | Electronic equipment for use in power installations | Approved |
| UL508 (E251279)    | Industrial control equipment                        | Approved |



**Product discontinued.**  
**Not to be used for new designs.**

### Features

- Based on the Anisotropic MagnetoResistive (AMR) effect
- Measuring range up to 4 times nominal current
- Galvanic isolation between primary and measurement circuit
- Bipolar 15 V power supply

### Advantages

- High signal-to-noise ratio
- Highly dynamic step response
- Negligible hysteresis
- Excellent accuracy
- Low temperature drift
- Low primary inductance

### Applications

- Solar power converters
- Measurement devices
- AC variable speed drives
- Converters for DC motor drives
- Uninterruptible power supplies
- Switched mode power supplies
- Power supplies for welding applications



## Absolute Maximum Ratings Values

In accordance with the absolute maximum rating system (IEC60134).

| Symbol    | Parameter                             | Min.  | Max.  | Unit |
|-----------|---------------------------------------|-------|-------|------|
| $V_+$     | Positive supply voltage               | -0.3  | +17.0 | V    |
| $V_-$     | Negative supply voltage               | -17.0 | +0.3  | V    |
| $I_{PM}$  | Maximum primary current <sup>1)</sup> | -150  | +150  | A    |
| $T_{amb}$ | Ambient temperature                   | -25   | +85   | °C   |
| $T_{stg}$ | Storage temperature                   | -25   | +105  | °C   |
| $T_B$     | Busbar temperature                    | -25   | +105  | °C   |

<sup>1)</sup> For 20 ms in a 20 s interval. ( $RMS \leq I_{PN}$ ).

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

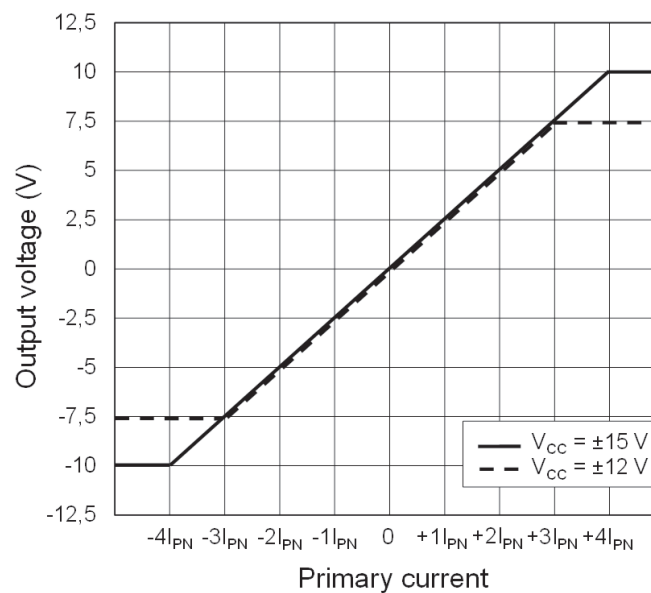


Fig. 1: Output voltage range for different supply voltages.

## Electrical Data of SP3 and SP10

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = \pm 15\text{ V}$ ; unless otherwise specified.

| Symbol     | Parameter                                  | Conditions                   | Min.  | Typ.  | Max.  | Unit       |
|------------|--------------------------------------------|------------------------------|-------|-------|-------|------------|
| $V_+$      | Positive supply voltage                    |                              | +14.3 | +15.0 | +15.7 | V          |
| $V_-$      | Negative supply voltage                    |                              | -14.3 | -15.0 | -15.7 | V          |
| $I_{PN}$   | Primary nominal current (RMS)              |                              | -     | -     | 15    | A          |
| $I_{PR}$   | Measuring range <sup>1)</sup>              |                              | -60   | -     | +60   | A          |
| $V_{outN}$ | Nominal output voltage (RMS)               | $I_P = I_{PN}$ , comp. Fig.1 | -     | 2.5   | -     | V          |
| $R_M$      | Internal burden resistor for output signal |                              | 80    | 126   | 150   | $\Omega$   |
| $R_P$      | Resistance of primary conductor            |                              | -     | 0.75  | 1.0   | m $\Omega$ |
| $I_Q$      | Quiescent current                          | $I_P = 0$                    | -     | 19    | 25    | mA         |
| $I_{CN}$   | Nominal current consumption                | $I_P = I_{PN}$               | -     | 37    | 50    | mA         |
| $I_{CR}$   | Measuring range current consumption        | $I_P = I_{PR}$               | -     | 105   | 110   | mA         |
| $I_{CM}$   | Maximal current consumption <sup>2)</sup>  | $I_P > I_{PR}$               | -     | -     | 120   | mA         |

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = \pm 12\text{ V}$ ; unless otherwise specified.

| Symbol     | Parameter                                  | Conditions                   | Min.  | Typ.  | Max.  | Unit       |
|------------|--------------------------------------------|------------------------------|-------|-------|-------|------------|
| $V_+$      | Positive supply voltage                    |                              | +11.4 | +12.0 | +12.6 | V          |
| $V_-$      | Negative supply voltage                    |                              | -11.4 | -12.0 | -12.6 | V          |
| $I_{PN}$   | Primary nominal current (RMS)              |                              | -     | -     | 15    | A          |
| $I_{PR}$   | Measuring range <sup>1)</sup>              |                              | -45   | -     | +45   | A          |
| $V_{outN}$ | Nominal output voltage (RMS)               | $I_P = I_{PN}$ , comp. Fig.1 | -     | 2.5   | -     | V          |
| $R_M$      | Internal burden resistor for output signal |                              | 80    | 126   | 150   | $\Omega$   |
| $R_P$      | Resistance of primary conductor            |                              | -     | 0.75  | 1.0   | m $\Omega$ |
| $I_Q$      | Quiescent current                          | $I_P = 0$                    | -     | 19    | 25    | mA         |
| $I_{CN}$   | Nominal current consumption                | $I_P = I_{PN}$               | -     | 37    | 50    | mA         |
| $I_{CR}$   | Measuring range current consumption        | $I_P = I_{PR}$               | -     | 80    | 90    | mA         |
| $I_{CM}$   | Maximal current consumption <sup>2)</sup>  | $I_P > I_{PR}$               | -     | -     | 95    | mA         |

<sup>1)</sup> For 3 s in a 60 s interval ( $RMS \leq I_{PN}$ ).

<sup>2)</sup> Limited by output driver.

## Accuracy of SP3

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = \pm 15\text{ V}$ ; unless otherwise specified.

| Symbol           | Parameter                   | Conditions                                      | Min. | Typ.      | Max.       | Unit          |
|------------------|-----------------------------|-------------------------------------------------|------|-----------|------------|---------------|
| $\epsilon_i$     | Accuracy <sup>1) 2)</sup>   | $I_P \leq I_{PN}$                               | -    | $\pm 0.6$ | $\pm 0.8$  | % of $I_{PN}$ |
| $\epsilon_G$     | Gain error <sup>2)</sup>    | $I_P \leq I_{PN}$                               | -    | $\pm 0.5$ | $\pm 0.7$  | % of $I_{PN}$ |
| $\epsilon_{off}$ | Offset error <sup>2)</sup>  | $I_P = 0$                                       | -    | $\pm 0.3$ | $\pm 0.8$  | % of $I_{PN}$ |
| $\epsilon_{Lin}$ | Linearity error             | $I_P \leq I_{PN}$ ;<br>symmetrical current feed | -    | $\pm 0.1$ | $\pm 0.12$ | % of $I_{PN}$ |
| $\epsilon_{Hys}$ | Hysteresis                  | $4 \cdot I_{PN}$ , $\Delta t = 20\text{ ms}$    | -    | -         | 0.02       | % of $I_{PN}$ |
| PSRR             | Power supply rejection rate | $f_{\Delta V_{CC}} \leq 100\text{ Hz}$          | -    | -65       | -          | dB            |
| PSRR             | Power supply rejection rate | $f_{\Delta V_{CC}} \leq 15\text{ kHz}$          | -    | -         | -23        | dB            |
| $N_{RMS}$        | Noise level (RMS)           | $f \leq 80\text{ kHz}$                          | -    | 0.25      | 0.3        | mV            |
| $N_{pk}$         | Noise level (peak)          | $f \leq 80\text{ kHz}$                          | -    | 2.2       | 3.0        | mV            |

$T_{amb} = (-25 \dots +85)\text{ °C}$ ;  $V_{CC} = \pm 15\text{ V}$ ; unless otherwise specified.

| Symbol               | Parameter                                      | Conditions        | Min. | Typ.      | Max.      | Unit          |
|----------------------|------------------------------------------------|-------------------|------|-----------|-----------|---------------|
| $T\epsilon_G$        | Additional temperature induced gain error      | $I_P \leq I_{PN}$ | -    | -         | $\pm 0.5$ | % of $I_{PN}$ |
| $T\epsilon_{off}$    | Additional temperature induced offset error    | $I_P = 0$         | -    | -         | $\pm 1.0$ | % of $I_{PN}$ |
| $T\epsilon_{Lin}$    | Additional temperature induced linearity error | $I_P \leq I_{PN}$ | -    | -         | $\pm 0.1$ | % of $I_{PN}$ |
| $T\epsilon_{\Sigma}$ | Typical total accuracy <sup>3)</sup>           | $I_P \leq I_{PN}$ | -    | $\pm 1.5$ | -         | % of $I_{PN}$ |

<sup>1)</sup> Accuracy contains  $\epsilon_G$  and  $\epsilon_{Lin}$ .

<sup>2)</sup> Does not include additional error of 0.5% ( $I_{PN}$ ) due to aging.

<sup>3)</sup> Typical total accuracy measured in temperature range (including error at  $T_{amb} = 25\text{ °C}$ ).

## Accuracy of SP10

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = \pm 15\text{ V}$ ; unless otherwise specified.

| Symbol           | Parameter                   | Conditions                                      | Min. | Typ.      | Max.       | Unit          |
|------------------|-----------------------------|-------------------------------------------------|------|-----------|------------|---------------|
| $\epsilon_t$     | Accuracy <sup>1) 2)</sup>   | $I_P \leq I_{PN}$                               | -    | -         | $\pm 0.5$  | % of $I_{PN}$ |
| $\epsilon_G$     | Gain error <sup>2)</sup>    | $I_P \leq I_{PN}$                               | -    | -         | $\pm 0.4$  | % of $I_{PN}$ |
| $\epsilon_{off}$ | Offset error <sup>2)</sup>  | $I_P = 0$                                       | -    | -         | $\pm 0.2$  | % of $I_{PN}$ |
| $\epsilon_{Lin}$ | Linearity error             | $I_P \leq I_{PN}$ ;<br>symmetrical current feed | -    | $\pm 0.1$ | $\pm 0.12$ | % of $I_{PN}$ |
| $\epsilon_{Hys}$ | Hysteresis                  | $4 \cdot I_{PN}$ , $\Delta t = 20\text{ ms}$    | -    | -         | 0.02       | % of $I_{PN}$ |
| PSRR             | Power supply rejection rate | $f_{\Delta V_{CC}} \leq 100\text{ Hz}$          | -    | -65       | -          | dB            |
| PSRR             | Power supply rejection rate | $f_{\Delta V_{CC}} \leq 15\text{ kHz}$          | -    | -         | -23        | dB            |
| $N_{RMS}$        | Noise level (RMS)           | $f \leq 80\text{ kHz}$                          | -    | 0.25      | 0.3        | mV            |
| $N_{pk}$         | Noise level (peak)          | $f \leq 80\text{ kHz}$                          | -    | 2.2       | 3.0        | mV            |

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = \pm 15\text{ V}$ ; unless otherwise specified.

| Symbol            | Parameter                                      | Conditions        | Min. | Typ.      | Max.      | Unit          |
|-------------------|------------------------------------------------|-------------------|------|-----------|-----------|---------------|
| $T\epsilon_G$     | Additional temperature induced gain error      | $I_P \leq I_{PN}$ | -    | -         | $\pm 0.5$ | % of $I_{PN}$ |
| $T\epsilon_{off}$ | Additional temperature induced offset error    | $I_P = 0$         | -    | -         | $\pm 1.0$ | % of $I_{PN}$ |
| $T\epsilon_{Lin}$ | Additional temperature induced linearity error | $I_P \leq I_{PN}$ | -    | -         | $\pm 0.1$ | % of $I_{PN}$ |
| $T\epsilon_t$     | Typical total accuracy <sup>3)</sup>           | $I_P \leq I_{PN}$ | -    | $\pm 1.5$ | -         | % of $I_{PN}$ |

<sup>1)</sup> Accuracy contains  $\epsilon_G$  and  $\epsilon_{Lin}$ .

<sup>2)</sup> Does not include additional error of 1.0% ( $I_{PN}$ ) due to aging.

<sup>3)</sup> Typical total accuracy measured in temperature range (including error at  $T_{amb} = 25\text{ °C}$ ).

## General Data

| Symbol    | Parameter                         | Conditions    | Min. | Typ. | Max. | Unit |
|-----------|-----------------------------------|---------------|------|------|------|------|
| $T_{amb}$ | Ambient temperature <sup>1)</sup> |               | -25  | -    | +85  | °C   |
| $T_{stg}$ | Storage temperature               |               | -25  | -    | +105 | °C   |
| $T_B$     | Busbar temperature <sup>1)</sup>  |               | -25  | -    | +105 | °C   |
| $T_{THT}$ | Solder temperature <sup>2)</sup>  | For 7 seconds | -    | -    | 265  | °C   |
| m         | Mass                              |               | -    | 4.3  | 4.5  | g    |

## Dynamic Data

$T_{amb} = 25^\circ\text{C}$ ;  $V_{CC} = \pm 15\text{ V}$ ; unless otherwise specified.

| Symbol          | Parameter                   | Conditions                                        | Min. | Typ.                | Max.               | Unit          |
|-----------------|-----------------------------|---------------------------------------------------|------|---------------------|--------------------|---------------|
| $t_{reac}$      | Reaction time <sup>3)</sup> | 10 % $I_{PN}$ to 10 % $I_{out,N}$                 | -    | 0.075               | 0.15 <sup>4)</sup> | $\mu\text{s}$ |
| $t_{rise}$      | Rise time <sup>3)</sup>     | 10 % $I_{out,N}$ to 90 % $I_{out,N}$              | -    | 1.0                 | 1.7 <sup>4)</sup>  | $\mu\text{s}$ |
| $t_{resp}$      | Response time <sup>3)</sup> | 90 % $I_{PN}$ to 90 % $I_{out,N}$                 | -    | 1.0                 | 1.8 <sup>4)</sup>  | $\mu\text{s}$ |
| $f_{co}$        | Upper cut-off frequency     | -3 dB                                             | 200  | -                   | -                  | kHz           |
| $\Delta V_{TR}$ | Transient output voltage    | 0 V to 530 V (3.7 kV/ $\mu\text{s}$ ); see Fig. 3 | -    | 0.075 <sup>4)</sup> | 0.085              | V             |
| $t_{recTR}$     | Transient recovery time     | 0 V to 530 V (3.7 kV/ $\mu\text{s}$ ); see Fig. 3 | -    | 3.0                 | 3.3 <sup>4)</sup>  | $\mu\text{s}$ |

## Isolation Characteristics

| Symbol    | Parameter                          | Conditions                        | Min. | Typ. | Max. | Unit |
|-----------|------------------------------------|-----------------------------------|------|------|------|------|
| $V_I$     | Isolation test voltage (RMS)       | 50/60 Hz, 60 s                    | 4.4  | -    | -    | kV   |
| $V_{imp}$ | Impulse withstand voltage          | 1.2/50 $\mu\text{s}$              | 8.0  | -    | -    | kV   |
| $d_{cp}$  | Creepage distance                  |                                   | 7.4  | -    | -    | mm   |
| $d_{cl}$  | Clearance distance <sup>5)</sup>   |                                   | 7.4  | -    | -    | mm   |
| $V_B$     | System voltage (RMS) <sup>6)</sup> | Reinforced isolation PD2, CAT III | 300  | -    | -    | V    |
| $V_B'$    | System voltage (RMS) <sup>6)</sup> | Basic isolation PD2, CAT III      | 600  | -    | -    | V    |
| ESD       | Electro static test voltage        | HBM, contact discharge method     | -    | 8.0  | -    | kV   |

<sup>1)</sup> Operating condition.

<sup>2)</sup> Depending on the size of the primary conductor, variation of pre-heating parameters (temperature, duration) might be necessary in order to ensure sufficient soldering results.

<sup>3)</sup>  $I_p = I_{PN}$ , di/dt of 200 A/ $\mu\text{s}$ .

<sup>4)</sup> With recommended RC output filter values according to page 9.

<sup>5)</sup> If mounted on a PCB, the minimal clearance distance might be reduced according to the PCB layout (e.g. diameter of drilling holes and annular rings).

<sup>6)</sup> According to DIN EN 50178, DIN EN 61800-5-1.

## Typical Performance Characteristics

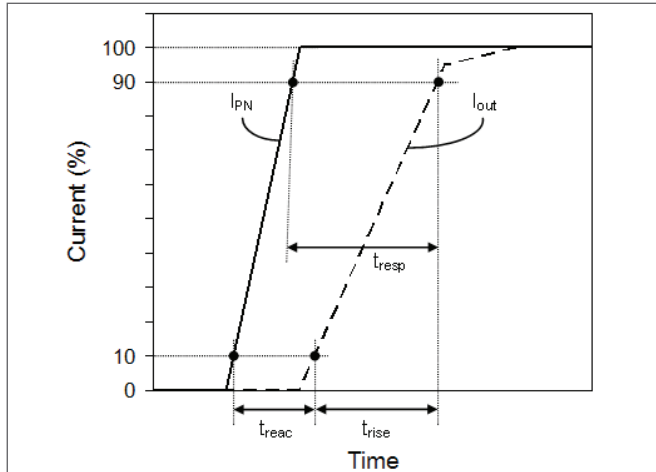


Fig. 2: Definition of reaction time ( $t_{\text{reac}}$ ), rise time ( $t_{\text{rise}}$ ) and response time ( $t_{\text{resp}}$ ).

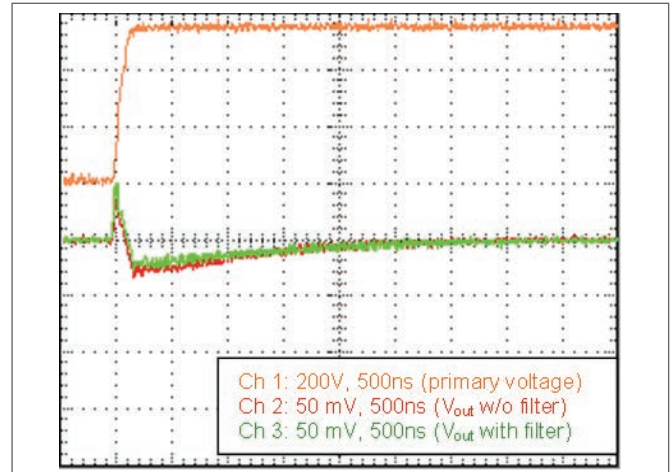


Fig. 3:  $dV/dt$  (3.7kV/ $\mu\text{s}$ ; 530V voltage on primary conductor; filter configuration acc. to Tab. 1).

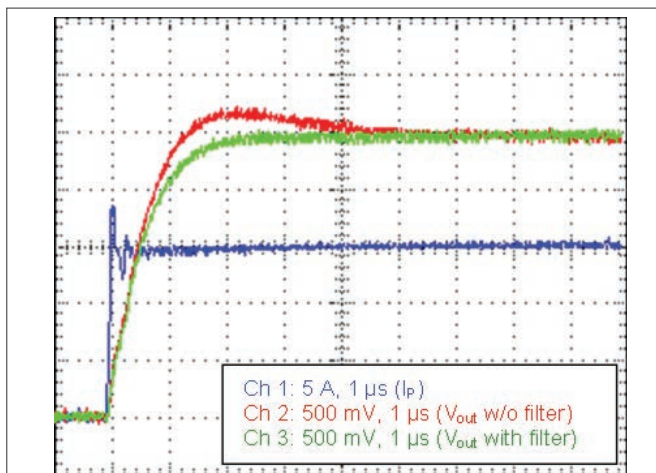


Fig. 4: Step response ( $I_p = 15\text{ A}$ ;  $di/dt \sim 200\text{ A}/\mu\text{s}$ ; filter configuration acc. to Tab. 1).

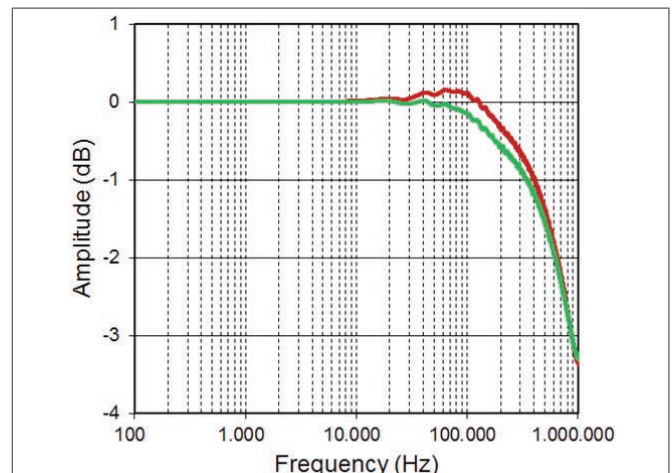


Fig. 5: Typical frequency response with RC-filter (green) and without (red). Filter configuration acc. to Tab. 1 on page 9.

## Pinning

| Pad | Symbol    | Parameter               |
|-----|-----------|-------------------------|
| 1   | $V_+$     | Positive supply voltage |
| 2   | $V_-$     | Negative supply voltage |
| 3   | GND       | Ground                  |
| 4   | SGND      | Signal ground           |
| 5   | $V_{out}$ | Signal output           |
| 6   | $I_{in}$  | Primary current input   |
| 7   | $I_{out}$ | Primary current output  |

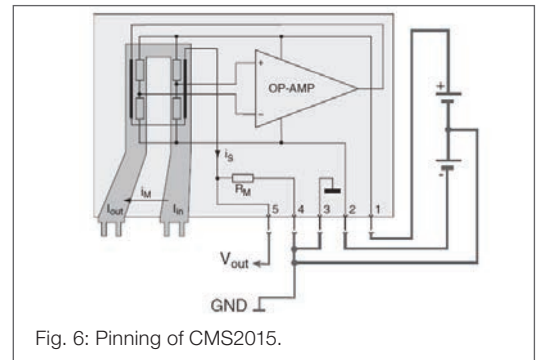


Fig. 6: Pinning of CMS2015.

## Dimensions

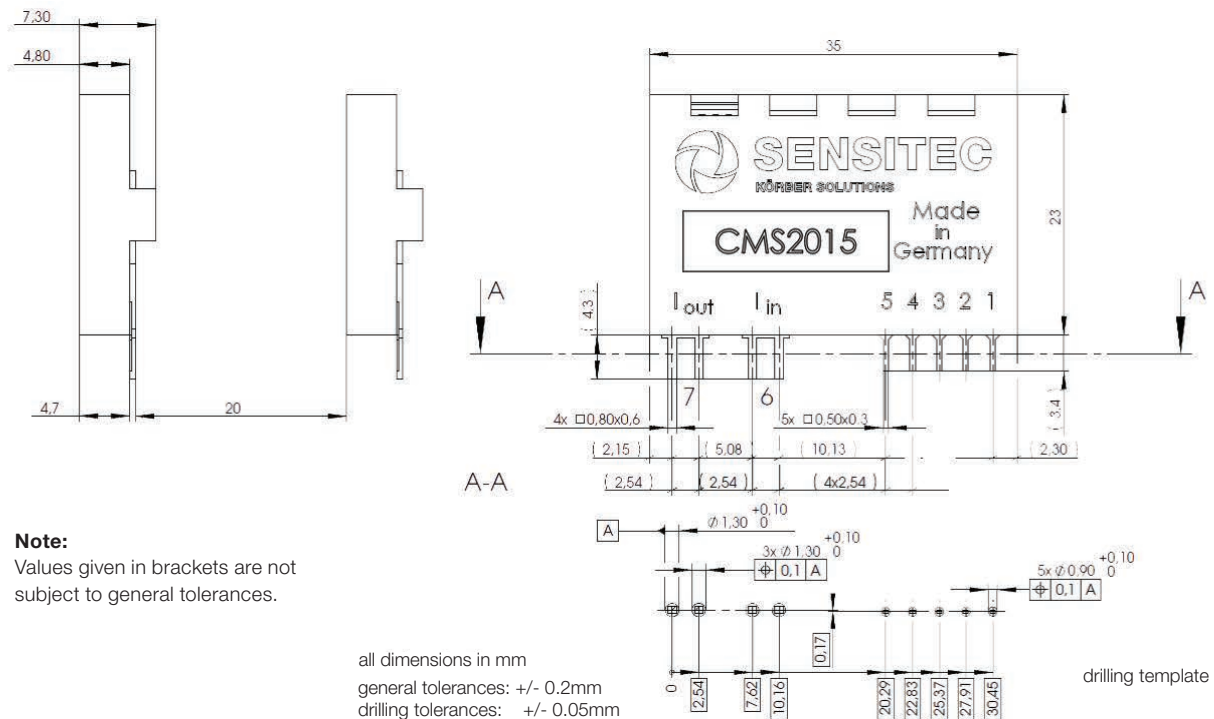
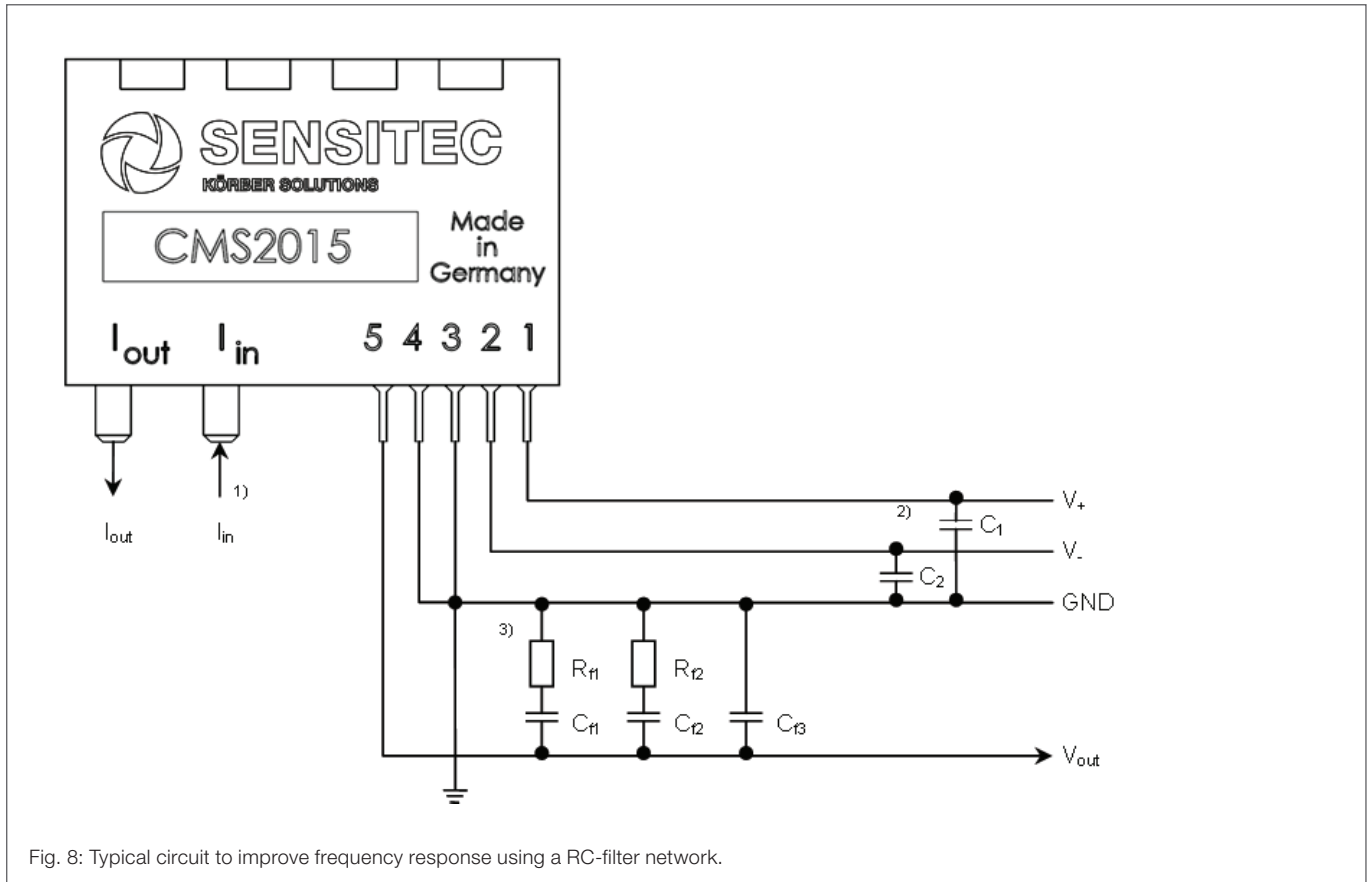


Fig. 7: Package outline.

## Application Circuit



## Filter Configuration

Recommended RC-filter values for  $di/dt \approx 200\text{ A}/\mu\text{s}$ :

| Type                | $R_{f1}$     | $C_{f1}$ | $R_{f2}$ | $C_{f2}$ | $C_{f3}$ |
|---------------------|--------------|----------|----------|----------|----------|
| CMS2015-SP3 / -SP10 | 680 $\Omega$ | 3.3 nF   | -        | -        | -        |

<sup>1)</sup>  $V_{out}$  is positive, if  $I_p$  flows from pin "I<sub>in</sub>" to pin "I<sub>out</sub>".

<sup>2)</sup> The power supply should always be buffered by 47  $\mu\text{F}$  electrolytic capacitor  $C_1$  and  $C_2$ .

<sup>3)</sup> To improve the frequency response, an RC-filter is recommended according to Tab.1 on page 9. Depending on the application, further optimization is possible.

## PCB Layout

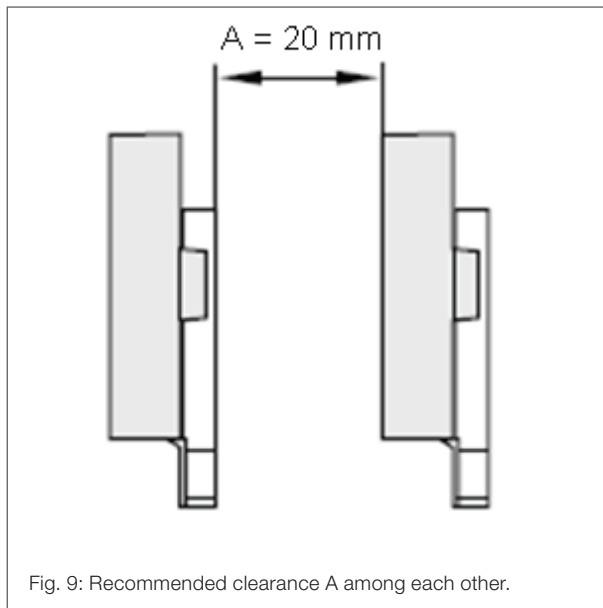


Fig. 9: Recommended clearance A among each other.

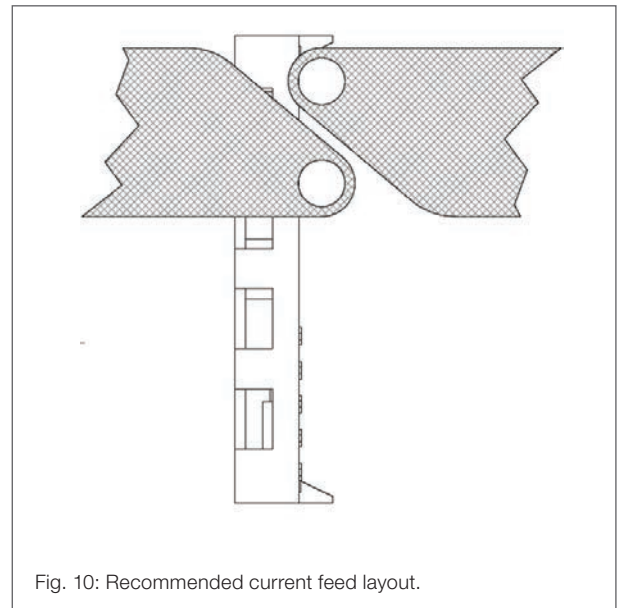


Fig. 10: Recommended current feed layout.

## Additional Notes for the Designer

To operate the sensor within the specified accuracy, the following recommendations should be taken into account:

- In order to limit self-heating of the sensor and hence to not exceed the maximal allowed busbar temperature of 105°C, it is recommended to maximise the area of the current feeds on the PCB to provide a heat sink for the busbar. The required clearance and creepage distances need to be observed.
- The minimum clearance to other sources of magnetic fields (e.g. relays, motors, current conductors or permanent magnets) depends on the strength of the magnetic field. In order to keep the influence of magnetic stray fields on the current sensor signal below 1% (of  $I_{PN}$ ), both homogeneous magnetic fields and magnetic field gradients at the position of the sensor chip (located at the centre of the primary conductor) should be below 1 kA/m and 15 (A/m)/mm (18.7  $\mu\text{T/mm}$ ), respectively. Generally, shielding is possible to avoid influence of magnetic stray fields.

Example: A conductor carrying 1 A generates a magnetic field of 20 A/m and a magnetic field gradient of 2.5 (A/m)/mm at a distance of 8 mm.

- For multiple sensor arrangements, it is recommended to place the sensors including their current feeds with a clearance (A) of at least 20mm to each other as shown in Fig. 9. A smaller distance may cause cross talk to adjacent sensors. The primary current feeds in the PCB may not to be routed underneath a sensor.
- Parts made of electrically conductive material (e.g. housing parts made of aluminium) placed in close proximity to the sensor may affect the dynamic sensor behaviour due to the induced eddy currents in these parts.
- Parts made of ferromagnetic material (e.g. housing parts made of steel) placed in close proximity to the sensor may affect the sensor's accuracy as the magnetic field generated by the sensor's primary conductor may be disturbed.

### The CMS2000 Product Family

The CMS2005 is a member of the CMS2000 product family offering PCB-mountable THT current sensors from 5 A up to 100 A nominal current for various industrial applications.

|               | CMS2005                                                                           | CMS2015                                                                           | CMS2025                                                                           | CMS2050                                                                            | CMS2100                                                                             |
|---------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|               |  |  |  |  |  |
| $I_{PN}^{1)}$ | 5 A                                                                               | 15 A                                                                              | 25 A                                                                              | 50 A                                                                               | 100 A                                                                               |
| $I_{PR}^{2)}$ | 20 A                                                                              | 60 A                                                                              | 100 A                                                                             | 200 A                                                                              | 400 A                                                                               |

The CMK2000 demoboard offers the opportunity to learn the features and benefits of the CMS2000 current sensors in a quick and simple manner.

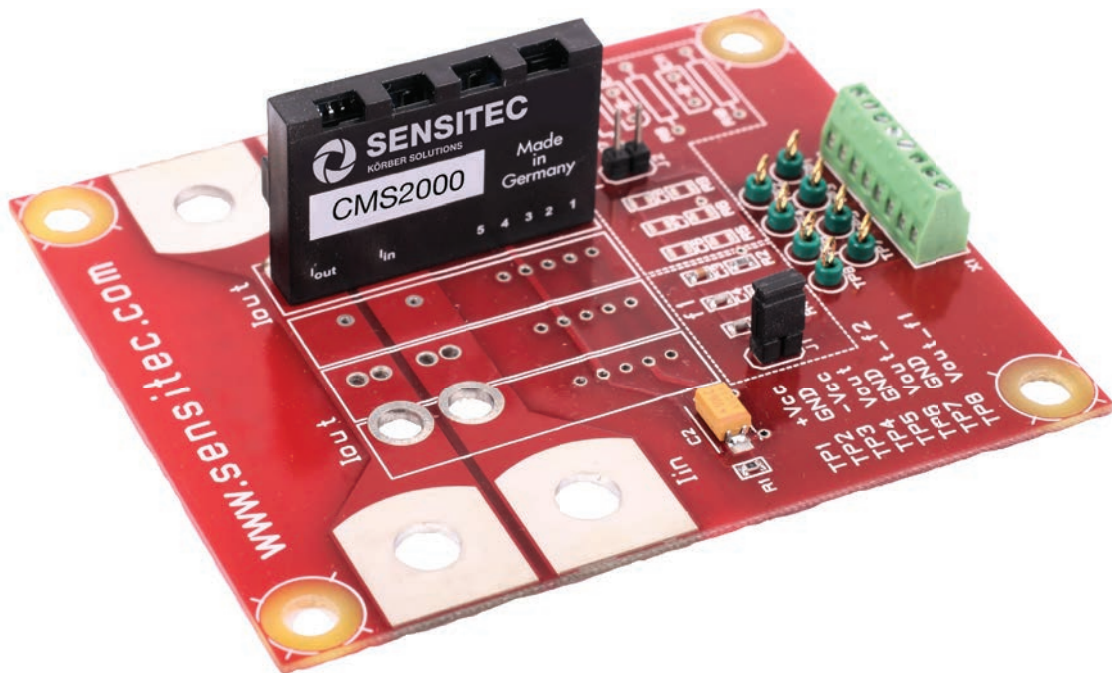


Fig. 10: The CMK2000 demoboards are available for different current ranges.

<sup>1)</sup> Nominal primary current (RMS).

<sup>2)</sup> Measurement range.

## Safety Notes



### Warning!

This sensor shall be used in electric and electronic devices according to applicable standards and safety requirements. Sensitec's datasheet and handling instructions must be complied with. Handling instructions for current sensors are available at [www.sensitec.com](http://www.sensitec.com).



### Caution! Risk of electric shock!

When operating the sensor, certain parts, e. g. the primary busbar or the power supply, may carry hazardous voltage. Ignoring this warning may lead to serious injuries! Conducting parts of the sensor shall not be accessible after installation.

## General Information

### Product Status

| Article     | Status                                                                                                                                                                                          |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CMS2005     | The product is in series production.                                                                                                                                                            |
| <b>Note</b> | The status of the product may have changed since this data sheet was published. The latest information is available on the internet at <a href="http://www.sensitec.com">www.sensitec.com</a> . |

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## General Information

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