

# CDS4006

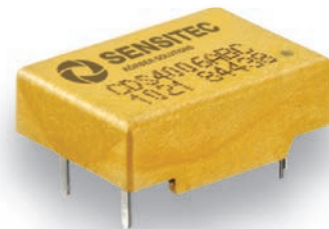
## MagnetoResistive Current Sensor ( $I_{PN} = 6\text{ A}$ )

The CDS4000 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 system accuracy can be improved by using either the internal or an external reference voltage. This further reduces temperature drift and several sensors can share the same reference voltage.

The adjustable overcurrent detection enables a fast response in overload situations to prevent damage to the power units.

The CDS4000 product family offers PCB-mountable THT current sensors from 6 A up to 150 A nominal current for industrial applications.



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

### Product Overview

Article description	Package	Delivery Type
CDS4006ABC-KA (discontinued)	THT	Tray
CDK4006ABC-KA (discontinued)	Demoboard	Pocketbox

### Quick Reference Guide

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{CC}$	Supply voltage	4.75	5.0	5.25	V
$I_{PN}$	Primary nominal current (RMS)	-	-	6	A
$I_{PR}$	Primary measuring range <sup>1)</sup>	-18	-	+18	A
$\epsilon_z$	Overall accuracy <sup>2)</sup>	-	0.8	1.3	% of $I_{PN}$
$f_{co}$	Upper cut-off frequency (-1 dB)	200	400	-	kHz
$T_{amb}$	Ambient temperature <sup>3)</sup>	-40	-	+105	°C
$T_B$	Busbar temperature <sup>3)</sup>	-40	-	+105	°C

<sup>1)</sup> For 1 s in a 60 s interval;  $R_M = 300\ \Omega$ .

<sup>2)</sup> Overall accuracy contains  $\epsilon_{G^+}$ ,  $\epsilon_{off}$  and  $\epsilon_{Lin}$  at  $V_{CC} = 5\text{ V}$ ;  $R_M = 300\ \Omega$ ;  $T_{amb} = 25\text{ °C}$ .

<sup>3)</sup> Operating condition. Above +85 °C the PCB requires a RTI of minimum +130 °C.

### Qualification Overview

Standard	Name	Status
EN 61800-5-1: 2007-09	Adjustable speed electrical power drive systems	Approved
IEC 62103	Electronic equipment for use in power installations	Approved
DIN EN 50178	Electronic equipment for use in power installations	Approved
UL508	Power conversion equipment	Approved

### Features

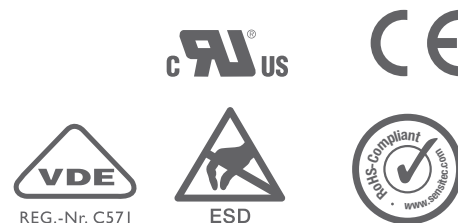
- Based on the AnisotropicMagnetoResistive (AMR) effect
- Galvanic isolation between primary and measurement circuit
- Single 5 V power supply
- Adjustable overcurrent detection

### Advantages

- Excellent accuracy
- Low temperature drift
- Very small size
- Highly dynamic response
- External reference possible
- Low primary inductance
- Negligible hysteresis

### Applications

- Solar power converters
- AC variable speed drives
- Converters for DC motor drives
- Uninterruptible power supplies
- Switched mode power supplies
- Power supplies for welding applications
- Diodes laser drivers



### Electrical Data

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = 5\text{ V}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$I_{PN}$	Primary nominal current (RMS)		-	-	6	A
$I_{PR}$	Measuring range <sup>1)</sup>		-18	-	+18	A
$I_{outN}$	Nominal output current (RMS)	$I_p = I_{PN}$	-	2	-	mA
$I_{outM}$	Maximum output current (abs) <sup>1)</sup>	$I_p = 3 \cdot I_{PN}$	-	-	6	mA
$R_M$	TBurden resistor for output signal <sup>2)</sup>		100	300	1000	$\Omega$
$R_p$	Resistance of primary conductor		1.0	1.6	2.2	m $\Omega$
$R_i$	Internal output resistor	See Fig. 1	9.5	10.5	11.5	k $\Omega$
$V_{CC}$	Supply voltage		4.75	5.0	5.25	V
$I_o$	Quiescent current	$I_p = 0$	-	25	30	mA
$I_{CN}$	Nominal current consumption	$I_p = I_{PN}$	-	50	60	mA
$I_{CM}$	Maximum current consumption	$I_p \leq I_{PR}$	-	100	110	mA
$V_{out}$	Maximum output voltage range <sup>3)</sup>		0.625	-	4.375	V
$V_{refout}$	Reference voltage output	$V_{refin}$ connected to GND	2.49	2.5	2.51	V
$V_{refin}$	Reference voltage input		1.5	2.5	2.6	V
$G_V$	Voltage gain	$R_M = 300\ \Omega$	-	100	-	mV/A
$G_I$	Current gain		-	1/3	-	mA/A
$I_L$	Maximum additional load $V_{refout}$	$\Delta V_{refout} \leq 10\text{ mV}$	-	-	1	mA

<sup>1)</sup> For 1 s in a 60 s interval;  $R_M = 300\ \Omega$ .

<sup>2)</sup>  $R_M > 300\ \Omega$ : reduces  $I_{PR}$  but increases  $G_V$ .

<sup>3)</sup> Output voltage is scaled by changing  $R_M$  but not beyond these limits. See Fig. 2.

### Block Diagram

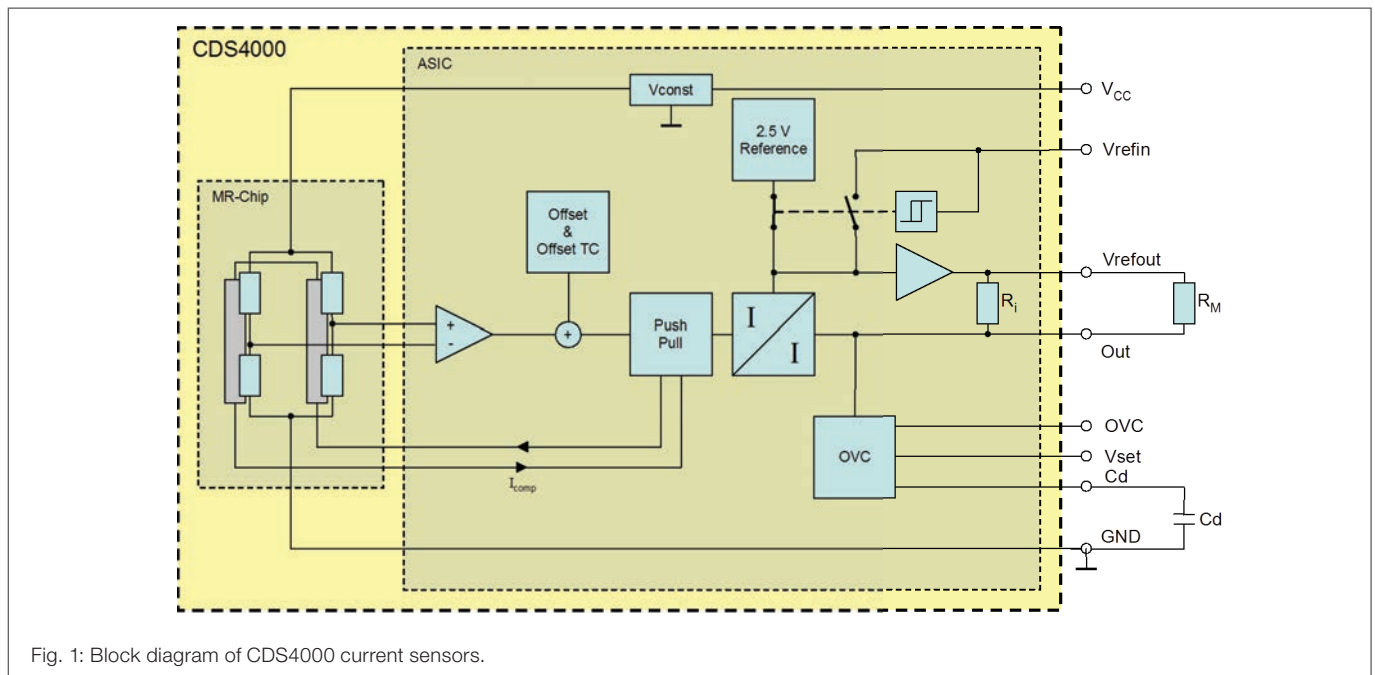


Fig. 1: Block diagram of CDS4000 current sensors.

### Accuracy

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = 5\text{ V}$ ;  $R_M = 300\ \Omega$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$\epsilon_E$	Overall accuracy <sup>1)</sup>	$I_P \leq I_{PN}$	-	0.8	1.3	% of $I_{PN}$
$\epsilon_G$	Gain error <sup>2)</sup>	$I_P \leq I_{PN}$	-	0.3	0.5	% of $I_{PN}$
$\epsilon_{off}$	Offset error <sup>2)</sup>	$I_P = 0$	-	0.3	0.5	% of $I_{PN}$
$\epsilon_{Lin}$	Linearity error <sup>2)</sup>	$I_P \leq I_{PN}$	-	0.2	0.3	% of $I_{PR}$
$\epsilon_{Vrefint}$	Internal reference error		-10	0	+10	mV
$\epsilon_{Vrefext}$	External reference error <sup>3)</sup>	$V_{refin} = 1.5\text{ to }2.6\text{ V}$	-3	0	+3	mV
$\epsilon_{Hys}$	Hysteresis <sup>4)</sup>		-	-	0.1	% of $I_{PN}$
PSRR	Power supply rejection rate	$f_{\Delta V_{CC}} < 15\text{ kHz}$	-	40	30	dB
N	Noise level (RMS)	$f < 300\text{ kHz}$	-	1.7	-	$\mu\text{A}$

$T_{amb} = (-25\dots+85)\text{ °C}$ ;  $V_{CC} = 5\text{ V}$ ;  $R_M = 300\ \Omega$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$T\epsilon_G$	Maximum temperature induced gain error		-0.5	0	+0.5	% of $I_{PN}$
$T\epsilon_{off}$	Maximum temperature induced offset error		-1.5	0	+1.5	% of $I_{PN}$
$T\epsilon_{Lin}$	Maximum temperature induced linearity error		-	0	0.1	% of $2 \cdot I_{PR}$
$T\epsilon_{Vrefint}$	Maximum temperature induced error of internal reference	$I_P \leq I_{PN}$	-0.6	0	+0.6	% of $V_{refout}$
$T\epsilon_{Vrefext}$	Maximum temperature induced error of external reference		-0.05	0	+0.05	% of $V_{refout}$

$T_{amb} = (-40\dots+105)\text{ °C}$ ;  $V_{CC} = 5\text{ V}$ ;  $R_M = 300\ \Omega$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$T\epsilon_G$	Maximum temperature induced gain error		-0.5	0	+0.5	% of $I_{PN}$
$T\epsilon_{off}$	Maximum temperature induced offset error		-2.0	0	+2.0	% of $I_{PN}$
$T\epsilon_{Lin}$	Maximum temperature induced linearity error		-	0	0.1	% of $2 \cdot I_{PR}$
$T\epsilon_{Vrefint}$	Maximum temperature induced error of internal reference	$I_P \leq I_{PN}$	-0.6	0	+0.6	% of $V_{refout}$
$T\epsilon_{Vrefext}$	Maximum temperature induced error of external reference		-0.05	0	+0.05	% of $V_{refout}$

<sup>1)</sup> Overall accuracy contains  $\epsilon_G$ ,  $\epsilon_{off}$  and  $\epsilon_{Lin}$ .

<sup>2)</sup> Long term stability after 10,000 hours at 85 °C operating temperature:

The gain and linearity error is less than  $\pm 1.8\%$  of  $I_{PN}$ .

The offset error is less than  $\pm 2.0\%$  of  $I_{PN}$ .

<sup>3)</sup>  $\epsilon_{Vrefext} = V_{refin} - V_{refout}$

<sup>4)</sup> Residual voltage after  $3 \cdot I_{PN}$  DC.

### Absolute Maximum Ratings Values

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

Symbol	Parameter	Min.	Max.	Unit
$V_{CC}$	Supply voltage	-0.3	+7	V
$I_{PM}$	Maximum primary current <sup>1)</sup>	-	60	A
$T_{amb}$	Ambient temperature	-40	+105	°C
$T_{stg}$	Storage temperature	-40	+105	°C
TB	Busbar temperature	-40	+105	°C

<sup>1)</sup> For 3 ms in a 100 ms interval.

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.

### Qualifications

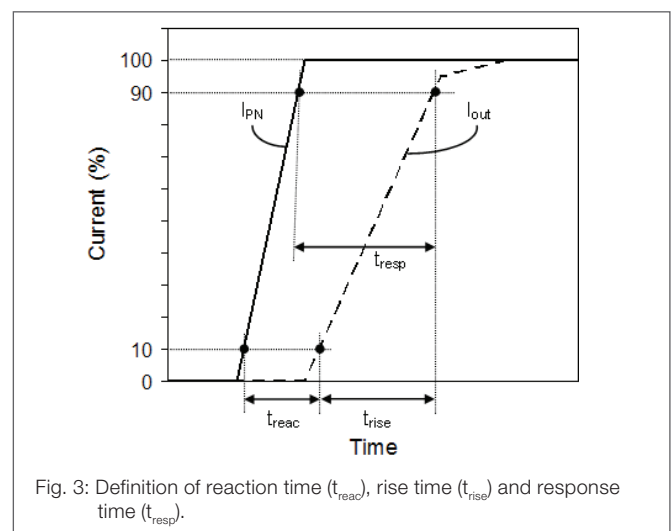
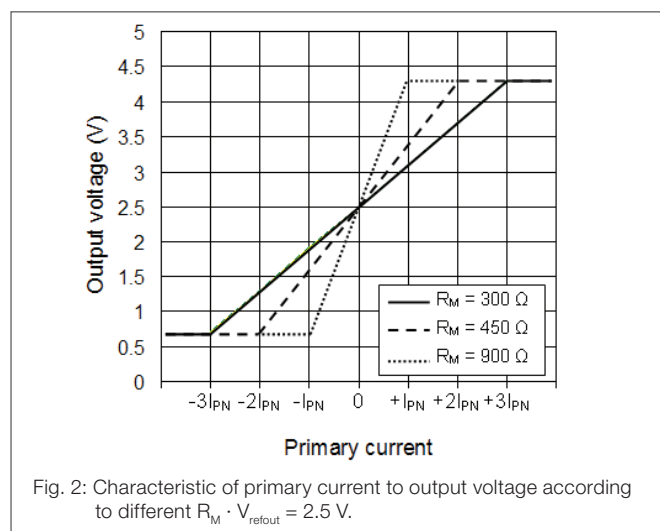
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
VI	Isolation test voltage (RMS)	50/60 Hz, 60 s	-	5	-	kV
$V_{imp}$	Impulse withstand voltage	1.2/50 $\mu$ s	-	12	-	kV
$V_{pde}$	Partial discharge extinction voltage		1900	-	-	V
$d_{cp}$	Creepage distance		-	15	-	mm
$d_{cl}$	Clearance distance		-	15	-	mm
CTI	Comparative Tracking Index		-	600	-	-

### Dynamic Data

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = 5\text{ V}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$t_{reac}$	Reaction time <sup>2)</sup>	10% $I_{PN}$ to 10% $I_{out,N}$	-	-	0.25	$\mu$ s
$t_{rise}$	Rise time <sup>2)</sup>	10% $I_{out,N}$ to 90% $I_{out,N}$	-	-	0.55	$\mu$ s
$t_{resp}$	Response time <sup>2)</sup>	90% $I_{PN}$ to 90% $I_{out,N}$	-	-	0.55	$\mu$ s
$f_{co}$	Upper cut-off frequency	-1 dB	200	400	-	kHz

<sup>2)</sup>  $I_p = I_{PN}$  with di/dt of 80 A/ $\mu$ s. See Fig. 3.



### General Data

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$T_{amb}$	Ambient temperature <sup>1)</sup>		-40	-	+105	°C
$T_{stg}$	Storage temperature <sup>1)</sup>		-40	-	+105	°C
$T_B$	Busbar temperature <sup>1)</sup>		-40	-	+105	°C
$T_{THT}$	Solder temperature	For 7 seconds	-	-	260	°C
m	Mass CDS4006ABC		-	3.6	-	g
RTI	Relative temperature index <sup>1)</sup>	$T_{amb} \geq +85\text{ °C}$	+130	-	-	°C

<sup>1)</sup> Operating condition. Above +85 °C the PCB requires a RTI of minimum +130 °C.

### Overcurrent Detection (OVC) Related Data

The CDS4006 current sensor offers with OVC a digital comparator output to signal primary current overloads. The output is pulled low when a user defined critical current value is exceeded. The overcurrent detection is adjustable for both threshold voltage and delay time. The OVC output is an open collector output with internal 10 kΩ pull up resistor.

A maximum of 3 CDS (for 3-Phase-detection) can be connected in parallel as a wired-or signal.

$T_{amb} = 25\text{ °C}$ ;  $V_{CC} = 5\text{ V}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{OVCH}$	Overcurrent output high level		4.5	-	5.0	V
$V_{OVCL}$	Overcurrent output low level		0.0	-	0.7	V
$V_{set}$	Threshold input		0.625	-	2.5	V
$\epsilon_{OVset}$	Error of OVC Threshold	$R_M = 300\ \Omega$ , $I_P = I_{PN}$	-3	-	+3	% of $V_{out,N}$
$\epsilon_{OVhys}$	Switching Hysteresis		1	5	10	mV
$R_D$	Internal pull up resistance		7	10	13	kΩ
$I_s$	Maximum current sink at OVC output		-	-	2	mA

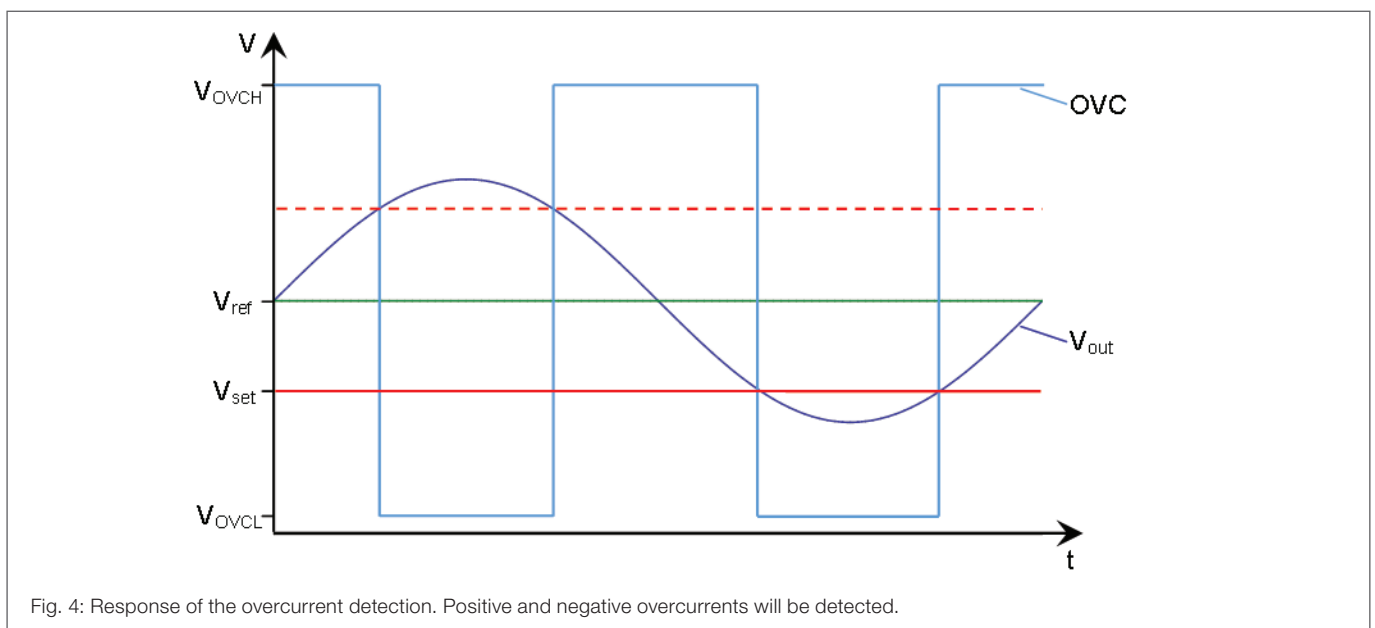
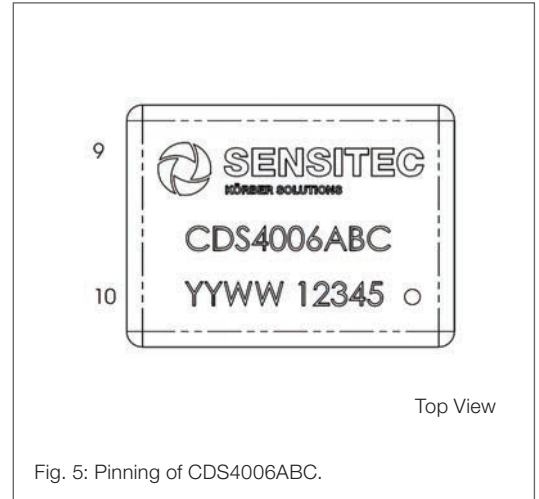


Fig. 4: Response of the overcurrent detection. Positive and negative overcurrents will be detected.

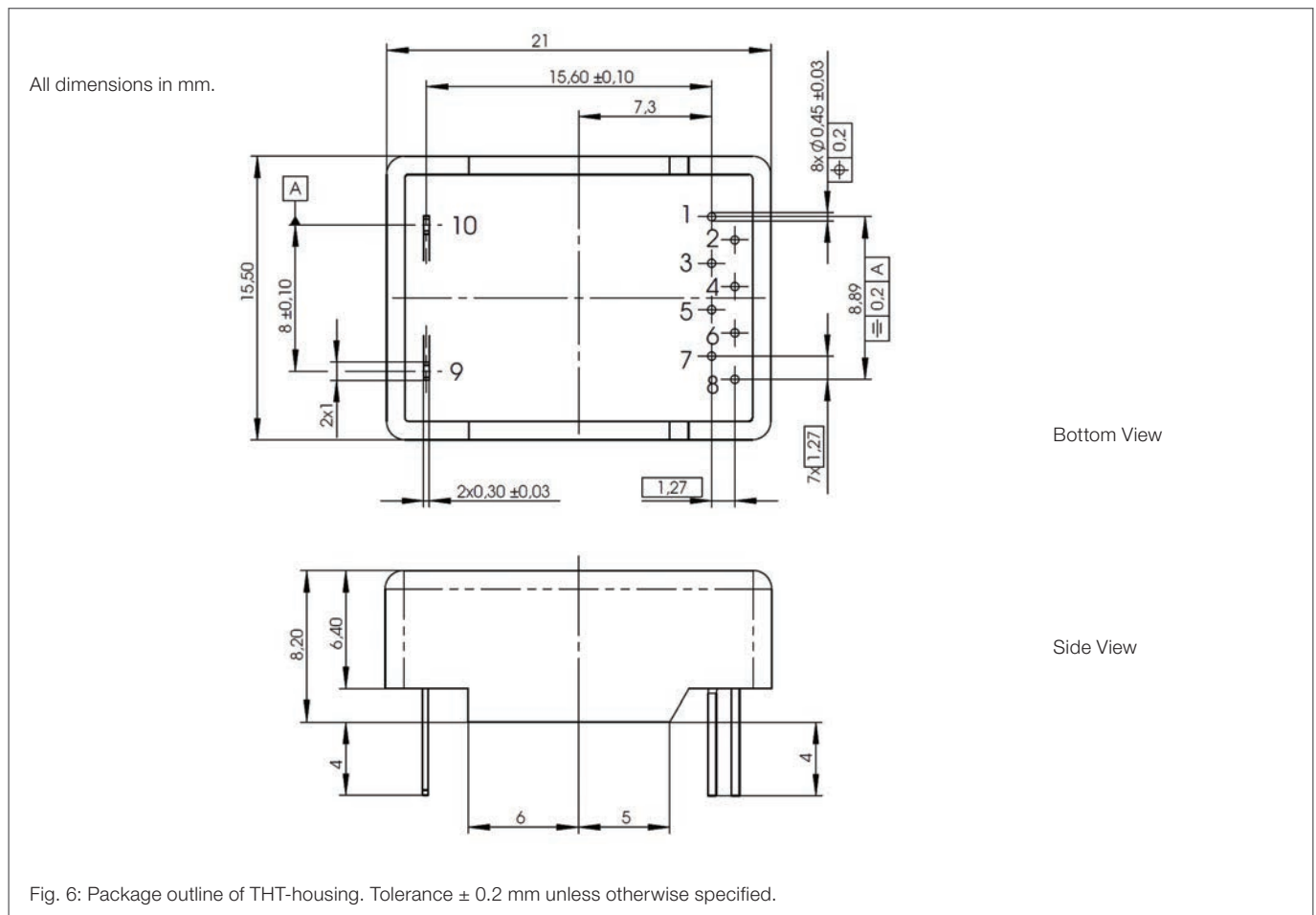
CDS4006 in THT-housing

**Pinning**

Pad	Symbol	Parameter
1	$V_{\text{refout}}$	Reference voltage output
2	Out	Signal output
3	GND	Ground
4	$V_{\text{CC}}$	Supply voltage
5	$V_{\text{refin}}$	External reference voltage input
6	$C_d$	Overcurrent delay capacitor input
7	OVC	Overcurrent detection output
8	$V_{\text{set}}$	Threshold voltage for overcurrent detection
9	$I_{\text{in}}$	Primary current input
10	$I_{\text{out}}$	Primary current output



**Dimensions**



**Application Circuit**

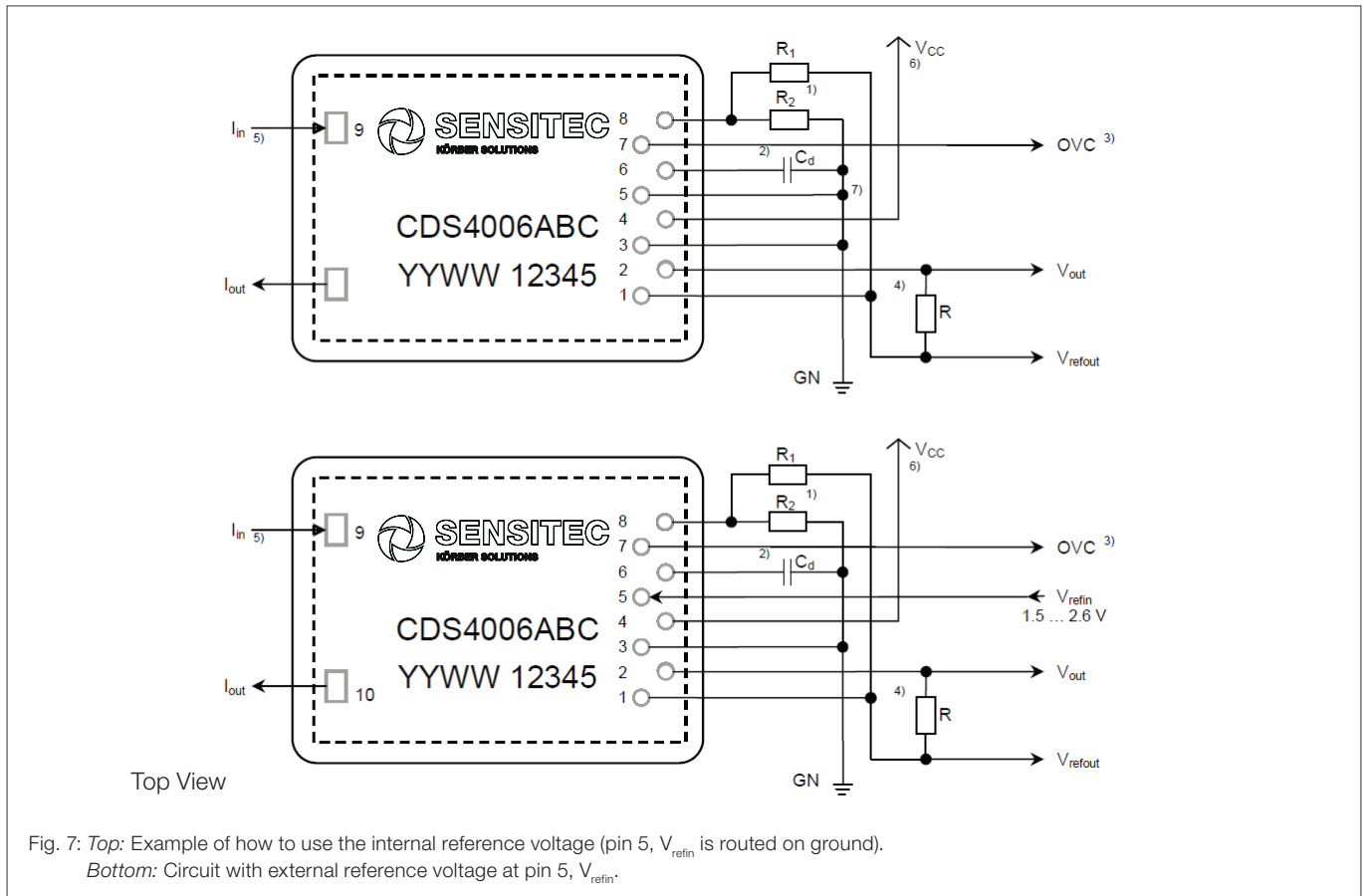


Fig. 7: *Top*: Example of how to use the internal reference voltage (pin 5,  $V_{refin}$  is routed on ground).  
*Bottom*: Circuit with external reference voltage at pin 5,  $V_{refin}$ .

<sup>1)</sup> The overcurrent threshold is set by applying a voltage to pin 8 ( $V_{set}$ ) according to the formula:

$$V_{set} = V_{refout} - I_{OC} \cdot R_M \cdot G_I \quad \text{Example: } V_{refout} = 2.5\text{ V}; R_M = 300\ \Omega; I_{OC} = 12\text{ A} \rightarrow V_{set} = 1.3\text{ V}$$

In the above Fig. 7 the potential divider with  $R_1$  and  $R_2$  on pin 8 ( $V_{set}$ ) is used to adjust the threshold for the overcurrent detection. In consideration of internal  $60\text{ k}\Omega$  in parallel to  $R_1$  the divider calculates as follows:

$$\frac{V_{set}}{V_{refout}} = \frac{R_2}{\frac{R_1 \cdot 60\text{ k}\Omega}{R_1 + 60\text{ k}\Omega} + R_2} \quad \text{with } 1.0\text{ k}\Omega < (R_1 + R_2) < 7.5\text{ k}\Omega \text{ and } R_1 \text{ or } R_2 < 1.0\text{ k}\Omega.$$

<sup>2)</sup> The overcurrent delay time is adjustable with the capacitor  $C_d$  on pin 6. Without  $C_d$  the delay time has its minimum value. The minimum delay time is achieved by not using a capacity  $C_d$  (not connected on ground).

$$t_d \approx 0.5\ \mu\text{s} + \frac{C_d\ (\text{pF})}{50\ \text{pF}}\ \mu\text{s} \text{ or } C_d \approx 50\ \text{pF} \cdot (t_d\ (\mu\text{s}) - 0.5\ \mu\text{s}).$$

<sup>3)</sup> If the overcurrent detection is unused,  $V_{set}$  and  $C_d$  should be routed on ground, OVC pin is not connected.

<sup>4)</sup>  $R_M > 300\ \Omega$ : reduces  $I_{PR}$  but increases  $G_V$ . See Fig. 2.

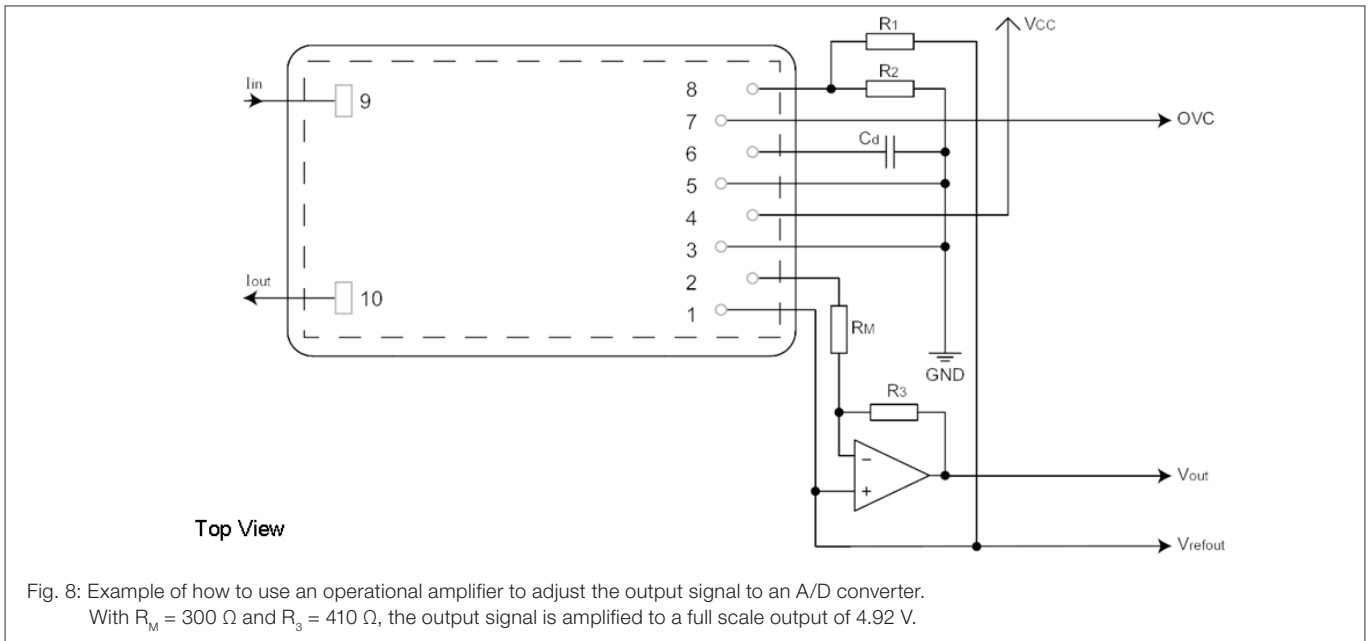
Output voltage depending on primary current as: 
$$V_{out} = V_{refout} + I_P \cdot G_I \cdot 1.03 \cdot \frac{R_1 \cdot R_M}{R_1 + R_M}.$$

<sup>5)</sup>  $V_{out}$  is positive, if  $I_P$  flows from pin 9 "I<sub>in</sub>" to pin 10 "I<sub>out</sub>".

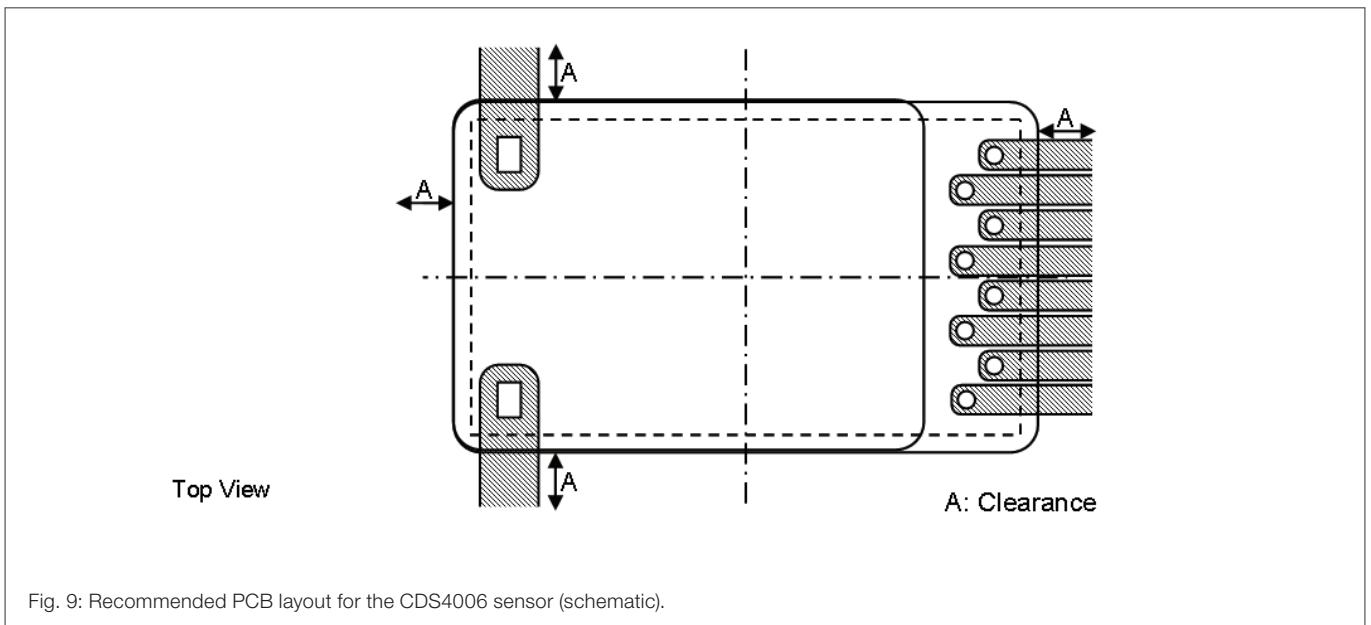
<sup>6)</sup>  $V_{CC}$  should always be buffered with a capacity of at least  $100\text{ nF}$ .

<sup>7)</sup>  $V_{refin}$  should always be routed on ground if not used.

**Application Circuit**



**PCB Layout**



**Additional Notes for the Designer**

- The minimum clearance to other magnetic devices (for example: relay, current conductors and permanent magnets) depends on the strength of their magnetic field. Homogeneous fields should be below 1 kA/m and magnetic field gradients should be lower than 4 kA/m<sup>2</sup>. A conductor carrying 1 A produces a magnetic field of 20 A/m and a magnetic field gradient of 2.5 kA/m<sup>2</sup> at a distance of 8 mm.
- The maximum operating temperature is primarily limited by the busbar temperature. Care must be taken to keep the busbar temperature below 105 °C.
- It is recommended to place multiple CDS4006 sensors with a clearance (A) of at least 10 mm. A smaller distance will cause cross-talk to adjacent sensors. The current paths in the PCB however may not be routed underneath a CDS4000 sensor.
- Above the ambient temperature of +85 °C a relative temperature index (RTI) of minimum +130 °C is required for the PCB.



**Typical Performance Graphs**

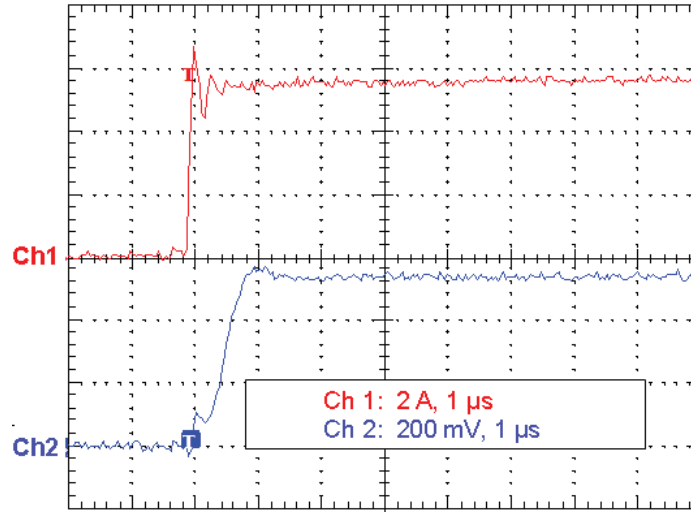


Fig. 10: Typical output characteristic due to a current jump from 0 to  $I_{PN}$ .  
Input  $di/dt \approx 60\text{ A}/\mu\text{s}$ .

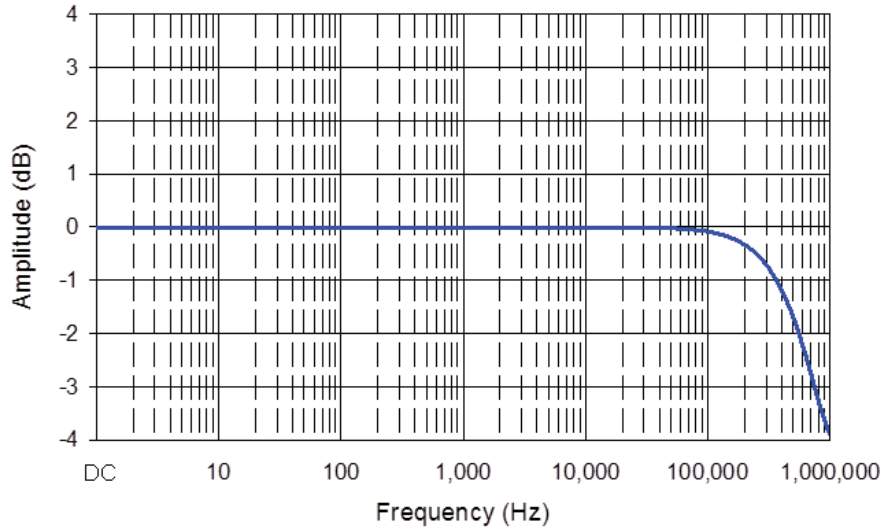


Fig. 11: Typical frequency response without using a RC-Filter.

**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.

### The CDS4000 Product Family

The CDS4006 is a member of the CDS4000 product family offering PCB-mountable THT current sensors from 6 A up to 150 A nominal current for various industrial applications. For each sensor type a demoboard for evaluation and testing is available.

Product	$I_{PN}$ (A)	$I_{PR}$ (A)	Package	Demoboard
CDS4006ABC-KA	6	18		
CDS4010ABC-KA	10	30		
CDS4015ABC-KA	15	45		
CDS4025ABC-KA	25	75		
CDS4050ABC-KA	50	150		
CDS4050ACC-KA	50	150		
CDS4100ACC-KA	100	300		
CDS4125ACC-KA	125	375		
CDS4150ACC-KA	150	450		

$I_{PN}$ : Nominal primary current (RMS).

$I_{PR}$ : Measurement range (For 1 s in a 60 s interval;  $R_M = 300\ \Omega$ ).

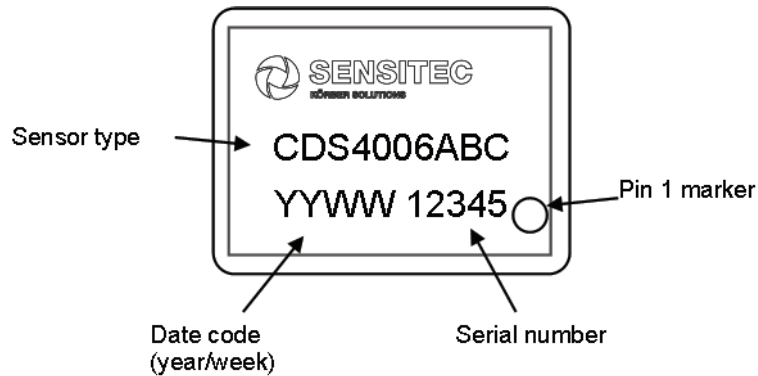


Fig. 12: Sensor inscription.

## General Information

### Product Status

The product is in series production.

**Note:** The status of the product may have changed since this data sheet was published. The latest information is available on the internet at [www.sensitec.com](http://www.sensitec.com)

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