

# Model CDS4050

# Current Sensors

## MagnetoResistive Current Sensor ( $I_{PN} = 50A$ )

### Description

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 10 A up to 150 A nominal current for industrial applications.

### Product overview

Product description	Package	Delivery Type
CDS4050ABB	THT (small)	Tray
CDS4050ACB	THT (medium)	Tray
CDK4050ABB	Demoboard (small)	Pocketbox
CDK4050ACB	Demoboard (medium)	Pocketbox

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{CC}$	Supply voltage	4.75	5	5.25	V
$I_{PN}$	Primary nominal current (RMS)	-	-	50	A
$I_{PR}$	Primary measuring range <sup>1)</sup>	-150	-	+150	A
$\epsilon_{\Sigma}$	Overall accuracy <sup>2)</sup>	-	0.8	1.3	% of $I_{PN}$
$f_{co}$	Upper cut-off frequency (-1 dB)	100	200	-	kHz
$T_{amb}$	Ambient temperature <sup>3)</sup>	-25	-	+85	°C
$T_B$	Busbar temperature <sup>3)</sup>	-25	-	+100	°C

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

2)  $\epsilon_{\Sigma} = \epsilon_G + \epsilon_{off} + \epsilon_{lin}$  with  $V_{CC} = 5 V$  and  $T_{amb} = 25 ^\circ C$ .

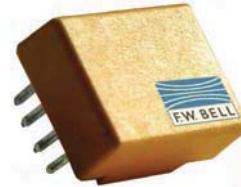
3) Operating condition.

### Qualification overview

Standard	Name	Status
EN 61800-5-1: 2003	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
UL508C	Power conversion equipment	Pending



CDS4050ABB



CDS4050ACB

### Features

- Based on the Anisotropic Magneto Resistive (AMR) effect
- Galvanic isolation between primary and measurement circuit
- Single 5V 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



## 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)		-	-	50	A
$I_{PR}$	Measuring range <sup>1)</sup>		-150	-	+150	A
$I_{PM}$	Maximum primary peak current (abs) <sup>2)</sup>		-	-	500	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
$R_M$	Burden resistor for output signal <sup>3)</sup>		100	300	1000	$\Omega$
$R_P$	Resistance of primary conductor		0.15	0.20	0.25	m $\Omega$
$V_{CC}$	Supply voltage		4.75	5	5.25	V
$I_Q$	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		-	105	150	mA
$V_{out}$	Maximum output voltage range <sup>4)</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	$R_M = 300\ \Omega$	-	12	-	mV/A
$G_I$	Current gain		-	1/25	-	mA/A
$I_L$	Maximum additional load $V_{refout}$	$\Delta V_{refout} \leq 10\text{ mV}$	-	-	1	mA

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

2) For 3 ms in a 100 ms interval.

3)  $R_M > 300\ \Omega$ : reduces  $I_{PR}$  but increases  $G_V$ .

4) Output voltage is scaled by changing  $R_M$  but not beyond these limits.

## Absolute maximum ratings

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>5)</sup>	-	500	A
$T_{amb}$	Ambient temperature	-25	+130	°C
$T_{stg}$	Storage temperature	-25	+100	°C
$T_B$	Busbar temperature	-25	+100	°C

5) 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

$V_I$	Isolation test voltage (RMS)	50/60 Hz, 60 s	-	3	-	kV
$V_{imp}$	Impulse withstand voltage	1.2/50 $\mu$ s	-	6	-	kV
$V_{pde}$	Partial discharge extinction voltage		1	-	-	kV
$d_{cp}$	Creepage distance		-	15	-	mm
$d_{cl}$	Clearance distance		-	15	-	mm
CTI	Comparative Tracking Index		-	600	-	-

**Accuracy**

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$\epsilon_{\Sigma}$	Overall accuracy <sup>1)</sup>	$I_P \leq I_{PN}$	-	0.8	1.3	% of $I_{PN}$
$\epsilon_G$	Gain error	$I_P \leq I_{PN}$	-	0.3	0.5	% of $I_{PN}$
$\epsilon_{off}$	Offset error	$I_P = 0$	-	0.3	0.5	% of $I_{PN}$
$\epsilon_{Lin}$	Linearity error	$I_P \leq I_{PN}$	-	0.2	0.3	% of $2 \cdot I_{PN}$
$\epsilon_{Vrefint}$	Internal reference error		-10	0	+10	mV
$\epsilon_{Vrefext}$	External reference error <sup>2)</sup>	$V_{refin} = 1.5\text{ to }2.6\text{ V}$	-3	0	+3	mV
$\epsilon_{Hys}$	Hysteresis <sup>3)</sup>		-	-	-	% of $I_{PN}$
$T\epsilon_G$	Maximum temperature induced gain error	$T_B = (-25...+85)\text{ °C}$	-1	0	+1	% of $I_{PN}$
$T\epsilon_{off}$	Maximum temperature induced offset error	$T_B = (-25...+85)\text{ °C}$	-1	0	+1	% of $I_{PN}$
$T\epsilon_{Lin}$	Maximum temperature induced linearity error	$T_B = (-25...+85)\text{ °C}$	-	0	0.1	% of $2 \cdot I_{PN}$
$T\epsilon_{Vrefint}$	Maximum temperature induced error of internal reference	$T_B = (-25...+85)\text{ °C}$	-0.6	0	+0.6	% of $V_{refout}$
$T\epsilon_{Vrefext}$	Maximum temperature induced error of external reference	$T_B = (-25...+85)\text{ °C}$	-0.1	0	+0.1	% of $V_{refout}$
PSRR	Power supply rejection rate		-	40	30	dB
N	Noise level (RMS)	$f < 300\text{ kHz}$	-	1.7	-	$\mu\text{A}$

**Dynamical data**

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$t_{ra}$	Reaction time <sup>4)</sup>	$10\% I_{PN}$ to $10\% I_{out}$	-	650	-	ns
$t_r$	Response time <sup>4)</sup>	$90\% I_{PN}$ to $90\% I_{out}$	-	850	-	ns
$f_{co}$	Upper cut-off frequency	-1 dB	100	200	-	kHz

**Notes**

- $\epsilon_{\Sigma} = \epsilon_G + \epsilon_{off} + \epsilon_{Lin}$
- $\epsilon_{Vrefext} = V_{refin} - V_{refout}$
- Residual voltage after  $3 \cdot I_{PN}$  DC.  
Hysteresis is smaller than noise level N.
- $I_P = I_{PN}$  with  $di/dt$  of  $50\text{ A}/\mu\text{s}$ . See Fig.1.

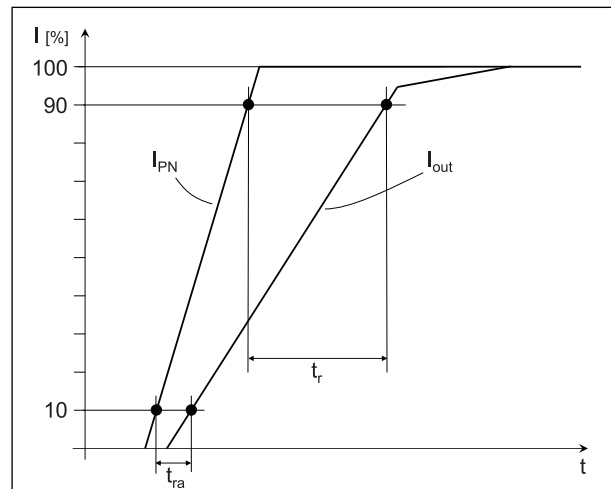


Fig.1: Definition of reaction ( $t_{ra}$ ) and response time ( $t_r$ ).

## General data

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$T_{amb}$	Ambient temperature		-25	-	+85	°C
$T_{stg}$	Storage temperature		-25	-	+100	°C
$T_B$	Busbar temperature		-25	-	+100	°C
$T_{THT}$	Solder temperature	For 7 Seconds	-	-	+250°C	°C
m	Mass		-	4.4	-	g

## Overcurrent detection (OVC) related data

The CDS4050 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	V
$V_{OVCL}$	Overcurrent output low level		0	-	0.7	V
$V_{set}$	Threshold input		0.625	-	2.5	V
$\epsilon_{OVCVset}$	Error of OVC Threshold	$R_M = 300\ \Omega$ , $I_P = I_{PN}$	-3	-	+3	% of $V_{out,N}$
$\epsilon_{OVCHys}$	Switching Hysteresis		7	10	13	mV
$R_D$	Internal pull up resistance		7	10	13	kΩ
$I_S$	Maximum current sink at OVC output		-	-	2	mA

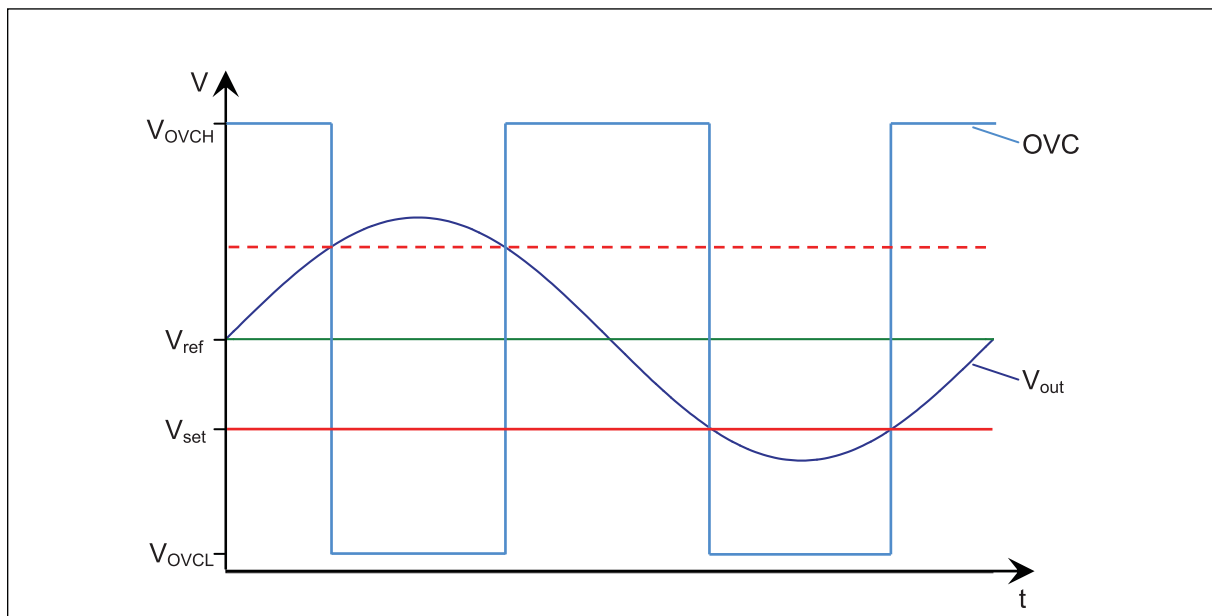


Fig. 2: Response of the overcurrent detection. Positive and negative overcurrents will be detected.

## CDS4050

### MagnetoResistive Current Sensor ( $I_{PN} = 50\text{ A}$ )

#### CDS4050 in THT-housing (small size)

##### Pinning

Pin	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

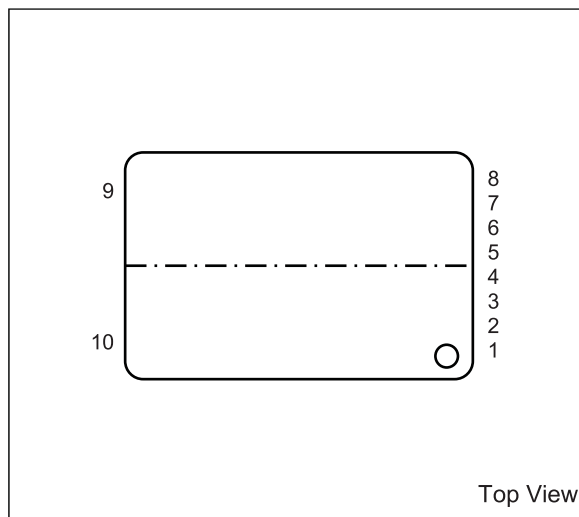


Fig. 3: Pinning of CDS4050ABB-IA.

##### Dimensions

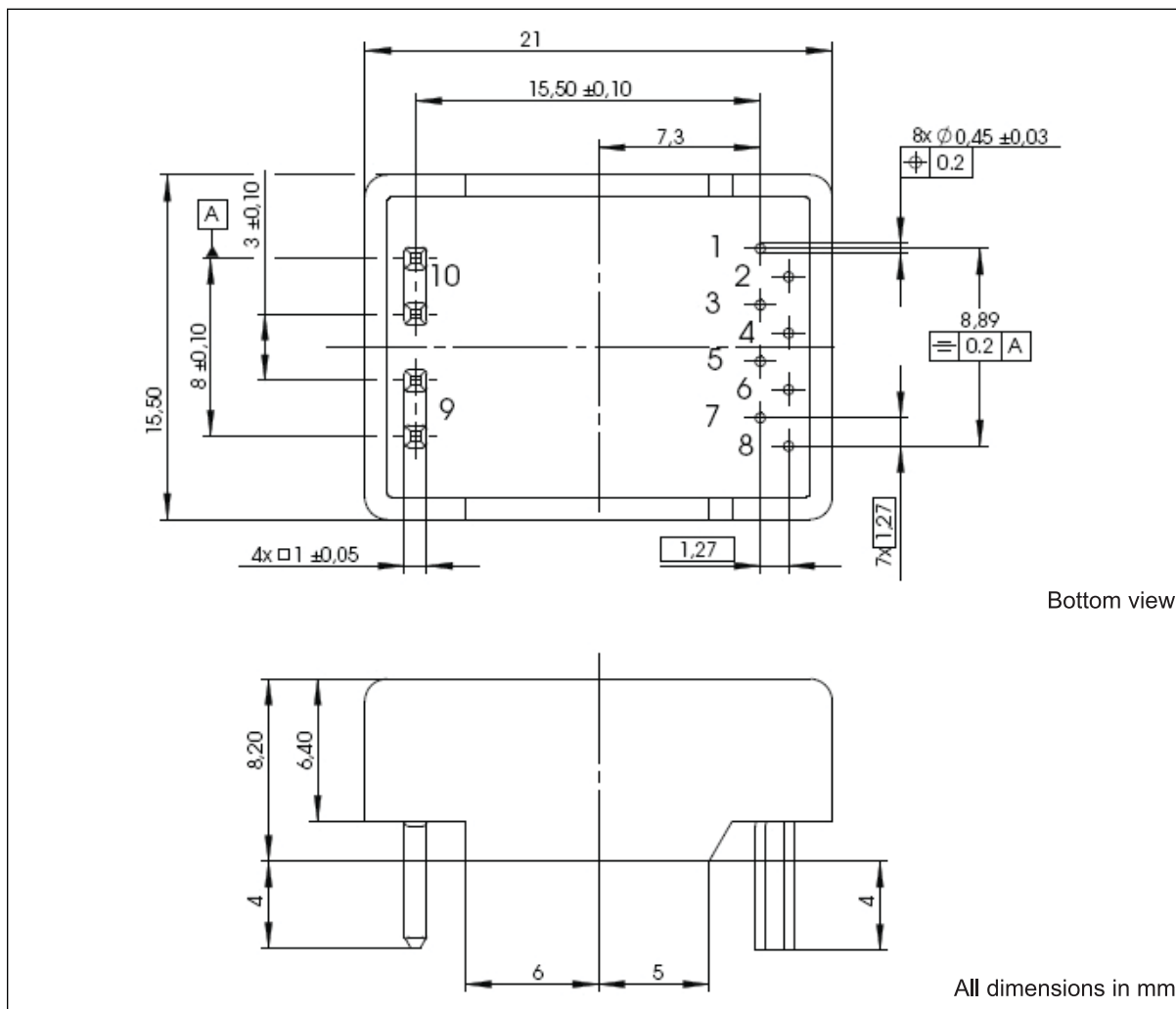


Fig.4: Package outline of THT-housing (small size). Tolerance  $\pm 0.2\text{ mm}$  unless otherwise specified.

## CDS4050

### MagnetoResistive Current Sensor ( $I_{PN} = 50\text{ A}$ )

#### CDS4050 in THT-housing (medium size)

##### Pinning

Pin	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

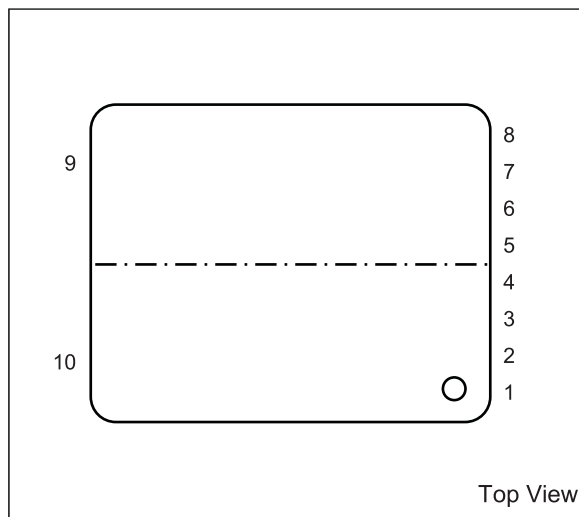


Fig. 5: Pinning of CDS4050ACB-IA.

##### Dimensions

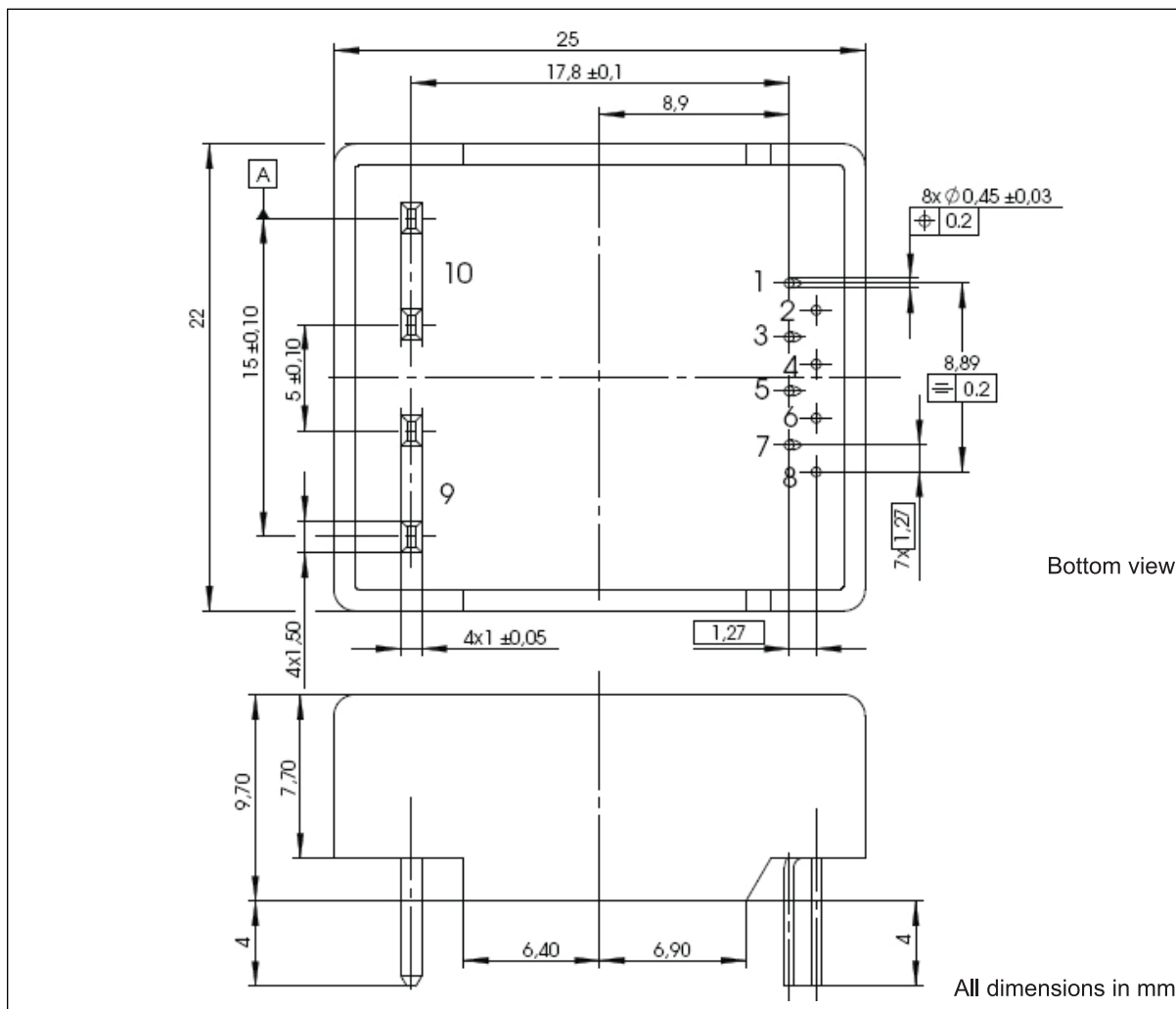


Fig.6: Package outline of THT-housing (medium size). Tolerance  $\pm 0.2\text{ mm}$  unless otherwise specified.

## Application circuit

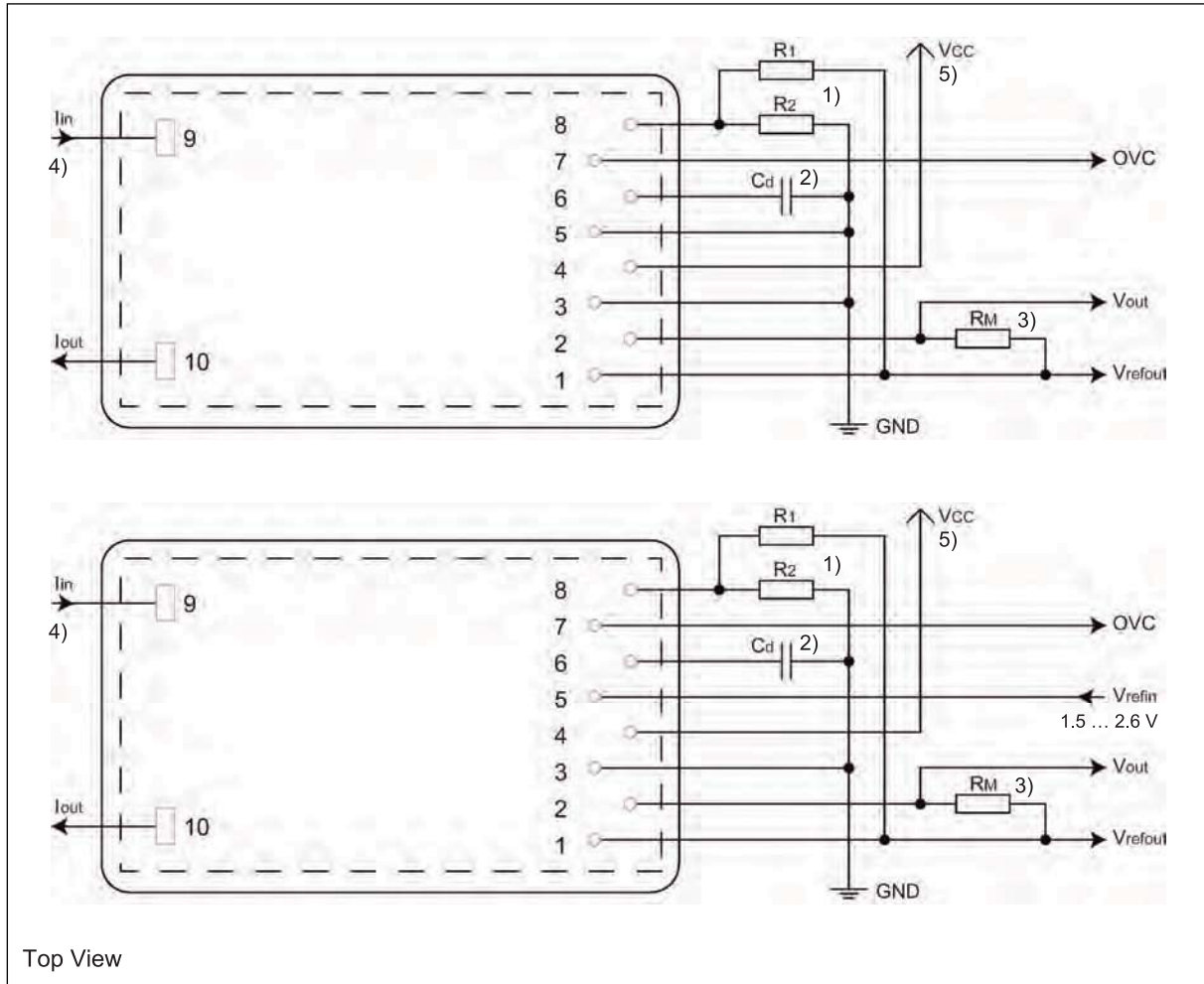


Fig.7: Top: Example of how to use the internal reference voltage.  
Bottom: Circuit with external reference voltage at  $V_{refin}$  (Pin 5).

## Notes

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

$$I_{OC} = \frac{V_{refout} - V_{set}}{R_M \cdot G_I} \quad \text{Example: } V_{refout} = 2.5\text{ V}; R_M = 300\ \Omega; I_{OC} = 100\text{ A} \rightarrow V_{set} = \underline{1.3\text{ V}}$$

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.

$$I_{OC} \approx \left[ 1 - \frac{R_2}{R_1 + R_2} \right] \cdot \frac{V_{refout}}{R_M \cdot G_I} \quad \text{with } 2.5\text{ k}\Omega < (R_1 + R_2) < 25\text{ k}\Omega.$$

- 2) 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).

$$t_d \leq 0.5\ \mu\text{s} + \frac{C_d\ (\text{pF})}{50\ \text{pF}}\ \mu\text{s}$$

- 3)  $R_M > 300\ \Omega$ : reduces  $I_{PR}$  but increases  $G_V$ .  
4)  $V_{out}$  is positive, if  $I_P$  flows from Pin 9 " $I_{in}$ " to Pin 10 " $I_{out}$ ".  
5)  $V_{CC}$  should always be buffered with a capacity of at least 100 nF.

## Application circuit

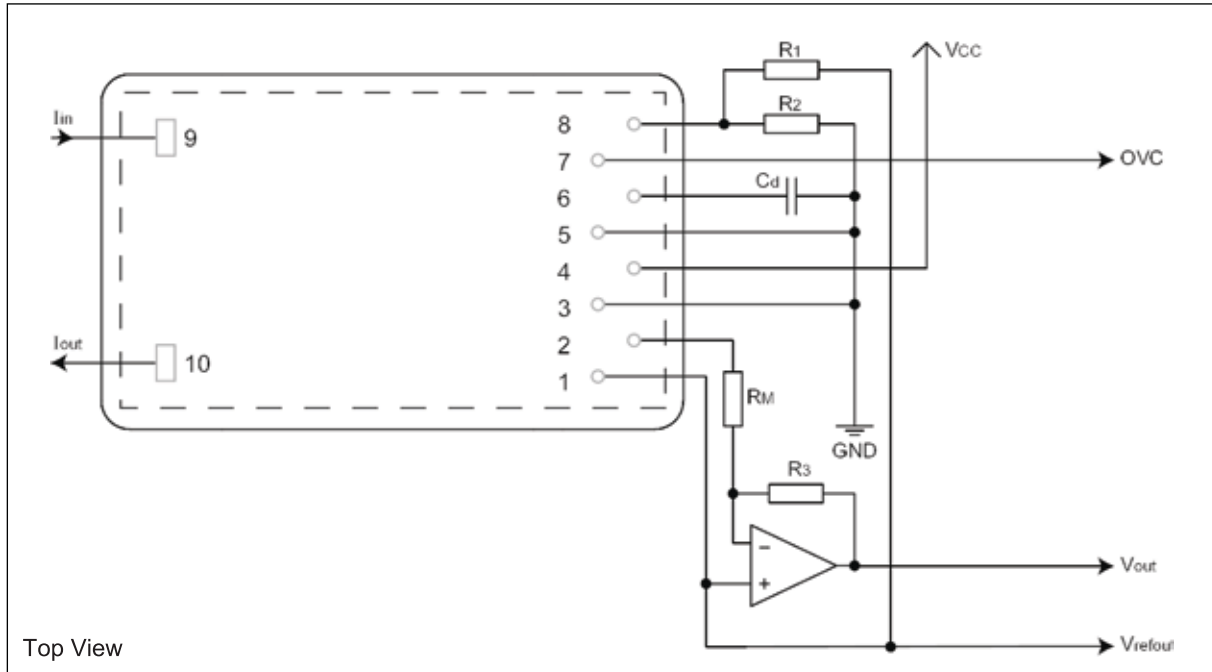


Fig.8: Example of how to use an operational amplifier to adjust the output signal to an A/D converter.  
With  $R_M = 300\ \Omega$  and  $R_3 = 410\ \Omega$ , the output signal is amplified to a full scale output of 4.92 V.

## PCB Layout

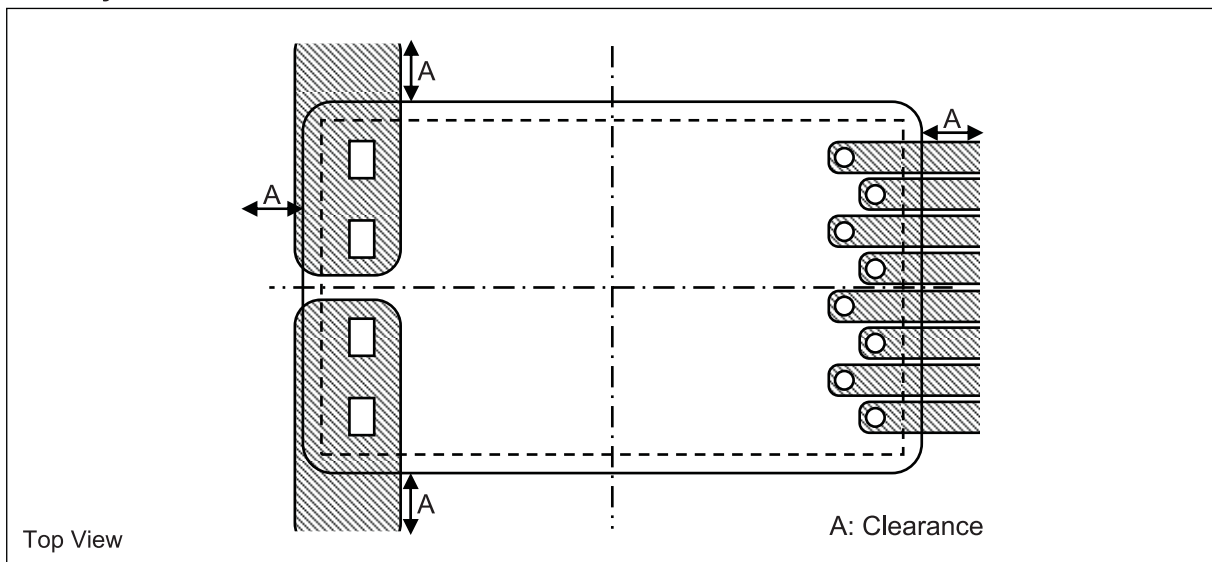


Fig.9: Recommended PCB Layout for the CDS4050 sensor.

## 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 100 °C.
- It is recommended to place multiple CDS4050 sensors with a clearance (A) of at least 10 mm. A smaller distance will only influence the offset. Cross-talk is not relevant. The current paths in the PCB however may not be routed underneath a CDS4000 sensor.



## Typical performance graphs

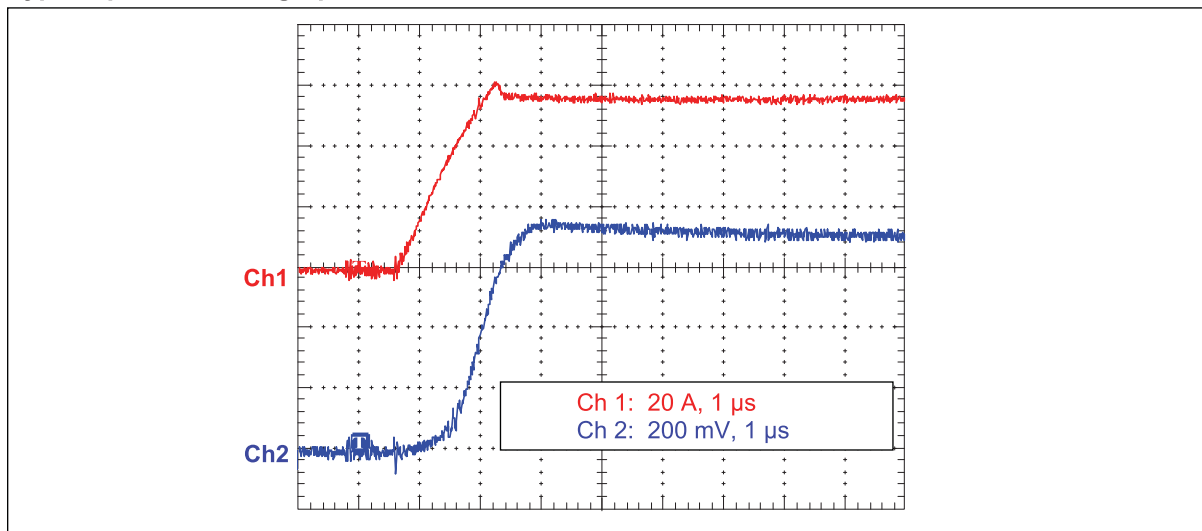


Fig.10: Typical output characteristic due to a current jump from 0 to  $I_{PN}$ . Input  $di/dt \approx 40\text{ A}/\mu\text{s}$ . Applied RC-Filter with the parameters  $R_F = 750\ \Omega$  and  $C_F = 15\text{ nF}$ .

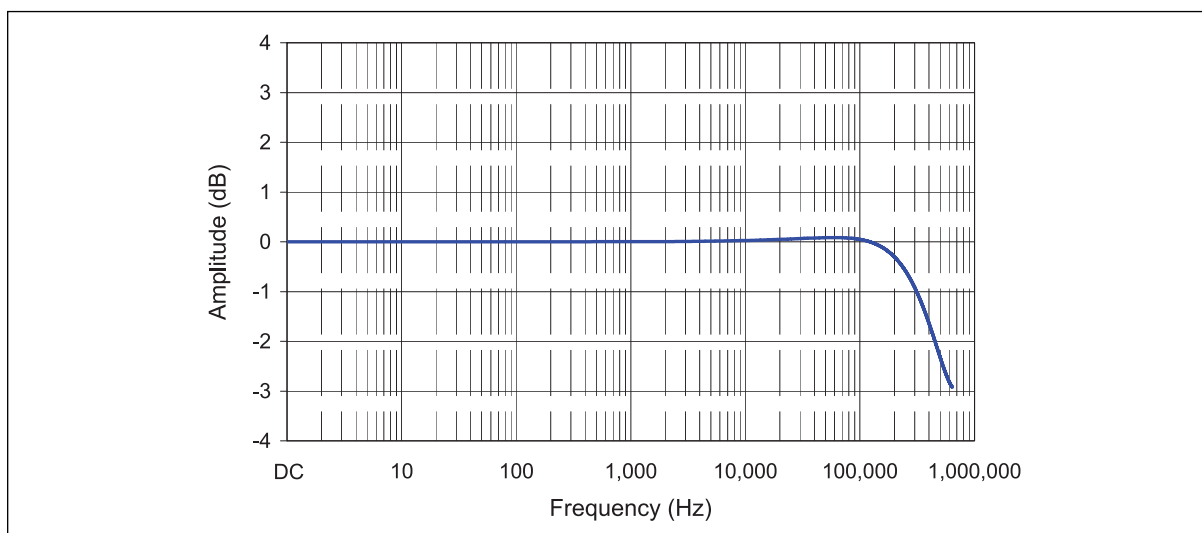


Fig.9: Typical frequency response applies RC-Filter with the parameters  $R_F = 750\ \Omega$  and  $C_F = 15\text{ nF}$ .



## CDS4050

### MagnetoResistive Current Sensor ( $I_{PN} = 50\text{ A}$ )

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#### The CDS4000 product family

The CDS4050 is a member of the CDS4000 product family offering PCB-mountable THT current sensors from 10 A up to 150 A nominal current for various industrial applications.

Product	$I_{PN}$ (A)	$I_{PR}$ (A)	Package
CDS4010ABB-Ix	10	30	
CDS4015ABB-Ix	15	45	
CDS4025ABB-Ix	25	75	
CDS4050ABB-Ix	50	150	
CDS4050ACB-Ix	50	150	
CDS4100ACB-Ix	100	300	
CDS4125ACB-Ix	125	375	
CDS4150ACB-Ix	150	450	

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

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

## General information

### Product status

The product is undergoing qualification tests. Deliverable have a sample status at this time. **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.sypris.com](http://www.sypris.com).

### Right to make changes

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