SENSITEC
MagnetoResistive Sensors

CDS4050

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

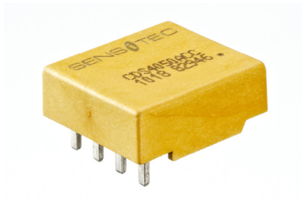
Data sheet

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.

CDS4050ABC



CDS4050ACC

Product overview

Product description	Package	Delivery Type
CDS4050ABC-KA	THT (small)	Tray
CDS4050ACC-KA	THT (medium)	Tray
CDK4050ABC-KA	Demoboard (small)	Pocketbox
CDK4050ACC-KA	Demoboard (medium)	Pocketbox

Quick reference guide

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 [1)]	-150	-	+150	A
ε_{Σ}	Overall accuracy [2)]	-	0.8	1.3	% of I_{PN}
f_{co}	Upper cut-off frequency (-1 dB)	200	400	-	kHz
T_{amb}	Ambient temperature [3)]	-40	-	+105	°C
T_B	Busbar temperature [3)]	-40	-	+105	°C

1) For 1 s in a 60 s interval; R_M = 300 Ω.
2) Overall accuracy contains ε_G, ε_{off} and ε_{Lin} at V_{CC} = 5 V; R_M = 300 Ω; T_{amb} = 25 °C.
3) 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 Anisotropic MagnetoResistive (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
- Laser diodes driver

REG.-Nr. C571

CDS4050.DSE.07

Electrical data

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
I_{PN}	Primary nominal current (RMS)		-	-	50	A
I_{PR}	Measuring range [1]		-150	-	+150	A
I_{outN}	Nominal output current (RMS)	$I_P = I_{PN}$	-	2	-	mA
I_{outM}	Maximum output current (abs) [1]	$I_P = 3 \cdot I_{PN}$	-	-	6	mA
R_M	Burden resistor for output signal [2]		100	300	1000	Ω
R_P	Resistance of primary conductor		0.15	0.20	0.25	mΩ
R_i	Internal output resistor	See Fig. 1	9.5	10.5	11.5	kΩ
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	$I_P \leq I_{PR}$	-	100	110	mA
V_{out}	Maximum output voltage range [3]		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 Ω	-	12	-	mV/A
G_I	Current gain		-	1/25	-	mA/A
I_L	Maximum additional load V_{refout}	$\Delta V_{refout} \leq$ 10 mV	-	-	1	mA

1) For 1 s in a 60 s interval; R_M = 300 Ω.
2) R_M > 300 Ω: reduces I_{PR} but increases G_V.
3) Output voltage is scaled by changing R_M but not beyond these limits. See Fig. 2.

Block diagram

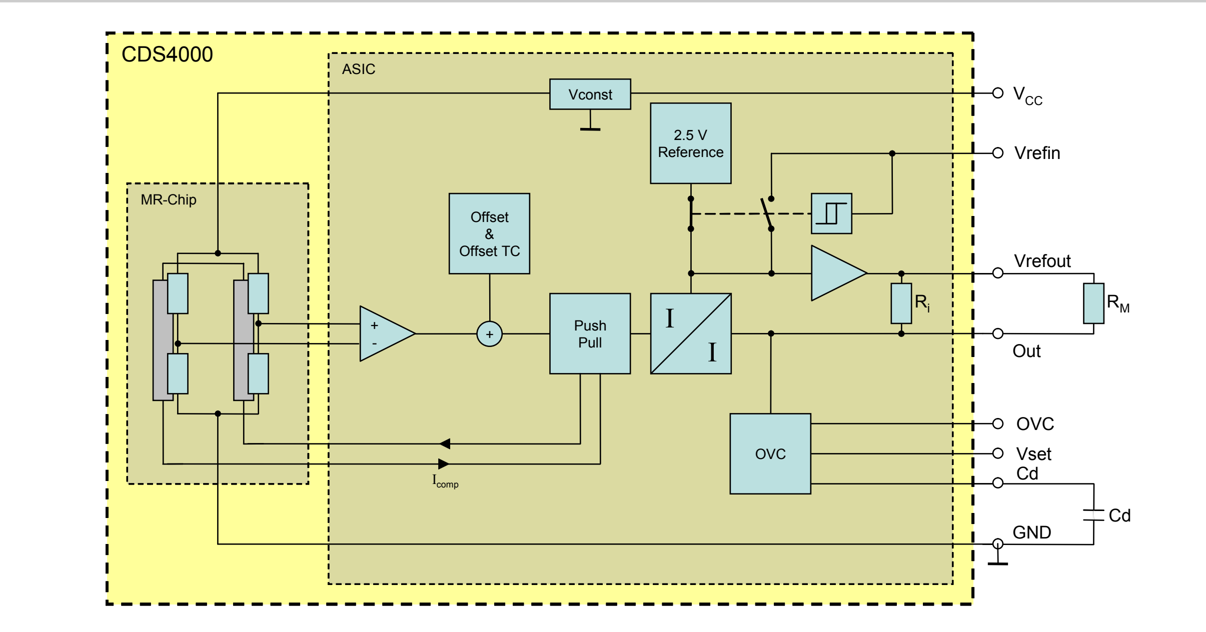


Fig. 1: Block diagram of CDS4000 current sensors.

Accuracy

T_{amb} = 25 °C; V_{CC} = 5 V; R_M = 300 Ω; unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
ε_Σ	Overall accuracy [1]	$I_P \le I_{PN}$	-	0.8	1.3	% of I_{PN}
ε_G	Gain error [2]	$I_P \le I_{PN}$	-	0.3	0.5	% of I_{PN}
ε_{off}	Offset error [2]	$I_P = 0$	-	0.3	0.5	% of I_{PN}
ε_{Lin}	Linearity error [2]	$I_P \le I_{PN}$	-	0.2	0.3	% of I_{PR}
$\varepsilon_{Vrefint}$	Internal reference error		-10	0	+10	mV
$\varepsilon_{Vrefext}$	External reference error [3]	V_{refin} = 1.5 to 2.6 V	-3	0	+3	mV
ε_{Hys}	Hysteresis [4]		-	-	0.1	% of I_{PN}
PSRR	Power supply rejection rate	$f_{\Delta Vcc}$ < 15 kHz	-	40	30	dB
N	Noise level (RMS)	f < 300 kHz	-	1.7	-	µA

T_{amb} = (-25…+85)°C; V_{CC} = 5 V; R_M = 300 Ω; unless otherwise specified.

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

T_{amb} = (-40…+105)°C; V_{CC} = 5 V; R_M = 300 Ω; unless otherwise specified.

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

Notes

1) Overall accuracy contains ε_G, ε_{off} and ε_{Lin}.

2) Long term stability after 10,000 hours at 85 °C operating temperature:
The gain and linearity error is less than ±1.8 % of I_{PN}.
The offset error is less than ±2.0 % of I_{PN}.

3) $\varepsilon_{Vrefext} = V_{refin} - V_{refout}$

4) Residual voltage after 3 · I_{PN} DC.

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 [1)]	-	500	A
T_{amb}	Ambient temperature	-40	+105	°C
T_{stg}	Storage temperature	-40	+105	°C
T_B	Busbar temperature	-40	+105	°C

1) 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
V_I	Isolation test voltage (RMS)	50/60 Hz, 60 s	-	5	-	kV
V_{imp}	Impulse withstand voltage	1.2/50 µs	-	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	-	-

Dynamical data

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
t_{reac}	Reaction time [2)]	10% I_{PN} to 10% $I_{out,N}$	-	-	0.50	µs
t_{rise}	Rise time [2)]	10% $I_{out,N}$ to 90% $I_{out,N}$	-	-	0.55	µs
t_{resp}	Response time [2)]	90% I_{PN} to 90% $I_{out,N}$	-	-	0.35	µs
f_{co}	Upper cut-off frequency	-1 dB	200	400	-	kHz

2) $I_P = I_{PN}$ with di/dt of 75 A/µs. See Fig.3.

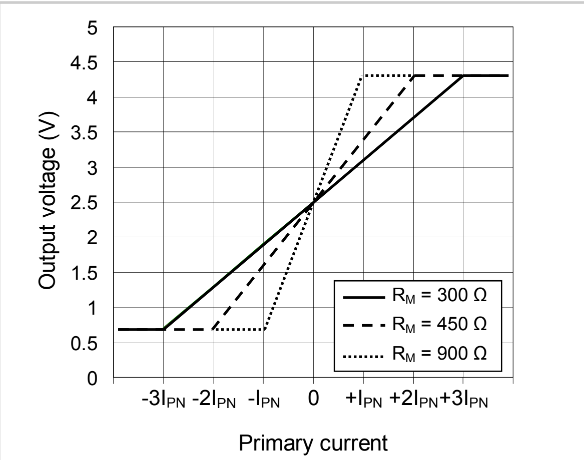


Fig. 2: Characteristic of primary current to output voltage according to different R_M. V_{refout} = 2.5 V.

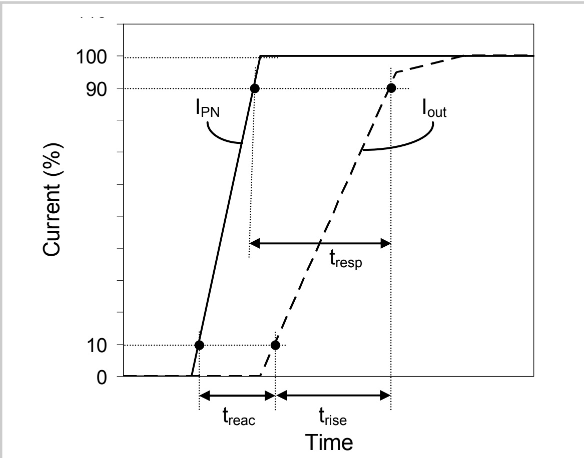


Fig.3: Definition of reaction time (t_{reac}), rise time (t_{rise}) and response time (t_{resp}).

General data

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
T_{amb}	Ambient temperature [1]		-40	-	+105	°C
T_{stg}	Storage temperature [1]		-40	-	+105	°C
T_B	Busbar temperature [1]		-40	-	+105	°C
T_{THT}	Solder temperature	For 7 seconds	-	-	260	°C
m	Mass CDS4050ABC		-	4.4	-	g
m	Mass CDS4050ACC		-	7.7	-	g
RTI	Relative temperature index [1]	$T_{amb} \geq +85$ °C	+130	-	-	°C

[1] Operating condition. Above +85 °C the PCB requires a RTI of minimum +130 °C.

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 °C; V_{CC} = 5 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
$\varepsilon_{OVCVset}$	Error of OVC Threshold	R_M = 300 Ω, $I_P = I_{PN}$	-3	-	+3	% of $V_{out,N}$
ε_{OVCHys}	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

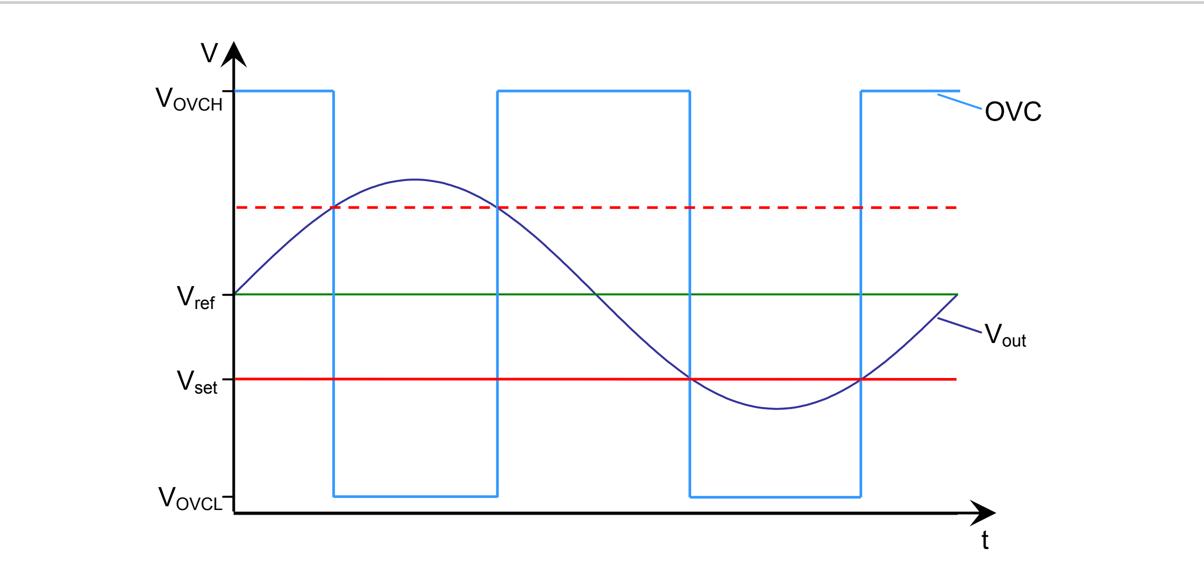


Fig. 4: Response of the overcurrent detection. Positive and negative overcurrents will be detected.

CDS4050 in THT-housing (small size)

Pinning

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

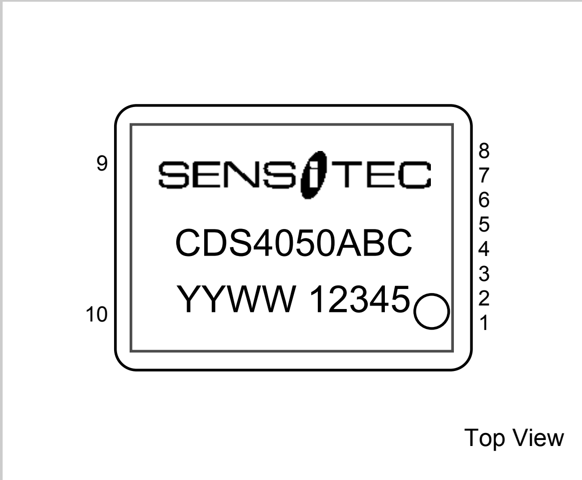


Fig. 5: Pinning of CDS4050ABC.

Dimensions

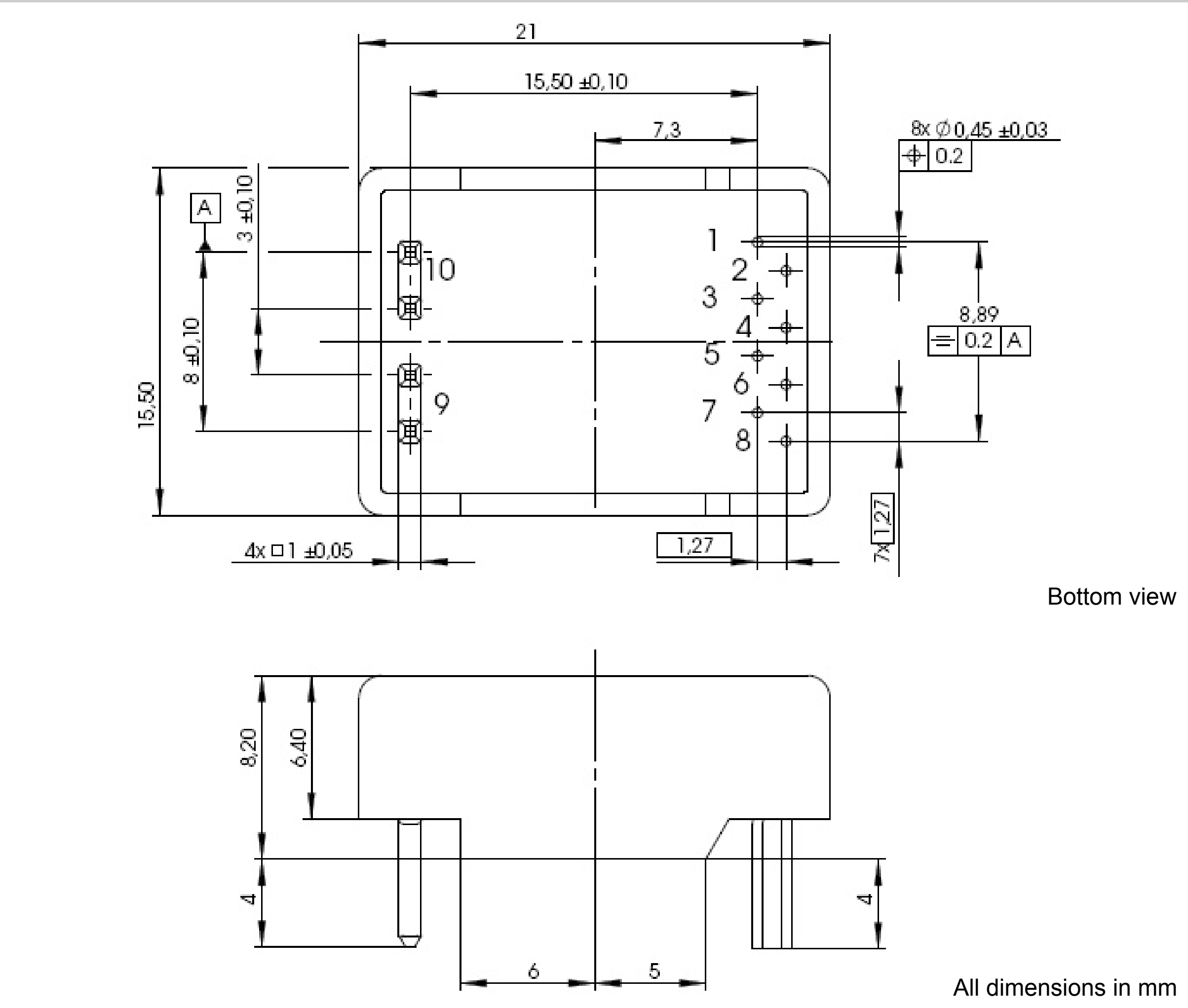


Fig. 6: Package outline of THT-housing (small size). Tolerance ± 0.2 mm unless otherwise specified.

CDS4050 in THT-housing (medium size)

Pinning

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

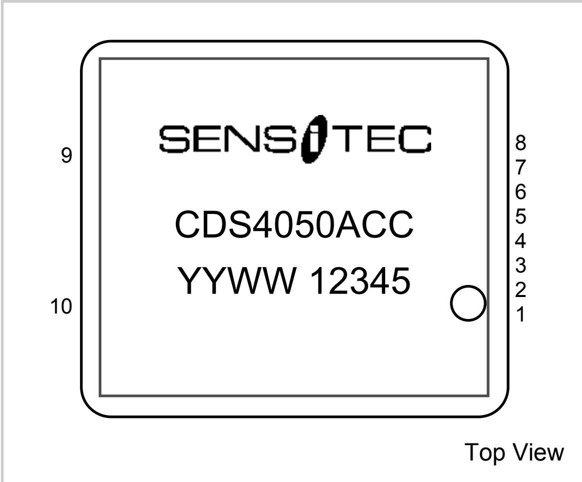


Fig. 7: Pinning of CDS4050ACC.

Dimensions

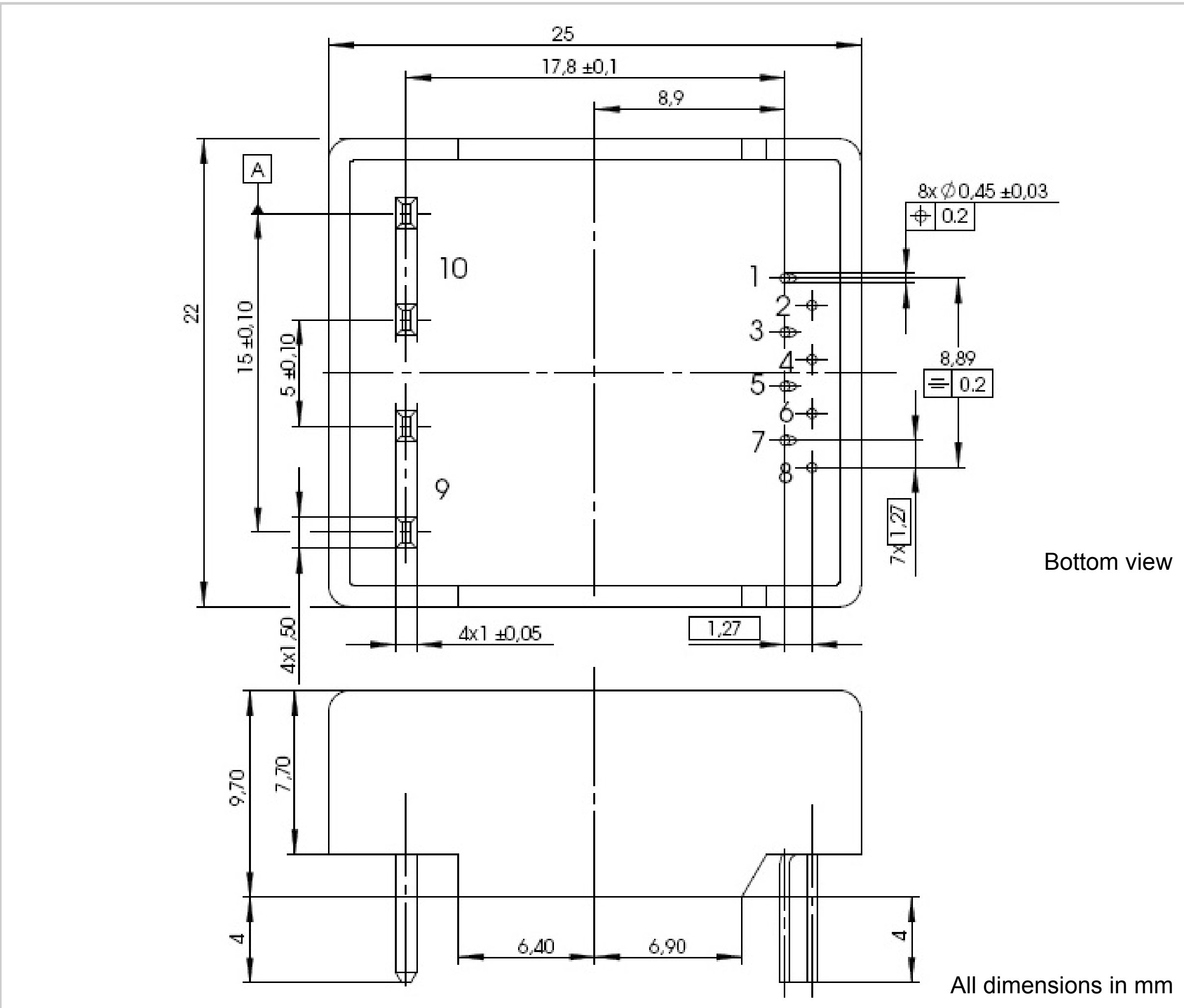


Fig. 8: Package outline of THT-housing (medium size). Tolerance ± 0.2 mm unless otherwise specified.

Application circuit

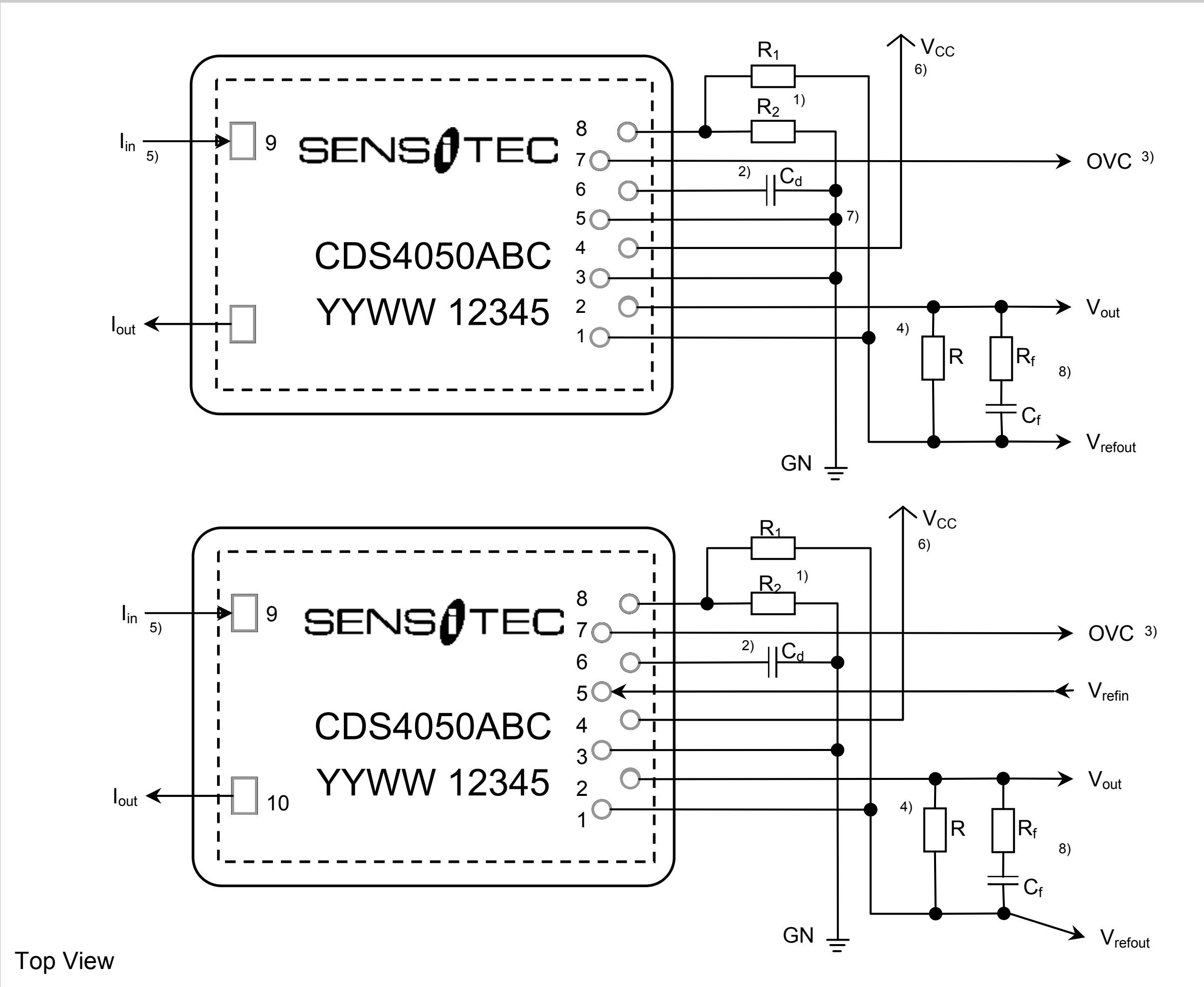


Fig. 9: *Top:* Example of how to use the internal reference voltage (pin 5, V_{refin} is routed on ground).
Bottom: Circuit with external reference voltage at pin 5, V_{refin}.

Notes

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

$V_{set} = V_{refout} - I_{OC} \cdot R_M \cdot G_I$ Example: V_{refout} = 2.5 V; R_M = 300 Ω; I_{OC} = 100 A → V_{set} = 1.3 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 kΩ in parallel to R1 the divider calculates as follows:

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

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).

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

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

4) R_M > 300 Ω: reduces I_{PR} but increases G_V. See Fig. 2.

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

5) V_{out} is positive, if I_P flows from pin 9 "I_{in}" to pin10 "I_{out}".

6) V_{CC} should always be buffered with a capacity of at least 100 nF.

7) V_{refin} should always be routed on ground if not used.

8) An additional RC-filter is recommended for frequency response correction. R_f = 0.68 kΩ; C_f = 22 nF.

Application circuit

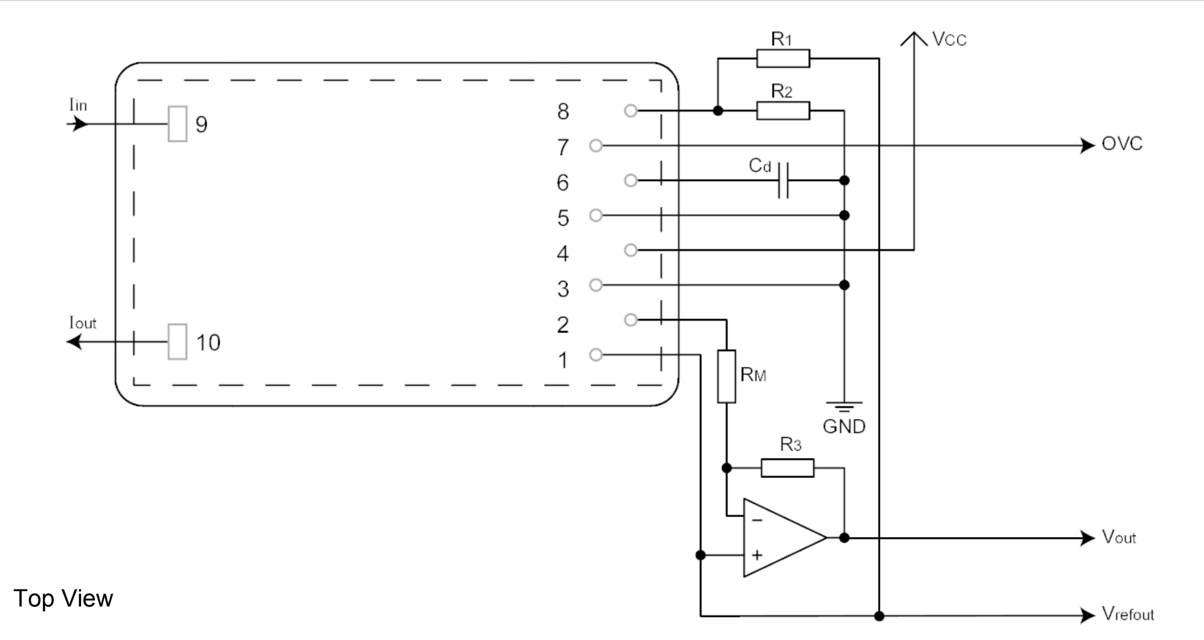


Fig. 10: Example of how to use an operational amplifier to adjust the output signal to an A/D converter. With R_M = 300 Ω and R_3 = 410 Ω, the output signal is amplified to a full scale output of 4.92 V.

PCB layout

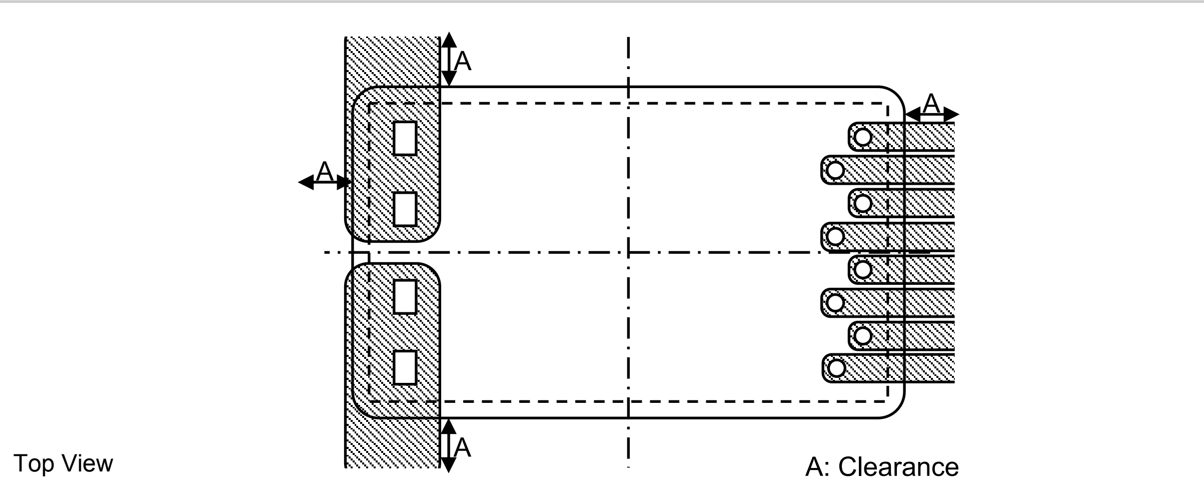


Fig. 11: Recommended PCB layout for the CDS4050 sensor (schematic).

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/m². A conductor carrying 1 A produces a magnetic field of 20 A/m and a magnetic field gradient of 2.5 kA/m² 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 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.
- Above the ambient temperature of +85 °C a relative temperature index (RTI) of minimum +130 °C is required for the PCB.

Typical performance graphs

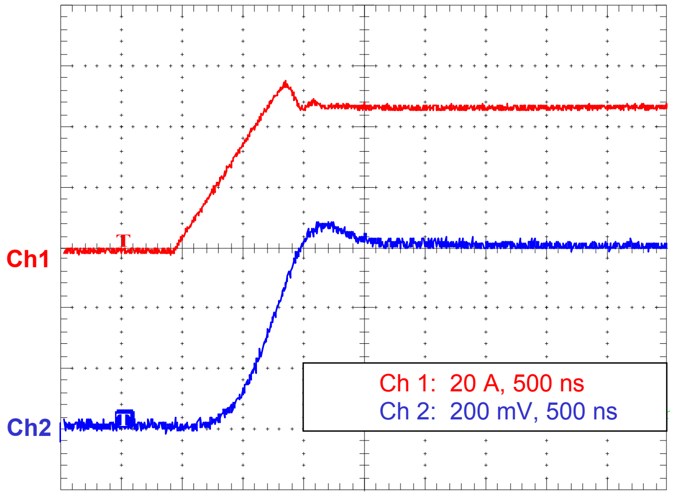


Fig. 12: Typical output characteristic due to a current jump from 0 to I_{PN}. Input di/dt ≈ 75 A/µs.
An RC-filter with the parameters R_f = 0.68 kΩ and C_f = 22 nF is used.

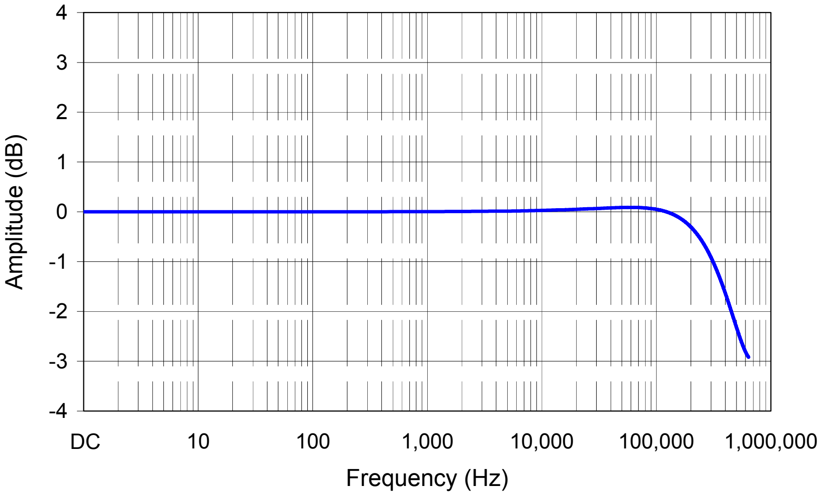


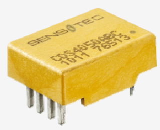
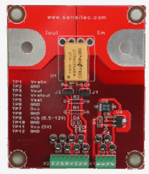
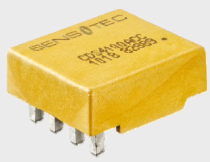
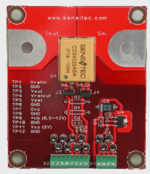
Fig. 13: Typical frequency response by using RC-filter with the parameters R_f = 0.68 kΩ and C_f = 22 nF.

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.
⚡	**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 CDS4050 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 Ω).

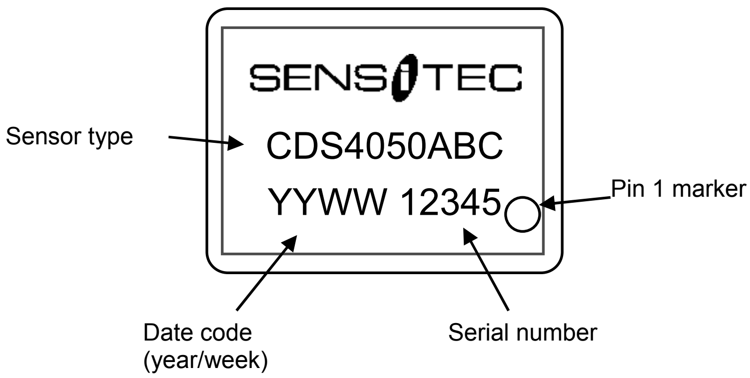


Fig. 12: Sensor inscription.

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.

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MagnetoResistive Sensors

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