XENSIV™ current sensor with high bandwidth and high accuracy for integrated current rail applications

Features

- Extremely low noise: 38 mA_{RMS} over full bandwidth
- High bandwidth provides fast response time and low phase delay
- High accurate, scalable, DC and AC current sensing:
  - Sensitivity error of < 0.85% over full temperature range
- Differential sensor principle ensures superior magnetic stray field suppression
- Pre-calibrated current sensor with Integrated current rail (typ. insertion resistance of 550 μΩ)
- High continuous current capability: 90 A_{RMS} (all product types)
- ISO 26262 SEooC for safety requirements up to ASIL B
- Single ended mode output with fixed sensitivity
- Operating ambient temperature -40°C to 125°C
- Fast over current detection (OCD) with 100 ns response time
- Digital control and diagnostic interface (DCDI) enables complete sensor customization to users' needs. For example: write access to OCD threshold, OCD deglitch filter time and many more useful functionalities
- Suitable for basic and reinforced galvanic isolation applications
  - For use with 650 V/1200 V/1700 V IGBTs, Si, SiC and GaN MOSFETs
- DSO type 300 mil wide-body package with large creepage distance (>8 mm)
- Green (RoHS compliant) 8 mm x 8 mm 16-pin SMD package

AEC Qualified
RoHS
Halogen-free
ISO 26262 compliant

Potential applications

- DC-DC Converters
- OBC (On-Board Charger)
- Drives
- PV Inverter (Solar)
- Smart circuit breakers
- Telecommunication

Product validation

Product validation according to AEC-Q100, Grade 1. Qualified for automotive applications.

Description

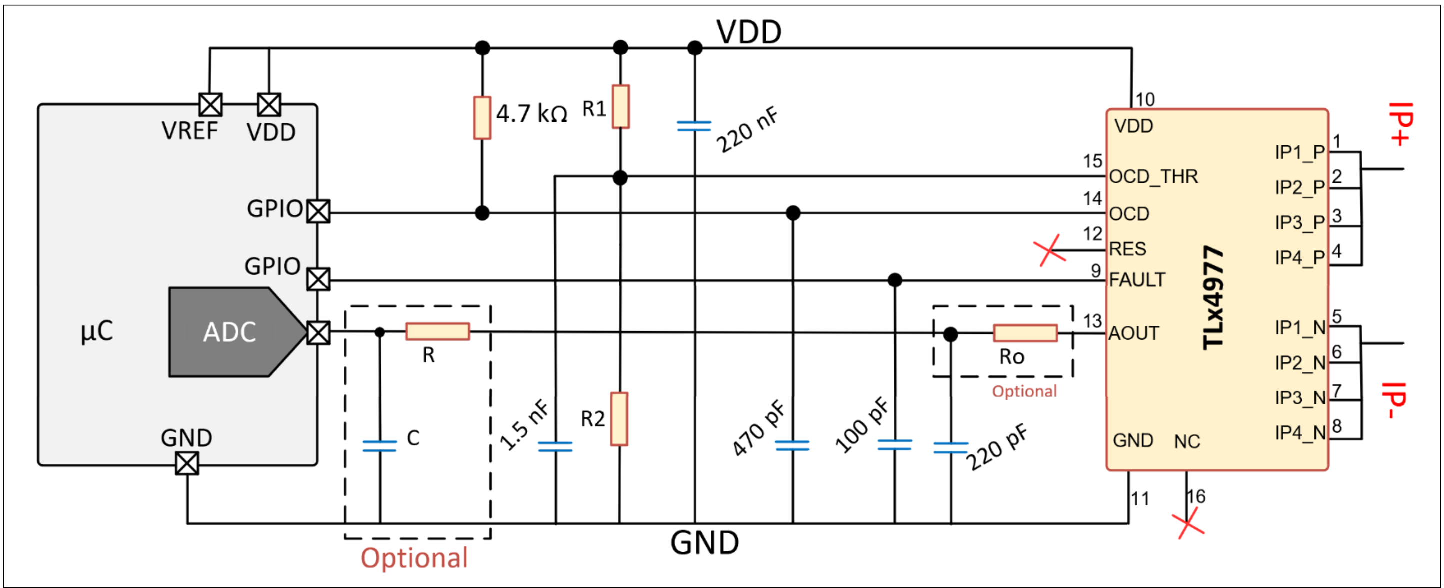
The TLE4977 is a new high bandwidth and high accurate coreless current sensor IC from Infineon based on Hall-effect and coil sensing elements with configurable overcurrent detection (OCD). Infineon's well-established and robust magnetic sensing technology enables accurate and highly linear measurement of currents with a full scale current up to ±81 A. All negative effects (saturation, hysteresis) commonly known from open-loop sensors using flux concentration techniques are avoided. It provides fast and accurate solution for measuring high-frequency currents in DC/DC converters and other switch mode power supply applications. This datasheet focuses on the TLE4977 variants with 5 V supply. Please refer to other relevant datasheet document for 3.3 V variants.

Product type	Description and features	Marking	Order code
TLE4977-R060W5-O-S0010	Grade A: XENSIV™ high bandwidth and high accurate current sensor; 5 V supply; 67.5 A range	H77E2ROW52	SP006150433
TLE4977-R060W5-O-S1010	Grade B: XENSIV™ high bandwidth and high accurate current sensor; 5 V supply; 67.5 A range	H77E2ROW5A	SP006137009
TLE4977-R050W5-O-S0010	Grade A: XENSIV™ high bandwidth and high accurate current sensor; 5 V supply; 56 A range	H77E3ROW52	SP006150437
TLE4977-R050W5-O-S1010	Grade B: XENSIV™ high bandwidth and high accurate current sensor; 5 V supply; 56 A range	H77E3ROW5A	SP006137028

Product type	Description and features	Marking	Order code
TLE4977-R040W5-O-S0010	Grade A: XENSIV™ high bandwidth and high accurate current sensor; 5 V supply; 45 A range	H77E4ROW52	SP006150441
TLE4977-R040W5-O-S1010	Grade B: XENSIV™ high bandwidth and high accurate current sensor; 5 V supply; 45 A range	H77E4ROW5A	SP006137032

***Note:** The table above provides the list of available product types. For additional possible product types please refer to* Standard configuration*.*

The low profile, surface mount DSO-16 wide body package of TLE4977 allows easy implementation in high voltage environment. The fully integrated package with internal copper conductive path has a typical resistance of 0.55 mΩ, providing low power loss. The applied current flowing through the copper conduction path generates a magnetic field that is sensed by the IC and converted to a proportional voltage. The differential current measurement principle allows stray field suppression for operation in harsh environments.



The sensor is shipped as a fully calibrated product without requiring any end-of-line calibration for high accuracy. The OCD threshold is programmable, refer to Over current detection characteristics. The current-carrying pins (pins 1 through 8) are electrically isolated from the sensor leads (pins 9 through 16), which allows the device to be used in high-side current sensing applications without the use of further expensive isolation components.

Typical applications are high voltage automotive converter applications like on board chargers (OBC), and HV to LV standalone DC-DC converters. Also, industrial applications like photovoltaic converters, general purpose inverters, switch mode power supplies (SMPS), data center and fast overload and overcurrent detection.

Table of contents

1 Functional block diagram

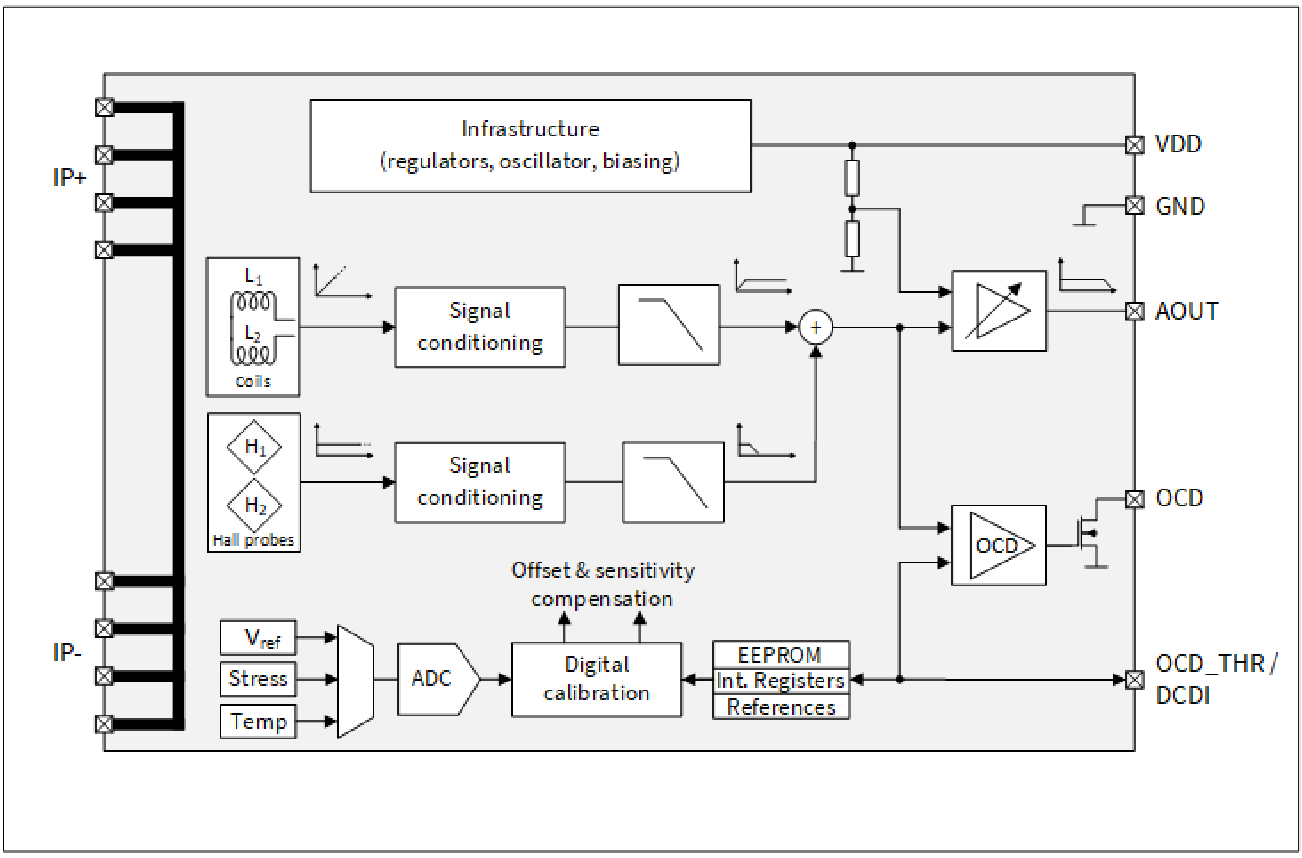


Figure 1 **Device functional block diagram**

TLE4977 is an automotive-qualified sensor capable of supporting 5 V power supply applications (This datasheet focuses on the TLE4977 variants with 5 V supply. Please refer to other relevant datasheet document for 3.3 V variants). It is developed as a Safety Element out of Context (SEooC) for safety requirements up to ASIL B rating. The functional architecture block diagram of the current sensor is shown above. The high bandwidth and high accuracy is achieved using Hall-effect and coil sensing elements with users configurable overcurrent detection (OCD). The two Hall probes and coils are embedded on the IC and their output is differentially connected, which provides a voltage level proportional to the differential magnetic field at the probes' location. The well-known Hall sensing principle provides DC measurement capability with very low offset whereas the coils can provide high signal at high frequency.

The output of the differential Hall probes is processed by an analog signal path that includes ripple compensation loop and digital assisted gain regulation.

The signal output of the coils is naturally proportional to the magnetic field frequency and is processed by an independent signal path that implements low pass filtering to flatten the frequency response. The offset contribution of this path is properly removed by a DC servo loop.

The 2 signals from Hall probes and coils are then properly combined so that the Hall signal is dominant at low frequency and the coil signal is dominant at high frequency, thus creating an overall flat frequency response. The combined signal is finally further processed by an output buffer equipped with fine offset and gain regulation for precision calibration.

The details of each defined safety mechanism are described here:

- External supply and internal regulated supplies are continuously monitored by hardware (HW) comparators for detecting under or over-voltages.
- Memories and trimming registers are monitored by proven and widely used safety mechanisms such as parity, CRC and ECC.

Several other safety checks are implemented in the firmware (FW) and they exploit the fact that several safety critical parameters are already available in the digital part for functional purposes. The additional implementation of the FW safety checks consists of periodically comparing the value of these parameters with thresholds during the regular operational life of the device. The monitored parameters, include temperature, mechanical stress, offset and ripple.

A fail in the internal safety checks leads to a fault indication that is externally visible on the OCD and FAULT pin.

2 Standard configuration

Note: *The table below includes available and possible product types. Please contact Infineon sales for additional product types (current ranges, unidirectional mode, 3.3 V supply...).*

Table 1 TLE4977 standard configuration

Name	Grade	*FS* [A]	*Sx* [mV/A]	I_{THR} [A]	V_{OQ} [V]	OP_{MODE}	RATIOMETRICITY (V_{DD5})
TLE4977-R020W5-O-S0010	A	±22.5	97.5	125%FS (default)[1)]	V_{DD5} / 2	Single Ended	ON
TLE4977-R020W5-O-S1010	B	±22.5	97.5				
TLE4977-R030W5-O-S0010	A	±33.5	65				
TLE4977-R030W5-O-S1010	B	±33.5	65				
TLE4977-R040W5-O-S0010	A	±45	48.75				
TLE4977-R040W5-O-S1010	B	±45	48.75				
TLE4977-R050W5-O-S0010	A	±56	39				
TLE4977-R050W5-O-S1010	B	±56	39				
TLE4977-R060W5-O-S0010	A	±67.5	32.5				
TLE4977-R060W5-O-S1010	B	±67.5	32.5				
TLE4977-R080W5-O-S0010	A	±81	27				
TLE4977-R080W5-O-S1010	B	±81	27				

RATIOMETRICITY (V_{DD5}) = Ratiometricity to V_{DD5}, *FS* = Full Scale, *Sx* = Sensitivity, I_{THR} = OCD threshold level, V_{OQ} = Quiescent output voltage, OP_{MODE} = Output mode, V_{DD5} = 5 V supply

1) If at start up the DCDI is activated the OCD threshold is set to the default value indicated in the table. Afterwards the user can program the desired threshold via DCDI. Otherwise the OCD threshold is set to the value corresponding to the voltage at the OCD_THR pin. More information regarding OCD options and settings is available in the device user manual.

3 Pin configuration

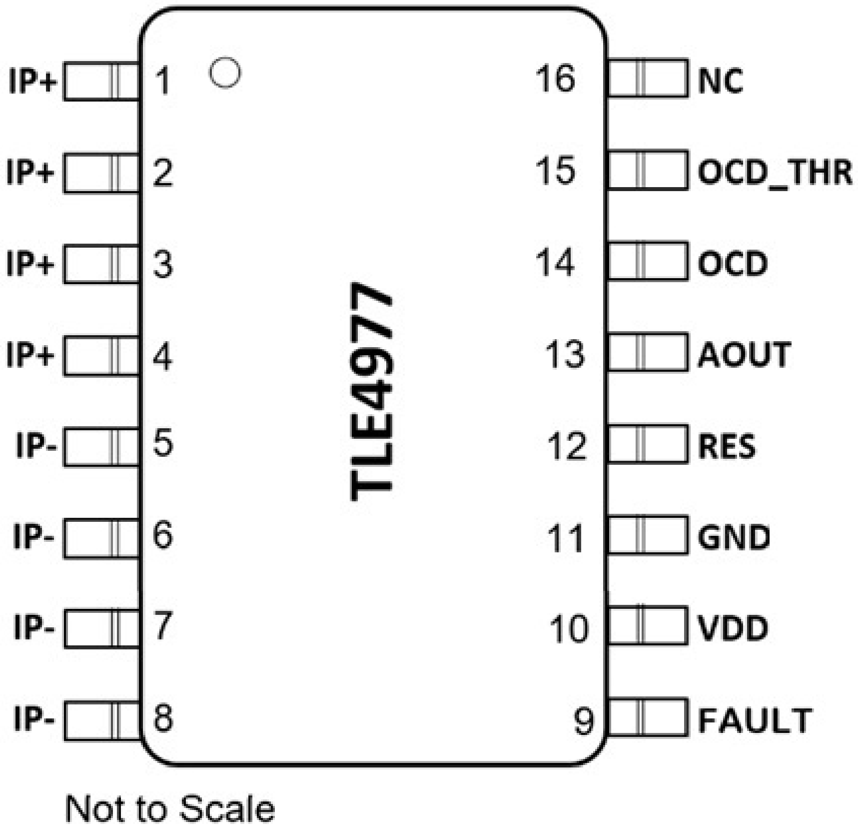


Figure 2 TLE4977 PG DSO-16 pin top view

Table 2 TLE4977 - DSO-16 pin function

Pin no.	Symbol	Pin type	Function
16	NC	Not connected with lead frame or sensor	Keep it open
15	OCD_THR / DCDI	Analog	OCD threshold selection
14	OCD	Digital output	Over current detection output (Open drain output)
13	AOUT	Analog output	Analog signal output
12	RES	Reserved	Keep it open
11	GND	Analog	Ground
10	VDD	Analog	Supply voltage
9	FAULT	Digital output	Internal fault indication
1-4	IP+	Analog input	Current in
5-8	IP-	Analog input	Current out

4 General product characteristics

4.1 Absolute maximum ratings

Table 3 Absolute maximum ratings

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Supply voltage	$V_{DD(AMR)}$	-0.3	–	6.5	V	Maximum 10 h between 5.5 V to 6.5 V
Surge strength test current	I_{Surge}	–	–	5	kA	Tested on an Infineon reference PCB with 5 pulses. Based on IEC61000-4-5, 1 pulse/minute with 8 µs / 20 µs waveform.
Voltage on interface pins OCD, VREF, OCD_THR	V_{IO_A}	-0.3	–	V_{DD} + 0.3 V	V	V_{IO_A} < 6.5 V Maximum 10 h between 5.5 V to 6.5 V
AOUT pin current capability	I_{AOUT}	-40	–	40	mA	Maximum 10 s at 25°C
Junction temperature maximum ratings	T_{J_MAX}	–	–	+165	°C	–
Storage temperature	T_{A_STORE}	-40	–	+150	°C	–
Lifetime	LT	15	–	–	years	–

***Attention**: Stresses above 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 above those indicated in the section "functional range" is not implied. Furthermore, only single error cases are assumed. More than one stress/error case may also damage the device. Exposure to absolute maximum rating conditions may affect device reliability. During absolute maximum rating overload conditions, the voltage on VDD pins with respect to ground shall not exceed the values defined by the absolute maximum ratings. Lifetime statements are an anticipation based on an extrapolation of Infineon’s qualification test results. The actual lifetime of a component depends on its form of application and type of use etc. and may deviate from such statement. Lifetime statements shall in no event extend the agreed warranty period.*

4.1.1 ESD ratings

Table 4 ESD ratings

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
ESD voltage HBM (human body model)	V_{ESD_HBM}	–	–	±2	kV	Human body model (HBM), according to standard AEC-Q 100-002.
ESD voltage CDM (charged device model)	V_{ESD_CDM}	–	–	±0.75	kV	According to AEC-Q100-011 standard. Corner pins: 0.75 kV; non corner pins: 0.5 kV

4.2 Functional range

The following functional range must not be exceeded in order to ensure correct operation of the device. All parameters specified in the following sections refer to these operating conditions unless otherwise indicated.

***Note**: General conditions (unless otherwise specified): V_{DD} = 5.0 V; T_S = -40°C to +125°C*

Table 5 Functional range

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Operating supply voltage	V_{DD5}	4.5	5	5.5	V	–
Ambient temperature at solder point	T_s	-40	–	+125	°C	–
Operating junction temperature	T_{J_OP}	–	–	+165	°C	–
Capacitance on analog output pin	C_O	42	–	242	pF	Without series resistor; including parasitic capacitance on the board.

5 Product features

5.1 Electrical characteristics

Table 6 Electrical characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Current consumption	I_{DD}	–	18	25	mA	I_{AOUT} = 0 mA
Primary path (CR) resistance	R_{PN}	–	550	–	µΩ	25°C, when soldered on PCB with 140 µm copper thickness
Power-ON delay time	t_{POD}	–	1.7	–	ms	Supply rising from 0 V to V_{DD}. Starts when the V_{DD} reaches the minimum allowed operating conditions and stops when the device is fully operational. OCD stays low within this time
Quiescent output voltage bidirectional	V_{OQBID}	–	V_{DD} / 2	–	V	I_{PN} = 0 A
Analog output drive capability	I_O	-2	–	+2	mA	DC current
Analog output saturation voltage, source	V_{CLH}	–	–	300	mV	V_{DD} - V_O; I_{SINK} = 2 mA
Analog output saturation voltage, sink	V_{CLL}	–	–	300	mV	I_{SOURCE} = 2 mA

5.2 Isolation characteristics

Table 7 Isolation characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
GENERAL						
External clearance	CRP	8.0	–	–	mm	Shortest distance in air between any CR pin to any LV output pin
External creepage	CLR	8.0	–	–	mm	Shortest distance over package surface between any CR pin to any LV output pin
Comparative tracking index	CTI	600	–	–	–	According to DIN EN 60112 (VDE 0303-11)
Pollution degree	PD	–	–	2	–	–
Material group	–	I	–	–	–	According to IEC 60112
Altitude	–	–	–	4000	m	–
Overvoltage category	OVC	–	1 to 4	–	–	Rated mains voltage ≤ 150 V_{RMS}
Overvoltage category	*OVC*	–	1 to 4	–	–	Rated mains voltage ≤ 300 V_{RMS}
Overvoltage category	OVC	–	1 to 3	–		Rated mains voltage ≤ 600 V_{RMS}
Overvoltage category	OVC	–	1 to 2	–	–	Rated mains voltage ≤ 1000 V_{RMS}
Maximum rated transient isolation voltage	V_{IOTM}	–	–	7071	V_{pk}	$V_{TEST} = V_{IOTM}$ for t_{ini} = 60 s (qualification) V_{TEST} = 1.2 x V_{IOTM} for t_{ini} = 1 s (100% productive tests)
Maximum rated isolation working voltage, basic insulation	V_{IOWM}	–	–	1700	Vpk	AC voltage (sine wave)
Maximum rated isolation working voltage, reinforced insulation	V_{IOWM}	–	–	1130	Vpk	AC Voltage (Sine wave)

(table continues...)

Table 7 (continued) Isolation characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Maximum rated repetitive peak isolation voltage for basic insulation	V_{IORM}	–	–	1700	V_{pk}	AC voltage (bipolar)
Maximum rated repetitive peak isolation voltage for reinforced insulation	V_{IORM}	–	–	1700	Vpk	AC voltage (bipolar)
Apparent charge method a	q_{PD}	–	–	5	pC	After subgroup 1 life tests (type test) and in quarterly monitoring $V_{ini,a}$= V_{IOTM} for tini = 60 s; V_{pd}(m)= 1.6 x V_{IORM} for tm = 10 s After subgroup 2, 3 endurance tests (type test) $V_{ini,a}$= VIOTM for t_{ini} = 60 s; V_{pd}(m)= 1.2 x V_{IORM} for tm = 10 s
Apparent charge method b	q_{PD}	–	–	5	pC	Method b1: 100% productive tests and type tests preconditioning, $V_{ini,b1}$=1.2 x VIOTM, t_{ini} =1 s, V_{pd}(m) = 1.647 x V_{IORM} for tm =1 s
Partial discharge extinction voltage	V_{PDm}	–	–	3200	Vpk	Lowest peak value of the test voltage at which the apparent charge becomes less than the specified discharge magnitude when the test voltage is reduced below a high level where such discharges have occurred.
Initial test voltage for partial discharge	$V_{pd(ini)}$	–	–	8485	Vpk	–
Maximum surge isolation voltage	V_{IOSM}	–	–	10000	Vpk	Test method as per IEC 61000-4-5, 1.2/50 µs waveform, V_{IOSM_TEST}≥ 1.3 x V_{IOSM}
Isolation resistance input to output	R_{IO_25}	1000	–	–	GΩ	V_{IO} = 500 V_{dc} for t = 60 s, T_A = 25°C
Isolation resistance input to output	R_{IO_105}	100	–	–	GΩ	V_{IO} = 500 V_{dc} for t = 60 s, T_A = 105°C

(table continues...)

Table 7 (continued) Isolation characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Isolation resistance input to output	R_{IO_S}	10	–	–	GΩ	V_{IO} = 500 V_{dc} for t = 60 s, T_A = 150°C
Capacitance input to output	C_{IO}	–	–	1.7	pF	V_{IO} = 0.4×sin(2πft), f = 1 MHz
UL1577						
Input to output isolation voltage	$V_{ISO,B(AC)}$	–	–	5000	V_{RMS}	$V_{TEST} = V_{ISO,B(AC)}$ for t = 60 s (qualification) V_{TEST} = 1.2 x $V_{ISO,B(AC)}$ for t = 1 s (100% productive tests)
Input-to-output DC isolation voltage	$V_{ISO,B(DC)}$	–	–	7071	V_{DC}	$V_{TEST} = V_{ISO,B(DC)}$ for t = 60 s (qualification);

5.3 Sensing characteristics

***Note**: General conditions (unless otherwise specified): V_{DD} = 5.0 V; T_S = -40°C to +125°C*

Table 8 Sensing characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
OUTPUT						
Transfer function cutoff frequency bidirectional	BW	1	–	–	MHz	-3 dB criterion, Typical C_{AOUT} = 220 pF
Response time	t_{res}	–	54	–	ns	Time between input and output reaching 90% of final values with 400 mA/ns input step with Typical C_{AOUT} = 220 pF
Propagation delay	t_{pd}	–	32	–	ns	Time between input and output reaching 10% of final values with a 400 mA/ns input step with Typical C_{AOUT} = 220 pF
Rise time	t_{rise}	–	49	–	ns	The time between when the sensor reaches 10% and 90% of its full-scale value with 800 mA/ns input step with Typical C_{AOUT} = 220 pF
Common mode transient immunity	CMTI	–	–	200	kV/µs	No false triggering of OCD. The disturbance on Analog signal is not greater than 200 mV for longer than 1µs at V_{CM}<700 V.
Input referred noise	I_{NOISE}	–	38	80	mA_{RMS}	RMS noise at full *BW*
MEASUREMENT RANGE						
Sensitivity, range S1	S1	–	27	–	mV/A	*FS* = ±81 A at V_{DD} = 5 V
Sensitivity, range S2	S2	–	32.5	–	mV/A	*FS* = ±67.5 A at V_{DD} = 5 V
Sensitivity, range S3	S3	–	39	–	mV/A	*FS* = ±56 A at V_{DD} = 5 V
Sensitivity, range S4	S4	–	48.75	–	mV/A	*FS* = ±45 A at V_{DD} = 5 V
Sensitivity, range S5	S5	–	65	–	mV/A	*FS* = ±33.5 A at V_{DD} = 5 V
Sensitivity, range S6	S6	–	97.5	–	mV/A	*FS* = ±22.5 A at V_{DD} = 5 V
SENSITIVITY AND OFFSET ERROR						
Sensitivity ratiometricity bandwidth	BW_{RAT_SENS}	–	1	–	kHz	–

(table continues...)

Table 8 **(continued) Sensing characteristics**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Quiescent voltage ratiometricity bandwidth	BW_{RAT_Q}	–	30	–	kHz	±100 mV on V_{DD}
Stray field error	E_{Stray}	–	18	–	mA/mT	DC to 1 kHz
Initial sensitivity error	E_{SENS}: Grade A	-0.65	±0.3	0.65	%	At T_S = 25°C, at 0 h.
Initial sensitivity error	E_{SENS}: Grade B	-1.2	–	1.2	%	At T_S = 25°C, at 0 h.
Initial offset error	E_{OFF}: Grade A	-130	±55	130	mA	At T_S = 25°C
Initial offset error	E_{OFF}: Grade B	-300	–	300	mA	At T_S = 25°C
Nonlinearity error	E_{NL}	–	0.1	–	%	V_{OUT} = from 0.3 V to V_{DD} – 0.3 V
Sensitivity ratiometricity error	E_{SENS_RAT}	-0.5	–	0.5	%	V_{DD} operating range
OVER TEMPERATURE AND LIFETIME ERRORS						
Sensitivity drift over temperature	E_{SENST} [1)]: Grade A	-0.2	–	0.2	%	At 0 h
Sensitivity drift over temperature	E_{SENST} [1)]: Grade B	-1.5	–	1.5	%	At 0 h
Sensitivity drift over temperature and lifetime	E_{SENSL} [2)]: Grade A	-0.55	–	0.55	%	–
Sensitivity drift over temperature and lifetime	E_{SENSL} [3)]: Grade B	-2.6	–	2.6	%	–
Offset drift over temperature	E_{OFFT} [3)]: Grade A	-30	–	30	mA	–
Offset drift over temperature	E_{OFFT} [3)]: Grade B	-120	–	120	mA	–

(table continues...)

Table 8 **(continued) Sensing characteristics**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Offset drift over temperature & lifetime	E_{OFF_LV} [2)] : Grade A	-30	–	30	mA	–
Offset drift over temperature & lifetime	E_{OFF_LV} [3)] : Grade B	-120	–	120	mA	–
Offset ratiometricity error	E_{OFF_RAT}	-20	±9.3	20	mA/ %V_{DD}	Max ±10% V_{DD} variation [3)]

1) Typical values are mean ±3 σ
2) Lifetime drift minimum/maximum values are mean ±3 σ, and are based on a statistical evaluation of worst-case performance observed after AEC-Q100 qualification stresses.
3) Specified based on qualification. Typical values are population ±3 σ from worst case stress test condition. Devices tested in AECQ-100 qualification stayed within min/max limits for all stress conditions.

5.4 Functional description

The sensor features an analog output, which is used to provide the information of the measured current. The analog output measurement result is available as the output voltage. In the following paragraphs, the output modes and respective sensitivity as well as quiescent output voltage definitions for the sensor are discussed. The following figure shows the definitions of different parameters, such as sensitivity, which represents the slope of the first-order transfer function, offset error (E_{OFF}), and non-linearity error (NL).

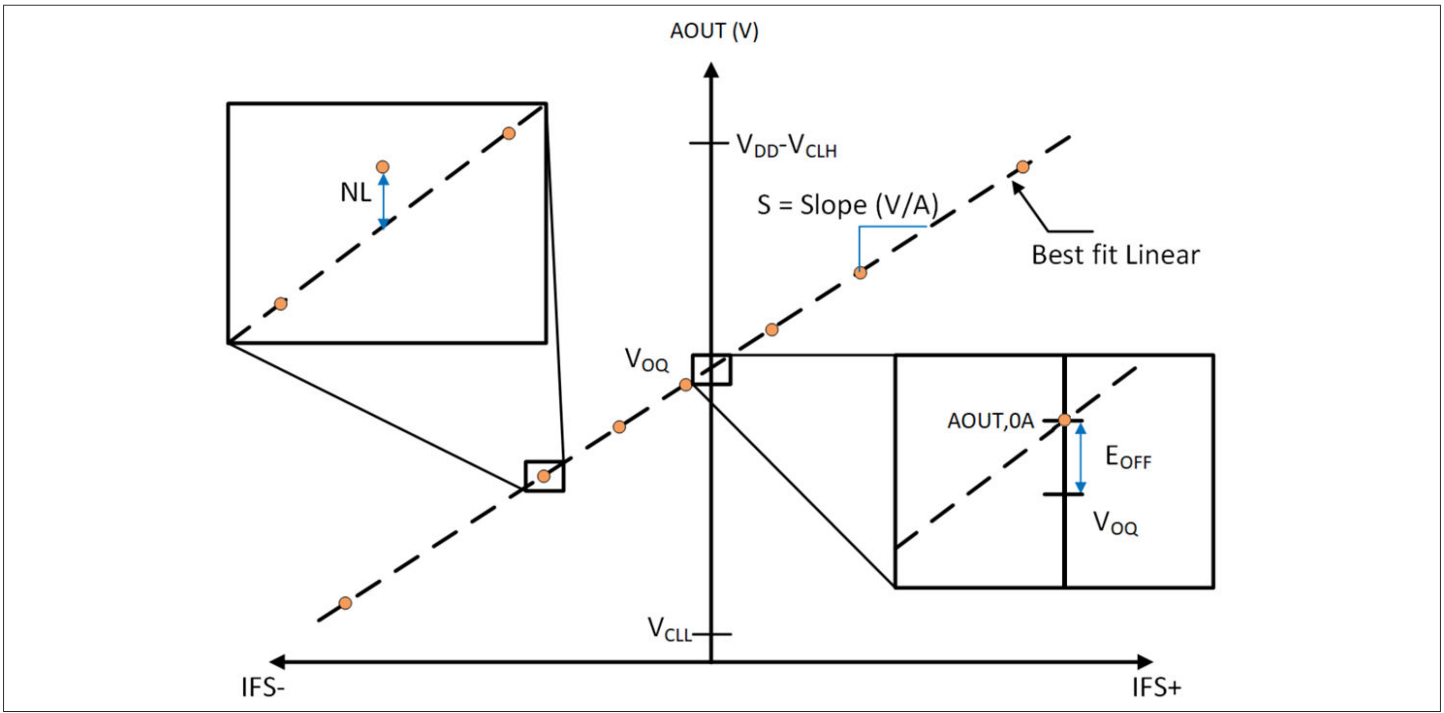


Figure 3 **Sensitivity, offset and nonlinearity error**

5.4.1 Output behavior

5.4.1.1 Output voltage and current polarity

This is a coreless magnetic current sensor, it measures the differential magnetic field caused by current flowing in the internal current rail.

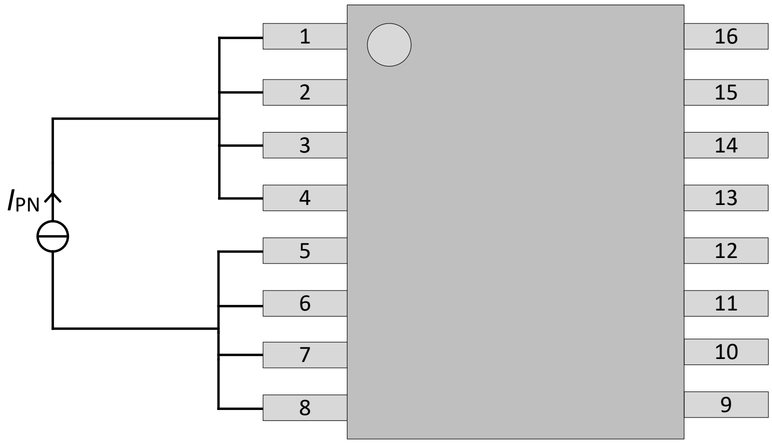


Figure 4 **Polarity illustration DSO-16 300 mil package**

The current I_{PN} is positive when it flows in the direction from pins 1,2,3,4 (+) to pin 5,6,7,8 (-) through an internal current rail.

In single ended output mode, the AOUT pin operates as an output and provides the output voltage representing the measured current I_{PN} flowing in the current rail. The device provides the output signal on AOUT only. The quiescent voltage and sensitivity are ratiometric to the sensor $V_{DD.}$

Being, "*S*" the sensitivity and "V_{OQ}" the quiescent voltage of the sensor, the output voltage on AOUT is described as follows:

$$V(A_{OUT}) = V_{OQ} + S \times I_{PN} \quad (1)$$

The nominal quiescent voltage value (V_{OQ}) at the pin AOUT is ratiometric with respect to V_{DD} as defined in the following formula:

$$V_{OQ}(V_{DD}) = \frac{V_{DD}}{2} \quad (2)$$

The sensitivity *S* is ratiometric to V_{DD} and is expressed as follows:

$$S\left(V_{\mathrm{DD}}\right) = S_{\mathrm{x}} \times \frac{V_{\mathrm{DD}}}{V_{\mathrm{DD\_nom}}} \quad (3)$$

5.4.2 Typical characteristics

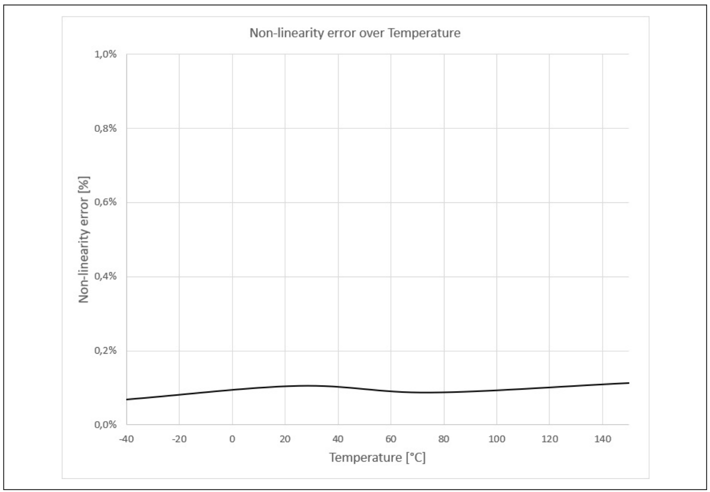


Figure 5 Non-linearity error vs temperature

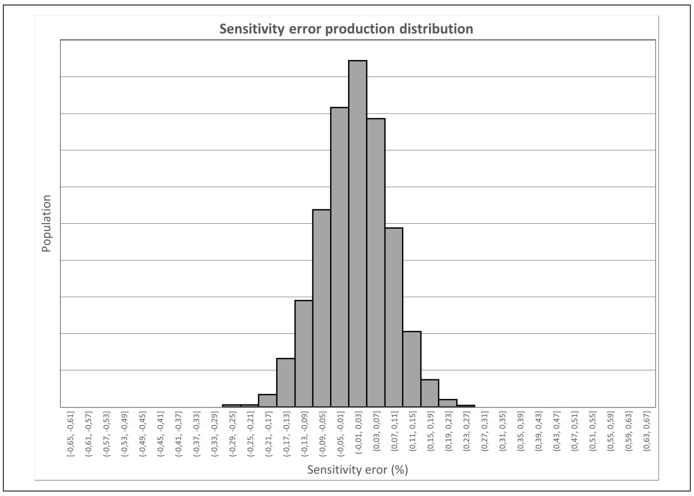


Figure 6 Sensitivity error vs population

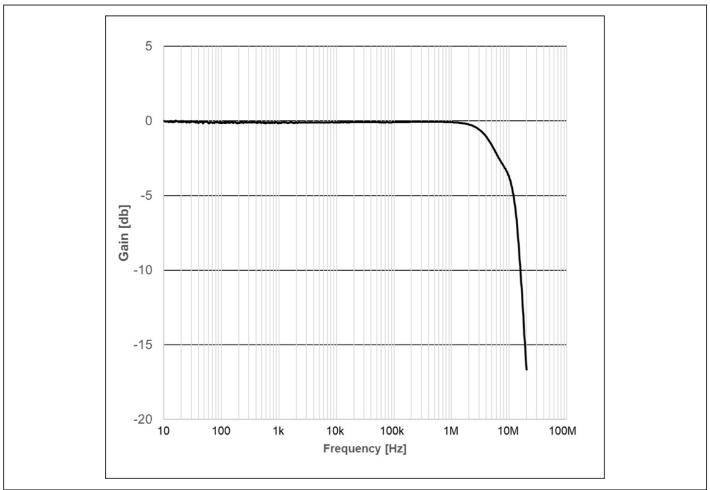


Figure 7 Gain vs frequency

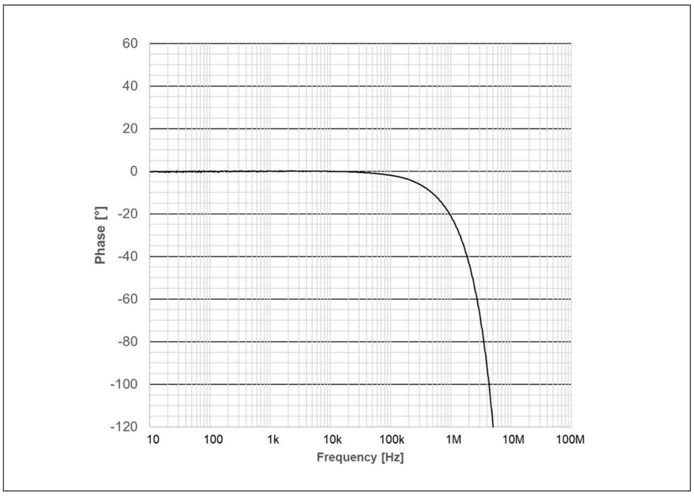


Figure 8 Phase delay vs frequency

5.4.3 Thermal performance

When designing a current sensing module, it is crucial to consider the self-heating effect caused by the flow of current. This phenomenon occurs in various components of the system, including the sensor, printed circuit board (PCB), and contacts to the PCB, as current flows through them.

The thermal response of the system is highly dependent on several factors, including the PCB layout, copper thickness, cooling techniques employed, number of vias and the profile of the injected current. The current profile encompasses several key parameters, such as peak current, current "on-time", and duty cycle. Although the data presented in this section was collected using direct current (DC), it can be used to approximate the thermal response for both alternating current (AC) signals and current pulses.

To ensure accurate and reliable current sensing, it is essential to carefully consider these factors during the design phase. This includes optimizing the PCB layout, selecting appropriate copper thickness, and implementing effective cooling techniques to minimize the thermal response. By doing so, designers can create a current sensing system that provides accurate and reliable measurements while minimizing the risk of overheating. For more information please refer to the device user manual.

The below figure illustrates the target maximum continuous current-handling capability of the device when mounted on the Infineon reference board. The PCB consists of top & bottom layers with 140 um copper thickness and two inner layers with 140 um copper thickness. It is essential to understand that the current capability decreases at higher ambient temperatures due to the reduced thermal transfer from junction-to-ambient and increased power dissipation in the lead frame.

The plot serves as a guideline for continuous current operation, but it does not imply that the system is incapable of handling current surges or peaks above the maximum current listed. In fact, surges beyond the maximum current are permissible, as long as the maximum junction temperature T_{J_MAX} of 165°C is not exceeded. This is a critical consideration, as it allows for temporary current spikes without compromising the device's overall performance and reliability.

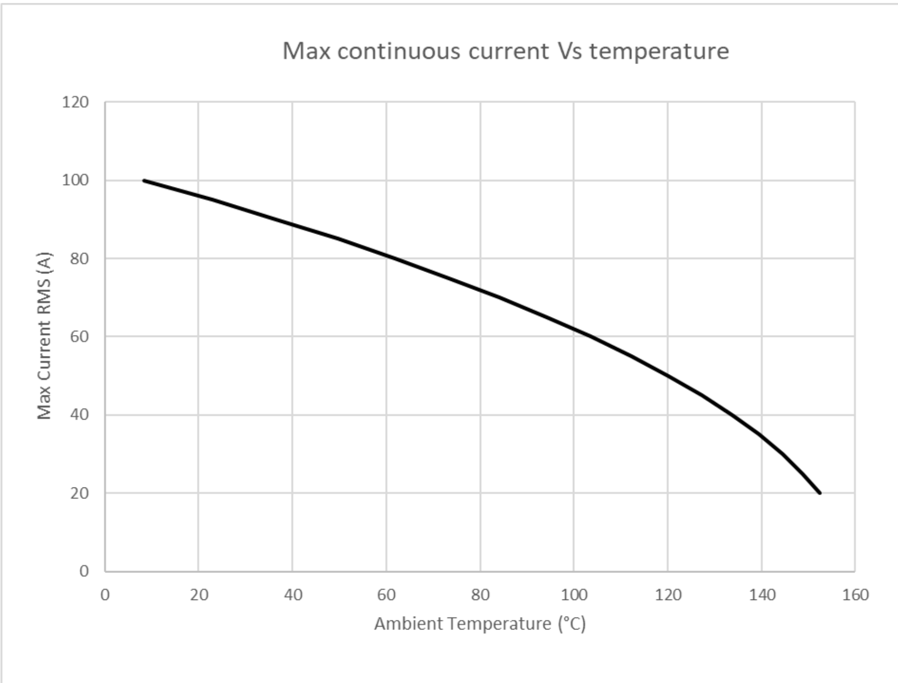


Figure 9 **Maximum continuous RMS current vs ambient temperature**

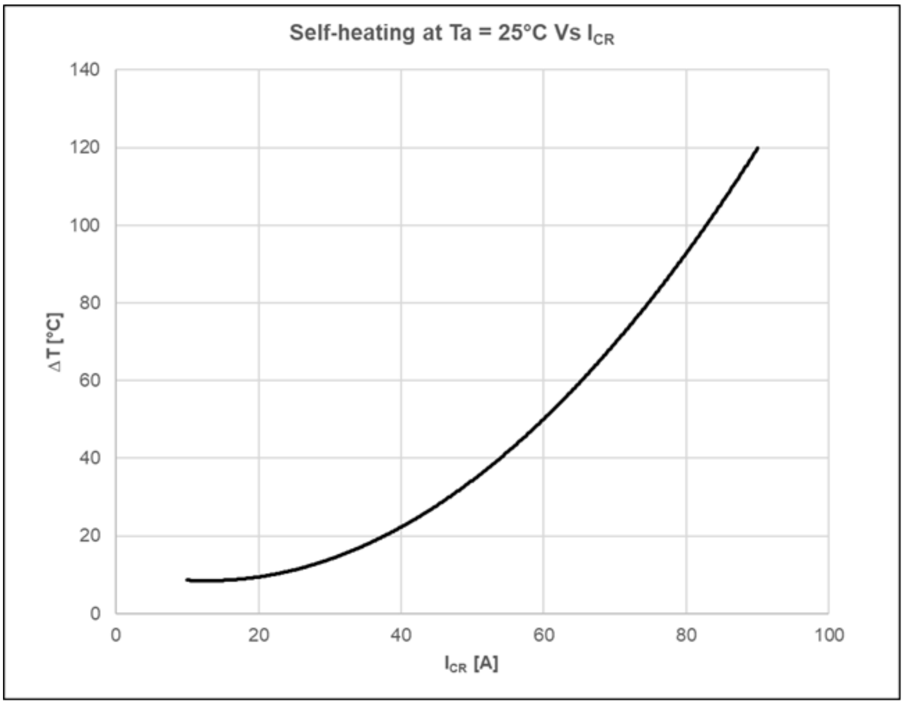


Figure 10 Self heating vs maximum continuous RMS current

5.4.3.1 Safe operating area (SOA)

Current applied to the IP+ and IP- pins of the sensor in the PG-DSO-16 package generates heat. If sufficient energy is applied, the copper lead may melt and open the circuit. Depending on the use case, the safe operating area (SOA) is governed by multiple conditions, including exceeding the maximum junction temperature, Joule heating in the lead frame, or lead frame fusing under extremely high currents. These mechanisms depend on pulse duration, amplitude, and device thermal states. It is important to note that the maximum junction temperature (T_{J_MAX}) is 165°C, and exceeding this threshold for extended periods can potentially damage the die, leading to changes in product performance or creating long-term reliability risks. Additionally, the PG-DSO-16 package includes an insulation barrier to support high working voltages. Prolonged heating can cause deterioration of the insulation material, reducing the package's insulation effectiveness. Also, other absolute maximum rating levels in Table 3 need to be complied with, as excessive voltage/current conditions lead to performance degradation. AOUT pin must not be actively driven.

Any continuous DC or sinusoidal AC periodic waveform with a frequency higher than 1 Hz can be evaluated based on the RMS continuous-current levels. The continuous-current capability is significantly influenced by the expected operating ambient temperature range. At higher ambient temperatures, the current capability diminishes due to reduced thermal transfer from junction to ambient and increased power dissipation in the lead frame. Through improved thermal design of an application, the safe operating area (SOA) can be extended to accommodate higher currents at elevated temperatures. Strategies such as using larger and heavier copper power planes, providing airflow over the board, or adding heat sinking structures to the device area can enhance thermal performance.

5.4.4 Galvanic isolation

TLE4977 provides intrinsic galvanic isolation between package pins 1-4 and 5-8 on the high-voltage input side, and pins 9-16 on the low-voltage side of the package, thanks to the internal physical separation and isolation barrier between the input low resistance current rail and the sensor die, ensured by the TLE4977 construction. Insulation capability parameters following standard definitions are reported in the isolation characteristic table.

Following the indications given by the IEC 60747-17 standard for basic and reinforced insulation, an assessment of the device lifetime working voltages requires time-dependent dielectric breakdown (TDDB) data-projection. The assessment consists of projected failure rates of less than 1ppm for reinforced insulation and less than 1000ppm for basic insulation, considering a minimum insulation lifetime of 20 years.

For reinforced insulation, the IEC 60747-17 standard requires additional safety margins of 20% for working voltage, and 50% for insulation lifetime, translating into a minimum required lifetime of 30 years at 2040 Vpk for the TLE4977.

The intrinsic capability of the isolation barrier to withstand high-voltage stress over lifetime of the device is shown in the plot below. Based on the TDDB results for TLE4977, the intrinsic capability of this device is > 1200 Vrms with a lifetime > 20 years.

Please note that operating environment conditions and other factors such as pollution degree can cause further limitation of the working voltage lifetime in a system.

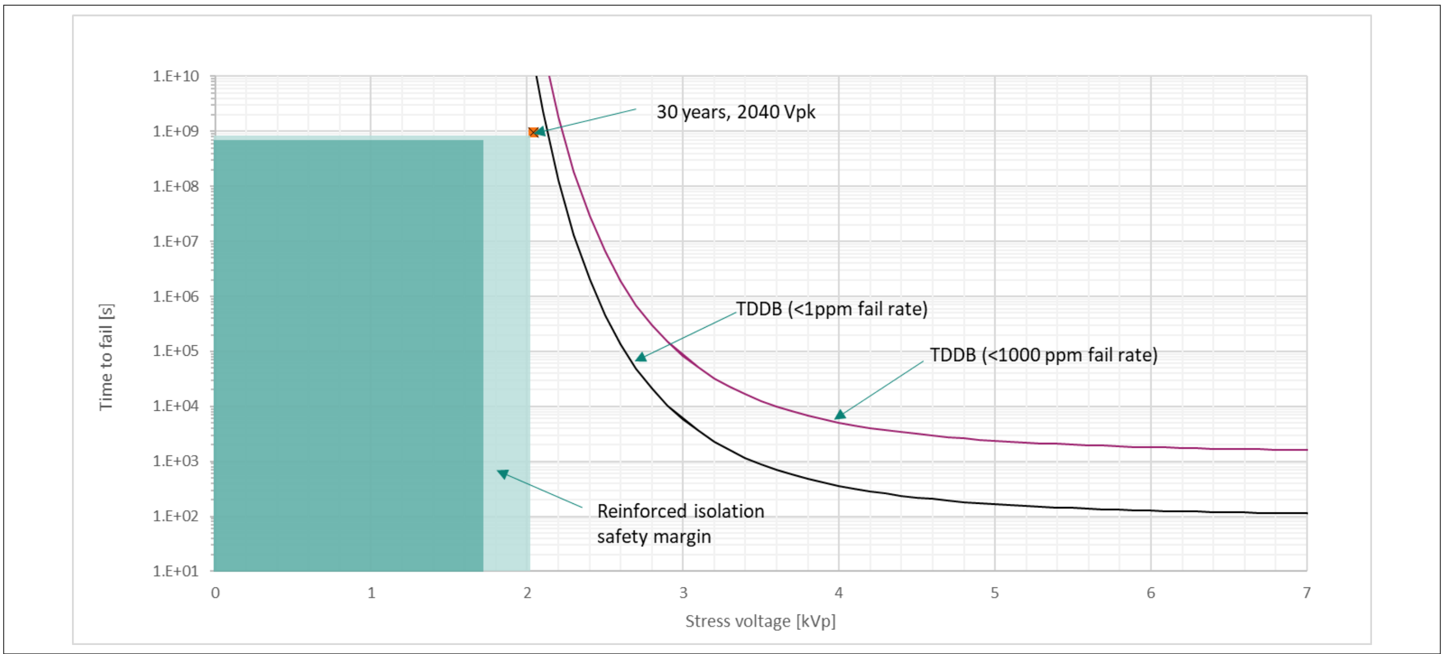


Figure 11 **Insulation lifetime**

5.4.5 Noise performance

In many state-of-the-art current sensors, output noise increases as the usable bandwidth is extended. Designers desire higher bandwidth to achieve low, stable phase delay and fast response. This typically comes at the penalty of increasing analog output noise, forcing a trade-off between accuracy and speed of the current sensing. The TLE4977 is superior in this context, by employing a hybrid Hall and coil architecture which delivers both low noise and high bandwidth. By leveraging the coil's stronger high frequency signal, the device maintains a low output noise level, even as bandwidth increases, supporting stable phase behavior and fast transient response without compromising precision.

A typical noise performance of the TLE4977 graph is shown in the next plots. The first plot shows the typical accumulated noise over frequency. Thanks to the hybrid Hall + coil architecture and to proprietary solutions, the total accumulated noise is only 35 mArms over a 9 MHz bandwidth, representing less than 0.06% of the TLE4977 measurement range. From both plots, it can be observed that starting from a few kHz, the noise density reduces as the frequency increases so that the accumulated noise is practically constant after 10 kHz. This means that, unlike in other current sensors, the rms noise at TLE4977 output does not significantly increase with increasing bandwidth (above 10 kHz), thus enabling extremely fast response without jeopardizing accuracy and signal to noise ratio.

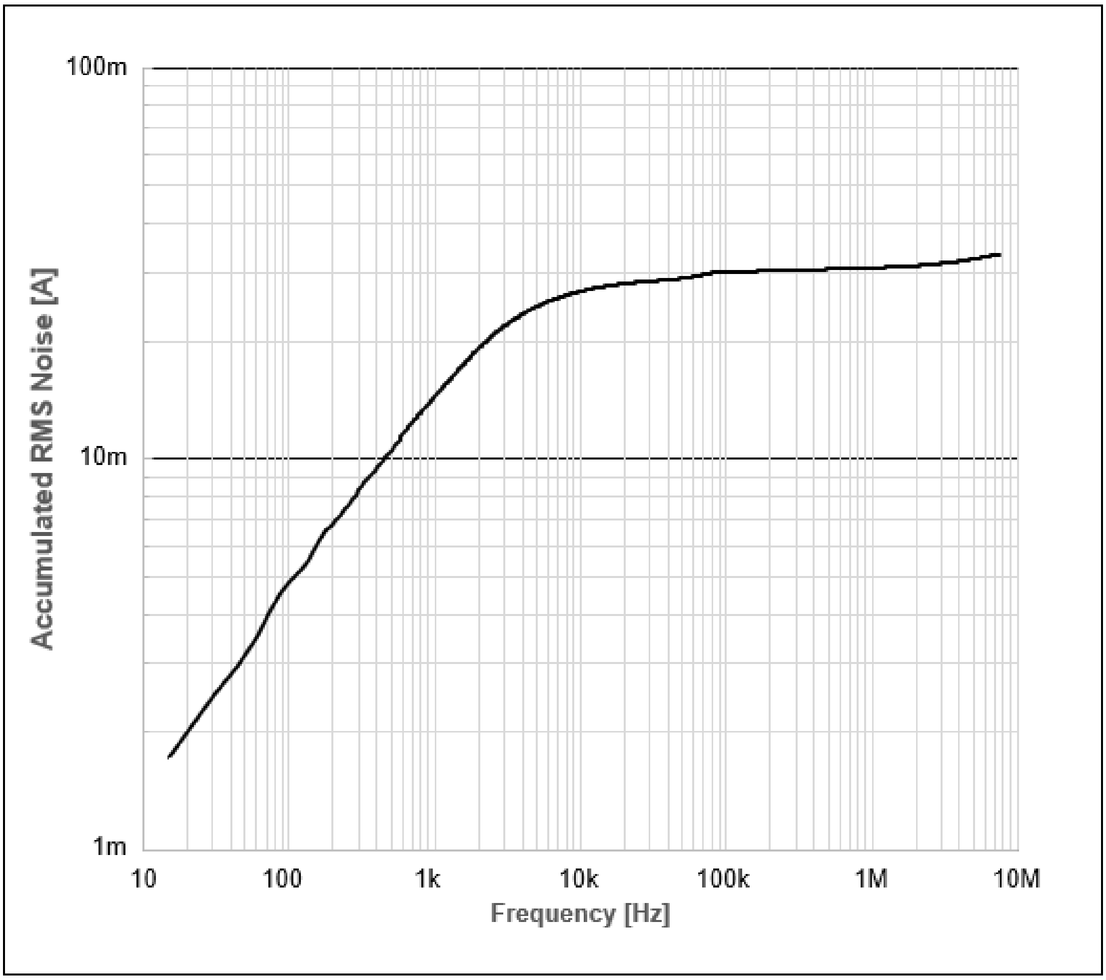


Figure 12 **Input referred accumulated noise vs frequency**

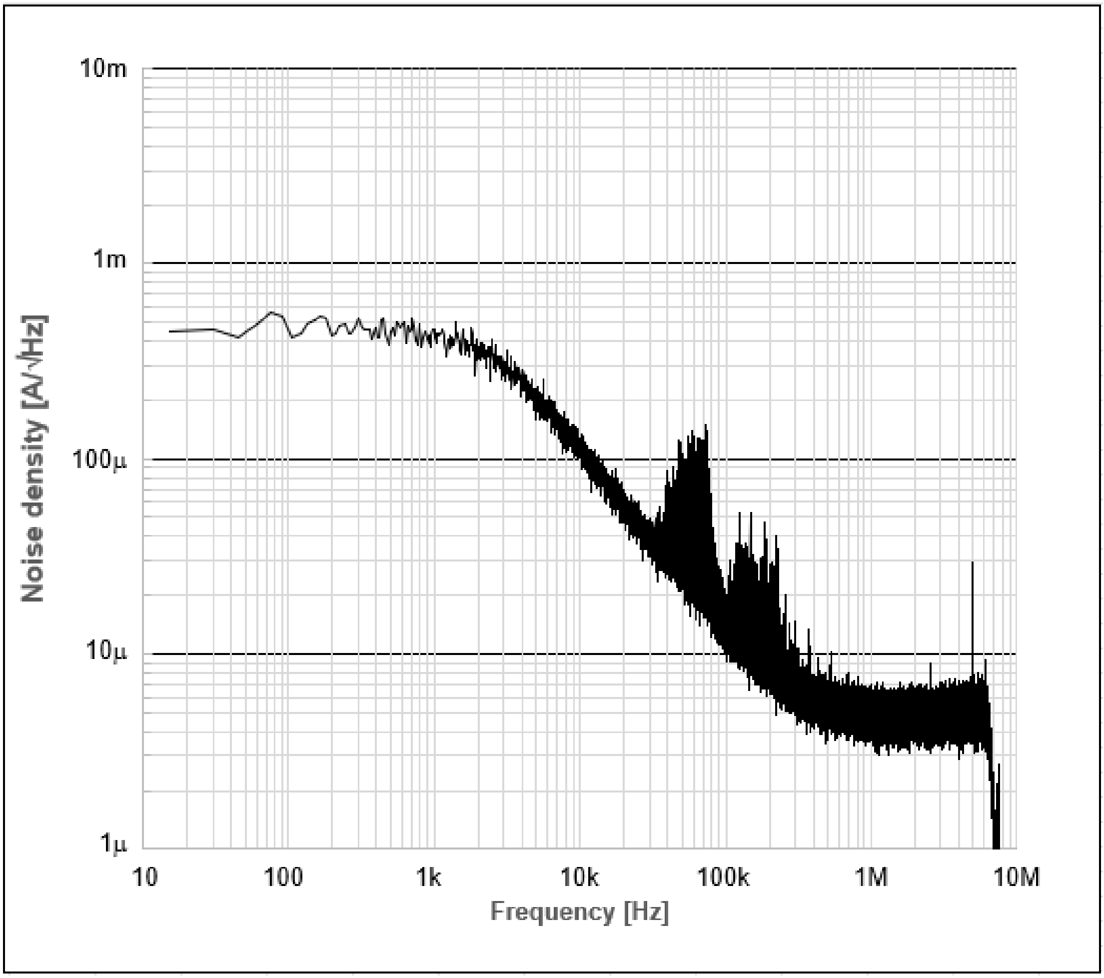


Figure 13 **Noise density vs frequency**

5.4.6 High precision signal chain and stability over temperature

The current sensor integrates a high precision, end-to-end signal path providing a voltage output that is proportional to the current conducted through the lead-frame of the isolated input. The low-drift measurement signal path is equipped with advanced circuit techniques to deliver highly accurate and stable current sensing across the whole specified operating temperature range and throughout the entire device's service life. Each unit is rigorously tested and pre-calibrated to compensate for variations arising from silicon processing, assembly, and packaging.

The device implements a digitally assisted temperature-compensation scheme that greatly reduces parametric drift over the specified operating temperature range. This compensation addresses variations due to ambient temperature changes, device self-heating, and package-induced mechanical stress. In combination with a zero-drift signal-chain architecture and Hall sensor temperature-compensation methods, the device maintains a stable sensitivity while minimizing offset errors across temperature. As a result, the system-level performance is improved under the required operating conditions.

5.4.7 Lifetime and environmental stability

Typically, magnetic current sensors experience a 2% to 3% sensitivity drift over life in addition to thermal drift, driven by aging, mechanical stress, and environmental effects. The sensor implements proprietary compensation techniques to mitigate these effects, yielding robust lifetime performance under harsh conditions. Electrical characteristics confirm best-in-class lifetime offset and sensitivity drift following life-acceleration stresses including UHAST, THB, HTOL, HTSL and temperature cycling within the standardized three-lot AEC-Q100 grade 0 qualification.

Performance has been measured before and after the exposure to AEC-Q100 defined stresses for grade 0 and beyond, over the defined operating temperature range, always showing statistical distributions inside the limits indicated in the sensing characteristics table. These data indicate outstanding robustness of the accuracy parameters over lifetime and a substantial advantage in long-term stability and reliability relative to competition. As an example, figures below show the total sensitivity error and the total offset distributions after a 3000 temperature cycles test.

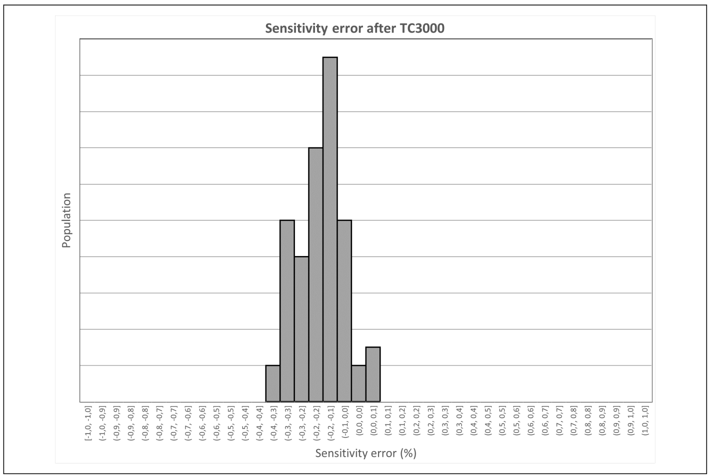


Figure 14 **Population vs sensitivity error**

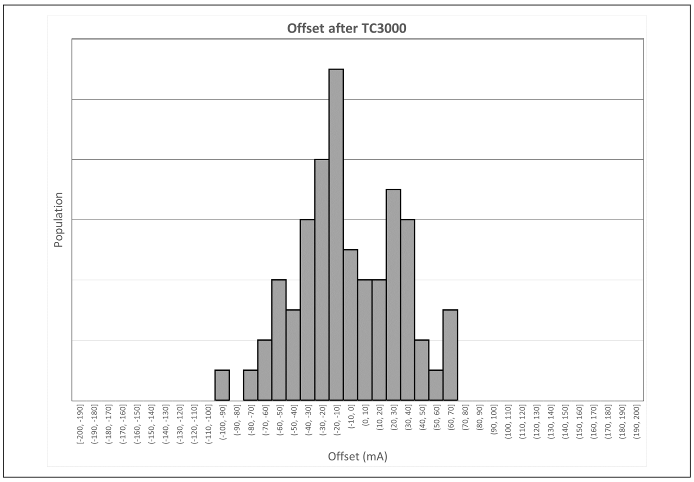


Figure 15 **Population vs offset**

5.4.8 Measurable linear analog output voltage range

The sensor linear input current measurement ranges listed in the respective Table 8 are determined by the zero current output voltage (V_{OQ}), device sensitivity (S), and supply voltage (V_{DD}). The maximum linear output voltage $V(AOUT)_{max}$ is limited to V_{CLH} less than the supply voltage, as shown in the equation below. Similarly, the minimum linear output voltage $V(AOUT)_{min}$ is limited to V_{CLL} above ground, as shown in the equation below:

$$V(AOUT)_{max} = V_{DD} - V_{CLH}$$
$$V(AOUT)_{min} = V_{CLL} \tag{4}$$

The overall maximum dynamic range can indeed be optimized by referring to the minimum and maximum linear output voltage swing in relation to the minimum and maximum linear input current range. This can be achieved by dividing the output voltage by the sensitivity, S.

$$I_{FS,max} = \frac{V(AOUT)_{max} - V_{OQ}}{S}$$
$$I_{FS,min} = \frac{V(AOUT)_{min} - V_{OQ}}{S} \tag{5}$$

where

- $I_{FS,max}$ is the maximum linear measurable positive input current.
- $I_{FS,min}$ is the minimum linear measurable negative input current.
- S is the sensitivity of the device variant.
- V_{OQ} is the zero current output voltage

5.4.9 Nonlinearity error (NL)

Nonlinearity is the deviation of the output voltage from a linear relationship to the input current. Nonlinearity error is reported in terms of %FS in Table 8.

5.4.10 Ratiometricity error

Ratiometricity implies that the quiescent voltage and sensitivity are directly proportional to the supply voltage. Therefore, in an ideal condition, if the supply voltage fluctuates, the output voltage varies proportionally thus avoiding system level errors when the sensor output is read by a ratiometric ADC. Due to non-idealities however there is a ratiometricity error present, which represents the relative deviation from the proportional output voltage with respect to the change in supply voltage.

5.4.10.1 Sensitivity ratiometricity error (ESENS_RAT)

Ideally, a 1% increase in V_{CC} results in a 1% increase in sensitivity. However, the ratiometric response of any sensor is not ideal. Ratiometric sensitivity error E_{SENS_RAT} is calculated as follows:

$$E_{SENS\_RAT} = \left(\frac{S_{Meas}}{S} \times \frac{V_{DD(NOM)}}{V_{DD(Meas)}} - 1 \right) \times 100 \tag{6}$$

Where, S_{Meas} is the measured sensitivity at the measured V_{DD} supply in an application and S is the sensitivity at the nominal V_{DD} supply. The sensitivity ratiometricity error (E_{SENS_RAT}) is defined in percentage in the respective Table 8.

5.4.10.2 Offset ratiometricity error (EOFF_RAT)

Ideally, a 1% increase in V_{DD} results in a 1% increase in quiescent voltage. However, the ratiometric response of any sensor is not ideal. Offset ratiometricity error E_{OFF_RAT} accounts for such error and is calculated as follows:

$$\begin{aligned} VDD_{VAR\%} &= \frac{V_{DD} - V_{DD\_NOM}}{V_{DD\_NOM}} \times 100 \\ E_{OFF\_RAT} &= \frac{V_{OQ}(V_{DD}) - (V_{DD}/2)}{S(V_{DD}) \quad \times \quad VDD_{VAR\%}} \end{aligned} \tag{7}$$

Where, $V_{OQ}(V_{DD})$ is the measured quiescent voltage at the measured supply in an application. The Offset Ratiometricity Error (E_{OFF_RAT}) is expressed in mA/%V_{DD} in the respective Table 8. In order to find the max offset error due to ratiometricity the value has to be multiplied by the V_{DD} variation expressed in %.

5.4.11 Sensitivity and offset error calculation

5.4.11.1 Total offset error

The offset error is a key performance parameter that characterizes the deviation from the ideal output with zero input current. To ensure high precision and accuracy, the offset of the current sensor is tested and calibrated during Infineon production. The offset drift over temperature, which refers to the change in the offset as a function of temperature, and lifetime is reported in milliamperes (mA). To determine the total offset error at a given condition, the initial offset error (E_{OFF}) must be added to the offset drift over temperature and lifetime (E_{OFF_LV}) and then quadratically added to offset ratiometricity error (E_{OFF_RAT}) as shown in the below equation.

$$E_{OFF}\left(\%\right) = \frac{E_{OFF}}{I_{FS}} \times 100$$
$$E_{OFF\_RAT}\left(\%\right) = \frac{E_{OFF\_RAT} \times VDD_{VAR\%}}{I_{FS}} \times 100$$
$$E_{OFF\_LV}\left(\%\right) = \frac{E_{OFF\_LV}}{I_{FS}} \times 100 \qquad (8)$$
$$E_{Total\_OFF}\left(\%\right) = \sqrt{(|E_{OFF}(\%)| + |E_{OFF\_LV}(\%)|)^2 + |E_{OFF\_RAT}(\%)|^2}$$

note that the offset ratiometricity error contribution depends on the percent variation of the VDD that is possible in the application.

5.4.11.2 Total sensitivity error

Sensitivity is the proportional change in the sensor output voltage due to a change in the input conductor current. The current sensor is designed to deliver high precision and accuracy, and it undergoes rigorous sensitivity testing and calibration procedures to ensure optimal performance. Total sensitivity error is the sum of the Initial sensitivity error (E_{SENS}), and Sensitivity drift over temperature and lifetime (E_{SENSL}), quadratically added to the sensitivity ratiometricity error (E_{SENS_RAT}). Refer the respective Table 8.

Note that since E_{SENS_RAT} is reported in the sensing characteristics table as the maximum error at 10% variation of the V_{DD}, the actual possible V_{DD} variation in the system must be considered in the total error calculation.

$$E_{SENS\_RAT} = E_{SENS\_RAT(MAX)} \times \frac{VDD_{VAR\%}}{10} \qquad (9)$$
$$E_{Total\_SENS}\left(\%\right) = \sqrt{(E_{SENS} + E_{SENSL})^2 + E_{SENS\_RAT}{}^2}$$

5.4.12 Common-mode transient immunity or slew rate (dV/dt)

Common mode transient immunity (CMTI) is a critical performance parameter that characterizes a device's ability to withstand rising or falling voltage steps on the input without disrupting its output signal. Specifically, the device is designed to operate within a maximum common-mode transition rate that ensures the output signal is not impacted by disturbance. It is worth noting that higher edge rates than the specified CMTI can be supported using appropriate filtering or blanking time after common-mode transitions. This parameter is particularly critical for a wide band gap applications, especially those that operate at higher switching frequencies and voltage levels, which can induce higher leakage current through the input to output capacitance, unless a proper shielding is in place. By ensuring that the device meets the specified CMTI requirements, we can minimize the risk of voltage disturbances and ensure consistent and reliable performance, even in challenging environments.

5.4.13 Stray field error (EStray)

The current sensor operates on the basis of sensing the magnetic field created by the current flowing through the package. The sensor is able to differentiate between the field created by the current we want to measure and the background field, thanks to the differential measurement principle that cancels the external stray field effect. However, an unavoidable small mismatch in the 2 sensing elements make the cancellation not perfect. This can lead to errors in the sensor output caused by external magnetic fields. Fortunately, the sensor is equipped with stray field-rejection capabilities that effectively suppress the interference from external magnetic fields generated by adjacent high-current carrying conductors, nearby motors, magnets, or any other sources of stray magnetic fields. By carefully considering and controlling these factors, we can ensure that the sensor delivers reliable and precise measurements, even in the presence of external magnetic fields. This is particularly important for applications that require high levels of accuracy and precision, where even small errors can have significant consequences. To calculate the percentage error contribution from stray external magnetic fields (B_{Ext}) and stray field error (E_{Stray}) from Table 8, use the following equation, where the I_{in} is the current currently running through the current rail of the sensor in mA:

$$E_{Stray\_Error}\left(\%\right) = \frac{B_{Ext} \times E_{Stray}}{I_{in}} \times 100 \quad (10)$$

5.4.14 Total error calculation

In order to accurately calculate the total expected error of a device, it is imperative to comprehend the contributions made by each individual component listed in the above sections with respect to its operating conditions. In order to account for statistically uncorrelated error sources, a root sum square (RSS) error calculation must be employed. This calculation enables the total error to be determined with precision. For the device, only the offset error (E_{OFF}) in mA and stray field error (E_{Stray}) are statistically correlated. As such, these error terms must be combined using an RSS calculation to reflect their nature.

The equation below illustrates the calculation for room temperature (E_{TOT_RT}):

$$E_{TOT\_RT}\left(\%\right) = \sqrt{\left(|E_{OFF}(\%)|\right)^2 + \left(|E_{OFF\_RAT}(\%))|\right)^2 + \left(|E_{Stray\_error}|\right)^2 + \left(|E_{SENS\_RAT}|\right)^2 + |(E_{SENS}|)^2 + \left(|E_{NL}|\right)^2} \quad (11)$$

The equation below illustrates the total error calculation over temperature (E_{TOT_T}) with initial sensitivity and offset error:

$$E_{TOT\_T}\left(\%\right) = \sqrt{\left(||E_{OFF}(\%)| + |E_{OFFT}(\%)||\right)^2 + \left(|E_{OFF\_RAT}(\%))|\right)^2 + \left(|E_{SENS\_RAT}|\right)^2 + \left(|E_{Stray\_error}|\right)^2 + \left(|E_{SENS}| + |E_{SENST}|\right)^2 + \left(|E_{NL}|\right)^2} \quad (12)$$

The equation below illustrates the total error calculation over temperature and lifetime (E_{TOT_LT}) with initial sensitivity and offset error:

$$E_{TOT\_LT}\left(\%\right) = \sqrt{\left(||E_{OFF}(\%)| + |E_{OFF\_LV}(\%)||\right)^2 + \left(|E_{OFF\_RAT}(\%))|\right)^2 + \left(|E_{SENS\_RAT}|\right)^2 + \left(|E_{Stray\_error}|\right)^2 + \left(|E_{SENS}| + |E_{SENSL}|\right)^2 + \left(|E_{NL}|\right)^2} \quad (13)$$

5.4.15 Power supply recommendations

The sensor relies on a low-voltage power supply connected to VDD pin to operate the analog circuitry independently from the isolated primary current input. The analog output (A_{OUT}) realizes its full-scale output range based on the voltage supplied to VDD pin. To mitigate noise in the power-supply path, a decoupling capacitor with low equivalent series resistance (ESR) must be placed between the VDD and GND pins, in close proximity to the supply and ground pins of the device. In situations where the power supply is noisy or has high-impedance, additional decoupling capacitance may be necessary. V_{DD} can be separately sequenced from primary current that flows through the input.

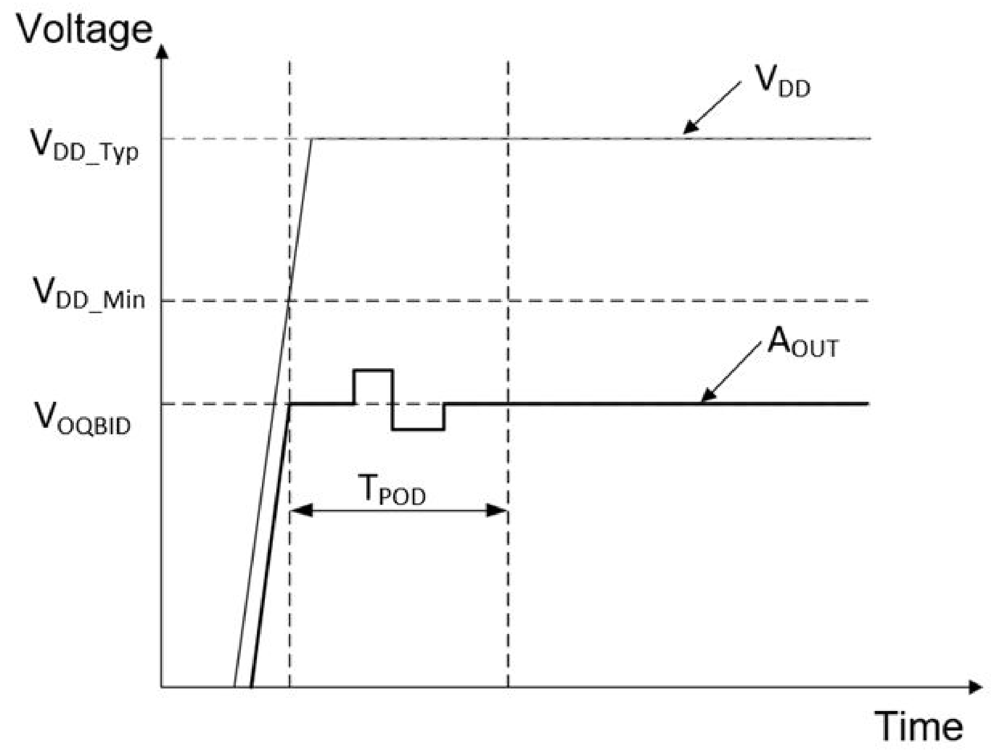


Figure 16 **Power ON delay behavior**

The graph above demonstrates the correlation between the behavior of the A_{OUT} signal and the V_{DD} supply voltage as it varies. As V_{DD} ramps up and surpasses the V_{DD_Min} threshold, the A_{OUT} pin transitions to and stabilizes at the V_{OQBID} level. During the power-on delay period (t_{POD}), the A_{OUT} signal initially oscillates before settling at V_{OQBID}. Upon the completion of t_{POD}, the A_{OUT} pin transitions into normal operating mode.

5.4.16 OCD - Over current detection

The device provides an Over Current Detection (OCD) output on the OCD pin in case of an over-current event. Over-current condition is present when the input current absolute value (positive or negative) is higher than the chosen threshold level.

5.4.16.1 OCD output timing behavior

Deglitching delay associated with OCD output is reset as soon as the over-current condition is removed.

Figure below shows the OCD output pin nominal behavior during an overcurrent event and defines important timing quantities for which the limits are listed in the parameters Table 9.

Overcurrent pulse (1) is an overcurrent event, where the duration of the overcurrent condition exceeds the overcurrent response time (t_{D_OCD}) + response time jitter (Δt_{D_OCD}) + deglitch filter time ($t_{DEGLITCH}$). Overcurrent conditions (2) and (3) are not long enough to trigger the OCD output. Pulse (2) is shorter than the overcurrent response time (t_{D_OCD}) and therefore no OCD event is generated. In overcurrent condition (3), the overcurrent condition is longer than the response time (t_{D_OCD}) + response time jitter (Δt_{D_OCD}), but is not exceeding the glitch filter time ($t_{DEGLITCH}$) and no OCD event is generated.

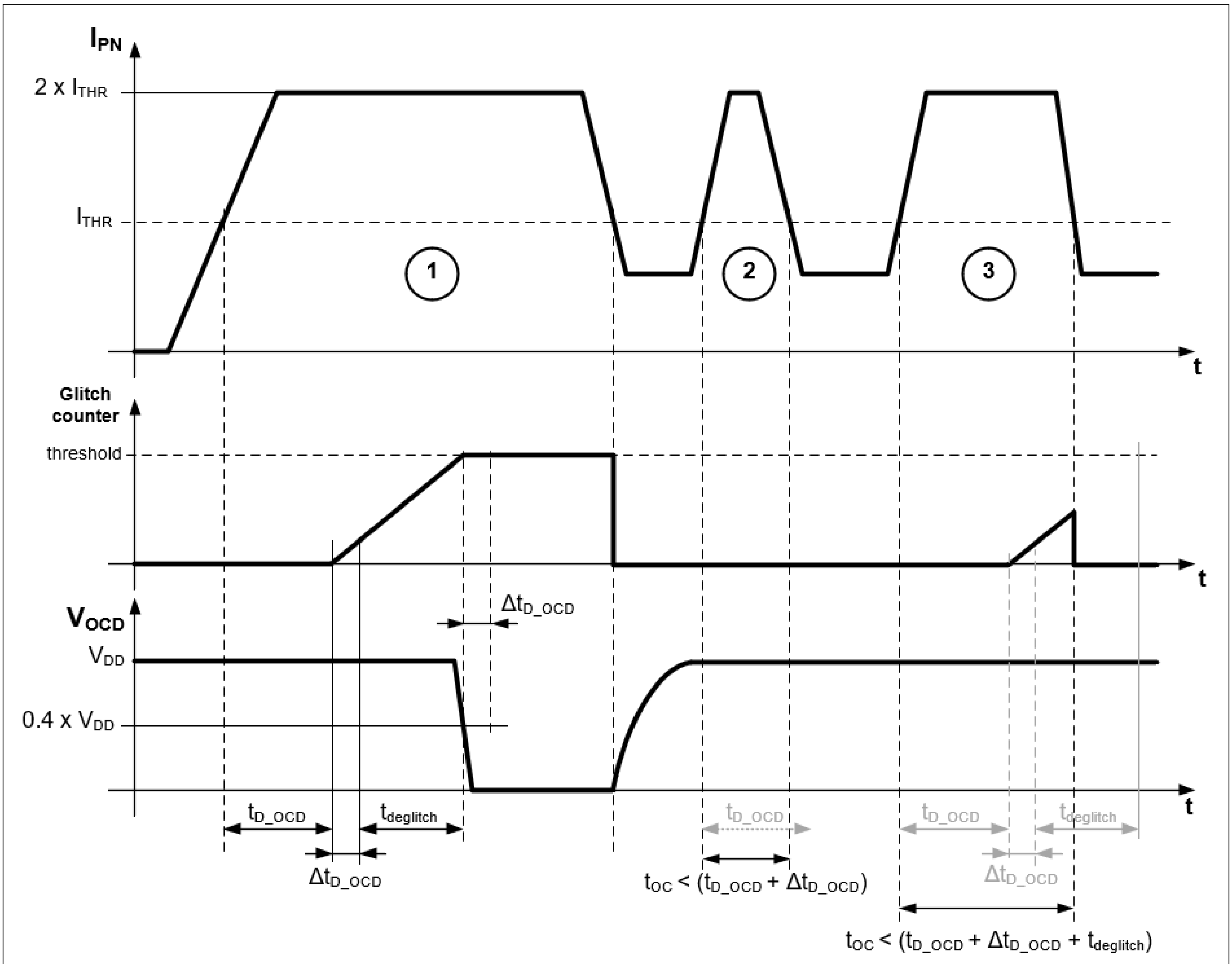


Figure 17 **OCD output timing behavior**

5.4.16.2 OCD pins external connection

The OCD pin operates as active low, open-drain output. This allows easy setup of a wired-AND configuration enabling the monitoring of several current sensors outputs via only one microcontroller pin. The OCD pins can be connected to a logic input pin of the microcontroller and/or the gate-driver, to quickly react to over current events.

5.4.16.3 OCD thresholds

The OCD threshold is determined at startup. If the DCDI interface is activated at start-up, the OCD threshold is set to the value corresponding to the related EEPROM setting, which by default is the highest threshold.

Otherwise, it is set to the value corresponding to the voltage at the OCD_THR pin. Refer to the device user manual for more information on OCD threshold setup.

If the OCD threshold is set by the DCDI interface the following formula applies:

$$eep\_ocd\_thrsh[7:0] = I_{THR}(A) \times 1.755 \tag{14}$$

If it is set by the voltage on the OCD_THR pin then, the voltage input from 0.5 V to 1.73 V corresponds to currents from 10 A to 100 A in a linear relationship.

Given the desired threshold in current (I_{THR}) in A, the corresponding input voltage in V to be applied (V_{OCD_THR}) can be found with the following formula:

$$V_{\mathrm{OCD\_THR}}\left(V\right) = \frac{150}{11000} \times I_{\mathrm{THR}}\left(A\right) + \frac{4000}{11000} \tag{15}$$

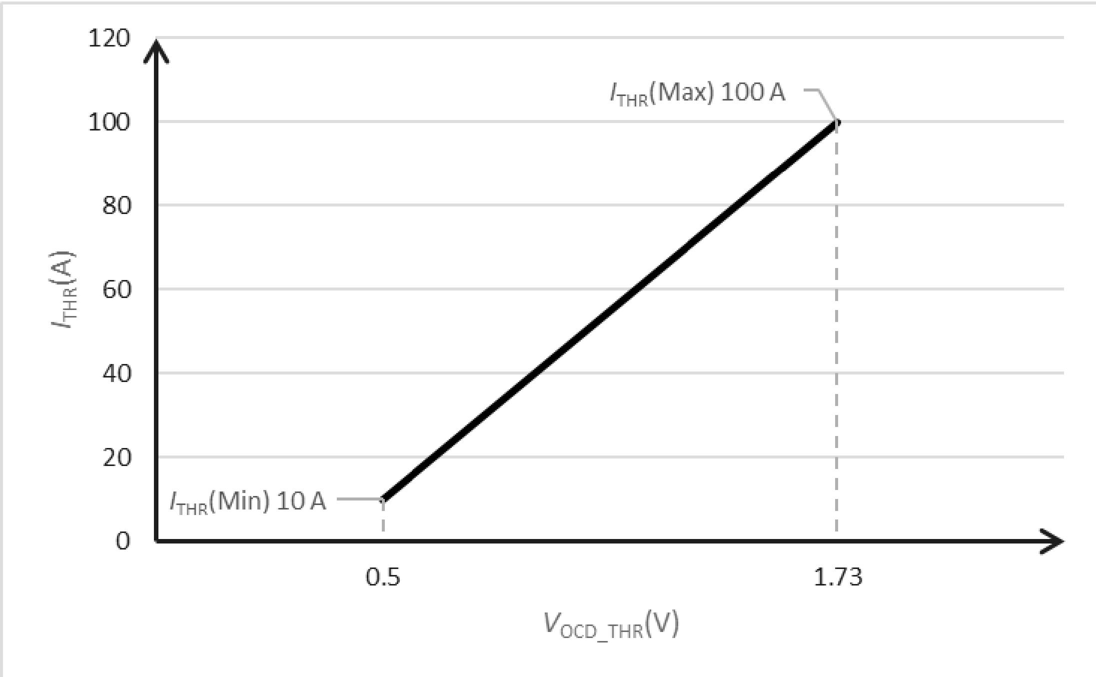


Figure 18 Threshold voltage (V_{OCD_THR}) vs threshold current (I_{THR})

For the TLE4977-R080x product type (81 A range), if the OCD threshold is set by the DCDI interface the following formula applies:

$$eep\_ocd\_thrsh[7:0] = I_{THR}(A) \times 1.465 \tag{16}$$

For the TLE4977-x080x product type (81 A range), a Voltage input from 0.5 V to 1.73 V corresponds to currents from 12 A to 120 A in a linear relationship.

Given the desired threshold in current (I_{THR}) in A, the corresponding input voltage to be applied (V_{OCD_THR}) can be found with the following formula:

$$V_{\mathrm{OCD\_THR}} = \frac{125}{11000} \times I_{\mathrm{THR}} + \frac{4000}{11000} \tag{17}$$

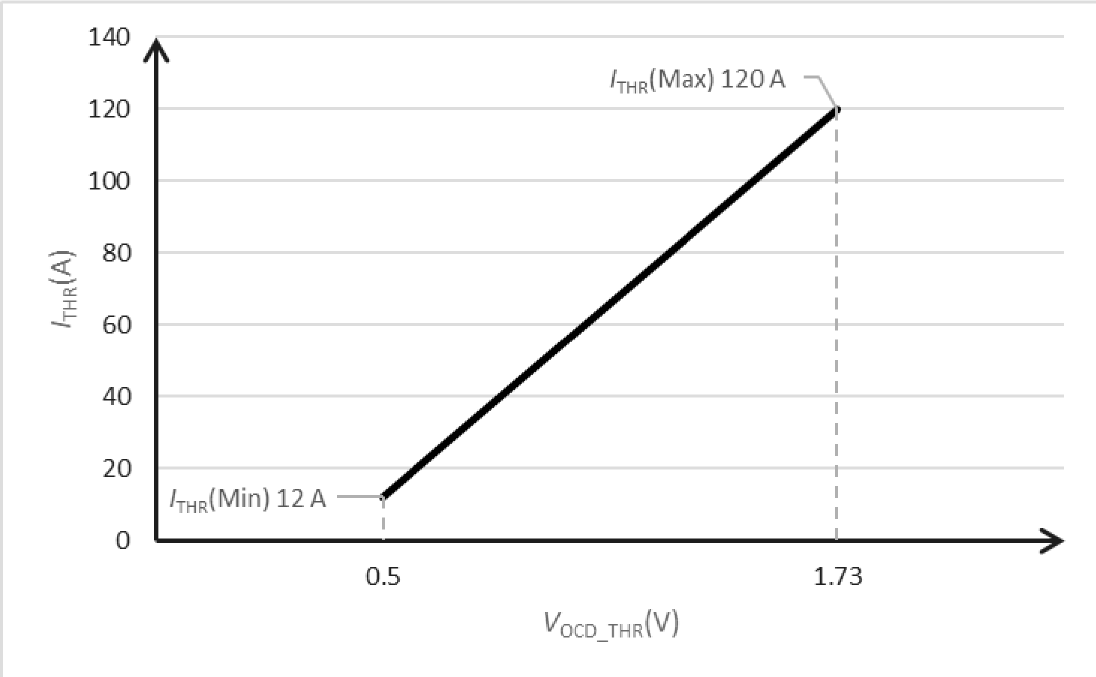


Figure 19 **Threshold voltage (V_{OCD_THR}) vs threshold current (I_{THR}) for the TLE4977-x080x product type**

5.4.16.4 Over current detection characteristics

***Note**: General conditions (unless otherwise specified): V_{DD} = 5.0 V; T_S = -40°C to +125°C, C_L = 1 nF; R_{PU} = 4.7 kΩ*

Table 9 **Over current detection characteristics**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
OCD response time	t_{D_OCD}	–	0.1	0.2	µs	Time from input current > I_{THR} to when OCD pin is pulled below V_{OCD_LOW} input current step from 0 to 2 × I_{THR}
OCD fall time	t_{F_OCD}	–	–	100	ns	From 90% to 10% VDD. Load capacitance Cl = 470 pF
OCD output low voltage	V_{OCD_LOW}	–	–	0.4	V	–
OCD hysteresis current	I_{HYST}	–	6.25	–	%	Percentage of actual OCD threshold value. After input current goes above I_{THR}, tripping the internal comparator, input current must fall below I_{THR} – I_{HYST}, before the internal comparator resets. Parameter can be programmed. Check the user manual of the device for more details on options and how to set the parameter.
OCD_THR input voltage range	V_{OCD_THR}	0.5	–	1.73	V	–

(table continues...)

Table 9 (continued) Over current detection characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
OCD_THR input current	I_{VOCD}	–	10	100	nA	–
Threshold level range	I_{THR}	10	–	100	A	Parameter can be set by the value corresponding to the voltage at the OCD_THR pin or programmed. Check the user manual of the device for more details on options and how to set the parameter.
Threshold level range	I_{THR_81A}	12	–	120	A	TLE4977-x080x product type. Parameter can be set by the value corresponding to the voltage at the OCD_THR pin or programmed. Check the user manual of the device for more details on options and how to set the parameter.
Threshold level resolution	I_{THT}	–	0.56	–	A	–
Threshold level resolution	I_{THT_81A}	–	0.68	–	A	TLE4977-x080x product type
Threshold level tolerance	OCD_{THR_LVL}	–	±5	–	%	Minimum and maximum depends on the externally connected resistor selection
OCD response time jitter	Δt_{D_OCD}	–	–	0.1	µs	At 3 σ, I_{rail} = 2 x I_{THR}, input rise time 0.1 µs
OCD deglitch filter time	$t_{deglitch}$	–	300	–	ns	Parameter can be programmed. Check the user manual of the device for more details on options and how to set the parameter.
OCD load capacitance	C_L	–	470	–	pF	–
Pull-up resistor	R_{PU}	1	–	10	kΩ	Connected to V_{DD}

5.4.17 Undervoltage / overvoltage detection

The device pulls the OCD output low when its own voltage power supply (V_{DD}) is in under-voltage condition. Under-voltage condition is present when V_{DD} is between the values indicated in the V_{DD_OCD} parameter.
In case of overvoltage condition, the sensor provides supply fault indication by pulling the OCD output low. Over-voltage condition is present if V_{DD} higher than the over-voltage threshold parameter (V_{OV_RES}).

Table 10 Undervoltage / overvoltage characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Undervoltage/ Overvoltage detection delay	t_{UVOV_DELAY}	–	2.6	3.2	µs	–

(table continues...)

Table 10 (continued) Undervoltage / overvoltage characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Overvoltage reset threshold	V_{OV_RES}	–	–	5.9	V	V_{DD} rising
Overvoltage release threshold	V_{OV_REL}	5.5	–	–	V	V_{DD} falling
Undervoltage reset threshold	V_{UV_RES}	4.2	–	–	V	V_{DD} falling
Undervoltage release threshold	V_{UV_REL}	–	–	4.5	V	V_{DD} rising
Undervoltage condition	V_{DD_OCD}	1.8	–	V_{UV_REL}	V	OCD pulled to "low" level

5.4.18 DCDI - Digital control diagnostic interface

The device provides a bus compatible fast one-wire DCDI communication interface operating as input/output.
The DCDI interface is a single-master, multi-slave UART based interface.
The DCDI communication is robust against disturbances caused by 500 kHz switching frequencies.

Note: *500 kHz squared input signal. Slew rate max. 150 V/ns, Max Voltage 1.6 kV.*

Digital control and diagnostic interface (DCDI) enables complete sensor customization to users needs. For example:
- Multi sensor communication (allows the connection of up to 8 sensors per bus),
- sensor diagnostics,
- write access to OCD threshold,
- OCD deglitch filter time and
- many more useful functionalities.

For all DCDI functionalities please refer to the device user manual.

Table 11 DCDI characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
DCDI number of slaves	$DCDI_{SLV}$	–	–	8	–	The number of slaves to be addressed and served in one system
DCDI bus voltage	$DCDI_{VBUS}$	–	V_{DD5}	–	V	The voltage level for the pull up resistor has the same specification as the sensor supply voltage V_{DD}.
DCDI low voltage level	V_{DCDI_LOW}	–	–	1	V	Low state, transition from high to low

(table continues...)

Table 11 (continued) DCDI characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
DCDI high voltage level	V_{DCDI_HIGH}	1.6	–	–	V	High state, transition from low to high
DCDI pull-up resistor	R_{DCDI_PU}	433	–	1320	Ω	–
DCDI low-side resistance	R_{DCDI_LOW}	–	–	120	Ω	From DCDI pin to GND, when DCDI pin is driven low
DCDI wiring length	$DCDI_{WIRE}$	–	–	40	cm	The interface operates within its specification up to specified wire length
DCDI maximum bus load	C_{DCDI}	–	–	1.25	nF	Baud rate = 57600 bit/s. For slower baud rates higher capacitance values are allowed.

5.4.18.1 DCDI slave addressing

The device provides an auto-addressing functionality in order to allow the master in the system to address different sensors connected on a bus.

It is possible that the sensor uses the static address stored in EEPROM, if the EEPROM is configured to use stored address (static). In this case the broadcast command to automatically change the address is ignored.

5.4.18.2 DCDI features

The EEPROM of the device is programmable via the DCDI interface.

It is possible to read the calibration related register content via the DCDI interface.

The DCDI interface protocol layer provides internal errors status information to the master node within each communication frame.

The DCDI end-to-end frame protection provides a failure detection rate of more than 99%.

For additional information please refer to the user manual of the device.

6 Package

The device is mounted in the PG-DSO-16 Package.

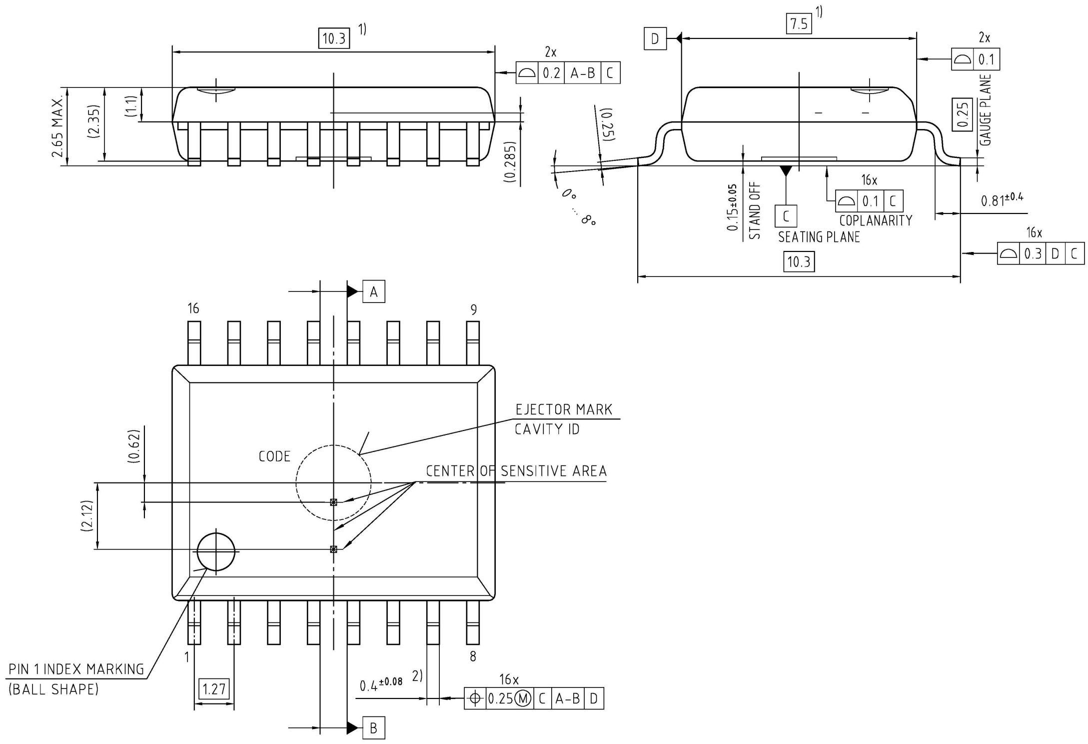


Figure 20 PG-DSO-16 package outline

Table 12

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Junction-to-ambient thermal resistance	$R\theta_{JA}$	–	12.5	–	K/W	Measurement was done in still air box according JESD51-2A by mounting on the Infineon reference PCB.

7 Revision history

Revision number	Date of release	Description of changes
1.10	2026-07-28	Classification change. Editorial changes.
1.00	2026-06-03	Initial release.

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