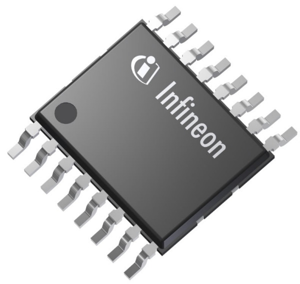
## XENSIV™ high bandwidth and high slew rate TMR current sensor

### Features

- Accurate and galvanic isolated AC and DC current sensing with stable sensitivity and offset over temperature and lifetime
- Contactless current measurement to reduce resistance and inductance in the system
- Fast Over Current Detection pin (OCD)
- High bandwidth and high slew rate for fast response time
- Differential magnetic input range from ±5 mT up to ±30 mT
- Suitable to measure full scale currents from > 100 A on PCBA up to > 1000 A on external busbar
- 5 V supply voltage
- Differential sensing principle for superior magnetic stray field suppression

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### Potential applications

- Fast current measurement with necessity of over current protection
- Electronic fuse (eFuse)
- Circuit breakers
- Battery disconnect switch
- Motor drives

### Product validation

Product validation according to JEDEC JESD47.

### Description

The TLE5571 is a TMR (Tunnel Magneto Resistance) based coreless current sensor with ultra fast analog output and Over Current Detection (OCD), suitable for protection and high frequency switching applications that require current sensing with extremely small input to output delay.

| Product type | Description and features | Package | Marking | Ordering code |
|---|---|---|---|---|
| TLE5571-AE36O5-I-S0001 | 5 V supply, S1 sensitivity | PG-TDSO-16-10 | T71E1O51 | SP005911576 |
| TLE5571-AE24O5-I-S0001 | 5 V supply, S2 sensitivity | PG-TDSO-16-10 | T71E2O51 | SP005911580 |
| TLE5571-AE12O5-I-S0001 | 5 V supply, S3 sensitivity | PG-TDSO-16-10 | T71E3O51 | SP005911584 |
| TLE5571-AE06O5-I-S0001 | 5 V supply, S4 sensitivity | PG-TDSO-16-10 | T71E4O51 | SP005911631 |

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# 1 Functional block diagram

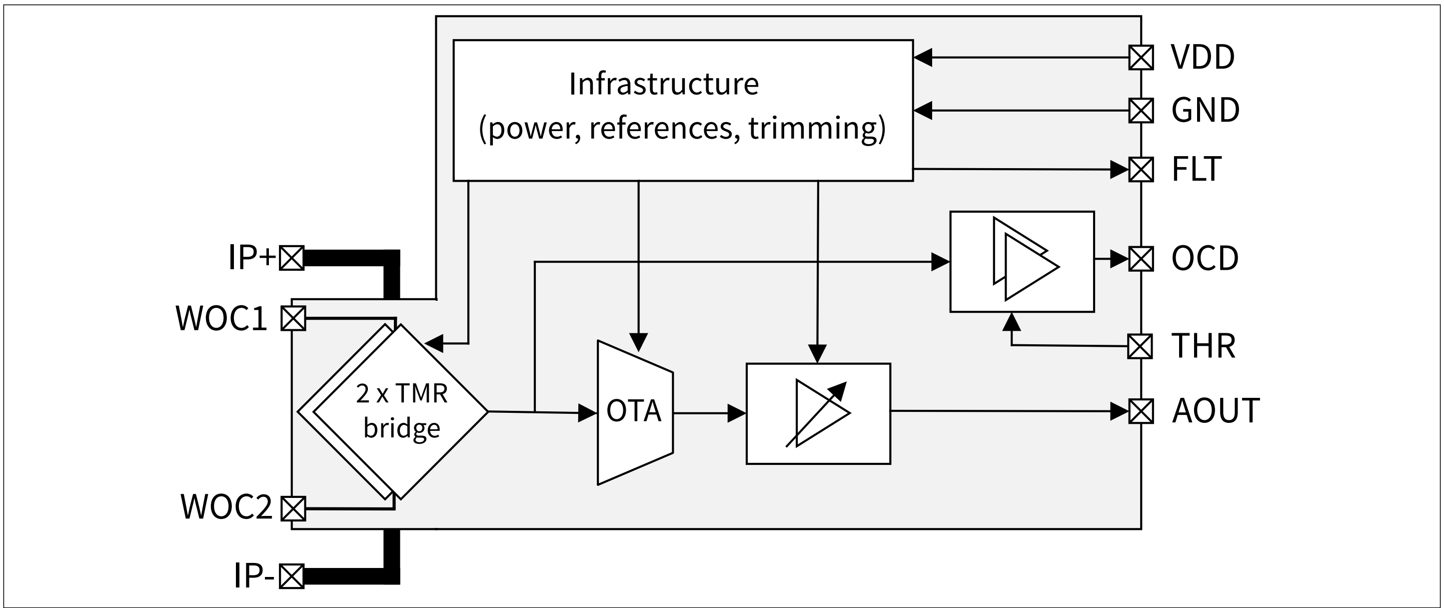


**Figure 1** **Device functional block diagram**

The TLE5571 is a TMR (Tunnel Magneto Resistance) based coreless current sensor for sensing AC and DC currents in external current rail applications. The device measures a magnetic field via two TMR bridges. The output signals from the TMR bridges are fed into a first stage of amplification via an Operational Transconductance Amplifier (OTA). The output of the OTA runs through a high-bandwidth and high slew rate differential amplifier, which provides a signal on the AOUT pin. Two fast comparators react to overcurrent events on positive and equivalent negative threshold by triggering the OCD pin. The threshold for the overcurrent detection is set externally using the THR pin. In case of internal failures, the sensor provides a fault information on the FLT pin. The sensor is temperature compensated, pre-calibrated and trimmed. Wire On Chip (WOC) pins provide testing capabilities of the device in the application with low test current.

# 2 Pin configuration

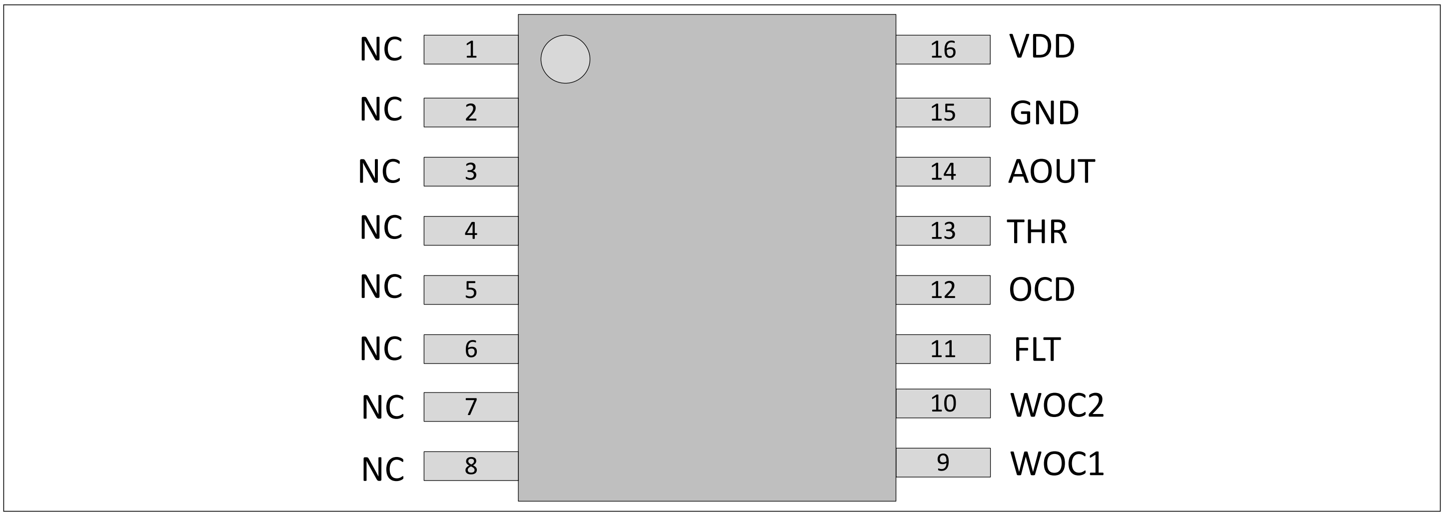


**Figure 2 Pin configuration**

**Table 1 Pin definitions and function**

| Pin No. | Symbol | Function | Comment |
|---|---|---|---|
| 1-8 | NC | Not connected with lead frame or sensor | Keep open |
| 9 | WOC1 | Wire On Chip negative terminal | Test pin 1) |
| 10 | WOC2 | Wire On Chip positive terminal | Test pin 1) |
| 11 | FLT | Fault pin for internal safety mechanisms indication | Open drain output, active low. Connect to GND if not used |
| 12 | OCD | Overcurrent detection pin | Open drain output, active low. Connect to GND if not used |
| 13 | THR | Pin to set the overcurrent detection threshold | Connect to GND if not used |
| 14 | AOUT | Analog output | – |
| 15 | GND | Ground | – |
| 16 | VDD | Supply voltage | – |

1) If the WOC1 and WOC2 pins are not used, connect either WOC1 or WOC2 to GND. If the WOC1 and WOC2 pins are used, it is recommended to ensure low impedance connection (< 500 Ω) of either WOC1 or WOC2 to either $V_{DD}$ or GND for best EMC performance.

# 3 General product characteristics

## 3.1 Absolute maximum ratings

***Note**: Please contact your Infineon sales representative for information about storage and shipping conditions.*

**Table 2 Absolute maximum ratings**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Electrical** | | | | | | |
| Supply voltage | $V_{DD}$ | -0.3 | – | 6.5 | V | |
| Voltage on AOUT, THR, OCD, FLT, WOC1, WOC2 pins | $V_{PINS}$ | -0.3 | – | $V_{DD}$ | V | |
| ESD voltage | $V_{ESD\_HBM}$ | -2 | – | 2 | kV | Human Body Model, according to AEC-Q100-002 |
| | $V_{ESD\_CDM}$ | -1 | – | 1 | kV | Charged Device Model, according to AEC-Q100-011 |
| Current through WOC1 and WOC2 pins | $I_{WOC}$ | -800 | – | 800 | mA | $t \leq 1$ ms consecutive; $t \leq 20$ h over lifetime; positive when entering WOC1 pin and exiting WOC2 pin |
| **Temperature** | | | | | | |
| Ambient temperature ABS MAX | $T_{A\_ABS}$ | -40 | – | 165 | °C | |
| **Magnetic** | | | | | | |
| Magnetic field at each TMR | $B_{TMR}$ | -75 | – | 75 | mT | $B_{TMR} = \pm\sqrt{(B_X^2 + B_Y^2)}$ |

***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 for extended periods 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.*

## 3.2 Functional range

The following functional range shall 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.

**Table 3 Functional range**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| **Electrical** | | | | | | |
| Supply voltage | $V_{DD}$ | 4.5 | 5 | 5.5 | V | |
| Undervoltage and overvoltage detection delay | $t_{D\_UVOV}$ | 0.3 | 2.4 | 3 | µs | From undervoltage/overvoltage event to $V_{FLT}$ = 50% $V_{DD}$ |
| Undervoltage reset threshold | $V_{UV\_RES}$ | 4 | – | – | V | $V_{DD}$ falling |
| Undervoltage release threshold | $V_{UV\_REL}$ | – | – | 4.5 | V | $V_{DD}$ rising |
| Overvoltage reset threshold | $V_{OV\_RES}$ | – | – | 6.15 | V | $V_{DD}$ rising |
| Overvoltage release threshold | $V_{OV\_REL}$ | 5.5 | – | – | V | $V_{DD}$ falling |
| Voltage on AOUT, OCD, FLT pins | $V_{AOUT\_OCD\_FLT}$ | -0.3 | – | $V_{DD}$ | V | |
| Voltage on THR pin | $V_{THR}$ | 0.432 | – | 3.89 | V | Non-ratiometric voltage. Refer to Chapter 4.3.4.1 for the min/max threshold limits for each $S_X$ range |
| **Temperature** | | | | | | |
| Ambient temperature | $T_A$ | -40 | – | 150 | °C | |
| **Magnetic** | | | | | | |
| Magnetic field at each TMR | $B_{TMR}$ | -35 | – | 35 | mT | $B_{TMR} = \pm\sqrt{(B_X^2+B_Y^2)}$ |
| Differential magnetic input range (BDIFF1) | $B_{DIFF1}$ | -30 | – | 30 | mT | $V_{DD}$ = 5 V |
| Differential magnetic input range (BDIFF2) | $B_{DIFF2}$ | -20 | – | 20 | mT | $V_{DD}$ = 5 V |
| Differential magnetic input range (BDIFF3) | $B_{DIFF3}$ | -10 | – | 10 | mT | $V_{DD}$ = 5 V |

**(table continues...)**

**Table 3 (continued) Functional range**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Differential magnetic input range (BDIFF4) | $B_{DIFF4}$ | -5 | – | 5 | mT | $V_{DD}$ = 5 V |
| **Circuit** | | | | | | |
| Capacitance on VDD and THR pins | $C_{VDD\_THR}$ | 90 | 100 | – | nF | External capacitance connected to VDD and THR pins. Typical value is a condition valid for all performance parameters unless otherwise specified |
| Capacitance on AOUT pin | $C_{AOUT}$ | 297 | 330 | 363 | pF | External capacitance connected to AOUT. Typical value is a condition valid for all performance parameters unless otherwise specified |
| Capacitance on OCD and FLT pins | $C_{OCD\_FLT}$ | 180 | 200 | 220 | pF | External capacitance connected to OCD and FLT pins. Typical value is a condition valid for all performance parameters unless otherwise specified |
| Pull-up resistor on AOUT pin | $R_{PU\_AOUT}$ | 24.3 | 33 | 42.9 | kΩ | External pull-up resistor to $V_{DD}$ connected to AOUT pin. Typical value is a condition valid for all performance parameters unless otherwise specified |
| Pull-up resistor on OCD and FLT pins | $R_{PU\_OCD\_FLT}$ | 0.9 | 4.7 | 6.2 | kΩ | External pull-up resistor to $V_{DD}$ connected to OCD and FLT pins. Typical value is a condition valid for all performance parameters unless otherwise specified |

## 3.3 Thermal resistance

**Table 4 Thermal resistance**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance | $R_{th,JA}$ | – | 102.9 | 150 | K/W | Junction to air on JEDEC 2s2p PCB, according to JEDEC JESD51-7 |

# 4 Product features

## 4.1 Electrical characteristics

**Table 5 Electrical characteristics**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Current consumption | $I_{DD}$ | – | 9 | 18 | mA | |
| Power-on time | $t_{PON}$ | – | – | 100 | µs | 1) |
| Analog output quiescent voltage | $V_{OQ}$ | – | $V_{DD}/2$ | – | V | 2) |
| Analog output low saturation voltage | $V_{AOUT\_SAT\_L}$ | – | – | 0.3 | V | |
| Analog output high saturation voltage | $V_{AOUT\_SAT\_H}$ | $V_{DD}$ - 0.3 | – | – | V | |
| Analog output slew rate | $SL_{AOUT}$ | 11 | – | – | V/µs | |
| Analog output drive capability | $I_{AOUT}$ | – | – | 4 | mA | |
| Analog output maximum impedance | $Z_{AOUT}$ | – | 0.5 | 1 | Ω | V(AOUT) = 0.5×$V_{DD}$ and I(AOUT) = $I_{AOUT\ (Max.)}$ |
| THR input impedance | $R_{IN\_THR}$ | 50 | 100 | 150 | kΩ | |
| OCD low voltage level | $V_{OCD\_LOW}$ | – | – | $V_{DD}/20$ | V | |
| FLT low voltage level | $V_{FLT\_LOW}$ | – | – | $V_{DD}/10$ | V | |

1) Device functions according to specification after power-on time, from the point in time when the supply voltage reaches the minimum value specified in the functional range.
2) Typical values are nominal design targets. The deviations from typical quiescent voltage are reported as offset error in Chapter 4.2.

## 4.2 Sensing characteristics

**Table 6 Sensing characteristics valid for all product types**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| OCD delay | $t_{D\_OCD}$ | – | 105 | 150 | ns | $B_{DIFF} = 2 \times B_{THR}$; differential magnetic input rise time ≥ 50 ns; from OCD event to $V_{OCD}$ = 50% $V_{DD}$ |
| OCD delay jitter | $\Delta t_{D\_OCD}$ | – | – | 16.5 | ns | $B_{DIFF} = 2 \times B_{THR}$; differential magnetic input rise time ≥ 50 ns; from OCD event to $V_{OCD}$ = 50% $V_{DD}$, standard deviation |
| OCD fall time | $t_{FALL\_OCD}$ | – | 15 | 22.5 | ns | From 90% of $V_{DD}$ to 10% of $V_{DD}$ |
| Analog output propagation delay | $t_{PD}$ | – | – | 90 | ns | From 20% of the differential magnetic input field to 20% of the output voltage |
| Analog output response time | $t_{RESPONSE}$ | – | – | 200 | ns | From 90% of the differential magnetic input field to 90% of the output voltage |
| Transfer function cutoff frequency | $BW$ | 2.5 | – | – | MHz | -3dB criterion |
| External homogeneous magnetic field suppression | $B_{SR}$ | – | 32 | – | dB | $\lvert B_{STRAY\_DC}\rvert \leq 5$ mT; $\lvert B_{STRAY\_AC}\rvert \leq 1.25$ mT; $f_{STRAY} \leq 1000$ Hz; AC RMS value, according to ISO 11452-8:2015 |
| Output noise | $B_{NOISE}$ | – | – | 6.6 | $\mu T_{RMS}$ | $BW$ = 2.5 MHz; referenced to differential magnetic input field |
| Initial offset | $E_{OFF\_INIT}$ | -180 | [-105, 130] | 200 | µT | $T_A$ = 25°C, 0 h; it can be compensated in the application by user end of line calibration [1)] |
| Offset drift over temperature | $E_{OFF\_T}$ | -145 | [-85, 119] | 183 | µT | -40°C ≤ $T_A$ < 25°C [1)] |
| | | -149 | [-91, 91] | 149 | µT | 25°C ≤ $T_A$ ≤ 125°C [1)] |
| | | -186 | [-114, 114] | 186 | µT | 25°C ≤ $T_A$ ≤ 150°C [1)] |
| Offset drift over temperature and lifetime | $E_{OFF\_L}$ | -211 | [-141, 119] | 183 | µT | -40°C ≤ $T_A$ < 25°C [1)] |
| | | -215 | [-139, 122] | 189 | µT | 25°C ≤ $T_A$ ≤ 125°C [1)] |
| | | -215 | [-139, 122] | 191 | µT | 25°C ≤ $T_A$ ≤ 150°C [1)] |

*1)* Typical value is defined as a range based on 3$\sigma$ analysis.

**Table 7** **Sensing characteristics TLE5571-AE36O5-I-S0001**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Sensitivity (S1) | $S1$ | – | 72 | – | mV/mT | $T_A$ = 25°C, 0 h [1)] |
| WOC sensitivity (S1) | $S1_{WOC}$ | – | 682.56 | – | mV/A | $T_A$ = 25°C, 0 h [1)] |
| OCD threshold level accuracy (S1) | $OCD_{THR\_TOL}$ | – | [-5.8, 5.5] | – | % | -40°C ≤ $T_A$ ≤ 25°C [2) 3) 4) 5) 6)] |
| | | – | [-5.6, 4.9] | – | % | 25°C ≤ $T_A$ ≤ 125°C [2) 3) 4) 5) 6)] |
| | | – | [-5.8, 5] | – | % | 25°C ≤ $T_A$ ≤ 150°C [2) 3) 4) 5) 6)] |
| Hysteresis error (S1) | $E_{HYST}$ | – | [-322.3, 322.3] | – | µT | [3) 4)] |
| Non-linearity error (S1) | $E_{NL}$ | – | [-1.4, 1.4] | – | % | [4) 5)] |
| Initial sensitivity error (S1) | $E_{SENS}$ | – | [-0.5, 4.7] | – | % | $T_A$ = 25°C, 0 h; it can be compensated in the application by user end of line calibration [3) 4) 6)] |
| Sensitivity drift over temperature (S1) | $E_{SENS\_T}$ | – | [-2.3, 2.5] | – | % | -40°C ≤ $T_A$ < 25°C [3) 4) 6)] |
| | | – | [-2.5, 2.2] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3) 4) 6)] |
| | | – | [-2.6, 2.2] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3) 4) 6)] |
| Sensitivity drift over temperature and lifetime (S1) | $E_{SENS\_L}$ | – | [-2.3, 4.1] | – | % | -40°C ≤ $T_A$ < 25°C [3) 4) 6)] |
| | | – | [-3.2, 2.6] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3) 4) 6)] |
| | | – | [-3.4, 2.6] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3) 4) 6)] |
| Total drift over temperature (S1) | $E_{TOT\_T}$ | – | [-3.3, 3.3] | – | % | -40°C ≤ $T_A$ < 25°C [3) 4) 5) 6)] |
| | | – | [-3.3, 3.1] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3) 4) 5) 6)] |
| | | – | [-3.3, 3.4] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3) 4) 5) 6)] |
| Total drift over temperature and lifetime (S1) | $E_{TOT\_L}$ | – | [-4.3, 4.2] | – | % | -40°C ≤ $T_A$ < 25°C [3) 4) 5) 6)] |
| | | – | [-3.9, 4] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3) 4) 5) 6)] |
| | | – | [-4.2, 4] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3) 4) 5) 6)] |

1) Typical values refer to best-fit characteristic.
2) OCD threshold limits in [%*FS*] and in [V] on THR pin are reported in Chapter 4.3.4.1.

3) Typical value is defined as a range based on 3σ analysis.
4) Valid only within functional range (Table 3) and: -5 ≤ $B_{X1}/B_{X2}$ ≤ -1 or -5 ≤ $B_{X2}/B_{X1}$ ≤ -1. In addition, $|B_{DIFF\_ABS\_MAX}|$ ≤ 6×*FS;* if this limit is exceeded, the hysteresis error might be out of specifications, impacting the total drift.
5) Percentage of full scale (*FS*) of the differential magnetic input range.
6) Total drift, OCD threshold level accuracy and sensitivity related error parameters are defined after an end-of-line best-fit calibration at system level to compensate initial errors. In addition, they consider that a systematic error is compensated by applying a systematic sensitivity compensation factor ($K_{COMP\_S}$) to the sensitivity measured during calibration, as described in Chapter 5.3. The total drift is calculated for each individual sensor by combining noise, hysteresis, non-linearity, offset drift and sensitivity drift errors, referenced to $T_A$ = 25°C, 0 h.

**Table 8 Sensing characteristics TLE5571-AE24O5-I-S0001**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Sensitivity (S2) | *S2* | – | 108 | – | mV/mT | $T_A$ = 25°C, 0 h [1)] |
| WOC sensitivity (S2) | $S2_{WOC}$ | – | 1023.84 | – | mV/A | $T_A$ = 25°C, 0 h [1)] |
| OCD threshold level accuracy (S2) | $OCD_{THR\_TOL}$ | – | [-8.3, 7.8] | – | % | -40°C ≤ $T_A$ < 25°C [2) 3) 4) 5) 6)] |
| | | – | [-8.6, 7.3] | – | % | 25°C ≤ $T_A$ ≤ 125°C [2) 3) 4) 5) 6)] |
| | | – | [-9, 7.6] | – | % | 25°C ≤ $T_A$ ≤ 150°C [2) 3) 4) 5) 6)] |
| Hysteresis error (S2) | $E_{HYST}$ | – | [-257.8, 257.8] | – | µT | [3) 4)] |
| Non-linearity error (S2) | $E_{NL}$ | – | [-0.7, 0.7] | – | % | [4) 5)] |
| Initial sensitivity error (S2) | $E_{SENS}$ | – | [0.4, 5.3] | – | % | $T_A$ = 25°C, 0 h; it can be compensated in the application by user end of line calibration [3) 4) 6)] |
| Sensitivity drift over temperature (S2) | $E_{SENS\_T}$ | – | [-2.4, 2.4] | – | % | -40°C ≤ $T_A$ < 25°C [3) 4) 6)] |
| | | – | [-2.3, 2.4] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3) 4) 6)] |
| | | – | [-2.3, 2.5] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3) 4) 6)] |
| Sensitivity drift over temperature and lifetime (S2) | $E_{SENS\_L}$ | – | [-2.4, 3.9] | – | % | -40°C ≤ $T_A$ < 25°C [3) 4) 6)] |
| | | – | [-3, 2.6] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3) 4) 6)] |
| | | – | [-3.2, 2.6] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3) 4) 6)] |

**(table continues...)**

**Table 8 (continued) Sensing characteristics TLE5571-AE24O5-I-S0001**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Total drift over temperature (S2) | $E_{TOT\_T}$ | – | [-3.5, 3.4] | – | % | -40°C ≤ $T_A$ < 25°C 3) 4) 5) 6) |
| | | – | [-3.3, 3.1] | – | % | 25°C ≤ $T_A$ ≤ 125°C 3) 4) 5) 6) |
| | | – | [-3.3, 3.1] | – | % | 25°C ≤ $T_A$ ≤ 150°C 3) 4) 5) 6) |
| Total drift over temperature and lifetime (S2) | $E_{TOT\_L}$ | – | [-4.6, 4.6] | – | % | -40°C ≤ $T_A$ < 25°C 3) 4) 5) 6) |
| | | – | [-3.5, 3.5] | – | % | 25°C ≤ $T_A$ ≤ 125°C 3) 4) 5) 6) |
| | | – | [-3.8, 3.5] | – | % | 25°C ≤ $T_A$ ≤ 150°C 3) 4) 5) 6) |

1) Typical values refer to best-fit characteristic.
2) OCD threshold limits in [%*FS*] and in [V] on THR pin are reported in Chapter 4.3.4.1.
3) Typical value is defined as a range based on 3σ analysis.
4) Valid only within functional range (Table 3) and: -5 ≤ $B_{X1}/B_{X2}$ ≤ -1 or -5 ≤ $B_{X2}/B_{X1}$ ≤ -1. In addition, $|B_{DIFF\_ABS\_MAX}|$ ≤ 6×*FS;* if this limit is exceeded, the hysteresis error might be out of specifications, impacting the total drift.
5) Percentage of full scale (*FS*) of the differential magnetic input range.
6) Total drift, OCD threshold level accuracy and sensitivity related error parameters are defined after an end-of-line best-fit calibration at system level to compensate initial errors. In addition, they consider that a systematic error is compensated by applying a systematic sensitivity compensation factor ($K_{COMP\_S}$) to the sensitivity measured during calibration, as described in Chapter 5.3. The total drift is calculated for each individual sensor by combining noise, hysteresis, non-linearity, offset drift and sensitivity drift errors, referenced to $T_A$ = 25°C, 0 h.

**Table 9 Sensing characteristics TLE5571-AE12O5-I-S0001**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Sensitivity (S3) | *S3* | – | 216 | – | mV/mT | $T_A$ = 25°C, 0 h 1) |
| WOC sensitivity (S3) | $S3_{WOC}$ | – | 2047.68 | – | mV/A | $T_A$ = 25°C, 0 h 1) |
| OCD threshold level accuracy (S3) | $OCD_{THR\_TOL}$ | – | [-12.6, 11.7] | – | % | -40°C ≤ $T_A$ < 25°C 2) 3) 4) 5) 6) |
| | | – | [-10.6, 9.3] | – | % | 25°C ≤ $T_A$ ≤ 125°C 2) 3) 4) 5) 6) |
| | | – | [-10.6, 9.3] | – | % | 25°C ≤ $T_A$ ≤ 150°C 2) 3) 4) 5) 6) |
| Hysteresis error (S3) | $E_{HYST}$ | – | [-128.9, 132.9] | – | µT | 3) 4) |
| Non-linearity error (S3) | $E_{NL}$ | – | [-0.6, 0.6] | – | % | 4) 5) |

**(table continues...)**

**Table 9** **(continued) Sensing characteristics TLE5571-AE12O5-I-S0001**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Initial sensitivity error (S3) | $E_{SENS}$ | – | [-0.3, 4.6] | – | % | $T_A$ = 25°C, 0 h; it can be compensated in the application by user end of line calibration 3) 4) 6) |
| Sensitivity drift over temperature (S3) | $E_{SENS\_T}$ | – | [-2.7, 2.2] | – | % | -40°C ≤ $T_A$ < 25°C 3) 4) 6) |
| | | – | [-2, 2.6] | – | % | 25°C ≤ $T_A$ ≤ 125°C 3) 4) 6) |
| | | – | [-2.1, 2.8] | – | % | 25°C ≤ $T_A$ ≤ 150°C 3) 4) 6) |
| Sensitivity drift over temperature and lifetime (S3) | $E_{SENS\_L}$ | – | [-2.7, 3.5] | – | % | -40°C ≤ $T_A$ < 25°C 3) 4) 6) |
| | | – | [-2.8, 2.6] | – | % | 25°C ≤ $T_A$ ≤ 125°C 3) 4) 6) |
| | | – | [-2.9, 2.8] | – | % | 25°C ≤ $T_A$ ≤ 150°C 3) 4) 6) |
| Total drift over temperature (S3) | $E_{TOT\_T}$ | – | [-3.8, 3.8] | – | % | -40°C ≤ $T_A$ < 25°C 3) 4) 5) 6) |
| | | – | [-3.9, 3.8] | – | % | 25°C ≤ $T_A$ ≤ 125°C 3) 4) 5) 6) |
| | | – | [-3.9, 3.8] | – | % | 25°C ≤ $T_A$ ≤ 150°C 3) 4) 5) 6) |
| Total drift over temperature and lifetime (S3) | $E_{TOT\_L}$ | – | [-5.1, 5] | – | % | -40°C ≤ $T_A$ < 25°C 3) 4) 5) 6) |
| | | – | [-3.9, 3.8] | – | % | 25°C ≤ $T_A$ ≤ 125°C 3) 4) 5) 6) |
| | | – | [-3.9, 3.8] | – | % | 25°C ≤ $T_A$ ≤ 150°C 3) 4) 5) 6) |

1) Typical values refer to best-fit characteristic.
2) OCD threshold limits in [%*FS*] and in [V] on THR pin are reported in Chapter 4.3.4.1.
3) Typical value is defined as a range based on 3σ analysis.
4) Valid only within functional range (Table 3) and: -5 ≤ $B_{X1}/B_{X2}$ ≤ -1 or -5 ≤ $B_{X2}/B_{X1}$ ≤ -1. In addition, $|B_{DIFF\_ABS\_MAX}| \leq 6\times FS$; if this limit is exceeded, the hysteresis error might be out of specifications, impacting the total drift.
5) Percentage of full scale (*FS*) of the differential magnetic input range.
6) Total drift, OCD threshold level accuracy and sensitivity related error parameters are defined after an end-of-line best-fit calibration at system level to compensate initial errors. In addition, they consider that a systematic error is compensated by applying a systematic sensitivity compensation factor ($K_{COMP\_S}$) to the sensitivity measured during calibration, as described in Chapter 5.3. The total drift is calculated for each individual sensor by combining noise, hysteresis, non-linearity, offset drift and sensitivity drift errors, referenced to $T_A$ = 25°C, 0 h.

**Table 10** **Sensing characteristics TLE5571-AE06O5-I-S0001**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Sensitivity (S4) | $S4$ | – | 432 | – | mV/mT | $T_A$ = 25°C, 0 h [1] |
| WOC sensitivity (S4) | $S4_{WOC}$ | – | 4095.36 | – | mV/A | $T_A$ = 25°C, 0 h [1] |
| OCD threshold level accuracy (S4) | $OCD_{THR\_TOL}$ | – | [-17.7, 16.1] | – | % | -40°C ≤ $T_A$ < 25°C [2] [3] [4] [5] [6] |
| | | – | [-16.5, 13.7] | – | % | 25°C ≤ $T_A$ ≤ 125°C [2] [3] [4] [5] [6] |
| | | – | [-16.5, 13.7] | – | % | 25°C ≤ $T_A$ ≤ 150°C [2] [3] [4] [5] [6] |
| Hysteresis error (S4) | $E_{HYST}$ | – | [-64.5, 66.5] | – | µT | [3] [4] |
| Non-linearity error (S4) | $E_{NL}$ | – | [-0.6, 0.6] | – | % | [4] [5] |
| Initial sensitivity error (S4) | $E_{SENS}$ | – | [-0.3, 4.6] | – | % | $T_A$ = 25°C, 0 h; it can be compensated in the application by user end of line calibration [3] [4] [6] |
| Sensitivity drift over temperature (S4) | $E_{SENS\_T}$ | – | [-2.7, 2.1] | – | % | -40°C ≤ $T_A$ < 25°C [3] [4] [6] |
| | | – | [-2, 2.7] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3] [4] [6] |
| | | – | [-2, 2.9] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3] [4] [6] |
| Sensitivity drift over temperature and lifetime (S4) | $E_{SENS\_L}$ | – | [-2.7, 3.3] | – | % | -40°C ≤ $T_A$ < 25°C [3] [4] [6] |
| | | – | [-2.8, 2.7] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3] [4] [6] |
| | | – | [-2.9, 2.9] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3] [4] [6] |
| Total drift over temperature (S4) | $E_{TOT\_T}$ | – | [-4.3, 4.1] | – | % | -40°C ≤ $T_A$ < 25°C [3] [4] [5] [6] |
| | | – | [-4.6, 4.4] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3] [4] [5] [6] |
| | | – | [-4.6, 4.4] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3] [4] [5] [6] |
| Total drift over temperature and lifetime (S4) | $E_{TOT\_L}$ | – | [-6.1, 5.3] | – | % | -40°C ≤ $T_A$ < 25°C [3] [4] [5] [6] |
| | | – | [-4.6, 4.4] | – | % | 25°C ≤ $T_A$ ≤ 125°C [3] [4] [5] [6] |
| | | – | [-4.6, 4.6] | – | % | 25°C ≤ $T_A$ ≤ 150°C [3] [4] [5] [6] |

1) Typical values refer to best-fit characteristic.

*2)* OCD threshold limits in [%*FS*] and in [V] on THR pin are reported in Chapter 4.3.4.1.
*3)* Typical value is defined as a range based on 3σ analysis.
*4)* Valid only within functional range (Table 3) and: $-5 \leq B_{X1}/B_{X2} \leq -1$ or $-5 \leq B_{X2}/B_{X1} \leq -1$. In addition, $|B_{DIFF\_ABS\_MAX}| \leq 6 \times FS$; if this limit is exceeded, the hysteresis error might be out of specifications, impacting the total drift.
*5)* Percentage of full scale (*FS*) of the differential magnetic input range.
*6)* Total drift, OCD threshold level accuracy and sensitivity related error parameters are defined after an end-of-line best-fit calibration at system level to compensate initial errors. In addition, they consider that a systematic error is compensated by applying a systematic sensitivity compensation factor ($K_{COMP\_S}$) to the sensitivity measured during calibration, as described in Chapter 5.3. The total drift is calculated for each individual sensor by combining noise, hysteresis, non-linearity, offset drift and sensitivity drift errors, referenced to $T_A$ = 25°C, 0 h.

## 4.3 Functional description

### 4.3.1 Output behavior

The AOUT pin operates as an output and provides an analog output voltage with high bandwidth and high slew rate. Being $S$ the sensitivity and $V_{OQ}$ the quiescent voltage of the sensor, the output voltage on AOUT is described as follows:

$$V\left(AOUT\right) = V_{OQ} + S \times B_{DIFF} = \frac{V_{DD}}{2} + S \times B_{DIFF} \tag{1}$$

Where $B_{DIFF}$ is defined as the differential magnetic field $B_X$ at the two TMR bridges location:

$$B_{DIFF} = B_{X1} - B_{X2} \tag{2}$$

### 4.3.2 Output voltage and current polarity

The output voltage V(AOUT) is higher than then quiescent voltage $V_{OQ}$ if $B_X$ on $TMR_1$ is higher than $B_X$ on $TMR_2$ ($B_{DIFF}$ > 0). In the figure below, the current flowing through the external conductor underneath the sensor is positive when it flows from pin 1 to 8. When a current is flowing in the integrated WOC test circuit, the output voltage V(AOUT) is higher than then quiescent voltage $V_{OQ}$ if the test current $I_{WOC}$ enters WOC1 pin and exits WOC2 pin.

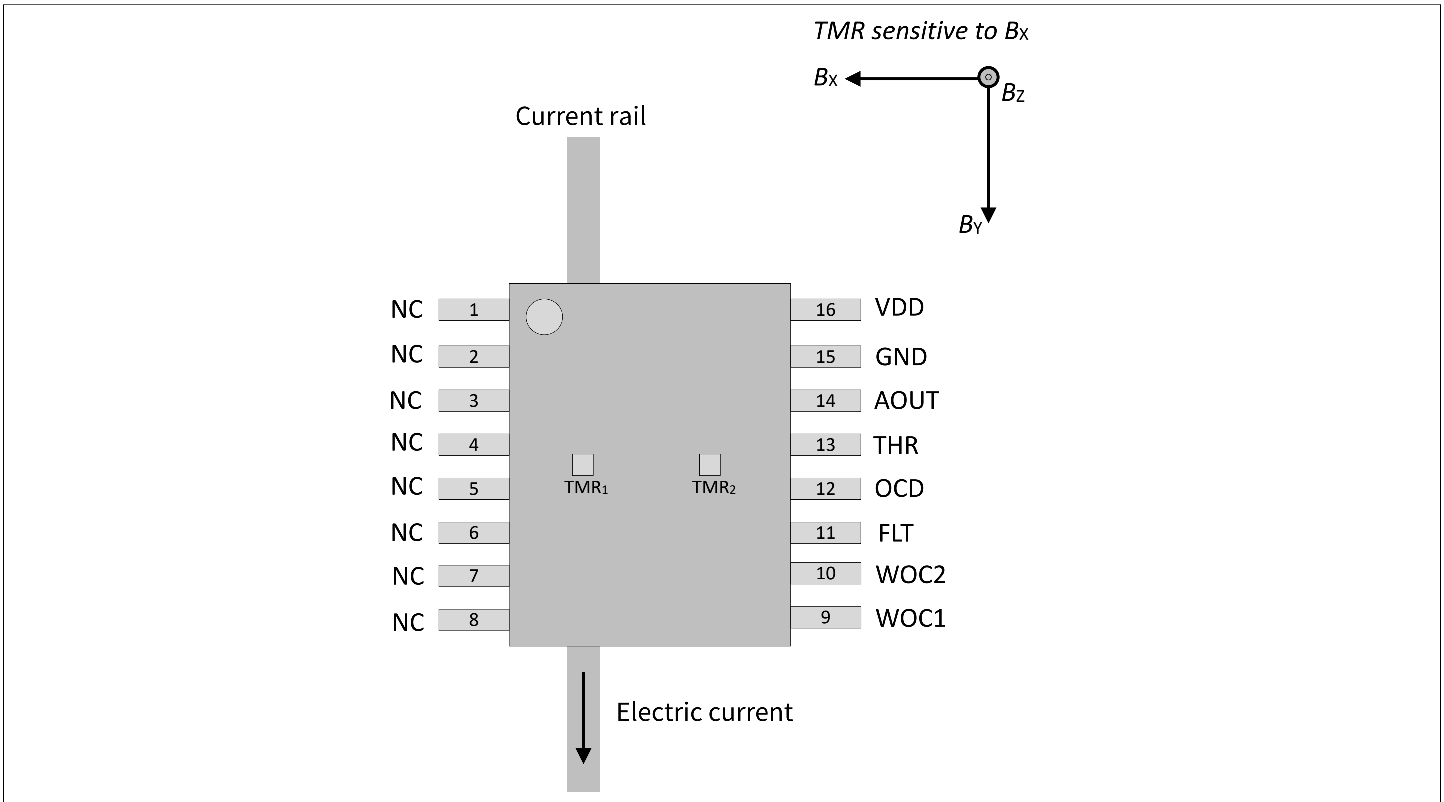


**Figure 3 Polarity definition based on the Right-Hand rule and conventional electric current flow notation**

### 4.3.3 Definition of full scale and errors

The differential magnetic input full scale (*FS* [mT]), analog output full scale (*FS* [V]), $E_{OFF}$, $E_{SENS}$ and $E_{NL}$ errors are defined in the following figure.

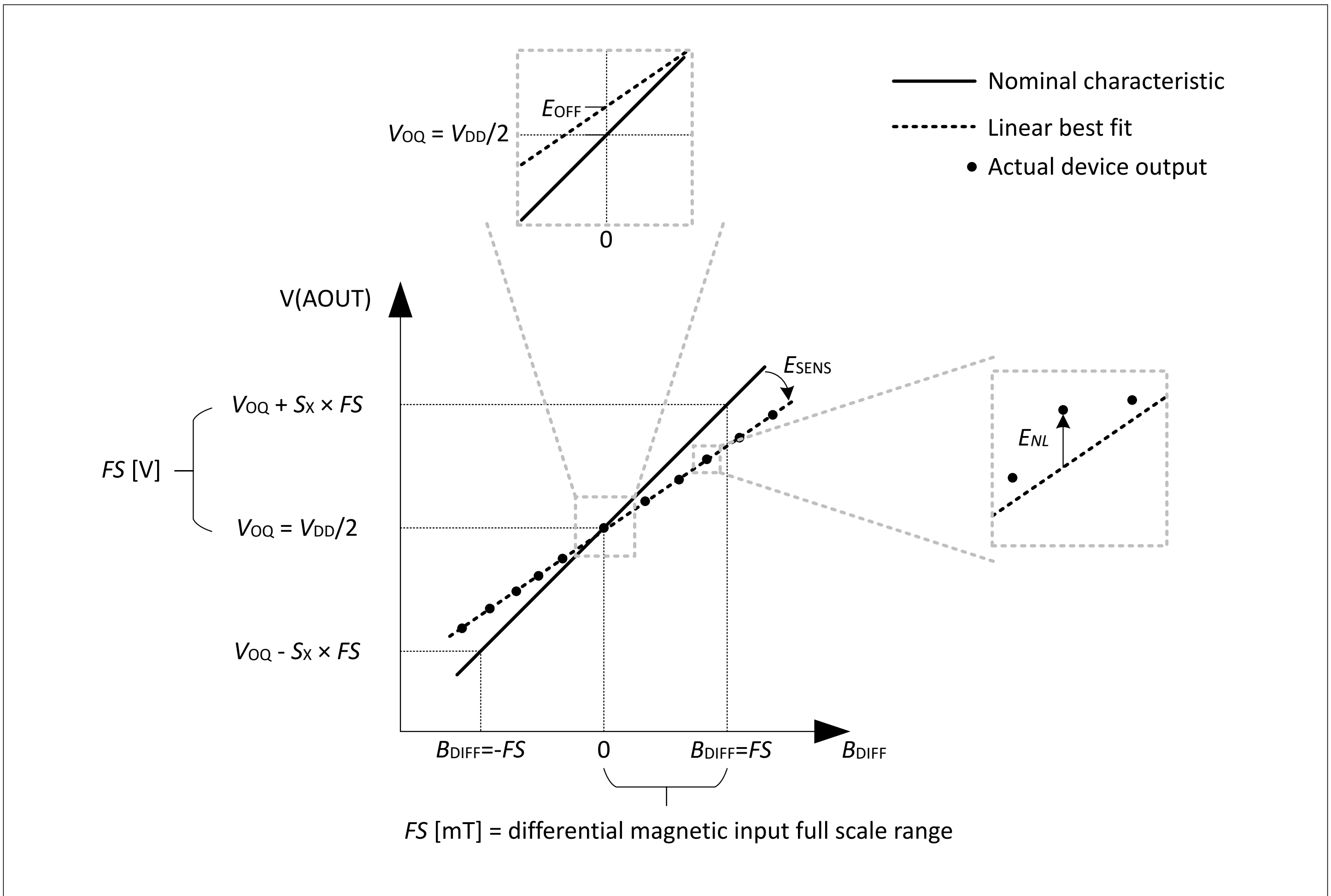


**Figure 4 Full scale (*FS*), $E_{OFF}$, $E_{SENS}$, $E_{NL}$ definitions**

***Note**: The errors specified in Chapter 4.2 are referred to the differential magnetic input full scale (FS). Referring the errors to the whole [-FS ... FS] range would reduce the errors by a factor of two.*

### 4.3.4 OCD - Over Current Detection

The device provides fast Over Current Detection (OCD) on the OCD pin in case of an overcurrent event. The overcurrent condition is present when the input current absolute value (positive or negative) is higher than the chosen threshold level. The threshold can be set externally via the THR pin.

#### 4.3.4.1 OCD threshold

The threshold level of the OCD output is set externally via the THR pin. The threshold level is used symmetrically for positive and negative overcurrent events. The min/max OCD thresholds in percentage of the full scale range for each measurement range ($S_X$) and the corresponding THR pin voltages are defined in the table below.

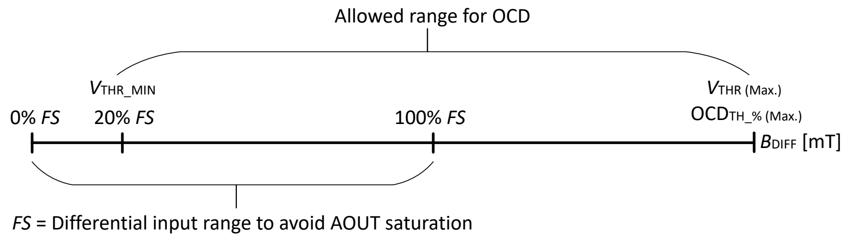


**Figure 5 OCD range with respect to the magnetic input range full scale**

**Table 11 OCD threshold**

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| OCD threshold | $OCD_{TH\_\%}$ | 20 | – | 90 | % | *S1* range. $\|B_{TMR}\| \leq 35$ mT [1] |
| | | 20 | – | 135 | % | *S2* range. $\|B_{TMR}\| \leq 35$ mT [1] |
| | | 20 | – | 180 | % | *S3* range. $\|B_{TMR}\| \leq 35$ mT [1] |
| | | 20 | – | 180 | % | *S4* range. $\|B_{TMR}\| \leq 35$ mT [1] |
| | $V_{THR}$ | 0.432 | – | 1.94 | V | *S1* range. $\|B_{TMR}\| \leq 35$ mT |
| | | 0.432 | – | 2.92 | V | *S2* range. $\|B_{TMR}\| \leq 35$ mT |
| | | 0.432 | – | 3.89 | V | *S3* range. $\|B_{TMR}\| \leq 35$ mT |
| | | 0.432 | – | 3.89 | V | *S4* range. $\|B_{TMR}\| \leq 35$ mT |

*1)* Percentage of differential magnetic input range full scale (*FS*).

The voltage $V_{THR}$ to be set externally on the THR pin to reach a desired OCD threshold can be calculated with the following formula:

$$V_{\mathrm{THR}} = \frac{OCD_{\mathrm{THR}} \times S_X \times TF}{10^6} = OCD_{\mathrm{THR}} \times S \qquad (3)$$

Where:

- $V_{THR}$ is the voltage set externally on the THR pin in [V]. It is recommended to use a non-ratiometric voltage to set the threshold;
- $OCD_{THR}$ is the desired OCD threshold level in [A];
- $S_X$ is the sensitivity in [mV/mT];
- *TF* is the current rail transfer factor in [µT/A];
- *S* is the sensitivity in [V/A].

***Note**: While setting the OCD threshold the $B_{TMR}$ limits specified in Table 2 and Table 3 shall be taken into account. If $B_{TMR}$ value specified in the Functional Range is exceeded, the OCD threshold accuracy may be out of specification. If $B_{TMR}$ value specified in the Absolute Maximum Ratings is exceeded, some device characteristics may be permanently altered.*

#### 4.3.4.2 OCD pins external connection

The OCD pin operates as active low, open-drain output. This allows easy setup of a wired-AND configuration (logic OR) 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.

The OCD output is not latched, hence it is set to low state when there is an overcurrent event on the current rail and is released when the overcurrent event disappears.

#### 4.3.4.3 OCD output timing behavior

The figure below shows the OCD output pin behavior during an overcurrent event and defines important timing quantities for which the limits are listed in Chapter 4.2.

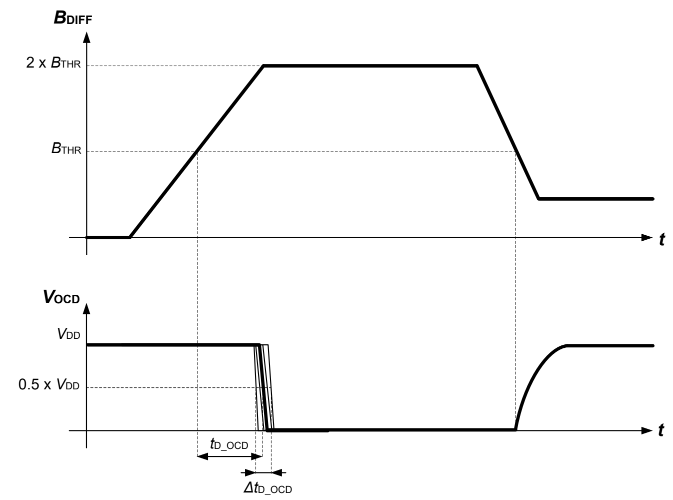


**Figure 6 OCD output timing behavior**

### 4.3.5 Output noise

Output noise referenced to differential magnetic input field can be expressed according to the following formula:

$$V_{\mathrm{NOISE}} = B_{\mathrm{NOISE}} \times S \times 10^{-3} \tag{4}$$

Where:

- $V_{NOISE}$ is the output noise voltage in [$mV_{RMS}$];
- $B_{NOISE}$ is the output noise referenced to differential magnetic input field [$\mu T_{RMS}$];
- $S$ is the sensitivity in [mV/mT].

### 4.3.6 Undervoltage and overvoltage detection

In case of undervoltage condition ($V_{DD} \leq V_{UV\_RES}$), the sensor provides a fault indication by setting the voltage on FLT pin to low.

In case of overvoltage condition ($V_{DD} \geq V_{OV\_RES}$), the sensor provides a fault indication by setting the voltage on FLT pin to low.

# 5 Application information

## 5.1 Application circuit

The figures below shows an example application circuit of the device.

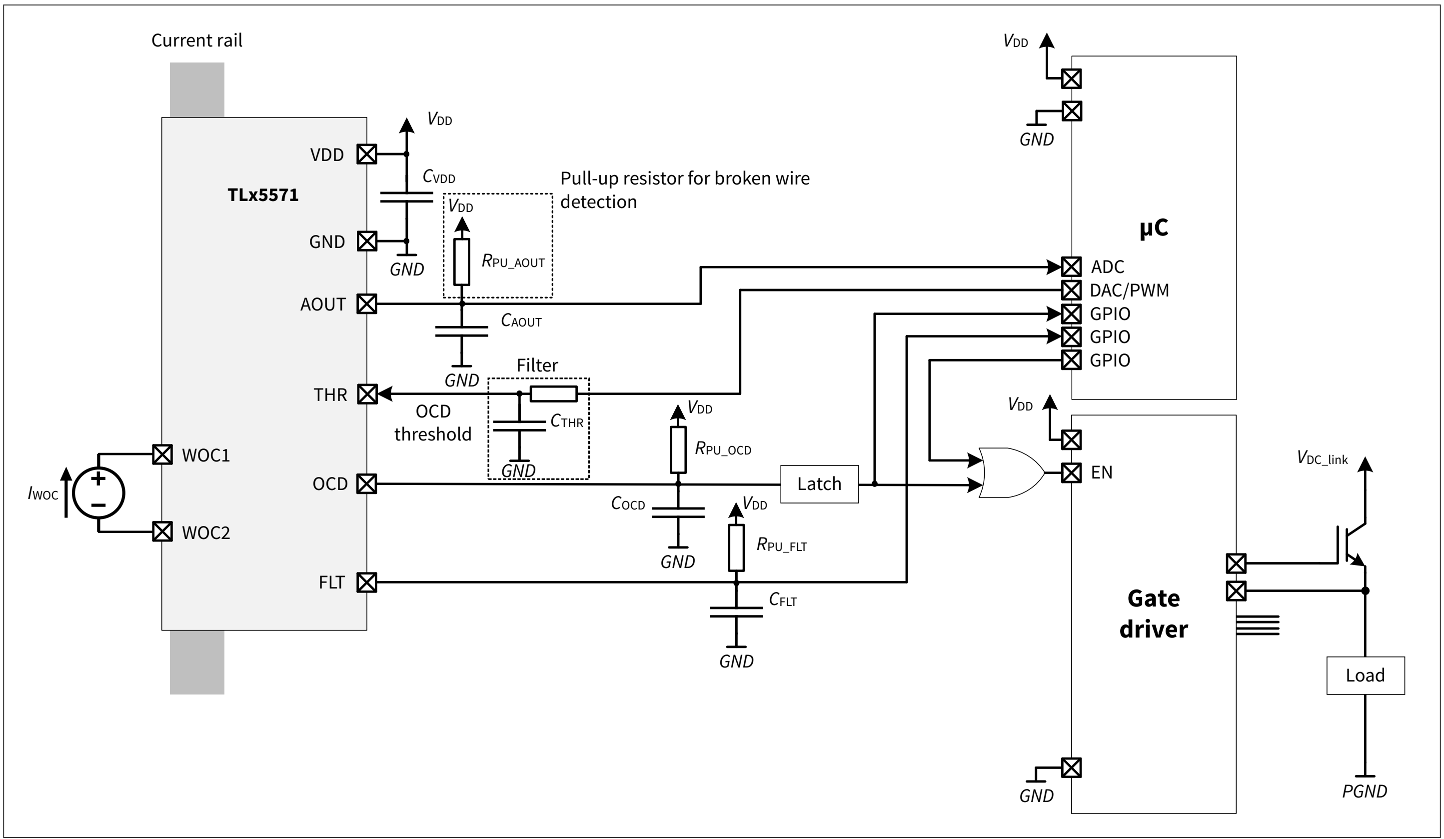


**Figure 7** **Example application diagram**

*Note: This is a simplified example of an application circuit. The function must be verified in the real application.*

## 5.2 External current rail design

TLE5571 senses the current flowing in an external conductor. Depending on the external conductor design, different transfer factors [T/A] can be achieved. Additionally, depending on the conductor design and sensor placement, different performance in terms of accuracy and response time are obtained at system level.

### 5.2.1 U-shape conductor

The following figure shows an example of U-shape conductor configuration. The conductor consists in 3 layers of a 4 layers PCB (the top layer is used for routing). 3 slits are used to generate a "U shape" electric current path. In this example, TLE5571 is centered on the central slit. In this configuration, the magnetic field in X direction on $TMR_1$ and $TMR_2$ is respectively positive and negative, however equal in absolute value in case of symmetric placement. As a result $B_{DIFF}$ >0, hence the sensor indicates a positive current. It is important to ensure that the $B_{TMR}$ limits specified in Table 2 and Table 3 are respected. If $B_{TMR}$ value specified in the Functional Range is exceeded, the accuracy may be out of specification. If $B_{TMR}$ value specified in the Absolute Maximum Ratings is exceeded, some device characteristics may be permanently altered.

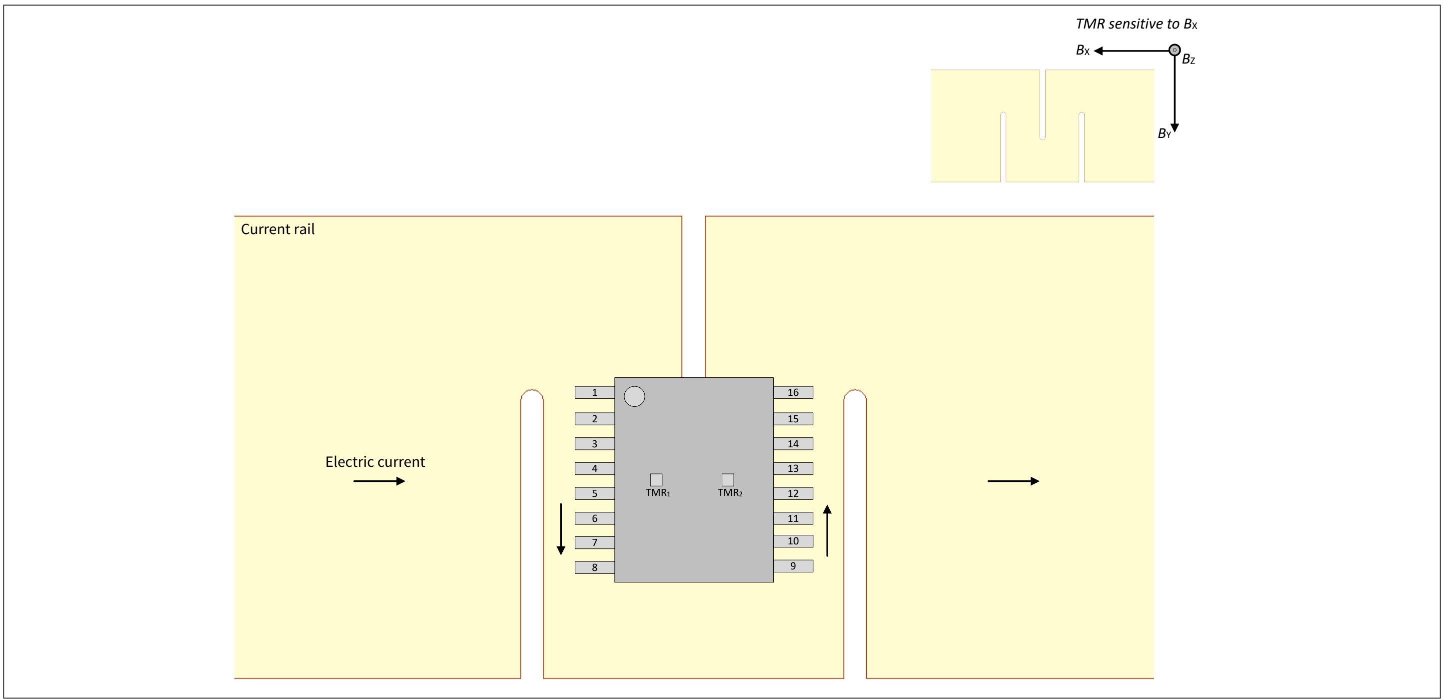


**Figure 8** U-shape sensing structure example

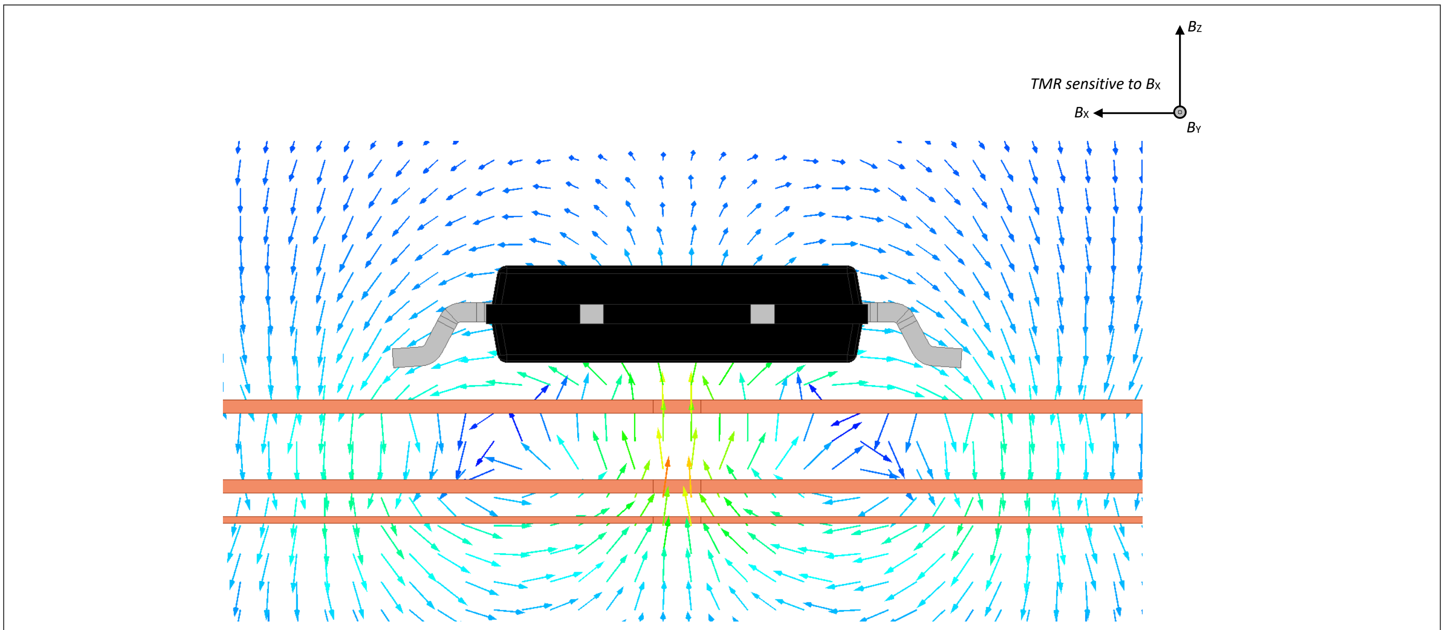


**Figure 9** U-shape sensing structure *B* field distribution

## 5.3 In-system calibration

In order to achieve optimal accuracy performance at system level it is recommended to perform the calibration of sensitivity [V/A] and offset [V] at room temperature when the sensor is integrated into the system during an end of line test.

The sensitivity needs to be calibrated in order to compensate the errors due to displacement of the sensor during mounting and soldering, as well as the initial sensitivity error of the sensor [mV/mT] due to part to part variation.

The offset needs to be calibrated in order to compensate the offset introduced by the interface between sensor and microcontroller, as well as the initial offset error of the sensor due to part to part variation.

### 5.3.1 Error due to mechanical displacement

Due to mechanical placement and production tolerances, the sensor may not be perfectly aligned to the external conductor, and the transfer factor of the system [mT/A] may be different compared to the nominal value simulated during the design. For this reason, to achieve optimal accuracy performance a calibration is recommended in the system.

### 5.3.2 Initial offset error calibration

The initial offset error $V_{OFF}$ is defined as the difference between the output voltage on the AOUT pin when the current flowing in the external conductor is zero and the quiescent voltage $V_{OQ}$.

$$V_{\mathrm{OFF}} = V_{\mathrm{AOUT}}(0\mathrm{A}) - V_{\mathrm{OQ}} = V_{\mathrm{AOUT}}(0\mathrm{A}) - \frac{\mathrm{V_{DD}}}{2} \tag{5}$$

In order to measure the offset of the sensor, the user shall:

- control the current in the external conductor to zero;
- measure the voltage on the AOUT pin in correspondence of zero current;
- subtract the quiescent voltage from the measured value.

The obtained value corresponds to the offset.

***Note**: Being $V_{OQ}$ equal to $V_{DD}/2$, $V_{DD}$ shall also be measured to exclude the errors due to $V_{DD}$ variations.*

### 5.3.3 Initial sensitivity error calibration

In order to measure the sensitivity of the sensor (including the errors due to mechanical displacement described in Chapter 5.3.1), the user shall:

- measure the voltage on the AOUT pin when no current is flowing in order to measure the offset (see Chapter 5.3.2); perform the offset measurement before applying any test current to avoid an impact of hysteresis;
- inject a test current $I_{TEST}$ in the sensing structure. $I_{TEST}$ shall be at least 10% of the target full scale current in order to achieve low noise in the sensitivity measurement and it shall be applied for a low enough time to prevent a high temperature rise of the device during calibration;
- measure the voltage on the AOUT pin in correspondence of $I_{TEST}$;
- measure the $I_{TEST}$ itself using a calibrated current source, a shunt combined with a multimeter or any other precise current measurement device.

The measured sensitivity $S_{TEST}$ is then calculated using the following formula:

$$S_{\mathrm{TEST}} = \frac{V_{\mathrm{AOUT}}(I_{\mathrm{TEST}}) - V_{\mathrm{AOUT}}(0\mathrm{A})}{I_{\mathrm{TEST}}} \tag{6}$$

Repeat the voltage measurement on AOUT pin for multiple test current values up to full scale range and determine the best-fit value $S_{BEST\_FIT.}$ Finally, the calibrated sensitivity $S_M$ is defined as:

$$S_M = S_{BEST\_FIT} \times \frac{(100 + K_{COMP\_S})}{100} \tag{7}$$

where $K_{COMP\_S}$ = 1 is the systematic sensitivity compensation factor. Correcting the measured sensitivity by this factor symmetrizes the sensitivity drift and total drift over temperature at 0 h.

### 5.3.4 Initial errors compensation

Once the initial offset and sensitivity errors due to mechanical displacement and part to part variations are known, they can be compensated in the microcontroller by using the following formula:

$$I = \frac{V_{\mathrm{AOUT}} - V_{\mathrm{OQ}} - V_{\mathrm{OFF}}}{S_{\mathrm{M}}} = \frac{V_{\mathrm{AOUT}} - \frac{V_{\mathrm{DD}}}{2} - V_{\mathrm{OFF}}}{S_{\mathrm{M}}} \tag{8}$$

The sensitivity measured on AOUT pin during the calibration phase shall also be taken into account when setting the OCD (Over Current Detection) threshold in order to compensate the initial OCD threshold error and the sensitivity error due to mechanical tolerances:

$$V_{\mathrm{THR}} = OCD_{\mathrm{THR}} \times S_M \tag{9}$$

Where:

- $V_{THR}$ is the voltage to be applied on the THR pin [V];
- $OCD_{THR}$ is the desired OCD threshold level in [A];
- $S_M$ is the calibrated sensitivity in [V/A].

# 6 Package

The device is mounted in the PG-TDSO-16-10 package.

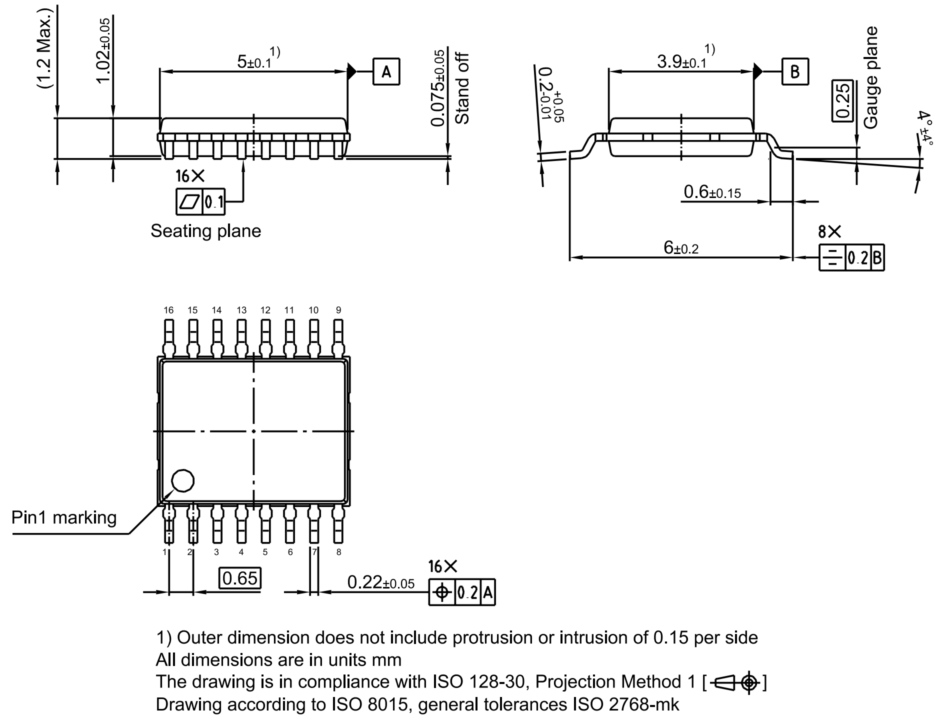


**Figure 10 PG-TDSO-16-10 package outline**

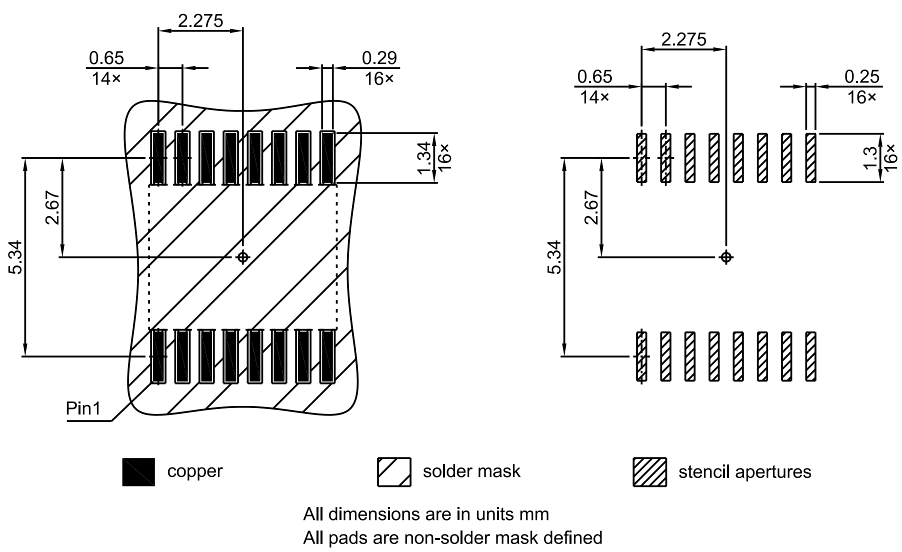


**Figure 11 PG-TDSO-16-10 package footprint**

The sensing elements are placed symmetrically with respect to the center of the package, at a distance of 0.6 mm. Hence, the sensor pitch (distance between the two TMR bridges) is 1.2 mm. The sensing elements position tolerance is reported in the drawing below.

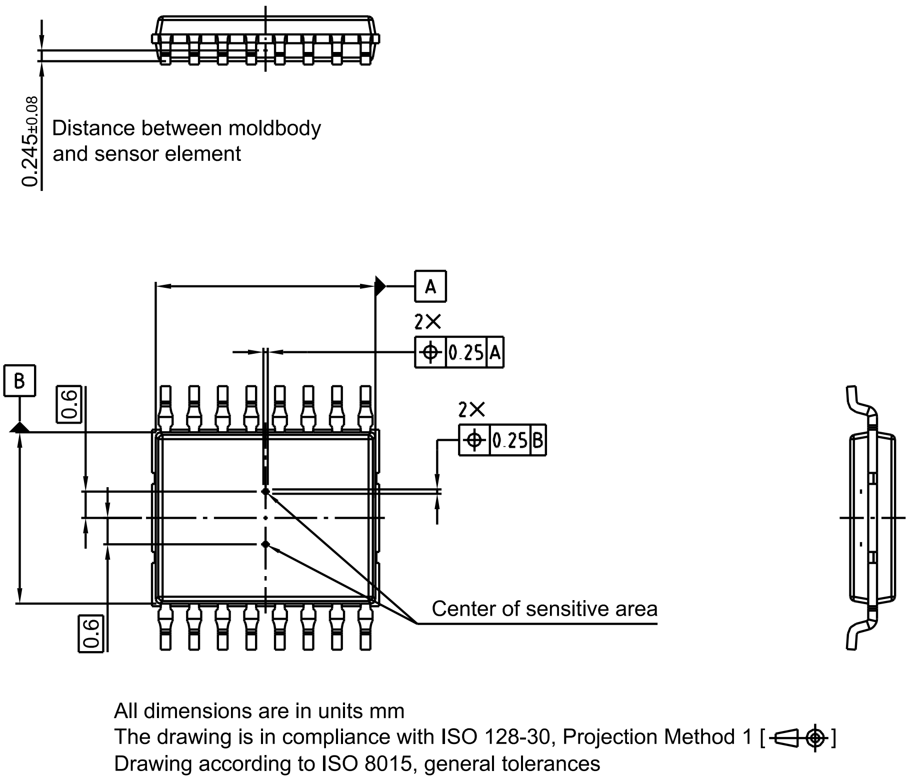


**Figure 12** **PG-TDSO-16-10 sensitive area specifications**

The PG-TDSO-16-10 package fulfills the MSL level 2a according to IPC/JEDEC J-STD-033B.1.

The package marking of the device is as shown in the figure below.

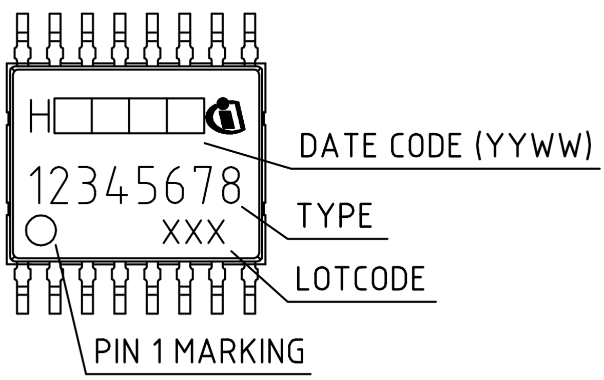


**Figure 13** **Package marking frontside**

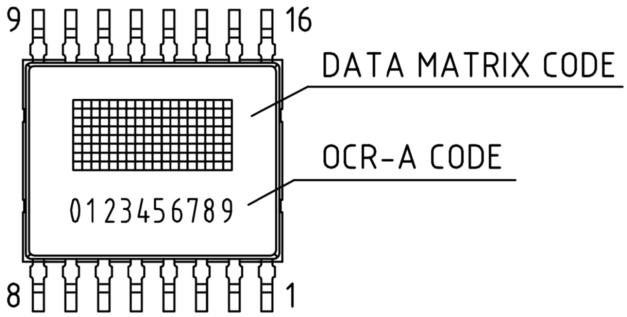


**Figure 14** **Package marking backside**

# 7 Revision history

**Table 12 Revision history**

| Revision number | Date of release | Description of changes |
|---|---|---|
| Rev. 1.00 | 2026-01-13 | Initial release |

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