# AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
# DHAB S/106

## Introduction

The DHAB family is best suited for DC, AC, or pulsed currents measurement in high power and low voltage automotive applications. It features galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The DHAB family gives you a choice of having different current measuring ranges in the same housing (from ± 20 up to ± 900 A).

## Features

- Ratiometric transducer
- Open Loop transducer using the Hall effect
- Low voltage application
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±20 A for channel 1 and ±500 A for channel 2
- Maximum RMS primary admissible current: defined by busbar to have $T < +150$ °C
- Operating temperature range: −40 °C < $T$ < +125 °C
- Output voltage: full ratiometric (in sensitivity and offset).

## Special feature

- Dual channel sensor for wider measurement range and redundancy.

## Advantages

- Good accuracy for high and low current range
- Good linearity
- Low thermal offset drift
- Low thermal sensitivity drift
- Hermetic package.

## Automotive applications

- Battery Pack Monitoring
- Hybrid Vehicles
- EV and utility vehicles.

## Principle of DHAB family

The open loop transducers uses a Hall effect integrated circuit. The magnetic flux density $B$, contributing to the rise of the Hall voltage, is generated by the primary current $I_P$ to be measured.
The current to be measured $I_P$ is supplied by a current source i.e. battery or generator (Figure 1).
Within the linear region of the hysteresis cycle, $B$ is proportional to:

$$B\ (I_P) = a \times I_P$$

The Hall voltage is thus expressed by:

$$V_H = (c_H / d) \times I_H \times a \times I_P$$

Except for $I_P$, all terms of this equation are constant.
Therefore:

$$V_H = b \times I_P$$

| | |
|---|---|
| $a$ | constant |
| $b$ | constant |
| $c_H$ | Hall coefficient |
| $d$ | thickness of the Hall plate |
| $I_H$ | current across the Hall plates |

The measurement signal $V_H$ amplified to supply the user output voltage or current.

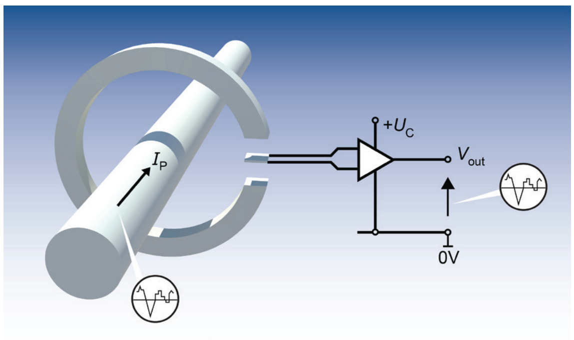
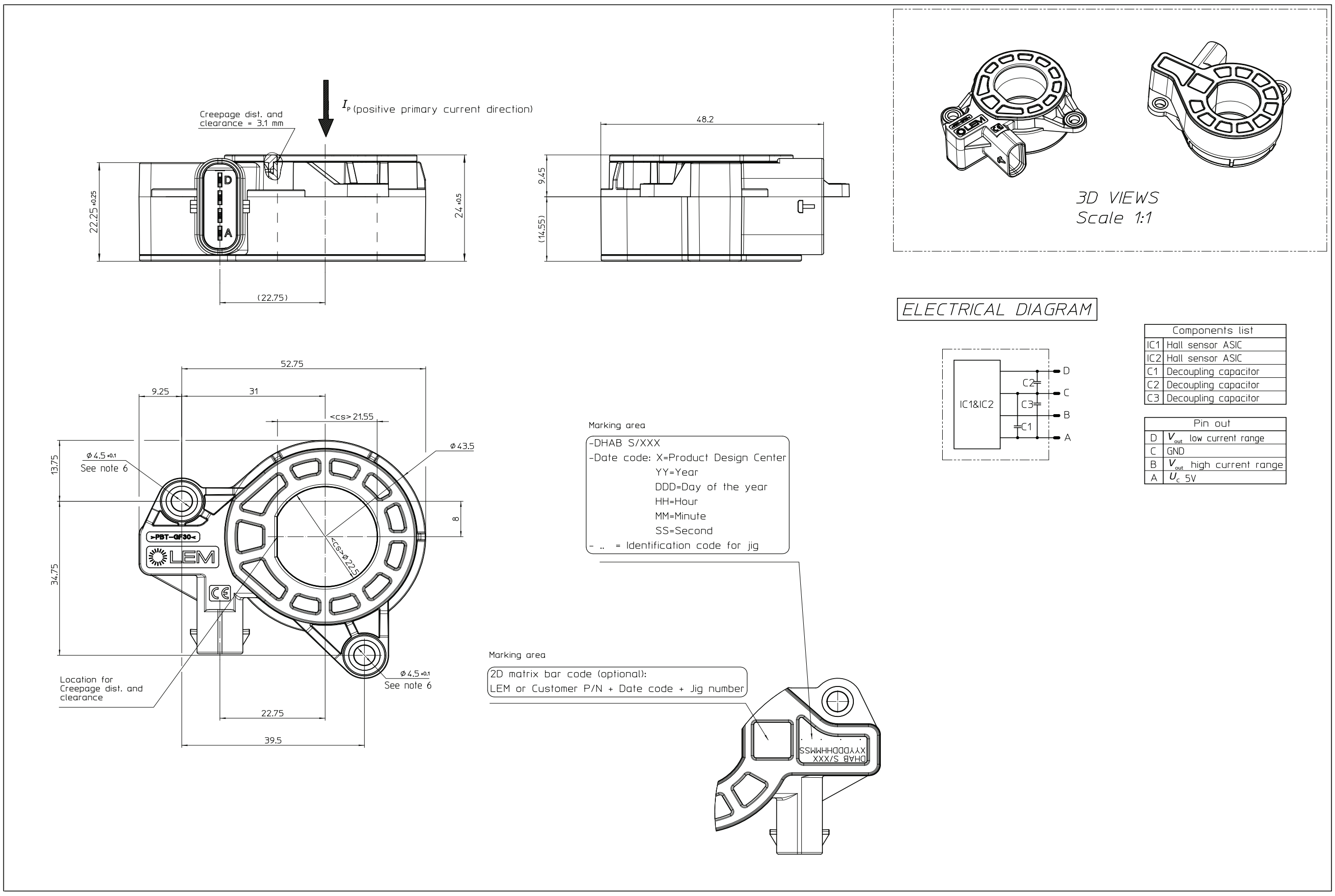



Fig. 1: Principle of the open loop transducer.

## Dimensions (in mm)




## Mechanical characteristics

- Plastic case >PBT-GF30<
- Magnetic core Channel 1: FeNi alloy
  Channel 2: FeSi alloy
- Mass 82 g
- Electrical terminal coating Brass tin plated
- Degrees of protection provided by enclosure IP6K9K

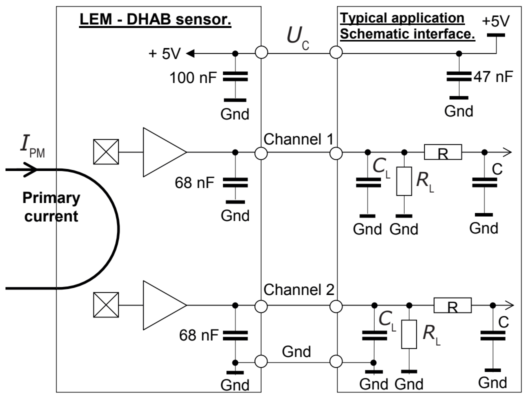
## Mounting recommendations

- Connector type TYCO 1-1456426-5
- Assembly torque max 2.5 N·m (for M4 x 0.7)
- Soldering type N/A

## Remark

- $V_{out} > V_O$ when $I_P$ flows in the positive direction (see arrow on drawing).

## System architecture (example)




$R_L$ > 10 kΩ optional resistor for signal line diagnostic
$C_L$ < 100 nF EMC protection
$R_C$ Low pass filter EMC protection (optional)


LEM reserves the right to carry out modifications on its transducers, in order to improve them, without prior notice

## Absolute ratings (not operating)

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---|---|---|---|---|---|---|
| | | | Min | Typical | Max | |
| Maximun supply voltage | $U_C$ | V | −14 | | 14 | |
| Ambient storage temperature | $T_S$ | °C | −40 | | 125 | |
| Electrostatic discharge voltage | $U_{ESD}$ | V | | | 8 | IEC 61000-4-2-ISO 10605 |
| RMS voltage for AC insulation test, 50 Hz, 1 min | $U_d$ | V | | | 2.5 | ISO 16750-2 |
| Creepage distance | $d_{Cp}$ | mm | | 3.1 | | |
| Clearance | $d_{Cl}$ | mm | | 3.1 | | |
| Comparative tracking index | $CTI$ | | | PLC3 | | |
| Maximum output current | $I_{out}$ | mA | −10 | | 10 | Continuous |
| Maximum output voltage (Analog) | $V_{out}$ | V | −14 | | 14 | Ouput over voltage, 1 min @ $T_A$ = 25 °C |
| Insulation resistance | $R_{IS}$ | mΩ | 500 | | | 500 V DC, ISO 16750-2 |
| Maximum output short circuit duration | $t_c$ | s | | | 120 | |

## Operating characteristics in nominal range ($I_{PN}$)

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---|---|---|---|---|---|---|
| | | | Min | Typical | Max | |
| **Electrical Data** | | | | | | |
| Supply voltage [1] | $U_C$ | V | 4.75 | 5 | 5.25 | |
| Current consumption | $I_C$ | mA | | 15 | 20 | |
| Maximum output current | $I_{out}$ | mA | −1 | | 1 | |
| Load resistance | $R_L$ | KΩ | 10 | | | |
| Capacitive loading | $C_L$ | nF | 1 | | 100 | |
| Ambient operating temperature | $T_A$ | °C | −10 | | 65 | High accuracy |
| | | | −40 | | 125 | Reduced accuracy |
| **Performance Data channel 1** | | | | | | |
| Primary current, measuring range | $I_{PM\ channel\ 1}$ | A | −20 | | 20 | |
| Primary nominal DC or RMS current | $I_{PN\ channel\ 1}$ | A | −20 | | 20 | @ $T_A$ = 25 °C |
| Offset voltage | $V_O$ | V | | 2.5 | | @ $U_C$ = 5 V |
| Sensitivity | $G$ | mV/A | | 100 | | @ $U_C$ = 5 V |
| Resolution | | mV | | 2.5 | | @ $U_C$ = 5 V |
| Output clamping voltage min [1] | $V_{SZ}$ | V | 0.2 | 0.25 | 0.3 | @ $U_C$ = 5 V |
| Output clamping voltage max [1] | | V | 4.7 | 4.75 | 4.8 | @ $U_C$ = 5 V |
| Output internal resistance | $R_{out}$ | Ω | | 1 | 10 | |
| Frequency bandwidth [2] | $BW$ | Hz | | 70 | | @ −3 dB |
| Power up time | | ms | | 25 | 200 | |
| Setting time after over load | | ms | | | 25 | |
| Ratiometricity error | $\varepsilon_r$ | % | −0.6 | | 0.6 | |
| Output voltage noise peak-peak | $V_{no\ p\text{-}p}$ | mV | −10 | | 10 | |
| **Performance Data channel 2** | | | | | | |
| Primary current, measuring range | $I_{PM\ channel\ 2}$ | A | −500 | | 500 | |
| Primary nominal DC or RMS current | $I_{PN\ channel\ 2}$ | A | −500 | | 500 | @ $T_A$ = 25 °C |
| Offset voltage | $V_O$ | V | | 2.5 | | @ $U_C$ = 5 V |
| Sensitivity | $G$ | mV/A | | 4 | | @ $U_C$ = 5 V |
| Resolution | | mV | | 2.5 | | @ $U_C$ = 5 V |
| Output clamping voltage min [1] | $V_{SZ}$ | V | 0.2 | 0.25 | 0.3 | @ $U_C$ = 5 V |
| Output clamping voltage max [1] | | V | 4.7 | 4.75 | 4.8 | @ $U_C$ = 5 V |
| Output internal resistance | $R_{out}$ | Ω | | 1 | 10 | |
| Frequency bandwidth [2] | $BW$ | Hz | | 70 | | @ −3 dB |
| Power up time | | ms | | 25 | 200 | |
| Setting time after over load | | ms | | | 25 | |
| Ratiometricity error | $\varepsilon_r$ | % | −0.6 | | 0.6 | |
| Output voltage noise peak-peak | $V_{no\ p\text{-}p}$ | mV | −10 | | 10 | |

Notes: [1] The output voltage $V_{out}$ is fully ratiometric. The offset and sensitivity are dependent on the supply voltage $U_C$ relative to the following formula:

$$I_P = \left(\frac{5}{U_C} \times V_{out} - V_O\right) \times \frac{1}{G} \text{ with } G \text{ in (V/A)}$$

[2] Primary current frequencies must be limited in order to avoid excessive heating of the busbar, magnetic core and the ASIC (see feature paragraph in page 1).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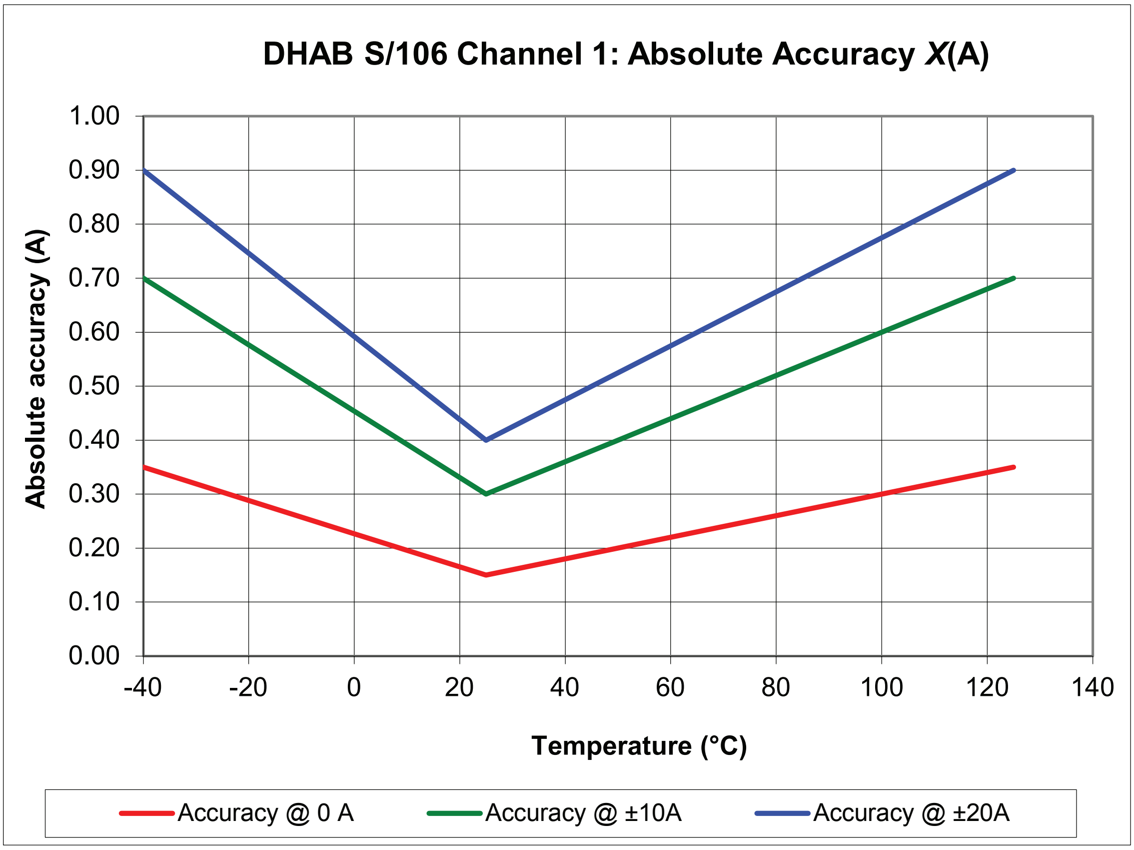
# Accuracy

### Channel 1

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---|---|---|---|---|---|---|
| | | | Min | Typical | Max | |
| **Electrical Data** | | | | | | |
| Electrical offset current | $I_{OE}$ | A | | ±0.07 | | @$T_A$ = 25 °C |
| Magnetic offset current | $I_{OM}$ | A | | ±0.03 | | @$T_A$ = 25 °C |
| Offset current | $I_O$ | A | −0.15 | | 0.15 | @$T_A$ = 25 °C |
| | | | −0.23 | | 0.23 | @ −10 °C < $T°$ < 65 °C |
| | | | −0.35 | | 0.35 | @ −40 °C < $T°$ < 125 °C |
| Sensitivity error | $\varepsilon_G$ | % | | ±0.4 | | @$T_A$ = 25 °C |
| | | | | ±1.0 | | @ −10 °C < $T°$ < 65 °C |
| | | | | ±1.5 | | @ −40 °C < $T°$ < 125 °C |
| Linearity error | $\varepsilon_L$ | % | | ±0.5 | | @$T_A$ = 25 °C, @ $U_c$ = 5 V, of full range |

### Accuracy table

| Parameter | Symbol | Unit | Temperature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | −40 °C | −20 °C | 0 °C | 25 °C | 65 °C | 125 °C |
| Accuracy @ 0 A | $X$ | A | 0.35 | 0.29 | 0.23 | 0.15 | 0.23 | 0.35 |
| Accuracy @ ±10 A | | | 0.70 | 0.58 | 0.45 | 0.30 | 0.46 | 0.70 |
| Accuracy @ ±20 A | | | 0.90 | 0.75 | 0.59 | 0.40 | 0.60 | 0.90 |



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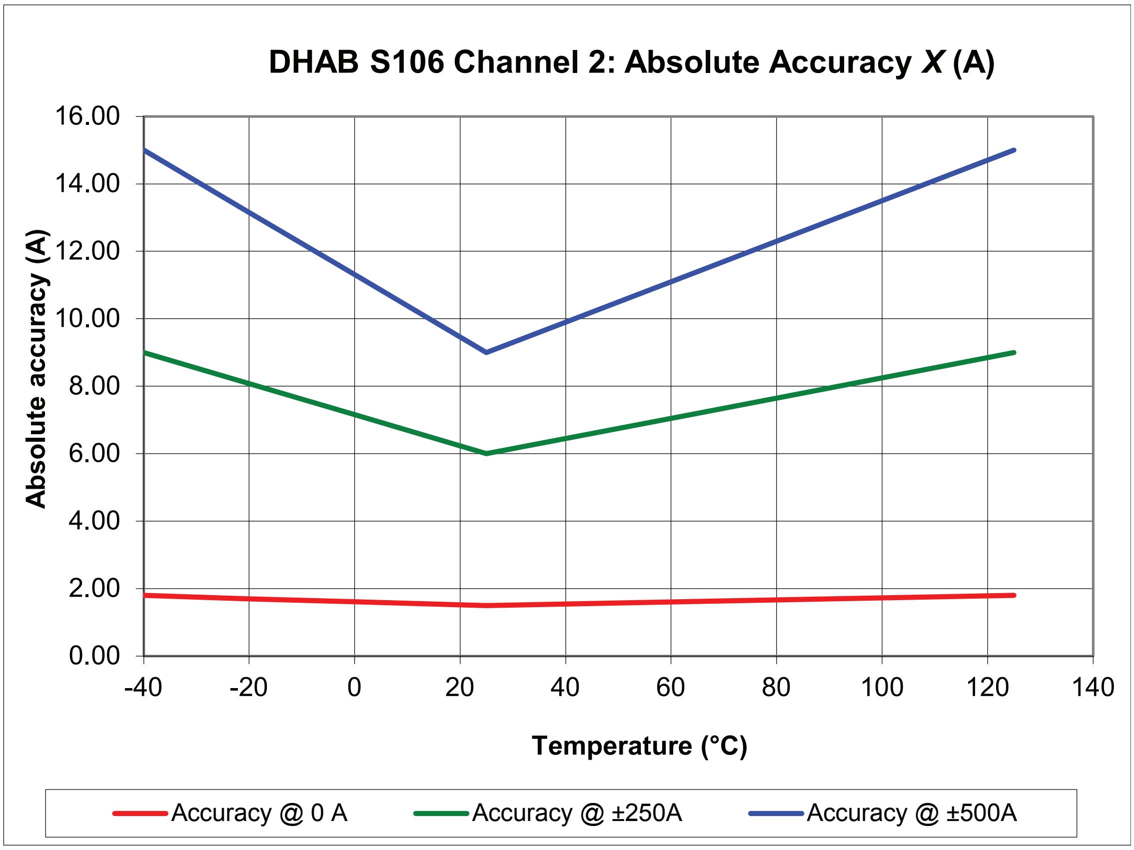
## Accuracy

### Channel 2

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---|---|---|---|---|---|---|
| | | | Min | Typical | Max | |
| **Electrical Data** | | | | | | |
| Electrical offset current | $I_{OE}$ | A | | ±0.6 | | @$T_A$= 25 °C |
| Magnetic offset current | $I_{OM}$ | A | | ±0.25 | | @$T_A$= 25 °C |
| Offset current | $I_O$ | A | −1.5 | | 1.5 | @$T_A$= 25 °C |
| | | | −1.62 | | 1.62 | @ −10 °C < $T°$ < 65 °C |
| | | | −1.8 | | 1.8 | @ - 40 °C < $T°$ < 125 °C |
| Sensitivity error | $\varepsilon_G$ | % | | ±0.4 | | @$T_A$= 25 °C |
| | | | | ±0.8 | | @ −10 °C < $T°$ < 65 °C |
| | | | | ±1.2 | | @ −40 °C < $T°$ < 125 °C |
| Linearity error | $\varepsilon_L$ | % | | ±0.5 | | @ $T_A$ = 25 °C, @ $U_c$ = 5 V, of full range |

### Accuracy table

| Parameter | Symbol | Unit | Temperature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | −40 °C | −20 °C | 0 °C | 25 °C | 65 °C | 125 °C |
| Accuracy @ 0 A | $X$ | A | 1.80 | 1.70 | 1.61 | 1.50 | 1.62 | 1.80 |
| Accuracy @ ±250 A | | | 9.00 | 8.08 | 7.15 | 6.00 | 7.20 | 9.00 |
| Accuracy @ ±500 A | | | 15.00 | 13.15 | 11.31 | 9.00 | 11.40 | 15.00 |





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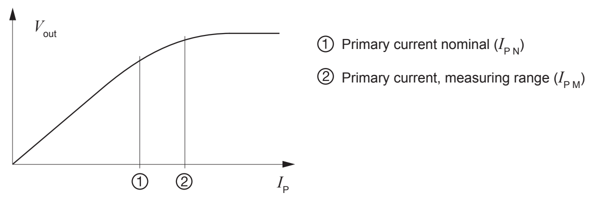
## PERFORMANCES PARAMETERS DEFINITIONS

### Primary current definition:




### Definition of typical, minimum and maximum values:

Minimum and maximum values for specified limiting and safety conditions have to be understood as such as values shown in “typical” graphs. On the other hand, measured values are part of a statistical distribution that can be specified by an interval with upper and lower limits and a probability for measured values to lie within this interval. Unless otherwise stated (e.g. “100 % tested”), the LEM definition for such intervals designated with “min” and “max” is that the probability for values of samples to lie in this interval is 99.73 %. For a normal (Gaussian) distribution, this corresponds to an interval between −3 sigma and +3 sigma. If “typical” values are not obviously mean or average values, those values are defined to delimit intervals with a probability of 68.27 %, corresponding to an interval between −sigma and +sigma for a normal distribution. Typical, minimum and maximum values are determined during the initial characterization of a product.

### Output noise voltage:

The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

### Magnetic offset:

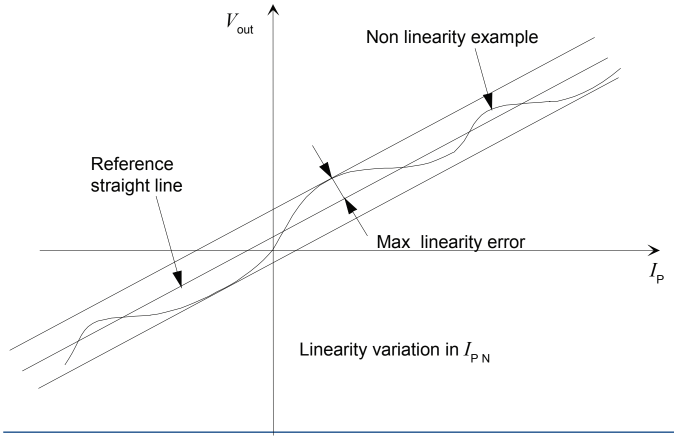
The magnetic offset is the consequence of an over-current on the primary side. It’s defined after an excursion of $I_{PN}$.

### Linearity:

The maximum positive or negative discrepancy with a reference straight line $V_{out} = f(I_P)$.
Unit: linearity (%) expressed with full scale of $I_{PN}$.

### Response time (delay time) $t_r$:

The time between the primary current signal ($I_{PN}$) and the output signal reach at 90 % of its final value.

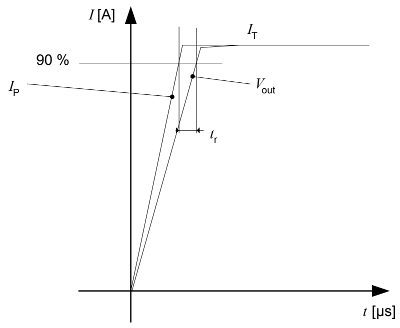



### Sensitivity:

The transducer’s sensitivity $G$ is the slope of the straight line $V_{out} = f(I_P)$, it must establish the relation:

$$V_{out}(I_P) = U_C/5\,(G \times I_P + V_O)$$

### Offset with temperature:




The error of the offset in the operating temperature is the variation of the offset in the temperature considered with the initial offset at 25 °C.

The offset variation $I_{OT}$ is a maximum variation the offset in the temperature range:

$$I_{OT} = I_{OE}\,\text{max} - I_{OE}\,\text{min}$$

The offset drift $TCI_{OE\,AV}$ is the $I_{OT}$ value divided by the temperature range.

### Sensitivity with temperature:

The error of the sensitivity in the operating temperature is the relative variation of sensitivity with the temperature considered with the initial offset at 25 °C.

The sensitivity variation $G_T$ is the maximum variation (in ppm or %) of the sensitivity in the temperature range:

$G_T$ = (Sensitivity max − Sensitivity min) / Sensitivity at 25 °C.

The sensitivity drift $TCG_{AV}$ is the $G_T$ value divided by the temperature range. Deeper and detailed info available is our LEM technical sales offices (www.lem.com).

### Offset voltage @ $I_P$ = 0 A:

The offset voltage is the output voltage when the primary current is zero. The ideal value of $V_O$ is $U_C/2$. So, the difference of $V_O - U_C/2$ is called the total offset voltage error. This offset error can be attributed to the electrical offset (due to the resolution of the ASIC quiescent voltage trimming), the magnetic offset, the thermal drift and the thermal hysteresis. Deeper and detailed info available is our LEM technical sales offices (www.lem.com).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## Environmental test specifications:

Refer to LEM GROUP test plan laboratory CO.11.11.515.0 with “Tracking_Test Plan_Auto” sheet

| Name | Standard | Conditions |
|---|---|---|
| Low temperature storage test | ISO 16750-4<br>IEC 60068-2-1 | −40 °C, 240 h; no power supply |
| Low temperature operation test | ISO 16750-4<br>IEC 60068-2-1 Ad | −40 °C, 240 h; power ON |
| HTOE (high temperature operating endurance test) | ISO 16750-4<br>IEC 60068-2-2 Bd | 1000 h; power supply @ 125 °C |
| Powered thermal cycle endurance | IEC 60068-2-14 Nb | −40 °C (20 min), +125 °C (20 min), 600 cycles ; offset monitored |
| Thermal shock | IEC 60068-2-14 Na | −40 °C (20 min soak) / 125 °C (20 min soak) , 1000 cycles, with connectors => 667 h (28 days) |
| High temperature and humidity endurance | JESD22-A101 | 1000 H; 85 °C / 85 % *HR*; power ON; Monitored once a day |
| Salt fog | IEC 60068-2-11 | 96 h @ 35 °C , 5 % of salt water solution, characterization before and after test only at 25 °C and $U_C$ nominal |
| **Mechanical tests** | | |
| Vibration in temperature | ISO 16750-3 § 4.1.2.4<br>mass suspended | Continuous monitoring: offset |
| Shocks | ISO 16750-3<br>§ 4.2 | Power ON. Profile 1 (500 m·s$^{-2}$; 11 ms) 10 shocks per axe Half sinusoidal pulse |
| Free Fall test | ISO 16750-3 | 3 axis, 2 directions by axis;1 sample per axis; 1 m. ; concrete floor |
| **EMC test** | | |
| BCI (bulk current injection) | ISO 11452-4<br>Annex E.1.1, Table E.1 | From 1 to 400 MHz.<br>Level 1: 60 mA; Functional class: A<br>Level 2: 100 mA; Functional class: A<br>Level 4: 200 mA; Functional class: B |
| Radiated electromagnetic immunity | ISO 11452-2<br>GMW 3097 (04.2012)<br>table 12 p.21 (level 2) | Level: 100V/m (rms); from 400 M to 1 GHz Functional class: A<br>Level: 70V/m (rms) from 1 G to 2 GHz Functional class: A |
| Emission | CISPR 25 | Table 9, Class 5 by default<br>Freq = 150kHz to 2.5GHz |
| ESD not supplied | IEC 61000-4-2 +<br>ISO 10605<br>(07/2008) | Contact discharge: ±4 kV & ±8 kV<br>Air discharge: ±15 kV<br>Functionnal class: A after reconnection<br>(150 pF, 330 Ω) |
| **Connector tests** | | |
| Connector to connector engagement force | GMW 3191 § 4.11 | |
| Locked connector disengagement force | GMW 3191 § 4.13 | |
| Unlocked connector disengagement force | GMW 3191 § 4.14 | |


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