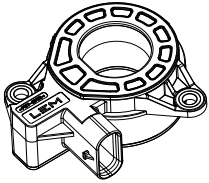


AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

DHAB S/137



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

- Open Loop transducer using the Hall effect
- Low voltage application
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±75 A for channel 1 and ±1000 A for channel 2
- Maximum RMS primary admissible current: defined by busbar to have $T^{\circ} < +150^{\circ}C$
- Operating temperature range: $-40^{\circ}C < T^{\circ} < +125^{\circ}C$
- Output voltage: full ratio-metric (in sensitivity and offset).

Special feature

- Dual channel transducer 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:

$$U_{Hall} = (c_{Hall} / d) \times I_{Hall} \times a \times I_p$$

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

$$U_{Hall} = b \times I_p$$

a constant

b constant

c_{Hall} Hall coefficient

d thickness of the Hall plate

I_{Hall} current across Hall plates

The measurement signal U_{Hall} is amplified to supply the user output voltage or current.

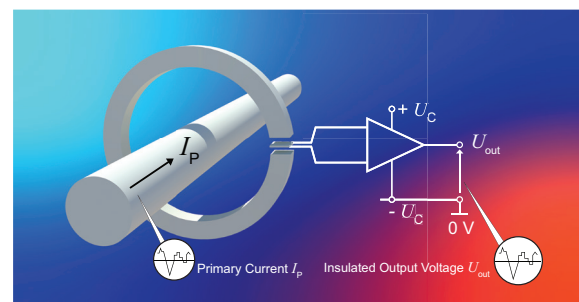


Fig. 1: Principle of the open loop transducer.

UL 508: Ratings and assumptions of certification

File # E189713 Volume: 2 Section: 13

Standards

- CSA C22.2 NO. 14-10 INDUSTRIAL CONTROL EQUIPMENT - Edition 11
- UL 508 STANDARD FOR INDUSTRIAL CONTROL EQUIPMENT - Edition 17

Ratings

| Parameter | Symbol | Unit | Value |
|---------------------------------|-----------|---------|---------|
| Primary involved potential | | V AC/DC | 300 |
| Max surrounding air temperature | T_A | °C | 100 |
| Primary current | I_P | A | 0 - 500 |
| Supply Voltage | U_C | V DC | 5 |
| Output voltage | U_{out} | V DC | 0 to 5 |

Conditions of acceptability

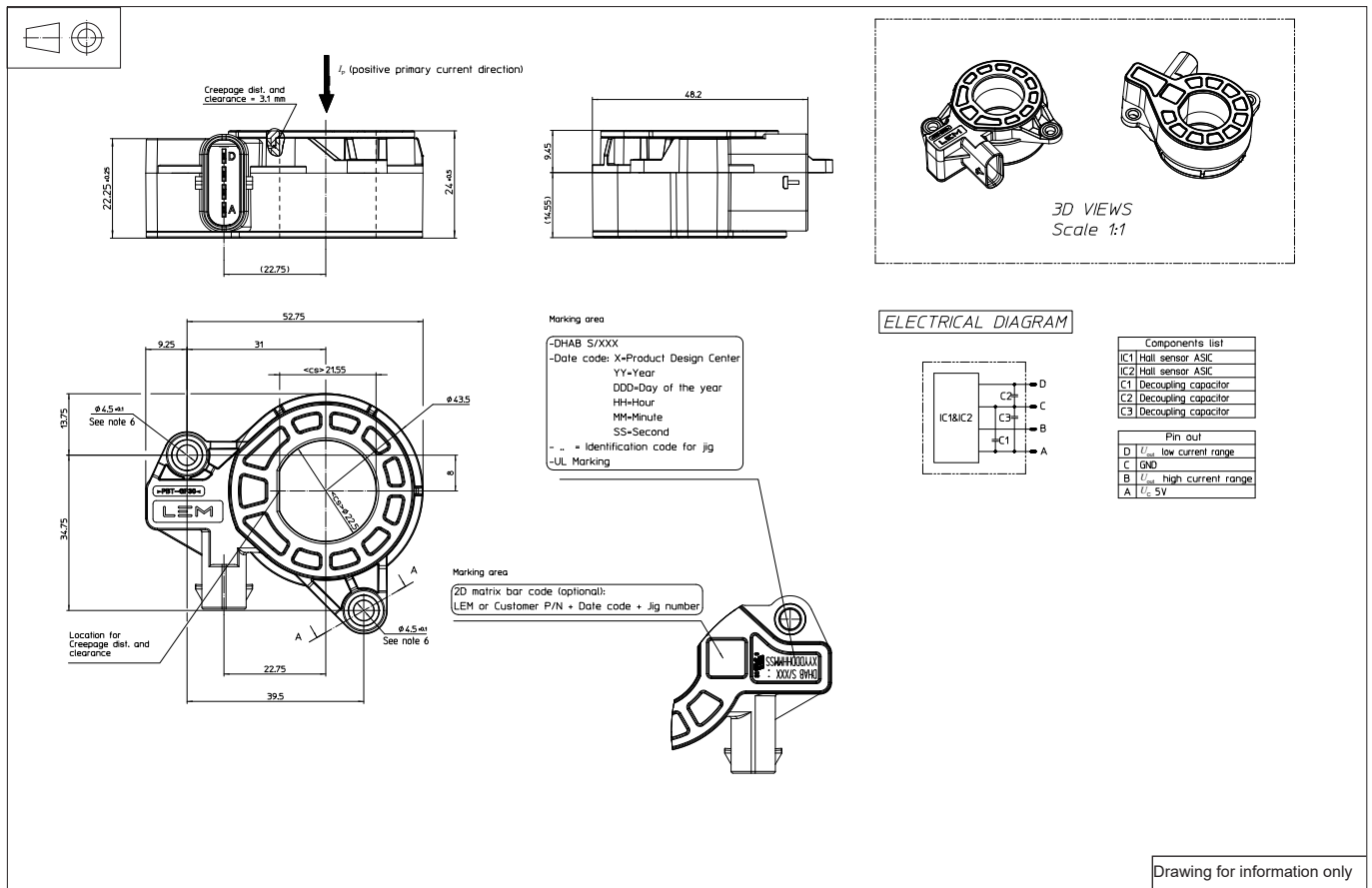
When installed in the end-use equipment, consideration shall be given to the following:

- 1 - These products must be mounted in a suitable end-use enclosure*
- 2 - The secondary circuit pin terminals have not been evaluated for field wiring*
- 3 - Low voltage control circuit shall be supplied by an isolating source of supply*
- 4 - These products shall be used in a pollution degree 2 environments or better*
- 5 - Primary feeder of the devices shall be connected after an overvoltage device or system which has been evaluated by the Standard for Transient Voltage Surge Suppressors, UL 1449 with a maximum clamping voltage of 4 kV.*

Marking

Only those products bearing the UL or UR Mark should be considered to be Listed or Recognized and covered under UL's Follow-Up Service. Always look for the Mark on the product.

Dimensions (in mm)



Mechanical characteristics

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

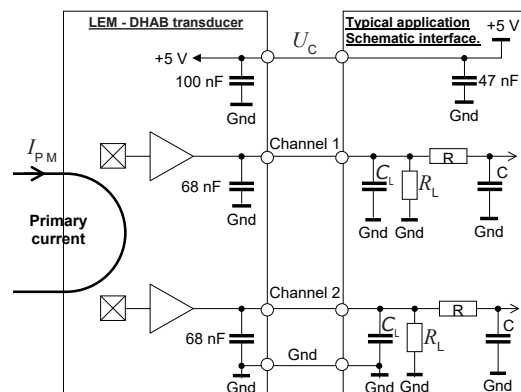
Mounting recommendation

- Mating connector P/N TYCO 1-1456426-5
- Max assembly torque 2.5 N·m (for M4 × 0.7)
- Clamping force must be applied on the compression limiter

Remark

- $U_{out} > U_O$ when I_p flows in the positive direction (see arrow on drawing).

System architecture (example)



$R_L > 10 \text{ k}\Omega$ optional resistor for signal line diagnostic
 $C_L < 100 \text{ nF}$ EMC protection
 RC Low pass filter EMC protection (optional)

| Parameter | Symbol | Unit | Specification | | | Conditions |
|--|----------------------|------|---------------|---------|-----|---|
| | | | Min | Typical | Max | |
| Maximum supply voltage | $U_{C\max}$ | V | -14 | | 14 | |
| Ambient storage temperature | $T_{A\text{st}}$ | °C | -40 | | 125 | |
| Electrostatic discharge voltage | U_{ESD} | kV | | | 8 | IEC 61000-4-2 - ISO 10605 |
| RMS voltage for AC insulation test, 50 Hz, 1 min | U_d | kV | | | 2.5 | ISO 16750-2 |
| Creepage distance | d_{CP} | mm | | 3.1 | | |
| Clearance | d_{CI} | mm | | 3.1 | | |
| Comparative tracking index | CTI | | | PLC3 | | |
| Maximum output current | $I_{\text{out max}}$ | mA | -10 | | 10 | Continuous |
| Maximum output voltage (Analog) | $U_{\text{out max}}$ | V | -14 | | 14 | Output over voltage, 1 min @ $T_A = 25^\circ\text{C}$ |
| Insulation resistance | R_{INS} | MΩ | 500 | | | 500 V DC, ISO 16750-2 |
| Output short circuit maximum 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 | $I_{\text{out max}}$ | 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 | $I_{\text{PM channel 1}}$ | A | -75 | | 75 | |
| Primary nominal DC or RMS current | $I_{\text{PN channel 1}}$ | A | -75 | | 75 | @ $T_A = 25^\circ\text{C}$ |
| Offset voltage | U_O | V | | 2.5 | | @ $U_C = 5\text{ V}$ |
| Sensitivity | S | mV/A | | 26.67 | | @ $U_C = 5\text{ V}$ |
| Resolution | | mV | | 2.5 | | @ $U_C = 5\text{ V}$ |
| Output clamping voltage min ¹⁾ | U_{SZ} | V | 0.2 | 0.25 | 0.3 | @ $U_C = 5\text{ V}$ |
| Output clamping voltage max ¹⁾ | | V | 4.7 | 4.75 | 4.8 | @ $U_C = 5\text{ V}$ |
| Output internal resistance | R_{out} | Ω | | 1 | 10 | |
| Frequency bandwidth ²⁾ | BW | Hz | | 70 | | @ -3 dB |
| Power up time | | ms | | | 1 | |
| Setting time after overload | t_s | ms | | | 10 | |
| Ratiometricity error | ϵ_r | % | -0.6 | | 0.6 | |
| Peak-to-peak noise voltage | $U_{\text{no pp}}$ | mV | -10 | | 10 | |
| Performance Data channel 2 | | | | | | |
| Primary current, measuring range | $I_{\text{PM channel 2}}$ | A | -1000 | | 1000 | |
| Primary nominal DC or RMS current | $I_{\text{PN channel 2}}$ | A | -1000 | | 1000 | @ $T_A = 25^\circ\text{C}$ |
| Offset voltage | U_O | V | | 2.5 | | @ $U_C = 5\text{ V}$ |
| Sensitivity | S | mV/A | | 2 | | @ $U_C = 5\text{ V}$ |
| Resolution | | mV | | 2.5 | | @ $U_C = 5\text{ V}$ |
| Output clamping voltage min ¹⁾ | U_{SZ} | V | 0.2 | 0.25 | 0.3 | @ $U_C = 5\text{ V}$ |
| Output clamping voltage max ¹⁾ | | V | 4.7 | 4.75 | 4.8 | @ $U_C = 5\text{ V}$ |
| Output internal resistance | R_{out} | Ω | | 1 | 10 | |
| Frequency bandwidth ²⁾ | BW | Hz | | 70 | | @ -3 dB |
| Power up time | | ms | | | 1 | |
| Setting time after overload | t_s | ms | | | 10 | |
| Ratiometricity error | ϵ_r | % | -0.6 | | 0.6 | |
| Peak-to-peak noise voltage | $U_{\text{no pp}}$ | mV | -10 | | 10 | |

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

$$I_P = \left(\frac{5}{U_C} \times U_{\text{out}} - U_O \right) \times \frac{1}{S} \text{ with } S \text{ in (V/A)}$$

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.)

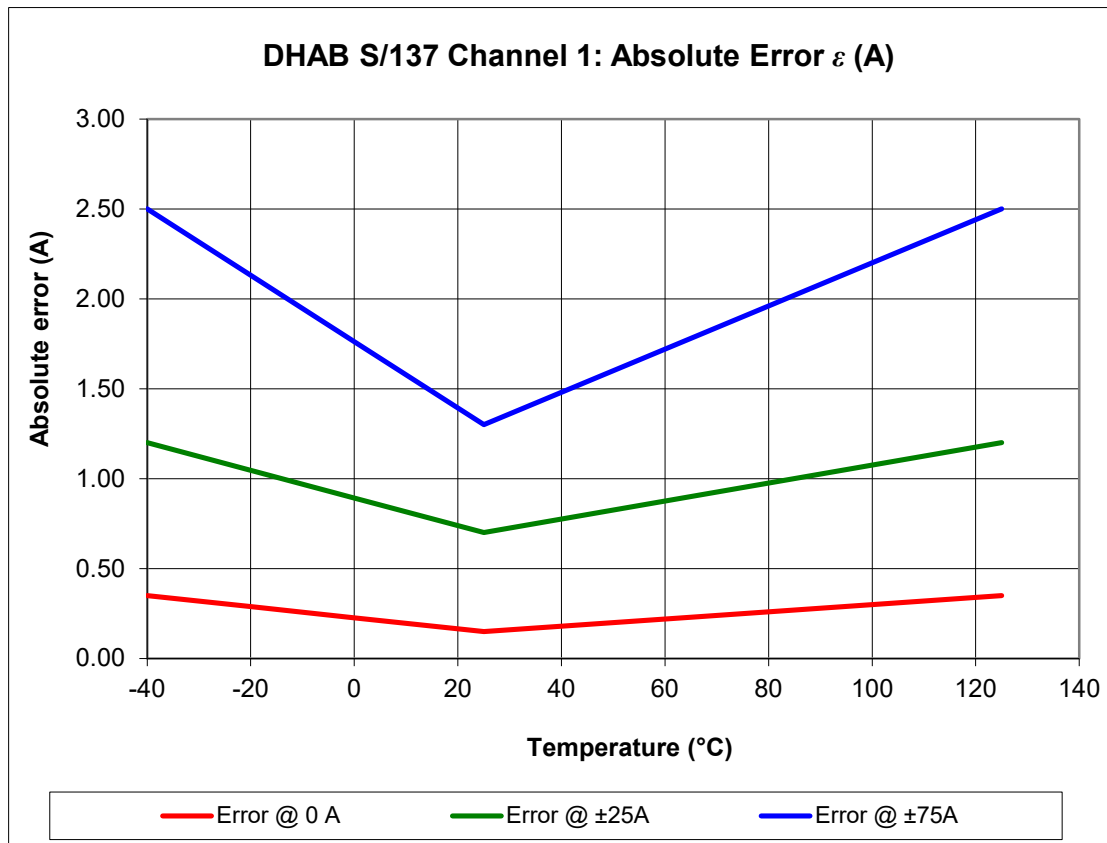
Error

Channel 1

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

Error table

| Parameter | Symbol | Unit | Temperature | | | | | |
|---------------|------------|------|-------------|--------|------|-------|-------|--------|
| | | | -40 °C | -20 °C | 0 °C | 25 °C | 65 °C | 125 °C |
| Error @ 0 A | ϵ | A | 0.35 | 0.29 | 0.23 | 0.15 | 0.23 | 0.35 |
| Error @ ±25 A | | | 1.20 | 1.05 | 0.89 | 0.70 | 0.90 | 1.20 |
| Error @ ±75 A | | | 2.50 | 2.13 | 1.76 | 1.30 | 1.78 | 2.50 |



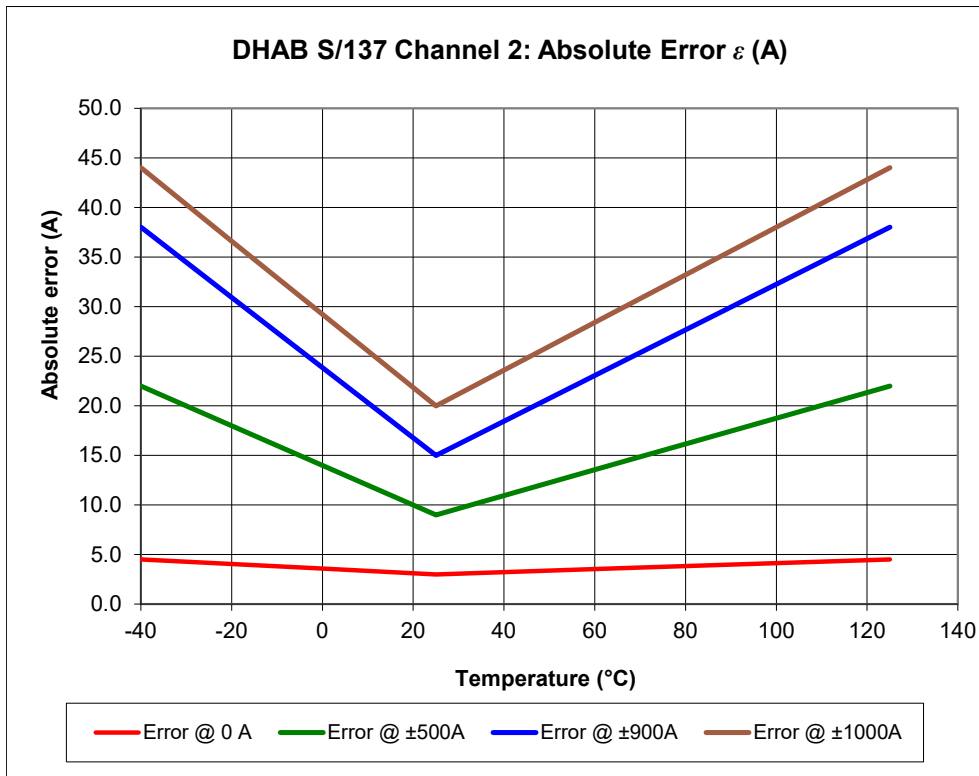
Error

Channel 2

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---------------------------|--------------|------|---------------|---------|-----|---|
| | | | Min | Typical | Max | |
| Electrical Data | | | | | | |
| Electrical offset current | I_{OE} | A | | ±0.6 | | @ $T_A = 25\text{ °C}$ |
| Magnetic offset current | I_{OM} | A | | ±0.25 | | @ $T_A = 25\text{ °C}$ |
| Offset current | I_O | A | -3 | | 3 | @ $T_A = 25\text{ °C}$ |
| | | | -3.6 | | 3.6 | @ $-10\text{ °C} < T^\circ < 65\text{ °C}$ |
| | | | -4.5 | | 4.5 | @ $-40\text{ °C} < T^\circ < 125\text{ °C}$ |
| Sensitivity error | ϵ_S | % | | ±0.4 | | @ $T_A = 25\text{ °C}$ |
| | | | | ±0.8 | | @ $-10\text{ °C} < T^\circ < 65\text{ °C}$ |
| | | | | ±1.2 | | @ $-40\text{ °C} < T^\circ < 125\text{ °C}$ |
| Linearity error | ϵ_L | % | | ±0.5 | | @ $T_A = 25\text{ °C}$, @ $U_C = 5\text{ V}$, of full range |

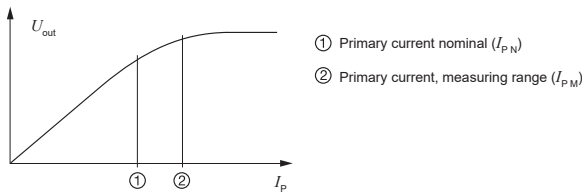
Error table

| Parameter | Symbol | Unit | Temperature | | | | | |
|-----------------|------------|------|-------------|--------|------|-------|-------|--------|
| | | | -40 °C | -20 °C | 0 °C | 25 °C | 65 °C | 125 °C |
| Error @ 0 A | ϵ | A | 4.5 | 4.0 | 3.6 | 3.0 | 3.6 | 4.5 |
| Error @ ±500 A | | | 22.0 | 18.0 | 14.0 | 9.0 | 14.2 | 22.0 |
| Error @ ±900 A | | | 38.0 | 30.9 | 23.9 | 15.0 | 24.2 | 38.0 |
| Error @ ±1000 A | | | 44.0 | 36.6 | 29.2 | 20.0 | 29.6 | 44.0 |



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:

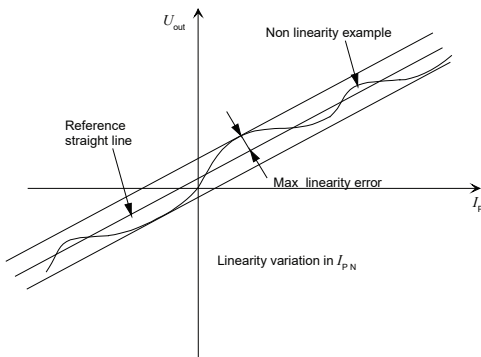
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

Magnetic offset:

The magnetic offset is the consequence of an any current on the primary side. It's defined after a stated excursion of primary current.

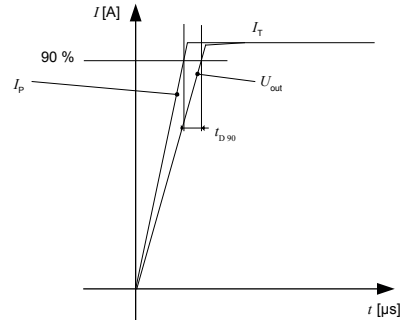
Linearity:

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



Delay time t_{D90} :

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 S is the slope of the straight line $U_{out} = f(I_p)$, it must establish the relation:

$$U_{out}(I_p) = U_c/5 (S \times I_p + U_o)$$

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:

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

The offset drift TCI_{OEAV} 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 average temperature coefficient of sensitivity TCS_{AV} , S_T is the maximum temperature variation of S (in ppm or %) of the sensitivity in the temperature range:

$$S_T = (\text{Sensitivity max} - \text{Sensitivity min}) / \text{Sensitivity at } 25 \text{ }^\circ\text{C}$$

The average temperature coefficient of sensitivity TCS_{AV} is the S_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 U_o is $U_c/2$. So, the difference of $U_o - U_c/2$ 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).



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 IEC 60068-2-1 | -40 °C, 240 h; no power supply |
| Low temperature operation test | ISO 16750-4 IEC 60068-2-1 Ad | -40 °C, 240 h; power ON |
| HTOE (high temperature operating endurance test) | ISO 16750-4 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 mass suspended | Continuous monitoring: offset |
| Shocks | ISO 16750-3 § 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 Annex E.1.1, Table E.1 | From 1 to 400 MHz Level 1: 60 mA; Functional class: A Level 2: 100 mA; Functional class: A Level 4: 200 mA; Functional class: B |
| Radiated electromagnetic immunity | ISO 11452-2 GMW 3097 (04.2012) table 12 p.21 (level 2) | Level: 100V/m (RMS); from 400 M to 1 GHz Functional class: A Level: 70V/m (RMS) from 1 G to 2 GHz Functional class: A |
| Emission | CISPR 25 | Table 9, Class 5 by default $f = 150$ kHz to 2.5 GHz |
| ESD not supplied | IEC 61000-4-2 + ISO 10605 (07/2008) | Contact discharge: ±4 kV & ±8 kV Air discharge: ±15 kV Functionnal class: A after reconnection (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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