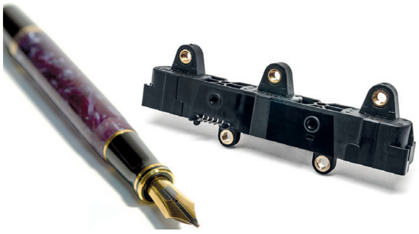
AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
HAH3DR 1000-S07



Introduction

The HAH3DR-S07 family is a tri-phase transducer for DC, AC, or pulsed currents measurement in automotive applications. It offers a galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).

Features

- Open Loop transducer using the Hall effect sensor
- Low voltage application
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±1200 A
- Maximum RMS primary admissible current: limited by the busbar, the magnetic core or ASIC $T < +125$ °C
- Operating temperature range: −40 °C < T < +125 °C
- Output voltage fully ratiometric (in sensitivity and offset).

Special features

- All in one tri-phase transducer
- Perfect fit to 'HybridPACK TM' drive Infineon
- Simplified installation with press fit contacts eliminates soldering
- Built-in nuts for busbar attachement.

Advantages

- Excellent accuracy
- Very good linearity
- Very low thermal offset drift
- Very low thermal sensitivity drift
- Wide frequency bandwith
- No insertion losses
- Very fast response time.

Automotive applications

- Starter Generators
- Inverters
- HEV applications
- EV applications
- DC / DC converter.

Fig. 1: Principle of the open loop transducer.

Principle of HAH3DR S07 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.

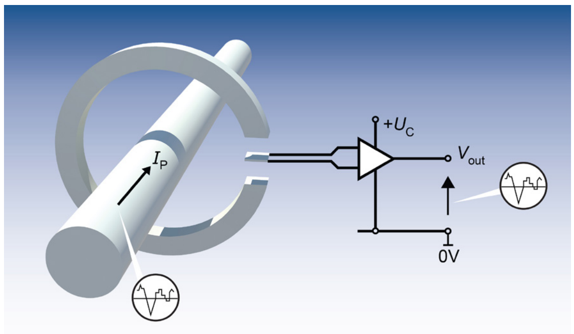
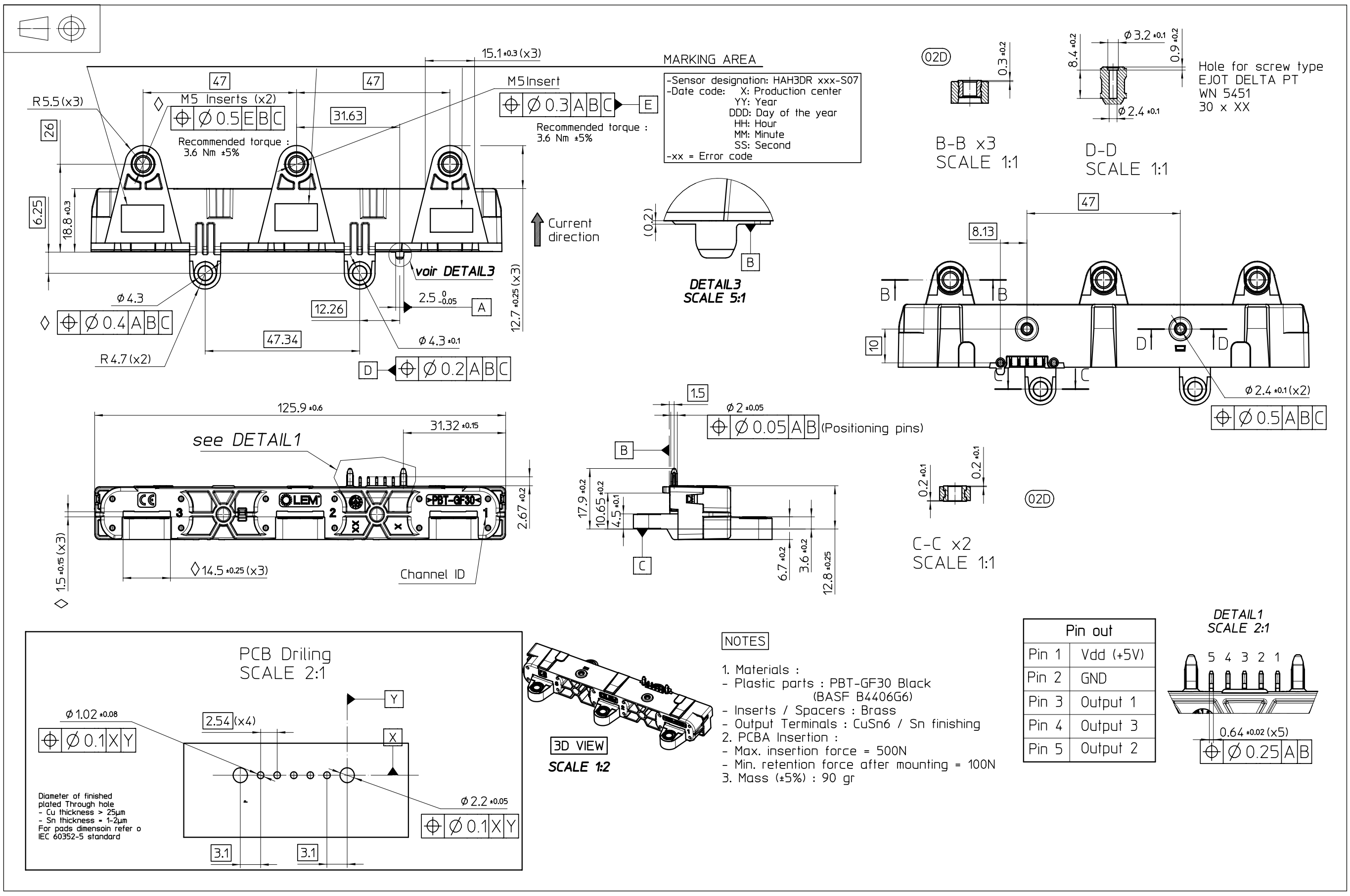


Fig. 1: Principle of the open loop transducer.

Dimensions (in mm)



Mechanical characteristics

- Materials — See dimensions
- Magnetic core — FeSi wound core
- Pins — See dimensions
- Mass — 90 g ±5 %
- IP level — IPxx.

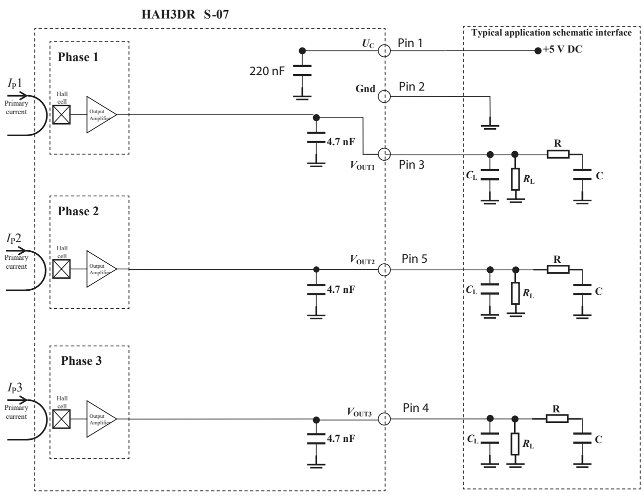
Mounting recommendation

- See dimensions
- The clamping force must be applied to the compression limiter, washer recommended.
- Secondary connection — Pressfit

Remark

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

System architecture (example)



C_L < 2.2 nF EMC protection (optional)
RC Low pass filter (optional)

On board diagnostic

R_L > 10 kΩ. Resistor for signal line diagnostic (optional)

Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Maximun supply voltage	U_C	V	−0.5		8	Continuous not operating
					6.5	Exceeding this voltage may temporarily reconfigure the circuit until the next power on
Ambient storage temperature	T_S	°C	−40		125	
Electrostatic discharge voltage	U_{ESD}	kV			8	IEC 61000-4-2
RMS voltage for AC insulation test	U_d	kV			2.5	50 Hz, 1 min, IEC 60664 part1
Creepage distance	d_{Cp}	mm	5.2			
Clearance	d_{Cl}	mm	4.6			
Comparative traking index	CTI		PLC3			
Insulation resistance	R_{IS}	MΩ	500			500 V DC, ISO 16750
Primary current	I_P	A				Current limited by busbar temperature < 125°C

Operating characteristics

All characteristics noted under conditions -1000 A ≤ I_P ≤ 1000 A, 4.75 V ≤ U_C ≤ 5.25 V, -40 °C ≤ T_A ≤ 125 °C, unless otherwise noted.

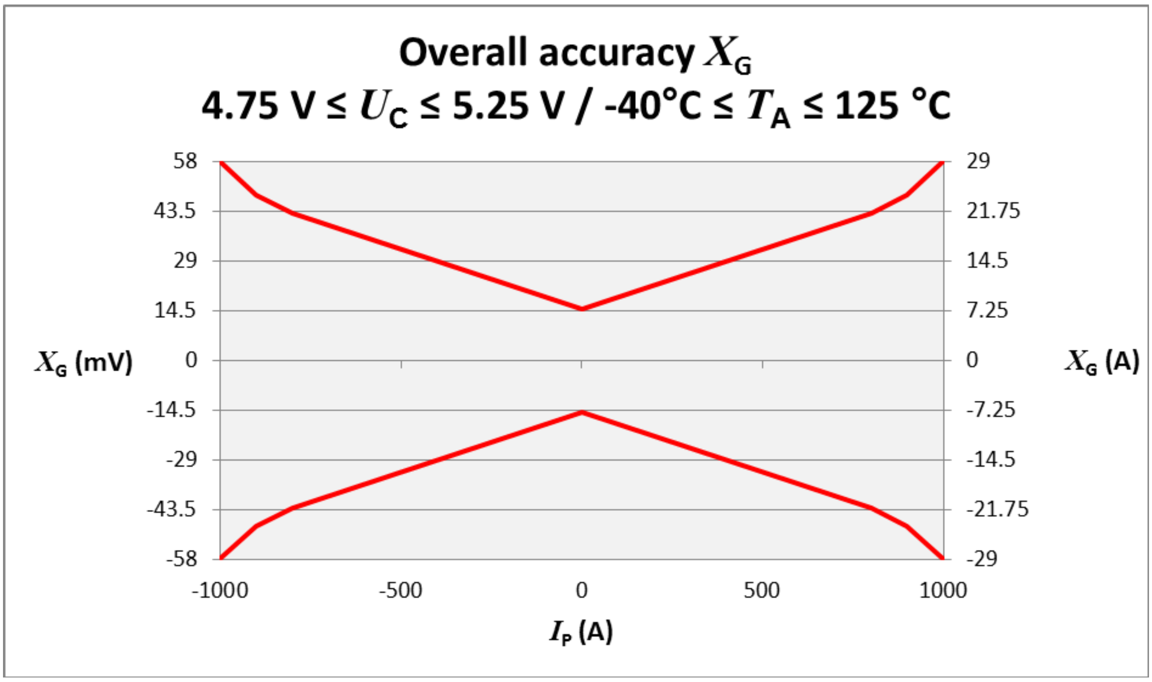
Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−1000		1000	
Supply voltage [1]	U_C	V	4.75	5	5.25	
Ambient operating temperature	T_A	°C	−40		125	
Output voltage (Analog)	V_{out}	V	$V_{out} = (U_C/5) \times (V_o + G \times I_P)$			@ T_A = 25 °C
Sensitivity	G	mV/A		2		
Offset voltage	V_O	V		2.5		
Current consumption	I_C	mA		45	60	@ U_C = 5 V
Load resistance	R_L	KΩ	10			
Output internal resistance	R_{out}	Ω		1	10	
Performance Data						
Ratiometricity error	ε_r	%		±0.5		
Sensitivity error	ε_G	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	V_{OE}	mV		±4		@ T_A = 25 °C, @ U_C = 5 V
Magnetic offset voltage	V_{OM}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V, after ± I_{PM}
Average temperature coefficient of V_{OE}	$TCV_{OE\,AV}$	mV/°C		±0.05		
Average temperature coefficient of G	TCG_{AV}	%/°C		±0.03		
Linearity error	ε_L	%	−1		1	% of full scale
Step response time to 90 % I_{PN}	t_r	µs		2	6	di/dt = 100 A/µs
Frequency bandwidth [2]	BW	kHz	40			@ −3 dB
Output voltage noise peak-peak	$V_{no\,pp}$	mV			4	@ DC to 1 MHz
Start up time	t_{start}	µs			800	
Phase shift	$\Delta\varphi$	°	−4			@ DC to 1 kHz

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:

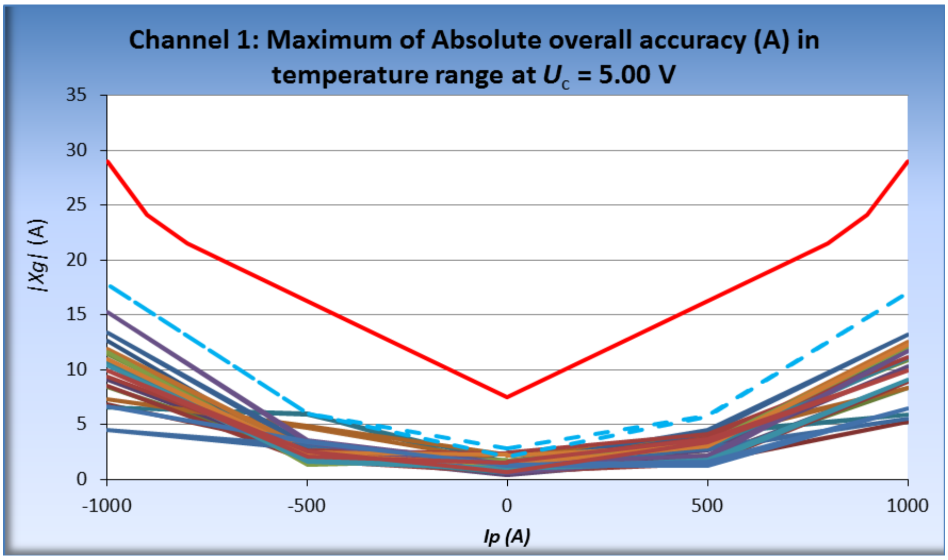
$$I_P = \left(\frac{5}{U_C} \times V_{out} - V_O\right) \times \frac{1}{G} \text{ with } G \text{ in (V/A)}$$

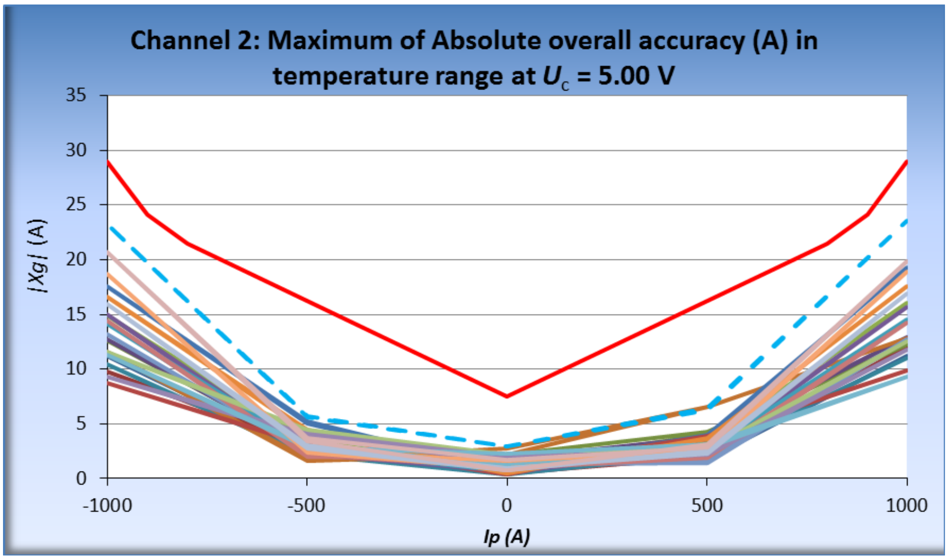
[2] Primary current frequencies must be limited in order to avoid excessive heating of the busbar, magnetic core and the ASIC (see feature paragraph in page 1).

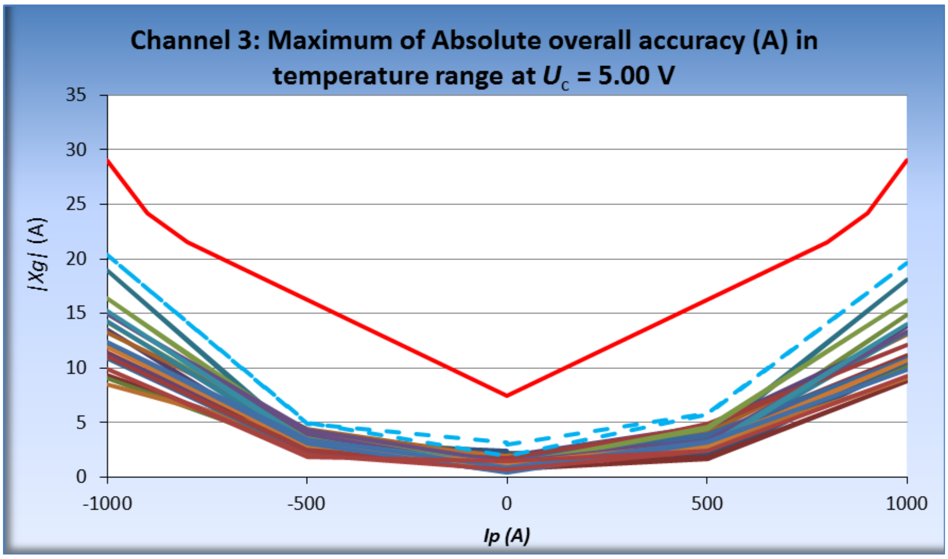
Accuracy

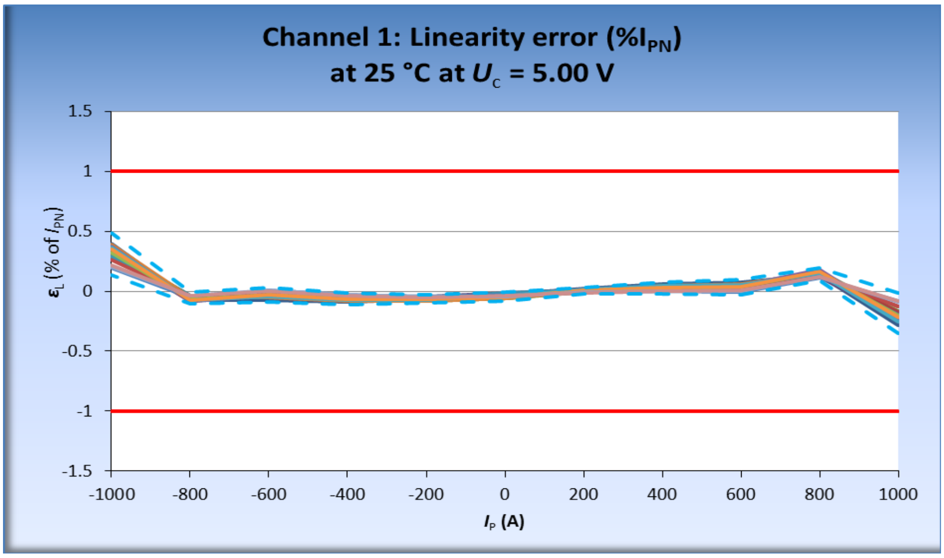


Overall accuracy X_G
4.75 V ≤ U_C ≤ 5.25 V / -40°C ≤ T_A ≤ 125 °C
58
43.5
29
14.5
0
-14.5
-29
-43.5
-58
X_G (mV)
29
21.75
14.5
7.25
0
-7.25
-14.5
-21.75
-29
X_G (A)
-1000
-500
0
500
1000
I_P (A)

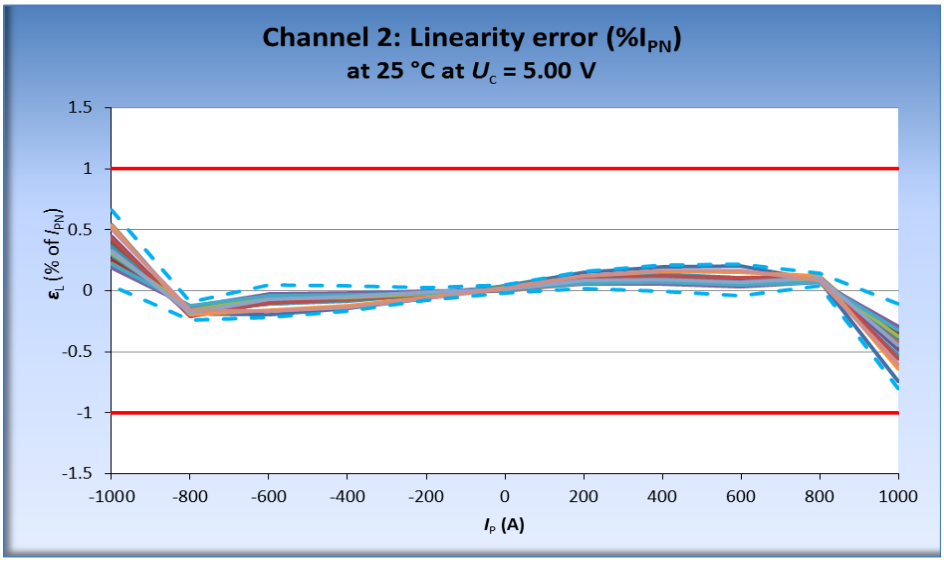

Channel 1: Maximum of Absolute overall accuracy (A) in temperature range at U_C = 5.00 V
|Xg| (A)
Ip (A)
35
30
25
20
15
10
5
0
-1000
-500
0
500
1000


Channel 2: Maximum of Absolute overall accuracy (A) in temperature range at U_C = 5.00 V
|Xg| (A)
Ip (A)
35
30
25
20
15
10
5
0
-1000
-500
0
500
1000

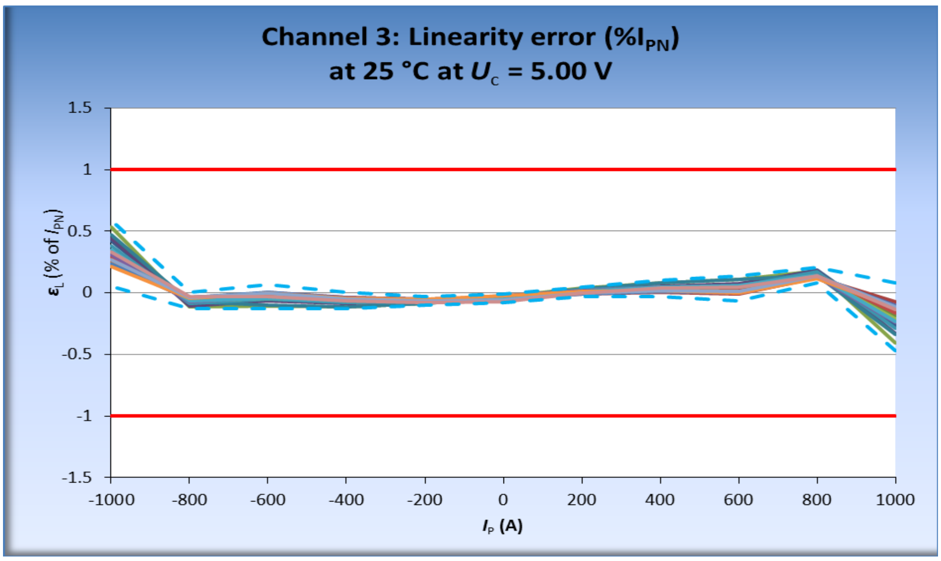

Channel 3: Maximum of Absolute overall accuracy (A) in temperature range at U_C = 5.00 V
|Xg| (A)
Ip (A)
35
30
25
20
15
10
5
0
-1000
-500
0
500
1000



Channel 1: Linearity error (%I_PN)
at 25 °C at U_C = 5.00 V
ε_L (% of I_PN)
I_P (A)



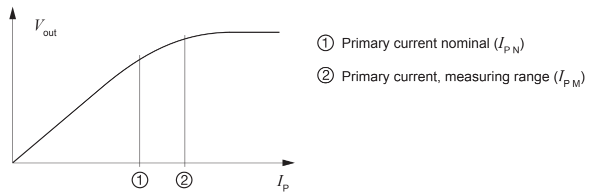
Channel 2: Linearity error (%I_PN)
at 25 °C at U_C = 5.00 V
ε_L (% of I_PN)
I_P (A)



Channel 3: Linearity error (%I_PN)
at 25 °C at U_C = 5.00 V
ε_L (% of I_PN)
I_P (A)

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:

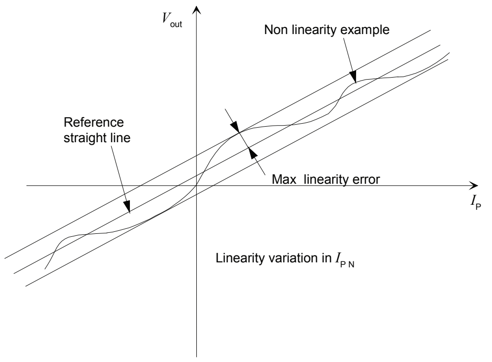
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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.

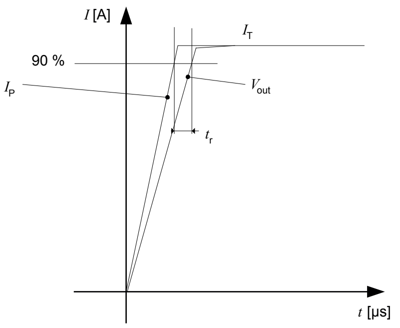
Linearity:

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



Response time (delay time) t_r:

The time between the primary current signal ($I_{P\,N}$) 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 $I_{O\,T}$ is a maximum variation the offset in the temperature range:

$$I_{O\,T} = I_{O\,E}\ \text{max} - I_{O\,E}\ \text{min}$$

The offset drift $TCI_{O\,E\,AV}$ is the $I_{O\,T}$ 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).

Environmental test specifications:

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

Test	Test Standards
INITIAL CHARACTERZATION	---
Linearity error at 25 °C	LEM CO.60.09.014.0
Characterization in temperature range	LEM CO.60.09.014.0
LEG 1 : ELECTRICAL PERFORMANCES	---
LEG 1: Frequency bandwidth	LEM 98.20.00.538.0
LEG 1 : Output noise (peak-peak)	LEM 98.20.00.575.0
LEG 1 : Response time - di/dt	LEM 98.20.00.575.0
LEG 1: dv/dt	LEM 98.20.00.545.0
ENVIRONMENTAL TESTS (Climatic)	---
LEG 2 : Thermal shocks	IEC 60068-2-14
LEG 3 : High temperature storage	IEC 60068-2-2
LEG 4 : Low temperature storage	ISO 16750-4 § 5.1.1.1
LEG 5 : Powered temperature cycle	ISO 16750-4 § 5.3.1
LEG 1 : Ageing with 85 °C; 85 % *RH*	CETP: 00.00-E412 § 5.17
LEG 6 : Sine vibration test	ISO 16750-3 § 4.1.2.2.2.2
LEG 6 : Random vibration test	ISO 16750-3 § 4.1.2.2.2.3
LEG 7 : Mechanical shocks test	ISO 16750-3 § 4.2
SAFETY : Mechanical tests	---
LEG 8 : Free Fall	IEC 60068-2-31 § 5.2 Method 1
SAFETY : Insulation tests	---
LEG 1 : Isolation Resistance Test	IEC 60664-1
LEG 1 : Dielectric Withstand Voltage	IEC 61010-1 § 6.8.3
EMC TESTS	---
Electrostatic discharge immunity test	IEC 61000-4-2
Immunity to conducted disturbances	IEC 61000-4-6
Radiated electromagnetic field immunity test	IEC 61000-4-3
Electrical fast transient/burst immunity test	IEC 61000-4-4
FINAL CHARACTERIZATION	---
Linearity error at 25 °C	LEM CO.60.09.014.0
Characterization in temperature range	LEM CO.60.09.014.0
ANNEX	---
END OF REPORT	---