AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
HAM 250-S04

Introduction

The HAM family is for the electronic measurement of DC, AC or pulsed currents in automotive applications with galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).
The HAM family gives you the choice of having different current measuring ranges in the same housing (from ±100 A up to ±300 A).

The HAM 250-S04 is designed for high frequency applications current with high primary current ripple.

Features

- Open Loop transducer using the Hall effect
- High voltage application
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±250 A
- Maximum RMS primary admissible current: defined by busbar to have T < +150 °C
- Operating temperature range: −40 °C < T < +125 °C
- Output voltage: full ratio-metric (in sensitivity and offset)
- Ferrite material magnetic core allowing high frequency primary current ripple with low self-heating.

Advantages

- Excellent accuracy
- Very good linearity
- Very low thermal offset drift
- Very low thermal sensitivity drift
- High frequency bandwith
- Non insertion losses
- Very fast response time.

Automotive applications

- DC / DC converter for fuel cell, for xEV or PHEV
- DC/AC Inverter.

Principle of HAM 250-S04 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.

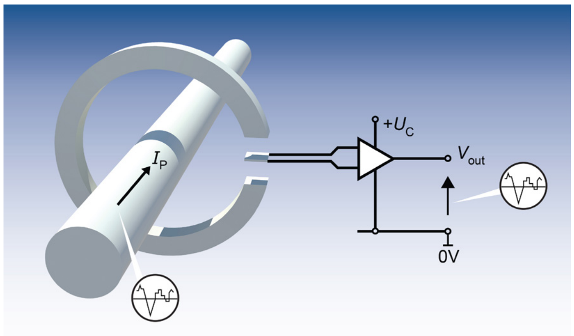
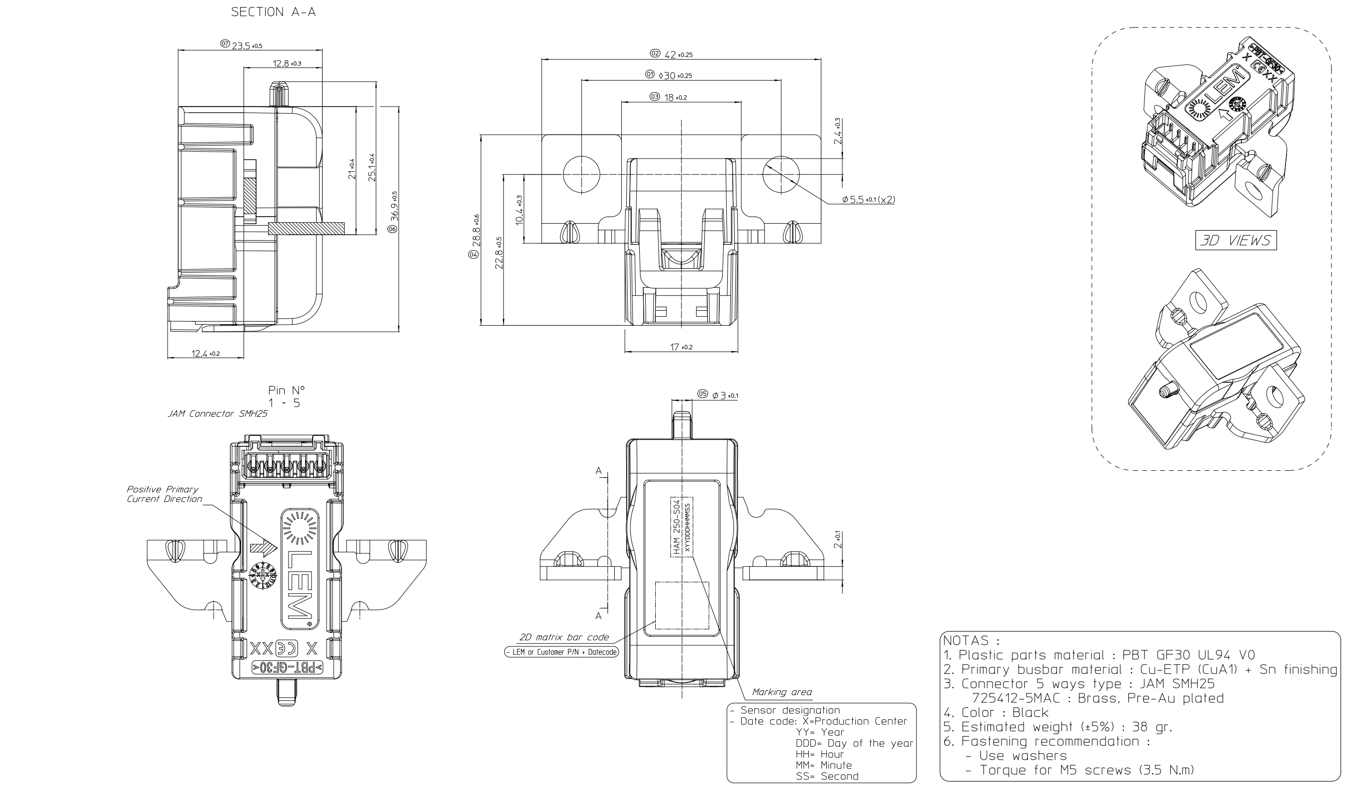


Fig. 1: Principle of the open loop transducer.

Dimensions (in mm)

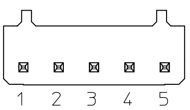


Mechanical characteristics

- Plastic case PBT GF 30 % (color black)
- Magnetic core Ferrite
- Mass see drawing
- Pins see drawing
- IP level IPx2.

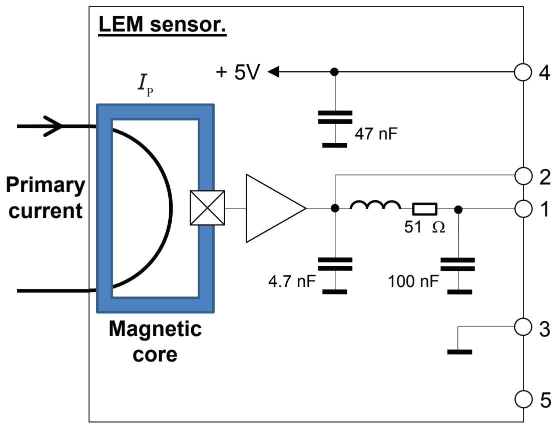
Current sensor Pinmap

Connector: Connector JAM SMH25 5 ways mates with:
- Housing 5w black: SMH25-05HG
- Retainer 5w grey: RM25-05S
- Terminal Gold plated: 725412-5MAC

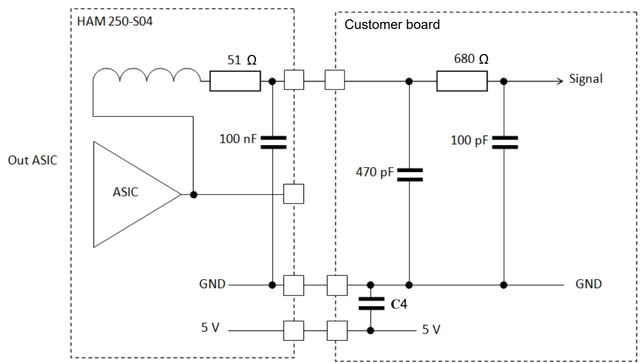


PIN	FUNCTION	PIN	FUNCTION
1	V_{out}	4	5 V
2	ASIC - Do not connected	5	Not connected
3	Gnd		

Electronic schematic



System architecture (example)



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

Absolute ratings (not operating)

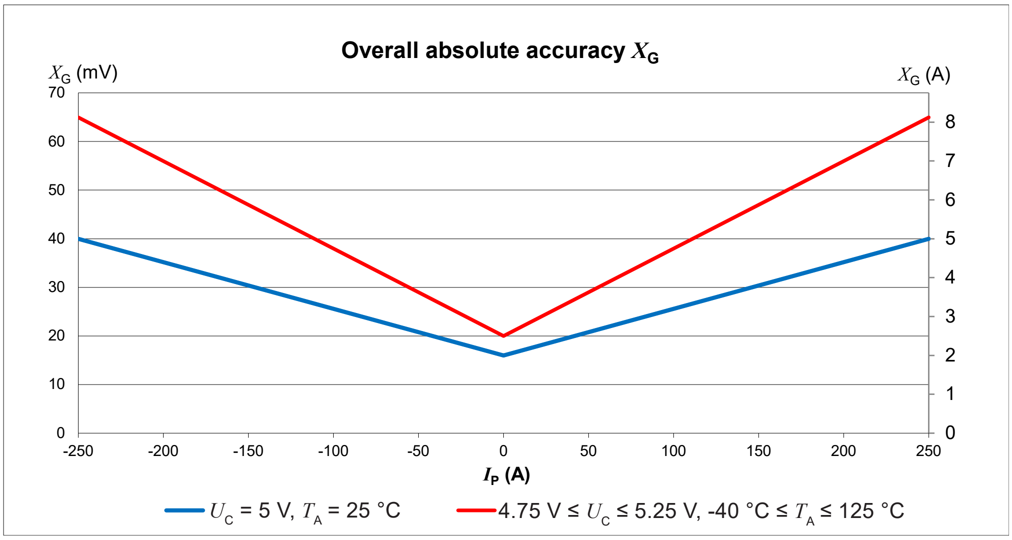
Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Maximum supply voltage	$U_{C\ max}$	V	−0.5		8	[1]
Ambient storage temperature	T_S	°C	−40		125	
Electrostatic discharge voltage	U_{ESD}	kV				±4 kV contact discharges (R = 330 Ω, C = 150 pF) ±8 kV air discharges (R = 330 Ω, C = 150 pF)
RMS voltage for AC insulation test	U_d	kV			2.5	50 Hz, 1 min
Creepage distance	d_{Cp}	mm	4			
Clearance	d_{Cl}	mm	4			
Comparative traking index	CTI		PLC3			

Operating characteristics in nominal range ($I_{P\ N}$)

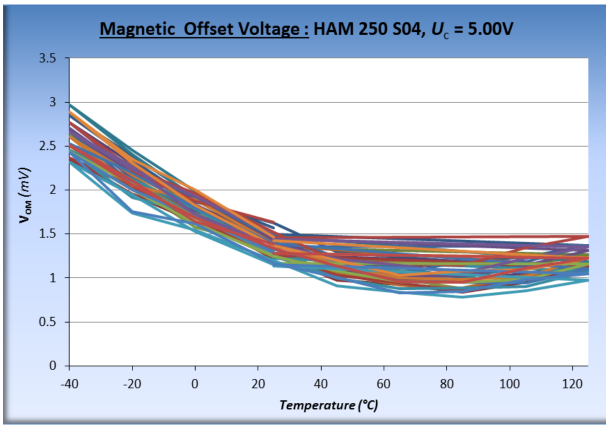
Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	$I_{P\ M}$	A	−250		250	
Primary nominal RMS current	$I_{P\ N}$	A	−250		250	
Supply voltage	U_C	V	4.75	5	5.25	
Ambient operating temperature	T_A	°C	−40		125	SMH-25-05HG connector limited to −40 °C~ +85 °C
Output voltage	V_{out}	V	$V_{out} = (U_C/5) \times (V_o + G \times I_P)$			
Sensitivity	G	mV/A		8		@ T_A = 25 °C, @ U_C = 5 V
Offset voltage	V_O	V		2.5		
Current consumption	I_C	mA		15	20	
Output filter	R_{out}	Ω				see system architecture (example)
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	$V_{O\ E}$	mV		±3		@ T_A = 25 °C, @ U_C = 5 V
Magnetic offset voltage	$V_{O\ M}$	mV		±2		@ T_A = 25 °C, @ U_C = 5 V
Linearity error	ε_L	%	−1		1	% of full scale
Average temperature coefficient of $V_{O\ E}$	$TCV_{O\ E\ AV}$	mV/°C		±0.04		
Average temperature coefficient of G	TCG_{AV}	%/°C		±0.02		
Step response time to 90% of $I_{P\ M}$	t_r	µs			2	Slope = 10 A/µs
Frequency bandwidth	BW	kHz				See graph on page 5
Peak-to-peak noise voltage	$V_{no\ pp}$	mV			14	DC to 1 MHz
Phase shift	$\Delta\varphi$	°				See graph on page 5
Start up time	t_{start}	µs			800	

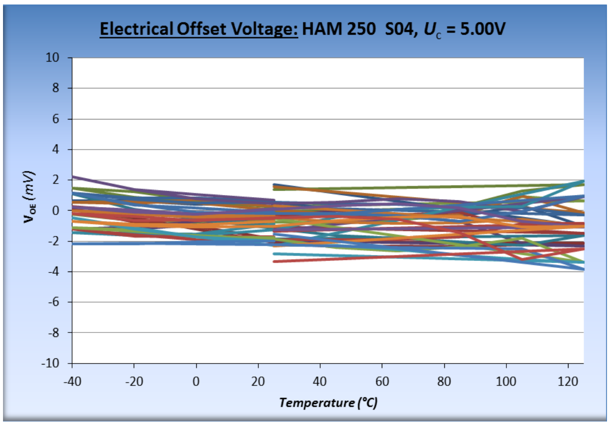
Note: [1] Exceeding 6.5 V may temporarily reconfigure the device until next power on.

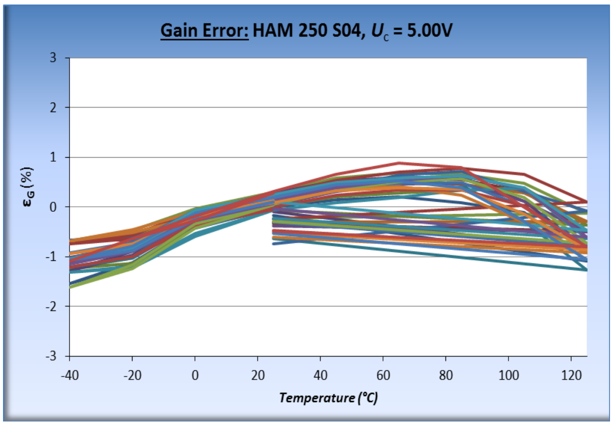
Overall absolute accuracy X_G

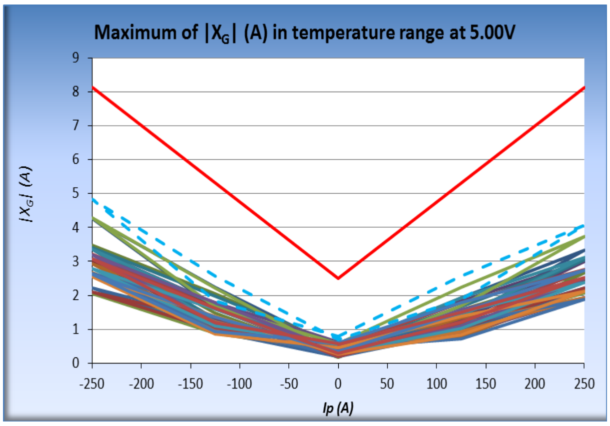


	Overall absolute accuracy X_G specification					
I_P (A)	U_C = 5 V, T_A = 25 °C			4.75 V ≤ U_C ≤ 5.25 V, −40 °C ≤ T_A ≤ 125 °C		
−250	40 mV	5.00 A	2.00 %	65 mV	8.12 A	3.25 %
0	16 mV	2.00 A	0.80 %	20 mV	2.5 A	1.00 %
250	40 mV	5.00 A	2.00 %	65 mV	8.12 A	3.25 %

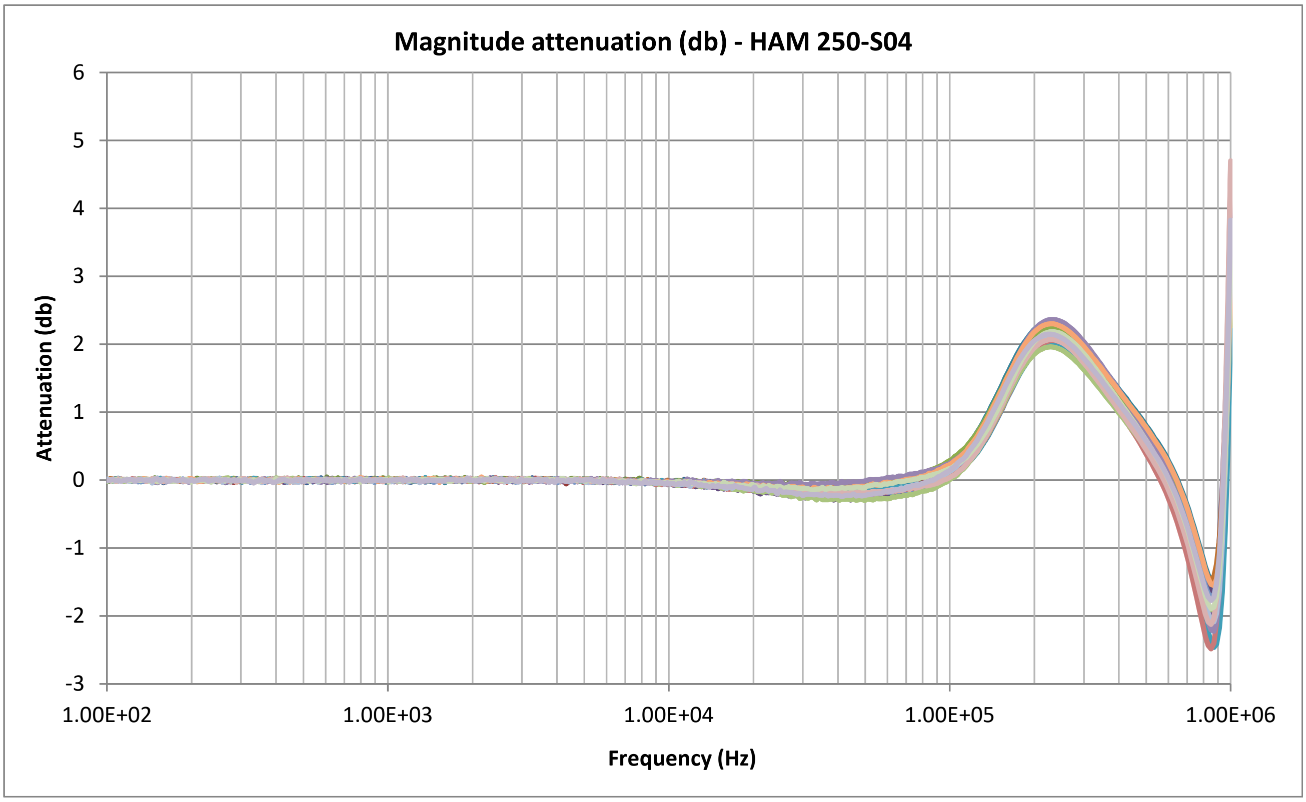


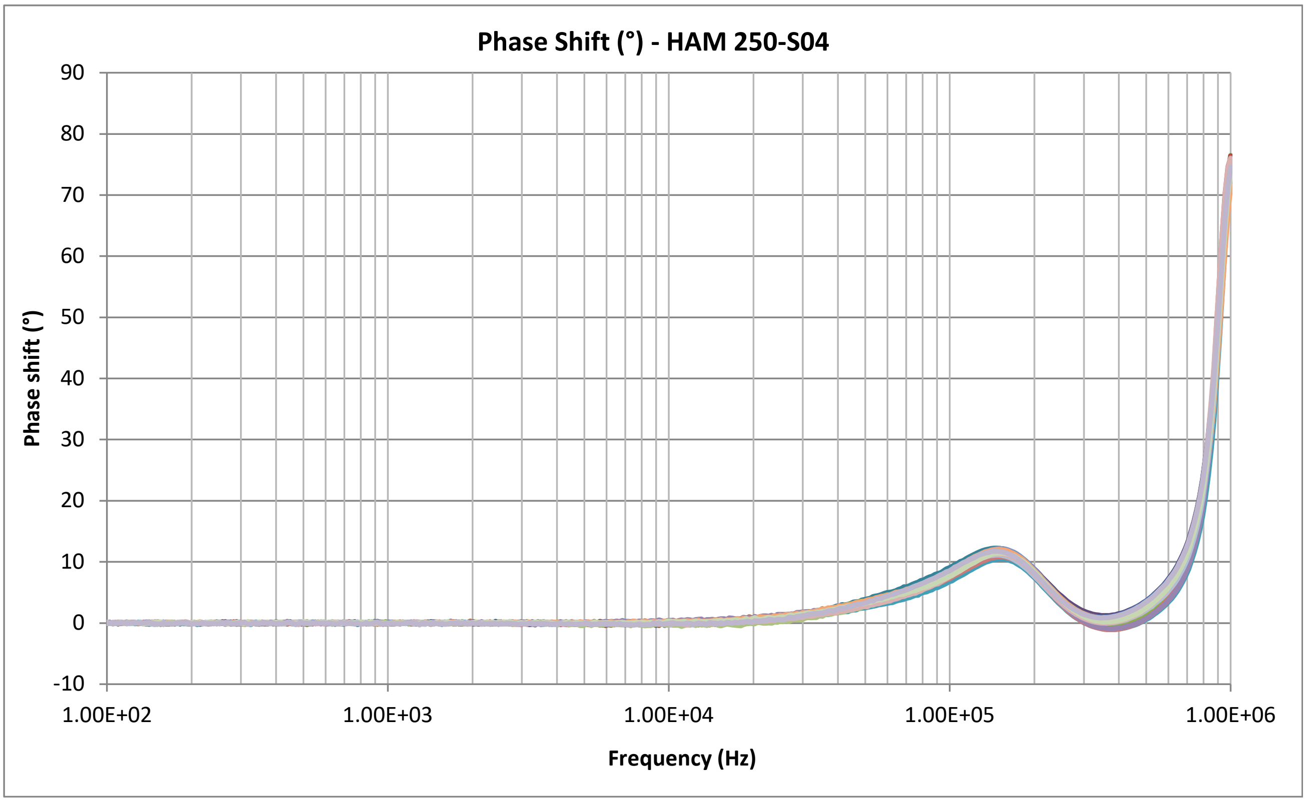






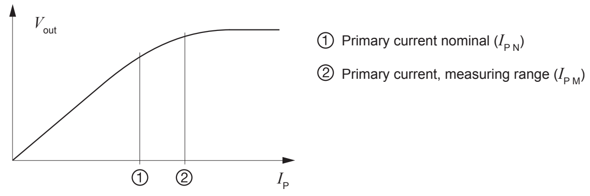
LEM reserves the right to carry out modifications on its transducers, in order to improve them, without prior notice


Magnitude attenuation (db) - HAM 250-S04
Attenuation (db)
6
5
4
3
2
1
0
-1
-2
-3
1.00E+02
1.00E+03
1.00E+04
1.00E+05
1.00E+06
Frequency (Hz)


Phase Shift (°) - HAM 250-S04
Phase shift (°)
90
80
70
60
50
40
30
20
10
0
-10
1.00E+02
1.00E+03
1.00E+04
1.00E+05
1.00E+06
Frequency (Hz)

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:

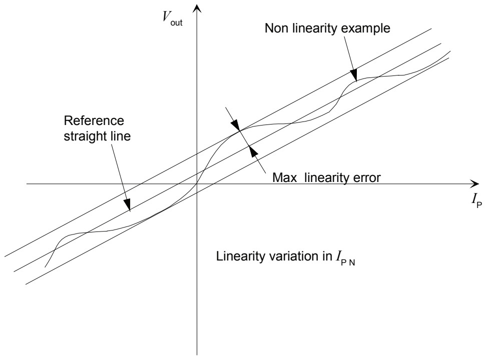
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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.

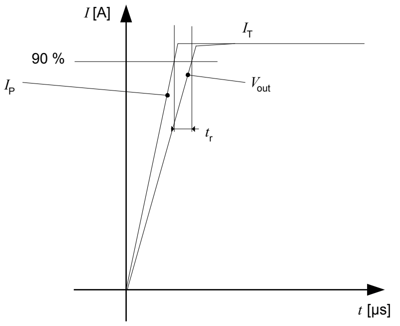
Linearity:

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

Environmental test specifications:

PV TESTS PLAN - HAM 250-S04			
TEST	**Standard (generic)**	**Paragraph**	**Specific conditions**
CHARACTERIZATION AT 25 °C (Initial)			Relative Humidity = 60 % ±15 %
Sensitivity ; Overall accuracy; Accuracy at 0 .. $\pm I_{PN}$	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = ±250 A (step: 10 % of I_{PN}), R_L = NC
Offset / Electrical Offset / Magnetic Offset	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = 250 A, R_L = NC
Magnetic Offset at $+I_{PM}$	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = 250 A, R_L = NC
Linearity error at 0 .. $\pm I_{PN}$	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = ±"x" A (step: 10 % of I_{PN}), R_L = NC
Current Consumption	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = 0 A, R_L = NC
CHARACTERIZATION IN TEMPERATURE RANGE (Initial)			
SENSITIVITY ; OVERALL ACCURACY; ACCURACY AT 0..$\pm I_{PN}$	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = ±250 A (step: 10 % of I_{PN}), R_L = NC
T °C variation of ... / Temperature Coefficient of G	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = ±250 A (step: 10 % of I_{PN}), R_L = NC
Offset / Electrical Offset / Magnetic Offset	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = 0 A, R_L = NC
T °C variation of ... / Temperature Coefficient of Offset	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V, I_P = 0 A, R_L = NC
Current Consumption	LEM CO.60.09.014.0	-	U_C = 4.75 V - 5 V - 5.25 V , I_P = 0 A, R_L = NC
ELECTRICAL PERFORMANCES			
Frequency bandwidth	LEM 98.20.00.538.0	-	U_C = 5 V, I_P = 20 A, R_L = NC At -3 dB, -1 dB, & phase (°) - Measure : 30 Hz -> 100 kHz
Output voltage Noise (spectral density)	LEM 98.20.00.575.0	-	U_C = 5 V, I_P = 0 A, R_L = NC F_{MIN} = 0 Hz; F_{MAX} = 1 MHz Power supply: Battery
Output voltage Noise (peak peak)	LEM 98.20.00.575.0	-	U_C = 5 V, I_P = 0 A, R_L = NC F_{MIN} = 0 Hz; F_{MAX} = 1 MHz Power supply: Battery
Response time ; di/dt	LEM 98.20.00.545.0	-	U_C = 5 V, R_L = NC I_P = 250 A; Slope = 10 A/µs
dv/dt	LEM 98.20.00.545.0	-	U_C = 5 V, R_L = NC V_P = 1 kV ; Slope = 10 kV/µs
ENVIRONMENTAL TESTS(Climatic)			
Class definition	IEC 60721	IEC 62477-1 §5.2.6 (07/2012) Table 30	
Ageing 85 °C / 85 % RH	LEM 98.20.00.566.0	-	T = 85 °C; RH = 85 %; Duration = 1000 h U_C = 5 V (≡ connected); I_P = 50 A; Monitoring each 5 min WARNING : CONNECTOR DOWNSIDE Check After stab. @ 25 °C (End test), & Insulation Test
Low temperature storage test	IEC 60068-2-1 Ad (03/2007)	ISO 16750-4 § 5.1.1.1 (04/2010)	T = −40 °C (or Tmin of storage) Duration = 1000 h; U_C = NO power supply (≡ unconnected) No wiring harness connected Check After stab. @ 25 °C (End test)
High temperature storage test	IEC 60068-2-2 Bd (07/2007)	ISO 16750-4 § 5.1.2.1 (04/2010)	T = +125 °C Duration = 1000 h; U_C = NO power supply (≡ unconnected) No wiring harness Check After stab. @ 25°C (End test)
Temperature cycle with specified change rate	IEC 60068-2-14 Nb (01/2009)	ISO 16750-4 § 5.3.1 (04/2010)	−40 °C (30') / + 25 °C (15') / + 105 °C (30') Slope = 6 °C/min 500 cycles (≥ 1167 h) U_C not connected ; I_P = 0 A

Environmental test specifications:

PV TESTS PLAN HAM 250-S04			
TEST	**Standard (generic)**	**Paragraph**	**Specific conditions**
ENVIRONMENTAL TESTS (Mechanical)			
Class definition	IEC 60721	IEC 62477-1 §5.2.6 (07/2012) Table 30	
Sinus Vibration	IEC 60068-2-6 Fc (02/2008)		Vibration Sinus at 25 °C 10 Hz -> 500 Hz -> 10 Hz sweep 15', 2 h/axe @ 10 g Monitoring Vout during vibration @ U_C = 5 V DC, I_P = 0 A Check the torque of the Screw before and after vibration test.
Research of natural frequency	IEC 60068-2-6 (02/2008)		Resonance: Research of natural frequency, 1 axe Sinus, Frequency: 10 Hz to 1000 Hz, Level: 1 g Monitoring V_{out}
Mechanical Shocks	IEC 60068-2-27 (02/2008)	"ISO 16750-3 § 4.2.2 (12/2012)"	Acceleration: 500 m/s^2; Duration: 6 ms; Half-sine pulse: 10 * in each direction U_C = NO power supply
Free Fall	IEC 60068-2-31 §5.2 method 1 (05/2008)	ISO 16750-3 § 4.3 (12/2012)	Height = 1 m; Concrete floor 3 axis; 2 directions by axis; 1 sample by axis
CHARACTERIZATION (Final)			
Visual Check after Test	-	-	Idem
Internal check	-	-	1. Fastening torque 2. Core appearance 3. Circuit board apperance (see report 1302PU222, p.93)
Characterization at 25 °C (Final)	LEM CO.60.09.014.0	-	See § Initial characterization above for condition test
Characterization in temperature range (Final)	LEM CO.60.09.014.0	-	See § Initial characterization above for condition test