AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

**HAH3DR 800-S07/SP1; HAH3DR 900-S07/SP1; HAH3DR 1000-S07/SP1; HAH3DR 1100-S07/SP1; HAH3DR 1200-S07/SP1;
HAH3DR 800-S07/SP4; HAH3DR 900-S07/SP4; HAH3DR 1000-S07/SP4; HAH3DR 1100-S07/SP4; HAH3DR 1200-S07/SP4**

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: defined 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)
- All in one tri-phase transducer
- Perfect fit to ‘HybridPACK TM’ drive Infineon
- Simplified installation with press fit contacts eliminates soldering.

Special features

- HAH3DR S07/SP1 series offer three built-in brass spacers with through hole for busbar attachment
- HAH3DR S07/SP4 series offer three built-in brass blind threaded nuts for busbar attachment.

Advantages

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

Automotive applications

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

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:

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

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.

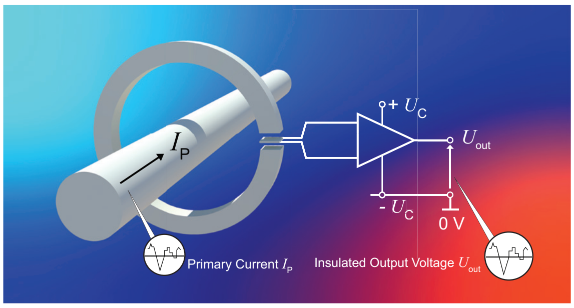
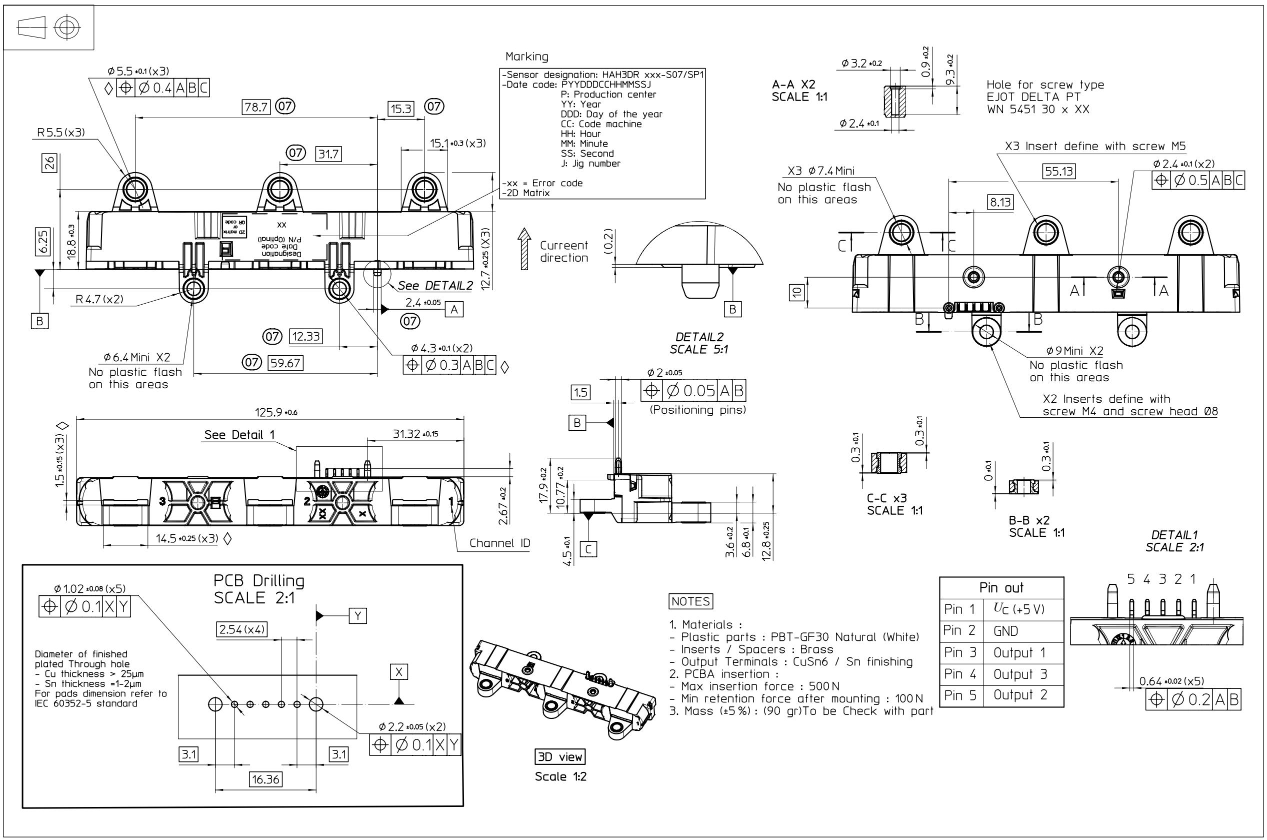


Fig. 1: Principle of the open loop transducer.

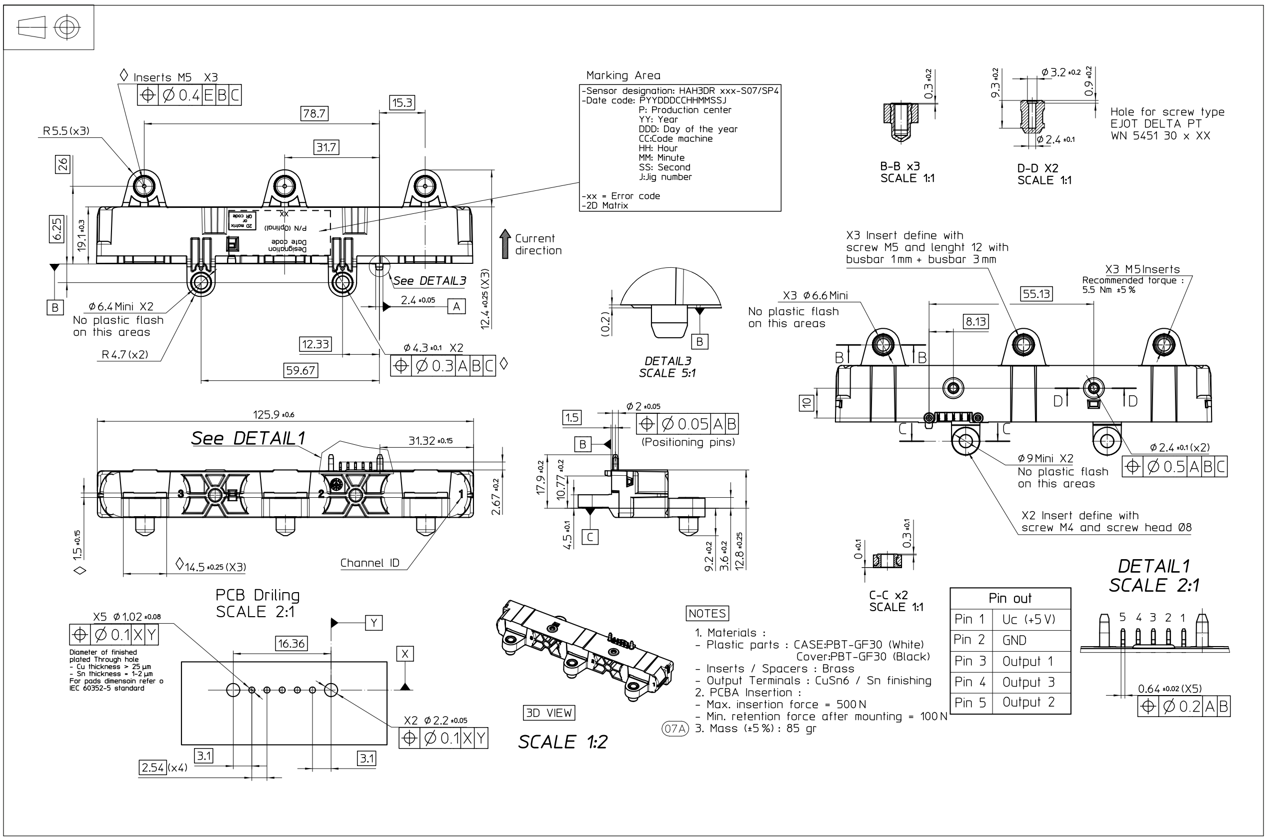
Dimensions (in mm)

HAH3DR XXXX-S07/SP1



Pin out	
Pin 1	U_C (+5 V)
Pin 2	GND
Pin 3	Output 1
Pin 4	Output 3
Pin 5	Output 2

HAH3DR XXXX-S07/SP4



Pin out	
Pin 1	Uc (+5 V)
Pin 2	GND
Pin 3	Output 1
Pin 4	Output 3
Pin 5	Output 2

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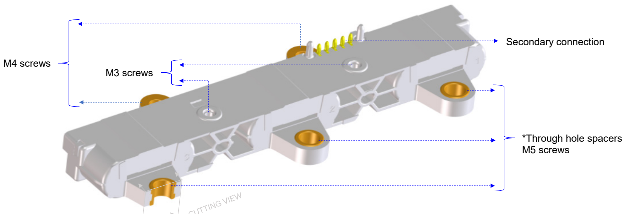
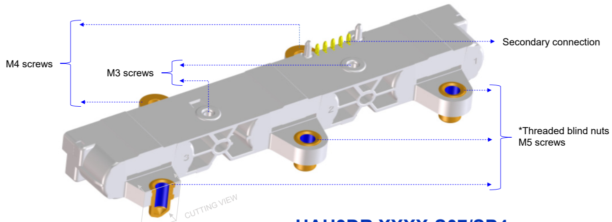
Mounting Recommendation



HAH3DR XXXX-S07/SP1



HAH3DR XXXX-S07/SP4

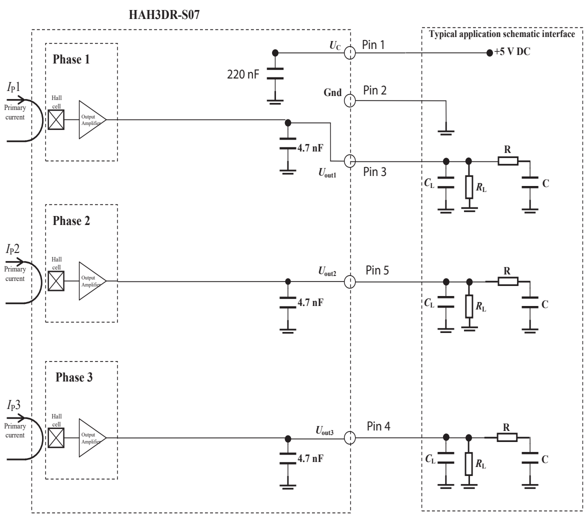
Reference	Mass (g ±5 %)	Secondary Connection		Stainless Iron - M5 screw [3]			Stainless Iron - M4 screw [3]		Stainless Iron - M3 screw	
		Type	Force (N)	Spacer	Type	Torque (Nm ±5%)	Type	Torque (Nm ±5 %)	Type	Torque (Nm ±5 %)
HAH3DR S07/SP1	90	Press-fit terminals	[1]	Through hole	-	5.5	-	2	DELTA PT® self-tapping screw	0.8
HAH3DR S07/SP4	85			Threaded hole	L = 12 mm [2]	5.5				

Notes: [1] Max. insertion force for 5 press fit pins = 500 N; Min. retention force after mounting = 100 N
[2] The length recommended is based on 1mm thickness of IGBT's busbar and 3mm thickness of customer's busbar
[3] The lockwasher and flatwasher are recommended.

Remark

U_{out} **>** U_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).

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Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification Min	Typical	Max	Conditions
Maximum supply voltage	$U_{C\ max}$	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	$T_{A\ st}$	°C	−40		125	
Electrostatic discharge voltage (HBM - Human Body Model)	$U_{ESD\ HBM}$	kV			8	
RMS voltage for AC insulation test	U_d	kV			3.06	50 Hz, 1 min, IEC 60664 part1
Creepage distance	d_{Cp}	mm		6.4		
Clearance	d_{Cl}	mm		4.8		
Comparative traking index	CTI			PLC3		
Insulation resistance	R_{INS}	MΩ	500			500 V DC, ISO 16750

Operating characteristics

All characteristics noted under conditions $-I_{PM} \le I_P \le I_{PM}$, 4.75 V ≤ U_C ≤ 5.25 V, −40 °C ≤ T_A ≤ 125 °C, unless otherwise noted.

Parameter	Symbol	Unit	Specification Min	Typical	Max	Conditions
Electrical Data						
Supply voltage [1]	U_C	V	4.75	5	5.25	
Ambient operating temperature	T_A	°C	−40		125	
Output voltage (Analog)	U_{out}	V	$U_{out} = (U_C/5) \times (U_O + S \times I_P)$			@ T_A = 25 °C
Offset voltage	U_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_S	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±4		@ T_A = 25 °C, @ U_C = 5 V
Magnetic offset voltage	U_{OM}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V, after $\pm I_{PM}$
Average temperature coefficient of U_{OE}	$TCU_{OE\ AV}$	mV/°C		±0.05		
Average temperature coefficient of S	TCS_{AV}	%/°C		±0.03		
Linearity error	ε_L	%	−1		1	% of full scale For −1000 A < I_P < 1000 A
Delay time to 90 % to the final output value for I_{PN} step	$t_{D\ 90}$	µs		2	6	di/dt = 100 A /µs
Frequency bandwidth [2]	BW	kHz	40			@ −3 dB
Peak-to-peak noise voltage	$U_{no\ pp}$	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 U_{out} is fully ratiometric. The offset and sensitivity are dependent on the supply voltage U_C relative to the following formula:

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

[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).

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HAH3DR 800-S07/SP1, HAH3DR 800-S07/SP4

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	$I_{P M}$	A	−800		800	
Sensitivity	S	mV/A		2.50		

HAH3DR 900-S07/SP1, HAH3DR 900-S07/SP4

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	$I_{P M}$	A	−900		900	
Sensitivity	S	mV/A		2.22		

HAH3DR 1000-S07/SP1, HAH3DR 1000-S07/SP4

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	$I_{P M}$	A	−1000		1000	
Sensitivity	S	mV/A		2.00		

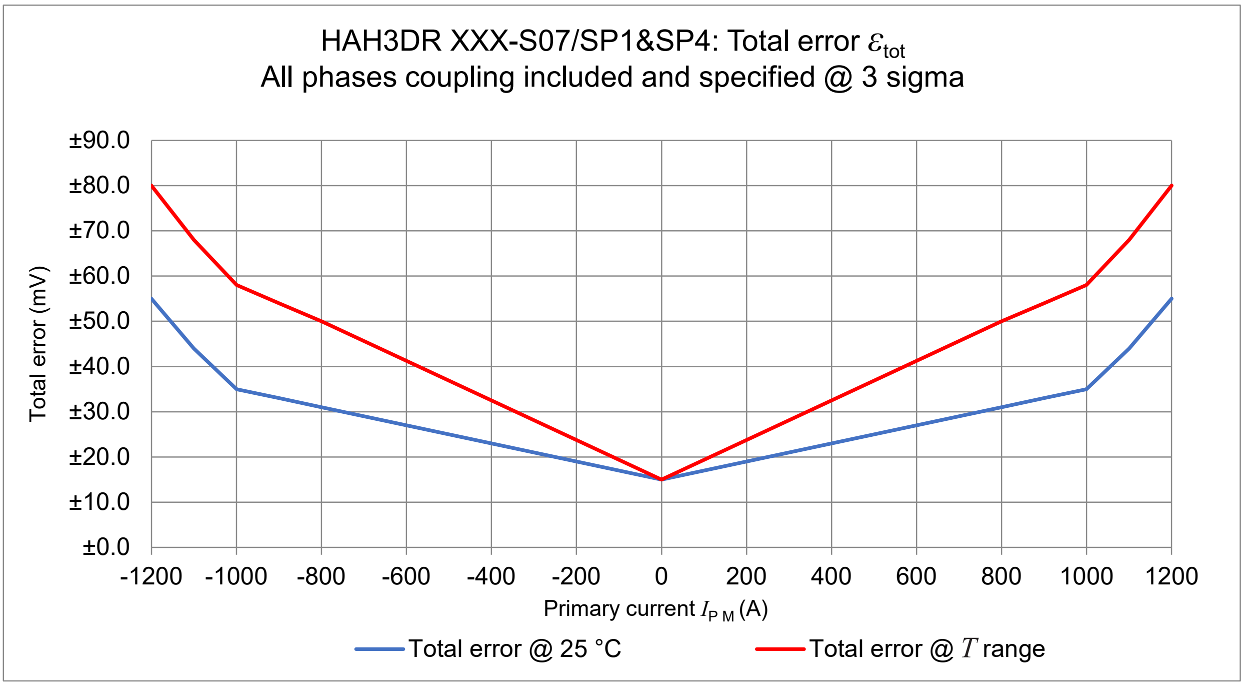
HAH3DR 1100-S07/SP1, HAH3DR 1100-S07/SP4

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	$I_{P M}$	A	−1100		1100	
Sensitivity	S	mV/A		1.82		

HAH3DR 1200-S07/SP1, HAH3DR 1200-S07/SP4

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	$I_{P M}$	A	−1200		1200	
Sensitivity	S	mV/A		1.67		

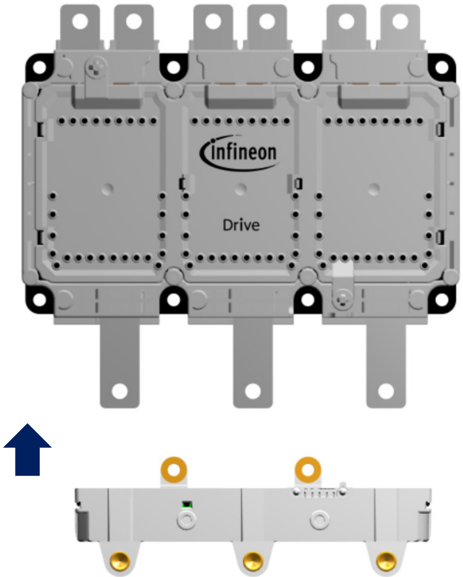
Total error



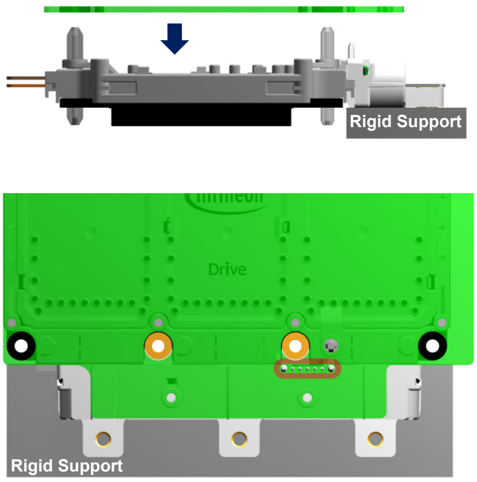
I_P	Total error specification	
	T_A = 25 °C, U_C = 5 V	−40 °C ≤ T_A ≤ 125 °C, U_C = 5 V
(A)	(mV)	(mV)
1200	±55	±80
1100	±44	±68
1000	±35	±58
900	±33	±54
800	±31	±50
0	±15	±15
−800	±31	±50
−900	±33	±54
−1000	±35	±58
−1100	±44	±68
−1200	±55	±80

Mounting Operation and Recommendations

OP10 – Transducer insertion

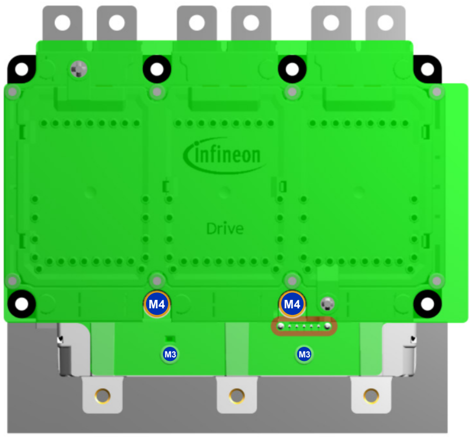


OP20 – PCB insertion



Notes:
1. Rigid support under LEM transducer during insertion
2. Press-fit terminal refers to outline drawing

OP30 – Screws mounting



Notes:
1. Stainless Iron M3 self-tapping screws (2pcs)
2. Stainless Iron M4 screws (2pcs relative with transducer)

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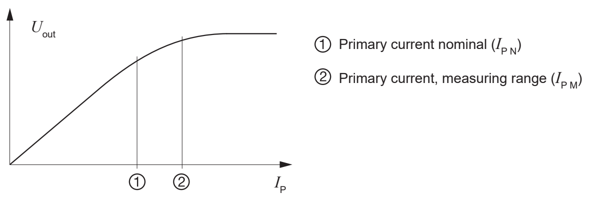
PERFORMANCES PARAMETERS DEFINITIONS

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:

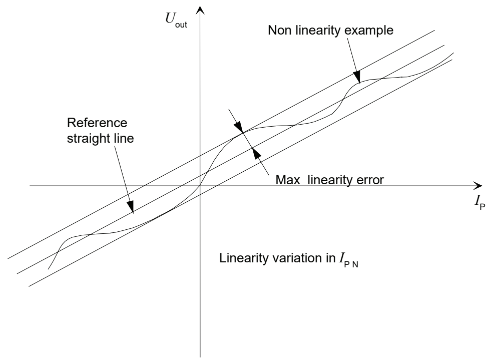
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

Magnetic offset:

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

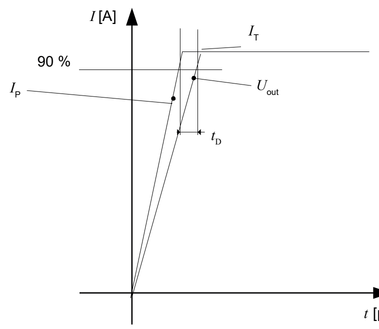
Linearity:

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 $t_{D\,90}$:

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:

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

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 S_T is the maximum variation (in ppm or %) of the sensitivity in the temperature range: S_T = (Sensitivity max − Sensitivity min) / Sensitivity at 25 °C.

The sensitivity drift 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
Electrical tests		
Phase delay check	LEM Procedure	30 Hz to 100 kHz @ 20 A peak
Frequency Bandwidth	LEM Procedure	30 Hz to 100 kHz @ 20 A peak
Noise measurement	LEM Procedure	Sweep from DC to 1 MHz
Delay time di/dt	LEM Procedure	100 A/µs, I pulse = I_{PM}
dv/dt	LEM Procedure	5000 V/µs, U = 1000 V
Dielectric Withstand Voltage test	ISO 16750-2 § 4.11	2500 V AC/ 1 min/ 50 Hz
Insulation resistance	ISO 16750-3 § 4.12	500 V DC, time = 60 s R_{INS} ≥ 500 MΩ minimum
Environmental tests		
Steady state T °C Humidity bias life test	JESD 22-A101 (03.2009)	1000 hours +85 °C/ 85 % RH U_C = 5 V , I_P = 0 A
Low temperature storage test	ISO 16750-4 § 5.1.1.1 (04.2010) IEC 60068-2-1 Ad (03.2007)	Storage: −40 °C for 96 h U_C not connected, I_P = 0 A
High temperature storage test	ISO16750-4 § 5.1.2.1 (04.2010) IEC 60068-2-2 Bd (07.2007)	Storage: 125 °C for 1000 h U_C not connected, I_P = 0 A
Thermal Shock	ISO16750-4 § 5.3.2 (04.2010) IEC 60068-2-14 Na (01.2009)	1000 cycles (1000 hours), 30 min @ −40 °C//30 mn @ +125 °C U_C not connected, I_P = 0 A
Power Temperature cycle test	ISO 16750-4 § 5.3.1 (04.2010) IEC 60068-2-14 Na (01.2009)	30 cycles(240 h), −40 °C ±125 °C U_C = 5 V , I_P = 0 A
Mechanical tests		
Mechanical Shock	ISO 16750-3 § 4.2.2 (12.2012)	50 g/ 6 ms Half Sine @ 25 °C 10 shocks of each direction (Total: 60) U_C not connected, I_P = 0 A
Sine Vibration in 25 °C	IEC 60068-2-6	Sine 30-60 m/s², 100 Hz - 440 Hz@ 25 °C 22 hr/axis U_C = 5 V , I_P = 0 A
Random Vibration in T °C	IEC 60068-2-64	96 m/s² ,10 Hz - 2000 Hz, −40 °C < T < 125 °C 22 hr/axis U_C = 5 V , I_P = 0 A
Free Fall (Device not packed)	ISO 16750-3 § 4.3 (12.2012)	Height = 1 m, Concrete floor 3 axes, 2 directions by axis, 1 sample by axis
EMC test		
Radiated Emission	CISPR 25:2016	0.15 MHz to 2500 MHz Table 9,Class 5
Immunity to conducted disturbances (BCI)	ISO 11452-4:2005	1 MHz to 400 MHz Level: 2 Criteria: A
Radiated electromagnetic field immunity test	ISO 11452-2:2004	F = 400 MHz to 1 GHz; Level = 100 V/m (CW, AM 80 %) F = 0.8 GHz to 2 GHz; Level = 70 V/m (CW, PM PRR = 217 Hz , PD = 0.57 ms)
ESD Test	ISO 10605 (07.2008) IEC 61000-4-2	Contact: ±4, ±6 kV Air: ±8 kV U_C not connected

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