AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

HAH3DR 300-S0E, HAH3DR 600-S0E, HAH3DR 700-S0E, HAH3DR 800-S0E, HAH3DR 900-S0E, HAH3DR 1000-S0E, HAH3DR 1100-S0E, HAH3DR 1200-S0E

Introduction

The HAH3DR-S0E series is a tri-phase transducer for DC, AC, or pulsed currents measurement in high power and low voltage automotive applications. It offers a galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).
The HAH3DR-S0E family gives you a choice of having different current measuring ranges in the same housing (from ±300 up to ±1200 A).

Features

- Open Loop transducer using the Hall effect sensor
- Low voltage application
- Unipolar +5 V DC power supply
- Maximum RMS primary admissible current: defined by the busbar, the magnetic core or ASIC T < +150 °C
- Operating temperature range: −40 °C < T < +125 °C
- Output voltage: fully ratiometric (in sensitivity and offset).

Special feature

- Tri-phase transducer.

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 S0E Series

The open loop transducers use 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 the Hall plates

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

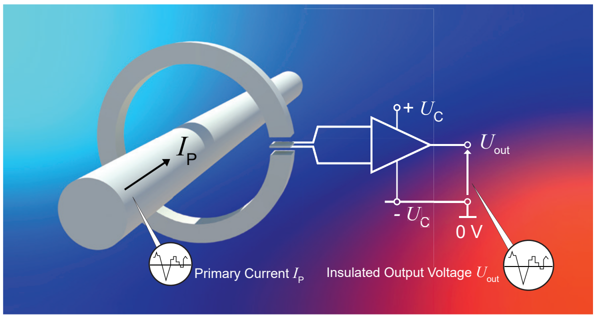

Fig. 1: Principle of the open loop transducer

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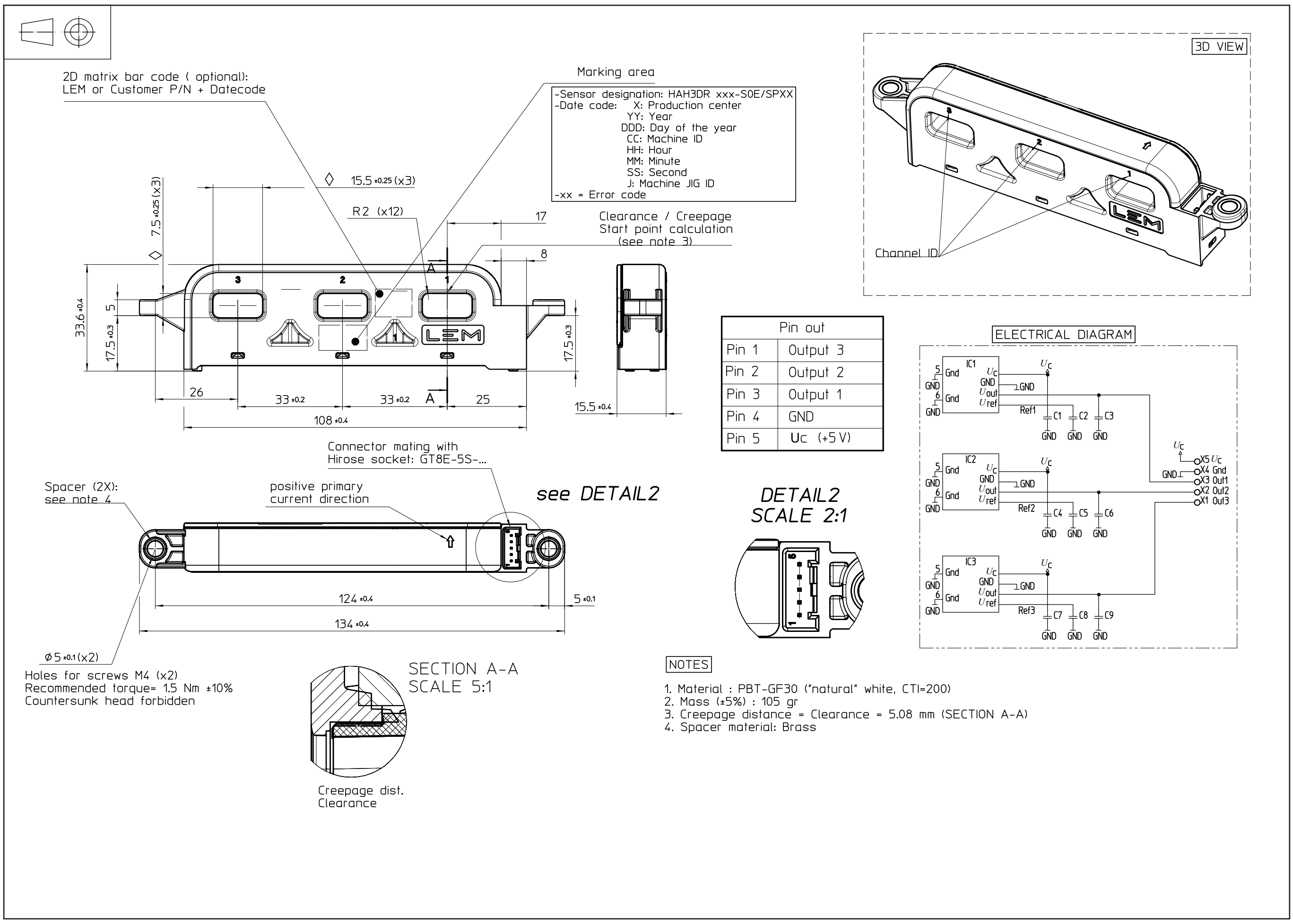
Dimensions (in mm)



Mechanical characteristics

- Plastic case >PBT-GF 30< (natural)
- Magnetic core FeSi wound core
- Pins Copper alloy gold plated
- Mass 105 g ±5 %

Mounting recommendation

- Mating connector type Hirose Socket GT8E-5S-...
- Assembly torque max 1.5 N·m ±10 %
- The clamping force must be applied to the compression limiter, washer recommended.

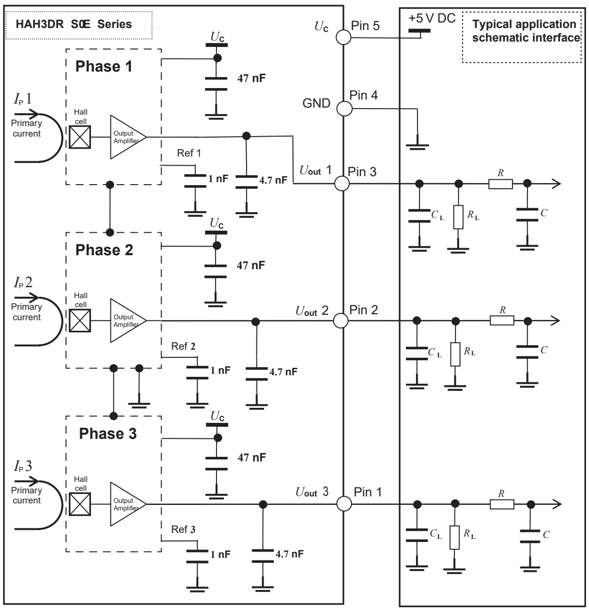
R_L > 10 kΩ optional resistor for signal line diagnostic
C_L < 2.2 nF EMC protection
RC: low pass filter (optional)

Capacitor U_{ref} / Gnd	1 nF
Capacitor U_C / Gnd	47 nF
Capacitor U_{out} / Gnd	4.7 nF

Remark

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

System architecture (example)



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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	−50		125	
Electrostatic discharge voltage (HBM)	$U_{ESD\,HBM}$	kV			2	JESD 22-A 114-B class 2
RMS voltage for AC insulation test	U_d	kV			2.5	50 Hz, 1 min, IEC 60664 part 1
Creepage distance	d_{Cp}	mm		5.08		
Clearance	d_{Cl}	mm		5.08		
Comparative tracking index	CTI			PLC 3		
Insulation resistance	R_{INS}	MΩ	500			500 V DC, ISO 16750
Primary withstand peak current (maximum)	$\hat{I}_{P\,max}$	A			[2]	

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

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	
Load capacitance	C_L	nF			2.2	
Output voltage (Analog) [1]	U_{out}	V	$U_{out} = (U_C/5) \times (U_O + S \times I_P)$			
Offset voltage	U_O	V		2.5		
Current consumption (for 3 phases)	I_C	mA		45	60	@ U_C = 5 V, @ −40 ° C < T_A < 125 °C
Load resistance	R_L	KΩ	10			
Output internal resistance	R_{out}	Ω			10	DC to1 kHz
Performance Data @ 3 Sigma (including phases coupling)						
Ratiometricity error	ε_r	%		0.5		
Sensitivity error	ε_S	%		±0.5		@ T_A = 25 °C
				±1		@ T_A = 25 °C, After T° Cycles
Electrical offset voltage	$U_{O\,E}$	mV		±4		@ T_A = 25 °C, @ U_C = 5 V
Magnetic offset voltage	$U_{O\,M}$	mV	−7.5		7.5	@ T_A = 25 °C, @ U_C = 5 V
Average temperature coefficient of $U_{O\,E}$	$TCU_{O\,E\,AV}$	mV/°C	−0.08		0.08	@ −40 ° C < T_A < 125 °C
Average temperature coefficient of S	TCS_{AV}	%/°C	−0.03	±0.01	0.03	@ −40 ° C < T_A < 125 °C
Linearity error	ε_L	% I_P	−3		3	of Full range, I_P > 900 A or < −900 A @ U_C = 5 V, @ T_A = 25 °C
			−1		1	of Full range, −900 A ≤ I_P ≤ 900 A @ U_C = 5 V, @ T_A = 25 °C
Delay time to 90 % of the final output value for $I_{P\,N}$ step	$t_{D\,90}$	µs		4	6	di/dt = 100 A/µs
Frequency bandwidth [2]	BW	kHz	40			@ −3 dB
Peak-to-peak noise voltage	$U_{no\,pp}$	mV			10	@ DC to 1 MHz
Phase shift	$\Delta\varphi$	°	−4		0	@ 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)

3) Transducer is not protected against reverse polarity.

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HAH3DR 300-S0E

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−300		300	
Primary nominal RMS current	I_{PN}	A	−300		300	
Sensitivity	S	mV/A		6.67		

HAH3DR 600-S0E

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−600		600	
Primary nominal RMS current	I_{PN}	A	−600		600	
Sensitivity	S	mV/A		3.33		

HAH3DR 700-S0E

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−700		700	
Primary nominal RMS current	I_{PN}	A	−700		700	
Sensitivity	S	mV/A		2.86		

HAH3DR 800-S0E

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−800		800	
Primary nominal RMS current	I_{PN}	A	−800		800	
Sensitivity	S	mV/A		2.50		

HAH3DR 900-S0E

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−900		900	
Primary nominal RMS current	I_{PN}	A	−900		900	
Sensitivity	S	mV/A		2.22		

HAH3DR 1000-S0E

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−1000		1000	
Primary nominal RMS current	I_{PN}	A	−1000		1000	
Sensitivity	S	mV/A		2.00		

HAH3DR 1100-S0E

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−1100		1100	
Primary nominal RMS current	I_{PN}	A	−1100		1100	
Sensitivity	S	mV/A		1.82		

HAH3DR 1200-S0E

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−1200		1200	
Primary nominal RMS current	I_{PN}	A	−1200		1200	
Sensitivity	S	mV/A		1.67		

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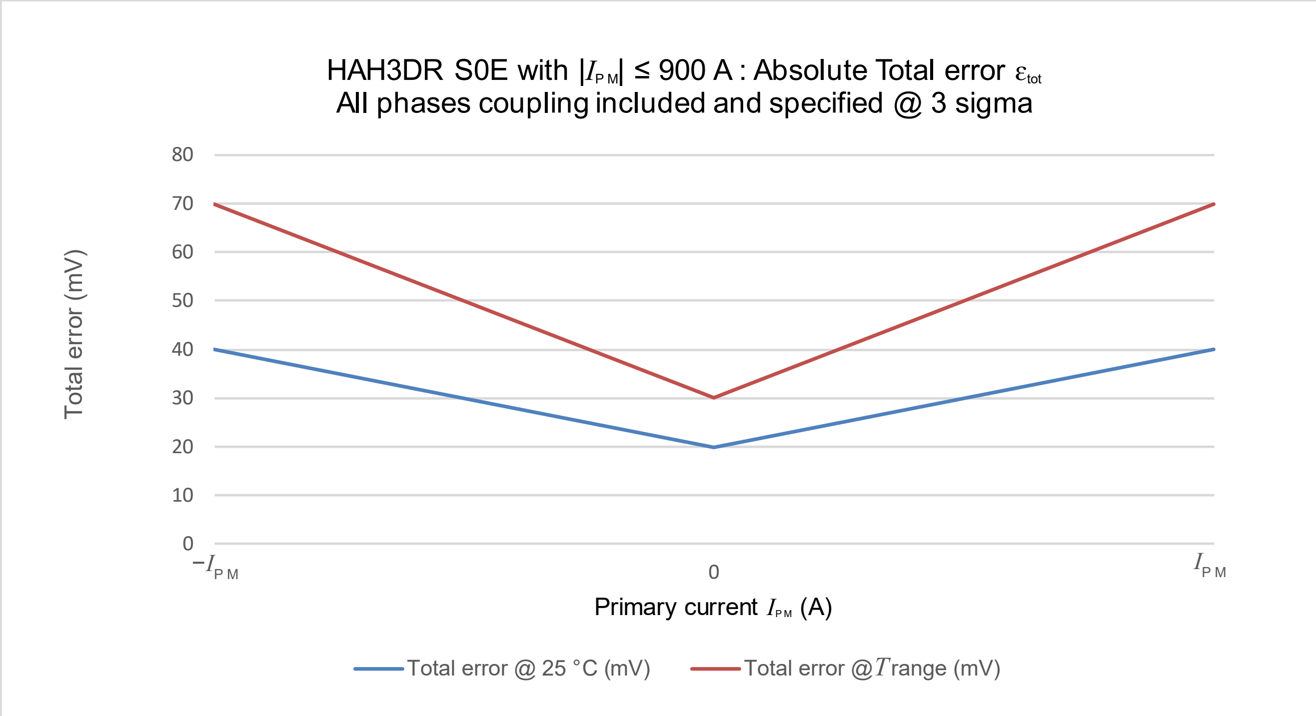
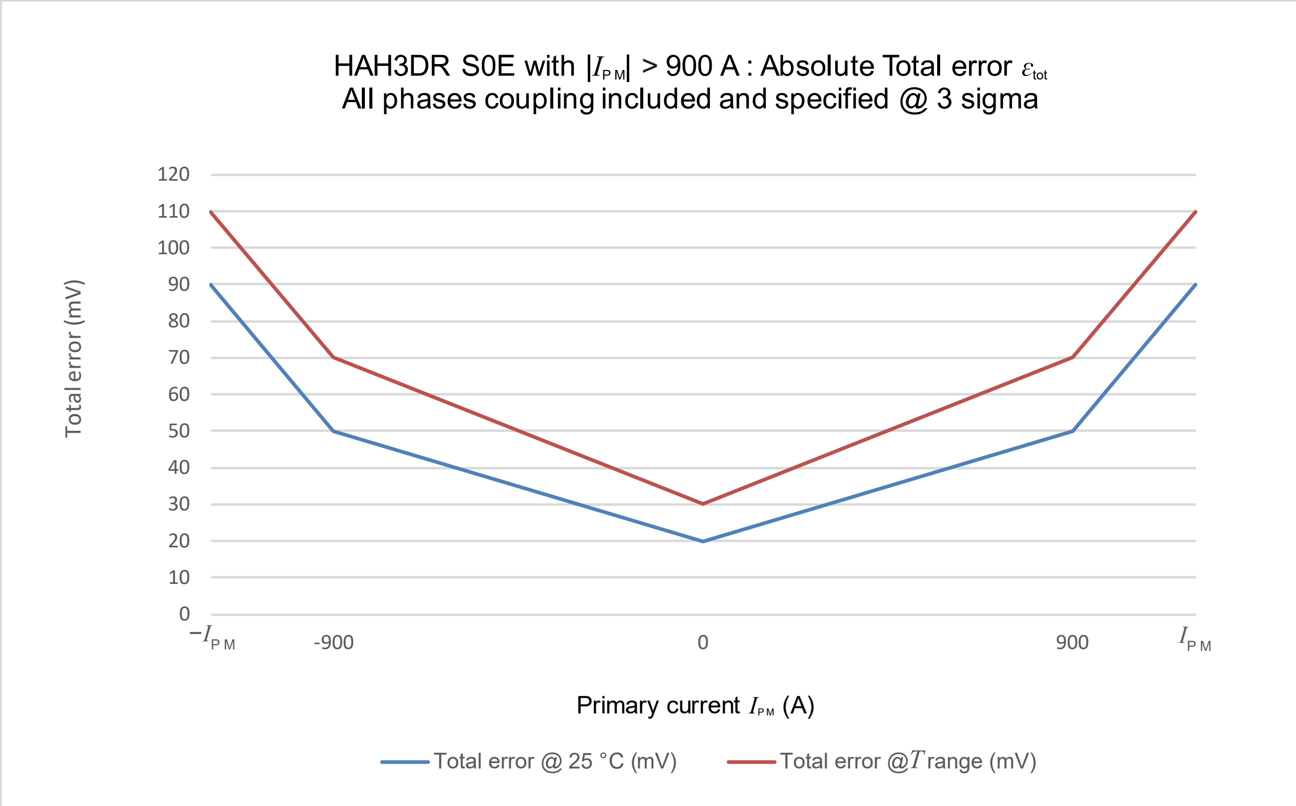
Total error(mV) for $I_{P\,M} \leq 900$ A



	Total error ε_{tot} specification			
I_P (A)	**T_A = 25 °C, U_C = 5 V**		**−40 °C < T_A < 125 °C, U_C = 5 V**	
$-I_{P\,M}$	±40 mV	2 %	±70 mV	3.5 %
0	±20 mV	1 %	±30 mV	1.5 %
$I_{P\,M}$	±40 mV	2 %	±70 mV	3.5 %

Total error(mV) for I_{PM} > 900 A



	Total error ε_{tot} specification			
I_P (A)	T_A = 25 °C, U_C = 5 V		−40 °C < T_A < 125 °C, U_C = 5 V	
I_{PM}	90 mV	4.50 %	110 mV	5.50 %
900	50 mV	2.50 %	70 mV	3.50 %
0	20 mV	1.00 %	30 mV	1.50 %
−900	50 mV	2.50 %	70 mV	3.50 %
− I_{PM}	90 mV	4.50 %	110 mV	5.50 %

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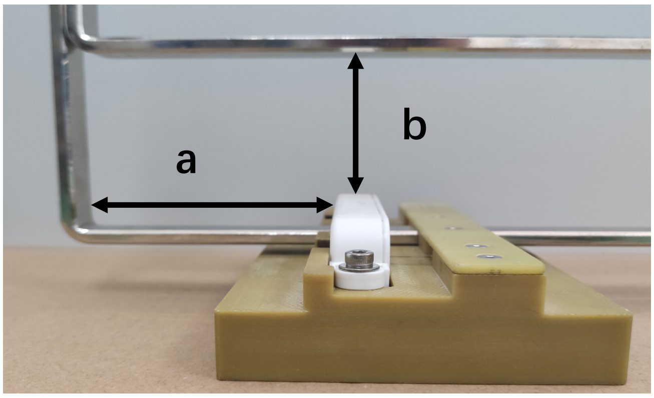

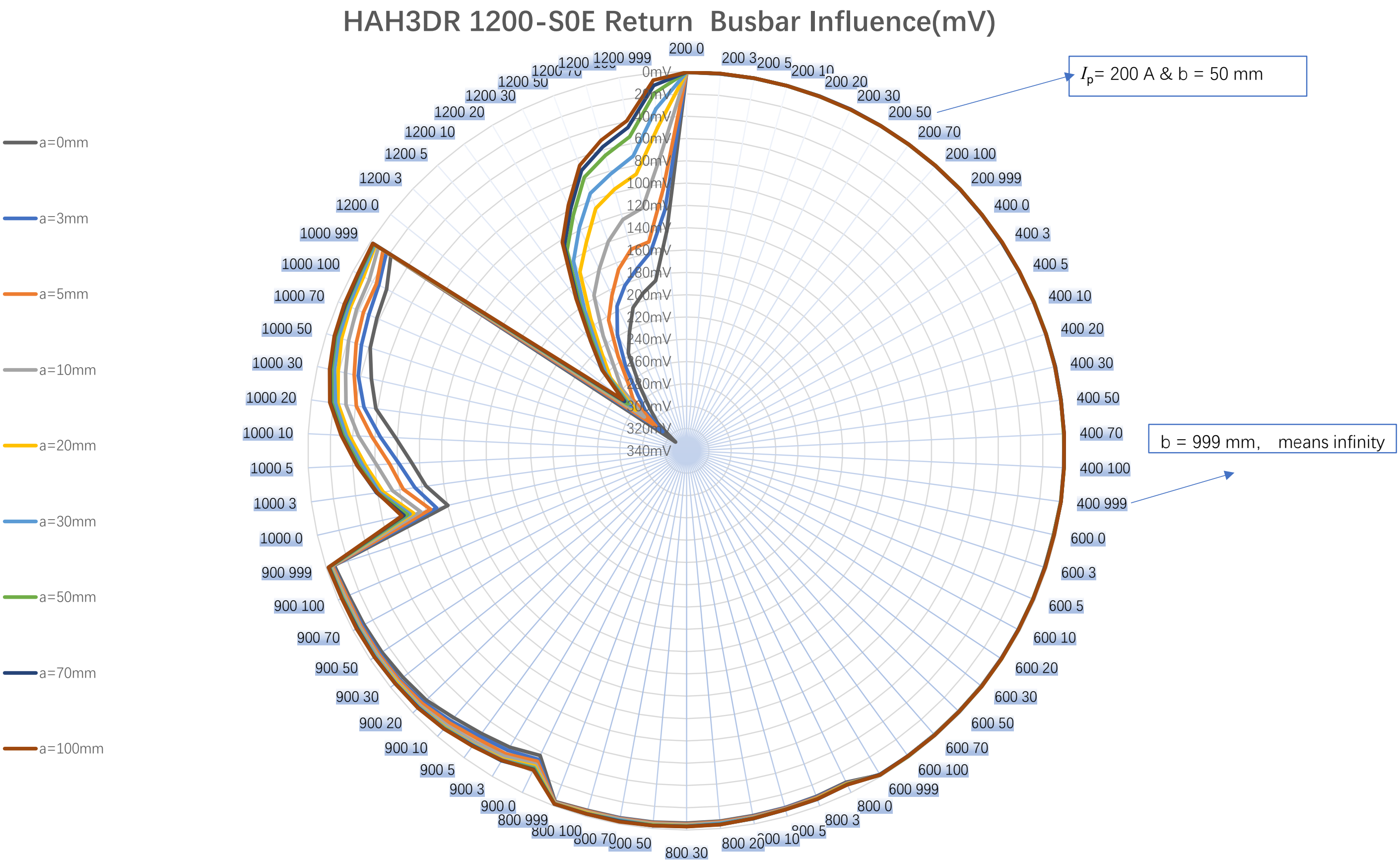

*Return Busbar Influence:

Difference of the U_{out} between the return busbar (U-shape) vs reference (straight busbar).

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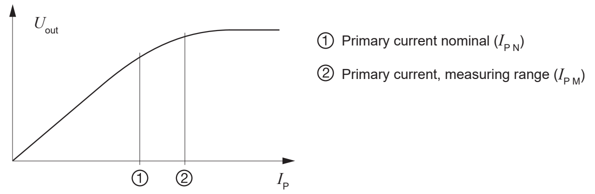
PERFORMANCES PARAMETERS DEFINITIONS

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:

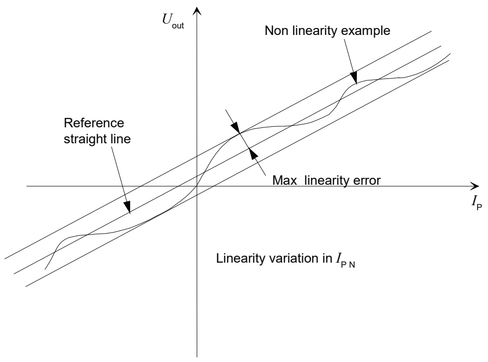
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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.

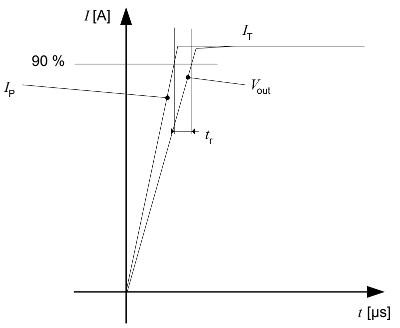
Linearity:

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 $I_{O\,T}$ 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 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.

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Environmental test specifications:

Name	Standard	Conditions
Electrical tests		
Phase delay check	LEM Procedure	100 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 = $I_{P\ max}$
dv/dt	LEM Procedure	5000 V/µs, U = 1000 V
Dielectric Withstand Voltage test	ISO 16750-2 §4.11 §4.12	2500 V AC / 1 min / 50 Hz
Insulation resistance	ISO 16750-2 (2010)	500 V DC, time = 60 s R_{INS} ≥ 500 MΩ minimum
Environmental tests		
High T °C, High Humidity, Electrical connection	IEC 60068-2-78 (2001)	1000 hours +85 °C/85 % RH U_C = 5 V DC, I_P= 0
Thermal Shock	ISO 16750-4 §5.3.2 (04.2010)	1000 cycles (1000 hours), 30 min @ −40 °C , 30 min @ +125 °C U_C not connected, I_P = 0
High T °C Storage + High T °C Exposure	ISO 16750-4 §5.1.2.1 (04.2010)	Storage: 125 °C for 1000 hours U_C not connected, I_P = 0 for both 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
Random Vibration in T °C	ISO 16750-3 §4.1.2.4 (12.2012)	ISO 16750-3 §4.1.2.4 96.6 m/s^2, 22 h/axe, 10 Hz - 2000 Hz
EMC tests		
Radiated Emission Absorber Lined Shielded Enclosure (ALSE)	CISPR 25	0.15 MHz to 2500 MHz Limit: CISPR 25 (ed 3.0) Class 5 Peak (table 9)
Radiated Immunity Bulk Current Injection (BCI)	GMW 3097 (2006) §3.4.1 ISO 11452-1 & - 4	1 MHz to 400 MHz Level: Level 2 (table 11)
Radiated Immunity Anechoic chamber	GMW 3097 (2006) §3.4.2 ISO 11452-1 & - 2	400 MHz to 2000 MHz Level: Level 2 (table 12)
ESD Test	GMW 3097 (2006) §3.6.3	150 pF / 2000 Ω Contact: ±4 kV, ±6 kV Air: ±8 kV U_C not connected

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