AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

HAH1DRW 100-S/SP5, HAH1DRW 200-S/SP5, HAH1DRW 300-S/SP5, HAH1DRW 400-S/SP5, HAH1DRW 500-S/SP5, HAH1DRW 600-S/SP5, HAH1DRW 700-S/SP5, HAH1DRW 800-S/SP5, HAH1DRW 900-S/SP5, HAH1DRW 1000-S/SP5, HAH1DRW 1100-S/SP5, HAH1DRW 1200-S/SP5, HAH1DRW 1500-S/SP5

Introduction

The HAH1DRW family for the electronic measurement of DC, AC or pulsed currents in high power and low voltage automotive applications with galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The HAH1DRW family gives you the choice of having different current measuring ranges in the same housing.

Features

- Ratiometric transducer
- Open Loop transducer using the Hall effect
- Low voltage application
- Unipolar +5 V DC power supply
- 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).

Special features

- Additional coating of the ASIC pins
- Compressor limiter for M4 screw.

Advantages

- Excellent accuracy
- Very good linearity
- Very low thermal offset drift
- Very low thermal sensitivity drift
- Galvanic separation
- High frequency bandwidth
- Non intrusive solution.

Automotive applications

- Electrical Power Steering
- Starter Generators
- Converters
- Battery Management
- Motor drive application.

Principle of HAH1DRW family

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.

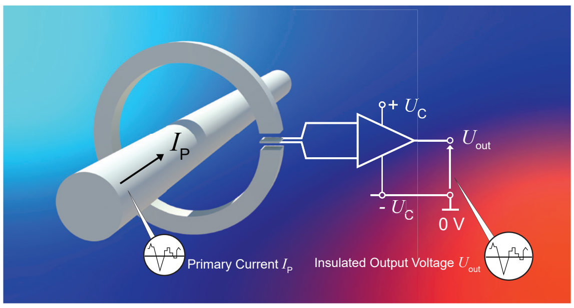

Fig. 1: Principle of the open loop transducer.

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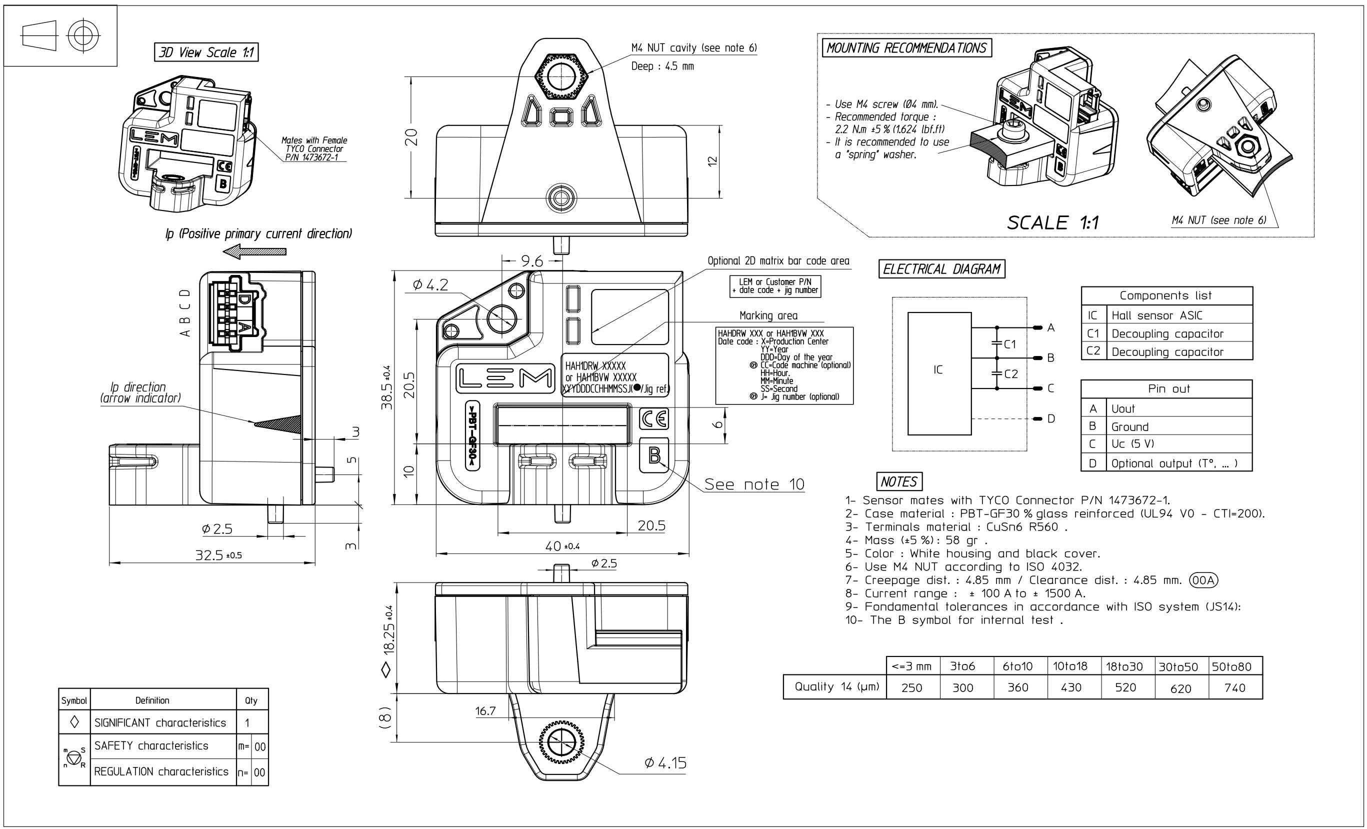
Dimensions (in mm)



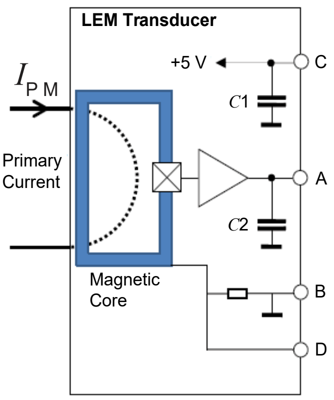
Mechanical characteristics

- Plastic case PBT GF 30
- Magnetic core FeSi wound core
- Mass 58 g ±5 %
- Pins Brass tin plated
- IP level IPx 2.

Mounting recommendation

- Connector type TYCO connector P/N 1473672-1
- Assembly torque max 2.2 N·m ±5 %

Electronic schematic



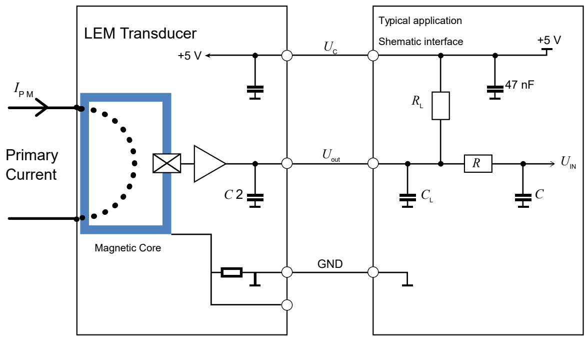
Components list		
IC	Hall sensor ASIC	
C1	Decoupling capacitor	47 nF
C2	EMC protection capacitor	4.7 nF

Pin out	
A	U_{out}
B	GND
C	U_C (5 V)
D	GND

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)

U_{out}	Diagnostic
Open circuit	$U_{IN} = U_C$
Short GND	U_{IN} = 0 V

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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	$T_{A\ st}$	°C	−40		125	
Electrostatic discharge voltage (HBM)	$U_{ESD\ HBM}$	kV			8	
Maximum admissible vibration (random RMS)	γ_{max}	$m \cdot s^{-2}$			27.1	10 to 1000 Hz, −40 °C to 125 °C
RMS voltage for AC insulation test	U_d	kV			2.5	50 Hz, 1 min
Creepage distance	d_{Cp}	mm	4.85			
Clearance	d_{Cl}	mm	4.85			
Comparative traking index	CTI		PLC 3			
Maximum output current	$I_{out\ max}$	mA	−10		10	
Maximum output voltage	$U_{out\ max}$	V	−0.5		$U_C + 0.5$	

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

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Supply voltage	U_C	V	4.75	5	5.25	
Ambient operating temperature	T_A	°C	−40		125	
Output voltage (Analog)	U_{out}	V	$U_{out} = (U_C / 5) \times (U_o + S \times I_P)$			
Offset voltage	U_O	V		2.5		
Current consumption	I_C	mA		20	25	
Load resistance	R_L	KΩ	10			
Output internal resistance	R_{out}	Ω		1	10	
Performance Data						
Ratiometricity error	ε_r	%		±0.5		
Magnetic offset voltage	$U_{O\ M}$	mV		±2		@ U_C = 5 V, @ T_A = 25 °C
Linearity error	ε_L	%	−1		1	% of full scale
Average temperature coefficient of $U_{O\ E}$	$TCU_{O\ E\ AV}$	mV/°C		±0.04		
Average temperature coefficient of S	TCS_{AV}	%/°C		±0.02		
Delay time to 90 % of the final output value for $I_{P\ N}$ step	$t_{D\ 90}$	µs		2	6	di/dt = 100 A / µs
Frequency bandwidth	BW	kHz	40			@ −3 dB
Peak-to-peak noise voltage	$U_{no\ pp}$	mV			14	DC to 1 MHz
Output RMS noise voltage	U_{no}	mV			2.2	
Phase shift	$\Delta\varphi$	°	−4			DC to 1 KHz

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

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HAH1DRW 100-S/SP5

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−100		100	
Primary nominal RMS current	I_{PN}	A	−100		100	
Sensitivity	S	mV/A		20		@ T_A = 25 °C
Sensitivity error	ε_S	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 200-S/SP5

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−200		200	
Primary nominal RMS current	I_{PN}	A	−200		200	
Sensitivity	S	mV/A		10		@ T_A = 25 °C
Sensitivity error	ε_S	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 300-S/SP5

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		6.667		@ T_A = 25 °C
Sensitivity error	ε_S	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 400-S/SP5

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−400		400	
Primary nominal RMS current	I_{PN}	A	−400		400	
Sensitivity	S	mV/A		5		@ T_A = 25 °C
Sensitivity error	ε_S	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 500-S/SP5

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−500		500	
Primary nominal RMS current	I_{PN}	A	−500		500	
Sensitivity	S	mV/A		4		@ T_A = 25 °C
Sensitivity error	ε_S	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 600-S/SP5

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		3.333		@ T_A = 25 °C
Sensitivity error	ε_S	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

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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		2.857		@ T_A = 25 °C
Sensitivity error	ε_s	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 800-S/SP5

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		2.5		@ T_A = 25 °C
Sensitivity error	ε_s	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 900-S/SP5

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		2.222		@ T_A = 25 °C
Sensitivity error	ε_s	%		±0.6		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 1000-S/SP5

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		@ T_A = 25 °C
Sensitivity error	ε_s	%		±0.7		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 1100-S/SP5

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		1.818		@ T_A = 25 °C
Sensitivity error	ε_s	%		±0.7		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

HAH1DRW 1200-S/SP5

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		@ T_A = 25 °C
Sensitivity error	ε_s	%		±0.7		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3		@ T_A = 25 °C, @ U_C = 5 V

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HAH1DRW 1500-S/SP5

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Performance Data						
Primary current, measuring range	I_{PM}	A	−1500		1500	
Primary nominal RMS current	I_{PN}	A	−1500		1500	
Sensitivity	S	mV/A		1.33		@ T_A = 25 °C
Sensitivity error	ε_s	%		±0.9		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	U_{OE}	mV		±3.6		@ T_A = 25 °C, @ U_C = 5 V

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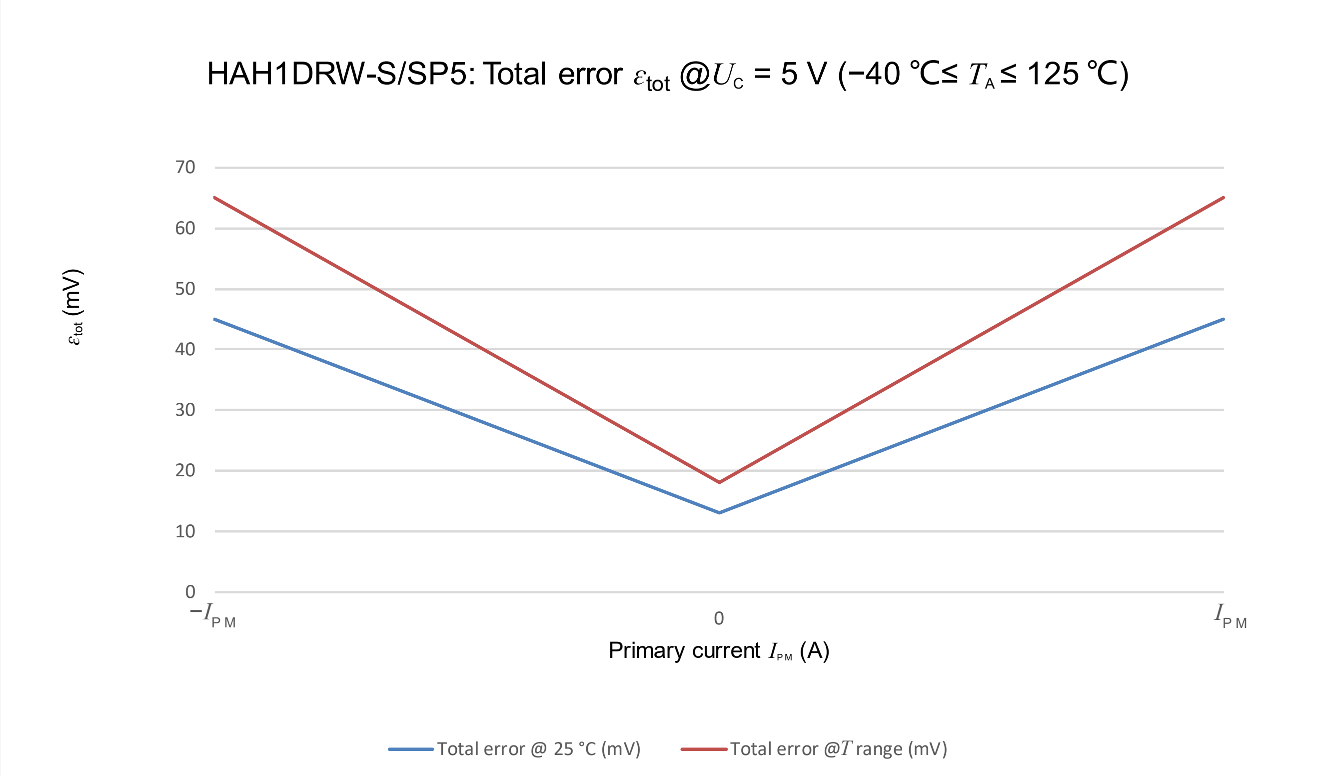
Total error ε_{tot}



	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	
$-I_{PM}$	45 mV	2.25 %	65 mV	3.25 %
0	13 mV	0.65 %	18 mV	0.90 %
I_{PM}	45 mV	2.25 %	65 mV	3.25 %

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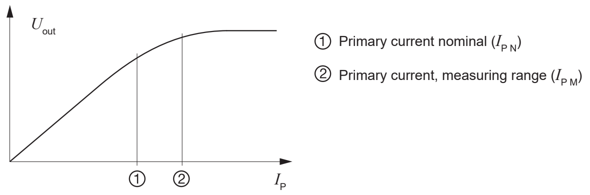
PERFORMANCES PARAMETERS DEFINITIONS

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:

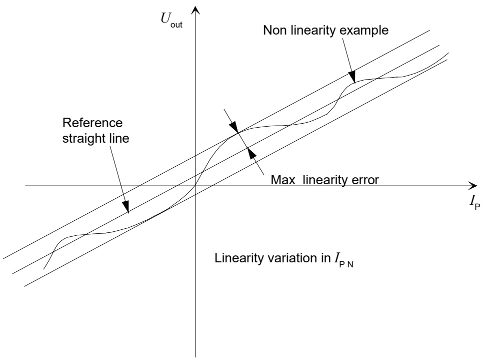
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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.

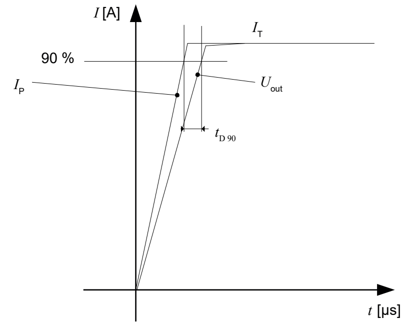
Linearity:

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



Delay time $t_{D 90}$:

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 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:

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

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:

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

Name	Standard
CHARACTERIZATION @ 25 °C (initial)	
Sensitivity / Accuracy / Total error	LEM 98.20.00.574.0
Offset / Electrical Offset / Magnetic Offset	LEM 98.20.00.573.0
Linearity error	LEM 98.20.00.370.0
Current Consumption	LEM 98.20.00.579.0
CHARACTERIZATION WITH T °C (initial)	
Sensitivity / Accuracy / Total error	LEM 98.20.00.574.0
T °C variation of ... / Temperature Coefficient of G	LEM 98.20.00.574.0
Offset / Electrical Offset / Magnetic Offset	LEM 98.20.00.573.0
T °C variation of ... /Temperature Coefficient of Offset	LEM 98.20.00.573.0
Linearity error	LEM 98.20.00.370.0
Current Consumption	LEM 98.20.00.579.0
ELECTRICAL TESTS @ 25 °C	
Phase delay check	100 Hz to 100 KHz @ 20 A peak
Noise measurement	Sweep from DC to 1 MHz
Delay time di/dt	100 A/µs. I pulse = $I_{P\ max}$
dv/dt	2000 V/µs. U = 2000 V
Dielectric Withstand Voltage test	2500 V AC / 1 min / 50 Hz
Insulation Resistance test	500 V DC, time = 60 s R_{INS} ≥ 500 MΩ Minimum
ENVIRONMENTAL TESTS (CLIMATIC)	
Thermal shock	ISO 16750-4 § 5.3.2 (04/2010) 500 cycles (500 hours), 30 min @ −40 °C // 30 min @ +125 °C U_C not connected, I_P = 0
Steady state T °C Humidity bias life test	JESD 22-A 101 (03/2009)
MECHANICAL TESTS	
Vibration Random in T °C	ISO 16750-3 § 4.1.2.4(12/2012) 27.1 m/s², 8 h/axe 10 Hz -1000 Hz
Shocks	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
Free Fall (Device not packaged)	IEC 60068-2-31 §5.2: method 1 (05/2008)
EMC	
Immunity to ElectroStatic Discharges (Handling of devices)	ISO 10605 (07/2008)
Immunity to Conducted disturbances (BCI)	ISO 11452-4 (12/2011)
Emission Radiated (ALSE)	CISPR 25 (03/2008)
FINAL CHARACTERIZATION	
Characterization @ 25 °C	
Characterization with T °C	

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