

AUTOMOTIVE CURRENTS TRANSDUCERS OPEN LOOP TECHNOLOGY

HSNDR 100-(*)X00; HSNDR 200-X00; HSNDR 300-X00; HSNDR 400-X00; HSNDR 500-X00; HSNDR 600-X00; HSNDR 700-X00; HSNDR 800-X00; HSNDR 900-X00; HSNDR 1000-X00; HSNDR-D01; HSNDR 700-S00/SP1;



Introduction

The HSNDR series is 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 HSNDR series 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 $T < +150^{\circ}\text{C}$
- Operating temperature range: $-40^{\circ}\text{C} < T < 125^{\circ}\text{C}$
- Output voltage: full ratio-metric (in sensitivity and offset).

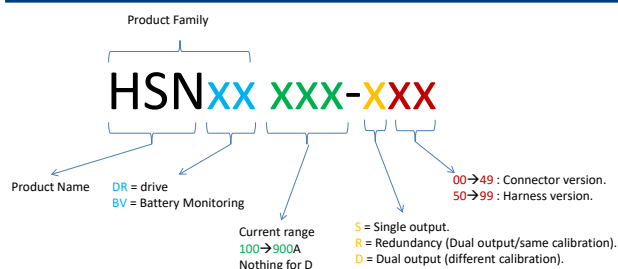
Special feature

- (*) Single (S) or dual channels sensor for wider measurement range (D) or redundancy (R).

Advantages

- Excellent accuracy
- Very good linearity
- Wide frequency bandwidth
- Very fast response time
- Very low thermal offset drift
- Very low thermal sensitivity drift
- Galvanic separation
- Non intrusive solution.

Part numbering



Automotive application

- Starter generators
- Inverters
- EV applications
- DC/DC converter.

Principle of HSNDR 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:

$$U_H = (c_H / d) \times I_H \times a \times I_p$$

Except for I_p , all terms of this equation are constant.

Therefore:

$$U_H = b \times I_p$$

a constant

b constant

c_H Hall coefficient

d thickness of the Hall plate

I_H current across the Hall plates

The measurement signal U_H amplified to supply the user output voltage or current.

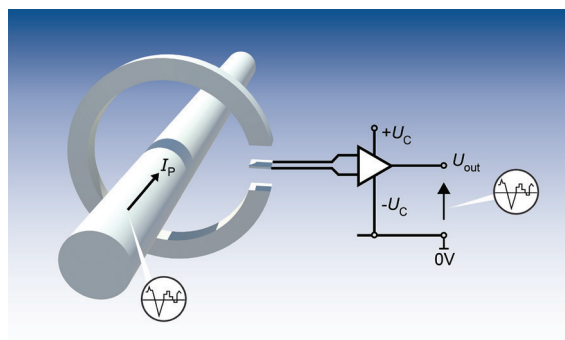
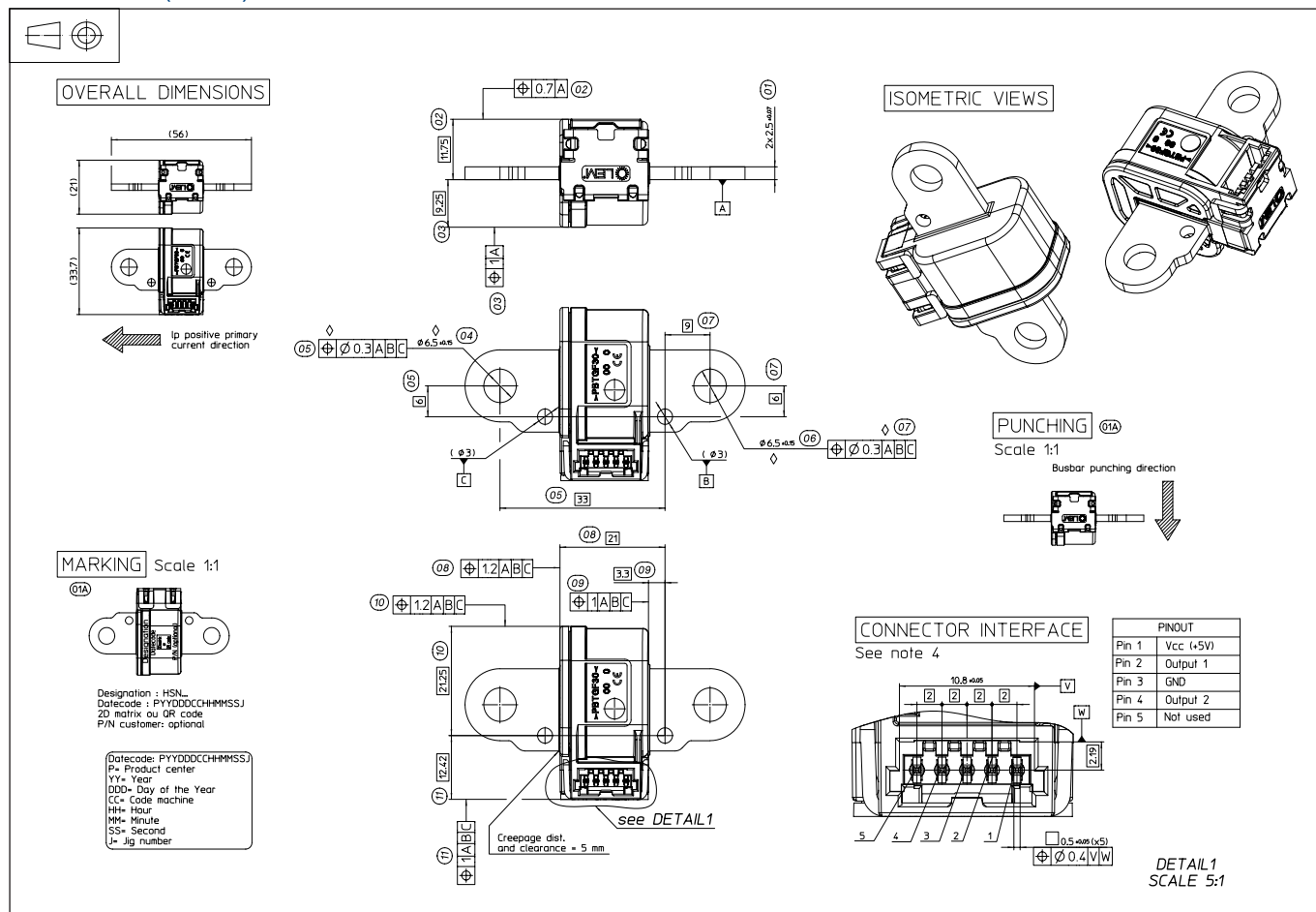


Fig. 1: Principle of the open loop transducer.

Dimensions (in mm)



Mechanical characteristics

- Plastic case PBT GF30
- Magnetic core FeSi alloy
- Busbar Copper tin plated
- Mass 41 g $\pm$ 5 %
- Pins Brass tin plated
- IP level IPx2.

Mounting recommendation

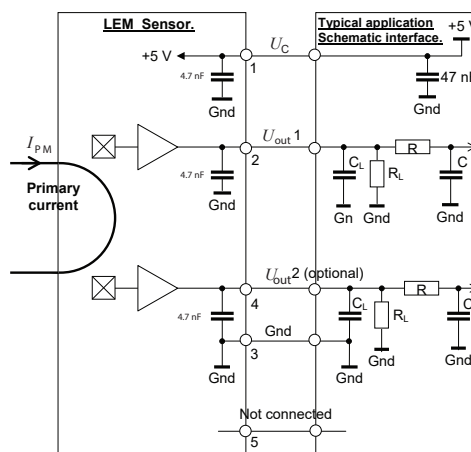
- Mating connector: Molex duraclick 5 ways:VV
ISL version
 - Housing 5 w black: 5601230501
 - Retainer 5 w grey: 5601250500
 - Terminal tin plated: 5601240101
- Assembly torque: 7 N·m $\pm$ 10 %

Screw ISO M6x1 (class 6.8) mounted with flat and spring washer or toothed screw serrated are recommended.

Remark

- $U_{out} > U_o$ when I_p flows in the positive direction (see arrow on drawing).

Electronic schematic



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

$R_L > 10$ K Ω .

Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Maximum supply voltage	$U_{C\max}$	V	-0.5		8	Continuous, not operating
					6.5	Exceeding this voltage may temporarily reconfigure the circuit until U_C comes back to 5V
Output voltage low	$U_{out\ L}$				0.2	@ $U_C = 5\text{ V}$, $T_A = 25\text{ °C}$
Output voltage high	$U_{out\ H}$		4.8			
Ambient storage temperature	T_S	°C	-40		125	
Electrostatic discharge voltage (HBM)	$U_{ESD\ HBM}$	kV			8	ISO 10605 (2008)
Maximum admissible vibration (Random RMS)	$\gamma_{\max}$	m.s ⁻²			94.8	see profile on page 10/11
RMS voltage for AC insulation test	U_d	kV			2.5	50 Hz, 1 min, IEC 60664 part1 (I < 0.1 mA)
Creepage distance	d_{Cp}	mm	5.12			
Clearance	d_{Ci}	mm	5.12			
Comparative tracking index	CTI	V	PLC0			≥ 600V
Maximum output current	$I_{out\ max}$	mA	-10		10	
Maximum output voltage	$U_{out\ max}$	V	-0.5		$U_C + 0.5$	
Insulation resistance	R_{INS}	MΩ	500			500 V DC, ISO 16750-2

Operating common characteristics in nominal range (I_{PN})

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	U_{out}	V	$U_{out} = (U_C/5) \times (U_o + S \times I_p)$			
Current consumption	I_C	mA		15 (30)	20 (40)	@ $T_A = 25\text{ °C}$, @ $U_C = 5\text{ V}$ (..) value for dual output
Load resistance	R_L	KΩ	10			
Output internal resistance	R_{out}	Ω		1	10	@ $T_A = 25\text{ °C}$
Performance Data						
Ratiometricity error	ε_r	%		±0.4		@ $T_A = 25\text{ °C}$
Sensitivity error	ε_S	%		±1		@ $T_A = 25\text{ °C}$, @ $U_C = 5\text{ V}$
Electrical offset voltage	U_{OE}	mV		±4		@ $T_A = 25\text{ °C}$, @ $U_C = 5\text{ V}$
Magnetic offset voltage	U_{OM}	mV		±3		@ $U_C = 5\text{ V}$, @ $T_A = 25\text{ °C}$ (±6mV for $I_p \leq 100A$)
Linearity error	ε_L	%		±0.5		% of full scale, method 2
Average temperature coefficient of U_{OE}	$TCU_{OE\ AV}$	mV/°K	-0.1	±0.04	0.1	@ $U_C = 5\text{ V}$
Average temperature coefficient of S	TCS_{AV}	%/°K	-0.03	±0.01	0.03	
Delay time @ 90 %	$t_{D\ 90}$	μs		3	6	100 A/μs
Frequency bandwidth	BW	KHz		50		@ -3 dB,
Peak-to-peak noise voltage	$U_{no\ pp}$	mV		10		DC to 1 MHz
RMS noise voltage	U_{no}	mV		1.5		
Start-up time	t_{start}	ms			1	
Phase shift	$\Delta\varphi$	°	-4			f = 1kHz

HSNDR 100-X00

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	$I_{P.M}$	A	-100		100	
Primary current, measuring range (output 2)	$I_{P.M}$	A	-100		100	As option
Sensitivity	S	mV/A		20		@ $T_A = 25\text{ }^{\circ}\text{C}$
Offset voltage	U_O	V		2.5		@ $U_C = 5\text{ V DC}$

HSNDR 200-X00

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	I_{PM}	A	-200		200	
Primary current, measuring range (output 2)	I_{PM}	A	-200		200	As option
Sensitivity	S	mV/A		10		@ $T_A = 25\text{ °C}$
Offset voltage	U_O	V		2.5		@ $U_C = 5V\text{ DC}$

HSNDR 300-X00

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	I_{PM}	A	−300		300	
Primary current, measuring range (output 2)	I_{PM}	A	−300		300	As option
Sensitivity	S	mV/A		6.67		@ $T_A = 25\text{ °C}$
Offset voltage	U_O	V		2.5		@ $U_C = 5V\text{ DC}$

HSNDR 400-X00

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	$I_{P.M}$	A	−400		400	
Primary current, measuring range (output 2)	$I_{P.M}$	A	−400		400	As option
Sensitivity	S	mV/A		5		@ $T_A = 25\text{ °C}$
Offset voltage	U_O	V		2.5		@ $U_C = 5V\text{ DC}$

HSNDR 500-X00

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	I_{PM}	A	−500		500	
Primary current, measuring range (output 2)	I_{PM}	A	−500		500	As option
Sensitivity	S	mV/A		4		@ $T_A = 25\text{ °C}$
Offset voltage	U_O	V		2.5		@ $U_C = 5V\text{ DC}$

HSNDR 600-X00

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	$I_{P.M}$	A	−600		600	
Primary current, measuring range (output 2)	$I_{P.M}$	A	−600		600	As option
Sensitivity	S	mV/A		3.33		@ $T_A = 25\text{ °C}$
Offset voltage	U_O	V		2.5		@ $U_C = 5V\text{ DC}$

HSNDR 700-X00 & HSNDR 700-S00/SP1

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	I_{PM}	A	−700		700	
Primary current, measuring range (output 2)	I_{PM}	A	−700		700	As option
Sensitivity	S	mV/A		2.86		@ $T_A = 25\text{ °C}$
Offset voltage	U_O	V		2.5		@ $U_G = 5V\text{ DC}$

HSNDR 800-X00

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	$I_{P.M}$	A	-800		800	
Primary current, measuring range (output 2)	$I_{P.M}$	A	-800		800	As option
Sensitivity	S	mV/A		2.5		@ $T_A = 25\text{ }^{\circ}\text{C}$
Offset voltage	U_O	V		2.5		@ $U_C = 5\text{V DC}$

HSNDR 900-X00

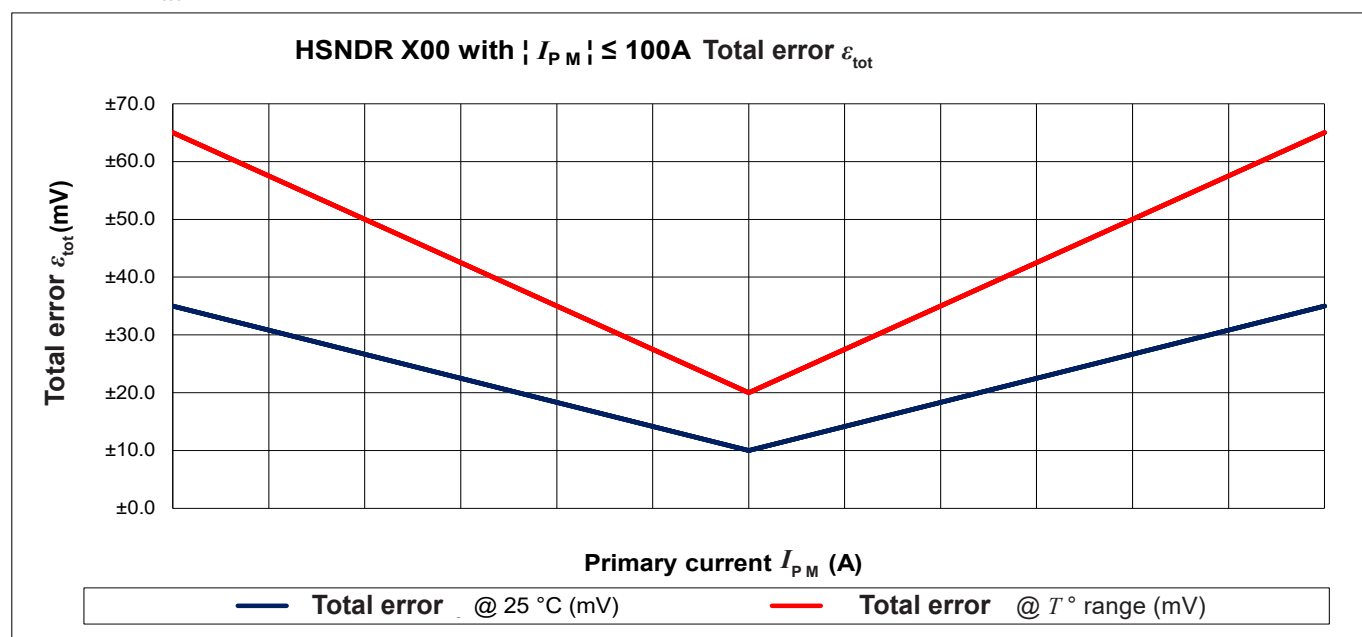
Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	I_{PM}	A	-900		900	
Primary current, measuring range (output 2)	I_{PM}	A	-900		900	As option
Sensitivity	S	mV/A		2.22		@ $T_A = 25\text{ }^{\circ}\text{C}$
Offset voltage	U_O	V		2.5		@ $U_C = 5\text{V DC}$

HSNDR 1000-X00

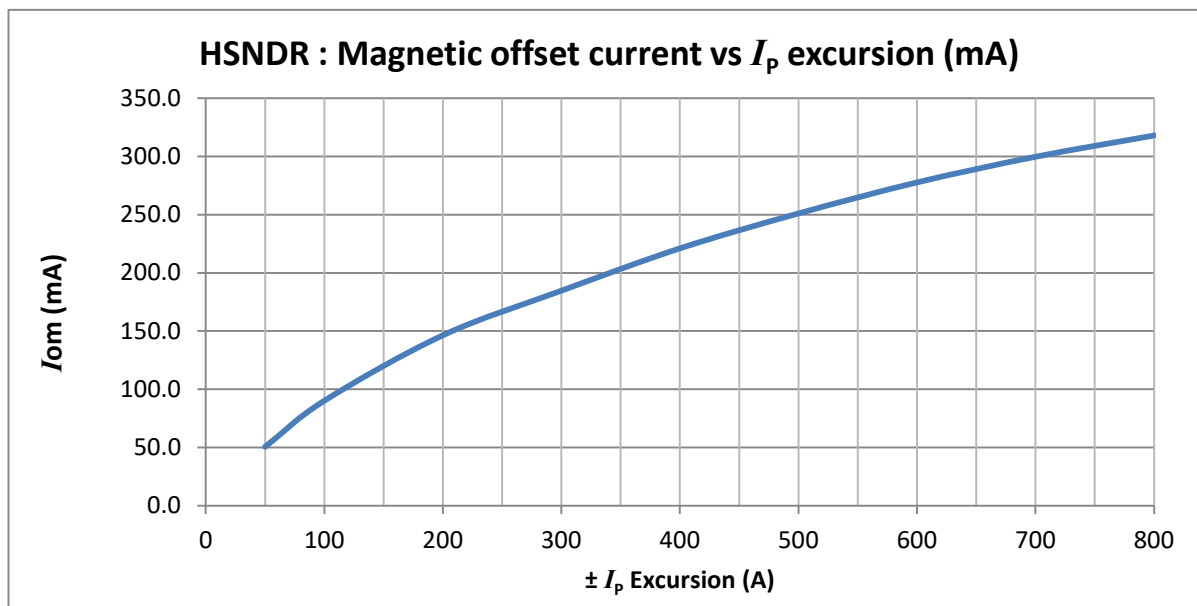
Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	I_{PM}	A	−1000		1000	Overall accuracy isn't warranty above 900A
Primary current, measuring range (output 2)	I_{PM}	A	−1000		1000	As option
Sensitivity	S	mV/A		2		@ $T_A = 25\text{ }^{\circ}\text{C}$
Offset voltage	U_O	V		2.5		@ $U_G = 5\text{ V DC}$

HSNDR-D01

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range (output 1)	$I_{PM}1$	A	−100		100	@ $T_A = 25\text{ °C}$ @ $U_c = 5V\text{ DC}$
Sensitivity (output 1)	$S1$	mV/A		20		
Offset voltage (output 1)	U_o1	V		2.5		
Primary current, measuring range (output 2)	$I_{PM}2$	A	−500		500	@ $T_A = 25\text{ °C}$ @ $U_c = 5V\text{ DC}$
Sensitivity (output 2)	$S2$	mV/A		4		
Offset voltage (output 2)	U_o2	V		2.5		

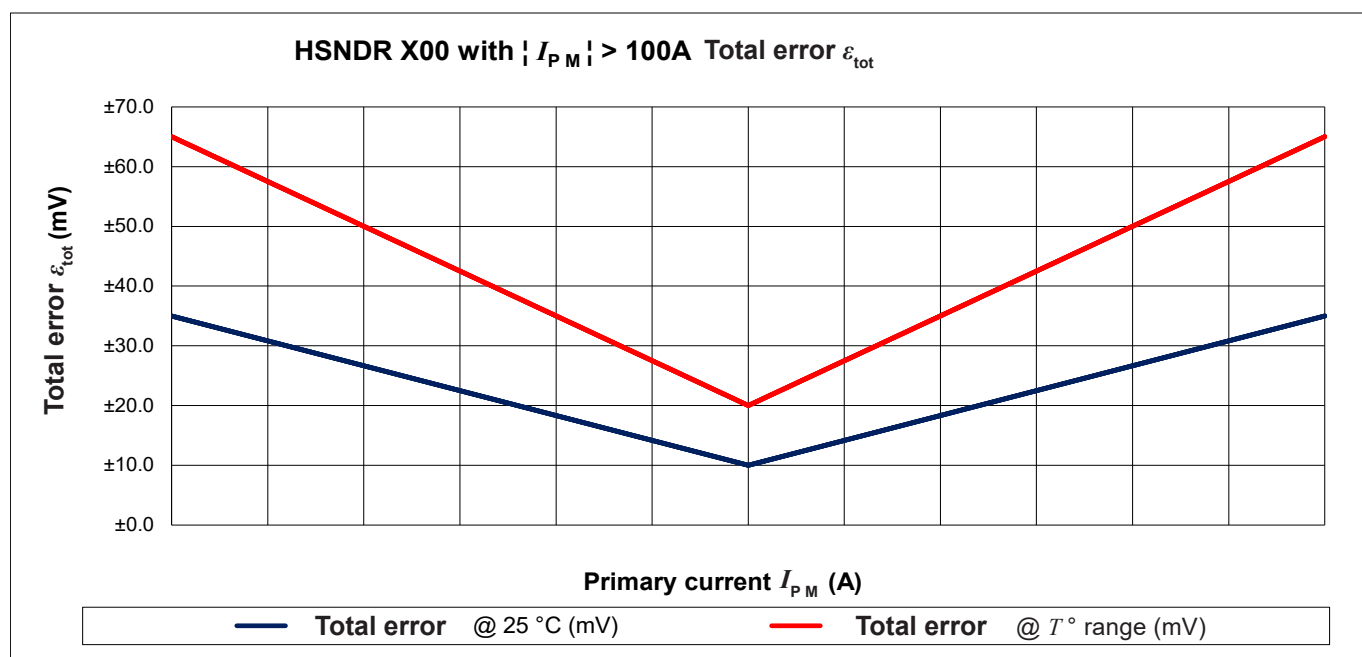
Total error ε_{tot} (mV) for $I_{PM} \leq 100A$

Total error ε_{tot} (mV) for $I_{PM} \leq 100 A$

I_p	25 °C Initial	T °C range Initial	25 °C After reliability	T °C After reliability
$-I_{PM}$	±35	±65	±35	±70
0	±10	±20	±10	±20
I_{PM}	±35	±65	±35	±70

Magnetic offset current I_{OM} VS I_p excursion

NOTE:

For HSNDR-Dxx and I_{PM} Low range $\leq 100 A$, the global offset (ε_{tot}) of Low range could slightly exceed the warranty value (± 15 mV). This is due to the magnetic offset generated by the high range current which is also seen by the Low range channel (see the above chart).

Total error ε_{tot} (mV) for $I_{PM} > 100A$

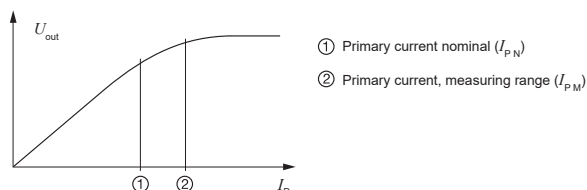


Total error ε_{tot} (mV) for $I_{PM} > 100 A$

I_p	25 °C Initial	T °C range Initial	25 °C After reliability	T °C After reliability
$-I_{PM}$	±35	±65	±35	±70
0	±10	±20	±10	±20
I_{PM}	±35	±65	±35	±70

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 $-\text{sigma}$ and $+\text{sigma}$ 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.

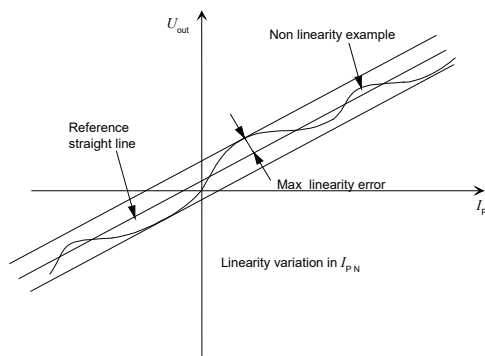
Magnetic offset:

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:

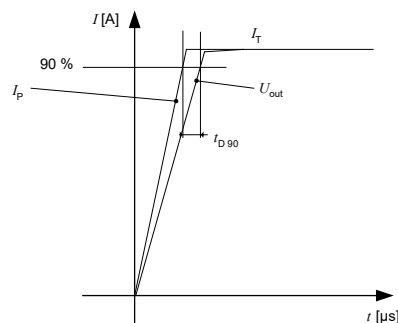
The maximum positive or negative discrepancy with a reference straight line $U_{out} = f(I_p)$.

Unit: linearity (%) expressed with full scale of I_{pN} .



Delay time t_{D90} :

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:

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

The offset drift $TCI_{OEA V}$ 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:

$S_T = (\text{Sensitivity max} - \text{Sensitivity min}) / \text{Sensitivity at } 25^\circ\text{C}$.

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).

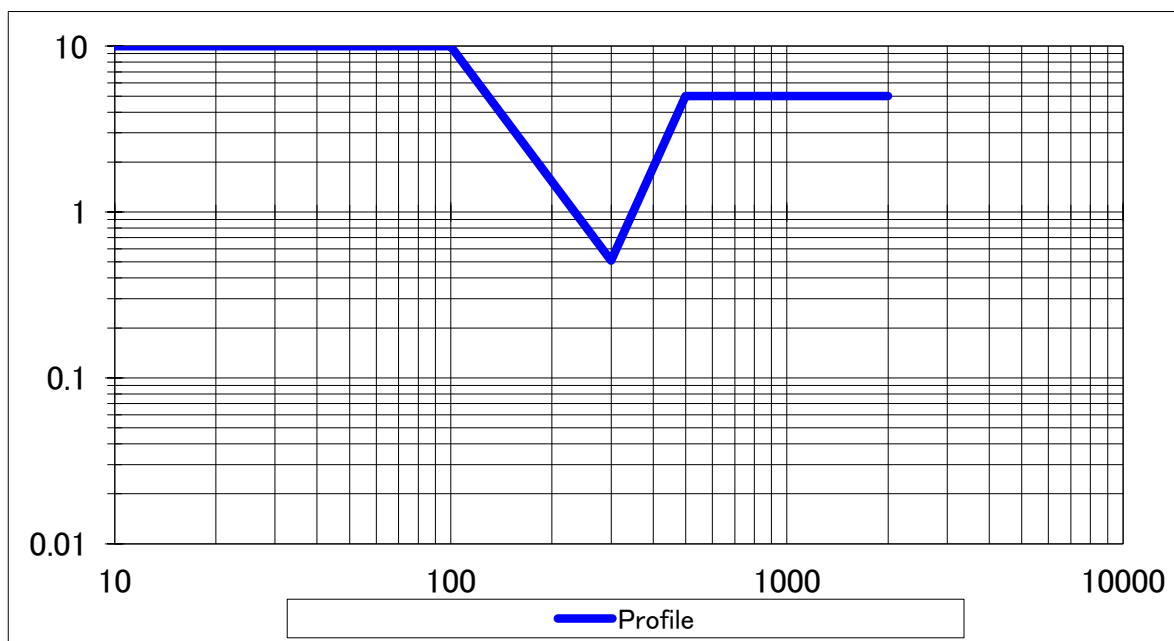
Environmental test specifications:

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

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

Name	Standard	Conditions
ELECTRICAL TESTS		
Phase shift	LEM Procedure	100 Hz to 100 kHz 20 A peak
Noise measurement	LEM Procedure	Sweep from DC to 1 MHz
Delay time d_i/d_r	LEM Procedure	100 A/ μ s $I_{pulse} = I_{p_{max}}$
d_v/d_r	LEM Procedure	5;10;20 kV/ μ s $V = 1000V$
RMS voltage for AC insulation test	IEC 60664 part 1	2.5 kV AC / 1 min /50 Hz ($I < 0.1$ mA)
Insulation resistance test	ISO 16750-2 (2010)	500 V DC time = 60 s $R_{INS} \geq 500$ M Ω Minimum
ENVIRONMENTAL TESTS		
High $T^{\circ}C$ High Humidity Electrical connection	JESD 22-A101 (03/2009)	1000 h 85 $^{\circ}C$ / 85 % RH $U_c = 5$ V DC, $I_p = 0$ A
Thermal Cycle Test (Simplified profile)	IEC 60068-2-14 Test Nb (01/2009)	$T_{min} -40^{\circ}C$, $T_{max} = +125^{\circ}C$ 1cycle = 480 min, 30 cycles
Thermal Shock	ISO 16750-4 § 5.3.2 (04/2010)	1000 cycles 30 min "-40 $^{\circ}C$ " // 30 min "+85 $^{\circ}C$ " U_c not connected $I_p = 0$ A
High $T^{\circ}C$ Storage	IEC 60068-2-2 Bd (07/2007)	125 $^{\circ}C$ for 1000 h U_c not connected $I_p = 0$ A
Low $T^{\circ}C$ Storage	IEC 60068-2-1 Ad (03/2007)	-40 $^{\circ}C$ for 240 h U_c not connected $I_p = 0$ A
Mechanical Shock	ISO 16750-3 § 4.2.2 (12/2012)	500 ms/s ² , 6 ms Half Sine @ 25 $^{\circ}C$ 10 shocks of each direction U_c not connected $I_p = 0$ A
Random Vibration in $T^{\circ}C$ profile	IEC 600068-2-27 (02/2008)	22 h for each axe; Test condition : see sheet "vibration profile". $U_c = 5$ V only during Op. mode 3.2; $I_p = 0$ A; monitoring.
EMC TESTS ES96200 (11.2011)		
Radiated Emission Absorber Lined Shielded Enclosure (ALSE)	CISPR25 (2008) Table9 - Class5	Freq = 150 kHz to 2.5 GHz Criteria A acceptance @ 5% of 2 V
Radiated Immunity Bulk Current Injection (BCI)	GWM3097 § 3.4.1 (2015)	Level : GMW 3097 (2015) § 3.4.1 Table 13 - Level1 (100mA) (ISO11452-4(2011) Annex E Table E1 Level2) F = 1MHz to 400 MHz , Criteria A acceptance @ 5% of 2V
Radiated Immunity Anechoic chamber	GWM3097 § 3.4.2 (2015)	Level : GMW3097 (2015) § 3.4.2 Table 14 - Level 2 (100V/m) 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); F = 1GHz to 2 GHz; Level = 70 V/m (CW) Criteria A acceptance @ 5% of 2 V
ESD Test	GWM3097 § 3.6.3 (2015)	Level :GMW3097 (2015) § 3.6.3.3 Table 28 Contact discharges: ± 4 , ± 6 kV; Air discharges: ± 8 kV $U_c = NO$ power supply ($\equiv$ unconnected), Criteria B
Free Fall	ISO 16750-3 § 4.3 (12/2012)	Height = 1 m Concrete floor 3 axis, 2 directions by axis, 1 sample by axis
Package drop	TBD	TBD

Random Vibration Profile @ $-40\text{ °C} < T < 125\text{ °C}$


Hz	PSD [(m/s²)² /Hz]
Frequency	Profile 1
10	10
100	10
300	0.51
500	5
1000	5
2000	5

Test duration: 22h (each X, Y, Z Axis)
RMS acceleration value: 9.66 g_{rms}

Climatic Profile

Temperatures:

- Step 1:** 60 min from +20 °C to -40 °C
- Step 2:** 90 min at -40 °C
- Step 3:** 150 min from -40 °C to +125 °C
- Step 4:** 110 min at +125 °C
- Step 5:** 70 min from +125 °C to +20 °C

Steps 1 to 5 are repeated 3 times

Steps 6: 60 min at +20 °C

Recommendations for use:

Storage:

The LEM transducers must be stored in a dry location, within the following ambient room conditions ($< 40^{\circ}\text{C}$ and $< 60\% \text{ RH}$). The product should be stored in its original packing. Ensure during storage and transport, the units are not damaged by applying excess weight to the packaging. The transducers must not be stored more than three months. Maximal stackup storage of secondary container (pallet) must not exceed 2.

Unpacking:

When unpacking, care must be taken with cutting tools not to damage the transducer.

Handling:

The LEM transducers must be handled with care and not undergo any shocks or falls (fall = scrap). It is recommended to handle the transducer as long as possible inside its original packing (thermoform tray on customer's assembly station). It is forbidden to handle the transducers by their terminals. To avoid problems of ESD, it is recommended not to touch secondary terminals. Any rework operation are forbidden and will conduct part out of LEM warranty.

Installation:

The workshop and the people in contact with the transducers must be ESD protected. Before installing, be sure to check that the transducer corresponds to the required application. Be sure that the air gap between the housing of the transducer and the primary bar is sufficient to avoid damage in case of vibrations.

LEM do not recommend customers to make any maintenance on LEM sensors other wise, it will drive sensors directly out of warranty.

Concerning installation and re-installation , cautiously care need to be taken for taped sensors same for screwed sensors.

Sensors fixed by clips must be scraped after any dismantling from the original locations.