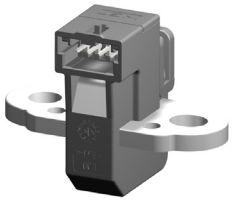
AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

HSTDR 300-000, HSTDR 400-000, HSTDR 600-000, HSTDR 900-000, HSTDR 1000-000, HSTDR 1200-000, HSTDR 1300-000, HSTDR 1500-000



Introduction

The HSTDR-000 family is a 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 HSTDR-000 family gives you a choice of having different current measuring ranges in the same housing (from ±300 A up to ±1500 A).

Features

- Open Loop transducer using the Hall effect sensor
- High insulation level
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±1500 A
- 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 ratio-metric (in sensitivity and offset).

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 converters
- DC link.

Principle of HSTDR-000 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 the Hall plates

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

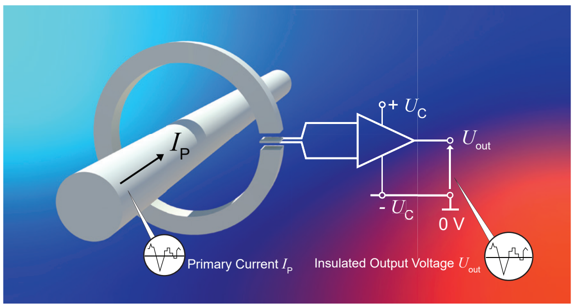


Fig. 1: Principle of the open loop transducer.

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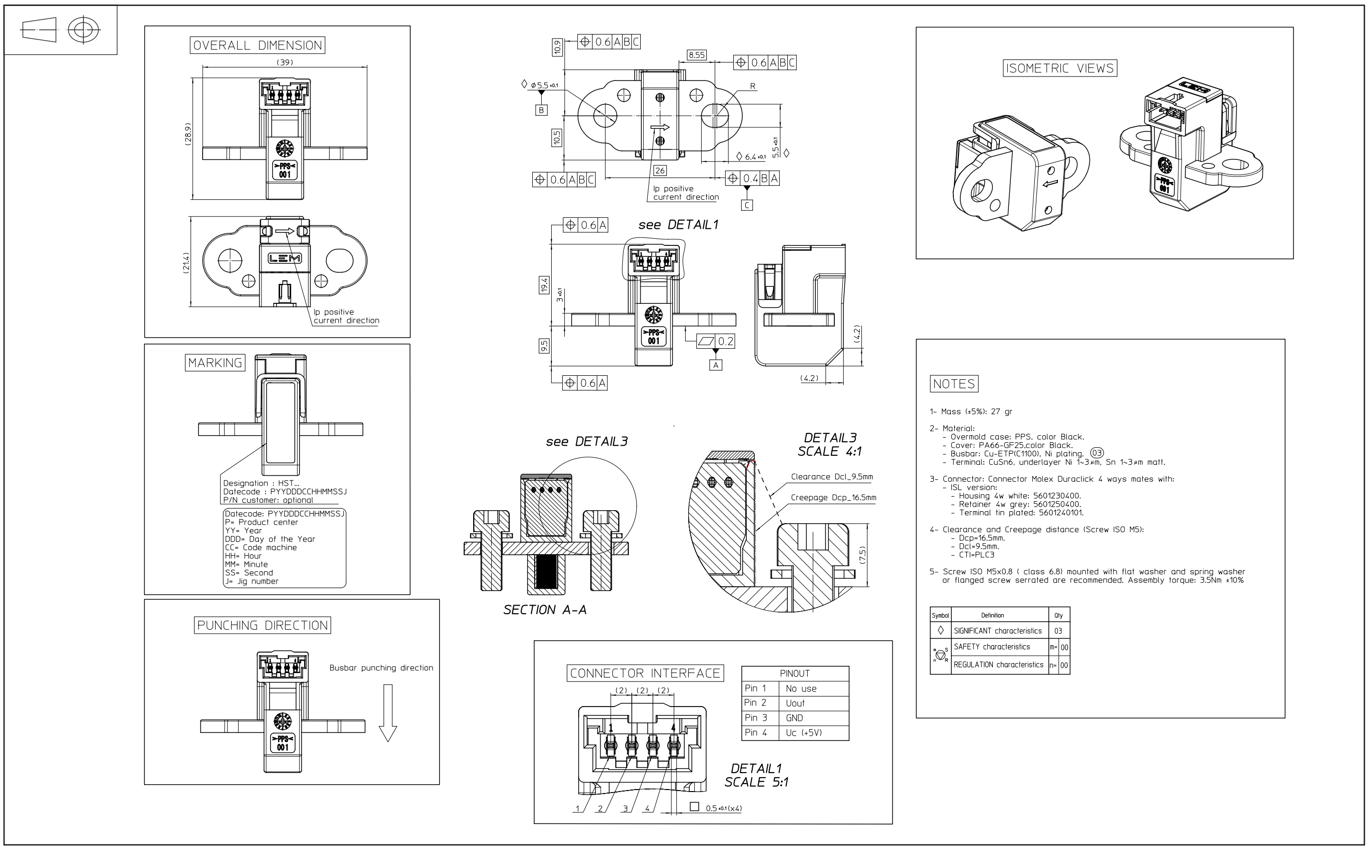
Dimensions (in mm)



Mechanical characteristics

- Plastic case PPS
- Pins Tin plated
- Mass 27 g ±5 %
- Busbar Copper, Ni plating

Mounting recommendation

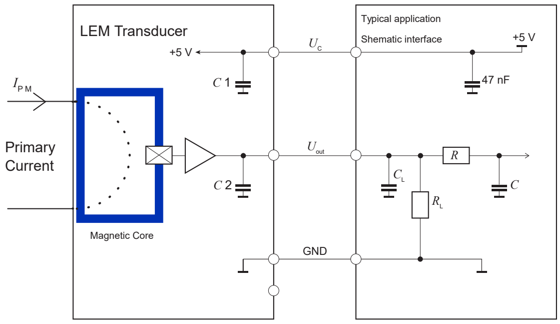
- Mating connector: Molex duraclik 4 pin:
  - Housing 4W white: 5601230400
  - Retainer 4W grey: 5601250400
  - Terminal tin plated: 5601240101
- Assembly torque: M5 screw with 3.5 N·m ±10 %

The clamping force must be applied to the compression limiter, washer recommended.

Remark

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

Electronic recommendation



R_L > 10 kΩ optional resistor for signal line diagnostic (optional)
C_L < 2.2 nF EMC protection (optional)
RC: low pass filter (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		8	Continuous, not operating
					6.5	Exceeding this voltage may temporarily reconfigure the circuit until U_C comes back to 5 V
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			4.7	50 Hz, 1 min, IEC 60664 part1
Creepage distance	d_{Cp}	mm		16.5		
Clearance	d_{Cl}	mm		9.5		
Comparative tracking index	CTI	-		PLC3		
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

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

Parameter	Symbol	Unit	Specification Min	Typical	Max	Conditions
Electrical Data						
Supply voltage	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		$U_{out} = (U_C / 5) \times (U_O + S \times I_P)$		@ U_C
Offset voltage	U_O	V		2.5		@ U_C = 5 V
Current consumption	I_C	mA		15		@ U_C = 5 V, @ T_A = 25 °C
Load resistance	R_L	KΩ	10			
Output internal resistance	R_{out}	Ω			10	DC to 1 KHz
Performance Data						
Ratiometricity error	ε_r	%		±0.3		@ T_A = 25 °C
Sensitivity error	ε_S	%		±1		@ T_A = 25 °C, @ U_C = 5 V
Electrical offset voltage	$U_{O\ E}$	mV		±4		@ T_A = 25 °C, @ U_C = 5 V
Magnetic offset voltage	$U_{O\ M}$	mV		±2		@ T_A = 25 °C, @ U_C = 5 V
Average temperature coefficient of $U_{O\ E}$	$TCU_{O\ E\ AV}$	mV/°C	−0.08	±0.04	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	% $I_{P\ M}$		±1		@ U_C = 5 V, @ T_A = 25 °C, @ I_P = $I_{P\ M}$
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 [2]	BW	kHz	40			@ −3 dB
Peak-to-peak noise voltage	$U_{no\ pp}$	mV		9		@ DC to 1 MHz for HSTDR 1500-000
Peak-to-peak noise voltage	$U_{no\ pp}$	mV		22		@ DC to 1 MHz for HSTDR 300-000
Phase shift	$\Delta\varphi$	°	−4			@ 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 1/9).

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HSTDR 300-000

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−300		300	
Sensitivity	S	mV/A		6.67		@ U_C = 5 V

HSTDR 400-000

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−400		400	
Sensitivity	S	mV/A		5		@ U_C = 5 V

HSTDR 600-000

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−600		600	
Sensitivity	S	mV/A		3.33		@ U_C = 5 V

HSTDR 900-000

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−900		900	
Sensitivity	S	mV/A		2.22		@ U_C = 5 V

HSTDR 1000-000

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−1000		1000	
Sensitivity	S	mV/A		2		@ U_C = 5 V

HSTDR 1200-000

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−1200		1200	
Sensitivity	S	mV/A		1.67		@ U_C = 5 V

HSTDR 1300-000

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−1300		1300	
Sensitivity	S	mV/A		1.54		@ U_C = 5 V

HSTDR 1500-000

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Primary current, measuring range	I_{PM}	A	−1500		1500	
Sensitivity	S	mV/A		1.33		@ U_C = 5 V

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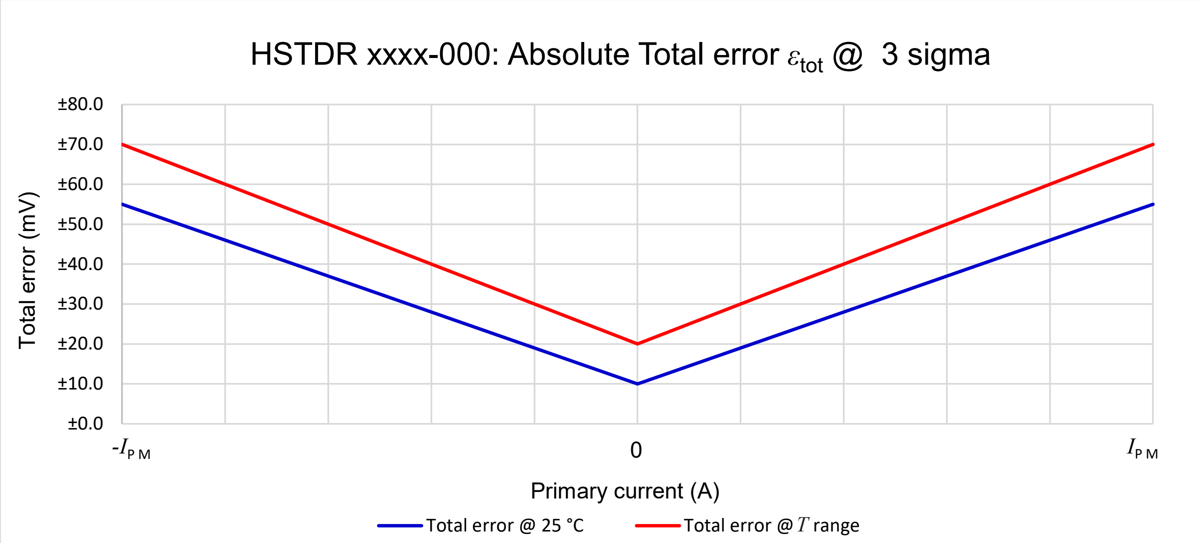
Total error



Primary current	Total error T = 25 °C, U_c = 5 V initial		Total error −40 °C ≤ T ≤ 125 °C, U_c = 5 V initial		Total error T = 25 °C, U_c = 5 V After reliability		Total error −40 °C ≤ T ≤ 125 °C, U_c = 5 V After reliability	
(A)	(mV)	(%)	(mV)	(%)	(mV)	(%)	(mV)	(%)
$-I_{PM}$	±55	±2.75 %	±70	±3.5 %	±65	±3.25 %	±70	±3.5 %
0	±10	±0.5 %	±20	±1 %	±15	±0.75 %	±20	±1 %
I_{PM}	±55	±2.75 %	±70	±3.5 %	±65	±3.25 %	±70	±3.5 %

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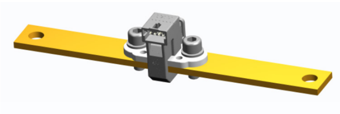
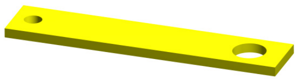
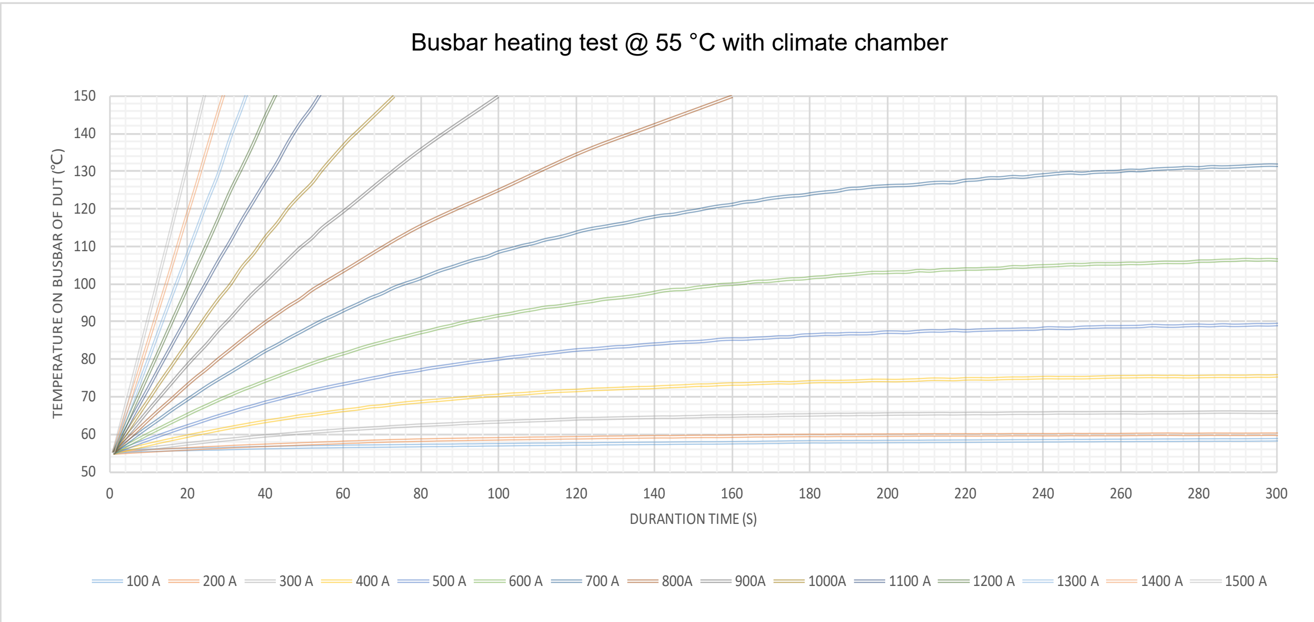
Heating generation on busbar due to primary current

Setup

Condition - Inside climate chamber - 55 °C setting up in chamber - I_P range: 100 A -1500 ADC - Mounting: refers to picture - Test points: middle of busbar, inside DUT - Resistance of system: 156 µΩ 	HST series: - Cu-ETP - Section: 3 x 16.7 (mm) - Length: 39 mm - Resistance: 20 µΩ 
	Distribution busbar besides: - Cu-ETP - Section: 3 x 16.7 (mm) - Length: 200 mm - Resistance: 68 µΩ  * Busbars besides are designed to simulate the application in customer system

Heating generation chart according to above condition



Max duration time to reach the limit 150 °C according to above condition

I_P	≤ 700	800	900	1000	1100	1200	1300	1400	1500
Max duration time (s)	Continue	160	100	73	52	43	34	31	25

* The result is for reference only according to certain condition as above.
* If the profile of primary current is over than the limit, please consider enlarging the section of busbar besides.

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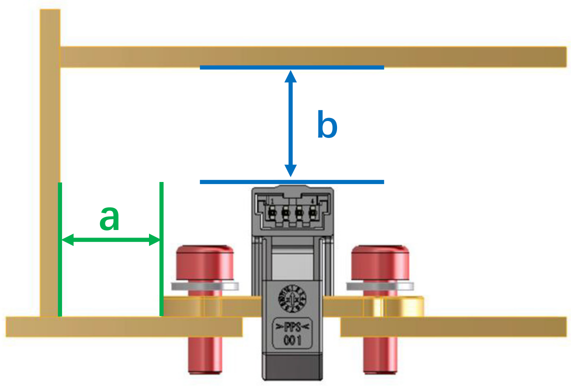
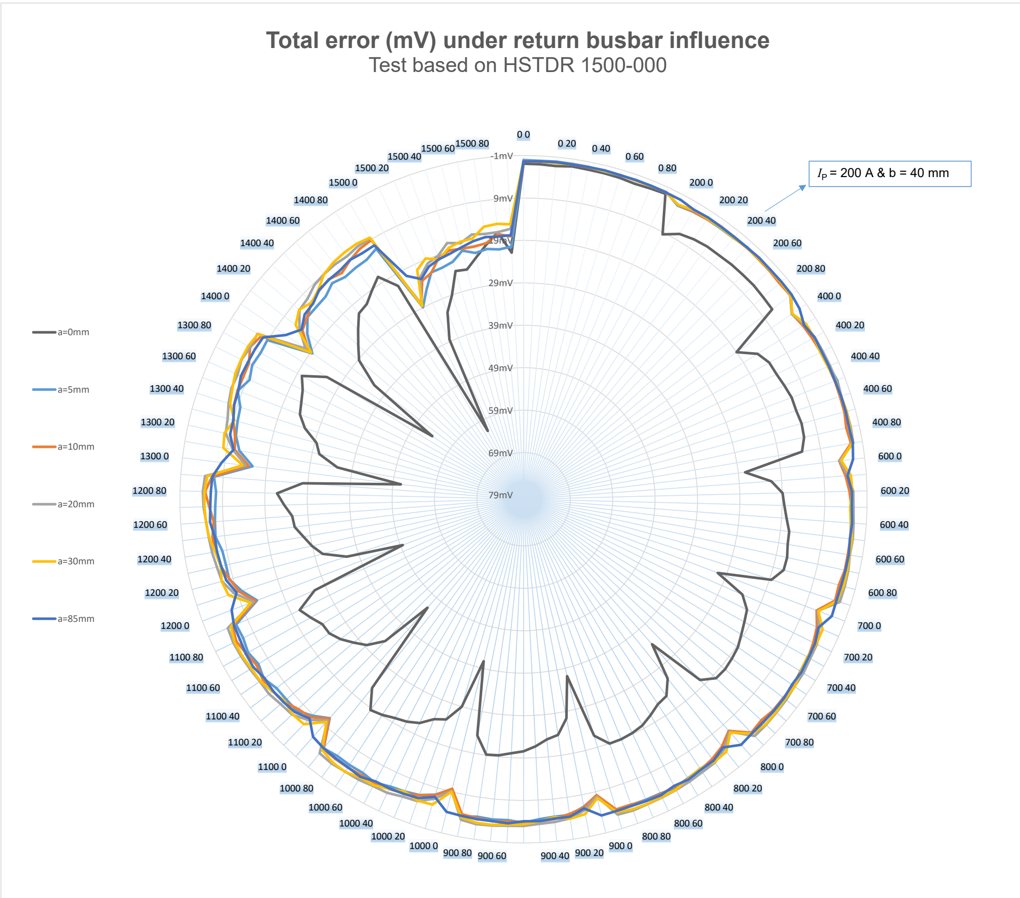
Return Busbar Influence On Transducer Output





*Return Busbar Influence:

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

LEM reserves the right to carry out modifications on its transducers, in order to improve them.

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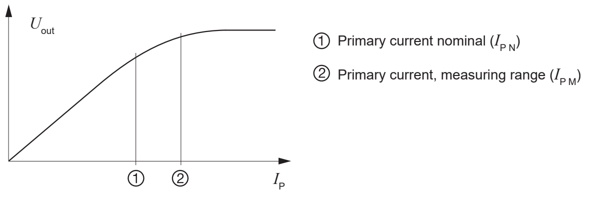
PERFORMANCES PARAMETERS DEFINITIONS

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:

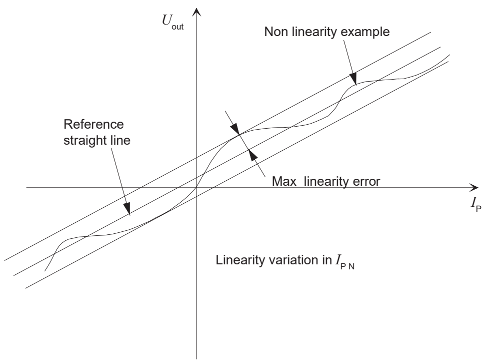
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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.

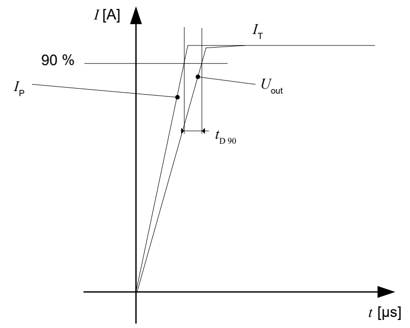
Linearity:

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



Response time (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:

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

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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Validation test specifications

Name	Standard	Condition
ELECTRICAL TESTS		
Frequency bandwidth	LEM 98.20.00.538.0	30 Hz to 100 kHz; At 20 A peak ; ≥ 40 kHz @ −3 dB
Phase delay	LEM 98.20.00.538.0	Power supply 5 V, I_P = 0 A 30 Hz to 100 kHz; At 20 A peak
Output voltage Noise (peak-to-peak)	LEM 98.20.00.575.0	Sweep from DC to 1 MHz
Delay time ; di/dt	LEM 98.20.00.545.0	100 A/µs ; $t_{D\ 90}$ of $I_{P\ N}$ ≤ 6 µs
du/dt	LEM 98.20.00.545.0	Slope: 5 kV/µs U = 1000 V
ENVIRONMENTAL TESTS		
Ageing 85 °C /85 % *RH*	JESD 22-A101 (03/2009)	85 °C/85 % *RH*; Duration = 1000 h; Power supply 5 V ; primary current 0 A; Monitoring output 1 time/hr
Low temperature operating endurance	ISO 16750-4 § 5.1.1.2 (04/2010)	−40 °C, 24 h; Power supply 5 V Monitoring: 2 times/hr
High temperature operating endurance	ISO 16750-4 § 5.1.2.2 (04/2010)	Temperature 125 °C; 96 h; power supply 5 V Monitoring 2 times/hr
Humidity heat, cyclic test: Test 2 Composite temperature/humidity cyclic test	ISO 16750-4 § 5.6.2.3 (04/2010)	Temperature range −10 °C/ +65 °C, 93 % *RH* Duration = 240 h (10 cycles)
Thermal shock	ISO 16750-4 § 5.3.2 (04/2010)	Temperature range −40 °C& 125 °C, 300 cycles; 20 min/20 min, no power supply
Sinus Vibration	ISO 16750-3 § 4.1.2.2.2.2 (12/2012)	Monitoring U_C and U_{out} is mandatory, Temperature −40/125 °C, 22 H/axis, 100 Hz to 440 Hz Sweep: ≤ 0.5 oct/min
Random Vibration	ISO 16750-3 § 4.1.2.2.2.3 (12/2012)	Monitoring U_C and U_{out} is mandatory, Temperature −40/125 °C, 22 H/axis, 10 to 2000 Hz 10 G (RMS)
Mechanical Shocks	ISO 16750-3 § 4.2.2 (12/2012)	Operating mode: 3.2 Pulse shape: half sine, 50 G, 6 ms 10 shocks per direction (total 60)
Free Fall	ISO 16750-3 § 4.3 (12/2012)	3 pcs, Falls/DUT: 2 times, Height = 1 m 3 axes, 2 directions by axis, Operating mode: 1.1
Cross section checking on PCBA	IPC-A-610G: 2017 Class 3W	IPC-TM-650 2.1.1F:2015
Cross section checking on solderless connections	GB/T 18290.5-2015	IPC-TM-650 2.1.1F:2015
Whisker checking on PCBA	Refer to JESD201-A (04/2010)	Refer to JESD22-A121A (04/2010) Class 2
INSULATION TESTS		
Dielectric withstand voltage	ISO 16750-2 § 4.11 (11/2012)	4.7 kV test voltage, time = 60 s, No dielectric breakdown, no flash-over, functional after test
Insulation test	ISO 16750-2 § 4.12 (11/2012)	500 V DC, time = 60 s, R_{INS} ≥ 500 MΩ Minimum
EMC TESTS		
Immunity to Electrostatic Discharges (Handling of devices)	ISO 10605 (07/2008)	Contact discharges: ±4.6 kV, Air discharges: ±8 kV U_C = NO power supply, Criteria B
Immunity to Radiated disturbances (ALSE)	ISO 11452-2 (11/2004)	Power supply: 5 V 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 f = 1 GHz to 2 GHz; Level = 70 V/m (CW) Criteria A acceptance @ 5 %
Immunity to Conducted disturbances (BCI)	ISO 11452-4 (12/2011)	Level = see Annex E Fig. & Table E.1 f = 1 MHz to 400 MHz Criteria A acceptance @ 5 %
Emission Radiated (ALSE)	CISPR 25 §6.5 (2016)	Table 7, Class 5 by default f = 150 kHz to 2.5 GHz Load simulator will be provided (R&D)

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Recommendations for use:

Storage:
The LEM transducers must be stored in a dry location, within the following ambient room conditions (< 40 °C and < 60 % *RH*). The product should be stored in its closed and original packing. Ensure during storage and transport, the units are not damaged by applying excess weight to the packaging. The transducers mustn't be stored more than 2 years. Ensure during storage and transport, the units are not damaged by applying excess weight to the boxes. 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.

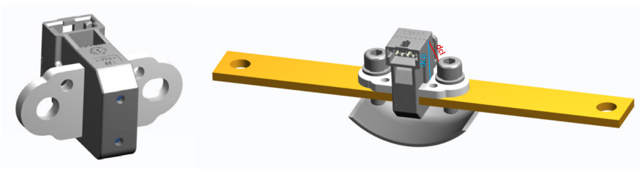
Handling:
The LEM transducers must be handled with care and not undergo any shocks or falls (fall=scrap). It is recommended to handle the transducer as long as possible inside its original packing (thermoform tray on customer's assembly station). It is forbidden to handle the transducers by their terminals.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

Do not install (or re-install) a damaged part (broken or crushed element…).
LEM do not recommend customers to make any maintenance on LEM sensors , otherwise it will drive sensors directly out of warranty.

Disassembly:
Suppress all electricity power before disassembling the transducer.

Mounting:
1. Recommend that customer's busbar are mounted under HSTDR, to avoid shorten clearance/creepage distance
2. Recommend to use insulation layer under HSTDR if the HSTDR bottom is close to other metal parts, to avoid potential insulation issue (two auxiliary holes of plastic injection on HSTDR bottom)



单击下面可查看定价，库存，交付和生命周期等信息

[>>LEM(莱姆)]