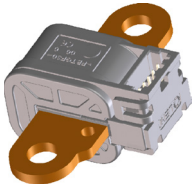


# AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

## HSNDR 1000-S05



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

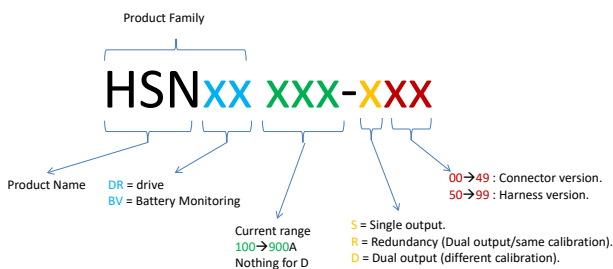
### Special feature

- Busbar uses passivation technology.

### Advantages

- Excellent accuracy
- Very good linearity
- High 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:

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

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.

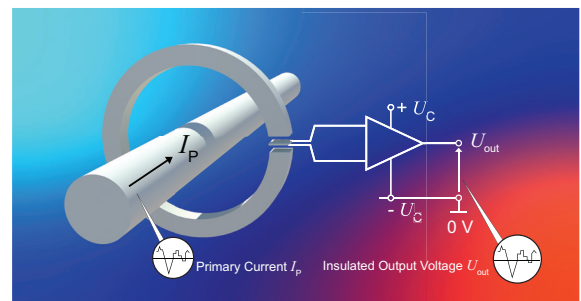


Fig. 1: Principle of the open loop transducer.

## Dimensions (in mm)

**OVERALL DIMENSIONS**

**MARKING** Scale 1:1

Designation : HSN...  
Datecode : PYYDDCCCHMMSSJ  
2D matrix or QR code  
P/N customer: optional

Datecode: PYYDDCCCHMMSSJ  
P- Product center  
YY- Year  
DD- Day of the Year  
CC- Code machine  
MM- Hour  
SS- Minute  
S- Second  
J- Jig number

**CONNECTOR INTERFACE**  
See note 4

PINOUT	
Pin 1	Vcc (+5V)
Pin 2	Output 1
Pin 3	GND
Pin 4	Output 2
Pin 5	Not used

**DETAIL2 SCALE 5:1**

**PUNCHING**  
Scale 1:1  
Busbar punching direction

**ISOMETRIC VIEWS**

**NOTES**

- Mass (+5%): 41 gr
- Material:
  - Plastic parts: PBT-GF30.
  - Busbar: CU-ETP (C1100 1/4H).
  - Terminal: CuSn6 or equivalent
- Finishing:
  - Plastic parts: graining CH21.
  - Busbar: No finishing.
  - Terminal: underlayer Ni 1 to 2 µm, Sn 1 to 2 µm matt
- Connector: Connector Molex Duraclick 5 ways mates with:
  - ISL version:
    - Housing 5w black: 5601230501.
    - Retainer 5w grey: 5601250500.
    - Terminal tin plated: 5601240101.
- Clearance and Creepage distance = 5,12mm
- Screw ISO M6x1 ( class 6,8) mounted with flat washer and spring washer or flanged screw serrated are recommended. Assembly torque: 7Nm ±10%
- Number of balloon for metrology: ⑦

Symbol	Definition	Qty
◊	SIGNIFICANT characteristics	04
SAFETY	SAFETY characteristics	00
REGULATION	REGULATION characteristics	00
<-	CAPABILITY dimensions	00

## Mechanical characteristics

- Plastic case PBT GF 30
- Magnetic core FeSi alloy
- Busbar C 1100 1/4 H with no finishing
- Mass 41 g ±5 %
- Pins Underlayer Ni 1 to 2 µm, Sn 1 to 2 µm matt
- IP level IPx 2.

## Mounting recommendation

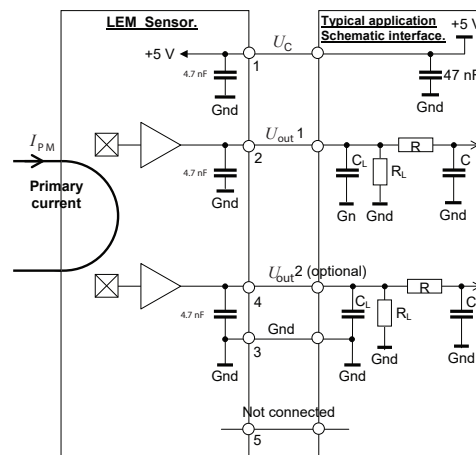
- Mating connector: Molex duraclick 5 ways:VV
  - ISL version
    - Housing 5 w black: 5601230501
    - Retainer 5 w grey: 5601250500
    - Terminal tin plated: 5601240101
- Assembly torque: 7 N·m ±10 %

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

## Remark

- $U_{out} > U_0$  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)
- $R_L > 10$  KΩ.

**Absolute ratings (not operating)**

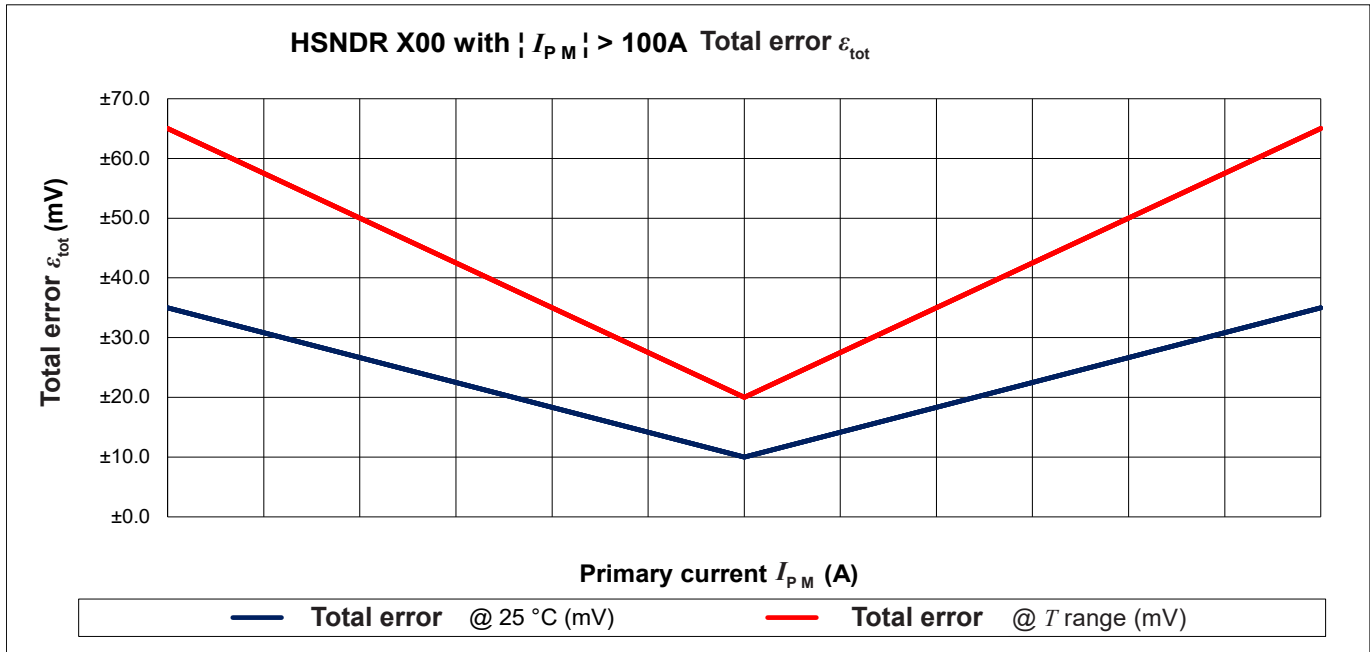
Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Maximum supply voltage	$U_{Cmax}$	V	-0.5		8	Continuous, not operating
					6.5	Exceeding this voltage may temporarily reconfigure the circuit until $U_C$ comes back to 5 V
Output voltage low	$U_{outL}$				0.2	@ $U_C = 5 V, T_A = 25 ^\circ C$
Output voltage high	$U_{outH}$		4.8			
Ambient storage temperature	$T_{Ast}$	$^\circ C$	-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 page7
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	$d_{Cl}$	mm	5.12			
Comparative tracking index	$CTI$	V	PLC0			$\geq 600 V$
Maximum output current	$I_{out max}$	mA	-10		10	
Maximum output voltage	$U_{out max}$	V	-0.5		$U_C + 0.5$	
Insulation resistance	$R_{INS}$	M $\Omega$	500			500 V DC, ISO 16750-2

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

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
<b>Electrical Data</b>						
Supply voltage	$U_C$	V	4.75	5	5.25	
Ambient operating temperature	$T_A$	$^\circ C$	-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)	@ $T_A = 25 ^\circ C, @ U_C = 5 V$ (..) value for dual output
Load resistance	$R_L$	K $\Omega$	10			
Output internal resistance	$R_{out}$	$\Omega$		1	10	@ $T_A = 25 ^\circ C$
<b>Performance Data</b>						
Ratiometricity error	$\varepsilon_r$	%		$\pm 0.4$		@ $T_A = 25 ^\circ C$
Sensitivity error	$\varepsilon_s$	%		$\pm 1$		@ $T_A = 25 ^\circ C, @ U_C = 5 V$
Electrical offset voltage	$U_{OE}$	mV		$\pm 4$		@ $T_A = 25 ^\circ C, @ U_C = 5 V$
Magnetic offset voltage	$U_{OM}$	mV		$\pm 3$		@ $U_C = 5 V, @ T_A = 25 ^\circ C$ ( $\pm 6 mV$ for $I_P \leq 100 A$ )
Linearity error	$\varepsilon_L$	%		$\pm 0.5$		% of full scale, method 2
Average temperature coefficient of $U_{OE}$	$T_{CU_{OEAV}}$	mV/ $^\circ K$	-0.1	$\pm 0.04$	0.1	@ $U_C = 5 V$
Average temperature coefficient of $S$	$T_{CS_{AV}}$	%/ $^\circ K$	-0.03	$\pm 0.01$	0.03	
Delay time to 90 % to the final output value for $I_{PN}$ step	$t_{D90}$	$\mu s$		3	6	100 A/ $\mu s$
Frequency bandwidth	$BW$	KHz		50		@ -3 dB
Peak-to-peak noise voltage	$U_{no pp}$	mV		10		DC to 1 MHz
RMS noise voltage referred to primary	$U_{no}$	mV		1.5		
Start-up time	$t_{start}$	ms			1	
Phase shift	$\Delta\phi$	$^\circ$	-4			f = 1 kHz

**HSNDR 1000-S05**

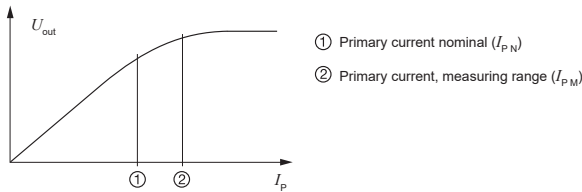
Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
<b>Electrical Data</b>						
Primary current, measuring range	$I_{PM}$	A	-1000		1000	
Sensitivity	$S$	mV/A		2		@ $T_A = 25\text{ °C}$
Offset voltage	$U_O$	V		2.5		@ $U_C = 5\text{ V DC}$

**Total error  $\varepsilon_{tot}$  (mV) for  $I_{PM} > 100\text{ A}$** 

**Total error  $\varepsilon_{tot}$  (mV) for  $I_{PM} > 100\text{ A}$** 

$I_P$	25 °C Initial	T range Initial	25 °C After reliability	T 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:

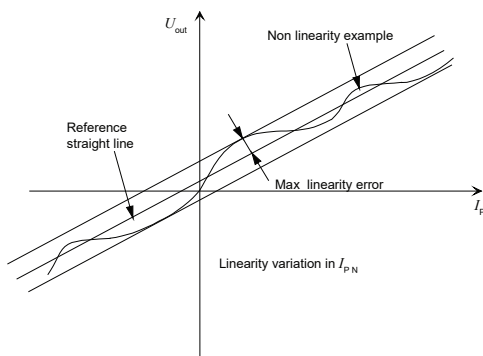
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

### 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.

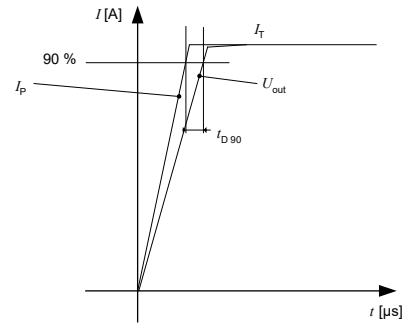
### Linearity:

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  $TCI_{OEAV}$  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:  
 $S_T = (\text{Sensitivity max} - \text{Sensitivity min}) / \text{Sensitivity at } 25 \text{ °C}$ .

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](http://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](http://www.lem.com)).

### Environmental test specifications:

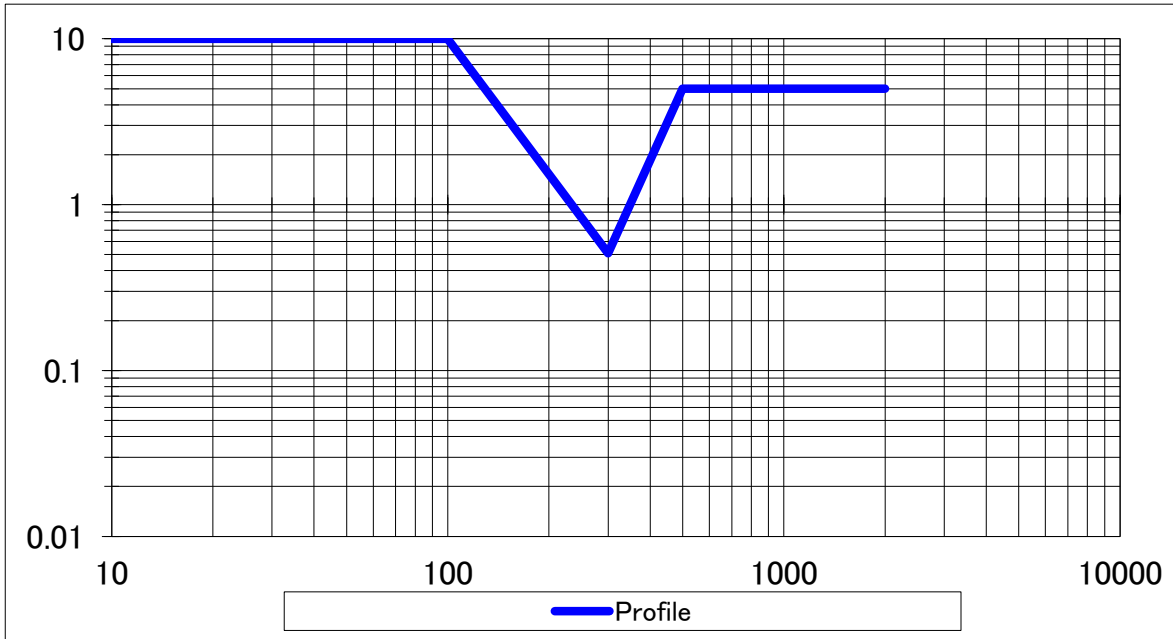
Refer to LEM GROUP test plan laboratory CO.11.11.515.0 with “Tracking\_Test Plan\_Auto” sheet.

## Environmental test specifications:

Refer to LEM GROUP test plan laboratory CO.11.11.515.0 with "Tracking\_Test Plan\_Auto" sheet.

Name	Standard	Conditions
<b>ELECTRICAL TESTS</b>		
Phase shift	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/ $\mu$ s $I_{pulse} = I_{p,max}$
$dv/dt$	LEM Procedure	5; 10; 20 kV/ $\mu$ s $U' = 1000$ V
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 $\Omega$ Minimum
<b>ENVIRONMENTAL TESTS</b>		
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 1 cycle = 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 <sup>2</sup> , 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
<b>EMC TESTS ES96200 (11.2011)</b>		
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 - Level 1 (100 mA) (ISO11452-4(2011) Annex E Table E1 Level 2) F = 1 MHz to 400 MHz , Criteria A acceptance @ 5 % of 2 V
Radiated Immunity Anechoic chamber	GWM3097 § 3.4.2 (2015)	Level : GMW3097 (2015) § 3.4.2 Table 14 - Level 2 (100 V/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 = 1 GHz 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: $\pm 4, \pm 6$ kV; Air discharges: $\pm 8$ 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	IEC 60068-2-31 § 5.2 method 1 (05.2008)	Drop Height = 1 m 1 in each direction

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



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

**Climatic Profile**

Temperatures:

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

*Steps 1 to 5 are repeated 3 times*

- Steps 6:** 60 mins at +20 °C

Test duration: 22 h (each X, Y, Z Axis)  
RMS acceleration value: 9.66 g RMS

**Recommendations for use:****Storage:**

The LEM transducers must be stored in a dry location, within the following ambient room conditions ( $< 40\text{ }^{\circ}\text{C}$  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 otherwise, 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.



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