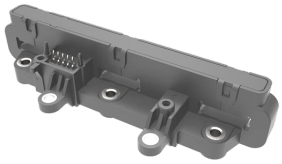
AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

HAH3DR 800-S07/SP32, HAH3DR 900-S07/SP32, HAH3DR 1000-S07/SP32, HAH3DR 1100-S07/SP32, HAH3DR 1200-S07/SP32



Introduction

The HAH3DR-S07/SP32 family is a tri-phase transducer for DC, AC, or pulsed currents measurement in automotive applications. It offers a galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The HAH3DR-S07/SP32 family gives you a choice of having different current measuring ranges in the same housing (from ±800 up to ±1200 A).

Features

- Open Loop transducer using the Hall effect sensor
- Low voltage application
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±1200 A
- Operating temperature range: −40 °C < T < +125 °C
- Output voltage fully ratiometric (in sensitivity and offset)
- All in one tri-phase transducer.

Special Feature

- Package body for high voltage insulation.

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 application

- High Voltage EV and HEV traction inverters.

Principle of HAH3DR S07/SP32 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 plate

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

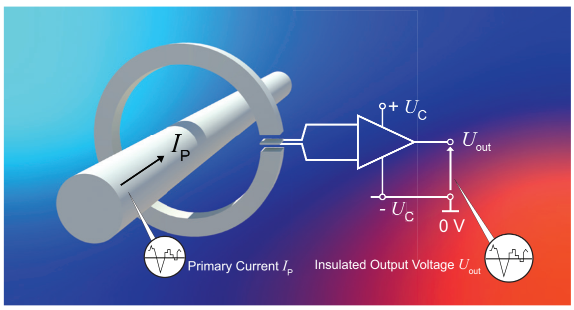


Fig. 1: Principle of the open loop transducer.

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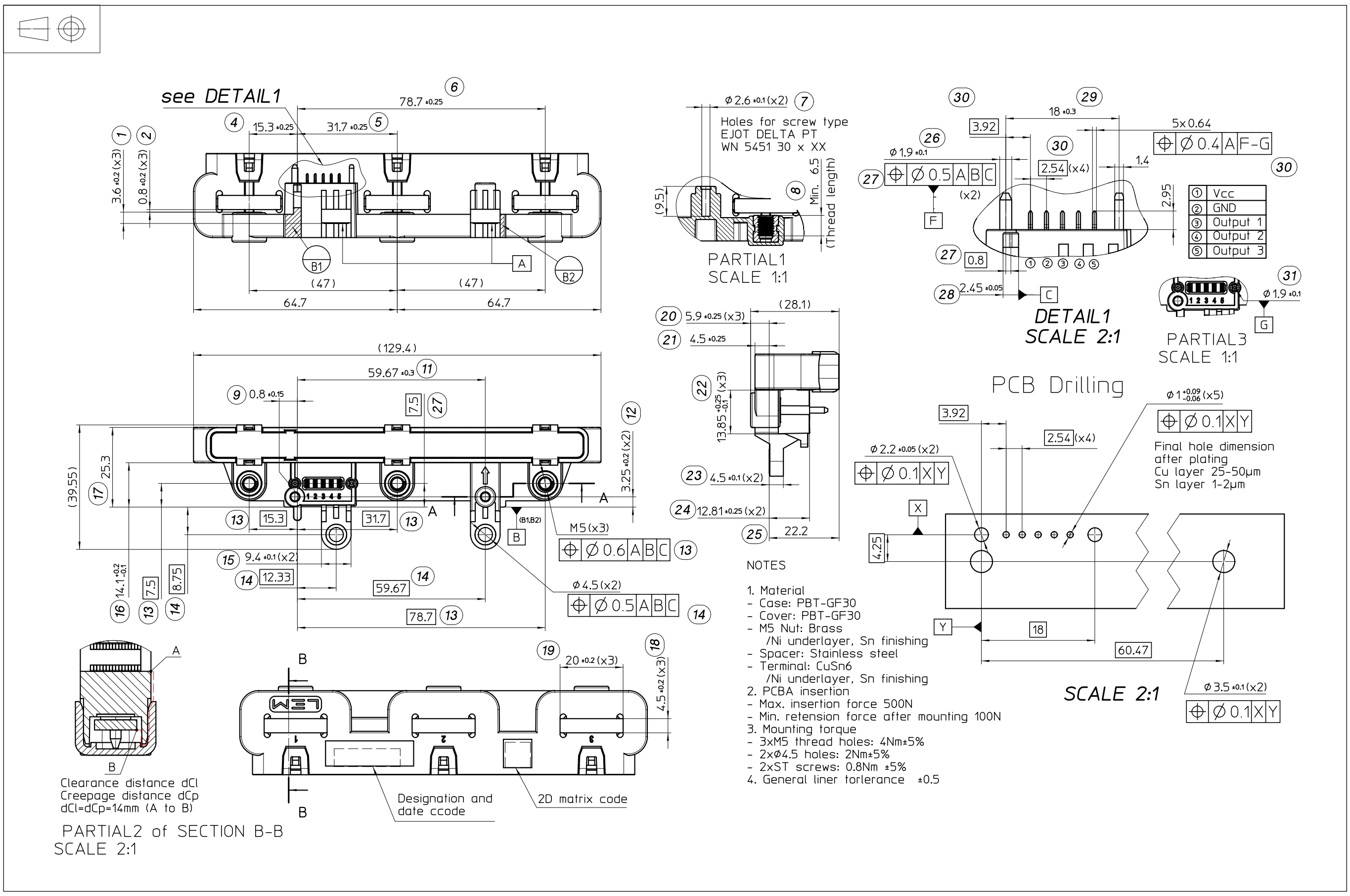
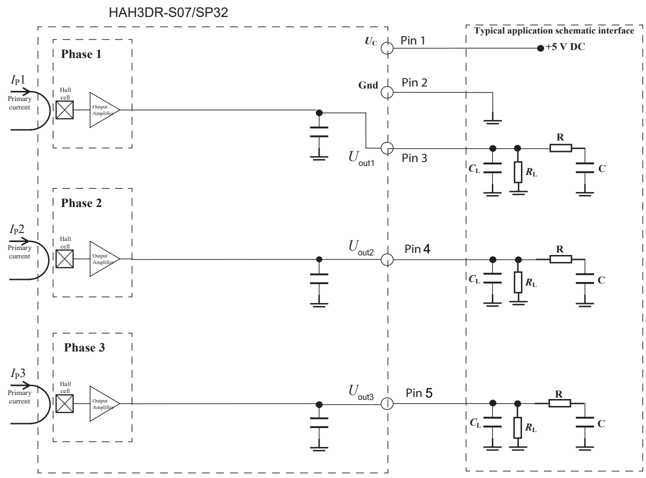
Dimensions (in mm)



Mechanical characteristics

• Case	See outline drawing
• Cover	See outline drawing
• Magnetic core	FeSi
• Pins	CuSn6
• Mass	115 g

System architecture (example)



C_L< 10 nF EMC protection (optional)
RC Low pass filter (optional).

On board diagnostic

R_L > 10 kΩ. Resistor for signal line diagnostic (optional).

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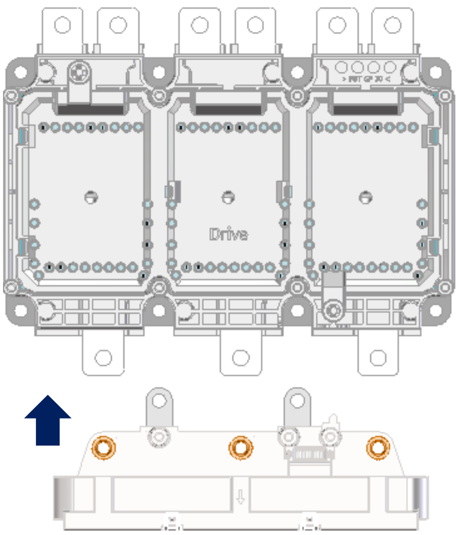
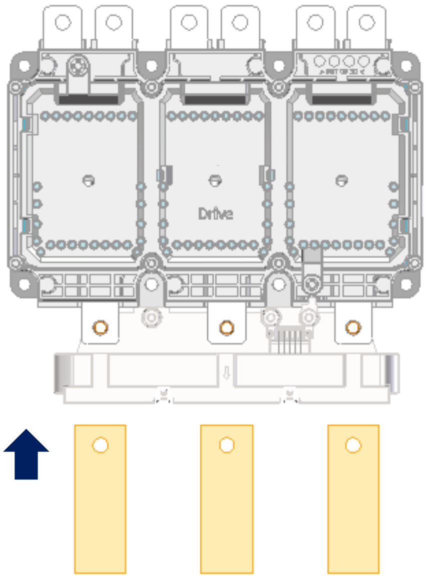
Mounting Operation and Recommendations

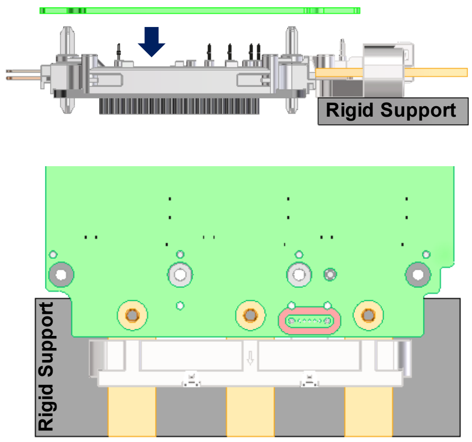
OP10 – Transducer insertion



OP20 – Busbar insertion

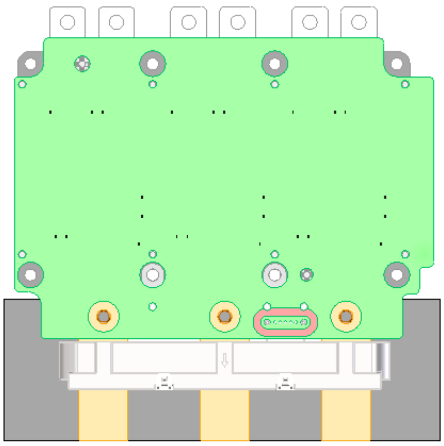


OP30 – PCB insertion



Notes:
1. Rigid support under LEM transducer during insertion
2. Press-fit terminal refers to outline drawing

OP40 – Screws mounting



Notes:
1. Stainless Iron M3 self-tapping screws (3 pcs)
2. Stainless Iron M5 screws (3 pcs)
3. Torque refers to outline drawing

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Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Maximum supply voltage	$U_{C\ max}$	V	−0.3		6.5	Continuous not operating
Ambient storage temperature	$T_{A\ st}$	°C	−40		125	
Creepage distance	d_{Cp}	mm	14			
Clearance	d_{Cl}	mm	14			
Comparative tracking index	CTI			PLC 3		
RMS voltage for AC insulation test	U_d	kV			3.52	@ Beijing
Insulation resistance	R_{INS}	MΩ	500			1160 V DC, ISO 16750

Operating characteristics

All characteristics noted under conditions −1200 A ≤ I_P ≤ 1200 A, −40 °C ≤ T_A ≤ 125 °C, unless otherwise noted.

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Supply voltage [1]	U_C	V	4.75	5	5.25	
Ambient operating temperature [2]	T_A	°C	−40		125	
Output voltage (Analog)	U_{out}	V	$U_{out} = (U_C/5) \times (U_O + S \times I_P)$			@ T_A = 25 °C
Offset voltage	U_O	V		2.5		
Current consumption	I_C	mA		30	60	@ U_C = 5 V,@ T_A = 25 °C, @ I_P = 0 A
Load resistance	R_L	KΩ	10			
Output internal resistance	R_{out}	Ω		1		
Performance Data						
Ratiometricity error	ε_r	%		±0.5		@ U_C = 5 V ± 5 %, full T range and full I_P range
Sensitivity error	ε_S	%		±1		@ T_A = 25 °C, @ U_C = 5 V after ±$I_{P\ M}$
Electrical offset voltage	$U_{O\ E}$	mV		±4		@ T_A = 25 °C, @ U_C = 5 V
Magnetic offset voltage	$U_{O\ M}$	mV		±4		@ T_A = 25 °C, @ U_C = 5 V, after ±$I_{P\ M}$
Average temperature coefficient of $U_{O\ E}$	$TCU_{O\ E\ AV}$	mV/°C		±0.05		
Average temperature coefficient of S	TCS_{AV}	%/°C		±0.03		
Linearity error	ε_L	%	−1		1	% of linear range I_P < |1000 A|
			−2		2	% of linear range |1000 A|<I_P < |1200 A|
Delay time to 90 % to the final output value for $I_{P\ N}$ step	$t_{D\ 90}$	µs		2	6	di/dt = 100 A/µs
Frequency bandwidth [3]	BW	kHz	50			@ −3 dB
Start-up time	t_{start}	ms		120		
Phase shift	$\Delta\varphi$	°	−4			@ 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] Absolute maximum ambient operating temperature (include busbar): +150 °C

[3] Primary current frequencies must be limited in order to avoid excessive heating of the sensor higher than 150 °C.

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HAH3DR 800-S07/SP32

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

HAH3DR 900-S07/SP32

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		

HAH3DR 1000-S07/SP32

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

HAH3DR 1100-S07/SP32

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

HAH3DR 1200-S07/SP32

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		

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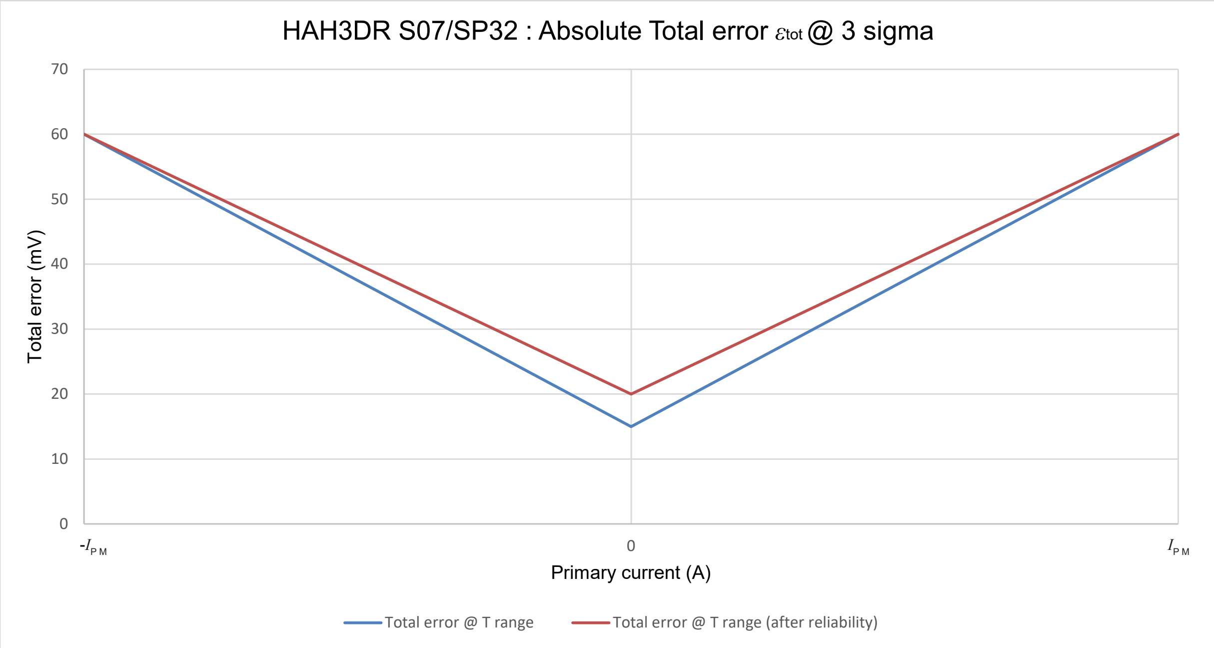
Total error



Primary current	Total error @ 25 °C		Total error @ T range		Total error @ T range(After reliability test)	
	T_A = 25 °C, U_C = 5 V		-40 °C ≤ T_A ≤125 °C, U_C = 5 V		-40 °C ≤ T_A ≤125 °C, U_C = 5 V	
(A)	(mV)	(%) I_{PM}	(mV)	(%) I_{PM}	(mV)	(%) I_{PM}
$-I_{PM}$	50	2.5	60	3	60	3
0	10	0.5	15	0.75	20	1
I_{PM}	50	2.5	60	3	60	3

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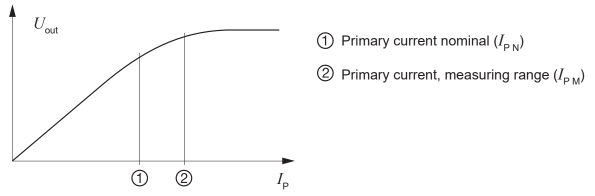
PERFORMANCES PARAMETERS DEFINITIONS

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:

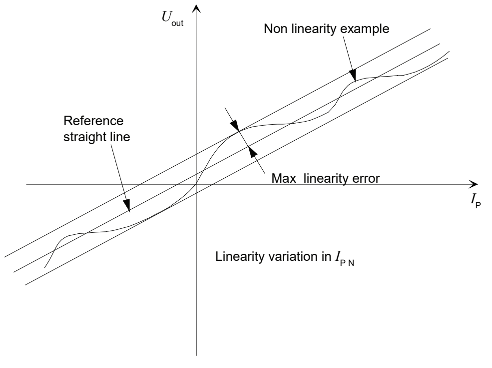
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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.

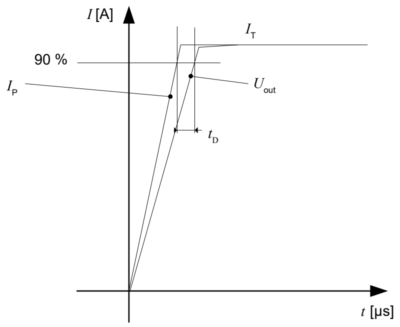
Linearity:

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:

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

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 in 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 in 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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Realiability Test

Tests	Standard	Specific Conditions
ELECTRICAL PERFORMANCES		
Frequency bandwidth	LEM 98.20.00.538.0	U_C = 5 V, 30 Hz to 100 kHz; At 20 A peak
Phase delay	LEM CO.20.00.538.0	U_C = 5 V, 30 Hz to 100 kHz; At 20 A peak ;
Delay time; di/dt	LEM 98.20.00.545.0	U_C = 5 V ,100 A/µs I_P = 1100 A
du/dt	LEM 98.20.00.545.0	U_C = 5 V, Slope: 5 kV/µs U = 1000 V
ENVIRONMENTAL TESTS (Climatic)		
HAST	JESD 22-A110E (2015)	T = 110 °C; RH = 85 %; Duration = 264 h U_C = 5 V ; I_P = 0 A; Monitoring each 10 min
Low temperature storage	ISO 16750-4 § 5.1.1.1 (04/2010)	T = −40 °C Duration = 96 h
High temperature storage	ISO 16750-4 § 5.1.2.1 (04/2010)	T = 135 °C Duration = 607 h
Power temperature cycle test	ISO 16750-4 § 5.3.1 (04/2010)	30 cycles (240 h), −40 °C /125 °C U_C = 5 V , I_P = 0 A; Monitoring U_{out} (30 min each test) Limit: 2.5 V ±0.015 V
Thermal shock	ISO 16750-4 § 5.3.2 (04/2010)	T = −40 °C & 125 °C Duration = 300 cycles 40 min/40 min U_C = NO power supply (unconnected) and No wiring harness
ENVIRONMENTAL TESTS (Mechanical)		
Sinus Vibration	ISO 16750-3 § 4.1.x (12/2012)	T Cycle:−40 °C /125°C Sweep: 0.5 oct/min 22 H/axis 100 Hz to 440 Hz
Random Vibration	ISO 16750-3 § 4.1.x (12/2012)	Temperature −40 °C /125°C 10 to 2000 Hz 10 G(RMS) 22 H/axis
Mechanical Shocks	ISO 16750-3 § 4.2 (12/2012)	Pulse shape: half sine, 50 G, 6 ms 10 shocks per direction (total 60)
Free Fall	ISO 16750-3 § 4.3 (12/2012)	Height = 1 m on Concrete floor 3 axes; 2 directions by axis; 1 sample by axis
SAFETY - Insulation tests		
Insulation test	ISO 16750-2 § 4.11 (11/2012)	T_A = 25 °C U_d = 3.52 kV RMS (50 Hz) for 60 s
Insulation resistance	ISO 16750-2 § 4.12 (12/2012)	AC = 1160 V RMS (50 Hz) for 60 s Criteria: ≥ 500 M Ohm.
EMC TESTS		
Immunity to Electrostatic Discharges (Handling of devices)	ISO 10605 (07/2008)	Contact discharges: ±4, 6 kV; Air discharges: ±8 kV U_C = 0
Immunity to Radiated disturbances (ALSE)	ISO 11452-2 (11/2004)	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)
Immunity to Conducted disturbances (BCI)	ISO 11452-4 (12/2011)	f = 1 MHz to 400 MHz
Emission Radiated (ALSE)	CISPR 25 § 6.5 (2021)	f = 150 kHz to 6 GHz
Low frequency magnetic field immunity	ISO 11452-8 (2015)	Table A.1 Level II Criteria : A

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