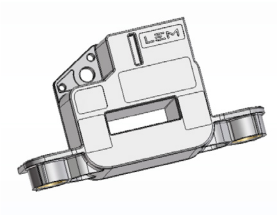
AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
HAH1BV S/D24



Introduction

The HAH1BV family is for the electronic measurement of DC, and low frequency current in high power and low voltage automotive applications with galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The HAH1BV 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
- Primary current measuring range −600 A / +300 A (high range) −100 A / +150 A (low range)
- Maximum RMS primary admissible current: defined by busbar to have T < +150 °C
- Operating temperature range: −40 °C < T < 70 °C
- Output voltage: full ratio-metric (in sensitivity and offset)
- Customer 2D Matrix.

Special features

- Compressor limiter for M6 screw
- Dual output
- Unsealed connector.

Advantages

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

Automotive application

- Battery Management.

Principle of HAH1BV 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 Hall plates

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

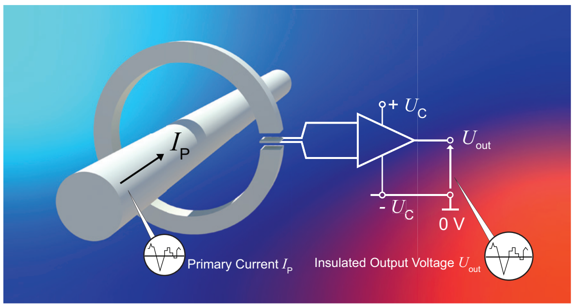


Fig. 1: Principle of the open loop transducer.

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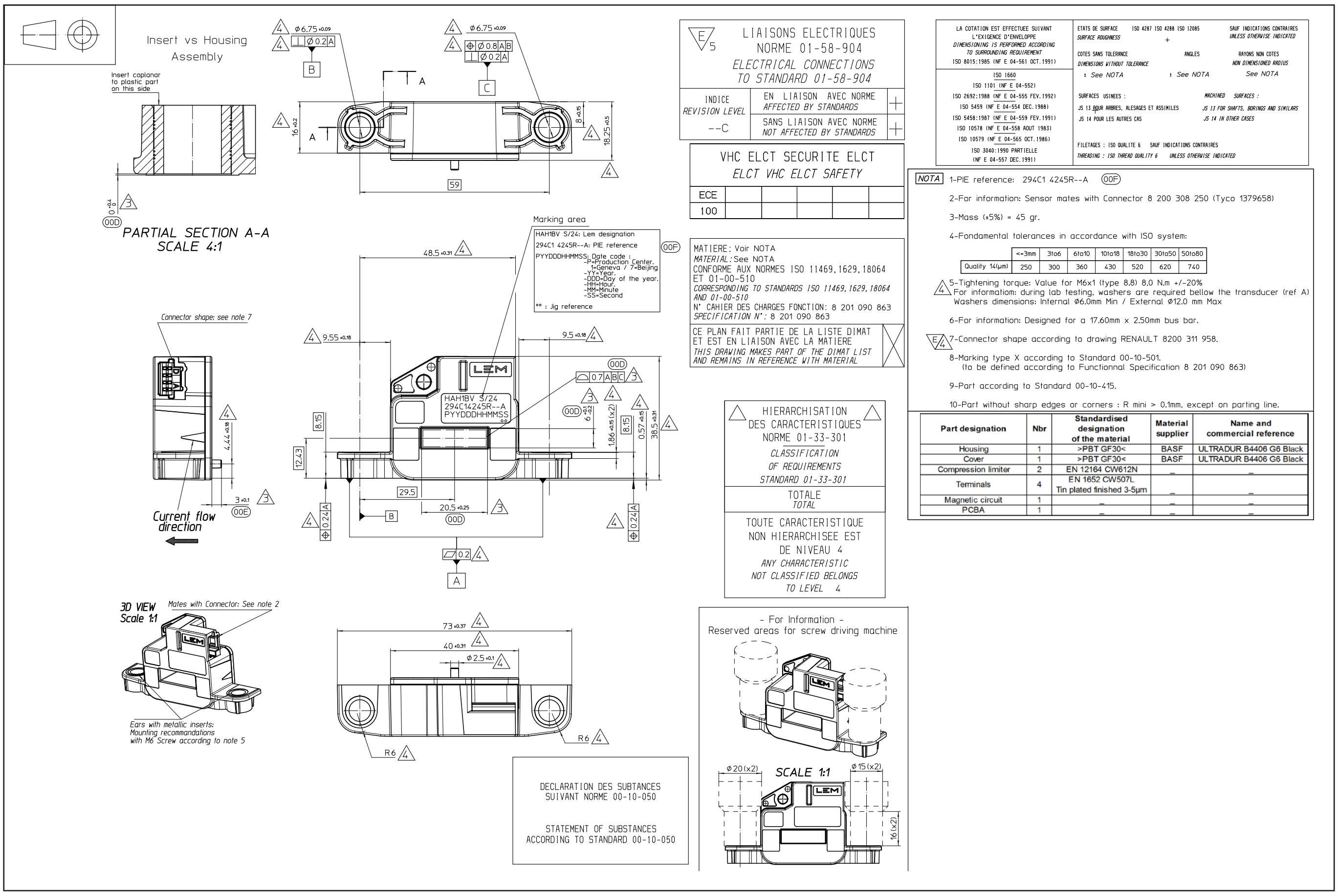
Dimensions (in mm)



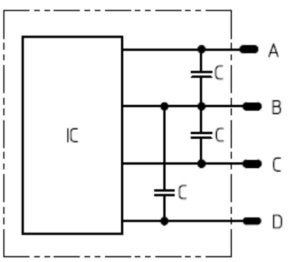
Mechanical characteristics

- Plastic case PBT GF 30
- Magnetic core Iron silicon alloy
- Mass 45 g (±5 %)
- Electrical terminal coating Brass tin plated

Mounting recommendation

- Connector type Tyco 1473672-1

Electronic schematic



Components list	
IC	Hall transducer ASIC
C	Decoupling capacitor

Pin out	
A	U_{out1} (Low Range)
B	Ground
C	U_C (5 V)
D	U_{out2} (High Range)

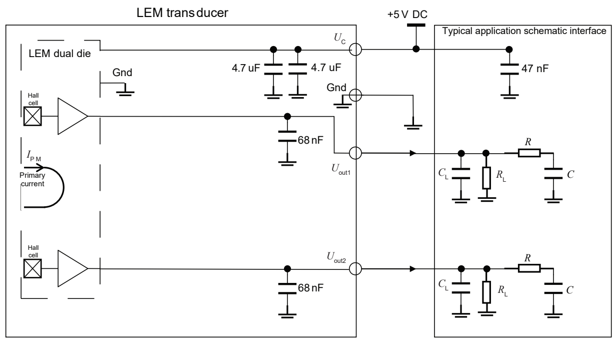
Remark

- U_{out} > 2.5 when I_P flows in the direction of the arrow.

U_{out}	Diagnostic
Open circuit	U_{in} ≤ 0.15 V
Short GND	U_{in} ≤ 0.15 V

System architecture (example)

R_L > 10 kΩ optional resistor for signal line diagnostic
C_L ≤ 100 nF EMC protection
RC Low pass filter EMC protection (optional)



Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification Min	Typical	Max	Conditions
Maximum primary current peak	$\hat{I}_{P\,max}$	A			[2]	
Supply over voltage	U_C	V			14	
Reverse voltage			−14			
Maximum output voltage	$U_{out\,max}$	V	−14		14	
Maximum output current	$I_{out\,max}$	mA	−10		10	
Output short-circuit duration	t_C	°C			∞	
Electrostatic discharge voltage (HBM)	$U_{ESD\,HBM}$	kV			8	JESD22-A114-B
RMS voltage for AC insulation test	U_d	kV			2	50 Hz, 1 min ISO 6469 3622
Insulation resistance	R_{INS}	MΩ	1000			500 V - ISO 16750-2
Ambient storage temperature	$T_{A\,st}$	°C	−40		125	50 Hz, 1 min ISO 6469 3622
Creepage distance	d_{Cp}	mm	5			
Clearance	d_{Cl}	mm	3.87			
Comparative tracking index	CTI		PLC3 (175 V − 250 V)			

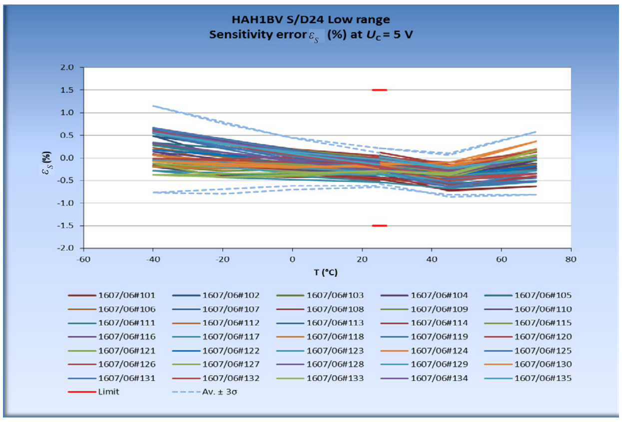
Operating characteristics in high/low range ($I_{P\,N}$)

Parameter	Symbol	Unit	Specification Min	Typical	Max	Conditions
Electrical Data						
Primary current, measuring range, high range	$I_{P\,M}$	A	−600		300	[2]
Primary current, measuring range, low range	$I_{P\,M}$	A	−100		150	[2]
Supply voltage [1]	U_C	V	4.75	5	5.25	
Ambient operating temperature	T_A	°C	−40		70	
Output voltage	U_{out}	V	$U_{out} = (U_C/5) \times (U_O + S \times I_P)$			
Sensitivity high range	S	mV/A		4.444		@ T_A = 25 °C
Sensitivity low range	S	mV/A		16		@ T_A = 25 °C
Offset voltage high range	U_O	V		3.167		@ T_A = 25 °C
Offset voltage low range	U_O	V		2.1		@ T_A = 25 °C
Output resolution		mV		1.25		
Output clamping high voltage	$U_{S\,Z}$	V	4.74	4.75		@ U_C = 5 V
Output clamping low voltage	$U_{S\,Z}$	V		0.25	0.26	@ U_C = 5 V
Current consumption	I_C	mA		14		@ T_A = 25 °C, @ U_C = 5 V
					21	
Load resistance	R_L	KΩ	10			@ T_A = 25 °C
Output internal resistance	R_{out}	Ω		1		@ T_A = 25 °C
					10	
Performance Data						
Ratiometricity error	ε_r	%		±0.2		@ T_A = 25 °C
Sensitivity error	ε_S	%	−1.5		1.5	@ T_A = 25 °C (initial state)
			−2.72		2.72	@ T_A = 25 °C, after endurance test
Electrical offset voltage	$U_{O\,E}$	mV	−20		20	@ T_A = 25 °C, @ U_C = 5 V (initial state)
			−33		33	@ T_A = 25 °C, after endurance test
Magnetic offset voltage low range	$U_{O\,M}$	mV	−3.54		5.31	@ U_C = 5 V, in temperature range
Magnetic offset voltage high range			−5.90		2.95	@ U_C = 5 V, in temperature range
Linearity error	ε_L	%	−0.5		0.5	% of full scale, @ T_A = 25 °C
Average temperature coefficient of $U_{O\,E}$	$TCU_{O\,E\,AV}$	mV/°C	−0.113		0.113	
Average temperature coefficient of S	TCS_{AV}	%/°C	−0.03		0.03	
Delay time to 90 % to the final output value for $I_{P\,N}$ step	$t_{D\,90}$	ms			10	
Frequency bandwidth [2]	BW	Hz		140		@ −3 dB
Peak-to-peak noise voltage	$U_{no\,pp}$	mV			10	DC to 1 MHz
Output RMS voltage noise	U_{no}	mV			1.6	
Start-up time	t_{start}	ms			10	@ U_C = 4.75 V
Setting time after overload	t_s	ms			10	

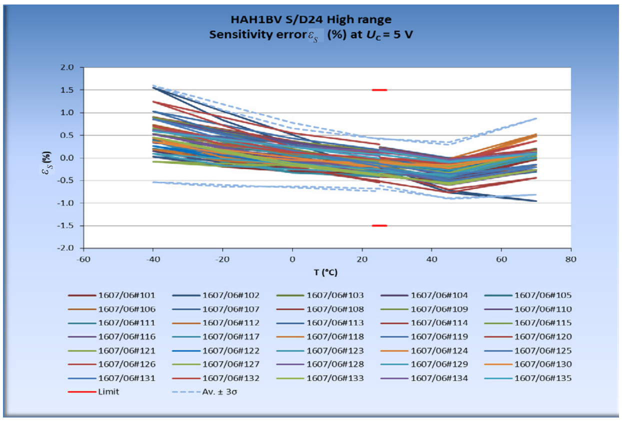
Notes: [1] The output voltage U_{out} is fully ratiometric. The offset and sensitivity are dependent on the supply voltage U_C relative to the following formula:

$$I_P = \left(\frac{5}{U_C} \times U_{out} - U_O\right) \times \frac{1}{S} \text{ with } S \text{ in (V/A)}$$

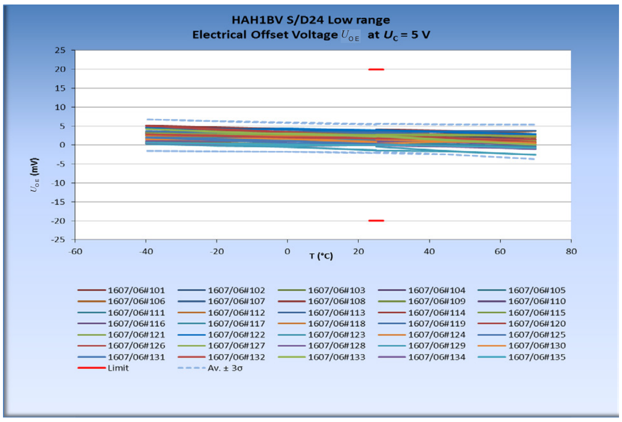
[2] Primary current frequencies must be limited in order to avoid excessive heating of the busbar, magnetic core and the ASIC (see feature paragraph in page 1.)



HAH1BV S/D24 Low range
Sensitivity error ε_S (%) at U_C = 5 V
ε_S (%)
T (°C)
1607/06#101 1607/06#102 1607/06#103 1607/06#104 1607/06#105
1607/06#106 1607/06#107 1607/06#108 1607/06#109 1607/06#110
1607/06#111 1607/06#112 1607/06#113 1607/06#114 1607/06#115
1607/06#116 1607/06#117 1607/06#118 1607/06#119 1607/06#120
1607/06#121 1607/06#122 1607/06#123 1607/06#124 1607/06#125
1607/06#126 1607/06#127 1607/06#128 1607/06#129 1607/06#130
1607/06#131 1607/06#132 1607/06#133 1607/06#134 1607/06#135
Limit Av. ± 3σ



HAH1BV S/D24 High range
Sensitivity error ε_S (%) at U_C = 5 V
ε_S (%)
T (°C)
1607/06#101 1607/06#102 1607/06#103 1607/06#104 1607/06#105
1607/06#106 1607/06#107 1607/06#108 1607/06#109 1607/06#110
1607/06#111 1607/06#112 1607/06#113 1607/06#114 1607/06#115
1607/06#116 1607/06#117 1607/06#118 1607/06#119 1607/06#120
1607/06#121 1607/06#122 1607/06#123 1607/06#124 1607/06#125
1607/06#126 1607/06#127 1607/06#128 1607/06#129 1607/06#130
1607/06#131 1607/06#132 1607/06#133 1607/06#134 1607/06#135
Limit Av. ± 3σ



HAH1BV S/D24 Low range
Electrical Offset Voltage U_{OE} at U_C = 5 V
U_{OE} (mV)
T (°C)
1607/06#101 1607/06#102 1607/06#103 1607/06#104 1607/06#105
1607/06#106 1607/06#107 1607/06#108 1607/06#109 1607/06#110
1607/06#111 1607/06#112 1607/06#113 1607/06#114 1607/06#115
1607/06#116 1607/06#117 1607/06#118 1607/06#119 1607/06#120
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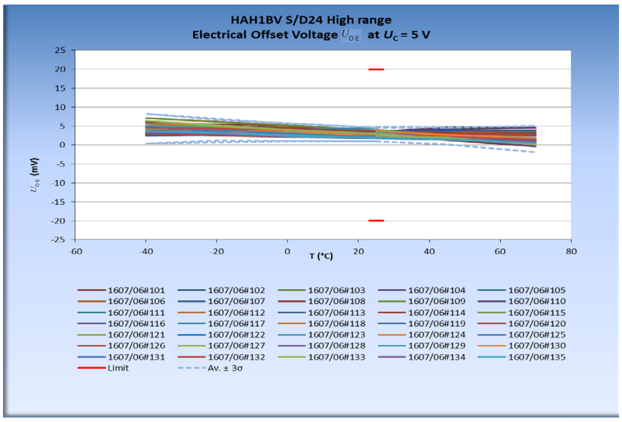
1607/06#126 1607/06#127 1607/06#128 1607/06#129 1607/06#130
1607/06#131 1607/06#132 1607/06#133 1607/06#134 1607/06#135
Limit Av. ± 3σ



HAH1BV S/D24 High range
Electrical Offset Voltage U_{OE} at U_C = 5 V
U_{OE} (mV)
T (°C)
1607/06#101 1607/06#102 1607/06#103 1607/06#104 1607/06#105
1607/06#106 1607/06#107 1607/06#108 1607/06#109 1607/06#110
1607/06#111 1607/06#112 1607/06#113 1607/06#114 1607/06#115
1607/06#116 1607/06#117 1607/06#118 1607/06#119 1607/06#120
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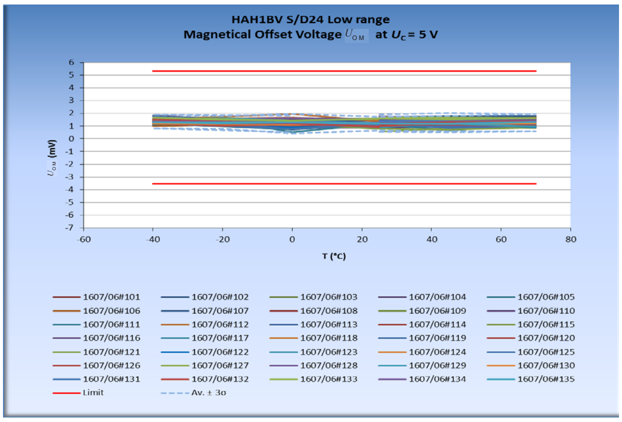
1607/06#126 1607/06#127 1607/06#128 1607/06#129 1607/06#130
1607/06#131 1607/06#132 1607/06#133 1607/06#134 1607/06#135
Limit Av. ± 3σ



HAH1BV S/D24 Low range
Magnetical Offset Voltage U_{OM} at U_C = 5 V
U_{OM} (mV)
T (°C)
1607/06#101 1607/06#102 1607/06#103 1607/06#104 1607/06#105
1607/06#106 1607/06#107 1607/06#108 1607/06#109 1607/06#110
1607/06#111 1607/06#112 1607/06#113 1607/06#114 1607/06#115
1607/06#116 1607/06#117 1607/06#118 1607/06#119 1607/06#120
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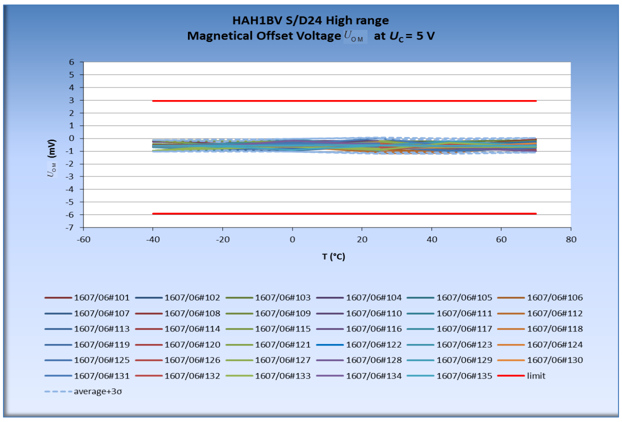
1607/06#126 1607/06#127 1607/06#128 1607/06#129 1607/06#130
1607/06#131 1607/06#132 1607/06#133 1607/06#134 1607/06#135
Limit Av. ± 3σ



HAH1BV S/D24 High range
Magnetical Offset Voltage U_{OM} at U_C = 5 V
U_{OM} (mV)
T (°C)
1607/06#101 1607/06#102 1607/06#103 1607/06#104 1607/06#105 1607/06#106
1607/06#107 1607/06#108 1607/06#109 1607/06#110 1607/06#111 1607/06#112
1607/06#113 1607/06#114 1607/06#115 1607/06#116 1607/06#117 1607/06#118
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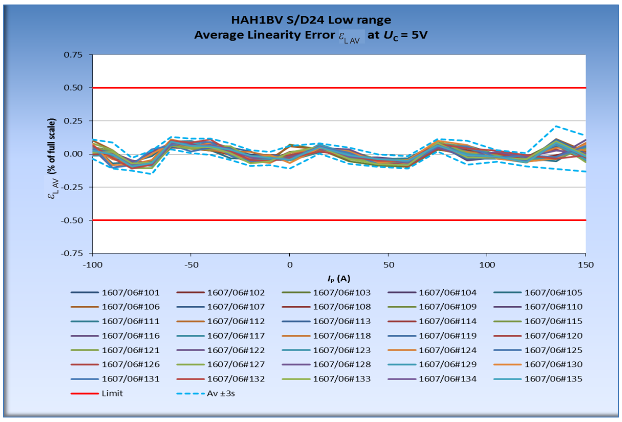
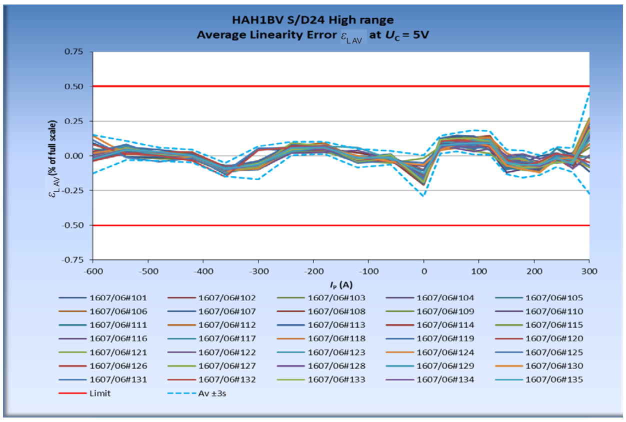
1607/06#125 1607/06#126 1607/06#127 1607/06#128 1607/06#129 1607/06#130
1607/06#131 1607/06#132 1607/06#133 1607/06#134 1607/06#135 limit
average+3σ



HAH1BV S/D24 Low range
Average Linearity Error $\varepsilon_{L\,AV}$ at U_C = 5V
$\varepsilon_{L\,AV}$ (% of full scale)
I_P (A)
1607/06#101 1607/06#102 1607/06#103 1607/06#104 1607/06#105
1607/06#106 1607/06#107 1607/06#108 1607/06#109 1607/06#110
1607/06#111 1607/06#112 1607/06#113 1607/06#114 1607/06#115
1607/06#116 1607/06#117 1607/06#118 1607/06#119 1607/06#120
1607/06#121 1607/06#122 1607/06#123 1607/06#124 1607/06#125
1607/06#126 1607/06#127 1607/06#128 1607/06#129 1607/06#130
1607/06#131 1607/06#132 1607/06#133 1607/06#134 1607/06#135
Limit Av ±3s



HAH1BV S/D24 High range
Average Linearity Error $\varepsilon_{L\,AV}$ at U_C = 5V
$\varepsilon_{L\,AV}$ (% of full scale)
I_P (A)
1607/06#101 1607/06#102 1607/06#103 1607/06#104 1607/06#105
1607/06#106 1607/06#107 1607/06#108 1607/06#109 1607/06#110
1607/06#111 1607/06#112 1607/06#113 1607/06#114 1607/06#115
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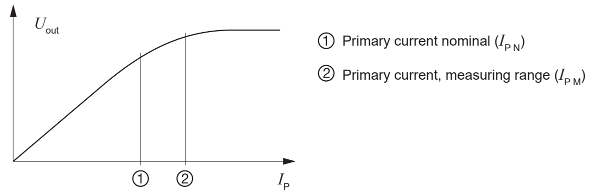
1607/06#131 1607/06#132 1607/06#133 1607/06#134 1607/06#135
Limit Av ±3s

HAH1BV S/D24

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:

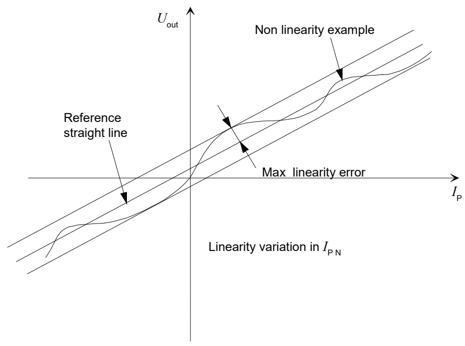
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

Magnetic offset:

The magnetic offset is the consequence of an over-current on the primary side. It's defined after an excursion of I_{PN}.

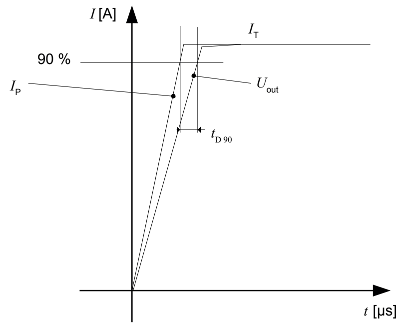
Linearity:

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:

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

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 = (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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Insulation characteristics

	Standards
d_{Cl} (Clearance distance)	>2.6 mm (according to EN 60664: Category overvoltage OV2, Altitude correction factor for 4000 m: 1.29).
d_{Cp} (Creepage distance)	>5 mm (according to EN 60664: Pollution degree PD2, inhomogeneous field, Class 1 basic insulation, *CTI* comparative tracking Index -group III a-: 200)
Dielectric rigidity	Regulation and standards:
	Test method: according to ISO 16750-2, applied voltage 2000 V AC during 1 minute Requirements: Neither dielectric breakdown nor flashover shall occur during the test.
Insulation regulation	Regulation and standards: - ECE R100
	Requirements: Insulation resistance shall be greater than 1G ohm. Test method according to ISO 16750-2 (test voltage 500 V during 1 minute)

PV tests

Transducers PV tests plan			
HAH1BV S/D24			
- Nissan Standards 28401NDS01 and 28401NDS02		Test Standards	Specific Conditions
VI/01	Resonance-point detecting test	2840NDS01[12] § VI/01	Vibration frequency: 10 to 1000 Hz Sweeping cycle: 33 min (Sweep rate: 1 Hz/s) Vibration acceleration: 9.81 m/s^2 Maximum amplitude: 20 mm peak/peak
VI/05	Resonance-point 1 h oscillation test	2840NDS01[12] § VI/05	Vibration acceleration: 29.43 m/s^2 Vibration frequency: 10 to 1000 Hz duration: 1 h for each direction
MS/03	Collision Impact	2840NDS01[12] § MS/03	acceleration: 400 m/s^2 duration: 11 ms 1 shocks per axis (total of 6 shocks)
MS/02	Mounting operator shock test	2840NDS01[12] § MS/02	acceleration: 100 m/s^2 duration: 6 ms 3 shocks per axis (total: 18 shocks)
CL/03	Warm Storage	2840NDS01[12] § CL/03	High temperature storage: 70 °C - Humidity ≤ 50 % *RH*. >1 h (device thermal inertia) Soak time t3 = 48 h Estimated duration: 51 h
CL/04	Cold Storage	2840NDS01[12] § CL/04	Low temperature storage : −40 °C t1 + t2 <1 h (device thermal inertia) Soak time t3 = 24 h Estimated duration: 27 h
MS/07	Curbstone shocks test	2840NDS01[12] § MS/07	acceleration: 400 m/s^2 duration: 11 ms 1 shocks per axis (total of 6 shocks)
CL/06	Climatic Sequence	2840NDS01[12] § CL/06	Upper temperature: 70 °C Upper relative humidity: 96 % *RH* Lower temperature: −10 °C duration : 10 cycle of 24 h
MS/01	Free Fall	2840NDS01[12] § MS/01	Number of axis: 3 Falls per device: 2 (1 per direction) Drop height: 1 m
VI/07	Random Vibration Endurance	2840NDS01[12] § VI/07	T_{min} = −40°C ; T_{max} = +70 °C Frequency range tested: 5 to 1000 Hz Level: 2.4 g RMS Total test duration for each axes: 36 h

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Transducers PV tests plan			
HAH1BV S/D24			
- Nissan Standards 28401NDS01 and 28401NDS02		Test Standards	Specific Conditions
CH/12	Corrosive Atmosphere	2840NDS01[12] § CH/12	Descriptions of the Flowing mixed gas: IEC 60068-2-60 “Ke” (12.1995) Method 4 Duration (days): 21 Days
CL/15	Continuous Humidity	2840NDS01[12] § CL/15	Temperature : 40 ±2 °C Relative humidity : 95 ± 5 % RH DUT with wire-harness connected. No power supply. duration : 1000 h
LT/01	Thermal cycling life	2840NDS01[12] § LT/01	Upper temperature: 120 °C Lower temperature: −40 °C Duration of transition: ~10 °C/min Duration of stabilization temperature (min): 30 min Number of cycles: 652 Duration of exposure : 652 h
CL/11	Withstand voltage	2840NDS01[12] § CL/11	RMS voltage for AC insulation test at 50 Hz: 0.5 kV Hold time: 60 s Rise time: 1 sec for 500 A Fall time: 1 sec for 500 A Detection: $\Delta I + I_{max}$ Leakage current limit: 2 mA
CL/12	Insulation Resistance	2840NDS01[12] § CL/12	Temperature: Room temperature Test voltage 500 V DC Hold time: 60 s
LT/02	Constant humid heat life	2840NDS01[12] § LT/02	Temperature: 85 °C Relative humidity: 85 % Duration total of exposure: 1000 h
LT/03	Thermal life & Combined load	2840NDS01[12] § LT/03	Upper temperature: 125 °C Lower temperature: 70 °C Duration of exposure: 1573 h Number of cycles: 793
CL/01	Thermal shock endurance	2840NDS01[12] § CL/01	Upper temperature: 125 °C Lower temperature: −40 °C Duration of Upper / Lower temperature: 15 min Transition time: <10 s Number of cycles: 1000 Duration of exposure: ~1000 h
CL/08	Warm Operation	2840NDS01[12] § CL/08	Temperature: 70 °C Relative humidity: Uncontrolled Duration of exposure: 8 h
CL/09	Cold operation	2840NDS01[12] § CL/09	Temperature: −40 °C Relative humidity: Uncontrolled Duration of exposure: 24 h
LT/00	Temperature Equivalent Δteq	2840NDS01[12] § LT/00	Temperature: −40 … 70 °C Relative humidity: Uncontrolled Number of steps: 6 Duration of temperature steps: 1 h soak time + DUT operating time until saturation temperature I_P= 80 A
CL/07	Temperature Range	2840NDS01[12] § CL/07D	Upper temperature: 80 °C Lower temperature: −40 °C From Tamb to −40 °C up to 80 °C Number of steps: 25
CL/13	Check of saturation Temperature	2840NDS01[12] § CL/13	Method 2 if "CL/13 Table 1 : Activation profiles" fulfilled by Renault/Nissan before the beginning of the test, else Method 1. Activation profiles : - Saturation temp 2: Temperature : 40 °C ; Primary current : 200 A, 15 min - Saturation temperature 1' Temperature : 25 °C ; Primary current : −170 A 40 min −> −340 A 15 sec −> −170 A 40 min - 'Sequence temperature 1' Temperature : 25 °C ; Primary current : −170 A 40 min −> +125 A 40 min −> +30 A 30 min −> −170 A 40 min −> 0 A 2 h

LEM International SA
Route du Nant-d’Avril, 152
1217 Meyrin
www.lem.com

HAH1BV S/D24

Transducers PV tests plan			
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- Nissan Standards 28401NDS01 and 28401NDS02		Test Standards	Specific Conditions
EQ/IR 03	Resistance to electrostatic discharges, equipment not supplied	2840NDS02[7] § EQ/IR03	- Contact discharge: ±4 kV and ±8 kV - Air discharge: ±15 kV - Discharge network : 150 pF / 330 Ω. U_C = NO power supply (≡ unconnected) Criteria A after reconnection
EQ/IC 07	Immunity to signal line transients	2840NDS02[7] § EQ/IC07	Test : - Apply pulses 3a (−150 V) for 10 minutes and pulses 3b (+100 V) for 10 minutes to the capacitive coupling clamp while monitoring the EUT. - Application point: Signal line, busbar -Connect the BMS imitation board which LEM made in DV phase validation. 50 Ω load. Monitoring : - U_{out}1 and U_{out}2 were monitored via oscilloscope and RMS multimeter - Additional U_C was monitored via oscilloscope Criteria A. The fluctuation voltage and duration time shall be in the range of DV test result.
EQ/IC 11	Resistance to impulsive transient	2840NDS02[7] § EQ/IC11	Run the EUT for a minimum duration of 10 minutes. - Specified positive impulse for 20 s minimum. - Specified negative impulse for 20 s minimum. - Pulse width 50 ns, 100 ns and 400 ns. - Pulse amplitude : ±400 V - Wires involved : all wires, one by one. Use 470 pF coupling capacitor. Criteria A
EQ/IC 04	Resistance to power supply micro-interruptions	2840NDS02[7] § EQ/IC04	Power supply 5.0 V Run the EUT for a minimum duration of 10 minutes. Wires involved for micro-interruptions of 10 µs (connectors): all power supply wire taken separately and simultaneously. external load (2 Ω) shall be connected in parallel with EUT Criteria A. The fluctuation voltage and duration time shall be in the range of DV test result.
EQ/IC 08	Immunity to bulk current injection (BCI)	2840NDS02[7] § EQ/IC08	Reference value : 60 mA Class-A 100 mA Class-B 200 mA Class-C
EQ/IR 01	Immunity to radiated field (semi-anechoic or anechoic chamber)	2840NDS02[7] § EQ/IR01	Substitution method. 200 MHz ~ 2 GHz, 60 V/m − Class-A 200 MHz ~ 2 GHz, 100 V/m − Class-B 200 MHz ~ 2 GHz, 200 V/m − Class-C
EQ/IR 02	Immunity to audio frequency magnetic field	2840NDS02[7] § EQ/IR02	The EUT must be placed directly between the loop antenna (Helmholtz coils) Frequency range 15 Hz to 200 kHz Apply the test "Magnetic field test level 1” Criteria A
EQ/IR 05	Resistance to handy transmitters	2840NDS02[7] § EQ/IR05	Power supply 5 V DC Length of the harness 1.5 m Power Return leads Grounded before LISN only Frequency range 28 MHz – 2590 MHz 32 Antennas Class: Level 1: A / Level 2: C Gravity: Level 1: 0 / Level 2: 2

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