AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
HSW S01

Introduction

The HSW family is best suited for DC and AC currents measurement in high power and high voltage automotive applications. It features galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The HSW family gives you a choice of having different current measuring ranges in the same housing (from ±50 up to ±400 A) or use dual output for redundancy measurement.

Features

- Open Loop transducer using the Hall effect
- Low voltage application
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±200 A
- Operating temperature range: −40 °C < T < +85 °C
- Output voltage: full ratio-metric (in sensitivity and offset).

Advantages

- Good accuracy
- Good linearity
- Low magnetic offset
- Low thermal offset drift
- Low thermal sensitivity drift.

Automotive applications

- Battery pack monitoring
- Hybrid vehicles
- EV and utility vehicles.

Principle of HSW 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.

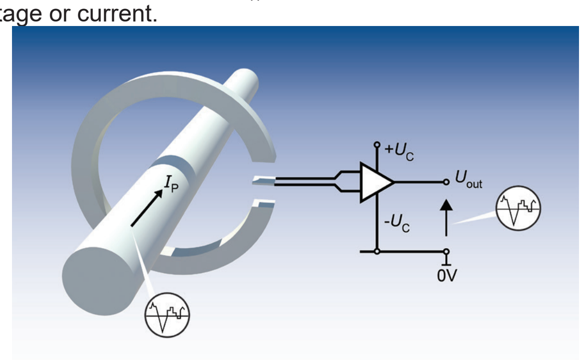

Fig. 1: Principle of the open loop transducer.

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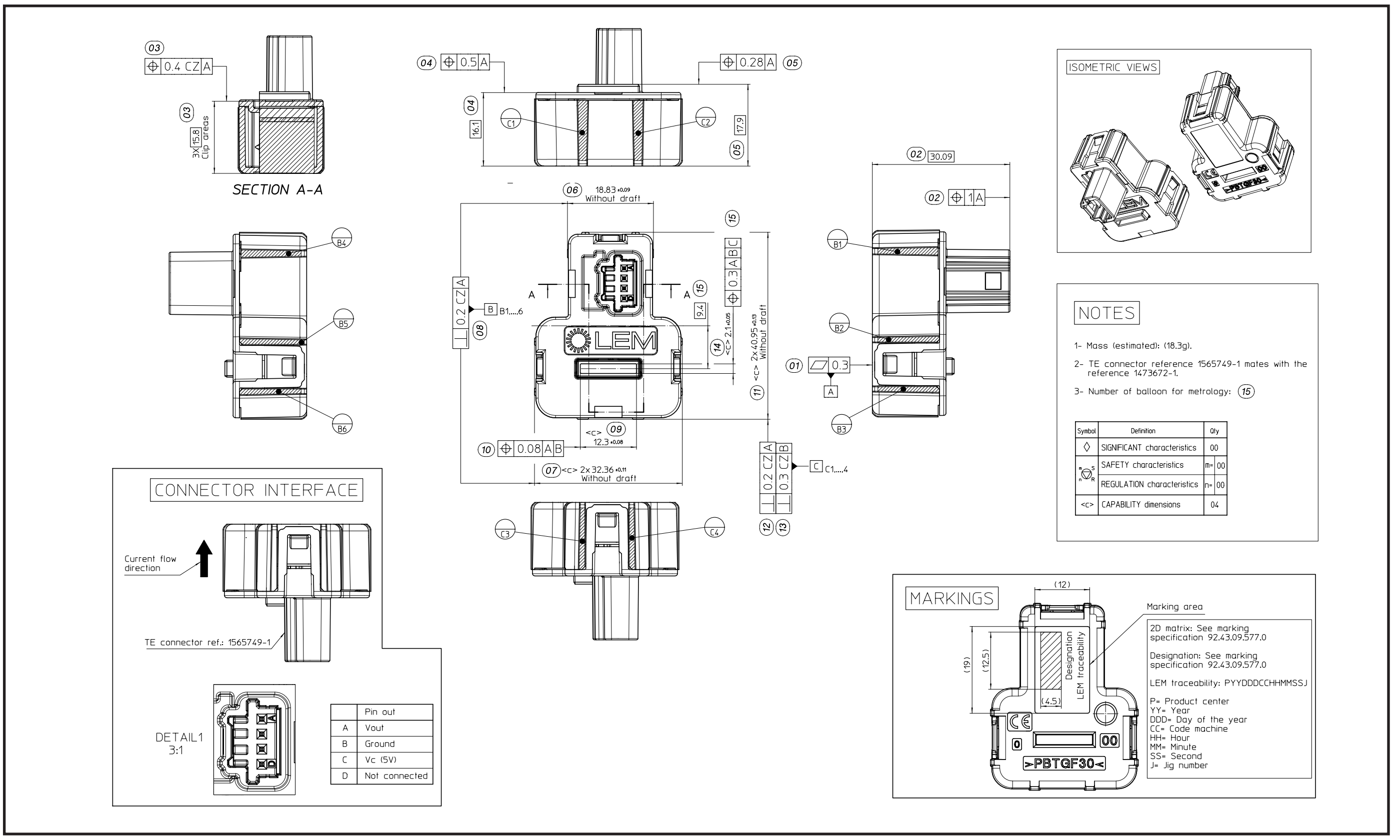
Dimensions (in mm)



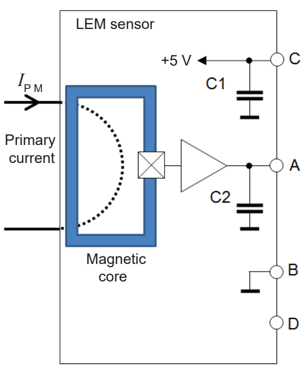
Mechanical characteristics

- Plastic case — PBT GF30
- Magnetic core — FeSi alloy
- Pins — Brass tin plated
- Mass — 18.3 g

Mounting recommendation

- Connector type — TYCO connector P/N 1473672-1

Electronic schematic



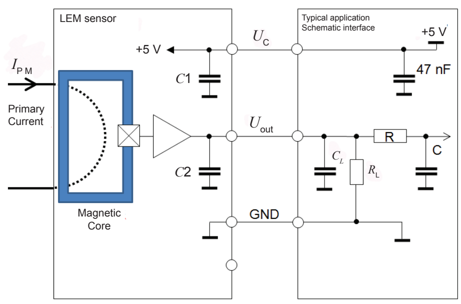
Components list		
IC	Hall sensor ASIC	
C1	Decoupling capacitor	1 µF
C2	EMC protection capacitor	68 nF

Pin out	
A	U_{out}
B	GND
C	U_C (5 V)
D	not connected

Remarks

- $I_P = \left(\frac{5}{U_C} \times U_{out} - U_O\right) \times \frac{1}{S}$ with S in (V/A)
- $U_{out} > U_o$ when I_P flows in the positive direction (see arrow on drawing).

System architecture (example)



C_L < 100 nF EMC protection (optional)
R_C Low pass filter (optional)

On board diagnostic
R_L > 10 KΩ. Resistor for signal line diagnostic (optional)

U_{out}	Diagnostic
Open circuit	$U_{IN} \leq 0.15$ V
Short GND	$U_{IN} \leq 0.15$ V

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Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification Min	Specification Typical	Specification Max	Conditions
Maximun supply voltage	$U_{C\ max}$	V			8.5	Continuous
					30	Over voltage, 2 min
			−14			Reverse voltage, 1 min @ T_A = 25 °C
Output voltage	U_{out}	V			8.5	Continuous
					14	Output over voltage, 1 min @ T_A = 25 °C
Ambient storage temperature	T_S	°C	−40		125	
Creepage distance	d_{Cp}	mm		6.7		
Clearance	d_{Cl}	mm		6.7		
Comparative traking index	CTI			125		
Maximum output current	$I_{out\ max}$	mA	−10		10	Continuous
Electrostatic discharge voltage	U_{ESD}	V			8	

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

Parameter	Symbol	Unit	Specification Min	Specification Typical	Specification Max	Conditions
Electrical Data						
Supply voltage [1]	U_C	V	4.5	5	5.5	
Current consumption	I_C	mA		8	10	
Output current	I_{out}	mA	−1		1	Continuous
Load resistance	R_L	kΩ	10			Pull down resistor
Output voltage (diagnostic detection open ground)	U_{out}	V			0.15	with pull-down resistor
Output voltage (diagnostic detection open supply)					0.15	with pull-down resistor
Capacitive loading	C_L	nF	1		100	
Ambient operating temperature	T_A	°C	−40		85	Temperature range with accuracy guaranteed ± 3 sigma
Performance Data [1]						
Primary nominal DC or current RMS	$I_{P\ N}$	A	−200		200	
Offset voltage	U_O	V		2.5		@ U_C = 5 V
Sensitivity	S	mV/A		10		@ U_C = 5 V
Output clamping voltage min [1]	$U_{S\ Z}$	V		0.25		@ U_C = 5 V
Output clamping voltage maxi [1]				4.75		@ U_C = 5 V
Output internal resistance	R_{out}	Ω		1	10	
Frequency bandwidth	BW	Hz		70		@ −3 dB, programmable up to 1114 Hz
Power-up time		ms			1	

Note: [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:

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

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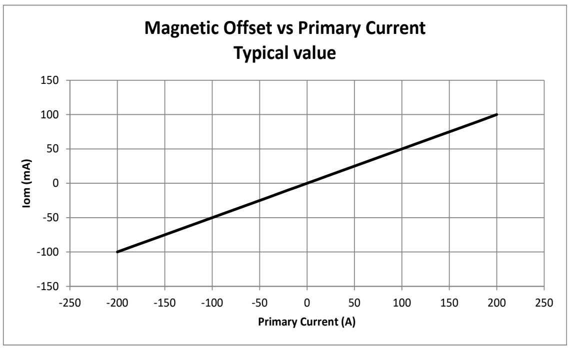
Accuracy data (±3δ, after PV test)

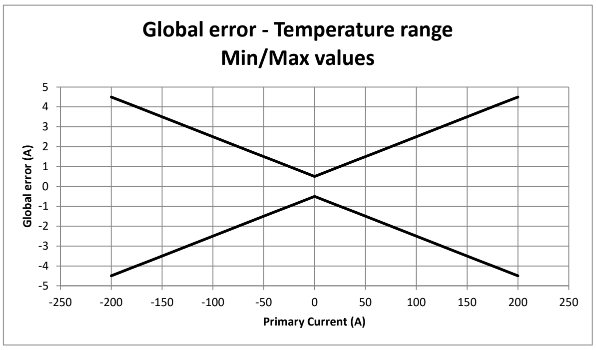
Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Electrical offset current	$I_{O E}$	mA		200		@ T_A = 25 °C, U_C = 5 V
Magnetic offsent current	$I_{O M}$	mA		70		@ T_A = 25 °C, U_C = 5 V
Offset current	I_O	A		0.3		@ T_A = 25 °C, U_C = 5 V
				0.5		@ −40 °C < T < 85 °C, U_C = 5 V
Sensitivity error	ε_S	%		1		@ T_A = 25 °C
				2		@ −40 °C < T < 85 °C
Linearity error	ε_L	%		0.3		of full range

Total error

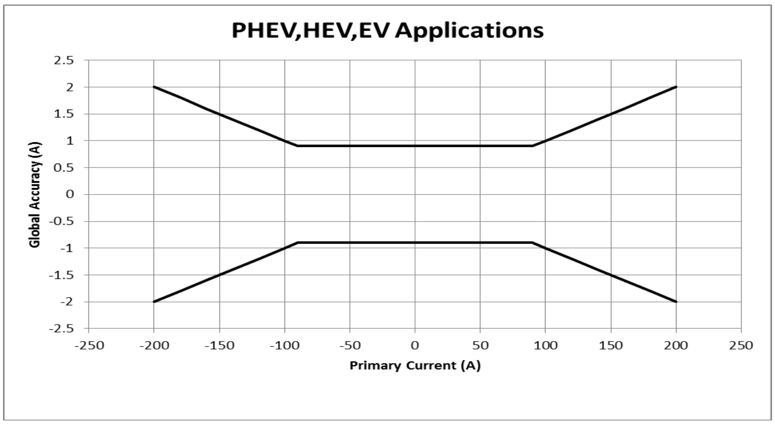
I_p	Symbol	Unit	Temperature					
			−40 °C	−20 °C	0 °C	25 °C	65 °C	85 °C
0 A	ε_{tot}	A	0.5	0.45	0.41	0.35	0.45	0.5
100 A			2.5	2.13	1.3	1.16	1.7	2.5
200 A			4.5	3.89	3.15	2.3	3.77	4.5

Accuracy curves





Additional accuracy data (±1δ, 0 KM)



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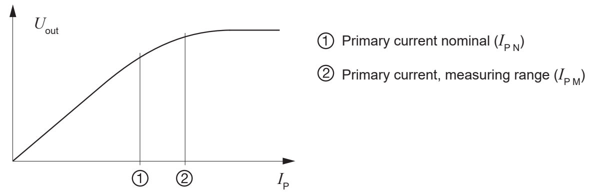
PERFORMANCES PARAMETERS DEFINITIONS

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:

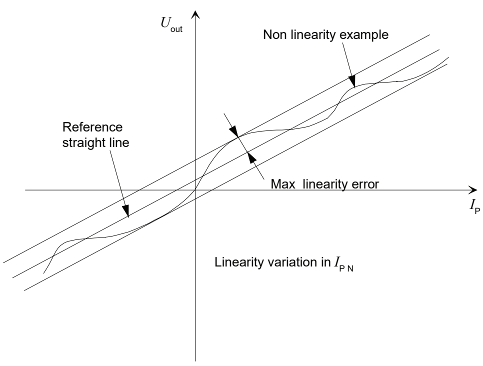
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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:

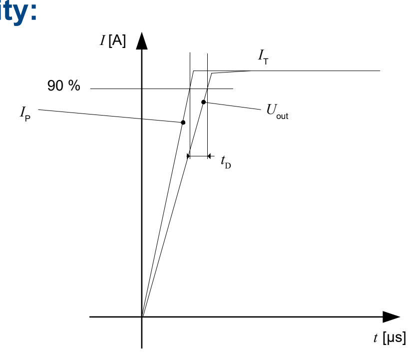
The maximum positive or negative discrepancy with a reference straight line $U_{out} = f(I_P)$.
Unit: linearity (%) expressed with full scale of $I_{P N}$.



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 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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Environmental test specifications:

Name	Standard	Condition	
ELECTRICAL TESTS @ 25 °C			
Dielectric Withstand Voltage test	2500 V AC / 1 min / 50 Hz	Functional Test Before & After test	Test done before and after 85/85 test. Test until destruction only on 1 part, at the end to have the limit level.
Insulation Resistance test	500 V DC, time = 60 s $R_{INS} \geqslant$ 500 MΩ Minimum	Functional Test Before & After test	Test done before and after 85/85 test.
ENVIRONMENTAL TESTS (CLIMATIC)			
Thermal shock	IEC 60068-2-14 Na (01/2009)	ISO 16750-4 ξ 5.3.2 (04/2010) Connector up-side, Cover over to sensor to emulate junction box	T = "T °C Operating Min & Max" °C, Duration = 500 cycles; 30 min/ 30 min U_C = NO power supply, but with handler; Check after stab. @ 25 °C (End test)
Steady state T °C Humidity bias life test	JESD 22-A101 (03/2009)	Conndtor up-side, Cover over to sensor to emulate junction box	T = 85 °C; RH = 85 %; Duration = 1000 h U_C = 5 V; I_P = 100 A; global error monitoring Check after stab. @ 25 °C (End test) Cross section with visual inspection according to IPC-A-610
MECHANICAL TESTS			
Vibration Random in T °C	IEC 60068-2-64 (02/2008)	ISO 16750-3 ξ 4.1.2.4 (vib. profil: sung masses) ISO 16750-3 ξ 4.1.1 (T°C) (12/2012)	8 h for each axes; T = "T °C Operating Min & Max" °C, U_C = 5 V; I_P = 0 A; Offset Monitoring Check after stab. @ 25 °C (End test)
Shocks	IEC 60068-2-27 (02/2008)	ISO 16750-3 ξ 4.2 (12/2012)	Level & Frequency = by default ξ 4.2.2 Half-sine pulse; 10 * in each direction (total 60 shocks) Peak acceleration; Longitudinal 500 m/s² duration 6 ms Transversal 500 m/s² duration 6 ms Vertical 500 m/s² duration 6ms U_C = NO power supply Check after stab. @ 25°C (End test)
EMC			
RE 310 - Radiated RF Emissions	FORD - FMC 1278		
RI 112 - RF Immunity, Bulk Current Injection	FORD - FMC 1278		
RI 114 - Immunity, Reverberation Method	FORD - FMC 1278		
RI 115	FORD - FMC 1278		
RI 140 - Immunity to Magnetic Field	FORD - FMC 1278		
RI 140 - Coupled Immunity	FORD - FMC 1278		
RI 150 - Couped Immunity	FORD - FMC 1278		
CI 260 - Immunity to Voltage Dropout	FORD - FMC 1278		
CI 280 - Electrostatic Discharge - Handling	FORD - FMC 1278		
CI 280 - Electrostatic Discharge - Powered	FORD - FMC 1278		

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