AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
HAB 400-V/SP1

Introduction

The HAB 400-V/SP1 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 HAB 400-V/SP1 gives you the choice of having different current measuring ranges in the same housing.

The HAB 400-V/SP1 is attached on the battery cable (or bus-bar) of a vehicle. It provides to a controller (ECU) the actual value of current flowing in the cable. The current value is provided by a voltage signal. The electrical connection is made with a waterproof connector. The output voltage V_{out} is fully ratiometric with the supply voltage U_C.

Features

- Open Loop transducer using the Hall effect
- Unipolar + 5 V DC power supply
- Primary current measuring range -400/+150 A
- Maximum RMS primary admissible current: defined by busbar to have T° < + 150 °C
- Operating temperature range: - 40 °C < T° < + 105 °C
- Output voltage: full ratio-metric (in sensitivity and offset)

Special feature

- Client dedicated.

Advantages

- Excellent accuracy
- Very good linearity
- Very low thermal offset drift
- Very low thermal sensitivity drift
- Current measurement
- No insertion losses.

Automotive applications

- Stop/Start Battery Management.

Principle of HAB 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:

$$B\ (I_P) = \text{constant (a)} \times I_P$$

The Hall voltage is thus expressed by:

$$V_H = (R_H/d) \times I \times \text{constant (a)} \times I_P$$

Except for I_P, all terms of this equation are constant. Therefore:

$$V_H = \text{constant (b)} \times I_P$$

The measurement signal V_H amplified to supply the user output voltage or current.

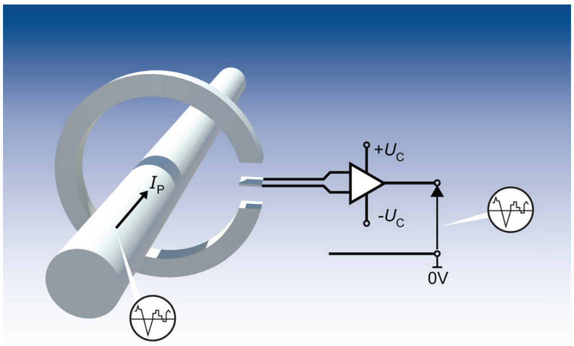
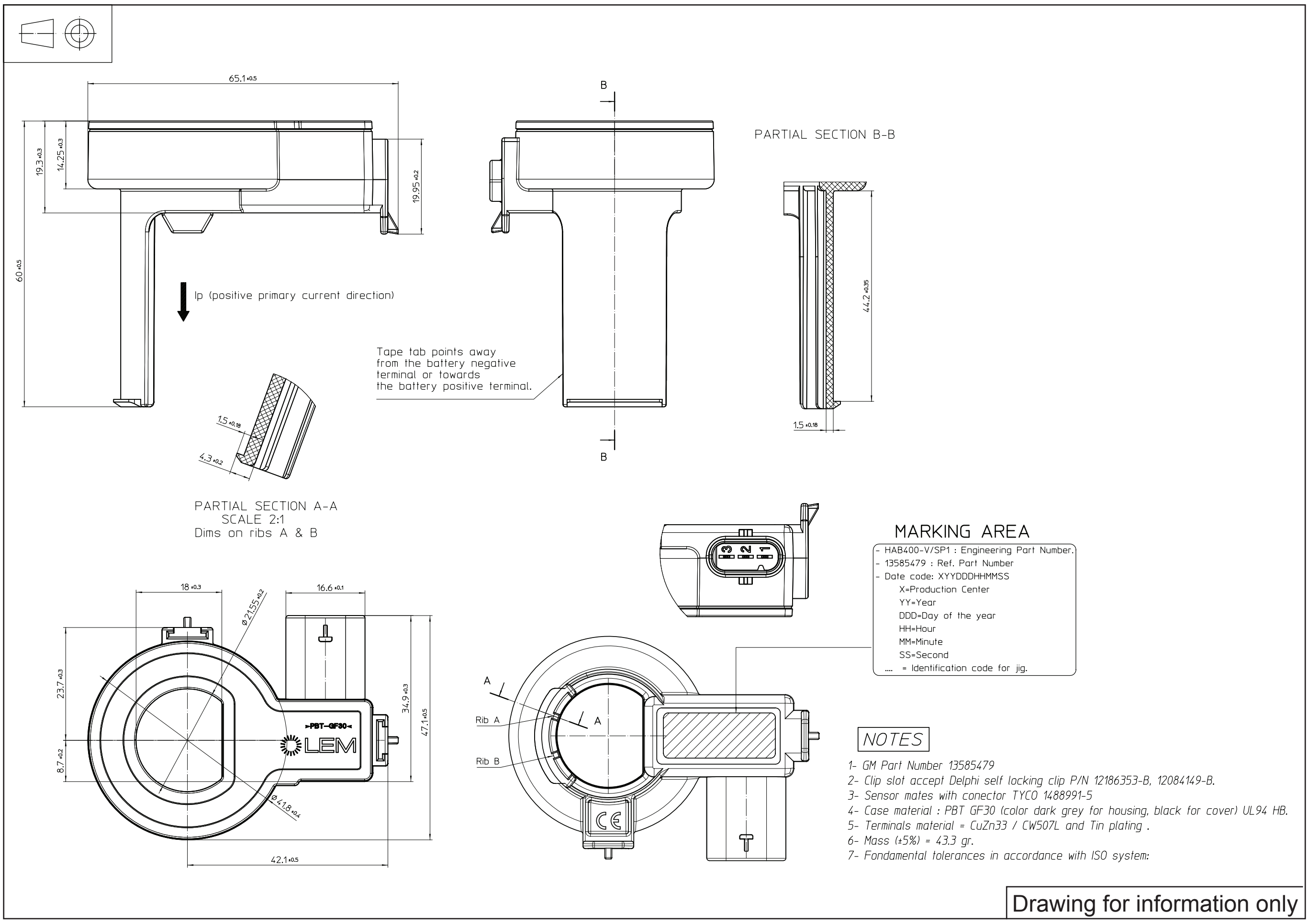


Fig. 1: Principle of the open loop transducer

Dimensions HAB 400-V/SP1 (in mm)



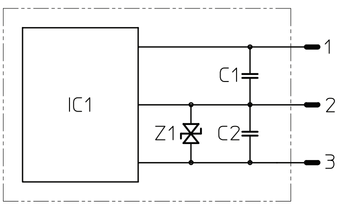
Mechanical characteristics

- Plastic case PBT GF 30
- Magnetic core Iron silicon alloy wound core
- Mass 43.3 g
- Electrical terminal coating Tin plated

Mounting recommendation

- Connector type TYCO 1488991-5

Electronic schematic



Components list	
IC1	Hall sensor ASIC
C1	1µF Capacitor
C2	68nF Capacitor
Z1	Bi-directional zener

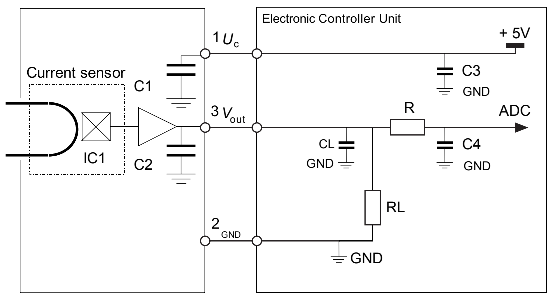
Pin out	
1	DC supply voltage (5V)
2	Ground
3	Output signal

Remarks

- $I_P = \left(\frac{5}{U_C} \cdot V_{out} - V_0\right) \cdot \frac{1}{G}$ with G in (V/A)
- $V_{out} > V_o$ when I_P flows in the positive direction (see arrow on drawing).

On board diagnostic

GND open	$V_{out} = 0.1\ V_{max}$
U_C open	$V_{out} = 0.1\ V_{max}$



C3= 47nF
C4= 100nF
C_L= 47nF
R_L= 39kΩ
R = 10kΩ

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Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification Min	Specification Typical	Specification Max	Conditions
Nominal supply voltage	U_C	V	4.5	5	5.5	
Supply continuous over voltage	U_C	V			8.5	
Reverse voltage	U_C	V	-14			1 min @ T_A = 25 °C
Over voltage	U_C	V			14	2 min
Ambient storage temperature	T_S	°C	-40		105	
Electrostatic discharge voltage	U_{ESD}	kV			2	JESD 22-A114-B
Maximum admissible vibration (random)	γ	m·s^{-2}		19.6		10 to 1000 Hz @ -40 °C to 105 °C
Creepage distance	d_{Cp}	mm		4		
Clearance	d_{Cl}	mm		3.5		
Comparative traking index	*CTI*	V		375		
Maximum continuous output current	I_{out}	mA	-10		10	
Maximum continuous output voltage (Analog)	V_{out}	V			14	1 min @ T_A = 25 °C
Isolation resistance	R_{IS}	MΩ	10			DC 500 V
Output Short circuit maximum duration	t_c	min			2	

Operating characteristics in nominal range (I_{PN})

Parameter	Symbol	Unit	Specification Min	Specification Typical	Specification Max	Conditions
Electrical Data						
Primary current, measuring range	I_{PM}	A	-400		150	
Primary nominal DC or rms current	I_{PN}	A	-400		150	
Supply voltage	U_C	V	4.5	5	5.5	
Ambient operating temperature	T_A	°C	-40		105	
Continuous output current	I_{out}	mA	-1		1	
Output voltage (Analog)	V_{out}	V		$V_{out} = (U_C/5) \cdot (V_o + G \cdot I_P)$		
Resolution		mV		2.5		
Sensitivity	G	mV/A		7.27		
Offset voltage	V_O	V		3.409		
Current consumption	I_C	mA	5	7		@ T_A= 25 °C
					10	Over temperature
Load resistance (pull down)	R_L	KΩ	9	39	100	Pull down resistance only
Capacitive loading	C_L	nF		47	100	
Output internal resistance	R_{out}	Ω		1		@ T_A= 25 °C
					10	Over temperature
Output voltage (diagnostic detection open ground)	V_{out}	V			0.1	
Output voltage (diagnostic detection open U_d)	V_{out}	V			0.1	
Output clamping voltage low	V_{SZ}	V	0.2	0.25	0.3	@ U_C= 5 V
Output clamping voltage high	V_{SZ}	V	4.7	4.75	4.80	@ U_C= 5 V

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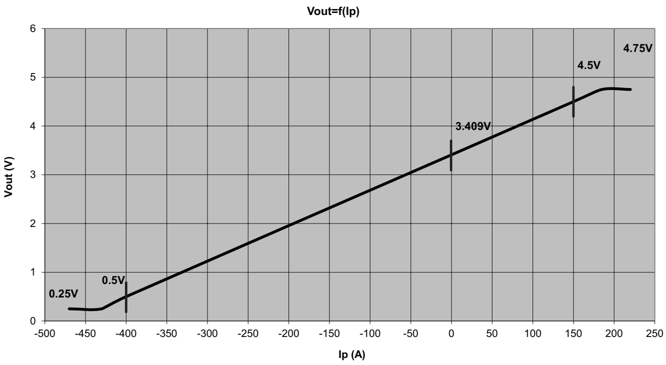
Operating characteristics in nominal range (I_{PN})

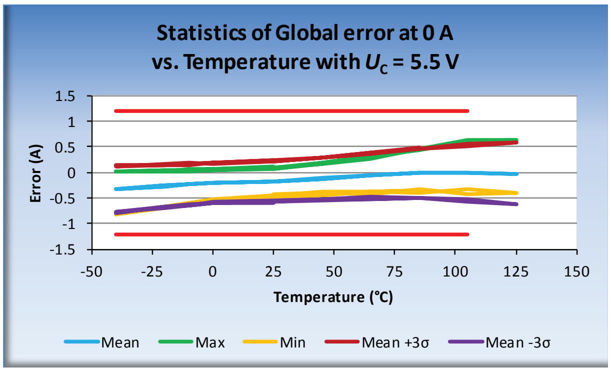
Parameter	Symbol	Unit	Specification Min	Specification Typical	Specification Max	Conditions
Performance Data [1]						
Electrical offset current	I_{OE}	mA		± 500		@ T_A = 25 °C
Magnetic offset current	I_{OM}	mA		± 400		@ T_A = 25 °C [3]
Linearity error	ε_L	% I_P	-0.5		0.5	-300 A up to 150 A @ 25 °C [2]
			-1		1	-400 A to -300 A @ 25 °C [2]
Overall accuracy @ I = 0 A @ - 40 °C to 105 °C	X_G	A	-1.2		1.2	V_{out} = ± 8.72 mV @ > U_C = 5 V ± 0.05 V [3]
Overall accuracy @ I = - 400 A @ - 10 °C to 85 °C			-14		14	V_{out} = ± 101.78 mV @ U_C = 5 V ± 0.05 V
Overall accuracy @ I =-400 A @ T°< -10 °C and T°> 85 °C			-16		16	V_{out} = ± 116.32 mV @ U_C = 5 V ± 0.05 V
Overall accuracy @ I = 150 A @ - 10 to 85 °C			-6		6	V_{out} = ± 43.62 mV @ U_C = 5 V ± 0.05 V
Overall accuracy @ I = +150 A @ T°< -10 °C and T°> 85 °C			-6		6	V_{out} = ± 43.62 mV @ U_C = 5 V ± 0.05 V
Frequency bandwidth [4]	BW	kHz		2		
Step response time to 90 % I_{PN} [1]	t_r	ms			1.1	
Power up time				25	200	
Setting time after overload					25	

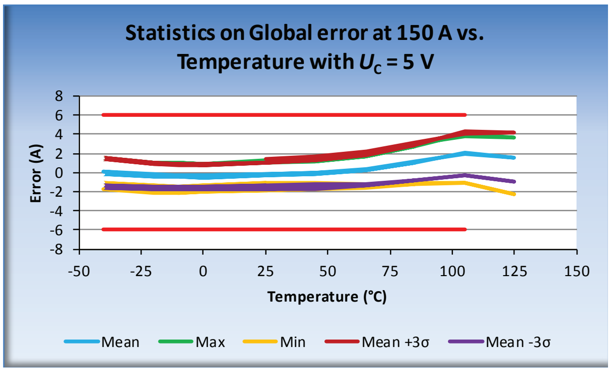
Notes:
1) With internal filter adjusted at 2 kHz and without customer load.
2) LEM standard 98.20.00.370.0 method 2
3) After cycle @ 400 A
4) Primary current frequencies must be limited in order to avoid excessive heating of the busbar, magnetic core and the ASIC (see feature paragraph in page 1).

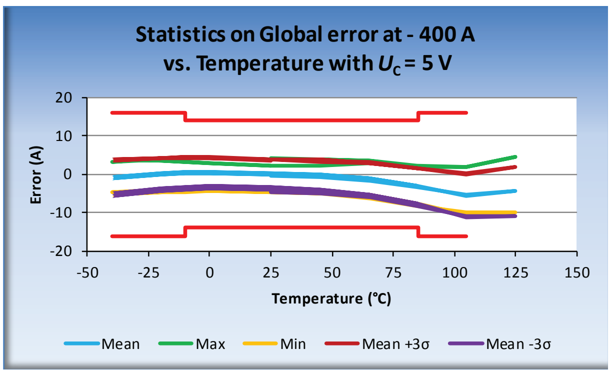
Output and clamping @ 0.25 & 4.75 V



$$V_{out} = \frac{U_C}{5} \cdot (V_O + G \times I_P)$$







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PERFORMANCES PARAMETERS DEFINITIONS

Definition of typical, minimum and maximum values:

Minimum and maximum values for specified limiting and safety conditions have to be understood as such as well 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, maximal and minimal values are determined during the initial characterization of a product.

Output noise voltage:

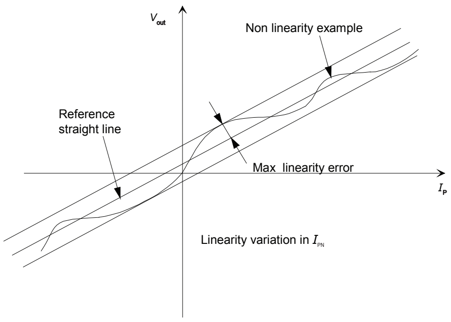
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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}.

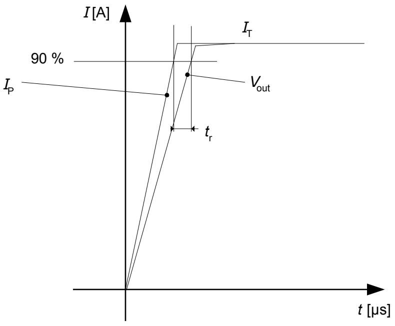
Linearity:

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



Response time (delay time) t_r:

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 G is the slope of the straight line $V_{out} = f\,(I_P)$, it must establish the relation:
$V_{out}(I_P) = U_C/5\,(G \cdot I_P + V_o)$

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 G_T is the maximum variation (in ppm or %) of the sensitivity in the temperature range:
G_T = (Sensitivity max - Sensitivity min) / Sensitivity at 25 °C.
The sensitivity drift TCG_{AV} is the G_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 null. The ideal value of V_O is $U_C/2$ at U_C = 5 V. So, the difference of $V_O - U_C/2$ 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).

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Environmental test specifications:

Name	Standard
MECHANICAL FATIGUE	
High temperature degradation	GMW3172 § 9.4.1 version July 2010
Dimensional	GMW3172 § 8.5.3 version July 2010
Mechanical shock - Pothole	GMW3172 § 9.3.3 version July 2010
Vibration with thermal cycling	GMW3172 § 9.3.1.2 version July 2010
Mechanical shock - Collision	GMW3172 § 9.3.4 version July 2010
THERMAL FATIGUE	
Thermal shocks	GMW3172 § 9.4.2 version July 2010
Powered temperature cycle	GMW3172 § 9.4.3 version July 2010
Humidity heat cyclic	GMW3172 § 9.4.5 version July 2010
Humidity heat constant	GMW3172 § 9.4.6 version July 2010
Thermal shocks	GMW3172 § 9.4.2 version July 2010
Post thermal fatigue vibration	GMW3172 § 9.3.2 version July 2010
Frost	GMW3172 § 8.5.1 version July 2010
ENCLOSURE TESTS	
Dust IP6K	GMW3172 § 9.5.1 version July 2010
Water IPx9K	GMW3172 § 9.5.1 version July 2010
CORROSION TESTS	
Salt spray	GMW3172 § 9.4.8 version July 2010
ELECTRICAL TESTS	
Reverse polarity	GMW3172 § 8.2.2 version July 2010
State change waveform characterization	GMW3172 § 8.2.4 version July 2010
Ground path inductance sensitivity	GMW3172 § 8.2.5 version July 2010
Power supply interruptions	GMW3172 § 9.2.2 version July 2010
Intermittent short circuit	GMW3172 § 9.2.6 version July 2010
Continuous short circuit	GMW3172 § 9.2.7 version July 2010
Open circuit – single line interruption	GMW3172 § 9.2.9 version July 2010
CONNECTORS TESTS	
Connector installation abuse: side forces	GMW3172 § 9.3.9 version July 2010
Crush for housing: elbow load	GMW3172 § 9.3.6 version July 2010
Terminal push out force	GMW 3191 § 4.10 version December 2007
Connector to connector engagement force	GMW 3191 § 4.11 version December 2007
Locked connector disengagement force	GMW 3191 § 4.13 version December 2007
Unlocked connector disengagement force	GMW 3191 § 4.14 version December 2007
Fretting corrosion	GMW3172 § 9.3.12 version July 2010
Water freeze	GMW3172 § 9.5.4 version July 2010
Thermal shock / Water splash	GMW3172 § 9.4.4 version July 2010
Mechanical shock - Collision	GMW3172 § 9.3.4 version July 2010
Free fall	GMW3172 § 9.3.11 version July 2010
EMC TESTS	
ALSE	GMW3097 §3.3.1 version April 2012
CE, Artificial Network	GMW3097 §3.3.2 version April 2012
Bulk Current Injection	GMW3097 §3.4.1 version April 2012
Reverb, mode tuning	GMW3097 §3.4.3 version April 2012
Magnetic field	GMW3097 §3.4.4 version April 2012
I/O Lines	GMW3097 §3.5.3 version April 2012
Sensor Lines	GMW3097 §3.5.4 version April 2012
(Optional) 85V I/O	GMW3097 §3.5.5 version April 2012
Handling	GMW3097 §3.6.3 version April 2012