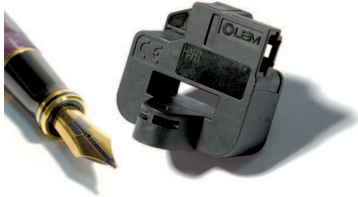


# AUTOMOTIVE CURRENT TRANSDUCER

## HAH1DR 400-S/SP1



### Introduction

The HAH1DR family is for the electronic measurement of DC, AC or pulsed currents in high power automotive applications with galvanic isolation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The HAH1DR family gives you the choice of having different current measuring ranges in the same housing (from  $\pm 200$  A up to  $\pm 900$  A).

### Features

- Open Loop transducer using the Hall effect
- Unipolar + 5 V DC power supply
- Primary current measuring range up to  $\pm 400$  A
- Maximum rms primary current limited by the busbar, the magnetic core or the ASIC temperature  $T^\circ < +150$  °C
- Operating temperature range:  $-40^\circ\text{C} < T^\circ < +125$  °C
- Output voltage: full ratiometric (in sensitivity and offset)
- Compact design.

### Advantages

- Excellent accuracy
- Very good linearity
- Very low thermal offset drift
- Very low thermal sensitivity drift
- Wide frequency bandwidth
- No insertion losses.

### Automotive applications

- Battery monitoring
- Starter Generators
- Inverters
- HEV application
- EV application.

### Principle of HAH1DR Family

The open loop transducers use an 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 (Fig. 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:

$$V_H = (R_H/d) \times l \times \text{constant}(a) \times I_p$$

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.

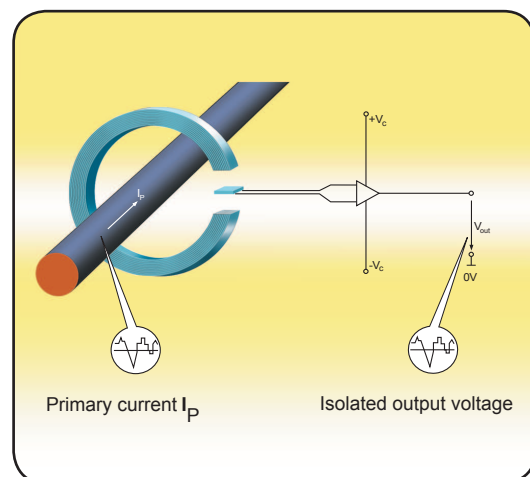
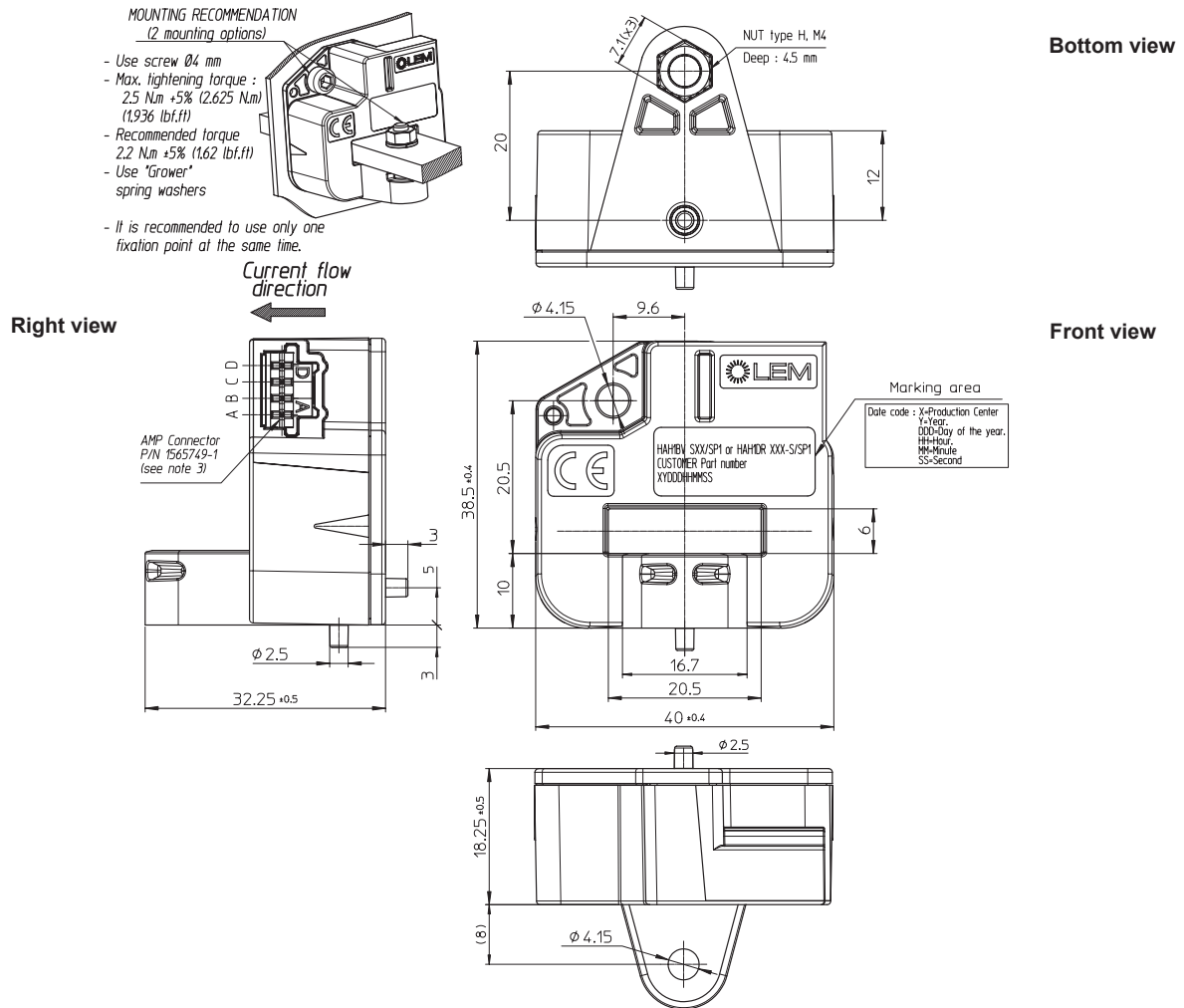


Fig. 1: Principle of the open loop transducer

# HAH1DR 400-S/SP1

Dimensions HAH1DR family (in mm. 1mm = 0.0394 inch)



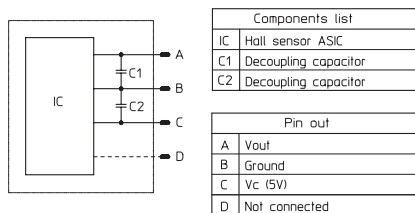
## Bill of materials

- Plastic case PBT GF 30
- Magnetic core Iron silicon alloy
- Pins Brass gold plated
- Mass 39 g

## Remarks

- $V_{OUT} > \frac{V_C}{2}$  when  $I_p$  flows in the direction of the arrow.

## System architecture



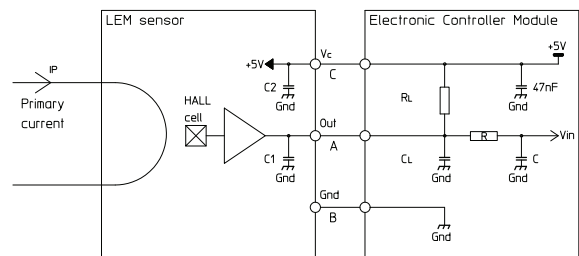
## System architecture (example)

$R_L > 10 \text{ kW}$  optional resistor for signal line diagnostic

| $V_{OUT}$    | Diagnosis      |
|--------------|----------------|
| Open circuit | $V_{IN} = V_C$ |
| Short GND    | $V_{IN} = OV$  |

$C_L < 100 \text{ nF}$  EMC protection

$R_C$  Low pass filter EMC protection (optional)



## HAH1DR 400-S/SP1

### Absolute maximum ratings

|                                   | Symbol     | Unit | Specification |     |             | Conditions                 |
|-----------------------------------|------------|------|---------------|-----|-------------|----------------------------|
|                                   |            |      | Min           | Typ | Max         |                            |
| <b>Electrical Data</b>            |            |      |               |     |             |                            |
| Maximum primary current peak      | $I_{Pmax}$ |      |               |     | 1)          |                            |
| Supply continuous over voltage    | $V_C$      |      |               |     | 7           | No operating               |
| Reverse voltage 2)                |            |      | -0.5          |     |             | 1 min @ $T_A = 25^\circ C$ |
| Output over voltage (continuous)  | $V_{OUT}$  | V    | -0.5          |     | $V_C + 0.5$ |                            |
| Continuous output current         | $I_{OUT}$  | mA   | -10           |     | 10          |                            |
| Output short-circuit duration     | $T_C$      | min  |               |     | 2           |                            |
| Rms voltage for AC isolation test | $V_d$      | kV   |               |     | 2           | 50 Hz, 1 min               |
| Isolation resistance              | $R_{IS}$   | MΩ   | 500           |     |             | 500 V - ISO 16750-2        |
| Electrostatic discharge voltage   | $V_{ESD}$  | kV   |               |     | 2           | JESD22-A114-B              |
| Ambient storage temperature       | $T_S$      | °C   | -55           |     | 125         |                            |

### Operating characteristics

|   | Symbol        | Unit  | Specification                                   |        |                                    | Conditions  |
|---|---------------|-------|---|--------|------------------------------------|---|
|   |               |       | Min   | Typ    | Max                                |   |
| <b>Electrical Data</b>                      |               |       |   |        |                                    |   |
| Primary current                             | $I_P$         | A     | -400  |        | 400                                |   |
| Calibration current                         | $I_{CAL}$     | A     | -400  |        | 400                                | @ $T_A = 25^\circ C$                                    |
| Supply voltage                              | $V_C$         | V     | 4.75  | 5.00   | 5.25                               |   |
| Output voltage (Analog) 3)                  | $V_{OUT}$     | V     | $V_{OUT} = (V_C/5) \times (2.5 + G \times I_P)$ |        |                                    | @ $V_C$   |
| Sensitivity 3)                              | $G$           | mV/A  |   | 5      |                                    | @ $V_C = 5 V$   |
| Current consumption                         | $I_C$         | mA    |   | 15     | 20                                 | @ $V_C = 5 V$ , @ $-40^\circ C < T^\circ < 125^\circ C$ |
| Load resistance                             | $R_L$         | kΩ    | 10  |        |                                    |   |
| Output internal resistance                  | $R_{OUT}$     | Ω     |   |        | 10                                 | DC to 1 kHz   |
| Capacitive loading                          | $C_L$         | nF    | 1   |        | 100                                |   |
| Ambient operating temperature               | $T_A$         | °C    | -40   |        | 125                                | Connector limited 105°C                                 |
| Output drift versus power supply            | $V_{OUT PS}$  | %     |   | 0.5    |                                    |   |
| <b>Performance Data</b>                     |               |       |   |        |                                    |   |
| Sensitivity error                           | $\epsilon_G$  | %     | -1.0  | ± 0.5  | 1.0                                | @ $T_A = 25^\circ C$ @ $I = I_P$                        |
| Electrical offset current                   | $I_{OE}$      | A     |   | ± 0.8  |                                    | @ $T_A = 25^\circ C$ , @ $V_C = 5 V$                    |
| Magnetic offset current                     | $I_{OM}$      |       |   | ± 1    |                                    | @ $T_A = 25^\circ C$ , @ $V_C = 5 V$ , after ± $I_P$    |
| Global offset current                       | $I_O$         |       | -2.2  |        | 2.2                                | @ $T_A = 25^\circ C$                                    |
| Average temperature coefficient of $V_{OE}$ | $TCV_{OE AV}$ | mV/°C | -0.08   | ± 0.03 | 0.08                               | @ $-40^\circ C < T^\circ < 125^\circ C$                 |
| Average temperature coefficient of $G$      | $TG_{AV}$     | %/°C  | -0.035  | ± 0.02 | 0.035                              | @ $-40^\circ C < T^\circ < 125^\circ C$                 |
| Linearity error                             | $\epsilon_L$  | %     | -1  |        | 1                                  | @ $V_C = 5 V$ @ $T_A = 25^\circ C$ , @ $I = I_P$        |
| Response time to 90 % of $I_{PN}$ step      | $t_t$         | μs    |   | 6      | 10                                 | @ $di/dt = 100 A/\mu s$                                 |
| Frequency bandwidth 4)                      | $BW$          | kHz   |   | 30     |                                    | @ -3 dB   |
| Output clamping voltage min                 | $V_{sz}$      | V     |   |        | 0.1                                | @ $V_C = 5 V$ , $T_A = 25^\circ C$                      |
| Output clamping voltage max                 |               |       | 4.9   |        | @ $V_C = 5 V$ , $T_A = 25^\circ C$ |   |
| Output voltage noise peak-peak              | $V_{R0 PP}$   | mV    |   |        | 20                                 | DC to 1MHz  |

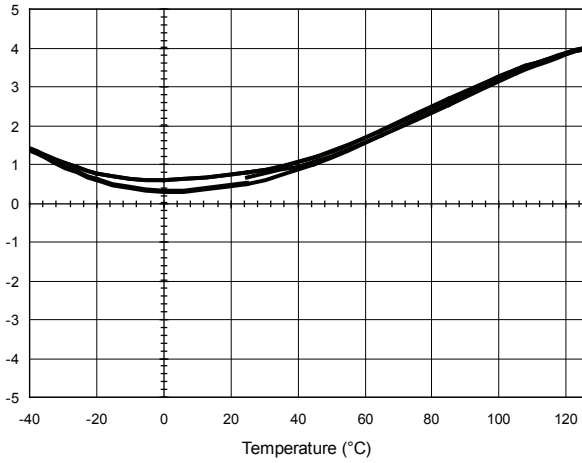
- Notes:
- 1) Busbar temperature must be below 150°C
  - 2) Transducer not protected against reverse polarity.
  - 3) The output voltage  $V_{OUT}$  is fully ratiometric. The offset and sensitivity are dependent on the supply voltage  $V_C$  relative to the following formula:

$$I_P = \left( V_{OUT} - \frac{V_C}{2} \right) \times \frac{1}{G} \times \frac{5}{V_C} \quad \text{with } G \text{ in } (V/A)$$

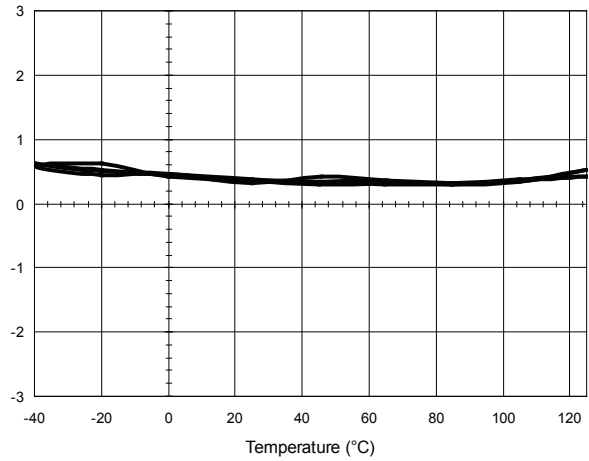
- 4) Tested only with small signal only to avoid excessive heating of the magnetic core.

## HAH1DR 400-S/SP1

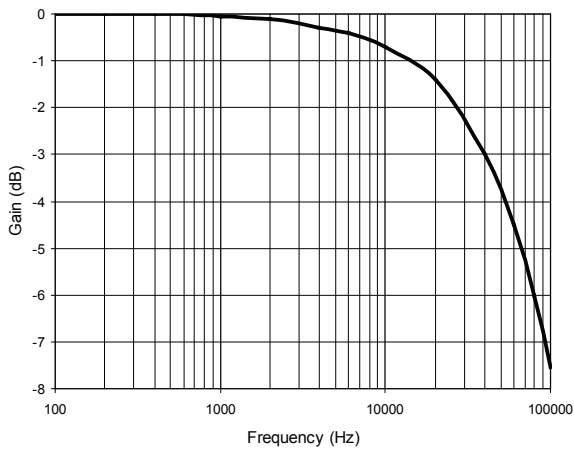
HAH1DR 400/SP1 Sensitivity error (%)



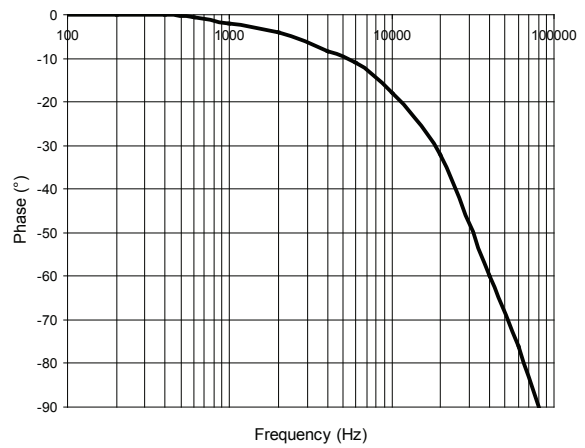
HAH1DR 400/SP1 Electrical offset error (A)



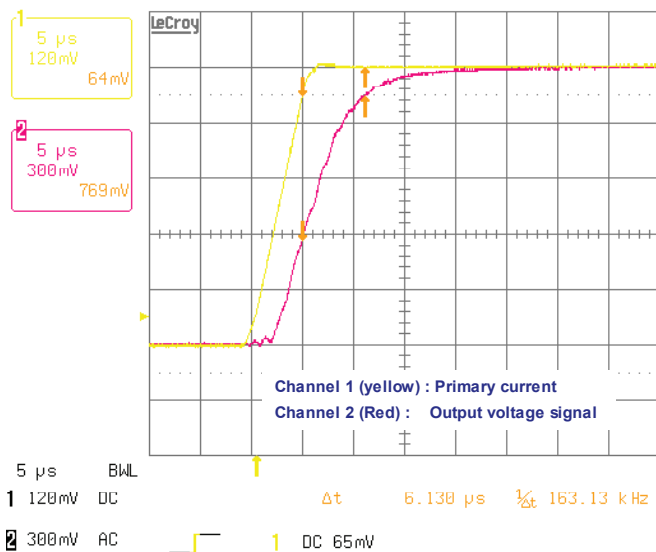
HAH1DR 400/SP1 Frequency bandwidth



HAH1DR 400/SP1 Phase



Typical response time at 100 A/μS



## HAH1DR 400-S/SP1

### PERFORMANCES PARAMETERS DEFINITIONS

#### Output noise voltage:

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

#### Magnetic offset:

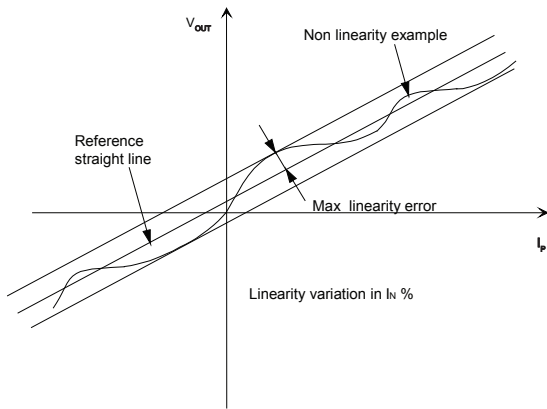
The magnetic offset is the consequence of an over-current on the primary side. It's defined after an excursion of  $I_{P \max}$ .

#### Linearity:

The maximum positive or negative discrepancy with a reference straight line  $V_{OUT} = f(I_P)$ .

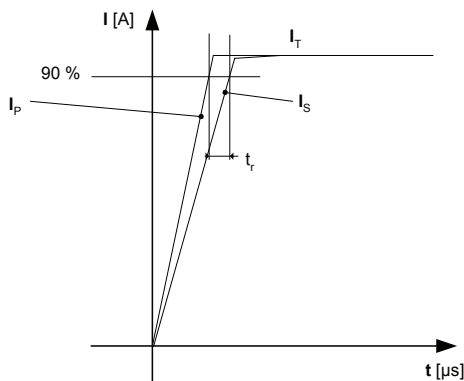
Unit: linearity (%) expressed with full scale of  $I_{P \max}$ .

Linearity is measured on cycle +  $I_P$ , 0, -  $I_P$ , 0, +  $I_P$  without magnetic offset (average values used)



#### Response time (delay time) $t_r$ :

The time between the primary current signal and the output signal reach at 90 % of its final value



#### Typical:

Theoretical value or usual accuracy recorded during the production.

#### Sensitivity:

The Transducer's sensitivity  $G$  is the slope of the straight line  $V_{out} = f(I_P)$ , it must establish the relation:

$$V_{out}(I_P) = V_C/5 (G \times I_P + 2.5) (*)$$

(\*) For all symetrics transducers.

#### 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  $G_T$  is the maximum variation (in ppm or %) of the sensitivity in the temperature range:

$$G_T = (Sensitivity \max - Sensitivity \min) / Sensitivity \text{ at } 25^\circ C.$$

The sensitivity drift  $TCG_{AV}$  is the  $G_T$  value divided by the temperature range.

#### Offset voltage @ $I_P = 0$ A:

Is the output voltage when the primary current is null. The ideal value of  $V_o$  is  $V_C/2$  at  $V_C = 5$  V. So, the difference of  $V_o - V_C/2$  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.

#### Environmental test specifications

| Name  | Standard                                       | Conditions                                  |
|---|--|---|
| Damp heat, steady state                                 | JESD22-A101                                    | 85°C - 85°C / 1000h                         |
| Isolation resistance                                    | ISO 16750-2 § 4.10                             | 500 V/1min                                  |
| Temperature humidity cycle test                         | ISO 16750-4                                    | -10 + 85°C 10 days                          |
| Isolation test  | IEC 60664-1                                    | 2 kV/50 Hz/1min                             |
| Mechanical tests  |  |   |
| Vibration test (random)                                 | IEC 60068-2-64<br>ISO 16750-3 & 4.1.2.5 (2007) | 20 ... 2000 Hz Random rms (11g rms) 8h/axis |
| Terminal strength test                                  | According to LEM                               |   |
| Thermal shocks  | IEC 60068-214 Na                               | -40 + 125°C 300 cycles                      |
| Free fall   | ISO 16750-3 § 4.3                              | 1m concrete ground                          |
| EMC Test  |  |   |
| Radiated electromagnetic immunity                       | Directive 2004/104/CE<br>ISO 11452-2           | 30 V/m 20-2000 MHz                          |
| Bulk current injection immunity                         | Directive 2004/104/CE<br>ISO 11452-4           | 1-400 MHz-60mA                              |
| Radiated radio frequency electromagnetic field immunity | IEC 61000-4-3                                  | 80 MHz to 1.000 MHz-10V/m                   |
| Electrostatic discharge immunity test                   | IEC 61000-4-2                                  | Air discharge=2 kV                          |