

AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

HAH1DRW 500-S



RoHS

Introduction

The HAH1DRW family 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 HAH1DRW 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 ± 500 A
- Maximum RMS primary admissible current: defined by busbar to have $T^\circ < +150$ °C
- Operating temperature range: -40 °C $< T^\circ < 125$ °C
- Output voltage: full ratio-metric (in sensitivity and offset).

Advantages

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

Automotive applications

- Electrical Power Steering
- Starter Generators
- Converters
- Battery Management
- Motor drive application.

Principle of HAH1DRW 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.

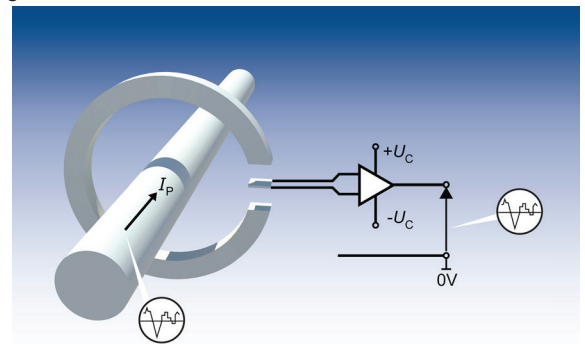
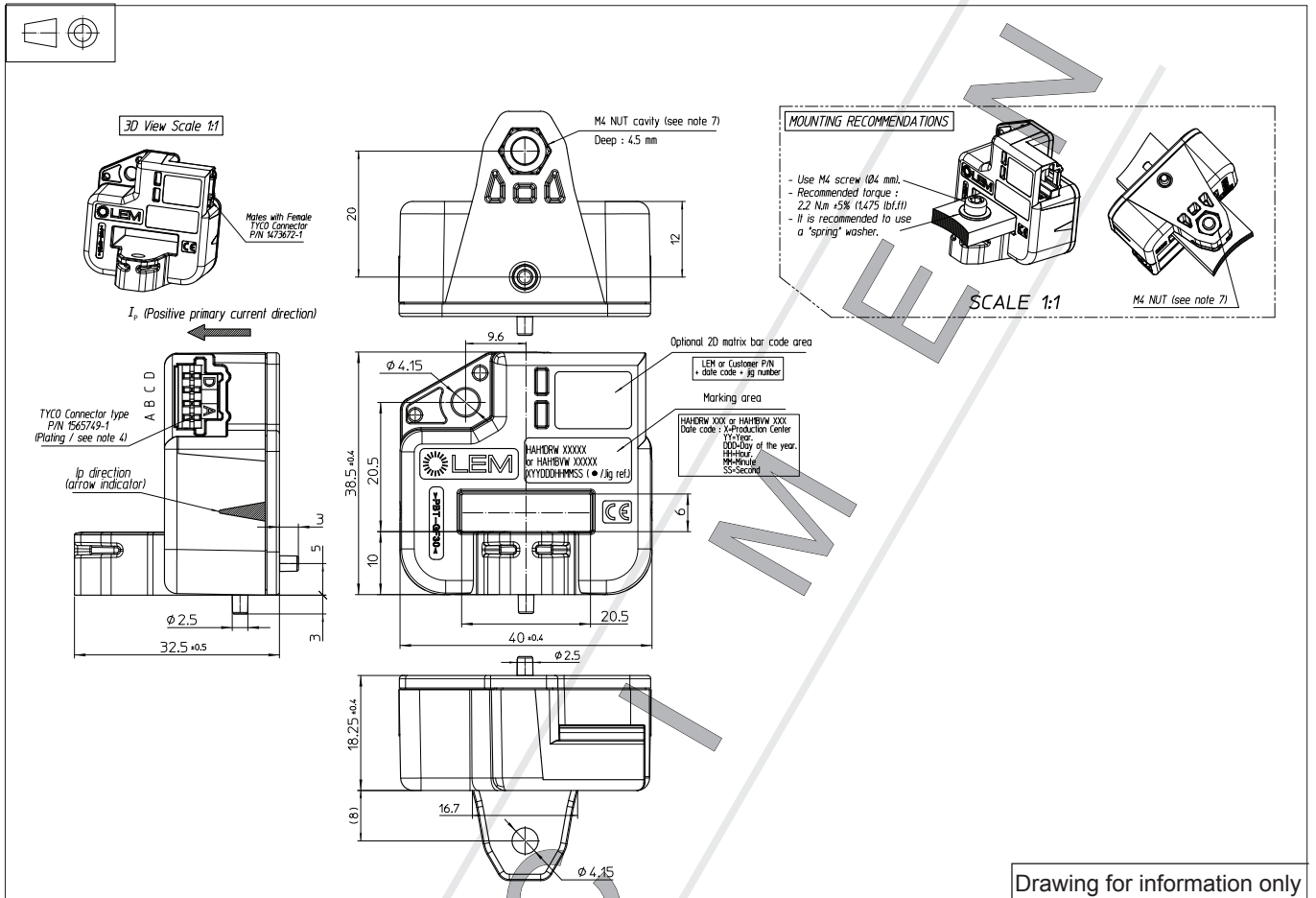


Fig. 1: Principle of the open loop transducer

Dimensions HAH1DRW 500-S (in mm)



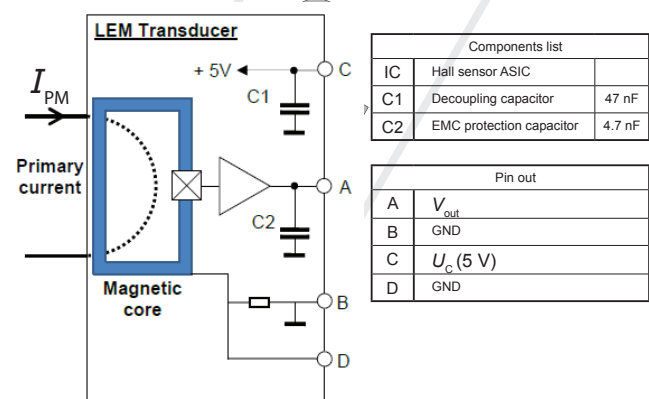
Mechanical characteristics

- Plastic case PBT GF30
- Magnetic core FeSi wound core
- Pins Brass tin plated
- Mass 57 g ± 5 %

Mounting recommendation

- Mating connector type TYCO connector P/N 1473672-1
- Assembly torque 2.2 Nm ± 5 %
- Soldering type N/A

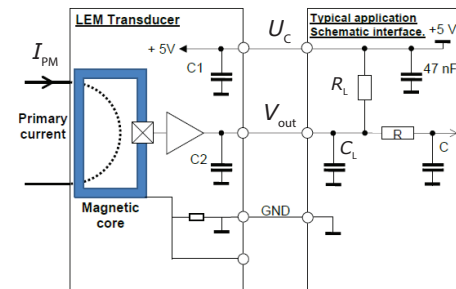
Electronic schematic



Remarks

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

System architecture (example)



$C_L < 2.2$ nF EMC protection (optional)

RC Low pass filter (optional)

On board diagnostic

$R_L > 10$ k Ω . Resistor for signal line diagnostic (optional)

| V_{out} | Diagnostic |
|--------------|----------------|
| Open circuit | $V_{IN} = U_C$ |
| Short GND | $V_{IN} = 0$ V |

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Absolute ratings (not operating)

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---|-----------|------------------|----------------------|---------|-------------|----------------------------------|
| | | | Min | Typical | Max | |
| Maximum supply voltage | U_C | V | - 0.5 | | 8 | 1) |
| Ambient storage temperature | T_S | °C | - 40 | | 125 | |
| Electrostatic discharge voltage (HBM) | U_{ESD} | kV | | | 2 | JESD22-A114-B |
| Maximum admissible vibration (random rms) | γ | $m \cdot s^{-2}$ | | | 96.6 | 10 to 2000 Hz, - 40 °C to 125 °C |
| RMS voltage for AC insulation test | U_d | kV | | | 2.5 | 50 Hz, 1 min |
| Creepage distance | d_{cp} | mm | 5.2 | | | |
| Clearance | d_{cl} | mm | 4.9 | | | |
| Comparative tracking index | CTI | V | PLC3 (175 V - 250 V) | | | |
| Maximum output Current | I_{out} | mA | - 10 | | 10 | |
| Maximum output Voltage | V_{out} | V | - 0.5 | | $U_C + 0.5$ | |
| Maximum reverse current | I_R | mA | | | 80 | |

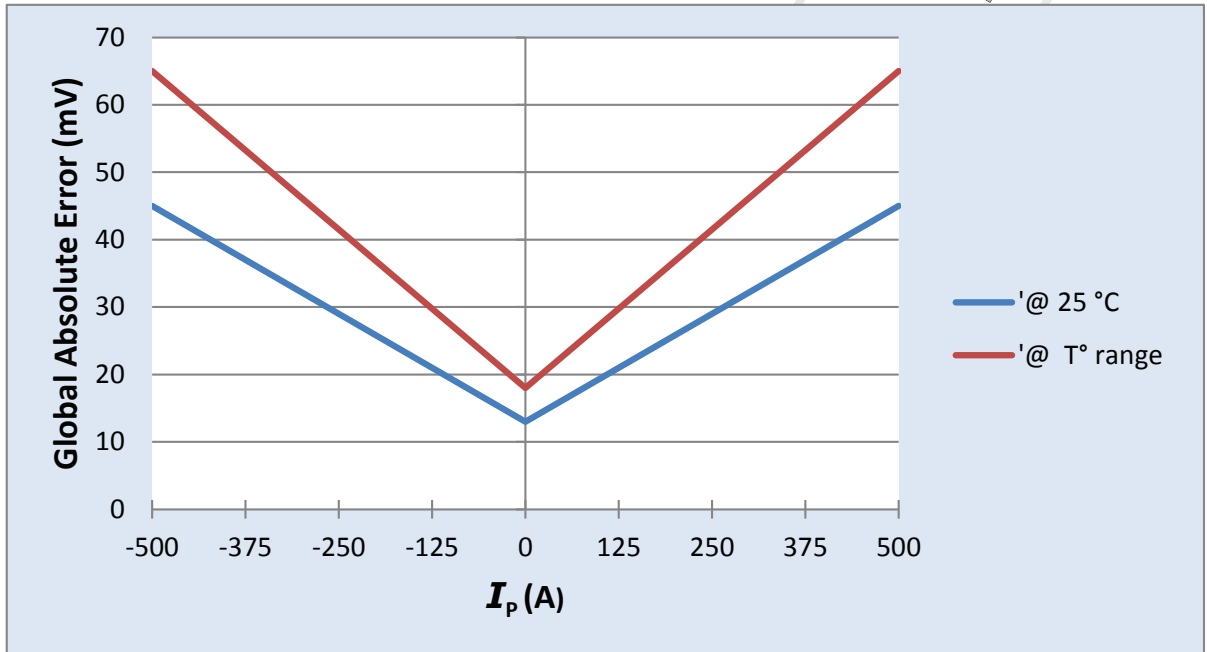
Operating characteristics in nominal range (I_{PN})

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---|--------------|------------|---|------------|------|--------------------------------|
| | | | Min | Typical | Max | |
| Electrical Data | | | | | | |
| Primary current, measuring range | I_{PM} | A | - 500 | | 500 | |
| Primary nominal DC or RMS current | I_{PN} | A | - 500 | | 500 | |
| Supply voltage | U_C | V | 4.75 | 5 | 5.25 | |
| Ambient operating temperature | T_A | °C | - 40 | | 125 | |
| Output voltage (Analog) | V_{out} | V | $V_{out} = (U_C/5) \cdot (V_o + G \cdot I_p)$ | | | |
| Sensitivity | G | mV/A | | 4 | | @ $T_A = 25$ °C |
| Offset voltage | V_o | V | | 2.5 | | |
| Current consumption | I_C | mA | | 20 | 25 | - 40 °C < T_A < 125 °C |
| Load resistance | R_L | K Ω | 10 | | | |
| Output internal resistance | R_{out} | Ω | | 1 | 10 | |
| Performance Data | | | | | | |
| Ratiometricity error | ϵ_r | % | | ± 0.5 | | |
| Sensitivity error | ϵ_g | % | | ± 0.6 | | @ $T_A = 25$ °C |
| Electrical offset voltage | V_{OE} | mV | | ± 3 | | @ $T_A = 25$ °C, @ $U_C = 5$ V |
| Magnetic offset voltage | V_{OM} | mV | | ± 2 | | @ $U_C = 5$ V, @ $T_A = 25$ °C |
| Linearity error | ϵ_L | % | - 1 | | 1 | % of full scale |
| Average temperature coefficient of V_{OE} | TCV_{OEAV} | mV/°C | | ± 0.04 | | @ $U_C = 5$ V |
| Average temperature coefficient of G | TCG_{AV} | %/°C | | ± 0.02 | | |
| Step response time @ 70 % | t_r | μs | | 2 | 6 | $di/dt = 100$ A / μs |
| Frequency bandwidth | BW | kHz | 40 | | | @ - 3 dB |
| Output voltage noise peak-peak | $V_{no p-p}$ | mV | | | 14 | DC to 1 MHz |
| Output RMS voltage noise | $V_{no rms}$ | mV | | | 2.2 | |
| Phase shift | $\Delta\phi$ | ° | - 4 | | | DC to 1 KHz |

Notes: 1) Exceeding 6.5 V may temporarily reconfigure the device until next power on.

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Global Absolute Error (mV) @ $U_c = 5\text{ V}$

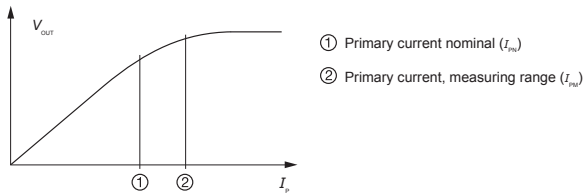


| I_p (A) | Accuracy @ 25 °C (mV) | Accuracy @ T ° range (mV) |
|------------------|-----------------------|---------------------------|
| $-I_p\text{MAX}$ | 45 | 65 |
| 0 | 13 | 18 |
| $I_p\text{MAX}$ | 45 | 65 |

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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 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.

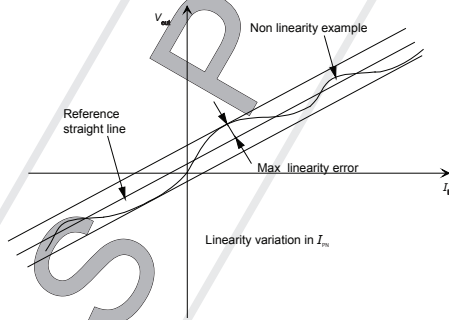
Magnetic offset:

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

Linearity:

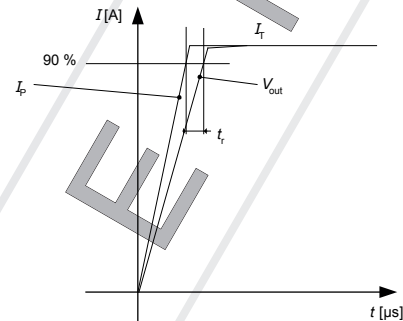
The maximum positive or negative discrepancy with a reference straight line $V_{out} = f(I_p)$.

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:

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

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:

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

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 zero. 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:

Refer to LEM GROUP test plan laboratory CO.11.11.515.0 with "Tracking_Test Plan_Auto" sheet.

| Name | Standard |
|--|--|
| CHARACTERIZATION @ 25 °C | |
| Sensitivity / Accuracy / Overall accuracy | LEM 98.20.00.574.0 |
| Offset / Electrical Offset / Magnetic Offset | LEM 98.20.00.573.0 |
| Linearity error | LEM 98.20.00.370.0 |
| Current Consumption | LEM 98.20.00.579.0 |
| CHARACTERIZATION WITH T °C (initial) | |
| Sensitivity / Accuracy / Overall accuracy | LEM 98.20.00.574.0 |
| T °C variation of ... / Temperature Coefficient of G | LEM 98.20.00.574.0 |
| Offset / Electrical Offset / Magnetic Offset | LEM 98.20.00.573.0 |
| T °C variation of ... / Temperature Coefficient of Offset | LEM 98.20.00.573.0 |
| Linearity error | LEM 98.20.00.370.0 |
| Current Consumption | LEM 98.20.00.579.0 |
| ELECTRICAL TESTS @ 25 °C | |
| Phase delay check | 100Hz to 10kHz At 20 A peak |
| Noise measurement | Sweep from DC to 1 MHz |
| Response time di/dt | 100 A/ μ s. / pulse = 700A |
| dv/dt | 2000 V/ μ s. V = 2000V |
| Dielectric Withstand Voltage test | 2500 VAC / 1 min / 50Hz |
| Isolation Resistance test | 500 V DC, time = 60 s R isolation \geq 500 M Ω Minimum |
| ENVIRONMENTAL TESTS (CLIMATIC) | |
| Thermal shock | IEC 60068-2-14 Na (01/2009) |
| Steady state T°C Humidity bias life test | JESD 22-A101 (03/2009) |
| MECHANICAL TESTS | |
| Vibration Random in T°C | IEC 60068-2-64 (02/2008) |
| Shocks | IEC 60068-2-27 (02/2008) |
| Free Fall (Device not packaged) | IEC 60068-2-31 §5.2: method 1 (05/2008) |
| EMC | |
| Immunity to ElectroStatic Discharges (Handling of devices) | ISO 10605 (07/2008) |
| Immunity to Conducted disturbances (BCI) | ISO 11452-4 (12/2011) |
| Emission Radiated (ALSE) | CISPR 25 (03/2008) |