AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
HAH3DR 1200-S03/SP4

Introduction

The HAH3DR-S03 family is a tri-phase transducer for DC, AC, or pulsed currents measurement in high power and low voltage automotive applications. It offers a galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The HAH3DR-S03 family gives you a choice of having different current measuring ranges in the same housing (from ±200 up to ±1200 A).

Features

- Open Loop transducer using the Hall effect sensor
- Low voltage application
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±1200 A
- Maximum Rms primary admissible current: limited by the busbar, the magnetic core or ASIC T < +150 °C
- Operating temperature range: −40 °C < T < +125 °C
- Output voltage: fully ratio-metric (in sensitivity and offset).

Special feature

- Tri-phase transducer.

Advantages

- Excellent accuracy
- Very good linearity
- Very low thermal offset drift
- Very low thermal sensitivity drift
- Wide frequency bandwith
- No insertion losses
- Very fast delay time.

Automotive applications

- Starter Generators
- Inverters
- HEV applications
- EV applications
- DC / DC converter.

Principle of HAH3DR S03 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.

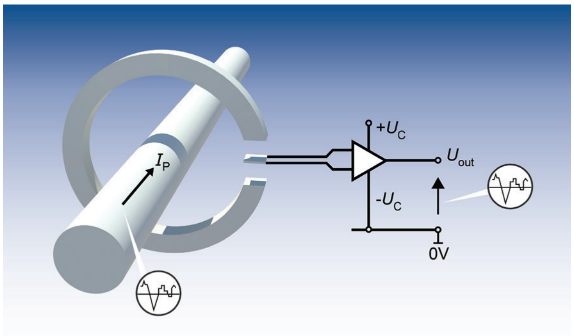

Fig. 1: Principle of the open loop transducer

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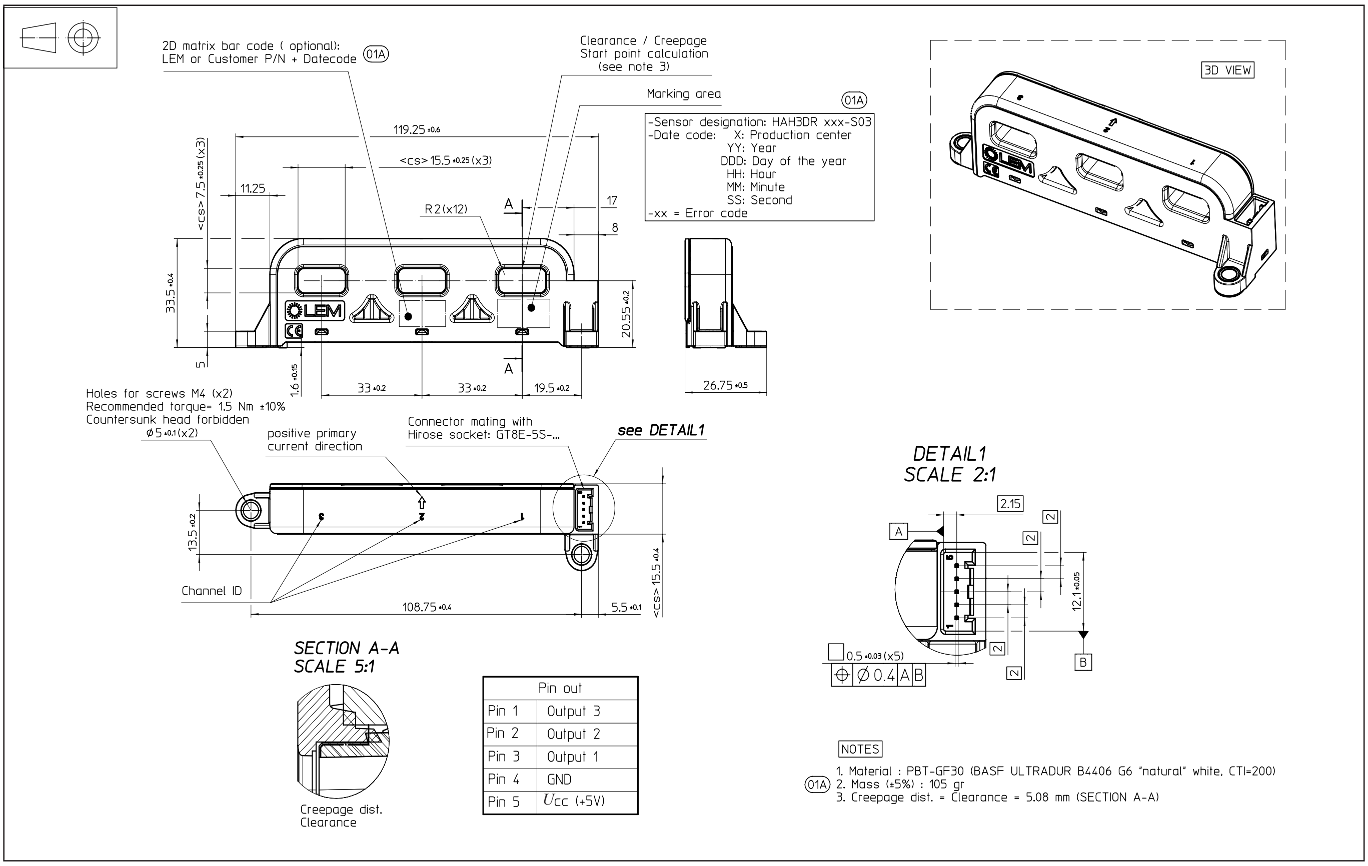
Dimensions HAH3DR 1200-S03/SP4 (in mm)



Pin out	
Pin 1	Output 3
Pin 2	Output 2
Pin 3	Output 1
Pin 4	GND
Pin 5	Ucc (+5V)

Mechanical characteristics

- Plastic case — >PBT-GF30< (Natural)
- Magnetic core — FeSi wound core
- Pins — Copper alloy gold plated
- Mass — 105 g ± 5 %

Mounting recommendation

- Mating connector type — Hirose Socket GT8E-5S-...
- Assembly torque — 1.5 N·m ± 10 %
- Soldering type — N/A

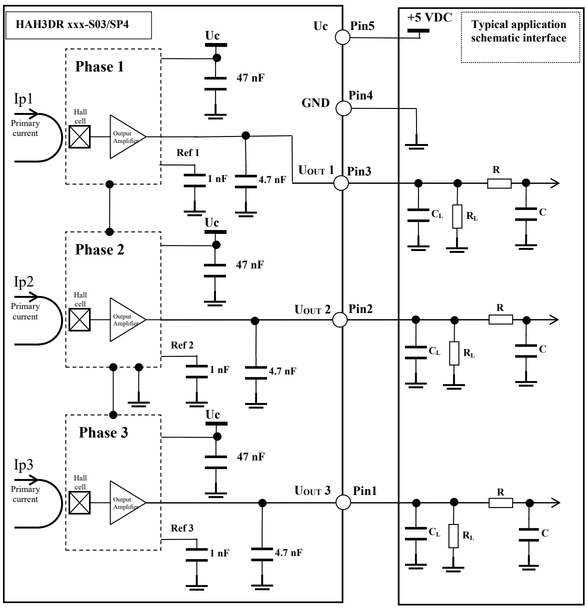
RL > 10 kΩ optional resistor for signal line diagnostic
CL < 2.2 nF EMC protection
RC: low pass filter (optional)

Capacitor U_{ref} / Gnd	1 nF
Capacitor U_C / Gnd	47 nF
Capacitor U_{out} / Gnd	4.7 nF

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)



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Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification Min	Typical	Max	Conditions
Maximum supply voltage	U_C	V	−0.5		8	Continuous, not operating
					6.5	Exceeding this voltage may temporarily reconfigure the circuit until the next power-on
Output voltage low [1]	$U_{out\ L}$				0.2	@ U_C = 5 V, T_A = 25 °C
Output voltage high [1]	$U_{out\ H}$		4.8			
Ambient storage temperature	T_S	°C	−50		125	
Electrostatic discharge voltage (HBM)	$U_{ESD\ HBM}$	kV			2	JESD22-A114-B class 2
RMS voltage for AC insulation test	U_d	kV			2.5	50 Hz, 1 min, IEC 60664 part1
Creepage distance	d_{Cp}	mm		5.08		
Clearance	d_{Cl}	mm		5.08		
Comparative traking index	CTI	V		PLC3		
Insulation resistance	R_{INS}	MΩ	500			500 V DC, ISO 16750
Primary nominal peak current	$\hat{I}_{P\ N}$	A			[2]	

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

Parameter	Symbol	Unit	Specification Min	Typical	Max	Conditions
Electrical Data						
Primary current, measuring range	$I_{P\ M}$	A	−1200		1200	
Primary nominal DC or RMS current	$I_{P\ N}$	A	−1200		1200	
Supply voltage [1]	U_C	V	4.75	5	5.25	
Ambient operating temperature	T_A	°C	−40		125	
Capacitive loading	C_L	nF	2.2	4.7	18	
Output voltage (Analog) [1]	U_{out}	V		$U_{out} = (U_C/5) \cdot (U_o + S \cdot I_P)$		@ U_C
Offset voltage	U_O	V		2.5		
Sensitivity [1]	S	mV/A		1.67		@ U_C = 5 V
Current consumption (for 3 phases)	I_C	mA		45	60	@ U_C = 5 V, @ −40 °C < T_A < 125 °C
Load resistance	R_L	KΩ	10			
Output internal resistance	R_{out}	Ω			10	DC to 1 KHz
Performance Data @ 3 Sigma (including phases coupling)						
Ratiometricity error	ε_r	%		0.5		
Sensitivity error	ε_S	%		±0.5		@ T_A = 25 °C
				±1		@ T_A = 25 °C, After T Cycles
Electrical offset current or voltage	$U_{O\ E}$	mV		±4		@ T_A = 25 °C, @ U_C = 5 V
Magnetic offset current or voltage	$U_{O\ M}$	mV		±7.5		@ T_A = 25 °C, @ U_C = 5 V
Global offset current or voltage	U_O	mV	−20		20	@ T_A = 25 °C, @ U_C = 5 V
Average temperature coefficient of $U_{O\ E}$	$TCU_{O\ E\ AV}$	mV/°C	−0.08		0.08	@ −40 °C < T_A < 125 °C
Average temperature coefficient of S	TCS_{AV}	%/°C	−0.03	±0.01	0.03	@ −40 °C < T_A < 125 °C
Linearity error	ε_L	% I_P	−3		3	of Full range, I_p > 900 A or < −900 A
			−1		1	of Full range, −900 A < I_p < 900 A
Delay time to 90 % of $\bar{I}_{P\ N}$	$t_{D\ 90}$	µs		4	6	di/dt = 100 A /µs
Frequency bandwidth [2]	BW	kHz	40			@ −3 dB
Peak-to-peak noise voltage	$U_{no\ pp}$	mV			10	@ DC to 1 MHz
Phase shift	$\Delta\varphi$	°	−4		0	@ DC to 1 KHz

Notes: [1] The output voltage U_{out}, the offset voltage U_O, the sensitivity S and the output voltage low/high $U_{out\ L+H}$ are fully ratiometric and dependant of the supply voltage U_C according the 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 1/6).

[3] Transducer is not protected against reverse polarity.

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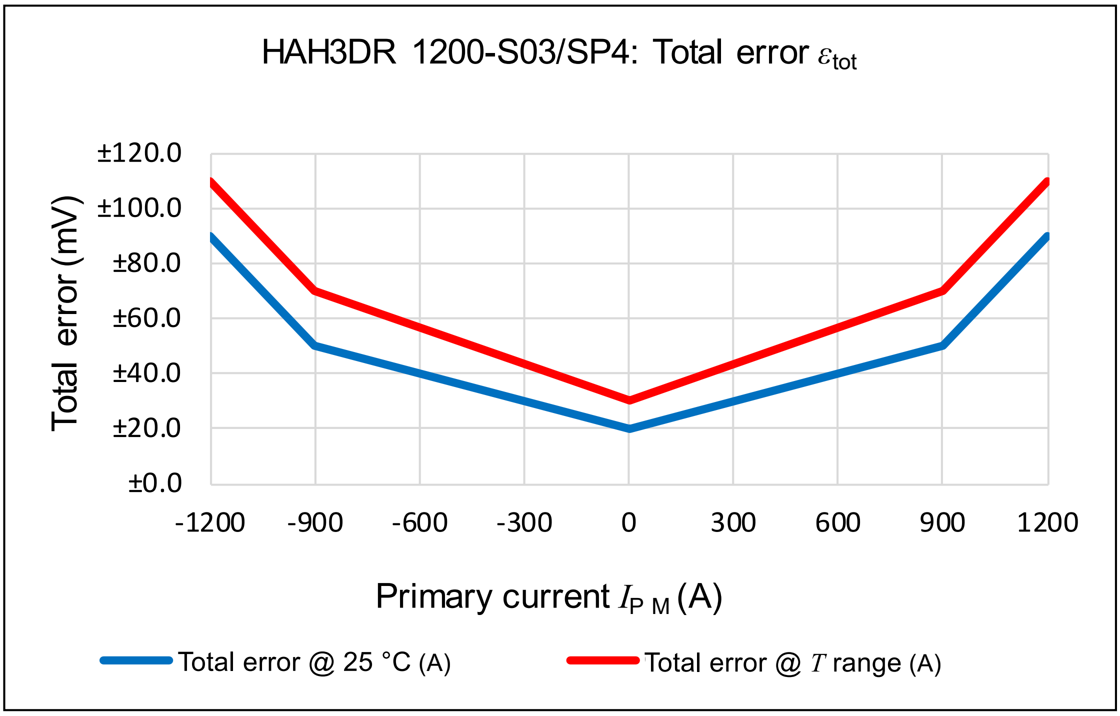
Total error ε_{tot}



	Total error ε_{tot} specification					
I_P (A)	T_A = 25 °C, U_C = 5 V			-40 °C < T_A < 125 °C, U_C = 5 V		
1200	90 mV	54 A	4.50 %	110 mV	66 A	5.50 %
900	50 mV	30 A	2.50 %	70 mV	42 A	3.50 %
0	20 mV	12 A	1.00 %	30 mV	18 A	1.50 %
−900	50 mV	30 A	2.50 %	70 mV	42 A	3.50 %
−1200	90 mV	54 A	4.50 %	110 mV	66 A	5.50 %

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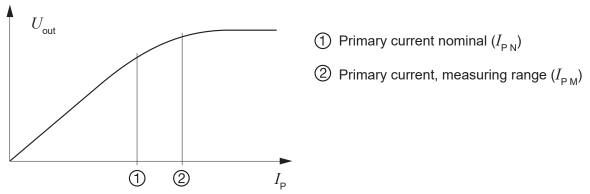
PERFORMANCES PARAMETERS DEFINITIONS

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:

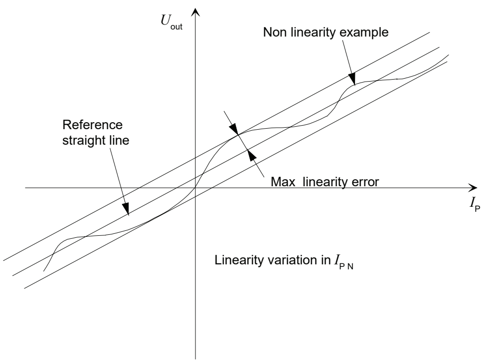
The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

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.

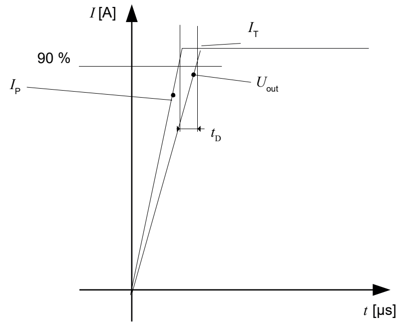
Linearity:

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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Name	Standard	Conditions
Electrical tests		
Phase delay check	LEM Procedure	100 Hz to 10 kHz @ 20 A peak
Noise measurement	LEM Procedure	Sweep from DC to 1 MHz
Delay time d*i*/d*t*	LEM Procedure	100 A/µs, *I* pulse = 1200 A
d*v*/d*t*	LEM Procedure	5 kV/µs, 10 kV/µs, 15 kV/µs, 20 kV/µs, *U* = 1000 V
Dielectric Withstand Voltage test		2500 VAC / 1 min / 50 Hz
Insulation resistance	ISO 16750-2 (2010)	500 V DC, time = 60 s R_{INS} ≥ 500 M Ω minimum
Environmental tests		
High *T*°C, High Humidity, Electrical connection	IEC 60068-2-78 (2001)	1364 h +85 °C / 85 % *RH* U_C = 5V DC, I_P= 0
Thermal Cycle Test (Simplified profile)	IEC 60068-2-14, Test Nb	1000 cycles (2000 h), Slope 10 °C / min - 40 °C (30') / + 25 °C (15') / +150 °C (30') U_C not connected, I_P = 0
Thermal Shock	IEC 60068-2-14 (2009) Test Na	1000 cycles (1000 h), 30 mn “”−40 °C”” // 30mn “” +125 °C”” U_C not connected, I_P = 0
Dew Condensation		See below “”Dew condensation”” tab. I_p = 0 all test. U_C = 0 for 2h then U_c = 5 V for end of test. 2 h “”−5 °C / 0 %HR // 10 mn “”35 °C / 85% *HR*”””
High *T*°C Storage + High *T*°C Exposure		Storage : 125 °C for 1364 hrs + Exposure : 150 °C for 1000 hrs. U_C not connected, I_P = 0 for both tests
Low *T*° C Storage.		- 50 °C for 1364 hrs. U_C not connected, I_P = 0
Mechanical Shock	IEC 60068-2-27 (2008) Test Ea	50 g / 5 ms Half Sine @ 25 °C 10 shocks of each direction (Total: 60) U_C not connected, I_P = 0
Random Vibration		Random profile @ 10 G and 25 °C - 36 h / axes No monitoring during vibration. U_C = 0, I_P = 0 Combined profile GM + Daimler
EMC test		
Radiated Emission Absorber Lined Shielded Enclosure (ALSE)	CISPR 25	0.15 MHz to 2500 MHz Limit: CISPR 25 (ed3.0) Class 5 Peak (table9)
Radiated Immunity Bulk Current Injection (BCI)	GMW3097 (2006) §3.4.1 ISO 11452-1 & - 4	1 MHz to 400 MHz Level: Level 2 (table 11)
Radiated Immunity Anechoic chamber	GMW3097 (2006) §3.4.2 ISO 11452-1 & - 2	400 MHz to 2000 MHz Level: Level 2 (table 12)
ESD Test	GMW3097 (2006) §3.6.5	150 pF / 2000 Ω Contact: ± 4, ± 6 kV Air: ± 8 kV U_C not connected
Miscellaneous tests		
Connector: Insertion and push test	CETP 00.00-E-412 §5.14.1	
Connector: Durability test	CETP 00.00-E-412 §5.14.3	
Connector: Lead/Lock pull test	CETP 00.00-E-412 §5.14.4	

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