

AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY

HC5F400-S



Introduction

The HC5F family is for the electronic measurement of DC, AC or pulsed currents in high power and low voltage automotive applications with galvanic isolation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The HC5F family gives you the choice of having different peak currents (from ± 200 A up to ± 900 A) in the same housing.

Features

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

Advantages

- Excellent accuracy
- Very good linearity
- Very low thermal offset drift
- Very low thermal sensitivity drift.

Automotive applications

- Electrical Power Steering
- Starter Generators
- Converters.

Principle of HC5F 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.

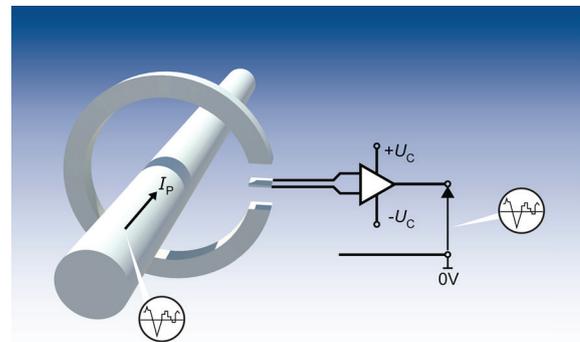


Fig. 1: Principle of the open loop transducer

Absolute ratings (not operating)

| Parameter | Symbol | Unit | Specification | | | Conditions |
|--------------------------------------------------|-----------|-------------------|----------------|---------|-------------|---------------------------------------|
| | | | Min | Typical | Max | |
| Supply over voltage | U_C | V | | | 7 | No operating, 1 min @ 25°C |
| Reverse voltage | | | Not applicable | | | No operating |
| Ambient storage temperature | T_S | °C | - 55 | | 150 | Tested after 64 h @ - 55 °C connected |
| Electrostatic discharge voltage | U_{ESD} | kV | | | 2 | JESD22-A 114-B |
| Maximum admissible vibration (random) | γ | m·s ⁻² | | | 200 | ISO 16750-3&4.1.2.1.2.1 |
| Rms voltage for AC insulation test, 50 Hz, 1 min | U_d | kV | | | 1.5 | IEC 60664 Part 1 |
| Creepage distance | d_{Cp} | mm | 1.7 | | | |
| Clearance distance | d_{Cl} | mm | 2.55 | | | |
| Maximum continuous output current | I_{out} | mA | - 10 | | 10 | No operating |
| Maximum output voltage | V_{out} | V | - 0.5 | | $U_C + 0.5$ | No operating |
| Maximum Output short circuit duration | t_c | s | | | 2 | |

Operating characteristics in nominal range (I_{PN})

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---------------------------------------------|--------------|---------|-----------------------------------------------|---------|------|----------------------------------------------|
| | | | Min | Typical | Max | |
| Electrical Data | | | | | | |
| Primary current, measuring range | I_{PM} | A | - 400 | | 400 | |
| Supply voltage ¹⁾ | U_C | V | 4.75 | 5.00 | 5.25 | |
| Ambient operating temperature | T_A | °C | - 40 | | 125 | |
| Output voltage (Analog) | V_{out} | V | $V_{out} = (U_C/5) \cdot (V_o + G \cdot I_P)$ | | | @ U_C |
| Sensitivity | G | mV/A | | 5 | | @ $U_C = 5 V$ |
| Current consumption | I_C | mA | | 12 | 20 | |
| Load resistance | R_L | KΩ | 10 | | | |
| Capacitive loading | C_L | F | | 4.7 | | |
| Output internal resistance | R_{out} | Ω | | | 10 | |
| Performance Data ¹⁾ | | | | | | |
| Sensitivity error | ϵ_G | % | - 2 | | 2 | @ $T_A = 25 °C$, @ $U_C = 5 V$ |
| Electrical offset | I_{OE} | A | - 2 | ± 1 | 2 | @ $T_A = 25 °C$ |
| Magnetic offset | I_{OM} | A | - 1.6 | ± 1 | 1.6 | @ After excursion to ± I_P @ $T_A = 25 °C$ |
| Offset current | I_O | A | - 2.7 | | 2.7 | $T_A = 25 °C$ |
| Average temperature coefficient of I_{OE} | TCI_{OEAV} | mA/°C | - 16 | ± 4 | 16 | @ - 40 °C < T < 125 °C, U_C |
| Average temperature coefficient of G | TCG_{AV} | %/°C | - 0.05 | ± 0.025 | 0.05 | @ - 40 °C < T < 125 °C, U_C |
| Linearity error | ϵ_L | % I_P | - 1 | | 1 | Of full range |
| Step response time to 90 % I_{PN} | t_r | µs | | 8 | 10 | |
| Frequency bandwidth ²⁾ | BW | kHz | 30 | | | @ - 3 dB |
| Output voltage low | V_{outL} | V | 0.1 | | | @ $U_C = 5 V$ |
| Output voltage high | V_{outH} | V | | | 4.9 | @ $U_C = 5 V$ |
| Output voltage noise peak-peak | $V_{no p-p}$ | mV | | | 20 | DC to 1 MHz |
| Output rms voltage noise rms | $V_{no rms}$ | mV | | | 3 | DC to 1 MHz |

Notes: ¹⁾ The output voltage V_{out} is fully ratiometric. The offset and sensitivity are dependent on the supply voltage U_C relative to the following formula:

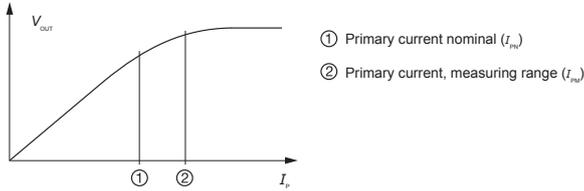
$$I_P = \left(\frac{5}{U_C} \cdot V_{out} - V_o \right) \cdot \frac{1}{G} \text{ with } G \text{ in (V/A)}$$

²⁾ Small signal only to avoid excessive heating of the busbar, the magnetic core and the ASIC.

PERFORMANCES PARAMETERS DEFINITIONS

Output noise voltage:

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



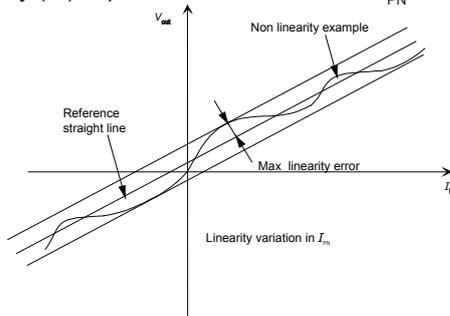
Magnetic offset:

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

Linearity:

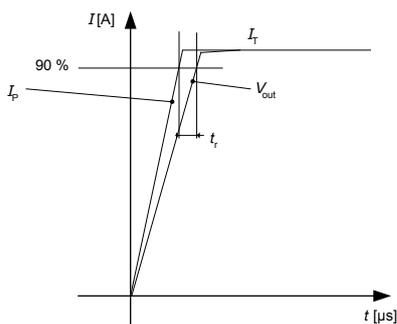
The maximum positive or negative discrepancy with a reference straight line $V_{out} = f(I_p)$.

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.



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:

$$V_{out}(I_p) = U_C/5 (G \cdot I_p + V_o)$$

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).

Environmental test specifications:

| NAME | STANDARD | CONDITIONS |
|------------------------------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ENVIRONMENTAL TESTS | | |
| Thermal shocks | IEC 60068-2-14 test Na (01/2009) | T° - 40 °C to 125 °C / 30 mn each, 300 cycles not connected |
| T° humidity cyclic | ISO 16750-4 | 10 cycles of 24 H, high T°, power supply on monitored |
| Power temp cycle | IEC 60068 Part 2-14 test Nb (01/2009) | T° - 40 °C to 125 °C, 15 mn/step, transition time 15 mn 600 cycles |
| Temperature humidity bias | JESD22-A101 (04/97) | T° 85 °C / 85 % RH / 1000 H power supply on, monitored each 6H |
| MECHANICAL TESTS | | |
| Sinus vibration | ISO 16750-3 & 4.1.2.1.2.1 (08/2007) | No power supply- profile 1 f = 100 to 1000 Hz, g = 100 to 200 m/s ² , 22 H/axis, 3 axis, T °C cycle - 40 °C to 125 °C |
| Random vibration | IEC 60068-2-64 (02/2008) | No power supply g rms = 27.8 m/s ² , f = 10 Hz to 1 kHz, PSD = 0.14 to 20 (m/s ²) ² /Hz 12 H/axis X and Y, 36 H for axis Z, T °C, cycle - 40 °C to 125 °C |
| Stocks | IEC 60068-2-27 (02/2008) | Half sine shocks @ 25 °C, 25 g / 15 ms, 132 shocks/direction, 6 directions, 100 g/11 ms, 3 shock/direction, 6 directions |
| Drop test | ISO 16750-3& 4.3 (08/2007) | Drop 1 m, 2 falls/part, 1 part/axis, 6 directions, parts without PCB |
| ELECTRICAL TESTS | | |
| Rms voltage for AC insulation test | IEC 60664-1 | 1.5 kV/50 Hz/1 mn |
| Insulation resistance | ISO 16750-2& 4.10 | 500 V DC, 25 °C, R _{insulation} > 10 MOhms |
| EMC TESTS | | |
| Electrostatic discharge | IEC 61000-4-2 | Contact ± 2 kV , air ± 2 kV |
| Electrostatic discharge | JESD22-A114-B | HBM: 1.5 kOhms / 100 pF 2kV |