AUTOMOTIVE CURRENT TRANSDUCER
HABT 120-V

Introduction

The HABT 120-V current transducer 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 and the ambient temperature. The current value is provided by a voltage signal. Temperature is given by an NTC thermistor. The transducer is linked to the BCM (Body Control Module) with the car harness. The electrical connection is made with a waterproof connector. The output voltage $\mathbf{V}_{OUT}$ is fully ratiometric with the supply voltage $\mathbf{V}_C$.

Features

- Open Loop transducer using the Hall effect
- Unipolar + 5 V DC power supply
- Primary current measuring range up to ± 120 A
- Maximum RMS primary current limited by the cable, the magnetic core or the ASIC temperature T° < + 150°C
- Operating temperature range: - 30°C < T° < 90°C
- Output voltage: full ratiometric (in sensitivity and offset)
- Temperature measurement by embedded NTC.

Advantages

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

Automotive applications

- Battery monitoring
- HEV application
- EV application.

Principle of HABT 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 $\mathbf{I}_P$ to be measured.
The current to be measured $\mathbf{I}_P$ 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:

$$\mathbf{B}\ (\mathbf{I}_P) = \text{constant (a)} \times \mathbf{I}_P$$

The Hall voltage is thus expressed by:

$$\mathbf{V}_H = (R_H/d) \times \mathbf{I} \times \text{constant (a)} \times \mathbf{I}_P$$

Except for $\mathbf{I}_P$, all terms of this equation are constant. Therefore:

$$\mathbf{V}_H = \text{constant (b)} \times \mathbf{I}_P$$

The measurement signal $\mathbf{V}_H$ amplified to supply the user output voltage or current.

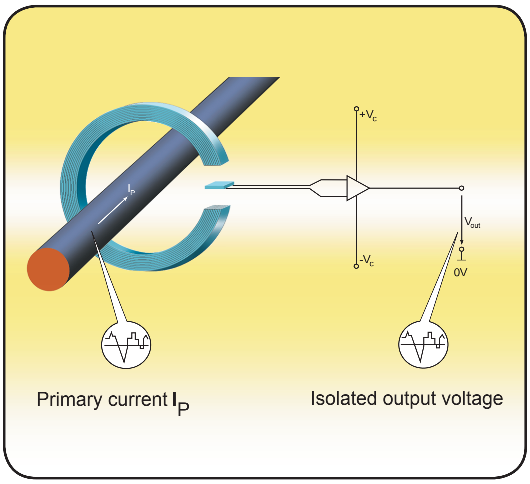

Fig. 1: Principle of the open loop transducer

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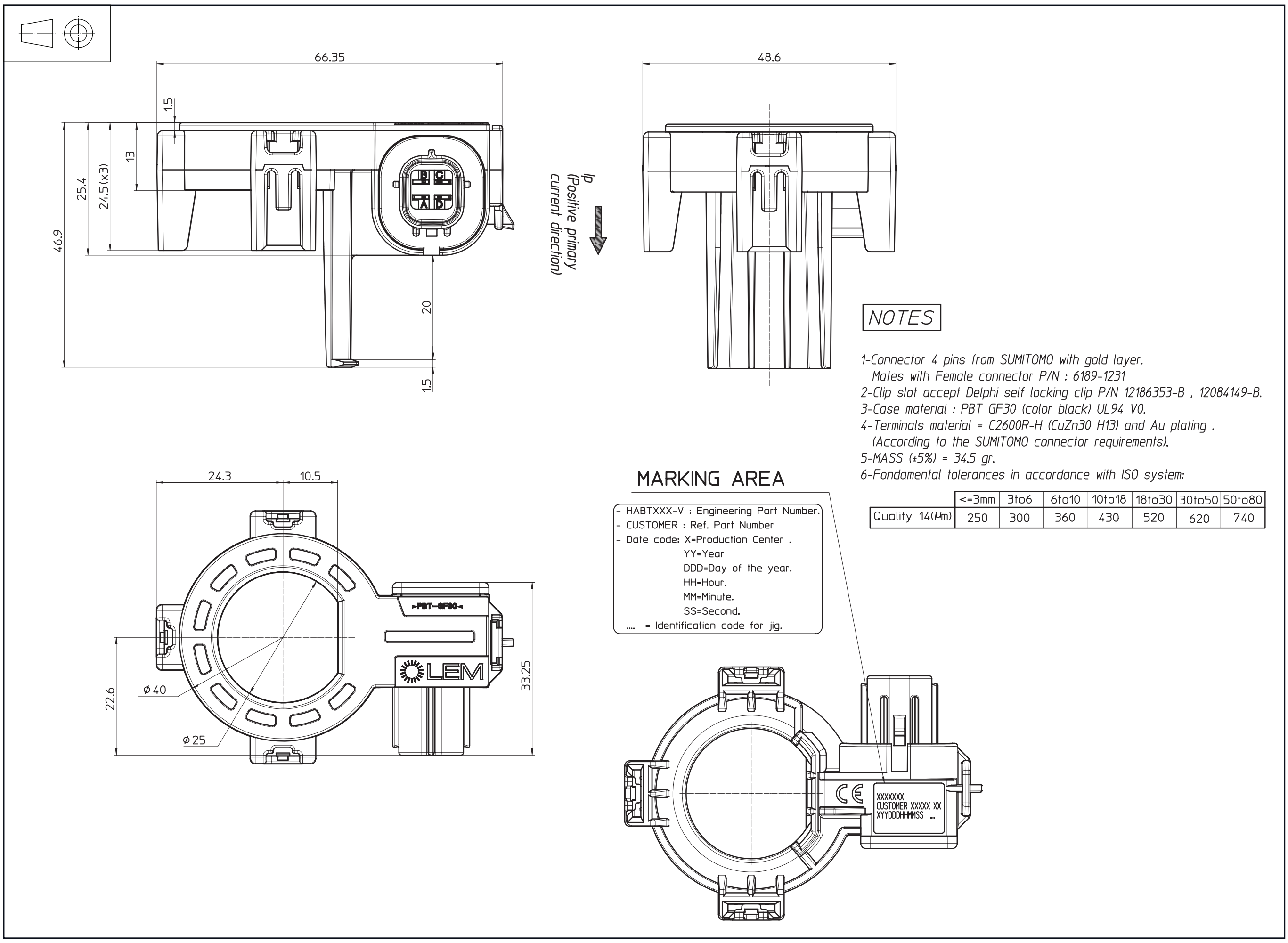
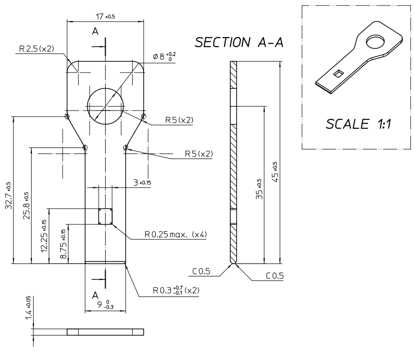
Dimensions HABT 120-V (in mm)





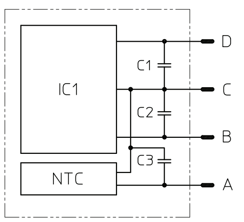
Bill of materials

- Plastic case PBT GF 30
- Magnetic core Iron silicon alloy
- Pins Gold plated

Remarks

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

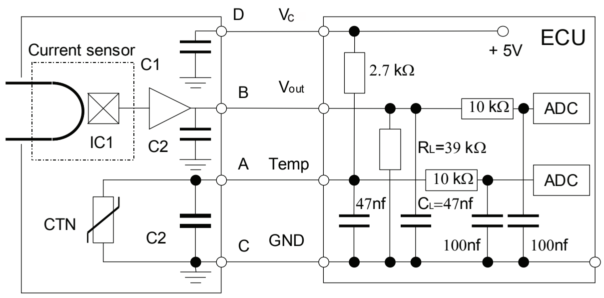
System architecture



Components list	
IC1	Hall sensor ASIC
C1	Capacitor
C2, C3	Capacitors
NTC	Thermistor

Pin out	
D	DC supply voltage (5V)
C	Ground
B	Output signal
A	Temperature signal

System architecture (example)



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Absolute maximum ratings

Parameter	Symbol	Unit	Specification Min	Specification Typ	Specification Max	Conditions
Electrical Data						
Nominal supply voltage	V_C	V	4.5	5	5.5	
Supply continuous over voltage	V_C	V			8.5	
Reverse voltage	V_C	V	-14			1 min @ T_A = 25°C
Over voltage	V_C	V			14	2 min
Continuous output voltage	V_{OUT}	V			14	1 min @ T_A = 25°C
Continuous output current	I_{OUT}	mA	-10		10	
Output short-circuit duration	T_c	min			2	
Isolation resistance	R_{IS}	MΩ	10			DC 500 V
Ambient storage temperature	T_S	°C	-40		125	

Operating characteristics

Parameter	Symbol	Unit	Specification Min	Specification Typ	Specification Max	Conditions
Electrical Data						
Supply voltage	V_C	V	4.5	5	5.5	
Continuous output current	I_{OUT}	mA	-1		1	
Sensitivity error	ε_G	%		± 0.5		
Load resistance	R_L	KΩ	4.7	10		
Capacitive loading	C_L	nF		10	100	
Ambient operating temperature	T_A	°C	-30		90	
Output voltage (diagnostic detection open ground)	V_{OUT}	V	4.7			
Output voltage (diagnostic detection open V_C)	V_{OUT}	V			0.2	
Performance Data						
Current consumption (High output impedance)	I_C	mA		7.5		@ T_A = 25°C
					10	Over temperature
Linearity error	ε_L	%	-0.5		0.5	Up to 80 A
			-2		2	Up to 120 A
Overall accuracy @ **I** = 0 A @ - 30 to 90°C	X_G	A	-1.7		1.7	V_{OUT} = ± 28.4 mV @ V_C= 5 V ± 0.05 V
Overall accuracy @ **I** = 100 A @ - 30 to 90°C	X_G	A	-6		6	V_{OUT} = ± 100.2 mV @ V_C= 5 V ± 0.05 V
Overall accuracy @ **I** = 120 A @ - 30 to 90°C	X_G	A	-8		8	V_{OUT} = ± 133.6 mV @ V_C = 5 V ± 0.05 V
Sensitivity	G	mV/A		16.7		
Global offset current	I_O	mA	-400		400	@ T_A = 25°C
Electrical offset current	I_{OE}	mA	-300		300	@ T_A = 25°C
Magnetic offset current	I_{OM}	mA		110		@ T_A = 25°C
Primary current, measuring range	I_{PM}	A	-120		120	
Output voltage @ I_P = 0	V_{OUT}	V		V_C/2		
Resolution		mV		2.5		
Output internal resistance	R_{OUT}	Ω		1		@ T_A = 25°C
					10	Over temperature
Response time to 90 % of I_{PN} step	t_r	ms			1.1	
Power up time	t_r	ms		25	200	
Setlling time after overload	t_r	ms			25	
Negative temperature coefficient resistance	R_{NTC}	KΩ	2.178	2.2	2.222	Accuracy ± 1 % @ T_A = 25°C
B 25/85 constant			3485	3520	3555	Accuracy ± 1 %
Output clamping voltage low	V_{sz}	%V_C	5.1	6	6.9	
Output clamping voltage high	V_{sz}	%V_C	92.1	93	93.9	
Temperature accuracy		°C	-2		2	- 40/90°C power off with complete formula
Frequency bandwidth	BW	Hz			80	@ -3 dB

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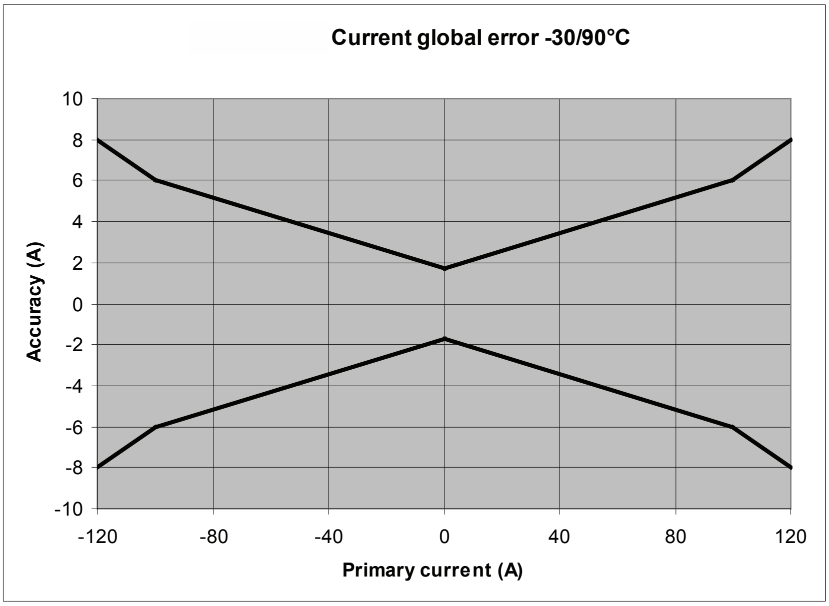
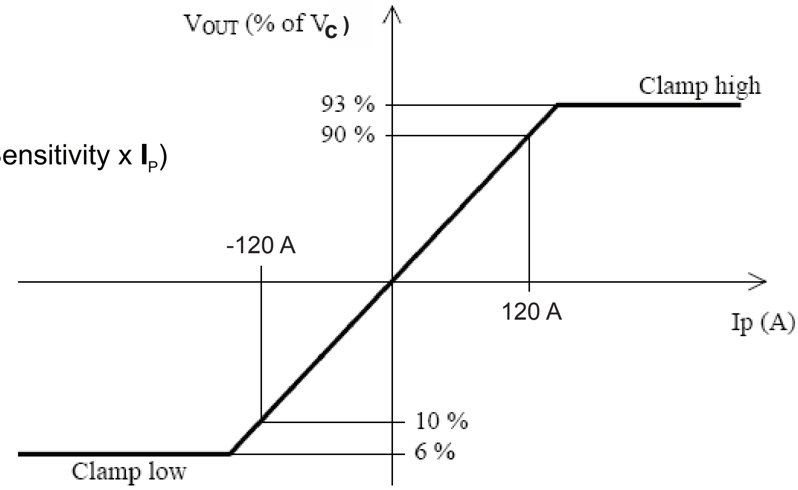
Global Error



Output and clamping

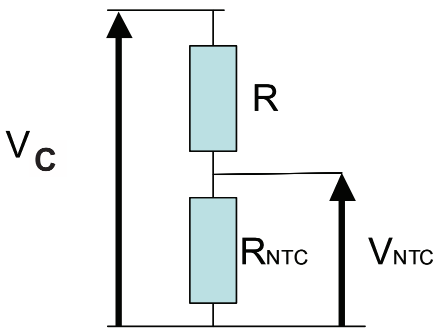
$$V_{OUT} = \frac{V_C}{5} \times (2.5 + \text{Sensitivity} \times I_P)$$



Temperature output

Simplified formula:
$T°C = 3520/ (\ln (R_{NTC}/2200) + 3520/298.15) - 273.15$
$R_{NTC} = R \times V_{NTC} / (V_C - V_{NTC})$

Complete formula:
$1/T°K=A1+B1*\ln(Rntc/2200)+C1*\ln(Rntc/2200)^2+D1*\ln(Rntc/2200)^3$
with A1 = 0.003354016
B1 = 0.0002866670
C1 = 1.563433 e^{-6}
D1 = 1.327213 e^{-7}
and T°C = T°K - 273.15



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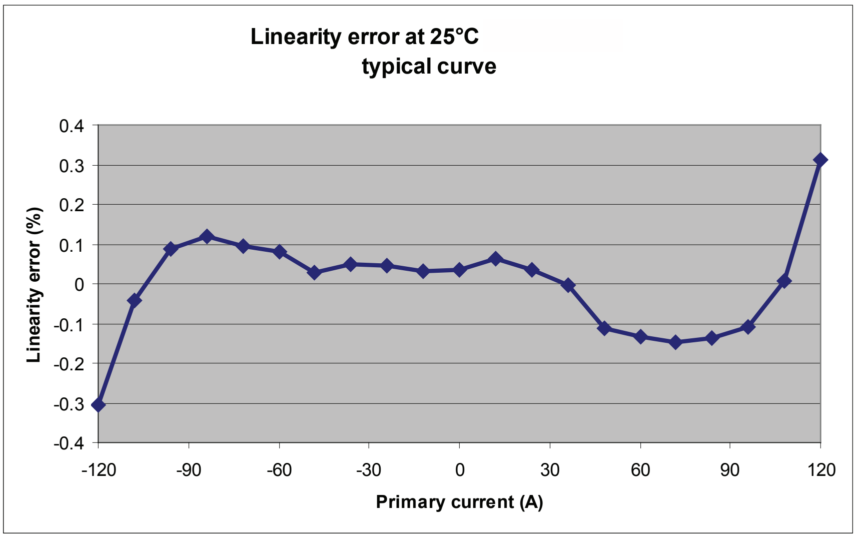
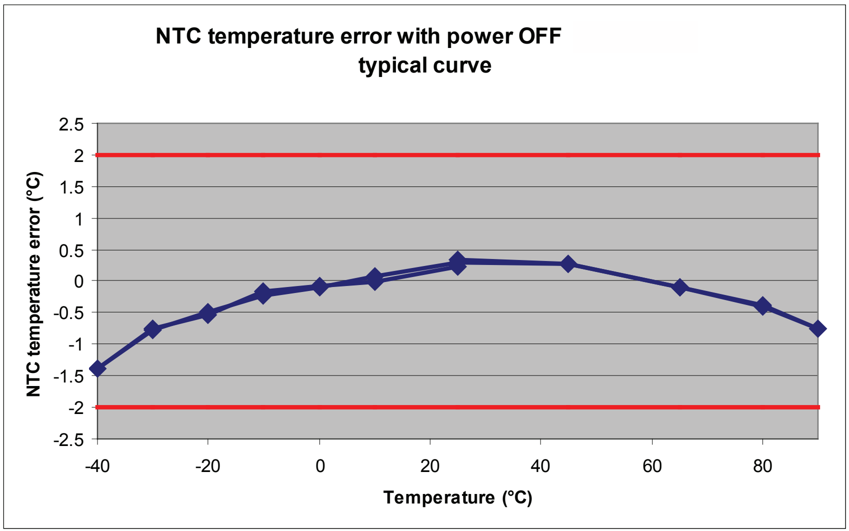
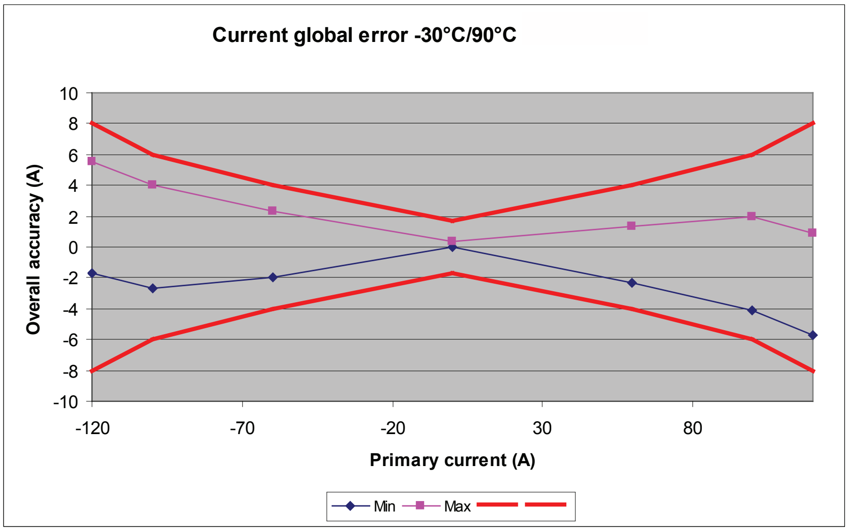

Linearity error at 25°C
typical curve
Linearity error (%)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-120
-90
-60
-30
0
30
60
90
120
Primary current (A)


NTC temperature error with power OFF
typical curve
NTC temperature error (°C)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-40
-20
0
20
40
60
80
Temperature (°C)


Current global error -30°C/90°C
Overall accuracy (A)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-120
-70
-20
30
80
Primary current (A)
Min
Max

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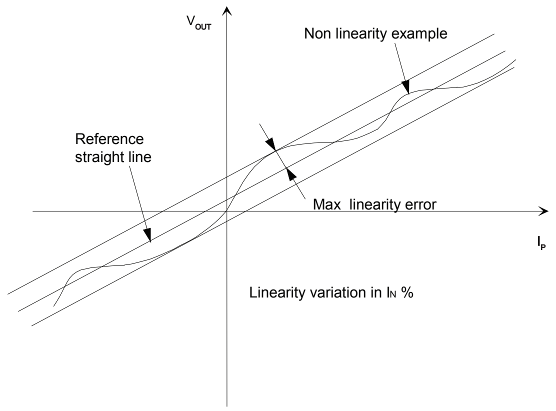
PERFORMANCES PARAMETERS DEFINITIONS

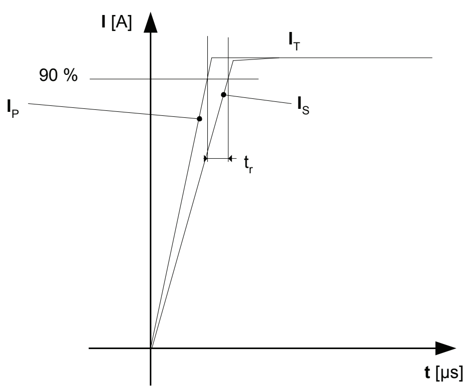
Output noise voltage:
The output voltage noise is the result of the noise floor of the Hall elements and the linear I_C amplifier gain.

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 $I_{P\ max}$.



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:
Theorical 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 at 25°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

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Immunity to conducted disturbance test		
Immunity to signal line transients	ISO 7637-3 (1995)	Operating Class C
Immunity to bulk current injection (BCI)	ISO 11452-4 (2005)	60 mA Class C, 100 mA Class C, 200 mA Class C
Resistance to impulse transient		Operating Class C
Immunity to radiated disturbance tests		
Immunity to audio frequency magnetic field	ISO / DIS 11452-8 (2006)	Operating Class A
Resistance to electrostatic discharge tests		
Resistance to electrostatic discharges, equipment not supplied	IEC 61000-4-2 (2001) C = 150 pF; R = 330 Ohms	± 4 kV Contact discharge: Class A ± 8 kV Contact discharge: Class B ± 15 kV Air discharge: Class B
Resistance to electrostatic discharges, equipment supplied	ISO 10605 (2001)	± 4 kV Contact discharge: Class A ± 8 kV Contact discharge: Class B ± 4 kV Air discharge: Class A ± 8 kV Air discharge: Class A ± 15 kV Air discharge: Class B ± 25 kV Air discharge: Class D
Electrical tests		
Engine starting voltage test		6 to 8 V, 1 Hz
Voltage dips tests		1, 5, 10, 15 and 20 ms
Reversed power connection test		13 V/1 min
Environmental tests		
Low T°C storage test		Not powered, - 40°C, 96 ± 2H
Low T°C operation test		- 30°C, 192H, powered
High T° storage test		No powered, 100°C ± 3.96H
High T° operation test		+90°C ±3, 192H, powered
Temperature cycle test		30 cycles, 90°C to -30°C, operational 5H and non operational 1 H (180H)
Thermal shock		-40°C/+90°C with 2000H (30 min + 30 min) no powered
Temperature humidity cycle test		
Constant humidity test		+60°C/90% rH, 96H, powered
Vibration in temperature		Resonnance point detection 3g, 5 to 200 Hz, sweep 10 min, 4+2+2 H
Impact test		Free fall @ 1 m, 3 times for each 5 planes, 15 times for connector plane on concrete
Dew condensation test		2H @ -5°C and 10 Min @ 85% rH @ 35°C no operational
Salt spray test	JIS Z 2371	Test according to JIS Z 2371. Leave transducers for 300H at ambient temperature of 35 ± 3°C
Dipping test		Storage temperature 80± 3°C, storage time 1H mini water temperature 25 ± 10°C Dip depth: 100 mm dipping time 1 min No water immersion into inside of connector
Spray frost test	JIS D 0203 R2e	Spray frost Conform to JIS D 0203 R2e
Vibration durability		Ambient temperature 80 ± 3°C, Frequency 20 to 200 Hz, Sweep time: 2 min, Acceleration 43.12m/s^2, Time: 3 hours for each directions (top/bottom, left/right front/back), Power voltage 5 ± 2 V, measured current: 50 to - 100 A
Chemical proof test		Chemical temperature: 25±10°C Dipping time: 1 min Exposenal temperature: 80 ± 3°C exposal time: 1H min Chemical name: Gasoline, engine, oil, brake oil, anti-freeze fluid. Torque converter oil. Washer fluid. Battery fluid. CRC. WÀX WAX remover. PS. Oil.