

AUTOMOTIVE CURRENT TRANSDUCER FLUXGATE TECHNOLOGY

CAB-SF 1500-000; CAB-SF 1500-001; CAB-SF 1500-003



Introduction

The CAB sensor family has been specially designed for the current measurement of the battery packs found in electric and hybrid vehicles. The CAB-SF 1500 sensor is equipped with electronic mechanisms and software that guarantee a level of reliability that is required by the security concepts of battery management systems.

Features

- Fluxgate transducer technology
- Busbar mounting or panel mounting
- Unipolar +12V battery power supply
- Output signal: High speed CAN (500kpbs).

	CAN Resistor Termination	Casing version
CAB-SF 1500-000	4800 Ω	Bus bar
CAB-SF 1500-001	4800 Ω	Panel mounting
CAB-SF 1500-003	120 Ω	Bus bar

Special features

- Connector type: Tyco AMP 1473672-1
- Configurable CAN speed
- Configurable CAN ID
- Configurable with UDS services (services list available on request).

Advantages

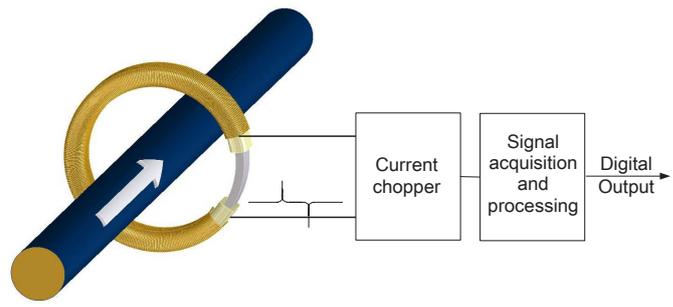
- Offset below 30 mA
- Overall accuracy before ageing
≤ 0.5 % error over temperature range: -40 °C to +85 °C
- Full galvanic separation.

Automotive applications

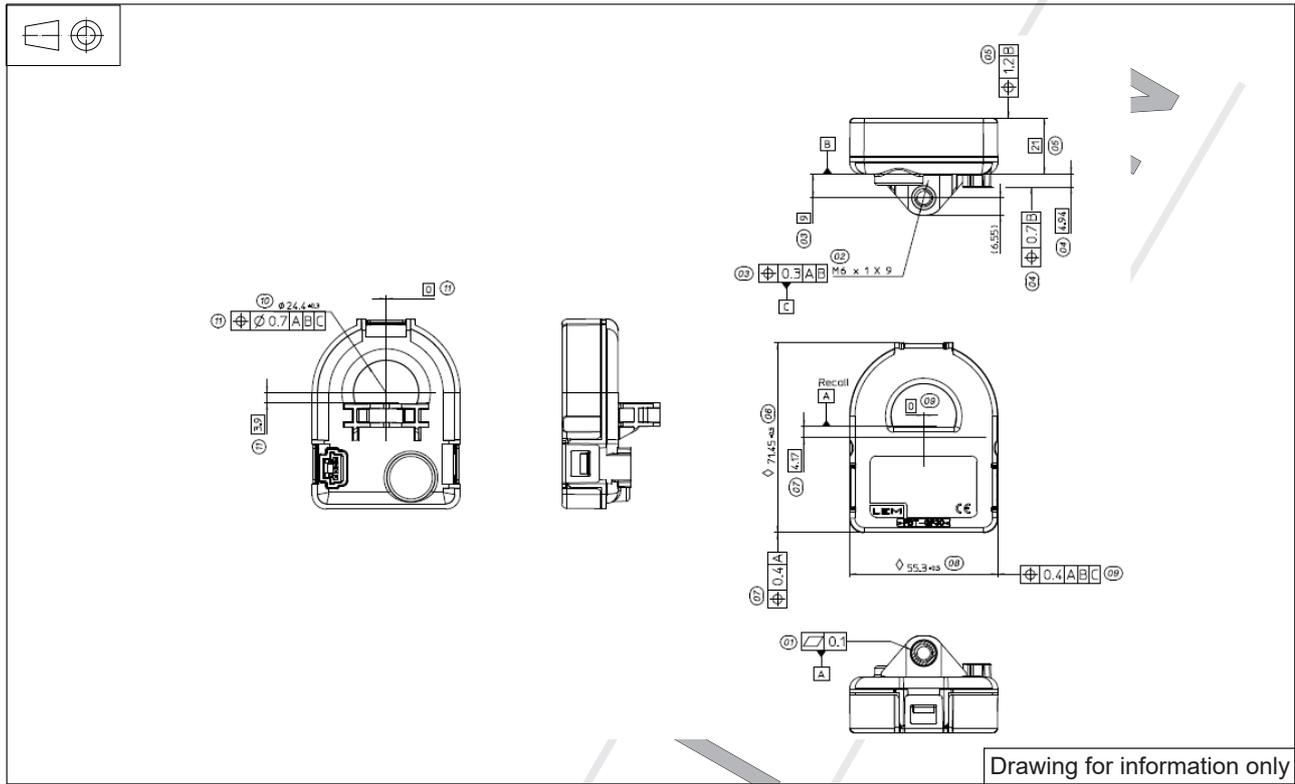
The CAB-SF 1500 is designed to run in a vehicle battery pack or in a battery disconnect unit and cannot be used in an environment exposed to water projections and gravel projections. The test plan used to validate the product is described at the end of the document.

Principle of Fluxgate Transducers

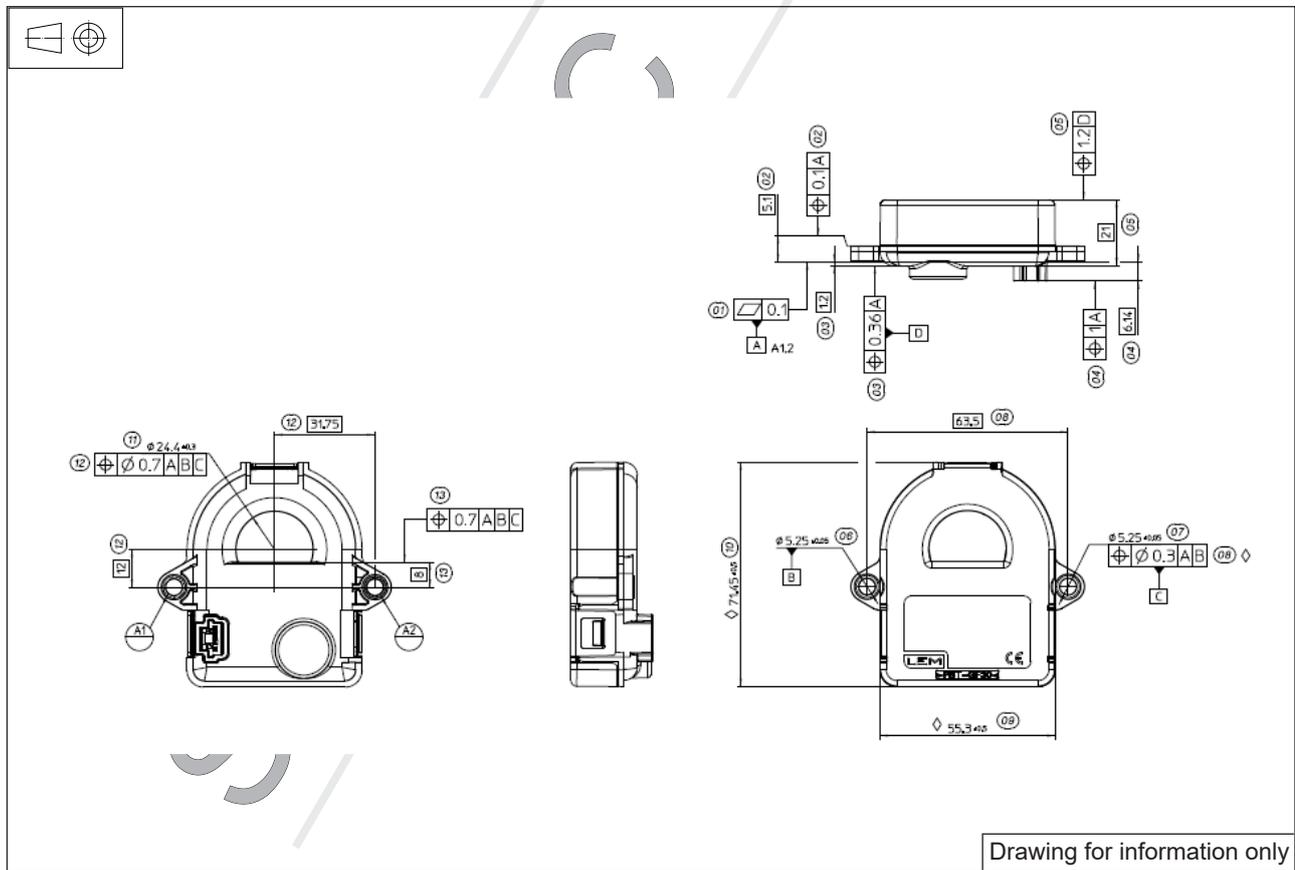
A low-frequency fluxgate transducer is made of a wound core which saturates under low induction. A current chopper switches the winding's current to saturate the magnetic core alternatively at $\pm B_{max}$ with a fixed frequency. Fluxgate transducers use the change of the saturation's point symmetry to measure the primary current. Due to the principle of switching the current, all offsets (electric and magnetic) are cancelled.



Busbar version:



Bracket version:



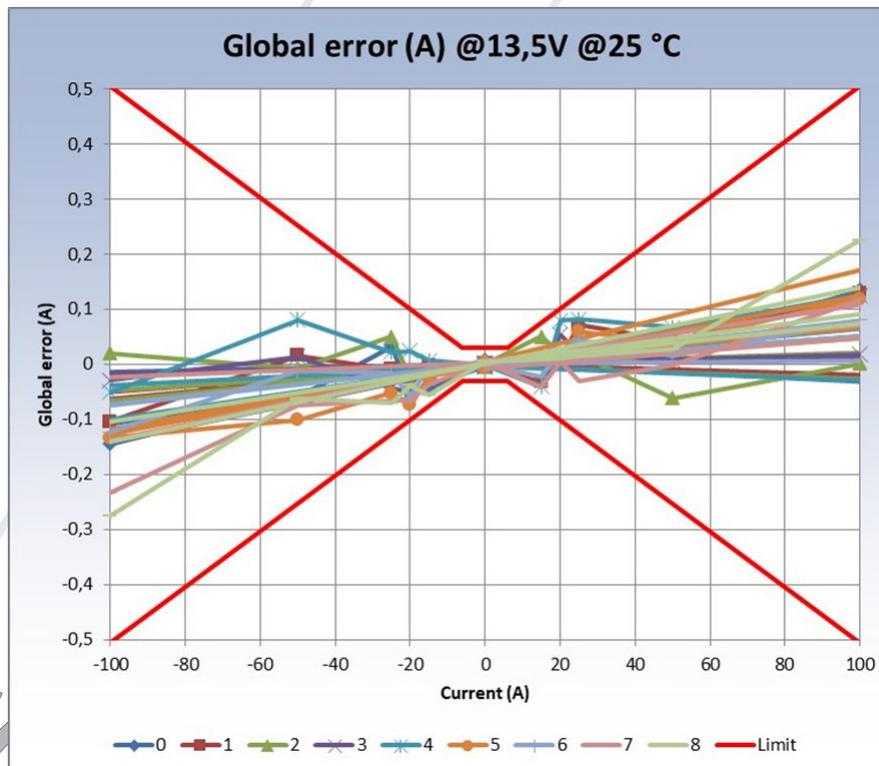
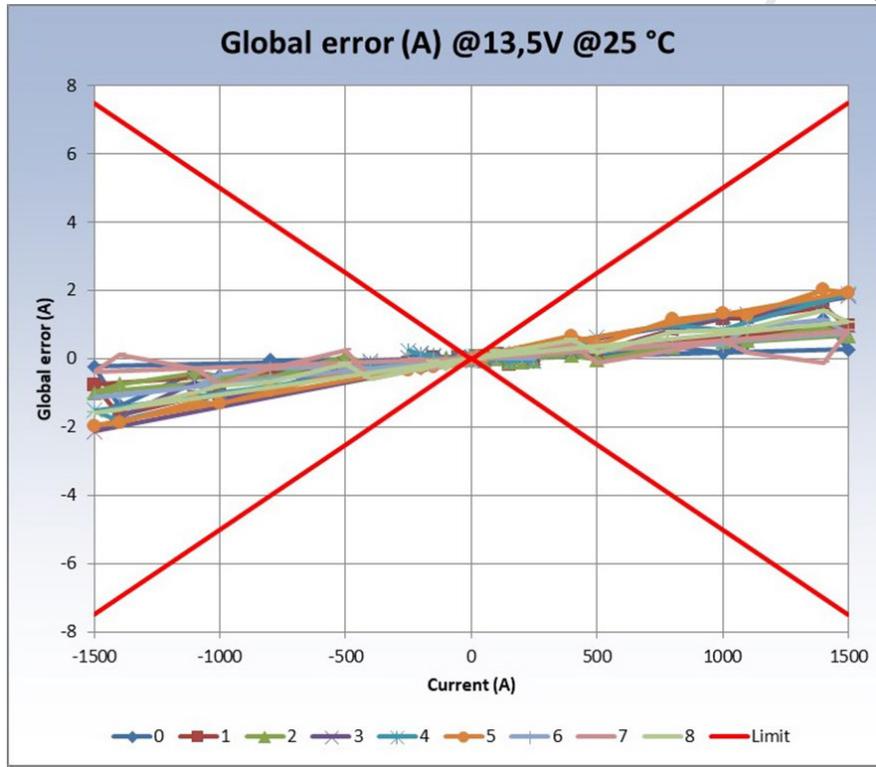
Parameter	Symbol	Unit	Specification	Conditions
Over-voltage	U_c	V	24	1 minute
Reverse polarity	U_c	V	-18	1 minute
Minimum supply voltage	U_c	V	6	continuous
Maximum supply voltage	U_c	V	18	continuous
Ambient storage temperature	T_s	°C	-50 / +105	
Creepage distance	d_{cp}	mm	5.5	
Clearance	d_{cl}	mm	5.5	
Rms voltage for AC insulation test	U_d	kV	2.5	50 Hz, 1 min
Insulation resistance	R_{INS}	MΩ	500	500 V -ISO 16750-2
IP Level			IP41	

Characteristics in nominal range

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
Electrical Data						
Supply voltage	U_c	V	8	13.5	16	
Current consumption @ $I_p = 0$ A	I_c	mA	70	85	95	@ $U_c = 13.5$ V, CAN acknowledge
Current consumption @ $\pm I_p = 1500$ A	I_c	mA	430	500	1200	@ $U_c = 13.5$ V, CAN acknowledge
Ambient operating temperature	T_A	°C	-40		+85	
Performance Data						
Primary nominal DC or rms current	I_{PN}	A	-1500		1500	
CAN signal 'CSM_BAT_CURRENT' clamping value		A	-1550		1550	For I_p between ± 1550 A and over current value
Frequency bandwidth	BW	Hz		20		With Periodic CAN message @ 10 ms
Power up time		ms		150		
Setting time after over load		ms		10		
Analog measurement Channel						
Linearity error	ϵ	%		±0.1		At room temperature
Total error	ϵ_{tot}	%	-0.5		+0.5	Over temperature range: -40 °C to +85 °C
Output noise		mA		±30		With Periodic CAN message @ 10ms. Peak to peak value. No averaging.
Digital measurement channel						
Total error	ϵ_{tot}	%		±7		With a minimum of ±2 A. Typical value after ageing

Total error graph

Analog Channel - Global error at 25°C:



External Magnetic Field Influences

The CAB-SF 1500 delivers an accurate current level measurement. However, to ensure its proper functioning and to ensure the current level accuracy, it is necessary to comply with rules for setting up in the BMS environment. Thus, some conditions must be respected during the design of the environment of the sensor:

- Primary busbar centering
- Busbar shape
- Contactors position

LEM's recommendations can be found in the application notes available on request. Please contact LEM support team to ensure that your busbars design fits with LEM's design guideline.

S P E C I M E N

Can output specification

- CAN protocol 2.0B
- Bit order: big endian (Motorola)
- CAN oscillator tolerance: 0.27 %
- No sleep mode capability
- Two versions of CAN resistor termination are available : 120 Ohms or 4800 Ohms.

CAB-SF 1500 CAN message table

- CAB1500_I_p message overview.
Default frame ID: 0x3C2; transmit period: 10 ms.

		CAN Frame Content							
		7	6	5	4	3	2	1	0
BYTE 0	SequenceCounterIp				StatusPowerSupply		Status InternalError	SafetyGoal Violation	
	MSB			LSB	MSB	LSB			
BYTE 1	AnalogCurrent								
	MSB								
BYTE 2	AnalogCurrent								
BYTE 3	AnalogCurrent								
									LSB
BYTE 4	DigitalCurent								
	MSB								
BYTE 5	DigitalCurent								
									LSB
BYTE 6	Reserved								
	MSB								LSB
BYTE 7	CRC_Ip								
	MSB								LSB

S P E C I M E N

- **'SequenceCounter I_p ' signal**

- Initialized with 0 and incremented by 1 for every subsequent send request
- When the counter reaches the value 15(0xF), then restart with 1 for the next send request.

- **'StatusPowerSupply' signal**

- If power supply voltage is strictly above 8 V and strictly below than 16 V, then 'StatusPowerSupply' = 0

LOW VOLTAGE use cases:

- If power supply goes down below 8 V (< 8 V) and over 6 V:
 'StatusPowerSupply' = 1 after 100 ms.
- If power supply goes over 8 V (≥ 8 V):
 Then 'StatusPowerSupply' is set to 0 (no filter)
- If power supply goes below 6 V (< 6 V), the sensor stops emitting CAN frame
- If power supply goes over 6 V (≥ 6 V), CAB starts emitting CAN frame.

OVER VOLTAGE use cases:

- If power supply goes over 16 V (> 16 V) and below 18 V:
 'StatusPowerSupply' = 2 after 100 ms
 Current level data (analog and digital) are frozen in the CAN frame
- If power supply goes below 16 V (≤ 16 V):
 Then 'StatusPowerSupply' is set to 0 (no filter)
- If power supply goes over 18 V (> 18 V), the sensor stops emitting CAN frame
- If power supply goes below 18 V (≤ 18 V), CAB starts emitting CAN frame

Power Supply voltage measurement not available:

- 'StatusPowerSupply' = 3.

- **'StatusInternalError' signal**

Internal hardware error (Memory , reference voltage, DAC, PGA errors).

- **'SafetyGoalViolation' signal**

Within the current range of $[-1500$ A; -220 A] and $[+220$ A; $+1500$ A], if there more than 20% of difference between analog current level and digital current level --> then SafetyGoalViolation = 1

Within the current range of $[-220$ A; 220 A], if there is a gap above 44 A between analog current level and digital current level --> then SafetyGoalViolation = 1

Safe State: To provide Safety Goal violation flag, keep providing data measurement
FTTI: 100ms.

- **'AnalogCurrent' signal**

Analog measurement of the primary current

- 1500 $\leq I_p \leq +1500$. 'AnalogCurrent' signal = I_p . Accuracy = 0.5 %
 - 1550 $\leq I_p < -1500$. 'AnalogCurrent' signal = I_p . Accuracy = 1 %
 - +1500 $< I_p \leq +1550$. 'AnalogCurrent' signal = I_p . Accuracy = 1 %
 - $I_{p_oc} \leq I_p < -1550$. 'AnalogCurrent' signal is clamped at -1550 A. Accuracy = NA
 - +1550 $< I_p \leq I_{p_oc}$. 'AnalogCurrent' signal is clamped at +1550. Accuracy = NA
 - $I_p < -I_{p_oc}$. 'AnalogCurrent' signal = 0xFFFFFFFF
 - $I_p > I_{p_oc}$. 'AnalogCurrent' signal = 0xFFFFFFFF
- Note: $|I_{p_oc}| \approx 1700$ A.

Here below the values for Byte 1, 2 and 3:

Ip	Hex value	MSB			LSB
		Byte 1	Byte 2	Byte 3	
1550.000	97A6B0	97	A6	B0	
1500.000	96E360	96	E3	60	
0.001	800001	80	00	01	
0.000	800000	80	00	00	
-0.001	7FFFFFFF	7F	FF	FF	
-1500.000	691CA0	69	69	A0	
-1550.000	685950	68	68	50	

- **'DigitalCurrent' signal**

Digital measurement of the primary current, Byte 4 and 5:

Ip	Hex value	MSB		LSB
		Byte 4	Byte 5	
1550	860E	86	0E	
1500	85DC	85	DC	
1	8001	80	01	
0	8000	80	00	
-1	7FFF	7F	FF	
-1500	7A24	7A	24	
-1550	79F2	79	F2	

- **'CRC_{I_p}' signal**

8-bit SAE J1850 CRC calculation of the first seven bytes.

SPECIMEN

Applicable standards - PV tests performed - CAB-SF 1500
• Electrical Tests:

Electrical tests		
Reverse voltage	ISO 16750-2 § 4.7 (12/2012)	Test performed at room temperature By default: case 2 ; Duration : 60s; Level defined in table 7 according to the nominal system voltage
Overvoltage (for 12V nominal voltage)	ISO 16750-2 § 4.3.1 (12/2012)	- T° = Tmax -20°C and room temperature ; At Tmax, apply 18V for 60 min to all inputs ; At room temperature, apply 24 V for 60s.
Superimposed alternating voltage	ISO 16750-2 § 4.4 (12/2012)	Usmax to be defined in accordance with the system voltage; Severity: class 1
Slow decrease and increase of supply voltage	ISO 16750-2 § 4.5 (12/2012)	Test performed at room temperature Decrease from U _{cmin} to 0 V and increase from 0 V to U _{cmin} ; Change rate: 0.5 V/ min.
Momentary drop in supply voltage	ISO 16750-2 § 4.6.1 (12/2012)	Test performed at room temperature See Fig 4 or 5 according to the nominal system voltage
Reset behaviour at voltage drop	ISO 16750-2 § 4.6.2 (12/2012)	Test is applicable only if sensor is equipped with a Reset function Test performed at room temperature See Fig 6
Load dump	ISO 16750-2 § 4.6.4 (12/2012)	Test performed at room temperature Pulse B Pulse described in tables 5 & 6
Ground reference and supply voltage	ISO 16750-2 § 4.8 (12/2012)	Test to be agreed between customer and manufacturer Test performed at room temperature and test method defined at § 4.8.2
Signal line interruption	ISO 16750-2 § 4.9.1 (12/2012)	Operating the sensor and open the circuit line after line. Opening duration for each line: 10s
Short circuit protection-Signals circuits	ISO 16750-2 § 4.10.2 (12/2012)	Connect all inputs and outputs to U _{cmax} and to GND for a duration of 60s.

S P E

• Environmental Tests:

ENVIRONMENTAL TESTS (Climatic)		
Ageing 85 °C /85 %RH	-	T °C = 85°C; RH = 85%; Duration = 1000h Sensor not supply Check After stab. @25°C (End test) Cross section with visual inspection according to IPC-A-610
Low temperature storage	ISO 16750-4 § 5.1.1.2 (04/2010)	T °C = -40 °C Operating min Duration = 24 h; UC = 13.5V (with typical operating mode). Monitoring: 1 minutes per hour Check After stab. @ 25 °C (End test)
High temperature storage	ISO 16750-4 § 5.1.2.2 (04/2010)	T °C = 125°C Operating max Duration = 96 h; UC = 13.5V (with typical operating mode). Monitoring 1 minute per hour Check After stab. @ 25 °C (End test)
Temperature cycle with specified change rate	ISO 16750-4 § 5.3.1 (04/2010)	T °C = "T °C Operating min & max" -40°C & +125°C, see fig.2 of ISO 16750-4 Duration = 30 cycles; 1 cycle = 8h Total duration = 10 days UC = 13.5V (≡ connected); IP = 400A; Operation: see fig 2 of ISO 16750-4 Check After stab. @ 25 °C (End test)
Thermal shock	ISO 16750-4 § 5.3.2 (04/2010)	T °C = "T °C Operating min & max" -40 to +125°C Duration = 300 cycles according to the climatic code (defined table 4); Exposure time : 20 min. UC = NO power supply (≡ unconnected) and No wiring harness Check After stab. @ 25 °C (End test)
ENVIRONMENTAL TESTS (Mechanical)		
Sinus Vibration	ISO 16750-3 § 4.1.x (12/2012)	Sinus; Monitoring is mandatory T° Cycle: according to fig 1 and associated operating modes. Level, Frequency and duration: depending of the situation of the sensor inside the vehicle; Sweep: 0.5 oct/min if nothing else precised; Check After stab. @ 25 °C (End test); & Meas. torque Bef. and After
Random Vibration	ISO 16750-3 § 4.1.x (12/2012)	Random; Monitoring is mandatory T° Cycle: according to fig 1 and associated operating modes. Level, Frequency and duration: depending of the situation of the sensor inside the vehicle; Check After stab. @ 25 °C (End test); & Meas. torque Bef. and After
Mechanical Shocks	ISO 16750-3 § 4.2 (12/2012)	Temperature: Ambient temperature. Level & Frequency TBD but by default § 4.2.2 Operating mode: 3.2 Pulse shape: half sine, 50 G, 6 ms 10 shocks per direction (total 60) If transducers is supplied: output monitoring with scope Check After stab. @ 25 °C (End test); & Meas. torque Bef. and After
Free Fall	ISO 16750-3 § 4.3 (12/2012)	Number of devices: 3 Falls/DUT: 2; Height = 1 m on Concrete floor 3 axes; 2 directions by axis; 1 sample by axis Operating mode: 1.1 Temperature: 25°C if not specified