AUTOMOTIVE CURRENT TRANSDUCER FLUXGATE TECHNOLOGY
CAB-SF 1500-C

Introduction

The CAB Safe family is best suited for battery monitoring application where safety is required by keeping a high accuracy and very low offset.
It offers galvanic isolation between the primary circuit (high voltage) and the secondary circuit (12V system).

Features

- Certified ASII C acc. ISO 26262 (target)
- Transducer using Fluxgate technology
- Unlimited over-current capability
- Busbar mounting or panel mounting
- Unipolar +12V battery power supply
- Output signal: High speed CAN (500kpbs)

Special feature(s)

- Plug&Play with standard CAB family
- Connector type: Tyco AMP 1473672-1
- Configurable CAN speed
- Configurable CAN ID

Advantages

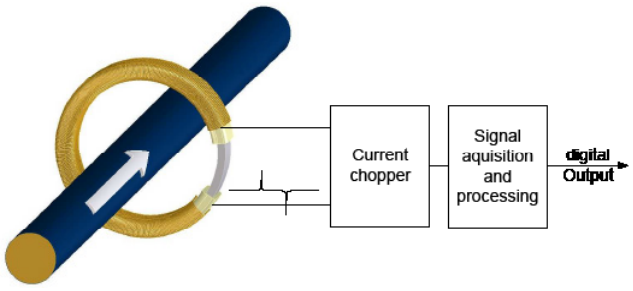
- Offset below 30 mA
- Overall accuracy before ageing
  - 0.1 % error at room temperature (Typ.)
  - 0.5 % error over temperature range (±3δ)
- Full galvanic separation

Automotive applications

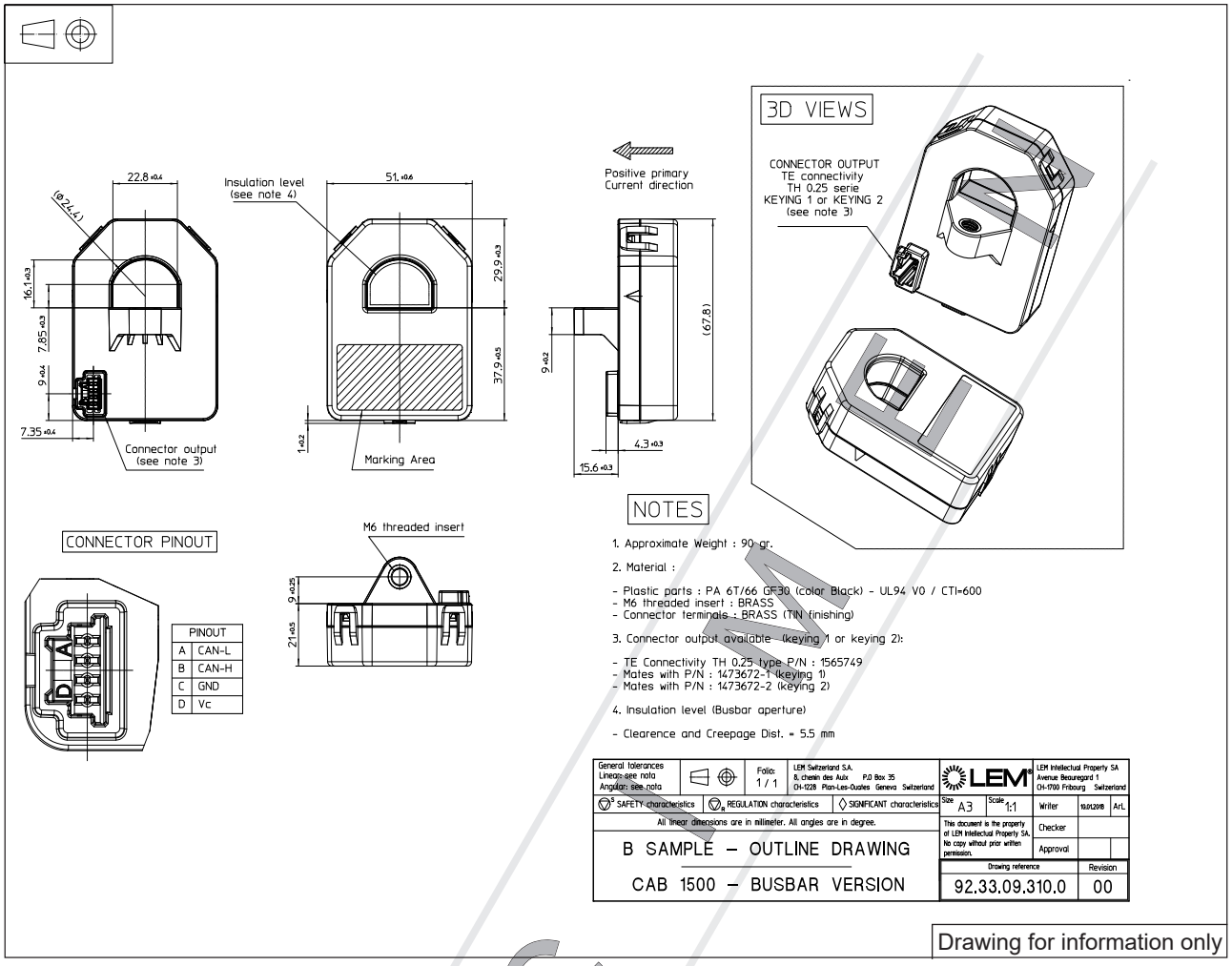
The CAB-SF 1500-C is assumed to be integrated in a vehicle battery pack or battery disconnect unit.
It is assumed that the CAB-SF 1500-C is used in a standard battery pack environement meaning without specific requirement on chemical constraints.
The test plan used to validate the product is described 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 ±Bmax 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.



Dimensions CAB500-C series (in mm)



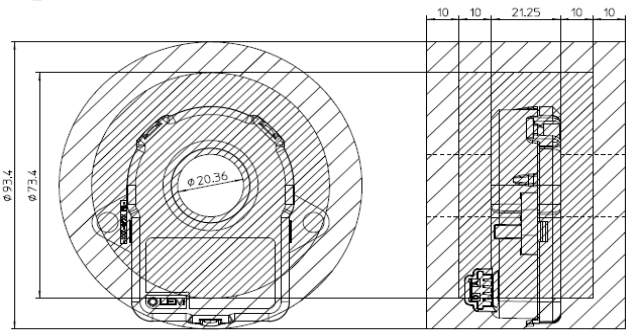
Mechanical characteristics

- Plastic case — See Drawing
- Magnetic core — Nanocrystalline
- Mass — See Drawing
- Electrical terminal coating Tin plated

Mounting recommendation

- Connector type — See Drawing

Connection: See Drawing



Forbidden areas – External Field Influences

Absolute maximum ratings (not operating)

Parameter	Symbol	Unit	Specification	Conditions
Over-voltage	U_C	V	24	1 minute
Reverse polarity	U_C	V	−50	1 minute
Minimum supply voltage	U_C	V	6	continuous, not measuring
Maximum supply voltage	U_C	V	18	continuous, not measuring
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		40	50	@U_C = 13.5 V, CAN acknowledge
Current consumption @ ±I_P = 1500 A	I_C	mA	270	500	1200	@UC = 13.5 V, CAN acknowledge
Ambient operating temperature	T_A	°C	−40		85	Temperature range with accuracy guaranteed ± 3 sigma
Performance Data						
Primary nominal DC or rms current	I_{PN}	A	−1500		1500	
CAN signal 'CSM_BAT_CURRENT' clamping value		A	−1550		1550	For Ip between ± 1550 A and over current value
Overcurrent value		A		To be defined		
Voltage clamping value max		V		20		When U_C increases
				19.5		When U_C decreases
Voltage clamping value min		V		7.5		When U_C increases
				7		When U_C decreases
Frequency bandwidth	BW	Hz		20		With Periodic CAN meassage @ 10 ms
Power up time		ms		150		
Setting time after over load		ms		20		
Analog measurement Channel						
Linearity error	ε_L	%		± 0.1		At room temperature
Global accuracy	ε_{tot}	%	−0.6		+0.6	± 3 sigma value after ageing
Output noise		mA		± 30		With Periodic CAN meassage @ 10ms. Peak to peak value. No averaging.
Digital measurement channel						
Global accuracy	ε_{tot}	%		± 6		With a minimum of ±1.2 A. Typical value after ageing

The accuracy of the sensor is guaranteed in the conditions given in the application notes ANE_120504 & ANE_14032017.

Accuracy - Enhanced Performances in Typical Application

PHEV and EV systems may use different technologies of batteries. One very important parameter that may influence the stability of the SOC is the temperature.
The battery temperature affects vehicle performance, reliability, safety and life-cycle cost.
The CAB 1500-C family is qualified between −40 °C to 85 °C but the sensor shows a better accuracy in a restricted temperature range in order to deliver a very accurate current measurement.
As shown in the picture below, the recommended and desired operating temperature range is between 15 °C to 35 °C, in this range the CAB 1500-C family has a very good accuracy.

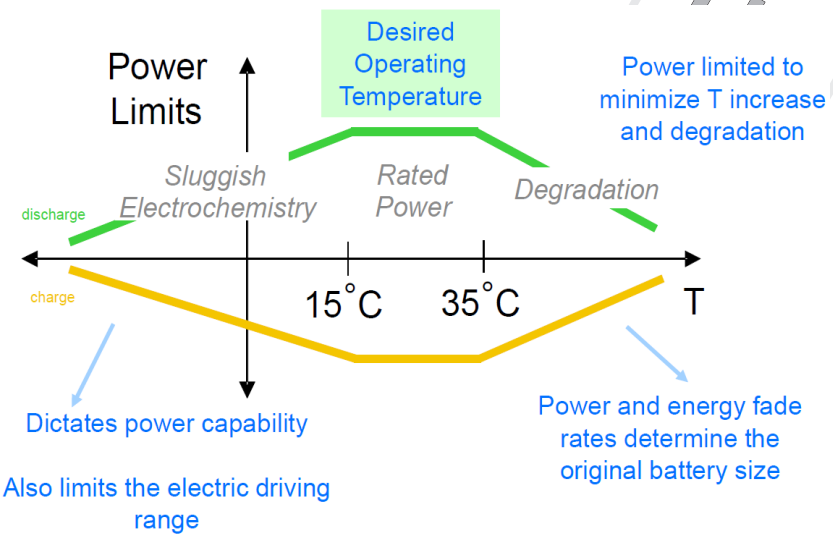
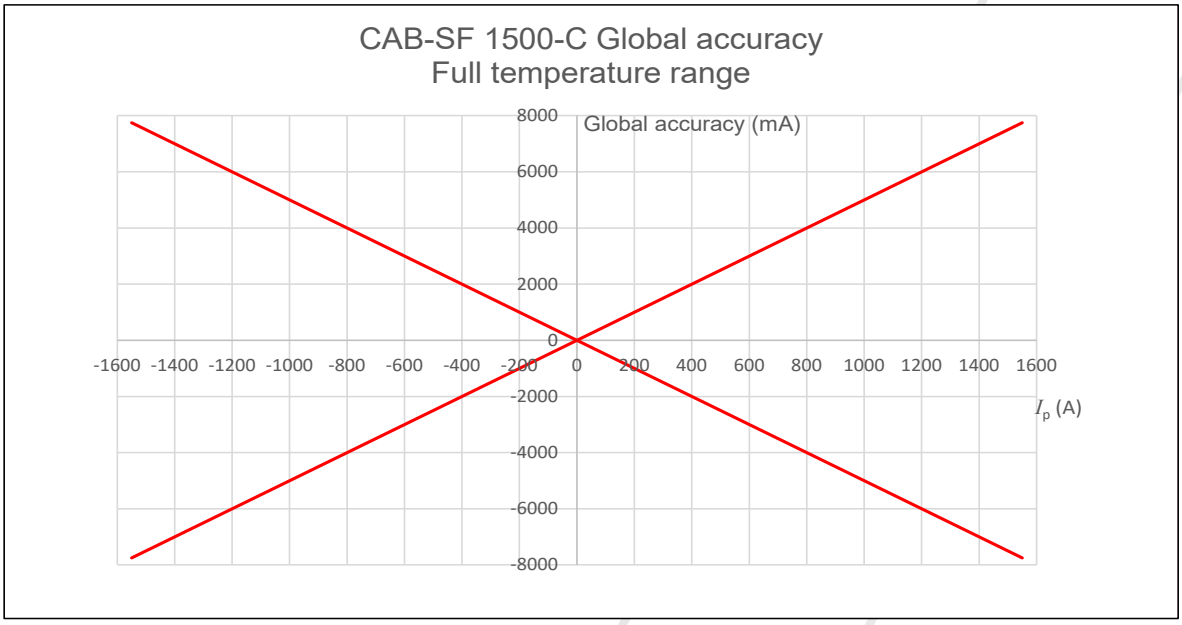


Figure 1 – Temperature impacts for battery life

Global Accuracy Graph



External Magnetic Field Influences

The CAB-SF 1500-C family uses a very accurate technology and offers to the customer the current measurement needed to the application.
In order to respect this accuracy, 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.

Can output specification

- CAN protocol 2.0B
- Bit order: big endian (Motorola)
- CAN oscillator tolerance: 0.27 %
- No sleep mode capability
- 120 ohm termination resistor to be added externally, internal CAN impedance = 2.4kohm.

CAN message table

- Described in addtional documentation.

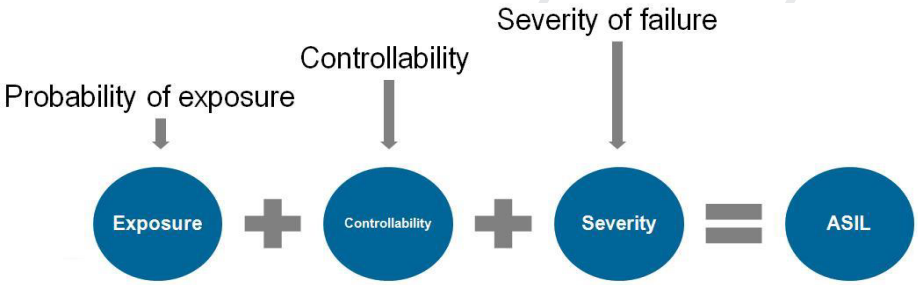
SAFETY – ISO 26262

Safety practices are becoming more regulated as industries adopt a standardized set of practices for designing and testing products. ISO 26262 addresses the needs for an automotive-specific international standard that focuses on safety critical components. ISO 26262 is a derivative of IEC 61508, the generic functional safety standard for electrical and electronic (E/E) systems.

Increasing complexity throughout the automotive industry is resulting in increased efforts to provide safety-compliant systems. It is a challenge of the automotive industry to test and validate smarter systems embedding a high level of complexity. The goal of ISO 26262 is to provide a unifying safety standard for all automotive E/E systems.

Automotive Safety Integrity Level (ASIL)

The ASIL is a key component for ISO 26262 compliance. The ASIL is determined at the beginning of the development process. The intended functions of the system are analyzed with respect to possible hazards. The ASIL ask the question, "If a failure arises, what will happen to the driver and associated road users?"



The estimation of this risk, based on a combination of the probability of exposure, the possible controllability by a driver, and the possible outcome's severity if a critical event occurs, leads to the ASIL. The ASIL does not address the technologies used in the system; it is purely focused on the harm to the driver and other road users.

Each safety requirement is assigned an ASIL of A, B, C, or D, with D having the most safety critical processes and strictest testing regulations. The ISO 26262 standard specifically identifies the minimum testing requirements depending on the ASIL of the component. This aids in determining the methods that must be used for test. Once the ASIL is determined, a safety goal for the system is formulated. This defines the system behavior needed to ensure safety (refer to the chapter "Safety Goals").

SAFETY GOALS for CAB-SF 1500-C

ID	Safety Goal	ASIL Level	Safe State	FTTI	Emergency Operation	Warning And Degradation Concept
SG1	Transmission of measurement signals shall be performed within the specified frame emission time to the BMS and communication must be secured.	C	Send No signal or Signal “invalid”	100ms	So far no emergency operations is defined as the goal is to bring the device into a safe state	The Warning concept consists in providing the BMS an error bit in the CAN message.
SG2	SG2: During normal** operation at an interval of less than 0.1 s, the maximum and minimum values of the measured current must be provided in the range of -1500A to +1500A.	C	Send No signal or Signal “invalid”	100ms	So far no emergency operations is defined as the goal is to bring the device into a safe state	The Warning concept consists in providing the BMS an error bit in the CAN message.
SG3	The primary current shall be compared internally to guarantee an accuracy of +/- 1.4 A for the current range [-20A;+20A] and with an accuracy of 7 % for the current ranges: [-1500A;-20A[&]+20A;+1500A].	The primary current shall be compared internally to guarantee an accuracy of +/-7% The sensor should send a warning information when the threshold is overpassed.			So far no emergency operations is defined as the goal is to bring the device into a safe state	The Warning concept consists in providing the BMS an error bit in the CAN message.

**: Normal operation means that the CAB is not running in degraded mode (error detected and brought to safe state). Normal operation includes “start-up”, “operation” and “shutdown”

Applicable standards (Not applicable for A Samples. Will be used for DV and PV tests)

ELECTRICAL TEST AT 25 °C		
Resistance to usual power supply voltages.	ISO16750-2 § 4.2	
Resistance to voltage fluctuation in the usual "volt control" range.	ISO16750-2	
Over Voltage	ISO16750-2 § 4.3.1.1	18V, 1h, 85°C 18V, 3h, 35°C
Resistance to slow decrease and increase of supply voltage.	ISO16750-2 § 4.5	
Re-initialization test.	ISO16750-2 § 4.6.2	
Resistance to unusual supply voltages: 24V.	ISO16750-2 § 4.3.1.2 § 4.7	24V, 1 min -16V, 1 min
Resistance to ground and positive supply voltage short circuit.	ISO 16750-2	
Superimposed Alternating Voltage		Supply voltage:14V DC 30Hz to 30kHz 1Vpp
Ground Reference and Supply Offset	ISO16750-2 § 4.8	
Open Circuit	ISO16750-2 § 4.9	
Short-circuit protection	ISO16750-2 § 4.10.2	
ENVIRONMENTAL TESTS (CLIMATIC)		
Continuous humidity		Duration = 1000h - T°C = 40°C HR = 95% Sensor not supplied
Shipping/Storage Temperature Exposure	ISO 16750-4	T °C = -40 °C / +105 °C Slope 0.6°C/min (164H) U_C = NO power supply
Low Temperature Operating Endurance	ISO 16750-4 §5.1.1	T °C = -40 °C - 120hrs U_C = 13.5V
High Temperature Operating Endurance	ISO 16750-4 §5.1.2	T °C = +85 °C - 120hrs U_C = 13.5V
Powered Thermal Cycle Endurance	ISO 16750-4 § 5.3.1 *(04/2010)*	T °C = -40 °C / +85 °C Duration = 540 cycles; 20 min/20 min Slope 4°C/min U_C = No power supply
Thermal Shock	ISO 16750-4 § 5.3.2 *(04/2010)*	T °C = -40 °C / +85 °C Duration = 1000 cycles; 20 min/20 min U_C = N power supply
Thermal Humidity Cycle	ISO 16750-4 § 5.6 *(04/2010)*	T °C = -10 °C/ +65 °C Humidity = 93% Duration = 240 h *UC = No power supply*
EMC TESTS		
Load Dump Resistance to 5b pulses.	ISO16750-2 § 4.6.4.2.3	
Measurement of radiofrequency (RF) conducted noises on the supply inputs.	CISPR 25 *(03/2008)*	
Measurement of radio frequency conducted noises on the outputs.	CISPR 25 *(03/2008)*	
Measurement of radio frequency radiated electric field.	CISPR 25 76 MHz - 960 MHz	
Immunity to current injection (BCI)	ISO 11452-4 *(12/2011)*	1MHz to 3MHz : 300mA * F(MHz) /3 3 to 200MHz : 300mA 200 to 400MHz : 300mA*200 / F(MHz)
Resistance to pulses 1 & 2a		1 : -100V 2a : 100V
Resistance to pulses 3a & 3b		3a : U -150V 3b : U 100 V
Resistance to pulses 4	ISO16750-2 § 4.6.3	
Resistance to pulses 5b	ISO16750-2 § 4.6.4.2.3	
Resistance to short interruptions.		Short interruptions of 2 µs Short interruptions of 100 µs Short interruptions of 5 ms
Resistance to pulse voltage "Volt control"		
Resistance to voltage ripples		F = 30 Hz - 30 kHz
Immunity to transients on the signal lines.		
ESD discharges. Handling	ISO 10605	Discharge in contact ± 2, 4 kV (on connector pin) Discharge in the air ± 8, 15 kV (on Equipment case)
Immunity to onboard transmitters	ISO 11452-9	
Immunity to radiated electric field in reverberation chamber	ISO 11452-11	
ENVIRONMENTAL TESTS (MECHANICAL)		
Vibration test (random)	ISO 16750-3:2012 4.1.2.4 Test IV — Passenger car, sprung masses (vehicle body)	16h per axis Temperture profile -40, +85°C
Mechanical shock	IEC 60068-2-32 Ed	3 shocks in each direction 40g, 11ms, half sinus
Free fall	ISO 16750-3	