AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
HAH3DR 300-S03

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 ±900 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 ±300 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 features

- Tri-phase transducer
- Not waterproof
- Gold plated terminals
- Compressor limiters
- 2D data matrix.

Advantages

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

Automotive applications

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

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:

$$B\ (I_P) = \text{constant (a)} \times I_P$$

The hall voltage is thus expressed by:

$$V_H = (\text{Hall coefficient / d}) \times I \times \text{constant (a)} \times I_P$$

With d = thickness of the hall plates
I = current accross the Hall plates

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.

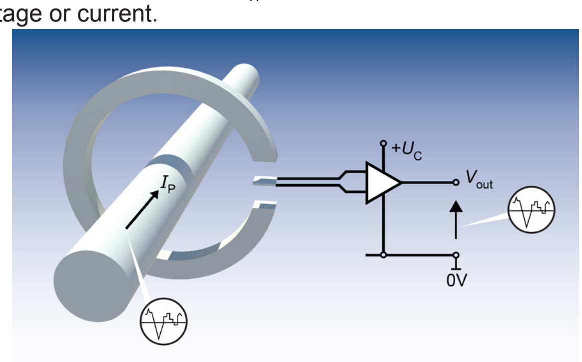
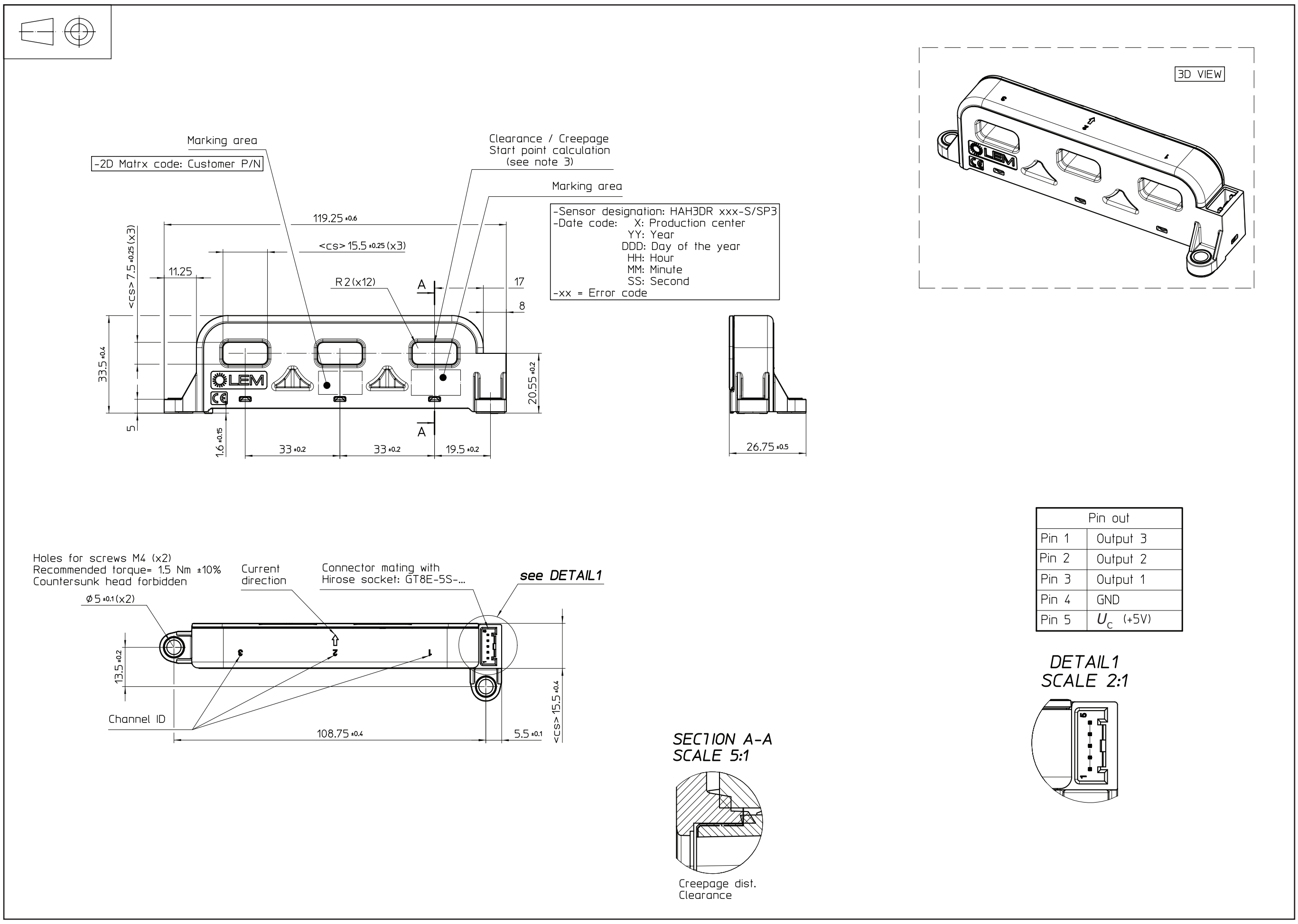


Fig. 1: Principle of the open loop transducer.

Dimensions (in mm)



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

Mechanical characteristics

- Plastic case >PBT-GF30< (Natural)
- Magnetic core FeSi wound core
- Pins Copper alloy gold plated
- Mass 99 g ±5 %

Mounting recommendation

- Mating connector type Hirose Socket GT8E-5S-...
- Assembly torque 1.5 N·m ±10 %
- Clamping force must be applied on the compressions limiter, not plastic
- Soldering type N/A

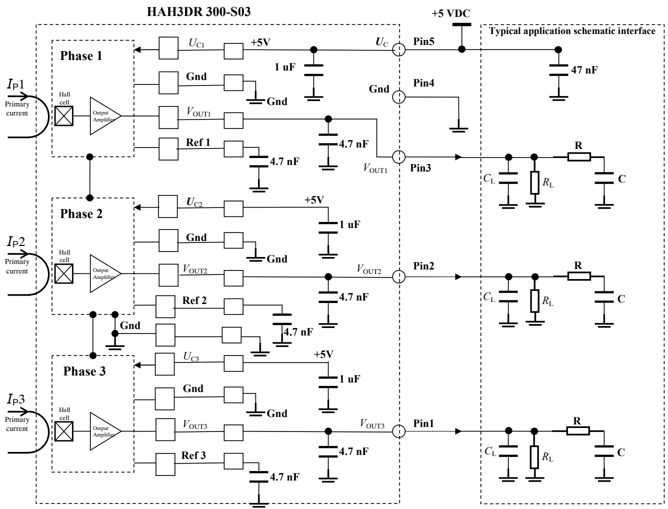
R_L > 10 kΩ optional resistor for signal line diagnostic
C_L 4 nF < C_L < 18 nF EMC protection
Normal value is 4.7 nF
Mandatory to stabilize the output signal.

RC: low pass filter, EMC protection (optional)
Capacitor V_{ref} / Gnd 4.7 nF
Capacitor U_C / Gnd 1 µF

Remark

- V_{out} > V_o when I_P flows in the positive direction (see arrow on drawing).

System architecture (example)



Absolute ratings (not operating)

Parameter	Symbol	Unit	Specification Min	Specification Typical	Specification Max	Conditions
Maximum supply voltage	U_C	V			8	Continuous, not operating
					6.5	Exceeding this voltage may temporarily reconfigure the circuit until the next power-on
Output voltage low [1]	$V_{out\ L}$				0.2	@ U_C = 5 V, T_A = 25 °C
Output voltage high [1]	$V_{out\ H}$		4.8			
Ambient storage temperature	T_S	°C	−50		125	
Electrostatic discharge voltage (HBM)	U_{ESD}	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		200		
Maximum reverse current [3]	I_R	mA	−80		80	
Insulation resistance	R_{IS}	MΩ	500			500 V DC, ISO 16750
Primary nominal peak current	$\hat{I}_{PN}$	A			[2]	

Operating characteristics in nominal range (I_{PN})

Parameter	Symbol	Unit	Specification Min	Specification Typical	Specification Max	Conditions
Electrical Data						
Primary current, measuring range	I_{PM}	A	−300		300	
Primary nominal DC or RMS current	I_{PN}	A	−300		300	
Supply voltage [1]	U_C	V	4.75	5	5.25	
Ambient operating temperature	T_A	°C	−40		125	
Capacitive loading	C_L	nF	4	4.7	18	
Output voltage (Analog) [1]	V_{out}	V		$V_{out} = (U_C/5) \cdot (V_o + G \cdot I_P)$		@ U_C
Offset voltage	V_O	V		2.5		
Sensitivity [1]	*G*	mV/A		6.67		@ U_C = 5 V
Current consumption (for 3 phases)	I_C	mA		44	50	@ 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						
Ratiometricity error	ε_r	%		±0.5		
Sensitivity error	ε_G	%		±0.5		@ T_A = 25 °C
				±1		@ T_A = 25 °C, After T° Cycles
Electrical offset voltage	V_{OE}	mV		±4		@ T_A = 25 °C, @ U_C = 5 V
Magnetic offset voltage	V_{OM}	mV	−7.5		7.5	@ T_A = 25 °C, @ U_C = 5 V
Average temperature coefficient of I_{OE}	TCV_{OEAV}	mV/°C	−0.15		0.15	@ −40 °C < T_A < 125 °C
Average temperature coefficient of *G*	TCG_{AV}	%/°C	−0.04	±0.01	0.04	@ −40 °C < T_A < 125 °C
Linearity error	ε_L	% I_{PM}	−1		1	@ U_C = 5 V, @ T_A = 25 °C, @ I_P = I_{PM}
Step response time to 90 % I_{PN}	t_r	µs		4	6	d*i*/d*t* = 100 A /µs
Frequency bandwidth [2]	*BW*	kHz	40			@ −3 dB
Output voltage noise peak-peak	$V_{no\ pp}$	mV			20	@ DC to 1 MHz
Phase shift	$\Delta\varphi$	°	−4		0	@ DC to 1 KHz

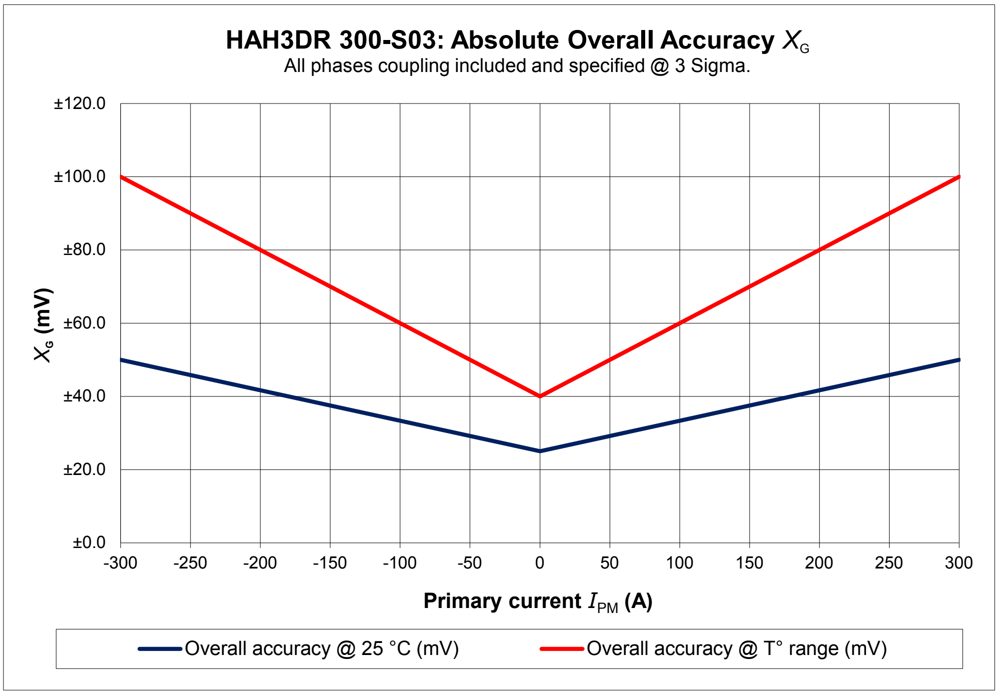
Notes: [1] The output voltage V_{out} is fully ratiometric. The offset and sensitivity are dependent on the supply voltage U_C relative to the following formula:

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

[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.

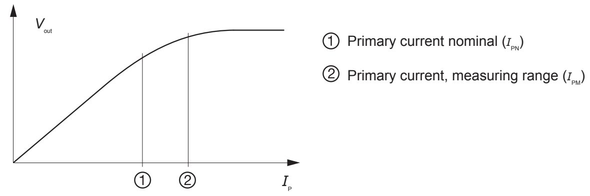
Accuracy



I_P (A)	Overall accuracy @ 25 °C	Overall accuracy @ T° range (mV)
−300	±50	±100
0	±25	±40
300	±50	±100

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:

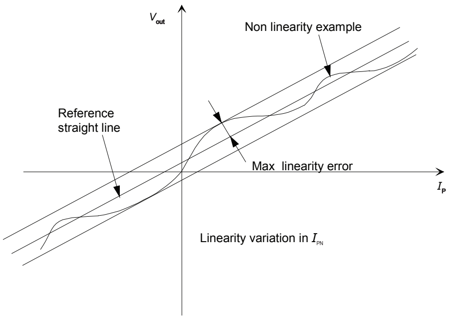
The magnetic offset is the consequence of an over-current on the primary side. It's defined after an excursion of I_{PN}.

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.

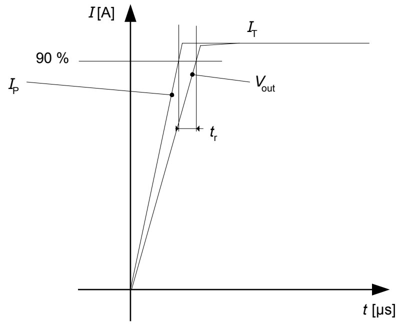


Sensitivity:

The transducer's sensitivity G is the slope of the straight line $V_{out} = f\,(I_P)$, it must establish the relation:

$$V_{out}\,(I_P) = U_C/5\,(G \times I_P + V_o)$$

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:

$$I_{OT} = I_{OE}\ \text{max} - I_{OE}\ \text{min}$$

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. 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 $U_C/2$. 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:

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 98.20.00.538.0	≥ −4° from DC to 1 kHz	30 Hz to 100 kHz at 20 A peak
Frequency bandwidth	LEM Procedure 98.20.00.538.0	≥ 40 kHz @ −3 dB	30 Hz to 100 kHz at 20 A peak
Noise measurement	LEM Procedure 98.20.00.575.0	10 mV maximum	Sweep from DC to 1 MHz
Response time d*i*/d*t*	LEM Procedure 98.20.00.545.0	t_r @ 90 % of I_{PN} step < 6 µs	100 A/µs, I pulse = 300 A and 900 A
d*v*/d*t*	LEM Procedure 98.20.00.545.0	Disturbance < ±50 mV pp Recovery time max 3 µs	Slope: 5; 10; 15 & 20 kV/µs V = 1000 V
Dielectric withstand voltage test		ISO 16750-2 § 4.11 (11/2012)	2500 V AC / 1 min / 50 Hz Functional test before and after test
Insulation resistance test		ISO 16750-2 § 4.12 (11/2012)	500 V DC, time = 60 s; R insulation ≥ 500 MΩ minimum; Functional test before and after test
ENVIRONMENTAL TESTS			
Steady state T °C humidity bias life test	JESD 22-A101 (03/2009)		T° C = 85 °C; *RH* = 85 %; Duration = 1000 H U_C = 5 V; I_P = 100 A; Monitoring each 5 min
Thermal shock	IEC 60068-2-14 Na (01/2009)	ISO 16750-4 § 5.3.2 (04/2010)	T °C = −40 °C to +125°C; Duration = 1000 cycles; 30 min/ 30 min; U_C = NO power supply
High temperature storage test	IEC 60068-2-2 Bd (07/2007)	ISO 16750-4 § 5.1.2.1 (04/2010)	Storage: 125 °C for 1000 hours
Research of natural frequency	IEC 60068-2-64 (02/2008)	ISO 16750-3§ 4.1.2.4 (12/2012)	
Vibration random in T°C	IEC 60068-2-64 (02/2008)	ISO 16750-3§ 4.1.2.4 (12/2012) ISO 16750-3§ 4.1.1 (12/2012)	Profile: Sprung; 8 H for each axes; temperature cycle: see sheet “vibration profile” U_C = 5 V only during Op. mode 3.2; I_P = 0 A; Offset Monitoring
Mechanical shock	IEC 60068-2-27 (02.2008)	ISO 16750-3§ 4.2.2 (12/2012)	Acceleration: 500 m·s²; Duration: 6 ms; Half-sine pulse 10 * in each direction (total 60 shocks) U_C = NO power supply
Sinus vibration	IEC 60068-2-6 (12.2007)		On the most critical axis, perform a sinus vibration test. Sweep from 350 Hz to 450 Hz during 4 hours for low peak acceleration (5 g to 8 g) Sweep from 350 Hz to 450 Hz during 8 hours for peak acceleration > 8 g; Temperature: 25 °C
Extraction test (on compression limiter)			
Free fall (device not packaged)	IEC 60068-2-31&5.2: method 1 (05/2008)	ISO 16750-3§ 4.3 (12/2012)	Height = 1 m; Concrete floor; 3 axis; 2 directions by axis; 1 sample by axis
EMC TESTS			
Radiated immunity, anechoic chamber	ISO 11452-1 (2005) ISO 11452-2 (2004)	GMW3097 §3.4.2 (2012)	400 MHz to 2000 MHz; Level: 2 (table 12); Method: Substitution
Bulk current injection	ISO 11452-1 (2005) ISO 11452-4 (2011)	GMW3097 §3.4.1 (2012)	1 MHz to 400 MHz; Level = Table 11 (Level 2); Acceptance criteria : A; Max deviation: ±25 mV
Emission radiated (ALSE)	CISPR 25 (03.2008)	CISPR 25	Table 9, Class 5 by default Freq = 150 kHz to 2.5 GHz
Immunity to Electrostatic Discharges (Handling of devices)	ISO 10605 (2001)	GMW3097 §3.6.3 (2012)	Contact discharges: ±4, 6 kV; Air discharges: ±8 kV U_C = NO power supply (≡ unconnected) Criteria B
MISCELLANEOUS TESTS			
Magnetic field external influence			Distance: 0 cm, 2 cm, 5 cm/axes; Primary current: I_P max/3; I_p max/2; I_p max; U_C = 5 V and T° = 25 °C
Mutuel influence between phases			V_{out} (Phase 2-3) vs Phase 1; V_{out} (Phase 1-3) vs Phase 2; V_{out} (Phase 1-2) vs Phase 3; I_P = 0; $I_{PN;}$ 0; $I_{PN;}$ 0;
Heating of CM, Busbar, ASIC vs I_p			Heating CM, Busbar, ASIC = *f* (I_p (amplitude, frequency)); Acceptance criteria T° ≤ 150°C; Current cycle: 3 A rms;6 A rms; 30 A rms; 90 A rms; 150 A rms;210 A rms; Frequency: 0, 100, 1000, 10 k, 20 k, 50 k, 100 k
Internal check; after ageing 85/85, Thermal shocks; Mechanical Shocks and Random vibration			1. Fastening torque; 2. Core appearance; 3. Circuit board apperance (see report 1302PU222 p 93)
Cross section; after Thermal shocks & Steady state T °C Humidity bias life test			See below cross section check; (or see report 1302PU222 p 53)
CETP 00.00-E-412 §5.14.1; Connector insertion and push test		CETP 00.00-E-412	(see report 1302PU222, p.108-111)
CETP 00.00-E-412 §5.14.3; Connector durability test		CETP 00.00-E-412	(see report 1302PU222, p.108-111)
CETP 00.00-E-412 §5.14.4; Lead/Lock pull test		CETP 00.00-E-412	(see report 1302PU222, p.108-111)