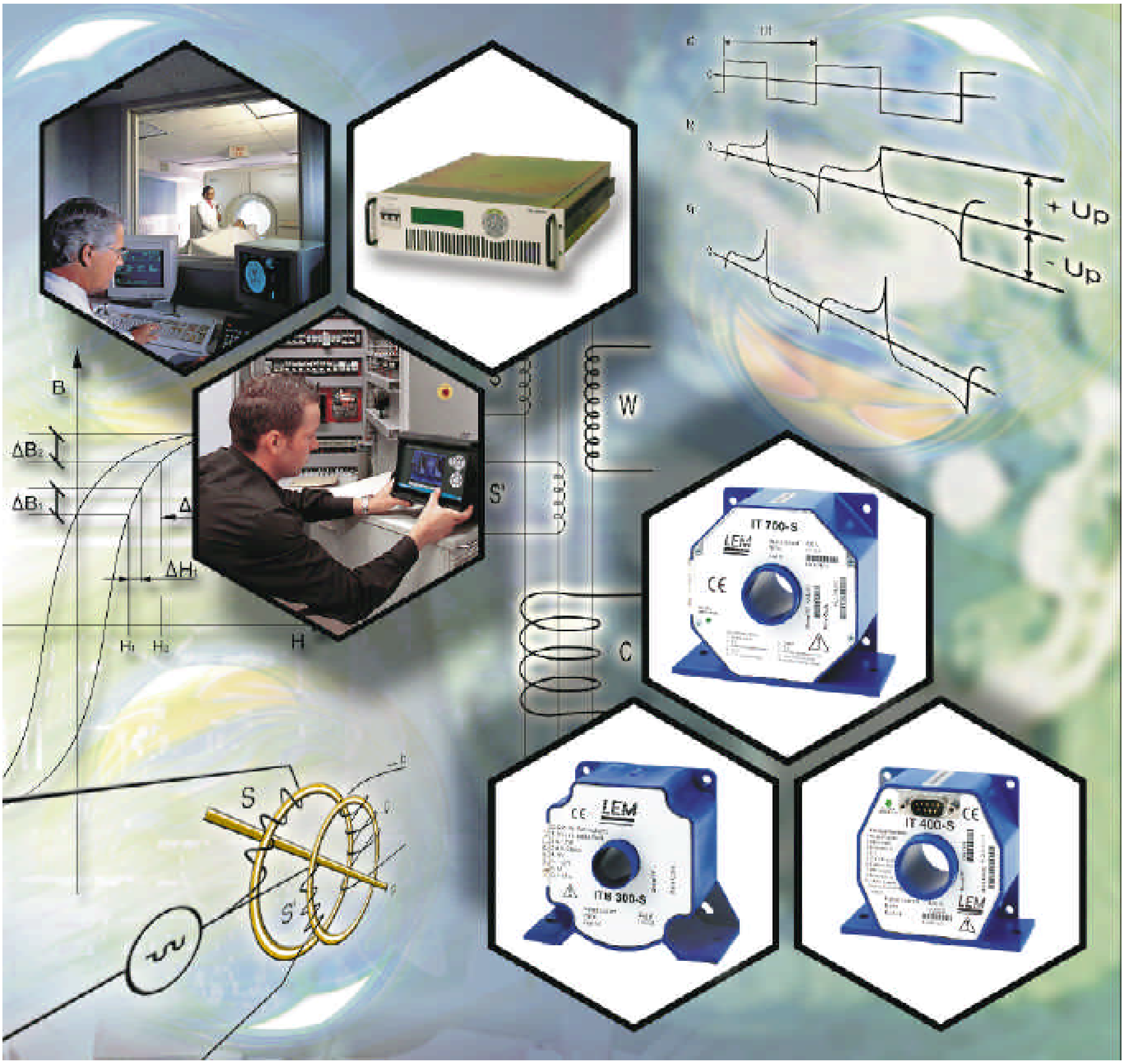
Technical Information

High Accuracy, High Technology : The Perfect Choice!
ITB 300-S / IT 400-S / IT 700-S Current Transducers



LEM

High Accuracy, High Technology: The Perfect Choice !
ITB 300-S / IT 400-S / IT 700-S Current Transducers.

by Stéphane Rollier

Certain Power Electronics applications require high performance in accuracy, drift or response time that it is necessary to switch to high technologies to achieve them. The validation of equipment is often made through recognised laboratories using highly accurate and performance test benches supported by high-tech subassemblies, including extremely accurate current transducers. These transducers are still in need today for such traditional applications, but are more and more requested to be part of high performance industrial applications, namely: medical equipment, metering or accessories for measuring equipment. It has been a great challenge for LEM to produce a transducer with high performance and costs appealing to the market target, but as a leader in current measurement for more than 30 years, the goal has been achieved.

To achieve the required accuracy performance, LEM's IT current transducers do not use Hall generators but are based on Fluxgate technology, an established technology LEM has used for many years. This is a proven high technology at the heart of several LEM current and voltage transducers families. Today, LEM uses different versions of Fluxgate technologies, each version providing different levels of performances and costs matching to the customer's requirements. For the IT range building, the IT Fluxgate technology applied is certainly the most efficient. Thanks to it, we can speak about accuracy by using ppm (part per million) of the nominal value which is quite representative of the performances reached.

IT Fluxgate Technology Principle

For accurate measurement of DC currents, the methods used since the beginning of the 20th century consist in compensating the flux (Φp) created in a core by the Ip current to be measured by an opposing flux (Φc) created by an Ic current flowing through a known number of turns Nc, to obtain (Figure 1) :

$\Phi p - \Phi c = 0$
or $Np.Ip - Nc.Ic = 0$
(Np : Number of primary turns)

To obtain an accurate measurement, it is necessary to have a highly accurate device to measure precisely the condition $\Phi = 0$. The aim is to uncover a current transducer with the following characteristics:

- Excellent linearity,
- Outstanding long-term stability,
- Low residual noise,
- High frequency response,
- High reliability.

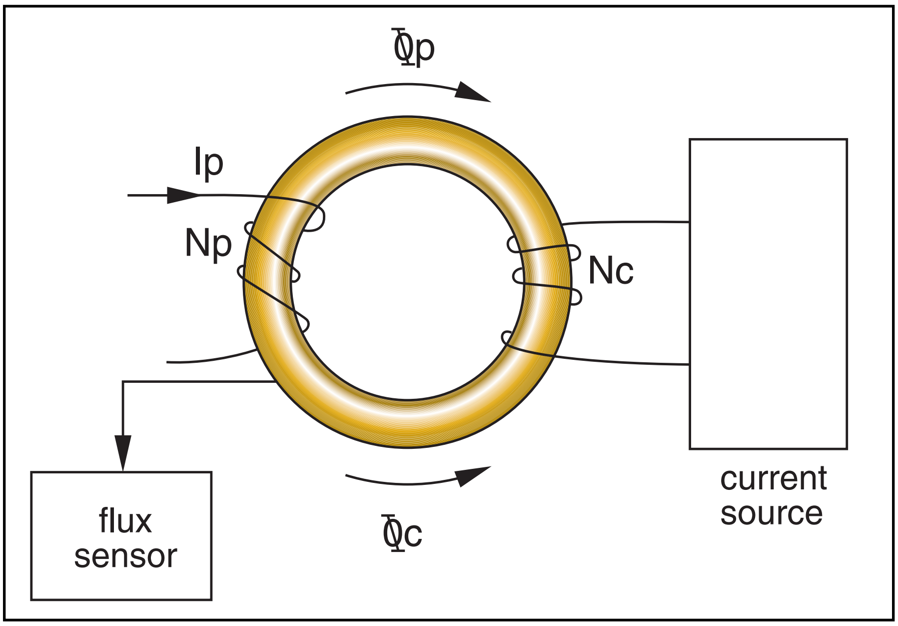


Fig 1. IT Fluxgate Technology Principle.

Operation principle

To achieve exceptional compensation of the two opposing magnetic fluxes (Φp - Φc = 0), a detector capable of accurately measuring Φ = 0 must be available, in other words, the detector must supply the greatest possible output signal for the smallest measured flux variations.

- The hysteresis cycles of the magnetic cores have a form comparable to the one represented in figure 2 (more or less square according to the type of material used),
- Observing B = f(H) on the magnetization curve, notice that for a given H1 field a ΔB1 variation

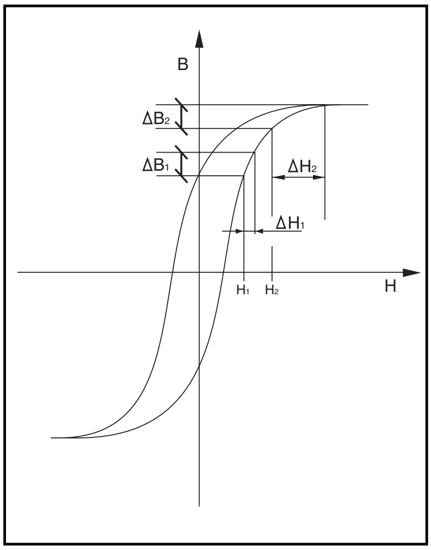


Fig 2. Hysteresis cycles of the magnetic cores.

corresponds to ΔH1. But, also observe that later along the cycle, for another given H2 field, for the same variation ΔB2 = ΔB1, the ΔH2 variation must be much greater.
The detection of the zero flux (Φ = 0) is based on this phenomenon,

- When injecting a square wave voltage (figure 3a) into a winding, wound on a core, until the magnetic circuit starts to become saturated, a current (figure 3b) is created; This current flowing through a measuring resistor will provide a systematic voltage relative to zero with peak values +Up = -Up,

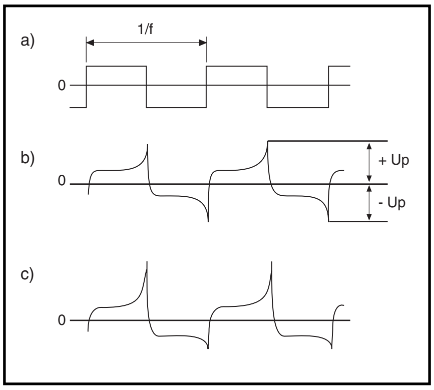


Fig 3. Square wave voltage (3a); Current created (3b); Asymmetry of the created current (3c).

- When a DC current flows through the aperture of the core, the path of the hysteresis cycle is then shifted causing asymmetry of the current produced by the square wave voltage (figure 3c) and leading to a measured voltage at the terminals of the resistor where I+UpI >I-UpI. By using peak detection to measure +Up and -Up and by comparing the two peak values, the variations of the flux in the core are thus detected as normally Φ = 0 when I+UpI = I-UpI. As soon as the flux varies, an error voltage I+UpI - I-UpI is supplied to a power amplifier that drives a current into a compensation winding until Φ = 0, thus I+UpI = I-UpI.

Figure 4 shows a very simplified base circuit for the compensation of a DC current.
If the primary current Ip = 0, the Ic compensation current will be equal to 0. When Ip varies, the flux varies. Therefore, we detect an error I+UpI - I-UpI which controls the power amplifier to send out an Ic compensation current until Φ = 0, thus:

$$Nc \times Ic = Np \times Ip$$

The Ic current flows through a resistor, allowing for proportional voltage measurement.

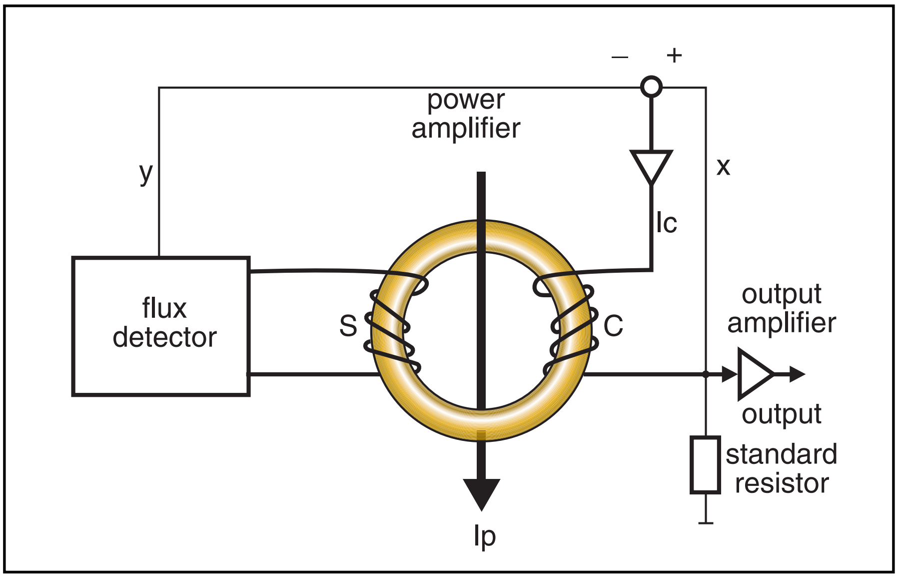


Fig 4. Simplified base circuit for DC current compensation.

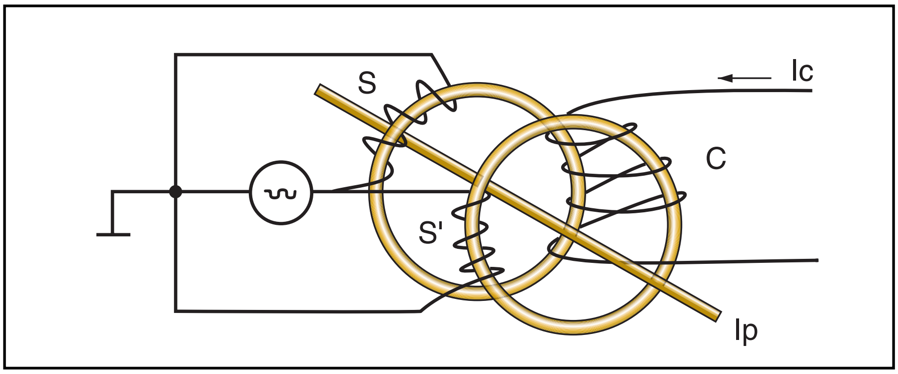


Fig 5. Solution against voltage peaks re-injection.

The accuracy of the measurement will not only depend on the accuracy of the measuring resistor but also very much on the sensitivity of the flux detector. However, in spite of the DC measurement function accuracy, there are some drawbacks to this DC measurement system (Figure 5) :

1. As the winding “S” of the flux detector is coupled with the compensation winding “C”, the voltage peaks, corresponding to the frequency of the applied square wave voltage, are re-injected into the compensation winding and into the measurement resistor,

2. The system's response frequency should be quite low due to the low scanning voltage frequency of the flux detector,

3. We recommend only to apply primary current to the transducer after powering up the current transducer. Failing to do so will result in oscillation on the output, and a delayed lock-on to the primary current. For IT models, it will further more result in an offset in the order of ± 50 ppm.

To compensate for these inconveniences, the magnetic portion of the transducer is realised as schematically represented in figure 6 :

- We can see that the winding S for the flux detection is directly coupled with the compensation winding C. However, the flux induced by the square wave voltage, injected into the S winding, may be practically cancelled out when a second S’ winding is mounted on a separate core (identical to S) into the compensation winding C. C will not see the flux created by the peaks since the flux generated by S’ is opposed to the one created by S (Figures 5 and 6),

- A fourth winding W, on a core and also installed in the compensation winding C is used to measure the alternating components. It is connected to a system allowing the power amplifier to compensate the flux produced by the alternate high frequency components which are not detected by the low frequency flux detector.

The diagram of the compensation loop is shown in figure 7.

The simplified overall diagram is shown in figure 8 and can be directly deduced from the diagram, figure 7. The saturation detector is activated when the DC flux detector is not at zero.

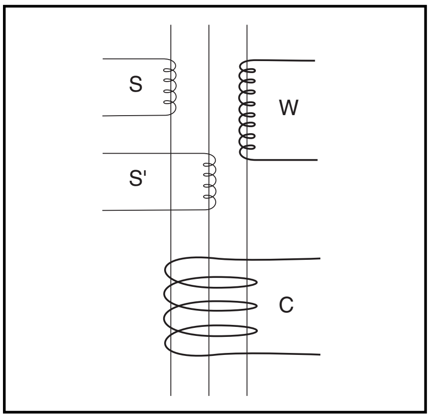


Fig 6. The various windings used and their arrangements.

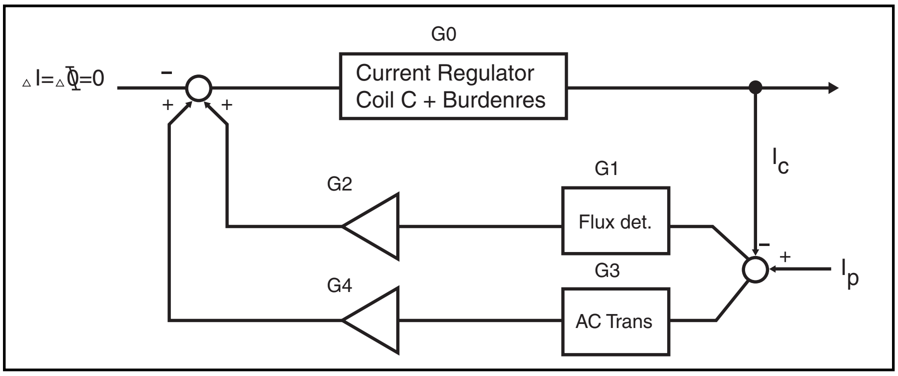


Fig 7. Compensation loop diagram.

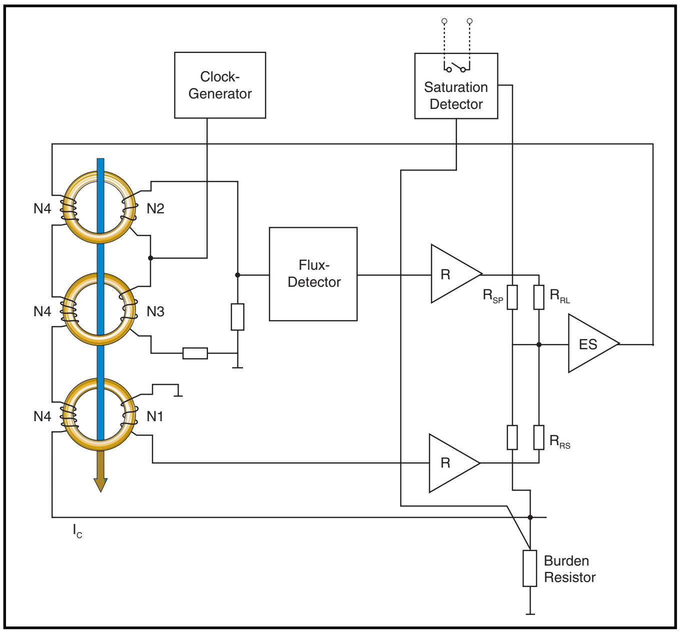


Fig 8. IT and ITB operation principle: simplified overall diagram.

Picture 1. IT 400-S & IT 700-S models.

This technology offers many benefits:

Parameter / Model	Linearity of I_{PN}	Initial offset at +25°C	Thermal offset drift	Overall accuracy at +25°C, % of I_{PN}
ITB 300-S	0.001%	+/- 0.1 mA	1 µA/K	+/- 0.05
IT 400-S	3 ppm	30 ppm of I_{PN}	0.5 ppm of I_{PN} /K	+/- 0.0033
IT 700-S	3 ppm	50 ppm of I_{PN}	0.5 ppm of I_{PN} /K	+/- 0.0053

The IT/ITB series transducers offer very high accuracy based on superior resolution (better than 0.05 ppm for IT 400-S and IT 700-S models). This technology provides galvanic isolation for current measurement of all types of waveforms including DC, AC, mixed and complex.

Three models emerged from this technology to cover two market driven requirements: One issued by the laboratories and one by industrial applications. IT 400-S and IT 700-S models are more dedicated for the first category and ITB 300-S is rather for the second one. All three have been designed to operate from a bipolar +/-15 VDC power supply.

IT 400-S and IT 700-S (Picture 1)

Specified for 400 A_{RMS} and 700 A_{RMS} nominal respectively, they operate in a temperature range from + 10 to + 50°C, making them ideal for applications such as high-precision power supplies and high-performance gradient amplifiers for MRI (Magnetic Resonance Imaging) including medical equipment such as medical X-Ray imaging and also calibration test benches in laboratories and test departments. LEM IT transducers can also be used as interfaces for power analyzers when high accuracy is required.

Thanks to their primary aperture, they accommodate round primary conductors of 26 and 30 mm diameter respectively.

In addition to their normal current output, the transducers offer an output indicating the transducer state (opened or closed contacts) and an external LED showing the normal operation. This output is provided by an integrated opto-coupler and an integrated relay for the IT 400-S and the IT 700-S, respectively.
When the two models are operating normally (current less than 110% of the nominal value), this output is activated (ON-state) and the contacts are normally closed. When the current goes above 110% of the nominal value (overload situation: fault level), the contacts are opened (OFF-state). Possible currents and voltages for these special outputs are indicated into the respective data sheets.

Picture 2. ITB 300-S model.

ITB 300-S (Picture 2)

Specified for 300 A_{RMS} nominal, it operates in an extended operating temperature range from - 40 to + 85°C, compared to the + 10 to + 50°C of the IT models, allowing its use in a wider range of applications including high precision power supplies, medical equipment, calibration units, precise and high stability inverters, power analyzers and metering. The round primary aperture accommodates primary conductors up to 21.5 mm diameter.
Similar to the two previous IT models, the ITB 300-S offers an additional output indicating the transducer state. However, the output is an integrated open collector transistor to be associated with an external relay. During normal operation, the output is active or a closed contact. When an operation considered as not normal occurs (fault level), the output or contact is opened. For example, this could happen during overload conditions (> 3000 A, longer than 10 ms) or when the transducer malfunctions.
This model at the opposite of IT models is suitable for industrial and railway applications complying with EN 50178 and EN 50155 standards.

Although the ITB uses the same technology as the IT current transducers, it is nevertheless proposed at a lower price while offering a level of performance, just slightly lower than other members of the family.

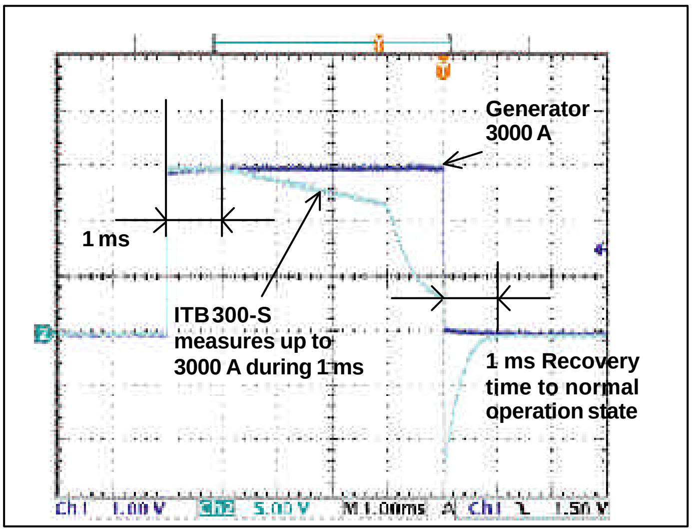


Fig 9. ITB 300-S : 3000 A pK applied with a di/dt=150A/ms-Rm=10W.

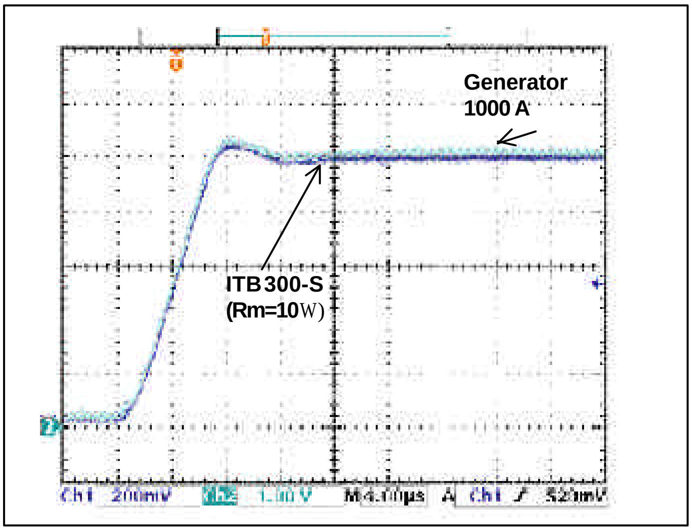


Fig 10. ITB 300-S : 1000 A pK applied with a di/dt=150A/ms.

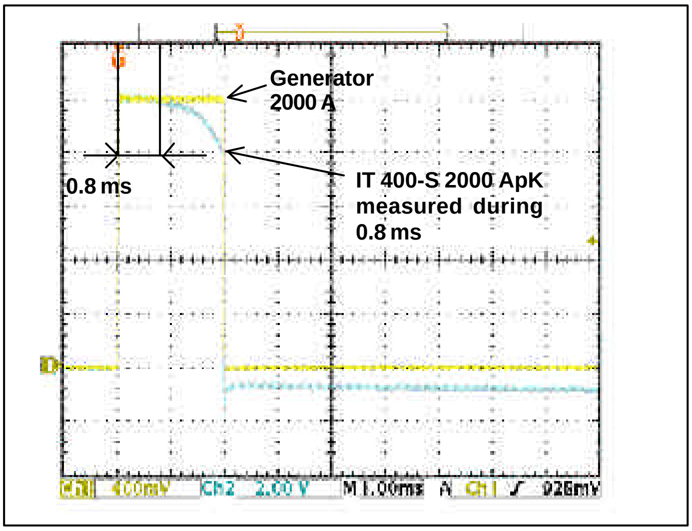


Fig 11. IT 400-S : 2000 A pK applied with a di/dt=100A/ms-Rm=10W.

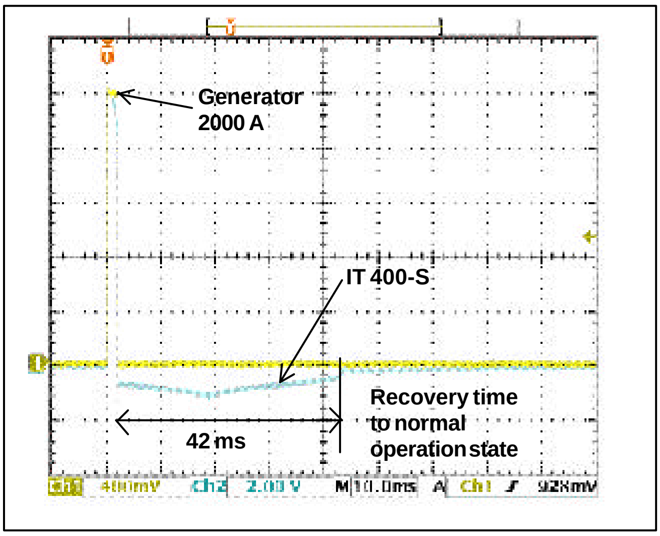


Fig 12. IT 400-S : 2000 A pK applied with a di/dt=100A/ms-Rm=10W.

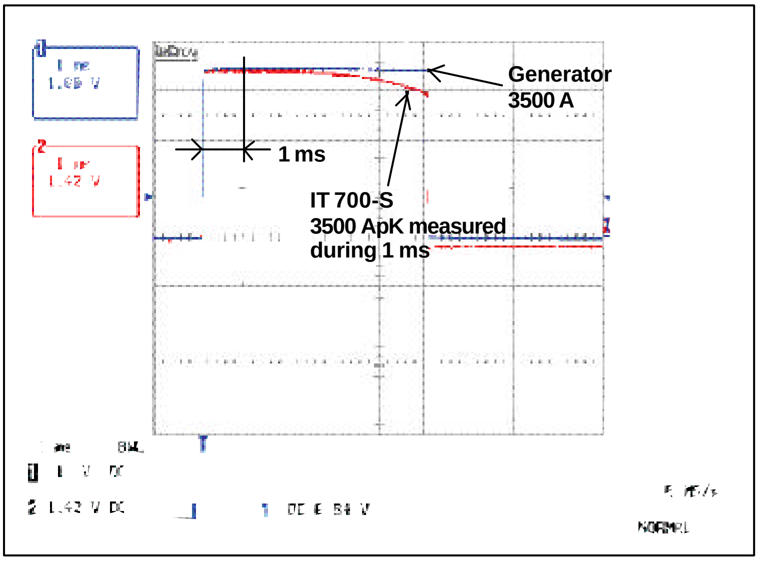


Fig 13. IT 700-S : 3500 A pK applied with a di/dt=100A/ms-Rm=2.5W.

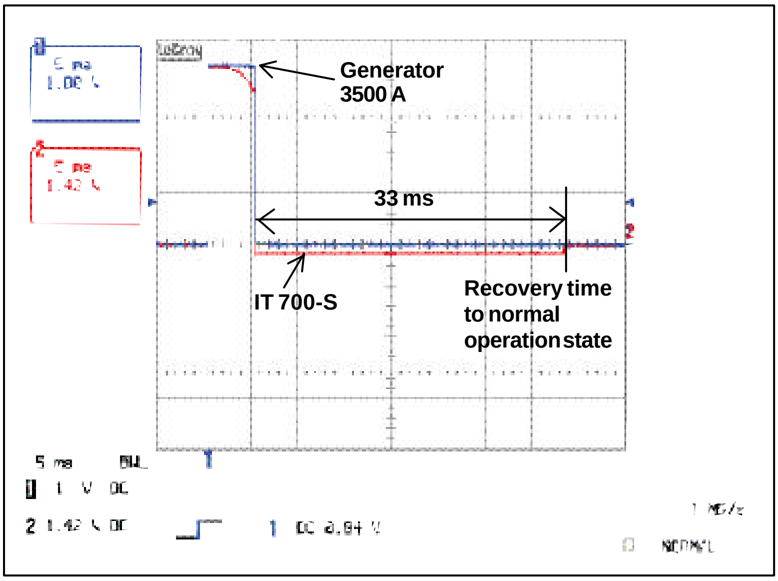


Fig 14. IT 700-S : 3500 A pK applied with a di/dt=100A/ms-Rm=2.5W.

Performance in Overload Conditions

All three models have a high capability against current overloads: 5 times the nominal current for the IT models and up to 10 times the nominal current for the ITB 300-S with a max duration of 100 ms and 10 ms, respectively (Figures 9 and 10 for ITB 300-S / Figures 11 and 12 for IT 400-S / Figures 13 and 14 for IT 700-S).

As you can notice it, at 5 x I_{PN}, thanks to the current transformer effect, the IT 400-S and IT 700-S can measure correctly the primary overcurrent if the duration does not exceed 0.8 ms and 1 ms respectively (with a di/dt of 100 A/µs) (the specifications given into the data sheets can not be guaranteed for this measurement). The products (current x time) are roughly 2000 A.t x 0.8 ms = 1600 and 3500 A.t x 1 ms for IT 400-S and IT 700-S respectively and beyond these values, the magnetic saturations occur.

With ITB 300-S, this is the same thing, the transducer can easily follow during a short period of time a current of 1000 A peak, and, even 3000 A peak (during 1 ms) with a di/dt of 150 A/µs, thanks to its current transformer effect (the specifications given into the data sheet can not be guaranteed for these measurements).

Execution of an auto-reset system occurs after the overload. A few seconds are then required to reset the transducers back to their normal operation state (please see the previous figures).

The ITB 300-S allows peak measurements up to +/- 450 A, conforming to the specifications in the datasheet.

When using the IT models, the sensors are fully operational until 110 % of their nominal value and will not be damaged but, under these conditions (> 100%), the specifications given into their data sheets can not be guaranteed.

Advice for Installation

To reduce the level of output noise, LEM recommends to make a connection between pin 4, the electrostatic shield and the cable shield external to the transducers (IT 400-S and IT 700-S).

To avoid disturbances coming from adjacent external conductors, it is also advised to locate these conductors at a certain minimum distance from the products. For IT 400-S and IT 700-S, distances of 75 mm and 70 mm respectively, from the center of the transducer's apertures. This has been defined as a minimum distance before locating adjacent conductors potentially affecting the performance.
All three transducers are equipped with an electrostatic shield built inside the case to ensure the best immunity against the external electrostatic fields. A shielded output cable and plug are nevertheless advised to be used to ensure maximum immunity.

Common Mode Transient Behavior (dv/dt)

Fast voltage changes during commutation of power semiconductors lead to disturbances of components within the current transducer. These disturbances are due to the capacitive currents generated between the primary conductor and the electronic circuit of the transducer and are superimposed to the output transducer signal.

IT and ITB models can nearly be defined as being insensitive to dv/dt. Indeed, a voltage change of 5 kV (ITB

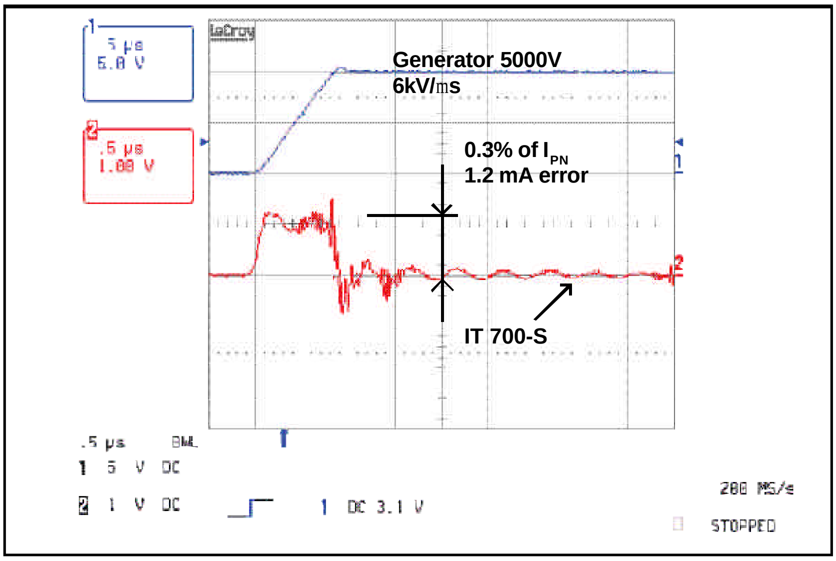


Fig 15. IT 700-S : Behaviour against dv/dt=6 kV/ms, 5000 V applied-Rm=1kW.

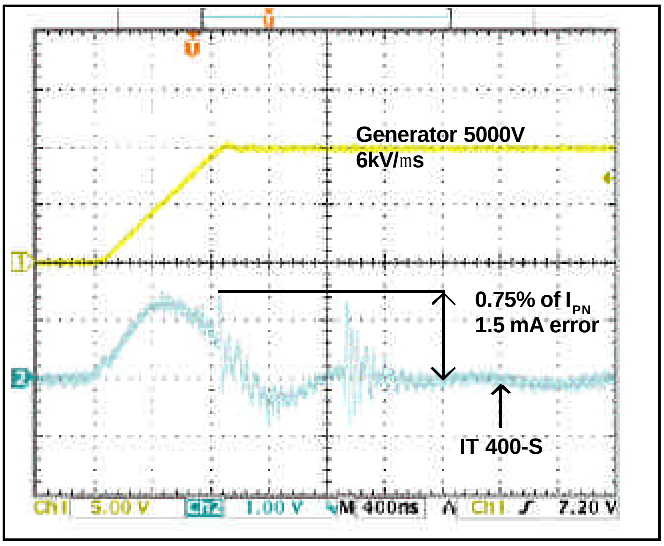


Fig 16. IT 400-S : Behaviour against dv/dt=6 kV/ms, 5000 V applied-Rm=1kW.

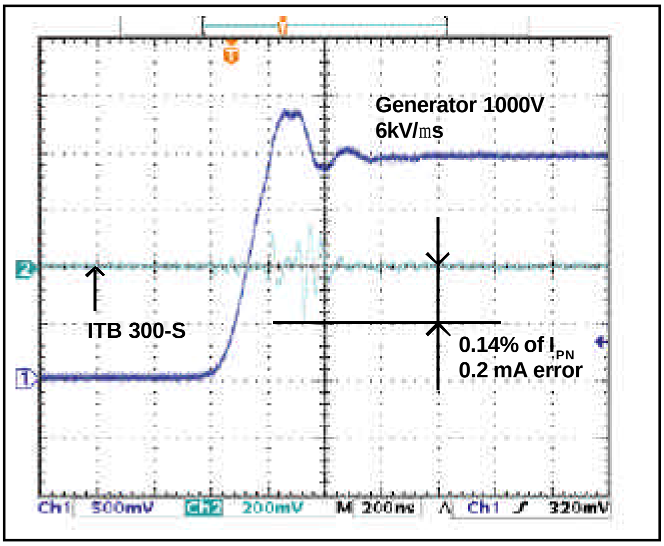


Fig 17. ITB 300-S : Behaviour against dv/dt=6 kV/ms, 1000 V applied-Rm=1kW.

300-S tested at 1 kV. *(ps : The peak voltage applied doesn't influence the disturbance produced)* applied with a dv/dt of 6 kV/µs, causes only an error of 0.3 % of I_{PN} for the IT 700-S model (0.75 % for IT 400-S and 0.14 % for ITB 300-S) (Figures 15,16 & 17).

Excellent Dynamic Performance

IT and ITB models react so quickly to a current step that it is difficult to establish exactly their response times at 90 % of I_{PN}. For instance, less than 250 ns as response times at 90 % of I_{PN} is a fact (Figures 18, 19 & 20).

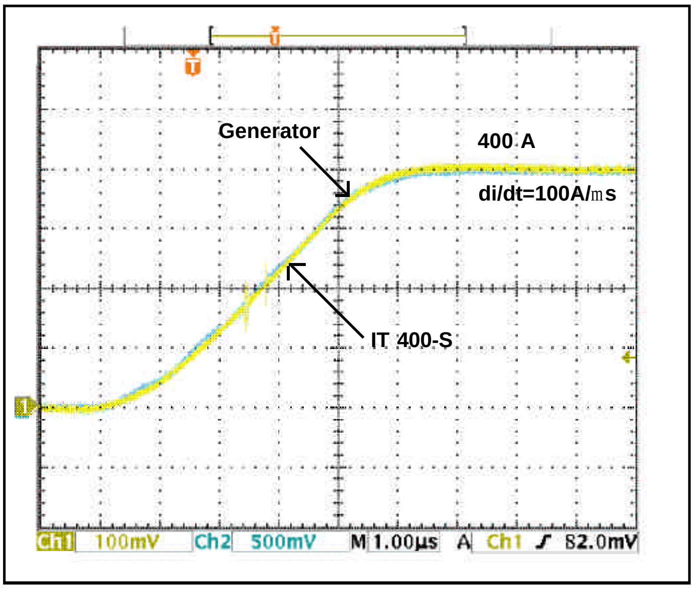


Fig 18. IT 400-S : Response time @ 90% of I_{PN} (I_P=400 A, di/dt=100A/ms)Rm=10W.

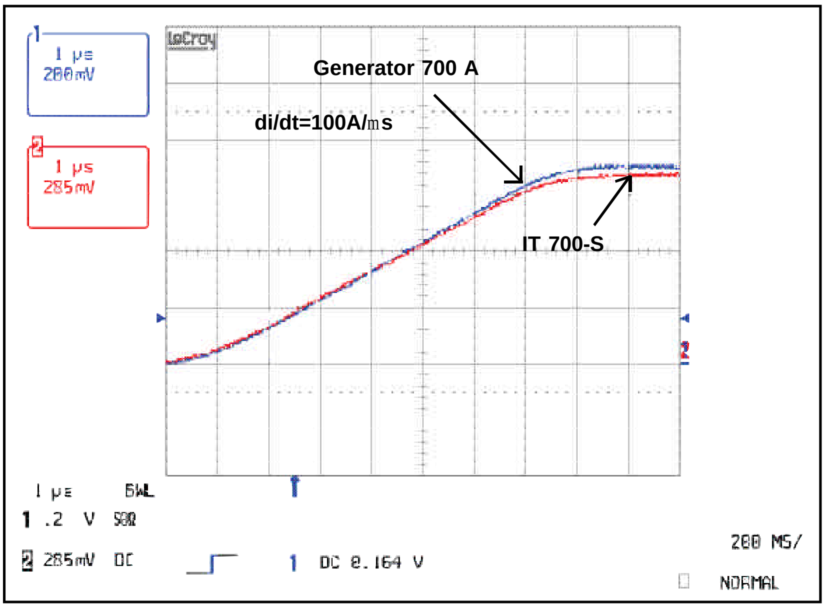


Fig 19. IT 700-S : Response time @ 90% of I_{PN} (I_P=700 A,di/dt=100A/ms)Rm=2.5W.

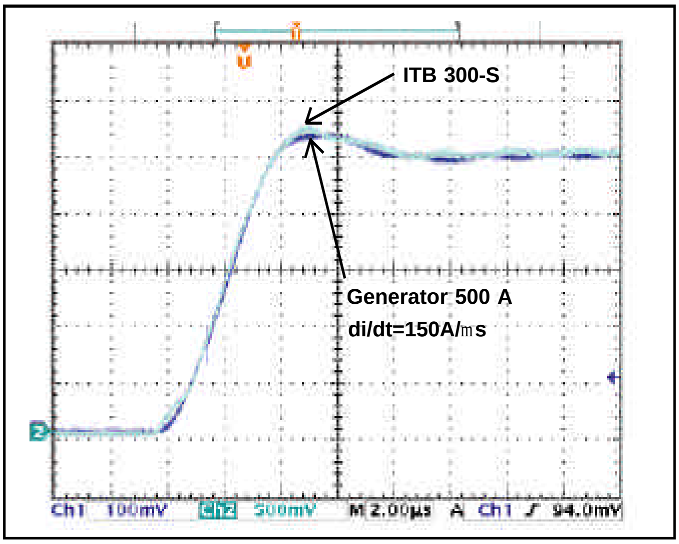


Fig 20. ITB 300-S : Response time @ 90% of I_P=500 A (di/dt=150A/ms)Rm=10W.

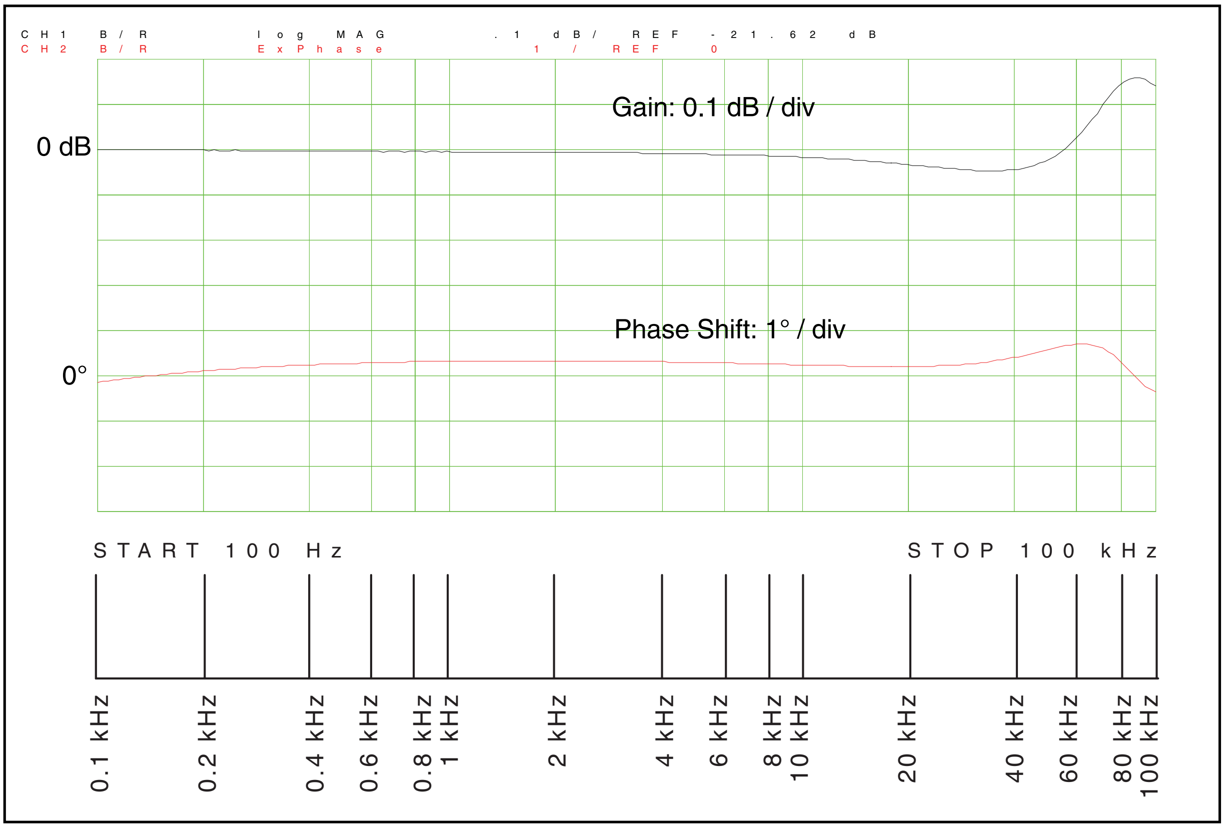


Fig 21. Frequency and phase response of the IT 400-S (10A sinusoidal).

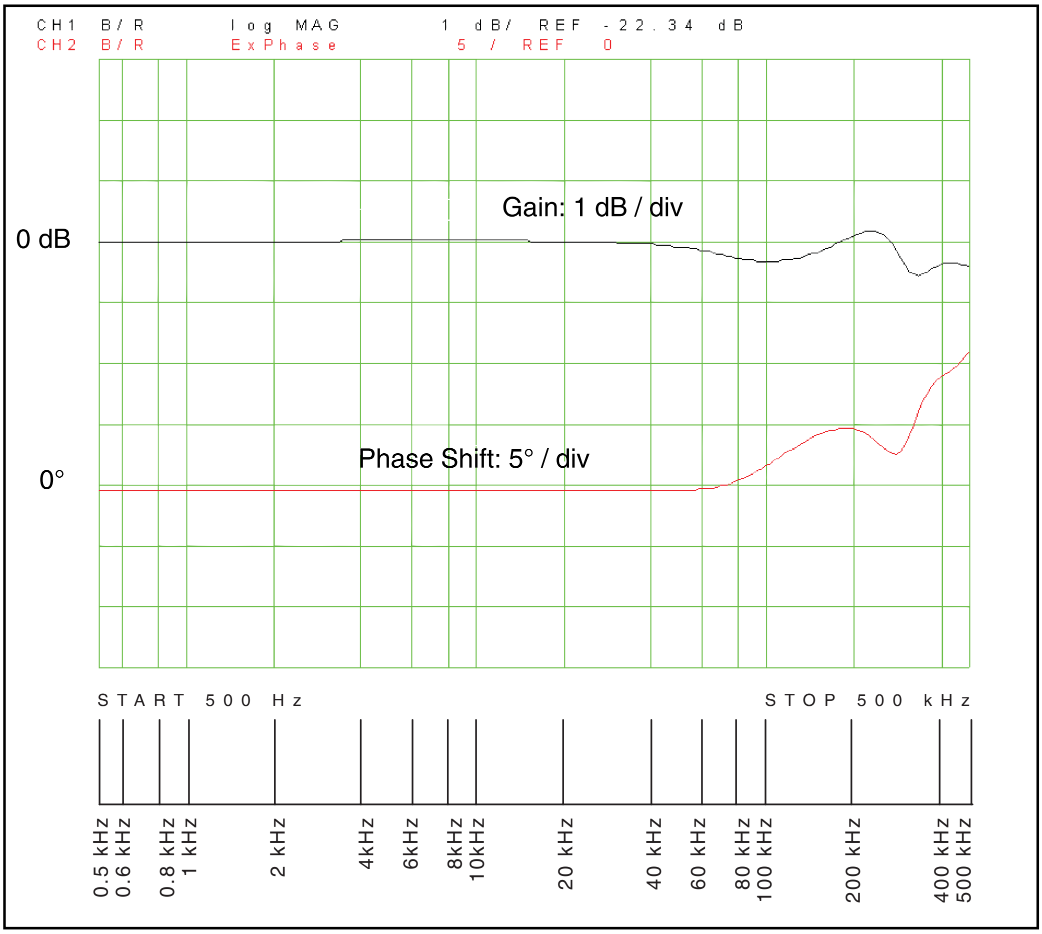


Fig 22. Frequency and phase response of the IT 700-S (10A sinusoidal).

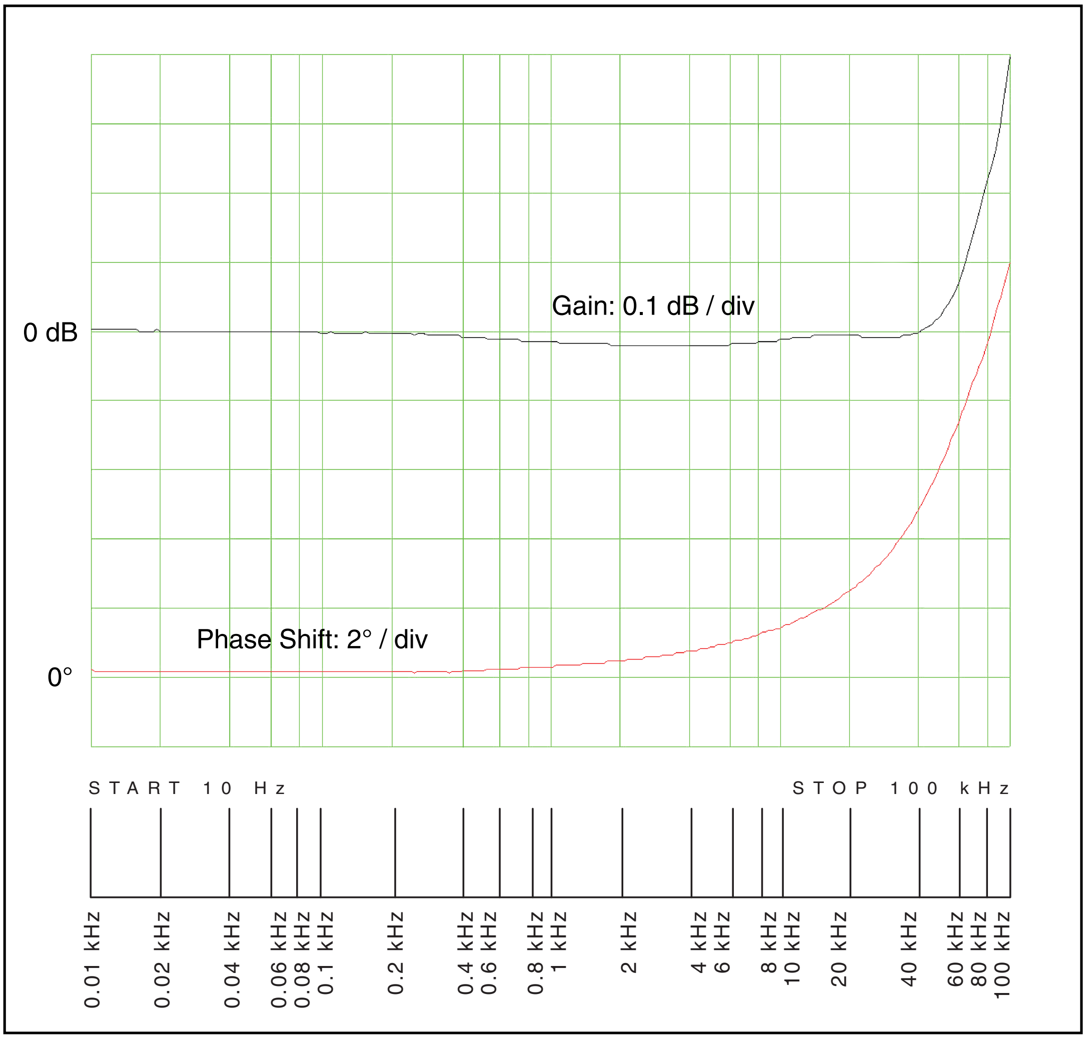


Fig 23. Frequency and phase response of the ITB 300-S (300A peak sinusoidal).

This performance contributes amply to wide bandwidths (Figures 21, 22 & 23).

Standards

The transducers are all CE marked, in accordance with the European EMC Directive 89/336/EEC and thus, satisfy the derived local EMC regulations. They also conform to EN 61010-1 for the safety requirements.

Conclusion

Each of these compact models allows a dual mounting possibility, horizontal or vertical, making them really versatile to the various applications.

The LEM IT/ITB transducers provide an analogue current output burdened by an external precision resistor, a resistor selected in a way not to corrupt the transducers performances.

IT or ITB products can bring the required solution to industrial, traction or laboratory applications. Often, the requirements are to get highly accurate transducers but less expensive and with some performances less “accurate” but still of a high level and more adapted to the industrial world. This is exactly the “raison d’être” of the ITB 300-S model.
A two-year warranty is proposed for all these models.

LEM - At the heart of power electronics.

High Accuracy and Stability Current Transducers

ITB 300-S I_{PN} = **300 A**
IT 400-S I_{PN} = **400 A**
IT 700-S I_{PN} = **700 A**

For the electronic measurement of currents : DC, AC, pulsed..., with a galvanic isolation between the primary circuit (high power) and the secondary circuit (electronic circuit).

Electrical data

Primary nominal r.m.s. current I_{PN} (A)	Primary current measuring range I_P (A) @ ± 15 V	Type
300	± 450	**ITB 300-S**
400	± 400	**IT 400-S**
700	± 700	**IT 700-S**

			ITB 300-S	**IT 400-S**	**IT 700-S**	
$\hat{I}_P$	Max overload capability [1]		± 3000/10ms	±2000/100ms	±3500/100ms	A
R_M	Measuring resistance	$R_{M\,min}$	0 (T_A=+85°C, I_P=±450A)	0 (T_A=+10..+50°C, I_P=±400A)	0 (T_A=+10..+50°C, I_P=±700A)	Ω
	@ V_C = ± 15 V	$R_{M\,max}$	5 (T_A=+85°C, I_P=±450A)	10 (T_A=+10..+50°C, I_P=±400A)	2.5 (T_A=+10..+50°C, I_P=±700A)	Ω
I_{SN}	Secondary nominal r.m.s. current		150	200	400	mA
K_N	Conversion ratio		1 : 2000	1 : 2000	1 : 1750	
V_C	Supply voltage (± 5 %)		± 15	± 15	± 15	V
I_C	Current consumption @ ± 15 V		< ± 90 + I_s	< ± 50 + I_s	< ± 70 + I_s	mA

Accuracy - Dynamic performance data

		ITB 300-S	IT 400-S	IT 700-S	
X_G	Overall accuracy @ I_{PN} , T_A = 25°C	<± 0.05	<±0.0033	<±0.0053	%
ε_L	Linearity error [2]	<0.001 %	<3	<3	ppm
		Max	Max	Max	
I_O	Offset current @ I_P = 0, T_A = 25°C	± 0.1 mA	<30[2]	<50[2]	ppm
TCI_O	Offset current drift temperature coefficient	<1 µA/K	<0.5[2]	<0.5[2]	ppm / K
t_r	Response time @ 90 % of I_{PN} [3]	<1 µs	<250	<250	ns
di/dt	di/dt accurately followed	>100	>100	>100	A / µs
f	Frequency bandwidth	DC .. 100 [4]	DC .. 100 [5]	DC .. 100 [6]	kHz

General data

		ITB 300-S	IT 400-S	IT 700-S	
T_A	Ambient operating temperature	-40 .. +85	+10 .. +50	+10 .. +50	°C
T_S	Ambient storage temperature	-45 .. +85	-20 .. +85	-20 .. +85	°C
R_S	Secondary coil resistance	31@ +85°C	51.2 @ +50°C	22.3 @ +50°C	Ω
m	Mass	0.49	0.5	0.8	kg
	Standards	EN 50178 : 1997 EN 50155 : 2001			
	UL 94 Classification	VO	VO	VO	

Notes :
1) Transducer may needs a few seconds to comeback to «Normal operation» state when autoreset system is running.
2) Refer to nominal.
3) With a di/dt ≥ 100 A / µs.
4) -3 dB with limited amplitude.
5) 10 A sinusoidal, -0.6 dB, 5 Ω as measuring resistor.
6) 10 A sinusoidal, -0.5 dB, 2.5 Ω as measuring resistor.

Isolation characteristics

		ITB 300-S	IT 400-S	IT 700-S	
V_d	R.m.s. voltage for AC isolation test, 50 Hz, 1 mn	5.3 [7]	5 [7]	5 [7]	kV
		1 [8] kV	0.2 [8] kVDC	0.2 [8]	kVDC
$\hat{V}_w$	Impulse withstand voltage 1.2/50 µs	10.8	8	8	kV
		Min	Min	Min	
V_e	R.m.s. voltage for partial discharge extinction @ 10 pC	2.2 [9]	1.52	1.51	kV
		Min	Min	Min	
dCp	Creepage distance	12.2 [10]	11	9	mm
dCI	Clearance distance	12.2 [10]	11	9	mm
CTI	Comparative Tracking Index (Group I)	600	600	600	V

Application examples

According to EN 50178 and CEI 61010-1 standards and following conditions :

- Overvoltage category OV3
- Pollution degree PD2
- Heterogeneous field.

	EN 50178			IEC 61010-1		
dCp, dCI, $\hat{V}_w$	Rated isolation voltage			Nominal voltage		
Model	ITB 300-S	IT 400-S	IT 700-S	ITB 300-S	IT 400-S	IT 700-S
Single Isolation	1600 V	1420 V	1140 V	2000 V	2000 V	1600 V
Reinforced isolation	880 V	800 V	660 V	770 V	650 V	500 V

Notes : [7] Between primary and secondary + shield.
[8] Between secondary and shield.
[9] Test carried out with a busbar ∅ 19 mm centered in the through-hole. With a busbar ∅ 21.5 mm (contact between busbar and housing) the min value is reduced to 1 kV.
[10] See outline drawing.

Features

- Closed loop (compensated) current transducer using fluxgate technology
- D-Sub 9 pole male output interface connector
- Output indicates the transducer state
- LED shows normal operation (IT 400-S & IT 700-S).

Advantages

- Excellent linearity
- High accuracy over high bandwidth
- Very low output noise
- Very low offset drift
- Optimized response time
- No insertion losses
- High immunity to external interference
- Current overload capability
- Autoreset after overload [1].

Applications

- High precision power supplies
- Calibration unit
- Precise and high stability inverters
- Energy measurement
- Medical equipment
- High performance gradient amplifiers for MRI.

Application domain

- Industrial & Traction (ITB 300-S)

Safety

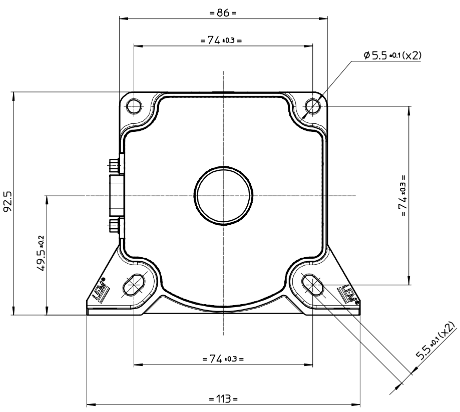
This transducer must be used in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the following manufacturer's operating instructions.

Caution, risk of electrical shock

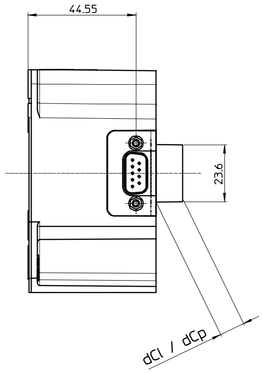
When operating the transducer, certain parts of the module can carry hazardous voltage (eg. primary busbar, power supply).
Ignoring this warning can lead to injury and/or cause serious damage.
This transducer is a built-in device, whose conducting parts must be inaccessible after installation.
A protective housing or additional shield could be used.
Main supply must be able to be disconnected.

Dimensions ITB 300-S (in mm. 1 mm = 0.0394 inch)

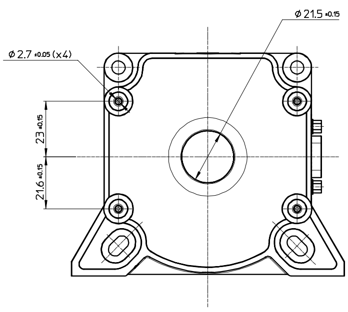
Front view

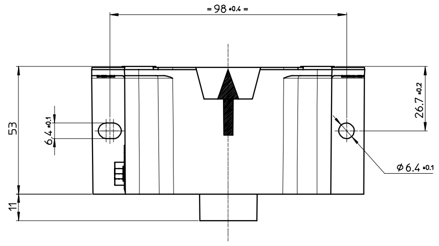


Left view



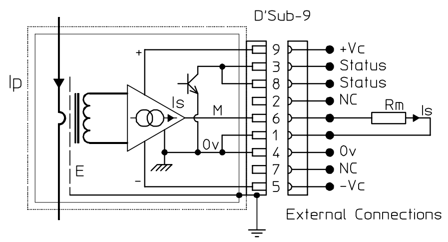
Rear view





Top view

Connection

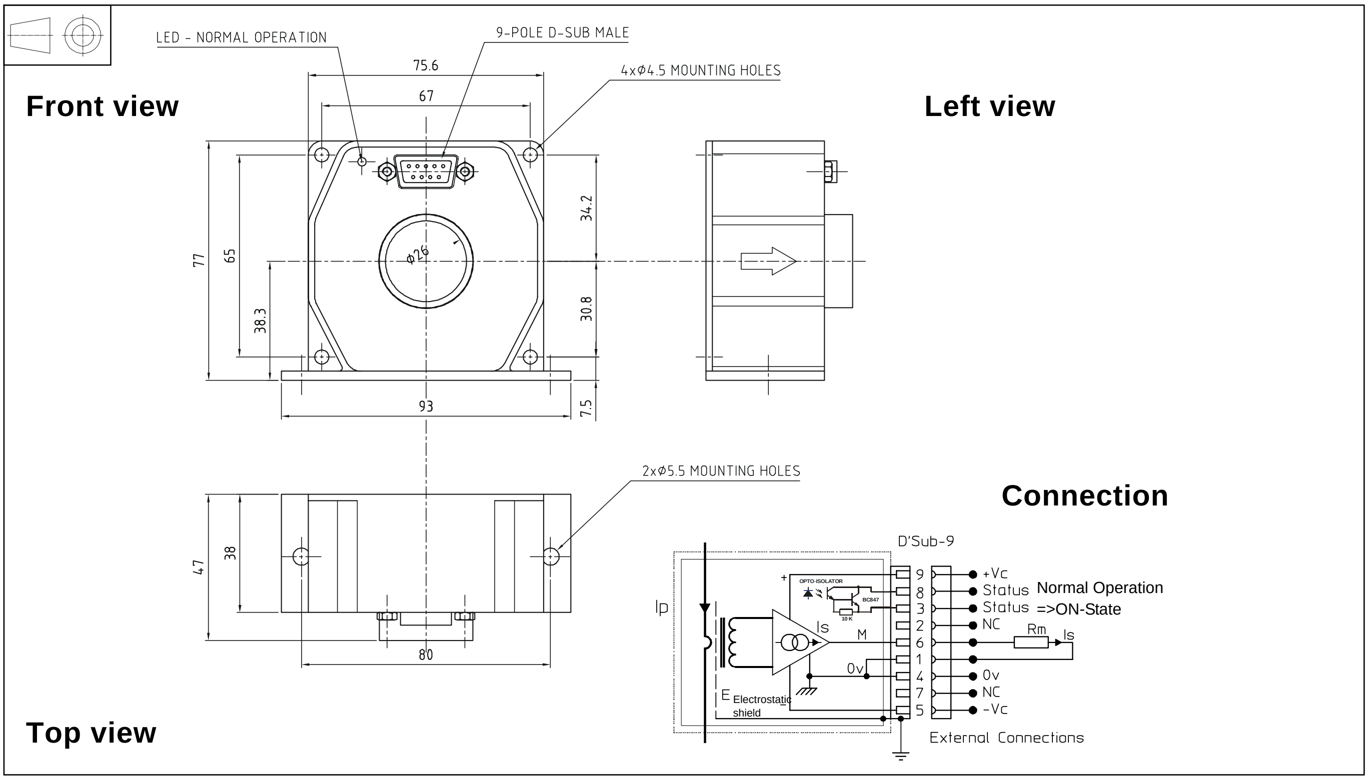


Status Output	**ITB 300-S**	**IT 400-S**	**IT 700-S**	
	Normal operation indicator : open collector, active low (Normal operation)			
Max. input Collector current	40 mA	-	-	
Max. Collector - Emitter voltage	50 V	-	-	
Fault level (off-state)	-	I_P>110	I_P>110	%
Max. voltage pin 8 to pin 3, off-state	-	45	100	V
Max. current pin 8 to pin 3, on-state	-	0.03	1	A
Reverse voltage pin 8 to pin 3, off-state	-	5	-	V
On-voltage pin 8 to pin 3, I = 5 mA	-	max. 1	-	V
Contact resistance pin 8 to pin 3	-	-	typ. 50	mΩ
Test voltage secondary (pin 4) to pin 8	-	300	500	VDC

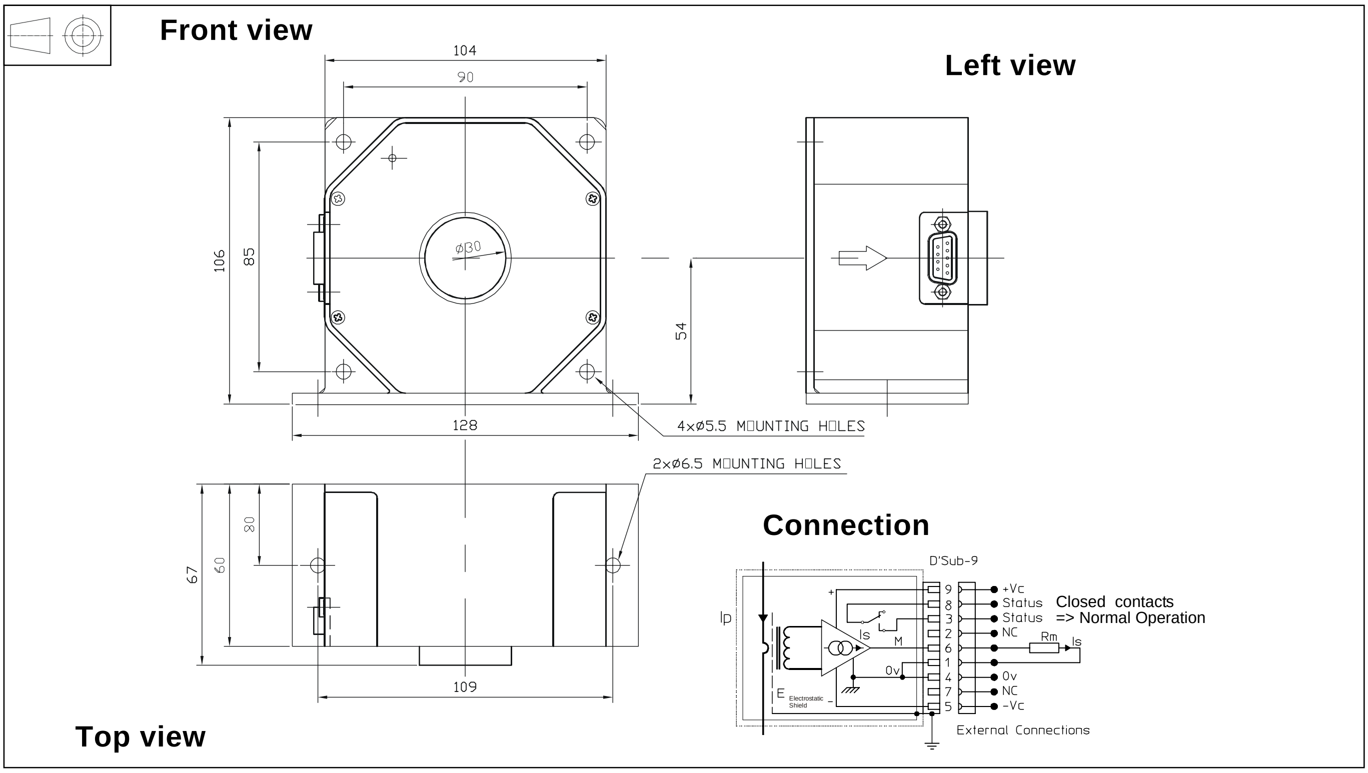
Mechanical Characteristics	**ITB 300-S**	**IT 400-S**	**IT 700-S**	
• General tolerance	± 1	± 0.3	± 0.3	mm
• Transducer fastening				
- Flat 1	4 x M5 steel screws	4 holes ∅ 4.5 mm 4 x M4 steel screws	4 holes ∅ 5.5 mm 4 x M5 steel screws	
Recommended fastening torque	3.4 Nm or 2.5 Lb.-Ft.	2.8 Nm or 2.07 Lb.-Ft.	3.7 Nm or 2.73 Lb.-Ft.	
- Flat 2	4 x PTKA30 steel screws	-	-	
Recommended fastening torque	1 Nm or 0.74 Lb.-Ft. @10 mm penetration	- -	- -	
- Upright	2 x M6 steel screws	2 holes ∅ 5.5 mm 2 x M5 steel screws	2 holes ∅ 6.5 mm 2 x M6 steel screws	
Recommended fastening torque	4.5 Nm or 3.3 Lb.-Ft.	3.7 Nm or 2.73 Lb.-Ft.	4.4 Nm or 3.25 Lb.-Ft.	
• Primary through hole	∅ ⩽ 21.5	∅ ⩽ 26	∅ ⩽ 30	mm

• All mounting recommendations are given for a standard mounting : Screws with flat and spring washers

Dimensions IT 400-S (in mm. 1 mm = 0.0394 inch)



Dimensions IT 700-S (in mm. 1 mm = 0.0394 inch)



Remarks

- I_S is positive when I_P flows in the direction of the arrow.
- Temperature of the primary conductors should not exceed 100°C (ITB 300-S) / 65°C (IT 400-S & IT 700-S).
- Transducer needs to be connected with a shielded secondary cable to comply with EN 50155 standard (ITB 300-S).

LEM International Sales Representatives

Europe • Middle East

Austria
LEM Components
Am Concorde Park 2
A-2320 Schwechat
Tel. +43 1 903 60 10 40
Fax +43 1 903 60 10 42
e-mail: jsc@lem.com

Belarus and Baltic Republics
DACPOL Co. Ltd.
Ul. Pulawska 34
PL-05-500 Piaseczno K. Warszawy
Tel. +48 22 7500868
Fax +48 22 7035101
e-mail: dacpol@dacpol.com.pl

BeNeLux
LEM Belgium sprl-bvba
Route de Petit-Roeulx, 95
B-7090 Braine-le-Comte
Tel. : +32 67 55 01 14
Fax : +32 67 55 01 15
e-mail : lbe@lem.com

Croatia
Proteus Electric
Via di Noghere 94/1
I-34147 Muggia-Aquilinia
Tel. +39 040 23 21 88
Fax +39 040 23 24 40
e-mail: dino.fabiani@proteuselectric.it

Czech Republic
PE & ED Spol. S.R.O.
Koblovska 101/23
CZ-71100 Ostrava/Koblov
Tel. +420 59 6239256
Fax +420 59 6239531
e-mail: peedova@peed.cz

Denmark
Motron A/S
Torsovej 4
DK-8240 Risskov
Tel. +45 87 36 86 00
Fax +45 87 36 86 01
e-mail: motron@motron.dk

Finland
Etra-Dielectric Oy
Lampputie 2
SF-00741 Helsinki
Tel. +358 207 65 160
Fax +358 207 65 23 11
e-mail: markku.soittila@etra.fi

Field Applications Engineer
Dominique Roggo
Tel. +358 40 564 22 91
e-mail: dro@lem.com

France
LEM France Sarl
La Ferme de Courtaboeuf
19 avenue des Indes
F-91969 Courtaboeuf Cedex
Tel. +33 1 69 18 17 50
Fax +33 1 69 28 24 29
e-mail: lfr@lem.com

Germany
Central Office:
LEM Deutschland GmbH
Frankfurter Strasse 74
D-64521 Gross-Gerau
Tel. +49 6152 9301 0
Fax +49 6152 8 46 61
e-mail: postoffice.lde@lem.com

Hauber & Graf Electronics GmbH
Bavaria / Baden Württemberg
Wahlwiesenstr. 3
D-71711 Steinheim
Tel: +49 7144 28 15 03/04
Fax: +49 7144 28 15 05
e-mail: electronics@hauber-graf.de

Hungary
Orszaczky Trading LTD.
Korányi Sandor U, 28
H-1089 Budapest
Tel. +36 1 314 4225
Fax +36 1 324 8757
e-mail: orszaczky@axelero.hu

Italy
LEM Italia Srl
via V. Bellini, 7
I-35030 Selvazzano Dentro, PD
Tel. +39 049 805 60 60
Fax +39 049 805 60 59
e-mail: lit@lem.com

Israel
Ofer Levin Technological Application
PO Box 18247
IL- Tel Aviv 611 81
Tel.+972 3 5586279
Fax +972 3 5586282
e-mail: ol_teap@netvision.net.il

Norway
Holst & Fleischer A/S
Stanseveien 6B
N-0975 Oslo
Tel. +47 2333 8500
Fax +47 2333 8501
e-mail: knut@hf-elektro.no

Poland
DACPOL Sp. z o.o.
Ul. Pulawska 34
PL-05-500 Piaseczno K. Warszawy
Tel. +48 22 7500868
Fax +48 22 7035101
e-mail: dacpol@dacpol.com.pl

Portugal
QEnergia, Lda
Praceta Cesário Verde - 10 S/Cave
P-2745-740 Massamá
Tel. +351 214 309320
Fax +351 214 309299
e-mail: qenergia@qenergia.pt

Romania
SYSCOM -18 Srl.
Protopopescu 10, bl. 4. ap 2
Sector 1
R-011728 Bucharest
Tel. +40 21 310 26 78
Fax +40 21 310 26 79
e-mail: georgeb@syscom.ro

Russia
Central Office:
TVELEM
Marshall Budionny Str.11
170023 Tver / Russia
Tel. +7 822 44 40 53
Fax +7 822 44 40 53
e-mail: tvelem@lem.com

TVELEM
Leningradski Avenue, d. 80
Korp. 32, 3d floor, room 19.
125190 Moscow
Tel. +7 095 363 07 67
Fax +7 095 363 07 67
e-mail: tvelem@lem.com

TVELEM
V.O., 2 linia, 19, Liter „A"
199053 S. Petersburg
Tel. +7 812 323 83 83
Fax +7 812 323 83 83
e-mail: tvelem@lem.com

Slovenia
Proteus Electric
Via di Noghere 94/1
I-34147 Muggia-Aquilinia
Tel. +39 040 23 21 88
Fax +39 040 23 24 40
e-mail: dino.fabiani@proteuselectric.it

Spain
LEM Components
Apartado 142
E-08500 VIC
Tel. +34 93 886 02 28
Fax +34 93 886 60 87
e-mail: slu@lem.com

AVANZEL COMPONENTES, S.L.
Madrid region
Avda. Sancho Rosa 66
E-28708 San Sebastián de los Reyes
Tel. +34 91 6236828
Fax +34 91 6236702
e-mail: ventas@avanzel.com

Sweden
Beving Elektronik A.B.
Jägerhorns väg 8
S-14105 Huddinge
Tel. +46 8 6801199
Fax +46 8 6801188
e-mail: information@bevingelektronik.se

Switzerland
SIMPEX Electronic AG
Binzackerstrasse 33
CH-8622 Wetzikon
Tel. +41 1 931 10 10
Fax +41 1 931 10 11
e-mail: contact@simpex.ch

LEM SA
8, Chemin des Aulx
CH-1228 Plan-les-Ouates
Tel. +41 22 706 11 11
Fax +41 22 794 94 78
e-mail: lsa@lem.com

Turkey
Özdisan Electronik Pazarlama
Galata Kulesi Sokak N° 34
TR-80020 Kuledibi / Istanbul
Tel. +90 212 2499806
Fax +90 212 2436946
e-mail: oabdi@ozdisan.com

Ukraine
"SP DAKPOL" OOO
Maksima Berlinskogo str. 4
UA-04060, KIEV, UKRAINE
Tel. +380 44 501 93 44
Fax +380 44 456 68 58
e-mail: kiev@dacpol.com

United Kingdom and Eire
LEM UK Ltd
West Lancs Investment Centre
Whitemoss Business Park
Skelmersdale, Lancs WN89TG
Tel. +44 1 695 71 25 60
Fax +44 1 695 71 25 61
e-mail: luk@lem.com

Africa • America

Brazil
AMDS4 Imp. Exp. e Com. de Equip. Electr. Ltda.
Rua Doutor Ulhôa Cintra, 489, Centro 13800-061 - Moji Mirim - Sao Paulo - Brazil
Tel. +55 19 3806 1950 / 8509
Fax +55 19 3806 8422
e-mail: jeduardo@amds4.speedycorp.com.br

Canada
Optimum Components Inc.
7750 Birchmount Road Unit 5
CAN-Markham ON L3R 0B4
Tel. +1 905 477 9393
Fax +1 905 477 6197
e-mail: mikep@optimumcomponents.com

Chile
ELECTROCHILE
Freire 979 of. 303-304
Quilpue
Tel. +56 32 92 32 22
Fax +56 32 92 32 22
e-mail: elechile@entchile.net

South Africa
Denver Technical Products Ltd.
P.O. Box 75810
SA-2047 Garden View
Tel. +27 11 626 20 23
Fax +27 11 626 20 09
e-mail: denvertech@pixie.co.za

U.S.A
Central Office:
LEM U.S.A., Inc.
6643 West Mill Road
USA Milwaukee, Wi 53218
Tel. +1 414 353 07 11
Toll free: 800 236 53 66
Fax +1 414 353 07 33
e-mail: lus@lem.com

LEM U.S.A., Inc
999, Pennsylvania Ave.
USA-Columbus, OH 43201
Tel. +1 614 298 84 34
Fax +1 614 540 74 36
Mobile +1 614 306 73 02
e-mail: afg@lem.com

LEM U.S.A., Inc.
27 Rt 191A
PO Box 1207
USA-Amherst, NH 03031
Tel. +1 603 672 71 57
Fax. +1 603 672 71 59
e-mail: gap@lem.com

LEM U.S.A., Inc.
7985 Vance Drive
USA Arvada, CO 80003
Tel. +1 303 403 17 69
Fax. +1 303 403 15 89
e-mail: dlw@lem.com

Asia • Pacific

Australia and New Zealand
Fastron Technologies Pty Ltd.
25 Kingsley Close
Rowville - Melbourne - Victoria 3178
Tel. +61 39 763 51 55
Fax +61 39 763 51 66
e-mail: sales@fastron.com.au

China
Beijing LEM Electronics Co. Ltd
No. 1 Standard Factory Building B, Airport Industrial Area, Beijing, China
Post code : 101300
Tel. +86 10 80 48 31 78
Fax +86 10 80 48 43 03
e-mail: bjl@lem.com

India
Globetek
122/49, 27th Cross
7th Block, Jayanagar
IN-Bangalore-560082
Tel. +91 80 2 663 57 76
Fax +91 80 2 653 40 20
e-mail: globetek@vsnl.com

Japan
NANALEM K.K.
2-1-2 Nakamachi
J-194-0021Tokyo
Tel. +81 42 725 8151
Fax +81 42 728 8119
e-mail: nle@lem.com

Korea
Youngwoo Ind. Co.
C.P.O. Box 10265
K-Seoul
Tel. +82 2 312 66 88 58
Fax +82 2 312 66 88 57
e-mail: c.k.park@ygwoo.co.kr

Malaysia
Acei Systems SDN BHD
No. 3, SB Jaya 7
Taman Industri SB Jaya
47000 Sungai Buloh
Selangor, Malaysia
Tel. +60 36157 85 08/55 08
Fax +60 3615715 18
e-mail: ssbhullar@aceisys.com.my

Singapore
Overseas Trade Center Ltd.
03 - 168 Bukit Merah L. 1
BLK 125/Alexandra Vil
RS-150125 Singapore
Tel. +65 6 272 60 77
Fax +65 6 278 21 34
e-mail: octpl@signet.com.sg

Taiwan
Tope Co., Ltd.
3F-4, 716 Chung Cheng Road
Chung Ho City, Taipei County, Taiwan 235, R.O.C
Tel. +886 2 8228 0658
Fax +886 2 8228 0659
e-mail: tope@ms1.hinet.net

POWERTRONICS CO. LTD
2F, No 138, Sec. 3
Chung-shin Rd, Shing-Tien, Taipei -Hsien 231, Taiwan, R.O.C.
Tel. +886 2 2915 7000
Fax +886 2 2915 3910
e-mail: powertro@ms22.hinet.net

LEM Components
8, Chemin des Aulx, CH-1228 Plan-les-Ouates
Tel. +41/22/706 11 11, Fax +41/22/794 94 78
e-mail: lsa@lem.com; www.lem.com

Distributor

Publication CH 25106 E/US (12.05 • 2.5/1.5 • CDH)