High Precision Current
Transducers Catalogue

High Precision Current Transducers

LEM

LEM solutions for High Precision current measurement IT Current Transducers:

Setting the benchmark for accurate current measurement

This catalog summarizes the most common LEM product offerings for highly-accurate electrical current measurements for industrial and laboratory applications. It is LEM's business to provide you with both standard and customized products and solutions optimized to your specific needs and requirements.

Certain power-electronics applications require such high performance in accuracy, drift and/or response time that is necessary to switch to other technologies to achieve these goals. The validation of customer equipment is made through recognized laboratories using high-performance test benches supported by high-technology equipment including extremely accurate current transducers. These transducers are still in need today for such traditional applications but are more and more in demand in high-performance industrial applications, specifically medical equipment (scanners, MRI, etc.), precision motor controllers, and metering or accessories for measuring and test equipment. LEM has been the leader for years in producing transducers with high performance and competitive costs for these markets. The 2009 acquisition of the Danish company, Danfysik ACP A/S, as being the world's leader in the development and manufacturing of very-high precision current transducers reinforces this position.

To achieve this challenging target of accuracy and performance, LEM's IT current transducers do not use the Hall Effect but are based upon Flux-gate technology, an established and proven technology we have used for many years and is already the heart of several current and voltage transducer families. Today, LEM uses different versions of Flux-gate technologies, each providing different levels of performance and cost to match the customer's requirements and needs. For the IT family, closed-loop Flux-gate is used as the most efficient and cost effective. Thanks to this technology, we can speak about accuracies in the parts per million (PPMs) of the nominal magnitude and is representative of the performance achieved.

The high-accuracy product range covers transducers for nominal current measurements from 12.5 A to 24 kA while providing overall accuracies at ambient temperatures (25°C) of only a few PPM. Thermal offset drifts are extremely low from only 0.1 to 6.7 PPM/K (per Kelvin). Models from 12.5 to 60 A nominal can be used for PCB-mounting, whereas models from 60 A to 24 kA are intended for panel and/or rack-mounting with either on-board or separate electronics. In addition, the Flux-gate technologies used provide Galvanic isolation for current measurements of all types of waveforms including AC, DC, mixed signal or complex waveform.

Most of the IT transducers feature a round aperture which can accommodate primary conductors of various diameters according to the model used (except the ITN 12-P which uses an integrated primary conductor). In addition to their normal current or voltage outputs, these models offer an output indicating the transducer state (operational status) via normally-open or closed contacts and an external LED (except the ITN 12-P and ITL 4000-S models). ITZ models provide even more features with additional outputs indicating if the measured current is extremely low or high, or if the transducer is in overload, with each of these conditions being supported by a dedicated LED.

The ITB 300-S and ITL 4000-S operate in extended temperature ranges from -40 to 85°C and -40 to 70°C respectively versus the other models of their families, allowing their use in broader applications. Although the ITB uses the same technology as the other IT current transducers, it is positioned at a lower price while still offering a level of performance just slightly lower than the other models of the family.

These products are all equipped with an electrostatic shield built inside the case to ensure their best immunity against external interference. A shielded output cable and plug are advised to ensure the maximum immunity. IT models react very quickly to sudden changes in primary current thanks to their secondary windings working as an excellent current transformer. This feature allows wide bandwidths (up to 800 kHz @ -3dB).

These transducers are all CE compliant and also conform to EN 61010-1 for safety requirements. LEM has ISO 9000 and ISO TS-16949 qualifications globally (ISO 9001:2008 at the Copenhagen, Denmark production and design center) and offers a five (5) year warranty on all of our products. We constantly strive to innovate and improve the performance, cost and size of our products. LEM is a world-wide company with sales offices across the globe and production facilities in Europe (including Russia) and Asia.

We hope you will find this catalog a useful guide for the selection of our products. Visit our Web site at www.lem.com or contact our sales team for further assistance. Detailed data sheets and application notes are available upon request.

Hans Dieter Huber
Vice President Industry

François Gabella
President & CEO LEM

LEM - At the heart of power electronics.

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IT - Fluxgate Technology Principle

For accurate measurement of DC currents, the methods used since the beginning of the 20th century consist in compensating the current linkage Θ_P created by the current I_P to be measured by an opposing current linkage $\Theta\Theta_S$ created by a current I_S flowing through a known number of turns N_S, to obtain (fig. 1):

$\Theta_P - \Theta_S = 0$

or $N_P \cdot I_P - N_S \cdot I_S = 0$

N_P: Number of primary turns

N_S: Number of secondary turns

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

Operation principle

To achieve really accurate compensation of the two opposing current linkages (Θ_P, Θ_S), a detector capable of accurately measuring $\Theta = 0$ must be available, which means that the detector must be very sensitive to small values of a residual magnetic flux ψ (created by the current linkage Θ) in order to achieve the greatest possible detector output signal.

Fluxgate detectors rely on the property of many magnetic materials to exhibit a non-linear relationship between the magnetic field strength H and the flux density B.

The hysteresis cycles of the magnetic cores have a form comparable to the one represented in fig. 2 (more or less square according to the type of material used).

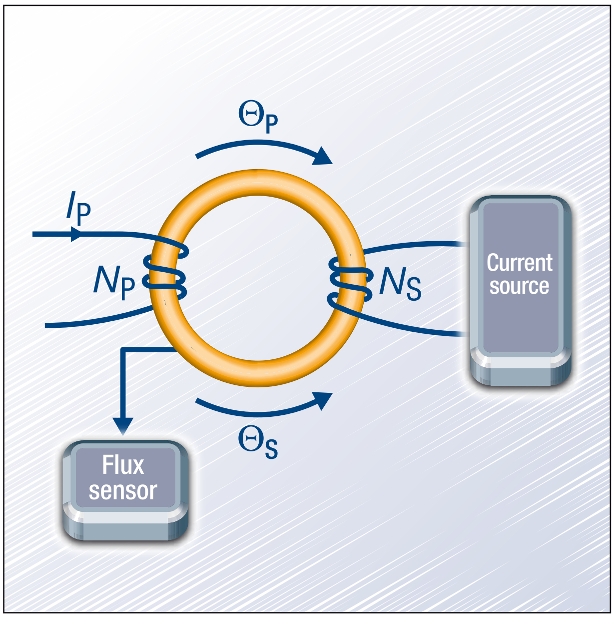


Fig 1. ITxx Fluxgate Technology Principle

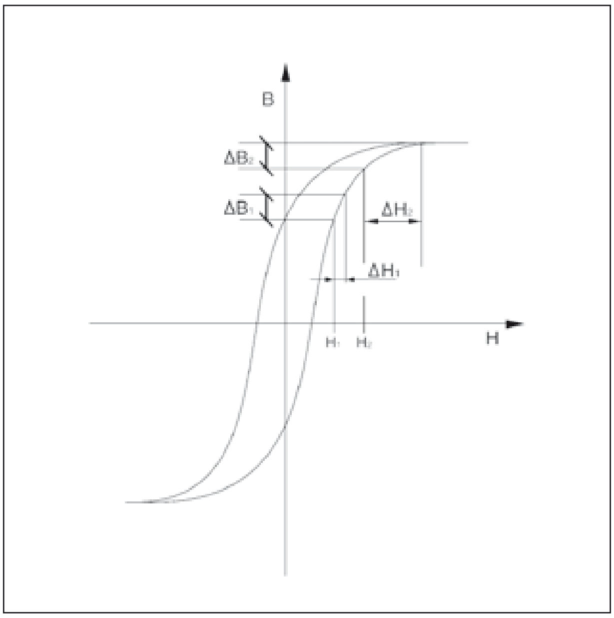


Fig 2. Hysteresis cycles of the magnetic cores

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

Observing $B = f(H)$ on the magnetization curve, notice that for a given field strength H_1 a flux density variation $\triangle B_1$ corresponds to $\triangle H_1$. But, also observe that further along the cycle, for another given field strength H_2, for the same variation $\triangle B_2 = \triangle B_1$, the $\triangle H_2$ variation must be much greater.

The detection of the zero flux condition ($\psi = 0$) is based on this phenomenon.

When applying a square wave voltage (fig. 3a) to a saturable inductor until its magnetic core starts to saturate, a current (fig. 3b) is created. This current flowing through a measuring resistor will provide a symmetric voltage relative to zero with peak values $+\hat{V} = -\hat{V}$.

When a DC current flows through the aperture of the core, the curve of the hysteresis cycle is then shifted causing asymmetry of the current produced by the square wave voltage (fig. 3c) and leading to a measured voltage at the terminals of the resistor where $|+\hat{V}| > |-\hat{V}|$. By using peak detection to measure $+\hat{V}$ and $-\hat{V}$ and by comparing the two peak values, the deviation of the flux in the core is thus detected. As soon as the flux ψ is not zero, an error voltage $|+\hat{V}| - |-\hat{V}|$ is supplied to a power amplifier that drives a current into a compensation winding until $\psi = 0$, thus $|+\hat{V}| = |-\hat{V}|$.

Fig. 4 shows a very simplified base circuit for the compensation of a DC current.

If the primary current $I_P = 0$, the compensation current I_S will be equal to 0. When I_P varies, the flux varies. Therefore, we detect an error $|+\hat{V}| - |-\hat{V}|$ which controls the power amplifier to supply a compensation current I_S until $\psi = 0$, thus:

$$N_S \cdot I_S = N_P \cdot I_P$$

The current I_S flows through a measuring resistor, transforming the current into a proportional voltage.

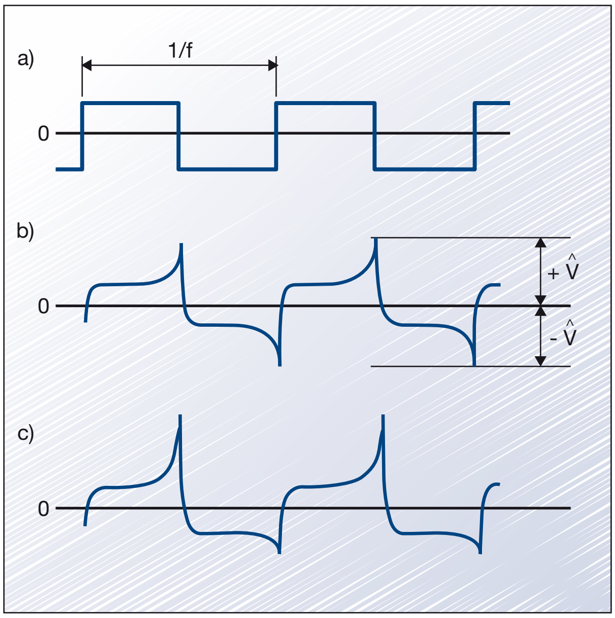


Fig 3. Square wave voltage (3a); Current created (3b); Asymmetry of the created current (3c)

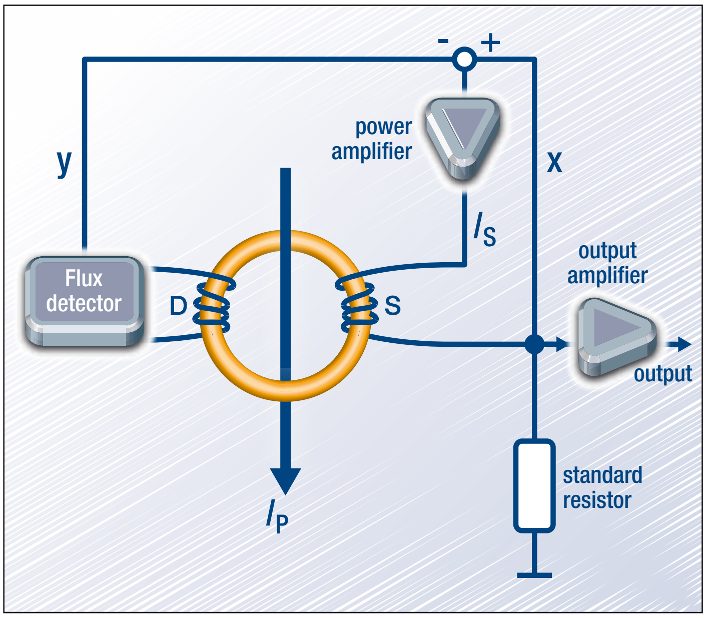


Fig 4. Simplified base circuit for DC current compensation

The accuracy of the measurement will not only depend on the accuracy of the measuring resistor but also strongly 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 (fig. 5):

As the winding “D” of the flux detector is coupled with the compensation winding “S”, the applied square wave voltage is re-injected into the compensation winding and creates a parasitic current in the measurement resistor.

However, the square wave voltage induced in the S winding by this flux may be practically cancelled out when a second D’ winding is mounted on a second detector core (identical to D) inside the compensation winding S. The residual flux (the sum of the opposed fluxes in D and D’) will create very small voltage peaks that cause the remaining signal correlated with the fluxgate excitation (fig. 5 and 6).

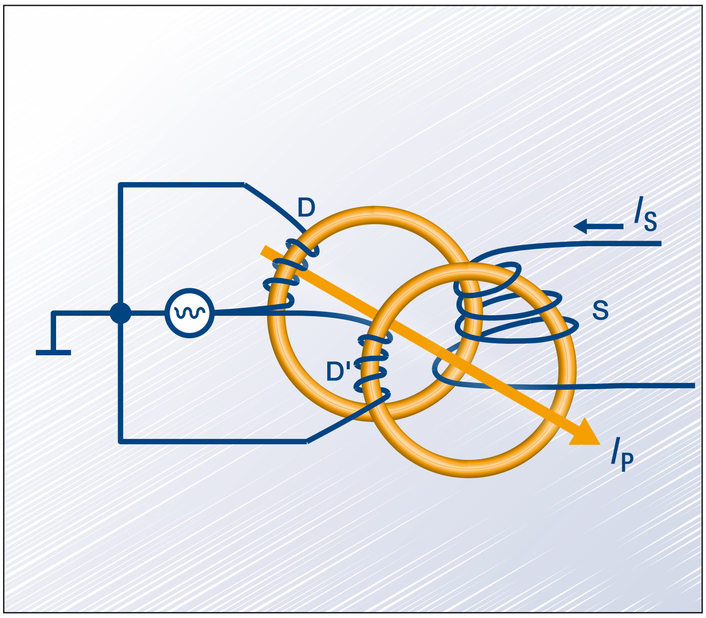


Fig 5. Solution against voltage peaks re-injection

If the application does not need a large bandwidth, the system’s cut-off frequency can be designed to be lower than the excitation frequency of the fluxgates. LEM offers transducers that allow a synchronization of the fluxgate excitation with a user supplied clock to provide a workaround.

We recommend only applying 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. It will further more result in an additional offset.

The magnetic part of the transducer is realized as schematically represented in fig. 6:

A fourth winding W is wound before the compensation winding S on the main core to extend the frequency range of the transformer effect to lower frequencies. It is connected to a circuit that adds some voltage via the power amplifier to compensate the too small induced voltage in a frequency range too high for the fluxgate detector.

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

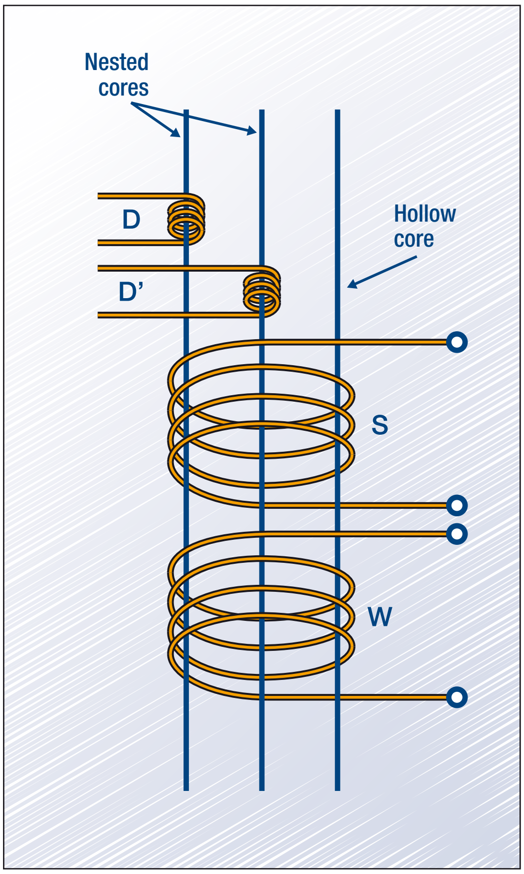


Fig 6. The various windings used and their arrangements

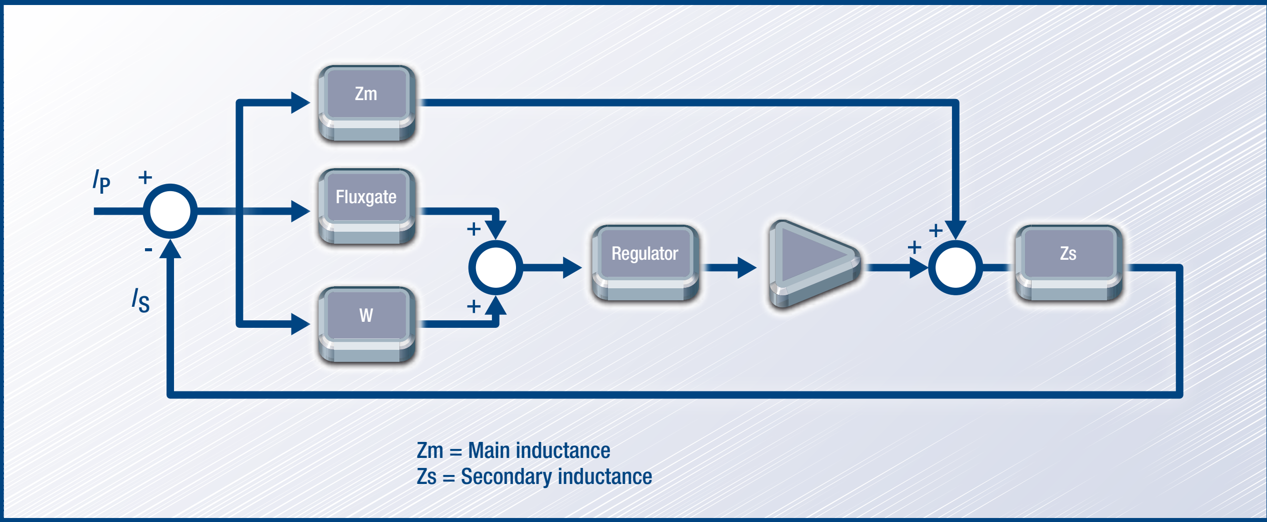
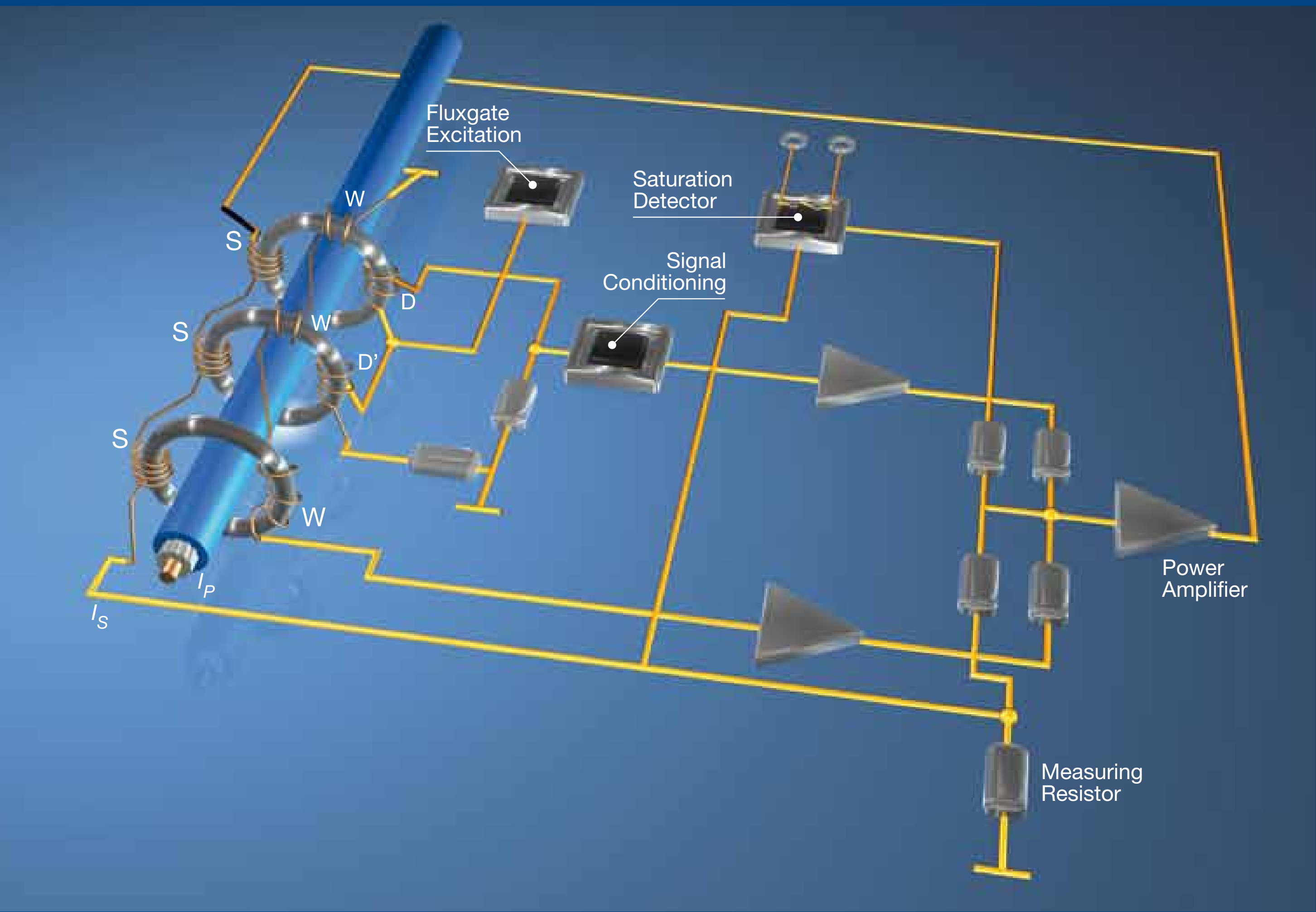


Fig 7. Compensation loop diagram

The simplified overall diagram is shown in fig. 8 and can be directly deduced from the diagram, fig. 7. The saturation detector is activated when the output voltage exceeds its specified range.

ITL 4000 model does not integrate W winding and uses a lower oscillation frequency for the fluxgate excitation. The design of the measuring head is simplified in comparison with the other ITxx models.

Fig 8. ITxx operation principle: simplified overall diagram



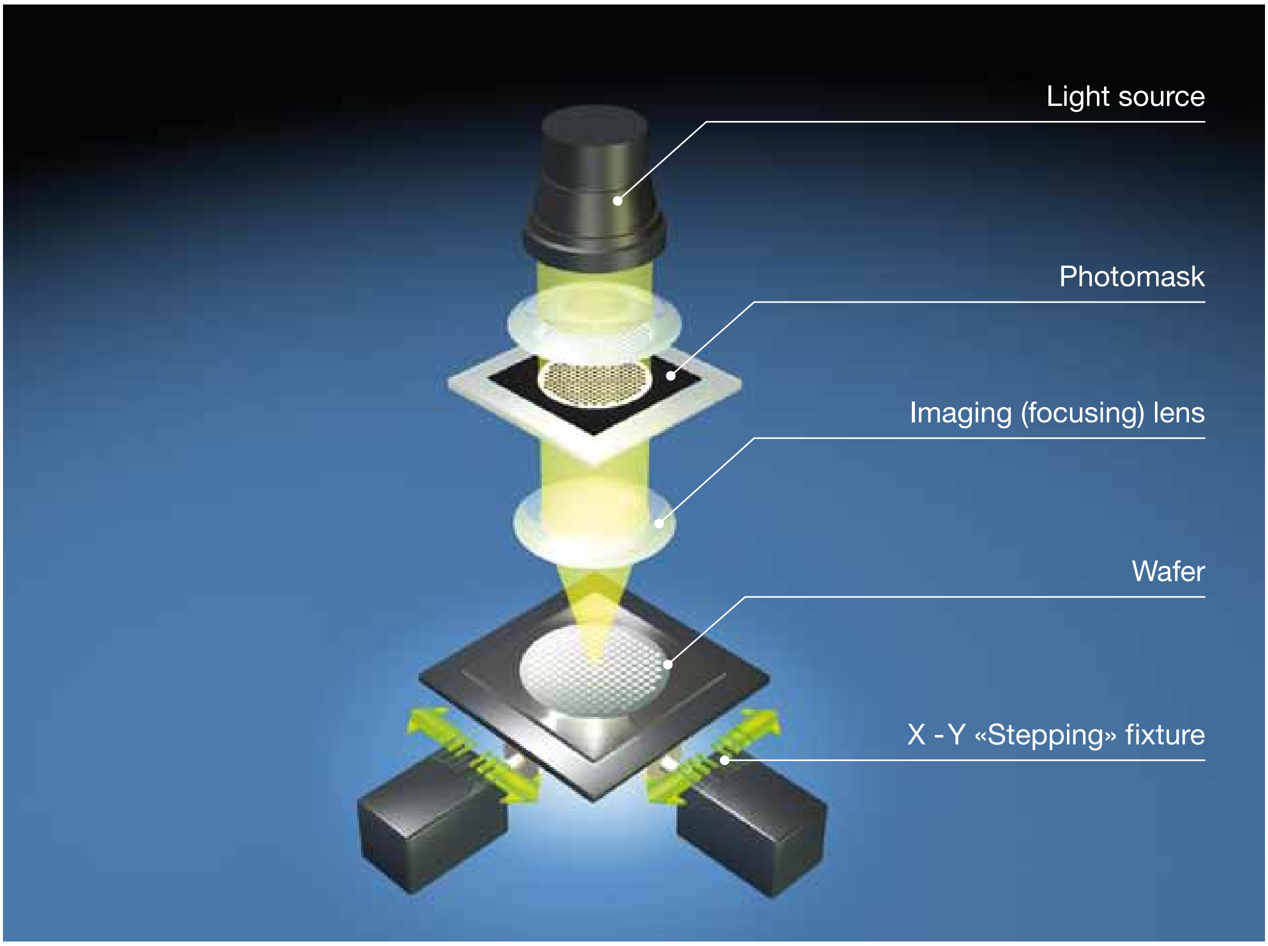
Precision motion control for photolithographic scanning steppers

Semiconductor manufacturing relies on complex photolithographic processes, to image and create the nanoscale structures that form the integrated circuit components on the chip. The basics are to a large extent comparable to a standard photographic process, wherein an illuminated object is imaged onto a light-sensitive surface such as a film emulsion or a CCD array through the use of a lens. Speaking in terms of wafer illumination, the object is a mask containing a (large-scale) geometrical “model” of the structure to be formed and the film/CCD is a silicon wafer with a so-called photoresist spun onto its surface. Illumination is not made by visible light, but by use of deep UV (ultra-violet) light-sources like an excimer laser operating at 193nm. The use of a very short wavelength is crucial since the resolution of the process is directly proportional to the wavelength – so by using a shorter wavelength for the illumination, smaller geometries can be created – and in the end a higher integration level (“transistors/area”) can be achieved.

The kind of machinery that illuminates a wafer by shining UV light through a photomask is called a wafer stepper. The term “stepper” stems from the fact that the machine steps the wafer through a series of positions in order to produce a number of “dies” (identical circuits or “chips”) on each wafer. When illuminating one specific die, mask, wafer and light-source are kept stationary relative to each other (fig. 1).

Because the full die is exposed in one process during each step, aberrations (imaging flaws) in the optics sets an upper limit to the die area and to the achievable detail of geometry. To overcome this, the method of scan-stepping the photomask pattern onto the die has been developed. Using this method each die is exposed in a process where mask and wafer are moved opposite each other during the illumination. In this way, the photomask pattern effectively “sweeps” the wafer only by use of the center portion of the lens system and a relatively large area can be covered, yet keeping the beam at the center of the optics to keep resolution and detail at max (fig. 2).

Fig 1. The basic principle of photolithography.



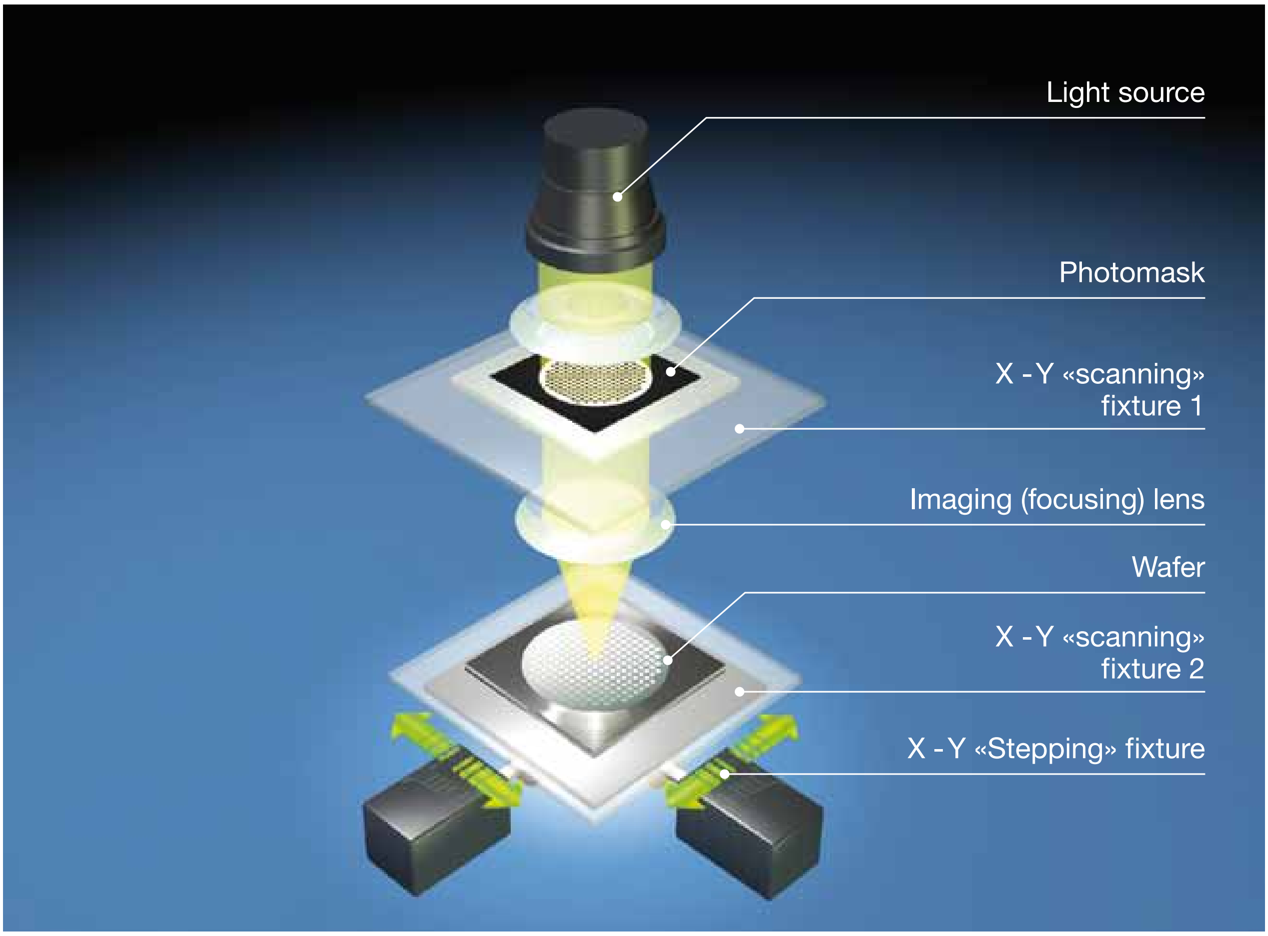


Fig 2. The photolithographic scanning stepper.

Since the core technique in the scanning stepper is to move "object" and "film" while exposing, and still hoping to reproduce nanometer scale geometries, it seems evident that position and motion control is vital in this scheme. Positioning is split over two mechanisms: stepping positioning, wherein the wafer is positioned to a specific die position, and the challenging scanning positioning, where the scanning positioning mechanism controls movement of wafer and photomask in opposite directions.

The scanning positioning mechanism has limited travel (on the order of 10-20mm) and is typically laid out using a linear ("voice coil") actuator. Motion control of this kind of mechanism can be implemented by measuring the drive current in the actuating coil; however, since it is of highest importance that near-perfect synchronization between the two movements is achieved, a high precision current measurement with extremely high differential linearity is crucial. Ultra-high precision DC Current Transducers like the PCB mount LEM ITN 12-P offers the required precision and differential linearity for use in this type of application. The only valid alternative offering the same level of linearity is a simple shunt resistor, but since the drive currents typically are several amperes (5-15A) this method is on the edge in terms of power loss and consequential temperature induced drift. Furthermore, the output from a shunt resistor intrinsically carries a common-mode contribution – this is not present using a DCCT where primary and secondary are galvanically isolated.

In conclusion, despite the higher cost of an ultra-high precision DCCT, the advantages offered by this technology outperforms the simpler alternative of a shunt resistor for applications in scanning steppers for semiconductor manufacturing.

Fluxgate current sensors sharpen MRI images

MRI – magnetic resonance imaging – is a powerful medical technology that has revolutionised diagnosis of a very wide range of illnesses and injuries, greatly reducing or in many cases eliminating the need for exploratory surgery. It provides medical practitioners with two- and three-dimensional images, as well as high-accuracy cross-section, of internal structures and organs within a patient's body.

Underpinning the results achieved by MRI scanning is a wide range of advanced technologies, including precision measurement techniques: the almost unbelievable sharpness of the pictures that MRI produces depends directly on measurements of basic electrical parameters.

MRI frequently sits alongside – and in some ways is complementary to – CT (computer tomography). CT scans are based on X-rays and are best at imaging high-density structures (such as bones), whereas MRI scanning reveals the details of soft-tissue structures.

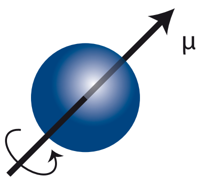
The working principle of MRI is based on nuclear magnetic resonance. In fact, what MRI actually detects is the magnetic resonance of the protons of hydrogen atoms contained in the water within the human body: water represents up to 70% of body weight. In more exact terms, MRI observes the response of the hydrogen nuclei exposed to excitation by both magnetic and electromagnetic fields.

The collected energy per volume element (voxel) depends on the water distribution in the place under analysis. So MRI can provide a three-dimensional image of the water distribution inside the human body. As each type of body tissue has a characteristic proportion of water within it, it becomes possible to image those tissues, and any deterioration, by looking at changes in water distribution.

Working principle of the nuclear magnetic resonance (NMR):

The nuclei of atoms have the property of behaving like magnetic dipoles or magnets when excited by a magnetic field (fig. 3). Nuclei of atoms have a spin (or magnetic moment) which we conventionally represent by a vector along the rotation axis.

Fig 3. Atomic nuclei of atoms have a magnetic moment, represented a vector quantity with its direction along the rotation axis.



In the absence of any external influence, this tiny magnet is not oriented in any particular direction. As soon as this magnet is illuminated by a constant and homogeneous static magnetic field (referred to as Ho) it aligns with Ho in two directions: parallel and anti-parallel to the field. The nuclear magnetic moment is tiny and requires an intense applied field to achieve the alignment; the related magnetic induction Bo is commonly between 0.2 and 3 Tesla. In the following – necessarily, simplified – explanation, only the parallel alignment is considered.

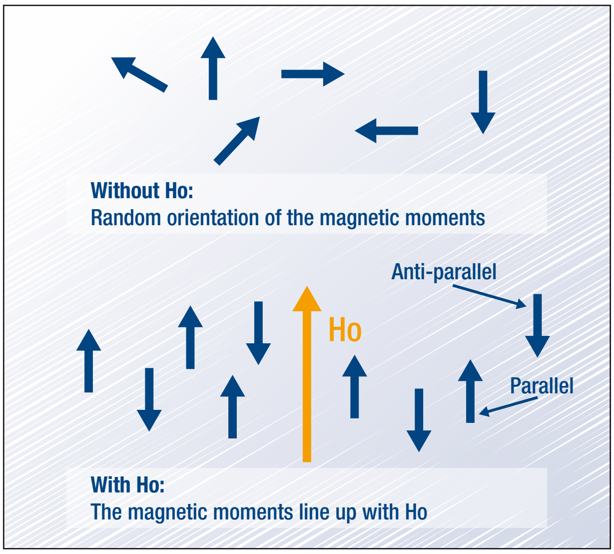
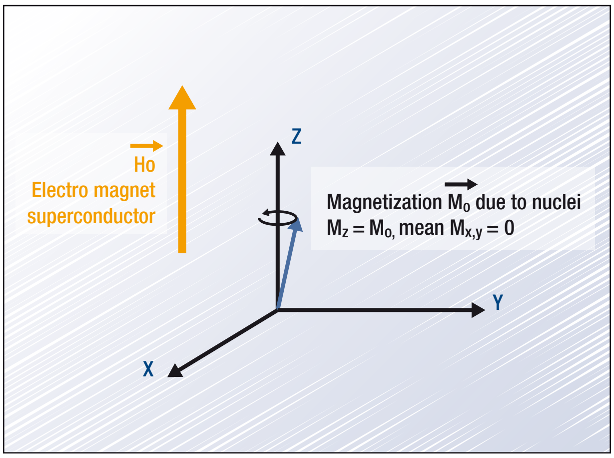


Fig 4. With a DC magnetic field H0 between 0.2 and 3 [T], the spins are in line with the field.

Fig 5. At any instant, the spin axis is not aligned with the applied field but due to its precession the average x and y components cancel out



The alignment process is more subtle than a simple setting of the spin axis along the field lines. If we take the z-axis (see fig. 5) as parallel to the applied field, the spin precesses or rotates around the z axis along a cone at angular speed ω_0 . The related frequency is called the Larmor frequency

$$\omega_0 = \gamma . B_0$$

The precession speed is therefore proportional to the static magnetic field; for example, a field of B_0 = 1Tesla gives a frequency f_0 = 42.5 MHz .

Resonance of the nuclei

In order to observe the resonance of the nuclei, some energy has to be provided allowing nuclei to move from steady state to excited one. This is achieved by applying a high frequency magnetic field H_1. When the frequency of H_1 equals the Larmor frequency, resonance occurs and the nuclei move to a higher energy state.

During the application of H_1, the spin axes of the nuclei are no longer aligned with H_0 (z axis) but move into the x-y plane. After the H_1 excitation is turned off, the spin axes once again align with H_0, and the extra energy they gained from the H_1 excitation radiates away in the form of a damped electromagnetic wave (also known as relaxation). An antenna detects damped wave, yielding an induced voltage called Free Induction Decay (FID).

It is the FID signal that the MRI's computer processes to a 3D or section image.

Applying the magnetic fields

The Static magnetic field H_0, as previously noted, must be very intense, with very high stability and homogeneity within the volume inside the aperture of the MRI scanner, where the patient lies.

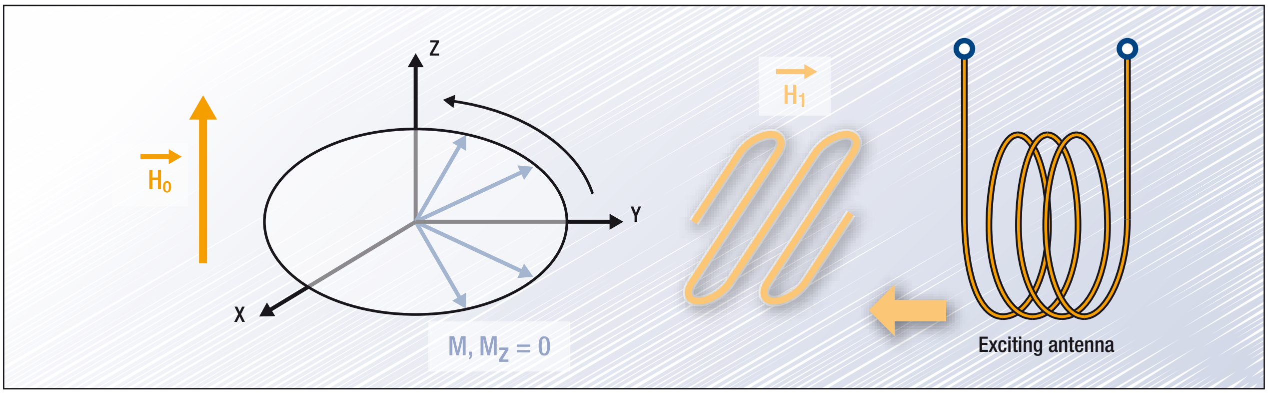
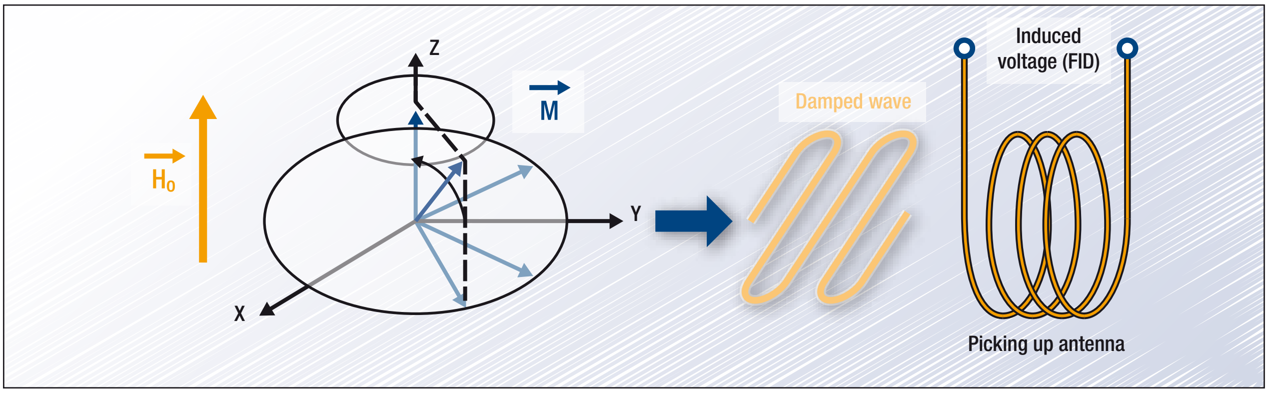


Fig 6. An excitation antenna excites the nuclei with a frequency matched to the Larmour frequency

Fig 7. Atomic nuclei radiate energy as they re-align with the static magnetic field, allowing their distribution to be mapped.



Most of today's MRIs generate the static field by means of a superconducting magnet located around the cylinder of the scanner. The coils of the magnet are made up of niobium-titanium (NbTi) wires immersed in liquid Helium at a temperature of 4K.

The Gradient coils superimpose a magnetic gradient to H_0 in order to provide a spatial coding of the image. Imaging takes place only in just one plane or slice at a time, and to ensure that signals are received only from nuclei in that plane, only those nuclei have to be pushed to resonance.

The appearance of the resonance is strongly dependent on the value of the magnetic field H_0: the gradient coils superimpose a magnetic field to ensure that the final magnetic field is exactly equal to H_0 only in the plane of interest.

How the gradient coils work

To create a gradient along an axis, a pair of coils is needed. In each pair, currents flow in opposite directions (the principle is shown in fig. 8).

In fact, 3 pairs of gradient coils are located around the cylinder of the MRI apparatus to create 3 orthogonal magnetic fields. So, it is possible to adjust the magnetic field at any point in the volume of the cylinder. Gradient amplifiers operating in a closed servo-type loop drive the currents in the gradient coils (fig. 9). Each MRI therefore needs three such current control loops.

As can be seen from the principle of MRI outlined above, the quality, the clarity and resolution of the images are directly linked to those of the magnetic field applied, and therefore to those of the current injected into the gradient coils. One of the key elements in the current control loop is the global accuracy of the current transducer.

In particular, the following parameters of the current transducer are critical :

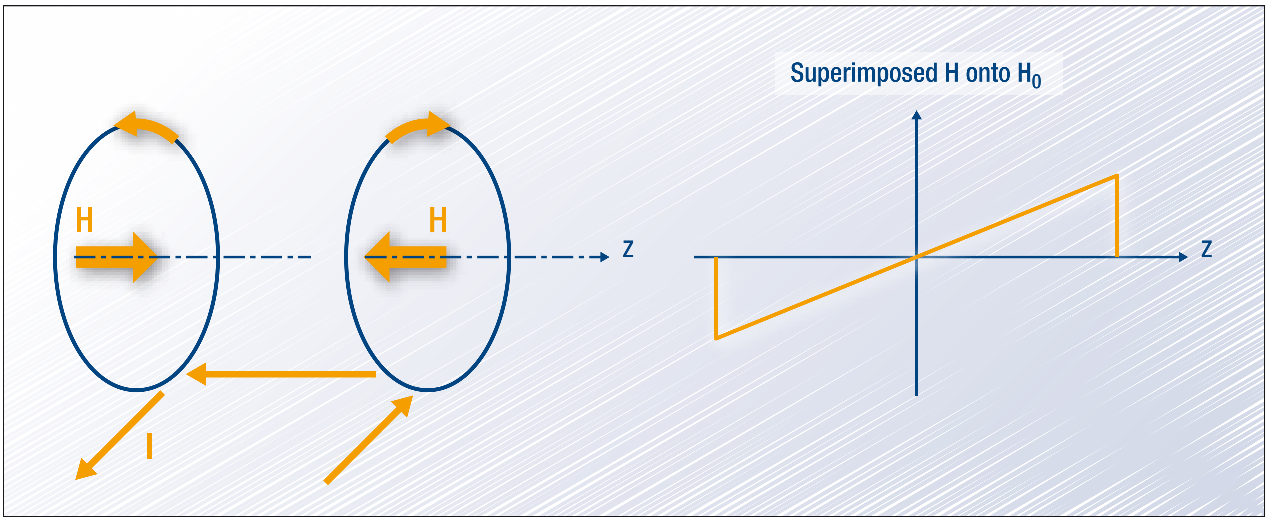


Fig 8. Gradient coils add to the static field at one end and diminish it at the other, controlling the plane in which the total field has exactly the correct value.

- Extremely low non linearity error (< 3 ppm of measuring range)
- Very low random noise (low frequency noise from 0.1Hz to 1kHz)
- Very low offset and sensitivity drifts over temperature range (<0.3 ppm/K)
- Very high stability of offset versus time (one reason for this is the duration of MRI scans, some of which may last several tens of minutes)
- Measuring range (around 1000 A peak)
- Bandwidth (–3dB point of 200 kHz)

To reach these performance levels, Hall Effect current transducers – which were used in previous generations of MRI scanners – are no longer adequate. The solution developed by LEM, primarily for this application area, has similarities to the Hall Effect technique but offers significant advantages. It is described as a double fluxgate closed loop transducer and identified as type ITL 900. Although fluxgate technology has been available for some time, LEM was able to take this technology and adapt and improve it.

As well as precise current control in gradient amplifiers for medical imaging, the ITL 900 is equally applicable to measuring feedback in precision current regulated power supplies, current measurement for power analysis, calibration equipment for test benches, and laboratory and metrology equipment which also require high accuracy.

In its present form, the technology is limited to a relatively narrow operating temperature (typically +10 °C to +50 °C). However, LEM is confident that the technology can be developed further and that the ITL 900 transducer could prove to be as significant for the future of MRI scanning as the Hall Effect transducers were for its introduction. As with Hall Effect itself, with its leading edge performance ITL900 could possibly enable any number of future applications.

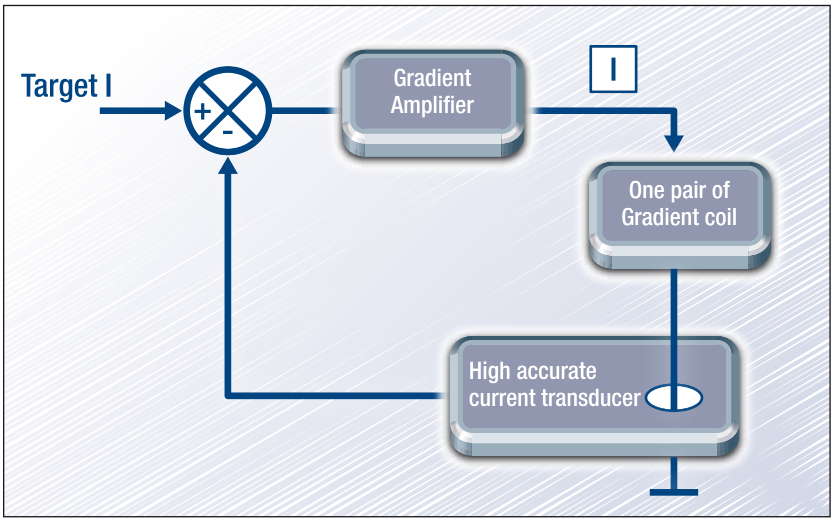


Fig 9. Feedback from output current transducers is fundamental to obtaining the required degree of precision from the gradient current amplifier

LEM High Precision Current Transducers for the Test & Measurement Market

General Overview

The world has to become more efficient and power electronics have played a crucial part to reach this goal. Hybrid- and electric vehicles, wind turbines and solar systems, industrial inverters and motors of higher efficiency. All these components must be optimized according their losses. Efficiency measurement for power electronics and drives components needs a power measurement system of highest accuracy. During the past 10 years the LEM IT and ULTRASTAB high precision current transducers became the standard for current range extension in power analysis and efficiency calculation.

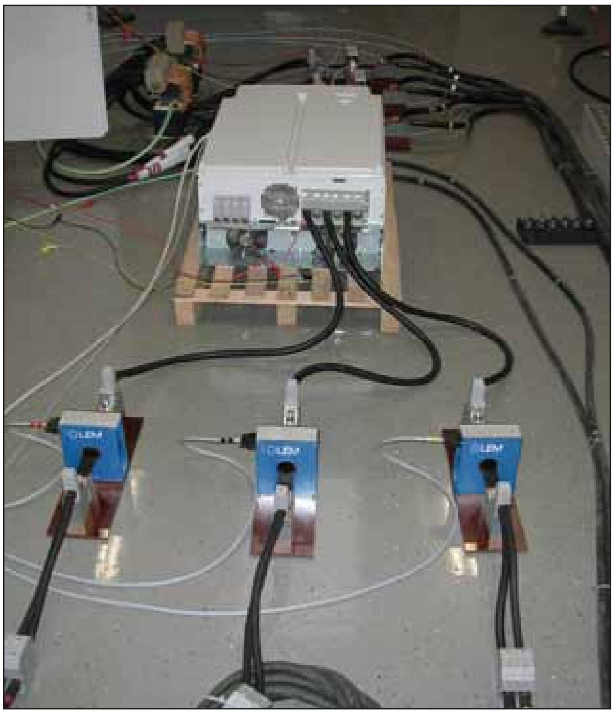


Fig 10. Six channel power measurement at KEB inverter

Demands on a Power Measurement System

Active electric power is defined in the following formula:

$$P = 1/T \bullet \int_0^T p(t)\,dt \quad \text{with} \quad p(t) = u(t) \bullet i(t)$$

The multiplication of voltage and current integrated over one signal period gives you active power. Besides a precise synchronization on the fundamental signal period the power accuracy depends on two items:

1) Amplitude error

How precise is voltage u (t) and current i (t) measured

2) Phase error

How long is the time (phase shift) between the sampling of voltage u (t) and current i (t)

Voltages up to 1000 V can be measured with a power meter directly. For current signals above some amps associated current transducers of highest precision are needed.

The influence of a phase error caused by an instrument or transducer increases with the decreasing of the power factor. Figure 12 shows this problem. At power factor 1 there is no phase shift between voltage

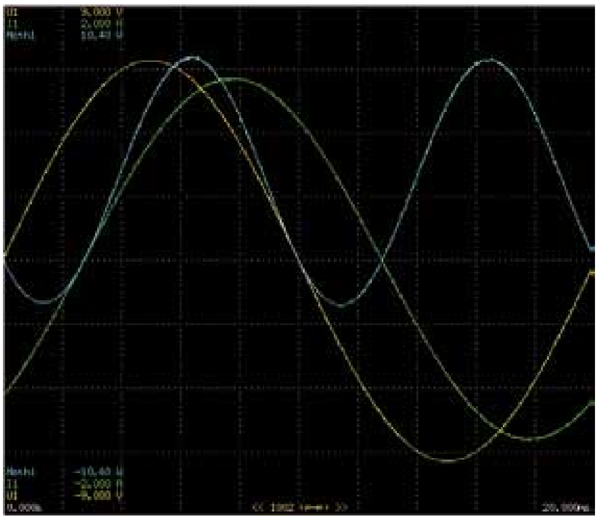
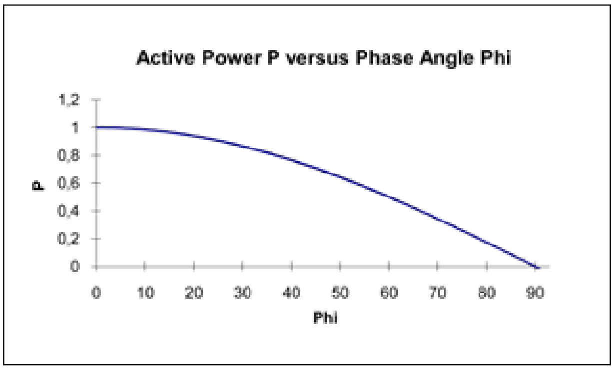


Fig 11. Power signal (blue) calculated from u (t) (yellow) and i (t) (green)

and current and even an additional phase shift of 1° caused by a current transducer would result in a small power error of 0.2 %. At power factor 0.1 the phase shift between voltage and current is already 84°. An additional transducer phase error of 1° would lead to a huge power error of 17.4 %.

Fig 12. Influence of power factor



Problem of Differential Measurement and high Efficiencies

The biggest problem in efficiency calculation is that losses cannot be measured directly with a high enough accuracy. The most precise power meters offer a basic accuracy of 0.02 to 0.1 %. The problem is that the losses cannot be measured directly but only input- and output power. The losses must be calculated from both power values. In the worst case the errors of both measurements are opposite. This problem increases with the efficiency of the load. Electric drives have an efficiency of around 95 %, inverters even up to 99 %. Only instruments and current transducers of highest precision are able to deliver reliable results.

Optimum Current Transducer for Power Measurement

LEM IT ULTRASTAB current transducers combine all the requirements for a power measurement current transducer. Offset and linearity are in the ppm range. 1 ppm is equal to 0.0001 %. Since the offset is so small one transducer can be used from a few A up to the kA-range. The transducers measure from DC up to several kHz large signals and some hundred kHz small signal bandwidths. The phase error of all transducer types is far below 1 minute which is 1/60 degree. The transducer is galvanically isolated. The analysis of medium voltage inverters and drives is fully sustainable. Due to the galvanic isolation there is no common mode signal which influences the result.

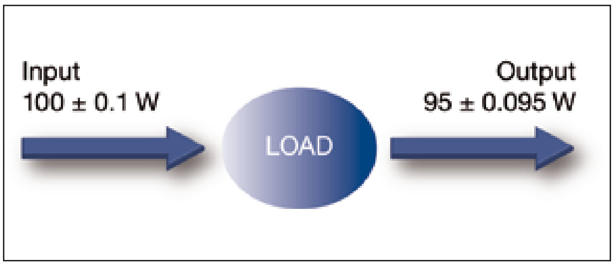
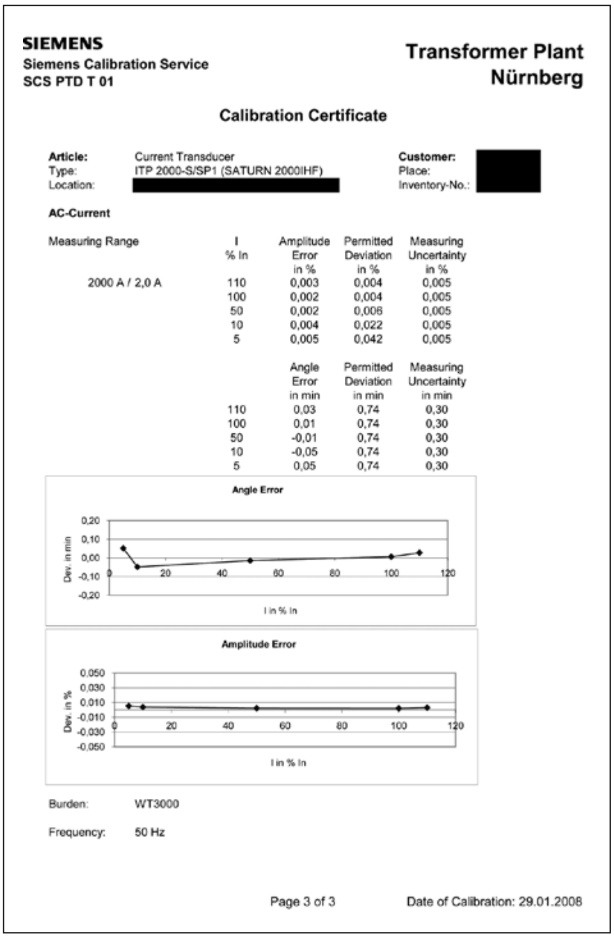


Fig 13. Deviations of input- and output power measured with a power system of 0.1 % accuracy. Result: Total power error of 0.195 W (worst case) compared to actual losses of 5 W is equal to an error of 3.9 % for the losses



SIEMENS
Siemens Calibration Service
SCS PTD T 01

Transformer Plant Nürnberg

Calibration Certificate

Article: Current Transducer
Type: ITP 2000-S/SP1 (SATURN 2000IHF)
Location: [redacted]

Customer: [redacted]
Place:
Inventory-No.: [redacted]

AC-Current

Measuring Range	I % In	Amplitude Error in %	Permitted Deviation in %	Measuring Uncertainty in %
2000 A / 2,0 A	110	0,003	0,004	0,005
	100	0,002	0,004	0,005
	50	0,002	0,006	0,005
	10	0,004	0,022	0,005
	5	0,005	0,042	0,005

I % In	Angle Error in min	Permitted Deviation in min	Measuring Uncertainty in min
110	0,03	0,74	0,30
100	0,01	0,74	0,30
50	-0,01	0,74	0,30
10	-0,05	0,74	0,30
5	0,05	0,74	0,30

Burden: WT3000

Frequency: 50 Hz

Page 3 of 3 Date of Calibration: 29.01.2008

Fig 14. Calibration protocol of a 2000 A transducer. Even at low range of 50 A the accuracy is better than 0.005 % and the phase error below 0.05 min.

Special Solutions for Power Analyzers

Most power measurement applications are 3-, 4- or even six channel applications. For an easy installation, wiring and use of our transducers we provide complete multi channel solutions including power supply and transducer connection cables. Thus a power measurement setup consisting of power meter and transducers is done within minutes.

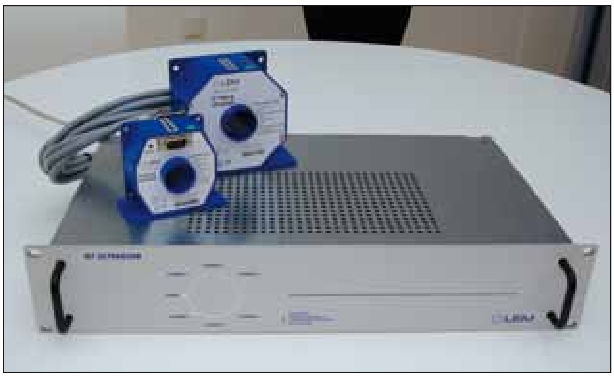


Fig 15. LEM multi channel system

Applications

You can find our current transducers everywhere where inverters or drives need to be developed or tested.

The ITZ 2000 and ITZ 5000 range of products are normally used for final test of large low voltage and medium voltage motors and generators. Even if the machine is a pure 50 or 60 Hz drive our transducers are a very economic way to measure. Other current sensor technologies demand to switch between different sensors to cover the entire current range. This increases the price of the test system remarkably. The large ITZ transducers for 2 kA and 5 kA are used for development of **wind generators** and **solar inverters**.

Fig 16. Electric vehicle

Fig 17. Wind turbine, solar panel

The IT transducer family can be used from 60 A to 1000 A for development and test of lower current applications such as **small solar inverters**, **small and medium motors** and **industrial inverters** and **power electronics components** for **automotive** applications.

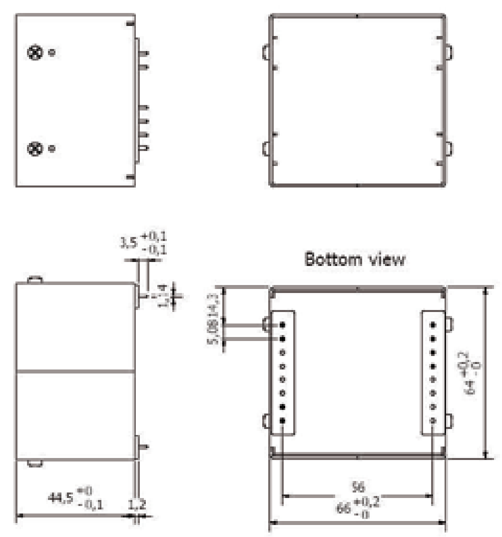
Most of the transducers are used for power and signal analysis but since this technology is so precise some of the transducers are used in **calibration labs** for **DC and AC current calibration**.

Fig 18. Calibration lab

ITN 12-P

Nominal current DC	12.5 A
Nominal current RMS	8.8 A
Power Supply	±15 V
Output	50 mA / 12.5 A
Frequency (Bandwidth) (±3 dB)	DC… 500 kHz*
Size (mm)	66 x 64 x 44.5
Operating temperature range	+10… +45° C
Mounting	Printed Circuit Board
Construction	Onboard Electronics Metal Housing

Primary conductor integrated
*small signal 0.5% of I_{PN} (DC)

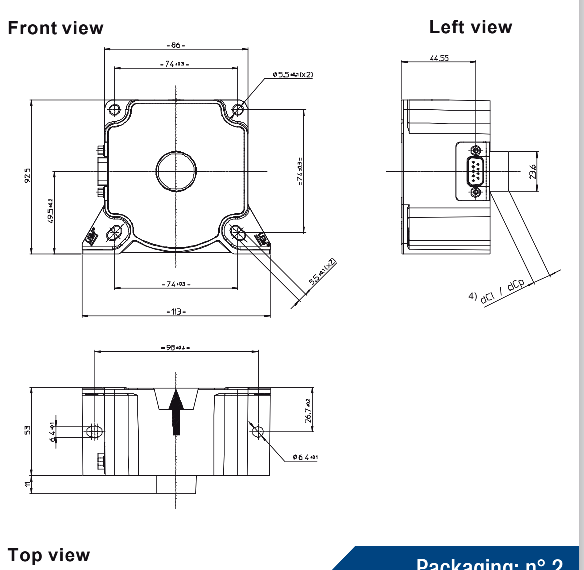


Packaging: n° 1

ITB 300-S

Nominal current DC	300 A
Nominal current RMS	300 A
Power Supply	±15 V
Output	150 mA / 300 A
Frequency (Bandwidth) (±3 dB)	DC… 100 kHz*
Size (mm)	113 x 92.5 x 64
Operating temperature range	-40… +85° C
Mounting	Panel
Construction	Onboard Electronics Electrostatic shield

Aperture ø 21.5 mm for primary conductor crossing
*small signal 0.5% of I_{PN} (DC)

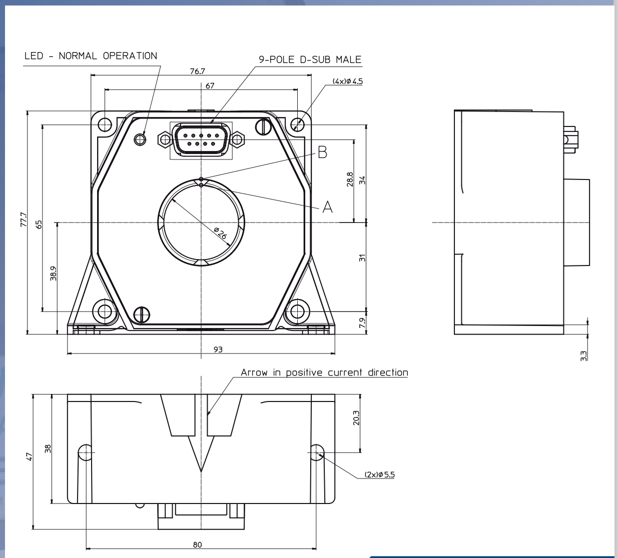


Packaging: n° 2

IT 60-S, IT 200-S, IT 400-S

Nominal current DC	60 A 200 A 400 A
Nominal current RMS	42 A 141 A 282 A
Power Supply	±15 V
Output	100 mA / 60 A 200 mA / 200 A 200 mA / 400 A
Frequency (Bandwidth) (±3 dB)	DC… 800 kHz* DC… 500 kHz* DC… 500 kHz*
Size (mm)	93 x 77 x 47
Operating temperature range	+10… +50° C
Mounting	Panel
Construction	Onboard Electronics Electrostatic shield

Aperture ø 26 mm for primary conductor crossing
*small signal 0.5% of I_{PN} (DC)

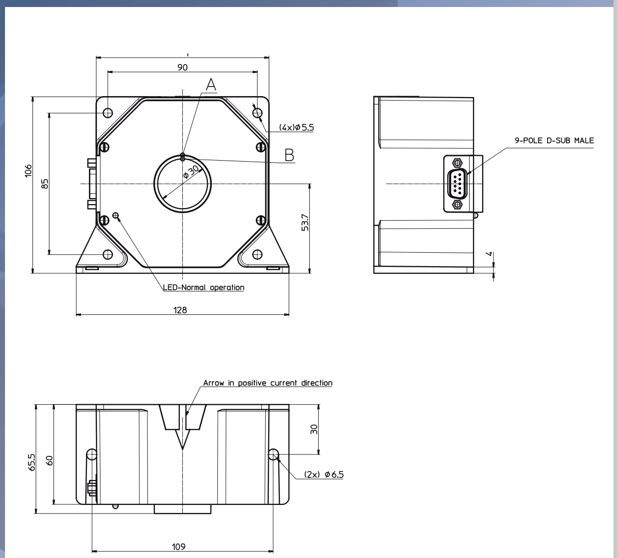


Packaging: n° 3

IT 700-S, IT 700-SB, IT 1000-S/SP1

Nominal current DC	700 A 700 A 1000 A
Nominal current RMS	495 A 495 A 707 A
Power Supply	±15 V
Output	400 mA / 700 A 10 V / 700 A 1 A / 1000 A
Frequency (Bandwidth) (±3 dB)	DC… 100 kHz* DC… 100 kHz* DC… 500 kHz
Size (mm)	128 x 106 x 67 128 x 106 x 67 128 x 106 x 85
Operating temperature range	+10… +50° C
Mounting	Panel
Construction	Onboard Electronics Electrostatic shield

Aperture ø 30 mm for primary conductor crossing
*small signal 0.5% of I_{PN} (DC)

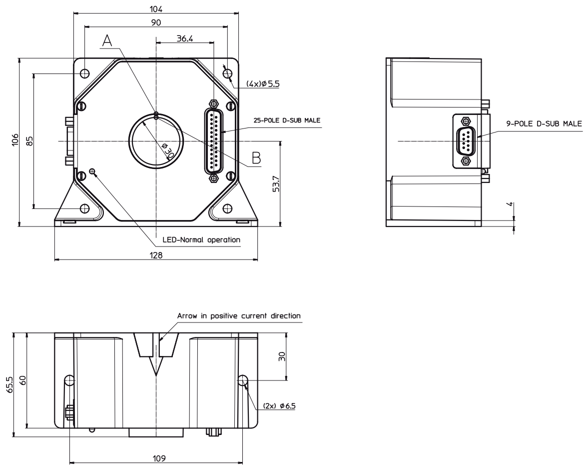


Packaging: n° 4

IT 700-SPR

Nominal current DC	700 A
Nominal current RMS	495 A
Power Supply	±15 V
Output	400 mA / 700 A
Frequency (Bandwidth) (±3 dB)	DC… 100 kHz*
Size (mm)	128 x 106 x 67
Operating temperature range	+10… +50° C
Mounting	Panel
Construction	Onboard Electronics Electrostatic shield

Aperture ø 30 mm for primary conductor crossing
*small signal 0.5% of I_{PN} (DC)
Programmable from 80 A in steps of 10 A

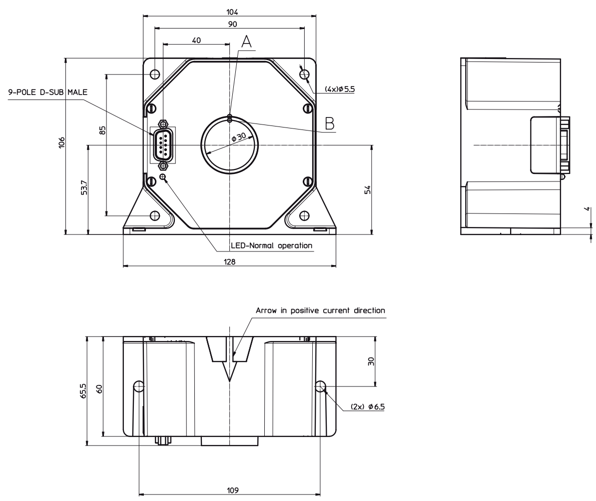


Packaging: n° 5

ITN 600-S, ITN 900-S

Nominal current DC	600 A 900 A
Nominal current RMS	424 A 636 A
Power Supply	±15 V
Output	400 mA / 600 A 600 mA / 900 A
Frequency (Bandwidth) (±3 dB)	DC… 300 kHz*
Size (mm)	128 x 106 x 67
Operating temperature range	+10… +50° C
Mounting	Panel
Construction	Onboard Electronics Electrostatic shield

Aperture ø 30 mm for primary conductor crossing
*small signal 0.5% of I_{PN} (DC)

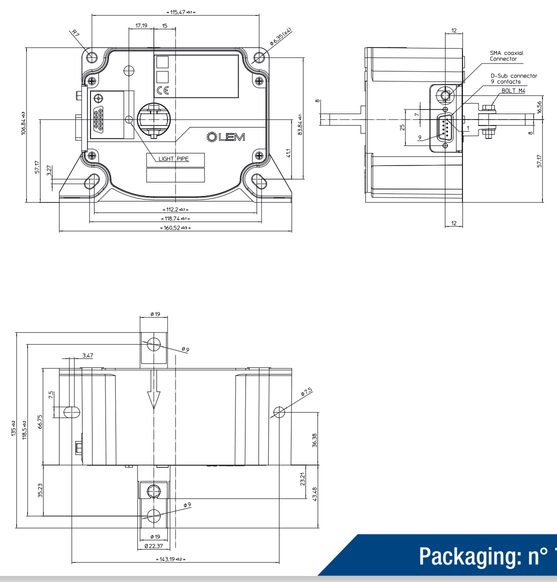


Packaging: n° 6

ITL 900-T

Nominal current DC	400 A To limit heating on primary integrated busbar
Nominal current RMS	400 A
Power Supply	±15 V
Output	600 mA / 900 A
Frequency (Bandwidth) (±3 dB)	DC… 200 kHz*
Size (mm)	160.52 x 106.84 x 66.75
Operating temperature range	+10… +50° C
Mounting	Panel
Construction	Onboard Electronics Electrostatic shield

Primary busbar integrated (conductor)
*small signal 32 A_{RMS}

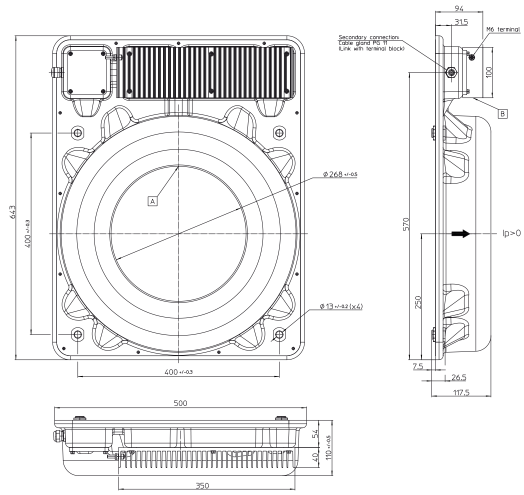


Packaging: n° 7

ITL 4000-S

Nominal current DC	4000 A
Nominal current RMS	4000 A
Power Supply	±24 V
Output	1.6 A / 4000 A
Frequency (Bandwidth) (±1 dB)	DC… 50 kHz*
Size (mm)	643 x 500 x 118
Operating temperature range	-40… +70° C
Mounting	Panel
Construction	Onboard Electronics Electrostatic shield

Large aperture ø 268 mm for primary conductor crossing
*small signal 40 A_{RMS}



Packaging: n° 8

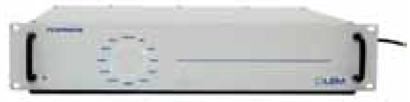
ITZ 600…24000-S & -SB & -SPR & -SBPR

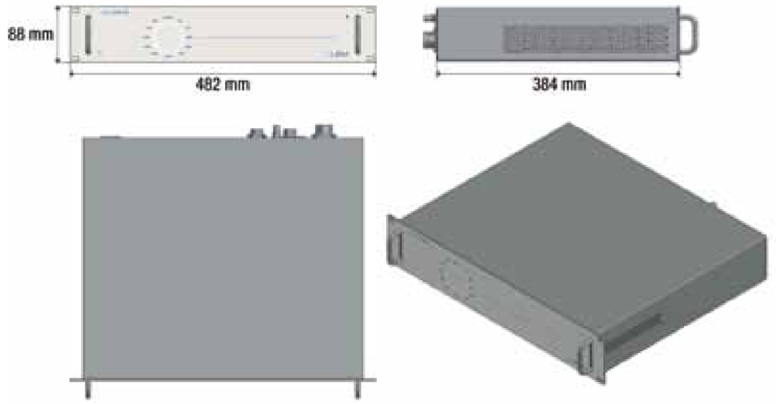
Model (-S: current output) (-SB: Voltage output) (-SPR: Current output/ programmable) (-SBPR: Voltage output/ programmable)	ITZ 600-SPR & -SBPR ITZ 2000-S & -SB & -SPR & -SBPR ITZ 5000-S & -SB	ITZ 10000-S & -SB ITZ 16000-S & -SB ITZ 24000-S & -SB
Nominal current DC	600 A 2000 A 5000 A	10000 A 16000 A 24000 A
Nominal current RMS	424 A 1414 A 3535 A	7070 A 11314 A 16970 A
Power Supply	100-240 VAC / 50-60 Hz	
Output (-S & -SB models)	1 A or 10 V / 600 A & 2000 A (for -SPR & -SBPR models) 2 A or 10 V / 2 & 5 & 10 & 16 KA 3 A or 10 V / 24 KA	
Frequency* (Bandwidth) (±3 dB)	DC… 500 kHz DC… 300 kHz (DC… 80 kHz for ITZ 2000 -SPR & -SBPR) DC… 80 kHz	DC… 20 kHz DC… 3 kHz DC… 2 kHz
Size (mm)	Measuring heads: ø 25.4 / ø 100 ø 50 / ø 150.3 ø 140.3 / ø 150.3	Electronic: 19'' Electronics Rack
Operating temperature range	Measuring heads: 0… +55° C Electronics Rack: +10… +40° C	
Mounting	19'' Electronics Rack	
Construction	Measuring head + deported 19'' Electronics rack	

19" Electronics Rack

ITZ standard delivery:

- Transducer head
- Electronics for 19'' rack installation
- Cable transducer electronics, length 10 m
- Cable output, length 1.5 m





Packaging: n° 9

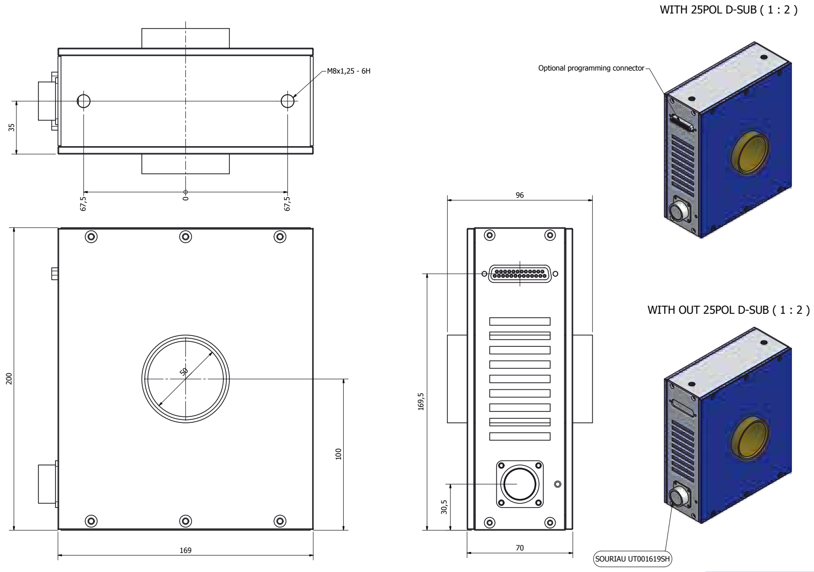
*small signal 1% of I_{PN} (DC)

ITZ 600 & 2000 models are available in -SPR and -SBPR versions, as programmable models for the primary current to be measured, providing respectively current and voltage output.

The 600 A head can be programmed from 40 A to 620 A in steps of 20 A

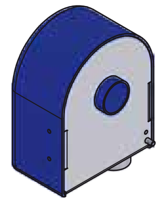
The 2000 A head can be programmed from 125 A to 2000 A in steps of 125 A

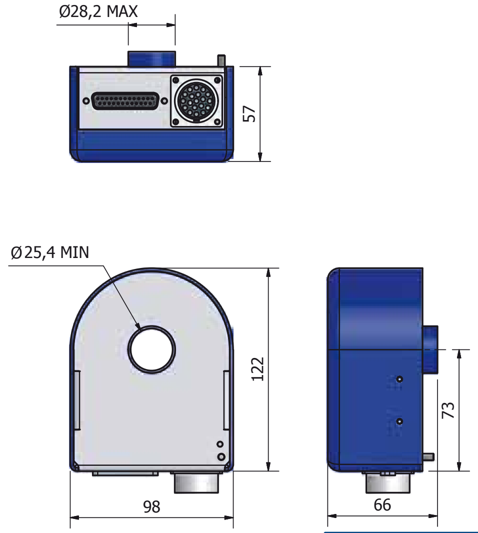
Measuring head **2kA**



Packaging: n° 9b

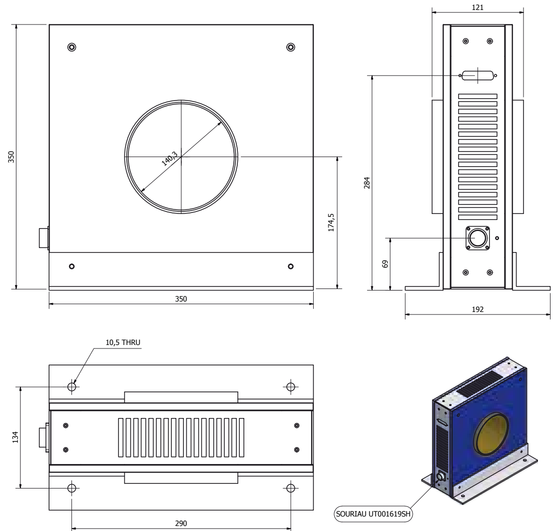
Measuring head **600A**





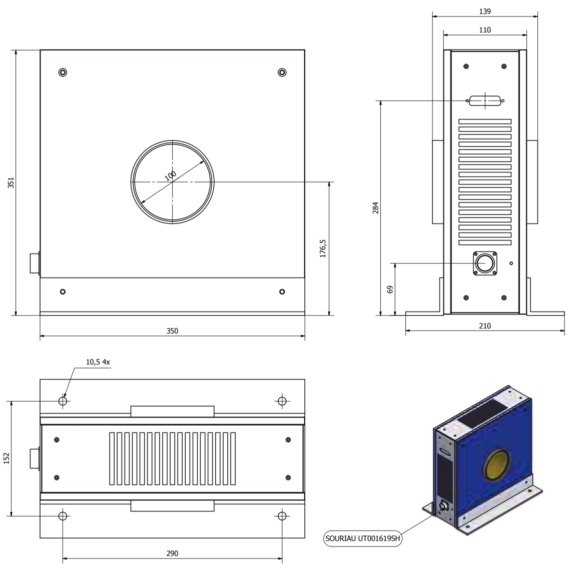
Packaging: n° 9a

Measuring head **5kA**



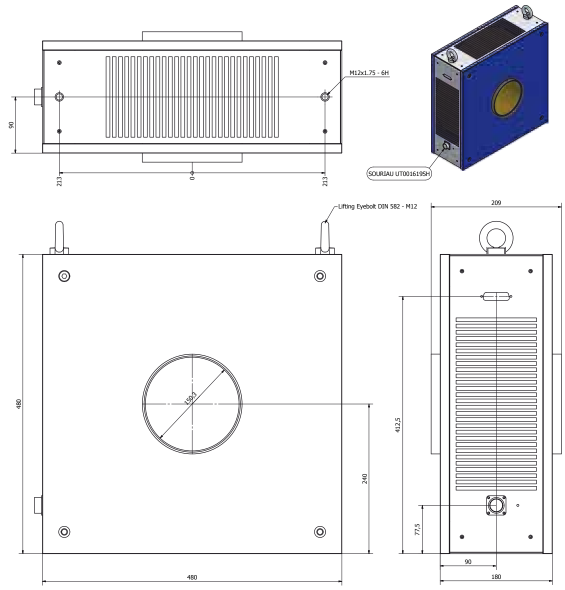
Packaging: n° 9c

Measuring head **10kA**



Packaging: n° 9d

Measuring head **16 - 24kA**



Packaging: n° 9e

PRODUCT CODING / Industry Transducers

Family
A : transducers using the principle of isolation amplifier
C : transducers using the principle of fluxgate compensation
D : digital transducers
F : transducers using the detector of fields
H : transducers using the Hall effect without magnetic compensation
I : compensation current transducers with high accuracy
L : transducers using the Hall effect with magnetic compensation
R : transducers using the principle of the Rogowski loop
T : transducers using the simple transformer effect

Group:
A or AK or AL or AS 1)
or AT or AX or AZ : with rectangular laminated magnetic circuit
AR or AW or AC or X or XN : with rectangular laminated magnetic circuit
AF : with rectangular laminated magnetic circuit and flat housing
AH : vertical mounting
AIS, XS, ASS, AFS : rectangular laminated magnetic circuit + unidirectional power supply + reference access
ASR, KSR : rectangular magnetic circuit + unipolar power supply + reference access
AY : rectangular magnetic circuit + hybrid
B : double toroidal core
C : apparent printed circuit
D : differential measurement
HS : Hall effect without magnetic compensation; magnetic concentrators + unidirectional power supply + reference access. When used with F (FHS): Minisens, SO8 transducer
F : flat design
I : shunt isolator
MS : surface mounted device + unidirectional power supply + reference access
OP : opening laminated magnetic circuit
TC : transducer reserved for the traction
TD : double measurement
TKS, TFS : core, flat case + unidirectional power supply + reference access
TP, TO, TN, TZ, TL, T, TA, TB, TY : toroidal core
TR : opening core
TS : core + unipolar power supply
TSR, TSP : core + unipolar power supply + reference access
TT : triple measurement
V : voltage measurement
Y : compact hybrid for PCB mounting

Nominal Amperage
- current transducer : rms amperes
- voltage tranducer : rms amperes-turns
  - 0000 : Nominal Voltage (-1000 meaning 1000 V, with built in primary resistor R1)
  - AW/2 : particular type of voltage transducer
  - AW/2/200: Nominal voltage for AW/2 design (200 meaning 200V with built in primary resistor R1)

Execution
N : multiple range
P : assembly on printed circuit
S(I) : with through-hole for primary conductor
T(I) : with incorporated primary busbar

Particularities (1or 2 optional characters or figures)
B : bipolar output voltage
BI : bipolar current output
C : fastening kit without bus bar
F : with mounting feet
FC : with mounting feet + fastening kit
P : assembly on printed circuit
PR : programmable
R : rms output
RI : rms current output
RU : rms voltage output

Variants
Differing from the standard product... /SPXX

ITZ 600-SPR/...

LEM

5 Year Warranty on LEM Transducers

We design and manufacture high quality and highly reliable products for our customers all over the world.

We have delivered several million current and voltage transducers since 1972 and most of them are still being used today for traction vehicles, industrial motor drives, UPS systems and many other applications requiring high quality standards.

The warranty granted on LEM transducers is for a period of 5 years (60 months) from the date of their delivery (not applicable to Energy-meter product family for traction and automotive transducers where the warranty period is 2 years).

During this period LEM shall replace or repair all defective parts at its' cost (provided the defect is due to defective material or workmanship).

Additional claims as well as claims for the compensation of damages, which do not occur on the delivered material itself, are not covered by this warranty.

All defects must be notified to LEM immediately and faulty material must be returned to the factory along with a description of the defect.

Warranty repairs and or replacements are carried out at LEM's discretion.

The customer bears the transport costs. An extension of the warranty period following repairs undertaken under warranty cannot be granted.

The warranty becomes invalid if the buyer has modified or repaired, or has had repaired by a third party the material without LEM's written consent.

The warranty does not cover any damage caused by incorrect conditions of use and cases of force majeure.

No responsibility will apply except legal requirements regarding product liability.
The warranty explicitly excludes all claims exceeding the above conditions.

Geneva, 21 June 2011

François Gabella
President & CEO LEM

June 2011/Version 1

Performances /Features — Model	I_{PN} (A DC)	I_{PN} (A RMS)	I_P (A)	V_{OUT} / I_{OUT} @ I_{PN} (DC)	Turns Ratio	V_C (V)	ε_L Linearity (ppm) Note 1) & 3)	I_{OE} Offset (ppm) Note 3) & 4)	Noise (RMS) (ppm) (DC-100Hz) (Note 3)
Stand-alone DC/AC Current Transducers									
ITN 12-P	12.5	8.8	+/-12.5	50 mA	250	+/-15V DC	<4	500	<0.5
IT 60-S	60	42	+/-60	100 mA	600	+/-15V DC	<20	<250	<1
IT 200-S	200	141	+/-200	200 mA	1000	+/-15V DC	<3	<80	<1
IT 400-S	400	282	+/-400	200 mA	2000	+/-15V DC	<3	<40	<0.5
IT 700-S	700	495	+/-700	400 mA	1750	+/-15V DC	<3	<50	<0.5
IT 700-SPR	700	495	+/-700	400 mA	1750	+/-15V DC	<3	<50	<1
IT 700-SB	700	495	+/-700	10V	N/A	+/-15V DC	<30	<60	<2
IT 1000-S/SP1	1000	707	+/-1000	1000 mA	1000	+/-15V DC	<3	<50	N/A
ITB 300-S	300	300	+/-450	150 mA	2000	+/-15V DC	10	666	N/A
ITN 600-S	600	424	+/-600	400 mA	1500	+/-15V DC	<1.5	<15	<0.3
ITN 900-S	900	636	+/-900	600 mA	1500	+/-15V DC	<1	<10	<0.2
ITL 900-T	400	400	+/-900	266.66 mA	1500	+/-15V DC	<1	<10	<0.017 (0.125Hz-1kHz)
ITL 4000-S	4000	4000	+/-12000	1600 mA	2500	+/-24V DC	<100	<62.5	<125 (0.1 Hz-10 kHz)
Rack System DC/AC Current Transducers									
ITZ 600-SPR	600	424	+/-600	1000 mA	600	100-240V AC - 50/60Hz	<1	<2	<11 (DC-10kHz)
ITZ 600-SBPR	600	424	+/-600	10 V	600	100-240V AC - 50/60Hz	<3	<2	8)
ITZ 2000-S	2000	1414	+/-2000	2000 mA	1000	100-240V AC - 50/60Hz	<2	<2	<3 (DC-10kHz)
ITZ 2000-SB	2000	1414	+/-2000	10 V	2000	100-240V AC - 50/60Hz	<4	<2	8)
ITZ 2000-SPR	2000	1414	+/-2000	1000 mA	2000	100-240V AC - 50/60Hz	<2	<2	<7 (DC-10kHz)
ITZ 2000-SBPR	2000	1414	+/-2000	10 V	2000	100-240V AC - 50/60Hz	<4	<2	8)
ITZ 5000-S	5000	3535	+/-5000	2000 mA	2500	100-240V AC - 50/60Hz	<3	<2	<2.5 (DC-10kHz)
ITZ 5000-SB	5000	3535	+/-5000	10 V	2500	100-240V AC - 50/60Hz	<5	<2	8)
ITZ 10000-S	10000	7070	+/-10000	2000 mA	5000	100-240V AC - 50/60Hz	<5	<2	<8 (DC-10kHz)
ITZ 10000-SB	10000	7070	+/-10000	10 V	5000	100-240V AC - 50/60Hz	<7	<2	8)
ITZ 16000-S	16000	11314	+/-16000	2000 mA	8000	100-240V AC - 50/60Hz	<6	<2	<8 (DC-10kHz)
ITZ 16000-SB	16000	11314	+/-16000	10 V	8000	100-240V AC - 50/60Hz	<8	<2	8)
ITZ 24000-S	24000	16970	+/-24000	3000 mA	8000	100-240V AC - 50/60Hz	<6	<2	<8 (DC-10kHz)
ITZ 24000-SB	24000	16970	+/-24000	10 V	8000	100-240V AC - 50/60Hz	<10	<2	8)

1) Linearity measured at DC
2) Bandwidth is measured under small signal conditions - amplitude of 0.5% I_{PN} (DC)
3) All ppm figures refer to V_{OUT} or I_{OUT} @ I_{PN} (DC) except for ITL 900-T where it refers to I_{OUT}=600 mA
4) Electrical offset current + self magnetization + effect of earth magnetic field @ T_A = + 25°C

Noise (RMS) (ppm) (DC-50kHz) (Note 3)	TCI_{OE} (ppm/K) (Note 3)	Bandwidth +/-3dB (kHz) (Note 2)	T_A (°C)	Mounting PCB	 On-board Panel	 Measuring head + 19'' rack electronic	Packaging n°	Busbar Aperture Ø (mm)
<10 (DC-100kHz)	<2	>500	+10…+45	•			1	Integrated
<15	<2.5	>800	+10…+50		•		3	26
<15	<2	>500	+10…+50		•		3	26
<8	<1	>500	+10…+50		•		3	26
<6	<0.5	>100	+10…+50		•		4	30
<16	<0.5	>100	+10…+50		•		5	30
<10	<4	<100	+10…+50		•		4	30
<6	<0.5	>500	+10…+50		•		4	30
N/A	6.66	>100	-40…+85		•		2	21.5
<15 (DC-100kHz)	<0.5	>300	+10…+50		•		6	30
<10	<0.3	>300	+10…+50		•		6	30
<0.006 (1kHz-30kHz)	<0.3	>200[5]	+10…+50		•		7	Integrated busbar 19 mm diameter
<125 (0.1 Hz-10 kHz)	<1.38	>50[6]	-40…+70		•		8	268
<28 (DC-100kHz)	<0.1	>500[7]	0…+55 Head +10…+40 Elec.			•	9 + 9a	25.4
[8]	<0.6	>300[7]	0…+55 Head +10…+40 Elec.			•	9 + 9a	25.4
<27 (DC-100kHz)	<0.1	>300[7]	0…+55 Head +10…+40 Elec.			•	9 + 9b	50
[8]	<0.6	>300[7]	0…+55 Head +10…+40 Elec.			•	9 + 9b	50
<42 (DC-100kHz)	<0.1	>80[7]	0…+55 Head +10…+40 Elec.			•	9 + 9b	50
[8]	<0.6	>80[7]	0…+55 Head +10…+40 Elec.			•	9 + 9b	50
<20 (DC-100kHz)	<0.1	>80[7]	0…+55 Head +10…+40 Elec.			•	9 + 9c	140.3
[8]	<0.6	>80[7]	0…+55 Head +10…+40 Elec.			•	9 + 9c	140.3
<20 (DC-100kHz)	<0.1	>20[7]	0…+55 Head +10…+40 Elec.			•	9 + 9d	100
[8]	<0.6	>20[7]	0…+55 Head +10…+40 Elec.			•	9 + 9d	100
<20 (DC-100kHz)	<0.1	>3[7]	0…+55 Head +10…+40 Elec.			•	9 + 9e	150.3
[8]	<0.6	>3[7]	0…+55 Head +10…+40 Elec.			•	9 + 9e	150.3
<20 (DC-100kHz)	<0.1	>2[7]	0…+55 Head +10…+40 Elec.			•	9 + 9e	150.3
[8]	<0.6	>2[7]	0…+55 Head +10…+40 Elec.			•	9 + 9e	150.3

5) Small signal 5 % of I_{PN} (DC), 32 A_{RMS}
6) Small signal 40 A_{RMS} @ +/- 1 dB

7) Bandwidth is measured under small signal conditions - amplitude of 1% I_{PN} (DC)
N/A: Not Available
8) Under request - Check online

Special features	Electrostatic Shield between primary and secondary	Transducer State output (operation status)	Transducer State output (Low measured current status)	Transducer State output (High current condition)	Transducer State output (Overload condition)	External Synchronization	Synchronization Status Output	Performances /Features — Model
Stand-alone DC/AC Current Transducers								
Metal housing for high immunity against external interference								ITN 12-P
	•	•						IT 60-S
	•	•						IT 200-S
	•	•						IT 400-S
	•	•						IT 700-S
Programmable from 80A in steps of 10A	•	•						IT 700-SPR
Voltage output +/- 10VDC for I_{PN} (DC)	•	•						IT 700-SB
High bandwidth	•	•						IT 1000-S/SP1
	•	•						ITB 300-S
	•	•						ITN 600-S
	•	•						ITN 900-S
	•	•				•	•	ITL 900-T
Large aperture	•							ITL 4000-S
Rack System DC/AC Current Transducers								
Programmable by steps of 20 A from 40 A to 620 A	•	•	•	•	•			ITZ 600-SPR
Programmable by steps of 20 A from 40 A to 620 A	•	•	•	•	•			ITZ 600-SBPR
	•	•	•	•	•			ITZ 2000-S
	•	•	•	•	•			ITZ 2000-SB
Programmable by steps of 125 A from 125 A to 2000 A	•	•	•	•	•			ITZ 2000-SPR
Programmable by steps of 125 A from 125 A to 2000 A	•	•	•	•	•			ITZ 2000-SBPR
	•	•	•	•	•			ITZ 5000-S
	•	•	•	•	•			ITZ 5000-SB
	•	•	•	•	•			ITZ 10000-S
	•	•	•	•	•			ITZ 10000-SB
	•	•	•	•	•			ITZ 16000-S
	•	•	•	•	•			ITZ 16000-SB
	•	•	•	•	•			ITZ 24000-S
	•	•	•	•	•			ITZ 24000-SB

Model	LED Normal Operation	LED Low measured Current	LED High current Condition	LED Overload Condition	LED Measuring head Range indication	LED Active Power supply	EN 50178 (1997)	EN 50155 (2001)	IEC 61010-1	EN 61000-6-2	EN 61000-6-3	EN 61000-6-4	EN 55022	EN 55024
Stand-alone DC/AC Current Transducers														
ITN 12-P									•				•	•
IT 60-S	•								•	•		•		
IT 200-S	•								•	•		•		
IT 400-S	•								•	•		•		
IT 700-S	•								•	•	•			
IT 700-SPR	•								•	•	•			
IT 700-SB	•								•	•	•			
IT 1000-S/SP1	•								•	•		•		
ITB 300-S							•	•	•					
ITN 600-S	•								•	•		•		
ITN 900-S	•								•	•		•		
ITL 900-T	•						•		•					
ITL 4000-S							•		•					

Rack System DC/AC Current Transducers									EN 61010-1	EN 61326-1				
ITZ 600-SPR	•	•	•	•	•	•			•	•				
ITZ 600-SBPR	•	•	•	•	•	•			•	•				
ITZ 2000-S	•	•	•	•	•	•			•	•				
ITZ 2000-SB	•	•	•	•	•	•			•	•				
ITZ 2000-SPR	•	•	•	•	•	•			•	•				
ITZ 2000-SBPR	•	•	•	•	•	•			•	•				
ITZ 5000-S	•	•	•	•	•	•			•	•				
ITZ 5000-SB	•	•	•	•	•	•			•	•				
ITZ 10000-S	•	•	•	•	•	•			•	•				
ITZ 10000-SB	•	•	•	•	•	•			•	•				
ITZ 16000-S	•	•	•	•	•	•			•	•				
ITZ 16000-SB	•	•	•	•	•	•			•	•				
ITZ 24000-S	•	•	•	•	•	•			•	•				
ITZ 24000-SB	•	•	•	•	•	•			•	•				

LEM International Sales Representatives

Europe • Middle East

Austria and CEE
Eltrotex HandelsgesmbH
Grundauerweg 7
A-2500 Baden
Tel. +43-2252-47040-0
Fax +43-2252-47040-7
e-mail: office@eltrotex.at

LEM
Concorde Business Park 2/F/6
A-2320 Schwechat
Tel. +43 1 706 56 14-10
Fax +43 1 706 56 14-30
e-mail: tbu@lem.com

Belarus and Baltic Republics
DACPOL Sp. z o.o.
ul. Pulawska 34
PL-05-500 Piaseczno
Tel. +48 22 7035100
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

Bosnia, Croatia, Herzegovina, Serbia and Slovenia
Proteus Electric S.r.l.
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, Slovakia
PE & ED, spol. s r.o.
Koblovska 101/23
CZ-71100 Ostrava
Tel. +420 596 239 256
Fax +420 596 239 531
e-mail: peedova@peed.cz

Denmark
Motron A/S
Torsoevej 3
DK-8240 Risskov
Tel. +45 87 36 86 00
Fax +45 87 36 86 01
e-mail: motron@motron.dk

Finland
ETRA Electronics Oy
Lampputie 2
FI-00740 Helsinki
Tel. +358 207 65 160
Fax +358 207 65 23 11
e-mail: markku.soittila@etra.fi
Field Applications Engineer
Mr. Pasi Leveälahti
Kausantie 668, 17150 Urajärvi
Tel. +358 50 5754435
Fax +358 37667 141
e-mail: pli@lem.com

France
LEM France Sarl
15, avenue Galois
F. 92340 Bourg-La-Reine
Tel. +33 1 45 36 46 20
Fax +33 1 45 36 06 16
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
Höpfigheimer Str. 8
D-71711 Steinheim
Tel. +49 7144 33905-0
Fax +49 7144 33905-55
e-mail: info@hg-electronics.de

Hungary
Ineltron GmbH
Hugenottenstr. 30
D-61381 Friedrichsdorf
Tel.: +36 20 7711744
Tel.: +49 (0)6172 598809
Fax.:+49 (0)617275933
email: i.laszlo@ineltron.hu

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
ofer.levin@tec-apps.co.il

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

Poland
DACPOL Sp. z o.o.
ul. Pulawska 34
PL-05-500 Piaseczno
Tel. +48 22 7035100
Fax +48 22 7035101
e-mail: dacpol@dacpol.com.pl

Portugal
QEnergia, Lda
Centro Empresarial S. Sebastião
Rua de S. Sebastião Lt 11 n.° 10, Albarraque
2635-448 Rio de Mouro
Portugal
Tel. +351 214 309 320
Fax +351 214 309 299
e-mail: qenergia@qenergia.pt

Romania
SYSCOM -18 Srl.
Calea Plevnei 139B Sector 6
RO-060011 Bucharest
Tel. +40 21 310 26 78
Fax +40 21 316 91 76
e-mail:
george.barbalata@syscom18.com

Russia
Central Office:
TVELEM. LLC
Str. Staritskoye shosse,15
170040 Tver / Russia
Tel./fax: + 7 4822 655672, 73
E-mail: tvelem@lem.com

Scandinavia
LEM
Hassellunden 16
2765 Smørum
Tel. +45 88 24 5555
e-mail: kck@lem.com

Spain
LEM France Sarl
15, avenue Galois
F-92340 Bourg-la-Reine
Tel. +34 93 886 02 28
Fax +34 93 886 60 87
e-mail: slu@lem.com

Sweden
ADIATOR AB
Hälsingegatan 40
SE-11343 Stockholm
Tel. +46 8 729 1700
Fax +46 8 729 1717
e-mail: info@adiator.se

Beving Elektronic AB
Storsätragränd 10
S. 12739 Skärholmen
Tel. +46 8 680 1199
Fax +46 8 680 1188
e-mail: lars.g.pahlsson@beving.se

Switzerland
SIMPEX Electronic AG
Binzackerstrasse 33
CH-8622 Wetzikon
Tel. +41 44 931 10 30
Fax +41 44 931 10 31
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
DES Sanayi Sitesi,
104.Sok.A07 Blok N°:02
TR-34776 Y.Dudullu
Umraniye / Istanbul
Tel. +90 216 420 1882
Fax +90 216 466 3686
e-mail: Ozdisan@ozdisan.com

Ukraine
“SP DACPOL” Co Ltd.
Snovskaya str., 20
UA-02090, KIEV, UKRAINE
Tel. +380 44 501 93 44
Fax +380 44 502 64 87
e-mail: kiev@dacpol.com

United Kingdom and Eire
LEM UK Ltd
West Lancs
Investment Centre
Whitemoss Business Park
Skelmersdale, Lancs WN8 9TG
Tel. +44 1 695 71 25 60
Fax +44 1 695 71 25 61
e-mail: luk@lem.com

Pulse Power & Measurement Ltd
65 Shrivenham Hundred
Business Park
Watchfield
Swindon
Wiltshire
SN6 8TY
Tel. +44 (0) 1793 784389
Fax +44 (0)1793 784391
e-mail: sales@ppm.co.uk

Africa • America

Argentina
Semak S.A.
Av. Belgrano 1580, 5° Piso
AR-1093 BUENOS AIRES
Tel. +54 11 4381 2108
Fax +54 11 4383 7420
e-mail: comex@semak.com.ar

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

Canada Ontario East
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

Canada Manitoba West
William P. Hall Contract Services
7045 NE 137th st.
CAN-Kirkland,
Washington 98034
Tel. +1 425 820 6216
Fax +1 206 390 2411

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.
11665 West Bradley Road
USA Milwaukee, Wi 53224
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
991, Michigan Avenue.
USA-Columbus, OH 43201
Tel. +1 414 353 07 11 ext. 200
Fax +1 614 540 74 36
Mobile +1 614 306 73 02
e-mail: afg@lem.com

LEM U.S.A., Inc.
37 Thornton Ferry Road II
USA-Amherst, NH 03031
Tel. +1 800 236 53 66 ext. 202
Fax +1 603 672 71 59
e-mail: gap@lem.com

LEM U.S.A., Inc.
6275 Simms st.
Suite # 110
USA Arvada, CO 80004
Tel. +1 800 236 53 66 ext. 201
Fax +1 303 403 15 89
e-mail: dlw@lem.com

LEM U.S.A, Inc.
1151 Sanborn Avenue
U.S.A - Los Angeles, CA 90029
Tel. +1 800 236 53 66 ext. 206
Fax +1 323 908 04 67
e-mail: dbl@lem.com

Asia • Pacific

Australia and New Zealand
Fastron Technologies Pty Ltd.
25 Kingsley Close
Rowville - Melbourne -
Victoria 3178
Tel. +61 3 9763 5155
Fax +61 3 9763 5166
e-mail: sales@fastron.com.au

China
LEM Electronics (China) Co., Ltd.
No. 28, Linhe Str. Linhe
Industrial Development Zone
Shunyi District, Beijing, China
Post code : 101300
Tel. +86 10 89 45 52 88
Fax +86 10 80 48 43 03
+86 10 80 48 31 20
e-mail: bjl@lem.com

LEM Electronics (China) Co., Ltd.
Shanghai Office
Room 510
Hualian Development Mansion,
Xinhua Road
Changning District
Shanghai, 200052 P.R. China
Tel. +86 21 3226 0881
Fax +86 21 5258 2262
e-mail: bjl@lem.com

LEM Electronics (China) Co., Ltd.
Shenzhen Office
R1205, Liantai Mansion, Zhuzilin,
Shennan Avenue, Futian District,
Shenzhen 518040 P.R. China
Tel. +86 755 3334 0779
+86 755 3336 9609
Fax +86 755 3334 0780
e-mail: bjl@lem.com

LEM Electronics (China) Co., Ltd.
Xi'an Office
R2909, HIBC, Technology Road 33,
High-tech District, Xi'an
710075 P.R. China
Tel. +86 29 8833 7168
Fax +86 29 8833 7158
e-mail: bjl@lem.com

India
LEM Management Services Sarl
India Branch Office
Mr. Sudhir Khandekar
Level 2, Connaught Place,
Bund Garden Road,
Pune-411001
Tel. +91 20 401 47 575
Mobile +91 98 331 35 223
e-mail: skh@lem.com

GLOBETEK
No.122, 27th Cross,
7th Block, Jayanagar,
Bangalore-560070 INDIA
Tel: +91 80 2663 5776
+91 80 2664 3375
Fax: +91 80 2653 4020
e-mail: sales@globetek.in

Japan
LEM Japan K.K.
2-1-2 Nakamachi
J-194-0021 Machida-Tokyo
Tel. +81 4 2725 8151
Fax +81 4 2728 8119
e-mail: ljp@lem.com

LEM Japan K.K.
1-14-24-701 Marunouchi,Naka-ku,
Nagoya
460-0002 Japan
Tel. +81 52 203 8065
Fax +81 52 203 8091
e-mail: ljp@lem.com

Korea
S&H TRADING
#B1 15-02, Chungang Yutong, 1258,
Gurobon-dong, Guro-gu,
Seoul, 152-721, Korea
Tel. +82 2 2686 83 46
+82 2 2613 83 45
Fax +82 2 2686 83 47
e-mail: snhlim@yahoo.co.kr

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

Malaysia
ACEI Systems Sdn. Bhd.
1A & 1A-1, Lintasan
Perajurit 6,
Taman Perak
31400 Ipoh
Perak Darul Ridzuan
Malaysia
Tel. +60 5 547 0761/0771
Fax +60 5 547 1518
e-mail: enquiry@aceisys.com.my

Singapore
Overseas Technology Center Pte Ltd
Blk 1003, Unit 04-16
Bukit Merah Central
Inno Center
RS-159836 Singapore
Tel. +65 272 6077
Fax. + 65 278 2134
e-mail: info@overseastechnology.com.sg

Taiwan
POWERTRONICS CO. LTD
The Tapei SUN-TECH Technology Park
10th Floor, No. 205-2, Section 3,
Beixin Road, Xindian City, Taipei County
23143, Taiwan, R. O. C.
Tel. +886 2 7741 7000
Fax +886 2 7741 7001
e-mail: sales@powertronics.com.tw

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

LEM®

LEM International SA
8, Chemin des Aulx, CH-1228 Plan-les-Ouates
Tel. +41/22/7 06 11 11, Fax +41/22/7 94 94 78
e-mail: lsa@lem.com; www.lem.com

Distributor

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