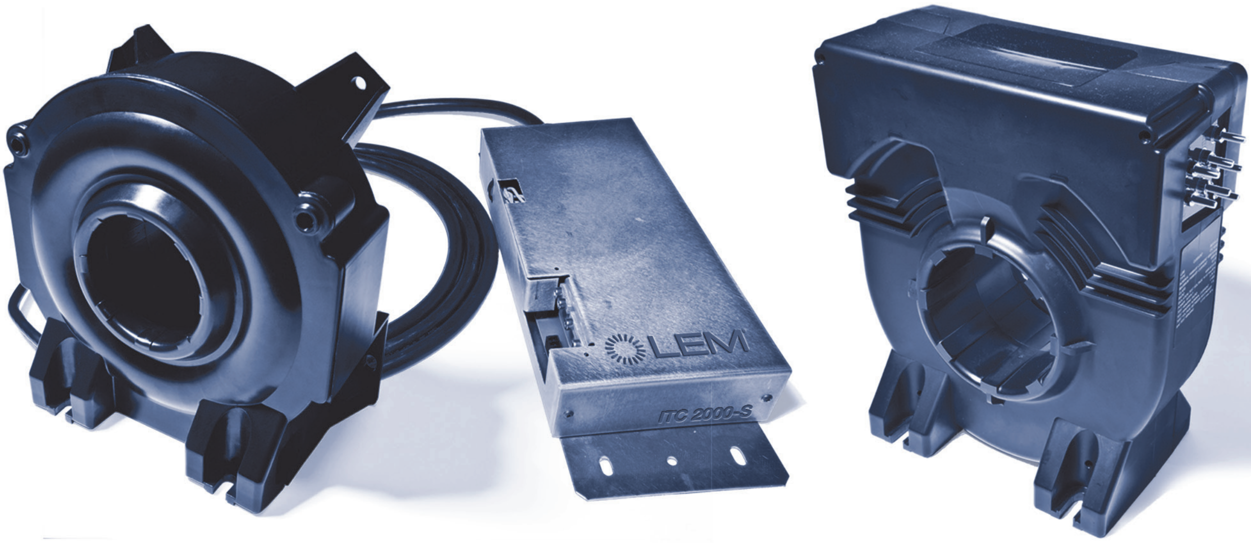
Technical Information

ITC series Current Transducers

DC & AC Class accuracy R current measurement



ITC series Current Transducers

Measure DC and AC currents with a Class accuracy R (Railway)

Market regulations require improvements for Railway Energy Billing.

- European rail freight markets are liberalized (privatization of the rail networks into infrastructure and operators)
- Since the beginning of January 2010 passenger rail markets are opened to cross-border competition

Liberalization of European railway markets leads to:

  - new competitors in each national market
  - increasing cross-border traffic
  - new situation concerning intra- und inter-modal competition
  - rising demands in terms of cost transparency (exact electricity consumption must be invoiced)

Traction Units consume energy in different countries along their way:

- Railway Undertaking (RU) have contractual relationships with the respective Infrastructure Manager (IM)
- In order to be able to transparently bill the energy consumption, the RU will need information regarding each border crossing
- The IM has to invoice the RU for the supply of energy

The on-board Energy Measuring System (EMS) is the system for measurement of electric energy taken from or returned (during regenerative braking) to the overhead contact line (OCL) by the traction unit, supplied from the external electric traction system.

This energy measurement allows the operators to better understand their real consumption and will enable energy management to reduce energy consumption for example.

The Energy Measurement Function (EMF), includes voltage and current measurement.

The new EN 50463 standard defines characteristics of transducers for current and voltage DC or AC measurement as well as the energy measurement function.

In order to fulfill this standard, LEM proposes different solutions for current and voltage measurements:

- DV family for DC voltage measurement Class 0.5R for a single network voltage
- ITC family for DC current measurement Class 0.5R

Common features:

- Measurement of all types of signals: DC, AC, pulsed and complex
- Compact size
- High galvanic insulation between primary (high power) and secondary circuits (electronic circuit)
- Low consumption technology
- Excellent accuracy to suit to high demanding applications such as energy metering
- Low temperature drift of accuracy
- High insulation and partial discharge levels in order to guarantee safety
- Good immunity against external electric, magnetic and electromagnetic fields for EMC protection
- Low level of emission
- Compliant to fire and smoke, mandatory in railway applications
- Low influence of common mode voltage
- Fast response time
- Large bandwidth
- Low noise
- Modular approach allows easy adaptation with various connections available for the secondary side like connectors, shielded cables, terminals (threaded studs, M4, M5, UNC ect) according to customer specifications
- Reliability and lifetime are guaranteed by the quality in design and process and ageing tests

The Energy Measurement Function must have a total accuracy of 1,5 % for AC and 2 % for DC at +25°C.

The accuracy of current transducer, voltage transducer and Energy Meter is measured separately and combined for the overall accuracy using the following formula:

$$\varepsilon_{EMF} = \sqrt{\varepsilon_{VMF}^2 + \varepsilon_{CMF}^2 + \varepsilon_{ECF}^2}$$

With ε_{EMF} = Overall accuracy of EMF (system of current sensor, voltage sensor and energy meter)
ε_{VMF} = Class accuracy of Voltage Measurement Function (Voltage transducer)
ε_{CMF} = Class accuracy of Current Measurement Function (Current transducer)
ε_{ECF} = Class accuracy of Energy Calculation Function (Energy meter)

The EN 50463 gives the following details for the measurement of DC & AC currents:

Percentage error limits — DC current transducers

Accuracy class	**± Maximum percentage current (ratio) error at percentage of rated primary current (I_{PN}) shown below, DC transducers Temperature condition: 23°C+/–2°C**					
	1 % [1]	5 %	10 %	20 %	100 %	120 %
0,2 R	2	0,4	0,2	0,2	0,2	0,2
0,5 R	5	1	0,5	0,5	0,5	0,5
0,75 R	7,5	1,5	0,75	0,75	0,75	0,75
1 R	10	2	1	1	1	1

[1] For AC current transducers, the maximum permissible error e.g. for Class 1R at 1% of I_{PN} is 5%, for Class 0.5R it is 2.5%.

Value of current	System type	± Maximum percentage error limits	
		Ambient temperature variation, main range –10 °C to +50 °C (or +60 °C for indoor)	**Ambient temperature variation, extended range –40 °C to –10 °C (and +60 °C to +75 °C for indoor)**
$10\ \%\ I_{PN} \leq I \leq 120\ \%\ I_{PN}$	AC and DC	$N^{b)} + (0,01 \times \Delta T^{a)})$	$N^{b)} + (0,02 \times \Delta T^{a)})$
$5\ \%\ I_{PN} \leq I < 10\ \%\ I_{PN}$	AC and DC	$N^{b)} + (0,02 \times \Delta T^{a)})$	$N^{b)} + (0,04 \times \Delta T^{a)})$
$1\ \%\ I_{PN} \leq I < 5\ \%\ I_{PN}$	AC and DC	$N^{b)} + (0,1 \times \Delta T^{a)})$	$N^{b)} + (0,2 \times \Delta T^{a)})$

[a] ΔT is the temperature variation in Kelvin between reference temperature 23 °C and the ambient temperature.

[b] The term N is the maximum allowed percentage error for the current transducer according to the Accuracy class as specified in the table above. For example, for a class 0,5 R current transducer and input signal in the range $10\ \%\ I_{PN} \leq I \leq 120\ \%\ I_{PN}$, the formula for main temperature range becomes $0,5 + (0,01 \times \Delta T)$ and for the input signal in the range $5\ \%\ I_{PN} \leq I < 10\ \%\ I_{PN}$ the formula becomes $1,0 + (0,02 \times \Delta T)$.

Maximum percentage error for a current transducer including ambient temperature variation.

Accuracy class	± Mean temperature coefficient (%/K)		
	$1\ \%\ I_{PN} \leq I < 5\ \%\ I_{PN}$	**$5\ \%\ I_{PN} \leq I < 10\ \%\ I_{PN}$**	**$10\ \%\ I_{PN} \leq I \leq 120\ \%\ I_{PN}$**
0,2 R	0,175	0,04	0,02
0,5 R	0,2	0,05	0,025
0,75 R	0,225	0,06	0,03
1,0 R	0,25	0,07	0,035

Temperature coefficient for current transducer.

Energy measurement
EN 50463

These transducers comply to the EN 50463 standard for energy measurement:

- DV family for DC voltage measurement Class 0.5R for a single network voltage
- ITC family for DC current measurement Class 0.5R

It is possible to use these transducers for bi voltage applications (when switching from a network to another one when crossing) with a slightly derated accuracy.

These transducers have a very low sensitivity to external magnetic DC or AC fields.

EMC
EN 50121-3-2

These transducers comply to the EN 50121-3-2 standard for emission and susceptibility (railway EMC standard) in its latest update, with EMC constraints higher than those of the typical industrial application standards.

CE Marking 2004/108/EEC & Low voltage directive

The DV, ITC products are CE marked as a guarantee of the product compliance to the European EMC directive 2004/108/EEC and low voltage directive. They also comply with the derived local EMC regulations (EMC: Electro-Magnetic Compatibility).

Insulation and safety
EN 50124-1

The EN 50124-1 (“Basic requirements – clearances and creepage distances for all electrical and electronic equipment”) standard has been used as a reference to design the creepage and clearance distances for the DV, ITC products.

Traction standard
EN 50155

The EN 50155 standard dedicated to “Electronic Equipment used on Rolling stock” in railway applications is our standard of reference for electrical, environmental and mechanical parameters.

It guarantees the overall performances of our products in railway environments.

Fire and smoke
NFF 16101/102

Materials used for the DV, ITC products comply with the NFF 16101/2 standards for fire and smoke classification (tests report for materials available on request).

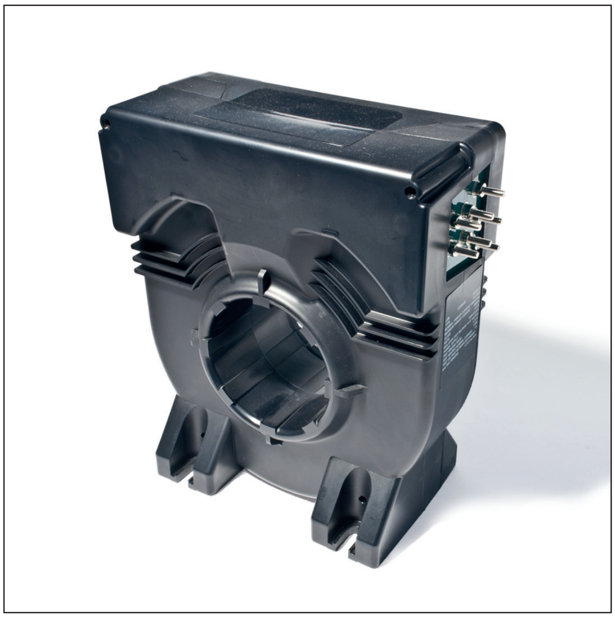
IRIS

Our main production centers for traction transducers are IRIS certified.

ISO 14000

LEM is proud to be able to contribute to energy savings and is certified ISO 14001 for environmental management standards.

ITC series Current Transducers



High Isolation

Class 0.5R accuracy

The ITC transducer series comprises three models to measure a current up to 4000 A_{RMS} (6000 Apk) in vehicles that are supplied with energy from networks up to 3000 V. The transmission of power and signals from a high voltage environment to a low voltage environment requires specific insulation features depending on the application. The ITC series fulfills all the necessary standards to enable these features.

These models are available for Traction and Industry applications.

ITC transducers have been specially designed for the railway environment and to respond to the energy measurement function evolution requiring better performances, ITC series is Class 0.5R measurement accuracy when Class 1R is required by the pr EN50463 standard for on-board energy monitoring. ITC models are not sensitive to the position of the conductor inside their apertures.

Beside the possible function in the Energy Measurement Systems, they can easily be used everywhere an accuracy of 0.5 % from 5 % to 120 % of the nominal current is required.

To reach this Class 0.5R accuracy, LEM used the Closed loop Fluxgate technology.

ITC series: Closed loop Fluxgate Technology

For accurate measurement of DC currents, the methods consist in compensating the current linkage Θ_P created by the current I_P to be measured by an opposing current linkage Θ_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 $N_P \cdot I_P - N_S \cdot I_S = 0$ with N_P: Number of primary turns and N_S: Number of secondary turns

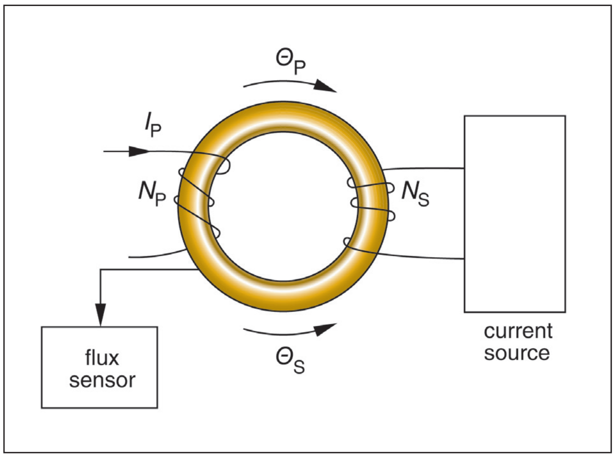


Fig 1. Closed loop current transducer Principle

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:

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

Operation principle

To achieve 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.

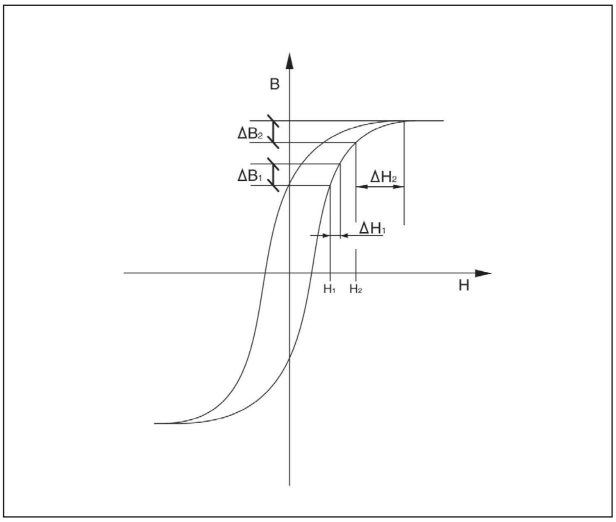


Fig 2. Hysteresis cycles of the magnetic cores

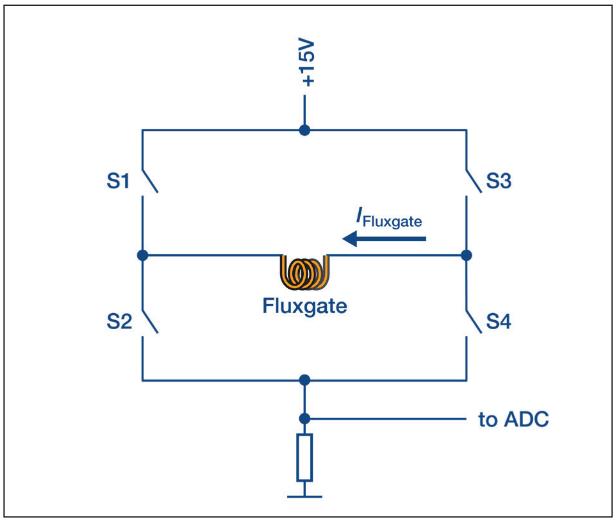
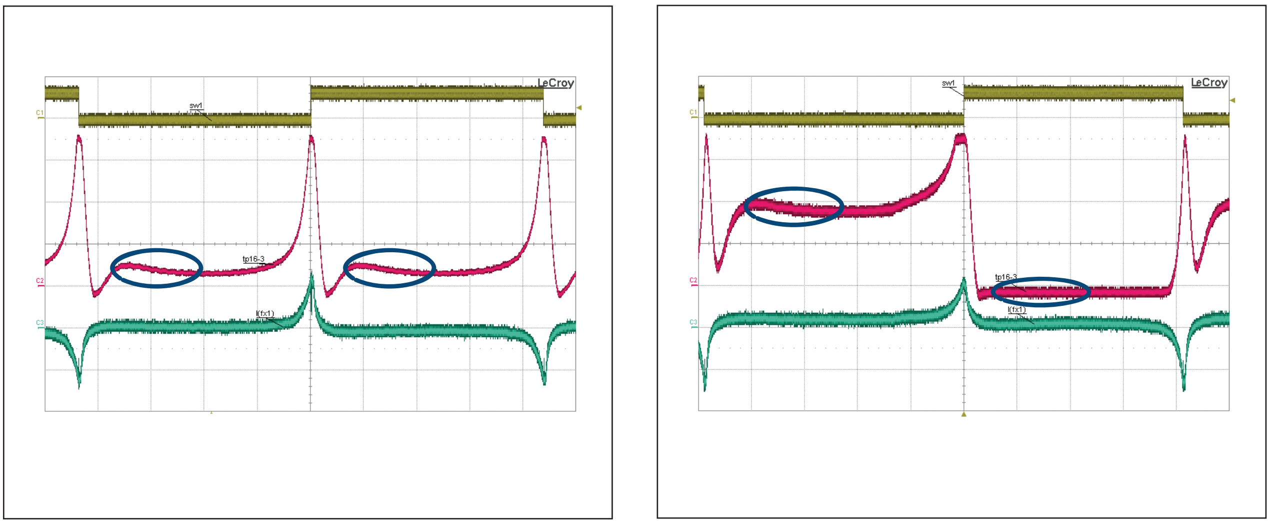


Fig 3. Full bridge to drive Fluxgate (saturable inductor)

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).

Observing $B = f(H)$ on the magnetization curve, notice that for a given field strength H_1 a flux density variation ΔB_1 corresponds to ΔH_1. But, also observe that further along the cycle, for another given field strength H_2, for the same variation $\Delta B_2 = \Delta B_1$, *the* ΔH_2 variation must be much greater.

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



$I_P = 0$

$I_P = 10$ A, no compensation

Fig 4. Square wave voltage; Current created; Asymmetry of the created current

A full bridge (Fig. 3) is used to drive the Fluxgate. A current, I_{Fluxgate} is created, flowing alternately through S1 / S4 and through S3 / S2, this current being measured by adequate means. When applying a square wave voltage (yellow signal) to a saturable inductor until its magnetic core starts to saturate, a current is created. Without primary current I_P =0, this current is symmetric.

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 4).

This current is then measured using an accurate resistor and allows to adjust the secondary current in the compensation winding so that it perfectly compensates the primary current.

The accuracy of the measurement will not only depend on the accuracy of the measured Fluxgate current, I_{Fluxgate}, 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 correlated with the fluxgate excitation (fig. 5).

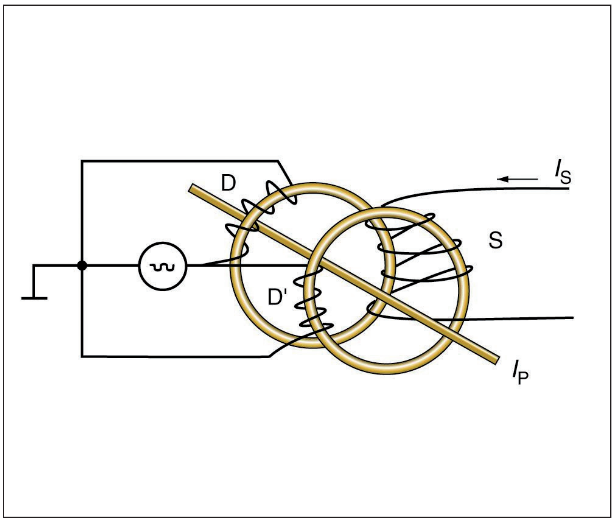


Fig 5. Solution against voltage peaks re-injection

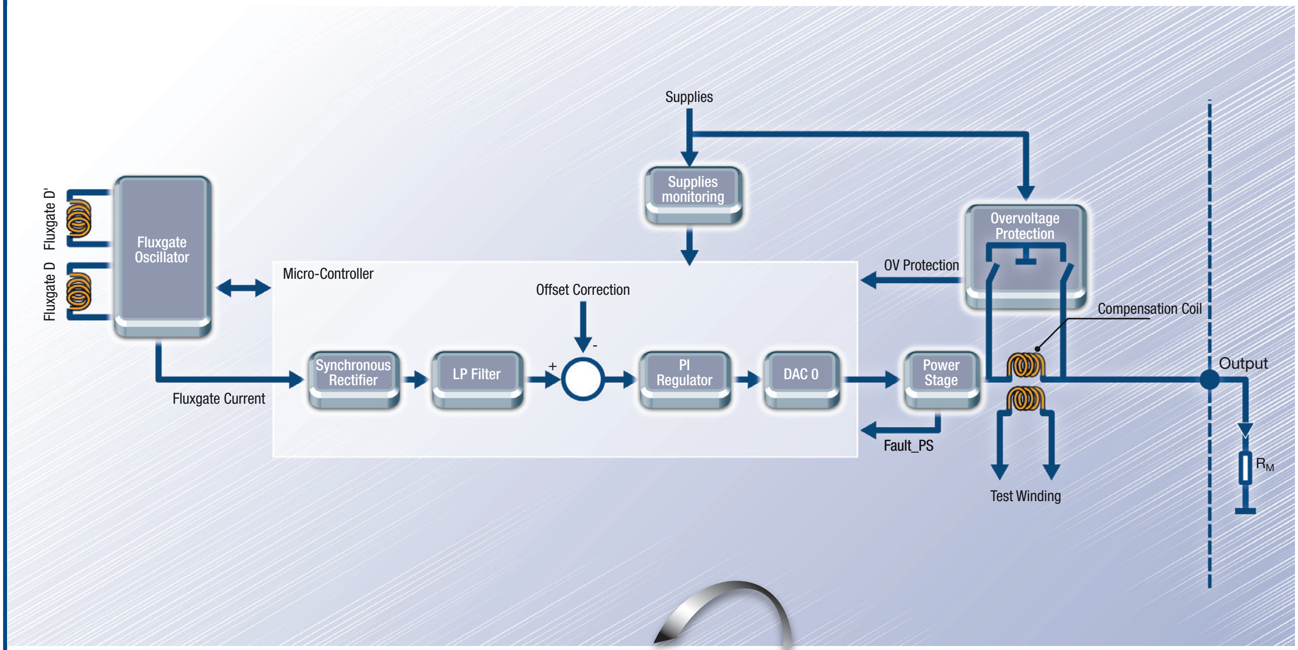
ITC series technology description

Fluxgates are self-oscillating, their currents are measured by the micro controller through an A/D converter. A micro controller is used for different reasons:

- Synchronous rectifier of fluxgate signal
- Low pass filter
- Compensation of offset and reduction of offset drift (micro controller replaces analogue circuits)
- Regulation of secondary current
- Protection management (supplies, over-voltage, overload)
- Output stages and Fluxgate management

The output of secondary current regulator is converted into an analogue value using a D/A converter that gives the reference to the PWM generator for the output stage.

ITC Technology: Bloc schematic



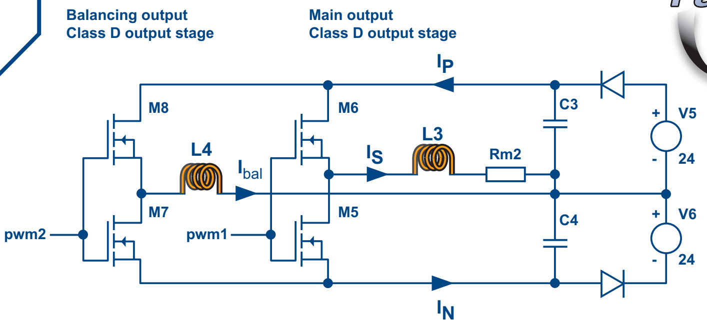


Fig 6. Class D output current generator

Closed loop Fluxgate ITC technology features

- Excellent linearity
- Better than Class 0.5R according to EN 50463
- Outstanding long-term stability
- Low residual noise
- Very low sensitivity to high external DC and AC fields
- High temperature stability

The Class D switch mode output stage (Fig. 6) is used to reduce losses, and then avoid using a heat sink outside the transducer.

In switched-mode amplifier, both transistors of the output bridge are switched on alternatively by a PWM signal which duty cycle is varied to adjust the output voltage.

The losses are therefore only caused by the conduction and commutations losses of the semiconductors. Compared to the standard Class AB (linear), the Class D allows the losses in the semiconductors to be reduced by a factor close to 5 improving also the reliability of the electronics. A LC filter removes most of the high frequency harmonics to keep the output noise low.

A second switch mode output stage is added only for balancing supply currents between positive and negative power supply (LEM patent).

Ibal is regulated to be exactly $-I_S$.

ITC Series Current Transducers: Main Characteristics

Absolute maximum ratings (ITC 4000-S)

Parameter	Symbol	Value
Maximum supply voltage (working) (-40..85°C)	$\pm V_C$	±26.4 V
Maximum input current	I_P	100 kA
Maximum steady state input current (-40..85°C)	I_{PN}	4000 A_{RMS}

Insulation characteristics

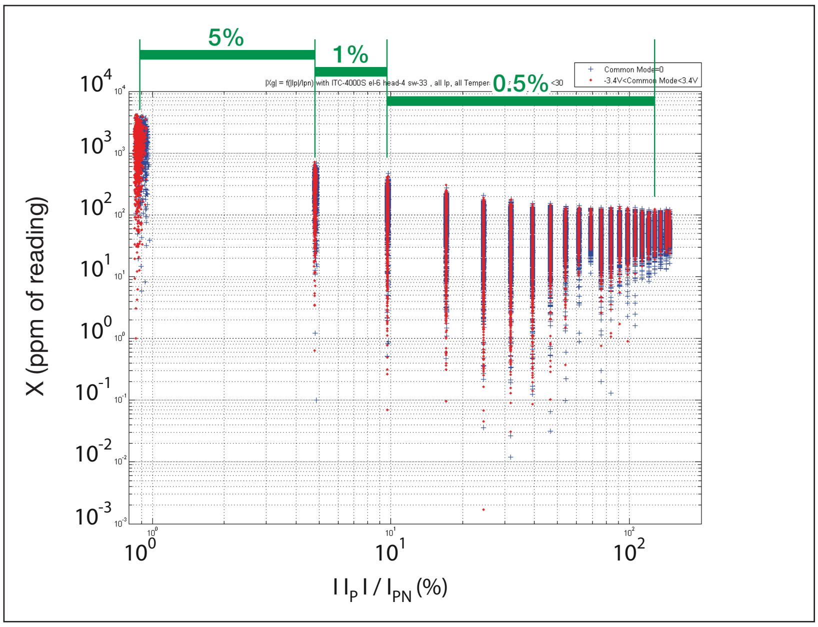
Parameter	Symbol	Unit	Min	Comment
RMS voltage for AC insulation test 50/60 Hz /1 min	V_d	kV	14	100% tested in production
RMS voltage for partial discharge extinction @ 10 pC	V_e	V	5000	Bar with centered bar Ø 95 mm
Clearance distance (pri. - sec.)	dCl	mm	88	Shortest distance through air
Creepage distance (pri. - sec.)	dCp	mm	171	Shortest path along device body
Comparative Tracking Index of case material	CTI	V	600	

Environmental and mechanical characteristics

Parameter	Symbol	Unit	Min	Typ	Max
Ambient operating temperature	$\mathbf{T_A}$	°C	-40		85
Ambient storage temperature	$\mathbf{T_S}$	°C	-50		85
Mass	***m***	kg		8.6	

ITC 4000-S typical accuracy over the whole temperature range and over the possible supply voltages variations; the green lines are the EN 50463 standard requirements (specifications) at 23 °C ambient temperature (fig.7).

High accuracy over temperature range and over measuring range



ITC series reaches the Class 0.5R measurement accuracy according to Pr EN 50463.

Linearity error is less than 0.05% of peak current, offset currents less than +/- 20 µA are really stable, and offset drift in temperature is less than 100 µA. ITC models provide a current output thanks to the Class D amplifier.

With the use of the double Class D output current generator, the supply currents are balanced and reduced versus a transducer using a Class AB amplifier.

The supply current is always positive and almost equal on both supplies: 0.3 A at nominal output current on each power supply polarity (Fig. 8), electronic losses are less than 6 W when supplied under +/- 24 V.

For instance, using a Class AB amplifier would have required a supply current of 1.6 A and would have created 30 W of losses at nominal current.

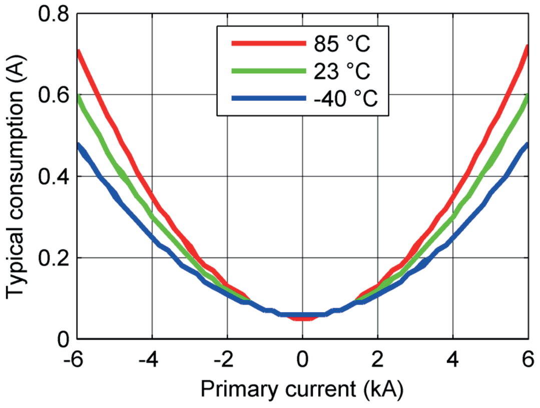


Fig. 8. Consumption currents on each power supply polarity in regards with the primary current ($R_M = 0.1\ \Omega$, $\pm V_C = \pm 24$ V) (both supply currents are identical)

Use of large heatsink is not anymore necessary due to this losses reduction leading to current transducer largely reduced in size.

With less current consumption needed, power supplies to be associated with the ITC transducers can be of a lower capacity and then cheaper.

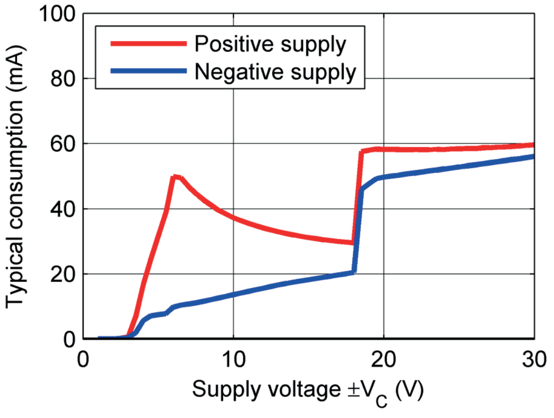


Fig. 9. Supply current function of supply voltage (I_P=0)

This technic is however creating a ripple of about 25 mA.t within the bandwidth 80 kHz and 3 A.t within the bandwidth 200 kHz, this noise can be easily reduced with the use of a filter.

High primary current overloads can occur in traction applications, that's why ITC series has been designed to support high overloads until 100 kA/100 ms.

100 kA means not less than 40 A on the secondary of the ITC 4000-S, and to protect the internal components and customer burden resistance, but also printed circuit tracks, a special dedicated electronic circuit has been designed. This protection is working with or without power supply, as well as with measuring resistor installed or not.

If the primary current becomes higher than the measuring range, the electronics cannot maintain the flux compensation.

If this state lasts too long, the fluxgate detector becomes completely saturated and unable to measure the flux error. When this happens, the transducer stops for 300 to 500 ms and then sweeps the output current to find the point at which compensation is correct again and the normal function can resume.

In addition to the analog current output, these models offer a logic output called "/VALID" (open collector) indicating the transducer state (operational status).

The pull-up resistor is external to the transducer. It is activated (pulled to 0V) to indicate that the regulation of the output current works normally. It is deactivated (pulled to the high level) to indicate that the output current is not the exact image of the primary current. It happens during the start-up of the transducer, after a large overcurrent, if there is an internal fault or if the measuring resistance is disconnected while a primary current is present.

A test winding is part of the ITC models which can be used for a re-verification of the transducer in the application, for example in the ITC 4000, 1 A in the test winding simulates 400 A primary, representing 10% of the nominal current.

It is then easy to check accuracy of the transducer on board by using a small current.

ITC transducers are insensitive to the position of the primary conductor within their large measurement aperture, offer high insulation test voltage of up to 14 kV_{RMS}/50 Hz/1 min (ITC 4000 model), and have excellent immunity to external interferences (such as magnetic fields typical of the rail environment).

Bandwidth for the ITC 4000-S & ITC 2000-S is 80 kHz (3 dB) and the transducers' apertures allow the insertion of large conductors: 102 mm diameter (for the ITC 4000-S) or 63 mm diameter (for the ITC 2000-S).

3 models form the ITC range today: ITC 1000-S, 2000-S and 4000-S, with corresponding nominal current measurement of 1000, 2000 and 4000 A_{RMS}.

They are proposed in either a one-piece housing (ITC 4000-S model), or a split construction (ITC 1000 and 2000-S models) with the measuring head in a case, and its control electronic mounted remotely in a metal enclosure, to facilitate locating the measuring head in confined spaces such as the train roof space.

They have been designed for the rail-traction industry sector, reaching the Class accuracy 0.5R defined in the prEN 50463 standard for on-board energy monitoring operating over the temperature range –40 to +85°C.

Beside the possible function in the Energy Measurement Systems, they can easily be used everywhere an accuracy of 0.5 % from 5 % to 120 % of the nominal current is required.

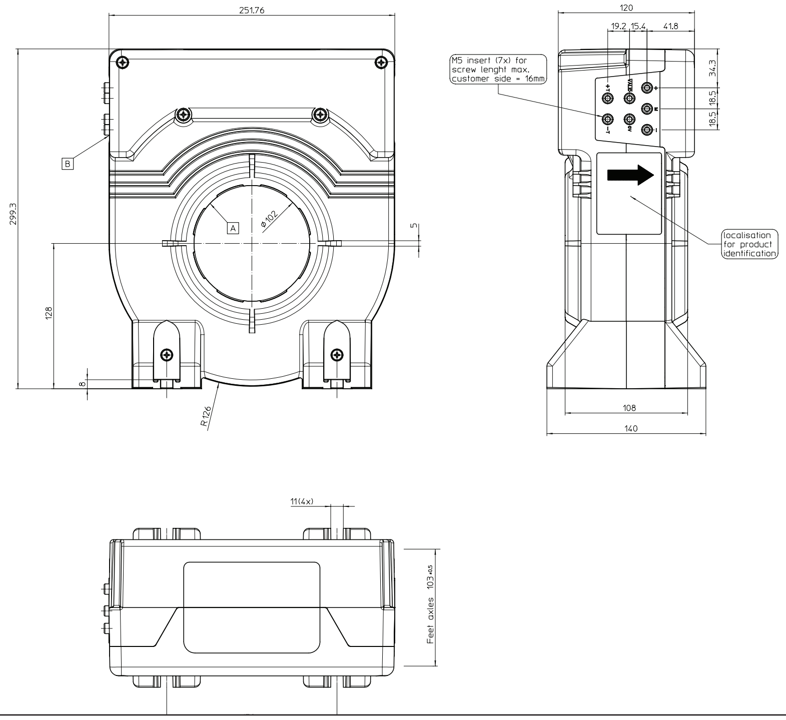
ITC series Current Transducers Main Characteristics: Electrical data

At T_A = 25 °C, V_C = ± 24 V, R_M = 0.1 Ω, unless otherwise noted.
Parameters with a * in the conditions column apply over the –40.. 85°C ambient temperature range.

Electrical data ITC 4000-S

Parameter	Symbol	Unit	Min	Typ	Max	Conditions	
Primary nominal current, $_{RMS}$	I_{PN}	A			4000	*	
Primary current, measuring range	I_{PM}	A	–6000		6000	*	
Measuring resistance	R_M	Ω	0		1	*	for $\lvert I_{PM}\rvert$<6kA, max value of R_M on the datasheet
Secondary nominal current, $_{RMS}$	I_{SN}	A		1.6	1.6	*	
Output range	I_S	A	–2.4		2.4	*	
Supply voltage	$\pm V_C$	V	±21.6	±24	±26.4	*	
Current consumption	I_C	mA	45	57	±70		I_P=0, $\pm V_C$=±24V, valid for + and – supplies (fig.8 & 9)
Number of secondary turns	Ns			2500			
Number of turns (test winding)	N_T			400			
Offset current referred to primary	I_O	mA	–50	3	50		100% tested in production
Magnetic offset current, referred to primary	I_{OM}	mA		5			After I_P = 15 kA
Offset drift referred to primary	I_{OT}	mA	–250	–3	250	*	–40 .. 85°C, 100% tested in production
Sensitivity	G	mA/A		0.4			
Sensitivity error	ε_G	%	–0.05	–0.0002	0.05		
Thermal drift of sensitivity	ε_{GT}	%	–0.01	0.0005	0.01	*	–40 .. 85°C
Linearity error	ε_L	% of I_{PM}	–0.01	–0.0004	0.01	*	±6000 A range
Overall accuracy at I_{PN}	X_G	% of I_{PN}	–0.05	–0.0003	0.05	*	–40 .. 85°C
Overall accuracy at I_{PN}	X_G	% of I_{PN}	–0.05	–0.0003	0.05		25°C; 100% tested in production
Overall accuracy	X_G	% of reading @ 10% I_{PN}	–0.2	–0.003	0.2		23°C; 100% tested in production
Overall accuracy	X_G	% of reading @ 5% I_{PN}	–0.4	–0.005	0.4		23°C; 100% tested in production
Overall accuracy	X_G	% of reading @ 1% I_{PN}	–2	–0.03	2		23°C; 100% tested in production
Overall accuracy	X_G	% of reading @ 0.4% of I_{PN}	–5	–0.08	5		
Output current noise referred to primary	i_{no}	A_{RMS}		3.2			1 Hz to 1 MHz
Reaction time @ 10 % of I_{PN}	t_{ra}	µs		0.1			0 to 4000 A step with a di/dt = 100 A/us
Response time @ 90 % of I_{PN}	t_r	µs		0.1			
Frequency bandwidth	BW	kHz		82,45,11			3 dB, 100 A 1 dB, 100 A 0.1 dB, 100 A
Start–up time		ms		400	500	*	

ITC 4000-S Current Transducer: Dimensions



Dimensions in mm. 1 mm = 0.0394 inches

Mechanical characteristics

General tolerance	±1 mm
Fastening of transducer	4 slots dia. 11 mm 4 steel screws M10
Recommended fastening torque	11.5 Nm (±10%)
Primary through–hole	dia. 102 mm
Connection of secondary	M5 insert
Recommended fastening torque	2.2 Nm. (±10%)

Remark

- Temperature of the primary conductor should not exceed 85 °C
- Dynamic performances (di/dt and response time) are best with a single bar completely filling the primary hole.
- This is a standard model. For different versions (supply voltages, turns ratios, unidirectional measurements…) please contact us.
- I_S is positive when I_P flows in direction of the arrow
- The secondary cables have to be routed together all the way.
- Installation of the transducer is to be done without primary current or secondary voltage present.

Safety

This transducer must be used in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the 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.

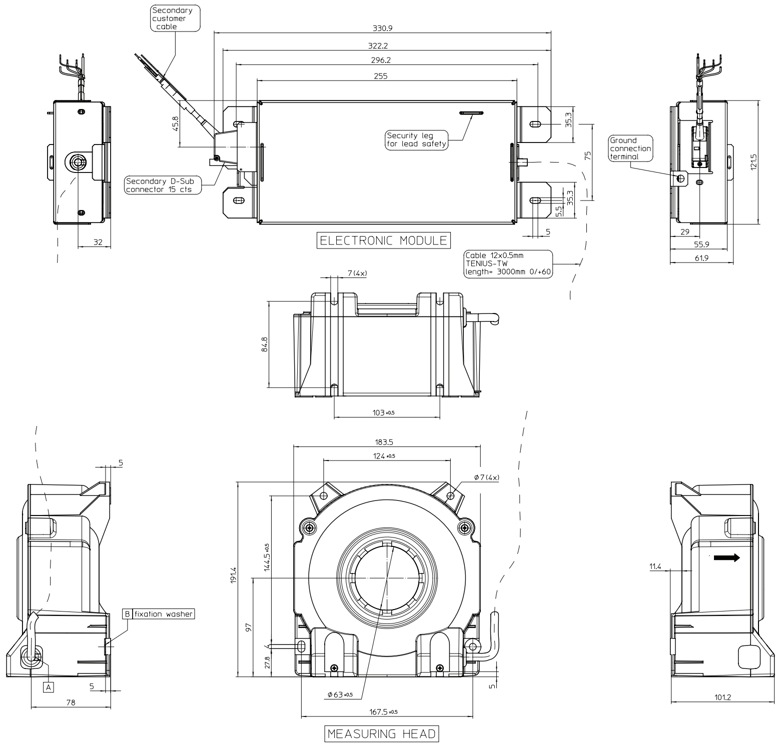
ITC series Current Transducers Main Characteristics: Electrical data

At T_A = 25 °C, V_C = ± 24 V, R_M = 0.1 Ω, unless otherwise noted.
Parameters with a * in the conditions column apply over the –40.. 85°C ambient temperature range.

Electrical data ITC 2000-S/SP1

Parameter	Symbol	Unit	Min	Typ	Max	Conditions	
Primary nominal current, $_{\mathrm{RMS}}$	I_{PN}	A			2000	*	
Primary current, measuring range	I_{PM}	A	–3000		3000	*	
Measuring resistance	R_M	Ω	0		2	*	for $\lvert I_{PM}\rvert$<3kA, max value of R_M on the datasheet
Secondary nominal current, $_{\mathrm{RMS}}$	I_{SN}	A		0.8		*	
Output range	I_S	A	–1.2		1.2	*	
Supply voltage	$\pm V_C$	V	±21.6	±24	±26.4	*	
Current consumption	I_C	mA	45	54	±70		I_P=0, $\pm V_C$=±24V, valid for + and – supplies
Number of secondary turns	Ns			2500			
Number of turns (test winding)	N_T			200			
Offset current referred to primary	I_O	mA	–10	4	10		100% tested in production
Magnetic offset current, referred to primary	I_{OM}	mA		5			After I_P = 10 kA
Offset drift referred to primary	I_{OT}	mA	–50	10	50	*	–40 .. 85°C, 100% tested in production
Sensitivity	G	mA/A		0.4			
Sensitivity error	ε_G	%	–0.005	–0.0002	0.005		
Thermal drift of sensitivity	ε_{GT}	%	–0.01	0.002	0.01	*	–40 .. 85°C
Linearity error	ε_L	% of I_{PM}	–0.01	–0.0004	0.01	*	±3000 A range
Overall accuracy at I_{PN}	X_G	% of I_{PN}	–0.01	–0.0015	0.01	*	–40 .. 85°C
Overall accuracy at I_{PN}	X_G	% of I_{PN}	–0.01	–0.0015	0.01		25°C; 100% tested in production
Overall accuracy	X_G	% of reading @ 10% I_{PN}	–0.1	–0.004	0.1		23°C; 100% tested in production
Overall accuracy	X_G	% of reading @ 5% I_{PN}	–0.2	–0.015	0.2		23°C; 100% tested in production
Overall accuracy	X_G	% of reading @ 1% I_{PN}	–1	–0.03	1		23°C; 100% tested in production
Overall accuracy	X_G	% of reading @ 0.4% of I_{PN}	–2.5	–0.3	2.5		23°C; 100% tested in production
Output current noise referred to primary	i_{no}	A_{RMS}		2			1 Hz to 1 MHz
Reaction time @ 10 % of I_{PN}	t_{ra}	µs		0.1			0 to 2000 A step with a di/dt = 100 A/us
Response time @ 90 % of I_{PN}	t_r	µs		0.1			
Frequency bandwidth	BW	kHz		27,23,3			3 dB, 100 A 1 dB, 100 A 0.1 dB, 100 A
Start–up time		ms		400	500	*	

ITC 2000-S/SP1 Current Transducer: Dimensions



Dimensions in mm. 1 mm = 0.0394 inches

Mechanical characteristics

General tolerance	± 1 mm
Fastening of measuring head	4 slots dia. 7 mm 4 steel screws M6
Recommended fastening torque	5 Nm (±10%)
Primary through–hole	dia. 63 mm
Fastening of electronic module	4 screws M5
Recommended fastening torque	5 Nm (±10%)
Connection of secondary	D–Sub male connector 15 cts

Remark

- Temperature of the primary conductor should not exceed 100 °C
- Dynamic performances (di/dt and response time) are best with a single bar completely filling the primary hole.
- For different versions (supply voltages, turns ratios, unidirectional measurements…) please contact us.
- I_S is positive when I_P flows in direction of the arrow
- The secondary cables have to be routed together all the way.
- Installation of the transducer is to be done without primary current or secondary voltage present.

Safety

This transducer must be used in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the 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.

5 Year Warranty on LEM Transducers

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

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