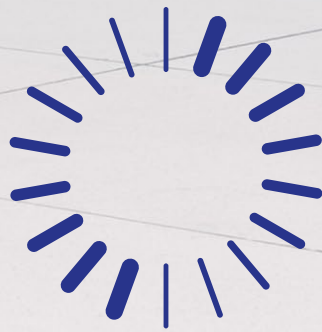


# LEM

Life Energy Motion

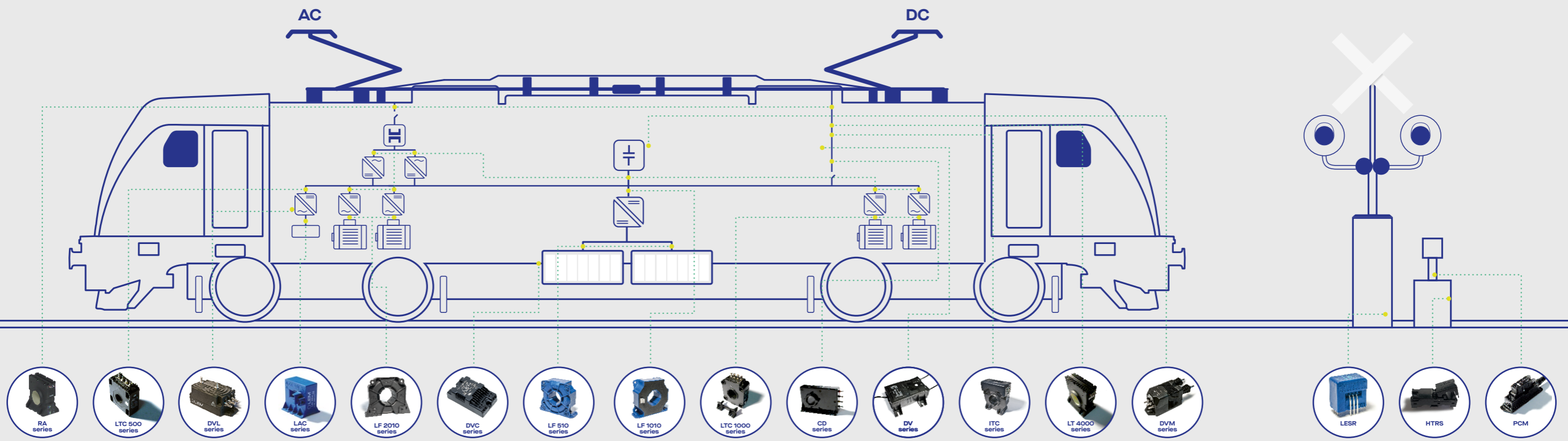
## Railway and traction

Our sensors and solutions



# Contents

- 4 On-board current sensors**  
Fluxgate, Hall effect Open Loop & Closed Loop
- 10 On-board voltage sensors**  
Hall effect, Digital insulation technology
- 14 Trackside sensors**  
Hall effect Open Loop & Closed Loop
- 18 On-board metering**  
Energy Meter, Modem



**Today, high speed trains, city transit systems (metro, trams and trolleybuses) as well as freight trains are the solutions against pollution and interstate traffic immobility, also providing significant energy savings. Furthermore, power electronics is essential to drive and control energy in these transportation systems.**

**LEM has been a main player in traction power electronics, onboard metering and trackside applications for the last 50 years. We leverage this vast experience to develop and supply solutions for isolated current and voltage measurements as well as for trackside applications and energy metering.**

# Onboard current sensors

Insulated and precise current measurement is key to support the efficiency of power electronics on board trains. On the other hand, we offer dedicated solutions to measure any other current positioned somewhere in the locomotive: input current to trigger the main circuit breaker, differential current to monitor earth leakages, interference currents to control the network harmonics, high precision DC currents as input for energy meter, etc.

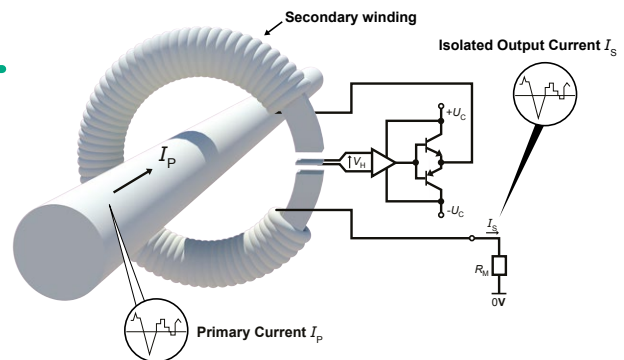
Considering the demanding requirements in the railway segment, LEM is strictly following international standards for the current sensors such as EN 50155, EN 50463, as well as offering an intermediate statement verification for TSI LOC&PAS. Furthermore, we commit to railway requirements RoHS, IRIS, ISO 9001.

# LEM current sensing technologies

In railway applications, Open Loop and Closed Loop technologies are most common in inverter applications. Fluxgate sensors are used for more specific measurements, such as differential current measurement and energy metering. Whatever your requirements are, LEM is supporting your application with best in class technology.

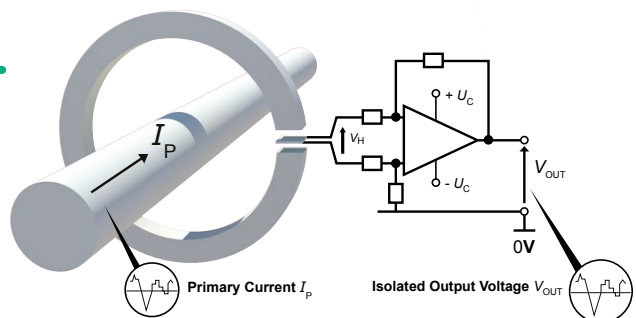
## Closed Loop

- Wide frequency range
- Good global accuracy
- Fast delay time
- Low temperature drift
- Excellent linearity
- No insertion losses



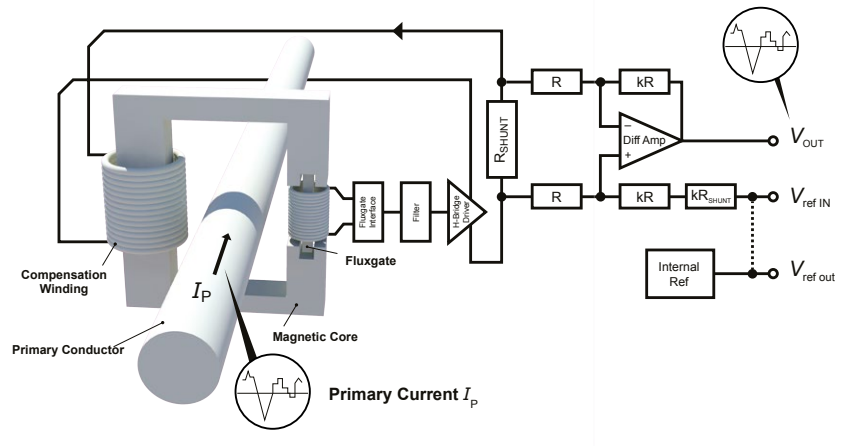
## Open Loop

- Small package size
- Extended measuring range
- Reduced weight
- Low power consumption
- No insertion losses



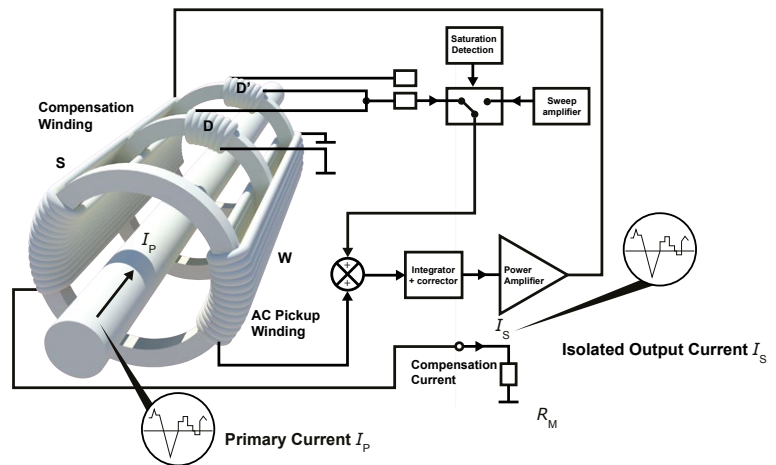
### Closed Loop Fluxgate CAS-CASR-CKSR type

- Any kind of AC, DC, pulsed and complex signal
- High accuracy
- High accuracy in temperature
- Very low drift in temperature (gain and offset)
- Galvanic insulation
- Fast delay time



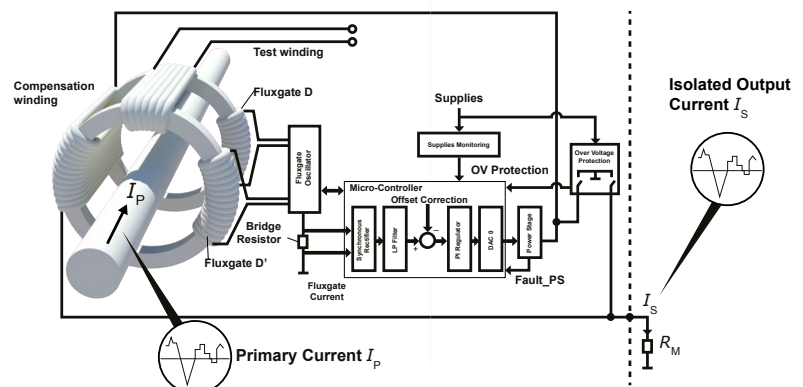
### Closed Loop Fluxgate IT type

- Very high accuracy
- Low residual noise
- Excellent linearity < 1 ppm
- Low cross-over distortion
- High temperature stability
- Wide frequency range



### Closed Loop Fluxgate ITC type

- 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





# Our range for on-board current sensors

## Standard current sensors

		Nominal current	Output ratio	V <sub>cc</sub>	error @25°C	Tech	T <sub>ambient</sub>
<b>LAC series</b>		200 ... 300A AC and DC	1:2000 to 1:5000	+/- 15V or +/- 24V	1.0%	Closed Loop	-40 ... +85°C
<b>LTC series</b>		200 ... 1000A AC and DC	1:1000 to 1:5000	+/- 15V ... +/- 24V	0.5%	Closed Loop	-40 ... +85°C
<b>LF series</b>		100 ... 2000A Bipolar DC	1:1000 to 1:5000	+/- 15V ... +/- 24V	0.2% or 0.7%	Closed Loop	-40 ... +85°C
<b>LF series</b>		1 ... 2kA AC (50Hz)	1:4000 to 1:6000	+/- 15V ... +/- 24V	0.2% or 0.5%	Closed Loop	-40 ... +85°C
<b>LT 4000 series</b>		3 ... 5kA Unipolar DC	1:4000 to 1:5000	+/- 24V or +/- 60V	0.5%	Closed Loop	-40 ... +70°C
<b>HAR series</b>		500 ... 1000A AC and DC		+/- 5V +/- 15V	1.0%	Open Loop	-40 ... +70°C
<b>NNC series</b>		1kA ... 2.5kA AC and DC	+/- 10V	+/- 15V or +/- 24V	1.0%	Open Loop	-40 ... +80°C
<b>DHR series</b>		100 ... 600A DC and AC >200Hz	0 ... 5V 0 ... 10V 0 ... 20mA	+20 ... 50V	1.0%	Open Loop RMS out	-25 ... +70°C
<b>HTA series</b>		250A, 1000A AC and DC	+/- 10V	+/- 15V	1.0%	Open Loop	-25 ... +70°C
<b>HTC series</b>		0.1 ... 4kA AC and DC	+/- 10V	+/- 15V	1.0%	Open Loop	-40 ... +85°C

## Special current sensors

		Nominal current	Output ratio	V <sub>cc</sub>	error @25°C	Tech	T <sub>ambient</sub>
<b>ITC 2000 series</b> On-board Metering		1.5 ... 4kA AC and DC	1:2500	+/- 24V	0.05%	Fluxgate	-40 ... +85°C
<b>ITC 4000 series</b> On-board Metering		500 ... 2000A AC and DC	1:2500	+/- 24V	0.05%	Fluxgate	-40 ... +85°C
<b>IN 1000 series</b> <b>Coming soon</b>		100 ...1000A Bipolar DC	1:5000	+/- 15V	0.05%	Fluxgate	-40 ... +85°C
<b>RA family</b> Interference detection		0.5kA ... 2kA AC (50Hz)	M*di/dt	none	3.0% @100mA	Rogowski	-40 ... +85°C
<b>CD family</b> Differential current		0.1A ... 2kA Bipolar DC	20mA	+/- 48V or +/- 24V	3.0% @100mA	Fluxgate	-40 ... +70°C
<b>Specific SP-type</b> Differential current	LF 2005-S/SP9 LF 310-S/SP20	100 ... 1000A DC + superimposed AC	1:2000 to 1:5000	+/- 15V or +/- 24V	Specific frequency behaviour	Closed Loop	-40 ... +85°C

# Onboard voltage sensors

Many railway applications require precise voltage measurement and demanding insulation characteristics. Following the EN 50163, our portfolio covers the need not only for 1.5 and 3kV DC-networks for countries like France, Italy, Netherlands, etc., but also for metro and light rail tracks on 600/750V level.

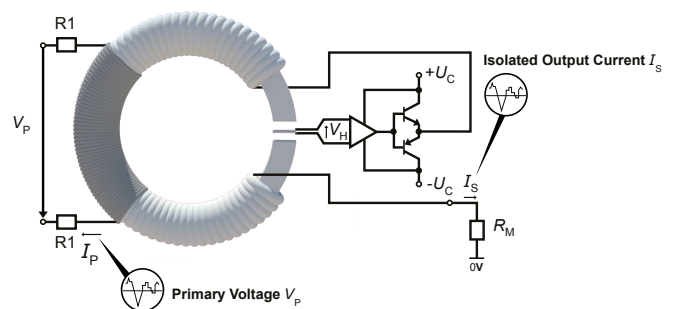
All LEM voltage sensors have been qualified to EN 50155, the DV-series has been tested to EN 50463, furthermore offering an intermediate statement verification (ISV) for TSI LOC&PAS. As for our current sensors, we adhere to railway requirements such as IRIS, RoHs, ISO 9001.

# LEM voltage sensing technologies

LEM offers a wide range of voltage sensor technologies providing galvanic insulation between primary and secondary circuits. In particular the Digital Voltage sensors offer a unique performance over the full temperature range. Whatever your requirements are, LEM is supporting your application with best in class technology.

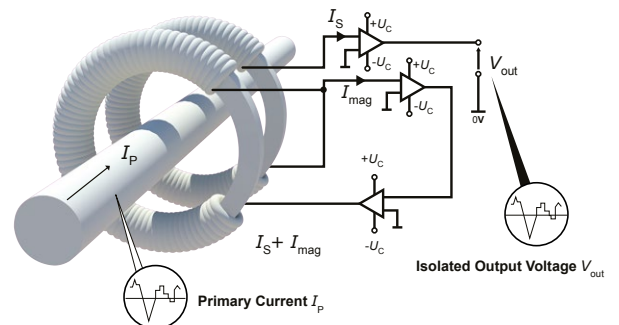
## Closed Loop Voltage Transducers

- Measurement of high voltages
- Safety isolation
- Good overall accuracy
- Low temperature drift
- Excellent linearity



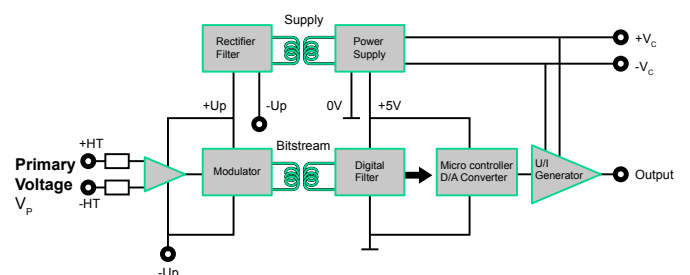
## Closed Loop Fluxgate C Type

- High accuracy
- Very wide frequency range
- Reduced temperature drift
- Excellent linearity
- Safety isolation
- Reduced loading on the primary








## DV & DVL Type Voltage Transducers

- Insulating digital technology
- Measurement of all types of signals: DC, AC, pulsed and complex
- Compact size, reduced volume
- High galvanic insulation
- Low consumption and losses
- Very high accuracy, Class 0.5R according to EN 50463 (DV models)
- Low temperature drift








# Our range for on-board voltage sensors

## Digital sensors

		Nominal voltage	Output	V <sub>cc</sub>	error @25°C	dcl/dcp [mm]	Test voltage 50Hz/60sec
<b>DVC PCBA series</b>		Up to 1000V Bipolar AC + DC	2.5V +/- 2V	+ 5V	1.0%	9.0/9.0	4.26kV
<b>DVC series</b>		Up to 1000V Bipolar AC + DC	10V 20mA 4 - 20mA	+/- 15V or +/- 24V	1.0%	9.0/9.0	4.26kV
<b>DVL series</b>		150 ... 2000V AC + DC	10V 50mA 4 - 20mA	+/- 15V or +/- 24V	0.5%	41.6/57.1	8.5kV
<b>DVM series</b>		1 ... 4.2 kV Bipolar AC + DC	10V 50mA 4 - 20mA <sup>1)</sup>	+/- 15V or +/- 24V	0.5%	74/101	12kV
<b>DV series</b>		2 ... 6.4kV <sup>2)</sup> Bipolar AC + DC	10V 50mA 20mA	+/- 15V or +/- 24V	0.5% <sup>3)</sup>	138/287 127/236 78/88	18.5kV

## Classic sensors

<b>LV 25-P series</b> w/o HV-resistor		Up to 1000V Bipolar AC + DC	20mA	+/- 15V	0.8%	19.5/19.5	4.2kV
<b>LV 25 series</b>		Up to 1000V Bipolar AC + DC	25mA 50mA	+/- 15V or +/- 24V	1.0%	13.8/13.8	4.1kV
<b>CV 3 series</b> High bandwidth		200 ... 2000V Bipolar AC & DC	10V	+/- 15V	0.2%	41.6/57.1	6.0kV
<b>CV 4 series</b> Spare parts only		1 ... 4.2kV Bipolar AC + DC	10V 70mA	+/- 15V or +/- 24V	0.5%	74/101	9.0kV
<b>LV 100 series</b> Test winding		250 ... 2500V Bipolar AC + DC	50mA	+/- 15V or +/- 24V	0.9%	27.9/55.1	6.0kV

1) Unipolar measurement – 2) Limited measuring range at 6.4kV nominal – 3) Variants conform to EN 50463:2017 (Metering)

# Track- side sensors

From the beginning in the 1970's, LEM has been offering solutions for the entire railway system. In various applications which are on the ground, the so-called trackside market, our huge portfolio of industrial sensors can address customer requirements. No matter what the application, e.g. control & monitoring of lamps, crossing gates, points machines or DC-substations, LEM always offers dedicated solutions.

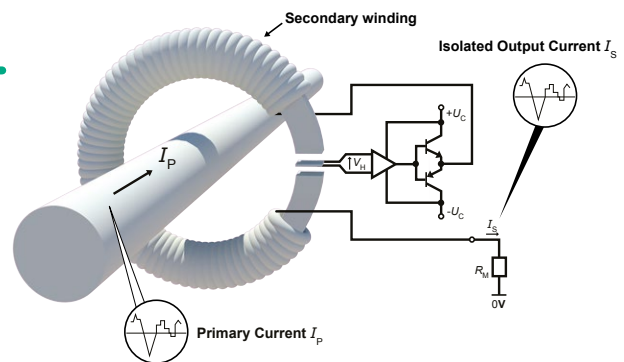


# LEM trackside sensing technologies

Railway signals, points machines and other trackside equipment are mainly measured with Open Loop or Closed Loop transducers. To support retrofit applications, LEM is offering a new double U-shape technology. Whatever your requirements are, LEM is supporting your application with best in class technology.

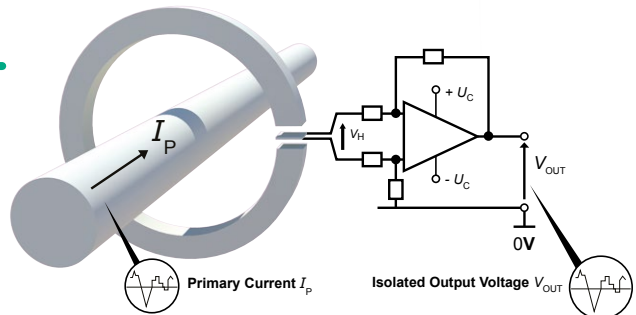
## Closed Loop

- Wide frequency range
- Good global accuracy
- Fast delay time
- Low temperature drift
- Excellent linearity
- No insertion losses



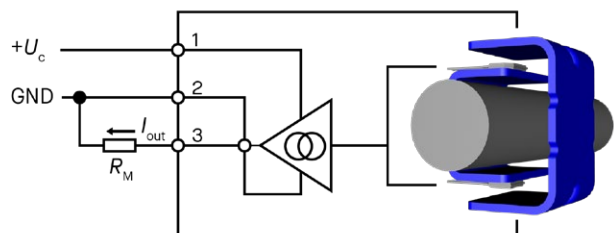
## Open Loop

- Small package size
- Extended measuring range
- Reduced weight
- Low power consumption
- No insertion losses







## Open Loop U-shape type

- Low offset
- High immunity against ext. fields
- Low temperature drift
- High accuracy
- Lightweight



# Our range for trackside sensors

## Standard and Split-core sensors

		Nominal current	Output	V <sub>cc</sub>	error @25°C	Tech	T <sub>ambient</sub>
<b>HTRS series</b>		10 ... 50A Bipolar AC + DC	4-20mA Instantaneous	12V ... 24V	2.0%	Open Loop	-40 ... +85°C
<b>New</b>							
<b>PCM series</b>		5 ... 30A Bipolar AC + DC	4-20mA True RMS	24V	2.0%	Closed Loop	-25 ... +85°C
<b>LESR series</b>		6 ... 25 A Bipolar AC + DC	+/- 625 mV Instantaneous	+/- 5V	0.2%	Closed Loop	-40 ... +105°C
<b>HAZ series</b>		4 ... 20kA Bipolar AC + DC	4-20mA 0 ... 20mA 10V Instantaneous or True RMS	+/- 15V	1.0%	Open Loop	-25 ... +85°C

# Onboard mete- ring

LEM's solutions for on-board energy metering offer a highly accurate measurement to avoid any doubt on the correctness of the energy bill (from energy supplier to the operator of rolling stock). Furthermore, the load profile data can be used to measure the energy efficiency of the rail vehicle as well as to train the driver for more sustainable behaviour.

All of the LEM equipment has been qualified to EN 50463:2017; they can be used in all European countries where legal relevant energy measurement is required. However, they can also be used in Asia and the Americas.

# Key functionality EM4TII / TEMA4G series

Supporting international cross border freight and passenger transport, an exact knowledge of consumed and regenerated energy of a railway vehicle is mandatory. Since more than 10 years, EM4TII+ is the key element of several Energy Metering Systems (EMS) in Europe. It consists of the mandatory functions ECF (Energy Calculation Function) and DHS (Data Handling System). Furthermore, it can be ordered as subsystem or integrated in LEM's EMS solution called TEMA4G which is offering in addition the PEMG2 communication device transferring the energy data to ground. EM4TII+ and TEMA4G are compatible with the most relevant current and voltage measurement devices (AC and DC), in particular with LEM's DC current and voltage transducers (DV and ITC series).

## Features of EM4TII+:

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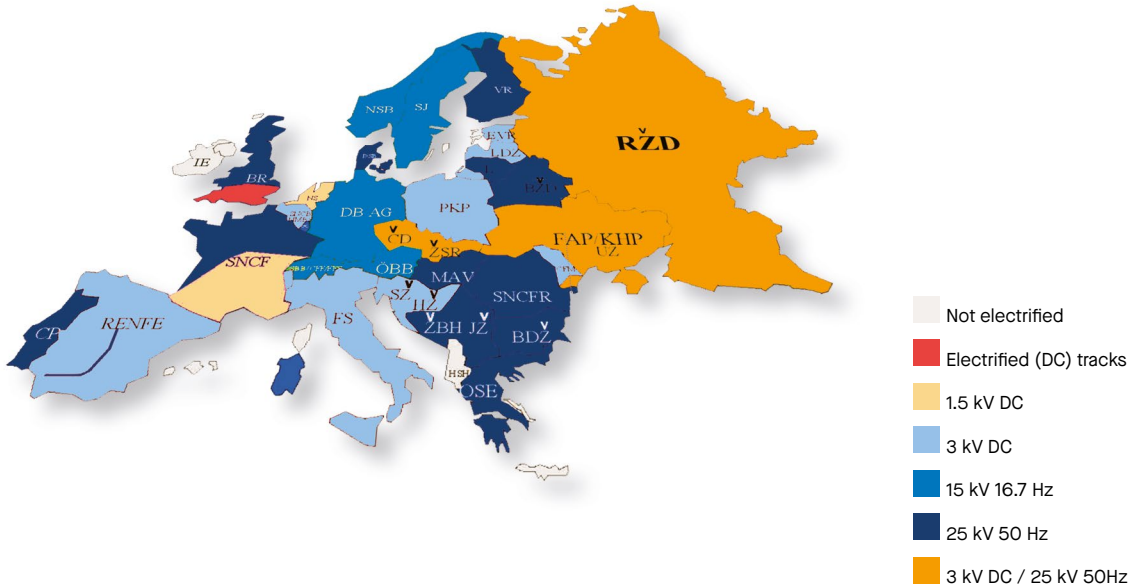
- 4 channel energy meter for AC, DC and multisystem applications
- Load profile (CEBD data) in accordance to EN 50463:2017
- Load profile length: 5min (1 or 15 min optional)
- Memory size: 300 days (if load profile length is set to 5 min)
- GPS I/O (RS 232, NMEA 0183 format)

## Features of TEMA4G (in addition to EM4TII+):

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- GPS interface (SMA connector for antenna)
- Integrated web browser
- Ethernet service interface
- 2G/4G modem with customized SIM-card

# European rail networks



## Our range for on-board metering

### Energy Metering Solutions

		Nominal voltage	Output	GPS interface	V <sub>cc</sub>	Class accuracy
<b>EM4TII</b> Meter VDEW protocol EN 50463:2021		25kV/50Hz 16kV/16,7Hz 750V 1.5/3kV	RS 232 RS 485	RS232 (NMEA 0183 format)	+24 ... 48V +72 ... 110V	0.5R
<b>EM4TII+</b> Meter TSI/LOC PAS EN 50463:2021		25kV/50Hz 15kV/16,7Hz 750V 1.5/3kV	RS 232 RS 485	RS232 (NMEA 0183 format)	+24 ... 48V +72 ... 110V	0.5R
<b>TEMA4G</b> EMS incl. 4G-modem & SIM card EN 50463:2017		25kV/50Hz 16kV/16,7Hz 750V 1.5/3kV	2G/4G Ethernet	GPS antenna, SMA connector	+24 ... 48V +72 ... 110V	0.5R
<b>PEMG2</b> 4G-modem & SIM EN 50463:2017		N/A	2G/4G Ethernet	GPS antenna, SMA connector	Powered by EMaTII+ oder 12Vdc	N/A

# LEM quality and standards

The different LEM design and production centers around the world are either ISO TS 16949, ISO 9001 and/or ISO 14001 certified. Our main production centers for traction transducers are IRIS certified, a must for companies supplying the railway market.

Several quality tools have been implemented at LEM to assess and analyze its performances. LEM utilizes this information to take the necessary corrective actions to remain a responsive player in the market, among which the most representatives are:

- DPT FMEA (Design, Process & Tool Failure Mode Effect Analysis)
- Control Plan
- Cpk – R&R (Capability for Processes & Measurement Systems)
- QOS – 8D (Quality Operating System – Eight Disciplines)
- IPQ (Interactive Purchase Questionnaire)

In addition to these quality programs, and since 2002, LEM embraces Six Sigma as its methodology in pursuit of business excellence. The main goal is to create an environment in which anything less than Six Sigma quality is unacceptable.

## LEM's Standards

LEM sensors are designed and tested according to recognized worldwide standards. 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.

All of the LEM traction products are designed according to the EN 50155 standard. CE marking is a guarantee that the product complies with the European EMC directive 2004/108/EEC and low voltage directive and therefore warrants the electro-magnetic compatibility of the transducers. Sensors comply to the EN 50121-3-2 standard (Railway EMC standard).

UL is used as a reference to define the flammability of the materials (UL94V0) as well as the NFF 16101 and 16102 standards for the fire/ smoke materials classification. LEM is currently UL recognized for main models.



# Leading the world in electrical measurement

- The broadest product portfolio in the industry
- Full suite of current sensing solutions from IC up to complex, fully instrumented modules
- 50 years as a pure player in current sensing
- 1,500 people in 15 countries serving industry and automotive customers around the world







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