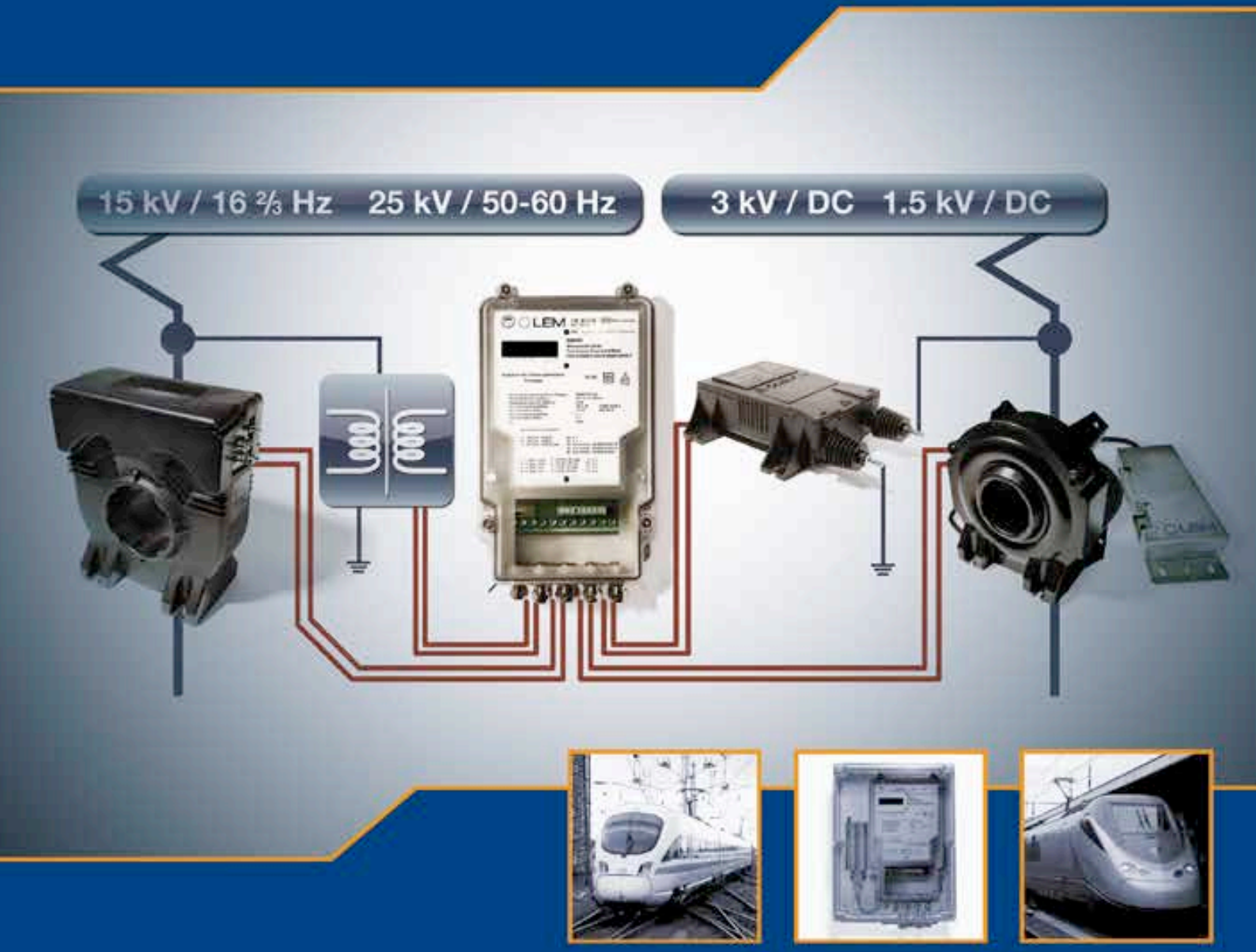
Technical Information

EM4T II
Energy Meter for On-Board Traction applications



LEM®

Energy Measurement for On-Board Applications: EM4T II

With the liberalization and/or privatization of some of the major rail networks, the opportunity for traction units to cross national boundaries now exists, using both the installed base of rail and planned rail networks.

This gave train designers the daunting task to develop multi-system locomotives to be used on the different existing networks.

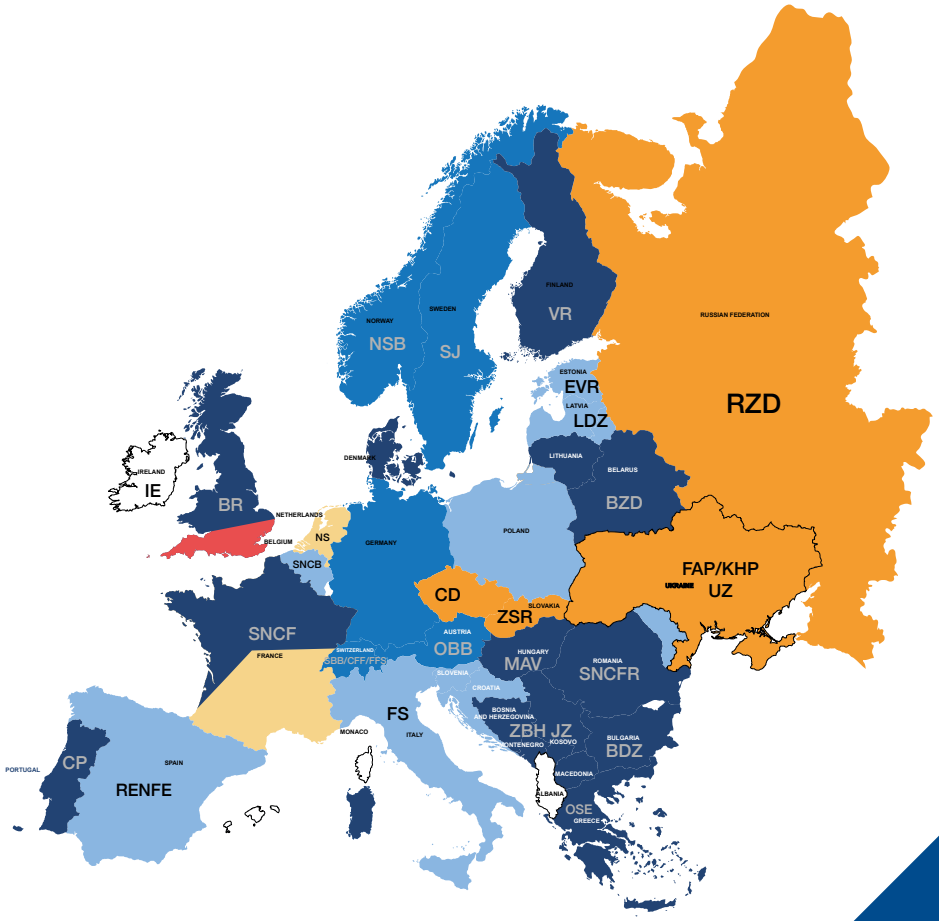
These prime movers would be needed to operate on the different supply networks of bordering countries along the route without requiring an equipment exchange at the regional or network supply border.

Today, it is therefore technically possible to transfer people or goods throughout Europe, from Norway to Sicily for example, without any physical exchange of the locomotive (Picture 1).

Changes in the Energy Markets in the form of deregulation and increased competition for large user contracts brought potential benefits for those willing to negotiate for their electrical traction supply requirements.

This negotiation however requires greater knowledge and understanding of the load profile of bulk supply points in one of the harshest electrical environments – the traction supply.

With the energy meter from LEM, the data for the precise calculation of both supplied and regenerated energy for billing purposes can be accomplished on the train, independently of the energy supplier.



Picture 1:

European rail networks

The second generation of universal energy meters for traction especially designed for on-board applications

With the EM4T II energy meter, LEM introduced the second generation of universal energy meters for electric traction units with the authorization for billings. Thanks to the advanced capability (such as input channels to connect any actual available current and voltage transducer or transformer) of the EM4T II, it is used both in new multi-system locomotives and for retrofitting to all types of electrical rail vehicles already in operation. Recently, the new EN 50463 standards define characteristics of energy measurement function (EMF) as well as transducers for current and voltage DC or AC measurement used for EMF. This evolution led LEM to upgrade EM4T to the latest model: EM4T II.

Siemens Train

Picture 2: EM4T II

EM4T II - The load profile provider

EM4T II is a single energy meter complying to all the requirements of EN 50463-x & EN 50155 standards for metering and On-Board use, and thus satisfies the requirements of EC Decision 2011/291/EC (TSI "Locomotives and passenger rolling stock").

EM4T II processes signals from the transformer and electronic converter systems for current and voltage to calculate energy values which are stored as load profile information.

In this load profile (set and stored in intervals of 1, 2, 3, 5, 10 or 15 minutes period length according to the user), the primary energy (delta) values are recorded together with data such as:

- Date and time stamp
- Events
- Train identification numbers
- Absolute energy values for consumption and regeneration of active and reactive energy
- Frequency of the network (16.7 Hz, 50 Hz, 60 Hz or DC)
- Additional "user" load profile like the voltage with a shorter time interval (feature coming in a second design step)
- Position of the train at the time the load profile was stored and/or the event arose
- Further functions, such as voltage detection can be set.

The measured energy information includes separately the consumed and regenerated active and reactive energy and is stored in the load profile memory (at 5 minutes period length) for at least 300 days.

The input variables - current and voltage - are connected to the measuring circuits of the EM4T II via differential inputs (Picture 2 and 3), designed for connection of all current and voltage transducers/ transformers currently available on the market.

Four input channels are proposed for metering of both DC and AC signals of any existing traction network (see chart 1).

The EM4T II is suitable for usage in multi-system vehicles. Supply systems 25 kV 50/60 Hz and 15 kV 16.7 Hz, or either 600 V DC, 750 V DC, 1.5 kV DC or 3 kV DC are covered. A system change is detected by the energy meter and stored in the load profile.

The requirements for current measurement at this level can be diverse.

A large aperture transducer is appropriate when the primary conductor is highly isolated to support the high level of voltage (15 to 25 kV AC as nominal level): LEM's ITC Transducer Series is of this category.

For the DC networks, the transducer's inherent isolation properties are adequate.

Analog to Digital Sigma-Delta conversion processors suppress high frequency disturbances in all channels, enhancing even further the capacity to handle the often rapid supply transitions within traction supplies.

The microprocessor reads the sampled values and calculates the real energy in adjustable intervals (standard value = 5 min). The results are then saved in flash memory (a special variant of an EEPROM).

The signals from 2 AC and 2 DC input channels (each for U- and I- input) are used to calculate the energy values. The high-accuracy measurement of the energy value is guaranteed by the digitally sampled signal converter implemented, providing the highest level of temperature and long-term stability.

Optionally, the EM4T II for DC measurement is available in a version with a single voltage input and up to three current inputs to measure the energy consumption for vehicles with multiple power supply points.

The EM4T II has a dedicated RS232 interface input for receiving serial GPS-data messages according to NMEA 0183, including the location data of the energy consumption point. It synchronizes also the internal clock of the meter using the obtained time information.

A log book in full conformity with EN 50463-3 is stored in the EM4T II. This log book information contains e.g. loss and gain of the operating voltage, power up/power down events of the supply voltage, clock synchronization, and the modification of parameters influencing the energy calculating.

Identification data of the vehicle or train are also stored and can be retrieved separately. The self-luminous display of the EM4T II shows cyclically all relevant energy and status information without required operations of a mechanical or optical button.

All measured and stored data can be read out via the RS-type interface (via modem or local).

The interface versions RS232, RS422 or RS485 are available. The applied data communications protocol is IEC 62056-21 and is therefore easily adaptable by all common remote reading systems. In the next version, the EM4T II will also provide an Ethernet-interface.

The supply voltage is selectable between 24 V and 110 V. Optionally, the EM4T II offers a power supply of 12 V for a communication unit (modem).

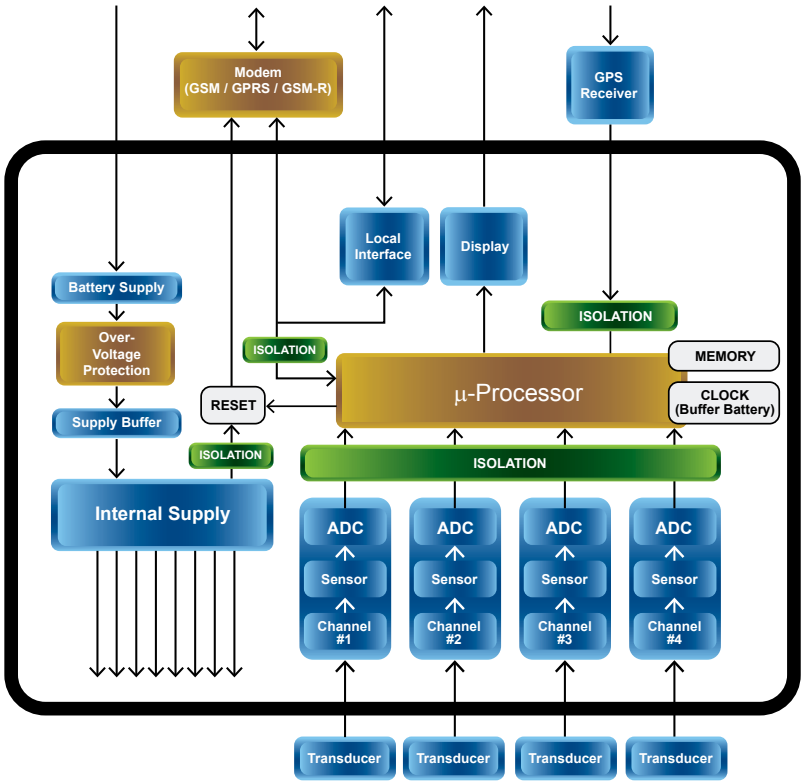
The operating conditions (considering EMC, temperature, vibration, etc.) meet the special requirements for traction use, including EN 50155, EN 50121-3-2, EN 50124-1, and EN 61373. The compact and fire-retardant enclosure provides protection against the ingress of moisture or foreign objects according IP 65.

EM4T II
Energy meter for On-Board Traction

- Data recording according to EN 50463-x
- Accuracy 0.5R according to EN 50463-2
- Multi-System capability for DC, 16.7 Hz, 50 Hz, 60 Hz
- Supply systems according to EN 50163: 25 kV 50 Hz, 15 kV 16.7 Hz, 600 V DC, 750 V DC, 1.5 kV DC, 3 kV DC
- Measurement of consumed and regenerated active and reactive energy
- For DC optionally with up to 3 DC current channels
- Input for GPS receiver
- Load profile recording including location data
- RS-type interface for data communication
- Ethernet-interface (Available in the next version)

Version	Channel 1	Channel 2	Channel 3	Channel 4
AC	AC-voltage	AC-current		
ACDC	AC-voltage	AC-current	DC-voltage	DC-current
DC	DC-voltage	DC-current		
DCDC	DC-voltage	DC-current	DC-current	
DCDCDC	DC-voltage	DC-current	DC-current	DC-current

Chart 1: EM4T II possible configurations for inputs



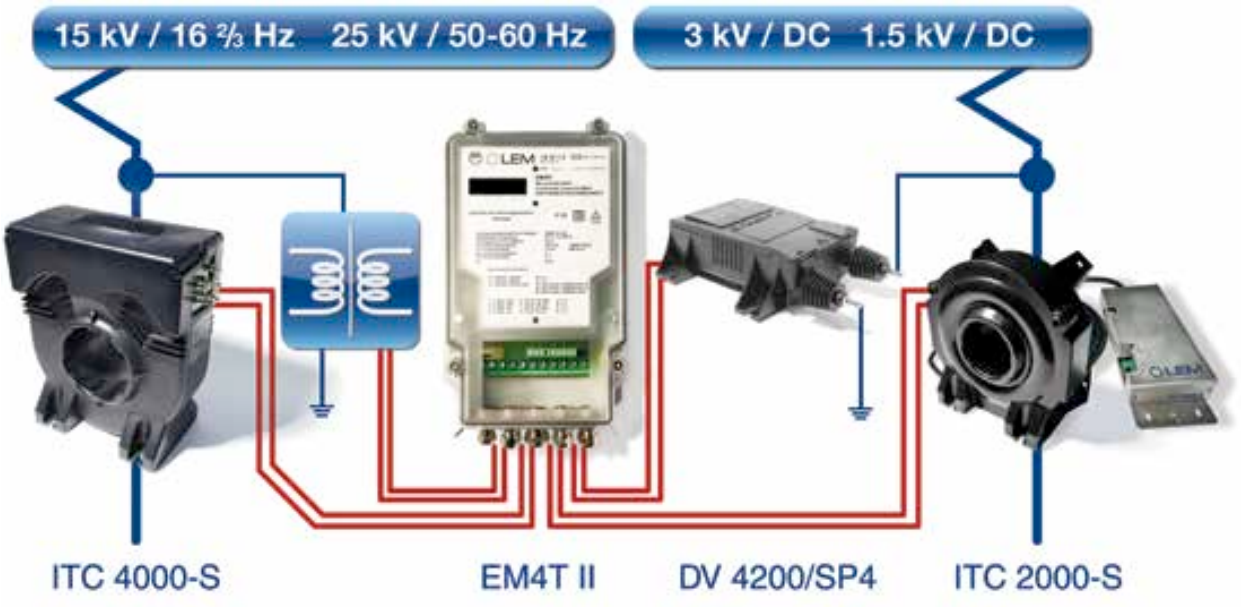
Picture 3: Block diagram of the LEM energy meter

Standards & Regulations

The EM4T II has been designed to comply with the following standards and regulations (excerpt)

EN 50463-x (2012)	Railway application – Energy measurement on board trains
EN 50155 (2007)	Railway applications – Electronic equipment used on rolling stock
EN 50121-3-2 (2006)	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock – Apparatus
EN 61373 (2010)	Railway applications - Rolling stock equipment - Shock and vibration tests
EN 50124-1 (2001)	Railway applications – Insulation coordination – Part 1: Basic requirements
IEC 62056-21 (2002)	Electricity metering - Data exchange for meter reading, tariff and load control - Part 21: Direct local data exchange

ITC 2000...4000-S FAMILY
Better than Class 0.5R current measurement
High temperature stability



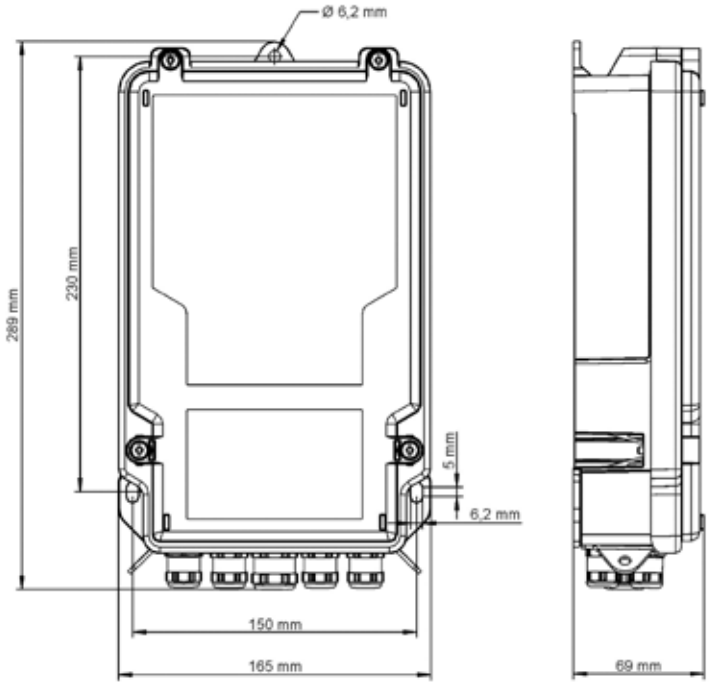
Part of high voltage frame of a multi-system locomotive with the positions needed for current & voltage measurement

DV-VOLTAGE FAMILY
1200 to 4200 V_{RMS}
One unique compact package
Class 0.5R accuracy - Low thermal drift

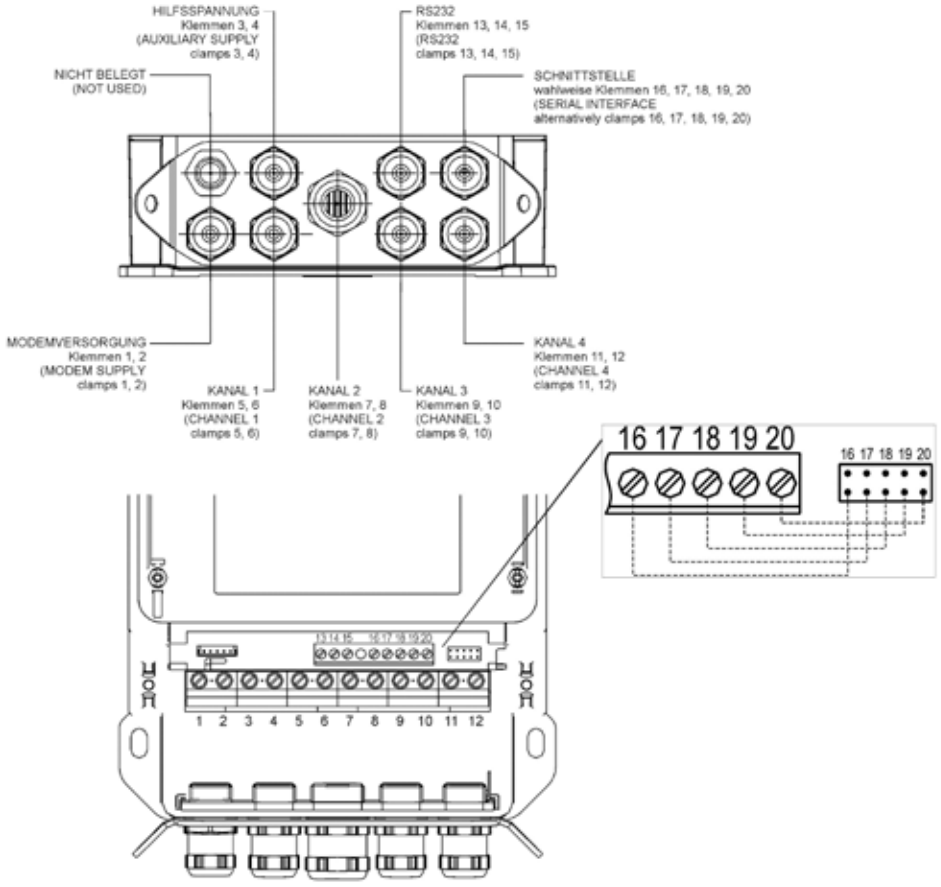
Technical Data EM4T II

Measuring input channels	• 4 galvanic isolated inputs for connection of U- and I-sensors (either for AC, DC or ACDC), or • for connection of one U-sensor (DC) and up to three I-sensors (DCDCDC)
Measuring ranges Rated voltage (secondary) Rated current (secondary)	 AC: 70 – 300 V or 17.9 – 100 mA DC: 17.9 – 100 mA AC: 1 – 5 A or 25 – 1000 mA DC: 25 – 2000 mA
Accuracy	Class 0.5R (acc. to EN 50463-2)
Sampling interval	4800 Hz
Load profile	• Recording of consumed and regenerated active and reactive energy • units kWh or kvarh • recording period length min. 1 minute • recording of location and status information acc. to EN 50463-3 • memory depth at least 60 days (for 1 minute period length)
Clock accuracy	< 20 ppm
Interfaces	• 1 x RS-interface (bidirectional, RS232, RS422 or RS485) with 2 connections in parallel (screw terminals and pin header), e.g. for modem connection; data protocol according to EN 50463-3 and IEC 62056-21 • 1 x RS232 (unidirectional) for registration of GPS-data telegrams according to NMEA 0183
Display	LCD, self-luminous, letter height approx. 4 mm
Degree of protection	IP 65
Supply voltage	24 – 110 V (acc. to EN 50155), power consumption (without modem) 3 W
Supply voltage for modem (optional)	12 V, continuous load 3 W, peak value 6 W Daily modem reset by EM4T II
Temperature ranges	Operating temperature: -40 °C – +75 °C Storage temperature: -40 °C – +85 °C
Dimensions	approx. 165 x 289 x 70 mm (W x H x D)
Weight	approx. 1.5 kg

Dimensions EM4T II



Terminal block and connections



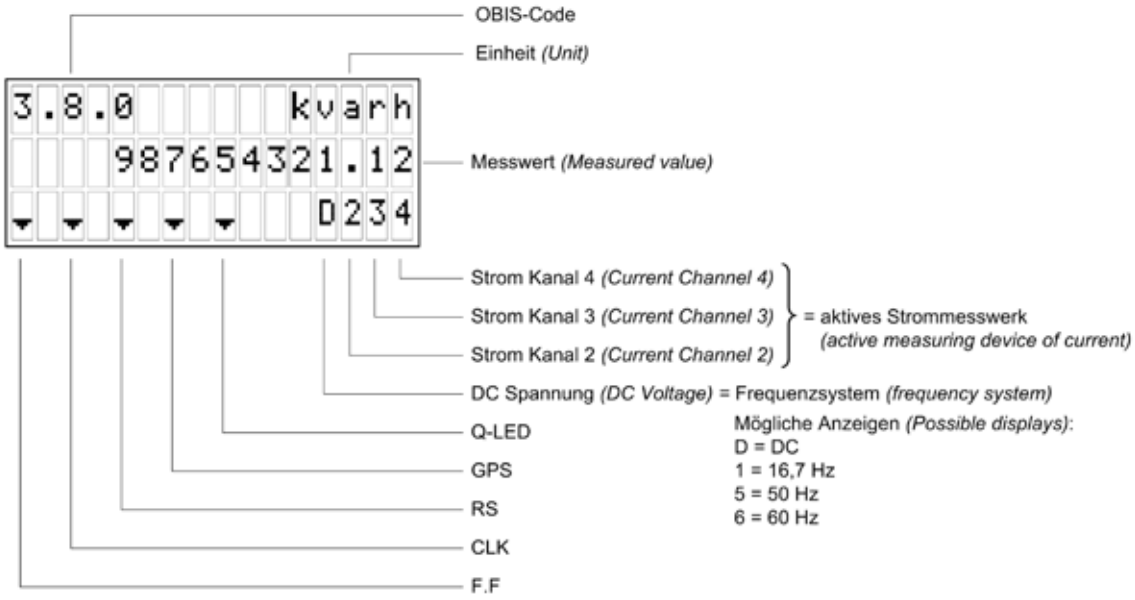
Connection EM4T II

Connectors

13 – GPS (in) - RS232-TxD	16 – RS232-n.c.	RS485-n.c.	RS422-A
14 – GPS (in) - RS232-RxD	17 – RS232-n.c.	RS485-n.c.	RS422-B
15 – GPS (in) - RS232-GND	18 – RS232-TxD	RS485-B	RS422-B’
	19 – RS232-RxD	RS485-A	RS422-A’
	20 – RS232-GND	RS485-GND	RS422-GND

1 – U_Modem + (out)	5 – CH1/U-AC high	9 – CH3/U-DC high
2 – U_Modem - (out)	6 – CH1/U-AC low	10 – CH3/U-DC low
3 – U_Batt + (in)	7 – CH2/I-AC high	11 – CH4/I-DC high
4 – U_Batt - (in)	8– CH2/I-AC low	12 – CH4/I-DC low

Display layout



Display of used mains system (possible values):

12	→ 16.7 Hz – Current measurement on Channel 2 (only possible for AC- or ACDC-devices)
52	→ 50 Hz – Current measurement on Channel 2 (only possible for AC- or ACDC-devices)
62	→ 60 Hz – Current measurement on Channel 2 (only possible for AC- or ACDC-devices)
D4	→ DC – Current measurement on Channel 4 (only possible for DC- or ACDC-devices)
D2	→ DC – Current measurement on Channel 2 (only possible for DCDC- or DCDCDC-devices)
D 3	→ DC – Current measurement on Channel 3 (only possible for DCDC- or DCDCDC-devices)
D 4	→ DC – Current measurement on Channel 4 (only possible for DCDCDC-devices)

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 useand 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

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