

EM4T II

Energy Meter for On-Board Traction applications





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.

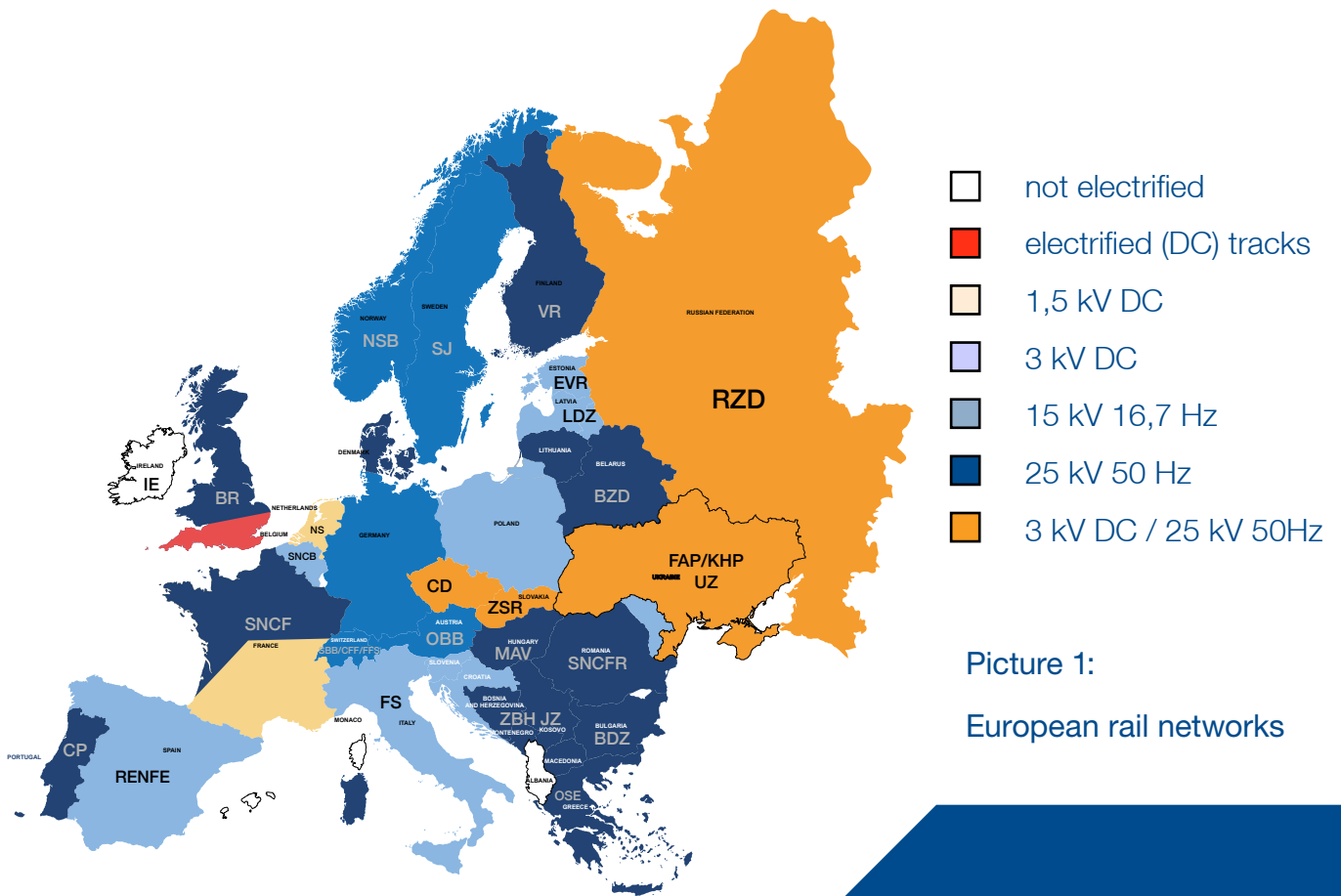
These prime movers would be needed to operate on the different supply networks of bordering countries along the route without requiring an equipment exchange at the regional or network supply border.

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



Picture 2: EM4T II



Siemens Train

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.

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).

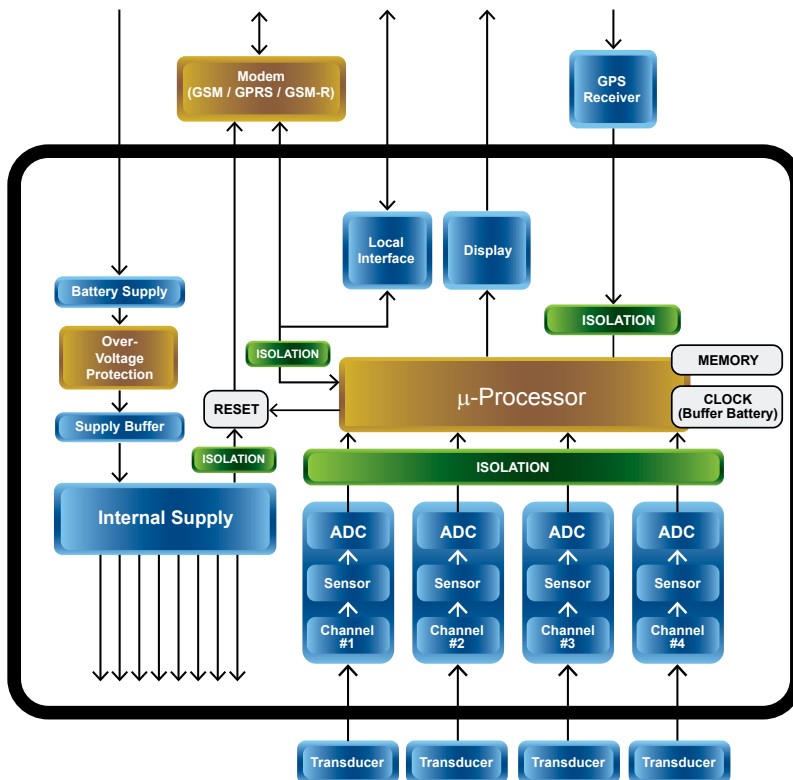
The operating conditions (considering EMC, temperature, vibration, etc.) meet the special requirements for traction use, including EN 50155, EN 50121-3-2, EN 50124-1, and EN 61373. The compact and fire-retardant enclosure provides protection against the ingress of moisture or foreign objects according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

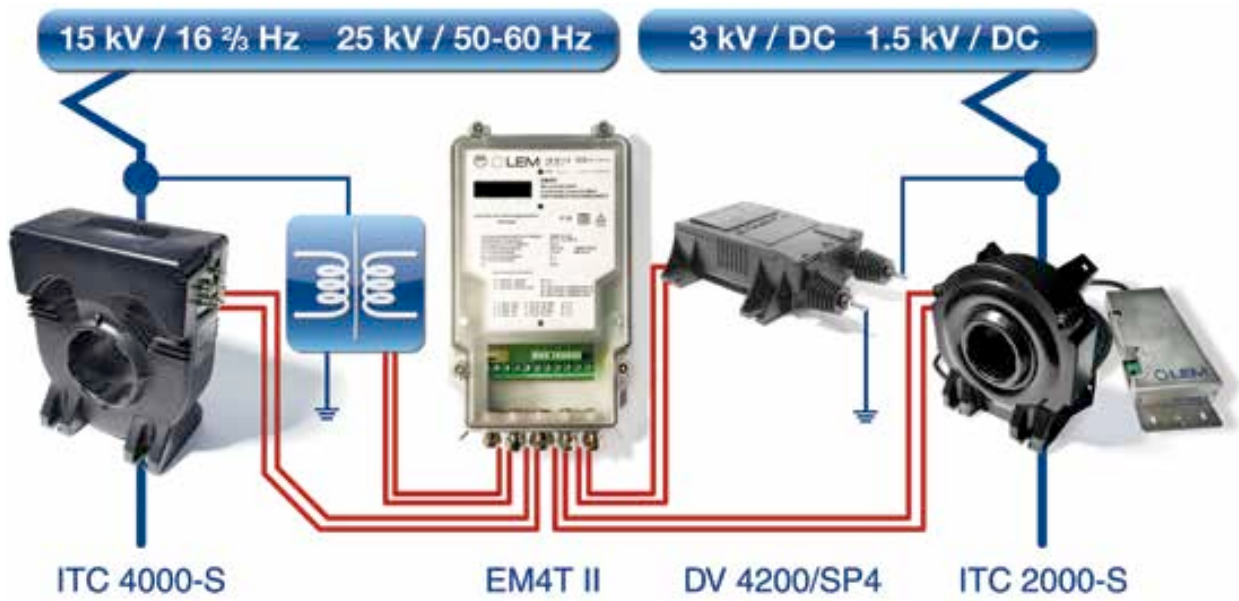
The EM4T II has been designed to comply with the following standards and regulations (excerpt)

| | |
|---------------------|---|
| 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}

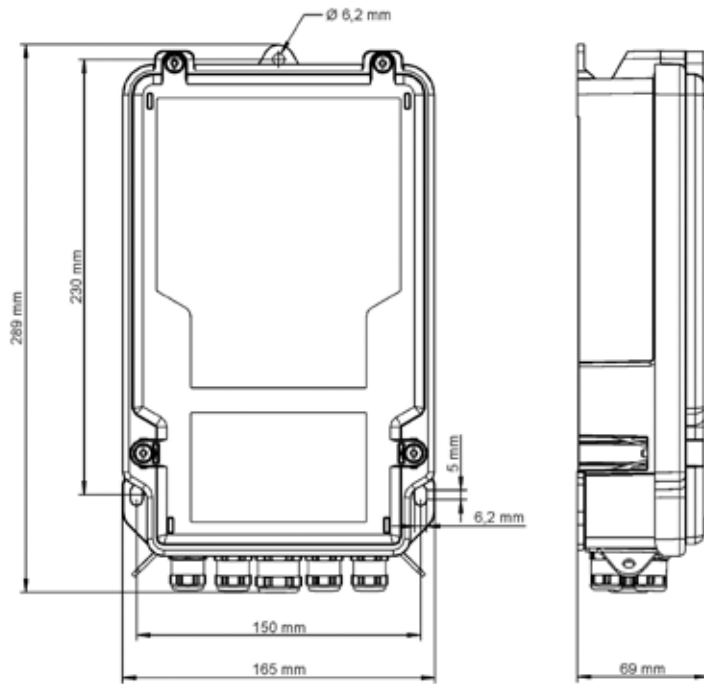
One unique compact package

Class 0.5R accuracy - Low thermal drift

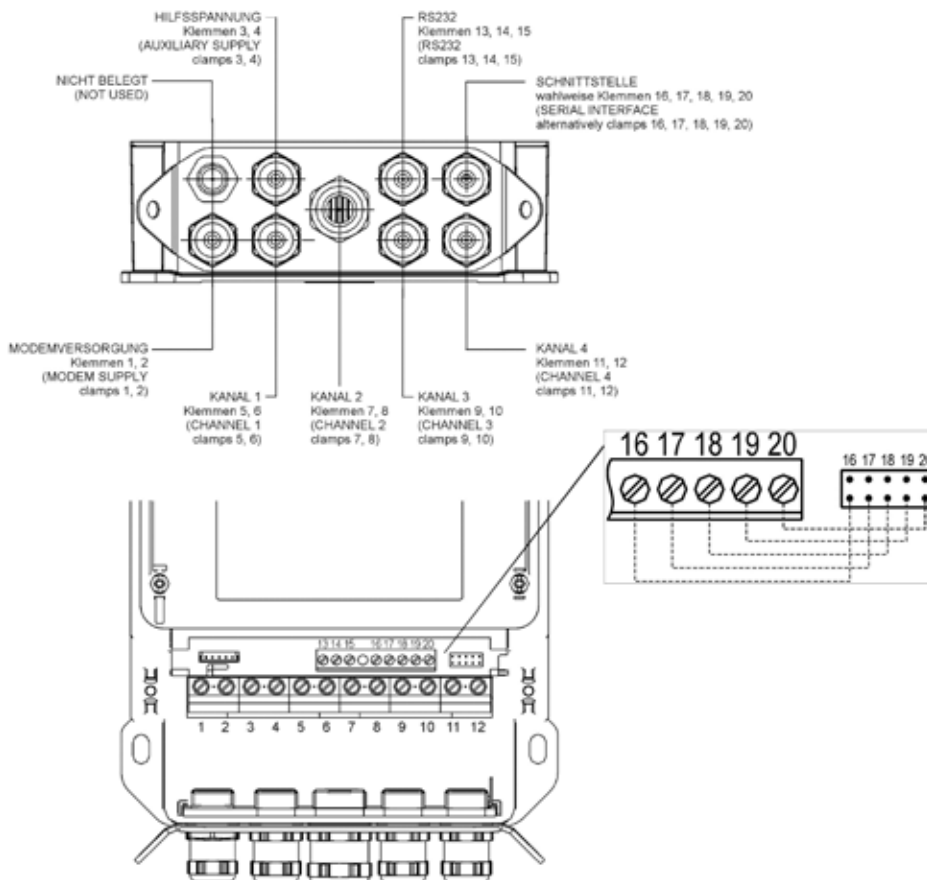
Technical Data EM4T II

| | |
|-------------------------------------|--|
| Measuring input channels | <ul style="list-style-type: none"> 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) | AC: 70 – 300 V or 17.9 – 100 mA DC: 17.9 – 100 mA |
| Rated current (secondary) | 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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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

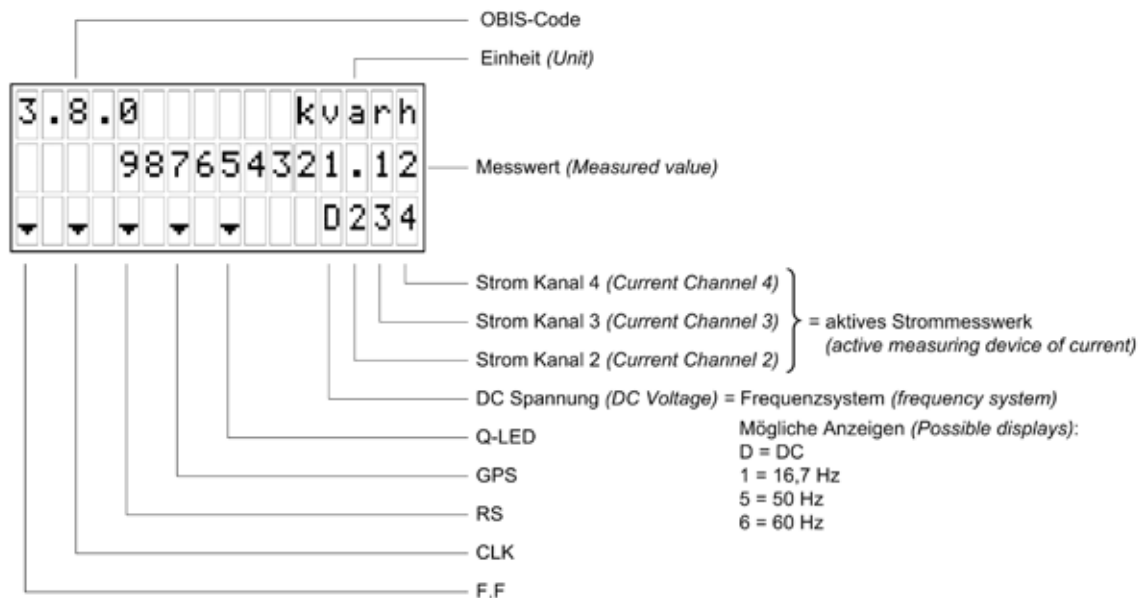


Connection EM4T II

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 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

A handwritten signature in black ink, appearing to read "François Gabella".

François Gabella
President & CEO LEM

June 2011/Version 1

Austria and CEE

LEM Deutschland GmbH,
Office Austria
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
Egelantierlaan, 2
B-1851 Humbeek
Tel. : +32 22 70 30 84
Fax : +32 22 70 30 85
e-mail : lbe@lem.com

Bosnia, Croatia, Herzegovina, Serbia and Slovenia

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

Bulgaria, Hungary

ineltron GmbH
Hugenottenstr. 30
D-61381 Friedrichsdorf
Tel.: +36 70 3666055
Tel.: +49 (0)6172 598809
Fax.:+49 (0)6172 75933
email: i.laszlo@ineltron.hu

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

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 Leveälähti
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

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

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: denvertch@pixie.co.za

LEM Electronics (China) Co., Ltd.
Shanghai Office, R510,
Hualian Development Mansion,
No. 728 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
R703, Tower B
Jinqiao International Plaza
No. 50, Technology Road
High-Tech District, Xi'an,
Shanxi, 710075 P.R. China
Tel. +86 29 8833 7168
Fax +86 29 8833 7158
e-mail: bjl@lem.com

Israel

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

Italy

LEM Regional Office Italy
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

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

USA, Canada, Mexico

LEM USA, Inc., Central Office
11665 West Bradley Road
Milwaukee, WI 53224
USA
Toll free: 800 236 5366
Tel. +1 414 353 0711
Fax +1 414 353 0733
e-mail: lus@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 4014 7575
Mobile +91 98 3313 5223
e-mail: skh@lem.com

GLOBETEK

No.739, 13th Cross,
7th Block, Jayanagar,
Bengaluru-560070
Karnataka, INDIA
Tel. +91 80 2677 1770
Fax. +91 80 2677 1777
e-mail: sales@globetek.in

Japan

LEM Japan K.K.
2-1-2 Nakamachi
J-194-0021 Machida-Tokyo
Tel. +81 42 725 81 51
Fax +81 42 728 81 19
e-mail: ljp@lem.com

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

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

Scandinavia

LEM Deutschland GmbH
Filial Denmark
Christian X's Allé 168
2800 Lyngby, Denmark
Tel. +45 60 43 1953
e-mail: ckk@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: sl@lem.com

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 International SA
8, Chemin des Aulx
P.O. Box 35

CH-1228 Plan-les-Ouates
Tel. +41 22 706 11 11
Fax +41 22 794 94 78
e-mail: lsa@lem.com

Turkey

Özdisan Elektronik 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 Regional Office UK
A Branch of LEM Deutschland GmbH
West Lincs Investment Centre
Suite 10, Maple view
Whitemoss Business Park
Skelmersdale, Lancs WN8 9TG
Tel. +44 (0)1942 388 440
Fax +44 (0)1942 388 441
e-mail: luk@lem.com

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.
Hefei Office, R804,
Qirong Building, No. 502 Wangjiang
West Road, High-tech Zone
Hefei, Anhui, 230022 P.R. China
Tel. +86 551 530 9772
Fax. +86 551 530 9773
e-mail: bjl@lem.com

LEM Japan K.K.
Nagoya Sales Office
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

LEM Korea Branch
D-Cube City, Office Tower 15F,
#662 Gyeongin-Ro, Guro-Gu,
Seoul, 152-706 Korea
Tel. +82 10 7150 2450
Fax. +82 2 2211 6698
e-mail: sbe@lem.com

S&H Trading
Rm.302 Eopmu A-dong,
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: snh@hinodekorea.co.kr

Young Woo Ind., Co.
#608 Penterium IT Tower,
282 Hakeui-ro, Dongan-gu,
Anyang-si, Gyeonggi-do
South Korea, 431-810
Tel. +82 31 266 8856
Fax +82 31 266 8857
e-mail: info@ygwoo.co.kr

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 International SA
8, Chemin des Aulx, P.O. Box 35
CH-1228 Plan-les-Ouates
Tel. +41 22 706 11 11, Fax +41 22 794 94 78
e-mail: lsa@lem.com; www.lem.com

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