Life Energy Motion

E-Mobility solutions

DCBM 400/600 Series - DC Energy Meter

Operation manual

21January2021/Version 0

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1. SAFETY RULES

1.1. Safety warning

In order to guarantee safe operation of the product and to be able to make proper use of all features and functions, please read these instructions thoroughly!

Safe operation can only be guaranteed if the product is used for the purpose it has been designed for and within the limits of the technical specifications. Ensure you get up-to-date technical information that can be found in the latest associated datasheet under www.lem.com.

Terminal protection cover delivered with the product must be installed to obtain proper electrical protection. The data link cable used between the product's elements shall be the one delivered by LEM.

Please note

Electrical equipment should be installed, operated, serviced and maintained only by qualified personnel.

No responsibility is assumed by LEM International SA for any consequences arising out of the use of this material. A qualified person is one who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved.

The meter must be installed inside an enclosure IP51 (indoor) or IP54 (outdoor) according to

EN 50470:2007.

DANGER! Electrical hazard - Fire hazard

When installing or changing the product, the conductor to which the product is connected must be de-energized. Ignoring the warnings can lead to serious injury and/or cause damage!

Notice! Damage or hazards

The appropriate torque is defined by LEM (see "Table 2: Torque values for installation" and "4.2. Mounting and unmounting")

The appropriate crimping of the connection elements is defined by the nationalities in force.

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1.2. Important notices

- Time source to set product's time must be provided by the customer. Product must be time synchronized to operate.
- Product's Ethernet interface mustn't be exposed to a public network; network must be private and secured.
- To ensure proper operation, product's logbook completion must be checked periodically; the maximum number of entries is approximately 40 000; product's operation stops if logbook is full.
- The product is designed with IP20, and is intended to be mounted in an enclosure with a suitable IP rating for the final application.

Accuracy notices according to PTB type examination certificate

- The direct current meters may only be used for billing purposes in business and official traffic in a charging device and only for measuring the energy supplied to the vehicle.
- The connection line for voltage measurement must be provided with the supplied ferrite so that the measurement reliability is guaranteed in the event of interference.
- For the device types DCBM_N0D_4000_0000, DCBM_N0D_4010_0000, DCBM_N0D_6000_0000 and DCBM_N0D_6010_0000, for which the compensation factor can be selected via the Ethernet interface, the interface must be sealed or a calibrated remote station must be directly connected and secured by means of seals. At the end of the transaction, this remote station must compare the cable ID specified in the data tuple signed by the DC meter with the cable ID originally transferred to the DC meter. If this comparison is valid then the data tuple can be used. The remote station can also directly overwrite the cable ID specified in the data tuple.

1.3. Symbols and conventions

The following symbols point out critical information. They can be found either in this document or on the product.


Instruction manual


Heating


Warning


Electrical hazard


Double insulation

The following symbols aim at improving reader's experience by highlighting sections.


Note


Tip

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2. DOCUMENT INFORMATION

2.1. Document overview

This document relates to the DCBM 400/600 product family. Those products are direct connected energy meters for DC applications. This manual describes all necessary information for proper use. It is organized by topics:

- Mechanical: product mounting and integration into an electrical system.
- Electrical: electrical functions and performances
- Software: integration of product family into information technology systems, and main software features

Audience of this document is wide. The following visual matches sections with associated publics.

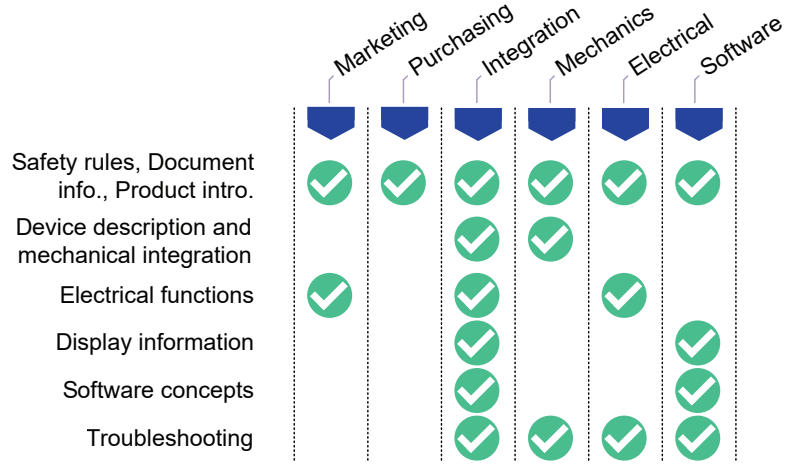

Figure 1: Documentation information versus associated publics

This document is part of a document set. Below illustration describes the set of documents for DCBM 400/600 product family with associated steps in product lifetime.

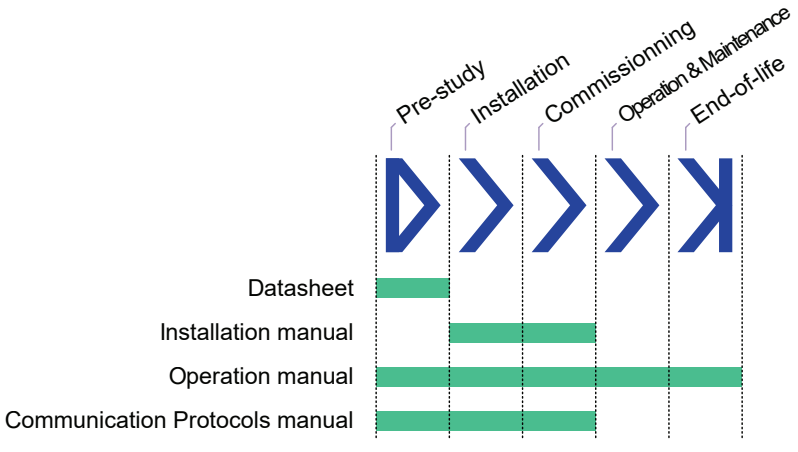

Figure 2: Documentation set for DCBM 400/600 product family

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2.2. Document issue

Targeted Product DCBM 400/DCBM 600

Release scope Public

2.3. Company details

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Switzerland

2.4. Revision history

Version	Date	Changes
0	21January2021	First issue

2.5. Related documents

Name	Revision
Datasheet	Publication pending
Communication Protocols manual	Publication pending
Installation manual	Version 1
EN 50470-1	2006
EN 50470-3	2006
CISPR22 Class-B emission	
IEC 62477-1	
EN 62052-31	2015
IEC 62052-11	2003
IEC 61000-6-2	2016
IEC 61000-6-3	2016
RoHS	
OCPP 1.6	1.6, 2.6
WELMEC 7.2 Software Guide	2015
REA-6A	
PTB 50.7	
VDE-AR-E 2418-3-100	2019-07-16

2.6. Abbreviations

Abbrevation	Description	Abbreviation	Description
ADC	Analog to Digital Converter	UTC	Coordinated Universal Time
API	Application Programming Interface	V2G	Vehicle To Grid
CCS	Combined Charging System	VP & VN	Voltage positive/negative input
CRC	Cyclic Redundancy Checksum		
DC / AC	Direct current / Alternating current		
DCBM	DC Billing Meter		
DHCP	Dynamic Host Configuration Protocol		
DNS	Domain Name System		
DST	Daylight Saving Time		
EMI	Electromagnetic interference		
EV	Electric Vehicle		
EVSE	Electric Vehicle Supply Equipment		
FW	Firmware		
HTTP[S]	Hypertext Transfer Protocol [Secured]		
IANA	Internet Assigned Numbers Authority		
ID	Identifier		
Info	Information		
Init	Initialization		
Intro	Introduction		
IP	Internet Protocol / Ingress Protection Code		
IR	Infrared		
JSON	JavaScript Object Notation		
LED	Light-emitting diode		
LR / LNR	Legally relevant / Legally non-relevant		
MSB & LSB	Most Significant Bit / Least Significant Bit		
MU	Meter Unit		
N/A	Not applicable		
NTP	Network Time Protocol		
OBIS	Object Identification System		
OCMF	Open Charge Metering Format		
OCPP	Open Charge Point Protocol		
OVC	Overvoltage Category		
PTB	German Physikalisch-Technische Bundesanstalt		
REST	Representational state transfer		
RMS	Root Mean Square		
RNG	Random Number Generator		
RTOS	Real-Time Operating System		
S.A.F.E.	Software Alliance For E-mobility		
SELV	Separated Extra-Low Voltage		
SU	Sensor Unit		
TLS	Transport Layer Security		
URL / URI	Uniform Resource Locator / Identifier		

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2.7. Disclaimer

LEM cannot be held liable for damage, injury or any legal responsibility incurred directly or indirectly from non product quality issues such as other use of the DCBM than according to LEM written installation instructions (see section "4. Device description and mechanical integration") or other external factors.

The user shall observe safe and lawful practices, including, but no limited to, those set forth in this document. Before any operation or use, please read “Safety” section carefully.

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2.10. Warranty

For information about applicable warranty for the DCBM, contact your nearest LEM sales representative.

In the absence of any written agreement with LEM governing the sale of the DCBM to you, LEM general terms and conditions of sale as referred on the order confirmation shall apply. LEM disclaims all warranties of any kind, except as expressly provided in the above agreement or terms and conditions of sale, whether express or implied, relating to the DCBM and its documentation, including any implied warranty of merchantability, fitness for a particular purpose or non-infringement.

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3. Product introduction

3.1. LEM and the DCBM

Leading the world in electrical measurement, LEM engineers the best solutions for energy and mobility, ensuring that its customers' systems are optimized, reliable and safe.

Enabling Better Billing for EV Charging Points

The automotive world is seeing a rapid transition to electric vehicles, driven by concern for the environment and accelerated by legislation. For the transition to EVs to be successful, a network of charging points is required.

Today there are increasing restrictions on how the billing must be managed: for example, the German Eichrecht regulations state that consumers should only be charged for the DC power supplied and not for any power loss associated with the conversion from AC to DC. Developing a DC metering solution is a complex challenge that could delay the successful transition to electric automobiles.

By using DCBM 400/600 product family, developers and installers of electric charging points can easily prove their compliance with legislation while reducing the time required to design the charging system.

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3.2. DCBM in EV charging systems

LEM Direct Current Billing Meters with 400 A and 600 A ratings, are connected DC energy meters, referred to as "DCBM" in this document. They are dedicated to energy metering in the field of DC applications such as fast and ultra-fast charging station for Electric Vehicles (covered by IEC 61851-23). Typical applications of the DCBM 400/600 product family are 50 kW up to 350 kW Electric Vehicle charging systems.

The following figure illustrates typical integration of the device, and lists equipment and protagonists as they are referred to in hereby document.

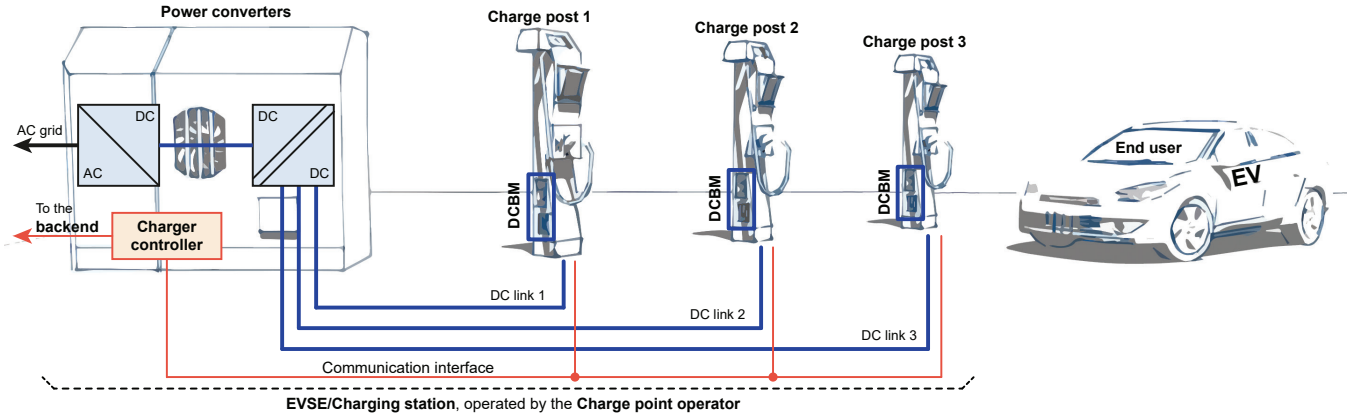

Figure 3: Namings designating equipment and protagonists

The DCBM comes with the following highlights:

Advantages

- Split meter concept easy to integrate into systems
- Flexible integration with bus bars or wires
- OCMF readouts compliant with S.A.F.E
- Compliant for energy billing or parking time billing
- System monitoring: Current, Voltage, Power, Temperature

Applications

- Electric Vehicle Charging infrastructures
- Data centers
- DC grids & Energy Monitoring
- Energy storage, Renewables

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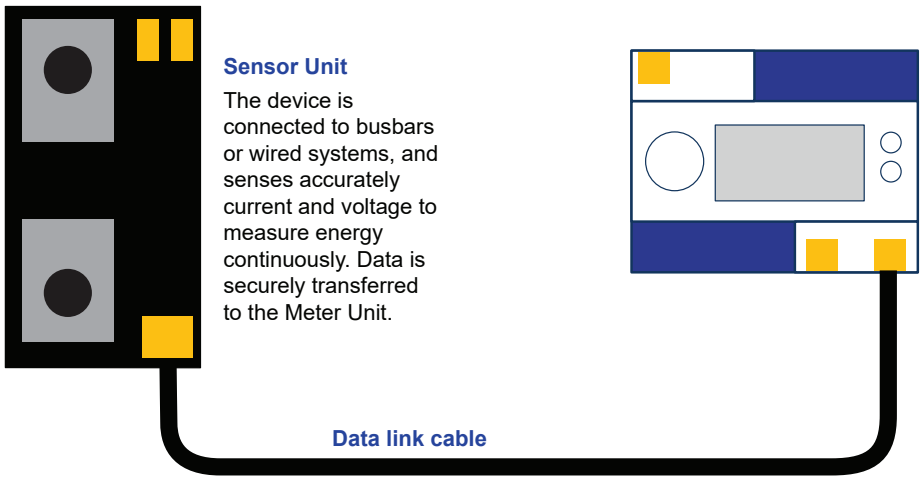
Features

- Range of operation 150…1000 V DC
- Two sizes: I_{max} 400 A and 600 A,
- Wide current terminals, compliant with bus bars
- Bi-directional energy metering (V2G)
- Accuracy Class B, -40°C to 85°C
- Compatible with 4 wire measurement
- Cable loss compensation
- Ethernet communication with HTTP/HTTPS
- Signed data readouts in OCMF or LEM format
- Monitoring data (current / voltage / temperature / energy)
- Transaction mechanisms with start & stop tags and client identification
- Auxiliary power supply range +12 ... +48 V DC
- DIN rail 35mm and screw mounting
- Length of Datalink cable from 30 cm up to 3.5 m
- Integrated display with backlight
- Reinforced insulation at 1000 V DC, OVC II
- Sealing of terminals and interfaces

The DCBM is split into two elements linked via a cable (delivered with the DCBM): the Sensor Unit and the Meter Unit. Figure hereunder depicts product construction.



Sensor Unit

The device is connected to busbars or wired systems, and senses accurately current and voltage to measure energy continuously. Data is securely transferred to the Meter Unit.

Meter Unit

The device stores, displays, communicates and authenticates measurement data. The Meter Unit delivers power supply to the Sensor Unit.

The Meter Unit offers communication with the charging station through Ethernet /REST APIs.

Data link cable

Delivered with the product, this cable connects Meter Unit to Sensor Unit, both terminals can be sealed.

Figure 4: Product construction

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Sensor Unit has four terminals: two terminals to measure current flow and two terminals to measure the DC link voltage. An arrow printed on the Sensor Unit indicates the default current flow used to measure imported energy.

The DC meter DCBM is designed in a hardware-based split and consists of the Sensor Unit, the Meter Unit and a datalink cable between the two units.

Two current rating Sensor Units are available. The possible installation variants of the sensor types are listed in this manual The Sensor Unit and the Meter Unit are paired together. If another Sensor Unit is connected to the Meter Unit a specific error flag is raised.

DCBM 400/600 operate from an auxiliary power supply (12... 48 V DC).

To cover the different power ratings of charging systems, the DCBM is available for 2 current ratings:

I_{max} = 400 A or I_{max} = 600 A. Two additional variants of Sensor Unit offer measurement with current measurement in the opposite direction.

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3.3. DCBM 400/600 in EVSE

This part describes the integration of LEM DCBM into different kind of Electric Vehicle Supply Equipment (EVSE). Two examples are given: a 50 kW power class system, and a 350 kW power class system.

3.3.1. DCBM in 50 kW EVSE

The following figure presents the typical structure used in 50 kW power class charging systems. These systems use to offer multiple output cable connectors (i.e. Combined Charged System and CHAdeMO). Several AC to DC converters deliver power to either one or the other output cable. Power relays select the output cable.

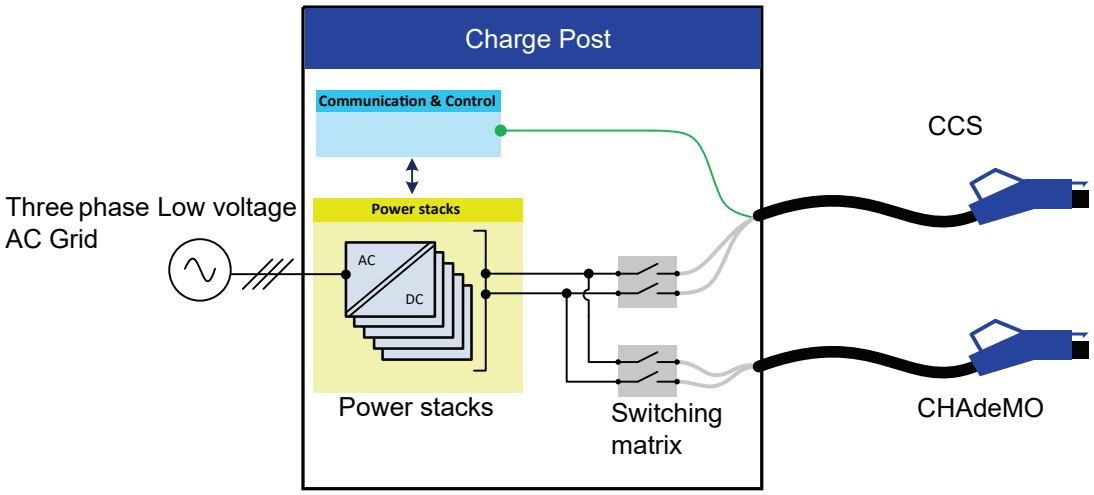

Figure 5: Typical 50 kW architecture

Specifications of a typical 50 kW EVSE

- Current range: 125 A DC
- Voltage range: 150 V DC – 920 V DC
- AC/DC converters and connection in a single cabinet
- Internal power connections made with cables

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In such application, the DCBM is integrated before the power relays. This integration is preferred because it optimizes space in the existing 50 kW charging station. Only one output cable can be supplied at the same time.

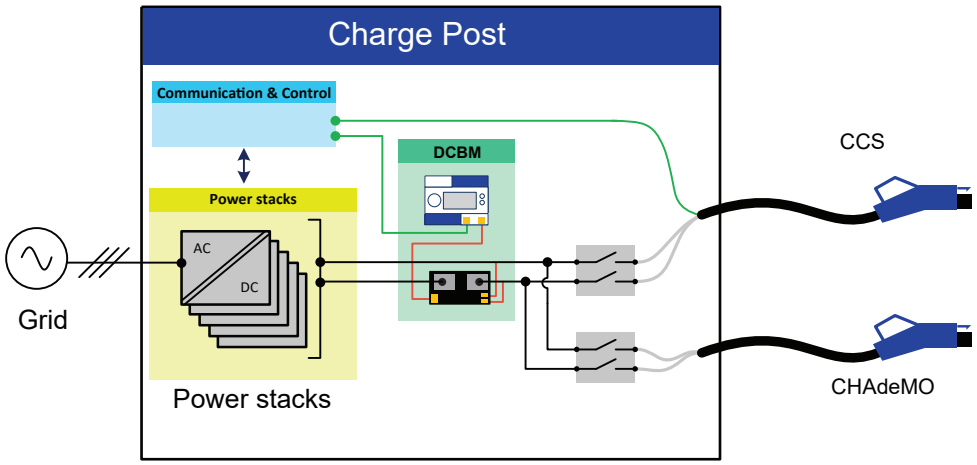

Figure 6: DCBM in a typical 50 kW EVSE

3.3.2. DCBM in 350 kW EVSE

To reduce charging time, high power charging is used. Specific power electronic techniques (e.g. liquid-cooled cables) are used. Currents up to 600 A are applied during charging, with a maximum system voltage of 1000 V DC.

To optimize system performance, central AC/DC converters are used instead of dedicated converters in the charge posts (the cabinet to connect the EV). Several DC buses link the central converters to the charge posts.

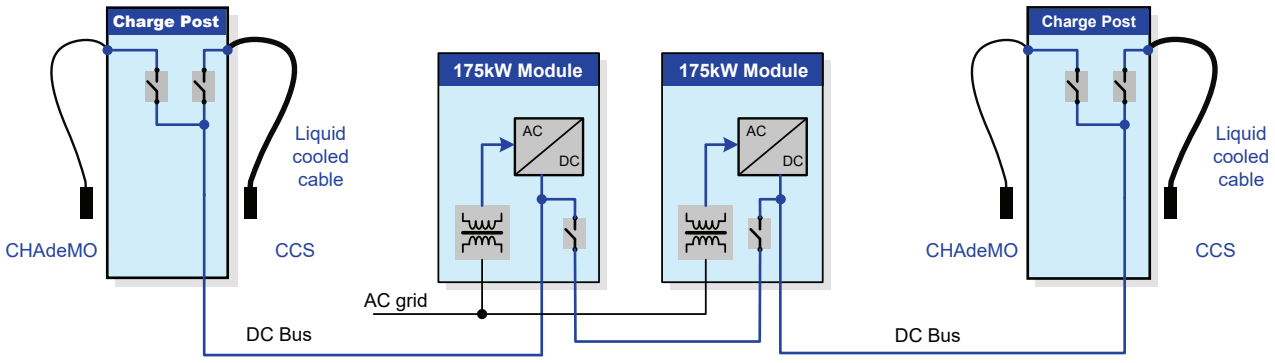

Figure 7: Typical 350 kW EVSE system

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Specifications of a typical 350 kW EVSE:

- 500 A DC
- Voltage range: 150 V DC – 920 V DC
- AC/DC converters separated from the charge posts
- Internal power connections made with bus bars
- Liquid-cooled cable between charge post and EV

The DCBM is integrated in the charge post. Figure hereunder gives an example of integration.

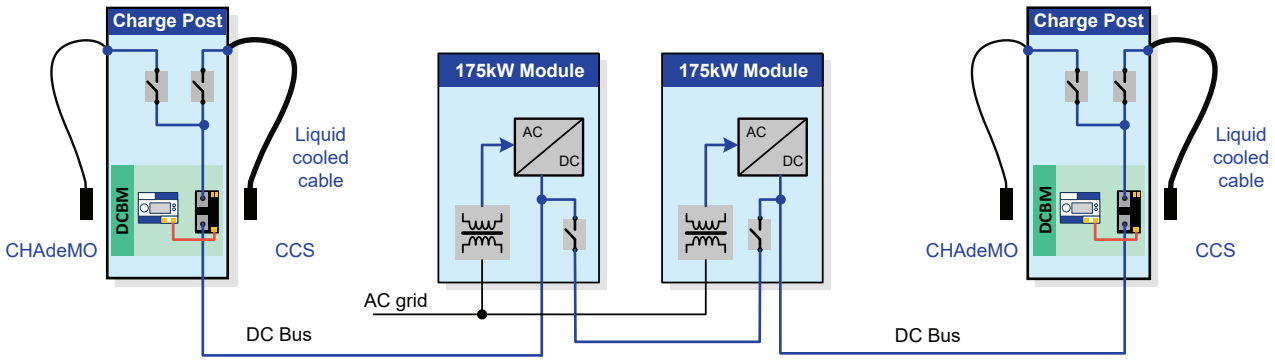

Figure 8: DCBM in a typical 350 kW EVSE

The DCBM has to be integrated using bus bars and connections in a hazardous area, usually separated from low voltage areas. Moreover, the operating temperature of bus bars can exceed +100 °C while charging at high power.

In such compact and space-limited environment, the specific split construction of the DCBM makes it easy to integrate, just as other electrotechnical components like power relays, power diodes or DC link fuses.

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3.4. Certification and compliance

3.4.1. Standards

The DCBM complies with the following standards.

- EN 50470-1: 2006, EN 50470-3: 2006
- PTB 50.7
- CISPR32 Class-B emission
- EN 62052-31: 2015
- IEC 62052-11: 2003
- IEC 61000-6-2: 2016
- IEC 61000-6-3: 2016
- UL94-V0
- Designed according to VDE-AR-E-2418-3-100.

3.4.2. Certification

The corresponding certificate for the DCBM is available in Appendix 1.

3.5. Product designation

Tables below summarize the product references depending on the possibles variants:

- Maximum current rating
- Current flow direction for default energy registering (i.e. imported energy direction)
- Compensation factor

Direction of current flow	Dynamic compensation factor	Fix compensation factor
Normal	DCBM_N0D_4000_0000	DCBM_N1D_4000_0000 ... DCBM_N4D_4000_0000
Reverse	DCBM_N0D_4010_0000	DCBM_N1D_4010_0000 ... DCBM_N4D_4010_0000

Figure 9: Simplified list of references for 400 A current rating

Direction of current flow	Dynamic compensation factor	Fix compensation factor
Normal	DCBM_N0D_6000_0000	DCBM_N1D_6000_0000 ... DCBM_N4D_6000_0000
Reverse	DCBM_N0D_6010_0000	DCBM_N1D_6010_0000 ... DCBM_N4D_6010_0000

Figure 10: Simplified list of references for 600 A current rating

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Complete list of references is designated as follows.

	D	C	B	M	_	N	0	D	_	4	0	0	0	_	0	0	0	0
Meter family DCBM : Direct Current Billing Meter	■	■	■	■														
Time source N : Time synchronization NTP						■												
Cable loss compensation 0 : Dynamic 0 - 14 mΩ (2 mΩ steps) 1 : No compensation 2 : 2 mΩ 3 : 4 mΩ 4 : 6 mΩ							■											
Certification 0 : without certification D : certified								■										
Sensor Unit family 40 : 400 A version 60 : 600 A version										■	■							
Counting direction 00 : direct (I1 -> I2) 10 : reverse (I2 -> I1)												■	■					
Reserved field 1 0000 : default															■	■	■	■

Figure 11: Full list of references for the DCBM 400/600 product family

The complete type designation of the whole DCBM is marked as relevant designation on the name plate of the Meter Unit.

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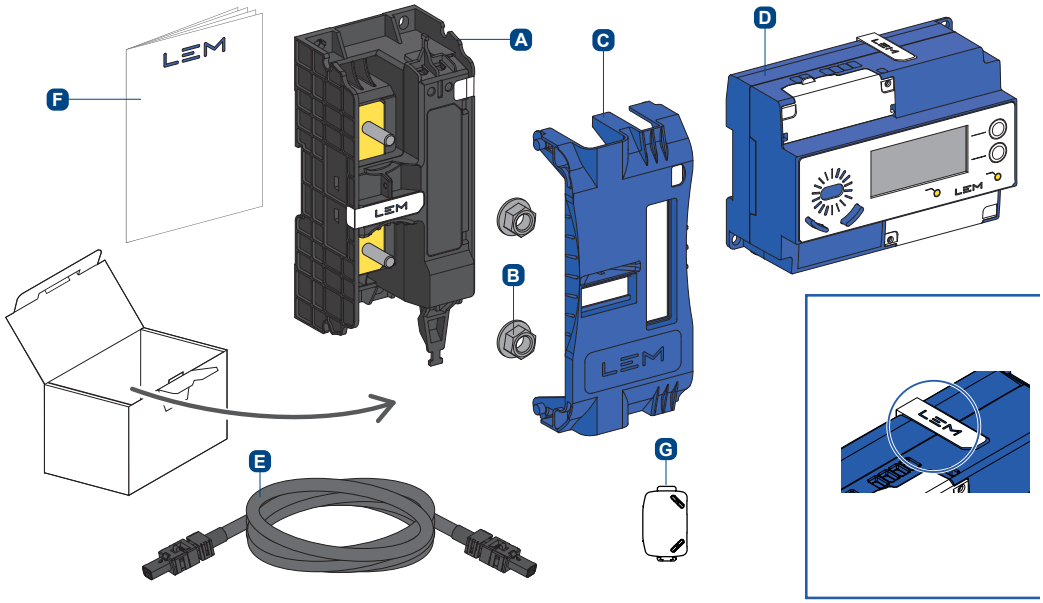
4. Device description and mechanical integration

4.1. Package content

The package is composed of:



A	1 Sensor Unit	D	1 Meter Unit	G	Ferrite
B	2 nuts with captive washer (already mounted on the product)	E	1 Data link cable		
C	1 Protection cover	F	1 Installation manual		

Before any operation, read section "4.6.1. Manufacturer seals".

The Meter Unit and Sensor Unit included in the package are paired and cannot be swapped with another set.

Protection cover C shall be mounted to ensure IP20 rating on the terminal areas.

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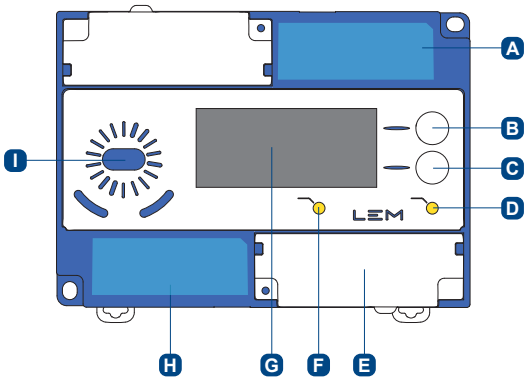
4.1.1. Meter Unit description



A	Public key and serial number	E	Connection cover	I	IR optical interface
B	Top button	F	Status LED		
C	Bottom button	G	Display		
D	Test LED	H	Verification marking		

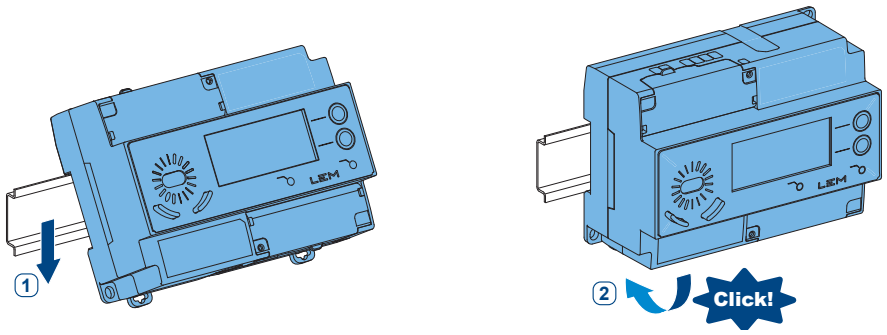
4.1.2. Sensor Unit description

Please refer to section 3.2.2.

4.2. Mounting and unmounting

4.2.1. Meter Unit

4.2.1.1. Mounting



To mount the Meter Unit, place it onto the DIN rail and rotate it backwards, until hearing the ‘click’.

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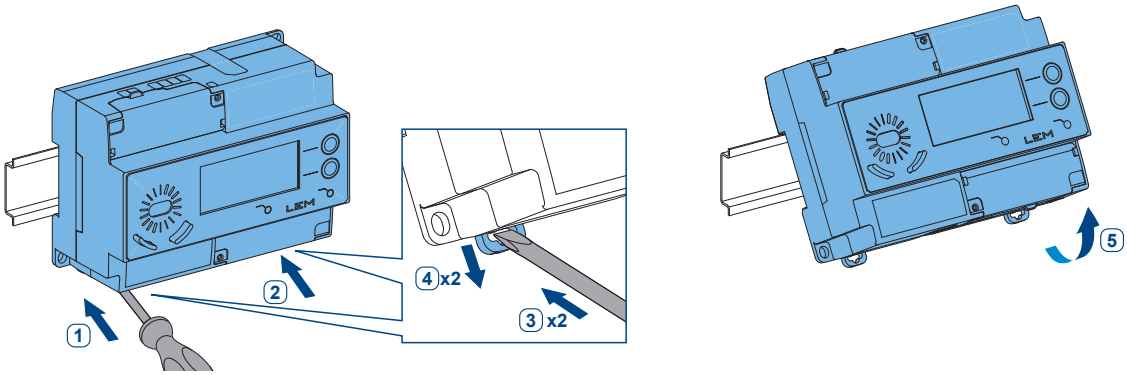
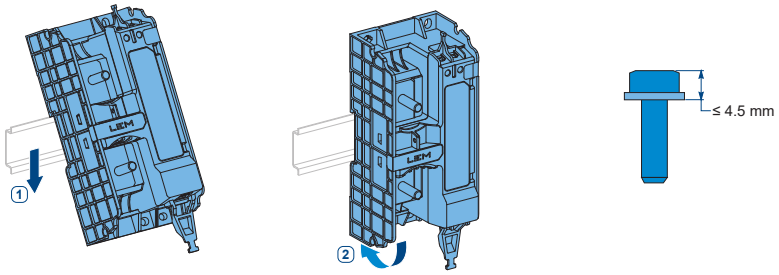
4.2.1.2. Unmounting



- The Meter Unit can be positioned on a DIN Rail TH 35-7.5 or TH 35-15 (IEC 60715: 2017)
- Possibility to fix the Meter Unit with 2x M4 screws (max), max torque 1.2 N·m.

4.2.2. Sensor Unit



- The Sensor Unit can be positioned on a DIN Rail TH 35-7.5 or TH 35-15 (IEC 60715: 2017)
- The Sensor Unit **shall be fixed** with 4x M4 screws with washer. Screw head + washer ≤ 4.5 mm, max torque 3.5 N·m.

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4.3. Product dimensions

4.3.1. Meter Unit

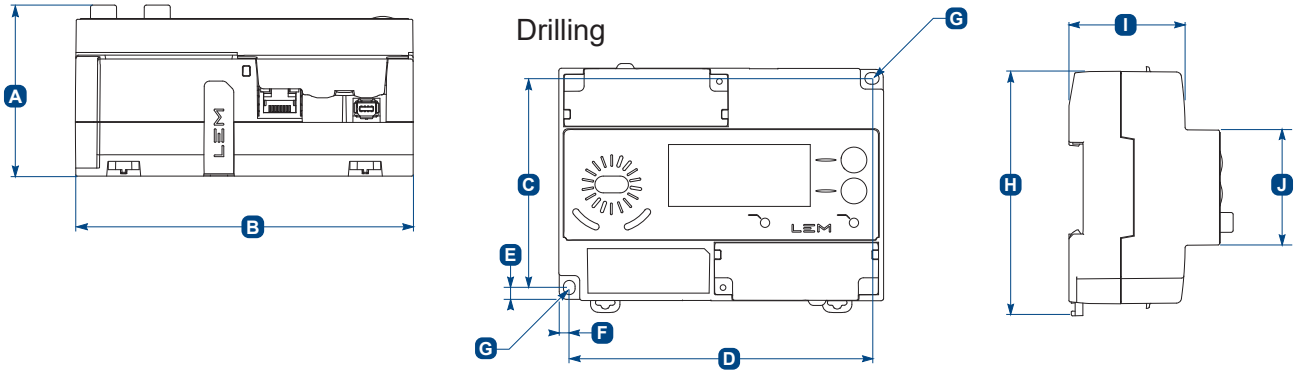

Figure 12: Meter Unit dimensions

A	63.7 mm	E	4.6 mm	I	45 mm
B	126.2 mm (±0.2)	F	3.9 mm	J	45 mm
C	81 mm (±0.2)	G	Max M4 screws (torque max 1.2 N·m)		
D	117.5 mm	H	94.8 mm		

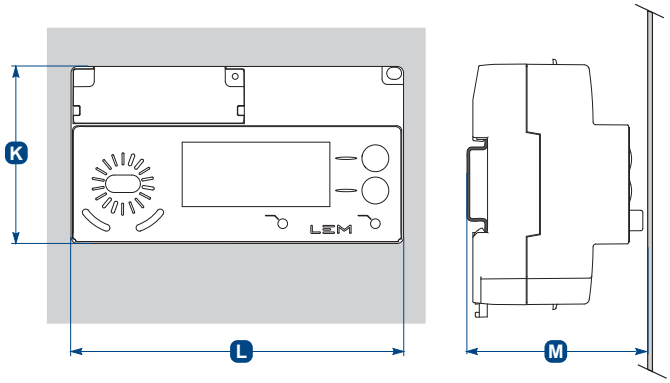

Figure 13: Meter Unit aperture for electrical cabinet

K	64 mm (±0.2
L	123 mm (±0.2)
M	67.2 mm: DIN rail TH 35-7.5 74.7 mm: DIN rail TH 35-15

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4.3.2. Sensor Unit

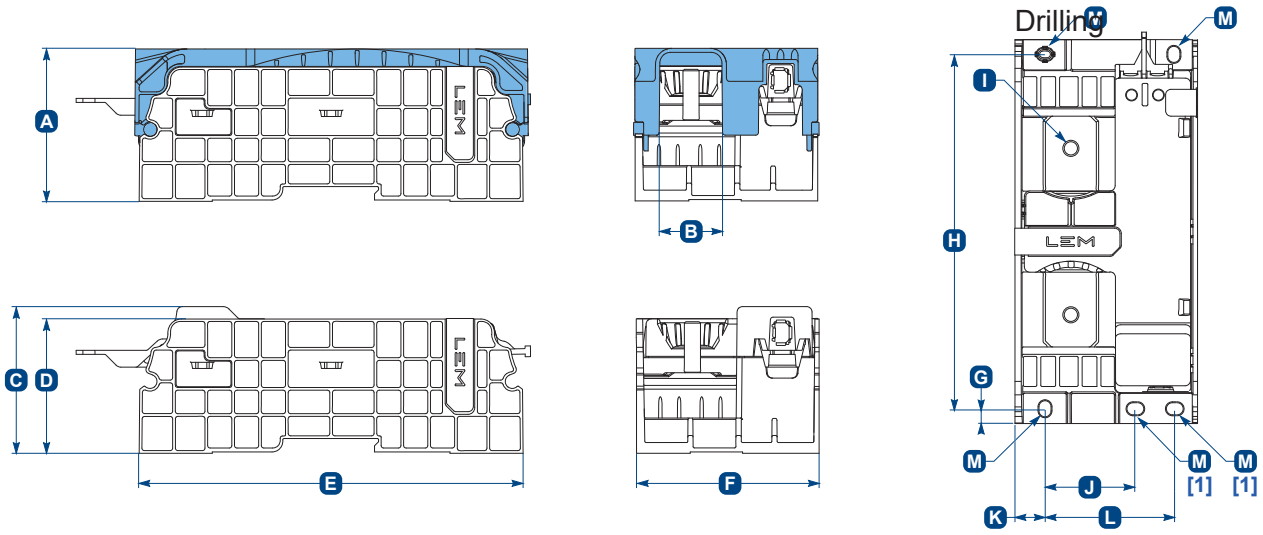

Figure 14: Sensor Unit dimensions

[1] Possible choice

	DCBM_SU40XX	DCBM_SU60XX
A	56.8 mm	74.2 mm
B	23 mm	36 mm
C	54.6 mm	67 mm
D	50 mm	65 mm
E	143 mm	143 mm
F	68 mm	86.3 mm
G	5.5 mm	5.5 mm
H	132 mm (±0.2)	132 mm (±0.2)
I	M8	M12
J	33.5 mm (±0.2)	51.6 mm (±0.2)
K	11.2 mm (±0.2)	11.2 mm (±0.2)
L	480mm (±0.2)	66 mm (±0.2)
M	M4	M4

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4.4. Connection

To connect and disconnect the wires, use a screwdriver 3 x 0.5 mm (DIN 5264)

For detailed explanation of this graph, please refer to the below table "Table 1: Ports definition" and figure "Figure 16: Connection and wiring diagrams".

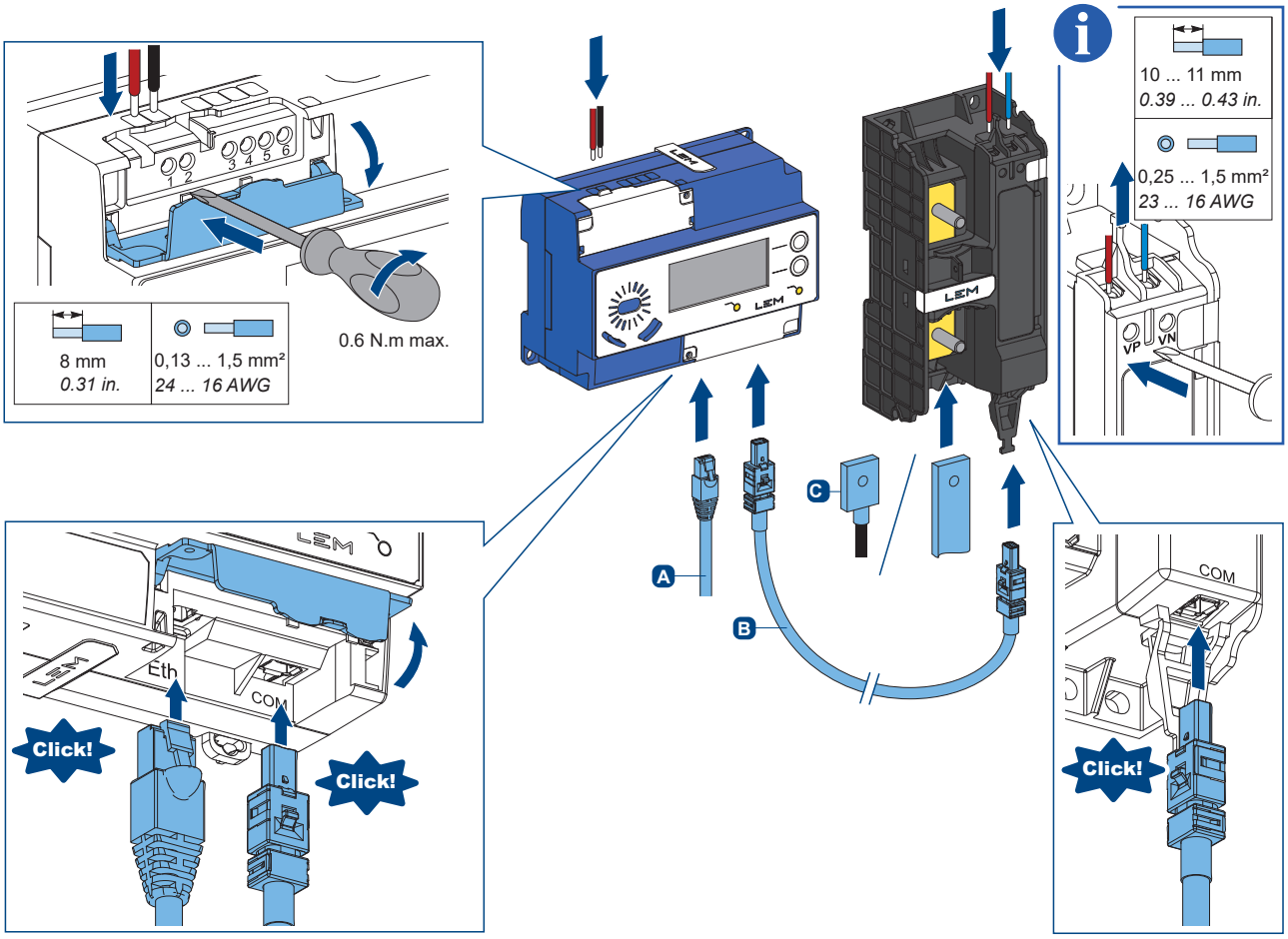

Figure 15: DCBM connection

A Ethernet cable

B Data Link cable

C Bus bars or lugs

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Port N°	Definition
1	Power Supply +
2	Power Supply −
3	Reserved
4	Reserved
5	Reserved
6	Reserved
Eth	Ethernet port
COM	Data link port
VP	Voltage measurement +
VN	Voltage measurement −

Table 1: Ports definition

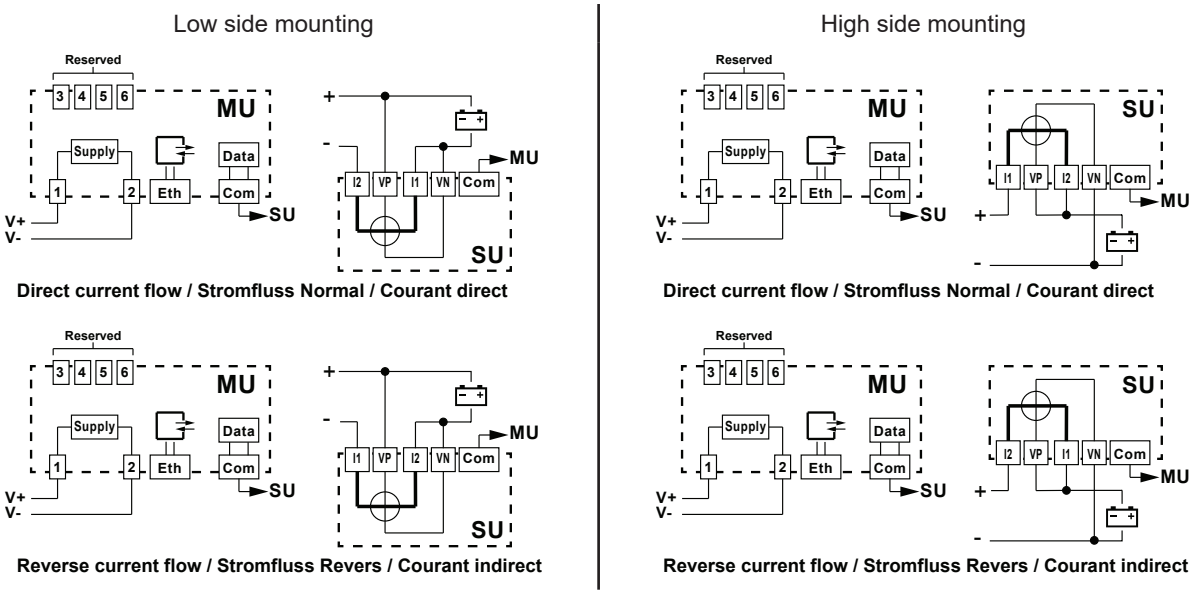

Figure 16: Connection and wiring diagrams

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You can connect the product with bus bars and lugs. F

The product is compatible for one lug per connection configuration with all lugs from standard:

- NF C 20-130: 2004
- DIN 46220: 1965
- DIN 46234: 1980
- DIN 46235: 1983

2 lugs can connect on each terminal, not all the lugs are compatible. Please check the dimensions.

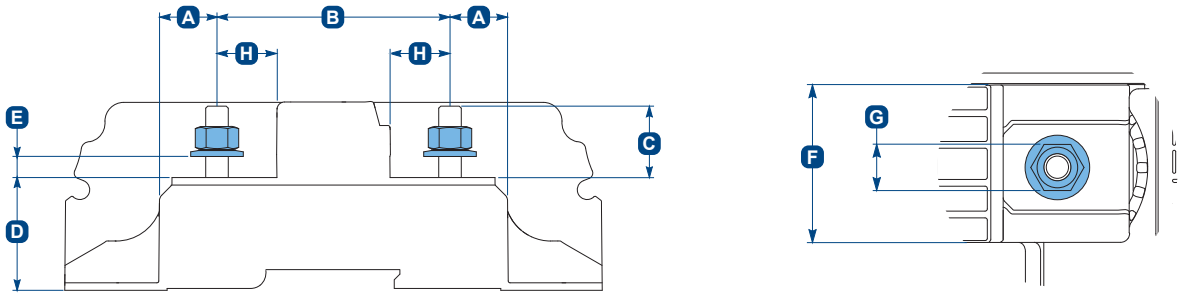

Figure 17: Sensor Unit integration

	DCBM_SU40XX	DCBM_SU60XX
A	15 mm	15 mm
B	62 mm	62 mm
C	19 mm	27 mm
D	30 mm	40 mm
E	9 mm max. [1]	13 mm max. [1]
F	34.6 mm	52.9 mm
G	13 mm	18 mm
H	15.9 mm	15.9 mm

[1] Maximum thickness for bus bar or lugs

Fire hazard

Reference	Nominal tightening torque (N.m)
DCBM_SU40XX	10.4 ±0.5
DCBM_SU60XX	36.4 ±0.5

Table 2: Torque values for installation

Size of stud	⌀ Drilling hole (mm)
M8	8.5
M12	12.5

Table 3: Bus bar drilling

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4.5. Cable management

1. To maintain the wires on the Sensor Unit use a tie (2.5 x 1 mm)
2. To maintain the Data link cable on the Sensor Unit use a tie (2.5 x 1 mm)

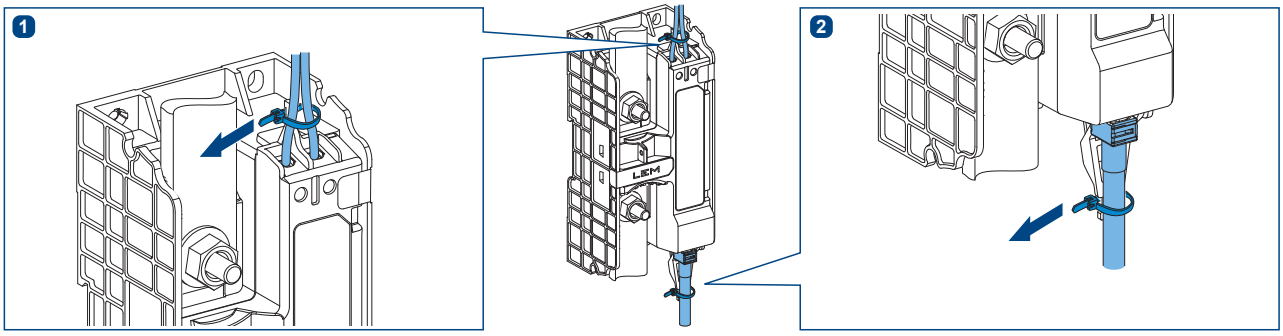

Figure 18: Cable management

4.6. Sealing

4.6.1. Manufacturer seals

Before any operation with the device, the manufacturer seals shall be checked.

Manufacturer seals are white tampering tapes set on the two parts of the device.

A total of 4 seals shall be present, 2 for each part of the device.

Any alteration to the seals invalidate device's measurement capabilities.

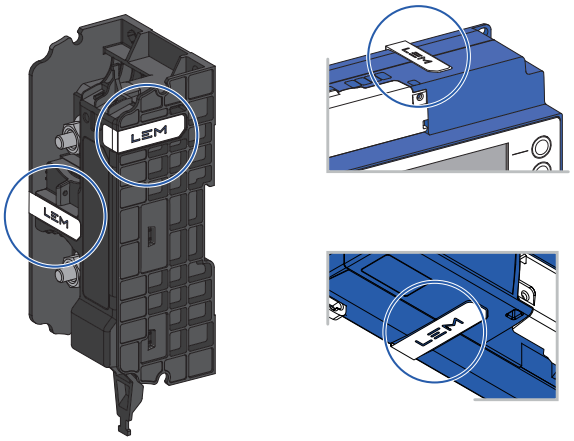

Figure 19: Manufacturer seals

4.6.2. Installation seals

Installation seals can be set at the end of installation of the device. They prevent unnoticed unmounting of the wiring and bus bars by unauthorized personnel.

Using installation seals is strongly recommended as unauthorized unmounting could lead to:

- Electrical risks
- Malfunction of the device (unavailable power supply or communication link)
- Alteration to device configuration
- Any software attacks

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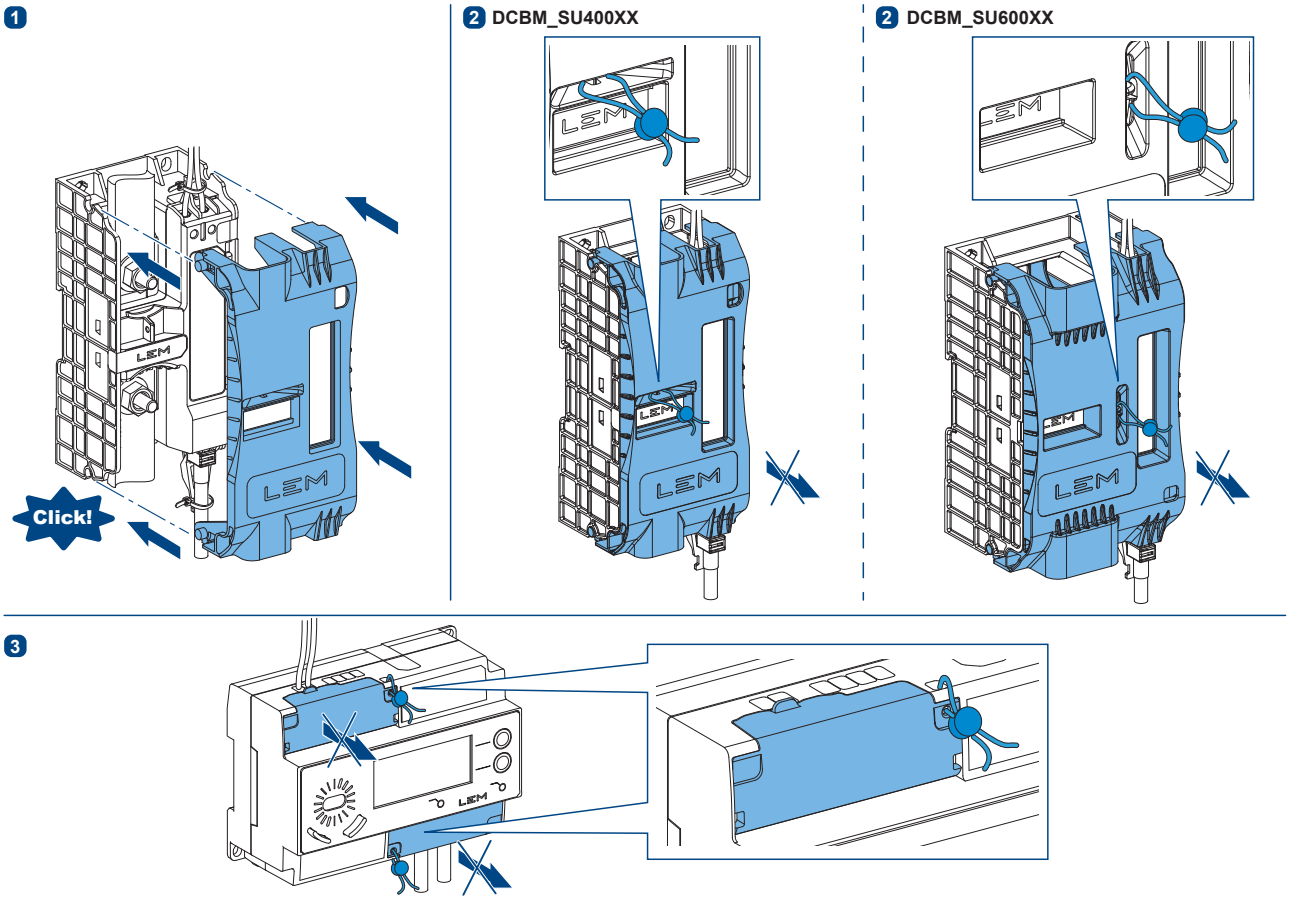
Once the product is installed

1. Mount the protection cover
2. Seal the Sensor Unit
3. Seal the Meter Unit



The sealing wires are not provided by LEM.

Max diameter of the sealing wire ⌀ ≤ 2.2 mm

4.7. Disposing

The device packaging materials can be recycled. Please help protect the environment by recycling them in appropriate containers. Thank you for your contribution to environmental protection.

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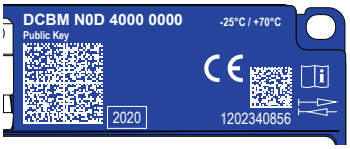
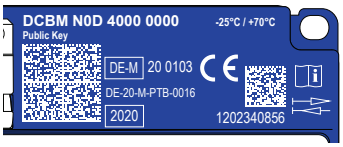
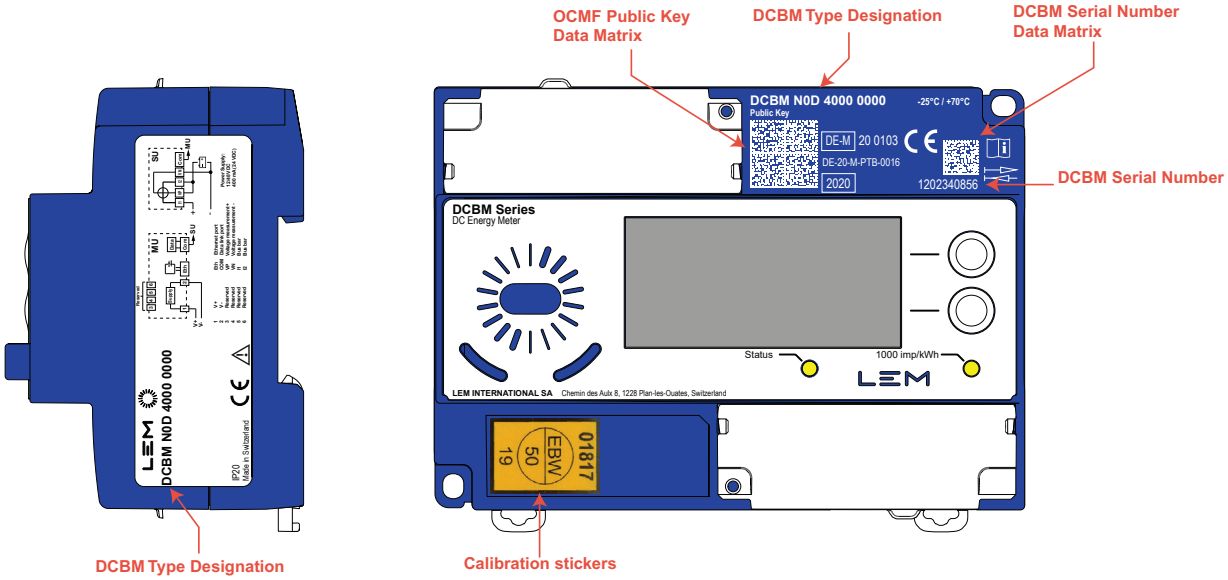
4.8. Marking

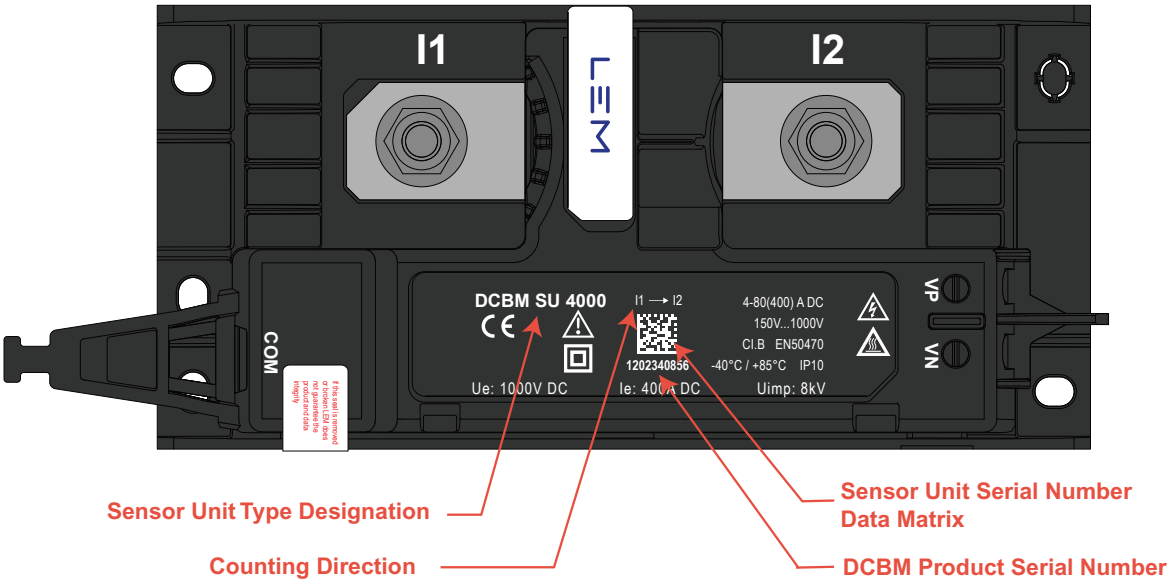
Meter Unit Marking Example – Without certification



Meter Unit Marking Example - With PTB certification







5. ELECTRICAL FUNCTIONS

5.1. Safety features

Reinforced insulation

- Reinforced insulation according to IEC 60664-1 is provided by the Sensor Unit.
- Rated insulation RMS voltage: 1000V

Thermal consideration

- The DCBM features temperature measurements on its shunt.
- Temperature can be read at any time using `/livemeasure` API (see "7.3.5. Other measurements")
- Furthermore, the Sensor Unit monitors those value. In case an over temperature is detected, a status flag is raised, and traced in the on-going transaction (see "7.5.3. Current status")

5.2. Integration solutions

5.2.1. Overview

The DCBM 400/600 product family offers multiple solutions for integration of its Sensor Unit. Choices can be made on:

- The current flow which is considered as regular counting direction
- The voltage side on which the DCBM is installed

Regardless of the Sensor Unit configuration, the Meter Unit connection is always the same.

The connection line for voltage measurement must include the supplied ferrite, ensuring measurement reliability despite EMI interferences, as shown on Figure 21 and Figure 22.

5.2.2. Counting direction

Two types of references are available, matched with different counting direction:

Naming	Counting direction	References designation
Direct	I1 ➔ I2	DCBM_Nxx_xx00_xxxx
Reverse	I2 ➔ I1	DCBM_Nxx_xx10_xxxx

Table 4: Counting direction references

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The goal of this choice is to always have registers as follows:

- Energy coming from the electrical grid into the vehicle increments Import energy register.
- Energy coming from the vehicle back to the grid increments Export energy register

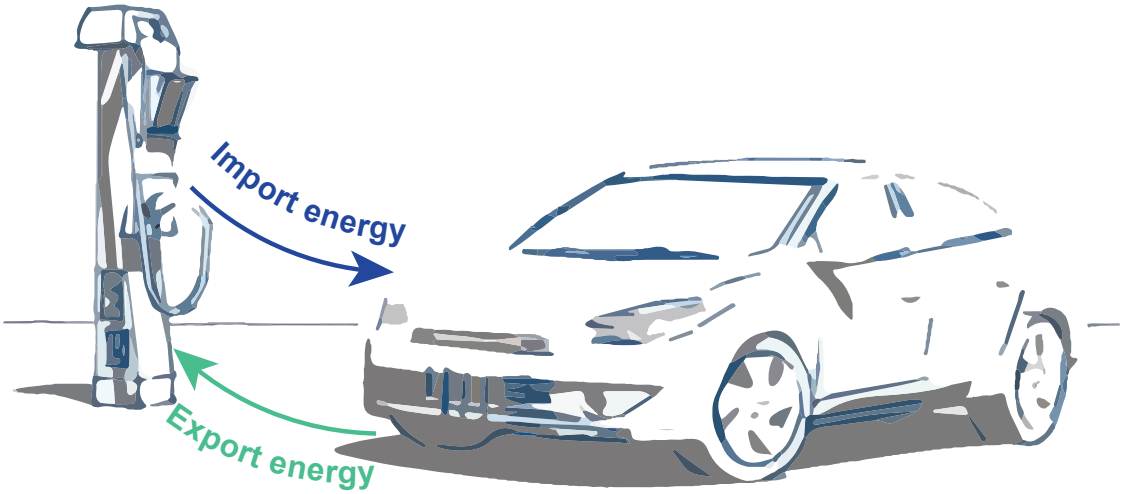

Figure 20: Import and export energy registers matched with energy flow

5.2.3. Voltage side

Regardless of the product reference, one of the following mounting options must be chosen:

- Mounting the Sensor Unit on the negative side of the DC link, referred as "Low side mounting"
- Mounting the Sensor Unit on the positive side of the DC link, referred as "High side mounting"

These possibilities offer flexible integration in existing environments. Hence the choice depends on existing architecture or foreseen integration. Decision influences how voltage inputs must be connected, as described in next sections.

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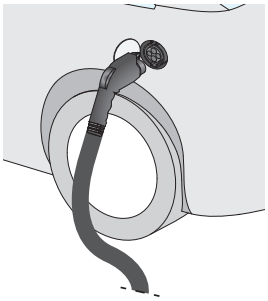
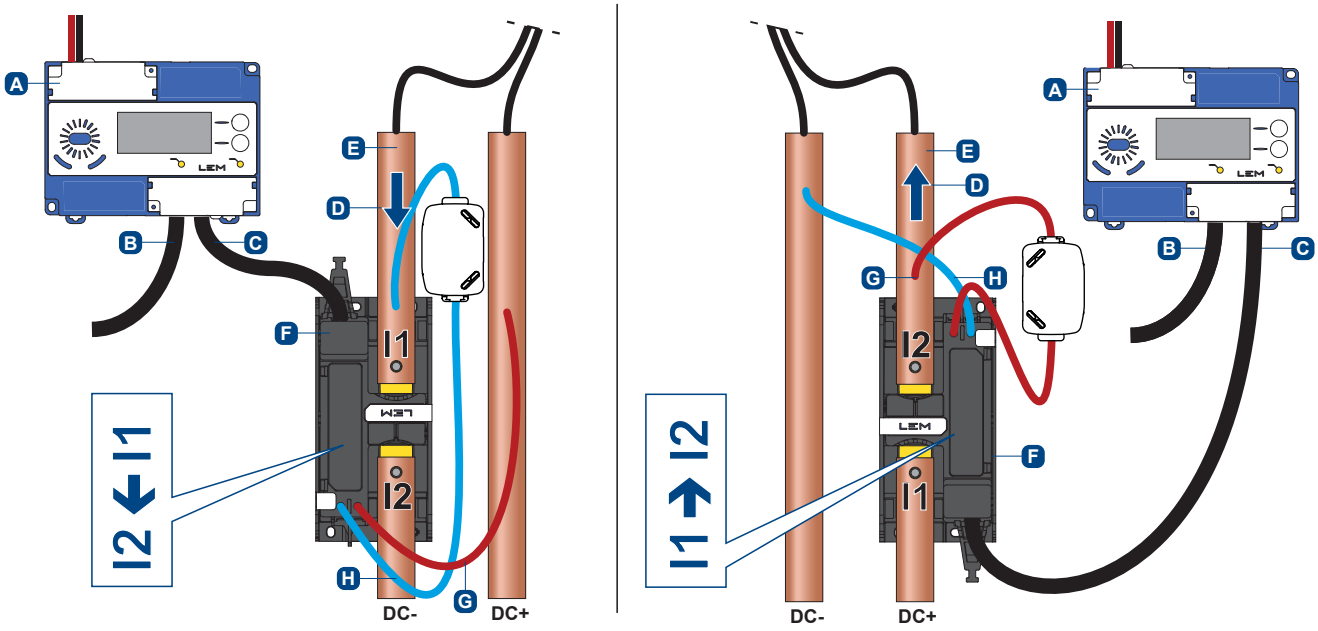
5.2.4. Direct counting direction connection requirements





Low side mounting

High side mounting

*Figure 21: Connection for direct counting direction references (DCBM_NxD_x0**00**_0000)*

A	Meter Unit	E	Charging station bus bars
B	Ethernet Cable	F	Sensor Unit
C	Data link cable	G	Voltage measurement cable +
D	Current flow	H	Voltage measurement cable -

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5.2.5. Reverse counting direction connection requirements

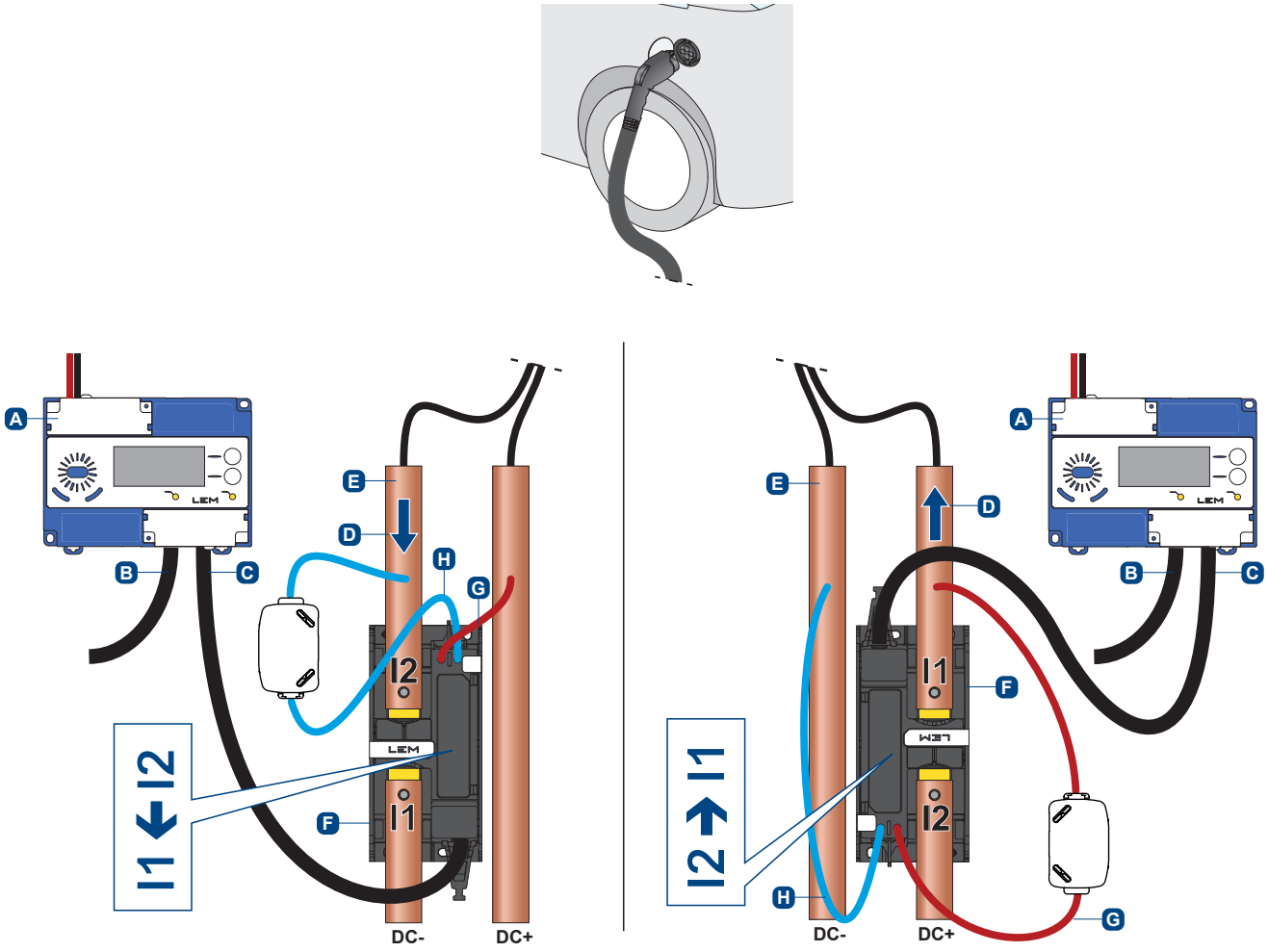

*Figure 22: Connection for reverse counting direction references (DCBM_NxD_x0**10**_0000)*

A	Meter Unit	E	Charging station bus bars
B	Ethernet Cable	F	Sensor Unit
C	Data link cable	G	Voltage measurement cable +
D	Current flow	H	Voltage measurement cable -

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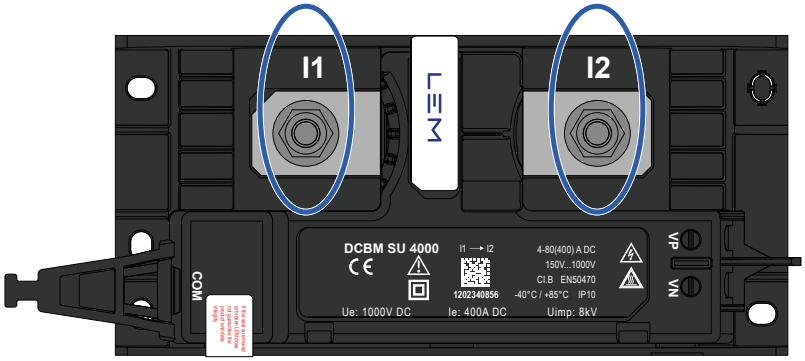
5.3. Energy registering

Conventional direction for current measurement fills the "import" energy register. This flow refers to I1 and I2 indications on Sensor Unit marking (see below figure), and depends on product reference: see "Table 4: Counting direction references".

A current flow the other way around fills the export energy register.



VP and VN shall be connected to the positive and negative bus bars respectively. Voltage inversion does not cause any damage to the DCBM but raises a status to indicate the wiring error (status `reversedVoltage`, see "7.5.3. Current status").

The following graph shows how directions of current flow and voltage difference are registered by the DCBM.

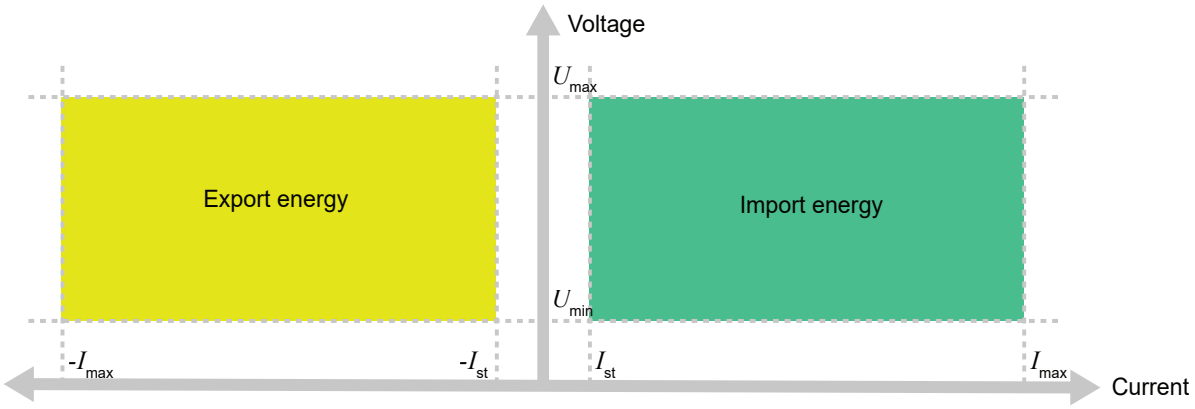


Figure 23: Counting quadrants for the DCBM

Anti-creep is performed on current and voltage measurements, as visible of above graph. Hence, no energy is accumulated in any of the following conditions:

- If voltage is below datasheet value "Minimum limit range of operation U_{min}"
- If current is between I_{st} and $-I_{st}$ ("Starting current" as in datasheet)

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5.4. Handling energy losses

High power charging implies non-negligible power losses through components of the electrical circuit. The DCBM offers solutions to avoid billing those losses to the end customer.

Two solutions are available:

- Achieve a compensation to subtract dissipated energy to the consumed energy; using cable loss compensation
- Achieve the energy measurement as close to the EV as possible, using four-wire measurement

5.4.1. Cable loss compensation

The DCBM 400/600 product family features a unique solution to compensate energy dissipated between the energy meter and the EV battery.

5.4.1.1. Principle

Below illustration gives an example of distribution of losses in an installation.

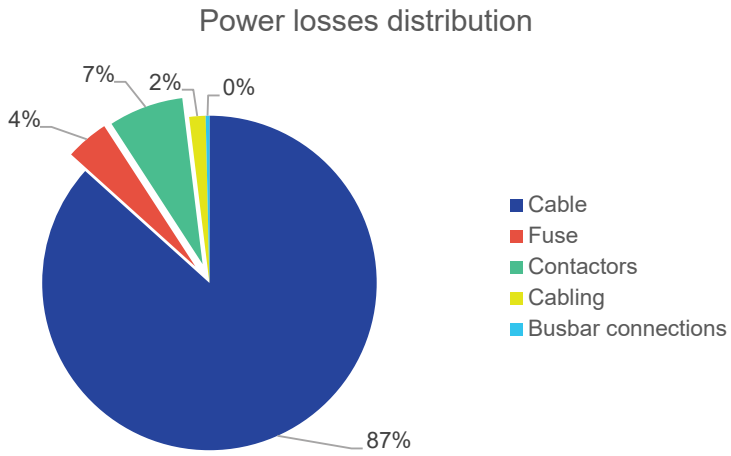

Figure 24: Example of energy losses in an EVSE electrical circuit

If no compensation is performed on the measurement, the total resistance will bend the accuracy characteristic of the metering system. This bending will be more significant at low system voltage.

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Figures hereunder depict an example of graph to compare system accuracy (standard offset and gain errors has been applied):

- Left hand figure displays a simulated accuracy graph with the 4-wire measurement technique (or perfect compensation of cable losses)
- Right hand figure displays the same results when cable losses are not compensated, and no 4-wire measurement is available.

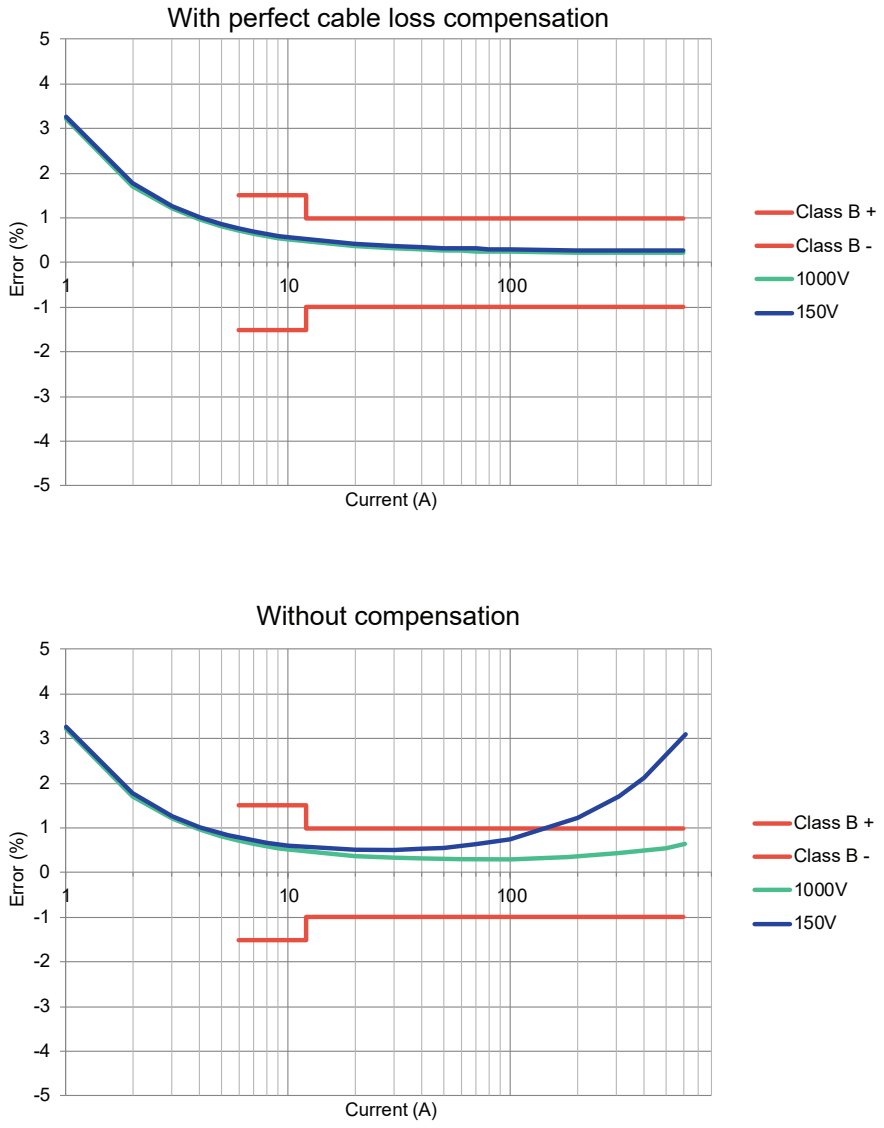

Figure 25: Current accuracy graphs with and without cable loss compensation

When no compensation is implemented, the metering system does not subtract the losses of electrical circuit; therefore the measurement energy is too high.

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5.4.1.2. Compensation mechanism

In standard installations, the voltage measurement terminals of the DCBM are connected directly to the bus bars inside the charging station. The voltage sense wires can be connected after the power relay if necessary.

In this case, the cable loss compensation mechanism must be used. Figure hereunder describes the possible integration.

i Only resistive losses can be compensated. Notably, power diodes losses cannot be compensated (i.e. right-hand solution cannot be used).

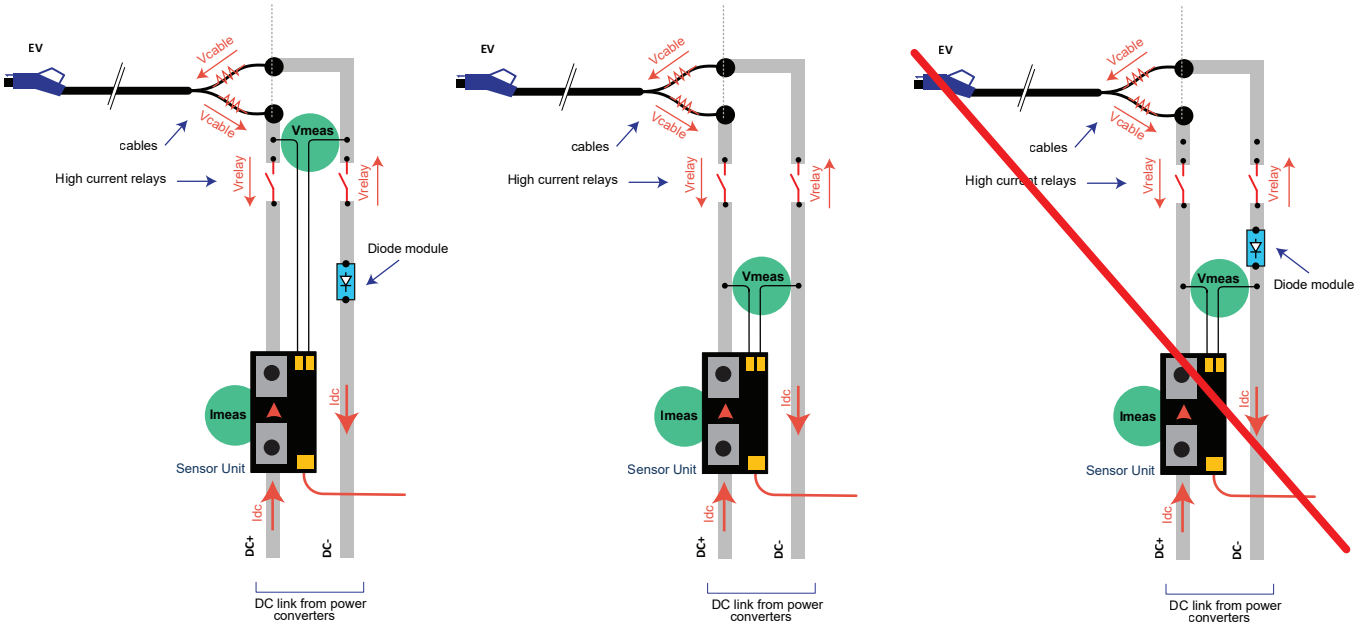

Figure 26: Integration examples using cable loss compensation

Cable loss compensation consists in subtracting estimated energy losses to actually measured energy. To do so, the DCBM uses a resistance value, which estimates the dissipation resistance of the circuit. This resistance value is referred to as R_P. The compensated energy is integration of compensated power, calculated as follows:

$$P_{compensated} = I_{measured} \times V_{compensated}$$
$$= I_{measured} \times (V_{measured} - I_{measured} \times R_P)$$

With:

$P_{compensated}$ & $V_{compensated}$	Compensated power & voltage
$I_{measured}$ & $V_{measured}$	Measured current & voltage
R_P	Resistive compensation

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5.4.1.3. Setting the compensation level

5.4.1.4. Setting `cableId` value

The DCBM includes a list of preset R_P table of 8 R_P values. Parameter `cableId` allows selection through the table.

Three types of DCBM references are available, with different preset tables:

- Dynamic compensation
- No compensation
- Fixed-value compensation

Product designation separates those types (see "3.5. Product designation"). Resistance values for all products are distributed as follows:

N0D ⇔ Dynamic compensation
N1D ⇔ No compensation
N2D ⇔ Compensated @ 2 mΩ
N3D ⇔ Compensated @ 4 mΩ
N4D ⇔ Compensated @ 6 mΩ

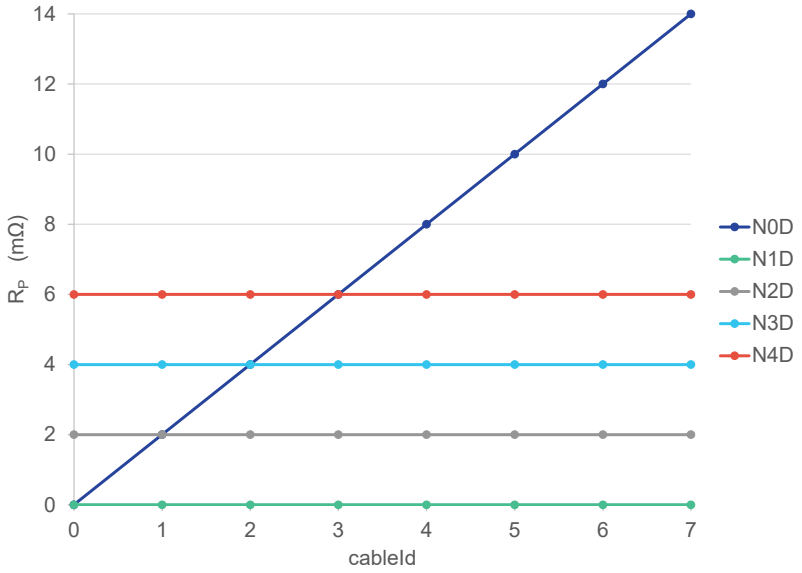

Figure 27: Distribution of R_P values depending on product designation

For references with dynamic compensation, R_P value to use is chosen at the start of each transaction by the charger controller. It cannot change during transactions. After the transaction, the used compensation level is securely stored within the corresponding signed transaction data structure.

The following items are excluded from compensation:

- Exported energy is not compensated
- Live voltage, current, power are never compensated
- Any energy outside transactions is not compensated

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5.4.2. Four-wire measurement

Product offers the possibility to use four-wire measurement to comply with the latest generation of high power charging cables.

This mode requires a charge cable featuring specific voltage measurement wires, to allow VP and VN to measure voltage directly onto the EV connector.

This mode is compatible with both high side and low side mounting, as described in "5.2.3. Voltage side".

Figure hereunder describes the connection and the system integration.

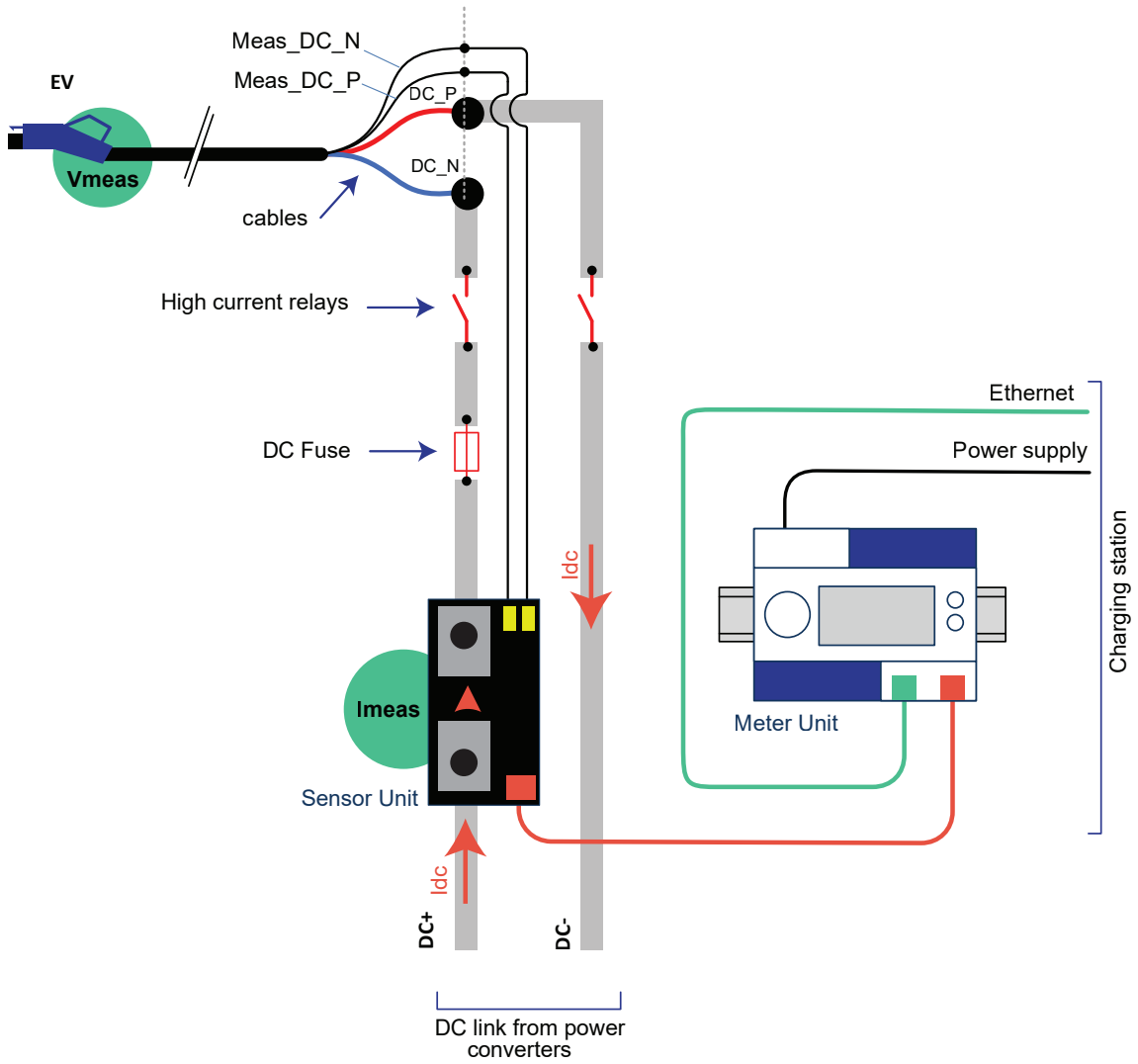

Figure 28: Integration example for four-wire measurement

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5.5. Performances

5.5.1. General

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Supply voltage		V DC	+12		+48	±5 % tolerance
Supply current		mA			400	At +12 V DC
Supply bridging time		s		0.5		At +24 V DC
Voltage restoration (power up)		s		5		At +24 V DC
Rated conventional thermal current		A		400 600		DCBM-SU40xx DCBM-SU60xx
Rated operational voltage		V		1000		
Insertion loss in current path		W		10		
Rated operational voltage		V		1000		
Insertion loss in current path		W		10		
Rated short time withstand current	I_{CW}	kA		12 18		DCBM-SU40xx DCBM-SU60xx 30 ms

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5.5.2. Accuracy

Parameter	Symbol	Unit	DCBM 400	DCBM 600	Comment
Accuracy class			B	B	
Meter type			Direct connected meter		
Current specification (Uninterrupted duty)					
Reference current	I_{ref}	A	80	120	According to EN 50470-3 and EN 50470-1
Minimum current	I_{min}	A	4	6	
Transitional current	I_{tr}	A	8	12	
Maximum current	I_{max}	A	400	600	
Starting current	I_{start}	mA	320	480	
Voltage specification					
Range of operation	U_n	V DC	150 - 1000		
Maximum limit range of operation	U_{max}	V DC	1100		
Minimum limit range of operation	U_{min}	V DC	130		
Energy measurement bandwidth			DC		
Cable loss compensation		mΩ	0 - 14		By steps of 2 mΩ, imported energy only. Selectable by charger controller or fix value
Test Output LED		Imp/ kWh	1000		(see product designation)
Counting direction			Bidirectional		

5.5.3. Insulation

Parameter	Symbol	Unit	Value	Comment
Insulation type			Reinforced insulation[1)]	According to IEC 60664-1
Rated insulation RMS voltage	U_{Nm}	V	1000	
Overvoltage category			OV II	
Impulse withstand voltage 1.2/50 µs	U_{Ni}	kV	8	
RMS voltage for AC insulation test, 50/60 Hz, 1 min	U_d	V	4400	
Pollution degree			PD2	
Maximum altitude m 2000		m	2000	
Voltage sense terminals - rated insulation between poles		kV DC	1	Basic insulation, PD2
Case material			V0	According to UL 94

Note: [1)] Reinforced insulation is provided by the Sensor Unit (DCBM-SU40xx/DCBM-SU60xx). The DCBM Meter Unit operates in SELV only

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5.5.4. Operating conditions

5.5.4.1. Sensor Unit

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Ambient operating temperature	T_A	°C	−40		+85	
Ambient storage temperature	$T_{A\,st}$	°C	−40		+85	
Relative humidity	RH	%			95	
Mass	m	g			300	DCBM-SU40xx
					415	DCBM-SU60xx

5.5.4.2. Meter Unit

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Ambient operating temperature	T_A	°C	−25		+70	
Ambient storage temperature	$T_{A\,st}$	°C	−40		+85	
Relative humidity	RH	%			95	
Mass	m	g			200	

5.5.4.3. Data link cable

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Ambient operating temperature	T_A	°C	−50		+120	
Nominal voltage		kV AC kV DC				0.6/1 kV AC 0.9/1.5 kV DC
Test insulation voltage		kV		3.5		
Length		m	0.3		3.5	See product designation for complete product references

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6. Display and navigation

6.1. Quick start

This section describes how to validate measurements of the DCBM from the display.

6.1.1. STEP 1 - Power up the DCBM

On powering up the DCBM, the following screens will be displayed successively. In particular, the following data allow metrological validation:

- The public key during the boot sequence, for further data authenticity check of LEM format (i.e. without OCMF RFC5480 header)
- The global energy registers (import and export), on the idle screen

Detail of data displayed can be found in section "6.3. Boot screens" and "6.4. Idle screen".

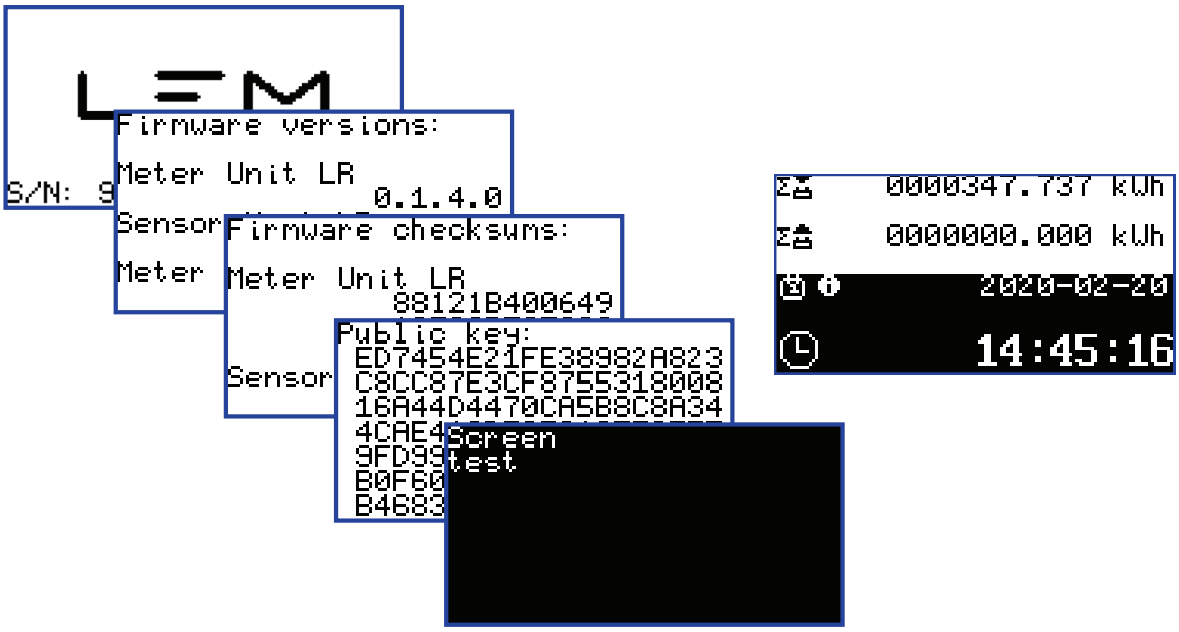

Figure 29: Sequence of screens on boot and during idle

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6.1.2. STEP 2 - Check transaction data

A transaction must be triggered. Sequences of screens are triggered by the beginning and end of the transaction, which are illustrated below. Description of those screens is available in section "6.5. Transactions screens".

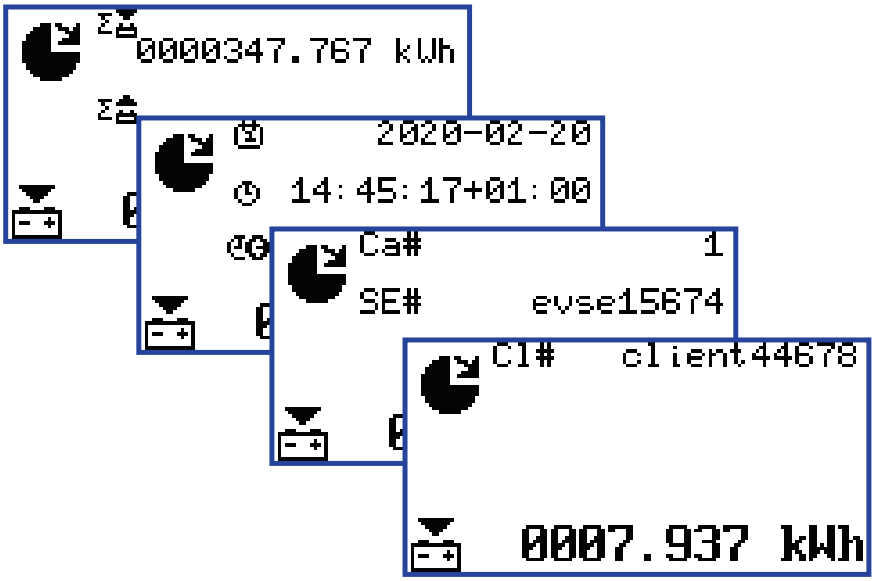

Figure 30: Sequence of screens for beginning of transactions

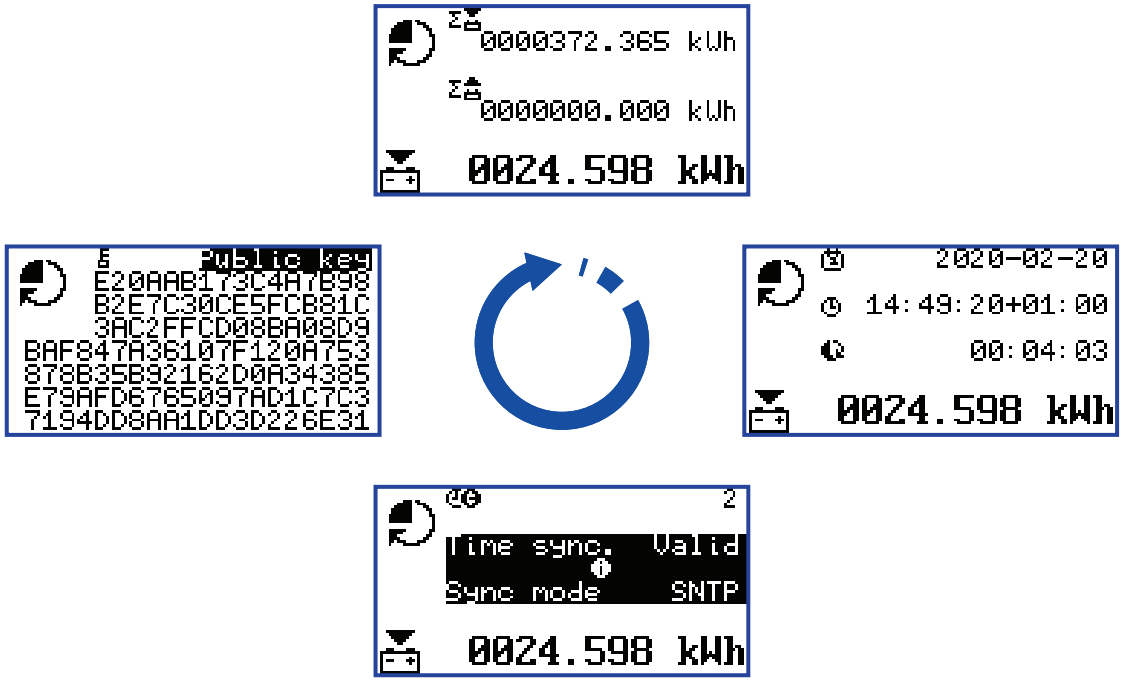

Figure 31: Sequences of screens for end of transactions

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In particular, the following data are of specific interest:

- The difference register for the current transaction, displayed at the bottom of every screen
- Total energy registers (import and export) at the beginning and end of the transaction
- Duration of the transaction, at the end of the transaction
- Public key for LEM format authenticity check (i.e. without OCMF RFC5480 header)

6.1.3. STEP 3 - Achieve further validation

Outside transactions, buttons give free access to data, which can help checking metrological status and registers. For instance, the following data can be of interest.

- Transaction prerequisites: Status of Sensor Unit link and of time synchronization
- Metrological follow-up: Total energy registers
- Data authenticity: Public key (without OCMF RFC5480 header)

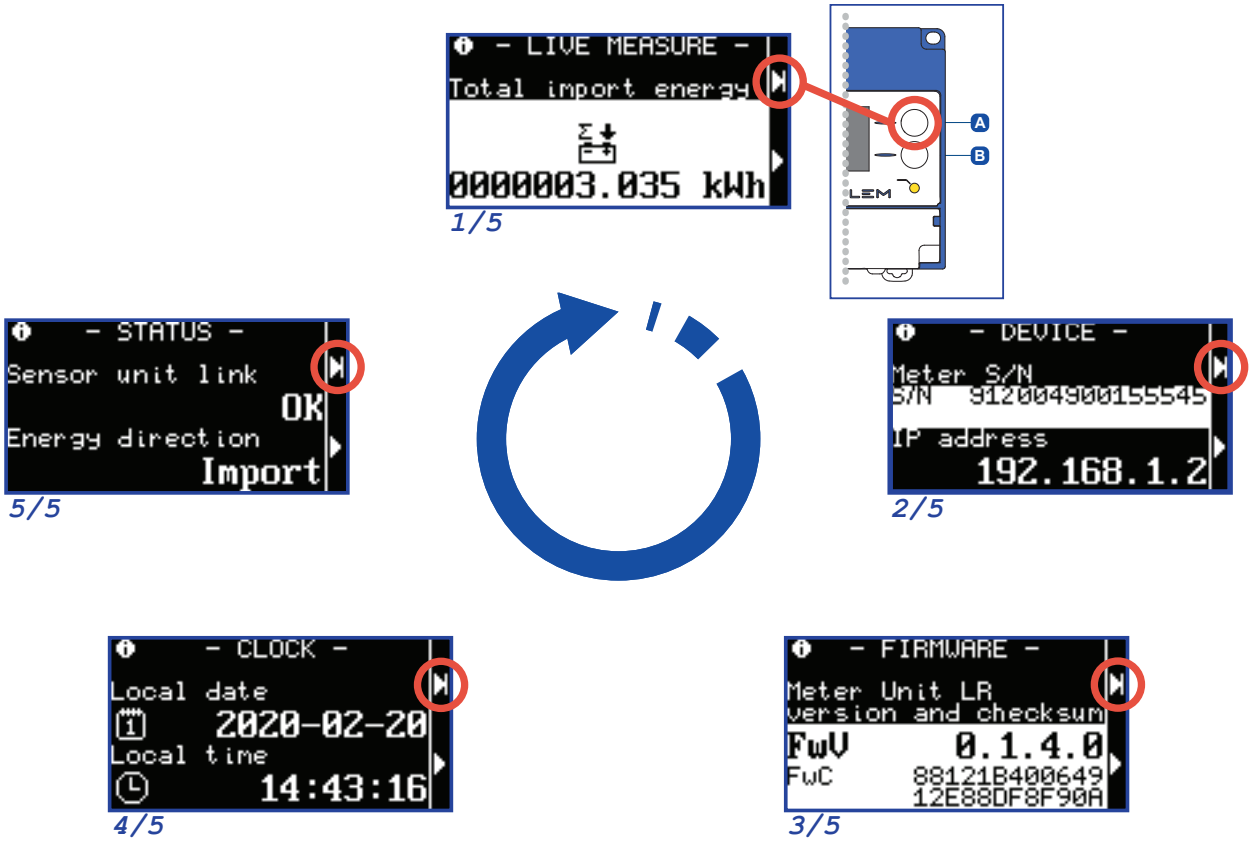

Figure 32: Maintenance screens which can help metrological validation

The full list of data is available in section "6.6. Maintenance state".

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6.2. General display concepts

The display of the DCBM primarily aims at displaying data relevant to certified billing. Screens are sequenced accordingly. The display also provides data which can be useful for installation and maintenance.

The screens are sequenced according to the adjacent block-diagram.

Those states are described individually in below sections.

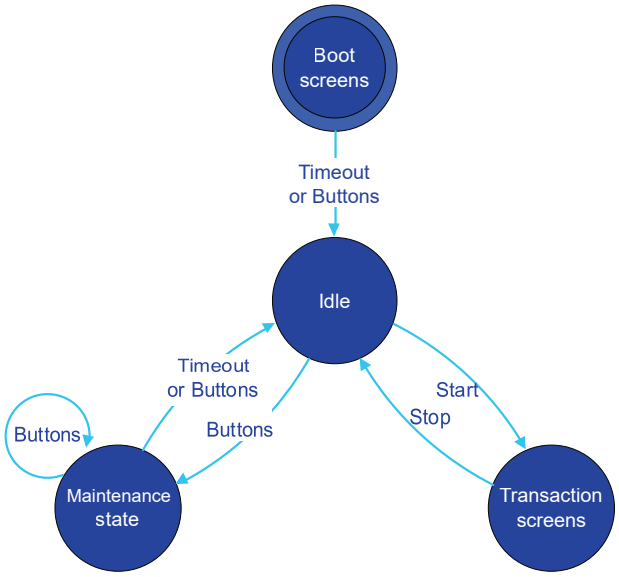
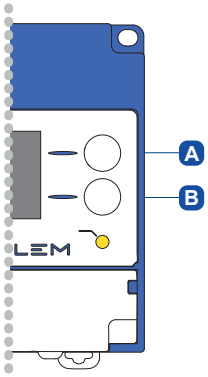


Figure 33: Global state machine of the display

Two buttons are present on the front panel. Their effect depends on the current state and is described along with states. Those buttons are referred to as follows:



Identification on figure	Naming in hereby document
A	Top button
B	Bottom button

Figure 34: Identification of buttons

i Due to certification function of the display, a visual distinction appears between certification data and user experience-oriented data. This distinction is illustrated on example of screen below.

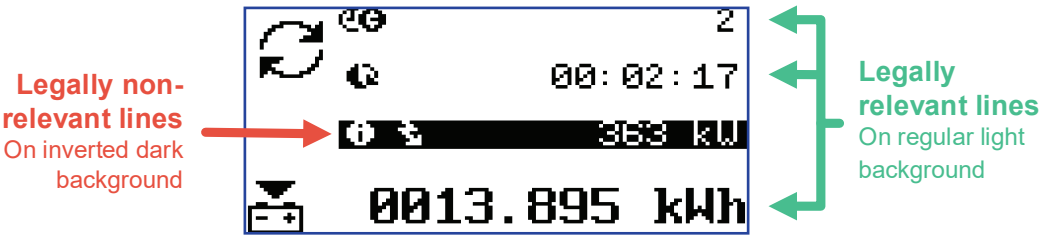


Figure 35: Visual distinction for legal relevance on the display

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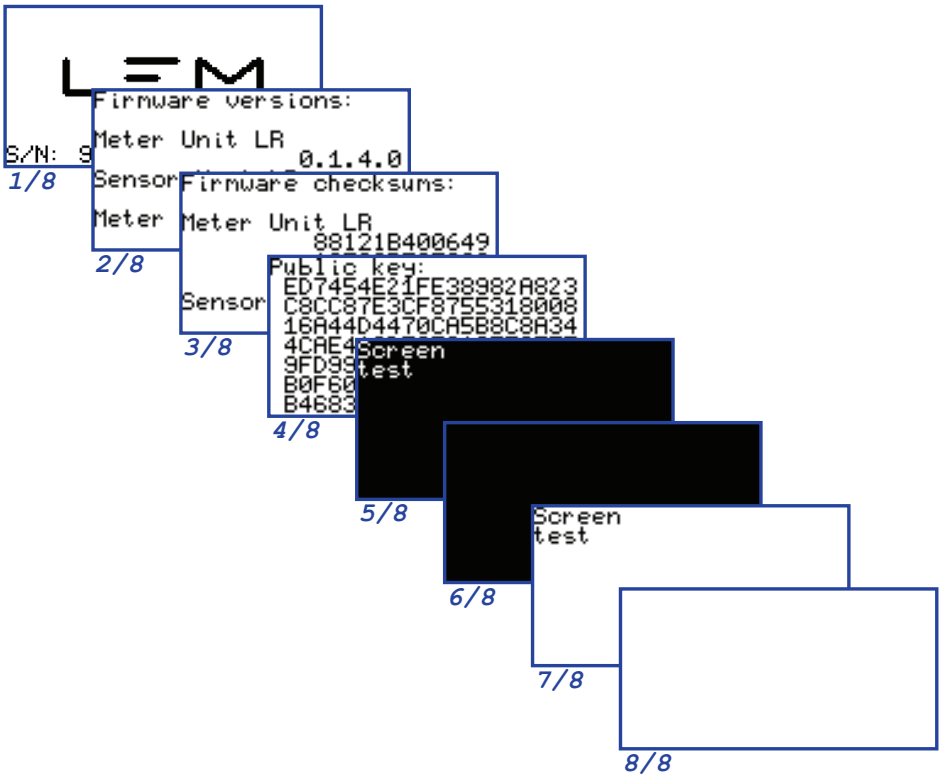
6.3. Boot screens

6.3.1. Overview

Boot screens provide general information on the device. The sequence rolls on a regular basis and can be overridden by a started transactions or a pressed button. The sequence ends with a screen test sequence, allowing to visually check the proper functioning of the whole pixel matrix.



Screen index	Solution
1/8	Company logo Serial number of device
2/8	Identifiers of the versions of each firmware parts
3/8	Integrity checksums for legally relevant firmware parts
4/8	Public key of the device, for LEM format authenticity check (i.e. without OCMF RFC5480 header)
5-8/8	Screen test sequence

6.3.2. Effect of buttons

Buttons used in this state abort the sequence and lead to the maintenance state.

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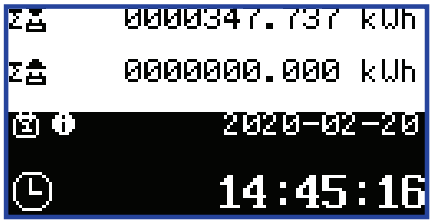
6.4. Idle screen



6.4.1. Overview

The idle screen is the central screen, following the boot sequence, the transaction screens and the maintenance state.

6.4.2. Available data

The data provided in the Idle screen are the following:

- Total import and export energy registers
- Current local date and time

6.4.3. Effect of buttons

Buttons used in this state give access to the maintenance screens.

6.5. Transactions screens

6.5.1. Layout of screens

All the transaction screens are built as follows:

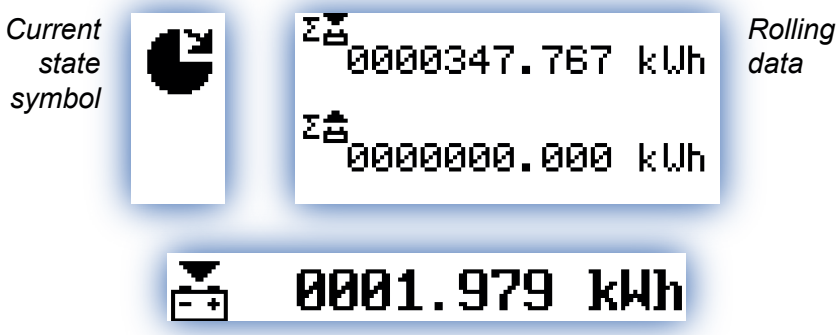


Figure 36: Transaction screens layout

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6.5.2. State symbols

The transaction screens are spread into 3 categories. Each category is associated to a symbol, displayed during the whole duration of the category.

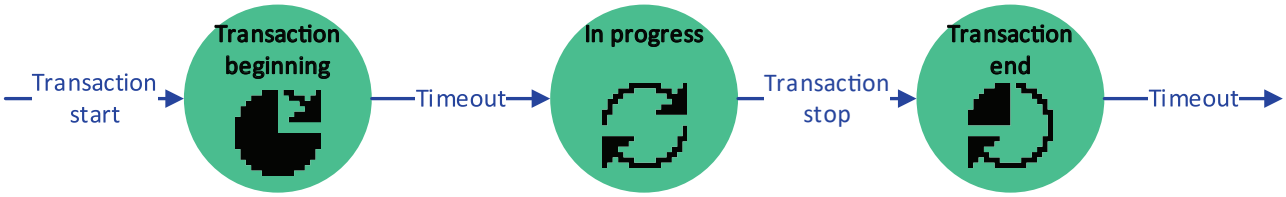

Figure 37: State machine for transaction screens

6.5.3. Transaction energy register

During the whole sequence and until the return to the Idle screen, the transaction energy counter is displayed.

Before the end of the transaction, the counter increments according to measured energy. The currently incrementing register is the one displayed: either import or export register.

Registers can be identified using an associated symbol.

	Import energy i.e. from the energy grid to the vehicle
	Export energy i.e. from the vehicle back to the energy grid

Figure 38: Transaction energy register

After the end of the transaction, the final definitive value of the energy register is displayed. If the import energy register is displayed alone, it means the export energy register was not used and vice-versa (an unused register has an energy exactly equal to 0.000 kWh). In case both registers were used, both are displayed successively.

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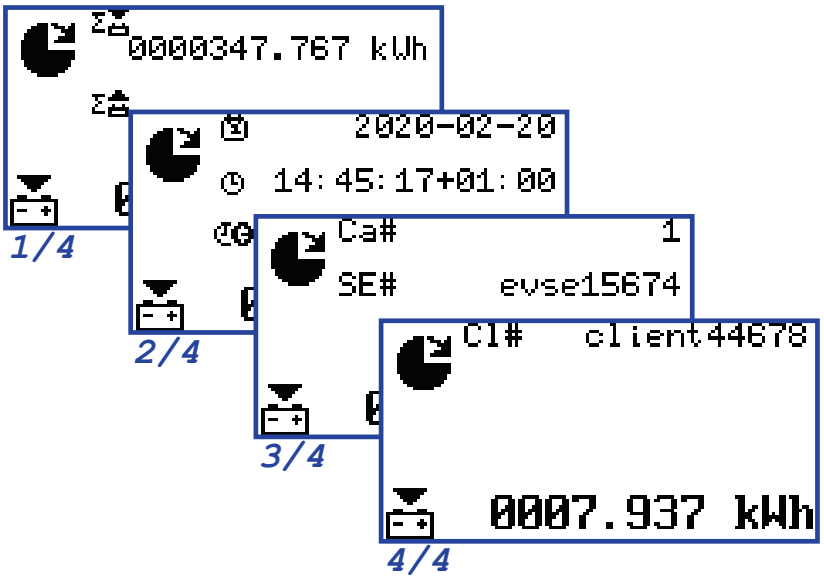
6.5.4. Rolling data

The rolling data pane features the following data.



Screen index	Data on rolling pane
1/4	Total energy registers on the beginning of the transaction
2/4	Local date and time on the beginning of the transaction Tariff input
3/4	Cable identifier input EVSE identifier input
4/4	Client identifier input

Data on rolling pane
Tariff identifier
Elapsed time of the transaction
Live charge power (not to be used for billing purposes)

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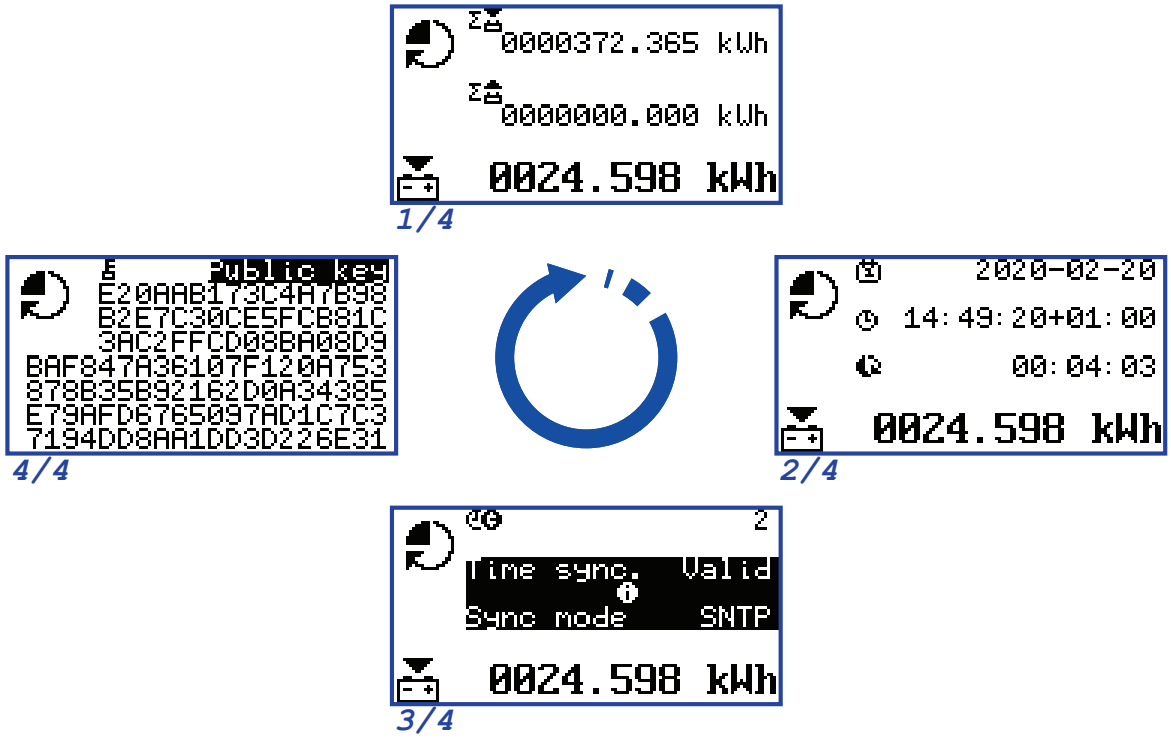

Screen index	Data on rolling pane
1/4	Total energy registers on the end of the transaction
2/4	Local date and time of the end of the transaction Total definitive duration of the transaction
3/4	Status of the time synchronization for this transaction, featuring validity and mode of synchronization (not to be used for billing purposes)
4/4	Public key of the device, for LEM format authenticity check (i.e. without OCMF RFC5480 header)

6.5.5. Effect of buttons

Symbol of transaction state	Effect of buttons
	No effect
	No effect
	Browse screen faster and in chosen order

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6.6. Maintenance state

6.6.1. Overview

Maintenance state is available from the Idle screen and from the Boot screens, by using the buttons. Its goal is to give access to some data that can ease installation and maintenance.

This state falls into several screens, split over 5 categories:

- STATUS
- LIVE MEASURE
- DEVICE
- FIRMWARE
- CLOCK

6.6.2. Layout of screens

The maintenance screens are built as follows:

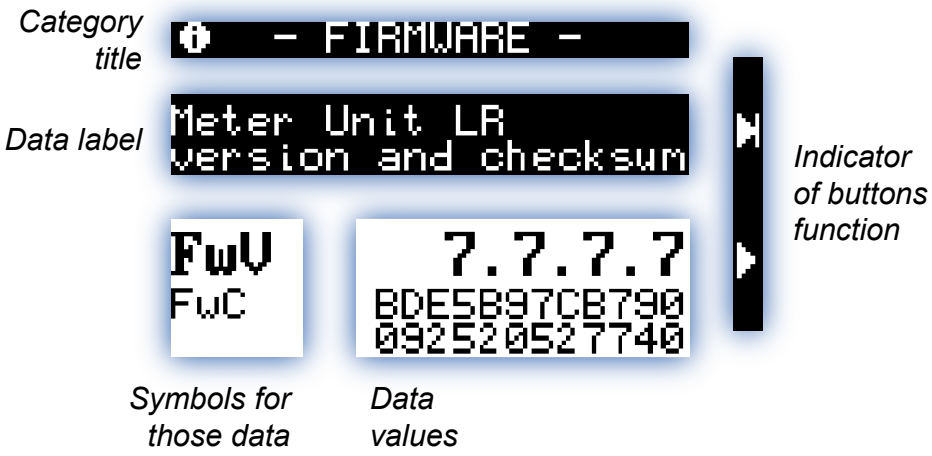

Figure 39: Maintenance screens layout

6.6.3. Effect of buttons

Over those 5 categories, the effect of buttons is the following:

Action	Effect
Top button pressed	Move on to next Maintenance state category
Bottom button pressed	Move on to next screen within the current Maintenance state category
Button long-pressed or buttons pressed simultaneously	Exit the Maintenance state

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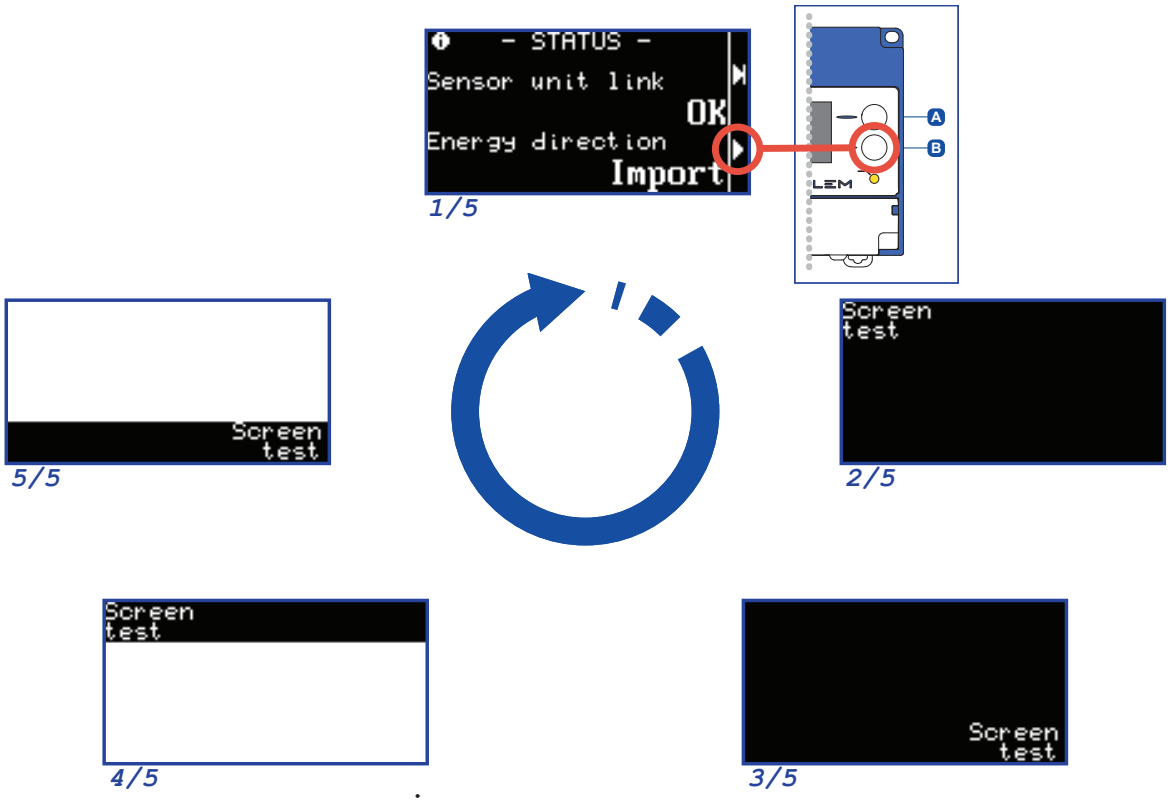
6.6.4. Available data

Below are pictures of screens, sorted by category, and provided together with the featured data.

6.6.4.1. STATUS category



Screen index	Included data
1/5	Status of the data link between the two parts Current direction of the energy flow
2-5/5	Screen test, over 4 screens

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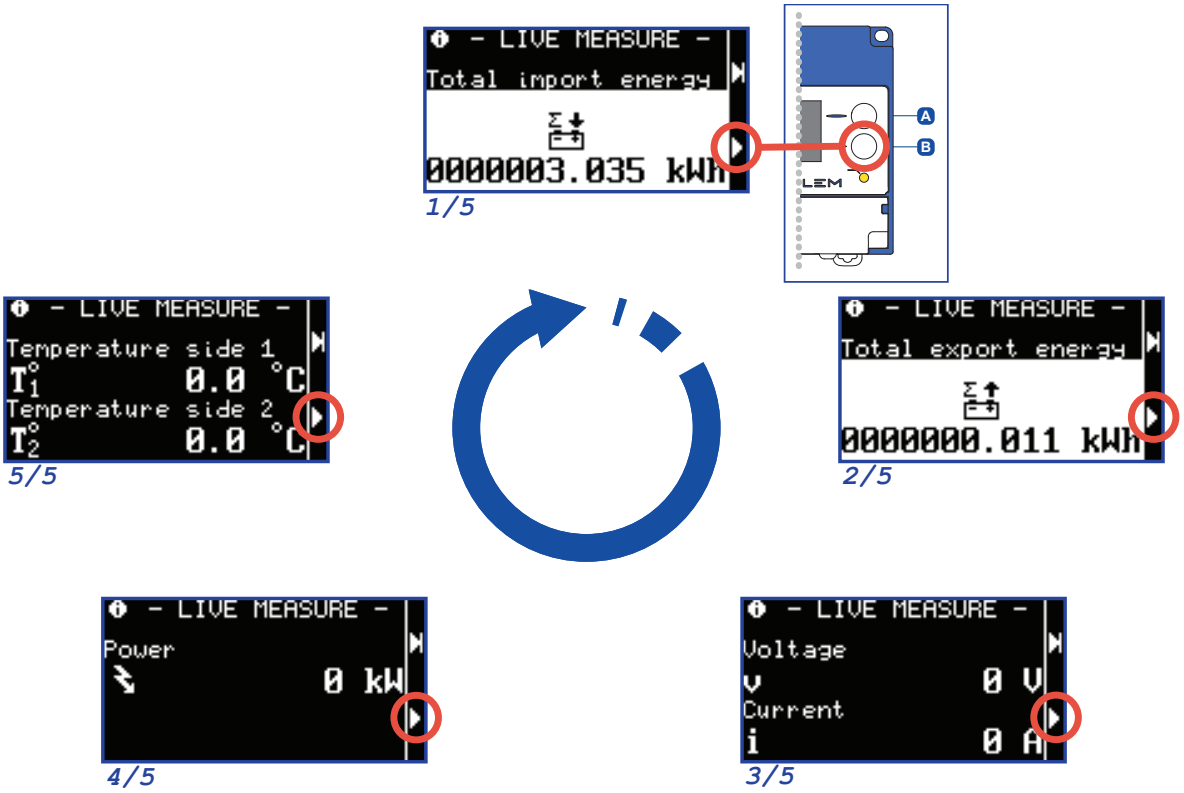
6.6.4.2. LIVE MEASURE category



Screen index	Included data
1/5	Total import energy register
2/5	Total export energy register
3/5	Live voltage and current
4/5	Live power
5/5	Live temperature of the two terminals of the Sensor Unit

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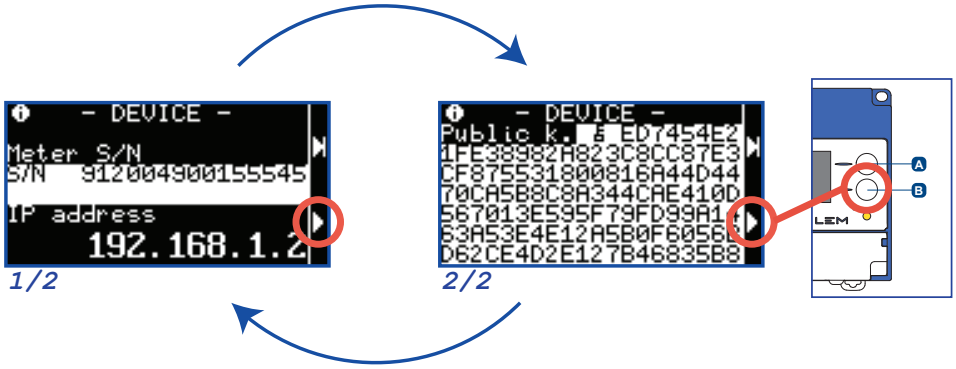
6.6.4.3. DEVICE category



Screen index	Included data
1/2	Serial number and IP address of the device
2/2	Public key of the device, for LEM format authenticity check (i.e. without OCMF RFC5480 header)

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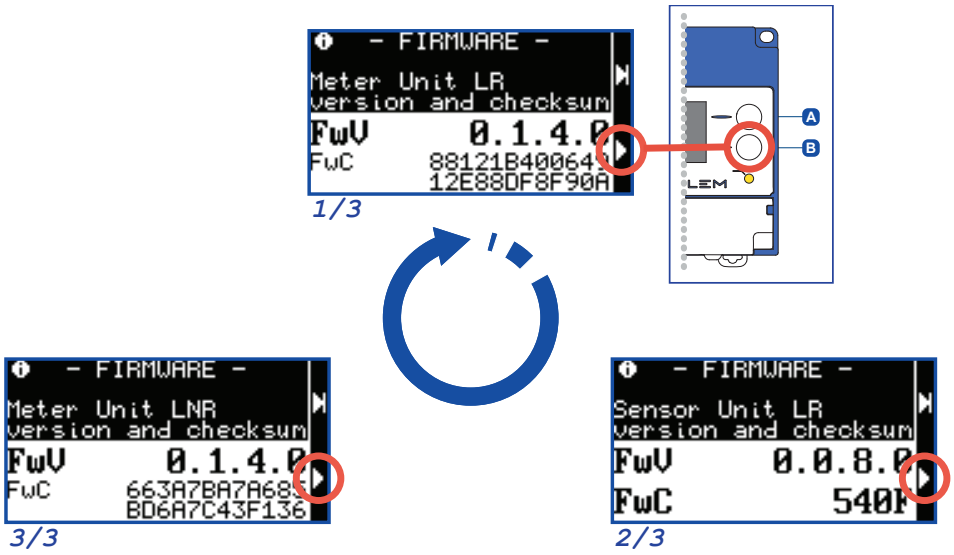
6.6.4.4. FIRMWARE category



Screen index	Included data
1/3	Identifier and checksum for the legally relevant firmware part of the Meter Unit
2/3	Identifier and checksum for the firmware of the Sensor Unit Note: This firmware is fully legally relevant
3/3	Identifier and checksum for the legally non-relevant firmware of the Meter Unit

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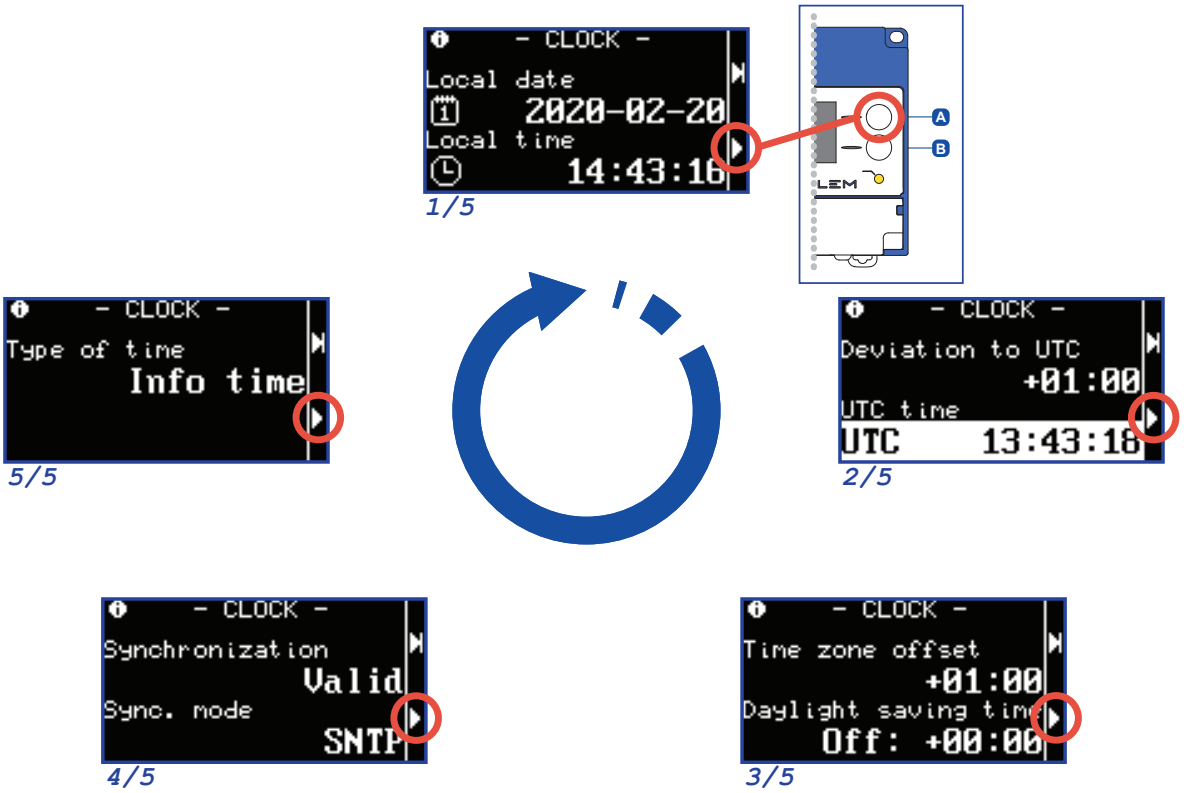
6.6.4.5. CLOCK category



Screen index	Included data
1/5	Local date and time
2/5	Total deviation to UTC and UTC time
3/5	Offsets of local time versus UTC: time zone offset and daylight savings time offset
4/5	Status of time synchronization: current validity and synchronization mode
5/5	Type of time management (info time or system time)

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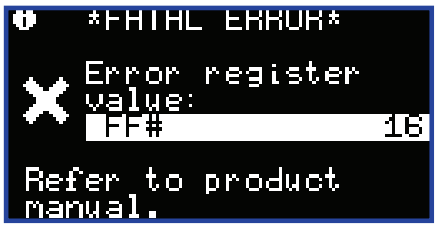
6.7. Error screen

The error screen is displayed when at least one error is raised. It is triggered with no delay, from any other screen.

Below figure is an example of the error screen.



The only data displayed on the error screen is the following:

- The current error code (see "7.5.5. Errors")

The rest of the screen is static.

Buttons allow access to the Maintenance screens, which could provide beneficial information during troubleshooting.

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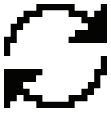
6.8. Index of symbols in screens

Below is the full list of symbols for the DCBM.

Tables match them with their label on HTTP/REST APIs and their OBIS code for data unicity.

Some symbols are rated as “informational”, meaning that they do not come with a data but inform of a current state.

6.8.1. Transaction-specific

Symbol	Meaning	Corresponding HTTP label and OBIS code
	Informational symbol: Transaction beginning. When displayed, the transaction has started and is currently on-going. This symbol is displayed along with the data necessary at the beginning of the transaction	N/A
	Informational symbol: Transaction running. When displayed, the transaction is running, and transaction beginning phase is over	N/A
	Informational symbol: Transaction end. When displayed, the transaction is over. This symbol is displayed along with the data necessary at the end of the transaction	N/A
	Data symbol: Import energy for current transaction	energyImport (/legal) 0.0.98.10.1.1
	Data symbol: Export energy for current transaction	energyExport (/legal) 0.0.98.10.1.2
	Data symbol: Elapsed time of transaction. Corresponds to the difference between transaction start timestamp and: • transaction stop timestamp (out of transaction) • or current timestamp (in-transaction)	transactionDuration (/legal) 0.0.0.1.0.255
	Data symbol: Currently active energy tariff	tariffId (/legal) 0.0.96.14.0.255
	Data symbol: Client identifier for current transaction	clientId (/legal) 0.0.96.58.0.255
	Data symbol: EVSE identifier for current transaction	evseId (/legal) 0.0.96.57.0.255
	Data symbol: Cable identifier for current transaction	cableSp/cableSpId (/legal) 0.0.96.59.0.255

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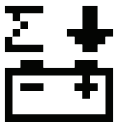
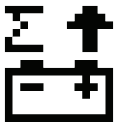
6.8.2. Metrology

Symbol	Meaning	Corresponding HTTP label and OBIS code
	Data symbol: Total import energy counter	energyImportTotal - 1.0.1.8.0.255 (/livemeasure) energyImportTotalStart (/legal) or RD[0]/RV (/ocmf) 1.0.1.8.0.1 energyImportTotalStop (/legal) or RD[2]/RV (/ocmf) 1.0.1.8.0.2
	Data symbol: Total export energy counter	energyExportTotal - 1.0.2.8.0.255 (/livemeasure) energyExportTotalStart (/legal) or RD[1]/RV (/ocmf) 1.0.2.8.0.1 energyExportTotalStop (/legal) or RD[3]/RV (/ocmf) 1.0.2.8.0.2
	Data symbol: Voltage *Data is legally non-relevant*	voltage (/livemeasure) 1.0.32.7.0.255
	Data symbol: Current *Data is legally non-relevant*	current (/livemeasure) 1.0.31.7.0.255
	Data symbol: Power *Data is legally non-relevant*	power (/livemeasure) 1.0.1.7.0.255
	Data symbol: Temperature measured on side I1 *Data is legally non-relevant*	temperatureL (/livemeasure) 1.0.131.7.0.255
	Data symbol: Temperature measured on side I2 *Data is legally non-relevant*	temperatureH (/livemeasure) 1.0.130.7.0.255

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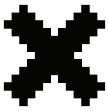
6.8.3. Time management

Symbol	Meaning	Corresponding HTTP label and OBIS code
	Data symbol: Current UTC time	time/utc (/settings) 0.0.0.9.0.255
	Data symbol: • Current local date (*Data is legally non-relevant*) • Date on transaction beginning • Date on transaction end	time (/status)
	Data symbol: • Current local time (*Data is legally non-relevant*) • Time on transaction beginning • Time on transaction end	time (/status)

6.8.4. Other data

Symbol	Meaning	Corresponding HTTP label and OBIS code
	Informational symbol: Fatal error When displayed, the DCBM detected a fatal error	N/A
	Data symbol: Fatal error code When displayed, the transaction is running, and transaction beginning phase is over	errors/value (/status)
	Informational symbol: Informational area Warns that the corresponding area contains legally non-relevant data and values	N/A
	Data symbol: DCBM serial number	meterId (/status, /settings, /logbook) 0.0.96.1.2.255
	Data symbol: Public key	publicKey (/status) (without OCMF RFC5480 header) 0.0.98.10.2.1
	Data symbol: Firmware version • LR firmware • LNR firmware • Sensor Unit firmware	version/applicationFirmwareVersion - 0.0.0.2.2.255 version/legalFirmwareVersion - 1.0.0.2.2.255 version/sensorFirmwareVersion - 1.1.0.2.0.255 (/status)
	Data symbol: Firmware Checksum / Signature • LR firmware • LNR firmware • Sensor Unit firmware	version/applicationFirmwareAuthTag - 1.1.0.2.8.255 version/legalFirmwareAuthTag - 1.0.0.2.8.255 version/sensorFirmwareCrc - 1.2.0.2.8.255 (/status)

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7. Software concepts

7.1. Interfaces

Ethernet is the communication channel for the DCBM. It supports HTTP/REST communication to receive requests and provide measurements and other data.

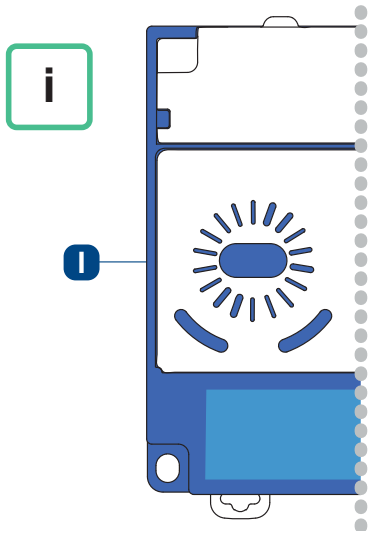
The REST-compatible API is an application programming interface that uses HTTP requests to obtain (GET), place (PUT) and publish (POST) data.

A RESTful API conforms to the Representational State Transfer or "REST" model.

This interface is using JSON format for the data payload.

URI with default IP	Methods	Description
192.168.1.2/v1/**status**	GET	Status of the DCBM
192.168.1.2/v1/**settings**	GET, PUT	Settings of the DCBM
192.168.1.2/v1/**logbook**	GET	Event logger of the DCBM
192.168.1.2/v1/**livemeasure**	GET	Live measurements
192.168.1.2/v1/**legal**	GET, PUT, POST	Transaction management (start & stop) and transaction data structure, current or stored, in LEM proprietary format
192.168.1.2/v1/**ocmf**	GET	Transaction data structure, current or stored, in certified, billable, OCMF-compliant format
192.168.1.2/v1/**certificate**	GET	HTTPS certificate of the DCBM

Table 5: REST API access and associated HTTP methods



The optical communication channel in the DCBM is disabled in the current version.

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7.2. Transactions

7.2.1. Concept

To log the energy used during a charging cycle, the DCBM handles two specific requests: “start transaction” and “stop transaction”.

When the “start transaction” command is received by the DCBM, the latter starts accumulating energy into a specific transaction. A transaction is made unique by its chosen transaction identifier, which can link it to the end user.

When the “stop transaction” command is received by the DCBM, the latter stops accumulating energy to the current transaction and sends a complete report in response. The data structure contains all the transaction information, e.g. energy registers, status information, timestamps. The whole data structure is authenticated by a signature mechanism.

The signature can be verified using product’s public key and a verification software, refer to section "7.4. Data authenticity".

Following figure illustrates the process of transaction.

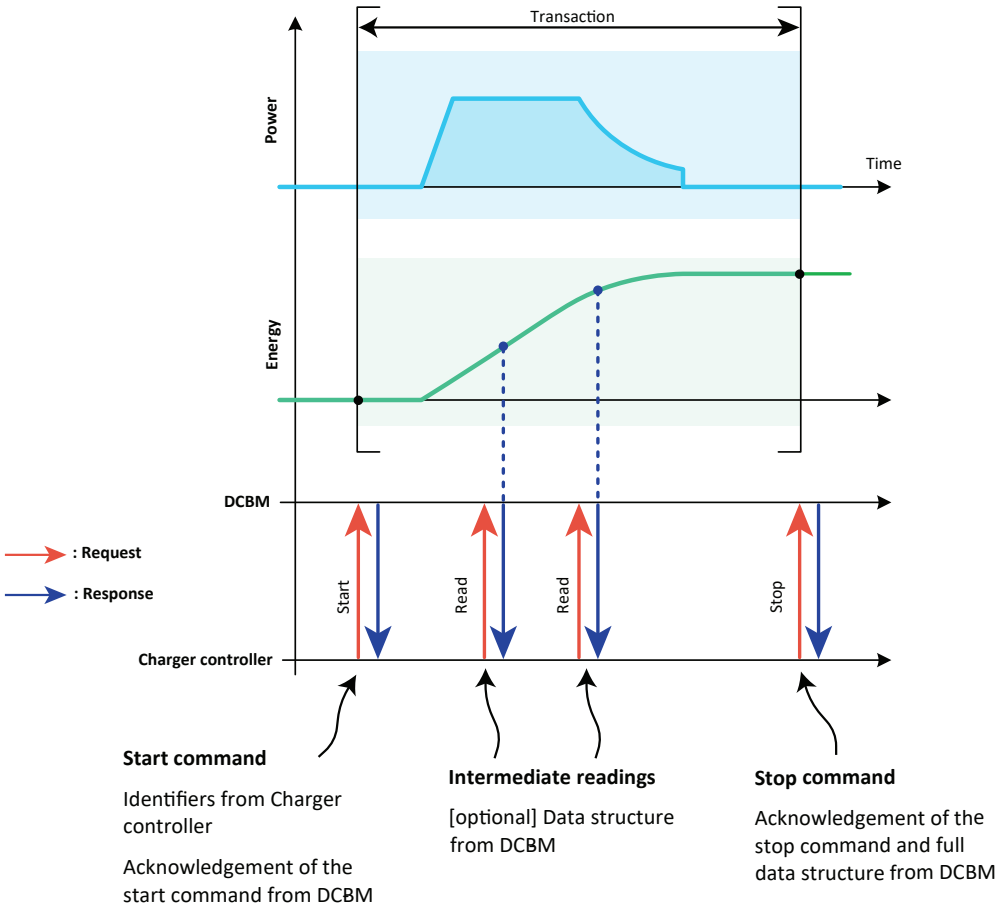

Figure 40: Transaction concept

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7.2.2. Conditions to start and input parameters

Prerequisites to a start command are:

- (1) The Meter Unit and Sensor Unit are mounted as per LEM instructions
- (2) There is no fatal error raised
- (3) There is no running transaction
- (4) Time synchronization is valid

In the device, this corresponds to the following values:

Above index	Parameter name	Value for readiness to new transaction
(1)	`suLinkStatusIsOk`	`True`
(2)	`muFatalErrorOccured`	`False`
(3)	`transactionIsOnGoing`	`False`
(4)	`timeSyncStatusIsOk`	`True`

Table 6: Transaction preconditions in device implementation

If those conditions are met, a start request on `/legal` API (see §7.1) initiates a transaction.

Minimum duration for transactions is 2 minutes, to prevent potential memory storage weaknesses.

The start request shall include the following inputs:

Input name	Type	Designates...
`evseId`	Character string, max 37 bytes-long	the EVSE in which the DCBM is located
`transactionId`	Character string, non-void and max 37 bytes-long	the transaction (from the backend)
`clientId`	Character string, max 37 bytes-long	the end user
`tariffId`	Integer from 0 to 4	the tariff used
`cableId`	Integer from 0 to 7	the cable loss compensation level to use
`userData`	Character string, max 128 bytes-long	a contract reference, or any other extra data

Table 7: Required inputs to a new transaction

Below is an example of request body to start a transaction.

```
{
      "evseId": "evse15674",
      "transactionId": "transac5765",
      "clientId": "client44678",
      "tariffId": 2,
      "cableId": 1,
      "userData": "Test of a transaction"
}
```

Figure 41: Example of body for start request

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The transaction must be terminated using a stop request. The necessary input to stop the active transaction is its `transactionId`. Response to the stop request contains the final data structure, in `/legal` format.

7.2.3. Transaction readouts

The last transaction and previous ones can be retrieved from the DCBM memory.

On the HTTP/REST interface, the DCBM supports two data formats for readouts:

- LEM proprietary format, in `/legal` API (see §7.1)
- Certified, billable, OCMF-compliant format in `/ocmf` API (see 7.1) (see "3.4. Certification and compliance")

For backend storage, OCMF format shall be preferred over LEM format. See "7.3.1. Energy registering".

Four modes of access are available. All the readings of transactions are digitally signed.

Retrieval mode	HTTP target	Detail
Retrieve the last transaction (or current)	`/v1/legal` `/v1/ocmf`	If a transaction is on-going, this request retrieves the current transaction. Otherwise, the last one is retrieved.
Retrieve by `transactionId` (search limited to **last 840** transactions)	`/v1/legal?transactionId=<xyz>` `/v1/ocmf?transactionId=<xyz>`	With `<xyz>` the `transactionId` of the transaction to retrieve (search limited to **last 840** transactions)
Retrieve by internal storage index	`/v1/legal/<index>` `/v1/ocmf/<index>`	With `<index>` a positive number. See below note. [1)] Internal **index number is provided** in the response to a start transaction request.
Retrieve by chronological storage index	`/v1/legal/-<index>` `/v1/ocmf/-<index>`	With `<index> = -1` the past transaction before the latest With `<index> = -20398` the oldest transaction stored (once storage reached full capacity).

Table 8: Solutions for retrieving past transactions

Note: [1)] Chronological storage index is advised for retrieving all stored transactions.
Indeed, behavior of internal storage index is as follows:

- Transaction storage is a circular buffer, allowing wrap-around (see "7.2.4. Memory depth"). Internal storage indexes can span from 0 to 20425, with a buffer gap of 27 transactions.
- Hence, retrieving all transactions through internal storage index might throw back HTTP error “404 - Not found” for some internal storage indexes.

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7.2.4. Memory depth

The DCBM transaction storage is limited to 20399 transactions. Once this threshold is crossed, oldest transactions are successively erased. This requires the charger controller to save the transaction elsewhere in order to comply with national regulation.

Following sections offer solutions for the charger controller to periodically and safely retrieve past transactions.

7.2.4.1. Required action following a transaction

In order to prevent data loss, individual backup shall be observed:

- Achieve a transaction stop
- Read the data using `/ocmf` API
- Backup the response in the backend.

7.2.4.2. Fallback procedure for unavailable upload

In case individual backup is temporarily unavailable, transactions can be backed up subsequently.

The charger controller must count the number of transactions that could not be uploaded.

Once communication is back, all the unsaved transactions can be retrieved recursively (using mode “Retrieve by chronogical storage index”, see "7.2.3. Transaction readouts")

- Retrieve last transaction

GET request on `http://192.168.1.2/v1/ocmf`

- 2. Retrieve the one before

GET request on `http://192.168.1.2/v1/ocmf/-1`

- 3. Retrieve the one before

GET request on `http://192.168.1.2/v1/ocmf/-2`

- X. And so on until all unsaved transactions are successfully backed up.

If a total of 20399 were not saved, the charger controller shall prevent any new transactions until upload is possible. Otherwise, the oldest transaction is deleted each time a new one is started.

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7.3. Measurements

7.3.1. Energy registering

As an energy meter, energy is the main output of the DCBM. Two types of energy registers are available:

- Total energy registers
- Transaction energy registers

As regard to certification of concerned product, the official registers to be used for billing are the following:

Name	Description
`transactionDuration`	Transaction duration in seconds
`energyImport`	Import DC energy during the transaction
`energyExport`	Export DC energy during the transaction
`energyImportTotal`	Non-resettable register for import energy ("A+")
`energyExportTotal`	Non-resettable register for import energy ("A-")

Table 9: Measurement results, metrologically relevant

7.3.2. Bidirectional current flow

Both sets of registers consist in two registers: Import energy and export energy (see "5.3. Energy registering"). They are always displayed and stored together.

i A single transaction stores both import and export energy values.

7.3.3. Total energy registers

Total energy registers are available:

- in the `/livemeasure` API (see §7.1)
- on Idle screen
- on dedicated maintenance screens (Livemeasure category)
- in the transaction data structures (both `/ocmf` and `/legal`) and on transaction screens, as frozen values corresponding to the start and end of the transaction

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7.3.4. Transaction energy registers

Transaction data in `/legal` API (see §7.1) include differential energy registers: import and export energy registers. Both of them are the difference of corresponding total energy register between the beginning and the end of the transaction, as illustrated on below figure.

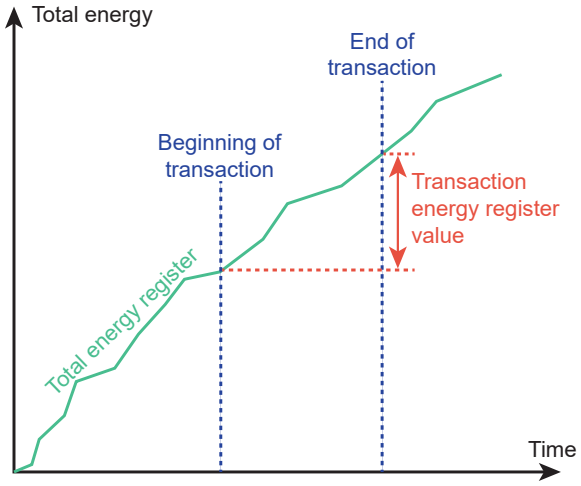
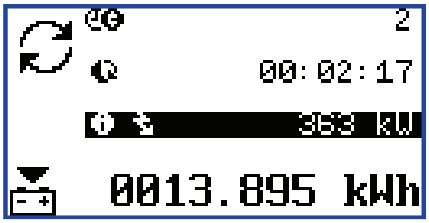


Figure 42: "Transaction" vs "Total" energy registers (Import or Export)

Transaction energy registers are stored among the transaction data. They can be retrieved by retrieving the transaction data.

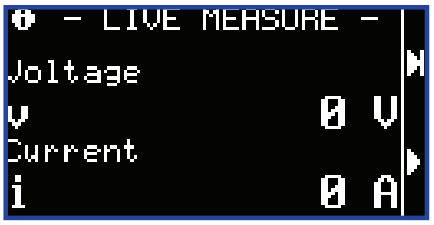
Hence, transaction energy registers can be accessed through `/legal` and `/ocmf` APIs (see §7.1). They can also be seen on most of the transaction screens.



7.3.5. Other measurements

The DCBM provides other measurements data:

- Voltage in V (with 3 fractional digits)
- Current in A (with 3 fractional digits)
- Power in kWh (with 3 fractional digits)
- Temperature measurement on both terminals of the Sensor Unit, in °C (with 1 fractional digit)



Those measurements are indicative and cannot be used for billing. They are provided as average of the last 100 ms, updated every second, and therefore they cannot reflect surges or other dynamic signals at any higher frequencies.

On HTTP/REST, those measurements are available only through `/livemeasure` API (see §7.1). On the screen, they can be accessed on maintenance screens, in Livemeasure category. Power is also available on transaction in progress screen.

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7.4. Data authenticity

7.4.1. Overview

In the context of metering, data are signed to ensure their authenticity (authentication and integrity).

Signatures secure the following sets of data:

- `/ocmf` certified, billable transaction data structure
- `/legal` LEM proprietary transaction data structure
- `/logbook` buffer

A signature cannot be used alone. The following set of inputs is necessary as a whole:

- Content to be verified
- Signature for this content
- Associated public key

Once gathered, data authenticity can be verified with the following solutions:

Verifiable data structure	`/ocmf` API	`/legal` API	`/logbook` API
Description	Transaction data structure, in certified, billable, OCMF-compliant format	Transaction data structure, in LEM proprietary format	Event logbook
Verification solution	OCMF official transparency software	LEM DCBM verification software	

Table 10: Solutions for signatures verification

Verification solutions are given as examples.

- LEM DCBM verification software is available on LEM website or from LEM support
- OCMF transparency software is available at https://transparenz.software/

! For `/legal` to be usable for billing in regards to certification, it shall be re-signed by the charger controller. That is why `/ocmf` shall be preferred for external backup.

7.4.2. Keys specifics

Two unique public keys coexist in each DCBM, to be used according to the dataset to check.

Public key	`publicKeyOcmf`	`publicKey`
Allows check of	`/ocmf`	`/legal`, `/logbook`
Availability	In `/status` API On the Meter Unit front face marking	In `/status` API In `/legal` API On the display (boot, end of transaction, maintenance screens)

Figure 43: Keys specifics for signature checks

i `publicKeyOcmf` is composed of an fix RFC5480 header and the `publicKey`

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7.5. `Status` and `errors` flags

7.5.1. Overview

The DCBM provides status and error flags allowing monitoring of its proper installation, its readiness towards transactions, the fulfillness of its logbook, its internal operation, among others.

Those flags are available under various formats as follows:

- In `/status` API: current status and errors
- In `/legal` API: transaction status
- In `/ocmf` API: OCMF `EF` and `ST` fields

Additionally, `/logbook` API keeps track of raised statuses when a new event occurs. Refer to "7.6. Event logbook".

7.5.2. Status/errors `value` field description

In `/status` API, status and error flags are available through two formats, as follows. In `/legal` API (see §7.1), only `value` field format is used.

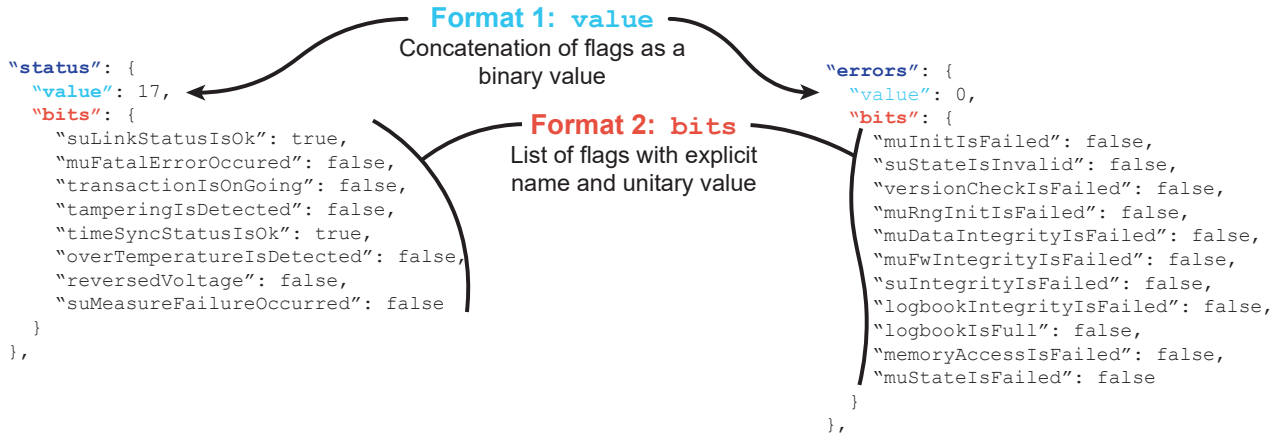

Figure 44: Description of the 2 formats of status and errors

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For both `status` and `errors`, the `value` field shall be used as follows:

- Flags are ordered in a binary word, from index 0.
- Index 0 is the Least Significant Bit (LSB)
- `true` corresponds to value 1; `false` corresponds to value 0
- If all flags are `false`, `value` fields equals 0.
- Any flag being `true` adds *2^(flag index)* to the value.

See next figure.

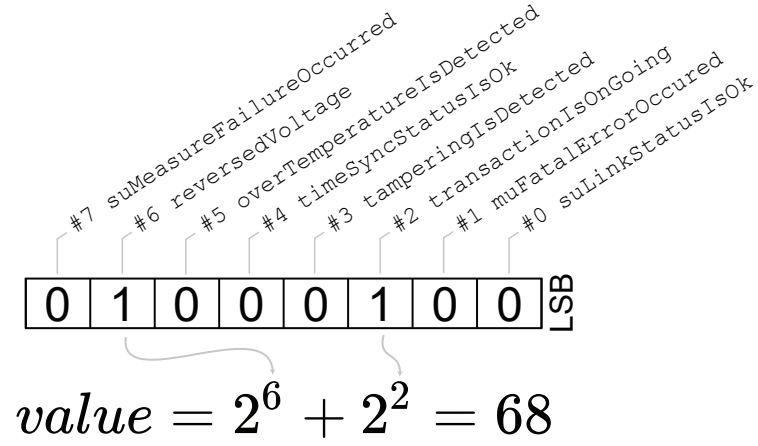

Figure 45: Illustration of using `value` field, example for `status` register

7.5.3. Current status

The current status is available in the `/status` API (see §7.1). It reflects the status of the DCBM at any time. Associated conditions can raise the flags. Once the condition disappears, the corresponding flag does too.

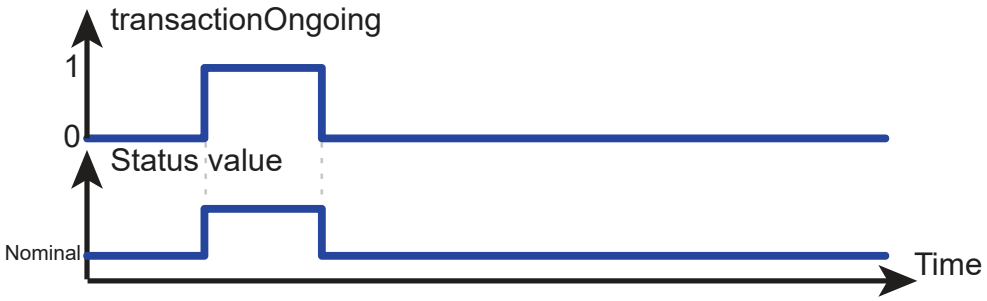

Figure 46: Status field persistence

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Flag `reversedVoltage` is an exception, it can only be turned off after a restart of the DCBM.

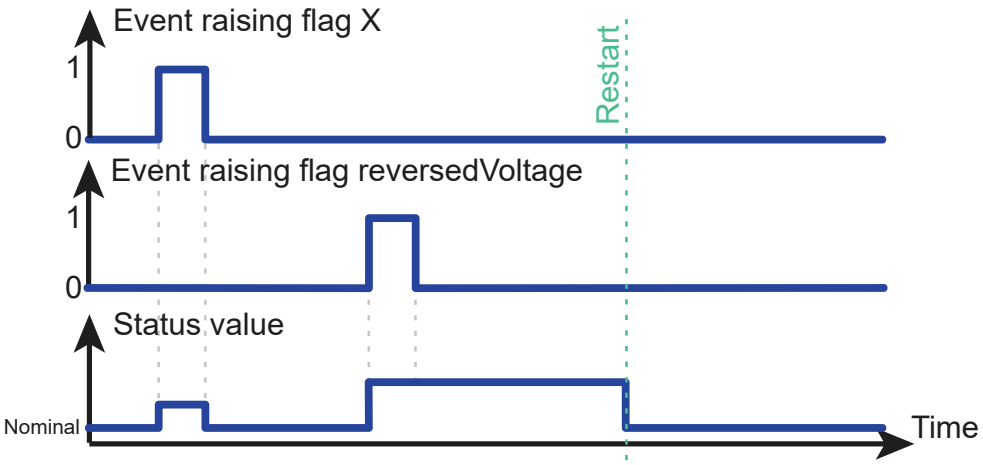

Figure 47: Specific `reversedVoltage` status persistence

The list of flags is as follows:

Flag index	Name	Description	Criticality
0	`suLinkStatusIsOk`	Data link cable is functional	Blocker
1	`muFatalErrorOccured`	At least an error is active	Blocker
2	`transactionIsOnGoing`	A transaction is on-going	Blocker
3	`tamperingIsDetected`	Tampering is currently detected	Indicator
4	`timeSyncStatusIsOk`	Time synchronization is active	Blocker
5	`overTemperatureIsDetected`	An over-temperature was detected by the Sensor Unit	Indicator
6	`reversedVoltage`	Reversed voltage is seen by the Sensor Unit	Indicator
7	`suMeasureFailureOccurred`	An error occurred in Sensor Unit ADC	Indicator

Table 11: List of `status` flags

Criticality levels are as follows:

- Indicator: A transaction is still possible, event is logged.
- Blocker: New transactions are rejected until status bit returns to nominal mode, event is logged.

17 is the status value corresponding to the nominal state of the DCBM, when ready for a transaction.

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7.5.4. `transactionStatus` field

`transactionStatus` keeps tracks of the status of the DCBM during the whole transaction. This value is available in the `/legal` API (stored with each transaction).

At the beginning of the transaction, the current status value is copied to `transactionStatus`, regardless of its value.

```
"transactionDuration": 7,
"intermediateRead": false,
"transactionStatus": 17,
"sampleValue": {
  "energyUnit": "kWh",
```

During the transaction, any raised flag is tracked by increasing `transactionStatus` until the end of the transaction.

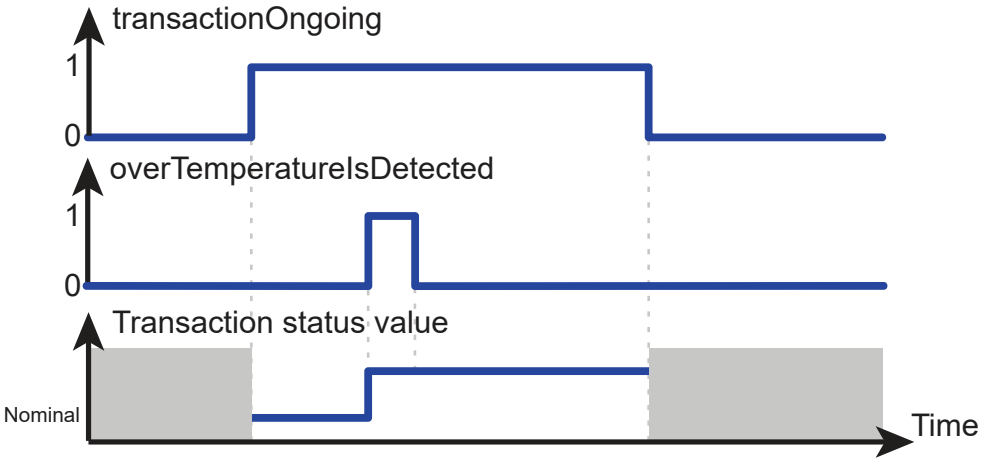

Figure 49: Transaction status field persistence

i 17 is the transaction status corresponding to a transaction which finished successfully, and which is therefore billable.

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7.5.5. Errors

DCBM errors caught are reported in the `errors` section of the `/status` API. This section is composed of a list of flags.

Any error has the following impact:

- Block new transactions
- Display the error(s) on screen

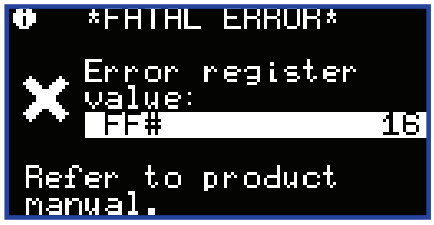
Any error remains until a power down. All errors are cleared on a reboot, then raised again if errors still exist. The DCBM checks the presence of all errors within the first 10 seconds, most of them are re-checked cyclically.

```
"errors": {
    "value": 0,
    "bits": {
      "muInitIsFailed": false,
      "suStateIsInvalid": false,
      "versionCheckIsFailed": false,
      "muRngInitIsFailed": false,
      "muDataIntegrityIsFailed": false,
      "muFwIntegrityIsFailed": false,
      "suIntegrityIsFailed": false,
      "logbookIntegrityIsFailed": false,
      "logbookIsFull": false,
      "memoryAccessIsFailed": false,
      "muStateIsFailed": false
    }
  },
```

i 0 is the error value corresponding to the nominal state of the DCBM. Any other value prevents new transactions.

i An on-going transaction is not interrupted by an error. But the error invalidates the transaction through the `transactionStatus`.

All errors display the screen shown on adjacent figure (the `FF#` value refers to `value` field)



Flag index	Name	Description	Check frequency
0	`muInitIsFailed`	Meter unit initialization failed	On startup
1	`suStateIsInvalid`	Sensor unit is in an invalid state	Any time
2	`versionCheckIsFailed`	Firmware version of the Sensor Unit is not the one the Meter Unit expects	On startup
3	`muRngInitIsFailed`	Random Number Generation initialization failed	On startup
4	`muDataIntegrityIsFailed`	CRC error on the operation data of the Meter Unit	Every 30 minutes
5	`muFwIntegrityIsFailed`	CRC error on the Meter Unit firmware memory	Every 30 minutes
6	`suIntegrityIsFailed`	CRC error on the data or firmware memory of the Sensor Unit	Any time
8	`logbookIntegrityIsFailed`	CRC error on logbook memory	Every 30 minutes
9	`logbookIsFull`	Logbook is full	Any time
10	`memoryAccessIsFailed`	Rejected access to memory	Any time
13	`muStateIsFailed`	Unexpected error in the Meter Unit	Every 30 minutes

Table 12: List of error flags

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7.5.6. OCMF error and status fields

In `/ocmf` API, in compliance with OCMF specification, statuses and errors are formatted differently. They are simplified and scattered into `EF` and `ST` fields. In case more than one line of `EF` or `ST` fields is active, only the letter with highest priority is displayed.

EF field value	Description	Status equivalent	Priority
blank	Nothing to report	None of the below	1
E	Energy issue	`suLinkStatusIsOk = false`	3
t	Time issue	`timeSyncStatusIsOk = false`	2

Table 13: OCMF `EF` field equivalents

ST field value	Description	Status equivalent	Priority
G	Nothing to report	None of the below	1
M	Manipulation detected	`tamperingIsDetected = true`	2
N	Sensor Unit link is broken	`suLinkStatusIsOk = false`	4
T	Time synchronization expired	`timeSyncStatusIsOk = false`	5
E	Other error	At least one of the other statuses is raised (except `transactionIsOnGoing`)	3 for `overTemperatureIsDetected` 6 for others

Table 14: OCMF `ST` field equivalents

Statuses have direct equivalents, while errors are represented through status `muFatalErrorOccured`, i.e. in OCMF `ST` field with value `E`.

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7.6. Event logbook

The DCBM features an event logbook, tracing metrological events as well as other events linked to the application software.

When an event occurs, it is permanently stored into the DCBM logbook, along with the current status register and the corresponding UTC timestamp.


```
{
  "meterId": "1202531106",
  "logbook": [
    {
      "timestamp": "2020-09-14T10:05:05Z",
      "eventCode": "EV_COMMISSIONING",
      "status": [
        "STATUS_SENSOR_LINK",
        "STATUS_TAMPERING",
        "STATUS_TIME_SYNC"
      ]
    },
    {
      "timestamp": "2020-09-14T10:06:03Z",
      "eventCode": "EV_POWER_SUPPLY_FAILURE",
      "status": [
        "STATUS_SENSOR_LINK",
        "STATUS_TIME_SYNC"
      ]
    },
    {
      "timestamp": "2020-09-18T07:34:33Z",
      "eventCode": "EV_TIME_SYNC_SUCCEEDED",
      "status": [
        "STATUS_SENSOR_LINK",
        "STATUS_TIME_SYNC"
      ]
    }
}
```


Logbook entries cannot be erased.

In case the logbook reaches maximal capacity, the DCBM is out of order (error `logbookIsFull` is raised irrevocably, preventing new transactions).

The DCBM can store approximately 40 000 events.

The content of the event logbook can be retrieved using the `/logbook` API (see §7.1). When a large number of events is stored, retrieving the logbook can take several minutes. The logbook cannot be retrieved partially.

The logbook is digitally signed to ensure its authenticity (authentication and integrity). Refer to section "7.4. Data authenticity".

The list of events is available in the Communication Protocols manual.

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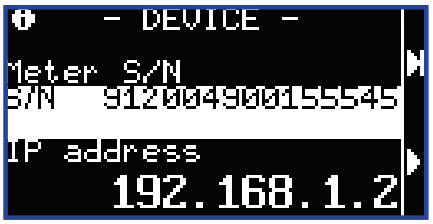
7.7. Connectivity settings

7.7.1. IP addressing



The DCBM IP address allows its registration onto a network. To avoid collisions, the IP of the DCBM shall not be identical to another device on the same network.

Two solutions exist for choosing the DCBM IP address

- Use a static address
- Get an address from a DHCP server

7.7.1.1. Static addressing

On simple networks, the easiest solution is to give a static IP address to the device.

The IP to set for the DCBM must be written through field `ipAddress` at the root of `/settings` API (see §7.1).

Do not confuse with `ipAddress` in the `dhcp` section.

Once set, the new IP address is available for use immediately. The value can be seen on the display, in the Maintenance screens.

Subnet mask: The subnet mask is “0.0.0.0”. It cannot be changed. This value allows access from any other IP address (i.e. no subnet mask restriction).

7.7.1.2. DHCP

When a Dynamic Host Configuration Protocol server is available on the network, the DCBM can be set to request an IP address. The server responds with an available IP address, avoiding conflicts.

The DCBM can be turned into DHCP mode using field `dhcp/activation` in `/settings` API. Other settings in section `dhcp` allow configuration of ports to use, for the client and for the server (respectively `clientPort` for the DCBM and `serverPort` for the server).

For advanced DHCP networks (e.g. multiple DHCP servers on a network), the IP address of the DHCP server can be configured in the DCBM, using field `dhcp/ipAddress`.

`ipAddress` in `dhcp` section is the address of the DHCP **server**. In most situations, it is not required and default value must be kept.

`ipAddress` at the root of `/settings` API will not be updated according to dynamic DHCP address, as it is an input for static addressing.

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7.7.1.3. DNS

The DCBM can be reached using its DNS name, just like using its IP address.

The DCBM's DNS name is "`lem-meter`".

7.7.2. HTTP & TLS

7.7.2.1. HTTPS

HTTP transports data on a clear channel, readable by any other device on the network. The DCBM supports TLS, for HTTPS communication. Enabling it creates an encrypted channel for communications, which prevents undesired listening. It also authenticates the DCBM based on its certificate.

The HTTPS certificate is available through the `/certificate` API. This API is read-only. It is described in Communication Protocols manual.

HTTPS can be enabled for the DCBM through field `http/tls_on` in `/settings` API.

7.7.2.2. HTTP port

The DCBM allows configuration of its HTTP port to use. Port can be set using `http/httpPort` in `/settings` API.

Default port numbers as defined by IANA are:

- 80 for HTTP
- 443 for HTTPS

Enabling HTTPS does not automatically change the port to use. Do not forget to set it to 443 if needed.

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7.8. Time management

7.8.1. Time synchronization

7.8.1.1. Overview

- Proper synchronization is required for any new transaction
- Synchronization expires after 48 hours
- It cannot be achieved during transactions

7.8.1.2. General constraints

Time synchronization is a prerequisite to new transactions. At a given time, synchronization is either valid or outdated.

A time synchronization remains valid for 48 hours. Any successful synchronization restarts the timer for a new 48 hours span. No event can shorten or extend this duration, including power down.

No time synchronization can be achieved during transactions. This 48 hours expiration can happen in any state of the DCBM, including during transactions and power down.

It is recommended to achieve time synchronization **at least once a day** (< 24 hours period), considering 48 hours expiration.

The time management is “Info time”. The DCBM does not support “System time” in this version.

7.8.1.3. Synchronization solutions

Two time synchronization modes are available:

- Synchronization by NTP
- Synchronization by a command sent to the DCBM

`/settings` API offers a setting to switch from one mode to another: `/ntp/activated` in `/settings` API. Switching mode has no effect on status of synchronization or on the 48 hours timeout.

In case NTP is used (`ntpEnabled` = true), achieving a time synchronization by command automatically disables `/ntp/activated` boolean (i.e. sets `ntpEnabled` = false)

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7.8.1.4. Command time synchronization

Command time synchronization requires nothing more than a HTTP request, consisting in writing a timestamp on field `/time/utc` in `/settings` API.

Timestamp shall be UTC time, and compliant with ISO-8601 format.

Here is an example of writable timestamp: "`2020-01-01T14:00:00Z`"

It is not necessary to specifically switch off NTP if used before triggering Command time synchronization request, as it is done automatically.

7.8.1.5. NTP synchronization

Network Time Synchronization allows reliable and automatic synchronization. NTP allows using a large amount of public and precise time references.

Use of NTP requires the following actions in `/settings` API:

- Configure at least one server, by entering an IP or URL in field `ntp/servers/ipAddress`, and the required port in field `ntp/servers/port`
- Switch `ntp/activated` to "true"

123 is the default IANA port for NTP.

No synchronization is allowed during a transaction

An attempt of NTP synchronization is achieved:

- As configured in field `ntp/syncPeriod` in `/settings` API
- On expiration of the synchronization
- Or at the end of the transaction, if synchronization expired during it
- On startup of the DCBM
- When switching to NTP mode

An attempt of NTP synchronization can end with the following outcomes:

- The synchronization succeeded. Time of valid synchronization is saved, and synchronization becomes valid for the next 48 hours.
- The synchronization failed. Synchronization status is not discarded; it stays valid until expiration (48 hours after the last valid synchronization).

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If two different NTP servers are configured:

- If only one server responds, its time is used
- If both servers respond, the time of the server 2 is used

NTP servers response time is limited to 30 seconds.

Starting a transaction aborts any on-going time synchronization, as transactions prevail over synchronization.

7.8.2. Local time

UTC is the reference time for the DCBM, timestamping logbook entries and getting updated from time synchronizations.

Though, the DCBM supports local time as an applicative, legally non-relevant feature. It offers more user-friendly information, for display and billing data notably.

Legal non-relevance of local time is due to unlocked settings configuring local time. Actually a local time timestamp can allow billing if it includes offset to UTC, such as in `/legal` timestamps.

Local time consists in an offset to UTC. Two features create this offset:

- Time zone offset
- DST offset

7.8.2.1. Time zone

Time zone configures the DCBM according to a geographical area. It consists in an offset of hours and minutes, which is added to the UTC.

Time zone is configured using field `time/tz` (`/settings` API). It can be either a positive or negative offset; hours can be set from -11 to +14 hours and minutes shall be picked between 00, 15, 30 and 45.

7.8.2.2. Daylight Saving Time

Daylight Saving Time is an offset of time to be added to time zone offset, usually half of the year.

It is configurable in field `time/dst` (`/settings` API). Boolean `activated` allows using it or not. Field `offset` is the offset in minutes to use, during the part of year when DST is on. Fields `start` and `end` configure the boundaries within which DST offset shall be added to time zone offset. Out of this range, the `offset` value is not used, allowing configuration of DST once and for all (DST does not have to be manually activated and deactivated).

The `hour` subfields (in fields `start` and `end`) shall be expressed in local time.

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8. Troubleshooting

For troubleshoot investigations and in support communications, make sure to save and provide status and error `value` fields rather than just active errors, to provide thorough information.

8.1. Wrong statuses

Status field behavior is described is section "7.5.3. Current status" and "7.5.4. transactionStatus field".

"Status flag #" is followed by the flag index number, as described in "7.5.1. Overview"

Status flag #0 - suLinkStatusIsOk		
Value	**Description**	**Solution**
True	Nominal	N/A
False	The Meter Unit is somehow disconnected from the Sensor Unit	1. Check that connectors are inserted properly, both on Meter Unit side and Sensor Unit side
		2. Make sure the Sensor Unit - Meter Unit couple is correct (marking on them can help)
		3. Check absence of dirt or fluid, on connectors of the Meter Unit, Sensor Unit and the cable. Check the sanity of the cable, look for cuts or mark of excessive mechanical effort. Try to replace the cable

Status flag #1 - muFatalErrorOccured		
Value	**Description**	**Solution**
False	Nominal	N/A
True	At least one error is active	Refer to errors troubleshooting: "8.2. Raised errors"

Status flag #2 - transactionIsOnGoing		
Value	**Description**	**Solution**
False	Nominal	N/A
True	A transaction is on-going	1. This status is informative and does not reflect an issue
		2. To start a new transaction, the on-going one shall be stopped first. Refer to section "5.2.2. Conditions and inputs"

Status flag #3 - tamperingIsDetected		
Value	**Description**	**Solution**
False	Nominal	N/A
True	Tampering is currently detected	1. The device might have received unauthorized manipulation
		2. Check the integrity of the device: manufacturer seals, front panel of the Meter Unit, Meter Unit housing forced open

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Status flag #4 - timeSyncStatusIsOk		
Value	**Description**	**Solution**
True	Nominal	N/A
False	Time synchronization expired: last valid synchronization is older than 48 hours	1. In command synchronization mode, achieve a new synchronization
		2. In NTP synchronization mode, check the settings, as well as network access to the NTP servers
		3. Refer to section "5.8.1. Time synchronization"

Status flag #5 - overTemperatureIsDetected		
Value	**Description**	**Solution**
False	Nominal	N/A
True	Over-temperature was detected by the Sensor Unit	1. Temperature shall be lowered with no delay, risking damage to the device and the infrastructure
		2. Check cabling issues, loosened bolts, over-confined architecture, insufficient ventilation...

Status flag #6 - reverseVoltage		
Value	**Description**	**Solution**
False	Nominal	N/A
True	Reversed voltage is seen by the Sensor Unit	1. The Sensor Unit sees voltage with a wrong sign. Voltage input wires shall be inverted and the DCBM restarted
		2. Refer to section "5.2. Integration solutions"

Status flag #7 - suMeasureFailureOccurred		
Value	**Description**	**Solution**
False	Nominal	N/A
True	An error occurred in Sensor Unit ADC	1. EMC surge may have occurred. Make sure to use a ferrite as recommended (refer to "5.2. Integration solutions"), check for other possible EMC interferences and limit them
		2. Restart the DCBM

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8.2. Raised errors

Errors correspond to protective behavior against malfunction, data corruption and data loss. In case below suggestions are not sufficient, it means that the DCBM reached a protective lock state. In this case the product is no longer usable and must be replaced.

Error field behavior is described in section "7.5.5. Errors".

Indexes are not contiguous. Make sure to use the right index.

FF# 1 - Error flag #0 - muInitIsFailed		
Value	**Description**	**Solution**
False	Nominal	N/A
True	Meter Unit initialization failed	1. Various initialization processes can cause this error, both hardware and software processes. The latter might be reverted on a reboot
		2. Try to reboot the DCBM.
		3. If not sufficient, reboot again a few more times.

FF# 2 - Error flag #1 - suStateIsInvalid		
Value	**Description**	**Solution**
False	Nominal	N/A
True	Sensor Unit is in an invalid state	1. Try to reboot the DCBM
		2. If not sufficient, reboot again a few more times

FF# 4 - Error flag #2 - versionCheckIsFailed		
Value	**Description**	**Solution**
False	Nominal	N/A
True	Firmware version of the Sensor Unit is not the one the Meter Unit expects	1. Make sure the Sensor Unit - Meter Unit couple is correct (marking on them can help)
		2. Try to reboot the DCBM to force a new check
		3. If not sufficient, a memory corruption occurred

FF# 8 - Error flag #3 - muRngInitIsFailed		
Value	**Description**	**Solution**
False	Nominal	N/A
True	Random Number Generation initialization failed	1. Try to reboot the DCBM
		2. If not sufficient, reboot again a few more times
		3. If not sufficient, the issue is probably hardware-related

FF# 16 - Error flag #4 - muDataIntegrityIsFailed		
Value	**Description**	**Solution**
False	Nominal	N/A
True	CRC error on the operation data of the Meter Unit	1. Try to reboot the DCBM to force a new check right away or wait for next check cycle (30 minutes)
		2. If not sufficient, then the memory is corrupted (global energy registers might be jeopardized)

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FF# 32 - Error flag #5 - muFwIntegrityIsFailed

Value	Description	Solution
False	Nominal	N/A
True	CRC error on the Meter Unit firmware memory	1. Try to reboot the DCBM to force a new check right away or wait for next check cycle (30 minutes)
		2. If not sufficient, then the memory is corrupted

FF# 64 - Error flag #6 - suIntegrityIsFailed

Value	Description	Solution
False	Nominal	N/A
True	CRC error on the date or firmware memory of the Sensor Unit	1. Try to reboot the DCBM to force a new check right away or wait for next check cycle (30 minutes)
		2. If not sufficient, then the memory is corrupted

FF# 256 - Error flag #8 - logbookIntegrityIsFailed

Value	Description	Solution
False	Nominal	N/A
True	CRC error on logbook memory	1. Try to reboot the DCBM to force a new check right away or wait for next check cycle (30 minutes)
		2. If not sufficient, reboot a few more times
		3. If not sufficient, then the memory is corrupted

FF# 512 - Error flag #9 - logbookIsFull

Value	Description	Solution
False	Nominal	N/A
True	Logbook is full	1. Once the logbook is full (approximately 40 000 events logged), no fix is possible (refer to "7.6. Event logbook")

FF# 1024 - Error flag #10 - memoryAccessIsFailed

Value	Description	Solution
False	Nominal	N/A
True	Rejected access to memory	1. Check for tampering marks, the DCBM code memory might have been altered
		2. Reboot the product, the issue could come from a unknown software issue

FF# 8192 - Error flag #13 - muStateIsFailed

Value	Description	Solution
False	Nominal	N/A
True	Unexpected error in the Meter Unit	1. Try to reboot the DCBM to force a new check right away or wait for next check cycle (30 minutes)
		2. If not sufficient, reboot again a few more times or wait for a couple of hours

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8.3. Other software issues

Lost connection on Ethernet	
Issue description	**Solution**
It looks like the DCBM is unresponsive on the Ethernet port	1. Make sure the right IP address is used when trying to contact the DCBM. The IP address can be seen on Maintenance screen, category “Device” (see "6.6.4.3. DEVICE category")
	2. Make sure to use the right port when trying to communicate. Port to use (customizable) is written in `/settings` API, `http` section (see "7.7.2. HTTP & TLS")
	3. Check the sanity of the cable, look for cuts or mark of excessive mechanical effort. In case of any doubt, try with another cable
	4. There might be a software issue with the Ethernet interface. Try to reboot the DCBM
	5. The issue might be hardware-related

IP address is 0.0.0.0 / DHCP enabled unintentinally	
Issue description	**Solution**
The IP address can be seen on Maintenance screen, category "Device" (see "4.6.4.3. DEVICE category screens")	1. The only solution is to provide a DHCP server, so the DCBM can be reverted to a regular IP address. LEM support can provide a walkthrough guide to do so.
In case IP address is "0.0.0.0", it likely means that DCHP was enabled but no DHCP server was available ("0.0.0.0" is fallback address for this case)	
This address is not reachable by any device, hence there is no solution to revert the DCBM to static IP	

Time does not sync	
Issue description	**Solution**
It looks like NTP synchronization does not happen	1. Tip: Rebooting the DCBM forces a NTP synchronization attempt
	2. Make sure to Ethernet connection is functional
	3. Make sure at least one time server is configured properly. Check IP address or URI, and check that the port set in the DCBM matches the port the server listens onto (see "7.8.1. Time synchronization")
	4. Make sure the network architecture gives functional access from the DCBM up to the time server. Make sure used ports are not filtered by any firewall
	5. The time server might be down temporarily. Try with another one
	6. To get rid of potential network issues, a local NTP server can be set up to validate the DCBM operation
	7. If the issue cannot be fixed, command time synchronization can be a workaround

Wrong signature	
Issue description	**Solution**
A signature check fails	1. Check your data: Make sure the input is entered properly, according to instructions of the checker software
	2. Check the public key: Make sure the public key used is the right one: make sure the public key, the data to check and the signature come from the same DCBM. Do not mix classical public key and OCMF public key (refer to "7.4. Data authenticity")
	3. Check the signature: Make sure the signature corresponds to the data to check (from same device; one signature for one set of data to check)
	4. Make sure no characters are missing or added in public key, signature and data to check
	5. A wrong signature can come from weak memory area. Check for presence of "Error #4 - muDataIntegrityIsFailed" and "Error #8 - logbookIntegrityIsFailed"

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9. APPENDIX - PTB TYPE-EXAMINATION CERTIFICATE FOR DCBM

Physikalisch-Technische Bundesanstalt
Nationales Metrologieinstitut

KBS
Konformitätsbewertungsstelle

Baumusterprüfbescheinigung

Type-examination Certificate

Ausgestellt für: *Issued to:*	LEM International SA Chemin des Aulx 8 1228 Plan-les-Ouates SCHWEIZ
gemäß: *In accordance with:*	Anlage 4 Modul B der Mess- und Eichverordnung vom 11.12.2014 (BGBl. I S. 2010) *Annex 4 Modul B of the Measures and Verification Ordinance dated 11.12.2014 (Federal Law Gazette I, p. 2010)*
Geräteart: *Type of instrument:*	Gleichstromzähler (elektronisches Messwerk)
Typbezeichnung: *Type designation:*	DCBM...
Nr. der Bescheinigung: *Certificate No.:*	DE-20-M-PTB-0075, Revision 1
Gültig bis: *Valid until:*	05.10.2030
Anzahl der Seiten: *Number of pages:*	45
Geschäftszeichen: *Reference No.:*	PTB-2.3-4102833
Nr. der Stelle: *Body No.:*	0102

Zertifizierung:
Certification:
Im Auftrag
On behalf of PTB
Dr. Christoph Leicht

Braunschweig, 01.12.2020

Siegel
Seal

PHYSIKALISCH-TECHNISCHE BUNDESANSTALT 10

Bewertung:
Evaluation:
Im Auftrag
On behalf of PTB
Dr. Michael Blaz