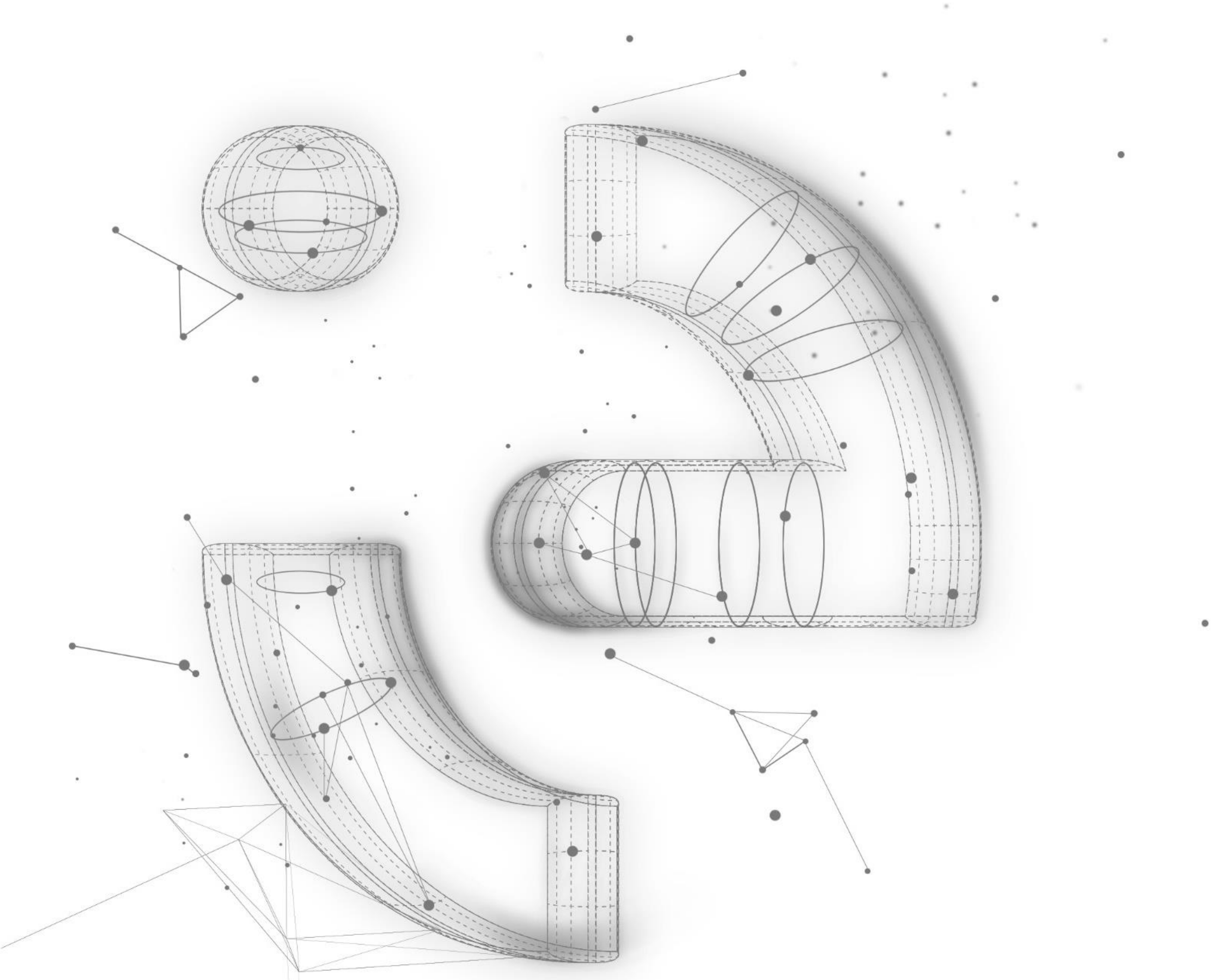
IE.x

User manual



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i. Device versions covered by this document

IE.5 SINGLE-PHASE DIRECT METER

- IE.5-ED1
  - 230 V, 5(85) A
- IE.5-EB2
  - 240 V, 5(100) A
  - 230 V, 5(100) A

IE.5 THREE-PHASE DIRECT METER

- IE.5-TD1
  - 3×240/415 V, 5(85) A
  - 3×230/400 V, 5(85) A
  - 3×230 V, 5(85) A
  - 1×230 V, 5(85) A
- IE.5-TD2
  - 3×240/415 V, 5(100) A
  - 3×230/400 V, 5(100) A
  - 3×230 V, 5(100) A
  - 1×230 V, 5(100) A
- IE.5-TD3
  - 3×230/400 V, 5/10(120) A
- IE.5-PD2
  - 3×230 V, 5(100) A

IE.7 THREE-PHASE INDIRECT METER

- IE.7-TT2
  - 3×240/415 V, 1(10) A
  - 3×230/400 V, 1(10) A
  - 3×63.5/110 V, 1(10) A
  - 3×230 V, 1(10) A
  - 3×110 V, 1(10) A
- IE.7-TV2
  - 3×63.5/110 V, 1(10) A
  - 3×57.7/100 V, 1(10) A
  - 3×110 V, 1(10) A
  - 3×100 V, 1(10) A
- IE.7-PT2
  - 3×230 V, 1(10) A

ii. About this document

- The document describes IE.5 and IE.7 meter types, their usage, installation, and maintenance. It represents the purpose of these meters, their construction, the way of deriving the measured quantities and meter functionalities.
- The document is intended for technically qualified personnel at energy supply companies, responsible for system planning and system operation.

iii. Reference documents

- Iskraemeco's general terms and conditions
- Technical descriptions of communication modules
- Technical description of antenna couplers

iv. Versioning

Date	Version	Update
2021/01/08	V1.00	The first version of the document.
2021/05/07	V2.00	• Added: - IE.5-TD2 meter type - wM-Bus antenna - additional grid monitoring functionalities - additional options of IE.5 meter wiring and their connection diagrams - electrical characteristics of P1 and FEM • Updated: - FEM1 renamed to FEM - Figure 18 and Figure 20 - 4.4.2.2. The nameplate - 4.4.3.1. The exchangeable communication module - Table 29 - Table 31 - 5. INSTALLATION - 10. MBUS - 14. TECHNICAL CHARACTERISTICS • Document improvements
2022/06/15	V2.10	• Added: - Installation with terminal reducing insert - Notes to the chapter 4.4.1.1 The terminal block - G3-PLC script table • Updated: - TECHNICAL CHARACTERISTICS - SAFETY NOTICES
2023/01/17	V2.20	• Added: - Phase angles - Prepayment - New meter types: IE.5-DD1, IE.5-QD1, IE.5-PD2, IE.7-PT2 - Demand registers for quadrants - Factory set and locked objects (national regulations)
2023/05/18	V2.30	• Added: New meter type: IE.7-TV2
2023/09/06	V2.40	• Added: - Chapter 9.4.2.4. Switching between G3-PLC and WAN
2023/11/13	V2.50	• Added: - Chapter 10: wired M-Bus - Chapter 9.11: alarm codes, filter, status, descriptor and signalling for Alarm 4
2024/03/25	V2.60	• Added: - New meter type: IE.5-TD3 – technical specifications and connection diagram - Note on clearing of "External alert" alarm

Date	Version	Update
2025/01/15	V2.61	• Added: - Terminal data for IE.5-TD3 - External overcurrent protection requirements for outputs - Additional output terminals
2025/03/17	V2.70	• Added: - New meter type: IE.5-EB2 - New voltage ranges for IE.5-ED and IE.5-TD - Connection diagrams of non-main terminals - Short terminal cover - Push on installation - Time switch (astronomic calendar) - Double RS-485 terminal • Removed: - The table of event codes was transferred to a separate new document, *IE.x Event codes – Appendix A3 to IE.x User manual*
2025/04/10	V2.71	• Added information on period of data retention during power down. • Added example for CT ratio label.

v. Definitions, acronyms and abbreviations

Abbreviation	Explanation
1P2W	Single-phase two-wire
3P3W	Three-phase three-wire
3P4W	Three-phase four-wire
AC	Alternating Current
A/D	Analog/Digital
AES	Advanced Encryption Standard
AFL	Authentication and Fragmentation Layer
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
APDU	Application Protocol Data Unit
ARP	Address Resolution Protocol
ASCII	American Standard Code for Information Interchange
BCD	Binary-Coded Decimal
BS	British Standard
CBC	Cipher Blocker Chaining
CDMA	Code Division Multiple Access
CIP	Consumer Information Push
CLRFW	Country Legally Relevant Firmware
COM	Communication
COSEM	Companion Specification for Energy Metering
CPU	Central Processing Unit
CT	Current Transformer
DC	Direct Current
DHCP	Dynamic Host Configuration Protocol
DIB	Data Information Block
DIN	Deutsches Institut für Normung
DLMS	Device Language Message Specification
DLMS UA	DLMS User Association
DNS	Domain Name Server

Abbreviation	Explanation
DSMR	Dutch Smart Meter
DST	Daylight Saving Time
EN	European Norm
ECDH	Elliptic Curve Diffie-HellmanGCM
ECDSA	Elliptic Curve Digital Signature Algorithm
EMC	Electromagnetic Compatibility
E-meter	Electricity meter
ESD	Electrostatic Discharge
ETSI	European Telecommunications Standards Institute
FAC	Frequent Access Cycle
FD/FM	Fraud Detection/Factory Mode
FEM	Field Exchangeable Module
FF	Fatal Failure
FIFO	First In, First Out
FSK	Frequency-Shift Keying
FW	Firmware
GCM	Galois/Counter Mode
G-meter	Gas meter
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HAN	Home Area Network
HDLC	High-level Data Link Control
HES	Head-End System
HLS	High Level Security
HHU	Hand-Held Unit
HW	Hardware
ICMP	Internet Control Message Protocol
ID	Identification
IDIS	Interoperable Device Interface Specifications
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IHD	In-House Display
I/O	Input/Output
IP	Internet Protocol
IR	Infra-Red
ISO	International Organization for Standardization
JEDEC	Joint Electron Device Engineering Council; JEDEC Solid State Technology Association – independent semiconductor engineering trade organization and standardization body
KDF	Key Derivation Function
LAN	Local Area Network
Last gasp	Synonym for the “Push on Power down” functionality
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LLS	Low Level Security
LNRFW	(also, NLRFW) Legally Non-Relevant Firmware
LP	Load Profile
LR	Legally relevant

Abbreviation	Explanation
LRFW	Legally Relevant Firmware
LSB	Least Significant Bit
LTE	Long-Term Evolution
MAC address	Media Access Control address
MB	M-Bus
MCU	Microcontroller Unit
MDI	Maximum Demand Indicator
MID	Measuring Instruments Directive
MP	Measurement Period
MSB	Most Significant Bit
MU	Multi-Utility
mW/sr	milli-Watts per steradian
NAN	Neighbourhood Area Network
N m	Newton metre
NTP	Network Time Protocol
NV memory	Non-Volatile memory
OBIS	Object Identification System
OMS	Open Metering System
OSM	Other Service Module
OVC	Over Voltage Category
OU	Opt-Out
P*	Meter’s interface for communication modules (WAN and HAN)
P0	Optical interface
P1	Communication port/interface for OSM
P2	Communication port/interface for M-Bus (Gas, Heat and Water meters)
P3	Communication port/interface for WAN and NAN communication
PAN	Personal Area Network
PC	Personal Computer
PCB	Printed Circuit Board
PDA	Personal Digital Assistant
PDP	Packet Data Protocol
PLC	Power Line Communication
PPP	Point-to-Point Protocol
RAM	Random-Access Memory
RF	Radio Frequency
RMS	Root Mean Square
RSSI	Received Signal Strength Indicator
RTC	Real Time Clock
SAP	Service Access Point
SD	Switching Device, disconnector, circuit breaker
SHA	Secure Hash Algorithm
SIM	Subscriber Identity Module
SITP	Security Information Transfer Protocol
SSR	Solid State Relay
SW	Software
TCO	Total Cost of Ownership

Abbreviation	Explanation
TPL	Transport Layer
TOU	Time Of Use
UC	Utilization Category
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
UTC	Coordinated Universal Time
UV	Ultraviolet
VDEW	Verband Der ElektrizitätsWirtschaft
VIB	Value Information Block
VT	Voltage Transformer
WAN	Wide Area Network
wM-Bus	Wireless M-Bus
W-meter	Water meter
WP	Width, Precision

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1. SAFETY NOTICES

1.1. Preface

This chapter provides safety information on handling, installation and disposal of an IE.x electricity meter and related accessories. This document is not a complete index of all safety measures required for operation of the device. However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:

DANGER: indicates a hazardous situation, which, if not avoided, could result in serious injury or death.

WARNING: indicates a hazardous situation, which, if not avoided, could result in moderate injury.

CAUTION: indicates a hazardous situation, which, if not avoided, could result in minor injury or material damage.

NOTE: contains important information to emphasize or supplement important points of the main text.

In all cases where one of the symbols above is used, the relevant technical documentation should be consulted to determine the nature of the potential hazards and any preventive actions required to avoid them.

1.2. Who may install, commission and operate the device

Only qualified electrotechnical professionals authorised by the utility company may install, commission, and operate the device described in this user manual. For the purpose of this document, qualified electro-technical professionals are people who can demonstrate technical qualifications and competences as an electrician (hereinafter referred to as "installers").

The installer is obligated to perform the installation procedure in accordance with the national legislation and internal norms of the utility.

Local jurisdiction may impose regulatory restrictions (e.g., minimum age, required training, licensing etc.) concerning electrical installation work. Aside from local regulations, the following requirements should also be assessed to determine an individual's technical qualifications and competences:

- Training to an appropriate level in electrical engineering to develop the required knowledge and skills, especially knowledge of installation procedures, awareness of potential hazards and precautions to be observed; ability to assess the safety in proceeding with a task at any point of time.
- Experience of achieving a suitable standard in similar work.
- Regular re-assessment.

People who do not demonstrate the required technical qualifications and competences are not allowed to handle the device unless they are supervised by a qualified mentor.

1.3. Responsibilities

The device owner is responsible to assess whether the installer is qualified to install, commission and operate the device in accordance with the requirements above. The device owner is required to implement a training policy that ensures that all installers are adequately trained, understand the risk and safety issues, and possess the relevant skills before they commence operational duties.

Prior to any work on the device, the owner needs to provide the designated installer with detailed instructions and adequate information regarding the nature, place and consequences to the electrical installation of the planned work.

The device owner is responsible for ensuring that every installer has read and understands the content of this user manual.

The device owner is responsible to nominate a/an:

- Operations Manager (person with the authority and responsibility to ensure the installation is constructed, operated and maintained according to applicable regulations)
- Safety Supervisor (person in control of the work activity and responsible for safety at the work site)

Prior to the commencement of work, the person established as controlling the work activity shall notify the person established as controlling the electrical installation about the nature, location or place and impact of the electrical installation that the intended work involves.

Prior to any work on the meter, the Operations Manager or the Safety Supervisor need to provide the designated installer with detailed instructions and adequate information regarding the nature, place and consequences to the electrical installation of the planned work.

⚠ WARNING **Comply with all applicable safety measures**

Any person handling the device is required to read and comply with this user manual, especially the safety measures.

1.4. Use as prescribed

To assure problem-free and safe operation of the device, the following must be observed:

- Proper transport
- Proper storage, installation and commissioning
- Proper operation environment and maintenance.

The owner of the device must take appropriate measures to maintain installation conditions that protect the device against external influences, such as fungus, plants, insects, vermin, corrosive solvents etc.

⚠ CAUTION **Use only as prescribed**

Any device misuse (e.g., outside prescribed conditions) may lead to potential danger.

1.5. Unpacking the device

⚠ CAUTION **Prevent the device from falling**

When unpacking the device, care should be taken to prevent the device from falling as this could cause personal injuries and material damage. Should the device fall despite all precautions, do not install the device, but instead return it to the manufacturer for inspection and additional testing.

1.6. Handling and installation safety notices

ϟ DANGER **Do not open the device**

The device must not be opened or penetrated under any circumstances, especially not in case of internal damage (e.g., due to a fire or explosion). Do not remove the meter cover. Any unauthorized manipulation of the device may cause serious injury or death and is prohibited according to applicable legislation.

⚠ CAUTION **Danger of cuts**

The edges of the seals, the sealing wires and the edges under the (removed) terminal/module cover are sharp. Handle with care to avoid injuries.

⚠ WARNING **Danger of burns**

In an operating device, the terminal block and meter housing cover may be hot. In extremely hot climatic conditions, the temperature of device surfaces close to the mounting surface may exceed 90 °C. Danger of ignition. If necessary, use heat-resistant gloves to avoid burns. Install the device on a surface made of non-combustible material to avoid the risk of ignition of the mounting surface.

DANGER **Only an authorised installer may remove seals and the meter terminal cover**

Any attempt of damaging the seals as well as any unauthorized removal of the meter terminal cover is strictly forbidden. Contact with non-insulated meter devices may cause serious injury or death. Removing the meter terminal cover is life-threatening due to live parts inside the meter.

DANGER **Only an authorised installer may install and operate the device**

The device installation must not be carried out by unauthorized and untrained persons. Contact with non-insulated meter devices may cause serious injury or death.

See chapters *1.2 Who may install, commission and operate the device* and *1.3. Responsibilities* for additional information.

DANGER **Follow instructions closely**

The IE.x meter is a device designed to be connected to the electrical network. The meter installation procedure is described in this user manual and must be followed closely when installing the meter. Only a properly connected meter can operate correctly. Any connection error may result in personal injury, material damage and/or financial loss for the utility company.

Prior to installation, make sure to read and understand the complete content of this user manual. Make sure to follow any applicable local regulations as well.

NOTE **Make sure the installation site is safe and secured**

Before starting the meter installation, check whether the metering point where the meter is to be installed has been properly prepared.

The place of work must be clearly marked. Adequate workspace, as well as convenient access options and suitable lighting must be available in order to be able to carry out the work processes properly.

Where necessary, clearly mark safe access to the workplace.

The metering point must not be exposed to running water or fire. The metering point must always be left clean and tidy.

NOTE **Use appropriate tools and equipment**

Tools, equipment and devices should comply with the requirements of the relevant national and international standards, if applicable. Tools, equipment and devices should be used in accordance with instructions and/or guidelines or advice from the manufacturer or supplier.

All tools, equipment and devices that are intended for the safe operation of electrical installations or work on them should be suitable for this application and also maintained and used accordingly.

NOTE **Use appropriate clothing**

An installer should wear clothing that is appropriate to the location and conditions of their workplace. This may include the use of tight-fitting clothing or PPE (personal protective equipment).

CAUTION **Be aware of hazardous electrical work**

The installer must be well aware of and understand the hazards and safety issues associated with electrical installations. The installer should always be aware of the possible danger of electric shock and should proceed with the necessary caution when completing the task.

NOTE **Understand the restrictions on live work**

Electrical work involves three different areas: (a) working on dead (unenergized) parts, (b) working on live (energized) parts, and (c) working near live parts. All of these procedures are based on the application of protective measures against electric shock and/or the effects of short-circuiting and arcing.

Prior to any work on the device, the installer must be informed whether the national regulations allow working on live parts involving installation on live equipment, i.e., “live work”, and must observe the rules of the applicable legislation.

DANGER **Connecting the meter into an energized network may cause serious injury or death. For safe work, observe the 5 safety rules.**

This subclause deals with the essential requirements ("the five safety or golden rules") for ensuring that the electrical installation at the work location is dead and secure for the duration of the work.

- **Disconnect completely.** The electrical installation must be disconnected from all live parts. Do not attempt to install the meter before you have disconnected the installation side from the mains. Make sure the conductors at the metering point are not connected to any voltage source during the connection procedure
- **Secure against re-connection**. Reliably prevent the accidental re-connection of an installation where work is in progress.
- **Verify that the installation is dead.** Use suitable measuring / test equipment, such as a voltage detector, to verify the absence of operating voltage on all poles of the electrical installation.
- **Carry out earthing and short-circuiting**. If the installation is dead, connect the cables and the earthing system with short-circuit-proof earthing and short-circuiting devices. **Important:** The relevant parts must be earthed before they are short-circuited!
- Provide protection against adjacent live parts.

⚠ WARNING **The open switch position does not provide isolation**

The open position (means disconnected) of the supply control switch (SCS) or output relay does not provide isolation from the mains network.

⚠ CAUTION **Use overvoltage and overcurrent protection**

On the supply side of the installation site, the installer must provide and set up an environment according to requirements for OVC III or lower, so proper **overvoltage protection** must be installed (max. overvoltage < 4 kV). Make sure to follow local regulations for the overvoltage protection as well. The protection must be done according to local regulation.

On the supply side of the installation site, the installer must also provide use of **overcurrent protection.** The cut-off current of the protection must not be higher or exceed the maximum meter current (I_{max}). The current capability of the overcurrent protection must be in accordance with to the UC rating of the meter equipment (applicable only to direct connected meters). Make sure to follow local regulations for the overcurrent protection must be done according to local regulation as well.

The installer is responsible for coordinating and selecting the appropriate rating and the characteristics of the supply side overvoltage and overcurrent protection devices.

⚠ WARNING **Use protection in case of local energy generation**

In case of local energy generation, the supply side protection shall comprise both: protection from supply from the distribution network and protection from supply from local generation.

ϟ DANGER **Prior to installation, remove temporary fuses**

The temporary fuses attached must be removed before any modifications are made to the installation and should be kept in a safe place until the work has been completed to prevent unnoticed new use.

⚠ CAUTION **Mount the meter appropriately**

The meter has to be mounted on a smooth vertical surface and fixed at 2 or 3 points with screws using the proper torque (the meter has two attachment holes and, optionally, a top hanger).

The meter is intended for mounting at an indoor metering point, in a meter cabinet, secured against the undesired access of unauthorized persons. Only the scroll push button may be accessible from the outside.

ϟ DANGER **Use appropriate cables and make sure they are insulated properly**

The cable type and dimensions must follow this user manual and applicable regulations. Do not use any cable types that do not comply with the regulations for the installation location and power requirements.

To connect the meter, follow the connection diagram printed on the meter nameplate. Alternative connection diagrams are available in this user manual or Appendix, if applicable.

The insulation of the connection cables must cover the entire visible part of the cables. Touching live parts may cause serious injury or death. If necessary, shorten the stripped part of the connection wire.

At the end of the installation, no cables that are unconnected or that hang freely from the measuring point may remain on the metering point.

⚠ CAUTION **Use only one wire or ferrule per terminal**

Only one wire or ferrule may be connected in one terminal. Otherwise, the terminal could be damaged, or the contact might be done improperly.

⚠ CAUTION Specific aspects and safety risks with regard to external voltage and current transformers, auxiliary supply and local generation must be secured (covered).

DANGER **Do not open secondary circuit**

Secondary circuit of current transformer must not be opened when current is flowing in the primary circuit. This would produce a dangerous voltage of several thousand volts at the terminals and the isolation of the transformer could be destroyed.

DANGER **After meter installation, reinstall preliminary fuses and seal the meter**

Preliminary fuses and/or voltage arresters must be reinstalled before the commissioning and functional testing of the meter.

After meter installation, make sure the meter is protected and sealed correctly, so that the end-customer or any unauthorised person may not come into contact with live meter parts.

DANGER **Power on the meter**

When powering on, always be aware of the risk of electric shock.

NOTE **Confirm the meter is installed correctly**

The functional test requires that the voltage is applied, and the load is in all phases. First, the direction of the energy flow is determined.

If there is no mains voltage, commissioning and functional tests must be carried out at a later point in time.

1.7. Meter maintenance

The meter is maintenance-free during its service life. The implemented metering technology, built-in components and manufacturing processes ensure the continuous stability of the meter and therefore no re-calibration is required during the meter's service life.

NOTE **If meter service is required, follow the requirements and safety notices for meter installation.**

NOTE **Clean the meter with a soft, dry or damp cloth**

The meter may only be cleaned in the upper part of the meter and in the LCD area. Do not clean the area of the terminal cover, where the cables are connected. Only persons responsible for meter maintenance are allowed to clean it.

⚠ CAUTION **Do not use running water or high-pressure equipment**

Never clean a soiled meter under running water or with high-pressure equipment. Penetrating water can cause a short-circuit. If the meter is extremely soiled, uninstall it and send it to the responsible service center.

NOTE **Check for signs of fraudulent activity regularly**

Regularly check for visible signs of fraudulent activity (e.g. mechanical damage, presence of fluid, etc.).

Regularly check the quality of the seals and the condition of the terminals and connecting cables.

If there is any suspicion that the meter is not operating properly, immediately inform the local utility company.

NOTE **Meter disposal**

At the end of the meter's service life, recycle its components in accordance with the applicable legislation and regulations. Special care should be taken to dispose of the battery in accordance with the applicable legislation and regulations. For additional information on safe meter disposal, please contact Iskraemeco.

NOTE **FF error**

The FF error name can vary. The corresponding action depends on specific settings for different countries or customers. In the event of an FF error, you should always contact your local distributor for additional instructions.

2. ENERGY METERING WITH IE.x METERS

The IE.5 and IE.7 meters are members of the Intelligent Energy IoT generation of Iskraemeco electronic single-phase and three-phase meters for a deregulated market of electrical energy. They are designed for up to eight-tariff measuring of active and reactive energy, in one or two energy flow directions. The meters measure consumed energy in single-phase two-wire and three-phase four-wire networks for direct connection. Meters can be connected directly or indirectly through measurement transformers.

Common functional properties of IE.x meters:

- Time-of-use measurement of active energy (in up to 8 tariffs),
- Load-profile registration (E-meter, 4 sub-meters),
- Segment LCD display,
- Internal real-time clock,
- Disconnector,
- Two push buttons,
- Optical port (IEC 62056-21 and IEC 62056-46 standards) for local meter programming and data downloading (P0 interface),
- P1 port for sending data to in-house display (P1 interface),
- Exchangeable/integrated communication modules for remote two-way communication (P3 interface),
- Sub-metering M-Bus interface for reading up to 4 other (heat, gas, water) meters (P2 interface),
- Magnetic field detector for detecting external magnetic influence (manipulation),
- Terminal-cover and communication-module-cover opening detection.

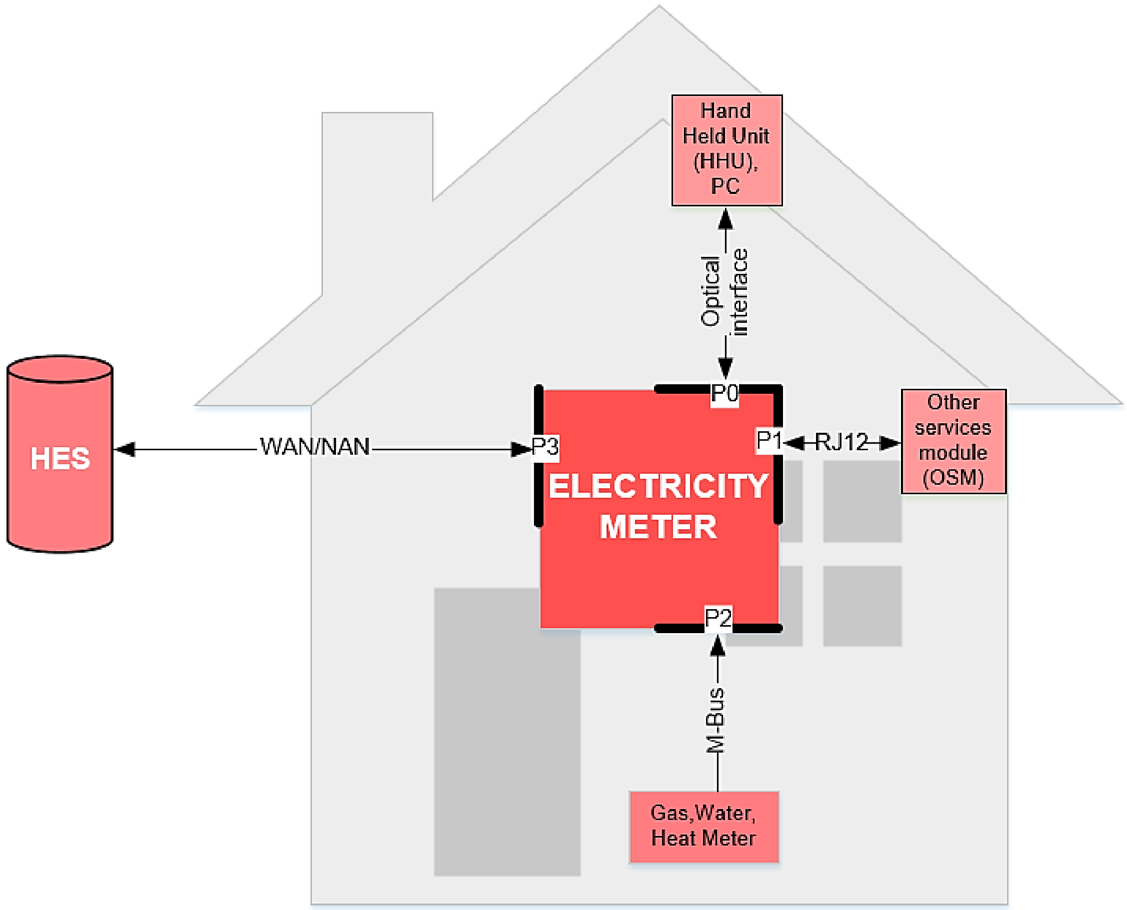


Figure 1: Smart metering system

3. METER INTRODUCTION

Measuring and technical characteristics of:

- direct connected meters comply with the IEC (International Electro technical Commission) 62052-11 and IEC 62053-21 international standards for electronic active energy meters, class 1 and 2, and reactive energy meters, classes 2 or 3 in compliance with IEC 62053-23 as well as a standard for time switches IEC 62052-21.
- indirect connected meters comply with following international standards:
  - IEC 62052-11,
  - IEC 62052-21 for time switches,
  - IEC 62053-21 for electronic active energy meters, class 1 and 2,
  - IEC 62053-22 for electronic active energy meters, class 0,5 S,
  - IEC 62053-23 for reactive energy meters, classes 2 or 3,
  - IEC 62053-24 for reactive energy meters, class 1.

Meters are designed and manufactured in compliance with the standards and ISO 9001 (International Organization for Standardization) as well as more severe Iskraemeco standards.

The meter utilizes the DLMS/COSEM communication protocol in compliance with IEC 62056-5-3, IEC 62056-6-1, IEC 62056-6-2, IEC 62056-4-7, IEC 62056-7-6, and IEC 62056-21 standards.

3.1. Standards and references

DIN 43857-1	Elektrizitätszähler in Isolierstoffgehäusen für unmittelbaren Anschluß bis 60A Grenzstromm; Hauptmaße für Wechselstromzähler
DIN 43857-2	Elektrizitätszähler in Isolierstoffgehäusen für unmittelbaren Anschluß bis 60A Grenzstromm; Hauptmaße für Drehstromzähler
DIN 43863-3	Elektrizitätszähler; Tarifgeräte als Zusatzeinrichtung zum Elektrizitätszähler EDIS (Energie-Daten-Identifikations-System)
EN 13757-3	Communication systems for meters and remote reading of meters Part 3: Dedicated application Layer
EN 13757-4	Communication systems for meters and remote reading of meters Part 4: Wireless meter readout (Radio Meter reading for operation in the 868–870 MHz SRD band)
EN 13757-7	Communication systems for meters Part 7: Transport and security services
EN 50160	Voltage characteristics of electricity supplied by public electricity networks
EN 50470-1	Electricity metering equipment (a.c.) – Part 1: General requirements, tests and test conditions Metering equipment (class indexes A, B and C)
EN 50470-3	Electricity metering equipment (a.c.) – Part 3: Particular requirements – Static meters for active energy (class indexes A, B and C)
IEC 60664-1:2007	Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests
EN 60870-5-1	Telecontrol equipment and systems: Transmission protocols – Transmission frame formats
EN 60870-5-2	Telecontrol equipment and systems: Transmission protocols – Link transmission procedures
IEC-61000-4-6	Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields
IEC 60068-2-75	Environmental testing – Part 2: Tests – Test Eh: Hammer tests
IEC 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test
IEC 61000-4-3	Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test
IEC 61000-4-4	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test
IEC 61000-4-5	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test
IEC 62052-11	Electricity metering equipment (AC.): General requirements, tests and test conditions – Metering equipment

IEC 62052-21	Electricity metering equipment (AC.) General requirements, tests and test conditions – Tariff and load control equipment
IEC 62052-31	Electricity Metering Equipment (AC) – General Requirements, Tests And Test Conditions – Part 31: Product Safety Requirements And Tests
IEC 62053-21	Electricity metering equipment; Particular requirements; Electronic meters for active energy (classes 1 and 2)
IEC 62053-22	Electricity metering equipment; Particular requirements; Electronic meters for active energy (classes 0,2S and 0,5S)
IEC 62053-23	Electricity metering equipment (AC.); Particular requirements; Static meters for reactive energy (classes 2 and 3)
IEC 62053-24	Electricity metering equipment (AC.); Particular requirements; Static meters for reactive energy at fundamental frequency (classes 0,5S,1S and 1)
IEC 62054-21	Electricity metering (ax.) – Tariff and load control – Particular requirements for time switches
IEC 62056-21	Data exchange for meter reading, tariff and load control – Direct local connection (3rd edition of IEC 61107)
IEC 62056-7-6	Electricity metering data exchange – The DLMS/COSEM suite – Part 7-6: The 3-layer, connection-oriented HDLC based communication profile
IEC 62056-4-7	Electricity metering data exchange – The DLMS/COSEM suite – Part 4-7: DLMS/COSEM transport layer for IP networks
IEC 62056-5-3	Electricity metering data exchange – The DLMS/COSEM suite – Part 5-3: DLMS/COSEM applica-tion layer
IEC 62056-6-1	Electricity metering data exchange – The DLMS/COSEM suite – Part 6-1: Object Identification System (OBIS)
IEC 62056-6-2	Electricity metering data exchange – The DLMS/COSEM suite – Part 6-2: COSEM interface classes
IEC 62056-46	Electricity metering; Data exchange for meter reading, tariff and load control; Part 46: Data link layer using HDLC-Protocol
IEC 62059-32-1	Electricity metering equipment – Dependability – Part 32-1: Durability – Testing of the stability of metrological characteristics by applying elevated temperature
IEC 61334-4-32	Distribution automation using distribution line carrier systems – Data communication protocols – Data link layer – Logical link control (LLC)
IEC 61334-4-512	Distribution automation using distribution line carrier systems – Data communication protocols – System management using profile 61334-5-1 – Management Information Base (MIB)
TP CLC/TR 50579	2012 – Severity levels, immunity requirements and test methods for conducted disturbances in the frequency range 2–150 kHz (CLC/TR 50579:2012)
IEC 60529	Degrees of protection provided by enclosures (IP code)
ISO/IEC 8802.2	Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements; Logical link control
RFC 1321	MD5 (Message Digest algorithm 5) Message-Digest Algorithm
RFC 1332	The Internet Protocol Control Protocol (IPCP)
RFC 1700	Assigned Numbers
RFC 3241	Robust Header Compression
FIPS PUB 180-1	Secure Hash Standard (SHA-1), 1993
DLMS UA 1000-2 Ed. 11, 2021	Green Book, DLMS/COSEM Architecture and Protocols
DLMS UA 1000-1 Ed. 15, 2021	Blue Book, COSEM Identification System and Interface Classes
DLMS UA 1001-1 Ed. 5, 2015	Yellow Book, DLMS/COSEM Conformance Testing Process
DLMS UA 1002 Ed. 1, 2003	White Book, COSEM Glossary of Terms
DSRM5 P1 Specification	Dutch Smart Meter Requirements, 2016 – 2020 SMR5 Meters – P1 companion standard
SRM5 P2 Specification	Smart Meter Requirements, 2016 - 2020 SMR5 Meters – P2 companion stand-ard
SRM5 P3 Specification	Smart Meter Requirements, 2016 - 2020 SMR5 Meters – P3 companion stand-ard
VDEW – specification for “Electronic Meters with load curve“ Version 2.1.2 7th November 2003	
IP (Internet Protocol) Header Compression over PPP	
3GPP TS 27.007	
3GPP TS 27.010	

3GPP TS 23.040
Open Metering System Specification, Primary Communication, Volume 2, Issue 4.1.2, 2016-12-16
Open Metering System Specification, Message examples, Annex N to Volume 2 Primary Communication, Issue 4.1.2, Release B, 2016-12-16
IDIS Interoperability Specification, Package 2, IP Profile, Edition 2.0 (including G3-PLC), 03.09.2014
NIST, Special Publication 800-38B, "Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication", May 2005
RFC4493, The AES-CMAC Algorithm, 2005
RoHS – Directive 2015/863 - Restriction of Hazardous Substances Directive

3.2. Meter type designation

The meter type designation is printed on the front side of the meter. For an explanation of the IE.x type designation, see the example below.

Example: IE.5-TD1-H01

	IE	.	5	-	T	D1	-	H	0	1
Program										
IE: Intelligent Energy IoT										
Series seperator: .(dot)										
Series										
1: *Reserved for future purposes*										
2: *Reserved for future purposes*										
3: Stand alone										
4: *Reserved for future purposes*										
5: Smart										
6: *Reserved for future purposes*										
7: Commercial										
8: Industrial										
9: Grid										
Separator: - (minus)										
Number of phases, Number of measurement elements and wires										
E: Single phase electronic meter 1 measurement element 2 wires										
D: Single phase electronic meter 2 measurement elements 2 wires										
P: Three phase electronic meter 3 measurement elements 3 wires										
T: Three phase electronic meter 3 measurement elements 4 wires										
Q: Three phase electronic meter 4 measurement elements 4 wires										
Connection type and current range										
B2: Current range up to 100 A, BS, Direct connection										
D0: Current range up to 60 A, DIN, Direct connection										
D1: Current range up to 85 A, DIN, Direct connection										
D2: Current range up to 100 A, DIN, Direct connection										
D3: Current range up to 120 A, DIN, Direct connection										
E0: Current range up to 60 A, EHZ, Direct connection (plug-in type)										
F0: Current range up to 60 A, ERDF, Direct connection										
F1: Current range up to 90 A, ERDF, Direct connection										
H0: Current range up to 60 A, ERDF, Direct connection (top connec.)										
H1: Current range up to 90 A, ERDF, Direct connection (top connec.)										
T1: Current range up to 6 A, DIN, Indirect connection (CT/VT)										
T2: Current range up to 10 A, DIN, Indirect connection (CT/VT)										
T3: Current range up to 20 A, DIN, Indirect connection (CT/VT)										
V1: Current range up to 6 A, DIN, Indirect connection (CT+VT)										
V2: Current range up to 10 A, DIN, Indirect connection (CT+VT)										
V3: Current range up to 20 A, DIN, Indirect connection (CT+VT)										
Separator: - (minus)										
Hardware Generation: H										
0..9: Generation of the device (change of technology)										
1..9: Version within the generation (related to re-approval)										

Table 1: Description of the IE.x type designation

3.3. Meter appearance

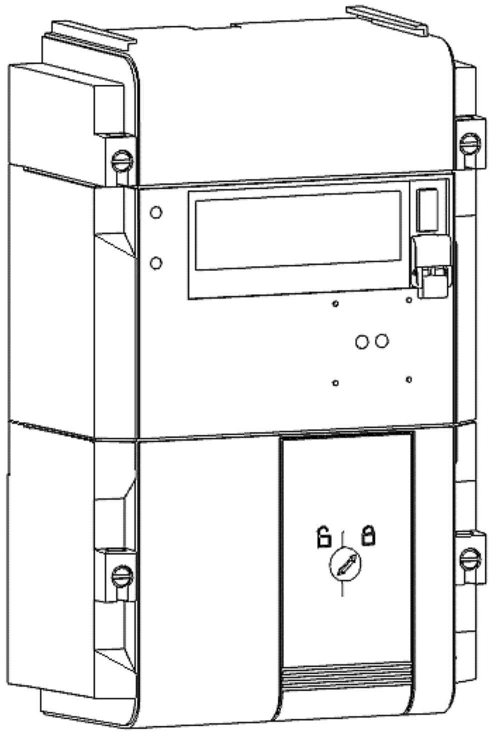


Figure 2: Appearance of IE.x single-phase meter (example)

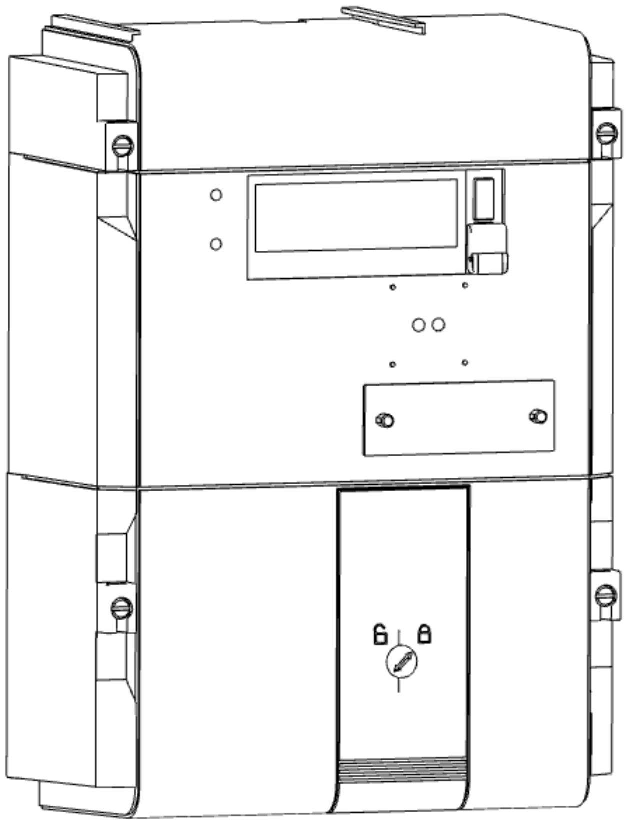


Figure 3: Appearance of IE.x three-phase meter (example)

3.4. The main meter properties

- Direct connected meter of:
  - active energy accuracy class A or B (EN 50470-3), class 2 or 1 (IEC 62053-21),
  - reactive energy accuracy class 2 or 3 (IEC 62053-23).
- Indirect connected meter of:
  - active energy accuracy class A, B or C (EN 50470-3), class 2 or 1 (IEC 62053-21), class 0.5 S (IEC 62053-22),
  - reactive energy accuracy class 2 or 3 (IEC 62053-23), class 1 (IEC 62053-24).
- Modes of energy measurement and registration:
  - single-phase meters: for two-way energy flow direction,
  - three-phase meters: for two-way energy flow direction, three-phase energy is a vector or arithmetical sum of energies registered in all phases.
- Meter connection:
  - direct or indirect connection of the meter,
  - 3-phase 4-wire,
  - 3-phase 3-wire,
  - 1-phase 2-wire,
  - the three-phase meter can function as a single-phase or a two-phase meter as well.
- Meter quality:
  - due to high accuracy and long-term stability of metering elements, no meter re-calibration over its lifetime is required,
  - high meter reliability,
  - high immunity to EMC.
- Additional meter functions:
  - measurement and registration of under- and over-voltage,
  - triggering of alarms and their transmitting via the P3 interface,
  - time-of-use registration (up to 8 tariffs),
  - load-profile recording.
- Communication channels:
  - WAN interface (P3 port) for remote access,
  - infrared optical port (P0 port) for local meter programming and data downloading,
  - built-in wireless M-Bus communication interface (P2 port) for sub-metering,
  - P1 consumer interface (P1 port).
- Segment LCD display.
- Data display modes:
  - automatic cyclic data display with display time of 5 seconds,
  - manual data display mode (by pressing the Scroll push-button),
  - service mode (mode with added objects for service personnel).
- Metrological LEDs: red (or other, depending on customer’s decision)
- Communication protocols:
  - optical port: IEC 62056-21, mode E or DLMS (in compliance with IEC 62056-7-6),
  - DLMS/COSEM application layer: IEC 62056-5-3,
  - OBIS identification system: IEC 62056-6-1,
  - COSEM organization of data: IEC 62056-6-2,
  - M-Bus: EN 13757-3, EN 13757-4, EN 13757-7 and OMS specification 4.1.2,
  - RS-485: IEC 62056-46 (DLMS UA).
- Programming of the meter, as well as FW upgrade, can be done locally (via the optical port) or remotely, in compliance with the predefined security levels.
- Detection of terminal and module cover removal.
- Simple and fast meter installation.
- Current terminals:

- ○ assured good contact with current conductors regardless of their design and material.
- Voltage terminals:
  - internal and/or external connection.
- Compact plastic meter case:
  - made of high-quality fire-extinguishing UV stabilized material that can be recycled,
  - some parts can be made of quality recycled fire-extinguishing UV stabilized material that can be recycled as well,
  - IP54 protection against dust and water penetration (according to IEC 60529).

3.5. Connection diagrams

A connection diagram shows the correct connection of a device into the electrical network.

Each meter has the appropriate connection diagram with its identification number (in the form IS*xxxxx*, where *x* stands for a digit 0–9) printed on the nameplate of the meter (see chapter *4.4.2.2. The nameplate*).

The connection diagrams of the IE.x meters are shown in the following subchapters.

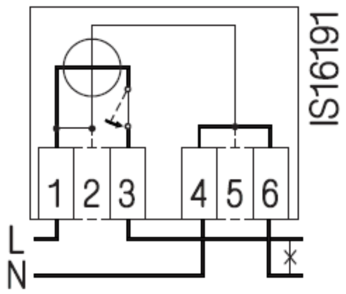
3.5.1. IE.5-xy single-phase direct connected meter

IE.5-xy single-phase direct connected meters are available in the following variants:

- IE.5-ED – 1P2W meter with 1 measuring element, DIN connection
- IE.5-DD – 1P2W meter with 2 measuring elements, DIN connection
- IE.5-EB – 1P2W meter with 1 measuring element, BS connection

3.5.1.1. IE.5-ED single-phase meter

The IE.5-ED meter has 1 measuring element and may be connected with DIN connection.



Legend:

– – – *Optional*

Figure 4: The connection diagram IS16191 for 1P2W meter with 1 measuring element, DIN connection

3.5.1.2. IE.5-DD single-phase meter

The IE.5-DD meter has 2 measuring elements and may be connected with DIN connection.

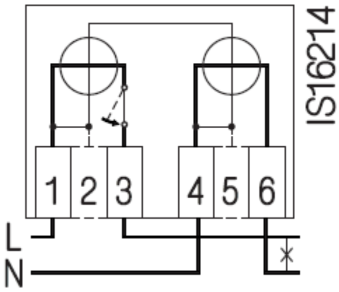


Figure 5: The connection diagram IS16214 for 1P2W meter with 2 measuring elements, DIN connection

3.5.1.3. IE.5-EB single-phase meter

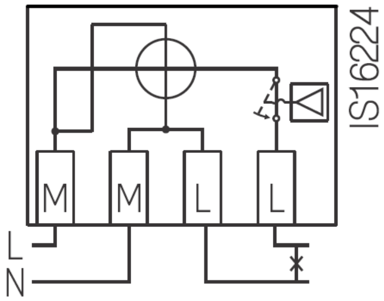


Figure 6: The connection diagram IS16224 for 1P2W meter with 1 measuring element, BS connection

3.5.2. IE.5-xD three-phase direct connected meters

IE.5-xD three-phase direct connected meters are available in the following variants:

- IE.5-TD – 3P4W meter with 3 measuring elements,
- IE.5-PD – 3P3W meter with 3 measuring elements,
- IE.5-QD – 3P4W meter with 4 measuring elements.

3.5.2.1. IE.5-TD three-phase four-wire direct connected meter

The IE.5-TD three-phase four-wire direct meter has 3 measuring elements and can be connected using the following connection types:

- 3P4W,
- 3P3W, or
- 1P2W (on L3 only).

NOTE
The IE.5-TD3 meter can be connected using 3P4W connection only.

3.5.2.1.1. IE.5-TD 3P4W meter with 3P4W connection

The basic connection for the IE.5-TD three-phase four-wire direct meter is 3P4W.

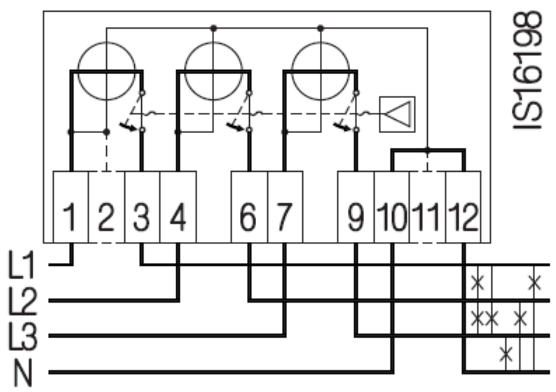


Figure 7: The connection diagram IS16198 for 3P4W direct meter with 3P4W connection

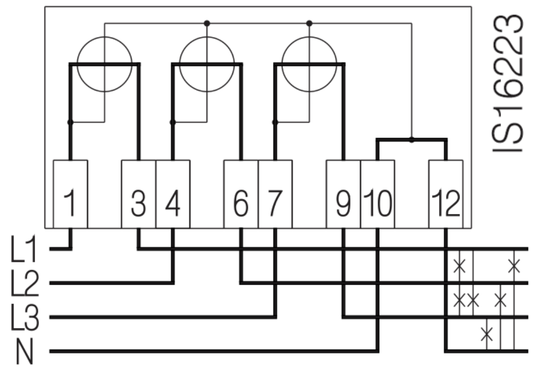


Figure 8: The connection diagram IS16223 for 3P4W direct meter with 3P4W connection without a disconnector (IE.5-TD3)

3.5.2.1.2. IE.5-TD 3P4W meter with 3P3W connection

The IE.5-TD three-phase four-wire direct meter may be connected using a 3P3W connection.

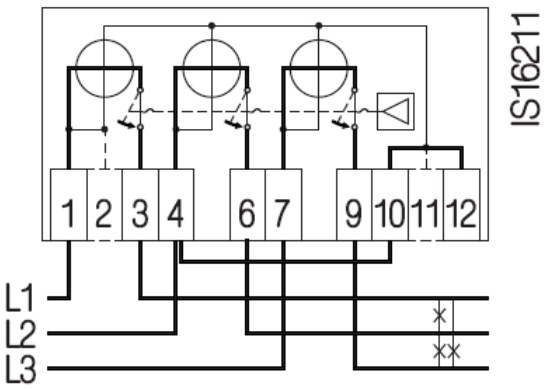


Figure 9: The connection diagram IS16211 for 3P4W direct meter with 3P3W connection

3.5.2.1.3. IE.5-TD 3P4W meter with 1P2W connection

The IE.5 three-phase four-wire meter may be connected using a 1P2W connection on L3.

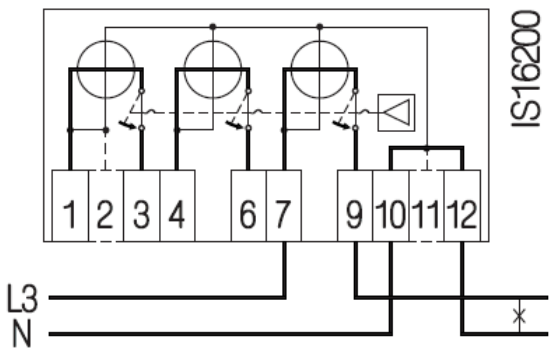


Figure 10: The connection diagram IS16200 for 3P4W direct meter with 1P2W_L3 connection

3.5.2.2. IE.5-PD three-phase three-wire direct connected meter

The IE.5-PD three-phase three-wire direct meter has 3 measuring elements and may be connected using a 3P3W connection only.

3.5.2.2.1. IE.5-PD 3P3W meter with 3P3W connection

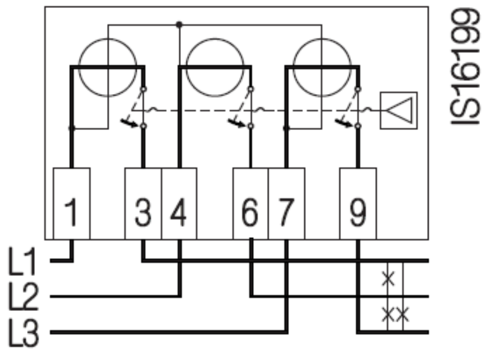


Figure 11: The connection diagram IS16199 for 3P3W direct meter with 3P3W connection

3.5.2.3. IE.5-QD three-phase four-wire direct connected meter

The IE.5-QD three-phase four-wire direct meter has 4 measuring elements and may be connected using a 3P4W connection only.

3.5.2.3.1. IE.5-QD 3P4W meter with 3P4W connection

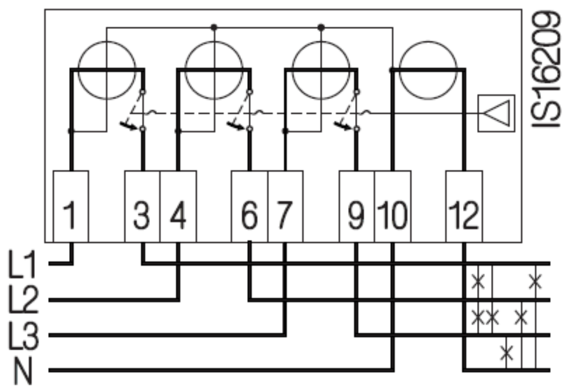


Figure 12: The connection diagram IS16209 for 3P4W direct meter with 3P4W connection, 4 measuring elements

3.5.3. IE.7 three-phase indirect connected meters

IE.7-TT three-phase four-wire indirect meters can be connected using the following connection types:

- 3P4W
- 3P3W

IE.7-TV three-phase four-wire indirect meters can be connected using the following connection types:

- 3P4W, 3×VT, 3×CT

IE.7-PT three-phase three-wire indirect meters can be connected using the following connection types:

- 3P3W, 2×CT

3.5.3.1. IE.7-TT 3P4W meter with 3P4W connection, 3×CT

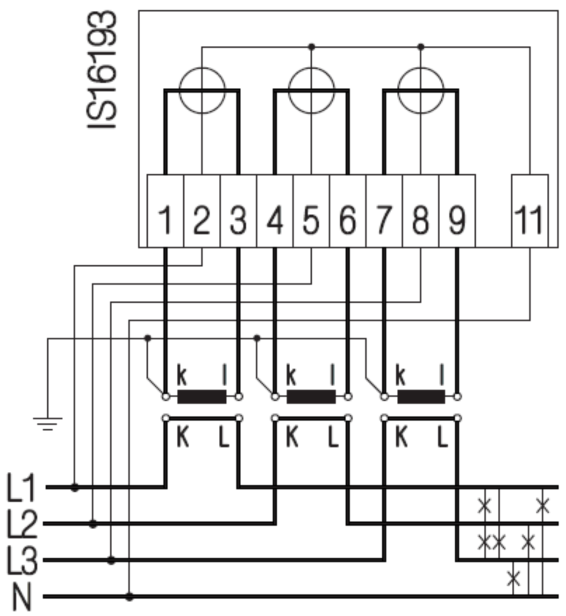


Figure 13: The connection diagram IS16193 for 3P4W indirect meter with 3P4W connection, 3×CT.

3.5.3.2. IE.7-TV 3P4W meter with 3P4W connection, 3×VT, 3×CT

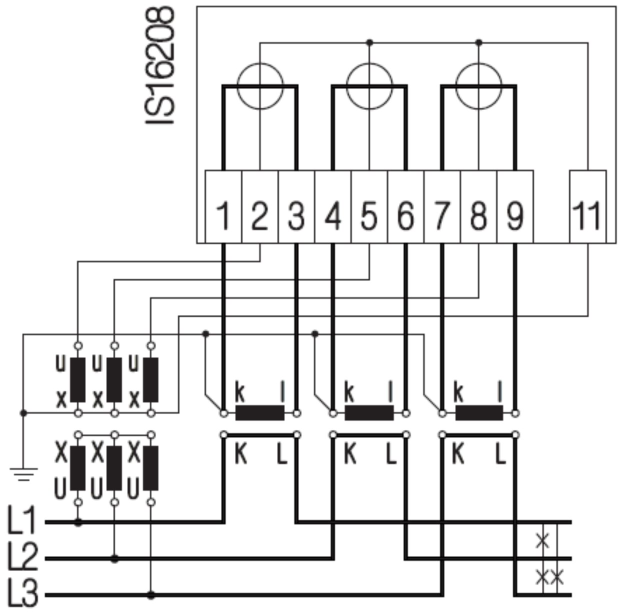


Figure 14: The connection diagram IS16208 for 3P4W indirect meter with 3P4W connection, 3×VT, 3×CT.

3.5.3.3. IE.7-TV 3P4W meter with 3P3W connection, 3×VT, 2×CT

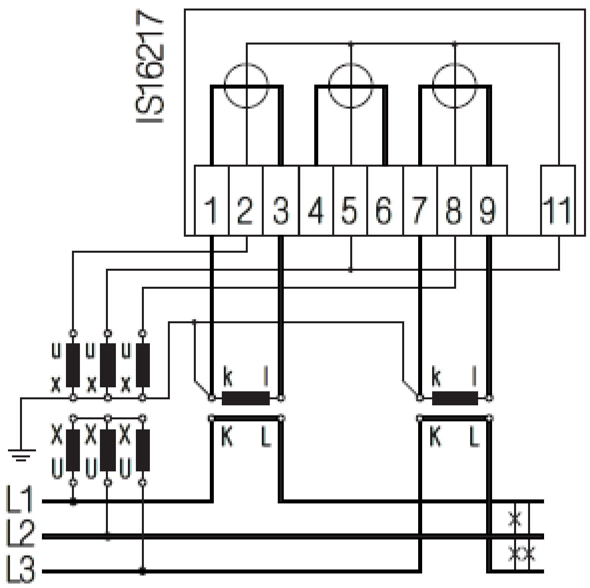


Figure 15: The connection diagram IS16217 for 3P4W indirect meter with 3P3W connection, 3×VT, 2×CT.

3.5.3.4. IE.7-PT 3P3W meter with 3P3W connection, 2×CT

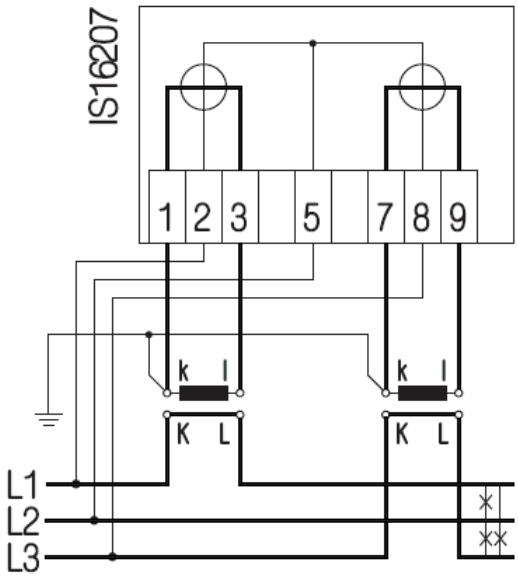


Figure 16: The connection diagram IS16207 for 3P3W indirect meter with 3P3W connection, 2×CT.

3.5.4. Connection diagrams of non-main terminals

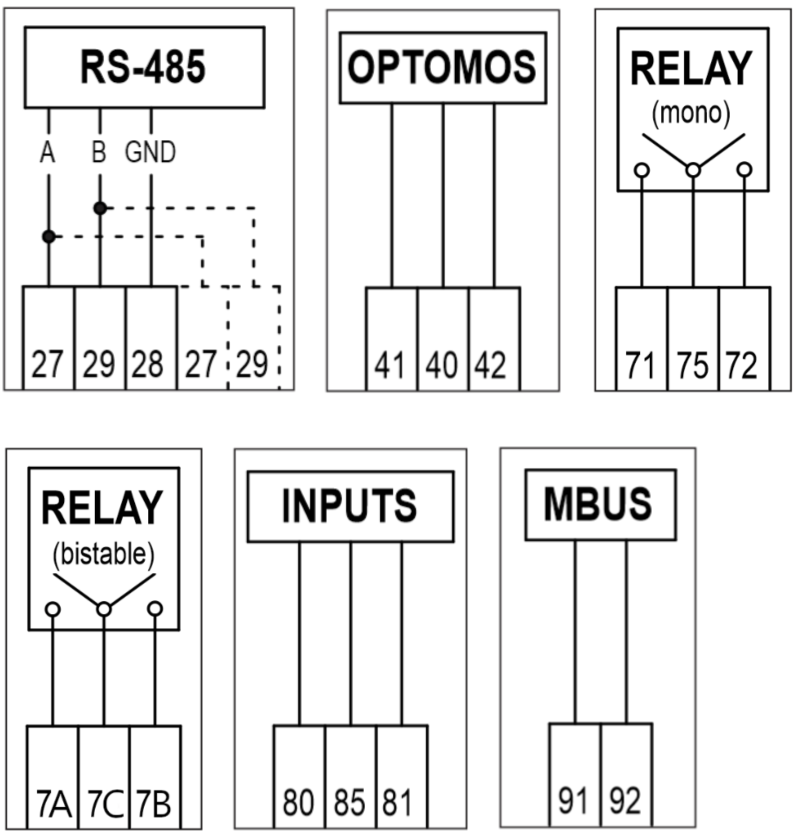


Figure 17: Connection diagrams of non-main terminals

4. MECHANICS

4.1. Technical figures and dimensions of a single-phase meter

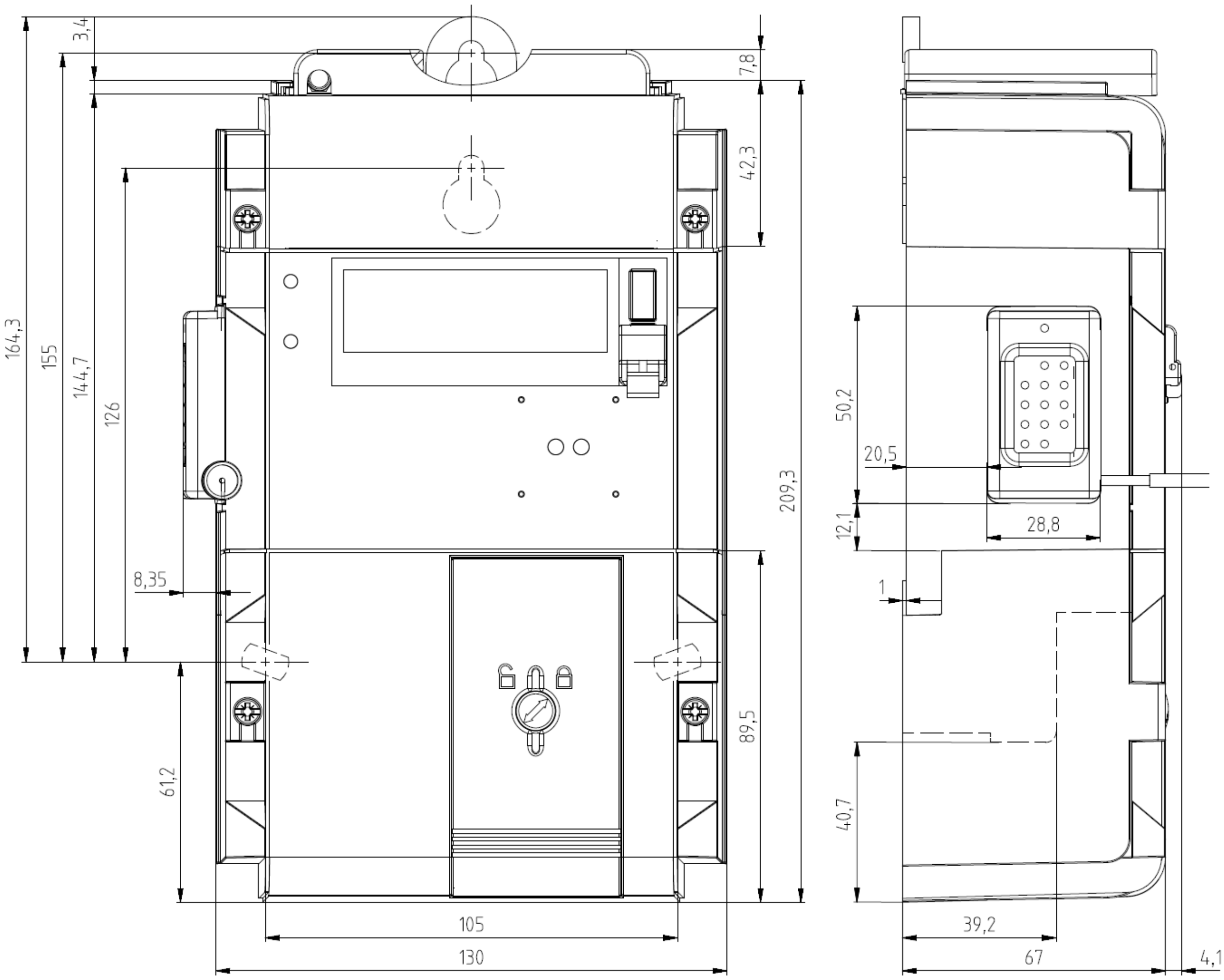


Figure 18: Dimensions of the single-phase meter, standard terminal cover (in mm)

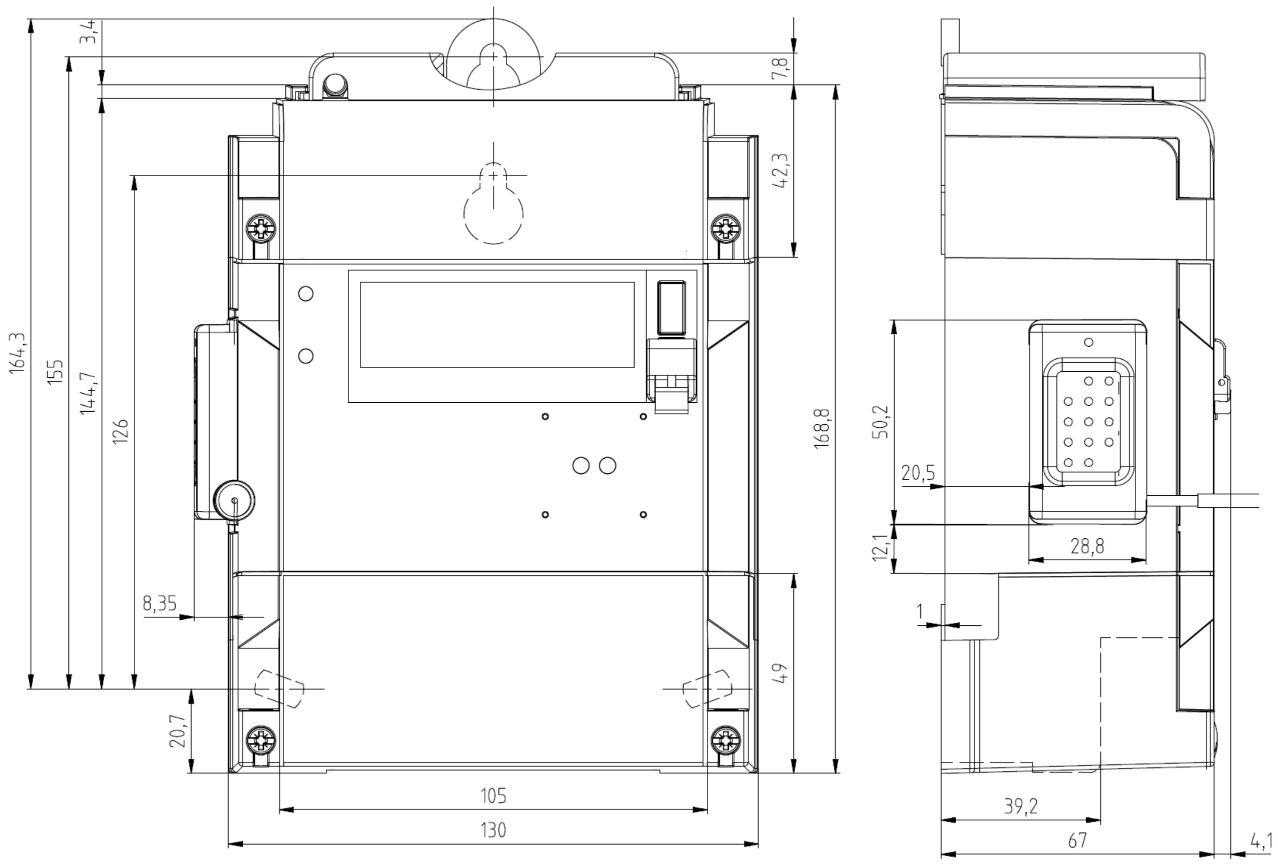


Figure 19: Dimensions of the single-phase meter, short terminal cover (in mm)

4.2. Technical figures and dimensions of a three-phase meter

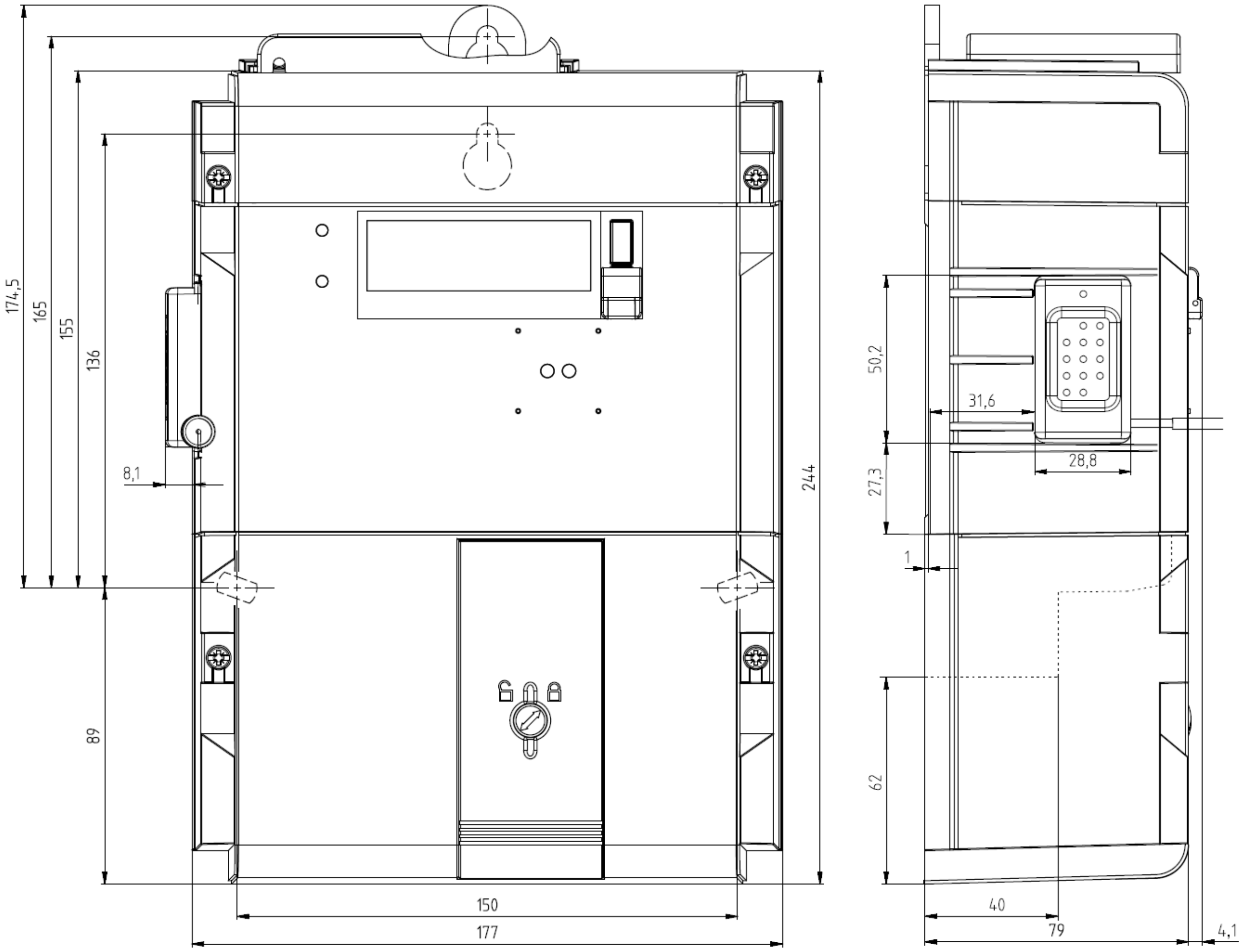


Figure 20: Dimensions of the three-phase meter, standard terminal cover (in mm)

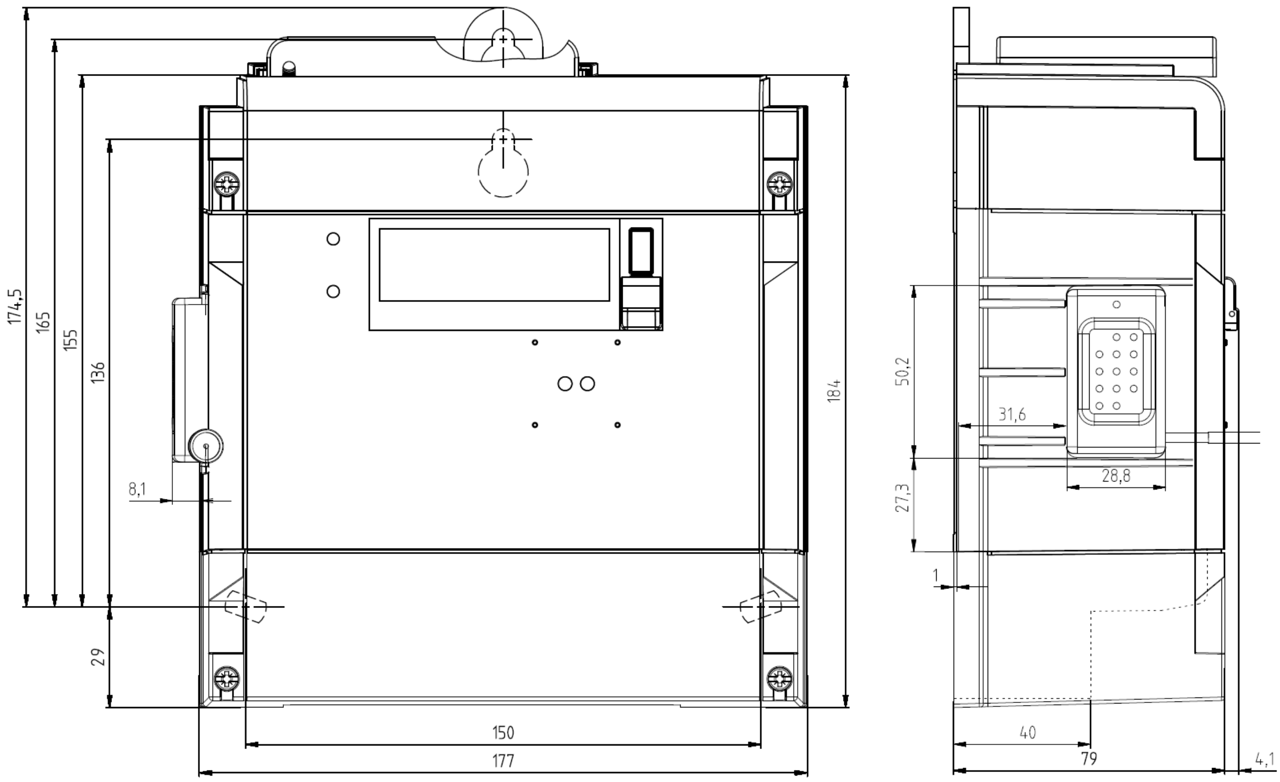


Figure 21: Dimensions of the three-phase meter, short terminal cover (in mm)

4.3. The meter housing

The housing of the IE.x meter (Figure 22) consists of:

- a meter base,
- a meter cover,
- a terminal block with a terminal cover, and
- a module cover.

The housing is made of self-extinguishing high-quality polycarbonate. Optionally, the terminal cover may contain recycled material.

The default housing colour is light grey (RAL7035). A sealable part of the lower button is in transparent colour. The terminal cover is also available in transparent and semi-transparent colour.

The plate for the CT-ratio label (only in the three-phase indirect connected meter) is in transparent colour.

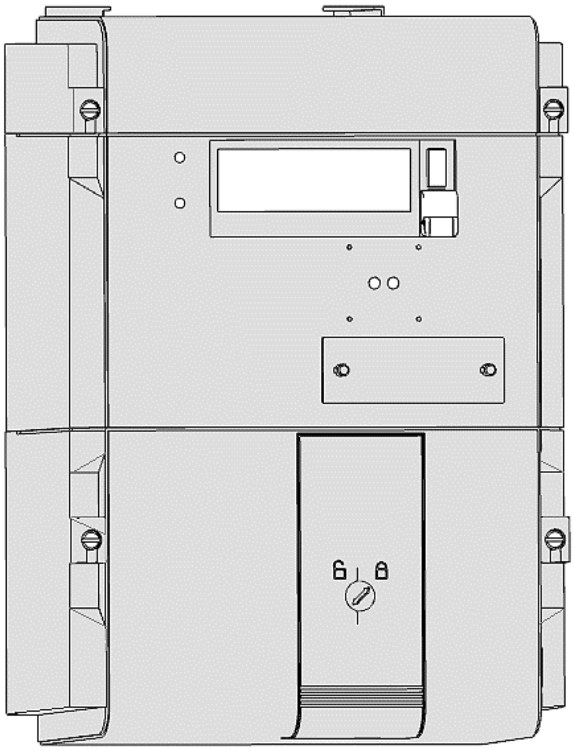


Figure 22: The meter housing

4.4. The main meter parts

The meter consists of:

- the modular part (1)
- the main part (2)
- the terminal part (3)

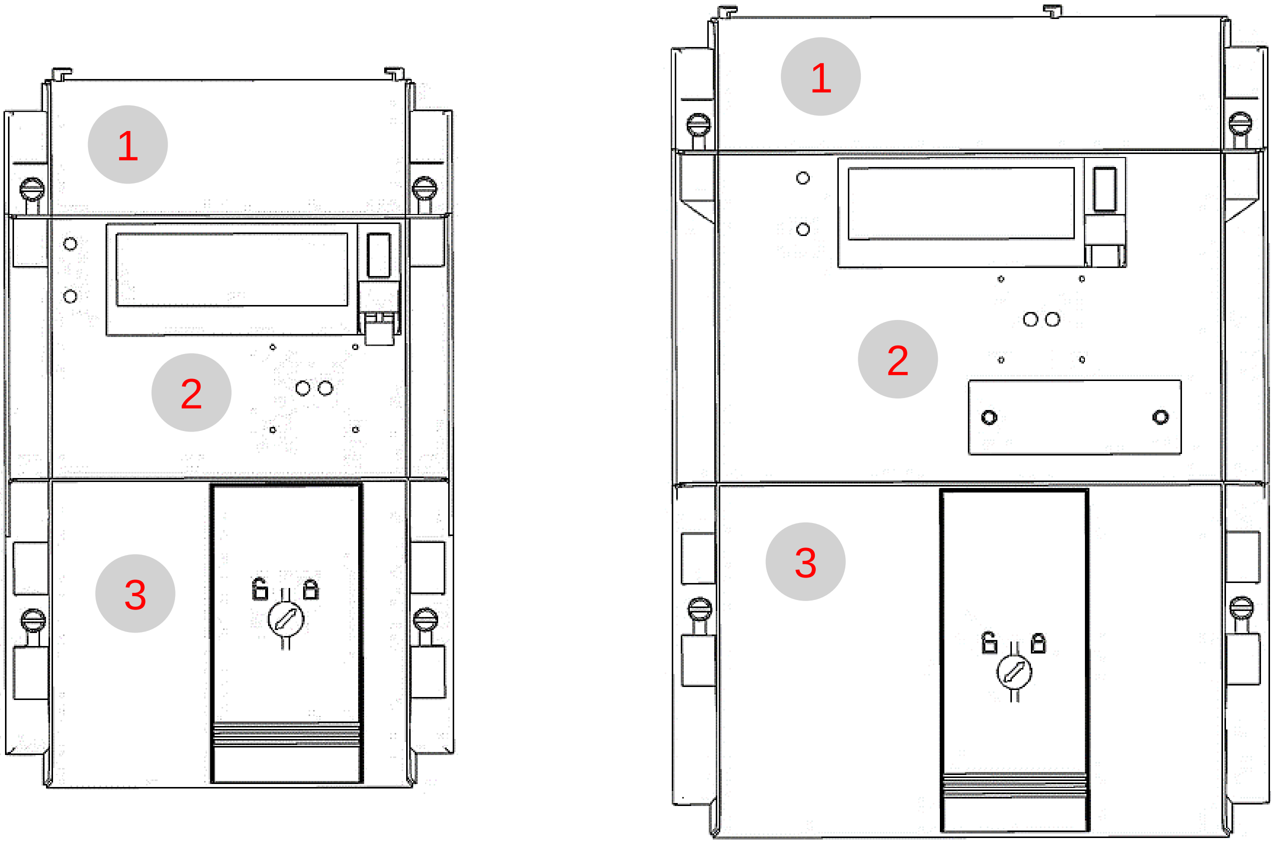


Figure 23: The main meter parts of the single-phase (left) and three-phase meter (right)

4.4.1. The terminal part of the meter

The terminal part of the meter consists of:

- a terminal block with terminals,
- a terminal cover,
- two terminal cover sealing screws.

4.4.1.1. The terminal block

The terminal block is located under the terminal cover. Two utility seals through fixing screws prevent unauthorized access to terminals and consequently prevent any fraud attempts via terminals.

The terminal block is designed to connect the meter to a grid and comprises of:

- main and (optional) auxiliary terminals for current and voltage,
- input and/or output terminals,
- communication interfaces,
- auxiliary power supply terminals (optional),
- a terminal cover opening detector,

The type of the terminal block is different according to the main terminals for current and voltage:

- the terminal block of the single-phase meter with DIN connection
- the terminal block of the single-phase meter with BS connection
- the terminal block of the three-phase direct connected meter
- the terminal block of the three-phase indirect connected meter (CT/VT)

Each terminal in the terminal block has an assigned terminal number according to the functionality, which it is used for.

4.4.1.1.1. Current and voltage terminals

Each main meter terminal for current is designed by two terminal screws. This type of main terminal doubled screws applies in all meter types covered by this document.

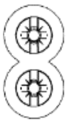
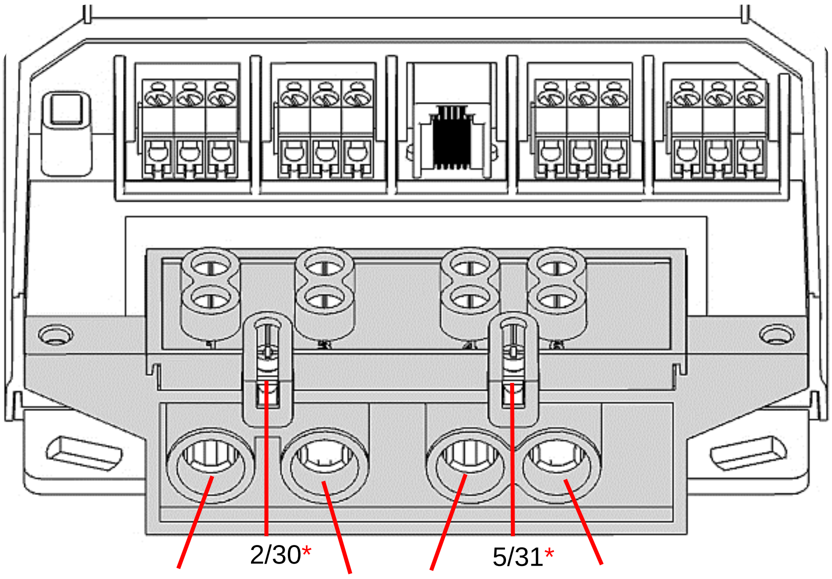


Figure 24: Main terminal doubled screws

4.4.1.1.1.1. Single-phase meter with DIN connection



* the terminals are marked according to the functionality, which the meter is equipped with

Figure 25: Current and voltage terminals of the single-phase meter with DIN connection

1 L-in
2 Aux Voltage L – output power supply (optional)
3 L-out
4 N-in
5 Aux N – output power supply (optional)
6 N-out
30 Aux Voltage L – input power supply (optional)
31 Aux N – input power supply (optional)

NOTE

The meter may be equipped with auxiliary terminals 2 and 5 or 30 and 31:

- If the meter is equipped with terminals 2 and 5, the meter can provide (output) power for external connected devices.
- If the meter is equipped with terminal 30 and 31, the external power supply source can be used for powering the meter (see chapter *4.4.1.1.2.1. Auxiliary power supply terminals*).
- When powering an external device over terminal 2 and 5, use a fast-acting fuse with the following rating:
  - Amp rating: < 150 mA
  - Voltage rating V AC/DC: 250 V
  - Interrupting rating at 250 V AC/DC: min. 4000 A

Termi-nal no.	**Function**	**Reference voltage**	**Max. current**	**Diam. *[mm]***	**Note**	**Wire *[mm²]* ***	**Screw head *type* and *size***	**Torque *[N m]***
1	L – in	230 V	D1: 85 A	8.5	current	4-25	Combi Pozidriv (2) + Slot	2,8-3,0
2 or 30 **	Aux Voltage L – output power supply or Aux Voltage L – input power supply	230 V	D1: –	3	voltage	0.5-2.5	Combi Pozidriv (1) + Slot	0.6

Termi-nal no.	Function	Reference voltage	Max. current	Diam. *[mm]*	Note	Wire *[mm²]* *	Screw head *type and size*	Torque *[N m]*
3	L – out	230 V	D1: 85 A	8.5	current	4-25	Combi Pozidriv (2) + Slot	2,8-3,0
4	N – in	–	D1: –	8.5	neutral	4-25	Combi Pozidriv (2) + Slot	2,8-3,0
5 or 31 **	Aux N (optional)	–	D1: –	3	neutral	0.5-2.5	Combi Pozidriv (1) + Slot	0.6
6	N – out	–	D1: –	8.5	neutral	4-25	Combi Pozidriv (2) + Slot	2,8-3,0

* See the note below.

** Optional; the terminals are marked according to the functionality, which the meter is equipped with.

Table 2: Terminal data for single-phase meter – DIN connection

NOTE

The minimum cross section of the wire shall be according to standards, and it is 2.5 mm². For the specific installation with the 2.5 mm² cross-section wire, see chapter *5. INSTALLATION.*

4.4.1.1.1.2. Single-phase meter with BS connection

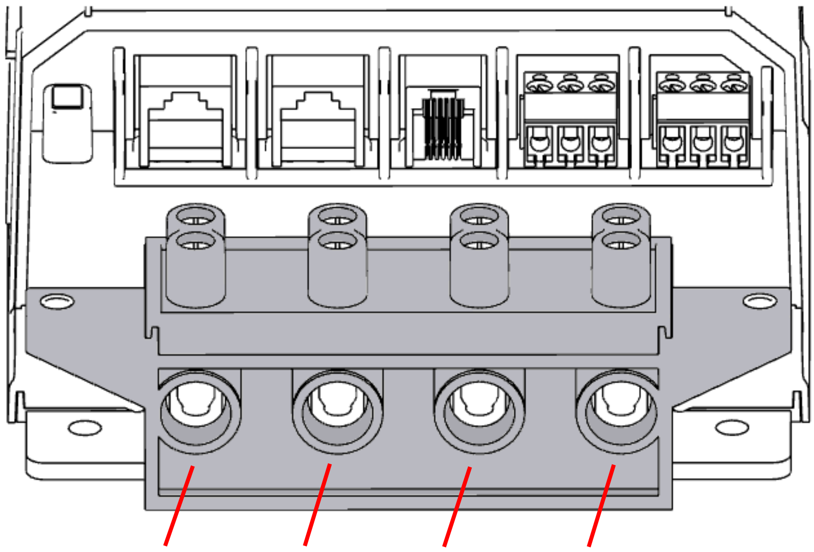


Figure 26: Current and voltage terminals of the single-phase meter with BS connection

Termi-nal no.	Function	Reference voltage	Max. current	Diam. *[mm]*	Note	Wire *[mm²]* *	Screw head *type and size*	Torque *[N m]*
M	L – in	230 V	100 A	9.5	current	6–35	Combi Pozidriv (2) + Slot	2.8-3.0
M	N – in	-	100 A	9.5	neutral	6–35	Combi Pozidriv (2) + Slot	2.8-3.0
L	N – out	-	100 A	9.5	neutral	6–35	Combi Pozidriv (2) + Slot	2.8-3.0
L	L – out	230 V	100 A	9.5	current	6–35	Combi Pozidriv (2) + Slot	2.8-3.0

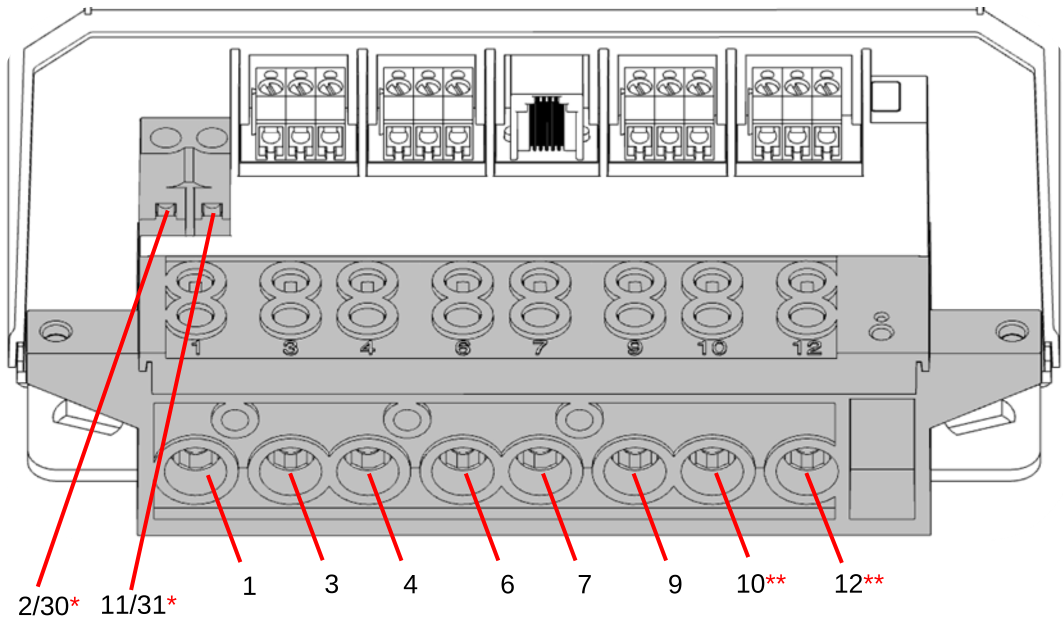
* See the note below.

Table 3: Terminal data for single-phase meter – BS connection

NOTE

The minimum cross section of the wire shall be according to standards: 2.5 mm². For the specific installation with a 2.5 mm² cross-section wire, see chapter *5. INSTALLATION.*

4.4.1.1.1.3. Three-phase direct connected meter



* the terminals are marked according to the functionality, which the meter is equipped with
** the terminals 10 and 12 are sealed in a three-phase three-wire meter

Figure 27: Current and voltage terminals of the three-phase direct connected meter

1	L1 – in	**9**	L3 – out
2	Aux Voltage L – output power supply (optional)	**10**	N – in
3	L1 – out	**11**	Aux N – output power supply (optional)
4	L2 – in	**12**	N – out
6	L2 – out	**30**	Aux Voltage L – input power supply (optional)
7	L3 – in	**31**	Aux N – input power supply (optional)

NOTE

The meter may be equipped with auxiliary terminals 2 and 11 or 30 and 31:

- If the meter is equipped with terminals 2 and 11, the meter can provide (output) power for external connected devices.
- If the meter is equipped with terminals 30 and 31, an external power supply source can be used for powering the meter (see chapter *4.4.1.1.2.1. Auxiliary power supply terminals*).
- Three-phase three-wire meters are not equipped with terminals 10 and 12.
- When powering an external device over terminals 2 and 11, use a fast-acting fuse with the following rating:
  - Amp rating: < 150 mA
  - Voltage rating V AC/DC: 250 V
  - Interrupting rating at 250 V AC/DC: min. 4000 A

Termi-nal no.	Function	Reference voltage	Max. current	Diam. *[mm]*	Note	Wire *[mm^2]* *	Screw head *type and size*	Torque *[N m]*
1	L1 – in	230 V	D1: 85 A	8.5	current	4–25	Combi Pozidriv (2) + Slot	2.8–3.0
			D2: 100 A	9.5		6–35		
			D3: 120 A					
3	L1 – out	230 V	D1: 85 A	8.5	current	4–25	Combi Pozidriv (2) + Slot	2.8–3.0
			D2: 100 A	9.5		6–35		
			D3: 120 A					
4	L2 – in	230 V	D1: 85 A	8.5	current	4–25	Combi Pozidriv (2) + Slot	2.8–3.0
			D2: 100 A	9.5		6–35		
			D3: 120 A					
6	L2 – out	230 V	D1: 85 A	8.5	current	4–25	Combi Pozidriv (2) + Slot	2.8–3.0
			D2: 100 A	9.5		6–35		
			D3: 120 A					
7	L3 – in	230 V	D1: 85 A	8.5	current	4–25	Combi Pozidriv (2) + Slot	2.8–3.0
			D2: 100 A	9.5		6–35		
			D3: 120 A					
9	L3 – out	230 V	D1: 85 A	8.5	current	4–25	Combi Pozidriv (2) + Slot	2.8–3.0
			D2: 100 A	9.5		6–35		
			D3: 120 A					
10	N – in	–	–	8.5	neutral	4–25	Combi Pozidriv (2) + Slot	2.8–3.0
			–	9.5		6–35		
12	N – out	–	–	8.5	neutral	4–25	Combi Pozidriv (2) + Slot	2.8–3.0
			–	9.5		6–35		
2 or 30 **	Aux Voltage L output power supply or Aux Voltage L – input power supply	230 V	–	3.0	voltage	0.5–2.5	Combi Pozidriv (1) + Slot	0.6
11 or 31**	Aux N (optional)	–	–	3.0	neutral	0.5–2.5	Combi Pozidriv (1) + Slot	0.6

* See the note below.

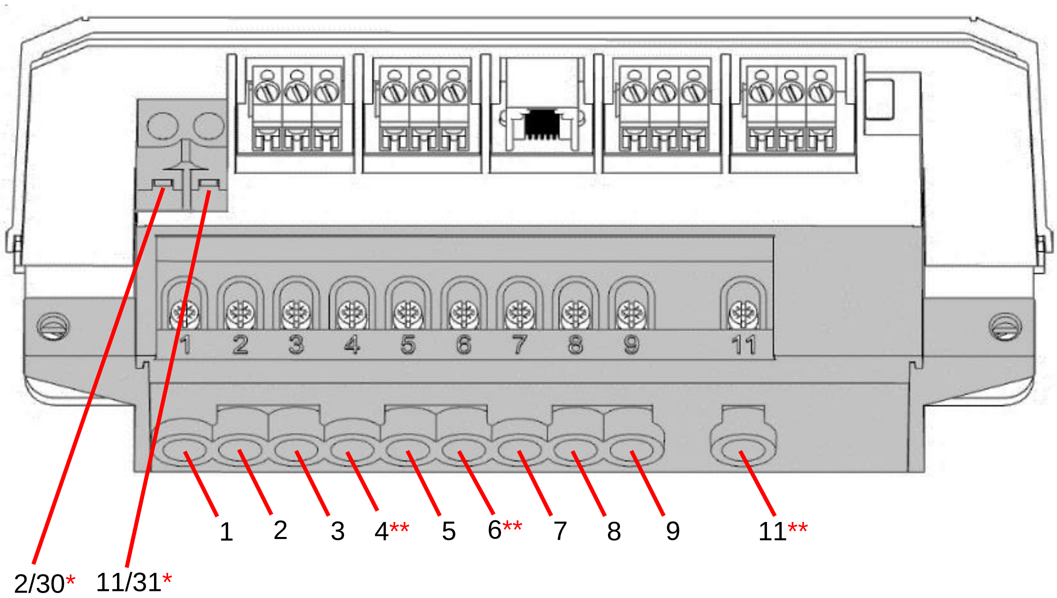
** Optional; the terminals are marked according to the functionality, which the meter is equipped with.

Table 4: Terminal data of three-phase meter with direct connection

NOTE

The minimum cross section of the wire conduction measuring current shall be according to standards and it is 2.5 mm^2. For the specific installation with the 2.5 mm^2 cross-section wire, see chapter *5. INSTALLATION.*

4.4.1.1.1.4. Three-phase indirect connected meter



* the terminals are marked according to the functionality, which the meter is equipped with
** the terminals 4, 6 and 11 are sealed in three-phase three-wire meter

Figure 28: Terminal block – example of a three-phase meter with indirect connection

1	I_{L1} – in	**8**	U_{L3}
2	U_{L1}	**9**	I_{L3} – out
3	I_{L1} – out	**11**	N
4	I_{L2} – in	**2**	Aux Voltage L – output power supply (optional)
5	U_{L2}	**11**	Aux N – output power supply (optional)
6	I_{L2} – out	**30**	Aux Voltage L – input power supply (optional)
7	I_{L3} – in	**31**	Aux N – input power supply (optional)

NOTE

The meter may be equipped with auxiliary terminals 2 and 11 or 30 and 31:

- If the meter is equipped with terminals 2 and 11, the meter can provide (output) power for external connected devices.
- If the meter is equipped with terminals 30 and 31, an external power supply source can be used for powering the meter (see chapter *4.4.1.1.2.1. Auxiliary power supply terminals*).
- The three-phase three-wire meters are not equipped with terminals 4, 6 and 11.
- When powering an external device over terminals 2 and 11, use a fast-acting fuse with the following rating:
  - Amp rating: < 150 mA
  - Voltage rating V AC/DC: 250 V
  - Interrupting rating at 250 V AC/DC: min. 4000 A

Termi-nal no.	Function	Refer-ence volt-age	Max. current	Diam. *[mm]*	Note	Wire *mm²*	Screw head *Type and size*	Torque *N m*
1	I_{L1} – in	–	1(10) A	5.0	current	1.5-6	Combi Pozidriv (1) + Slot	1.2
2	U_{L1}	230 V	–	5.0	voltage	1.5-6	Combi Pozidriv (1) + Slot	1.2
3	I_{L1} – out	–	1(10) A	5.0	current	1.5-6	Combi Pozidriv (1) + Slot	1.2
4	I_{L2} – in	–	1(10) A	5.0	current	1.5-6	Combi Pozidriv (1) + Slot	1.2
5	U_{L2}	230 V	–	5.0	voltage	1.5-6	Combi Pozidriv (1) + Slot	1.2

Termi-nal no.	Function	Refer-ence volt-age	Max. current	Diam. *[mm]*	Note	Wire *mm²*	Screw head *Type and size*	Torque *N m*
6	I_{L2} – out	–	1(10) A	5.0	current	1.5-6	Combi Pozidriv (1) + Slot	1.2
7	I_{L3} – in	–	1(10) A	5.0	current	1.5-6	Combi Pozidriv (1) + Slot	1.2
8	U_{L3}	230 V	–	5.0	voltage	1.5-6	Combi Pozidriv (1) + Slot	1.2
9	I_{L3} – out	–	1(10) A	5.0	current	1.5-6	Combi Pozidriv (1) + Slot	1.2
11	N	–	–	5.0	neutral	1.5-6	Combi Pozidriv (1) + Slot	1.2
2 or *30	Aux Voltage L out-put power supply or Aux Voltage L – in-put power supply	230 V	–	3.0	voltage	0.5-2.5	Combi Pozidriv (1) + Slot	0.6
11 or *31	Aux N (optional)	–	–	3.0	neutral	0.5-2.5	Combi Pozidriv (1) + Slot	0.6

* Optional; the terminals are marked according to the functionality, which the meter is equipped with

Table 5: Terminal data of three-phase meter with indirect connection

NOTE
The IE.7-TT2 allows only a current transformer (CT) connection.

4.4.1.1.2. Other connection terminals and interfaces

Other connection terminals and interfaces are located in the upper part of the terminal block. They are intended for connection of inputs and/or outputs, as well as for connection of the meter to a communication network. Which terminals and/or interfaces are implemented in the meter depends on customer preferences.

All connection terminals and interfaces are galvanic isolated from the main and auxiliary terminals for current and voltage.

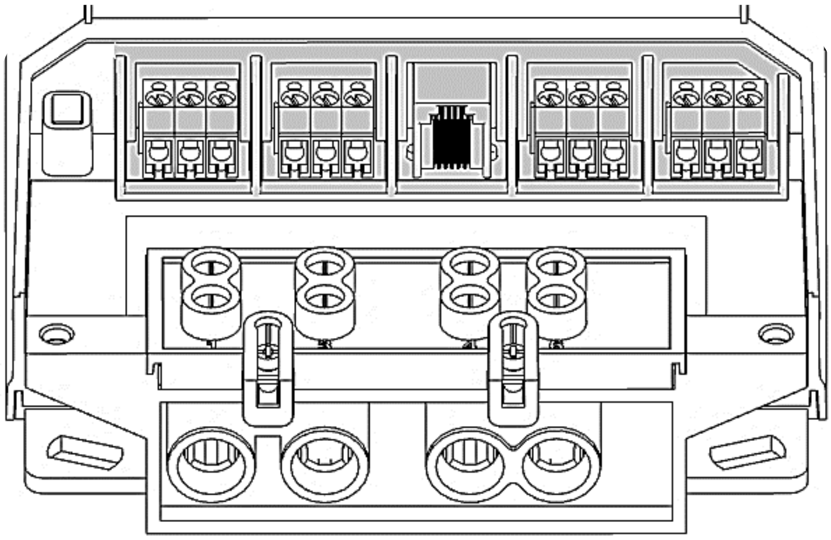


Figure 29: The position of other connection terminals and interfaces in the terminal block

In the upper part of the terminal block, the following types of terminals and interfaces may be implemented:

- a screw terminal Φ2.5,
- an RJ12 socket,
- an RJ45 socket.

The screw terminal Φ2.5

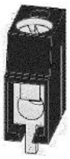


Figure 30: The screw terminal Φ2.5

Terminal data of the screw terminal Φ2.5:

Terminal data	Value
Diameter	2.5 mm
Wire	0.5–2.5 mm^2 (see the note below)
Screw head type and size	Slotted (0.6×3.5)
Torque	0.6 N m

NOTE
The minimum cross section of the wire shall be according to standards.

Screw terminals Φ2.5 are usually integrated in blocks by three (triple) or two (double) terminals.

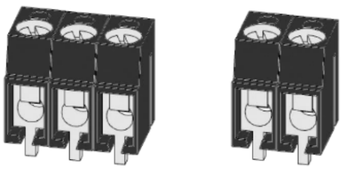


Figure 31: Triple and double screw terminal Φ2.5

The RJ12 female socket

The RJ12 female socket is intended for connecting the meter to a communication network. It is designed with six pins, where the first right pin is defined as pin no. 1.

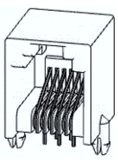


Figure 32: The RJ12 female socket

The RJ45 female socket

The RJ45 female socket is intended for connecting the meter to a communication network. It is designed by eight pins, where the first right pin is defined as pin no. 1.

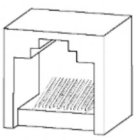


Figure 33: The RJ45 female socket

NOTE
The RJ45 female socket is not available yet.

4.4.1.1.2.1. Auxiliary power supply terminals

The meter can be equipped with an auxiliary power supply interface for external power supply in case of main power supply absence.

To connect the auxiliary power supply, use terminals 30 and 31.

NOTE
Currently, the auxiliary power supply interface is at the development stage. This functionality is not fully supported yet.

Termi-nal no.	Function	Refer-ence voltage	Extended operating voltage range	Reference frequency	Diam. *[mm]*	Note	Wire *[mm²]*	Screw head *Type and size*	Torque *[N m]*
30	U_L – ext	230 V	-20% to +15%	50 Hz	3.0	voltage	0.5–2.5	Slotted (0.6 × 3.5)	0.6
31	N – ext				3.0	neutral	0.5–2.5	Slotted (0.6 × 3.5)	0.6

Table 6: Terminal data for auxiliary power supply terminals

Characteristic	Value
Function	High voltage input
Type of a circuit	Power supply
Type of voltage	AC
Nominal voltage	230 V AC
Operating voltage range	230 V AC -20% / +15%
Maximum current consumption	100 mA
Nominal and maximum frequency	50 / 60 Hz
Insulation from other circuits	Functional insulation
Clamping of overvoltage	Varistor
Max surge overvoltage	4kV 1,2/50us

Table 7: Auxiliary power supply – electrical characteristics

4.4.1.1.2.2. Inputs

Inputs are integrated in the meter. They are placed on the top part of the terminal block. Which inputs are integrated into the meter depends on the customer preference in meter configuration.

For inputs, the screw terminal Φ2.5 type is used. When the output terminals are realized as a triple block, the middle terminal functions as a common terminal for the other two.

WARNING
With common terminals, there is no galvanic insulation between the other two terminals.

According to the input functionality, the appropriate terminal number is assigned.

Termi-nal no.	Function	Diam. *[mm]*	Note	Wire *[mm²]* *	Screw head type and size	Torque *[N m]*
55	Common terminal for terminals 50 and 51	2.5	Low voltage input	0.5-2.5	Slotted (0.6x3.5)	0.6
50	External key 1	2.5	Low voltage input	0.5-2.5	Slotted (0.6x3.5)	0.6
51	External key 2	2.5	Low voltage input	0.5-2.5	Slotted (0.6x3.5)	0.6
85	Common terminal for terminals 80 and 81 **	2.5	Low voltage input	0.5-2.5	Slotted (0.6x3.5)	0.6

Termi-nal no.	Function	Diam. *[mm]*	Note	Wire *[mm²]* *	Screw head type and size	Torque *[N m]*
80	Alarm input 1	2.5	Low voltage input	0.5-2.5	Slotted (0.6x3.5)	0.6
81	Alarm input 2	2.5	Low voltage input	0.5-2.5	Slotted (0.6x3.5)	0.6

* Minimum cross section of wire shall be according to standards.
** 85 is default terminal number for common terminal, where two inputs of different input groups are used.

Table 8: Terminal data of input terminals

Characteristic	Value
Function	Low voltage input
Type of a circuit	Optocoupler
Type of voltage	DC
Nominal voltage	4.7 V *
Maximum voltage	4.7 V *
Nominal current	/
Minimum current	/
Continuous current	/
Short time maximum current	/
Burden	/
Nominal and maximum frequency	/
Insulation from other circuits	Double insulation OVC III
Clamping of overvoltage	Zener diode

* No external voltage should be applied to the terminals. Only potential free (dry) contacts are allowed.

Table 9: Inputs – electrical characteristics

4.4.1.1.2.3. Outputs

The outputs are integrated in the meter. They are placed on the top part of the terminal block. Which outputs are integrated into the meter, depends on the customer choice of meter configuration.

For outputs, the screw terminal Φ2.5 type is used. When the output terminals are realized as a triple block, the middle terminal functions as a common terminal for the other two. The triple block may combine both Optomos and relay outputs. In this case, the common terminal is marked with number 40 and functions as common for both the Optomos and relay outputs.

The relay is available as monostable or bistable.

⚠ **WARNING**

In the case of the common terminal, there is no galvanic insulation between the other two terminals. The installer (or other authorized person) must provide overcurrent protection.

For the 5 A relay output, make sure to provide an external overcurrent protective device with a maximum value of 6 A.

For the Optomos output, make sure to provide an external overcurrent protective device with a maximum value of 0.1 A.

Depending on the output functionality, the relevant terminal number is assigned.

Termi-nal no.	Function	Diam. *[mm]*	Note	Wire *[mm²]* *	Screw head type and size	Torque *[N m]*
35	Common terminal for terminals 36 and 38	2.5	output – Optomos	0.5-2.5	Slotted (0.6x3.5)	0.6
36	Alarm output 1	2.5	output – Optomos	0.5-2.5	Slotted (0.6x3.5)	0.6
37	Measurement period output	2.5	output – Optomos	0.5-2.5	Slotted (0.6x3.5)	0.6

Termi-nal no.	Function	Diam. *[mm]*	Note	Wire *[mm²]* *	Screw head type and size	Torque *[N m]*
38	Alarm output 2	2.5	output – Optomos	0.5-2.5	Slotted (0.6x3.5)	0.6
40	Common terminal for terminals 41 to 48 **	2.5	output – Optomos	0.5-2.5	Slotted (0.6x3.5)	0.6
41-48	Digital output **	2.5	output – Optomos	0.5-2.5	Slotted (0.6x3.5)	0.6
71	Load control output 1	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
72	Load control output 2	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
73	Load control output 3	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
74	Load control output 4	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
75	Common terminal for 71 and 72	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
76	Common terminal for 73 and 74	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
77	Common terminal for 78 and 79	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
78	Load control output 5	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
79	Load control output 6	2.5	output – Relay	0.5-2.5	Slotted (0.6x3.5)	0.6
7A	Normally open	2.5	output – Bistable relay	0.5-2.5	Slotted (0.6x3.5)	0.6
7B	Normally closed	2.5		0.5-2.5	Slotted (0.6x3.5)	0.6
7C	Common terminal for 7A and 7B	2.5		0.5-2.5	Slotted (0.6x3.5)	0.6

* Minimum cross section of wire shall be according to standards.
** Metrological output

Table 10: Terminal data of output terminals

NOTE

For defining the terminal number of digital (metrological) outputs, Iskraemeco recommends using the following combinations of terminal numbers and functions:

Terminal number	Function
41	Metrological output for +A
42	Metrological output for -A
43	Metrological output for +R (programmable R1+R2 or R1+R4)
44	Metrological output for –R (programmable R3+R4 or R2+R3)
45	Metrological output for reactive energy QI
46	Metrological output for reactive energy QII
47	Metrological output for reactive energy QIII
48	Metrological output for reactive energy QIV

Characteristic/output type	Monostable relay	Bistable relay	Optomos
Function	Output	Output	Output
Type of a circuit	Relay	Relay	SSR
Type of voltage	AC or DC	AC or DC	AC or DC
Nominal voltage	230 V AC / 30 V DC	230 V AC / 24 V DC	230 V AC / DC
Maximum voltage	250 V AC	250 V AC	250 V peak
Switching current	5 A	16 A	100 mA
Minimum current	/	/	/
Continuous current	Max. 5 A / 250 V AC or max. 5 A / 30 V DC	Max. 16 A / 250 V AC or max. 16 A / 24 V DC	100 mA
Short time maximum current	NA	NA	120 mA
Burden	Max. 5 A / 250 V AC or max. 5 A / 30 V DC	Max. 16 A / 250 V AC or max. 16 A / 24 V DC	NA

Characteristic/output type	Monostable relay	Bistable relay	Optomos
Nominal and maximum frequency	50 Hz / 60 Hz	50 Hz / 60 Hz	50 Hz / 60 Hz
Insulation from other circuits	Double insulation OVC III	Double insulation OVC III	Double insulation OVC III
Clamping of overvoltage	/	/	Thyristor
Type of the contacts	Normally open (relay form A)	Normally open / Common / Normally closed (relay form C)	Normally open (relay form A)
Contact impedance	Contact resistance: max. 100 mΩ	Contact resistance: max. 100 mΩ	Max. 35 Ω at max. load current
Withstand voltage across open contacts	1 kV AC / 60 s	1 kV AC / 60 s	400 V DC/peak
Duty cycle	100%	100%	100%
Number of operating cycles	Mechanical endurance: 10^7 operations Electrical endurance: 10^5 operations	Mechanical endurance: 5×10^6 operations Electrical endurance: 5×10^4 operations	/

Table 11: Outputs – electrical characteristics

4.4.1.1.2.4. P1 port

The P1 port is a communication interface located in the top part of the terminal block. It is intended as an end-user interface for In-House Display (IHD) or Other Service Modules (OSM). The physical connector of the P1 interface is a RJ12 female socket. The P1 port may be accessible to the end user (when the terminal cover is sealed by a utility, and its sliding lid is not sealed), which depends on utility rules.

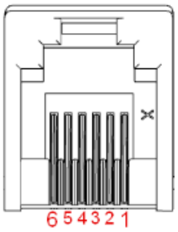


Figure 34: P1 port – RJ12 female socket

Two types of the P1 port are available, active and passive. The pin designation of the RJ12 socket connector differs based on the P1 type.

Passive P1

Pin #	Signal name	Description	Remark
1	+5 V	+5 V external power supply	Power supply line IN
2	Data Request	Data Request	Input
3	Data GND	Data Ground	/
4	n.c.	Not connected	/
5	Data	Data Line	Output. Open collector
6	Power GND	Power Ground	Power supply line IN

Table 12: The pin designation of the passive RJ12 connector

Active P1

Pin #	Signal name	Description	Remark
1	+5 V	+5 V power supply	Power supply line OUT
2	Data Request	Data Request	Input
3	Data GND	Data Ground	/

Pin #	Signal name	Description	Remark
4	n.c.	Not connected	/
5	Data	Data Line	Output. Open collector
6	Power GND	Power Ground	Power supply line OUT

Table 13: The pin designation of the active RJ12 connector

In the case of active P1, the first pin of the RJ12 connector (+5 V power supply line) provides a power source to OSM devices to enable their ability to process and transfer received metering data further wired.

Characteristic/P1 type	Active P1	Passive P1
Function	Communication and power supply	Communication
Type of voltage	DC	DC
Nominal voltage	5.0 V	/
Maximum voltage	5.5 V	/
Minimum voltage	4.9 V	/
Maximum continuous current	250 mA	/
Short circuit protection	YES	/
Type of short circuit protection	Foldback	/
Overvoltage protection	>15 V (Zener diode)	>15 V (Zener diode)
Type of data line output	Open collector	Open collector
Maximum baudrate	115200 baud	115200 baud
Insulation from other circuits	Double insulation OVC III	Double insulation OVC III

Table 14: Electrical characteristics of P1

4.4.1.1.2.5. RS-485

The RS-485 communication interface enables communication with external communication devices. It is integrated on the top of the terminal block.

One of the following types of RS-485 interfaces can be integrated in the meter:

- a triple screw terminal Φ2.5,
- a combination of a triple and double screw terminal Φ2.5 to easily make a cascade, or
- two RJ45 female sockets to easily make a cascade (not available yet).

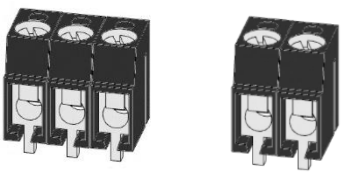


Figure 35: RS-485 terminals (triple and double screw terminal)

Terminal number	Diam. *[mm]*	Note	Wire *[mm²]* *	Screw head *type* and *size*	Torque *[N m]*
27	2.5	A	0.5-2.5	Slotted (0.6×3.5)	0.6
28	2.5	GND	0.5-2.5	Slotted (0.6×3.5)	0.6
29	2.5	B	0.5-2.5	Slotted (0.6×3.5)	0.6

* Minimum cross section of wire shall be according to standards.

Table 15: Terminal data of RS-485 interface

Characteristic	Value
Function	Communication

Characteristic	Value
Type of a circuit	/
Type of voltage	DC
Nominal voltage	/
Maximum voltage	/
Nominal current	/
Minimum current	/
Continuous current	/
Short time maximum current	/
Burden	RS-485 devices
Nominal and maximum frequency	/
Insulation from other circuits	Double insulation OVC III
Clamping of overvoltage	TVS diode

Table 16: Electrical characteristics of RS-485

4.4.1.1.2.6. G3-PLC

Optionally, the meter can be equipped with a built-in G3-PLC communication modem, which enables bidirectional communication through a power line network using G3-PLC technology.
The G3-PLC modem is connected to the low voltage network internally via L1 phase.

Technical characteristics of the built-in G3-PLC modem are:

- **Physical**: G3-PLC (ITU-T G.9903)
  - CENELEC A Band (35 kHz – 91 kHz)
  - Up to 36 tonnes (CENELEC A)
  - Modulation: ROBO, BPSK/DBPSK, QPSK/DQPSK, 8PSK /D8PSK
  - Data rate for CENELEC A up to 42619 bits/s
- **Data Link**: (IEEE 802.15.4)
  - Security: AES-128
  - CSMA-CA
  - ARQ
  - Link Adaptation
  - modulation type
  - tunes used
- **Network**: LOADng routing (RFC3561, RFC6130 and RFC5444)
  - Mesh
  - On-Demand
  - Ad-Hoc
  - Distance Vector
  - Next generation
  - Route repair Mechanism
- **Adaptation**: 6LoWPAN (RFC4944)
  - EAP-PSK Authentication
  - Packet Fragmentation
  - Header Compression

4.4.1.1.2.7. M-Bus

The meter may be optionally equipped with a wired or wireless M-Bus interface. It is used to connect sub-meters (gas, heat, and water) and other devices that are designed according to the EN 13757-3, EN 13757-4 and EN 13757-7 standards, and OMS specification 4.1.2. The maximum number of M-Bus devices connected to one electricity meter is four.

Wired M-Bus interface

The wired M-Bus interface is realized by a double screw terminal 90/91 in the top part of the terminal block.

Terminal number	Function	Reference voltage	Max. current	Diam. *[mm]*	Note	Wire type and size *[mm²]* *	Screw head type and size	Torque *[N m]*
90, 91	M-Bus	36 V	24 mA**	2.5	M-Bus	Twisted pair 0.5-2.5	Slotted (0.6×3.5)	0.6

* The minimum cross section of the wire must comply to any relevant standard.

** The maximum number of wired M-Bus devices associated to one electricity meter is four (each with a current consumption of max. 4 unit loads = 6 mA; in total 24 mA). The maximum current consumption of all connected M-Bus devices is 16 unit loads.

Table 17: Terminal data of wired M-Bus

Characteristic	Value
Function	Communication
Type of a circuit	NA
Type of voltage	DC
Nominal voltage	36 V
Maximum voltage	37 V
Nominal current	NA
Minimum current	NA
Continuous current	NA
Short time maximum current	NA
Burden	M-Bus devices
Nominal and maximum frequency	/
Insulation from other circuits	Double insulation CAT III
Clamping of overvoltage	Varistor

Table 18: Electrical characteristics of wired M-Bus

Wireless M-Bus interface

The wireless M-Bus (wM-Bus) interface is integrated in the meter under the meter housing and is physically not accessible to the installer or end user. Due to the wireless connection, there is no need for any terminal.

Characteristic	Value
Function	RF communication
Type of voltage	DC
Nominal voltage	3.3 V
Maximum voltage	3.6 V
Minimum voltage	3.0 V
Nominal current consumption	16 mA
Maximum current consumption	140 mA
Minimum current consumption	2.2 µA
Operating frequency	Tx: 868.3 MHz / Rx: 869.0 MHz
Conductive output power	18 dBm
ERP	10.4 dBm
TRP	8.6 dBm
Maximum input RF level	10 dBm
Sensitivity	-114 dBm (4.8 kbit/s) / -105 dBm (32.768 kbit/s) / -101 dBm (100 kbit/s)
Antenna type	Helical PCB Antenna
Operating temperature	-30 °C – 85 °C

Table 19: Electrical characteristics of wireless M-Bus

4.4.1.1.2.7.1. WM-Bus antenna

When the wM-Bus signal is weak, we recommend to use an external antenna. To connect an antenna, you may use an Iskraemeco AT160-A5 antenna coupler. For more information, please refer to the AT160-A5 technical description.

To select the appropriate antenna for your use case, we advise you to consult with our technical sales team.

The minimum required antenna technical specifications are:

- antenna connector: male SMA,
- support for single band 868 MHz.

Figure 36: SMA antenna male connector

NOTE

When selecting the antenna, please make sure the antenna gain does not exceed:

- **9 dBi** – applies to the antenna connected to a **single-phase** meter,
- **11 dBi** – applies to the antenna connected to a **three-phase** meter.

NOTE

For safety reasons, we advise to maintain a minimum distance of 20 cm between the external antenna and the end user during device operation.

4.4.1.1.3. Terminal cover opening detector

The terminal cover opening detector detects each opening of the terminal cover.

The terminal cover opening detector of the single-phase meter is located on the left side of the terminal block, while of the three-phase meter is on the right side.

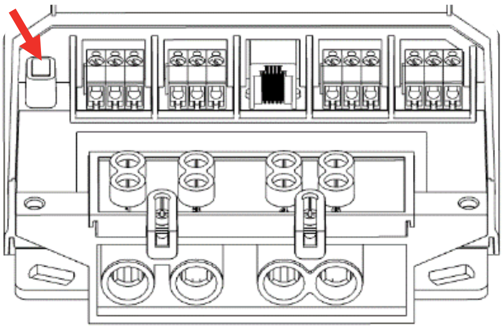


Figure 37: The terminal cover opening detector of the single-phase meter

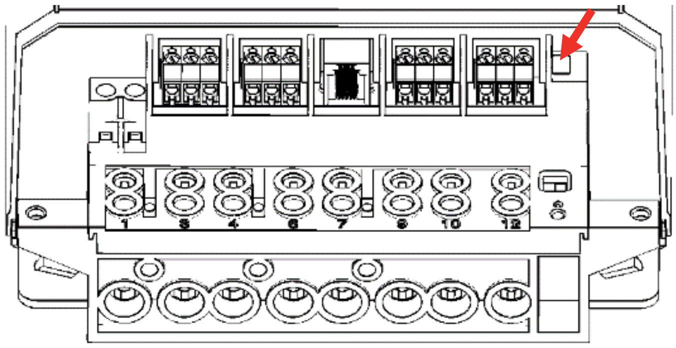


Figure 38: The terminal cover opening detector of the three-phase meter

4.4.1.2. The terminal cover

The terminal block is covered with a terminal cover. It is fixed to the meter with two sealing screws.

The terminal cover is made of high quality self-extinguishing UV-stabilized polycarbonate that can be recycled.

It is available in two sizes:

- long (standard), or
- short.

In the short cover, the connection terminals are accessible with the cover attached and sealed.

Optionally, the long terminal cover can be equipped with a sliding lid, which enables quick access to specific non-main terminals without removing the terminal cover (see Figure 41 and Figure 42). The sliding lid features a locking cap, which may be sealed in the locked position. How to use the sliding lid is described in chapter *5.2.2. Access to integrated terminals (option)*.

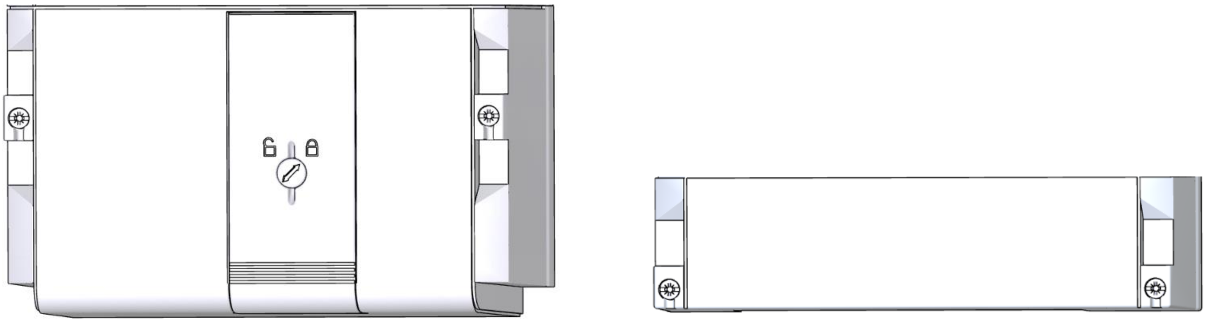


Figure 39: The terminal cover (left: long (standard), right: short)

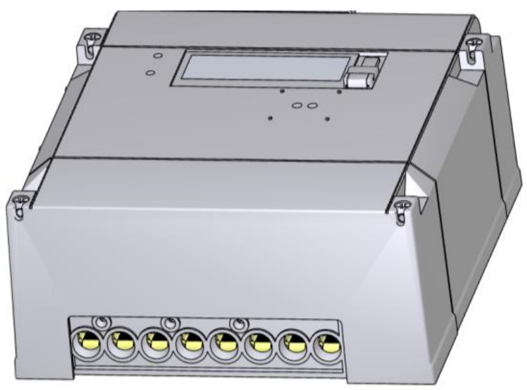


Figure 40: The short terminal cover with visible connection terminals

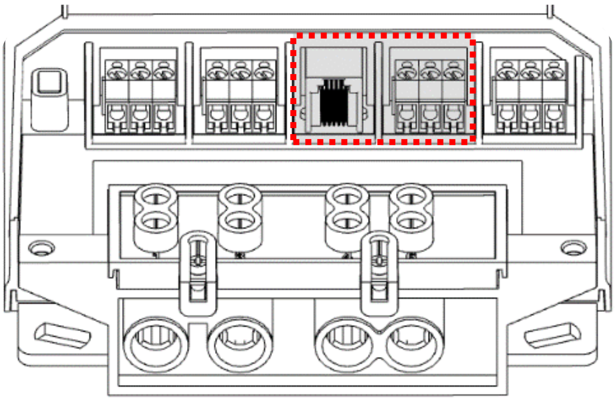


Figure 41: The position of accessible terminals when the sliding lid is removed – an example of the single-phase meter

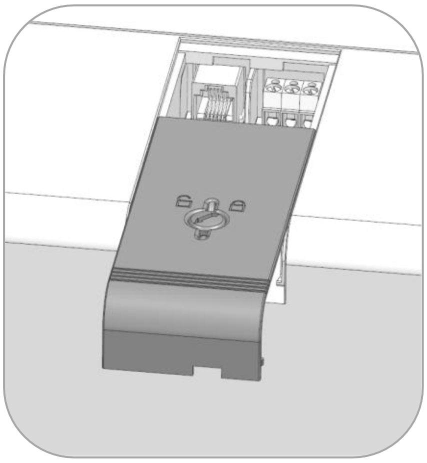


Figure 42: Enabled terminals, option with P1 port and I/O

On the inner side of the terminal cover, a meter hanger is attached.

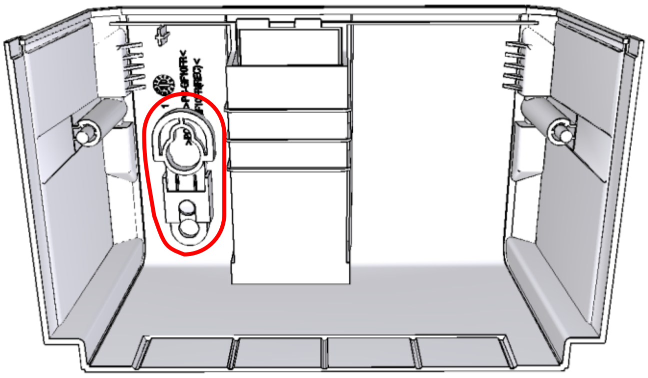


Figure 43: The inner side of the terminal cover with attached meter hanger

4.4.2. The main meter part

The main meter part consists of:

- a meter cover,
- a nameplate (the bottom part),
- a display,
- two pushbuttons,
- a disconnector LED,
- one or two metrological LEDs,
- an IR optical interface,
- a CT-ratio plate.

4.4.2.1. The meter cover

The meter cover is a part of the meter, which covers the main part of the meter. It is permanently fixed and has no possibility of opening.

The meter cover is made of non-transparent high quality self-extinguishing UV-stabilized polycarbonate that can be recycled.

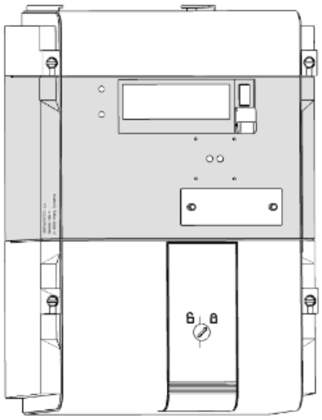


Figure 44: The meter cover

The bottom part of the nameplate is printed on the front plate of the meter cover. The manufacturer address is laser printed on the left-hand sloped side of the meter cover.

4.4.2.2. The nameplate

The nameplate is laser printed on the front plate of the meter main and modular part. A basic data, like type designation and connection diagram of the meter can be found on the nameplate.

The upper part of the nameplate, printed on the front of the module cover, includes four basic data. Figure 45 shows an example of the nameplate's upper part.

Figure 45: An example of the upper part of the IE.x meter nameplate

1 Iskraemeco corporate logo
2 Product brand name
3 Meter product family
4 Technology of the communication module

NOTE

Figures in the following subchapters represent examples of bottom parts of nameplates. The nameplate is customer specific.

4.4.2.2.1. Single-phase meter

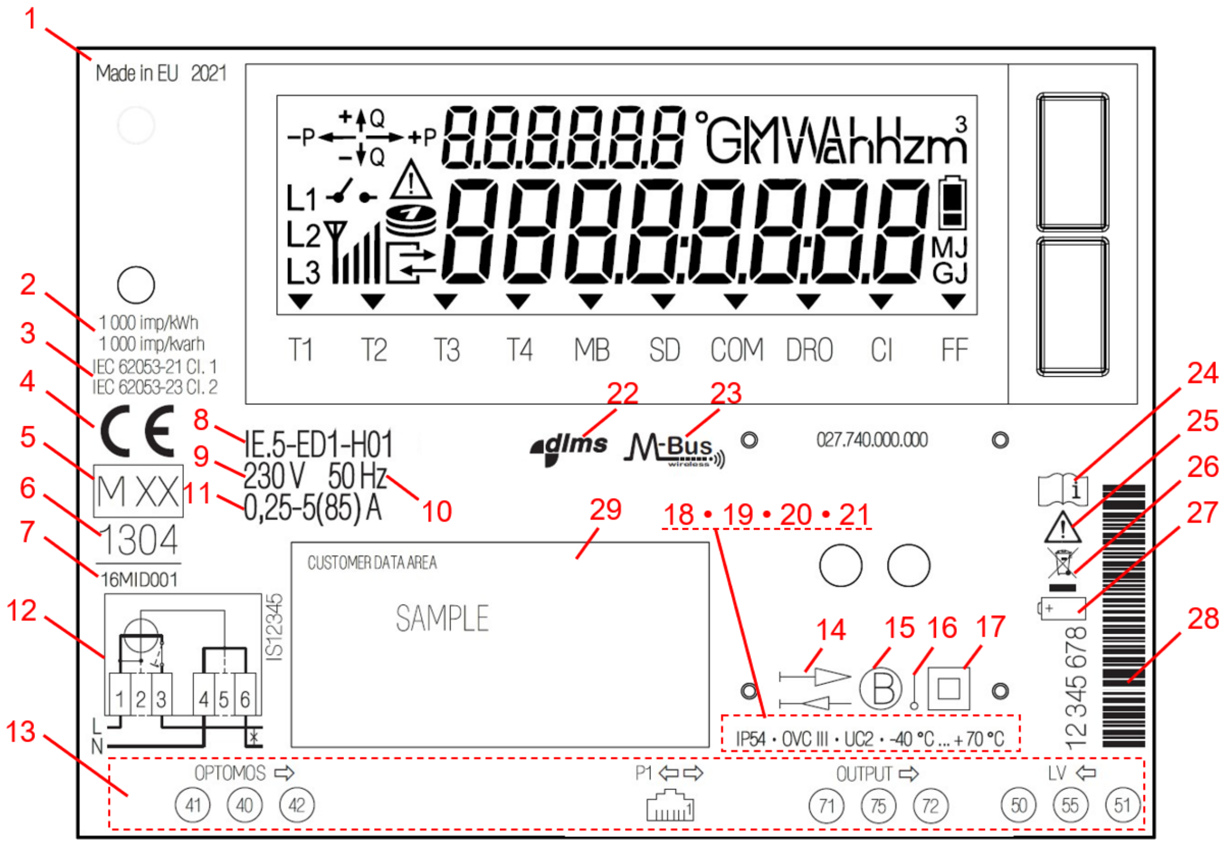


Figure 46: An example of the single-phase IE.5 meter nameplate

1	Country of origin and year of manufacture	**15**	Accuracy class (active energy, MID)
2	Accuracy test LED constants for active (kwh) / reactive (kvarh) energy	**16**	Connection type
3	Standard and accuracy class for active (top) and reactive (bottom) energy	**17**	Protection class (IEC 62052-11)
4	CE mark	**18**	Ingress protection (IEC 60529) – IP54
5	Year of MID approval	**19**	Overvoltage category
6	Code of MID approval institute	**20**	Utilization category
7	MID approval number	**21**	Operation temperature range
8	Meter type designation	**22**	DLMS/COSEM compliance
9	Reference voltage	**23**	Wireless M-Bus communication
10	Reference frequency	**24**	See user manual with operating instructions
11	Transition, reference, and max. current	**25**	Caution, refer to accompanying documents
12	Meter connection diagram	**26**	Dispose of in accordance with applicable legislation for electronic equipment
13	Area for non-main connection designations	**27**	Replaceable battery
14	Bidirectional meter	**28**	Meter serial number and its bar code
		29	Customer data area

4.4.2.2.2. Three-phase meter

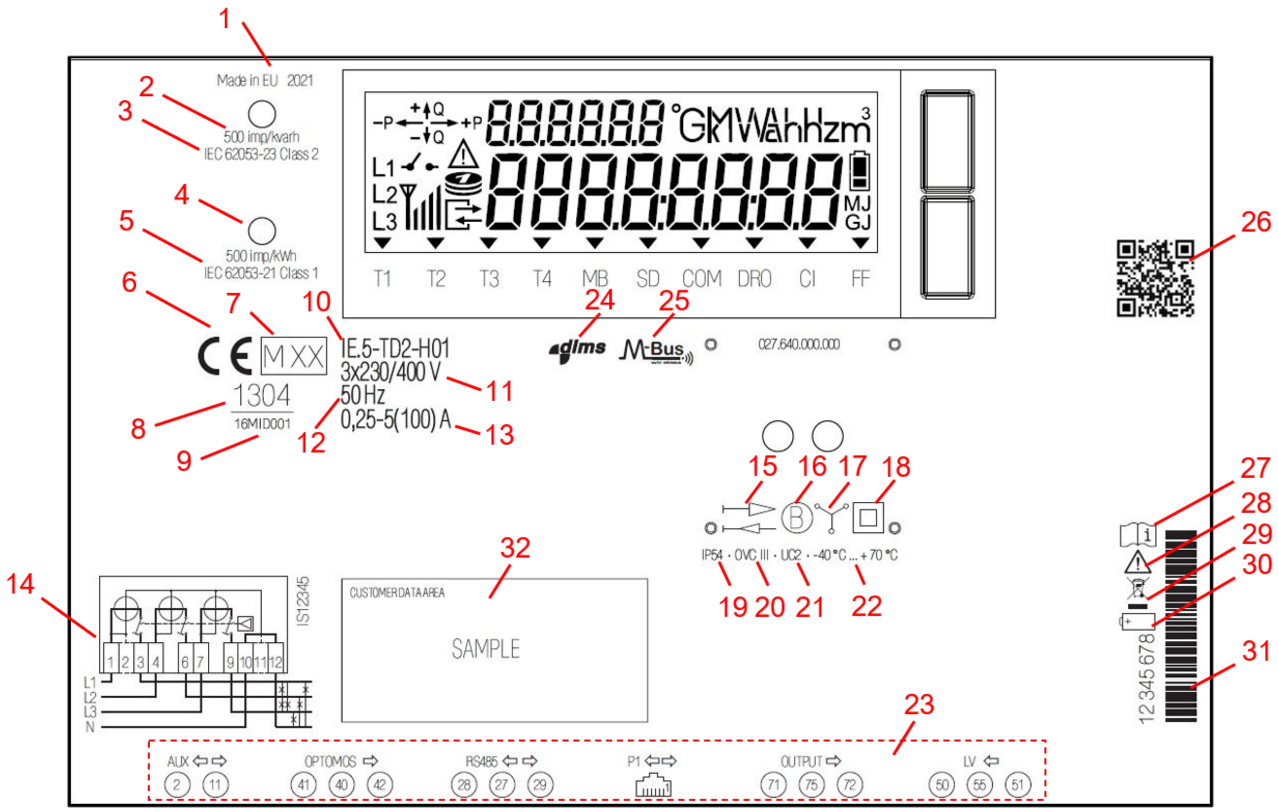


Figure 47: An example of the three-phase IE.5 meter nameplate

1 Country of origin and year of manufacture
2 Accuracy test LED constant for reactive (kvarh) energy
3 Standard and accuracy class for reactive energy
4 Accuracy test LED constant for active (kwh) energy
5 Standard and accuracy class for active energy
6 CE mark
7 Year of MID approval
8 Code of MID approval institute
9 MID approval number
10 Meter type designation
11 Reference voltage
12 Reference frequency
13 Transition, reference, and max. current
14 Meter connection diagram
15 Bidirectional meter
16 Accuracy class (active energy, MID)
17 Connection type
18 Protection class (IEC 62052-11)
19 Ingress protection (IEC 60529) – IP54
20 Overvoltage category
21 Utilization category
22 Operation temperature range
23 Area for non-main connection designations
24 DLMS/COSEM compliance
25 Wireless M-Bus communication
26 2D code with customer specific data
27 See user manual with operating instructions
28 Caution, refer to accompanying documents
29 Dispose of in accordance with applicable legislation for electronic equipment
30 Replaceable battery
31 Meter serial number and its bar code
32 Customer data area

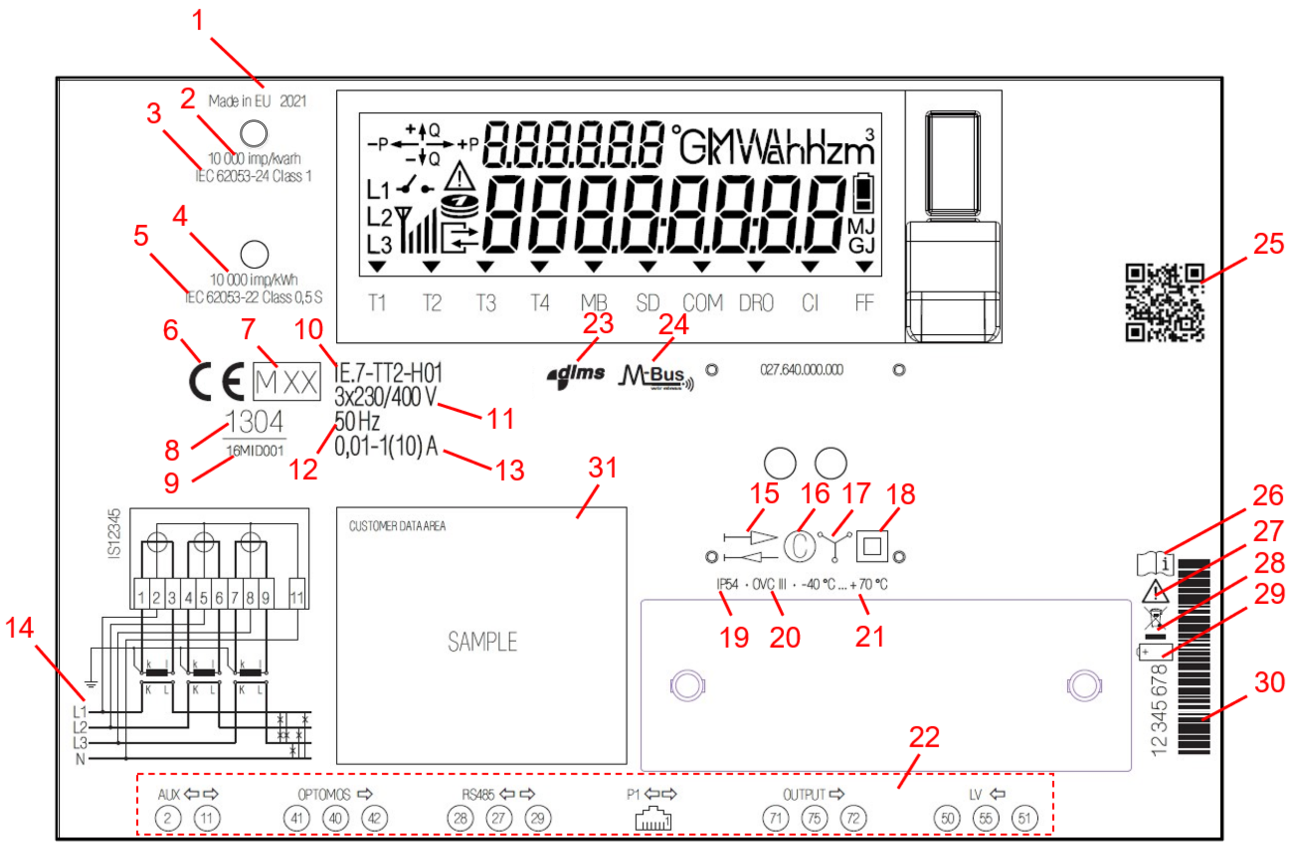


Figure 48: An example of the three-phase IE.7 meter nameplate

1	Country of origin and year of manufacture
2	Accuracy test LED constant for reactive (kvarh) energy
3	Standard and accuracy class for reactive energy
4	Accuracy test LED constant for active (kwh) energy
6	CE mark
5	Standard and accuracy class for active energy
7	Year of MID approval
8	Code of MID approval institute
9	MID approval number
10	Meter type designation
11	Reference voltage
12	Reference frequency
13	Transition, reference, and max. current
14	Meter connection diagram
15	Bidirectional meter
16	Accuracy class (active energy, MID)
17	Connection type
18	Protection class (IEC 62052-11)
19	Ingress protection (IEC 60529) – IP54
20	Overvoltage category
21	Operation temperature range
22	Area for non-main connection designations
23	DLMS/COSEM compliance
24	Wireless M-Bus communication
25	2D code with customer specific data
26	See user manual with operating instructions
27	Caution, refer to accompanying documents
28	Dispose of in accordance with applicable legislation for electronic equipment
29	Replaceable battery
30	Meter serial number and its bar code
31	Customer data area

4.4.2.3. The display

The display is a seven-segment liquid crystal display (LCD).

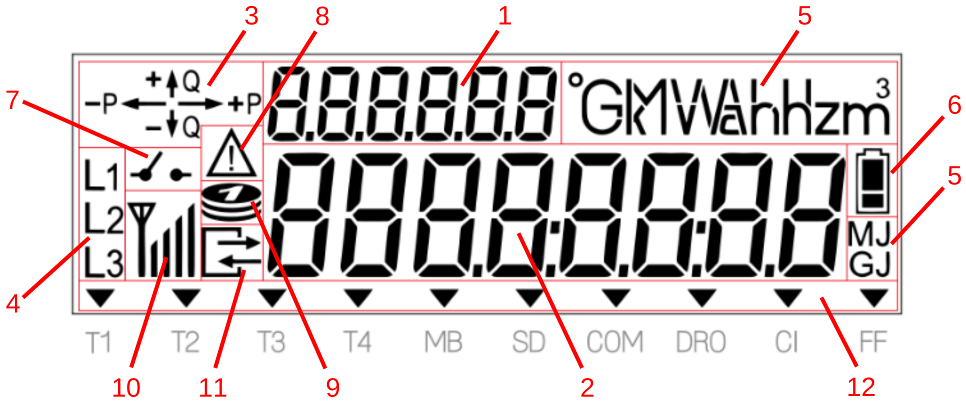


Figure 49: All segments of the LCD display (example)

1 Alphanumeric field, 1 – 6 small digits (6 mm in height) – OBIS identification code presentation	**6** Battery status
2 Alphanumeric field, 2 – 8 large digits (10 mm in height) – Data value presentation	**7** Disconnector status
3 Power flow direction cursors	**8** Fatal failure status
4 Indicators of voltage presence by phases	**9** Prepayment status
5 Physical unit field of the currently displayed data	**10** Cellular signal quality
	11 Data read out status
	12 Cursors

NOTE
Cursors are customer specific.

Alphanumeric fields (marks 1 and 2 in the Figure 49)

Alphanumeric field 1 is used for presentation the OBIS identification codes of the displayed data (in accordance with DIN 43863-3; see chapter *9.3.1. OBIS code on the display*). The character size is 6 mm.

Alphanumeric field 2 is used to present the data value. The character size is 10 mm.

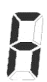
Available characters

In *Alphanumeric field 1* and *Alphanumeric field 2*, following characters can be presented:

"[*space*]", "_","-"
"0", "1", "2", "3", "4", "5", "6", "7", "8", "9",
"A", "B", "C", "D", "E", "F", "G", "H", "I", "J", "K" *, "L", "N", "O", "P", "R", "S", "T", "U", "Y", "Z" (Letters: B, D, N, O, R, T, U will be displayed as: b, d, n, o, r, t, u)
"a", "b", "c", "d", "e", "f", "g", "h", "i", "j", "k" *, "l", "n", "o", "p", "r", "s", "t", "u", "y", "z" (Letters: a, e, f, g, j, l, p, s, y, z will be displayed as: A, E, F, G, J, L, P, S, Y, Z)

* see the note below

NOTE
Characters "K" and "k" are displayed on LCD using the same character:



Energy flow direction cursors (mark 3 in the Figure 49)

Positive power on display (+P, +Q) is related to positive energy flow direction while negative power on display (-P, -Q) is related to negative energy flow direction.

There are four energy flow direction cursors on the display:

- Positive active energy flow (+P),
- Positive reactive energy flow (+Q),
- Negative active energy flow (-P),
- Negative reactive energy flow (-Q).

Energy flow direction cursors at simultaneous Import and Export of energy

Here are some examples that show which segment on the quadrant cross is displayed when Import and Export of the energy occurs simultaneously:

- Active Energy: SUM = L1 + L2 + (-L3) > 0; arrow on display →
- Active Energy: SUM = L1 + L2 + (-L3) < 0; arrow on display ←
- Reactive Energy: SUM = L1 + L2 + (-L3) > 0; arrow on display ↑
- Reactive Energy: SUM = L1 + L2 + (-L3) < 0; arrow on display ↓

The phases indicator (mark 4 in the Figure 49)

Segments L1, L2 and L3 show indicated phases on meter.

Blinking single segment indicates neutral and phase conductor mix in 3-phase meter (priority 1).

Blinking all segments represents wrong phase sequence connection (priority 2).

The physical unit field (mark 5 in the Figure 49)

Physical unit field shows the unit of currently displayed data. Following units can be displayed:

- Active energy in kWh
- Reactive energy in kvarh
- Apparent energy in kVAh
- Demand in kW
- Current in A
- Voltage in V

Battery status (mark 6 in the Figure 49)

Battery status symbol represents battery (power supply backup) state. The battery state is defined according to:

- a battery connection related to the meter
- a battery remaining use time (**Battery estimated remaining use time counter** (0-0:96.6.6*255))
- a battery health

Related to battery state, the battery status symbol is displayed on the LCD. A meaning of the symbol of different battery statuses is described in the Table 20.

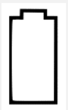
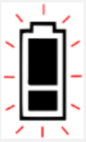
Battery status symbol on the LCD	Meaning
	The battery is not connected (the symbol is OFF)
	The battery connected and more than 40% of the battery time remains
	Battery connected and 20-40% of the battery time remains
	Battery connected and 10-20% of the battery time remains
	Battery connected and less than 10% of the battery time remains
	Battery voltage drop below threshold (3 V) due to: a battery failure or an action of battery disconnection

Table 20: The battery status symbol on the LCD and meanings

For a definition of the “battery remaining time”, refer to chapter *9.1.2. The role of the battery in* power supply backup.

NOTE
Battery fail checking is executed during a battery diagnostic function (measuring battery voltage). The battery diagnostic is performed daily.

Disconnector status (mark 7 in the Figure 49)

Disconnector status symbol on the LCD:

- is **ON** when the disconnector is in the *disconnected state*
- is **blinking** when the disconnector is *ready for connection*
- is **OFF** when the disconnector is in the *connected state*.

Fatal failure status (mark 8 in the Figure 49)

The symbol is ON when a Fatal failure is present.

Prepayment status (mark 9 in the Figure 49)
This symbol is related to prepayment mode.

Cellular signal quality (mark 10 in the Figure 49)

The symbol display the wireless signal quality, represented in range 0..31 as:

- 25..31 Excellent (all segments are on)
- 17..24 Good (all segments are on except biggest segment)
- 10..16 Fair (first three segments are on)

- 0..9 Poor (first two segments are on)
- 99 signal quality is not known or not detectable (first segments “antenna is blinking”)

Data read out status (mark 11 in the Figure 49)

Meter data reading is active (P1 port is excluded).

Cursors (mark 12 in the Figure 49)

The meter has laser-printed markings on the front plate below the LCD display. These markings belong to the cursors on the LCD. Depending on the meter configuration, these cursors have different meaning. Cursors show the state of a certain function that they represent. In Table 21, the meanings of available cursors are described.

NOTE

The selection of cursors is customer-specific (factory settable parameter), and their number is limited to 10. Defined configuration of LCD cursors can be accessible by **Display cursors configuration** (0-0:196.1.4*255).

Cursor mark	Function of the cursor	Meaning of displayed cursor
T1	Energy tariff 1 (5)	The cursor is: • ON – energy tariff 1 is active • Blinking – energy tariff 5 is active and the tariff 5 is not configured with the cursor T5
T2	Energy tariff 2 (6)	The cursor is: • ON – energy tariff 2 is active • Blinking – energy tariff 6 is active and the tariff 6 is not configured with the cursor T6
T3	Energy tariff 3 (7)	The cursor is: • ON – energy tariff 3 is active • Blinking – energy tariff 7 is active and the tariff 7 is not configured with the cursor T7
T4	Energy tariff 4 (8)	The cursor is: • ON – energy tariff 4 is active • Blinking – energy tariff 8 is active and the tariff 8 is not configured with the cursor T8
T5	Energy tariff 5	The cursor is ON – energy tariff 5 is active.
T6	Energy tariff 6	The cursor is ON – energy tariff 6 is active.
T7	Energy tariff 7	The cursor is ON – energy tariff 7 is active.
T8	Energy tariff 8	The cursor is ON – energy tariff 8 is active.
DRO	Data read out	The cursor is ON when a communication session on any interface is active, except on the P1 port.
CI	Consumer interface	The cursor is ON when a Consumer Information Push (CIP) is active on the P1 communication interface.
MU	Multi-utility	The cursor is ON when at least one M-Bus device is successfully installed on the meter.
SD	Circuit Breaker	The cursor is ON when a disconnector is disconnected (applies for states “Disconnected” and “Ready for reconnection”).
SD_B	Disconnector – blinking	The cursor is: • ON – the disconnector is disconnected (state “Disconnected”). • blinking – the disconnector is disconnected (state “Ready for reconnection”). • OFF – the disconnector is connected (state Connected).
COM	Communication network	The cursor is ON when a communication modem (in connected communication module in the FEM) is registered to communication network (applies for GSM, GPRS, CDMA, LTE, G3 PLC; see the note below this table).
FF	Fatal failure	The cursor is ON when any error of the Fatal Failure is detected.
LR	Legally relevant	The cursor is ON when a legally relevant data is displayed.
OU	Opt-out	The cursor is ON when the Load Profile recording is disabled.

Table 21: LCD – meaning of available cursors

NOTE

Registered to a mobile network means connected to a GSM/GPRS network or established default LTE bearer. A GSM/GPRS connection, or default LTE bearer does not mean that a PDP context or dedicated LTE bearer is established, that depends on other settings of the meter (for example ***Auto connect*** object).

4.4.2.4. Buttons and the disconnector status LED

On the right side of the LCD, two push-buttons are available, upper, and lower.

The following button sets are available:

a) a regular upper button, a non-sealable lower button,
b) a regular upper button, a sealable lower button with a transparent sealable sliding cap,
c) a regular upper button, a sealable lower button with a non-transparent sealable sliding cap.

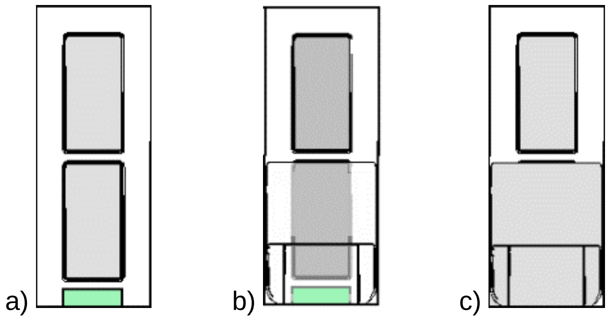


Figure 50: Available button sets

The buttons are available in standard grey or colour.

NOTE

The button set and colour must be defined before the meter production.

The disconnector LED is located under the bottom button. The LED diode is green.

The disconnector LED informs a user about disconnector status. When the LED diode:

- ***lights***, the disconnector is disconnected,
- ***blinks***, the disconnector is ready to connect,
- ***is off,*** the disconnector is connected.

If the bottom button is equipped with the non-transparent sealable sliding cap, the LED is not visible for the user; otherwise, it is.

4.4.2.5. The metrological LED

The single-phase meter is provided with one and three-phase with two red coloured metrological LEDs (accuracy test LED). It/They are located on the front plate of the meter plate.

The metrological LED is intended for checking/testing the meter accuracy (for active (kWh) / reactive (kvarh) energy / apparent (kVAh) energy). Impulse constant depends on the meter type (see Table 29).

In normal meter operation mode, the LED emits pulses with a frequency that is proportional to the measured energy and is intended for meter calibration and testing. The LED is permanently on if the present current is lower than the starting current of the meter.

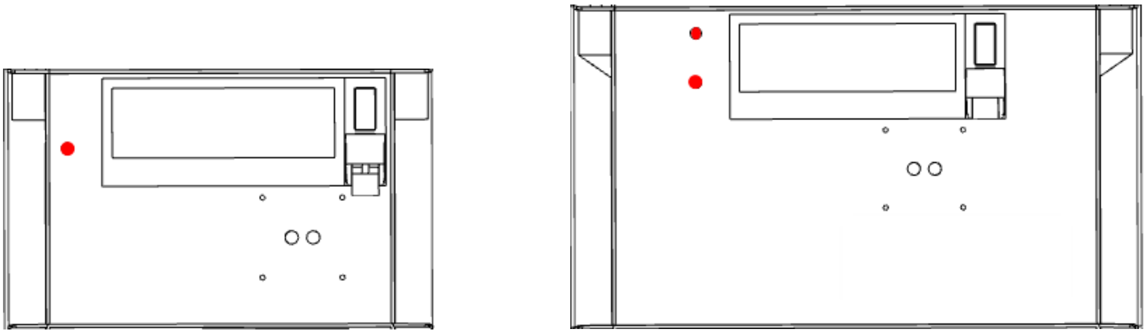


Figure 51: Metrological LEDs on the front plate of the meter (left: the single-phase meter, right: the three-phase meter)

4.4.2.6. The IR optical interface (P0)

The bottom right below the LCD, the optical interface (P0) is located. It is a bi-directional type of the optical interface and is intended for a local setting of the meter parameters and a local data readout. The optical interface (physical characteristics) is designed according to the IEC 62056-21 standard.

The wavelength of the optical port light is 875 nm; luminous intensity in active state is min. 1 mW/sr.

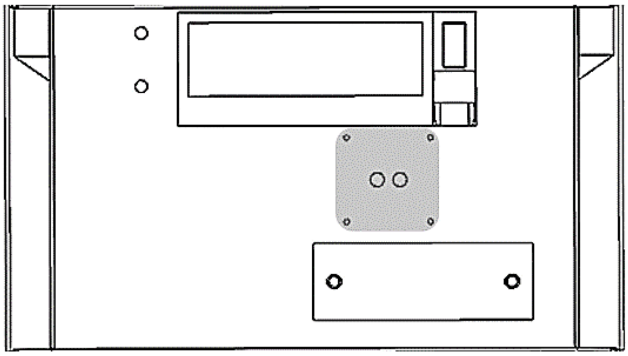


Figure 52: The IR optical interface

4.4.2.7. The CT-ratio plate

The CT-ratio plate is available only at three-phase indirect connected meters, where the ratio of current or voltage transformer can be written. The plate for a CT-ratio label is made in transparent colour.

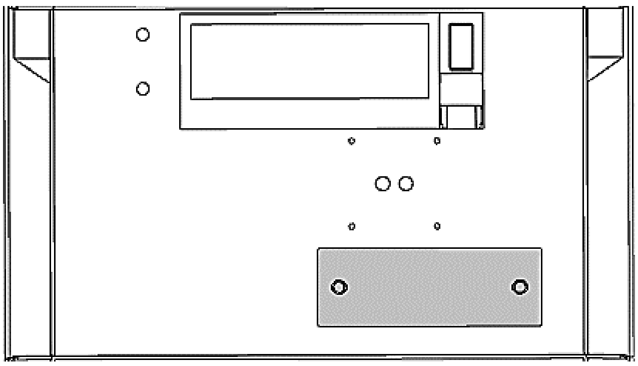


Figure 53: The CT-ratio plate

The current/transformer ratio can be written on the dedicated CT-ratio label. The label can be inserted on the front side of the meter, where a small plate with two pins is available for fixing and sealing the label.

If needed, the label can be sealed through both pins.

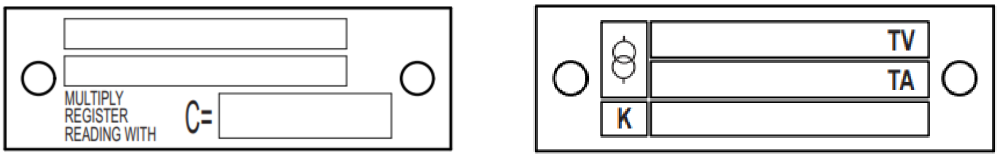


Figure 54: The CT ratio label (examples)

4.4.3. The modular part of the meter

The modular part of the meter consists of:

- an exchangeable communication module,
- a replaceable battery,
- a module cover,
- the upper part of the nameplate (refer to chapter 4.4.2.2. The nameplate)
- a module removal detector.

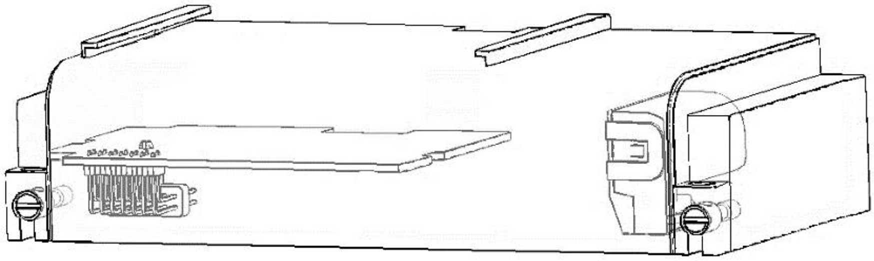


Figure 55: The modular part of the meter and its parts

4.4.3.1. The exchangeable communication module

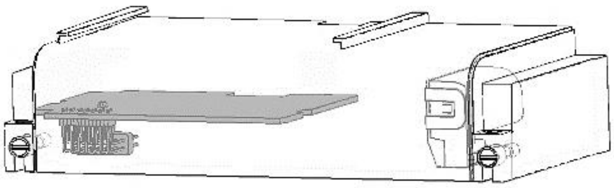


Figure 56: The module

A meter module is an exchangeable, plug-in hardware unit, which is fitted in the communication module cover. The module is exchangeable and can be replaced.

A cover of the communication module is made of non-transparent high quality self-extinguishing UV-stabilized polycarbonate that can be recycled.

The communication module is intended for bi-directional meter communication by WAN/NAN (P3). For IE.x meters, several communication modules with different supported WAN communication technologies are available.

The communication module is connected to the meter by 14-pin connector via a **FEM** connector socket. The **FEM** is a physical part of a so-called **P*** interface, which supports different Iskraemeco exchangeable communication modules. The FEM is integrated in the meter under the module cover.

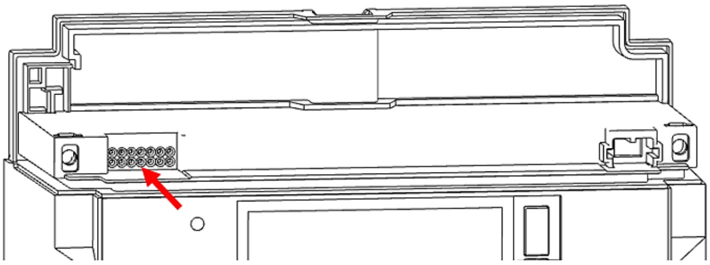


Figure 57: The FEM connector socket (P interface)*

Function	Power supply and communication
Type of a circuit	NA
Type of voltage	DC
Nominal voltage 1	4.0 V
Maximum voltage 1	4.15 V
Minimum voltage 1	3.6 V
Nominal current 1	NA
Minimum current 1	NA
Continuous current 1	NA
Short time maximum current 1	1 A max
Nominal voltage 2	3.3 V
Maximum voltage 2	3.45 V
Minimum voltage 2	3.15 V
Nominal current 2	NA
Minimum current 2	NA
Continuous current 2	NA
Short time maximum current 2	10 mA max
Maximum continuous total power	4 W
Short circuit protection	None
Type of short circuit protection	NA
Type of data line output	NA
Burden	NA
Maximum baudrate	115200 baud max
Insulation from other circuits	None
Clamping of overvoltage	None

Table 22: The communication module - electrical characteristics of the FEM

The module exchange can be performed even when the meter is in the full operational state, but only with awareness and consideration of all safety regulations and recommendations.

The meter ensures redundant power supply (up to 40 seconds of available time after a power outage) to itself as to the communication module in case of the power outage of the meter power supply.

The circuit enables Push on Power down feature (Last Gasp), which is managed by the meter (see chapter *9.5.1. Push on Power down (Last gasp)*).

NOTE

Charging of backup power supply starts after the primary power supply is re-established. It takes up to 60 minutes to fully charge the backup power supply.

DANGER!

Do not touch the communication module in form of a PCB if the meter is under voltage. It is dangerous for life.

In case the module cover is removed, and the PCB remains in the meter, the meter must be disconnected from the mains before the beginning of removing the PCB out of the FEM connector socket.

WARNING!

Electrostatic electricity may harm some parts of the module/host device. To prevent electrostatic damage:

- Discharge static electricity from your body before handling with the module
  or the battery. You can do so by touching an unpainted grounded metal surface.
- Do not touch electrical components and the connector of the communication module with bare hands due to the ESD susceptibility of the communication module. Use the gloves (ESD, fine cotton…).

WARNING

For safety reason, use only modules approved by Iskraemeco. The use of unconfirmed modules may cause electric shock.

WARNING

Due to general safety issues, it is recommended that the meter is disconnected from the mains before removal of module cover and communication modules!

WARNING

The FEM connector is not isolated from hazardous live voltage. Do not touch bare parts of the connector while connecting the module to the meter.

For more information on the communication module, refer to a corresponding technical description of the module.

4.4.3.2. The battery (optional)

The battery is fitted under the module cover, on the right side. It is replaceable. The battery has a plastic housing with an integrated connector to connect the battery to the meter.

The battery housing is sealed with a sealing label.

The battery has a flat discharge curve. This means that throughout its lifetime, the battery voltage remains constant almost until complete discharge.

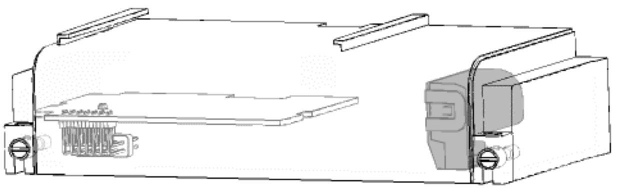


Figure 58: The battery location

Characteristic	Value
Battery type	Lithium-thionyl chloride (Li/$SOCl_2$)
Lifetime	20 years
Backup time for RTC	5 years
Function	RTC, (no power reading – the function is not supported yet)
Type of a circuit	Exchangeable circuit
Type of voltage	DC
Nominal voltage	3.6 V
Capacity	min. 1.0 Ah
Size	½ AA
Operating temperature	-55 to +85 °C
Insulation from other circuits	Functional insulation

Table 23: The battery characteristics

4.4.3.3. The module cover

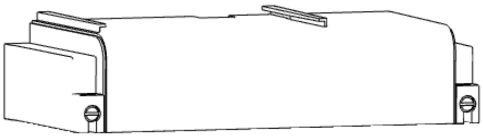


Figure 59: The module cover

The modular part of the meter is covered by the module cover (Figure 39). It is fixed to the meter with two sealing screws.

The module cover is made of non-transparent high quality self-extinguishing UV-stabilized polycarbonate that can be recycled.

The module cover is equipped with sliding tracks for an antenna coupler, which enables quick mounting of an antenna coupler and consequently quick mounting of an external antenna without removing the module cover.

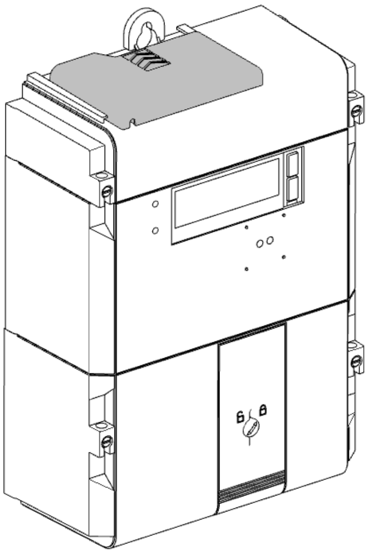


Figure 60: Mounted antenna coupler on the module cover

For more information about the antenna coupler, refer to installation instructions and the technical description of the coupler.

4.4.3.4. The module removal detector

The module removal detector is integrated in FEM connector socket (Figure 57).

When the module is removed, the detector detects the removal of the module. Since the module is fixed in the module cover, the detector also detects removal of the module cover.

CAUTION

Never insert the module into the meter without the module cover.

Do not remove the module from the module cover; it must be all the time fixed in the cover.

4.5. Sealing

The single-phase and three-phase meters can be sealed with four sealing screws, two of which are on the communication module cover and two on the terminal cover.

Optionally, the following sealing points may be sealed:

- the lower button
- the sliding lid
- the CT/VT-ratio label (only in indirect connected meters)

The sealing points may be sealed with a standard size sealing wire.

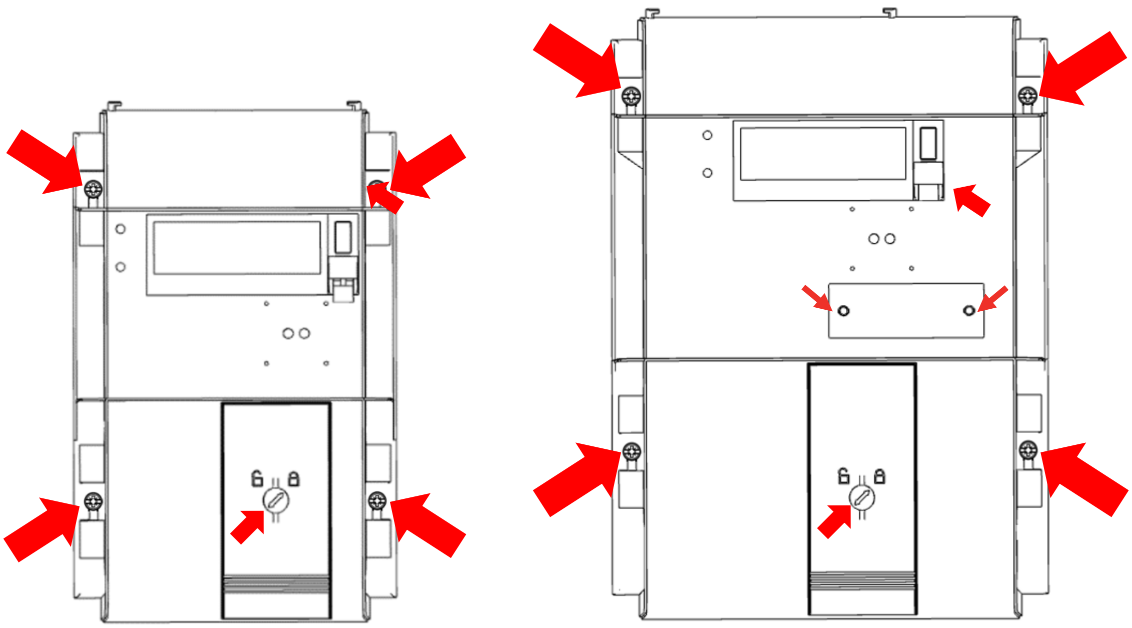


Figure 61: Sealing points

5. INSTALLATION

WARNING

The minimum cross section of a wire shall be according to standards and national regulations. The installer is obligated to perform the installation procedure in accordance with the national legislation and internal norms of the utility.

For more information, see chapter 1. SAFETY NOTICES.

The meter should be installed according to the enclosed connection diagram (see *3.5. Connection diagram*). The connection diagram can be found on the nameplate of the meter (see *4.4.2.2 The nameplate*).

5.1. Preparation of cables

WARNING

Usage of cable end sleeves is mandatory in the case of fine stranded wire and stranded wire cable types (Figure 62). In the case of a solid wire cable type, this is not necessary.

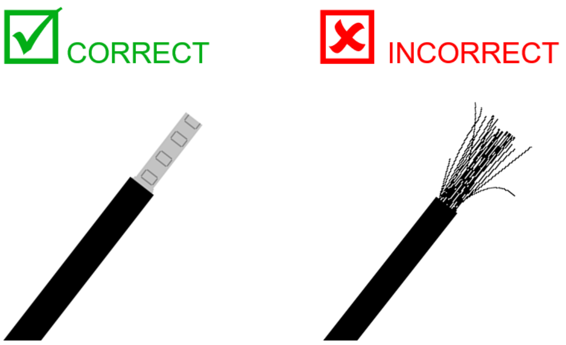


Figure 62: Properly prepared cables

5.1.1. Power (main) cables

CAUTION

See warning in chapter *5. INSTALLATION.*

For each meter type, use power cables with the appropriate cross section. For the specific cross section, refer to the following tables in chapter *4.4.1.1.1 Current and voltage terminals*:

- for single-phase DIN meter: Table 2
- for single-phase BS meter: Table 3
- for three-phase direct connected meter: Table 4
- for indirect connected meter: Table 5

Remove approx.18 mm of insulation on the power (main) cables.

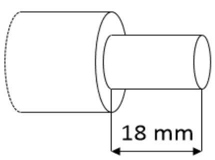


Figure 63: Power cables preparation for the meter

WARNING

Do not remove too much of the cable insulation as this could cause serious injury or death.

The instructions described in the following subchapter must be followed if the minimum allowed wire cross-section (2.5 mm^2) for main terminals is used.

5.1.1.1. Installation with terminal reducing insert

WARNING

If the cables are not fitted with an adequate torque, there is a possibility of overheating.

In case of two screws, both of them must be screwed with an adequate torque. If only one screw is tightened, there is a possibility of overheating.

The terminal reducing insert (Figure 64) is a size limiter, which helps the installer to centralize a cable with a 2.5 mm^2 cross-section into the centre of the terminal busbar.

The reducing insert is made of high quality self-extinguishing UV-stabilized polycarbonate that can be recycled. It is made in one piece of eight inserts and if needed, may be split into individual inserts.

Two different terminal inserts are available depending on the meter variant. Make sure to use the correct terminal insert:

- light grey: for 60 A and 85 A meters
- dark red: for 100 A and 120 A meters.

NOTE

The terminal reducing insert may be delivered upon customer request.

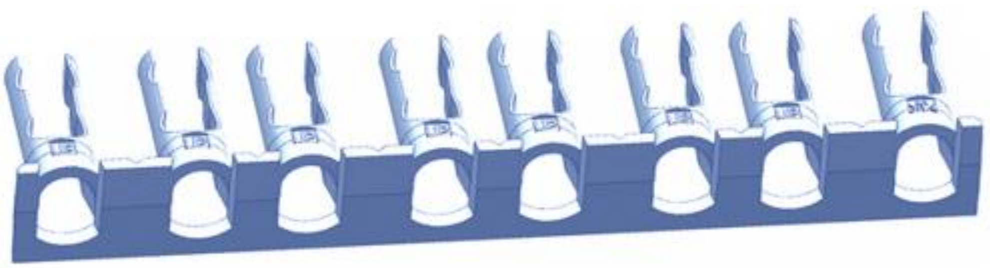


Figure 64: Terminal reducing insert (optional)

To install the terminal insert, see the steps below:

1. Loosen all the screws in the mains terminal.
2. Place the insert correctly: with a printed "UP" label on the top side.
3. Push the reducing insert all the way into the terminal hole/holes.

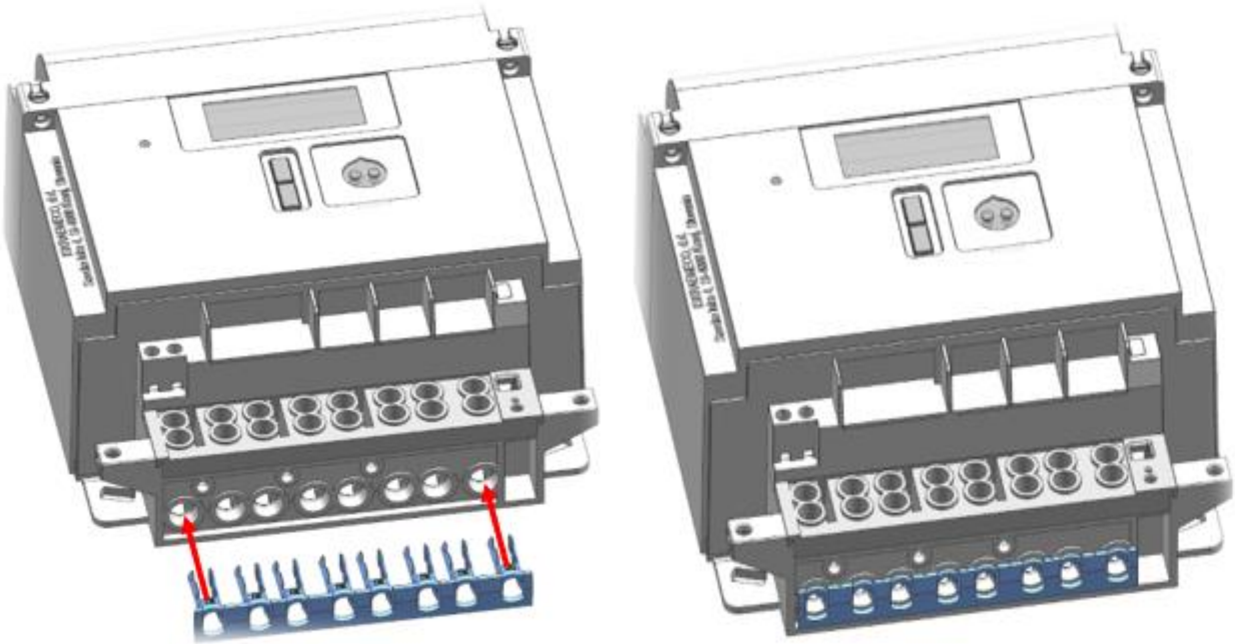


Figure 65: Installation of terminal reducing insert

When the terminal reducing insert is correctly inserted, insert the cables and screw the terminal screws with the appropriate torque (see chapter *4.4.1.1.1* Current and voltage terminals*).*

5.1.1.2. Installation without terminal reducing insert

WARNING

If the cables are not fitted with an adequate torque, there is a possibility of overheating.

In case of two screws, both of them must be screwed with an adequate torque. If only one screw is tightened, there is a possibility of overheating.

1. Insert a properly prepared cable with a 2.5 mm^2 wire cross-section **into the centre of the terminal busbar**.
2. Tighten the terminal screw with the appropriate torque (see Table 2 or Table 4).

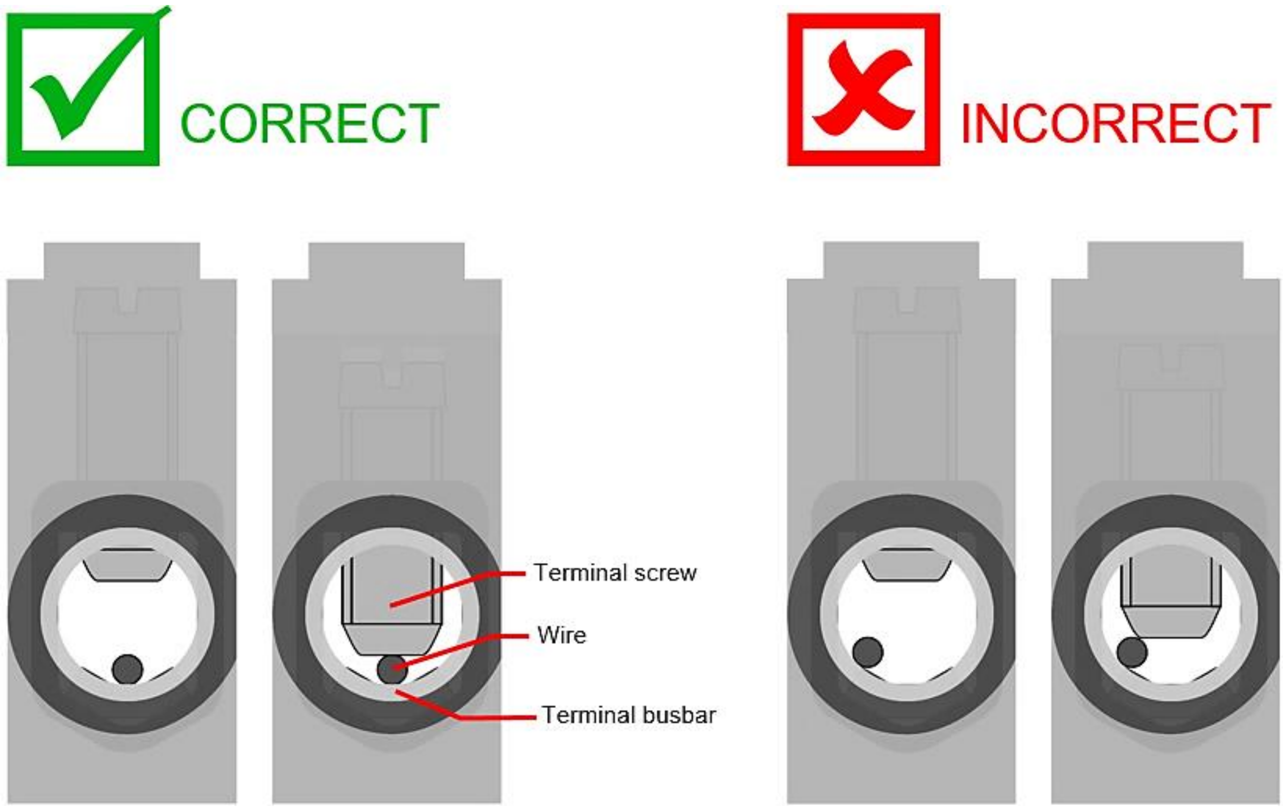


Figure 66: Properly inserting and fixing a cable with a 2.5 mm^2 wire cross-section in the main terminal

5.1.2. Cables/connectors for other connection terminals

5.1.2.1. Inputs/outputs, auxiliary power supply

Use cables with a cross section of maximum 2.5 mm^2 for:

- input/output terminals (see the relevant tables with terminal data in chapter *4.4.1.1.2. Other connection terminals and interfaces*),
- auxiliary power supply terminals (see Table 6),

5.1.2.2. P1 port

For connection to the P1 port, use a standard RJ12 male connector with a suitable 6-core cable.

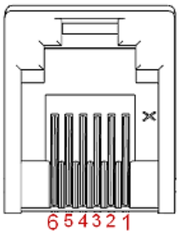


Figure 67: P1 port – RJ12 female socket

Pin #	Signal name	Description	Remark
1	+5 V	+5 V supply	Input – from external device [1] / Output – for external device [2]
2	Data Request	Data Request	Input
3	Data GND	Data Ground	
4	n.c.	Not connected	
5	Data	Data Line	Output. Open collector
6	Supply GND	Supply Ground	Power supply line IN [1] / Power supply line OUT [2]

[1] Passive P1
[2] Active P1

Table 24: Pin designation of RJ12 connector (for passive P1)

NOTE

Data Ground (pin 3) and Power Ground (pin 6) are internally connected (applies to both connectors, active and passive).

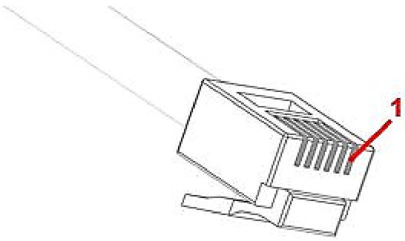


Figure 68: RJ12 male connector and the first pin

5.1.2.3. RS-485

5.1.2.3.1. Triple screw terminal as RS-485 interface

Connect the cables according to the terminal data. Refer to the chapter on meter construction.

NOTE

RS-485 interfaces of the last meter and standalone devices (unused interfaces) in RS-485 line have to be terminated with a 120 Ohm resistor.

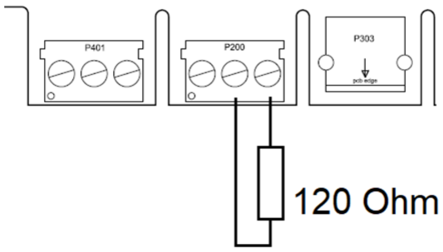


Figure 69: Example of how RS-485 line is terminated with 120 Ohm resistor

5.1.2.3.2. RS-485 port connector

For connection to RJ45 female socket, a standard RJ45 male connector with the appropriate 8-core cable should be used. (See Figure 70, Figure 71: and Table 25).

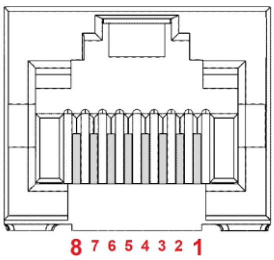


Figure 70: RS-485 port – RJ45 female socket

Pin #	Signal name	Description	Remark
1	VDC +5 V	+5 V	Power supply line OUT
2	n.c.	Not connected	
3	n.c.	Not connected	
4	A	A	Data line
5	B	B	Data line
6	n.c.	Not connected	n.c.
7	VDC -0 V	GND	Power supply ground
8	n.c.	Not connected	

Table 25: Pin designation of RJ45 port connector for RS-485

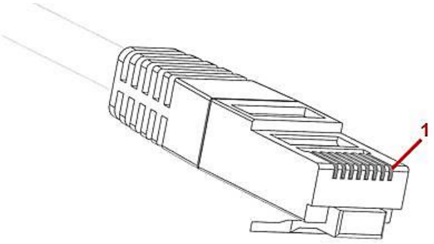


Figure 71: RJ45 male connector and pin designation

NOTE

RS-485 in the form of RJ45 is not available yet.

5.1.2.4. G3-PLC

The G3-PLC modem is built in the meter. Since it uses a power line for the G3-PLC communication, for a successful communication, make sure to connect **L1 phase and neutral conductors** to the meter.

5.1.2.5. Wired M-Bus

For wired M-Bus, use twisted pair cables with a cross section of maximum 2.5 mm^2. See Table 17 for more information.

5.2. Mounting and installation procedure

NOTE

Electrostatic electricity can harm some parts of the electronic meter.

To prevent electrostatic damage, discharge static electricity from your body before the procedure. You can do so by touching an unpainted grounded metal surface.

1. Disconnect the power cables from the mains, if applicable.
2. Remove the terminal cover.
3. Mount the meter to the wall or other vertical surface. For fixing dimensions, see technical figures and meter dimensions in chapter 4. MECHANICS.
4. Connect the power cables to the meter; the screws on the terminals should be tightened with a corresponding torque (see chapter 4.4.1.1.1. Current and voltage terminals).
5. Connect other terminals (inputs/outputs, M-Bus…) as needed (see chapter 4.4.1.1.2. Other connection terminals and interfaces).
6. Check whether the meter is properly connected.
7. Check the quality of the cable connection.
8. Close the terminal cover and seal the meter.
9. Connect other devices via P1 port (see chapter 5.1.2.2. P1 port), if needed.
10. Connect the meter to the mains; consider the accurate energy flow direction.
11. Use service mode to check the installation.

WARNING

Tighten both screws of each main terminal, where the cable is inserted.

Do not leave one of the screws not tightened enough!

5.2.1. Installing the hanger

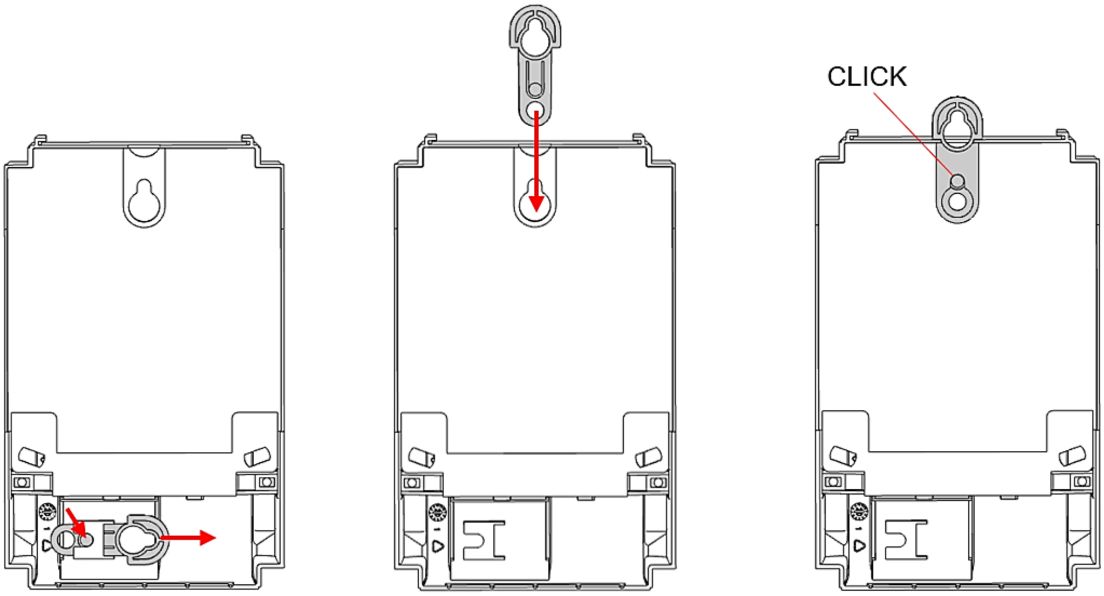


Figure 72: Installing the hanger

5.2.2. Access to integrated terminals (option)

The terminal cover may be equipped with an integrated terminal port and a sliding lid. The integrated terminal port provides access to certain terminals without removing the terminal cover.

To remove the sliding lid, follow the instructions below:

1. If necessary, remove the seal on the locking cap. Loosen the locking cap with a screwdriver or similar tool by rotating it left towards the *Open* symbol .
2. Slide the lid downwards. You can now access the terminals.

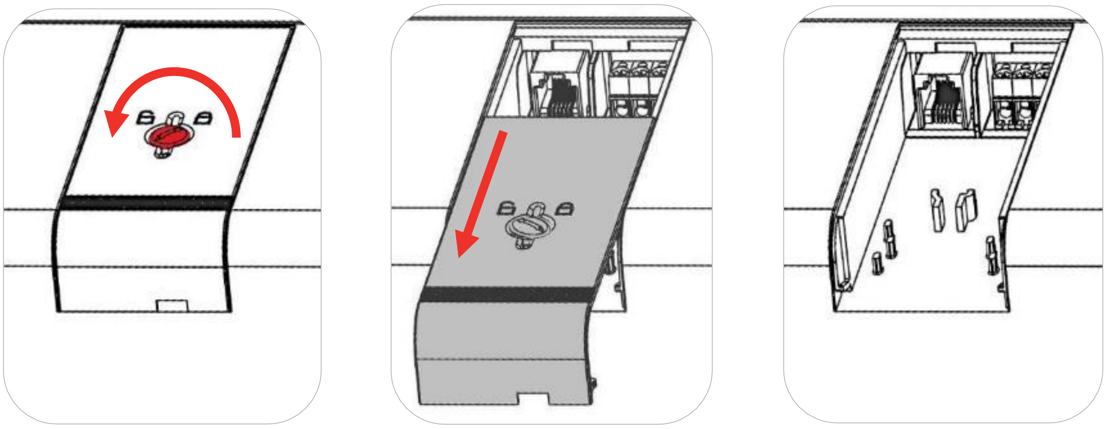


Figure 73: Removal of sliding lid in steps

3. After finishing the work on the terminals, follow the instructions below to re-install the sliding lid.
4. Slide the lid back into place (until it snaps into place).
5. Using a screwdriver, rotate the locking cap to the right towards the *Lock* symbol  until it locks into place.
6. If necessary, re-seal the cap.

5.2.3. Mounting the antenna coupler

In general, we distinguish two types of antenna couplers to connect an external antenna:

- for cellular signal strength of the exchangeable communication module (under the module cover),
- for **wM-Bus signal strength** (in the meter integrated wM-Bus module).

Depending on the type of antenna coupler, two defined locations on the meter are designed for mounting the antenna coupler.

5.2.3.1. Antenna coupler for the exchangeable communication module

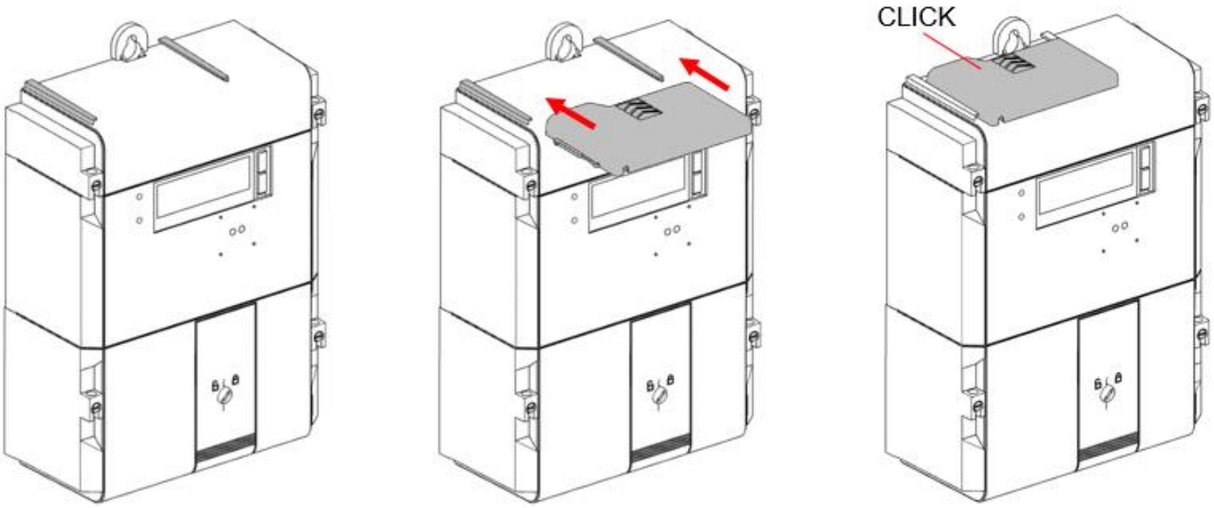


Figure 74: Mounting the antenna coupler on the meter

NOTE

Pay attention to a click-point position. The click-point position of the single-phase meter is at the back edge of the module cover, while the click-point position of the three-phase meter is located before the back edge of the module cover.

NOTE

If the coupler is placed too far i.e., forward from the click-point, it must be removed and reinstalled, as this is the only way to prevent interference.

Tip: To remove too far installed coupler, the coupler must be pushed forward. To do this, deinstall the meter from the wall or simply remove the module cover.

5.2.3.2. Antenna coupler for the wM-Bus

Refer on the technical description of the wM-bus antenna coupler to meet an installation procedure of the coupler to the meter.

5.3. Meter configuration (for three-phase only)

5.3.1. Configuring the measurement connection type

If required, the connection type of three-phase meters may be adjusted on field. For example, the same meter may be connected using 3P4W or 3P3W connection. Such meters require additional configuration to operate correctly. The following needs to be configured:

- the connection type, and
- the nominal voltage.

To set the connection type and nominal voltage, follow the steps below:

1. Run Script 1 from object **Measurement configuration process start/stop** (10.3.254*255).
2. Set the connection type and/or meter nominal voltage (see Table 26 and Table 27).
3. Update the meter with the new object values.
4. Run Script 2 from object **Measurement configuration process start/stop** (10.3.254*255).

5.3.1.1. Connection type

To define the connection type, use the object **Connection type** (196.0.2*255) and select the applicable value:

Value	Description
0	3P4W
2	3P3W, 2 × current sensors in use
3	3P3W, 3 × current sensors in use
5	NA
6	NA
7	3P4W meter connected as 1P2W, L3
10	1P2W meter

Table 26: Connection type

5.3.1.2. Nominal voltage

To set the nominal voltage of the meter, use object **Nominal voltage** (0.6.0*255) and insert the relevant value from the table below. The meter nominal voltage must be set according to the grid nominal voltage and the meter connection type.

	Meter nominal voltage [V]			
Grid nominal voltage [V]	**3P4W direct connected**	**3P3W direct connected**	**3P4W indirect connected**	**3P3W indirect connected**
3×220/380	220	/	220	/
3×230/400	230	/	230	/
3×220	/	127	/	127
3×230	/	133	/	133
3×57.7/100	/	/	57.7	/
3×63.5/110	/	/	63.5	/
3×100	/	/	/	57.7
3×110	/	/	/	63.5

Table 27: Nominal voltage

6. THE MODULE AND BATTERY REPLACEMENT

A described procedure demonstrates how an authorized person can perform the module or the battery replacement. The procedure can be performed even when the meter is fully operational, but only with awareness and consideration of all safety regulations and recommendations.

DANGER!

Do not touch the communication module in form of PCB. It is dangerous for life.

In case the module cover is removed, and the PCB remains in the meter, the meter must be disconnected from the mains before the beginning of removing the PCB out of the FEM connector socket.

WARNING!

Electrostatic electricity can harm some parts of the module/host device.

To prevent electrostatic damage:

- Discharge static electricity from your body before handling with the module or the battery. You can do so by touching an unpainted grounded metal surface.
- Do not touch electrical components and the connector of the communication module with bare hands due to the ESD susceptibility of the communication module. Use the gloves (ESD, fine cotton…).

WARNING

Only authorised personnel should open the module cover.

WARNING

Because of the general safety issues, it is recommended that the meter is disconnected from the mains before removal of the module cover and the communication module or the battery.

WARNING

For safety reason, use only modules and batteries approved by Iskraemeco. The use of unconfirmed modules may cause electric shock. The use of unconfirmed batteries may cause unreliable battery operation and thus unreliability of the power supply backup function.

DANGER

Only modules fitted in the module cover can be inserted into the meter. It is life-hazardous to insert only the module's PCB.

6.1. Module replacement

The following steps represent the procedure of the communication module replacement. Because the module's PCB is fitted in the module cover, this procedure also describes a removal and an installation of the module cover.

1. Remove sealings on the module cover.
2. Loose the sealing screws of the module cover.

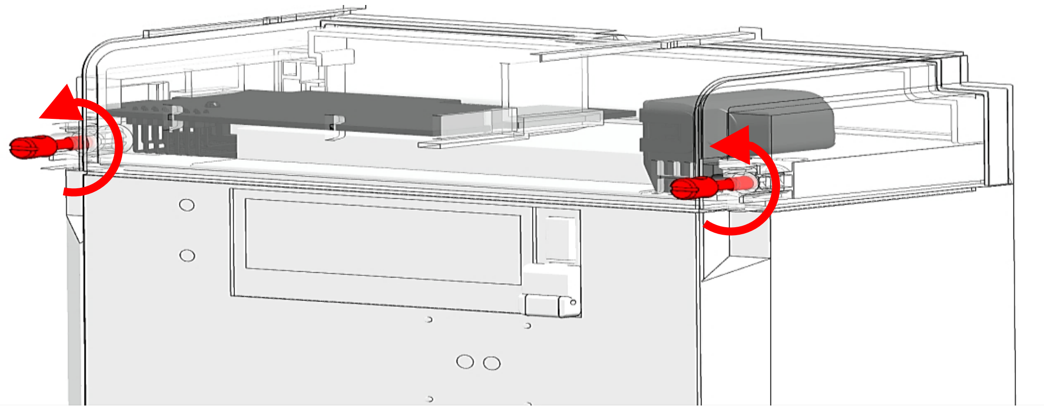


Figure 75: Replacing the communication module – step 1

3. Remove the module cover – slide it out from the base meter (Figure 76).

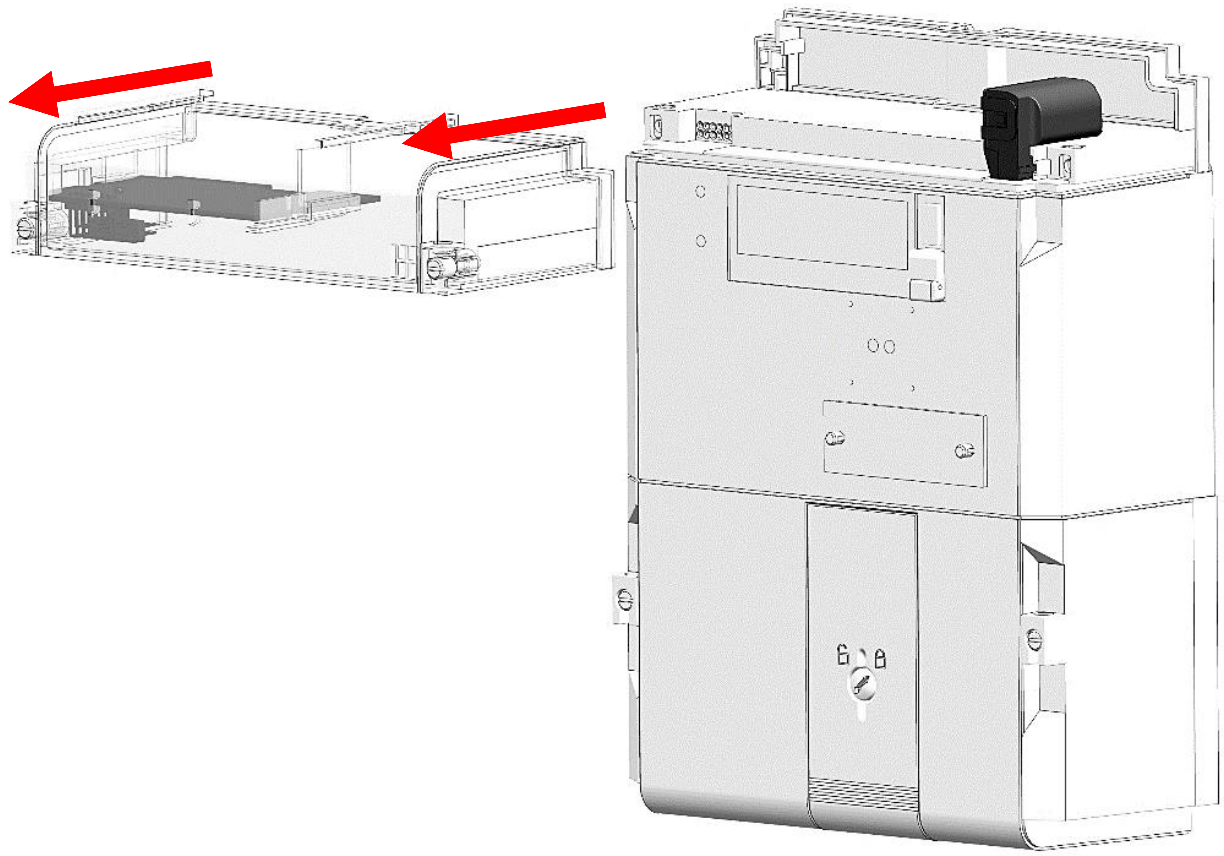


Figure 76: Replacing the communication module – step 2

NOTE

Do not remove the module's PCB from the module cover.

4. Take another module cover with an already fitted communication module.
5. Check that the module is securely fitted in the cover.

WARNING

For safety reason, use only modules fitted in the module cover and approved by Iskraemeco. Use of unconfirmed modules can cause electric shock.

6. Install the cover in the place where the removed cover was previously installed.

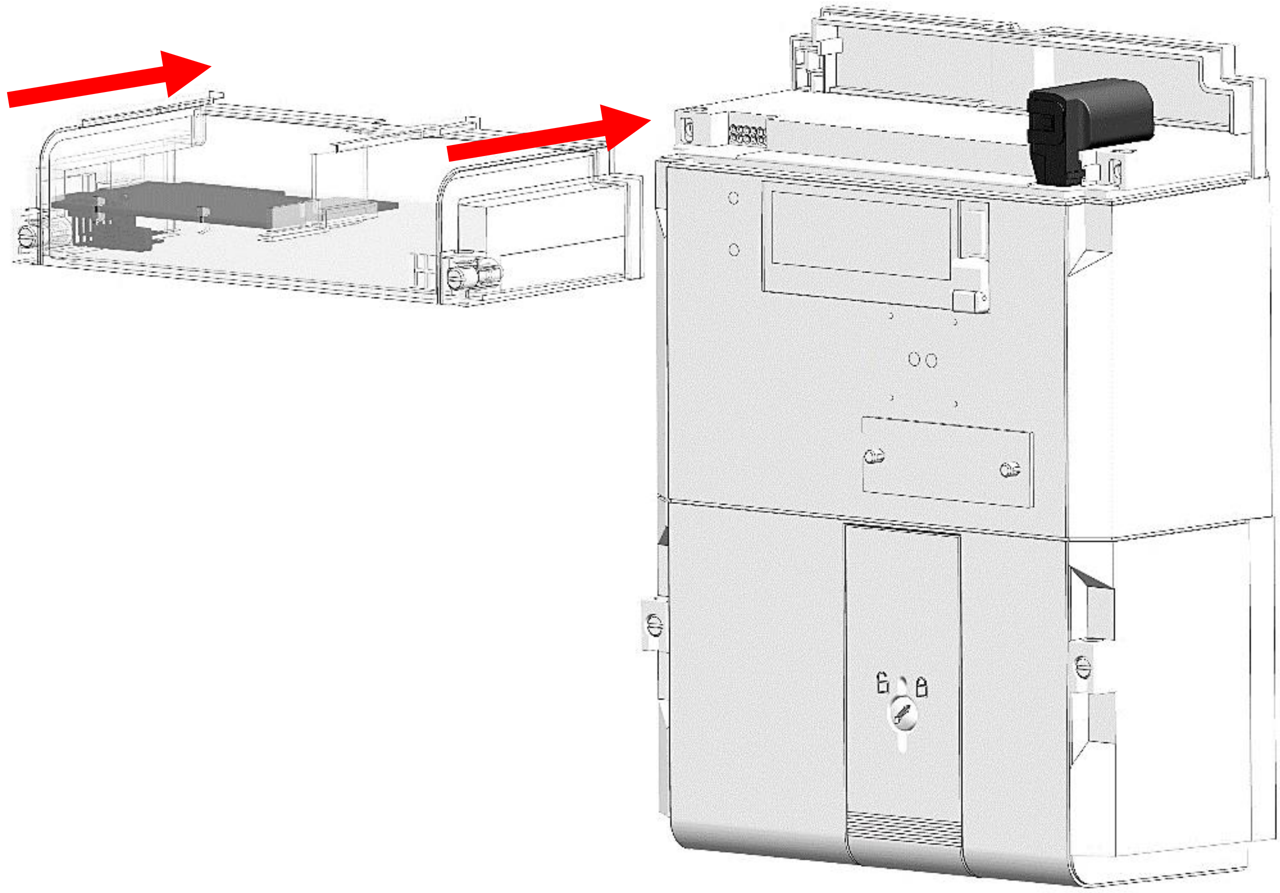


Figure 77: Replacing the communication module – step 4

7. Tighten the sealing screws of the module cover.
8. Seal the module cover sealing points.

6.2. Battery replacement

The battery with its housing is plugged in the battery connector socket under the module cover.

If the battery needs to be replaced, follow the next instructions.

NOTE

We advise to replace the battery only when the meter is powered on. The meter may be fully operational during battery replacement. Should a battery replacement be required in a meter that is not powered on, make sure to minimize the time frame from removing the old battery to inserting the new (less than 1 minute). The reason for this is that the capacitor for RTC backup has a backup time of 1 minute.

NOTE

The battery may be replaced only with a battery provided by Iskraemeco.

Battery replacement procedure

1. Remove the sealings on the module cover.
2. Remove the module cover. To remove the module cover, follow the procedure described in chapter *6. THE MODULE AND BATTERY REPLACEMENT*.
3. Pull the battery out of the meter.

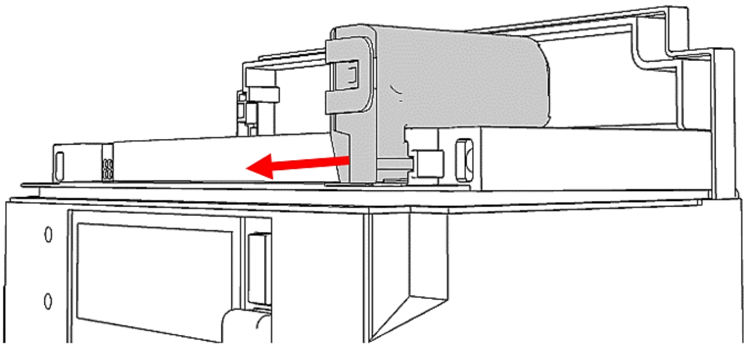


Figure 78: Removing the battery from the meter

4. Open the battery housing by unsnapping three snap fit elements.
5. Remove the battery (with a cable and a connector) from the housing.

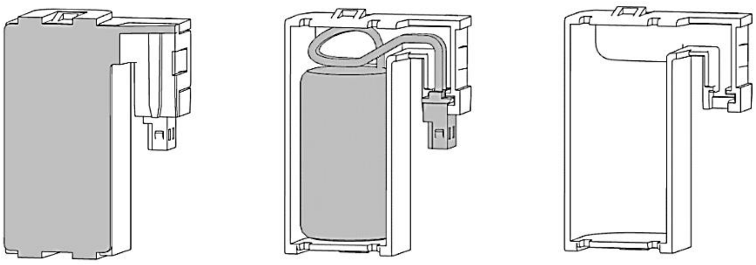


Figure 79: Steps of removing the battery from the battery housing

6. Take a new battery obtained from Iskraemeco.
7. Insert the new battery in empty battery housing. Pay attention to correctly fitting the cable and correct position and orientation of the connector in the housing.
8. Close the battery housing. Check if the housing is entirely closed. All three snap fits elements on the battery housing must be locked.

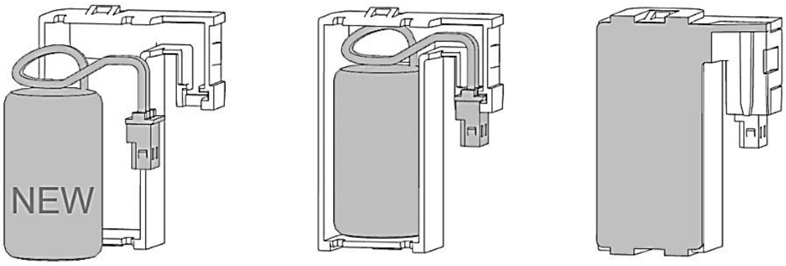


Figure 80: Steps of fitting the battery into the battery housing

9. When the housing is entirely closed, fit the battery back into a battery’s connector socket integrated in the meter.

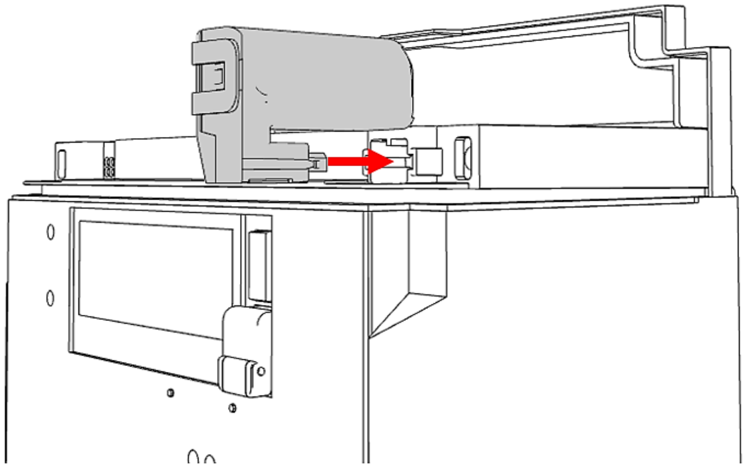


Figure 81: Fitting the battery into the meter

10. Install the module cover back to the meter.
11. Check the battery status on the LCD (Table 20).
12. Seal the module cover sealing points.

7. METER DEINSTALLATION

NOTE

The installer is obligated to perform the deinstallation procedure in accordance with the national legislation and internal norms of the utility.

For more information, see chapter *1. SAFETY NOTICES*.

.

1. Disconnect the meter from the network.
2. Remove the terminal cover.
3. Loosen all connected wires.
4. After the deinstallation, protect all disconnected wires against electric shock.
5. Loosen the fixing screws and remove the meter.

8. MEASUREMENT SYSTEM

8.1. Measuring configuration

The single-phase meter contains one measurement element for the current and voltage, while the three-phase meter contains three measurement elements for the currents and voltages.

The meters use different current sensors:

- the single-phase meter uses a shunt
- the directly connected three-phase meter uses an air coil based on the Rogowski principle
- the indirectly connected three-phase meter uses a current transformer.

The voltage sensor is a resistive voltage divider in all types of IE.x meters. The resistive dividers have different attenuations.

Voltage and current analog signals are fed into the A/D (analog to digital) converters.

8.2. Measurement principle

Current and voltage samples, obtained from the measurement system, are then processed in the meter's firmware to record:

- Consumed/generated energy (active, reactive and apparent separately) – per-phase and total values. Vector or arithmetical method (applicable only for 3 phase meters) is used to calculate the total energy.
- Instantaneous power (active, reactive and apparent separately) – per-phase and total values.
- Instantaneous reactive power by quadrant.
- Instantaneous RMS currents and voltages – per-phase RMS values of phase currents and voltages only.
- Instantaneous power-line frequency. The calculated frequency is the average value of the measured frequency of all three phases.
- Power factor measurements (optionally)

NOTE

The method (vector/arithmetical) is selected during the production phase and cannot be changed in the field.

In case of the single-phase meter, the calculated per-phase energy and power values (phase 1) and total values evaluate to the same value. All calculated values are available to the rest of the system through the measurement platform API functions. Measurement system also generates the metrology pulses, which are used to drive energy LED (the metrological LED) and digital outputs.

The frequency of the generated pulses is proportional to the selected instantaneous power and the output's metrology constant, while their number in the specified time window is proportional to the consumed/generated energy in this time window. The energy LED and the digital output operation mode is configurable.

8.3. Direct/indirect connection of the meter

According to the meter type, three-phase meters can be connected directly to the power supply network, or indirectly through the (external) current/voltage measurement transformer.

If the meter is connected indirectly, it must be configured properly to consider the external transformer ratio in the measurement process. **Transformer measurement type** object (0-0:196.0.1*255) defines if the current transformer ratio is used in measuring process or not (only for transformer type of three-phase meters). Definitions are:

- 0 – Secondary (default): transformer ratio is not used
- 1 – Primary – transformer ratio is used

Explanation:

If *Transformer measurement type* of CT meter is set to:

- "**0 – secondary**", transformer ratio is not used. In this case, values measured by the meter are registered.
- "**1 – primary**", transformer ratio K is used for calculation. In this case, values measured by the meter are transformed/calculated using transformer ratio K, and registered.

8.3.1. The ratio of the external measurement transformer

If the meter is connected through the external current measurement transformer, its ratio must be specified. The **Transformer ratio** objects are used for this purpose:

- Transformer ratio – current (numerator) – 1-0:4.0.2*255
- Transformer ratio – current (denominator) – 1-0:4.0.5*255

The transformer ratio ***K*** is calculated by equation

$$K = \frac{Numerator}{Denominator}$$

It is used to calculate primary current (power supply network current) from the secondary current (current at the meter's terminal) according to equation

$$Primary\ current = K * secondary\ current$$

Some examples of transformer ratio values (numerator, denominator, and K) are listed in Table 28.

Numerator	Denominator	Transformer ratio K
100	5	20
200	5	40
300	5	60
600	5	120
1000	5	200
1600	5	320

Table 28: Examples of current transformer ratio values

NOTE

In most cases, K value is a whole (an integer) number (not decimal).

8.4. Energy (Metrological) LED and digital output constants

These parameters define the energy LED and digital output constants. They are stored in an array *constants* of six elements. They are divided into two sets:

- Energy LED constants
- Digital output constants

Each set contains the parameters for the active, reactive, and apparent energy. Their default values are shown in Table 29.

Output	Array index	Energy	Default value *		
			60 and 85 A meters	100 and 120 A meters	10 A meter (CT)
LED	0	Active	1000	500	10,000
	1	Reactive	1000	500	10,000
	2	Apparent	1000	500	10,000
Digital output	3	Active	500	250	5,000
	4	Reactive	500	250	5,000
	5	Apparent	500	250	5,000

* The output constant is configurable.

Table 29: Default values for the energy output constants

These parameters define the energy LED and digital output constants.

One (the single-phase meter) or two (three-phase) metrological LEDs and different number of digital outputs are integrated in the IE.x meter. The LEDs and the digital outputs can be configured to show source energy valid values listed in the Table 30.

Source energy	Symbol
Active energy combined	||+A| + |-A||
Active energy import	+A
Active energy export	-A
Reactive energy combined	||+R| + |-R||
Reactive energy import	+R
Reactive energy export	-R
Reactive energy QI	QI
Reactive energy QII	QII
Reactive energy QIII	QIII
Reactive energy QIV	QIV
Apparent energy combined	||+VA| + |-VA||
Apparent energy import	+VA
Apparent energy export	-VA

Table 30: Source energy valid values with symbols

Source energy can be set in **Field settable parameters** object (0-0:128.5.11*255) (in the first position).

NOTE

In addition to pulse outputs, the meter also supports measurements period outputs.

8.4.1. Energy (metrological) LED constants

The LED constants are available through the following objects:

- for active energy – Metrological LED constant – active energy (1-0:0.3.0*255)
- for reactive energy – Metrological LED constant – reactive energy (1-0:0.3.1*255)
- for apparent energy – Metrological LED constant – apparent energy (1-0:0.3.2*255)

8.4.2. Energy (metrological) digital output constants

The energy pulse-output constants are available through the following objects:

- for active energy – Energy pulse-output constant – active energy (1-0:0.3.3*255)
- for reactive energy – Energy pulse-output constant – reactive energy (1-0:0.3.4*255)
- for apparent energy – Energy pulse-output constant – apparent energy (1-0:0.3.5*255)

8.5. Measured values

Three-phase meters measure and record the following total electric **energies**:

- positive and negative active energy (A+, A-) separately,
- positive and negative reactive energy (R+, R-) separately,
- positive and negative apparent energy (S+, S-) separately,
- absolute active energy çA+ç+ |A-|,
- net active energy |A+| - |A-|,
- reactive energy per quadrants (QI, QII, QIII, QIV).

Single-phase meters are provided with one LED on the front plate and three-phase meters with two of them. The LED is intended for checking the meter accuracy. Impulse constant depends on the meter version.

Demand (power) is measured inside a measuring period. The measuring period is a meter parameter and can be configured. Values that can be set are 1, 5, 10, 15, 30 and 60 minutes. After termination of the measuring period, the measured meter value is transferred from current measuring period registers to registers for previous measuring period that can be later used for the formation of billing values.

Averaging is calculated within a measuring period of 10 minutes. At the end of the corresponding measuring period, the measured meter value is transferred from current values to previous values. Previous values are used to store data in different profiles – if the profile period and measuring period coincide.

8.5.1. Energy

The electrical meter stores energy in respective cumulative energy registers (A+ or A-) expressed in Wh. The value attribute of energy register class instances is limited to maximum 999.999.999 before it overflows to 0. The registers can be accessed via communication interface in form of DLMS/COSEM objects with dedicated logical name, value, unit, and scaler of unit. Alternatively, energy registers can be shown **on display** or **P1 port** in **k*[unit]*h** (where unit stands for **W**, **var** or **VA**) and formatted with specific/configurable width and precision format (**Display format for energy** 0-0:196.1.0*255; see *9.3.5.1. Display format for energy*).

NOTE

Energy registers have resolution according to the unit-scaler parameter 1, 10, 100, 1000, 10000 [Wh, varh, VAh]. The scaler parameter is set in object **Results energy scaler** (0-0:196.0.4*255). For more information, see chapter *8.5.1.1. Energy scaler***.**

NOTE

In a 32-bit system:

For A+, A-, R+, R-, S+, S-, |A+|+|A-|, Qi+, Qi-, Qc+, Qc- energy registers, the register value can be from 0 to 999 999 999 [Wh, varh, VAh]. When the register reaches the maximum value (overflow), the register rolls over to 0 and counts from there.

For the |A+|-|A-| energy register, the values can be from -1 000 000 000 to 999 999 999 [Wh]. When the register reaches the maximum negative value (-1 000 000 000), the register rolls over and the next displayed value is -1 (instead of -1 000 000 001). When the register reaches the maximum positive value (999 999 999), the register rolls over and the next displayed value is 0 (instead of 1 000 000 000).

In a 64-bit system:

The number values may have additional 6 digits: e.g. the values of the |A+|-|A-| register are in the range from -1 000 000 000 000 000 to 999 999 999 999 999.

The micro-computer records different types of energy (active, reactive, apparent) for all phases in one or more tariffs and stores these values in various registers according to energy direction and active tariff.

The following **Energy** registers are supported:

+A	Active energy import (+A) and active energy per Tariff
-A	Active energy export (-A) and active energy per Tariff
+R	Reactive energy import (+R) and reactive energy per Tariff
-R	Reactive energy export (-R) and reactive energy per Tariff
+VA	Apparent energy import (+VA) and apparent energy per Tariff
-VA	Apparent energy export (-VA) and apparent energy per Tariff
ABS	Active energy combined (|+A|+|-A|) and active energy per Tariff
Net	Active energy combined (|+A|-|-A|) and active energy per Tariff *
Reactive per quadrants	Reactive energy per quadrants and reactive energy per Tariff

* **NET** – **Active Energy *per Tariff*** (1-0:16.8.x*255 (x=1…8)) is an option and is not available in all IE.x firmware versions.

NOTE

Not all the meter firmware versions/variants have all presented functionalities available.

8.5.1.1. Energy scaler

By raising energy scaler-unit, a span of energy registers increased up to 100 G*[unit]*h.

As an option, energy scaler is factory-settable parameter, defined in object **Results energy scaler** (0-0:196.0.4*255). A value of energy scaler object parameter can be 0, 1, 2, 3, or 4 (Table 31). By the default, value of the scaler is set to 0.

Value of energy scaler object parameter	Energy register resolution
0	1 [Wh, varh, VAh]
1	10 [Wh, varh, VAh]
2	100 [Wh, varh, VAh]

Table 31: Energy scaler – value of object meter and energy register solution

The scaler and a value form final value of energy register.

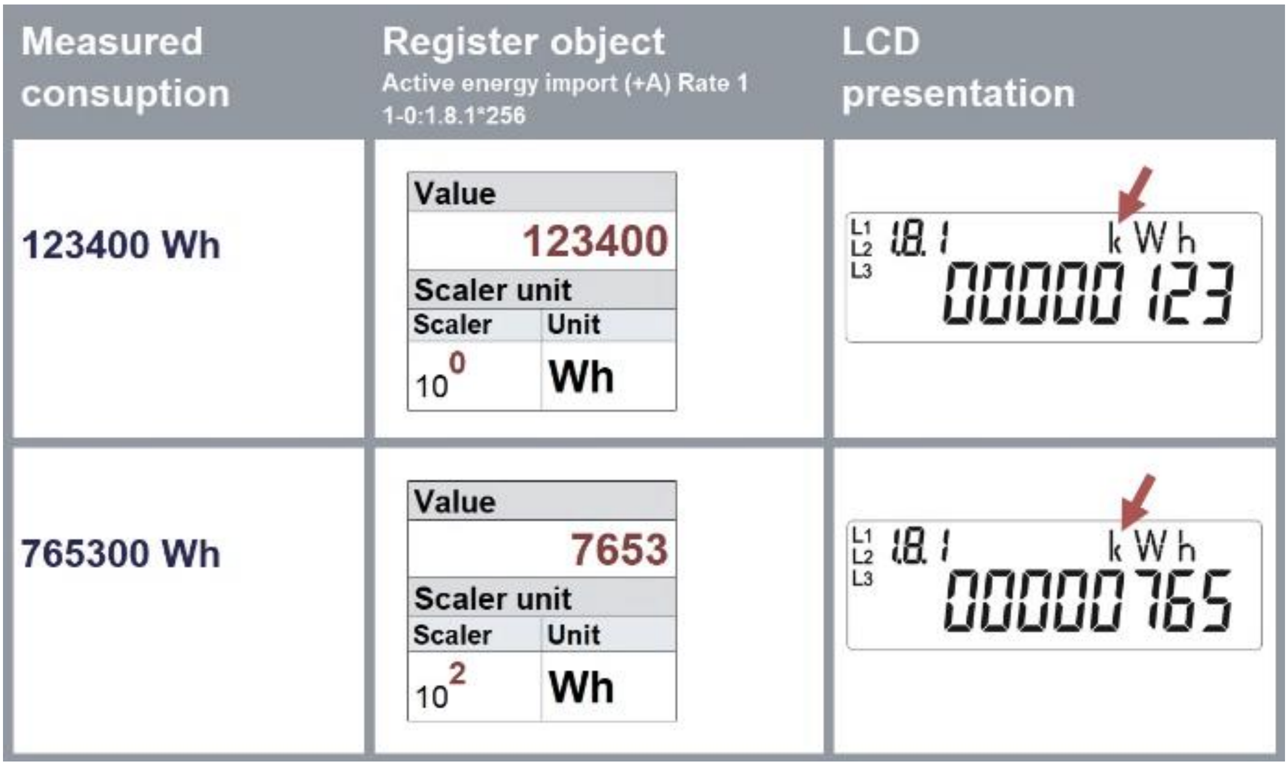


Figure 82: Different set energy scaler (example), where display format for energy is WP=80

NOTE
By a customer request, the scaler can be a factory-specific setting.

Energy scaler value can be seen in every energy register under the *Scaler unit*.

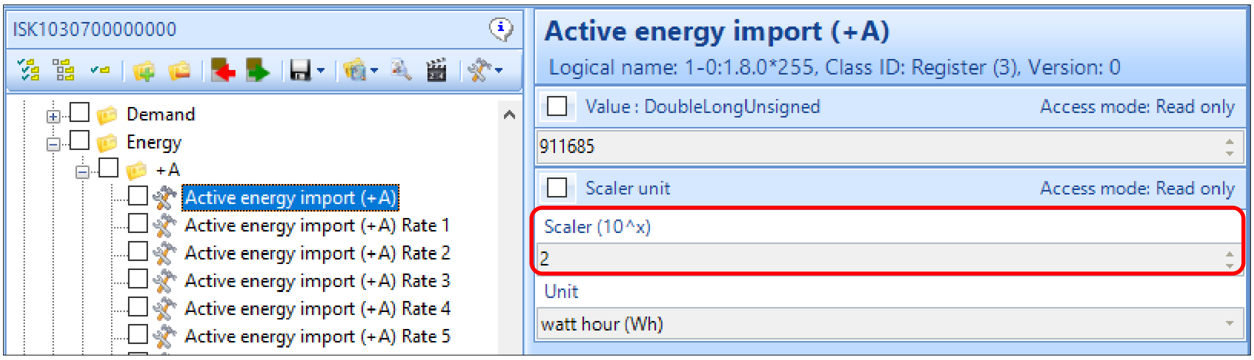


Figure 83: Read-only scaler in energy object (example)

8.5.2. Demand (power)

After completion of the measuring period, current average value (x.4.0) is stored to the register for previous measuring period (x.5.0) and compared with highest maximum value stored in the relevant register (x.6.0). If new value is larger, it is stored as new maximum value at corresponding position. At the same time, time stamp is stored representing the time conclusion of measuring period.

At the end of the billing period, maximum demand registers (x.6.y) are recorded to billing profiles (if profile is being properly configured). Maximum demand values (x.6.y) are added to cumulative maximum demand registers (x.2.y) before they are being cleared (set to zero). Also billing period counter is being increased by one.

The following **Demand (power)** registers are supported:

- +A
    - Cumulative maximum demand register - Active energy import (+A) and active energy per Tariff (1.2.x)
    - Demand register - Active energy import (+A) (1.4.0)
    - Last average demand register - Active energy import (+A) (1.5.0)
    - Maximum demand register - Active energy import (+A) and active energy per Tariff (1.6.x)
- -A
    - Cumulative maximum demand register - Active energy export (-A) and active energy per Tariff (2.2.x)
    - Demand register - Active energy export (-A) (2.4.0)
    - Last average demand register - Active energy export (-A) (2.5.0)
    - Maximum demand register - Active energy export (-A) and active energy per Tariff 1 (2.6.x)
- +R
    - Cumulative maximum demand register - Reactive energy import (+R) and reactive energy per Tariff
    - Demand register - Reactive energy import (+R)
    - Last average demand register - Reactive energy import (+R)
    - Maximum demand register - Reactive energy import (+R) and reactive energy per Tariff
- -R
    - Cumulative maximum demand register - Reactive energy export (-R)
    - Demand register - Reactive energy export (-R)
    - Last average demand register - Reactive energy export (-R)
    - Maximum demand register - Reactive energy export (-R) and reactive energy per Tariff
- +VA
    - Cumulative maximum demand register - Apparent energy import (+VA) and apparent energy per Tariff
    - Demand register - Apparent energy import (+VA)
    - Last average demand register - Apparent energy import (+VA)
    - Maximum demand register - Apparent energy import (+VA) and apparent energy per Tariff
- -VA
    - Cumulative maximum demand register - Apparent energy export (-VA) and apparent energy per Tariff
    - Demand register - Apparent energy export (-VA)
    - Last average demand register - Apparent energy export (-VA)
    - Maximum demand register - Apparent energy export (-VA) and apparent energy per Tariff
- ABS
    - Cumulative maximum demand register - Active energy combined (|+A|+|-A|) and active energy per Tariff
    - Demand register - Active energy combined (|+A|+|-A|)
    - Active demand last combined (|+A|+|-A|)
    - Maximum demand register - Active energy combined (|+A|+|-A|) and active energy per Tariff
- Other demand registers
    - Demand register - Active energy import (+A) per phase
    - Demand register - Active energy export (-A) per phase
    - Demand register - Reactive energy import (+R) per phase
    - Demand register - Reactive energy export (-R) per phase
- Demand registers for QI, QII, QIII, QIV
    - Cumulative maximum demand register - Reactive energy QI (+Ri)
    - Demand register - Reactive energy QI (+Ri)

- Last average demand register - Reactive energy QI (+Ri)
- Maximum demand register - Reactive energy QI (+Ri)
- Cumulative maximum demand register - Reactive energy QII (+Rc)
- Demand register - Reactive energy QII (+Rc)
- Last average demand register - Reactive energy QII (+Rc)
- Maximum demand register - Reactive energy QII (+Rc)
- Cumulative maximum demand register - Reactive energy QIII (-Ri)
- Demand register - Reactive energy QIII (-Ri)
- Last average demand register - Reactive energy QIII (-Ri)
- Maximum demand register - Reactive energy QIII (-Ri)
- Cumulative maximum demand register - Reactive energy QIV (-Rc)
- Demand register - Reactive energy QIV (-Rc)
- Last average demand register - Reactive energy QIV (-Rc)
- Maximum demand register - Reactive energy QIV (-Rc)

NOTE
Not all the meter firmware versions/variants have all presented functionalities available.

8.5.3. Average values

There are two measurement periods in use:

- Measurement period 1 (MP1) – **Measurement period 1, for average value 1** (1-0:0.8.0*255) is used for demand measurements (recommended periods are 5 min, 15 min, 30 min and 60 min).
- Measurement period 3 (MP3) – **Measurement period 3, for instantaneous values** (1-0:0.8.2*255) is used for COSEM objects mandated by averaging scheme 3 (average voltage and current).

The following average values are supported:

- Average total power (|+A|+|-A|)
- Average voltage per phase
- Average current per phase

The following last completed averaging period values are available per phase:

- Voltage, last completed averaging period, L1 (1-0:32.25.0*255)
- Voltage, last completed averaging period, L2 (1-0:52.25.0*255)
- Voltage, last completed averaging period, L3 (1-0:72.25.0*255)
- Current, last completed averaging period, L1 (1-0:31.25.0*255)
- Current, last completed averaging period, L2 (1-0:51.25.0*255)
- Current, last completed averaging period, L3 (1-0:71.25.0*255)

8.5.4. Instantaneous values

The following instantaneous values are supported:

- Current
  - Instantaneous current per phase
  - RMS filtered current per phase
  - Instantaneous current (sum over all phases)
  - RMS filtered current (sum over all phases)
- Frequency
  - Instantaneous net frequency: any phase
- Power
  - Instantaneous active import power (+A), total and per phase
  - Instantaneous active export power (-A) , total and per phase

  - Instantaneous reactive import power (+R), total and per phase
  - Instantaneous reactive export power (-R) , total and per phase
  - Instantaneous reactive power per quadrant (QI, QII, QIII, QIV)
  - Instantaneous apparent import power (+VA) , total and per phase
  - Instantaneous apparent export power (-VA) , total and per phase
  - Instantaneous active power combined (|+A|+|-A|), total and per phase
  - Instantaneous active power combined (|+A|-|-A|), total and per phase

- Power factor
  - Instantaneous power factor (+A/+VA)
  - Instantaneous power factor (+A/+VA) per phase
  - Instantaneous power factor negative (-A/-VA)
  - Instantaneous power factor negative (-A/-VA) per phase

- Voltage
  - Instantaneous voltage per phase
  - RMS filtered voltage per phase

8.5.5. Phase angles

Upon request, IE.x meters may be set to measure phase angles between voltages of different phases as well as phase angles between currents and voltages. To read the phase angle values, use the OBIS codes given below.

NOTE

The phase angles are in the range of 0°–360°. The meter renders values in the range of 0–3600 (with a scaler of 10^{-1}). The value 4000 (or 400 with a 10^{-1} scaler) indicates an invalid measurement.

8.5.5.1. Instantaneous phase angles between voltages (U-U)

Phase angle	OBIS code
U(L1) – U(L3)	1-0:81.7.20*255
U(L2) – U(L1)	1-0:81.7.1*255
U(L3) – U(L2)	1-0:81.7.12*255

8.5.5.2. Instantaneous phase angles between currents and voltages (I-U)

Phase angle	OBIS code
I(L1) – U(L1)	1-0:81.7.4*255
I(L2) – U(L2)	1-0:81.7.15*255
I(L3) – U(L3)	1-0:81.7.26*255

8.5.6. Measurement in neutral (optional)

IE.x meters support phase voltage and current measurement, as well as neutral current measurement.

The meters support the following objects for neutral current measurement:

- Instantaneous current neutral (1-0:91.7.0*255)
- RMS filtered current neutral (1-0:91.128.0*255)
- Instantaneous current residual (1-0:128.7.0*255)
- RMS filtered current residual (1-0:128.128.0*255)

8.5.6.1. Residual current

In order to facilitate fraud detection, the IE.x meters measure *neutral current* $\boldsymbol{i_N(t)}$ and calculate the *residual current* $\boldsymbol{i_{RES}(t)}$. There are slight differences between single-phase and three-phase meters:

- In single-phase meters, the residual current $i_{RES}(t)$ is calculated as follows:

  $$i_{RES}(t) = i_L(t) - i_N(t)$$

- In three-phase meters, the residual current $i_{RES}(t)$ is calculated as follows:

  $$i_{RES}(t) = i_{L1}(t) + i_{L2}(t) + i_{L3}(t) - i_N(t)$$

9. FUNCTIONAL DESCRIPTION

9.1. Power supply backup

IE.x meters support power supply backup, which guarantees operation of the real time clock (RTC) and the tamper functionality during a power failure.

Two types of power storage devices are available. The meter may be equipped only with one – this is defined in the meter ordering phase:

- a supercapacitor or
- a lithium battery.

9.1.1. The role of the supercapacitor in power supply backup

In case of a power failure, the supercapacitor enables RTC and tamper functionality operation for 7 days at ambient temperature 25°C, but only if the meter has been continuously connected to the mains for at least 24 hours prior to the power failure. If the meter has been connected to the mains for only 1 hour prior to the power failure, the power supply backup is reduced to 24 hour.

9.1.2. The role of the battery in power supply backup

In case of a power failure, the lithium battery enables RTC and tamper functionality operation for longer periods. The total battery backup time is 5 years. The battery backup time depends on the environmental and storage conditions. When the meter has a power failure, the backup time is reduced for the value corresponding to the length of the power failure.

To check the battery's remaining backup time, see the **Battery Estimated Remaining Use Time Counter** (0-0:96.6.6*255). The value is given in seconds. Once the backup capacity drops below 10%, the battery symbol on the LCD starts to blink (see *4.4.2.3.The display*). When this happens, we advise to replace the battery.

NOTE

In a meter that is equipped with a supercapacitor (i.e. without a battery), the value of **Battery Estimated Remaining Use Time Counter** is *0*.

9.2. Time

Time in the meter is defined according to <u>local time/date</u>, <u>time zone</u> and <u>daylight savings time</u> (DST). Time and date data format contains the <u>meter's local date and time</u>, <u>its deviation to UTC</u> (Coordinated Universal Time) in minutes and the <u>status showing if DST is active or not</u>. For providing the local date and time information (year, month, day, day in a week, hour, minute, second and lap year), the RTC integrated circuit is built in the meter.

9.2.1. Time synchronization

Time of the meter's clock can be synchronized by:

- COSEM/DLMS time synchronization methods
- NTP (Network Time Protocol)

9.2.1.1. NTP meter's time synchronization

Network time protocol (NTP) can be used for synchronizing meter time with the time of a remote server.

The meter supports NTP time synchronization over point-to-point communication (2G, 3G, 4G or Ethernet) using IPv4 or IPv6 and UDP. When meter operates with G3-PLC or other non-point-to-point communication, it will not send NTP requests towards the server.

9.2.1.1.1. NTP parameterization

The operation of NTP time synchronization implemented in the meter is defined and described by a set of parameters and attributes that can be accessed by following objects:

- NTP setup (0-0:25.10.0*255)
- NTP synchronization script table (0-0:10.1.249*255)
- NTP synchronization scheduler (0-0:15.0.251*255)
- NTP synchronization randomization interval (0-0:128.21.0*255)
- NTP last synchronization time (0-0:128.21.1*255)

NTP setup (0-0:25.10.0*255) attributes are used as follows:

- **Activated**
  - *False* (default) – allows corresponding single action scheduler to invoke NTP time synchronization by execution of NTP setup - synchronize method via specific script
  - *True* (not supported by the meter) – NTP client operates autonomously, and time period for NTP synchronization is not defined by scheduler but calculated by NTP client
- **Server address** – IP address (IPv4 or IPv6) or domain name of the NTP server, to which NTP requests from meter will be addressed (max. length = 63 octets)
- **Server port** – UDP port on which the meter will send NTP requests; standard port for NTP is 123
- **Authentication method**
  - (1) No security
  - (2) Shared secrets (not available)
  - (3) Auto key IFF (not available)

NOTE

Only "*No security*" method is implemented in the meter. Consequently, *Authentication keys* and *Client key* (related to *Shared secrets* and *Auto key IFF*) are not used in the meter.

The **NTP Setup** object also implements "Synchronize" method. This method is used to trigger NTP synchronization. When triggered via communication as action request on the **NTP Setup** object, this method will immediately trigger NTP request.

NTP synchronization script table (0-0:10.1.249*255) object implements one fixed script for invocation of "NTP Setup" synchronize method.

When this script is executed, the meter triggers NTP request after expiration of random delay calculated from the object **NTP synchronization randomization interval** (0-0:128.21.0*255).

NTP synchronization scheduler (0-0:15.0.251*255) defines when NTP client shall trigger requests towards specified NTP server. In order to parametrize periodic synchronization of meter time (clock) via NTP, this object should be configured to execute script 1 of **NTP synchronization script table** object at certain periodic time points.

NTP synchronization randomization interval (0-0:128.21.0*255)

Periodic time synchronization via NTP for large number of meters at the same time could cause communication overload. **NTP synchronization randomization interval** is used to spread NTP request for a larger population of meters over longer time interval still all meters having the same scheduler settings.

(Minimum = 0 s; Maximum = 65535 s; Default = 0 s)

NTP last synchronization time (0-0:128.21.1*255) enables user to read the time of the last successful synchronization of meter time via NTP.

NOTE

The information of **NTP last synchronization time** is lost with power down or meter reset (e.g., after FW upgrade) until new NTP synchronization is successfully executed.

9.2.1.1.2. NTP synchronization process

The NTP synchronization process running in the meter (Figure 84) is being driven by meter's internal clock that normally triggers NTP synchronization at scheduled periodic intervals configurable via dedicated single action schedule object. Random delay with configurable maximum value is implemented in order to prevent large population of meters to send NTP requests at the same time.

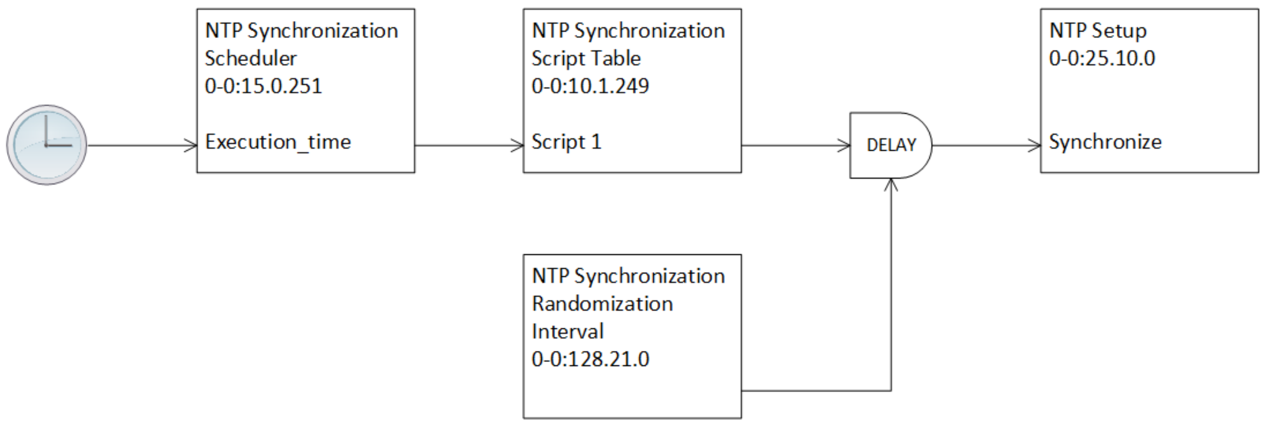


Figure 84: NTP synchronization process running in the meters

9.3. Display operation and use

Description of the main parts of the seven-segment LCD is described in chapter *4.4.2.3. The display*.

9.3.1. OBIS code on the display

On the left side of the display, 6 digits are reserved for OBIS code presentation (see field 1 in Figure 49). OBIS code is always displayed from the first digit on the left.

For presenting OBIS codes on the display, short OBIS code format is used by default: **C.D.E.**

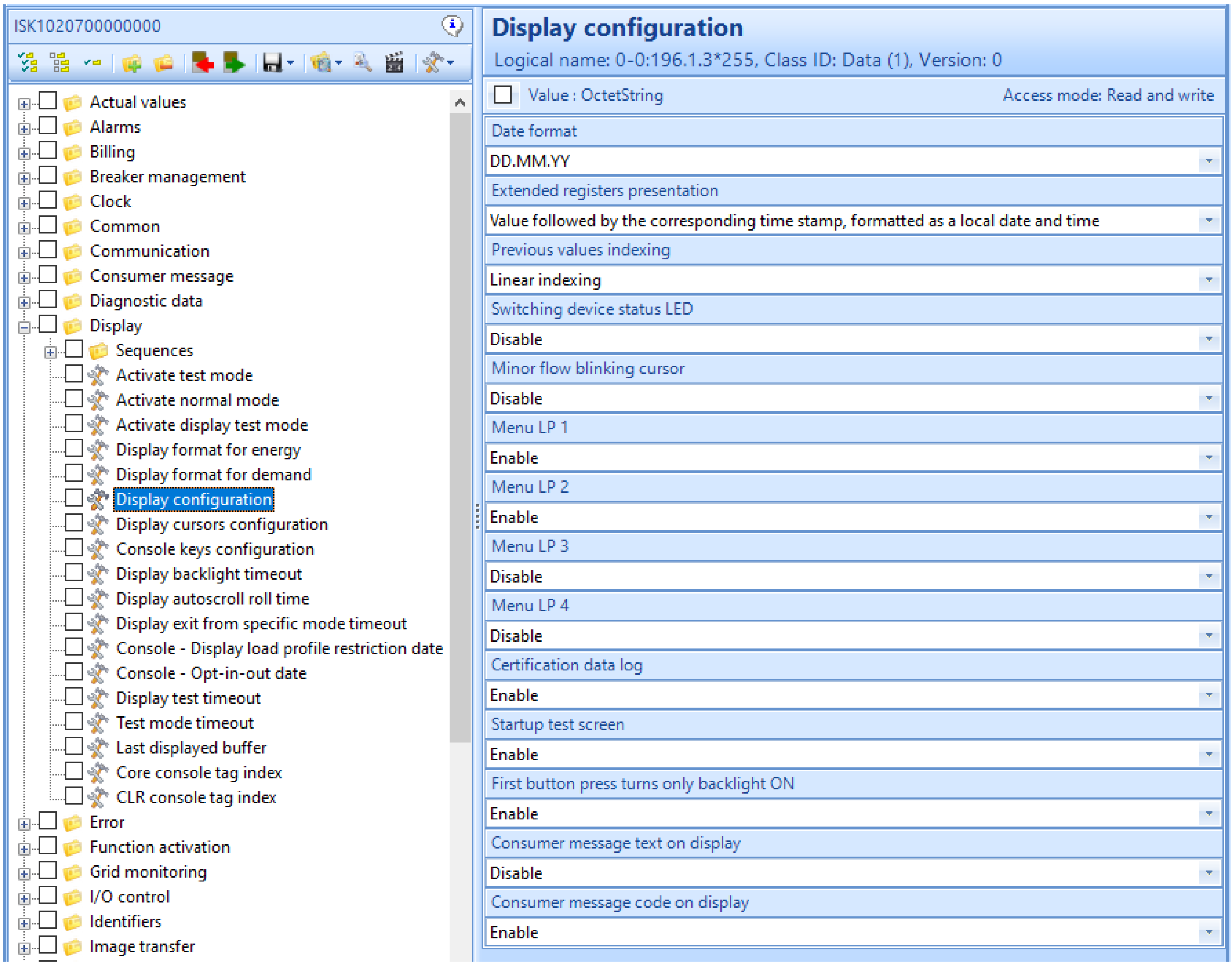


Figure 85: Display configuration object

There are some exceptions when extended OBIS name is displayed:

- **A.B.C.D.E** format is used for presentation of the following objects:
  - Core identification: **Active firmware identifier (LRFW)** (1-0:0.2.0*255)
  - Application identification: **Active firmware identifier 1 (NLRFW)** (1-1:0.2.0*255)
  - FEM identification: **Active firmware identifier 2 (FEM1)** (1-2:0.2.0*255)
  - CLR identification: **Active firmware identifier 5 (CLRFW)** (1-5:0.2.0*255)
  - Bootloader identification: **Active firmware identifier 6 (bootloader)** (1-6:0.2.0*255)
  - Kernel identification: **Active firmware identifier 7 (Kernel)** (1-7:0.2.0*255)
  - Core signature: **Active firmware signature (LRFW)** (1-0:0.2.8*255)
  - Application signature: **Active firmware signature 1 (NLRFW)** (1-1:0.2.8*255)
  - FEM signature: **Active firmware signature 2 (FEM1)** (1-2:0.2.8*255)
  - CLR signature: **Active firmware signature 5 (CLRFW)** (1-5:0.2.8*255)
  - Bootloader signature: **Active firmware signature 6 (bootloader)** (1-6:0.2.8*255)
  - Kernel signature: **Active firmware signature 7 (Kernel)** (1-7:0.2.8*255)

  - Core hash: **Active firmware hash (LRFW)** (1-0:128.2.8*255)
  - Application hash: **Active firmware hash 1 (NLRFW)** (1-1:128.2.8*255)
  - CLR hash: **Active firmware hash 5 (CLRFW)** (1-5:128.2.8*255)
  - Bootloader hash: **Active firmware hash 6 (bootloader)** (1-6:128.2.8*255)
  - Kernel hash: **Active firmware hash 7 (Kernel)** (1-7:128.2.8*255) – field C (128) is presented on display as letter “u”

- B.C.D.E format is used for presentation of the objects with field B ≠ 0.

In case mirror objects are enabled (see Figure 126), and A=1 and B ≠ 0, short OBIS name format (C.D.E) is used. For more information about the mirror objects functionality, see the chapter *9.19. Mirrored objects (optional)*.

Abbreviation characters

On the LCD, up to 6 characters of an OBIS code may be displayed. For specific multi-character OBIS code fields, abbreviation characters listed in Table 32 are used.

Multi-character field	Abbreviation character
96	C
97	F
98	L
99	P
128	U
196	A

Table 32: OBIS code abbreviation characters

9.3.2. Legally relevant data displayed on the LCD

Legally relevant objects enable the display of legally relevant data on the LCD. They are factory set and may not be configured after production. In the table below, available legally relevant objects are listed.

The LR cursor may be configured to turn ON when legally relevant data is displayed on the LCD.

Description	Full OBIS code	OBIS code on LCD
Active energy import	1-0:1.8.0*255	1.8.0
Active energy export	1-0:2.8.0*255	2.8.0
Reactive energy import	1-0:3.8.0*255	3.8.0
Reactive energy export	1-0:4.8.0*255	4.8.0
Reactive energy Q I	1-0:5.8.0*255	5.8.0
Reactive energy Q II	1-0:6.8.0*255	6.8.0
Reactive energy Q III	1-0:7.8.0*255	7.8.0
Reactive energy Q IV	1-0:8.8.0*255	8.8.0
Apparent energy import	1-0:9.8.0*255	9.8.0
Apparent energy export	1-0:10.8.0*255	10.8.0
Active energy, metrological LED	1-0:0.3.0*255	0.3.0
Reactive energy, metrological LED	1-0:0.3.1*255	0.3.1
Apparent energy, metrological LED	1-0:0.3.2*255	0.3.2
Active energy, output pulse meter constant	1-0:0.3.3*255	0.3.3
Reactive energy, output pulse meter constant	1-0:0.3.4*255	0.3.4
Apparent energy, output pulse meter constant	1-0:0.3.5*255	0.3.5

Description	Full OBIS code	OBIS code on LCD
Transformer ratio – current (numerator)	1-0:0.4.2*255	0.4.2
Transformer ratio – current (denominator)	1-0:0.4.5*255	0.4.5
Active firmware identifier (LRFW)	1-0:0.2.0*255	1.0.0.2.0
Active firmware signature (LRFW)	1-0:0.2.8*255	1.0.0.2.8
Active firmware hash (LRFW)	1-0:128.2.8*255	1.0.u.2.8
Fatal fault core status	0-0:196.97.40*255	A.F.40
Active firmware identifier (bootloader)	1-6:0.2.0*255	1.6.0.2.0
Active firmware signature (bootloader)	1-6:0.2.8*255	1.6.0.2.8
Active firmware hash (bootloader)	1-6:128.2.8*255	1.6.u.2.8

Table 33: Legally relevant objects

9.3.3. Console modes of operation

The meter has several modes to show data on the display:

- General display readout – Auto scroll mode (by default);
- Alternate display readout – Manual scroll mode
- Service mode.

All scroll sequences are configurable with parameters at meter run time.

9.3.3.1. General display readout mode (auto-scroll sequence)

The General display readout mode is implemented in the following way:

- General display readout mode is a general meter mode, where the items listed in the **General display readout** object (0-0:21.0.1*255) are cyclically displayed on the LCD.
- General display readout time is a configurable parameter and is set to 5 seconds by default.

General display readout object (0-0:21.0.1*255) is an instance of a COSEM Profile Generic class, where only the Capture Objects attribute is relevant (or other attributes are not used).

9.3.3.2. Alternate display readout mode (manual-scroll sequence)

Alternate display readout mode is implemented in the following way:

- Alternate display readout mode is used for manual data review on display.
- Displayed items are listed in Alternate display readout mode sequence list, defined by **Alternate display readout** object (0-0:21.0.2*255).
- Alternate display readout mode is accessible by appropriate pressing of the **Scroll** button.
- The next item from the sequence list is displayed by a short press on the **Scroll** button.
- At the end of sequence, the *End* notice is displayed.
- Escape in General display readout mode is performed by an extended press on the **Scroll** button when tip 'Esc' is shown. General display readout mode is automatically accessed after Exit time period while no button is pressed.

Alternate display readout object (0-0:21.0.2*255) is an instance of COSEM Profile Generic class, where only the Capture Objects attribute is relevant (or other attributes are no used).

NOTE

Depending on the button configuration, their functionality may vary. For more information, refer to chapter *9.3.8. Functionality of buttons and the disconnector status LED.*

9.3.3.3. Service mode (service manual-scroll sequence)

Service mode is similar to manual scroll, but it is accessible only to authorized persons (installers, technicians), and is not intended for the consumer.

- It is used for manual review of detailed information about the meter on the display.
- The meter enters the service mode when the terminal cover is opened, and it exits the service mode when the terminal cover is closed.
- In service mode, only the closing of the terminal cover causes access to any other mode.
- The next item from the service sequence list is displayed by a short press on the **Scroll** button.
- At the end of the service sequence list, the “End sequence” is displayed, which is not a part of the service display readout sequence. With another press on the **Scroll** button, first sequence from the service sequence list is displayed.

NOTE

Depending on the button configuration, their functionality may vary. For more information, refer to chapter *9.3.8. Functionality of buttons and the disconnector status LED.*.

In the service mode, displayed items are listed in the sequence list, defined by the **Service display readout sequence** (0-0:21.0.3*255).

Service display readout object (0-0:21.0.3*255) is an instance of COSEM Profile Generic class, where only the Capture Objects attribute is relevant (or other attributes are no used).

9.3.4. Console menu types

Selecting a console menu type sets the list of sequences that are displayed in the General and/or Alternate display mode. Two types of the console menu are available: **reduced** and **normal**.

9.3.4.1.1. Reduced console menu type

Reduced console menu type can be activated by executing Script 12 (via configuration tool, e.g., Iskraemeco SEP2 MeterView), which can be found in the **Function activation control script table** (0-0:10.0.111*255).

Button press	Press duration - T_p	Triggering event	Tip on display
Short press	$T_p < 1$ s	Perform the LCD test. Enter the Alternate display readout mode from the LCD test mode. Scroll forward to the next item in Alternate display readout mode.	/
Medium press	$1 \text{ s} \leq T_p < 2$ s	Scroll forward and skip the previous values in Alternate display readout mode.	/
Long press	$2 \text{ s} \leq T_p < 5$ s	Escape from the Consumer message code presentation (0-0:96.13.1*255)	ESC
Extended press	$5 \text{ s} \leq T_p < 8$ s	Escape from the Alternate display readout mode to the General display readout mode	ESC

Table 34: Usage of the Scroll button in the reduced console menu type

Press duration - T_p	Tip on display
$5 \text{ s} \leq T_p < 10$ s	EntEr
$10 \text{ s} \leq T_p < 15$ s	diSconn

Table 35: Usage of the disconnector button regardless of console mode

NOTE

Depending on the button configuration, their functionality may vary. For more information, refer to chapter *9.3.8. Functionality of buttons and the disconnector status LED.*

9.3.4.1.2. Normal console menu type

Normal console menu type can be activated by executing the Script 11 (via configuration tool, e.g., Iskraemeco SEP2 MeterView), which can be found in the **Function activation control script table** – 0-0:10.0.111*255 (class_id: 9).

Button press	**Press duration - T_p**	**Triggering event**	**Tip on display**
Scroll push-button			
Short press	$T_p < 1s$	Scroll forward / Go to the next item	/
Medium press	$1s \le T_p < 2s$	Scroll forward and skip the previous values (General display readout mode, Alternate display readout mode)	/
Long press	$2s \le T_p < 5s$	Enter to the current item / Go to the lower layer	EntEr
		Return to the upper layer at the End of list / Return to the upper layer from the lowest layer	LAYEr UP
		Return to the General display readout mode at the End of list in Set menu / Data menu	ESC
		Escape from the Consumer message code presentation (0-0:96.13.1*255)	ESC
Extended press	$5s \le T_p < 8s$	Escape to the General display readout mode from any mode	ESC

Table 36: Usage of the Scroll button in the normal console menu type

NOTE

Depending on the button configuration, their functionality may vary. For more information, refer to chapter *9.3.8. Functionality of buttons and the disconnector status LED.*

9.3.5. Display format

Display format objects are used to configure format for energy and demand presentation on the display. The display format is supported for Energy and Demand registrations.

Units for displayed data are represented as:

- Active energy in kWh,
- Reactive energy in kvarh,
- Apparent energy in kVAh,
- Active power in kW,
- Reactive power in kvar
- Apparent power in kVA
- Current in A,
- Voltage in V.

9.3.5.1. Display format for energy

Display format for energy object (0-0:196.1.0*255) holds the value WP, which follows these rules:

- Definition of value: WP
- W = Width:
  - Width is a number of digits for energy presentation on display.
  - It is a sum of integer digits and decimal digits.

- First nibble of object's value (upper half of byte).
- Maximum width value is 8 digits.

- P = Precision:
    - Precision is a number of decimal digits for energy presentation on display.
    - Last nibble of object's value (lower half of byte).
    - Precision value (number of decimal digits) should be between 0 and 3.
- Default value: WP = 60
    - Width: 6 digits
    - Precision: 0 digits
    - Resulting format form: 000000

Example:

WP = 82

- Width: 8 digits
- Precision: 2 digits
- Resulting format form: 000000.00

NOTE

Not all combinations of Width and Precision are valid.

Energy registers: The value of energy registers is limited to maximum 999999999 before it overflows to 0. By default, the energy registers have a span up to 1 G*[unit]*h (a default value of **Results energy scaler** (0-0:196.0.4*255) is 0). With maximum scaler value 4 and display format value 80, the span can increase up to 100 G*[unit]*h (for more information, see chapter *8.5.1. Energy*).

Display: Since all energy registers on the display are shown in k*[unit]*h, their maximum span has to be taken into consideration when choosing the Energy display format (e.g: 00000000.0 is thus not allowed).

When choosing Energy display format, consider about the value of scaler unit as well.

9.3.5.2. Display format for demand

Display format for demand object (0-0:196.1.1*255) holds the value WP, which follows these rules:

- Definition of value: WP
- W = Width:
    - Width is a number of digits for demand presentation on display.
    - It is a sum of integer digits and decimal digits.
    - First nibble of object's value (upper half of byte).
    - Maximum width value is 8 digits.
- P = Precision:
    - Precision is a number of decimal digits for demand presentation on display.
    - Last nibble of object's value (lower half of byte).
    - Precision value (number of decimal digits) should be between 0 and 3.
    - Default value: WP = 53Width: 5 digits
    - Precision: 3 digits
    - Resulting format form: 00.000

9.3.6. Other supported display functions

9.3.6.1. FW version data display mode

The firmware (FW) version data display mode sequence enables user to read FW version data (FW identifier, FW signature, FW hash) on the display. In Table 37, a predefined list of firmware data is presented.

Item	OBIS code	Description	Image
1	1-6:0.2.0*255	Active firmware identifier (bootloader)	Bootloader
2	1-6:128.2.8*255	Active firmware hash (bootloader)	Bootloader
3	1-6:0.2.8*255	Active firmware signature (bootloader)	Bootloader
4	1-0:0.2.0*255	Active firmware identifier (LRFW)	Core
5	1-0:128.2.8*255	Active firmware hash (LRFW)	Core
6	1-0:0.2.8*255	Active firmware signature (LRFW)	Core
7	1-7:0.2.0*255	Active firmware identifier 7 (NLRFW)	Kernel
8	1-7:128.2.8*255	Active firmware hash 7 (NLRFW)	Kernel
9	1-7:0.2.8*255	Active firmware signature 7 (NLRFW)	Kernel
10	1-5:0.2.0*255	Active firmware identifier 5 (CLRFW)	Country Legally Relevant
11	1-5:128.2.8*255	Active firmware hash 5 (CLRFW)	Country Legally Relevant
12	1-5:0.2.8*255	Active firmware signature 5 (CLRFW)	Country Legally Relevant
13	1-1:0.2.0*255	Active firmware identifier 1 (NLRFW)	Application
14	1-1:128.2.8*255	Active firmware hash 1 (NLRFW)	Application
15	1-1:0.2.8*255	Active firmware signature 1 (NLRFW)	Application

Table 37: FW version data list

Scrolling between the data is not automatically; it can be done only by manual scroll – with short press on the Scroll button.

The FW version data display mode can only be started under the following condition: power on the meter with removed terminal cover.

The FW version data display mode is automatically ended after 15 minutes. Every press on the Scroll button resets this timer. To exit it manually, extended press (> 5s) of the Scroll button shall be performed. Closing terminal cover also triggers escape from the FW version data display mode. Exiting the display mode results in going back to the auto scroll mode. In case terminal cover remains open, it goes to service display mode.

9.3.6.2. Display consumer message text

Consumer message text - Consumer information (object: 0-0:96.13.0*255) is sent to the display (and P1 port) without any further interpretation, with a maximum of 1024 characters in ASCII format. Messages that exceed the maximum size will be shortened; only the first 1024 characters will be displayed, while rest of them will not be displayed.

If the message text exceeds 8 characters, it is presented on display with horizontal scroll function.

9.3.6.3. Neutral – Phase wrong connection indication

In 3-phase meters, when phase and neutral conductor are mixed up, dedicated phase indicator (L1, L2 or L3) blinks and fixed text (no specific object) is displayed on LCD (for example, see Figure 86):

n-L *(phase)* **Err**

Figure 86: Example of wrong Neutral-Phase connection indication text on display

In this state, fixed text on the LCD can be escaped by an extended press (5 s ≤ T_p < 8 s) on the Scroll button (before releasing the button, tip 'Esc' is displayed on the LCD). The dedicated phase indicator that is misconnected is still blinking.

This alarm state has the highest priority to be shown on display as a matter of the greatest importance.

9.3.6.4. Disconnection indication of the disconnector

With extended press on the Disconnector button (> 10 s < 15 s) tip 'Disconn' is displayed and if we release button in during that tip, the disconnector is disconnected (considering appropriate disconnection controlling mode). In the case of permission for reconnection, the disconnector disconnection alarm is displayed on the LCD (Figure 87).

Figure 87: Connect text on display

This alarm state has a higher priority than the auto scroll mode.

9.3.7. Practical cases

NOTE

The order of the displayed items listed in individual modes is defined in corresponding object as follows:

- General display readout mode (Auto scroll mode) in object **General display readout** (0-0:21.0.1*255)
- Alternate display readout mode (Manual scroll mode) in object **Alternate display readout** (0-0:21.0.2*255)
- Service mode (service manual-scroll sequence) in object **Service display readout** (0-0:21.0.3*255)

NOTE

The order of registers in the *Std dAtA* and *Ser dAtA* menu is already set in the relevant object (see objects above) and can be changed by them.

9.3.7.1. Reading firmware version, signature, and hash on LCD

1. Remove the terminal cover. On the LCD *SEr dAtA* appears.
2. To enter the *SEr dAtA* menu long press the **Scroll** button until *EntEr* appears. By short pressing the **Scroll** button, manually listing between registers is now available.
3. Press the **Scroll** button repeatedly until the desired register (appropriate register's code can be found below this procedure or in the object lists) can be seen on the top left side of the LCD. The value of this register is displayed below. In case of signature/hash, the value is automatically scrolled on the LCD.
4. By next short press on the **Scroll** button, the value for next register appears (if at the end of the register list, instead of a register, *End* is displayed; the list is cyclic). Press the **Scroll** button repeatedly until the desired register appears. Then, read its value.
5. If there is no need to read a value of any other register, exit Service mode. Put the terminal cover back on the meter and tighten screws.

Active firmware identifier (LRFW) can be found by the register **1-0:0.2.0*255**.
Active firmware signature (LRFW) can be found by the register **1-0:0.2.8*255**.
Active firmware hash (LRFW) can be found by the register **1-0:128.2.8*255**.
Active firmware identifier 1 (NLRFW) can be found by the register **1-1:0.2.0*255**.
Active firmware signature 1 (NLRFW) can be found by the register **1-1:0.2.8*255**.
Active firmware hash 1 (NLRFW) can be found by the register **1-1:128.2.8*255**.
Active firmware identifier 5 (CLRFW) can be found by the register **1-5:0.2.0*255**.
Active firmware signature 5 (CLRFW) can be found by the register **1-5:0.2.8*255**.
Active firmware hash 5 (CLRFW) can be found by the register **1-5:128.2.8*255**.
Active firmware identifier 6 (bootloader) can be found by the register **1-6:0.2.0*255**.
Active firmware signature 6 (bootloader) can be found by the register **1-6:0.2.8*255**.
Active firmware hash 6 (bootloader) can be found by the register **1-6:128.2.8*255**.
Active firmware identifier 7 (Kernel) can be found by the register **1-7:0.2.0*255**.
Active firmware signature 7 (Kernel) can be found by the register **1-7:0.2.8*255**.
Active firmware hash 7 (Kernel) can be found by the register **1-7:128.2.8*255**.

9.3.7.2. Reading load profile values on LCD

NOTE
The load profile values can be read only in NORMAL console menu type.

1. Short press the **Scroll** button (< 1 s); the display test mode displays.
2. Short press the **Scroll** button; *Std dAtA* appears.
3. Short press the **Scroll** button repeatedly until the register **P.0x** (x stands for load profile number; x = 1, 2, 3 or 4) can be seen on the LCD.
4. With long press on the **Scroll** button, enter the selected P.0x register.
5. Short press the **Scroll** button repeatedly until wanted **date** is displayed. With long press enter desired **date**.
6. Short press the **Scroll** button repeatedly until wanted **time** is displayed. With long press enter desired **time**.
7. To scroll between the Load profile's values, short press the **Scroll** button. To read all the values keep short pressing the button until *End* is displayed.
8. If there is no need to read a value of any other register, exit by extended press (≥ 5 s < 8 s) on the **Scroll** button until *ESC* is displayed. The transition from Manual to Auto scroll mode can happen automatically; the transition time is configurable.

9.3.7.3. Reading the certification log (P.99) values on LCD

NOTE
The certification log values can be read only in NORMAL console menu type.

1. Short press the **Scroll** button (< 1 s); the display test mode displays.
2. Short press the **Scroll** button; *Std dAtA* appears.
3. Short press the **Scroll** button repeatedly until the register **P.99** can be seen on the LCD.
4. To enter the desired register, long press the **Scroll** button until *EntEr* shows – release the button then. On the LCD, the date values of P.99 is displayed.
5. To scroll between the certification log's date values, short press the **Scroll** button. To read all the values keep short pressing the button until *End* is displayed.

6. To read the date's corresponding time value, long press the **Scroll** button until *EntEr* shows – release the button then.
7. The list of time values with corresponding old and new values is displayed on the LCD. Scroll between them with short press on the **Scroll** button.
8. To return to the date value list (which is one layer up), long press the **Scroll** button until *LAYEr uP* shows – release the button then.
9. If there is no need to read a value of any other register, exit by extended press (≥ 5 s < 8 s) on the **Scroll** button until *ESC* is displayed. The transition from Manual to Auto scroll mode can happen automatically; the transition time is configurable.

9.3.8. Functionality of buttons and the disconnector status LED

On the meter's front side, there are two built-in buttons (

Figure 88), top (key 1) and bottom (key 2). By a customer choice, the bottom button can be sealable. The meter additionally supports two external keys (only with appropriate HW configuration; see Table 8).

Their functionalities may vary. The buttons' functionalities are defined by a customer needs and performed during the meter's production.

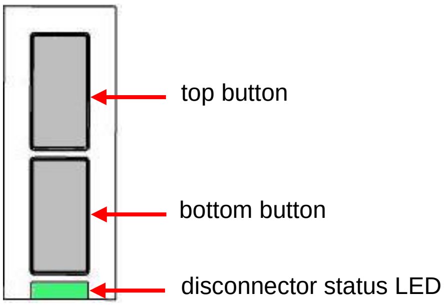


Figure 88: Top and bottom button, and disconnector status LED

In general, a **Short press** means pressing a button less than 1 second. A **Long press** means pressing a button for 2–5 seconds, and an **Extended press** means pressing a button at least for 5 seconds or more. When the buttons are the first time pressed (in auto scroll and manual scroll modes), the display backlight is on.

During a meter production, functionalities of the top and bottom button of the meter as well as external buttons are defined by the object **Console keys configuration** (0-0:196.1.5*255; see Figure 89). The top button is usually used for scrolling the data and navigating through the menus on the display. If the meter supports an M-Bus functionality, then the bottom button shall be configured for an M-Bus device control, since it can be sealed. Otherwise, the bottom button can be used for other functionalities, e.g., for a Disconnector control.

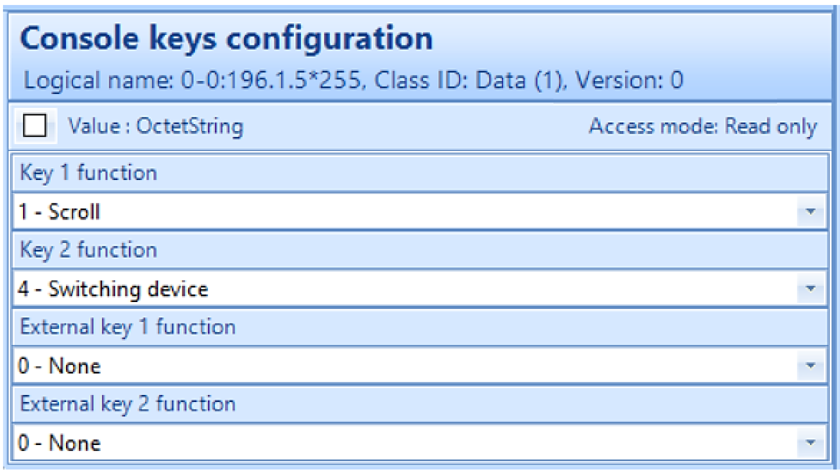


Figure 89: Console keys configuration

NOTE

In the **Console keys configuration object** (0-0:196.1.5*255), a functionality of each button is defined, integrated buttons (keys) on the front plate of the meter as external buttons.

The buttons (keys) functionalities can be configured as it is presented in Table 38.

Function name	Function description
0 – None	No functionality
1 – Scroll	Scroll functionality
2 – Scroll + switching device	Scroll functionality with disconnector (switching device) functionality
3 – Binding	Binding button functionality
4 – Switching device	Disconnector (switching device) functionality
5 – Switching device simple	Simple disconnector (switching device) functionality (typically for external keys)

Table 38: Button functionalities – possible configurations

Button functionalities:

- **None** – the button is defined without any of the functionalities.
- **Scroll button** is used to scroll data in the Manual scroll mode and Service mode sequences (short press).
- **Scroll + Switching device** – the button's primary functionality is to scroll data in the Manual scroll mode and Service mode sequences (short press). As a secondary functionality, it is used for disconnect/reconnect control of the disconnector. Disconnection can be performed with the press duration between 10 and 15 seconds, while reconnection can be performed with the press duration between 5 and 10 seconds.
- **Switching device button** is used to connect/disconnect the disconnector (switching device).
- **Binding button** is used for controlling of M-Bus devices (wireless).
- **Switching device simple** is used for disconnect/reconnect control of the disconnector (switching device) via the one of external buttons.

NOTE

The button functionality "Switching device" differs from the functionality "Switching device simple".

- While using the button with the "**Switching device**" functionality, messages about the disconnector status show on the LCD. These messages guide a user when to make particular action or give him/her an information about the status.
- While using the button with the "**Switching device simple**" functionality, action of disconnection/reconnection is performed after 5 seconds.

The disconnector status LED is placed just below the buttons (see

Figure 88). It is used to indicate disconnector status information. A using of the disconnector status LED can be enabled or disabled by **Display configuration** object (0-0:196.1.3*255), attribute 7. When its use is enabled and the LED:

- ***lights***, the disconnector is disconnected,
- ***blinks***, the disconnector is ready to connect,
- ***is off,*** the disconnector is connected.

When its functionality is disabled, the LED is off regardless of the disconnector status.

9.4. Communication

The device supports several communication technologies for a local and a remote communication. The communication is provided by an integrated communication interface, or by a field-exchangeable communication module (shortly communication module).

For more information about the modules, see chapters *4.4.3. The modular part of the meter* and *9.4.2.3. Field-exchangeable communication* modules of this document, and corresponding technical description of the module.

9.4.1. Local communication

The meter supports the following communication technologies for local communication:

- the optical interface (P0)
- the P1 interface (P1)
- the M-Bus interface (P2)

9.4.1.1. The optical interface (P0)

The optical interface operates according DLMS (IEC 62056-46) standard.

Every meter has built-in optical interface on the front plate of the meter. The optical interface provides 2-way communication (read and write) and is used for local meter data readouts and settings via a PC, laptops or HHU (Hand Held Units) devices by an optical probe.

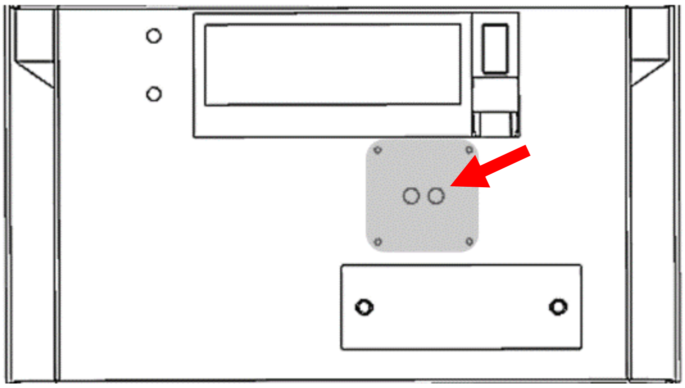


Figure 90: The optical interface

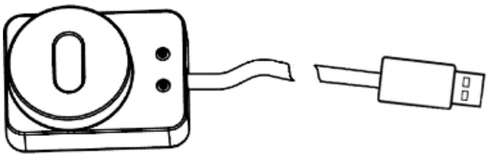


Figure 91: An optical probe

NOTE
The minimum communication speed to be used on the optical interface is 600 baud. Less than the minimum communication speed can result in communication errors.

9.4.1.2. The P1 interface (P1) (optional)

The P1 interface is a one-way read-only communication interface, which operates according to DSMRP1 Specification. The meter has one physical P1 port, which allows the connection of more than one OSM (Other Service Module) devices by using a splitter. The P1 port is mainly intended to connect an In-House Display (IHD) to the E-meter.

The default baud rate setting is 115200.

The P1 interface supports three different modes of sending data, depending on the choice of communication mode attribute in a dedicated IEC local port setup object.

Using IEC 62056-21 (IEC 1107) as the communication mode, the E-meter can send data out with the following predefined object:

- **General local port readout** (0-0:21.0.0*255) Used for defining objects sent out over the P1 port. Up to 64 objects can be defined. Also, a period of sending data is set in the attribute *Capture period.*

Using IEC 62056-21 (IEC 1107) with custom extensions as the communication mode, the E-meter can send data predefined with objects:

- General local port readout (0-0:21.0.0*255)
- Consumer message code (0-0:96.13.0*255)
- Consumer message text (0-0:96.13.1*255)

NOTE

The difference between IEC 62056-21 and IEC 62056-21 with extensions is in different speed and character formatting as well as in the data readout message structure.

The meter supports IEC 62056-46 (DLMS UA) over P1, which is used as a communication protocol. In this case, the E-meter sends data using the Consumer Information Push (CIP) functionality according to IDIS Package 2 specification and predefined settings of dedicated CIP objects:

- Push setup - Consumer Information (0-6:25.9.0*255)
- **Push script table** (0-0:10.0.108*255)
- Push action scheduler – Consumer Information (0-4:15.0.4*255)
- Security Setup – CIP Client Association (0-0:43.0.1*255)
- Consumer message text – Consumer information (0-0:96.13.0*255)

The port is activated by activating (raising) the request signal (~5 V). While receiving data, the requesting device must keep the request port activated (raised). Using IEC 62056-21 (IEC 1107) or IEC 62056-21 (IEC 1107) with extensions as communication mode, the E-meter sends data to the P1 port with a period defined in the *Capture period* attribute of the **General local port readout** (P1 port readout list) object. When the DLMS UA communication protocol is selected, the E-meter sends data to the P1 port with period defined in the object **Push action scheduler – Consumer Information** / **Push short interval scheduler – Consumer information**.

When more than one OSM (e.g. an in-house display) is connected to the meter, each OSM may request data input and all OSMs will receive the same data sent by the meter.

There is no address for P1 devices and more than one OSM can be connected, activated or not. Dropping the request line by connecting to ground is not allowed, to prevent short circuit. Modulating the request signal is not allowed. Data transfer will stop immediately after the request signal is dropped.

9.4.1.3. The M-Bus interface (P2)

The electricity meter (E-meter) IE.x can communicate with several types of sub-metering devices, which are connected to the e-meter via an **M-Bus communication interface** (P2). The E-meter supports sub-metering devices for gas (G-meter), thermal (heat/cold), water (W-meter), electricity meters and other devices, which are based on the M-Bus European standard EN 13757.

For more information about M-Bus, refer to chapter 10. M-BUS.

9.4.2. Remote communication (P3)

9.4.2.1. RS-485 (optional)

The meter can be equipped with integrated RS-485 communication module (refer to the chapter describing the meter construction). The RS-485 communication interface operates according to IEC 62056–21 (IEC 1107) and IEC 62056-46 (DLMS UA) standards.

The RS-485 communication interface typically uses a protocol according to IEC 62056-46, which enables a connection of up to 111 meters to a RS-485 master device (communicator, modem, RS-485/RS-232 converter...). Each meter in the RS-485 network must have an assigned unique HDLC (High-Level Data Link Control) address. Available HDLC addresses are from 16 to 126. If the IEC 62056–21 (modes A..D) protocol is used, then each meter must have a unique device address (8 octets). The number of connected devices to the network is thus limited by a hardware. The RS-485 connection enables the communication with only one meter in the RS-485 line at the same time – simultaneous communication with more meters at the same time is not possible. Maximum distance between the master device and the last meter of the RS-485 Master—Slave connection is 1200 m. In some cases, there is no need to connect GND for smaller distances.

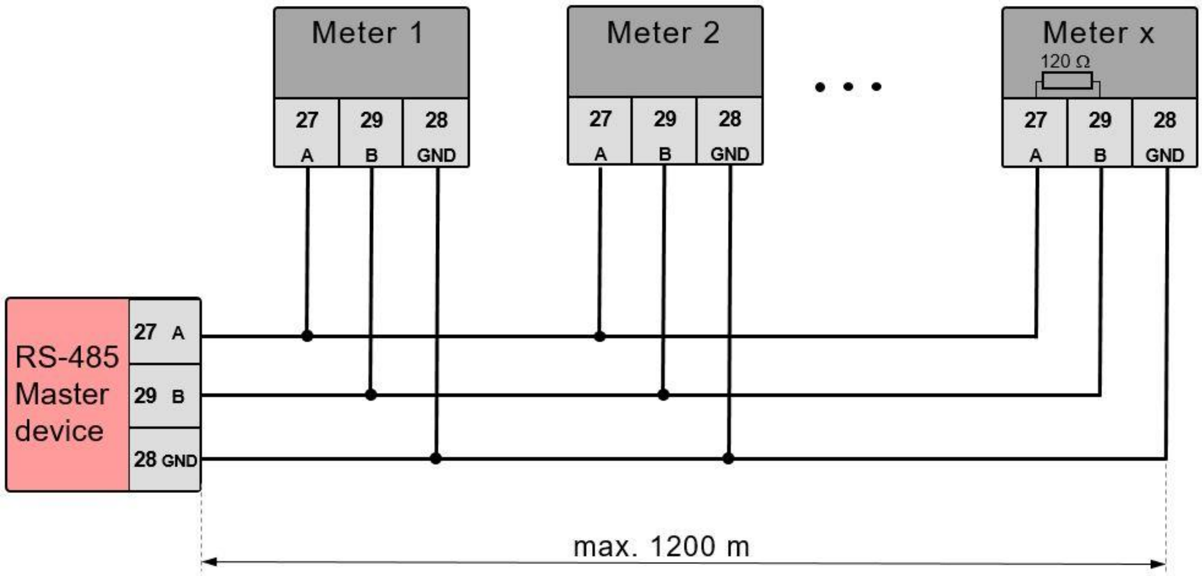


Figure 92: RS-485 Master – Slave connection diagram

NOTE

RS-485 interfaces of the last meter and standalone devices (unused interfaces) in the RS-485 line have to be terminated with a 120 Ohm resistor.

9.4.2.1.1. Port setup

9.4.2.1.1.1. IEC local port setup

This object includes parameters for RS-485 interface communication.

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	19	0-3:20.0.0	R			
2. Communication mode	Enum			R/(W)	0	2	0
3. Default baud rate	Enum			R/(W)	0	9	0
4. Proposed baud rate	Enum			R/(W)	0	9	5
5. Response time	Enum			R/(W)	0	1	0

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
6. Device address	Octet-string			R/(W)			00000000
7. Setting password	Octet-string			(R)/(W)			12345678
8. Parameterization Password	Octet-string			(R)/(W)			12345678
9. W5 password	Octet-string			(R)/(W)			12345678

Table 39: IEC local port object

Communication Mode

Defines the protocol used by the meter on the port. It is possible to select between these modes:

- (0) - protocol according to IEC 62056-21 (IEC 1107);
- (1) - protocol according to IEC 62056-46 (DLMS UA);
- (2) - protocol not specified; proposed baud rate is used for setting the communication speed.

Communication Speed

The default baud rate is the baud rate for the opening sequence and the proposed baud rate is the baud rate to be proposed by the meter (relevant only for communication mode 0 – IEC1107, modes A to E). Communication speed up to 115200 baud/s is possible. Selection can be made between the following rates:

- (0) – 300 baud
- (1) – 600 baud
- (2) – 1200 baud
- (3) – 2400 baud
- (4) – 4800 baud
- (5) – 9600 baud
- (6) – 19200 baud
- (7) – 38400 baud
- (8) – 57600 baud
- (9) – 115200 baud

Response Time

The Communication response time is the time between the reception of a request and the transmitting of the response. It defines the minimum time between the reception of a request (end of the request telegram) and the transmission of the response (beginning of the response telegram). Two response time options are available:

- (0) – 20 ms;
- (1) – 200 ms.

Device Address

The Device address is intended to identify a meter in the group of meters. Each meter in one group must therefore have a unique number. Eight-digit numbers should be used.

Passwords

There are three different passwords for communication channels:

- **Settings password** (used in IEC 1107, where the entrance password needs to match this password and one of the four authentication keys). Eight-digit numbers should be used.
- Parameterization password (not used).
- W5 password (not used).

9.4.2.1.1.2. IEC HDLC setup

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	23	0-3:22.0.0	R			
2. Communication speed	Enum			R/(W)	0	9	5
3. Window size transmit	Unsigned8			R/(W)	1	7	1

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
4. Window size receive	Unsigned8			R/(W)	1	7	1
5. Max info field length transmit	Unsigned16			R/(W)	32	2030	154
6. Max info field length receive	Unsigned16			R/(W)	32	2030	154
7. Inter octet timeout	Unsigned16			R/(W)	20	6000	50
8. Inactivity timeout	Unsigned16			R/(W)	0	65535	120
9. Device address	Unsigned16			R/(W)	0	65535	17

Table 40: IEC HDLC setup object

Communication Speed

Selection can be made between the following rates:

- (0) – 300 baud
- (1) – 600 baud
- (2) – 1200 baud
- (3) – 2400 baud
- (4) – 4800 baud
- (5) – 9600 baud
- (6) – 19200 baud
- (7) – 38400 baud
- (8) – 57600 baud
- (9) – 115200 baud

Window Size Transmit

The attribute defines the maximum number of frames that a device or system can transmit before it needs to receive an acknowledgement from a corresponding station. During logon, other values can be negotiated.

Window Size Receive

The attribute defines the maximum number of frames that a device or system can receive before it needs to transmit an acknowledgement to the corresponding station.

Maximum Info Length Transmit

The attribute defines the maximum information field length that a device can transmit.

Maximum Info Length Receive

The attribute defines the maximum information field length that a device can receive.

Inter Octet Time Out

The attribute defines the time, expressed in milliseconds, over which, when any character is received from the primary station, the device will treat the already received data as a complete frame.

Inactivity Time Out

The attribute defines the time, expressed in seconds over which, when any frame is received from the primary station, the device will process a disconnection. When set to 0, this means that the inactivity time out is not operational.

Device Address

The attribute contains the physical device address of a device. In case of a single byte addressing:

- 0x00 No Station Address
- 0x01…0x0F Reserved for future use
- 0x10...0x7D Usable address space
- 0x7E 'Calling' device address
- 0x7F Broadcast address

9.4.2.2. G3-PLC (optional)

The G3-PLC communication modem enables the meter to communicate through the power line network using the G3-PLC technology. The G3-PLC communication modem is integrated inside the meter; therefore, no additional wiring is required.

Modem initialization

At every meter power-up (also the meter reset), the modem initialization starts.

When the G3-PLC communication modem is detected, the meter tries to identify the modem by sending a so called *G3-PLC Modem System Reset* command. When the modem normally responds with *G3-PLC Modem Status Indication* message, it continues by identifying the modem with *Get System Info* request. The modem returns versions and time stamps of firmware running in the modem. During modem initialization phase meter manages the related parameters stored in the meter and properly transforms them to modem settings. Most of parameters are included in standard **G3-PLC MAC setup** object (0-0:29.1.0*255) and **G3-PLC 6LoWPAN adaptation layer setup** object (0-0:29.2.0*255). However, additional manufacturer specific **G3 init configuration** (0-0:128.0.16*255) is implemented to provide some more initialization functionality. If meter recognizes that specific phase of initialization process has failed, it resets the modem and starts the whole initialization process again.

Bootstrap process

After initialization, the meter starts with the G3-PLC bootstrap process in order to assure proper discovery and joining to the best available G3 PLC network. The process provides functionality to spread bootstrapping of meter population in time. Subsequent discover/join requests are scheduled in time slots. Inside one time slot, one discovers request is executed. Based on meter rules, the best node is selected for joining. When join action is successful the meter enters a connected state, and the bootstrap process is finished. If the meter fails to discover or join the selected PAN (Personal Area Network), it resets the modem and starts the whole initialization process again.

Each PAN discover request sent by the meter is logged into **Communication event log** (0-0:99.98.5*255) as the *G3-PLC discover* event (202). Also, every successful join is logged as the *G3-PLC joined* event (200).

Data transfer

After the bootstrap process ends successfully, data transfer can start. UDP protocol is used for transferring COSEM/DLMS data over G3-PLC networks. The port, used by COSEM Wrapper to listen for incoming UDP requests, is defined by **TCP-UDP Setup** object (0-0.25.0.0*255), same as for other IP-based communication technologies. Maximum received and sent PDU (Protocol Data Unit) sizes on the COSEM layer are 1224 bytes.

Kicked from the PAN

When the meter is kicked from the PAN network by the coordinator this is logged into the **Communication event log** (0-0:99.98.5*255) as the *G3-PLC kicked* event (201). The same event is generated when the user disables the WAN port, and the meter intentionally leaves the PAN network.

Detection of no-connection timeout and the modem reset

When no communication is detected over a certain communication interface for a preconfigured time (set in the object **No connection timeout** (0-0:128.20.30)), the meter requests the modem reset. Every G3-PLC communication modem reset is logged into the **Communication event log** by the *Modem SW reset* event (149). This event is also generated at startup time because the SW reset is a standard part of the G3-PLC communication modem initialization procedure.

9.4.2.2.1. Configuration of the G3-PLC communication

The operation of the G3-PLC communication modem is defined and described by a set of parameters and attributes that can be accessed by a group of dedicated COSEM objects listed in Table 41.

OBIS code	Object name
0-0:128.0.16*255	G3 init configuration
0-0:128.0.17*255	G3 bootstrap configuration
0-0:128.0.19*255	G3-PLC scan result
0-0:128.0.20*255	G3-PLC diagnostic data
0-0:128.0.21*255	G3-PLC sniffer mask
0-0:128.0.22*255	G3-PLC PSK change
0-0:128.0.23*255	G3-PLC Tone mask CENELEC-A
0-0:128.0.24*255	G3-PLC Tone mask FCC
0-0:25.2.0*255	MAC address setup
0-0:29.0.0*255	G3-PLC MAC layer counters
0-0:29.1.0*255	G3-PLC MAC setup
0-0:29.2.0*255	G3-PLC MAC 6LoWPAN adaptation layer setup
0-0:25.7.0*255	IPv6 setup
0-0:10.1.250*255	G3-PLC script table
0-0:15.0.250*255	G3-PLC single action schedule
0-0:10.1.247*255	G3-PLC complex parameters script table
0-0:10.2.102*255	G3-PLC activate sniffing mode script table

Table 41: List of G3-PLC related objects

9.4.2.2.1.1. G3 init configuration

Basic initialization parameters of G3-PLC modem can be defined in object **G3 init configuration** (0-0:128.0.16*255); see Table 42.

Name	Logical Name	Attribute	Description
G3 init configuration	0-0:128.0.16*255	Standard	Interoperability standard, which defines the desired band. Attribute value is enumerated: **(0) ITU-T 9903:2015** **(1) IEEE 1901.2** **(2) ITU-T 9903:2017**
		Band	Frequency band (considering the narrowband, in different regions of the world) used for G3-PLC communication. Attribute value is enumerated: **(0) CENELEC A** **(1) FCC** **(2) ARIB**
		Modulation	Modulation type. Attribute value is enumerated: **(0) ROBO** **(1) DBPSK/BPSK** **(2) DQPSK/QPSK** **(3) D8PSK/8PSK** **(4) 16QAM** **(5) SROBO**
		Control modulation	Attribute value is enumerated: **(0) Adapted** **(1) Fixed**
		Control tonemap	Attribute value is enumerated: **(0) Adapted** **(1) Fixed**
		Control DC offset compensation	Attribute value is enumerated: **(0) Compensation OFF** **(1) Compensation ON**
		Kalman estimator	Attribute value is enumerated: **(0) Disabled** **(1) Enabled**

Name	Logical Name	Attribute	Description
		Bitstring bit order	Defines presentation of tone mask bitstring, which appears in *G3-PLC MAC Setup (0-0:29.1.0*255)* and *G3-PLC Tone mask Cenelec A (0-0:128.0.23*255)* object. Attribute value is enumerated: **(0) Normal** – bitstring of tone mask is presented in normal order – as it specified by COSEM Blue Book (EXCERPT DLMS UA 1000-1, Ed. 12) **(1) Reversed** – bitstring of tone mask is presented in reversed order, meaning the most left bit becomes the most right bit; second most left bit becomes second most right bit and so on for all other bits.
		Power backoff	Power back off (in 1 dB step). Value range: 4–30 dB

Table 42: G3 init configuration

9.4.2.2.1.2. G3-PLC bootstrap configuration

G3-PLC bootstrap process is described in the introduction of chapter *9.4.2.2. G3-PLC (optional)*.

The timing parameters for execution of bootstrap process and criteria for selecting proper G3-PLC network can be configured in object **G3 bootstrap configuration** (0-0:11.128.0.17*255); see Table 43.

Name	Logical name	Attribute	Description
G3 bootstrap configuration	0-0:128.0.17*255	Active scan duration	The number of seconds the active scan shall last. (Min: 0 s – Max: 255 s)
		Randomisation time step	The duration of time slot (in seconds) for subsequent discover/join attempts. Inside the slot, single attempt randomisation is done. (Min: 0 – Max: 65535)
		Max retry	Maximum number of subsequent discover/join attempts. When defined number is reached, the meter resets the modem and starts from beginning. (Min: 0 – Max: 255)
		Join LQI threshold	Defines the minimal quality of the connection (in LQI) that meter requires in to start a join sequence. (Min: 0 – Max: 72)
		Join alternate PAN	Attribute value is enumerated: (0) **Disabled** (1) **Enabled**

Table 43: G3 bootstrap configuration

9.4.2.2.1.3. MAC address setup

The basic unique property of each G3-PLC communication modem is its MAC address. Based on the MAC address, each modem can be individually addressed inside the G3-PLC network. Because the MAC address is tightly bound to individual G3-PLC modem, it is written directly into the modem during production. The MAC address can be read in a dedicated object **MAC address setup** (0-0:25.2.0*255).

9.4.2.2.1.4. Setting the tone mask for band switching

The tone mask is a predefined (defined by attribute ***MAC tone mask*** in **G3-PLC MAC setup** object (0-0:29.1.0.*255); refer to Table 47) system-wide parameter defining the start, stop and notch frequencies.

According to selected band (**G3 init configuration** (0-0:128.0.16*255), att. ***Band***; refer to Table 42), dedicated tone mask must be set (with a correct set bitstring bit order – **G3 init configuration** (0-0:128.0.16*255), att. ***Bitstring bit order***; refer to Table 42). Dedicated tone mask for:

- Cenelec-A band must be defined in object **G3-PLC Tone mask Cenelec A** (0-0:128.0.23*255); default value is FF FF FF FF F0 00 00 00 00,
- FCC band must be defined in object **G3-PLC Tone mask FCC** (0-0:128.0.24*255); default value is FF FF FF FF FF FF FF FF FF.

NOTE

According to the selected band, the content of one object is also reflected in **G3-PLC MAC Setup** object (0-0:29.1.0.*255), attribute ***MAC tone mask***.

9.4.2.2.1.5. Scripts and scheduling

The meter also provides a way to change the "*Standard***"** and "*Band*" configuration on the field. The specific of this use case is that the configuration should be set at the same time on the whole population of meters. For this purpose, the meter provides the **G3-PLC script table** object (0-0:10.1.250*255) and the **G3-PLC single action schedule** object (0-0:15.0.250*255) through which the HES can configure G3-PLC operation switch-over at a specific time in the future.

9.4.2.2.1.5.1. G3-PLC script table

The meaning of the scripts implemented inside **G3-PLC script table** object is presented in Table 44. Execution of specific script also results in a change of "*Standard*" and "*Band*" fields of G3-PLC init configuration object.

Script ID	Executed action
1	Activate ITU-T G.9903:2015 CENELEC A Band
2	Activate ITU-T G.9903:2015 FCC Band
3	Activate ITU-T G.9903:2015 ARIB Band
4	Activate ITU-T G.9903:2017 CENELEC A Band
5	Activate ITU-T G.9903:2017 FCC Band
6	Activate ITU-T G.9903:2017 ARIB Band

Table 44: Available scripts of G3-PLC script table object

When the Script 1 or Script 4 (of the **G3-PLC script table** object) is executed, the meter copies a **tone mask** from the **G3-PLC Tone mask Cenelec A** (0-0:128.0.23*255) into the ***MAC tone mask*** attribute of **G3-PLC MAC setup** object (0-0:29.1.0*255). Similarly, for Script 2 and Script 5, the meter copies the tone mask from the **G3-PLC Tone mask FCC** (0-0:128.0.24*255) into the ***MAC tone mask*** attribute of **G3-PLC MAC setup** object (0-0:29.1.0*255). This way, 0-0:128.0.23*255 and 0-0:128.0.24*255 objects are used as passive tone masks for specific frequency band. For easier understanding, see Figure 93.

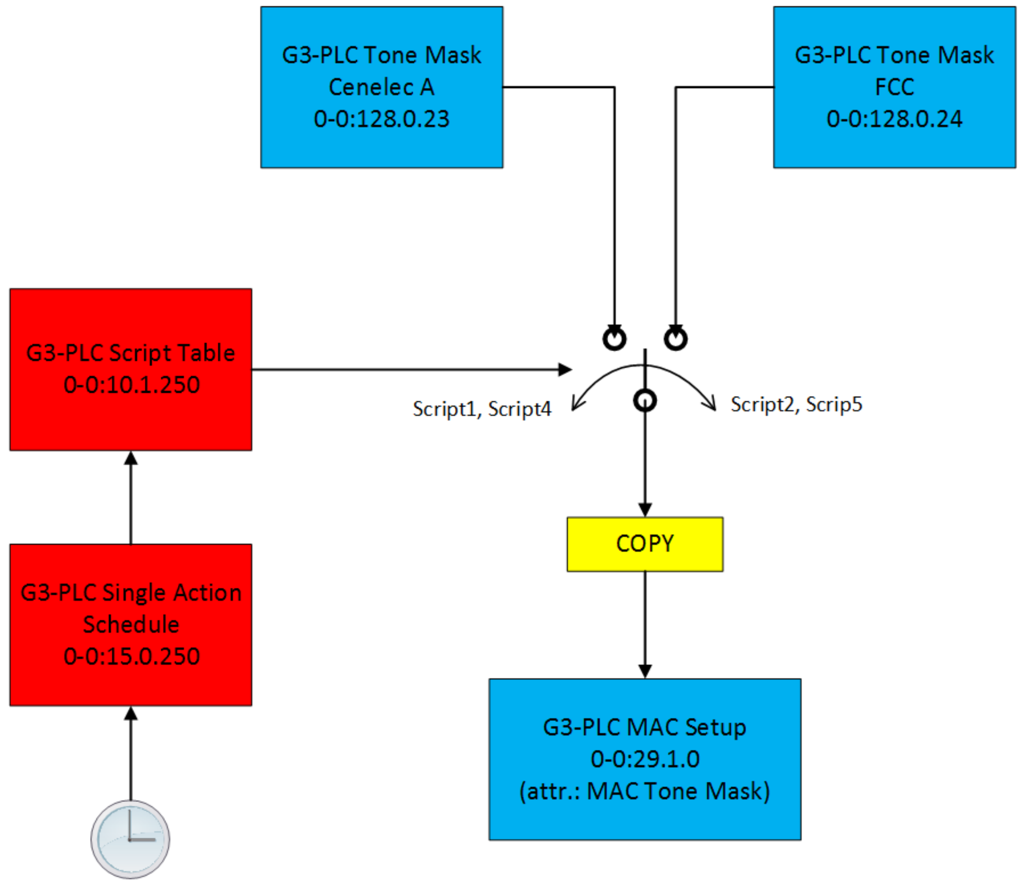


Figure 93: Activation of G3-PLC passive tone masks

9.4.2.2.1.5.2. G3-PLC single action schedule

G3-PLC single action schedule (0-0:15.0.250*255) triggers execution of a specific script from **G3-PLC script table** (0-0:10.1.250*255) at specified time.

Figure 94 presents an example of G3-PLC single action schedule for:

- execution of the Script **4** (defined in *Selector*) triggered from object **0-0:10.1.250*255** – G3-PLC script table (defined in *Logical name*)
- on **22.11.2019** at **00:00:00** (defined in *Execution time*).

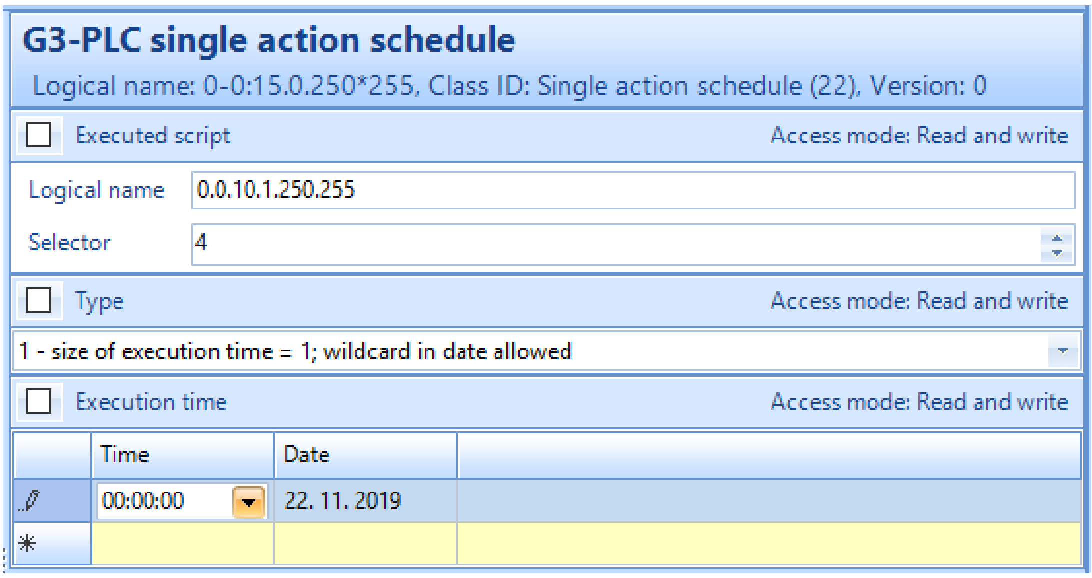


Figure 94: Example of G3-PLC single action schedule

9.4.2.2.1.6. IPv6 setup

Logical name: **0-0:25.7.0*255,** (class_id = 48, version = 0)

Attribute	Description
DL reference	References a Data link layer setup object by its logical name. Default: 0.0.25.2.0.255
Address config mode	Defines the IPv6 address configuration mode. Attribute value is enumerated: (0) **Auto configuration** (1) **DHCPv6** (2) **Manual** (3) **ND (Neighbour Discovery)** **NOTE 1:** *DHCPv6* and *Manual* modes are currently not supported. **NOTE 2:** When *Auto configuration* mode is selected, the meter automatically gets routable IPv6 address assigned after join. **NOTE 3:** When *ND (Neighbour Discovery)* mode is selected, the meter starts neighbour discovery procedure according to *Neighbour discovery setup* parameters after join. This involves receiving and sending specific ICMPv6 messages over the network so that the meter finally gets IPv6 address, over which it can be reached.
Unicast IPv6 addresses	Carries unicast IPv6 address(es) assigned to the related interface of the physical device on the network (unique local unicast, link local unicast and / or global unicast addresses).
Multicast IPv6 addresses	Contains an array of IPv6 addresses used for multicast.
Gateway IPv6 addresses	Contains the IPv6 addresses of the IPv6 gateway device.
Primary DNS address	Contains the IPv6 address of the primary Domain Name Server (DNS).
Secondary DNS address	Contains the IPv6 address of the secondary Domain Name Server (DNS).
Traffic class	Contains the traffic class element of the IPv6 header. **NOTE:** Currently not used by the meter.
Neighbour discovery setup	Contains the configuration to be used for both routers and hosts to support the Neighbour Discovery protocol for IPv6. • **RS max retry** Gives the maximum number of router solicitation retries to be performed by a node if the expected router advertisement has not been received. Range: 1–255 • **RS retry wait time [ms]** Gives the waiting time in milliseconds between two successive router solicitation retries. Range: 0–65535 • **RA send period** Gives the router advertisement transmission period in seconds. For a meter, this also means delay before transmitting the first RS message. Range: $0–2^{32}$

Table 45: IPv6 setup

9.4.2.2.1.7. G3-PLC 6LoWPAN adaptation layer setup

Logical name: **0-0:29.2.0*255,** (class_id = 92, version = 1)

Attribute	Description
Max hops	Defines the maximum number of hops to be used by the routing algorithm. Range: 1–14
Weak link value	The weak link value defines the LQI value below which a link to a neighbour is considered as a weak link. Range: 0–255
Security level	The minimum-security level to be used for incoming and outgoing adaptation frames. Only values 0 (no ciphering) and 5 (ciphering with 32 bits integrity code) are supported. Range: 0–7

Attribute	Description
Prefixes	Contains the list of prefixes defined on this PAN. **NOTE:** Current implementation does not provide list of prefixes and always outputs array of zero elements.
Routing configuration	The routing configuration element specifies all parameters linked to the routing mechanism described in ITU-T G.9903:2014. • **Net traversal time [s]** Maximum time that a packet is expected to take to reach any node from any node in seconds. Range: 0–255 • **Routing table entry TTL [min]** Maximum time-to-live of a routing table entry (in minutes). Range: 0–65535 • **Kr** A weight factor for the Robust Mode to calculate link cost. Range: 0–31 • **Km** A weight factor for modulation to calculate link cost. Range: 0–31 • **Kc** A weight factor for number of active tones to calculate link cost. Range: 0–31 • **Kq** A weight factor for LQI to calculate route cost. Range: 0–50 • **Kh** A weight factor for hop to calculate link cost. Range: 0–31 • **Krt** A weight factor for the number of active routes in the routing table to calculate link cost. Range: 0–31 • **Retries** The number of RREQ re-transmission in case of RREP reception time out. Range: 0–255 • **Wait [s]** The number of seconds to wait between two consecutive RREQ – RERR generations. Range: 0–255 • **Blacklist table entry time to live [min]** Maximum time-to-live of a blacklisted neighbour entry (in minutes). Range: 0–65536 • **RREQ generation** If TRUE, the RREQ shall be generated with its "unicast RREQ" flag set to '1'. If FALSE, the RREQ shall be generated with its "unicast RREQ" flag set to '0'. • **RLC enabled** Enable the sending of RLCREQ frame by the device. • **Link cost** It represents an additional cost to take into account a possible asymmetry in the link. Range: 0–255
Broadcast log table entry TTL	Maximum time to live of a *Broadcast log table entry* (in minutes). Range: 0–65535
Routing table	Contains the routing table.
Context information table	Contains the context information associated to each CID extension field. • **CID** Corresponds to the 4-bit context information used for source and destination addresses (SCI, DCI). Range: 0x00 – 0x0F • **Context length** Indicates the length of the carried context (up to 128-bit contexts may be carried). Range: 0–128 • **Context** Corresponds to the carried context used for compression/decompression purposes. Range: 0x0000:0000:0000:0000:0000:0000:0000:0000 – 0xFFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF • **C** Indicates if the context is valid for use in compression. FALSE: Only decompression is allowed, TRUE: Compression and decompression are allowed **NOTE**: A context may be used for decompression purposes only. Moreover, recommendations made in RFC 6775 should be followed to take into account the propagation of the context to all nodes of the PAN. • **Valid lifetime [min]** Remaining time in minutes during which the context information table is considered valid. It is updated upon reception of the advertised context. Range: 0–65535

Attribute	Description
Blacklist table	Contains the list of the blacklisted neighbours. • **Blacklisted neighbour address** The 16-bit source address of a blacklisted neighbour. This is the address of the broadcast initiator. • **Valid time [min]** Remaining time in minutes until which this entry in the blacklisted neighbour table is considered valid. **NOTE:** Current implementation does not provide list of blacklisted neighbours and always outputs array of zero elements.
Broadcast log table	Contains a list of broadcast packets recently received by this device. • **Source address** The 16-bit address of the broadcast packet. • **Sequence number** The sequence number contained in the BC0 header. • **Valid time [min]** Remaining time in minutes until when this entry in the broadcast log table is considered valid.
Group table	Contains the group addresses to which the device belongs. • **Group address** Group address to which this node has been subscribed.
Max join wait time	Network join timeout in seconds for LBD. Range: 0–1023
Path discovery time	Timeout for path discovery in seconds. Range: 0–255
Active key index	Index of the active GMK to be used for data transmission. Range: 0–1
Metric type	Metric type to be used for routing purposes. Range: 0x00 – 0x0F
Short address of the coordinator	Defines the short address of the coordinator. Range: 0x0000 – 0x7FFF
Default routing disabled	If TRUE, the default routing (LOADng) is disabled. If FALSE, the default routing (LOADng) is enabled. **NOTE**: Not used by the meter. Modem default value is FALSE.
Device type	Defines the type of the device connected to the modem. Attribute value is enumerated: (0) **PAN device** (default) (1) **PAN coordinator** (2) **Not defined** Regardless of the value of this parameter, the meter always operates as a PAN device.

Table 46: G3-PLC 6LoWPAN adaptation layer setup

9.4.2.2.1.8. G3-PLC MAC setup

Logical name: **0-0:29.1.0*255,** (class_id = 91, version = 1)

Attribute	Description
MAC short address	The 16-bit address the device is using to communicate through the PAN. Its value shall be equal to 0xFFFF when the device does not have a short address. An associated device necessarily has a short address, so that a device cannot be in the state where it is associated but does not have a short address. For some time after power up (or reconnection to the G3-PLC network), before the address is read from the modem, the meter will present address 0xFFFF. Range: 0x0000 – 0xFFFF
MAC route cost to co-ordinator	Route cost to coordinator, to be used in the beacon payload as RC_COORD
MAC PAN id	The 16-bit identifier of the PAN through which the device is operating. A value equal to 0xFFFF indi-cates that the device is not associated.
MAC key table	This attribute holds GMK keys required for MAC layer ciphering. The attribute can hold up to two 16-bytes keys. The Key Identifier value must be different for each key. For security reason, the key en-tries cannot be read, only written.
MAC frame counter	The outgoing frame counter for this device, used when ciphering frames at MAC layer.
MAC tone mask	Defines the tone mask to use during symbol formation.
MAC TMR TTL	Maximum time to live of tone map parameters entry in the neighbour table in minutes.
MAC max frame retries	Maximum number of retransmissions.
MAC neighbour table entry TTL	Maximum time to live for an entry in the neighbour table in minutes.
MAC neighbour table	The neighbour table contains information about all the devices within the POS of the device. One ele-ment of the table represents one PLC direct neighbour of the device. See ITU-T G.9903:2014 9.3.7.2 for CENELEC and FCC bands. **NOTE:** This table is actualized each time any frame is received from a neighbour device, and each time a Tone Map Response is received.
MAC high priority con-nection window size	The high priority connection window size in number of slots.
MAC CSMA fairness limit	Channel access fairness limit. Specifies how many failed back-off attempts, back-off exponent is set to minBE. This attribute can take a value between 2 × (macMaxBE – macMinBE) and 255.
MAC beacon ran-domization window length	Duration time in seconds for the beacon randomization.
MAC a	This parameter controls the adaptive CW linear decrease.
MAC k	Rate adaptation factor for channel access fairness limit. This attribute can take a value between 1 and macCSMAFairnessLimit.
MAC min CW at-tempts	Number of consecutive attempts while using minimum CW.
MAC Cenelec legacy mode	This read only attribute indicates the capability of the node.
MAC FCC legacy mode	This read only attribute indicates the capability of the node.
MAC max BE	Maximum value of backoff exponent. It should always be greater than macMinBE.
MAC max CSMA backoffs	Maximum number of backoff attempts.
MAC min BE	Minimum value of backoff exponent.

Table 47: G3-PLC MAC setup

9.4.2.2.1.9. G3-PLC MAC layer counters

Logical name: **0-0:29.0.0*255,** (class_id = 90, version = 1)

Attributes	Attribute description
MAC Tx data packet count	Statistic counter of successfully transmitted data packets (MSDUs).
MAC Rx data packet_count	Statistic counter of successfully received data packets (MSDUs).
MAC Tx command packet_count	Statistic counter of successfully transmitted command packets.
MAC Rx command packet_count	Statistic counter of successfully received command packets.
MAC CSMA fail count	Counts the number of times when CSMA backoffs reach macMaxCSMABackoffs.
MAC CSMA no ACK count	Counts the number of times when an ACK is not received while transmitting a unicast data frame (the loss of ACK is attributed to collisions).
MAC bad CRC count	Statistic counter of the number of frames received with bad CRC.
MAC Tx data broadcast count	Statistic counter of the number of broadcast frames sent.
MAC Rx data broadcast count	Statistic counters of successfully received broadcast packets.

Table 48: G3-PLC MAC layer counters

NOTE
When a counter reaches the maximum value (0xFFFFFFFF), it is automatically rolled-over.

9.4.2.2.1.10. G3-PLC Scan Result

With the **G3-PLC scan result** object (0-0:128.0.19*255), the meter provides possibility to monitor the G3-PLC environment that a specific meter sees when scanning the network before join.

The object value is the octet-string data type. The octet-string carries the following information:

- Status (1 Byte)
  - Enumeration:

    0 - Success
    1 – Limit Reached
    2 – No Beacon
    3 – Scan in Progress
    4 – Counter Error
    5 – Frame too long
    6 – Unavailable Key
    7 – Unsupported Security
    8 – Invalid Parameter
- PAN Count (1 Byte)
  - First PAN descriptor

    Short address (2 Bytes)
    PAN Id (2 Bytes)
    RC_COORD (2 Bytes) (RC_COORD means estimated route cost from the LBA to the coordinator
    LQI (1 Byte)
    Flags (1 Byte)

Bit[0], 0-Agent, 1-Coordinator
Bit[1], 0-Not allowed, 1- Allowed

RSSI (2 Bytes)
SNR (1 Byte, -128 to +127)
Reserved (1 Byte)

…

Last PAN descriptor (according to “PAN Count” field).

9.4.2.2.1.11. G3-PLC diagnostic data

The meter with integrated G3-PLC modem processes specific MAC layer diagnostic data and provides them via dedicated **G3-PLC diagnostic data** object (0-0:128.0.20*255). The provided data are calculated from the last power-up and lost with the power down. With the meter power-up, the diagnostic data calculation starts from the beginning.

An explanation of the G3-PLC diagnostic data value is given in Table 49.

Field Name	Content
Device extended address	G3-PLC MAC layer extended address of the meter.
LQI – average value	Average LQI value calculated over last 60 samples.
LQI – variance value	LQI variance value calculated over last 60 samples.
Minimum active RSSI	Absolute minimum active RSSI measured per Node MAC address.
TMC1	Tone map counter for tone mask 0x1F
TMC2	Tone map counter for tone mask 0x30
TMC3	Tone map counter for tone mask 0x0C
TMC4	Tone map counter for tone mask 0x03
PER	Packet error rate in 0.1 percent.
Samples count	Total number of samples taken.
Route request count	Absolute route request counter incremented each time when route request is successful.

Table 49: G3-PLC diagnostic data value explanation

9.4.2.2.1.12. G3-PLC Sniffing

The meter provides the ability to sniff G3-PLC communication over the optical port that can be useful for communication troubleshooting. This functionality can be activated by executing ***Script 1*** of the **G3-PLC activate sniffing mode script table** object (0-0:10.2.102*255). When the script is executed, the meter waits that the optical interface to be disconnected then activates sniffing mode on the G3-PLC modem and connects the G3-PLC sniffer with the optical interface. Sniffing messages are output on the optical interface at a fixed baud rate of 57600. The sniffing mode remains activated until power down or fixed timeout of 60 seconds. The timer of 60 seconds timeout used for detection is refreshed with every byte received over the optical interface. This means that transmit line of the optical interface is used for outputting sniffer messages, while the optical interface receive line is used for keeping the sniffer mode alive. No other communication can run on the optical interface at that time and any data received on the optical interface is used just for keeping alive the function with no other special meaning.

In order to limit the amount of messages output in sniffing mode, the **G3-PLC sniffer mask** (0-0:128.0.21*255) object is implemented in the meter, see Table 50. With this object, the user can filter out just the messages he wants to check. The length of each single message data field is limited by the meter to 12 bytes.

Bit	Meaning
B0	BEACON frame
B1	MAC command frame
B2	MAC ACK frame
B3	MAC data frame
B4	6LoWPAN header information
B5	MAC header + payload
B6	6LoWPAN header + payload
B7	Reserved
B8	Receive frame additional information
B9	PHY state change
B10	MAC event

Bit	Meaning
B11	Carrier sense debug
B12	CSMA/CA slot selection debug
B13–B15	Unused

Table 50: G3-PLC sniffer mask

9.4.2.2.1.13. G3-PLC PSK change

The Pre-Shared Key (PSK) is written into the G3-PLC modem during production. Because of its secure nature, PSK cannot be read out from the meter.

The meter provides a secure way of changing G3-PLC PSK on the field. The PSK can be changed using the **G3-PLC PSK change** (0-0:128.0.22*255) object.

The action of changing PSK does not unregister the meter from the G3-PLC. The new PSK will be used during the next regular bootstrap procedure when invoked.

In case of PSK change failure, either because of the wrong key used for wrapping or wrapped PSK not being delivered, the G3-PLC modem keeps the old PSK.

9.4.2.2.1.14. G3-PLC complex parameters script table

The ***Script 1*** of the **G3-PLC complex parameters script table** (0-0:10.1.247*255) object in cooperation with the **G3-PLC single action schedule** (0-0:15.0.250*255) enables the user to change multiple G3-PLC settings at once at a predetermined time on a part or entire population of meters.

Most of G3-PLC parameters are implemented in special COSEM classes that have complex attributes. G3-PLC complex parameters script table is designed to support changing complex attributes of complex classes.

G3-PLC complex parameters script table is implemented with the following characteristics:

- maximum one script,
- maximum 5 actions per script,
- maximum size of parameter field for each action 34 bytes.

9.4.2.3. Field-exchangeable communication modules

Communication modules of different communication technologies may be connected to the meter. They enable communication between the meter and a HES (Head-End System) by WAN.

The module is attached by using a proprietary **P* interface** (P3) (see chapter *4.4.3. The modular part of the meter*). The **P* interface** enables easy field replacement of any Iskraemeco communication module AC160.

For more information about the communication module you own, refer to the relevant technical description.

9.4.2.4. Switching between G3-PLC and WAN

A meter may be equipped with an integrated G3-PLC modem as well as with a field-exchangeable WAN communication module. Simultaneous operation of both G3-PLC and WAN communication is not possible –only one of these communication types may be enabled, either G3-PLC or WAN.

To select the preferred communication type, use object **P* communication interface switching mode** (0-0:128.20.40*255). The following modes are available:

Attribute value	Mode	Description
0	Presence based FEM priority	When a WAN module is inserted, it always has priority over G3-PLC. The G3-PLC is used only if there is no WAN module inserted.
1	FEM interface preferred	The preferred communication type is WAN. If the meter cannot establish a connection with a HES by using WAN, the meter will switch to G3-PLC. If the issue persists on G3-PLC as well, the meter will again switch to WAN and restart the connection process.
2	Integrated interface preferred	The preferred communication type is G3-PLC. If the meter cannot establish a connection with a HES by using G3-PLC, the meter will switch

Attribute value	Mode	Description
		to WAN. If the issue persists on WAN as well, the meter will again switch to G3-PLC and restart the connection process.

For modes 1 and 2, it is possible to define how many times the meter should try to establish the communication before switching to the second communication type. To do this, use object **Number of no connection timeouts before P* communication interface switch** (0-0:128.20.45*255). You may define a value between 0 and 255. For instance, if you set it to 0, the meter will never switch to the second communication type, even if the preferred communication type fails; if you set it to 5, the meter will make 5 attempts of establishing communication with the preferred communication type, before switching to the second communication type.

With every switch from G3-PLC to WAN or vice a versa, a Modem hardware restart event is logged in the **Communication event log** (0-0:99.98.6*255).

9.5. Push

Generally, communications run from the central system (Client) to the meter (Server).

In contrast, in Push operation, communication runs from the meter (Server) to the central system (Client), where the meter initiates the communication and pushes information to the central system without any request. In some cases, Push can also be requested by the central system (Client).

The Push method activates the push process leading to the elaboration and the sending of the push data considering the values of the attributes defined in dedicated class.

For different push triggers, the following objects are implemented:

- Push setup – On Connectivity
- Push setup – Interval_1
- Push setup – Interval_2
- Push setup – Interval_3
- Push setup – On Alarm
- Push setup – On power down
- Push setup – On Installation
- Push setup – Consumer Information
- Push action scheduler – Interval_1
- Push action scheduler – Interval_2
- Push action scheduler – Interval_3
- Push action scheduler – Consumer Information
- Push script table

Push setup – On connectivity (0-0:25.9.0*255) is used after the PDP context is established. The meter sends its IP address and system title, using the Data_notification service, to the HES.

Push setup – Interval 1, 2, 3 (0-1:25.9.0*255; 0-2:25.9.0*255; 0-3:25.9.0*255) can be used for various periodical data reporting (profiles, billing, etc.).

Push setup – On alarm (0-4:25.9.0*255) is used to send alarms and/or for sending Quality of Supply data and/or Meter supervision data to the HES using the Data_notification service.

Push setup – On power down (0-5:25.9.0*255) is optional and is used to inform HES that meter is going to power down and/or for sending Quality of Supply data. Using the Data_notification service, the meter send its IP address and its system title to the HES. See chapter *9.5.1. Push on Power down (Last gasp)* for more information.

Push setup – On installation (0-7:25.9.0*255) is used to inform HES that meter is installed to the system (e.g., meter sends its IP address and its system title to the HES using the Data_notification service).

Push setup – Consumer information (0-6:25.9.0*255) is used to transmit information to local P1 port (i.e., IHD) serving as Consumer Information Interface (CII) to support the optional Consumer Information Push (CIP) functionality. The Field Send destination and method need to be properly set. Depending on the market request, this local port may be connected to a suitable home gateway.

Push action scheduler – Interval 1, 2, 3 (0-1:15.0.4*255; 0-2:15.0.4*255; 0-3:15.0.4*255) are used to periodically invoke the Push script table (0-0:10.0.108*255) with a predefined selector to trigger push method on dedicated Push setup object.

Push action scheduler – Consumer information (0-4:15.0.4*255) is used for dedicated CIP functionality. The scheduler defines the time instances when the meter is pushing information to the CII.

Push script table (0-0:10.0.108*255) contains scripts which are used to trigger a push method on configured Push setup objects.

9.5.1. Push on Power down (Last gasp)

Push on Power down (Last gasp) presents a functionality, which detects full power outage, generates and sends a notification message from the meter to the HES. Last gasp message is sent only when the power supply of the back-up capacitor is charged enough.

This function is implemented on both, single-phase and three-phase meters.

- For single-phase meters, the Push on Power down message is the only message sent in case of either phase or neutral missing, or both.
- For three-phase meters, the Push on Power down message will be sent only in case of full power outage. In case of partial power outage (one or two phases missing), an event is stored in the Event log. No message is sent.

Message characteristics:

- Push Alarm according to IDIS P2; the message is sent only once; it is not possible to identify whether message was delivered or not – TCP/IP.
- Message encryption and identification: not available.
- Message content: Identification of Full power outage.

NOTES

- The Push on Power down functionality is intended for meters with mobile communication module.
- If Push on Power Down is not finished due to lack of energy, then it is suspended.

9.5.1.1. Enabling and disabling Push on Power down (Last gasp)

The **Push on Power down** functionality may be turned on, or off. Its usage is optional.

It is enabled when all of the following is true:

- Attribute “Push object list” in the **Push setup – On power down** (0-5:25.9.0*255) object has a value,
- Attribute “Send destination and method” in the **Push setup – On power down** (0-5:25.9.0*255) object has a value,
- The value set in object **Power failure alarm filtering limit [s]** (1-0:96.239.0*255) is less than 40 seconds.

If at least one of the above requirements is not met, Push on Power down is disabled.

9.5.2. Push on installation

In service mode, the installer may trigger Push on installation.

To trigger Push on installation, follow the steps below:

1. In the SEr dAtA menu, short press the Scroll button. The InStALL text is displayed on the LCD.
2. Long press the Scroll button and release when EntEr appears on the LCD.
3. The LCD is now displaying StAtuS.
4. Short press the Scroll button. The LCD shows PuSH.
5. To trigger the Push on installation, long press the Scroll button and release when EntEr appears on the LCD.
6. The status of the Push on installation is displayed:
   - dOnE – the Push on installation was successfully completed,
   - FAIL – the Push on installation failed, or
   - run – the Push on installation is running.
7. To leave the Push on installation menu, short press the Scroll button repeatedly until End is displayed on the LCD.
8. Long press the Scroll button (or extended press).

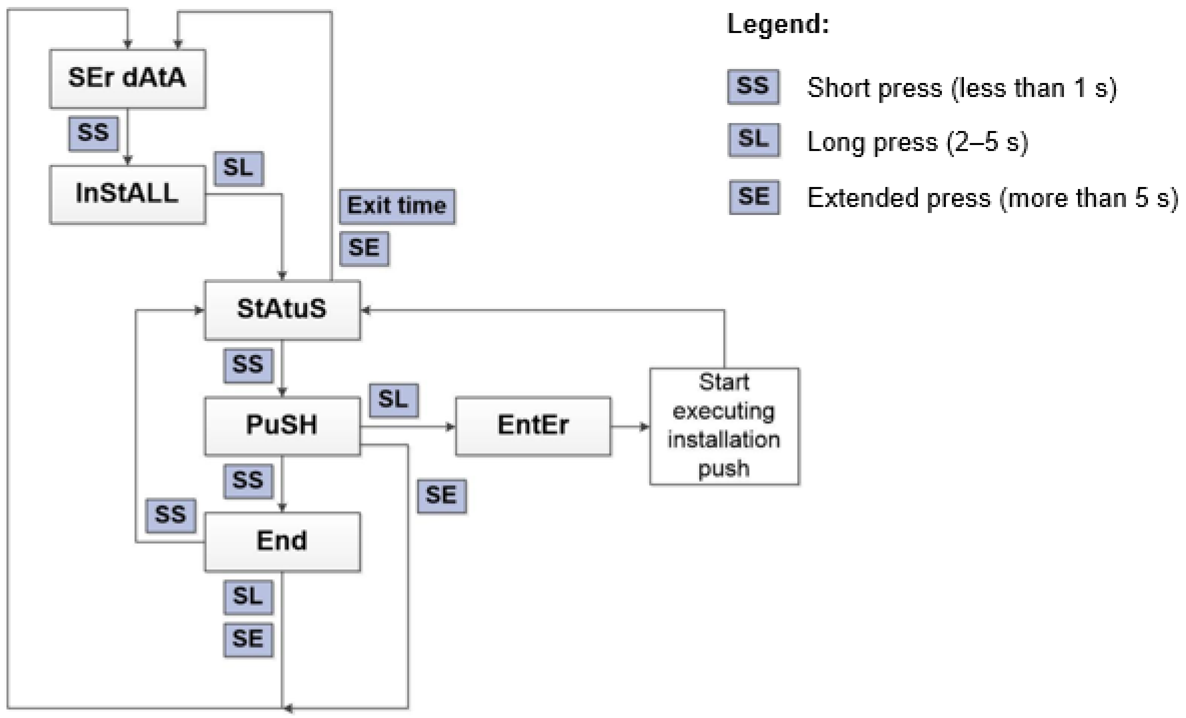


Figure 95: Push on installation

9.6. Fraud detection

The meter supports the detection of different fraud attempts:

- a detection of a terminal cover opening
- a detection if a communication module is plugged/connected to the meter
- a detection if an external magnetic field is detected near the meter

When a certain event and alarm is triggered, the next event of the same type can be triggered after set time period (the time period is set in object **Fraud detection hold-off period** (1-0:96.245.10); default value is 900 seconds (15 minutes).

9.7. Load profiles

A Load profile can capture any of the basic type of object value present in the meter.

Each profile has an internal memory space to store captured data, therefore it has a limit of stored data. The more capture objects we select, less total captured data is possible to store. After a call of the reset method, the buffer does not contain any entries, and this value is zero. Profile entries attribute specifies how many entries could be retained in the buffer. Entries in use attribute counts the number of entries stored in the buffer. In a Load profile, up to 32 objects (including clock and status) can be registered. Maximum profile capacity mainly depends on the number of capture objects set. Data in a load-profile recorder are accompanied with a timestamp and with the meter status in the last saving period as well as with a check sum. The timestamp indicates the end of a registration period. The profile is compressed type – only one (first) timestamp is shown. Compressed type allows more data to be store. Profile is implemented as FIFO (First In, First Out) buffers. Each record has associated a unique record number. Within a load profile, more records can have same timestamp (in case time is shifted back) but all have different record numbers. When reading load profiles, records are being put out according to their record number in increasing order.

Each load profile has the following general structure:

1. **Clock**
2. **Status** (specific per load profile)
3. **Captured values** (maximum 30 objects)

NOTES

- Profile is erased when new attribute capture period, capture objects, or profile entries are set.
- Demand registers should only be used in billing profiles.
- When master reset is performed, profiles are not immediately reset. After power-down and power-up, the profiles are cleared, and default capture objects are set.
- If profile is empty (value 0), then profile cleared event (254) will not be recorded if resetting (erasing) of profile is triggered.

All supported profiles in the meter are listed in Table 51.

Object name (profile name)	OBIS code
Load profile with period 1, i.e., General load profile	1-0:99.1.0*255
Load profile with period 2, i.e., Daily values profile	1-0:99.2.0*255
Data of billing period 1	0-0:98.1.0*255
Data of billing period 2	0-0:98.2.0*255
Power quality profile	1-0:99.14.0*255
M-Bus master load profile for channel 1	0-1:24.3.0*255
M-Bus master load profile for channel 2	0-2:24.3.0*255
M-Bus master load profile for channel 3	0-3:24.3.0*255
M-Bus master load profile for channel 4	0-4:24.3.0*255
M-Bus master daily load profile for channel 1	0-1:24.3.1*255
M-Bus master daily load profile for channel 2	0-2:24.3.1*255
M-Bus master daily load profile for channel 3	0-3:24.3.1*255
M-Bus master daily load profile for channel 4	0-4:24.3.1*255

Table 51: All supported profiles in meter

E-meter-related load profiles (definable load profiles)

- **Load profile with period 1** (1-0:99.1.0*255); 15 min values; up to 32 objects can be defined
- **Load profile with period 2** (1-0:99.2.0*255); daily values; up to 32 objects can be defined
- **Power Quality Profile** (1-0:99.14.0*255); 10 min values; up to 32 objects can be defined

NOTE
Integration period and capture objects of all above listed load profiles are settable.

Capture Objects

By default, capture objects of load profiles are set as follows:

- in Load profile with period 1 (1-0:99.1.0*255):
  - **Clock** (0-0:1.0.0*255), attribute 2
  - **Profile status 0 - Load profile with period 1** (0-0:96.10.1*255), attribute 2
  - **Active energy import (+A)** (1-0:1.8.0*255), attribute 2 (active energy plus)
  - **Active energy export (-A)** (1-0:2.8.0*255), attribute 2 (active energy minus)
- in Load profile with period 2 (1-0:99.2.0*255):
  - **Clock** (0-0:1.0.0*255), attribute 2
  - **Profile status 1 - Load profile with period 2** (0-0:96.10.2*255), attribute 2
  - **Active energy import (+A) Rate 1** (1-0:1.8.1*255), attribute 2 (active energy plus, tariff 1)
  - **Active energy import (+A) Rate 2** (1-0:1.8.2*255), attribute 2 (active energy plus, tariff 2)
  - **Active energy export (-A) Rate 1** (1-0:2.8.1*255), attribute 2 (active energy minus, tariff 1)
  - **Active energy export (-A) Rate 2** (1-0:2.8.2*255), attribute 2 (active energy minus, tariff 2)

For capture objects of Power Quality Profile, see chapter *9.7.2. Billing load profile*.

Capture Period – see chapter *9.7.1.1. Capture period.*

Sort Method is an attribute for sorting captured data. It is fixed to FIFO (First in First Out).

Sort Object attribute uses Clock object as sort object.

Entries in Use attribute shows how many recordings have been made and are recorded (captured).

Profile Entries attribute shows how many recordings are possible in the meter.

Specific Method – *Billing profile* has two methods implemented:

- Reset (erases captured values)
- Capture (new records are stored).

9.7.1.1. Capture period

Capture period is variable, which defines the time distance between two captured data. It can be set to following values (in seconds):

- **0** – No registration
- **300** – 5-minute recording period
- **600** – 10-minute recording period (default value of Power Quality Profile)
- **900** – 15-minute recording period (default value of Load profile with period 1)
- **1800** – 30-minute recording period
- **3600** – 1 hour recording period
- **86400** – 1 day recording period (default value of Load profile with period 2)

The period is synchronized with the hour; it always begins at completed hour.

Load profiles are dynamically organized, meaning the less capture objects are chosen, the higher roll over time is, and vice versa.

9.7.1.2. Profile status

Profile status objects are specific according to a load profile:

- **Profile status 0 – Load profile with period 1** (0-0:96.10.1*255)
- **Profile status 1 – Load profile with period 2** (0-0:96.10.2*255)
- **Profile status 2 – Data of billing period 1** (0-0:96.10.3*255)

- **Profile status 3 – Data of billing period 2** (0-0:96.10.4*255)
- **Profile status 7 – Power Quality Profile** (1-0:96.10.1*255)
- **Profile status for M-Bus master load profile *x*** (0-*x*:96.10.3*255; where *x* = 1…4 and represents the channel number)
- **M-Bus daily load profile (channel *x*)** 0-*x*:96.10.5*255; where *x* = 1…4 and represents the channel number)

The state and the function of all bits are described in Table 52.

If one of the events defined in the Table 52 has occurred during capture period, corresponding event code is added to the profile status register. By adding event codes to the profile status register all events occurred during capture period are stored to the profile buffer at the end of capture period. After storing a value of profile status register in the profile buffer meter resets profile status register to zero value. These status notifications shown in load profile readout are listed in the Table 52

Bit	Status	Description
B0	Critical error	A serious error such as a hardware failure or a checksum error has occurred.
B1	Clock invalid	The power reserve of the clock has been exhausted. The time is declared as invalid.
B2	Data not valid	Indicates that the current entry may not be used for billing purposes without further validation, because a special event has been occurred.
B3	Daylight saving	Indicates that daylight savings is enabled.
B4	*Unused*	*Reserved: The reserved bit is always set to 0.*
B5	Clock adjusted	The bit is set when clock has been adjusted more than the synchronization limit.
B6	*Unused*	*Reserved: The reserved bit is always set to 0.*
B7	Power down	This bit is set to indicate that an all-phase power failure occurred.

Table 52: Profile status register notifications

9.7.2. Billing load profile

The Billing functionality provides a process and storage for managing billing data. There are two billing object implemented in the meter:

- **Data of billing period 1** (0-0:98.1.0*255); up to 32 objects can be defined
- **Data of billing period 2** (0-0:98.2.0*255); up to 32 objects can be defined

When the capture method is executed, capture objects values are stored in billing profile.

Capture Objects – in this attribute user can define capture objects.
Capture Period is set to 0 because records are recorded according to *end of billing period*.

Sort Method is an attribute for sorting captured data. It is fixed to FIFO (First in First Out).

Sort Object attribute uses Clock object as sort object.

Entries in Use attribute shows how many recordings have been made and are recorded (captured).

Profile Entries attribute shows how many recordings are possible in the meter.

Specific Method – *Billing profile* has two methods implemented:

- Reset (erases captured values)
- Capture (new records are stored).

NOTE

Integration period and capture objects of both above listed billing load profiles are settable.

End of billing with **MDI reset / End of billing period** (0-0:10.0.1*255) object can be executed:

- *Manually* – by executing Script 1 or Script 2 (of this object) using one of available communication channels (see Figure 96) or
- *Automatically* – using **End of billing period 1 scheduler** (0-0:15.0.0*255) and **End of billing period 2 scheduler** (0-0:15.1.0*255) objects, where for Script 1, *Selector* value is set to 1, and for Script 2, *Selector* value is set to 2.

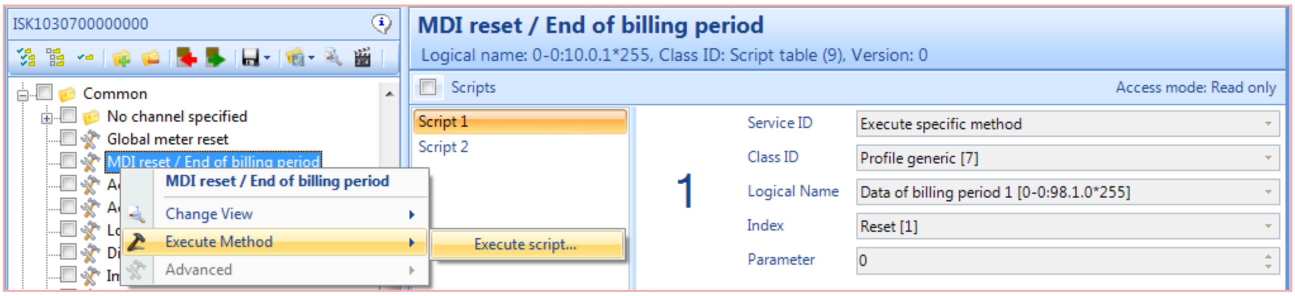


Figure 96: Manually executing MDI reset / End of billing period

When one of the script (Script 1, Script 2) of **MDI reset / End of billing period** is executed, actions for Billing profiles are carried out by the meter. List of actions executed by Script 1 and list of actions executed by Script 2 can be seen in the Table 53.

Action	Script 1	Script 2
Execute capture method for Billing profile	Yes	Yes
Reset maximum demand registers	Yes	No
Reset minimum power factor (value is set to 1)	Yes	No
Increment counter in the **Billing period counter** (1-0:0.1.0*255) object	Yes	No
Create event in event log-to-log execution of billing reset	Yes	No

Table 53: Billing profile – action list of Script 1 and of Script 2

NOTE

Reset of maximum demand registers is done only when Script 1 of “**MDI reset** / **End of billing period** (0-0:10.0.1*255)” object is executed.

9.7.3. Multi-utility-related load profiles

- Hourly load profile for each of the four M-Bus channels – **Profile status for M-Bus master load profile *x*** (0-*x*:96.10.3*255, where *x* stands for channel 1–4)
- Daily load profile for each of the four M-Bus channels – **M-Bus daily load profile (channel *x*)** (0-*x*:96.10.5*255, where *x* stands for channel 1–4)

The state and the function of all bits are described in Table 52.

For more information about M-Bus load profiles, refer to chapters *10.8.5. M-Bus master load profile* and *10.8.6. M-Bus master daily load profile (optional).*

9.8. Prepayment (optional)

Besides billing after energy consumption, IE.x meters, if requested, may run in prepayment mode. When this mode is enabled, the consumer needs to make advance payment before being able to consume electricity. When the meter is close to run out of credit, the consumer is notified by a blinking symbol on the meter LCD. When this happens, the consumer may apply emergency credit before being disconnected from the grid. The consumer may top up the credit remotely (token-less) or locally on the meter.

9.8.1. How to enable and disable prepayment mode

To enable or disable prepayment mode, use object **Payment mode** (0-0:128.60.0*255).

- To enable prepayment mode, select 1 – Prepayment function is activated.
- To disable prepayment mode, select 0 – Prepayment function is deactivated.

In prepayment mode, the meter may be set to:

- charge based on consumption only, or
- charge based on consumption and fixed costs.

For more information on charging standing costs and how to set this up, see chapter *9.8.3. Standing (auxiliary) charges*.

9.8.2. Consumption-based tariff charges

Consumption-based tariff charging is tied to **Active energy import (+A)** (1-0:1.8.0*255).

For each new accounting period, the meter calculates the increment of energy consumption from the previous accounting period. The increment is then multiplied by the appropriate tariff rate according to the meter tariff settings. The resulting number is then deducted from the consumer's credit. The prepayment accounting period is pre-defined to 1 second and cannot be changed.

9.8.2.1. How to define the prices for consumption-based charging

In the accounting process, active tariff rates are used. Those rates cannot be set directly but must be activated through passive tariff rate registers. To define active tariffs rates:

1. Define the passive tariff rates in Passive Rate x (0-0:128.60.4x*255). For x*, see below.
2. Activate the rates by calling Script 1 of Activate payment passive parameters (0-0:10.1.251*255). The active rates are now available in Active rate x (0-0:128.60.2x*255). For x*, see below.

There are eight passive rate objects available:

- Passive rate 1 (x=1)
- Passive rate 2 (x=2)
- Passive rate 3 (x=3)
- …
- Passive rate 8 (x=8)

The tariff rates must be entered as charges per unit of consumption register. The consumption register is defined by the **Energy Register Reference** (0-0:128.60.31*255) value. Because these charge values can be very small, a scaler for tariff rate registers may be applied. For more information on the scaler, see chapter *9.8.2.3. Rate currency scaler*.

9.8.2.2. Energy register reference

The **Energy register reference** (0-0:128.60.31*255) points to the energy register used, which is **Active energy import (+A)** (1-0:1.8.0*255).

9.8.2.3. Rate currency scaler

All prepayment tariff rate registers use the same currency scaler. The rate currency scaler is defined in the object **Rate currency scaler** (0-0:196.60.0*255). This way, currency registers can be interpreted in the local currency. The rate currency scaler is defined in production phase according to customer requirements and may not be changed later.

9.8.3. Standing (auxiliary) charges

This function is used for standing or auxiliary charges over a predefined period of time. To enable or disable auxiliary charges, use object **Auxiliary charge enabled** (0-0:128.60.18*255).

NOTE

Before uninstalling a meter that is planned for re-use, make sure to disable auxiliary charges. When the meter is later ready to be re-installed, enable the auxiliary charges. If the auxiliary charges are left enabled when uninstalling the meter, the auxiliary charges will be billed for the complete standing period after the next power-up.

Depending on the time period, two types of auxiliary charges may be billed:

- monthly auxiliary charge, and
- daily auxiliary charge.

Monthly auxiliary charges are charged every **minute**. This means that the meter calculates the minute charge value by dividing the monthly auxiliary charge by the number of minutes per month. The minute values are then charged from the customer's credit every minute.

Daily auxiliary charges are charged **once per day** after midnight.

When the meter is powered down, the auxiliary charge is done after the next power-up, including partial monthly charges for the whole period of time that the meter was powered off. The meter also checks if midnight passed during the power down in order to charge the daily auxiliary value. Daily charges are billed for all days that passed during the power down.

When meter time is synchronized forward (for a period that is shorter than the **Clock time shift limit** (1-0:0.9.11*255)) over midnight, the meter will bill the daily auxiliary charge. If the meter time is set forward for more than defined in "*Clock time shift limit*", no immediate daily charges are billed.

If the meter time is set backwards, the meter will not bill the daily auxiliary charges. Even more, if time is synchronized backwards over last midnight for a period that is shorter than the Clock time shift limit, the meter will also not bill the daily charges when later passing the midnight for which charges have already been billed before setting the time.

9.8.3.1. How to define the prices for standing (auxiliary) charges

Setting prices for standing (auxiliary) charges is similar to consumption-based charges. To activate auxiliary charge prices, you need to define them first in the passive registers and activate them according to the steps below. You may set to activate them automatically or manually. To set and activate them **manually**, follow the steps below:

1. To define daily prices, use object Passive daily auxiliary charge (0-0:128.60.49*255.
2. To define monthly prices, use object Passive monthly auxiliary charge (0-0:128.60.40*255).
3. Next, activate the passive prices by executing Script 1 of Activate payment passive parameters (0-0:10.1.251*255).
4. The prices are now active and available in the following objects:
   - Active daily auxiliary charge (0-0:128.60.29*255)
   - Active monthly auxiliary charge object (0-0:128.60.20*255)

To activate the auxiliary charge prices **automatically**:

1. Follow steps 1 and 2 above.

2. In Activate payment passive parameters time (0-0:128.60.19*255), define the time when you want the meter to activate the auxiliary charge prices.

As in tariff rate registers, auxiliary charge values use the same factory-set **Rate currency scaler** (0-0:196.60.0*255).

9.8.4. Token credit

Credit is loaded onto the meter by using credit tokens. The token credit function deals with managing credit registers according to transferred credit tokens. When the credit token is accepted, the values of "*Available credit*" and "*Total purchase value*" registers are adapted by the amount of credit carried by the specific token.

9.8.4.1. Available credit

The **Available credit** (0-0:128.60.1*255) register presents the amount of credit available on the meter. The value of this register is positive if the customer pre-paid more than has been consumed until the time of reading the available credit register. Otherwise, if more has been consumed than pre-paid, the value of the available credit register is negative.

The **Available credit** object contains the scaler as configured in the **Credit currency scaler** (0-0:196.60.1*255) object.

9.8.4.2. Total purchase register

The **Total purchase** (0-0:128.60.4*255) register accounts every credit transfer to the meter.

The **Total purchase** object contains the scaler as configured in the **Credit currency scaler** (0-0:196.60.1*255) object.

9.8.4.3. Credit currency scaler

Prepayment registers related to credit values are defined with a scaler of credit currency. Those registers are:

- **Available credit** (0-0:128.60.1*255),
- **Total purchase register** (0-0:128.60.4*255),
- **Emergency credit** (0-0:128.60.2*255),
- **Emergency credit initial limit** (0-0:128.60.10*255),
- **Emergency credit limit** (0-0:128.60.11*255),
- **Emergency credit threshold** (0-0:128.60.12*255),
- **Active daily auxiliary charge** (0-0:128.60.29*255),
- **Active monthly auxiliary charge** (0-0:128.60.20*255),
- **Passive daily auxiliary charge** (0-0:128.60.49*255),
- **Passive monthly auxiliary charge** (0-0:128.60.40*255).

The scaler of credit currency is configurable via dedicated object **Credit currency scaler** (0-0:196.60.1*255). This way, currency registers can be interpreted as any local currency. The different worth of local currencies can be adapted by configuring the "*Credit currency scaler*".

NOTE

The "*Credit currency scaler*" is defined during the meter production and is set as required by the customer.

9.8.4.4. Token transfer

The token transfer functionality implemented in the meter supports the following features:

- Loading credit on to the meter,
- Subtracting credit from the meter,
- Clearing credit on the meter to zero.

Tokens are submitted to the meter as a 20-digit token code via:

- dedicated **Token transfer** object,
- the meter console using dedicated menu as described in 9.8.9. Prepayment console.

The **Token transfer** (0-0:128.60.30*255) object provides the possibility to transfer tokens in form of visible string to the meter remotely via different communication paths supported by the meter.

Tokens of length different from 20 octets are immediately rejected by the meter with error result returned in DLMS response. Set operation for tokens with correct length is confirmed by the meter before processing the token content. The actual result of token transfer processing is given in the **Token transfer result** object (0-0:128.60.5*255), which is described later in this chapter.

When reading the token transfer object, the meter returns the last token submitted to the meter. This includes tokens that were submitted but not accepted by the meter. Also, tokens submitted via the meter console are returned in the value attribute when reading the token transfer object. The token transfer returns the last submitted token only until power down. With meter power down, the last submitted token is deleted from the token transfer object.

The meter accepts tokens constructed according to STS specification (IEC 62055-41). The following tokens are supported:

- **TransferCredit** (token class 0, token subclass 4 – electricity currency),
- **ClearCredit** (token class 2, token subclass 1).

The "*TransferCredit"* token can carry positive or negative credit values using S&E token field (for detailed explanation, refer on the STS specification – IEC 62055-41). Amount value carried by the "*TransferCredit*" token is defined with relation to the "*Credit currency scaler*" parameter.

Example:

The user wants to load 1 euro of credit to the meter, which has "*Credit currency scaler*" set to *-2*. In this case, amount value of "*TransferCredit*" token shall be set to 100. Mathematical equation is as follows:

*credit = amount * 10^[Credit Currency Scaler]*

"ClearCredit" tokens shall have "register" field set to 4, meaning "Clear electricity currency credit register". Tokens with other register references are rejected by the meter.

Each token shall have its unique ID. According to the STS, token IDs are defined as a number of elapsed minutes from a so-called base date. Token ID is defined according to UTC and is carried inside the token as a 24-bit value. Because of a limited range of token IDs, the STS specifies three base date values. The base date currently used by the meter can be configured via the **Token base date** (0-0:128.60.35*255) object. The following values of the token base date are available (the attribute values are enumerated):

- (0) – 1st January 1993
- (1) – 1st January 2014
- (2) – 1st January 2035

Because token IDs generated with different base dates repeat themselves but mean different date-time, a token buffer (*Token buffer*) is cleared when the base date is changed in the meter. This way, the meter is able to accept new tokens with IDs according to the new base date.

The meter will reject a token that contains token ID, which has already been successfully submitted on that same meter. In this case, the meter does not distinguish between "TransferCredit" and "ClearCredit" tokens. If the "TransferCredit" token with its ID *x* has been accepted by the meter, later "ClearCredit" token with the same ID *x* will be rejected because that token ID has already been used for credit transfer.

The meter also validates token ID according to other parameters and rejects tokens if:

- ID converted to date-time is larger than current meter date-time,
- ID converted to date-time is older than current meter date-time minus "*Token validity period*",
- ID is older than the oldest ID already accepted by the meter (if no token has yet been accepted, this check passes successfully).

The meter can be configured to reject tokens older than a certain time period. This period can be set by the **Token validity period** (0-0:128.60.36*255) object.

Token validity period is defined in number of days. Its maximum value can be set to 3650 days, which corresponds to approximately 10 years. Token validity period checking can be disabled by setting the value to 0.

The meter accepts tokens that are encrypted using MISTY1 encryption algorithm as defined in the STS specification. For successful decryption of a token, the meter requires a decoder key. This key is written in the **Decoder key** (0-0:128.60.37*255) object. The decoder key is a 128-bit long key. The decoder key shall be changed after changing the token base date in order to assure that no old, reused tokens will be accepted by the meter because of the token buffer being cleared.

The decoder key cannot be readout from the locked meter.

The process of generating decoder key is left up to a meter operator with appropriate authentication level access. According to the STS, the input to generating the decoder key shall also be the meter serial number.

Tokens submitted to the meters are first converted from 20-digit format to 66-bit format. 64 bits are taken into decryption process and 2 bits are passed through as defined by the STS specification. Resulting decrypted 66 bits are checked for CRC (Cyclic Redundancy Check) correctness. Tokens with incorrect CRC are rejected by the meter, and the corresponding result code is set in the **Token transfer result** (0-0:128.60.5*255) object.

The **Token transfer result** object contains a result code for the last token transfer operation. The result code remains in the object only until the first power down of the meter. Table 54 presents token transfer result codes and their meaning.

Enum value	Meaning	Description
0	Result none	No token transfer result available.
1	Token accepted	Token was accepted by the meter.
2	Token CRC error	Token CRC was not correct.
3	Token old error	• Token ID is older than the oldest ID stored in the token buffer. • Token ID is older than current meter time minus the validity period.
4	Token used error	Token ID already exists in the token buffer.
5	Token field range error	• Unsupported token class or subclass elements. • Base date set in the meter is larger than current meter time. • Token ID is larger than current meter time. • Negative credit value is below -99992624. • Positive credit value is above 100002624. • Clear credit token register ID field is different from 4 (electricity currency register ID).
6	Token causes credit overflow	• Loading negative credit value would result in the total purchase register below 0. • Loading positive credit value would result in overflow of available credit register.

Table 54: Token transfer result codes

After checking the correctness of token CRC, the token is processed according to token class and subclass field values. Token field values are checked for validity and the possibility to be accepted by the meter. If all checks pass successfully, the token is accepted by the meter and required action is carried out (e.g., required credit registers values are adapted).

In order to reject tokens already being used, the meter implements a token buffer for storing the tokens already being accepted. The token buffer contains up to 50 accepted tokens. The meter will reject every token with ID being lower than the lowest ID stored in the buffer. When the token buffer is full and the new token is accepted by the meter, the oldest token with the lowest token ID is removed from the buffer. The token buffer is cleared with changing the *Token base date* parameter. The token buffer can also be read out from the meter via the **Token buffer** (0-0:128.60.6*255) object.

Token buffer

Logical name: 0-0:128.60.6*255, Class ID: Data (1), Version: 0

☑ Value : Array

	Received timestamp	Token ID	Token code
1	26. 03. 2025 16:56:11	00 02 2D	68225541539457591997
2	26. 03. 2025 17:00:05	09 F2 CD	26566507400805848641
3	26. 03. 2021 14:27:10	09 F2 CF	18109191831362607387
4	26. 03. 2021 14:27:40	09 F2 CA	63651992064719954352
5	26. 03. 2021 14:29:47	3A 0A AC	36112893705420474739
6	29. 03. 2021 08:02:48	3A 19 DD	34219216480118961842
7	29. 03. 2021 10:57:46	3A 19 DE	08849144914685626325
8	29. 03. 2021 11:53:29	3A 19 DF	48001617242534051796
9	29. 03. 2021 12:04:52	3A 19 E0	04917715919106592010
10	29. 03. 2021 12:05:26	3A 19 E1	70694251168251785742
11	29. 03. 2021 12:06:18	3A 19 E2	70628793990924642724
12	29. 03. 2021 12:57:30	3A 19 E3	54996113451532342598
13	30. 03. 2021 00:03:50	3A 19 E4	62766088420757570992
14	31. 03. 2021 01:22:14	3A 19 E5	04282778967611392186
15	31. 03. 2021 12:03:37	3A 19 E6	35167329871773320843
16	31. 03. 2021 12:03:59	3A 19 E7	00734017699357580426
17	31. 03. 2021 12:07:24	3A 19 E8	21901161946966384454
18	1. 04. 2021 05:20:51	3A 1A 24	49663506728211373841
19	30. 03. 2021 09:04:02	3A 1A 25	00072262551074765142
20	30. 03. 2021 00:29:38	3A 1A 27	27938553064458743953
21	30. 03. 2021 00:59:58	3A 1A 28	46666598108612121500

Figure 97: Token buffer – an example of records

Each token buffer record contains:

- received timestamp – meter date-time when token was accepted (formatted as COSEM date-time octet-string),
- token ID – 24-bit token ID extracted from the token,
- Token code – original 20-digit token code (formatted as a visible-string).

The meter always returns the complete buffer of 50 records. Empty records are filled with empty strings.

9.8.4.5. Last received valid token

The IE.x meters provide a **Last received valid token object** (0:128.60.7*255). The value of this object is formatted as token_buffer_recordstructure, which is also used in the **Token buffer** object.

9.8.5. Emergency credit

The emergency credit function is used in situations when the value of "*Available credit*" register approaches or goes under zero.

The **Emergency credit** (0-0:128.60.2*255) gives information on how much available emergency credit is still available.

The **Emergency credit initial limit** (0-0:128.60.10*255) is used after meter installation, only once, for the purpose of enabling the customer to make first buy (or transferring the first credit from the management centre). It defines the credit value, which is available when the emergency credit is first selected by the customer.

The **Emergency credit limit** (0-0:128.60.10*255) defines the credit value, which is available after the value of the "*Available credit*" register reaches zero and the customer selects the emergency credit.

The **Emergency credit threshold** (0-0:128.60.12*255) defines the positive value of the "*Available credit*" register, at which the meter begins to notify the customer that the credit will expire. When the value of the "*Available credit*" register falls below the value of the "*Emergency credit threshold*", the meter starts notification.

Emergency credit objects contain scaler as configured in the "*Credit currency scaler*" object.

Normally, emergency credit should always be selected by the customer otherwise the meter would disconnect the customer from the grid when the value of the "*Available credit*" register reaches zero. However, the meter can also be configured not to disconnect the customer if some special conditions are met, e.g.:

- the customer critically depends on supplied energy,
- the customer is unable to make a purchase.

9.8.5.1. Disabling prepayment delivery disconnect

The **Prepayment delivery disconnect disabled** (0-0:128.60.50*255) object defines whether prepayment functionality running in the meter will disconnect customer from the grid or not.

When the value is set to "*True*", the prepayment functionality will not disconnect the customer from the grid. This parameter can be set permanently to a specific value or included in e.g., tariffication script table called by activity calendar in order to implement so-called "Friendly hours" with delayed disconnection functionality. "Friendly hours" means the prepayment will not disconnect the customer from the grid during some period of the day or during weekends when point-of-sale is unavailable. When the "*Prepayment delivery disconnect disabled*" parameter is set to "*True*", even if the "*Total emergency credit*" value drops to zero, the meter will not disconnect from the grid until the parameter changes the value to false. The meter will also not disconnect in the case when the value of the "*Available credit*" register reaches zero and the emergency credit function is not selected (refer to chapter *9.8.5.3. Emergency credit activation*).

9.8.5.2. Emergency credit accounting auxiliary charges

When the meter operates with the emergency credit (available credit below 0 and emergency credit above 0), it is possible to have auxiliary charges accounted for in the emergency credit register or not. This can be configured with the **Emergency credit accounting auxiliary charges** (0-0:128.60.13*255) object.

When the value of this object is set to "*True*", the meter will account for the emergency credit with consumption and auxiliary charges. If set to "*False*", the meter will not account for auxiliary charges with the emergency credit register and emergency credit will not change if no energy is consumed. Independent of this parameter, auxiliary charges are always accounted for in the available credit register.

9.8.5.3. Emergency credit activation

When the available credit value crosses the emergency credit threshold, the meter generates a notification that the available credit value is below predefined level, and the emergency credit should be selected to gain more time for loading additional credit to the meter in order to avoid being disconnected from the grid.

The notification is generated in the **Payment status** (0-0:128.60.3*255) object and displayed on the meter LCD (refer to chapter *9.8.9. Prepayment console*). In this state, the emergency credit can be selected:

- Loc**ally**, by the customer via **the scroll button**:
  - The scroll button shall be pressed and hold down until "***CrEdIt***" is displayed on the LCD.
  - The scroll button shall be released.
  - The meter will display "***EC SEl***" on the LCD meaning the emergency credit is selected to be used.
  - If the emergency credit has already been consumed, the meter will display "***EC null***" when the scroll button is released.
- **Rem**o**tely**, by executing the **Script 1** of the **Select emergency credit** (0-0:10.1.248*255) object.

9.8.6. Payment status

Prepayment operation can be monitored via **Payment status** (0-0:128.60.3) object.

Bits of 16 bit value attribute carry various information about prepayment operation (Table 55).

Bit	Description 1	Description 2
0	Emergency credit available	Bit is set when the available credit falls below the emergency credit threshold.
1	Emergency credit selected	Bit is set when the emergency credit available bit is set, and the customer has selected the emergency credit.
2	Emergency credit activated	Bit is set when the emergency credit is activated – is being used for charges.

Bit	Description 1	Description 2
3	Initial emergency credit used	Bit is set after the initial emergency credit has been selected by the customer.
4	Delivery disconnect/con-nect	Represents status of delivery function. When set, the customer is disconnected from the grid.
5-15	*Unused*	

Table 55: Payment status

9.8.7. Prepayment events

Events related to the prepayment functionality are logged in the "*Standard event log*" and are listed in *IE.x Event codes – Appendix A3*, event codes 239–243 and 500–504.

9.8.8. Prepayment push notifications

The meter provides the capability to autonomously send information about prepayment operation to a remote server. Sending information is implemented by using the specific push setup **Push setup - on prepayment event** (0-13:25.9.0*255) object and data notification service.

Triggers for prepayment push are implemented within the meter firmware. Specific triggers can be enabled/disabled by the **Prepayment push notification filter** (0-0:128.60.53) object.

Table 56 presents bits corresponding to specific trigger for push notification. When the specific bit is set to 1, the corresponding notification trigger is enabled.

All prepayment push notification triggers that are related to "*Available credit*" or "*Emergency credit*" are triggered when the specific credit decreases from a higher value to or below a trigger threshold value. No action is triggered when the credit token is loaded, and credit registers rise above those thresholds.

Bit	Description
0	Push when AvailableCredit reaches (EmergencyCreditThreshold + NotificationThreshold)
1	Push when AvailableCredit reaches EmergencyCreditThreshold
2	Push when EmergencyCredit is selected
3	Push when AvailableCredit reaches 0
4	Push when EmergencyCredit reaches NotificationThreshold
5	Push when EmergencyCredit reaches 0
6-15	*Unused*

Table 56: Bit assignment for prepayment push notification filter

The notification threshold used for triggering prepayment push notifications can be set in the **Prepayment push notification threshold** (0-0:128.60.52*255) object.

The threshold is defined together with "*Credit currency scaler*". "*Prepayment push notification threshold*" object contains scaler as configured in the "*Credit currency scaler*" (0-0:196.60.1*255) object.

9.8.9. Prepayment console

All credit, charge and rate objects contain currency unit and scalers according to "*Credit currency scaler*" or "*Rate currency scaler*" objects. The value attribute of those register objects can be presented on the meter LCD. If the value contains more digits than the LCD width, the following rules apply:

- Up to 8 digits can be displayed for positive values.
- Up to 7 digits with a minus sign can be displayed for negative values.
- If the scaler is less than 0, so many digits behind the decimal point are truncated that the value fits the LCD width.
- If all digits behind the decimal point are truncated and the value is still too large, the value is truncated on the left side so that the most significant digits are not displayed.

- If the scaler is less than -5, the meter displays five digits behind the decimal point.

The prepayment functionality requires some special console features including:

- the notification for the customer via LCD,
- disconnection/reconnection of the switching device with possibility to display credit registers,
- a menu for local entering of tokens.

9.8.9.1. Emergency credit notifications

Emergency credit notifications relate to the "*Prepayment status*" notification field on LCD (Figure 98). The notification field behaves as follows:

- The notification field on LCD is lit if the emergency credit is active (available credit less than 0).
- The notification field blinks if the available credit is less than the emergency credit threshold, but the emergency credit is not yet active.

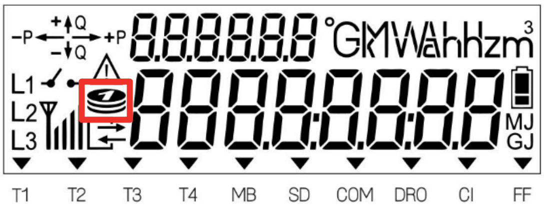


Figure 98: "Prepayment status" notification field on LCD

The notification is non-configurable and always active with the prepayment functionality.

9.8.9.2. Disabling connect mode on display

By default, the meter is in "Switching device special mode", which means that it displays a "ConnECt" message on LCD when the switching device is disconnected.

For more information about the switching device functionality, refer to chapter *9.14. Disconnector (optional*).

With prepayment, it is desired to have credit registers visible on the meter display, e.g., inside the *general display readout mode*, even when the switching device is disconnected. This can be achieved by properly setting the "*Connect message*" in the "*Display configuration*" (0-0:196.1.3.255) object to "*Disable*". In this case, the meter will not display the "ConnECt" message when the switching device is disconnected.

When the connect mode on the display is disabled, local reconnection of the switching device is possible by pressing and holding the scroll button until the "ConnECt" message is displayed. The "ConneCt" message will appear on the display after holding the scroll button pressed for 10 seconds. If the button is released while the "Connect" message is displayed, the switching device will try to reconnect according to the configured switching device mode. In the same way, it is also possible to manually disconnect the switching device. In this case, when the switching device is connected meter will display a "dISConn" message after holding the scroll button pressed for 10 seconds. Releasing the button while having the "dISConn" message on display will try to disconnect the switching device according to configured switching device mode.

It is advised to configure the meter having the switching device status visible via other signals on the meter:

- SD cursor,
- Switching device status LED.

9.8.9.3. Loading token via meter console

The meter allows local submission of the token to the meter via the meter console. The "**tnLoAd**" menu shall be used for local submission of tokens. This menu is positioned at the end of data menu items and is visible only when the prepayment functionality is configured as active via the "*Payment mode*" (0-0:128.60.0*255) object. Figure 99 shows the navigation to the token loading menu.

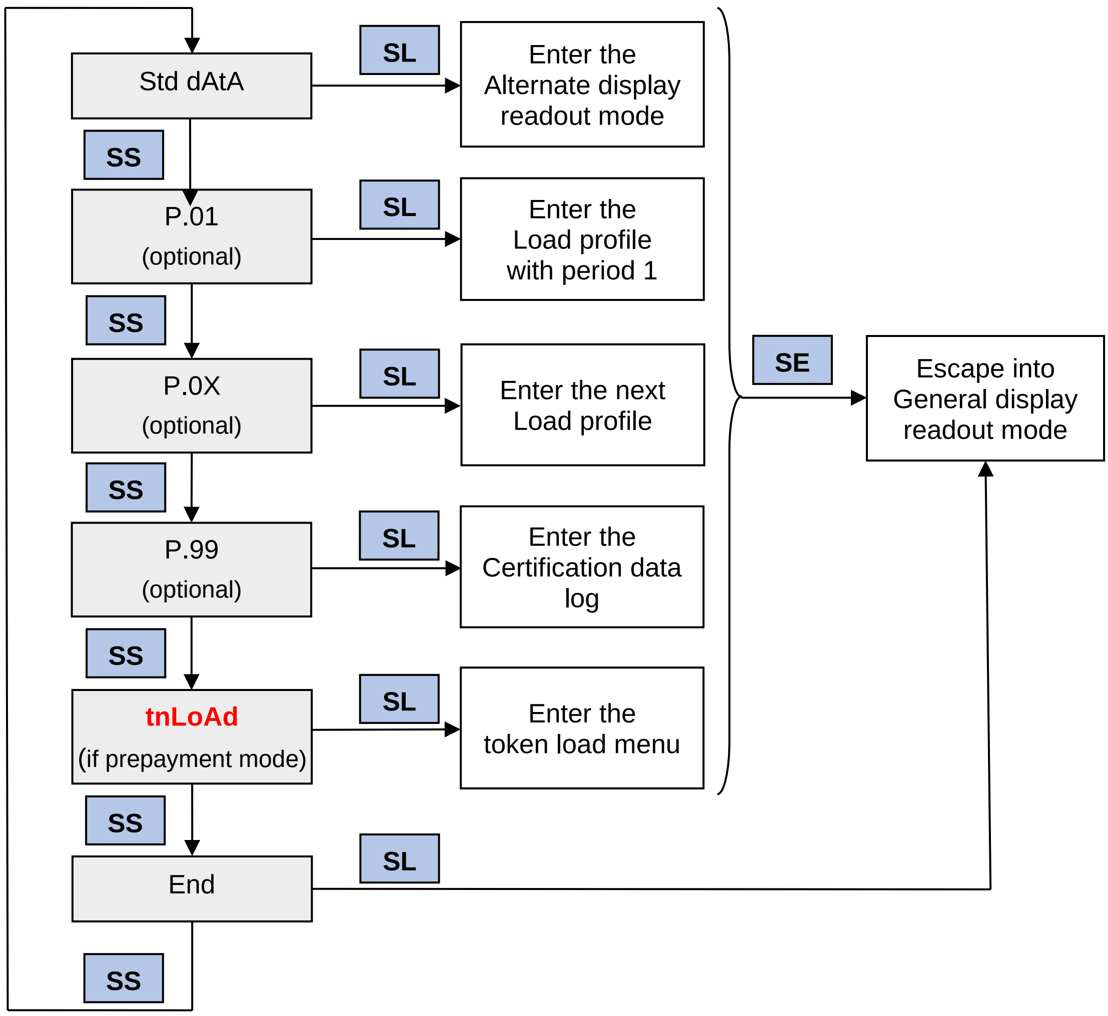


Figure 99: Data menu navigation – the token load menu "tnLoAd"

9.8.9.3.1. Use of buttons in the token loading menu

When the customer enters the menu for loading tokens, the "tnLoAd" text is displayed inside the alphanumeric field 1 on the meter display. Additionally, the first digit of the initial token is displayed on the right most position of the alphanumeric field 2. The initial token is set to all zeroes at power-up. After first entering of token digits, the selected digits are preserved in the meter until power down even if the token was not submitted. Whenever the token loading menu is re-entered, the last stored token digits are displayed.

The customer changes the token digit on the right most position by shortly pressing the scroll button for less than 1 second. With each button press, the active digit increments by 1. When the active digit reaches the desired value, the customer can move to the next digit by pressing the scroll button for a time duration between 1 and 5 seconds. After the meter detects the button is pressed for longer than 1 second, it displays a "roLL" text inside the alphanumeric field 2. If the customer releases the scroll button while the "roLL" text is displayed, the meter will shift token digits on the display to the left by one position. Again, by short pressing the scroll button (< 1 second) the right most token digit on display can be incremented. All 20 token digits shall be entered this way. When the last digit is entered, the customer can still shift token digits to the left by pressing the scroll button for a duration between 1 and 5 seconds. Digits already entered will shift to the left and empty spaces will be displayed on the right side of the alphanumeric field 2. When the last digit disappears on the left side, the first token digit is displayed on the right side. This way, the customer can scroll through all token digits multiple times in order to check correctness before submitting the token.

The token can be submitted by pressing and holding the scroll button between 5 and 8 seconds. After having the scroll button pressed for 5 seconds, the meter will display an “EntEr” text inside the alphanumeric field 2. If the scroll button is released while “enter” is displayed, the token will be submitted to the meter. The meter will execute all the required checking of the token and display the result. If the token successfully passes all the checks, the meter displays text “AccEPtEd”. The token that is not accepted by the meter results in a “rEJEctEd” message on the display. The result message is displayed for 2 seconds before the meter switches to the auto scroll mode.

In order to leave the token loading menu without submitting, the customer shall press the scroll button for duration between 8 and 10 seconds. After 8 seconds, the meter will display an “ESC” text inside the alphanumeric field 2. The escape press switches the meter display to the auto scroll mode.

Button press	Press duration - T_p	Triggering event	Tip on display
Short press	$T_p < 1$ s	Increment most right digit	/
Medium & long press	1 s $\leq T_p <$ 5 s	Roll token digits to the left by one position	roLL
Extended press	5 s $\leq T_p <$ 8 s	Submit the token	EntEr
Escape press	8 s $\leq T_p <$ 10 s	Escape to the General display readout mode	ESC

Table 57: Use of the Scroll button in the token loading menu

9.8.10. Count-down timer

A special part of the prepayment functionality presents the **Count-down timer** (0-0:128.60.60*255) object, which represents the timer value. The value up to 9999 hours, 59 minutes and 59 seconds can be written into this object. Values above the maximum are rejected by the meter. When written into the meter, input time is added to current meter time and stored in non-volatile memory. Reading the object returns the difference between time stored in non-volatile memory and current meter time. If meter time has passed stored time or calculated difference is larger than 9999 hours, 59 minutes and 59 seconds, the object returns time 0, otherwise time difference is returned.

The “*Count-down timer*” object can be presented on the meter LCD with general or alternate readout display readout sequences. The meter will display the count-down timer value in format **hhhh:mm:ss**. Leading zeroes for hours are not presented.

The “*Count-down timer*” object operates independently from the “*Payment mode*”.

9.9. Event logs

Basic principle is shown in the diagram (Figure 100).

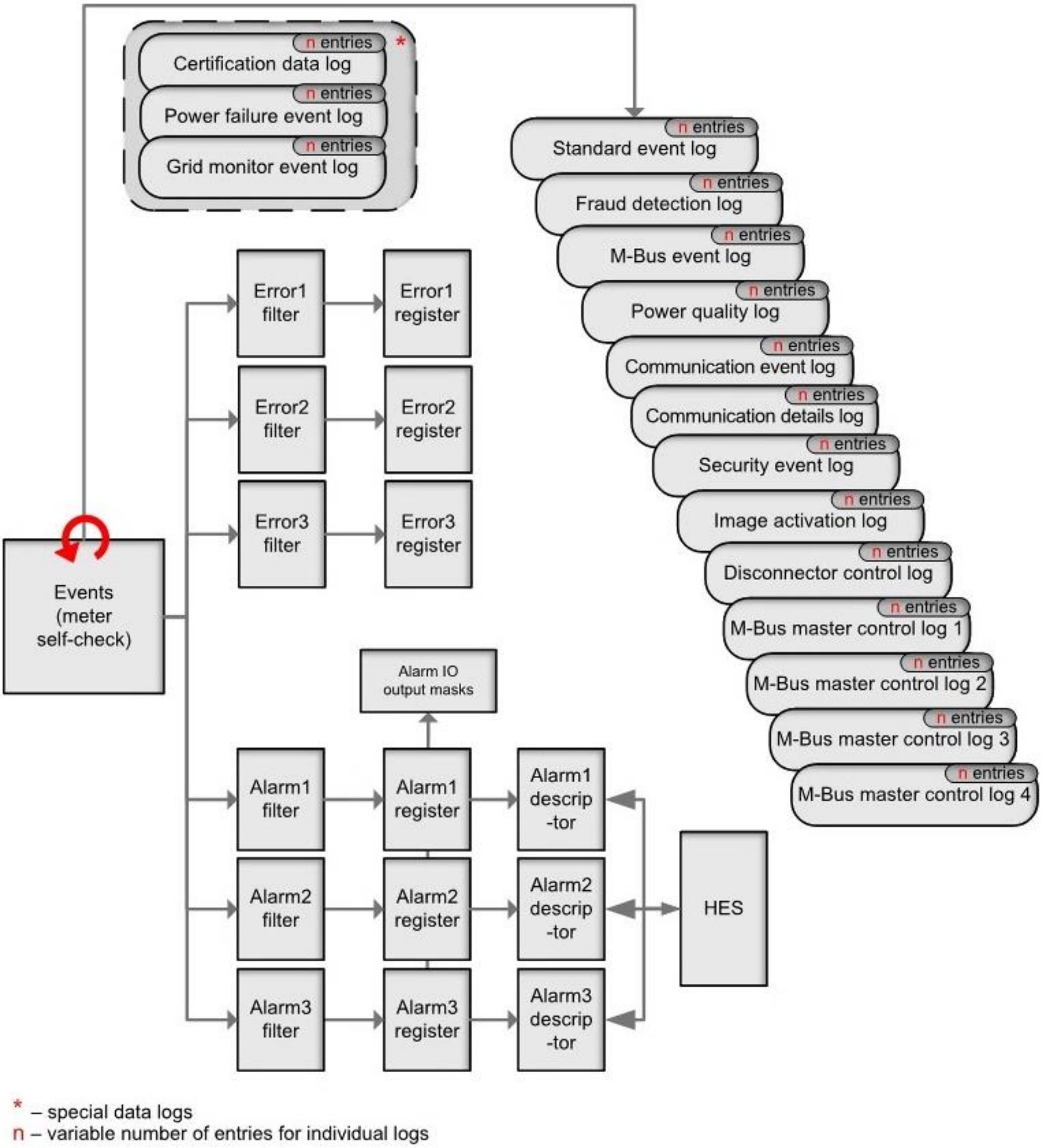


Figure 100: Event handling

For the number of entries for each log (n), refer to Table 59.

Events are generated by the meter itself or by its environment. All these events are logged in several event logs. Every event has a unique code to identify the action, which has triggered it. Every event is assigned to one event log (see Table 58) and it is stored there. The E-meter contains different event logs as described below. All logs, except the *Security event log,* the *Certification data log,* the *Communication details log,* the *Image activation log* and the *Power failure event log* and *Grid monitor event log* have the same basic structure (timestamp and event code). The structure per event log is fixed, i.e., it is not possible to store different parameters per event.

In the list of event log are exceptions:

- the *Security event log* additionally logs the Client SAP,
- the *Certification data log* logs changes in the value of predefined objects,
- the *Communication details log* logs predefined details of the communication session,
- the *Image activation log* additionally logs the signature of the last upgraded FW,
- the *Power failure event log* logs the durations of power failures in any phase
- The *Grid monitor event log* logs the durations and magnitudes of grid monitoring events.

Exceptions for each exception log are described in corresponding chapters below.

9.9.1. Event code objects

Events are generated by the meter itself of by its environment. Each type of an event is presented with a unique code (event code) to identify the action, which has triggered it. Event codes are stored in corresponding **Event code** objects. Each event object holds only the most recent event. The event code object has the value of 255 until the first event is detected/generated by the meter, or every time a power up is performed. The meter provides the event code objects listed in Table 58.

Event code object	Logical name
Event object – Standard event log	0-0:96.11.0*255
Event object – Fraud detection log	0-0:96.11.1*255
Event object – Disconnector control log	0-0:96.11.2*255
Event object – M-Bus event log	0-0:96.11.3*255
Event object – Power quality log	0-0:96.11.4*255
Event object – Communication event log	0-0:96.11.5*255
Event object – Communication details log	0-0:96.11.6*255
Event object – Security event log	0-0:96.11.7*255
Event object – Image activation log	0-0:96.11.8*255
Event object – Grid monitoring event log	0-0:96.11.9*255
Event object – M-Bus master control logs 1	0-1:96.11.4*255
Event object – M-Bus master control logs 2	0-2:96.11.4*255
Event object – M-Bus master control logs 3	0-3:96.11.4*255
Event object – M-Bus master control logs 4	0-4:96.11.4*255

Table 58: Event code objects

9.9.2. Event log objects

Instances of event code objects are captured in corresponding event logs. Event log objects are instances of COSEM class “profile generic” and are used to store events. They are organized as FIFO buffers. Once the buffer is full, the oldest entry in the buffer is the first to be replaced. Exceptions are the *Certification data log* and the *Image activation log* (for details, see the corresponding chapter). The capacity (maximum number of records in a buffer) of the event log objects varies from object to object. Records in the buffer are captured asynchronously, as the events occur.

The majority of the supported event log objects (with the exception of the *Security event log,* the *Certification data log,* the *Communication details log,* the *Image activation log*, the *Power failure event log* and *Grid monitor event log*) follow the same basic structure containing the timestamp (time of the occurrence of the event) and the event code object. A more detailed structure of the event log along with the additional explanation follows:

- **Buffer**: Contains a sequence of entries, where each entry contains values of the captured objects.
- **Captured objects**: Defines the objects and the corresponding attributes, which are to be copied into the buffer (the value is event log specific).
- **Capture period**: Set to 0, because events are triggered and recorded as they occur.
- **Sort method**: Captured data is organized as FIFO (first in first out) and cannot be changed.
- **Sort Object**: Captured data is sorted using the **Clock** object (0-0:1.0.0*255).
- **Entries in use**: Counts the number of entries in the buffer.

- **Profile entries**: Specifies how many entries can be retained in the buffer (the capacity of the event log).
- **Specific methods**: Reset and Capture methods are implemented.

The meter features the following event log objects (see Table 59).

Event log object	Logical name	Capacity	Captured objects
Standard event log	0-0:99.98.0*255	100	0-0:1.0.0*255 0-0:96.11.0*255
Fraud detection log	0-0:99.98.1*255	30	0-0:1.0.0*255 0-0:96.11.1*255
Disconnector control log	0-0:99.98.2*255	30	0-0:1.0.0*255 0-0:96.11.2*255
M-Bus event log	0-0:99.98.3*255	25	0-0:1.0.0*255 0-0:96.11.3*255
Power quality log	0-0:99.98.4*255	100	0-0:1.0.0*255 0-0:96.11.4*255
Communication event log	0-0:99.98.5*255	255	0-0:1.0.0*255 0-0:96.11.5*255
Communication details log	0-0:99.98.6*255	100	0-0:1.0.0*255 0-0:96.11.6*255 0-0:40.0.0*255 0-0:40.0.0*255 0-0:128.100.38*255 0-0:96.15.0*255 0-0:96.15.1*255 0-0:96.15.2*255
Security event log	0-0:99.98.7*255	100	0-0:1.0.0*255 0-0:96.11.7*255 0-0:128.100.39*255
Image activation log	0-0:99.98.8*255	100	0-0:1.0.0*255 0-0:96.11.8*255 0-0:96.128.10*255
Grid monitor event log	0-0:99.98.9*255	200	0-0:1.0.0*255 0-0:96.11.9*255 0-0:96.11.20*255 0-0:96.11.21*255
Power failure event log	1-0:99.97.0*255	10	0-0:1.0.0*255 0-0:96.7.19*255
Certification data log	1-0:99.99.0*255	100	0-0:1.0.0*255 0-0:96.128.0*255 0-0:96.128.1*255 0-0:96.128.2*255
M-Bus master control log object 1	0-1:24.5.0*255	10	0-0:1.0.0*255 0-1:96.11.4*255
M-Bus master control log object 2	0-2:24.5.0*255	10	0-0:1.0.0*255 0-2:96.11.4*255
M-Bus master control log object 3	0-3:24.5.0*255	10	0-0:1.0.0*255 0-3:96.11.4*255
M-Bus master control log object 4	0-4:24.5.0*255	10	0-0:1.0.0*255 0-4:96.11.4*255

Table 59: Event log objects

9.9.2.1. Standard event log

The **Standard event log** (0-0:99.98.0*255) contains all events that are not recorded in other special event logs, e.g., changes of the clock, changes of the configuration, clearing of profiles, all kind of self-check errors, activation of new parameters, activation of new time of use, etc.

The **Standard event log** structure consists of timestamp and event code (*IE.x Event codes – Appendix A3*). The **Event object – Standard event log** object (0-0:96.11.0*255) holds the code from the last event triggered. See Table 59.

Standard event log

Logical name: 0-0:99.98.0*255, Class ID: Profile generic (7), Version: 1

☐ Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.0*255
1	25. 11. 2020 07:09:46 {+60} (+60)	1 - Power down
2	25. 11. 2020 07:09:55 {+60} (+60)	2 - Power up
3	25. 11. 2020 07:09:57 {+60} (+60)	1 - Power down
4	25. 11. 2020 07:10:12 {+60} (+60)	2 - Power up
5	25. 11. 2020 07:10:12 {+60} (+60)	1 - Power down
6	25. 11. 2020 07:10:18 {+60} (+60)	2 - Power up
7	25. 11. 2020 07:10:19 {+60} (+60)	1 - Power down
8	25. 11. 2020 07:10:25 {+60} (+60)	2 - Power up
9	25. 11. 2020 07:10:25 {+60} (+60)	1 - Power down
10	25. 11. 2020 07:10:43 {+60} (+60)	2 - Power up

Figure 101: Example of Standard event log buffer content

9.9.2.2. Fraud detection log

The **Fraud detection log** object (0-0:99.98.1*255) contains all events related to the detection of fraud attempts, e.g., removal of the terminal cover, removal of the module, strong DC field detection, an access with wrong password, etc.

By the default, there is a 15-minute (900 s) hold-off period between two events (only events detected after 15 minutes of the latest one are recorded). The hold-off period is started at fraud event, which disables another logging of same fraud event for its duration. This prevents filling the fraud detection log too quickly with repeating the same fraud events.

The hold-off period between two events is set in **Fraud detection hold-off period** (1-0:96.245.10*255).

The **Event object – Fraud detection log** object (0-0:96.11.1*255) holds the code (*IE.x Event codes – Appendix A3*) from the last event triggered. See Table 59.

Fraud detection log

Logical name: 0-0:99.98.1*255, Class ID: Profile generic (7), Version: 1

☐ Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.1*255
7	24. 11. 2020 10:32:01 {+60} (+60)	40 - Terminal cover removed
8	24. 11. 2020 18:19:53 {+60} (+60)	41 - Terminal cover closed
9	3. 01. 2020 07:32:52 {+60} (+60)	244 - Module cover opened
10	3. 01. 2020 07:33:02 {+60} (+60)	245 - Module cover closed
11	3. 01. 2020 07:33:57 {+60} (+60)	40 - Terminal cover removed
12	3. 01. 2020 07:34:08 {+60} (+60)	41 - Terminal cover closed
13	3. 01. 2020 07:34:13 {+60} (+60)	42 - Strong DC field detected
14	3. 01. 2020 07:34:15 {+60} (+60)	43 - No strong DC field detected anymore
15	24. 11. 2020 15:40:10 {+60} (+60)	40 - Terminal cover removed
16	24. 11. 2020 15:40:21 {+60} (+60)	41 - Terminal cover closed

Figure 102: Example of Fraud detection log buffer content

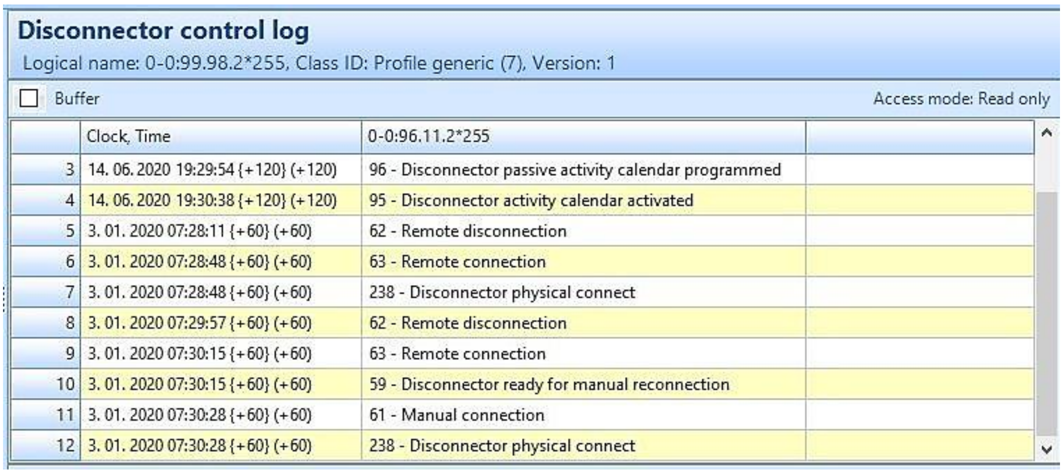
Example:

When strong DC field is detected, the event is saved in the fraud log and time interval is started. DC field is then removed, event is saved in the fraud log, and another time interval is started. For the next 15 minutes, no such event is recorded if we apply and remove DC field. We can apply strong DC field that will not be marked with event, wait until the time interval for DC removed runs out and then remove DC field. Event will be logged in fraud log and time interval will be started again.

9:00 strong DC field detected - event 42 saved in fraud log
900s time interval for DC ON started
9:01 strong DC field removed - event 43 saved in fraud log
900s time interval for DC OFF started
9:14 strong DC field detected - logging of event 42 is blocked!
Time interval for DC ON ends, time interval for DC OFF ends
9:17 strong DC field removed - event 43 saved in fraud log
900s time interval for DC OFF started

9.9.2.3. Disconnector control log

The **Disconnector control log** (0-0:99.98.2*255) contains all events related to the disconnector functionality, e.g., connect, disconnect, changing of the disconnector threshold. The **Disconnector control log** structure contains timestamp and event code (*IE.x Event codes – Appendix A3*). The **Event object – Disconnector control log** object (0-0:96.11.2*255) holds the code from the last event triggered. These codes along with timestamps are then used in the event log. See Table 59.

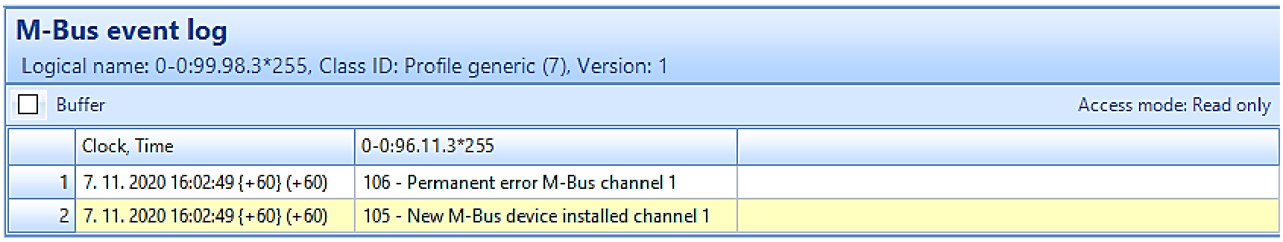

Disconnector control log
Logical name: 0-0:99.98.2*255, Class ID: Profile generic (7), Version: 1
Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.2*255	
3	14. 06. 2020 19:29:54 {+120} (+120)	96 - Disconnector passive activity calendar programmed	
4	14. 06. 2020 19:30:38 {+120} (+120)	95 - Disconnector activity calendar activated	
5	3. 01. 2020 07:28:11 {+60} (+60)	62 - Remote disconnection	
6	3. 01. 2020 07:28:48 {+60} (+60)	63 - Remote connection	
7	3. 01. 2020 07:28:48 {+60} (+60)	238 - Disconnector physical connect	
8	3. 01. 2020 07:29:57 {+60} (+60)	62 - Remote disconnection	
9	3. 01. 2020 07:30:15 {+60} (+60)	63 - Remote connection	
10	3. 01. 2020 07:30:15 {+60} (+60)	59 - Disconnector ready for manual reconnection	
11	3. 01. 2020 07:30:28 {+60} (+60)	61 - Manual connection	
12	3. 01. 2020 07:30:28 {+60} (+60)	238 - Disconnector physical connect	

Figure 103: Example of Disconnector control log buffer content

9.9.2.4. M-Bus event log

The **M-Bus event log** (0-0:99.98.3*255) contains events related to meter M-Bus communication functionality (e.g., changes of the clock, communication errors, fraud attempt, etc.). The buffer must be filled monotonously, i.e., no irregular entries are allowed. The **M-Bus Event Log** structure consists of timestamp and event code. See Table 59.


M-Bus event log
Logical name: 0-0:99.98.3*255, Class ID: Profile generic (7), Version: 1
Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.3*255	
1	7. 11. 2020 16:02:49 {+60} (+60)	106 - Permanent error M-Bus channel 1	
2	7. 11. 2020 16:02:49 {+60} (+60)	105 - New M-Bus device installed channel 1	

Figure 104: Example of M-Bus event log buffer content

9.9.2.5. Power quality log

The **Power quality log** (0-0:99.98.4*255) contains all events related to power quality. The Power quality event log structure consists of timestamp and event code. The **Event object – Power quality log object** (0-0:96.11.4*255) holds the code from the last event triggered. See Table 59.

Power quality log

Logical name: 0-0:99.98.4*255, Class ID: Profile generic (7), Version: 1

Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.4*255
1	25. 11. 2020 07:05:58 {+60} (+60)	85 - Voltage L1 normal
2	25. 11. 2020 07:05:59 {+60} (+60)	82 - Missing voltage L1
3	25. 11. 2020 07:06:15 {+60} (+60)	85 - Voltage L1 normal
4	25. 11. 2020 07:06:15 {+60} (+60)	82 - Missing voltage L1
5	25. 11. 2020 07:06:34 {+60} (+60)	85 - Voltage L1 normal
6	25. 11. 2020 07:06:35 {+60} (+60)	82 - Missing voltage L1

Figure 105: Example of Power quality log buffer content

9.9.2.6. Communication event log

The **Communication event log** (0-0:99.98.5*255) object contains all events related to the communication, e.g., no connection timeout, modem related events (modem reset, initialization failure, SIM failure, GSM/GPRS registration failure…), auto answer. The **Communication event log** structure consists of timestamp and event code.

Description of the attributes and methods for this object is the same as for *Standard event log*. The **Event object – Communication event log** object (0-0:96.11.5*255) holds the code from the last event triggered. These codes along with timestamps are then used in event log. See Table 59.

Communication event log

Logical name: 0-0:99.98.5*255, Class ID: Profile generic (7), Version: 1

Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.5*255
1	19. 10. 2020 16:51:11 {+120} (+120)	158 - Local communication attempt
2	19. 10. 2020 19:09:44 {+120} (+120)	158 - Local communication attempt
3	22. 10. 2020 09:57:50 {+120} (+120)	158 - Local communication attempt
4	22. 10. 2020 10:29:19 {+120} (+120)	158 - Local communication attempt
5	22. 10. 2020 12:10:07 {+120} (+120)	158 - Local communication attempt
6	22. 10. 2020 12:44:32 {+120} (+120)	158 - Local communication attempt

Figure 106: Example of Communication event log buffer content

9.9.2.7. Communication details log

The **Communication details log** (0-0:99.98.6*255) registers the communication sessions (**Event Object–Communication Details Log**, 0-0:96.11.6*255) on the local and remote interface and provides an access statistic for different groups of attributes and methods (*Event counter objects*).

Communication details log

Logical name: 0-0:99.98.6*255, Class ID: Profile generic (7), Version: 1

Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.6*255	0-0:40.0.0*255	0-0:40.0.0*255	0-0:128.100.38*255	0-0:96.15.0*255	0-0:96.15.1*255	0-0:96.15.2*2
91	24. 11. 2020 15:46:13 {+60} (+...	29 - Communication ended on local interface IE-M	1	1	49 53 4B 30 30 30 30 37	280077	702	6123
92	24. 11. 2020 15:46:13 {+60} (+...	28 - Communication started on local interface IE-M	1	1	49 53 4B 30 30 30 30 37	280077	702	6123
93	24. 11. 2020 15:49:08 {+60} (+...	29 - Communication ended on local interface IE-M	1	1	49 53 4B 30 30 30 30 37	316469	802	8343
94	25. 11. 2020 07:17:54 {+60} (+...	28 - Communication started on local interface IE-M	16	1	30 30 30 30 30 30 30 30	321663	802	8343
95	25. 11. 2020 07:17:54 {+60} (+...	29 - Communication ended on local interface IE-M	16	1	30 30 30 30 30 30 30 30	321664	802	8343
96	25. 11. 2020 07:17:54 {+60} (+...	28 - Communication started on local interface IE-M	1	1	27 09 67 01 02 03 04 05	321664	802	8343
97	25. 11. 2020 07:18:10 {+60} (+...	29 - Communication ended on local interface IE-M	1	1	27 09 67 01 02 03 04 05	327176	802	8343
98	25. 11. 2020 07:18:10 {+60} (+...	28 - Communication started on local interface IE-M	16	1	27 09 67 01 02 03 04 05	327176	802	8343
99	25. 11. 2020 07:18:10 {+60} (+...	29 - Communication ended on local interface IE-M	16	1	27 09 67 01 02 03 04 05	327177	802	8343
100	25. 11. 2020 07:18:10 {+60} (+...	28 - Communication started on local interface IE-M	1	1	27 09 67 01 02 03 04 05	327177	802	8343

Figure 107: Example of Communication details log buffer content

Capture Objects

When an event is triggered, the timestamp and event-code set are recorded in this attribute.

By default, capture objects are set to:

- 0-0:1.0.0*255, attribute 2 (System Time)
- 0-0:96.11.6*255, attribute 2 (Event Object – Communication Details Log)
- 0-0:40.0.0*255, attribute 3, index 1 (Current Association Client SAP)
- 0-0:40.0.0*255, attribute 3, index 2 (Current Association Server SAP)
- 0-0:128.100.38*255, attribute 2 (Current Client System Title)
- 0-0:96.15.0*255, attribute 2 (Event counter Object 1 – E-Meter Global Total)
- 0-0:96.15.1*255, attribute 2 (Event counter Object 2 – E-Meter Billing Total)
- 0-0:96.15.2*255, attribute 2 (Event counter Object 3 – E-Meter Load Profile Reading Total)
- 0-0:96.15.3*255, attribute 2 (Event counter Object 4 – M-Bus Device 1 Billing Total)
- 0-0:96.15.4*255, attribute 2 (Event counter Object 5 – M-Bus Device 1 Load Profile Reading Total)
- 0-0:96.15.5*255, attribute 2 (Event counter Object 6 – M-Bus Device 2 Billing Total)
- 0-0:96.15.6*255, attribute 2 (Event counter Object 7 – M-Bus Device 2 Load Profile Reading Total)
- 0-0:96.15.7*255, attribute 2 (Event counter Object 8 – M-Bus Device 3 Billing Total)
- 0-0:96.15.8*255, attribute 2 (Event counter Object 9 – M-Bus Device 3 Load Profile Reading Total)
- 0-0:96.15.9*255, attribute 2 (Event counter Object 10 – M-Bus Device 4 Billing Total)
- 0-0:96.15.10*255, attribute 2 (Event counter Object 11 – M-Bus Device 4 Load Profile Reading Total)

Capture Period

Capture period is set to 0 because events are triggered and recorded as they occur. Period different from 0 is meaningless.

Sort Method

Attribute for sorting captured data. It is fixed to FIFO (First in, First Out).

Sort Object

Clock object is used as sort object.

Entries in Use

This attribute shows how many recordings have been made and are recorded (captured).

Profile Entries

This attribute shows how many recordings are possible in the meter. This number depends on the capture period selected and number of capture objects set.

Specific Methods

Object has two methods implemented:

- Reset (erases captured values)
- Capture (not implemented)

9.9.2.7.1. Communication details event counters

Communication details event counter values are stored in a dedicated objects as shown in Table 60.

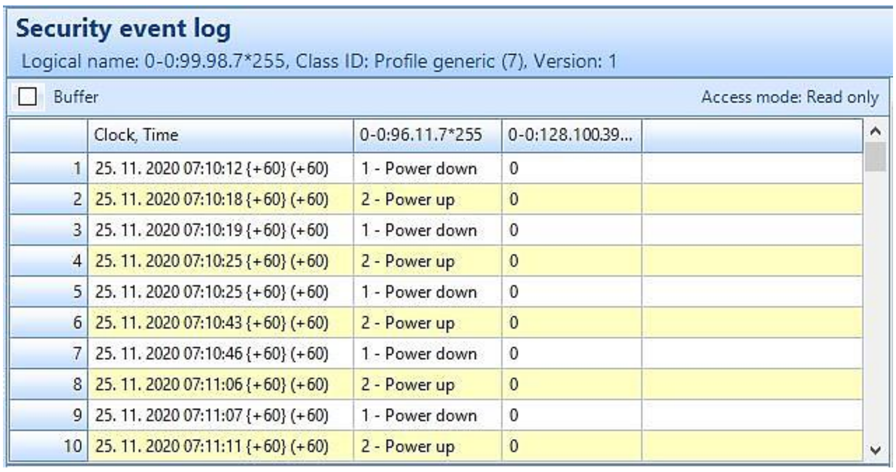
Object name	Logical name	Description
Event counter Object 1 – E-Meter Global Total	0-0:96.15.0*255	The object contains the total number of accesses on attributes and methods. Accesses are counted per attribute or per method.
Event counter Object 2 – E-Meter Billing Total	0-0:96.15.1*255	The object contains the total number of accesses to the electricity related objects: • totals, rated registers - the counter counts the number of accesses to attribute 2 (value),

Object name	Logical name	Description
		• data of billing period 1 - the counter counts the number of accesses to attribute 2 (buffer).
Event counter Object 3 – E-Meter Load Profile Reading Total	0-0:96.15.2*255	The object contains the total number of accesses to the Load profile with period 1 and Load profile with period 2. The counter counts the number of accesses to attribute 2 (buffer).
Event counter Object 4 – M-Bus Device 1 Billing Total	0-0:96.15.3*255	The object contains the total number of accesses to the M-Bus Value channel 1, instance 1 to 8. The counter counts the number of accesses to attribute 2 (value).
Event counter Object 5 – M-Bus Device 1 Load Profile Reading Total	0-0:96.15.4*255	The object contains the total number of accesses to the M-Bus Master Load profile for channel 1. The counter counts the number of accesses to attribute 2 (value).
Event counter Object 6 – M-Bus Device 2 Billing Total	0-0:96.15.5*255	The object contains the total number of accesses to the M-Bus Value channel 2, instance 1 to 8. The counter counts the number of accesses to attribute 2 (value).
Event counter Object 7 – M-Bus Device 2 Load Profile Reading Total	0-0:96.15.6*255	The object contains the total number of accesses to the M-Bus Master Load profile for channel 2. The counter counts the number of accesses to attribute 2 (value).
Event counter Object 8 – M-Bus Device 3 Billing Total	0-0:96.15.7*255	The object contains the total number of accesses to the M-Bus Value channel 3, instance 1 to 8. The counter counts the number of accesses to attribute 2 (value).
Event counter Object 9 – M-Bus Device 3 Load Profile Reading Total	0-0:96.15.8*255	The object contains the total number of accesses to the M-Bus Master Load profile for channel 3. The counter counts the number of accesses to attribute 2 (value).
Event counter Object 10 – M-Bus Device 4 Billing Total	0-0:96.15.9*255	The object contains the total number of accesses to the M-Bus Value channel 4, instance 1 to instance 8. The counter counts the number of accesses to attribute 2 (value).
Event counter Object 11 – M-Bus Device 4 Load Profile Reading Total	0-0:96.15.10*255	The object contains the total number of accesses to the M-Bus Master Load profile for channel 4. The counter counts the number of accesses to attribute 2 (value).

Table 60: Communication details event counters

9.9.2.8. Security event log

The **Security event log** contains all events related to security part. It has three capture objects: *Clock* (0 0:1.0.0*255), *Event object – Security event log* (0-0:96.11.7*255) and *Client SAP* (0-0:128.100.39*255). The *Client SAP* shows an association number, which is attached in the event time. When the event is triggered in time of without association then the *Client SAP* value is set to 0. See Table 59.



Security event log

Logical name: 0-0:99.98.7*255, Class ID: Profile generic (7), Version: 1

Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.7*255	0-0:128.100.39...
1	25. 11. 2020 07:10:12 {+60} (+60)	1 - Power down	0
2	25. 11. 2020 07:10:18 {+60} (+60)	2 - Power up	0
3	25. 11. 2020 07:10:19 {+60} (+60)	1 - Power down	0
4	25. 11. 2020 07:10:25 {+60} (+60)	2 - Power up	0
5	25. 11. 2020 07:10:25 {+60} (+60)	1 - Power down	0
6	25. 11. 2020 07:10:43 {+60} (+60)	2 - Power up	0
7	25. 11. 2020 07:10:46 {+60} (+60)	1 - Power down	0
8	25. 11. 2020 07:11:06 {+60} (+60)	2 - Power up	0
9	25. 11. 2020 07:11:07 {+60} (+60)	1 - Power down	0
10	25. 11. 2020 07:11:11 {+60} (+60)	2 - Power up	0

Figure 108: Example of Security event log buffer content

NOTE
A buffer of the Security event log cannot be reset.

Events logged in the *Security event log* and *Fraud event log* simultaneously have same hold-off period between two events as defined for fraud events in chapter *9.9.2.2. Fraud detection log*.

9.9.2.8.1. Security event counters

Each security event has a dedicated security event-counter object, which is counting the occurrence of each security related event. When number of security event occurrences overflows maximum counter value, a special overflow counter (0-0:96.15.30*255) is increased by one.

Security event-counter values are stored in a dedicated objects as shown in Table 61.

Object name	Logical name
Security event counter - event overflow	0-0:96.15.30.255
Security event counter - *event 1*	0-0:96.15.31.255
Security event counter - *event 2*	0-0:96.15.32.255
Security event counter - *event 4_5*	0-0:96.15.33.255
Security event counter - *event 6*	0-0:96.15.34.255
Security event counter - *event 10*	0-0:96.15.35.255
Security event counter - *event 11*	0-0:96.15.36.255
Security event counter - *event 12*	0-0:96.15.37.255
Security event counter - *event 13*	0-0:96.15.38.255
Security event counter - *event 14*	0-0:96.15.39.255
Security event counter - *event 15*	0-0:96.15.40.255
Security event counter - *event 17*	0-0:96.15.41.255
Security event counter - *event 18*	0-0:96.15.42.255
Security event counter - *event 38*	0-0:96.15.43.255
Security event counter - *event 39*	0-0:96.15.44.255
Security event counter - *event 40*	0-0:96.15.45.255
Security event counter - *event 41*	0-0:96.15.46.255
Security event counter - *event 42*	0-0:96.15.47.255
Security event counter - *event 43*	0-0:96.15.48.255
Security event counter - *event 44*	0-0:96.15.49.255
Security event counter - *event 45*	0-0:96.15.50.255
Security event counter - *event 46*	0-0:96.15.51.255
Security event counter - *event 48*	0-0:96.15.52.255
Security event counter - *event 49*	0-0:96.15.53.255
Security event counter - *event 50*	0-0:96.15.54.255
Security event counter - *event 51*	0-0:96.15.55.255
Security event counter - *event 59*	0-0:96.15.56.255
Security event counter - *event 60*	0-0:96.15.57.255
Security event counter - *event 62*	0-0:96.15.59.255
Security event counter - *event 63*	0-0:96.15.60.255
Security event counter - *event 64*	0-0:96.15.61.255
Security event counter - *event 105*	0-0:96.15.62.255
Security event counter - *event 115*	0-0:96.15.63.255
Security event counter - *event 125*	0-0:96.15.64.255

Object name	Logical name
Security event counter - *event 128*	0-0:96.15.65.255
Security event counter - *event 135*	0-0:96.15.66.255
Security event counter - *event 238*	0-0:96.15.67.255
Security event counter - *event 246*	0-0:96.15.68.255
Security event counter - *event 247*	0-0:96.15.69.255
Security event counter - *event 248*	0-0:96.15.70.255
Security event counter - *event 249*	0-0:96.15.71.255
Security event counter - *event 250*	0-0:96.15.72.255
Security event counter - *event 46, role 1*	0-0:96.15.73.255
Security event counter - *event 46, role 2*	0-0:96.15.74.255
Security event counter - *event 46, role 3*	0-0:96.15.75.255
Security event counter - *event 46, role 4*	0-0:96.15.76.255
Security event counter - *event 46, role 5*	0-0:96.15.77.255
Security event counter - *event 46, role 6*	0-0:96.15.78.255
Security event counter - *event 46, role 7*	0-0:96.15.79.255
Security event counter - *event 46, role 8*	0-0:96.15.80.255
Security event counter - *event 46, role 9*	0-0:96.15.81.255
Security event counter - *event 250, role 1*	0-0:96.15.82.255
Security event counter - *event 250, role 2*	0-0:96.15.83.255
Security event counter - *event 250, role 3*	0-0:96.15.84.255
Security event counter - *event 250, role 4*	0-0:96.15.85.255
Security event counter - *event 250, role 5*	0-0:96.15.86.255
Security event counter - *event 250, role 6*	0-0:96.15.87.255
Security event counter - *event 250, role 7*	0-0:96.15.88.255
Security event counter - *event 250, role 8*	0-0:96.15.89.255
Security event counter - *event 250, role 9*	0-0:96.15.90.255
Security event counter - *event 244*	0-0:96.15.91.255
Security event counter - *event 245*	0-0:96.15.92.255
Security event counter - *event 226*	0-0:96.15.93.255
Security event counter - *event 227*	0-0:96.15.94.255
Security event counter - *event 228*	0-0:96.15.95.255
Security event counter - *event 204*	0-0:96.15.96.255

For object names of events, see document *IE.x Event codes – Appendix A3*; find event number in column "IDIS event code" and read its "Event name" (example: "*Event 18"* = "*Firmware activated*")

Table 61: Security event counters - objects

9.9.2.9. Image activation data log

The **Image activation log** (0-0:99.98.8*255) is special log, used for events related to the E-meter image activation. It has three capture objects:

- **Clock** (0-0:1.0.0*255),
- **Event object – Image activation log** (0-0:96.11.8*255),
- **Log Image version** (0-0:96.128.10*255).

In the image activation log, two events can be logged:

- 18 Firmware activated Indicates that a new firmware has been activated
- 228 LR firmware activated Indicates that the LR firmware is activated

The image version of the firmware, which runs in the meter, is recorded as well. For this application, the specific object (0-0:96.128.10*255) is introduced.

Log image version holds the information about new firmware version, which is activated on the meter. The following firmware versions are recorded:

- Core (C: CORE LRFW)
- Application (A: APP)
- CLR (R: NATIONAL LRFW)
- Kernel (K: KER)

Capacity of this event log is 100 events. The meter image activation is not possible when log buffer is full.

Image activation log
Logical name: 0-0:99.98.8*255, Class ID: Profile generic (7), Version: 1
Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.8*255	0-0:96.128.10*255
1	6. 01. 2021 11:31:46 {+60} (+60)	18 - Firmware activated	TA01100005
2	6. 01. 2021 11:31:46 {+60} (+60)	18 - Firmware activated	TK01100004
3	6. 01. 2021 11:31:46 {+60} (+60)	228 - LR firmware activated	TR01100004
4	6. 01. 2021 11:31:46 {+60} (+60)	228 - LR firmware activated	TC01100006

Figure 109: Example of image activation log buffer content

9.9.2.10. M-Bus master control logs (optional)

The **M-Bus master control log** (0-x:24.5.0*255), where x represents one of the M-Bus channels (from 1 to 4), indicates both states (connected, disconnected) of disconnector and valve alarm registrations. See Table 59.

This log is in use if M-Bus device physically supports Valve disconnector.

9.9.2.11. Power failure event log

Power failure event log (1-0:99.97.0*255) contains records of long power failure events. If there is a power outage longer than specified in object **Time threshold for long power failure** (0-0:96.7.20*255), a new record is logged in next power-up, consisting of timestamp and duration of last long power failure, in any phase.

Power failure event log
Logical name: 1-0:99.97.0*255, Class ID: Profile generic (7), Version: 1
Buffer — Access mode: Read only

	Clock, Time	0-0:96.7.19*255
1	25. 11. 2020 07:08:56 {+60} (+60)	25
2	25. 11. 2020 07:09:56 {+60} (+60)	22
3	25. 11. 2020 07:10:18 {+60} (+60)	25
4	25. 11. 2020 07:10:45 {+60} (+60)	21
5	25. 11. 2020 07:11:45 {+60} (+60)	31
6	25. 11. 2020 07:12:16 {+60} (+60)	39
7	25. 11. 2020 07:13:16 {+60} (+60)	25
8	25. 11. 2020 07:14:21 {+60} (+60)	23
9	25. 11. 2020 07:15:18 {+60} (+60)	29
10	25. 11. 2020 07:15:48 {+60} (+60)	29

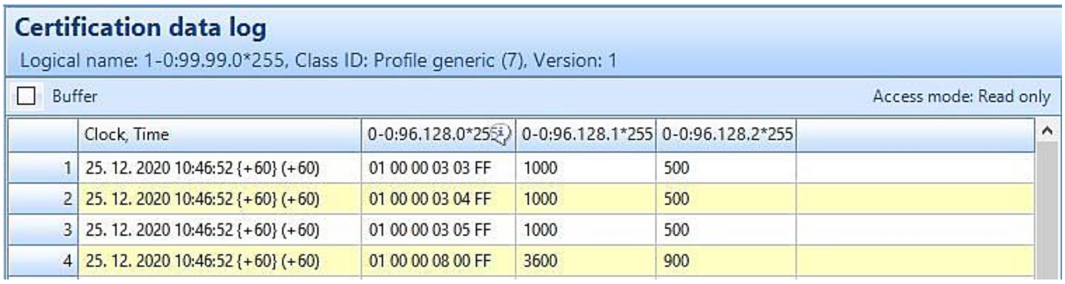
Figure 110: Example of Power failure event log buffer content

9.9.2.12. Certification data log

Certification data log (1-0:99.99.0*255) is a special log, used to log modifications of critical parameters, which influence measurement values. The basic structure of the data log contains the timestamp and three additional objects:

- Last modified secure parameter identifier (0-0:96.128.0*255),

- Last modified secure parameter old value (0-0:96.128.1*255),
- Last modified secure parameter new value (0-0:96.128.2*255).



Certification data log
Logical name: 1-0:99.99.0*255, Class ID: Profile generic (7), Version: 1
Buffer   Access mode: Read only

	Clock, Time	0-0:96.128.0*255	0-0:96.128.1*255	0-0:96.128.2*255
1	25. 12. 2020 10:46:52 {+60} (+60)	01 00 00 03 03 FF	1000	500
2	25. 12. 2020 10:46:52 {+60} (+60)	01 00 00 03 04 FF	1000	500
3	25. 12. 2020 10:46:52 {+60} (+60)	01 00 00 03 05 FF	1000	500
4	25. 12. 2020 10:46:52 {+60} (+60)	01 00 00 08 00 FF	3600	900

Figure 111: Example of Certification data log buffer content

Last modified secure parameter identifier contains the logical name of the most recently modified critical measurement parameter object. Last modified secure parameter old value and the Last modified secure parameter new value contain the last modified object's previous and newly set values.

The following critical parameters are being monitored:

- Active energy, metrological LED (1-0:0.3.0*255)
- Reactive energy, metrological LED (1-0:0.3.1*255)
- Apparent energy, metrological LED (1-0:0.3.2*255)
- Transformer ratio – current (numerator) (1-0:0.4.2*255)
- Transformer ratio – current (denominator) (1-0:0.4.5*255)
- Transformer ratio – voltage (numerator) (1-0:0.4.3*255)
- Transformer ratio – voltage (denominator) (1-0:0.4.6*255)
- Measurement period 1, for average value 1 (1-0:0.8.0*255)
- Active energy, output pulse meter constant [impulses/kWh] (1-0:0.3.3*255)
- Reactive energy, output pulse meter constant [impulses/kvarh] (1-0:0.3.4*255)
- Apparent energy, output pulse meter constant [impulses/kVAh] (1-0:0.3.5*255)
- **Nominal voltage** (1-0:0.6.0*255)

The capacity of the Certification data log is set to 100 entries. When the log is full, an event is triggered. Then the critical measurement object can be changed only if first entry in log is 14 months old. If not, then change request is rejected and event is triggered.

9.9.2.13. Grid monitor event log

The **Grid monitor event log** (0-0:99.98.9*255) contains all events related to grid monitoring.

The basic structure of the data log contains the following information:

- **Clock** (0-0:1.0.0*255),
- **Event code** (0-0:96.11.9*255)
- **Event status – duration** (0-0:96.11.20*255)
- **Event status – magnitude** (0-0.96.11.21*255)

The **Event status – duration** object contains information about the duration of the event detected. The **Event status – magnitude** object contains information about the maximum value reached during the event duration.
For most situations, two events is logged into the **Grid monitor event log**:

- start event and
- end event.

For **start event** applies, that duration of the event is set to 0 and magnitude is set to the threshold that monitoring value exceeded.

For **end event** applies, that duration is set to the value of the event duration and magnitude is set to the maximum value of the event.

NOTE

If value for duration or magnitude of some event cannot be determined, value 0 is written in the log for this particular event.

Grid monitor event log

Logical name: 0-0:99.98.9*255, Class ID: Profile generic (7), Version: 1

☐ Buffer — Access mode: Read only

	Clock, Time	0-0:96.11.9*255	0-0:96.11.20*255	0-0:96.11.21*255
1	17. 07. 2020 15:25:18 {+180} (+120)	82 - Missing voltage L1	0	1656
2	17. 07. 2020 15:25:19 {+180} (+120)	85 - Voltage L1 normal	1	0
3	17. 07. 2020 15:25:22 {+180} (+120)	82 - Missing voltage L1	0	0
4	17. 07. 2020 15:25:18 {+180} (+120)	83 - Missing voltage L2	0	0
5	17. 07. 2020 15:25:18 {+180} (+120)	84 - Missing voltage L3	0	0
6	17. 07. 2020 15:30:23 {+180} (+120)	85 - Voltage L1 normal	301	0
7	17. 07. 2020 15:30:23 {+180} (+120)	86 - Voltage L2 normal	305	0
8	17. 07. 2020 15:30:23 {+180} (+120)	87 - Voltage L3 normal	305	0
9	17. 07. 2020 15:57:03 {+180} (+120)	82 - Missing voltage L1	0	1656
10	17. 07. 2020 15:57:10 {+180} (+120)	85 - Voltage L1 normal	7	0

Figure 112: Example of Grid monitor event log

9.9.3. Event codes

For the complete list of event codes, see document *IE.x Event codes – Appendix A3*.

9.10. Errors

During operation, the meter uses its automatic supervision mechanism to detect and log different types of events related to meter operation. These events can be a part of meter's internal functionality or can occur due to changes in the meter's environment. When an event, which indicates a malfunction in the meter operation, is triggered, the appropriate flag in an **Error register *x*** object (*x* = 1, 2 or 3) is set (see chapter *9.10.1. Error register*).

The **Error object *x*** value register is 32 bits long and is organized in three groups of errors:

- Other errors
- Critical errors
- M-Bus errors

For more information about the groups, refer to chapter *9.10.5. Error types*.

Depending on the type of error, some errors clear themselves if the reason for the error has disappeared. Others must be cleared in corresponding Error register object via the management client by setting the selected bit to logical 0 (cleared flag).

Once the flag in the **Error register x** object is set, it remains active even after the corresponding error condition has disappeared. The **Error register x** object has to be cleared manually (using supported communication interfaces).

NOTE

<u>**Exception**</u>: FF errors (B8–B11 in Table 62) cannot be cleared in any case.

For more information refer to chapter *9.10.4. Error erase filter*.

If, after the flag in the error register has been cleared, the corresponding error-condition still remains, the flag in the error register is re-set by the meter.

During operation, the meter performs tests of individual functions. In a case of an error, it is represented with corresponding error bit in the Error Object register.

Depending on the capabilities of the system and the policy of a utility, errors can be filtered. For more information, refer to the chapter *9.10.2. Error filter*.

9.10.1. Error register

The meter contains four sets of error register:

- **Error register 1** (0-0:97.97.0*255) object contains the first set of error registers, which is used for reporting errors with IDIS specifications (Table 62)
- **Error register 2** (0-0:97.97.1*255) object contains the second set, which is used for backward capability with other Iskraemeco AMI meters (Table 63).
- **Error register 3** (0-0:97.97.2*255) object contains the third set, which holds a general purpose (Table 64). Currently, it is used to report the deviations in the grid monitor measurements.
- **Error register 4** (0-0:97.97.3*255) object contains the fourth set, which is used for reporting errors related to overvoltage and undervoltage (currently not yet available).

Group	Byte	Bit	Meaning	Events
Other Errors (part 1)	1 (LSB)	0	Clock invalid	6
		1	Replace battery	7
		2–7	*Not used*	
Critical Errors	2	0	Program memory error	12
		1	RAM error	13
		2	NV memory error	14
		3	Measurement system error	16
Other Errors (part 2)		4	Watchdog error	15
		5	Fraud attempt	40, 42, 44, 46, 49, 50, 244
		6–7	*Not used*	
M-Bus Errors	3	0	Communication error M-Bus Ch1	100
		1	Communication error M-Bus Ch2	110
		2	Communication error M-Bus Ch3	120
		3	Communication error M-Bus Ch4	130
		4	Fraud attempt M-Bus Ch1 *	103
		5	Fraud attempt M-Bus Ch2 *	113
		6	Fraud attempt M-Bus Ch3 *	123
		7	Fraud attempt M-Bus Ch4 *	133
	4 (MSB)	0	Permanent error M-Bus Ch1	106
		1	Permanent error M-Bus Ch2	116
		2	Permanent error M-Bus Ch3	126
		3	Permanent error M-Bus Ch4	136
		4	Battery low M-Bus Ch1	102
		5	Battery low M-Bus Ch2	112
		6	Battery low M-Bus Ch2	122
		7	Battery low M-Bus Ch3	132

* Fraud attempt M-Bus Chx errors are customer specific.

Table 62: Error register 1 – IDIS error codes

Group	Byte	Bit	Meaning	Events
IE Error codes	1 (LSB)	0	Total power failure	1
		1	Power resume	2
		2	Voltage missing phase L1	82
		3	Voltage missing phase L2	83
		4	Voltage missing phase L3	84
		5	Voltage normal phase L1	85
		6	Voltage normal phase L2	86
		7	Voltage normal phase L3	87
	2	0	Missing neutral	89
		1	Phase asymmetry	90
		2	Current reversal	91
		3	Wrong phase sequence	88
		4	Unexpected consumption	52
		5	Key exchanged	48
		6	Bad voltage quality L1	92
		7	Bad voltage quality L2	93
	3	0	Bad voltage quality L3	94
		1	External alert	20
		2	Local communication attempt	158
		3	New M-Bus device installed channel 1	105
		4	New M-Bus device installed channel 2	115
		5	New M-Bus device installed channel 3	125
		6	New M-Bus device installed channel 4	135
		7	M-Bus decryption failed Ch1	/
	4 (MSB)	0	M-Bus decryption failed Ch2	/
		1	M-Bus decryption failed Ch3	/
		2	M-Bus decryption failed Ch4	/
		3	M-Bus valve alarm channel 1 *	164
		4	M-Bus valve alarm channel 2 *	174
		5	M-Bus valve alarm channel 3 *	184
		6	M-Bus valve alarm channel 4 *	194
		7	Disconnect/Reconnect Failure	68

* M-Bus valve alarm channel x errors are customer specific.

Table 63: Error register 2 – Iskraemeco error codes

Group	Byte	Bit	Meaning	Events
General purpose codes	1 (LSB)	0–7	*Not used*	
	2	8–14	*Not used*	
		15	Power supply main *	461
	3	16	Power supply auxiliary *	462
		17–23	*Not used*	
	4 (MSB)	24	Neutral missing disconnection	/
		25	External alert 2	469
		26–31	*Not used*	

* not supported yet

Table 64: Error register 3 – general purpose codes

9.10.2. Error filter

Depending on the capabilities of the system and the policy of the utility, not all possible errors are desired. Therefore, the ***Error filter*** object can be programmed to mask out unwanted errors.

The structure of the **Error filter *x*** is the same as the structure of the corresponding **Error register *x*** (*x* = 1, 2, 3):

- **Error filter 1** (0-0:196.97.0*255) – **Error register 1** (0-0:97.97.0*255)
- **Error filter 2** (0-0:196.97.1*255) – **Error register 2** (0-0:97.97.1*255),
- **Error filter 3** (0-0:196.97.2*255) – **Error register 3** (0-0:97.97.2*255)

To mask out unwanted errors the corresponding bit in the error filter should be set to logical 1.

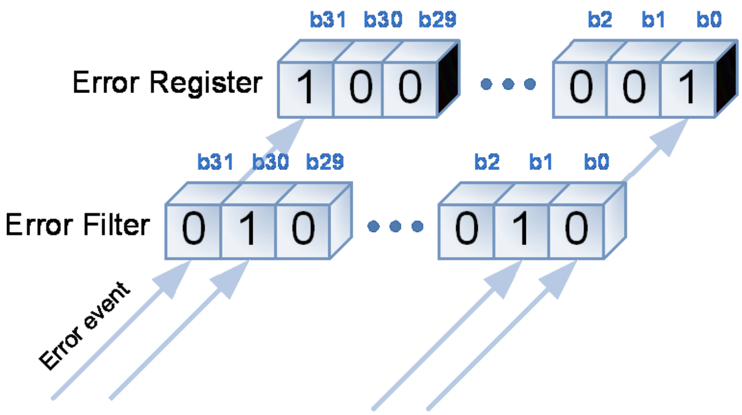


Figure 113: Error filtering

9.10.3. Error display filter

By using an **Error display filter *x*** object (*x* = 1, 2, 3), errors can be filtered out on display as the FF flag. In order to filter out the right error, the corresponding bit in the **Error display filter 1** (0-0:196.97.10*255), the **Error display filter 2** (0-0:196.97.11*255) and **Error display filter 3** (0-0:196.97.12*255) should be set to logical 1.

9.10.4. Error erase filter

All errors set to logical 1 in **Error erase filter *x*** object (*x* = 1, 2, 3). It is considered that registered errors cannot be cleared in any case from the Error register (neither automatically nor manually).

The objects of ***Error erase filter x*** are:

- Error erase filter 1 (0-0:196.97.20)
- Error erase filter 2 (0-0:196.97.21)
- Error erase filter 3 (0-0:196.97.22)

9.10.5. Error types

By an error type, errors are classified in three groups:

- Other errors
- Critical errors
- M-Bus errors

9.10.5.1. Other errors

Clock invalid

Current clock is compared with internal clock structure and if there is any deviation, error “Clock invalid” will be set. When the meter clock is set, the meter will clear clock invalid flag in error register. If the flag is cleared through communication before set the meter clock, the flag is re-set. The energy registers are not affected by the “Clock invalid” error.

Replace battery

The state of a battery or a real time backup capacitor is monitored continuously and if voltage level falls under specified threshold, an error is reported by setting “Replace battery” error flag. The flag is cleared when battery is replaced, and the meter clock is set.

Watchdog error

In case of watch dog reset of the microcontroller the watchdog reset counter is incremented. If the counter achieve the limit of ten events watchdog error flag is set. The flag can be cleared only through communication.

Fraud attempt

Events that trigger the “Fraud attempt” flag: terminal cover open, communication module removal, magnetic field detect, replay attack, decryption or authentication failure. Fraud attempt flag can be cleared only through the management client. The flag is re-set if a new trigger event occurs.

9.10.5.2. Critical errors

Program memory error

Program memory is checked by verifying the integrity of stored program code. The program code is signed by the ECDSA algorithm during build time. The signature is stored together with program code in program memory. In run time, the meter calculates the signature over program code and compares it with the previously stored one. If differ, the “Program memory error” flag is set.

If the public key for the image verification is not set at all, in the meter this error will be ON.

RAM error

The entire data memory (RAM) is checked during the initialization process of the meter, which is started after power-up or firmware upgrade. During the initialization procedure, the meter performs a test of the RAM through the whole address range. The test is executed for every memory location and it is non-destructive. The original content of the memory location under test is loaded to the CPU register, then, the inverted content is stored to the same memory location and compared with the inverted content stored in the CPU register. Upon successful comparison of the inverted content, the original content of the memory location is restored and compared with its copy stored in CPU register at the beginning of the test. If the test fails, the meter sets the “RAM error” flag.

Otherwise, during the normal operation, the meter checks the integrity of data structures where critical data is stored. Each time when such a data structure is intentionally changed, a new signature is calculated and stored. Later on, when the data is accessed again by the program, the integrity can be checked by comparing the newly calculated signature with the one calculated during last intentionally change. If signatures do not match, the meter sets the “RAM error” flag. That way, continuous monitoring of RAM is achieved.

Non-Volatile memory error

The non-volatile (NV) memory is used to retain the stored information, even when the meter is not powered. The NV memory ensures that data is safely retained and remains accessible for more than 12 months (standard conditions) during power down, any critical error related to metrology or memory due to any circumstances might impact the data retention capabilities.

It is used as a long-term persistent storage for periodical historical data, billing data, event logs, register back-up copies, parameters, and any other data that the meter needs for a normal start.

Data-integrity checking is performed periodically or randomly, during data access. Checking of data, which is the result of meter processes and changes more often, is done during data access. The meter-configuration parameters are checked periodically with a period of one hour. If any of the checks fail, the “NV memory error” is set in the error register.

Measurement system error

Checking of undisturbed operation and accuracy of the meter is, to a certain extent, performed by the meter by itself. If any error is detected, the meter reports it by setting the “Measurement system error” flag.

All critical errors remain permanent on the meter and cannot be cleared.

If one of the critical errors appears, also FF (Fatal Fault) error is raised on the meter.

9.10.5.3. M-Bus errors

M-Bus communication

A connection of meter with hosted M-Bus meter is checked during communication with an M-Bus slave device. If there is no respond from the slave device or there is a respond but structure of the data frame on data link layer is incorrect, the meter will set corresponding error bit.

M-Bus fraud attempt

If the M-Bus slave device detected a fraud attempt, “Fraud attempt M-Bus” error bit is set.

Permanent error M-Bus

If the M-Bus slave device detects permanent error, “Permanent M-Bus” error bit is set. Meaning of error is device specific.

Battery low M-Bus

The M-Bus slave device indicates that the battery must be exchanged due to the expected end of life time. If the M-Bus slave device detects battery low state, “Battery low M-Bus” error bit is set.

M-Bus decryption failure

The error is set after unsuccessful decryption of the received frame.

M-Bus valve

If the M-Bus slave device detects valve error, “M-Bus valve alarm” error bit is set.

New M-Bus device discovered

Indicates that new M-Bus device is discovered.

9.10.6. Error codes interpretation

Example: The register or meter’s LCD displays the code **97.97.0**, which represents the **Error register 1** object.

To determine the error:

1. Read its value (a decimal number) from the LCD (or register).

   Example: 00002801
2. Convert the decimal number into a binary one

   00002801_{dec} = $10\ 1000\ 0000\ 0001_{bin}$
3. Write out the positions of digit 1 (bits). In Table 65, we can see the positions of digit 1. It stands on B0, B11, and B13.

NOTE

Positions in binary numbers are always counted from right to left, starting with 0.

The error code in binary format has 32 digits. Normally, the calculator does not display leading zeroes, so we need to add them in order to get the 32-digits number. See Table 65.

Bit																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1

Table 65: Error code interpretation

4. Use the error codes table (see Table 62) to interpret what the bits represent:
   - B0 – Clock invalid
   - B11 – Measurement system error (FF)
   - B13 – Fraud attempt (FF)

9.11. Alarms

Based on constant monitoring, the meter also implements alarm registration. Alarms are information about presence or occurrence of some special conditions detected by the meter. Different conditions can have their source internally in the meter or in the meter environment. Alarms are mostly used for presentation of detected special condition to the user:

- via communication interfaces,
- via dedicated alarm outputs

When specific alarm condition is detected by the meter, this information passes through the dedicated alarm filter, which can filter out unwanted alarm information. Depending on the capabilities of the HES and the policy of the utility, not all supported alarms are wanted. Therefore, the alarm filters can be configured by the user to mask out unwanted alarms. The structure of the filters is the same as the structure of the alarm registers. Filtered alarm information is stored in several alarm objects, which all have their special operation and usage. (See Figure 114.)

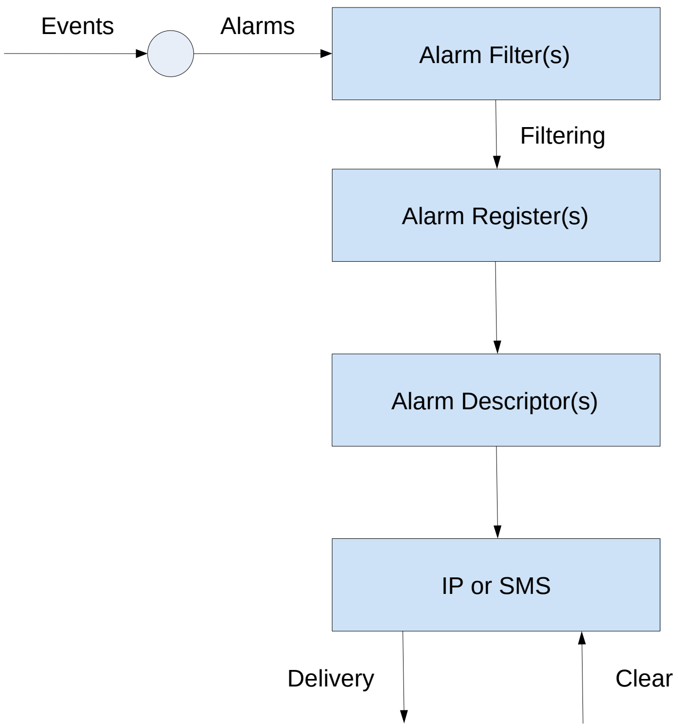


Figure 114: Alarm reporting process

Each bit in the alarm register represents a different alarm. If any bit is set, corresponding alarm was recorded. Value of the alarm register is a 32-bit value of all active and inactive alarms. Depending on the capabilities of the HES and the utility policy, it is possible to mask unwanted alarms through the alarm filter.

Alarm monitoring is also supported. Alarm monitor is a special implementation of the Register monitor functionality, which is used to trigger action up, when any new alarm occurs in the meter.

Alarm system (0-0:96.246.0*255) object represents alarm system used in the meter. The meter supports only one alarm system, therefore this parameter must always be set to “1 – IDIS”.

NOTE
When the meter is powered down, alarm inputs are not detected.

9.11.1. Alarm codes

In the following tables, three sets of alarm codes are given:

- in Table 66, the alarm codes for **Alarm Register 1**,
- in Table 67, the alarm codes for **Alarm Register 2**,
- in Table 68, the alarm codes for **Alarm register 3**, and
- in Table 69, the alarm codes for **Alarm register 4.**

Alarm 1 codes

Group	Byte	Bit	Meaning	Events
Other Alarms	1 (LSB)	0	Clock invalid	6
		1	Replace battery	7
		2–7	*Not used*	
Critical Alarms	2	8	Program memory error	12
		9	RAM error	13
		10	NV memory error	14
		11	Measurement system error	16
		12	Watchdog error	15
		13	Fraud attempt	40, 43, 46, 49, 50, 244, 493
		14	*Not used*	
		15	*Not used*	
M-Bus Alarms	3	16	Comm. error M-Bus Ch1	100
		17	Comm. error M-Bus Ch2	110
		18	Comm. error M-Bus Ch3	120
		19	Comm. error M-Bus Ch4	130
		20	Fraud attempt M-Bus Ch1 *	103
		21	Fraud attempt M-Bus Ch2 *	113
		22	Fraud attempt M-Bus Ch3 *	123
		23	Fraud attempt M-Bus Ch4 *	133
	4 (MSB)	24	Permanent error M-Bus Ch1	106
		25	Permanent error M-Bus Ch2	116
		26	Permanent error M-Bus Ch3	126
		27	Permanent error M-Bus Ch4	136
		28	Battery low on M-Bus Ch1	102
		29	Battery low on M-Bus Ch2	112

Group	Byte	Bit	Meaning	Events
		30	Battery low on M-Bus Ch3	122
		31	Battery low on M-Bus Ch4	132

* the alarm is customer/device specific

Table 66: Alarms in Alarm Register 1

A Fraud attempt alarm is generated in the following cases:

- Terminal cover is removed,
- Strong DC field is detected,
- Authentication on communication fails more than N times (N is set in 0-0:196.98.2*255),
- Decryption on communication fails more than N times (N is set in 0-0:196.98.2*255),
- Replay attack on communication is detected,
- Communication module is removed (customer specific).

Alarm 2 codes

Bit	Alarm	Description	Events
0	Total Power Failure	Set when power-down on meter occurs.	1
1	Power Resume	Set when meter power returns.	2
2	Voltage Missing Phase L1	Set when voltage on at least L1 phase has fallen below the Umin threshold for longer than time delay.	82
3	Voltage Missing Phase L2	Set when voltage on at least L2 phase has fallen below the Umin threshold for longer than time delay.	83
4	Voltage Missing Phase L3	Set when voltage on at least L3 phase has fallen below the Umin threshold for longer than time delay.	84
5	Voltage Normal Phase L1	Set when the mains voltage on L1 is in normal limits again.	85
6	Voltage Normal Phase L2	Set when the mains voltage on L2 is in normal limits again.	86
7	Voltage Normal Phase L3	Set when the mains voltage on L3 is in normal limits again.	87
8	Missing Neutral	Set when the neutral connection from the supplier to the meter is interrupted.	89, 456
9	Phase Asymmetry	Set when large unbalance loads is present	90
10	Current Reversal *	Set when unexpected energy export is present (for energy import configured devices only).	91
11	Wrong Phase Sequence	Set when wrong mains connection or fraud (three-phase meters only).	88
12	Unexpected Consumption	Set when consumption is detected on at least one phase when dis-connector has been disconnected.	52, 457–459
13	Key Exchanged	Set when one or more global keys changed.	48
14	Bad Voltage Quality L1	Set when L1 voltage is not within ranges for defined period of time (see EN50160:2010).	92
15	Bad Voltage Quality L2	Set when L2 voltage is not within ranges for defined period of time (see EN50160:2010).	93
16	Bad Voltage Quality L3	Set when L3 voltage is not within ranges for defined period of time (see EN50160:2010).	94
17	External Alert	Set when signal is detected on meter's INPUT terminal.	20
18	Local Communication Attempt	Set when communication on any local port is detected (i.e., unauthor-ized access)	158
19	New M-Bus Device Installed Ch1	Set when new M-Bus device is registered on the Ch1 with new serial number.	105
20	New M-Bus Device Installed Ch2	Set when new M-Bus device is registered on the Ch2 with new serial number.	115
21	New M-Bus Device Installed Ch3	Set when new M-Bus device is registered on the Ch3 with new serial number.	125
22	New M-Bus Device Installed Ch4	Set when new M-Bus device is registered on the Ch4 with new serial number.	135

Bit	Alarm	Description	Events
23	M-Bus decryption failed Ch1	Set after unsuccessfully decryption of the received M-Bus frame on the Ch1.	—
24	M-Bus decryption failed Ch2	Set after unsuccessfully decryption of the received M-Bus frame on the Ch2.	—
25	M-Bus decryption failed Ch3	Set after unsuccessfully decryption of the received M-Bus frame on the Ch3.	—
26	M-Bus decryption failed Ch4	Set after unsuccessfully decryption of the received M-Bus frame on the Ch4.	—
27	M-Bus Valve Alarm Ch1 **	Set when ALARM STATUS bit is received from device on Ch1.	164
28	M-Bus Valve Alarm Ch2 **	Set when ALARM STATUS bit is received from device on Ch2.	174
29	M-Bus Valve Alarm Ch3 **	Set when ALARM STATUS bit is received from device on Ch3.	184
30	M-Bus Valve Alarm Ch4 **	Set when ALARM STATUS bit is received from device on Ch4.	194
31	Disconnect/Reconnect Failure	Set when disconnector failed to connect/disconnect.	68

* not supported yet
** the alarm is customer/device specific

Table 67: Alarms in Alarm Register 2

Alarm 3 codes

Bit	Alarm	Description	Events
0	Overvoltage start	Set when the voltage (L1, L2 or L3) exceeds the threshold settings value for longer than time threshold.	79, 80, 81
1	Overvoltage end	Set when recovering from the overvoltage and no other phase is above swell threshold longer than time threshold. (long event on one of the other phases).	85, 86, 87, 827, 828, 829
2	Undervoltage start	Set when the voltage (L1, L2 or L3) drops below the sag threshold settings value for longer than sag time threshold. If it drops below cut threshold for longer than cut time threshold, the alarm is also raised, but no event is emitted.	76, 77 78
3	Undervoltage end	Set when recovering from undervoltage and no other phase is below sag threshold longer than time threshold. (long event on one of the other phases - some other phase exceeds the time threshold).	85, 86, 87, 824 825, 826
4–5	*Not used*		
6	Fraud attempt end	Set when fraud attempt is resolved.	41, 43, 245,
7	Communication module removed	Set when communication module is removed.	495
8	Communication module inserted	Set when communication module is inserted.	496
9–10	*Not used*		
11	Credit top-up	Set when prepaid credit level is increased by charging.	480
12	Credit low	Set when the prepaid credit level achieves the set threshold value.	481, 482
13	Credit exhausted	Set when the prepaid credit runs out and the switch is opened.	241
14	Magnitude minimum or maximum exceeded	Set when the magnitude of any monitoring value (event in the last column) exceeded the predefined level for more than predefined percentage of time within one week.	454, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450,
15–16	*Not used*		
17	Energy theft	Set when one of the attempts for energy theft is detected by the meter.	52,
18	Register monitor threshold exceeded	Set when register monitor threshold exceeded.	70, 72, 74
19	Register monitor threshold OK	Set when monitoring value no longer exceeds any threshold value for supervision monitors L1, L2 and L3.	71, 73, 75
20	Limiter Threshold exceeded	Set when monitored value load exceeds the threshold setting value. Switching device disconnects when configurable time threshold is reached.	65, 211

Bit	Alarm	Description	Events
21	Limiter threshold ok exceeded	Set when monitored value drops below threshold on all limiters.	66, 212
22–23	*Not used*		
24	Neutral missing dis-connection	Breaker disconnection in case of neutral missing.	776
25	External Alert 2	Set when signal is detected on meter's INPUT terminal configured with MKE2 – Alarm input function.	469
26–31	*Not used*		

Table 68: Alarms in Alarm register 3

Alarm 4 codes

Bit	Alarm	Description	Events
0	Overvoltage start L1	Set when the voltage L1 exceeds the threshold settings value for longer than time threshold.	79
1	Overvoltage end L1	Set when recovering from the overvoltage L1	85, 827
2	Overvoltage start L2	Set when the voltage L2 exceeds the threshold settings value for longer than time threshold.	80
3	Overvoltage end L2	Set when recovering from the overvoltage L2	86, 828
4	Overvoltage start L3	Set when the voltage L3 exceeds the threshold settings value for longer than time threshold.	81
5	Overvoltage end L3	Set when recovering from the overvoltage L3	87, 829
6	Undervoltage start L1	Set when the voltage L1 drops below the sag threshold settings value for longer than sag time threshold. If it drops below cut threshold for longer than cut time threshold, the alarm is also raised, but no event is emitted.	76
7	Undervoltage end L1	Set when recovering from undervoltage L1	85, 824
8	Undervoltage start L2	Set when the voltage L2 drops below the sag threshold settings value for longer than sag time threshold. If it drops below cut threshold for longer than cut time threshold, the alarm is also raised, but no event is emitted.	77
9	Undervoltage end L2	Set when recovering from undervoltage L2	86, 825
10	Undervoltage start L3	Set when the voltage L3 drops below the sag threshold settings value for longer than sag time threshold. If it drops below cut threshold for longer than cut time threshold, the alarm is also raised, but no event is emitted.	78
11	Undervoltage end L3	Set when recovering from undervoltage L3	87, 826
12	Overvoltage continuation L1	Set every n sec, defined in 1-0:12.46.0 if L1 is above swell thr.	
13	Overvoltage continuation L2	Set every n sec, defined in 1-0:12.46.0 if L2 is above swell thr.	
14	Overvoltage continuation L3	Set every n sec, defined in 1-0:12.46.0 if L3 is above swell thr.	
15	Undervoltage continuation L1	Set every n sec, defined in 1-0:12.46.0 if L1 is below sag thr.	
16	Undervoltage continuation L2	Set every n sec, defined in 1-0:12.46.0 if L1 is below sag thr.	
17	Undervoltage continuation L3	Set every n sec, defined in 1-0:12.46.0 if L1 is below sag thr.	
18	Neutral missing start	Set when condition for neutral missing is satisfied	89
19	Neutral missing end	Set when condition for neutral missing is resolved	456
20–31	Not used		

Table 69: Alarms in Alarm register 4

9.11.2. Alarm register

Alarm register is a basic alarm object carrying information about active alarms. A selection of events that are to be treated as alarms can be made (alarm filter). If one of these selected events occurs, the corresponding flag in the alarm register is set and an alarm is then raised via the P3 port.

Typically, critical errors are selected as alarm triggers.

All fraud attempts are grouped, therefore, for alarming, it is not necessary to see the exact type of fraud, which caused the alarm. This can be found out by checking the error register or the appropriate event log.

The following alarm register objects are available:

- **Alarm register 1** (0-0.97.98.0*255)
- **Alarm register 2** (0-0.97.98.1*255)
- **Alarm register 3** (0-0.97.98.2*255)
- **Alarm register 4** (0-0.97.98.3*255)

The structure of the Alarm register is the same as for the Alarm filter.

NOTE

Specific bits of alarm registers may be automatically cleared – reset by the meter internally, if the "condition for alarm" has disappeared.

Alternatively, all bits i.e., all alarms may be externally reset via communication, by executing a SET service to the attribute value of the alarm register object. In the latter case, those bits, for which the "condition for alarm" still exists, will immediately be set to 1 again and an alarm will be issued. Clearing of critical alarms (bit 8 to 15 of Alarm Register 1 – see Table 67) is only possible from the HES, by invoking SET with all bits to 0 in the alarm register object. Otherwise, the command will be rejected, and an error will be returned.

The alarms in Alarm Register 3 may be cleared only from the HES.

The "External alert" alarm is not cleared automatically, but only manually.

9.11.3. Alarm filter

Alarm filter objects are used to mask out unwanted alarms. The structure of the filters is the same as of the corresponding alarm register objects. The following alarm filter objects are implemented:

- **Alarm filter 1** (0-0.97.98.10*255)
- **Alarm filter 2** (0-0.97.98.11*255)
- **Alarm filter 3** (0-0.97.98.12*255)
- **Alarm filter 4** (0-0.97.98.13*255)

To mask out an unwanted alarm, a corresponding bit in the alarm filter should be cleared (logical 0, un-checked). By default, all bits in the alarm filters are cleared, which means that no alarm is generated.

9.11.4. Alarm status

The **Alarm status** register shows which alarm has been triggered. There is a separate register for ON and OFF statuses:

- **Alarm on status 1**, 1-0:96.242.0*255
- **Alarm off status 1**, 1-0:96.243.0*255
- **Alarm on status 2,** 1-0:96.242.10*255
- **Alarm off status 2**, 1-0:96.243.10*255
- **Alarm on status 3**, 1-0:96:242.20*255
- **Alarm off status 3**, 1-0:96:243.20*255
- **Alarm on status 4**, 1-0:96:242.30*255
- **Alarm off status 4**, 1-0:96:243.30*255

Each bit represents a corresponding alarm. A recorded bit remains active until it is cleared by the client. These registers cannot be cleared by the device. The structure of the Alarm status is the same as for the Alarm register.

9.11.5. Alarm descriptor

Whenever a bit in the Alarm registers changes from 0 to 1, a corresponding **Alarm descriptor** bit is set to 1. The structure of the Alarm descriptor is the same as for the Alarm register. There are three Alarm descriptor objects:

- **Alarm descriptor 1**, 0-0:97.98.20*255,
- **Alarm descriptor 2**, 0-0:97.98.21*255,
- **Alarm descriptor 3**, 0-0:97.98.22*255,
- **Alarm descriptor 4**, 0-0:97.98.23*255.

Resetting the Alarm registers does not affect the Alarm descriptors; their bits are not reset. The set bits of the Alarm descriptors can only be reset explicitly, by the client (HES).

The Alarm descriptors are used by client (HES) to identify those past alarms that have already been cleared from the Alarm registers.

9.11.6. Alarm signalling

9.11.6.1. Alarm signalling via remote communication

For the purpose of triggering alarm reporting via remote communication (WAN), each set of alarm objects includes dedicated alarm monitor object. This means that there are three alarm monitor objects in the meter, one for each alarm set:

- **Alarm monitor 1**, 0-0:16.1.0*255,
- **Alarm monitor 2**, 0-0:16.1.1*255,
- **Alarm monitor 3**, 0-0:16.1.2*255,
- **Alarm monitor 4**, 0-0:16.1.3*255.

The alarm monitor objects should be configured for monitoring the corresponding alarm descriptor object.

Alarm monitors are bit monitors, meaning that they are able to execute actions according to a transition of a specific bit of the configured monitored value. The monitors are configured for monitoring the corresponding alarm descriptor (0-0:97.98.20*255, 0-0:97.98.21*255 and 0-0:97.98.22*255) objects. The actions up are configured for executing script of push script table, which refers to a "**Push setup – on alarm**" push method. When specific bit of alarm descriptor changes from 0 to 1, action up is triggered, causing the initiation of push process.

In order to re-enable the triggering of alarm that already occurred, the corresponding bit in alarm descriptor must be cleared from the HES. Additionally, for those alarms that are not reset by the meter, also alarm register must be cleared from the HES, so that bit transition from 0 to 1 is possible.

In order to prevent that execution of the script is aborted because of a power-down, comparison of the monitored value is done every time the meter is powered up. This will result in the triggering of the "Actions" again when one or more alarms in the alarm register are still active after a power down.

9.11.6.2. Alarm outputs signalling

From generated alarm information, the meter can also drive up to two alarm outputs (assuming the outputs are properly configured), which can be used as a signal for any external connected devices.

Alarm output state is derived from the two alarm registers. In addition, meter provides the ability to activate alarm output only for some active alarms. For this purpose, each alarm output has two configurable alarm output masks for the two alarm registers. Each alarm output is activated (output state goes to active) when at least one alarm bit in any of the alarm registers (0-0:97.98.0*255, 0-0:97.98.1*255 or 0-0:97.98.2*255) is set and when the same corresponding bit in any of the alarm output mask objects is set, see Figure 115.

Six alarm output mask objects are implemented in the meter:

- Alarm output 1 mask 1, 1-0:96.244.2*255
- Alarm output 2 mask 1, 1-0:96.244.3*255
- Alarm output 1 mask 2, 1-0:96.244.12*255

- Alarm output 2 mask 2, 1-0:96.244.13*255
- Alarm output 1 mask 3, 1-0:96.244.22*255
- Alarm output 2 mask 3, 1-0:96.244.23*255
- Alarm output 1 mask 4, 1-0:96.244.32*255
- Alarm output 2 mask 4, 1-0:96.244.33*255

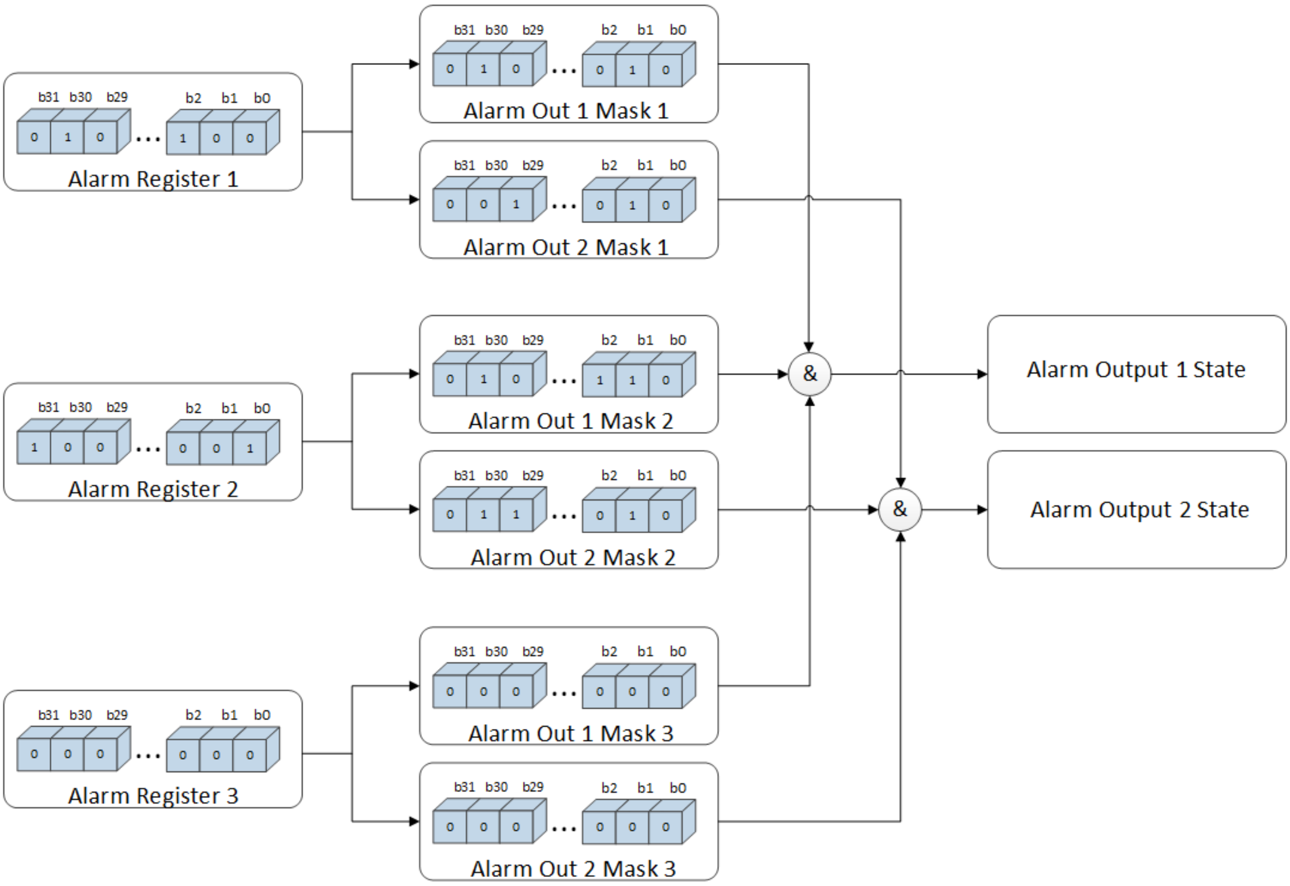


Figure 115: Alarm outputs generation

NOTE

Both alarm outputs can have the same functionality if all alarm mask objects have the same configuration.

9.12. Activity calendar and TOU registration

Activity calendar is time of use (TOU) object for tariff control. It allows modelling and handling of various tariff structures in the meter.

A Tariff program is implemented with set of objects that are used to configure different seasons or weekly and daily programs, to define which tariff should be active. Different actions can be performed with tariff switching, like registering energy values in different tariffs. The Tariff-program-illustration concept can be seen in Figure 116.

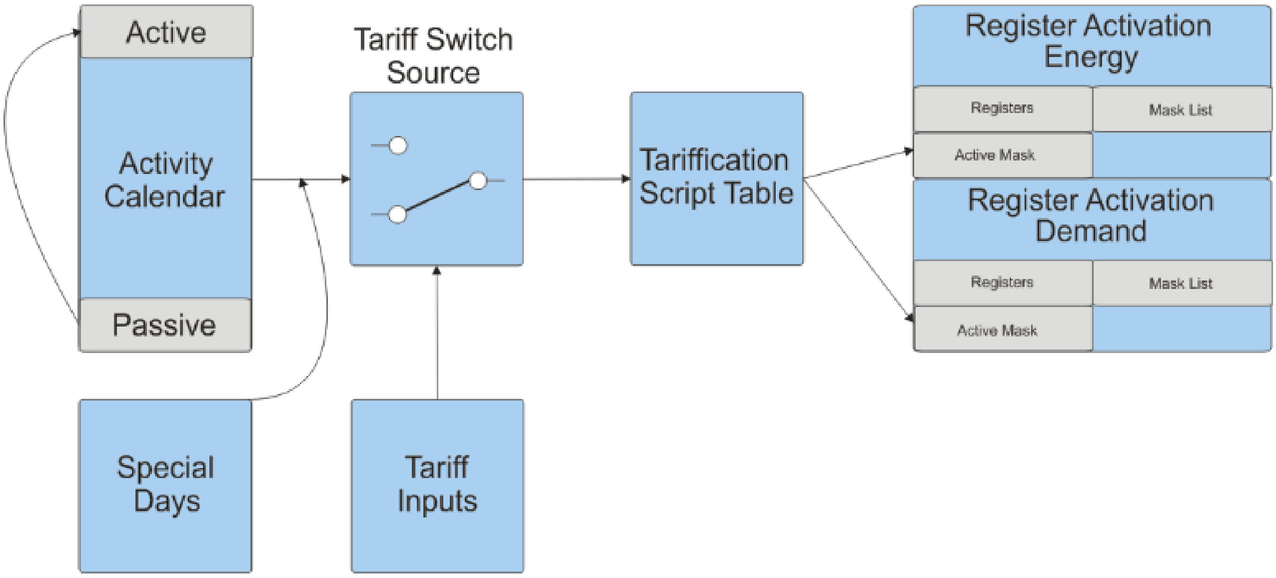


Figure 116: Graphical tariff program

TOU capabilities (object 0-0:13.0.0*255) are the following:

- up to 8 tariffs,
- up to 8 masks for configuring different combinations of tariff registers,
- up to 12 seasons tariff programs,
- up to 12 week tariff programs,
- up to 12 day tariff programs,
- up to 16 actions per day tariff program,
- up to 105 special day date definitions.

Tariff program configures different seasons or weekly and daily programs to define when a certain tariff should be active. Different actions can be performed with tariff switching like registering energy values in different tariffs.

Activity calendar is time of use (TOU) object for tariff control. It allows modelling and handling of various tariff structures in the meter. It is used to store energy and demand according to tariff rate schedule. Scheduled actions are defined inside the meter. They follow the classical way of calendar-based schedules by defining seasons, weeks, and days. After a power failure, only the last action missed from Activity calendar is executed (delayed). This is to ensure proper tariff after power up.

In the **Activity Calendar** (0-0:13.0.0*255), Active and Passive tariff programs are set.

The meter uses the tariffication schema, which is set with the Active tariff program. The Passive tariff program is activated by overwriting the Active tariff program. This can be done with method Activate passive calendar using time schedule. Activation of Passive schema is recorded in the Standard Event log (event 9-TOU activated).

NOTE
First action start time in a day must be set to 0:00:00.

NOTE
When multiple actions exist for the same time, only the first action is executed.

9.12.1. Activity calendar disconnector

Activity calendar – Disconnector is time of use used to drive disconnector. This meter function is used when the integrated meter disconnector is used for the specific switching actions. There is supported configuration of switching table with set of objects that are used to configure different seasons, or weekly and daily programs, to define when the disconnector should be activated.

TOU capabilities (object 0-0:13.0.1*255) of this specific activity calendar is the following:

- up to 4 seasons tariff programs,
- up to 4 week tariff programs,
- up to 4 day tariff programs,
- up to 8 actions per day tariff program,
- up to 48 special day date definitions.

9.13. Grid monitoring

Power quality issues and other grid disturbances cause major financial losses for companies and power utilities, as well as equipment failure. To improve the quality of the grid, power utilities need accurate and reliable information on the grid to be able to assess grid performance, monitor trends and conditions, and develop suitable mitigation techniques to improve the grid quality.

To collect the required information, voltages, currents, powers, supply frequency and THD signals, measured by the meter, are constantly monitored, and processed. Monitoring results are then stored in a dedicated event logs as Grid monitor event log and Power quality event log, and also reported to the HES to inform the network operator about detected signal deviation. Information about detected events can be accessed from the meter through several COSEM objects remotely, which are presented in the following chapters.

For more information on Grid monitor event log, see chapter *9.9.2.13 Grid monitor event log*, on Power quality event log, see chapter *9.9.2.5. Power quality log*.

NOTE
In 3-phase 3-wire connection, the grid monitoring functions use line-to-line voltage values.

9.13.1. Classification of signals

Variation speed

The focus of the monitoring depends on what we want to analyse. In grid monitoring, a utility may be interested in specific signal variations, such as individual voltage swells, which last for a short period of time. Or, the utility may want to analyse long-term variations, e.g., the fluctuation of the supply voltage in the complete distribution network, which lasts several hours or even days. Therefore, the processing of grid variations depends on how fast they occur. Based on this, grid variations have been divided into two groups:

- fast variations
- slow variations

Signal dynamics

In addition to variation length, the monitored signal disturbances vary in signal dynamics as well. Some variations, such as voltage or current events have high dynamic, while other (e.g., supply frequency) have low dynamic.

In high dynamic signals, variations occur within 20–40 milliseconds, in low dynamic signals within 0.5–1 second. In order to capture all variations, high dynamic signals are sampled at a higher rate than low dynamic signals.

Table 70 shows how different monitored signals vary in dynamics and length.

Signal dynamics	Monitored signal	Variation speed	
		Fast variations	**Slow variations**
High	**Voltage**	Voltage events	Magnitude of supply voltage
	Current	Current events *	Magnitude of current *
	Power	Power events (active, reactive) *	Magnitude of power (active, reactive) *
Low	**Supply frequency**	Frequency events *	Magnitude of supply frequency
	Total harmonics distortion (THD) (voltage and current)	THD events *	Magnitude of THD *

* option

Table 70: Classification of signals

NOTE

Not all grid monitoring functionalities are included in the meter. Functionalities marked as "option" are included in the meter only by the customer's request.

9.13.2. Fast variations

Fast signal variations are individual disturbances in the grid that last up to a few minutes. For the purpose of grid monitoring, fast signal variations are referred to as events:

- voltage events (sag, swell, cut, power failure)
- current events (overcurrent)
- power events (overpower)
- supply frequency events (underfrequency, overfrequency)
- THD events (overvoltage THD, overcurrent THD).

9.13.2.1. Voltage events

Voltage events are deviations in voltage from normal values. For each voltage event, the following parameters are set:

- voltage threshold
- time threshold

Voltage thresholds are needed to detect start and end of a voltage deviation and to determine its type (overvoltage or undervoltage) and severity.

Time thresholds are used to define the length of voltage variations and severity, and also which actions need to be executed at the end of a voltage event.

The voltage thresholds are the following:

- Swell threshold
- Sag threshold
- Cut threshold

The time thresholds related to voltage events are the following:

- Ignore time threshold
- Time threshold for voltage swell
- Time threshold for voltage sag
- Time threshold for voltage cut

Voltage thresholds and time thresholds are explained in Figure 117. Please note the time thresholds do not need to follow the order shown.

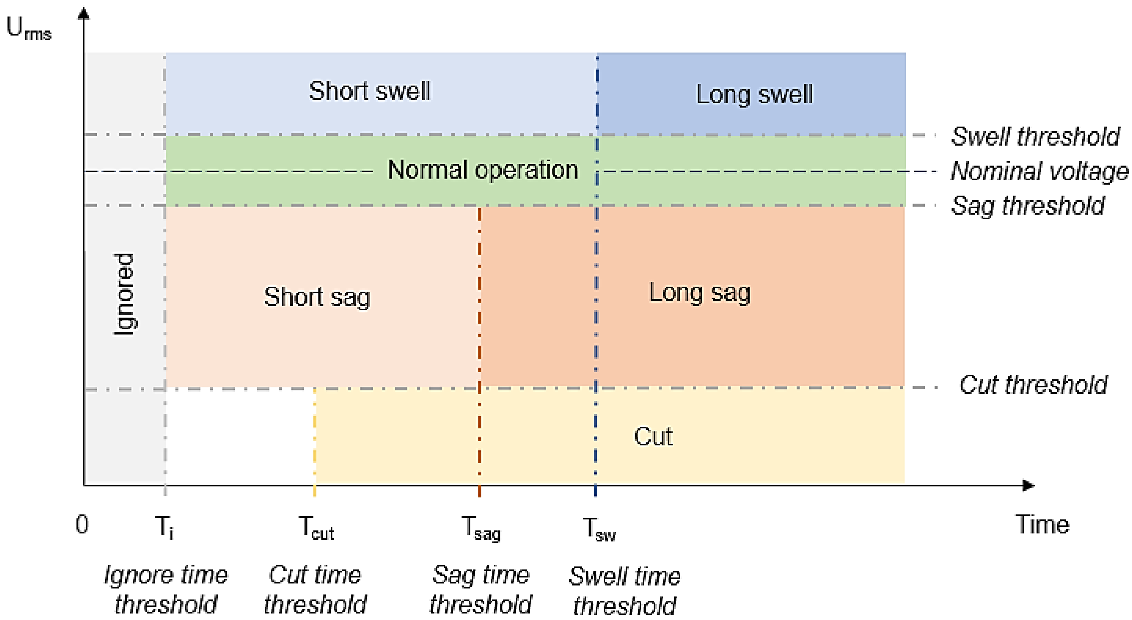


Figure 117: Voltage thresholds

Ignore time threshold voltage

This object defines the minimum duration of a voltage increase to be regarded as a significant deviation. Any voltage increase shorter than this threshold is regarded as insignificant and ignored. This value is configurable through the object **Ignore time threshold voltage** (0-0:196.21.0*255).

9.13.2.1.1. Voltage sag

A Voltage sag is a phase voltage drop in the interval between the *Threshold for voltage sag* and the *Threshold for voltage cut*. The objects related to voltage sags are described in the following subsections.

Voltage sag events are counted per-phase.

Threshold for voltage sag

The value set in the object **Threshold for voltage sag** (1-0:12.31.0*255) is the upper voltage limit for the voltage sag.

Time threshold for voltage sag

The value set in the object **Time threshold for voltage sag** (1-0:12.43.0*255) represents the limit between short and long voltage sag event.

Counter for voltage sag (per phase)

The number of voltage sags in phases L1, L2 and L3 is counted; each has its own counter:

- **Number of voltage sags in phase L1** (1-0:32.32.0*255),
- **Number of voltage sags in phase L2** (1-0:52.32.0*255),
- **Number of voltage sags in phase L3** (1-0:72.32.0*255).

Magnitude for voltage sag (per phase)

The magnitude of a voltage sag is the maximum signal value measured during a voltage sag event.

Magnitudes for voltage sag per phase can be accessed through the following objects:

- **Magnitude of last voltage sag in phase L1** (1-0:32.34.0*255),

- **Magnitude of last voltage sag in phase L2** (1-0:52.34.0*255),
- **Magnitude of last voltage sag in phase L3** (1-0:72.34.0*255).

Duration for voltage sag (per phase)

The duration of a voltage sag is counted as the difference between the *end* and *start* time of the voltage sag event. Durations for voltage sag per phase can be accessed through the following objects:

- **Duration of last voltage sag in phase L1** (1-0:32.33.0*255),
- **Duration of last voltage sag in phase L2** (1-0:52.33.0*255),
- **Duration of last voltage sag in phase L3** (1-0:72.33.0*255).

9.13.2.1.2. Voltage swell

A Voltage swell is a phase voltage increase above the *Threshold for voltage swell*. The objects related to the voltage swell are described in the following subsections.

Voltage swell events are counted per-phase.

Threshold for voltage swell

The value set in the object **Threshold for voltage swell** (1-0:12.35.0*255) is the lower voltage limit for the voltage swell.

Time threshold for voltage swell

The value set in the object **Time threshold for voltage swell** (1-0:12.44.0*255) represents the limit between short and long voltage swell events.

Counter for voltage swell (per phase)

The number of voltage swells in phases L1, L2 and L3 is counted; each has its own counter:

- **Number of voltage swells in phase L1** (1-0:32.36.0*255),
- **Number of voltage swells in phase L2** (1-0:52.36.0*255),
- **Number of voltage swells in phase L3** (1-0:72.36.0*255).

Magnitude for voltage swell (per phase)

The magnitude of a voltage swell is the maximum signal value measured during a voltage swell event. Magnitudes for voltage swell per phase can be accessed through the following objects:

- **Magnitude of last voltage swell in phase L1** (1-0:32.38.0*255),
- **Magnitude of last voltage swell in phase L2** (1-0:52.38.0*255),
- **Magnitude of last voltage swell in phase L3** (1-0:72.38.0*255).

Duration for voltage swell (per phase)

The duration of a voltage swell is counted as the difference between the *end* and *start* time of the voltage swell event. Durations for voltage swell per phase can be accessed through the following objects:

- **Duration of last voltage swell in phase L1** (1-0:32.37.0*255),
- **Duration of last voltage swell in phase L2** (1-0:52.37.0*255),
- **Duration of last voltage swell in phase L3** (1-0:72.37.0*255).

9.13.2.1.3. Voltage cut

A Voltage cut is a phase voltage drop below the *Threshold for missing voltage (voltage cut)*. The objects related to the voltage cut are described in the following subsections.

The voltage cut is recorded as a per-phase *Missing voltage* event, when phase voltage drops below the *Threshold for missing voltage (voltage cut)* for more than defined in *Time threshold for voltage cut*.

Threshold for voltage cut

The value set in the object **Threshold for missing voltage (voltage cut)** (1-0:12.39.0*255) is the upper voltage limit for the voltage cut.

Time threshold for voltage cut

The value set in the object **Time threshold for voltage cut** (1-0:12.45.0*255) represents the limit between short and long voltage cut event.

9.13.2.2. Power failure

Power failure is detected when phase voltage drop below the **Threshold for power failure on all phases** (1-0:12.128.0*255) for longer than **Ignore time threshold voltage** (0-0:196.21.0*255). The objects related to the power failure are described as follows.

Threshold for power failure on all phases

The value set in the object **Threshold for power failure on all phases** (1-0:12.128.0*255) is the upper voltage limit for the power fail.

Time threshold for long power failure

The value set in the object **Time threshold for long power failure** (0-0:96.7.20*255) represents the limit between short and long power failure events.

Meter registers the following aspects of power failure events:

- *Power failures* are counted in the following objects (x = 1,2,3):
  - Number of power failures, in all three phases (0-0:96.7.0*255);
  - Number of power failures, in any phase (0-0:96.7.21*255).
- *Short power failures* are registered when the voltage level reaches a value below 10% of the nominal voltage level (230V) for a period longer than configurable Ignore time threshold but shorter than **Time threshold for long power failure** (0-0:96.7.20*255).
- *Long power failures* are registered when the power fail time reaches the threshold defined (in seconds) in the object **Time threshold for long power failure** (0-0:96.7.20*255).
  - Long power *failures* are counted in:
  - Number of long power failures, in all three phases (0-0:96.7.5*255);
  - Number of long power failures, in any phase (0-0:96.7.9*255).
- Durations of long power failures are recorded in:
  - Duration of last long power failure, in all three phases (0-0:96.7.15*255);
  - Duration of last long power failure, in any phase (0-0:96.7.19*255).

The definitions related to the power fail thresholds are shown in Figure 118.

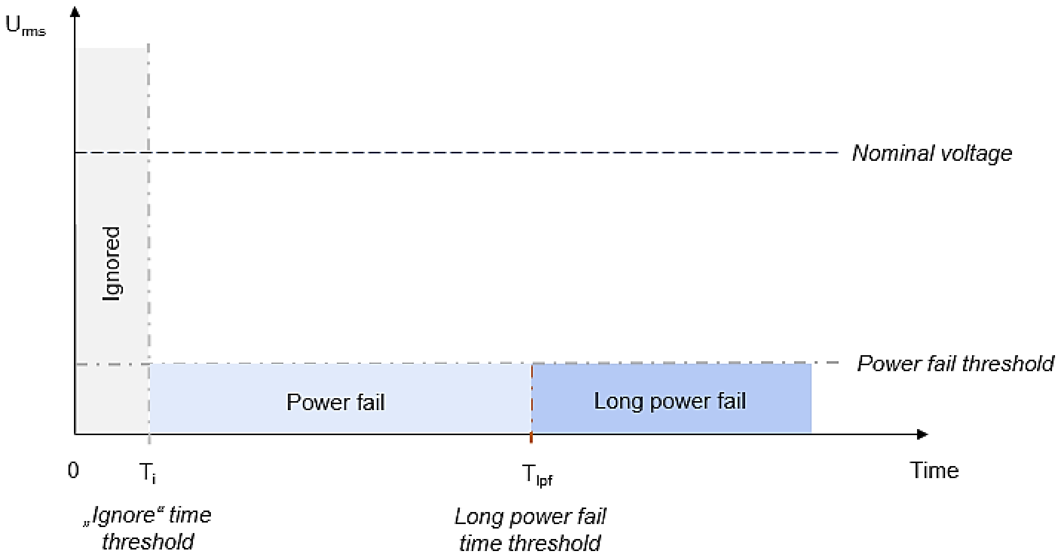


Figure 118: Definitions of the power fail thresholds

9.13.2.3. Current and power events (optional)

Current and power events are fast deviations of the current or power signal above a set threshold. When this occurs, a current or power event is recorded. For current and power events, no lower limit is applied.

Current and power over deviations are described by three characteristic parameters:

- The timestamp of the event set
- The maximum value, observed during the event
- The duration of the event

9.13.2.3.1. Overcurrent

An Overcurrent is a current increase over a certain threshold. Overcurrent events are monitored per phase.

Related events

Events related to the monitoring of Overcurrent (Table 71) are logged in the Grid monitor event log.

Event name	Event code	Event description
Overcurrent Lx	388–390	Indicates that the current in a certain phase has increased above the current overlimit threshold. Gives information on the start time of the overcurrent event.
Current Lx normal	391–393	Indicates that the current in a certain phase has dropped below the current overlimit threshold. Gives information on the end time of the overcurrent event.

Table 71: Overcurrent – events

Related configurable objects

To configure the thresholds for Overcurrent, use the objects listed in Table 72.

Object description	Logical name
Current limit hysteresis	0-0:196.20.1*255
Current ignore time threshold	0-0:196.21.1*255
Current overlimit threshold	1-0:11.35.0*255
Current overlimit time threshold	1-0:11.44.0*255

Table 72: Overcurrent – configuration parameters

Current limit hysteresis

This object defines the hysteresis, which is used to avoid registration of multiple events if the measured value fluctuates around the threshold level.

Current ignore time threshold

This object defines the minimum duration of a current increase to be regarded as a significant deviation. Any current increase shorter than this threshold is regarded as insignificant and ignored.

Current overlimit threshold

This object defines the limit, over which a current increase is regarded as a deviation. Any current value under this threshold is regarded as normal.

Current overlimit time threshold

This object defines the limit between short and long overcurrent events.

Related readable objects

For every significant current increase, the corresponding duration and magnitude are updated. If the event lasts longer than the predefined time threshold, the corresponding counter is updated as well. These values are accessible through the objects listed in Table 73. The values of these objects remain valid until the next overcurrent.

Object description	Logical name
Current Lx overlimit counter	1-0:a.36.0*255
Current Lx overlimit duration	1-0:a.37.0*255
Current Lx overlimit magnitude	1-0:a.38.0*255

Table 73: Overcurrent – counter, duration and magnitude objects

In Table 73, the “a” letter in the logical names represents the phase index. To get the full logical name, replace the “a” letter with one of the following numbers:

- a = 31 for L1
- a = 51 for L2
- a = 71 for L3

How and when are results reported

An Overcurrent event occurs when the current in a certain phase exceeds the *Current overlimit threshold* for a time period longer than the *Current ignore time threshold*. When this occurs, an *Overcurrent Lx* event is logged in the Grid monitor event log. When the current value returns to normal (i.e., the values drop below the *Current overlimit threshold*), a *Current Lx normal* event is recorded in the Grid monitor event log.

9.13.2.3.2. Overpower

Overpower is a power increase over a certain value, which lasts longer than a certain period. Overpower events are monitored per phase, separately for active and reactive power.

Related events

Events related to the monitoring of overpower (Table 74) are logged in the Grid monitor event log.

Event name	Event code	Event description
Overpower active plus Lx	394–396	Indicates that the active power plus in a certain phase has increased above the Active power plus overlimit threshold. Gives information on the start time of the overpower event.

Event name	Event code	Event description
Overpower active minus Lx	397–399	Indicates that the active power minus in a certain phase has increased above the Active power minus overlimit threshold. Gives information on the start time of the overpower event.
Power active plus Lx normal	400–402	Indicates that the active power plus in a certain phase has dropped below the Active power plus overlimit threshold. Gives information on the end time of the overpower event.
Power active minus Lx normal	403–405	Indicates that the active power minus in a certain phase has dropped below the Active power minus overlimit threshold. Gives information on the end time of the overpower event.
Overpower reactive plus Lx	406–408	Indicates that the reactive power plus in a certain phase has increased above the Reactive power plus overlimit threshold. Gives information on the start time of the overpower event.
Overpower reactive minus Lx	409–411	Indicates that the reactive power minus in a certain phase has increased above the Reactive power minus overlimit threshold. Gives information on the start time of the overpower event.
Power reactive plus Lx normal	412–414	Indicates that the reactive power plus in a certain phase has dropped below the Reactive power plus overlimit threshold. Gives information on the end time of the overpower event.
Power reactive minus Lx normal	415–417	Indicates that the reactive power minus in a certain phase has dropped below the Reactive power minus overlimit threshold. Gives information on the end time of the overpower event.

Table 74: Overpower – events

Related configurable objects

To configure the thresholds for overpower, use objects listed in Table 75.

Object description	Logical name
Active power plus/minus limit hysteresis	0-0:196.20.2 *255
Reactive power plus/minus limit hysteresis	0-0:196.20.3 *255
Power Ignore time threshold	0-0:196.21.2*255
Active/Reactive power plus/minus overlimit threshold	1-0:a.35.0*255
Active/Reactive power plus/minus overlimit time threshold	1-0:a.44.0*255

Table 75: Overpower – configuration parameters

In Table 75, the “a” letter in the logical names represents the power type. To get the full logical name, replace the “a” letter with one of the following numbers:

- a = 1 – active power plus; unit = W; default = 4000
- a = 2 – active power minus; unit = W; default = 4000
- a = 3 – reactive power plus; unit = VAr; default = 2000
- a = 4 – reactive power minus; unit = VAr; default = 2000

Active/Reactive power plus/minus limit hysteresis

This object defines the hysteresis, which is used to avoid registration of multiple events if the measured values fluctuate around the threshold level.

Power Ignore time threshold

This object defines the minimum duration of an overpower event to be regarded as significant and logged. Any overpower event shorter than this threshold, is regarded as insignificant and ignored.

Active/Reactive power plus/minus overlimit threshold

These objects define the limit, over which a power increase is regarded as significant and logged. Any power increase under this threshold is regarded as insignificant and ignored.

Active/Reactive power plus/minus overlimit time threshold
These objects define how to classify overpower events with regard to their duration. If the duration (in seconds) of the overpower event is shorter than the value defined in this object, a short overpower is logged, if longer, a long overpower is logged.

Related readable objects

For every significant power deviation, the corresponding duration and magnitude are updated. If the event lasts longer than the predefined time threshold, the corresponding counter is updated as well. These values are accessible through objects listed in Table 76. The values of these objects remain valid until the next overpower.

Object description	Logical name
Active/Reactive power plus/minus Lx overlimit counter	1-0:b.36.0*255
Active/Reactive power plus/minus Lx overlimit duration	1-0:b.37.0*255
Active/Reactive power plus/minus Lx overlimit magnitude	1-0:b.38.0*255

Table 76: Overpower – counter, duration and magnitude objects

In Table 76, the “b” letter in the logical names represents the power type and phase index. To get the full logical name, replace the “b” letter with one of the following numbers:

- b = 21 – active power plus L1; unit = W
- b = 22 – active power minus L1; unit = W
- b = 23 – reactive power plus L1; unit = VAr
- b = 24 – reactive power minus L1; unit = VAr
- b = 41 – active power plus L2; unit = W
- b = 42 – active power minus L2; unit = W
- b = 43 – reactive power plus L2; unit = VAr
- b = 44 – reactive power minus L2; unit = VAr
- b = 61 – active power plus L3; unit = W
- b = 62 – active power minus L3; unit = W
- b = 63 – reactive power plus L3; unit = VAr
- b = 64 – reactive power minus L3; unit = VAr

How and when are results reported

An Overpower event occurs when the power in a certain phase exceeds the *Active/Reactive power plus/minus overlimit threshold* for a time period longer than the *Power ignore time threshold*. When this occurs, an *Overpower active/reactive plus/minus Lx* event is logged in the Grid monitor event log. When the power value returns to normal (i.e., the values drop below the *Active/Reactive power plus/minus overlimit threshold*), a *Power active/reactive plus/minus Lx normal* event is recorded in the Grid monitor event log.

9.13.2.4. Supply frequency events (optional)

Supply frequency events are deviations in supply frequency, either above (overfrequency) or below (underfrequency) the nominal frequency. The supply frequency is monitored for all phases together.

Related events

Events related to the monitoring of the supply frequency (Table 77) are logged in the Grid monitor event log.

Event name	Event code	Event description
Overfrequency	418	Indicates that the frequency has increased above the Frequency overlimit threshold. Gives information on the start time of the overfrequency event.
Underfrequency	419	Indicates that the frequency has dropped below the Frequency underlimit threshold. Gives information on the start time of the underfrequency event.

Event name	Event code	Event description
Frequency normal	420	Indicates that the frequency has returned to normal values. Gives information on the end time of the overfrequency/underfrequency event.

Table 77: Supply frequency – events

Related configurable objects

To configure the thresholds for supply frequency, use objects listed in Table 78

Object description	Logical name
Frequency limit hysteresis	0-0:196.20.0 *255
Ignore time threshold frequency	0-0:196.21.3*255
Frequency underlimit threshold	1-0:14.31.0*255
Frequency overlimit threshold	1-0:14.35.0*255
Frequency underlimit time threshold	1-0:14.43.0*255
Frequency overlimit time threshold	1-0:14.44.0*255

Table 78: Supply frequency – configuration parameters

Frequency limit hysteresis

This object defines the hysteresis, which is used to avoid registration of multiple events if the measured values fluctuate around the threshold level.

Ignore time threshold frequency

This object defines the minimum duration of a frequency deviation to be regarded as significant and logged. Any frequency event shorter than this time threshold, is regarded as insignificant and ignored.

Frequency underlimit threshold

This object defines the limit, below which a frequency drop is regarded as a significant deviation and logged. Any frequency drop above this threshold is regarded as insignificant and ignored.

Frequency overlimit threshold

This object defines the limit, above which a frequency increase is regarded as a significant deviation and logged. Any frequency increase below this threshold is regarded as insignificant and ignored.

Frequency underlimit time threshold

This object defines how to classify underfrequencies in relation to their duration. Any underfrequency longer than this time threshold is logged as a long underfrequency, while underfrequencies shorter than this time threshold are logged as short underfrequencies.

Frequency overlimit time threshold

This object defines how to classify overfrequencies in relation to their duration. Any overfrequency longer than this time threshold is logged as a long overfrequency, while overfrequencies shorter than this time threshold are logged as short overfrequencies.

How and when are results reported

An overfrequency event occurs when the supply frequency exceeds the *Frequency overlimit threshold* for a time period longer than the *Ignore time threshold frequency*. When this occurs, an *Overfrequency* event is logged in the Grid monitor event log.

An underfrequency event occurs when the supply frequency drops below the *Frequency underlimit threshold* for a time period longer than the *Ignore time threshold frequency*. When this occurs, an *Underfrequency* event is logged in the Grid monitor event log.

When the supply frequency value returns to normal, a *Frequency normal* event is recorded in the Grid monitor event log.

9.13.2.5. Total harmonics distortion events (option)

The total harmonic distortion (THD) is a measurement of the harmonic distortion present in a signal. THD tells how much of the distortion of a voltage or current is due to harmonics in the signal.

Typically, THD values should be as low as possible. Over-THD events are fast variations of THD values above a certain threshold. THD values are monitored per phase, separately for voltage and current.

Related events

Events related to the monitoring of the voltage THD and current THD (Table 79) are logged in the Grid monitor event log.

Event name	Event code	Event description
Overvoltage THD Lx	421–423	Indicates that the voltage THD in a certain phase has increased above the THD voltage overlimit threshold. Gives information on the start time of the THD event.
Voltage THD Lx normal	424–426	Indicates that the voltage THD in a certain phase has dropped below the THD voltage overlimit threshold. Gives information on the end time of the THD event.
Overcurrent THD Lx	427–429	Indicates that the current THD in a certain phase has increased above the THD current overlimit threshold. Gives information on the start time of the THD event.
Current THD Lx normal	430–432	Indicates that the current THD in a certain phase has dropped below the THD current overlimit threshold. Gives information on the end time of the THD event.

Table 79: Voltage THD – events

Related configurable objects

To configure the thresholds for voltage and current THD deviations, use objects listed in Table 80.

Object description	Logical name
THD Ignore time threshold	0-0:196.21.4*255
THD voltage limit hysteresis	0-0:196.20.4*255
THD current limit hysteresis	0-0:196.20.5*255
THD voltage overlimit threshold	1-0:12.35.124*255
THD current overlimit threshold	1-0:11.35.124*255
THD voltage overlimit time threshold	1-0:12.44.124*255
THD current overlimit time threshold	1-0:11.44.124*255

Table 80: THD – configuration parameters

THD Ignore time threshold

This object defines the minimum duration of a THD deviation to be regarded as significant and logged. Any THD deviation shorter than this time threshold, is regarded as insignificant and ignored.

THD voltage/current limit hysteresis

This object defines the hysteresis, which is used to avoid registration of multiple events if the measured values fluctuate around the threshold level.

THD voltage/current overlimit threshold

These objects define the limits, above which a voltage/current THD increase is regarded as a significant deviation and logged. Any voltage/current THD increase below these thresholds is regarded as insignificant and ignored.

THD voltage/current overlimit time threshold

These objects define how to classify voltage/current over-THD deviation in relation to their duration. Any voltage/current over-THD deviation longer than these time thresholds is considered as a long over-THD deviation, while over-THD deviations shorter than these time thresholds are considered as short over-THD deviations.

Related readable objects

In case of the long over-THD deviation, the corresponding duration and magnitude are updated, and its counter is incremented. These values are accessible through objects listed in Table 81. The values of these objects remain valid until the next over-THD event.

Object description	Logical name
THD voltage/current Lx overlimit counter	1-0:a.36.124*255
THD voltage/current Lx overlimit duration	1-0:a.37.124*255
THD voltage/current Lx overlimit magnitude	1-0:a.38.124*255

Table 81: THD – readable objects

In Table 81, the “a” letter in the logical names represents the type of the measured quantity and the phase index. To get the full logical name, replace the “a” letter with one of the following numbers:

- a = 32 – voltage L1
- a = 31 – current L1
- a = 52 – voltage L2
- a = 51 – current L2
- a = 72 – voltage L3
- a = 71 – current L3

How and when are results reported

An over-THD event occurs when the THD values exceed the *THD overlimit threshold* for a time period longer than the *THD Ignore time threshold*. When this occurs, an *Overvoltage or overcurrent THD* event is logged in the Grid monitor event log.

When the THD values return to normal, a *Voltage/Current THD normal* event is recorded in the Grid monitor event log.

9.13.3. Slow variations

The aim of monitoring various magnitudes is to detect sustained poor grid quality. In order to do this, the evaluation period needs to be of an appropriate length, and the values must be averaged and/or aggregated to filter out fast variations.

The meter monitors the following slow variations:

- the Magnitude of supply voltage
- the Magnitude of supply frequency
- the Magnitude of current
- the Magnitude of power (active, reactive)
- the Magnitude of THD (voltage and current)

9.13.3.1. Magnitude of supply voltage

The meter evaluates slow deviations in RMS voltage above or below a standard threshold on a weekly basis. The values are first averaged and then aggregated to 10-minute intervals. The values are considered normal if they remain within the set range for more than a certain percentage of time within one week. The Magnitude of supply voltage is monitored for each phase separately.

Related events

Events related to the monitoring of the Magnitude of supply voltage (Table 82) are logged in the *Power quality log* and *Grid monitor event log*.

Event name	Event code	Event description
Bad voltage quality Lx	92 - 94	Indicates that the voltage of Lx does NOT fulfill the following condition: during each period of one week 95 % of the 10 min mean r.m.s, values of the supply voltage are within the range of Un+/- 10 % and all 10 mín mean r.m.s. values of the supply voltage shall be within the range of Un + 10%/- 15%.

Table 82: Magnitude of supply voltage – events

Related readable objects

Objects listed in Table 83 store data on the Magnitude of supply voltage monitoring.

Object description	Logical name
Percentage of bad magnitude of supply voltage L1	0-0:128.8.15*255
Percentage of bad magnitude of supply voltage L2	0-0:128.8.25*255
Percentage of bad magnitude of supply voltage L3	0-0:128.8.35*255
Daily minimum voltage L1	1-0:32.13.0*255
Daily minimum voltage L2	1-0:52.13.0*255
Daily minimum voltage L3	1-0:72.13.0*255
Daily maximum voltage L1	1-0:32.16.0*255
Daily maximum voltage L2	1-0:52.16.0*255
Daily maximum voltage L3	1-0:72.16.0*255

Table 83: Magnitude of supply voltage – readable objects

The per-phase objects *Percentage of bad magnitude of supply voltage* give information on the percentage of bad aggregated voltage values in a certain phase within the last complete week.

The objects *Daily maximum voltage* and *Daily minimum voltage* store per-phase daily peeks and lows of aggregated voltage values. The values are logged in Billing profile 2 and updated at a daily basis at midnight.

How and when are results reported

Normal values of the Magnitude of supply voltage are allowed to vary in the range between 90% and 110% of the nominal voltage.

The quality of the supply voltage is declared inadequate if one of the following conditions is NOT met:

- During the period of one week, at least 95% of the aggregated voltage values are within the range 90–110% of the nominal voltage.
- All aggregated voltage values are within the range 85–110% of the nominal voltage.

When one of the above conditions is not fulfilled, a per-phase *Bad voltage quality* event is logged in the *Power quality log* and *Grid monitor event log,* and a per-phase *Bad voltage quality* alarm is raised.

9.13.3.2. Magnitude of supply frequency

The monitoring of the Magnitude of supply frequency meter evaluates slow deviations in the supply frequency above or below a standard threshold. Since the signal frequency is relatively slow, the values are averaged over 10-second intervals. These values are then evaluated at the end of each week (24:00 Sunday). The values are considered normal if more than a certain percentage of values remains within the set range within one week. The Magnitude of supply frequency is monitored for all phases together.

Related events

Event related to the monitoring of the Magnitude of supply frequency (Table 84) is logged in the *Grid monitor event log*.

Event name	Event code	Event description
Magnitude frequency exceeded	454	Indicates that the magnitude of the actual frequency exceeded the predefined level for more than predefined percentage of time within one week.

Table 84: Magnitude of supply frequency – event

Related configurable objects

To configure the thresholds for *Bad limit of the supply frequency magnitude*, use objects listed in Table 85

Object description	Logical name
Bad overlimit of the supply frequency magnitude	0-0:128.14.90*255
Bad underlimit of the supply frequency magnitude	0-0:128.14.91*255

Table 85: Magnitude of frequency – configuration parameters

Objects *Bad overlimit of the supply frequency magnitude* and *Bad underlimit of the supply frequency magnitude* define the high and low frequency thresholds.

Related readable objects

Objects listed in Table 86 store data on the Magnitude of supply frequency monitoring.

Object description	Logical name
Percentage of bad magnitude of supply frequency	0-0:128.14.15*255
Daily minimum frequency	1-0:14.13.0*255
Daily maximum frequency	1-0:14.16.0*255

Table 86: Magnitude of supply frequency – readable objects

The object *Percentage of bad magnitude of supply frequency* gives information on the percentage of bad average frequency values within the last complete week.

The objects *Daily maximum frequency* and *Daily minimum frequency* store daily peeks and lows of average frequency values. The values are logged in *Billing profile 2* and updated at a daily basis at midnight.

How and when are results reported

Normal values of the *Magnitude of supply frequency* are allowed to vary in the range between 99% and 101% of the nominal frequency.

The quality of the supply frequency is declared inadequate if one of the following conditions is NOT met:

- During the period of one week, at least 99.5% of the averaged frequency values are within the range 99–101% of the nominal frequency.
- All averaged frequency values are within the range 94–104% of the nominal frequency.

When one of the conditions above is not fulfilled, a *Magnitude frequency exceeded* event is logged in the *Grid monitor event log* and a *Magnitude min/max exceeded* alarm is raised.

9.13.3.3. Magnitude of current (optional)

The monitoring of the Magnitude of current gives insight into slow deviations of the RMS current above a set threshold. The values are considered normal if more than a certain percentage of values remains under the set threshold within one week.

The Magnitude of current is evaluated at the end of each week (24:00 Sunday) based on values that are first averaged and then aggregated to 10-minute intervals. The values are monitored per phase.

Related events

Events related to the monitoring of the Magnitude of current (Table 87) are logged in the *Grid monitor event log*.

Event name	Event code	Event description
Magnitude current exceeded Lx	433 - 435	Indicates that the magnitude of the per-phase current exceeded the predefined level for more than predefined percentage of time within one week.

Table 87: Magnitude of current – events

Related configurable objects

To configure the threshold for the Magnitude of current, use object listed in Table 88.

Object description	Logical name
Bad overlimit of the current magnitude	0-0:128.9.90*255

Table 88: Magnitude of current – configuration parameters

Object *Bad overlimit of the current magnitude* defines the high bad overlimit threshold.

Related readable objects

Objects listed in Table 89 store data on the Magnitude of current monitoring.

Object description	Logical name
Percentage of bad magnitude of current L1	0-0:128.9.15*255
Percentage of bad magnitude of current L2	0-0:128.9.25*255
Percentage of bad magnitude of current L3	0-0:128.9.35*255
Daily maximum current L1	1-0:31.16.0*255
Daily maximum current L2	1-0:51.16.0*255
Daily maximum current L3	1-0:71.16.0*255

Table 89: Magnitude of current – readable objects

The per-phase objects *Percentage of bad magnitude of current* give information on the percentage of bad aggregated current values within the last complete week.

The objects *Daily maximum current* store per-phase daily peeks of aggregated current values. The values are logged in *Billing profile 2* and updated at a daily basis at midnight.

How and when are results reported

The quality of the current is declared inadequate if more than 5% of the aggregated values exceed the *Bad overlimit of the current magnitude* threshold within one week. When this occurs, a per-phase *Magnitude current exceeded* event is logged in the *Grid monitor event log* and a Magnitude min/max exceeded alarm is raised.

9.13.3.4. Magnitude of power (optional)

The monitoring of the Magnitude of power gives insight into slow deviations of this signal above a set threshold. The meter monitors the values separately for active power (plus and minus) and reactive power (plus and minus). The values are considered normal if more than a certain percentage of values remains under the set threshold within one week.

The Magnitude of power is evaluated at the end of each week (24:00 Sunday) based on values that are first averaged and then aggregated to 10-minute intervals. The values are monitored per phase.

Related events

Events related to the monitoring of the Magnitude of power (Table 90) are logged in the *Grid monitor event log*.

Event name	Event code	Event description
Magnitude power active plus exceeded Lx	436 - 438	Indicates that the magnitude of the per-phase active power plus exceeded the predefined level for more than predefined percentage of time within one week.
Magnitude power active minus exceeded Lx	439 - 441	Indicates that the magnitude of the per-phase active power minus exceeded the predefined level for more than predefined percentage of time within one week.
Magnitude power reactive plus exceeded Lx	442 - 444	Indicates that the magnitude of the per-phase reactive power plus exceeded the predefined level for more than predefined percentage of time within one week.
Magnitude power reactive minus exceeded Lx	445 - 447	Indicates that the magnitude of the per-phase reactive power minus exceeded the predefined level for more than predefined percentage of time within one week.

Table 90: Magnitude of power – events

Related configurable objects

To configure the thresholds for the Magnitude of power, use objects listed in Table 91.

Object description	Logical name
Bad overlimit of the active power plus magnitude	0-0:128.10.90*255
Bad overlimit of the active power minus magnitude	0-0:128.11.90*255
Bad overlimit of the reactive power plus magnitude	0-0:128.12.90*255
Bad overlimit of the reactive power minus magnitude	0-0:128.13.90*255

Table 91: Magnitude of power – configuration parameters

Related readable objects

The per-phase objects *Percentage of bad magnitude of active/reactive power plus/minus* give information on the percentage of bad aggregated power values within the last complete week.

Object description	Logical name
Percentage of bad magnitude of active power plus Lx	0-0:128.10.a*255
Percentage of bad magnitude of active power minus Lx	0-0:128.11.a*255
Percentage of bad magnitude of reactive power plus Lx	0-0:128.12.a*255
Percentage of bad magnitude of reactive power minus Lx	0-0:128.13.a*255

Table 92: Magnitude of power – readable objects

In Table 92, the “a” letter in the logical names represents the phase index. To get the full logical name, replace the “a” letter with one of the following numbers:

- a = 15 for L1
- a = 25 for L2
- a = 35 for L3

The objects *Daily maximum active/reactive power plus/minus* store per-phase daily peeks of aggregated active/reactive power plus/minus values. The values are logged in *Billing profile 2* and updated at a daily basis at midnight.

Object description	Logical name
Daily maximum active/reactive power plus/minus Lx	1-0:b.16.0*255

Table 93: Magnitude of power – readable objects

In Table 93, the "b" letter in the logical name represents the power type and phase index. To get the full logical name, replace the "b" letter with one of the following numbers:

- b = 21 – active power plus L1; unit = W
- b = 22 – active power minus L1; unit = W
- b = 23 – reactive power plus L1; unit = VAr
- b = 24 – reactive power minus L1; unit = VAr
- b = 41 – active power plus L2; unit = W
- b = 42 – active power minus L2; unit = W
- b = 43 – reactive power plus L2; unit = VAr
- b = 44 – reactive power minus L2; unit = VAr
- b = 61 – active power plus L3; unit = W
- b = 62 – active power minus L3; unit = W
- b = 63 – reactive power plus L3; unit = VAr
- b = 64 – reactive power minus L3; unit = VAr

How and when are results reported

The quality of the power is declared inadequate if more than 5% of the aggregated values exceed the *Bad overlimit of the active/reactive power plus/minus magnitude* threshold within one week. When this occurs, a per-phase *Magnitude power active/reactive plus/minus exceeded* event is logged in the *Grid monitor event log* and a Magnitude min/max exceeded alarm is raised.

9.13.3.5. Magnitude of THD (optional)

The monitoring of the Magnitude of THD gives insight into slow deviations of this signal above a predefined threshold. The meter monitors the values separately for voltage THD and current THD. The values are considered normal if more than a certain percentage of values remains under the set threshold within one week.

The Magnitude of THD is evaluated based on averaged values at the end of each week (24:00 Sunday). The values are monitored per phase.

Related events

Events related to the monitoring of the Magnitude of THD (Table 94) are logged in the *Grid monitor event log*.

Event name	Event code	Event description
Magnitude THD voltage exceeded Lx	448 - 450	Indicates that the magnitude of the per-phase THD voltage exceeded the predefined level for more than predefined percentage of time within one week.
Magnitude THD current exceeded Lx	451 - 453	Indicates that the magnitude of the per-phase THD current exceeded the predefined level for more than predefined percentage of time within one week.

Table 94: Magnitude of THD – events

Related configurable objects

To configure the thresholds for the Magnitude of THD, use objects listed in Table 95.

Object description	Logical name
Bad overlimit of the THD voltage magnitude	0-0:128.15.90*255
Bad overlimit of the THD current magnitude	0-0:128.16.90*255

Table 95: Magnitude of THD – configuration parameters

Related readable objects

The per-phase objects *Percentage of bad magnitude of THD voltage/current* give information on the percentage of bad aggregated THD values within the last complete week.

Object description	Logical name
Percentage of bad magnitude of THD voltage Lx	0-0:128.15.a*255
Percentage of bad magnitude of THD current Lx	0-0:128.16.a*255

Table 96: Magnitude of THD – readable objects

In Table 96, the “a” letter in the logical names represents the phase index. To get the full logical name, replace the “a” letter with one of the following numbers:

- a = 15 for L1
- a = 25 for L2
- a = 35 for L3

The objects *Daily maximum THD voltage/current* store per-phase daily peeks of aggregated THD values in voltage and current. The values are logged in Billing profile 2 and updated at a daily basis at midnight.

Object description	Logical name
Daily maximum THD voltage/current Lx	1-0:b.16.124

Table 97: Magnitude of THD – readable objects

In Table 97, the “b” letter in the logical name represents the THD type and phase index. To get the full logical name, replace the “b” letter with one of the following numbers:

- b = 31 – current L1
- b = 32 – voltage L1
- b = 51 – current L2
- b = 52 – voltage L2
- b = 71 – current L3
- b = 72 – voltage L3

How and when are results reported

The THD voltage or current is declared inadequate if more than 5% of the aggregated values exceed the *Bad overlimit of the THD voltage/current magnitude* threshold within one week. When this occurs, a per-phase *Magnitude THD voltage/current exceeded* event is logged in the Grid monitor event log and a Magnitude min/max exceeded alarm is raised.

9.13.4. Functionalities based on grid monitoring data

9.13.4.1. Voltage unbalance – symmetrical components

The voltage unbalance indicator is evaluated using the method of symmetrical components. The evaluation requires the negative sequence ratio u_2. It is calculated every 200 ms, using the phase RMS voltages, averaged over 200 ms. The voltage unbalance indicator K is then calculated as the average value of the negative sequence ratio u_2, averaged over 10 minutes. It is updated at every 10-min RTC time tick, starting at full hour. The value of K is calculated only if more than 150 samples of the negative sequence ratio u_2 are available within the 10-min interval.

The voltage unbalanced state is declared when calculated “10-minutes average value percentage” value (K) exceeds the max. allowed K value defined in **Voltage unbalance – max allowed K value** (0-0:128.7.140*255).

The voltage unbalanced state is resolved when the calculated “10-minutes average value percentage” value (K) drops below allowed K value defined in **Voltage unbalance – max allowed K value** (0-0:128.7.140*255).

Related objects

Configuration parameters for maximum allowable value for K is defined in the **Voltage unbalance – max allowed K value** (0-0:128.7.140*255) object.

The maximum allowable value of K is the configuration parameter. The last voltage unbalance average value, which is calculated every 10 minutes and can be read from **Voltage unbalance – last K value** (0-0:128.7.154*255) object.

Events and alarms for Voltage unbalance

When the voltage unbalance state is declared the following actions are executed:

- the event *Phase asymmetry (90)* is written to the *Power Quality Log (0-0:99.98.4*255)*, which marks the beginning of the fault,
- the event *Phase asymmetry (90)* is written to the *Grid event log (0-0:99.98.9*255)* with magnitude 0 and duration 0, which marks the beginning of the fault,
- the alarm Phase asymmetry, bit B9 in Alarm register 2 (0-0:97.98.1*255), is raised.

When the voltage unbalanced state is resolved, the following actions are executed:

- the event Voltage unbalance – asymmetric end (455) is written to Power Quality Log (0-0:99.98.4*255), which marks the end of the fault,
- the event *Voltage unbalance – asymmetric end (455)* is written to the *Grid monitor event log (0-0:99.98.9*255)* with magnitude 0 and duration 0, which marks the end of the fault,
- the alarm Phase asymmetry, bit B9 in Alarm register 2 (0-0-:97.98.1*255), is cleared.

9.13.4.2. Neutral missing

The aim of Neutral missing monitoring is to detect a Neutral missing state in the grid and to react in time to prevent any potential damage in the final client's premises. A Neutral missing state occurs when the neutral line is cut somewhere between the low voltage transformer and the final client's premises. If the final client is connected to a single-phase grid, the outcome of a missing neutral line is a broken electric circuit and loss of power supply. If the final client is connected to a poly-phase grid, the electric circuit is not broken as the current can flow through the phase lines. In this case, the voltage within the premises can range between 0 V and the line-to-line voltage. This condition is potentially dangerous and may cause damage to connected electrical appliances.

NOTE

The Neutral missing monitoring is available in three-phase meters only.

Related events

The following events related to Neutral missing monitoring are logged in the *Standard event log* and *Grid monitor event log*:

Event name	Event code	Event description
Missing neutral	89	Indicates that the neutral connection from the supplier to the meter is interrupted (but the neutral connection to the load prevails). The phase voltages measured by the meter may differ from their nominal values.
Missing neutral end	456	Indicates the end of the neutral missing event.

Table 98: Neutral missing events

Related configurable objects

To set the parameters for Neutral missing monitoring, use the object **Neutral missing thresholds** (0.0.196.21.10*255). The following thresholds may be configured:

- Low voltage threshold
- High voltage threshold
- Critical voltage threshold
- Time threshold (start time)

- Time threshold (end time)

When is a Neutral missing state declared?

A Neutral missing state is declared when all of the following three start conditions are fulfilled:

- One of the phase voltages is **above** the *High voltage threshold.*
- Another phase voltage is **below** the *Low voltage threshold*.
- Conditions 1 and 2 are maintained longer than the *Time threshold (start)*.

When a Neutral missing state is declared, a *Missing neutral* event is logged in the Standard event log and Grid monitor event log.

When is a Neutral missing state resolved?

A Neutral missing state is resolved when both of the following two conditions are fulfilled:

- At least one of start conditions 1 or 2 is removed.
- The condition remains removed for longer than the *Time threshold (end)*.

When a Neutral missing state is resolved, a *Missing neutral end* event is logged in the Standard event log and Grid monitor event log.

In the graph below, the time and voltage thresholds, as well as start and end conditions for a Neutral missing state are shown.

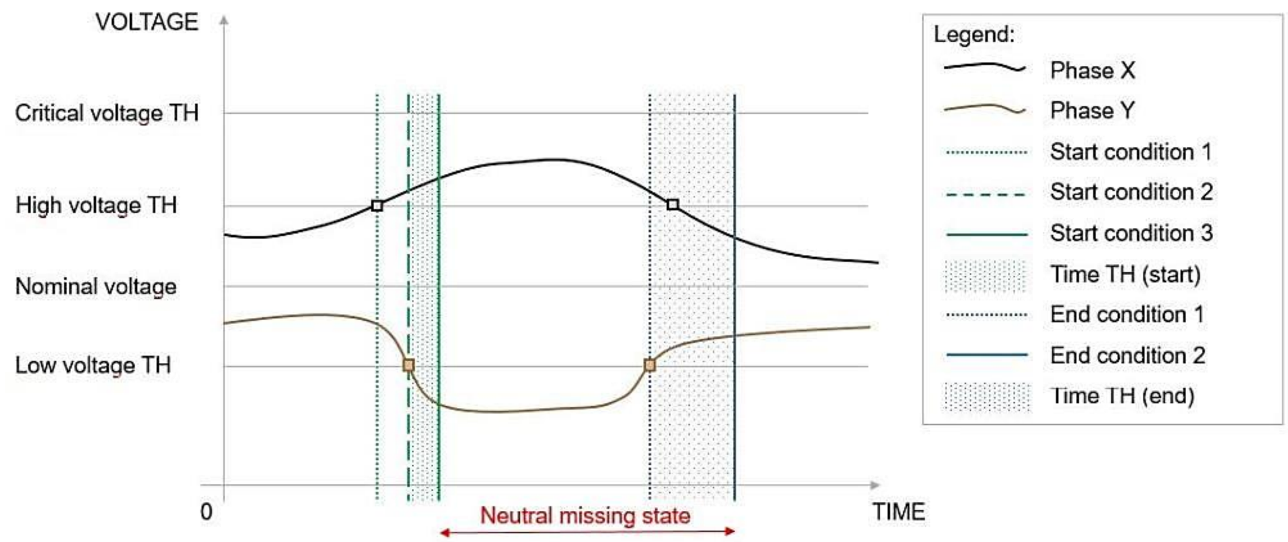


Figure 119: Neutral missing – thresholds and conditions

Critical neutral missing state

A Critical neutral missing state is declared when both of the following two conditions are fulfilled:

- One of the phase voltages is **above** the *Critical voltage threshold.*
- Another phase voltage is **below** the *Low voltage threshold*.

When a Critical neutral missing state is declared, the meter is disconnected to prevent any damage in the final client's premises. A *Neutral missing disconnection* alarm is raised in this case.

When the high phase voltage drops below the *Critical voltage threshold,* meter can be connected remotely by the HES, depending on the disconnector *Control mode* configuration.

NOTE

The meter is NOT disconnected immediately after a Critical neutral missing state has been declared. Instead, the meter waits for a certain configurable time period (*Disconnection delay*). If the critical state is still present at the end of this period, it disconnects the power supply.

To learn more about and how to configure the *Disconnection delay*, see chapter *9.14.4. Event-based disconnection*.

9.13.5. Harmonic analysis (FFT and THD) (optional)

The meter performs a harmonic analysis to obtain the harmonic contents of the phase voltages and currents for each phase. The harmonics from the 1st up to (and including) the 10th are calculated. The 1st harmonic is the component with the fundamental frequency (50/60 Hz).

Only the magnitudes of the harmonics are calculated (the phase angles are not calculated). The DC component and the inter-harmonics are not calculated.

The calculated harmonic components are then used to calculate the voltage and current Total Harmonic Distortion (THD) for each phase.

FFT (Fast Fourier Transform) for each voltage and current is performed on 64 samples which are collected over the sampling window of width T_w, which is exactly one period of the supply voltage. Resampling is used to achieve the synchronous sampling. It ensures that the side lobes do not appear in the frequency spectrum of the signal and that each spectral line is the multiple of the fundamental frequency, regardless of its actual value.

For the performance reasons, the FFT is not calculated continuously. Instead, the samples are collected periodically with the period T_{FFT}. This period can be configured, using the object **Harmonic analysis period** (0-0:128.8.60*255). The minimum value is 0.5, the maximum 2, and the default is 1.

The concept of the FFT and THD calculation is shown in Figure 120.

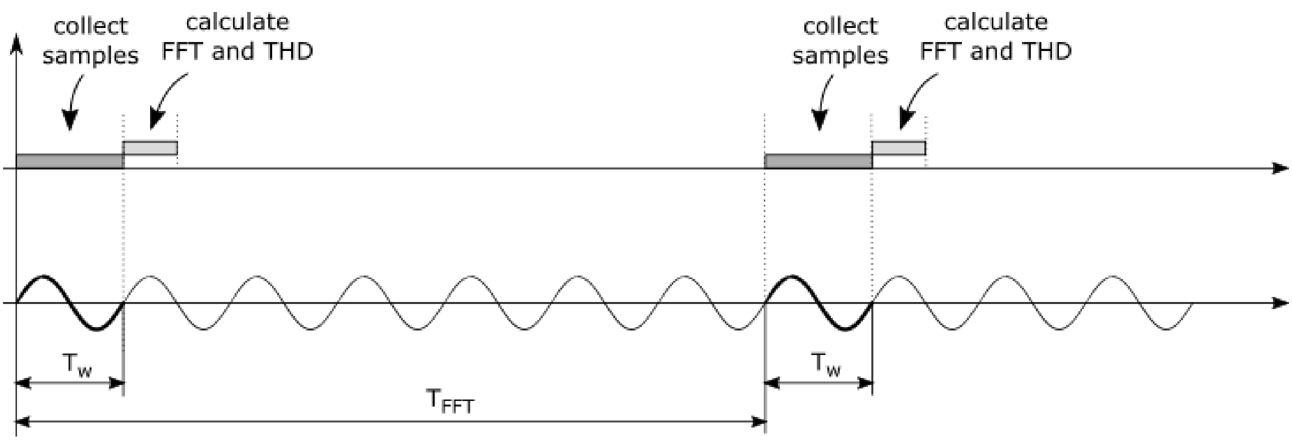


Figure 120: Calculation of the harmonic components and THD

9.13.5.1. Voltage harmonics and THD

Voltage harmonics and THD are calculated and presented in corresponding objects for each phase separately. Voltage harmonics are presented as RMS voltages. Voltage total harmonic distortion values THD_U are calculated according to the following equation:

$$THD_U = \frac{\sqrt{\sum_{m=2}^{13} C_{Um}^2}}{C_{U1}}$$

where

- C_{Um} is the magnitude of the voltage harmonic component *m*
- C_{U1} is the magnitude of the voltage harmonic component *1*

and are thus presented as non-dimensional numbers.

The voltage harmonics and the THDs for each phase can be read through the COSEM objects which are shown in Table 99. The symbol *m* represents the harmonic number.

	L1	L2	L3
Voltage harmonics (m=1...10)	32.7.m	52.7.m	72.7.m
Voltage THD	32.7.124	52.7.124	72.7.124

Table 99: Voltage harmonics and THDs per phase

9.13.5.2. Current harmonics and THD

Current harmonics and THD are calculated and presented in corresponding objects for each phase separately. Current harmonics are presented as RMS currents. Current total harmonic distortion values THD_I are calculated according to the following equation:

$$THD_I = \frac{\sqrt{\sum_{m=2}^{13} C_{Im}^2}}{C_{I1}}$$

where

- C_{Im} is the magnitude of the current harmonic component *m*
- C_{I1} is the magnitude of the current harmonic component *1*

and are thus presented as non-dimensional numbers.

The current harmonics and the THDs for each phase can be read through the objects which are shown in Table 100. The symbol *m* represents the harmonic number.

	L1	L2	L3
Current harmonics (m=1...10)	31.7.m	51.7.m	71.7.m
Current THD	31.7.124	51.7.124	71.7.124

Table 100: Current harmonics and THDs per phase

9.14. Disconnector (optional)

The disconnector is used to disconnect individual consumers from the grid. Disconnect control can be performed locally (from the meter functionality) or remotely, from the control centre HES over a primary communication.

The direct connected single-phase and three-phase meters may have an optional integrated disconnector, while the indirect connected three-phase meter is always without a disconnector. In the indirect connected meter, the load control relay may be configured to function as a disconnector, which can drive an external disconnect unit. For more information about the configuration, refer to chapter *9.14.1. Disconnector type*.

If the meter (HW, SW and FW) supports switching between the built-in disconnector and the external disconnect unit driven with a relay, a disconnector's current state is preserved, and all functionalities are used accordingly to a selected disconnector type.

Disconnect and reconnect can be requested:

- Remotely (via a communication): remote disconnect, remote reconnect.
- Locally (limiter, prepayment, register monitor, single action scheduler, etc.): local disconnect, local reconnect.
- Manually (using push button, external key): manual disconnect, manual reconnect.

A disconnector state diagram and available state transitions are shown in Figure 121.

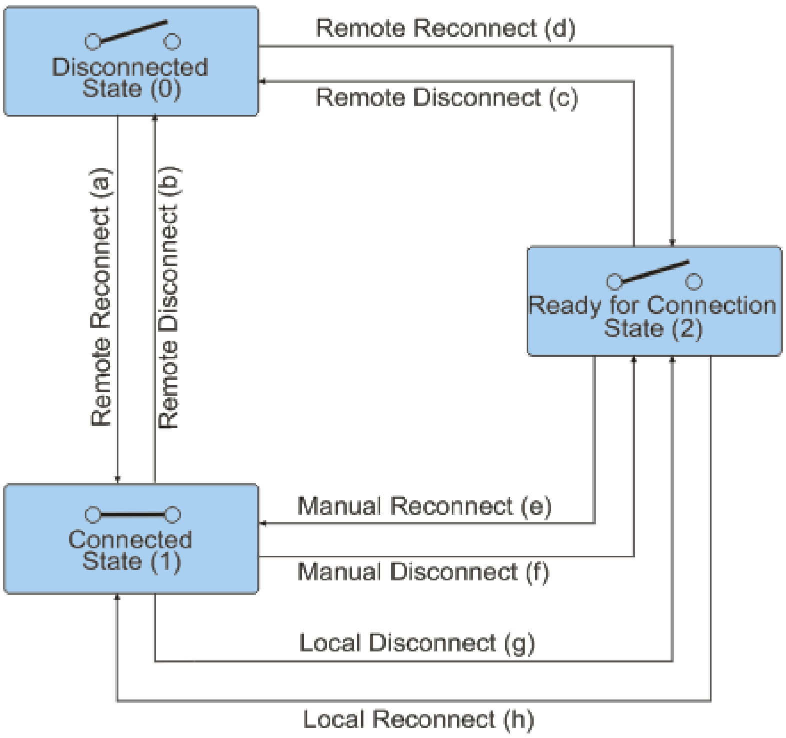


Figure 121: Disconnect state control diagram

Table 101 shows and describes all available disconnector transitions.

Transition	Transition name	Description
a	Remote reconnect	Moves the Disconnect control object from the Disconnected (0) state directly to the Connected (1) state without manual intervention.
b	Remote disconnect	Moves the Disconnect control object from the Connected (1) state to the Disconnected (0) state.
c	Remote disconnect	Moves the Disconnect control object from the Ready for reconnection (2) state to the Disconnected (0) state.

Transition	Transition name	Description
d	Remote reconnect	Moves the Disconnect control object from the Disconnected (0) state to the Ready for re-connection (2) state. From this state, it is possible to move to the Connected (2) state via the manual reconnect transition (e).
e	Manual reconnect	Moves the Disconnect control object from the Ready for connection (2) state to the Connected (1) state.
f	Manual disconnect	Moves the Disconnect control object from the Connected (1) state to the Ready for connection (2) state. From this state, it is possible to move back to the Connected (2) state via the manual reconnect transition (e)
g	Local disconnect	Moves the Disconnect control object from the Connected (1) state to the Ready for connection (2) state. From this state, it is possible to move back to the Connected (2) state via the manual reconnect transition (e). Transitions f) and g) are essentially the same, but their trigger is different.
h	Local reconnect	Moves the Disconnect control object from the Ready for connection (2) state to the Connected (1) state. Transitions e) and h) are essentially the same, but their trigger is different.

Table 101: Disconnect transitions

9.14.1. Disconnector type

For proper functioning, the appropriate type of a disconnector must be set in object **Switching device type** (0-0:128.30.20*255). The following options are available:

- 0 – None (disabled actions on switching device)
- 1 – Circuit breaker
- 4 – Relay driven (external disconnect unit driven with relay)

NOTE

If the disconnector type is set to "***0 – None"***, transitions on **Disconnect control** object (0-0:96.3.10.255) are not possible and the disconnector holds the state.

Disconnector type option "***4 – Relay driven (external disconnect unit driven with relay)"*** should only be used with transformer meter type.

9.14.2. Disconnect control

The disconnect control function is used for the connection and disconnection of the premises of the consumer.

The **Disconnect control** object (0-0:96.3.10*255) controls the connection and disconnection of the premises of the consumer.

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	70	0-0:96.3.10	R			
2. Output state	Boolean			R	0	1	1
3. Control state	Enum			R	0	2	1
4. Control mode	Enum			R/W	0	6	1
Specific methods							
1. remote disconnect							
2. remote reconnect							

Table 102: Disconnect control object

Object settings are:

- Output state
- Control state
- Control mode

Output state

The Disconnect Output state shows the actual physical state of the disconnector.

- FALSE – Open – The consumer is disconnected from the network - (0)
- TRUE – Closed – The consumer is connected to the network - (1)

Control State

Control state defines the internal logical state of the disconnector. Possible control states are:

- Disconnected – (0)
- Connected – (1)
- Ready for reconnection – (2)

When the disconnector is in the *Ready for reconnection* control state, it is possible to perform manual connection on the meter by holding the **Disconnector button** (see chapter *9.3.8. Functionality of buttons and the disconnector* status LED) until ConnEct is shown on the display.

Control Mode

Control mode defines available transitions in Disconnect control class (see Table 103).

Mode	Description	
0	None. The disconnect control object is always in 'connected' state	
1	Disconnection	Remote (b, c) Manual (f) – Press and hold the disconnector button until dISconn appears and then release the button. Disconnector status: LED is blinking. Local (g)
	Reconnection	Remote (d) Manual (e) – Press and hold the disconnector button until EntEr appears and then release the button. Disconnector status: LED turns off.
2	Disconnection	Remote (b, c) Manual (f) – Press and hold the disconnector button until dISconn appears and then release the button. Disconnector status: LED is blinking. Local (g)
	Reconnection	Remote (a) Manual (e) – Press and hold the disconnector button until EntEr appears and then release the button. Disconnector status: LED turns off.
3	Disconnection	Remote (b, c) Local (g)
	Reconnection	Remote (d) Manual (e)
4	Disconnection	Remote (b, c) Local (g)
	Reconnection	Remote (a) Manual (e) – Press and hold the disconnector button until EntEr appears and then release the button. Disconnector status: LED turns off.
5	Disconnection	Remote (b, c) Manual (f) – Press and hold the disconnector button until dISconn appears and then release the button. Disconnector status: LED is blinking. Local (g)
	Reconnection	Remote (d) Manual (e) – Press and hold the disconnector button until EntEr appears and then release the button. Disconnector status: LED turns off.

Mode	Description	
		Local (h)
6	Disconnection	Remote (b, c) Local (g)
	Reconnection	Remote (d) Manual (e) – Press and hold the disconnector button until EntEr appears and then release the button. Disconnector status: LED turns off. Local (h)

Table 103: Disconnect control modes

Depending on the selected mode, manual reconnection and disconnection is possible by pressing the disconnector button.

Manual reconnection (all control modes):

Display shows ConnEct (see Figure 122).Press the disconnector button for 5 seconds (until EntEr (see Figure 123) appears on the display) and then release it. If *Extended key behaviour* is configured in the **Display configuration** object (0-0:196.1.3*255), manual reconnection is performed immediately.

Figure 122: ConnEct on the display

Figure 123: EntEr on the display

NOTE

To ensure properly operation of disconnector functionality, all manual operations must be done with closed terminal cover.

Manual disconnection (control modes: 1, 2, 5):

Press the disconnector button for 10 seconds (until dIScconn (see Figure 124) appears on the display) and then release it.

Figure 124: dIScconn on the display

9.14.2.1. Disconnection counters

Disconnection counters represent number of disconnections made by a disconnector. Available disconnection counters are:

- **Manual disconnection** (0-0:96.15.57*255)
- **Remote disconnection** (0-0:96.15.59*255)
- **Local disconnection** (0-0:96.15.61*255)

9.14.3. Additional disconnection control functions

The meter supports the following additional disconnection-related functions:

- Disconnect control scheduler, which identifies, shows, and sets the dedicated time point for connection or disconnection.
- Disconnect control script table, which is used for remote reconnect and remote disconnect.
- Disconnection control status, which is used for manipulation with different physical disconnect control devices e.g., electricity disconnector, relay.
- Disconnect control delay mode, which adds configurable delay mode on a disconnector connection.

9.14.4. Event-based disconnection

The purpose of event-based disconnection is to prevent dangerous or damaging situations from occurring in the consumer's premises. The meter may be configured to disconnect the power supply in the following situations:

- Neutral missing
- Wrong phase sequence

To configure event-based disconnection, two COSEM objects are available:

- **Switching device Disconnect Event 1** (0-0:196.3.50*255)
- **Switching device Disconnect Event 2** (0-0:196.3.51*255)

The configurable elements are in the form of octet strings in the object value (Attribute 2):

- Event ID
- Bit attribute
- Connection delay
- Disconnection delay

Event ID

The Event ID defines what type of disconnection event the object is defined to manage. Available options are:

- 0 – None
- 1 – Neutral missing
- 2 – Wrong phase sequence

Bit attribute

The Bit attribute defines the event-based disconnection behaviour of the meter:

- ***State*** (B0) – A set bit means that event-based disconnection is enabled, otherwise it is disabled.
- ***Disconnection type*** (B1) – A set bit means that remote disconnect/connect transitions are used when an event occurs/disappears, otherwise local transitions are used.
- ***Connection disabled*** (B2) – This setting defines whether automatic re-connection is disabled or allowed. If the bit is set, automatic re-connection is disabled, otherwise the meter is allowed to establish a connection. When connection is disabled, the meter cannot establish a connection when the reason for disconnection is cleared. In this case, a manual/remote connection is needed to re-connect the disconnector.

Connection delay

This setting defines for how long the meter should wait before re-connecting the disconnector after the reason for disconnection has been cleared. Available range: 1–255 seconds.

Disconnection delay

This setting defines for how long the meter should wait before disconnecting the disconnector after the reason for disconnection has started. Available range: 1–255 seconds.

Example:

We want the meter to disconnect the disconnector in case of a Critical neutral missing state. When a Critical neutral missing state has been detected, the meter should wait for 200 seconds before disconnecting. When the critical state is cleared, it should wait for another 150 seconds before re-connecting the disconnector.

We need to set the following:

- Event ID: 1 – Neutral missing
- Bit attribute:
  - State (B0): **true**
  - Disconnection type (B1): **false**
  - Connection disabled (B2): **false**
- Connection delay: **200**
- Disconnection delay: **150**

9.15. Limitation

In addition to collecting and processing energy consumption data, the AMI system offers load balancing and control. To achieve this, a current and demand limitation is implemented in the meter. During the short time period when the power consumption excides the contractual value for a specified time interval, the consumer is disconnected from the grid until normal conditions are achieved or penalty time ends.

To handle consumption monitoring and disconnection of consumer premises, the following principles are used:

- Phase current measurement,
- Disconnection from the grid is performed by the disconnector,
- Threshold level settings in accordance with consumer contract and local regulator rules.

The supported limitation type is implemented as defined by IDIS (average phase current monitoring).

9.15.1. Limiter

Limiter functions are used to monitor the electrical network for exceeding maximum energy (power) in a pre-defined period of time. The Limiter object handles normal current, instantaneous power monitoring and (as an option) the emergency settings as well. The meter supports two limiter objects.

The consumer can (after correcting the exceeding level) reconnect the network manually (by pressing the scroll button on the meter) or with remote connection (depending on the disconnector mode used).

The threshold value can be a normal or an emergency threshold. The emergency threshold is activated via the emergency profile, which is defined by the emergency profile id, activation start time, and duration. The emergency profile id element is matched to the emergency profile group ID: this mechanism enables the activation of the emergency threshold only for a specific emergency group.

The limitation or disconnection functionality can be activated in the meter itself or by remote action. The meter disconnects the network (via the disconnector) if a maximum current or power limit has been exceeded during a predefined period of time. The current or power levels with the allowed exceeding periods are set in the meter.

The meter supports two limiter instances with OBIS codes 0-0:17.0.0*255 and 0-0:17.0.1*255. The IDIS specification defines only one limiter instance.

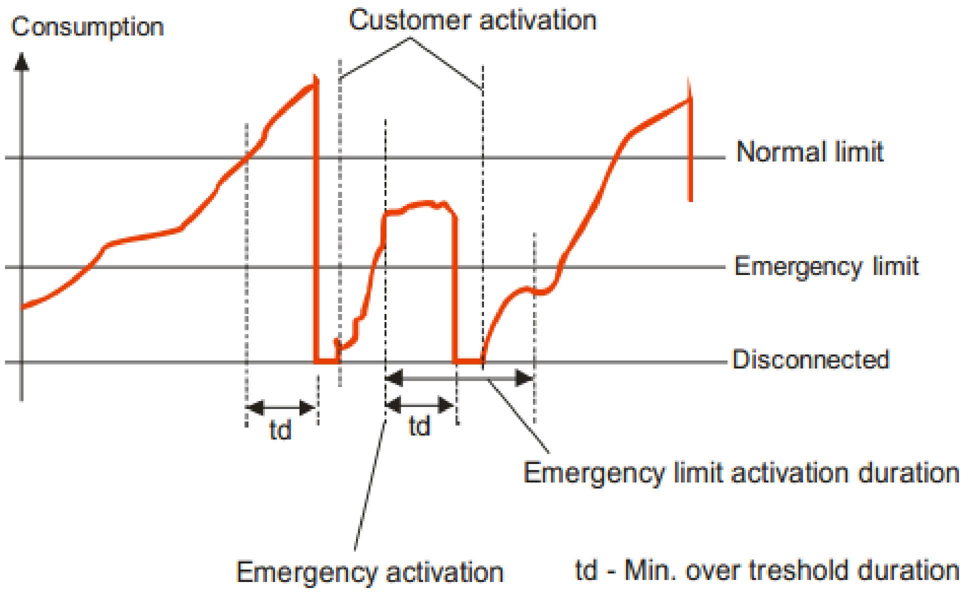


Figure 125: Limiter diagram

NOTE

By a customer request (option), no script (no action) is set for a limiter under threshold action. In this case (exception behaviour), the limiter under threshold action causes that appropriate bit of **Disconnect control status** (0-0:128.30.25*255) is cleared (*Bit 0 – Limiter 1* and *Bit 1 – Limiter 2*). Cleared bits allows other instances to reconnect disconnector. Exception is supported only for *Disconnect control mode 4* and *6* of **Disconnect control** (0-0:96.3.10*255).

9.15.2. Supervision monitor - IDIS

The meter features phase current limitation with three **Register monitor** objects:

- Supervision monitor 1 – Fuse supervision L1, 1-0:31.4.0*255,
- Supervision monitor 2 – Fuse supervision L2, 1-0:51.4.0*255,
- Supervision monitor 3 – Fuse supervision L3, 1-0:71.4.0*255.

Every register monitor monitors the corresponding phase demand register. When the monitored value passes the threshold in the upward or downward direction, *action up* or *action down* is taken, respectively. For the IE.x meters, two thresholds are allowed to be set.

IDIS specifies **Supervision monitor** objects 1-0:31.4.0*255 (SM1), 1-0:51.4.0*255 (SM2), and 1-0:71.4.0*255 (SM3) for a monitored value. This is not a directly measured phase current RMS (root mean square), but the averaged value over the number of periods. An action defines scripts to be executed when the monitored value of the reference object crosses the corresponding threshold:

- *action up* defines the action when the attribute value of the monitored register crosses the threshold in the upwards direction,
- *action down* defines the action when the attribute value of the monitored register crosses the threshold in the downwards direction.

9.16. Counters

The meter supports counters:

- presented in Table 104 and
- presented in the corresponding chapters.

Object name	Description	OBIS code
Number of power failures, in any phase	The number of power failures in any phase represents the number of power outages shorter than the long-power-failure-time threshold in any phase.	0-0:96.7.21*255
Number of long power failures, in any phase	The number of long power failures in any phase represents the number of power outages longer than the long-power-failure-time threshold (3 minutes) in any phase.	0-0:96.7.9*255
Watchdog resets	The number of watchdog resets.	0-0:128.6.0*255
Image transfer counter	The number of successfully transferred images (e.g., meter module image, modem image).	0-0:96.63.10*255

Table 104: Meter counters

9.17. Function activation

With **Function activation** object (0-0:44.1.0*255), it is possible to enable or disable different functions, which are supported by the meter device. The meter firmware supports the following functions, which can be controlled through the Function activation interface:

- Activate or deactivate the capturing in Load profile 1 (function LPCAP_1)
- Activate or deactivate the capturing in Load profile 2 (function LPCAP_2)
- Activate or deactivate the capturing in Load profile 3 (function LPCAP_3)
- Activate or deactivate the capturing in Load profile 4 (function LPCAP_4)
- Activate or deactivate the capturing in M-Bus master load profile for channel 1 (function LPCAP_M1)
- Activate or deactivate the capturing in M-Bus master load profile for channel 2 (function LPCAP_M2)
- Activate or deactivate the capturing in M-Bus master load profile for channel 3 (function LPCAP_M3)
- Activate or deactivate the capturing in M-Bus master load profile for channel 4 (function LPCAP_M4)
- Activate or deactivate CIP on the P1 port (function IF_HAN_1)
- Activate or deactivate display (function IF_DISPLAY)
- Activate or deactivate normal mode functionality on the display (function IF_DISP_TYP_NORM)
- Activate or deactivate disconnector functionality (function SWITCH_DEV)
- Activate or deactivate a multi-utility port (for M-Bus) functionality (function IF_MU)
- Activate or deactivate a communication on a local interface – an optical interface (function IF_LO_2W)
- Activate or deactivate a communication on a WAN port (P3) (function IF_WAN)

9.18. Factory set and locked objects (national regulations)

When required by national laws and/or regulations, the meter may be set to have certain objects factory set and locked, e.g. FW upgrade. This disables any subsequent changes (locally or remotely) to these objects after the meter has left the factory. The factory set objects due to national regulations are defined in the **Access rights exceptions table** (0-0:128.104.0*255). The table below list the objects which may be factory set and locked on demand.

Object description	Logical name
Image transfer object *	0-0:44.0.0*255
Active energy, metrological LED	1-0:0.3.0*255
Reactive energy, metrological LED	1-0:0.3.1*255
Apparent energy, metrological LED	1-0:0.3.2*255

Object description	Logical name
Display format for energy	0-0:196.1.0*255
Display format for demand	0-0:196.1.1*255

* FW upgrade

Table 105: List of factory settable objects due to national regulations

9.19. Mirrored objects (optional)

By a customer request, it is possible that OBIS codes of energy and demand objects can be "mirrored", and they are displayed as mirrored objects. This means that "**B**" field of OBIS codes (A-**B**:C.D.E*F) of energy and demand objects is translated from "1-**0**:x.x.x.x" to "1-**1**:x.x.x.x". The translation is also true for objects, which are used as configurable parameter settings (e.g., load profile capture objects, display list capture objects, etc).

If "Mirror objects" is enabled, in **System options** object (0-0:128.90.1*255), B0 is set to 1 (see Figure 126).

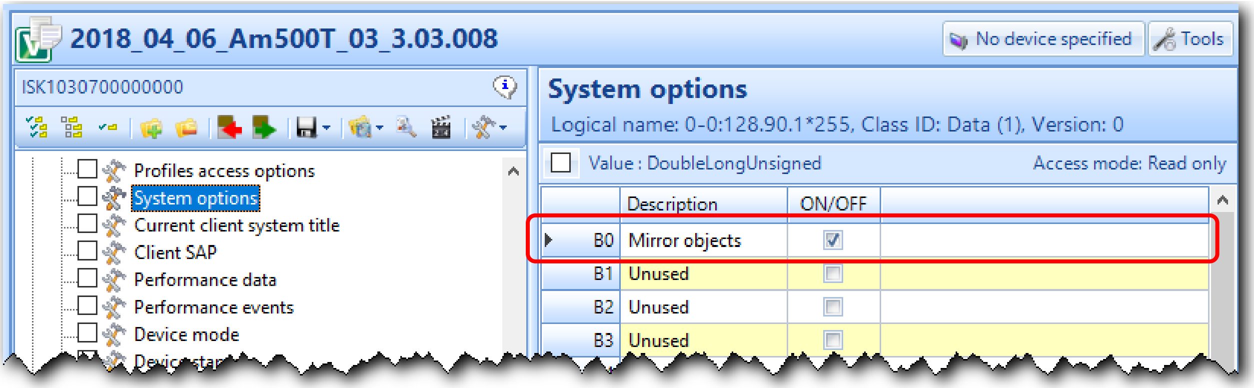


Figure 126: Enabled Mirror objects in System options object

Example of mirrored object of Active energy import (+A):

1-**0**:1.8.0*255 → 1-**1**:1.8.0*255.

NOTE

The functionality *Mirrored objects* is an option and only factory settable.

9.20. Time switch – Astronomic calendar (optional)

The meter may optionally support a Time switch or Astronomic calendar functionality that automatically controls the output state of the selected switching device, based on a calculated sunrise / sunset time. At sunrise time, the switching device is disconnected (OFF), and at sunset time, the switching device is re-connected (ON).

The switching device can either be a disconnector or one or more output relays. The type of the switching device used depends on the meter's hardware and software configuration.

To manage the selection of the switching device, use objects **Disconnect event x** (x = 1 …. 10).

To setup the Time switch functionality, you need to do the following:

- Enable the functionality in the **Time switch enable** object.
- Define the location in the **Time switch location** object.
- Define the solar zenith angle in the **Time switch zenith** object.
- Define exception days in the **Time switch single action scheduler** object.

9.20.1. How to enable/disable the Time switch functionality

To enable/disable the Time switch functionality, use **Time switch enable** (0-0:128.120.0*255). In the **Enable** attribute, select the desired option:

- Time switch is disabled
- Time switch is enabled (default)
- Time switch is enabled, disconnector is OFF

When enabled, this functionality will run every day, switching the switching device between OFF and ON at the calculated sunrise and sunset times. If there is a power outage when an action should be performed, it is performed automatically during the next power up of the meter. There are two exceptions:

- If the power outage occurs before the sunrise time and ends after the sunset time, the sunrise action is skipped.
- If the power outage occurs before the sunset time and ends after the sunrise time the next day, the sunset action is skipped.

9.20.2. How to define the Time switch location

To define the location, use object **Time switch location** (0-0:128.120.1*255). In the **Location** attribute, define the latitude and the longitude as follows:

- Latitude: 4 Bytes
  - Degrees: -90..90 [°]
  - Minutes: 0..60 [’]
  - Seconds: 0..60 [”]
- Longitude: 4 Bytes
  - Degrees: -180..180 [°]
  - Minutes: 0..60 [’]
  - Seconds: 0..60 [”]

9.20.3. How to define the zenith angle

The solar zenith angle is the angle between the sunrays and the vertical direction. It is used in sunrise and sunset calculation. To define the solar zenith angle, use object **Time switch zenith** (0-0:128.120.4*255). Select one of the following types of the zenith angle:

5. Official (90°50’)
6. Civil (96°)
7. Nautical (102°)
8. Astronomical (108°) (default)

9.20.4. How to define exception days

Exception days are days when the Time switch functionality is paused and the switching device is not switched ON/OFF at sunrise and sunset times. However, the sunrise and sunset times are still being calculated and displayed on the LCD (if the Time switch functionality is enabled).

To define exception days:

1. Go to object **Time switch single action scheduler** (0-0:15.0.252*255).
2. In the **execution_time** attribute, define up to 50 exception days.

9.20.5. How to view the sunrise/sunset times

To view the calculated sunrise/sunset time for the current day, go to object:

- **Time switch sunrise time** (0-0:128.120.2*255) or
- **Time switch sunset time** (0-0:128.120.3*255).

The calculated sunrise and sunset times are displayed in the local time format (date and time). They cannot be set manually.

The sunrise and sunset times are calculated at the following events:

- Every day at 00:00.
- When the time is changed.
- When powering up the meter.
- When new parameters are defined (zenith, location).

10. M-BUS

10.1. General system architecture

M-Bus is an interface that enables communication between an electricity meter (E-meter) and several types of sub-metering devices, such as a gas meter (G-meter), thermal meter (heat/cold), water meter, or another electricity meter. The M-Bus communication operates in accordance with standard EN 13757 and enables remote reading of connected sub-metering devices. The E-meter functions as the communication Master, and the connected sub-metering devices as Slaves.

In general, all sub-metering devices deliver their own measured data to a common E-meter. The E-meter stores this data and makes it available to the customer via the P1 communication interface, or to the central system via the P3 communication interface. Data can be retrieved by the E-meter periodically or on demand.

The IE.x E-meter optionally supports a wireless M-Bus (wM-Bus) and a wired M-Bus communication interface. Only one interface may be used at a time, either wired or wireless. However, by using a dongle, it's possible to connect wireless devices to the wired interface, thus both types of M-Bus devices can be used simulateneously.

10.1.1. Wired M-Bus architecture

IE.x may be equipped with a wired M-Bus communication interface. To this interface, it is possible to connect wired M-bus devices, and by using a dongle, wireless M-bus devices as well. The M-bus dongle functions as an adapter between wired and wireless M-Bus. When using a dongle, wireless meter data are exchanged according to the EN 13757-4 standard.

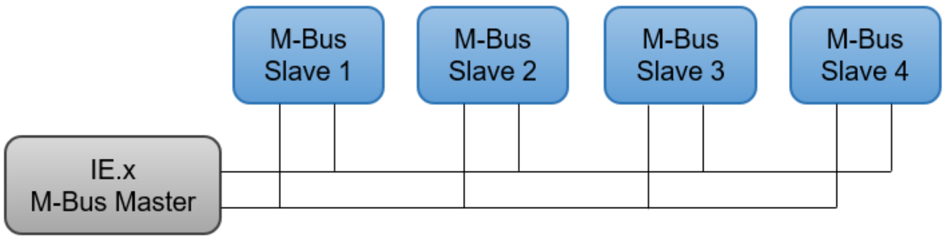


Figure 127: Connection with wired M-Bus devices

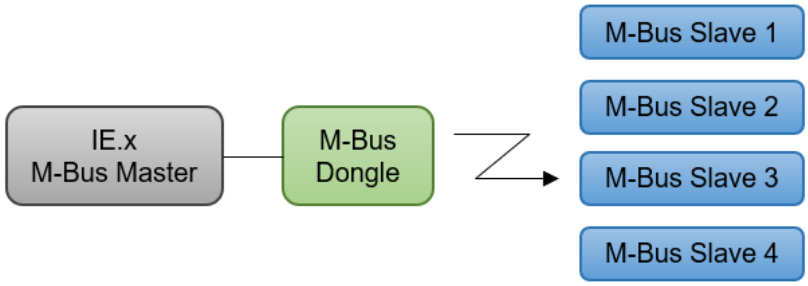


Figure 128: Connection with wireless M-Bus devices through a dongle

NOTE

Up to four wired submetering devices may be connected to the E-meter. The maximum current consumption may not exceed 16 unit loads, where one unit load is defined as the maximum mark state current of 1.5 mA.

10.1.2. Wireless M-Bus architecture

In wireless connection, the M-Bus device is battery operated device, which always initiates the communication and acts as a “Meter” while E-meter acts as “Other device” (or “Gateway”). The communication system is presented in Figure 129.

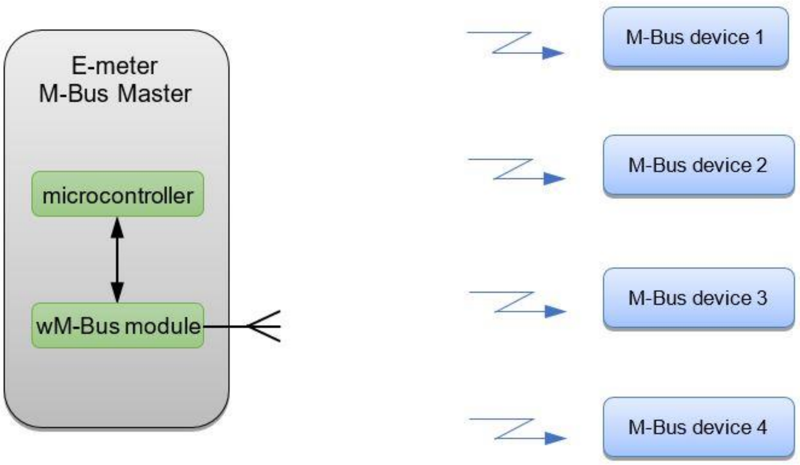


Figure 129: Wireless M-Bus communication system (with integrated RF interface)

Wireless meter data are exchanged according to EN 13757-4.

In Figure 129, M-Bus devices have integrated radio interface. Furthermore, M-Bus devices can be connected to the wireless M-Bus interface of the E-meter via an external RF-adapter as it is presented in Figure 130. The RF-adapter connects the hosted M-Bus device to the radio channel.

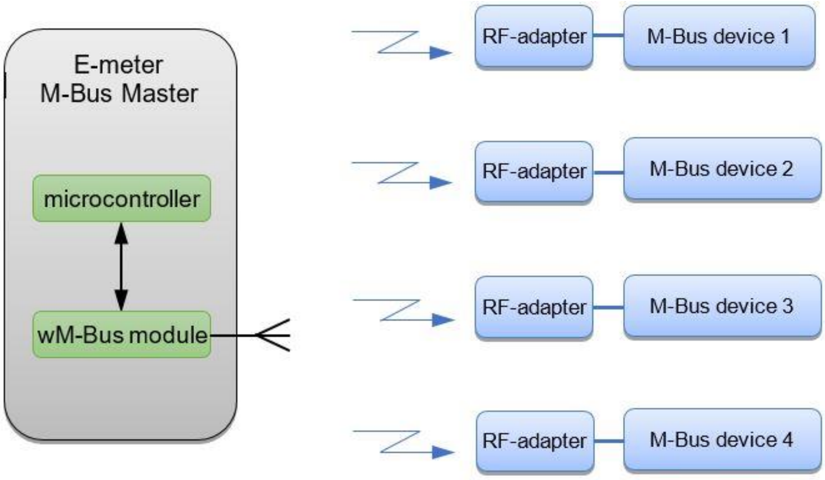


Figure 130: Wireless M-Bus communication system (with external RF-adapter)

10.1.3. M-Bus channel model

The M-Bus communication interface enables connection of **maximum four slave devices**. During operation, E-meter collects the consumption data of connected M-Bus devices. The retrieved data are organized in **four measuring channels**, **one channel per each connected sub-meter**.

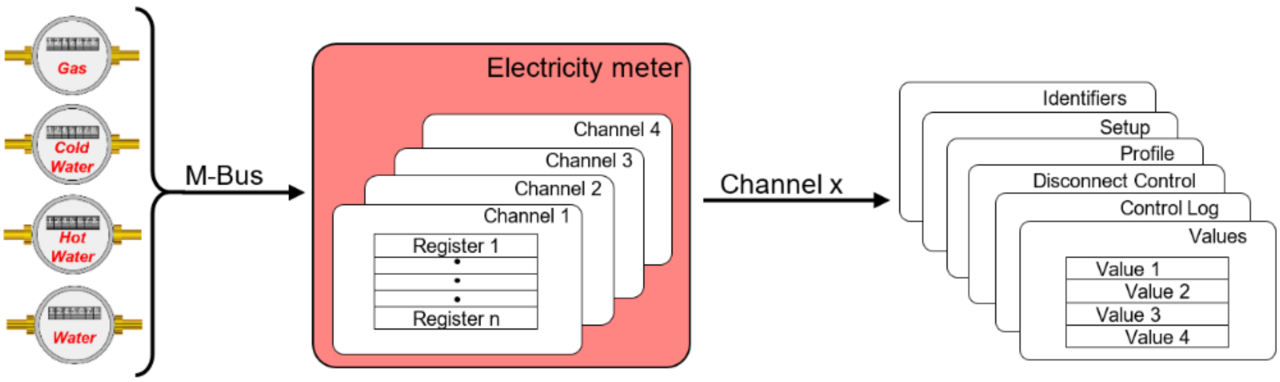


Figure 131: The M-Bus channel model

Up to 8 values related to consumption data can be stored to the E-meter registers. Rule, how to map data from the M-Bus data message to the E-meter register, can be defined by setting a DIB/VIB register for particular channel (**M-Bus client channel *x*** (0-*x*:24.1.0*255; *x* = 1…4), attribute 3 – ***Capture definition***).

Stored consumption values are available to a Central system (CS) as an extended registers. Billing data can be retrieved daily, weekly, or monthly, depending on E-meter configuration.

NOTE

Daily retrieving of billing data is available only as an option (see chapter *10.8.6. M-Bus master daily load profile (optional)*).

10.2. Wired connection

Wired M-Bus communication is implemented according to M-Bus standards EN 13757-2 and EN 13757-3.

The wired interface uses a two-wire system that provides power for the M-Bus devices. The bus interfaces of the slaves are polarity independent – both communication wires can be interchanged without affecting the operation of the M-Bus devices.

According to the standard, the E-meter allows a total maximum current consumption of 16 unit loads, where one unit load is defined as the maximum mark state current of 1.5 mA.

NOTE
If any M-Bus device (especially wireless with dongle) does not meet the requirements of maximum 4 unit loads of current consumption, there is no guarantee that M-Bus communication will work properly.

NOTE
The communication settings on M-Bus interface is fixed to 2400 baud, parity even, 8 data bits, 1 stop bit.

10.3. Wireless connection

Wireless M-Bus communication is implemented according to the M-Bus standard EN 13757-4 and the OMS specification 4.1.2. Due to the battery supply, the M-Bus device is most of the time in a sleep mode to save the energy. Periodically it wakes up, establishes unidirectional communication according to T1 mode, sends its measuring data to the E-meter and goes back to the sleep mode. The communication can also be bidirectional according to a T2 mode where the E-meter sends a command, a request or a data to M-Bus device. This can be performed during so called Frequent Access Cycle (FAC).

10.3.1. Wireless communication modes and sub-modes

A physical layer of a wireless M-Bus protocol is implemented according to the EN 13757-4 standard. In the standard, several different operation modes and sub-modes for the wireless M-Bus protocol are defined. By the meter and a wireless M-Bus module integrated in the meter, the following modes and sub-modes are supported:

- a **mode T** – a frequent transmit mode (868 MHz): **sub-modes T1** and **T2**
- a **mode C** – a compact mode (868 MHz): a **sub-mode C1**

For all sub-modes, an FSK modulation is used.

10.3.2. Message transactions

Several message flows between E-meter and wireless M-bus device are defined. All possible message transactions are described in Table 106.

Message type and content	Initiator	Data direction
Normalization message *: reset link, stop FAC	E-Meter	—
Meter data message: billing data, status, version	M-Bus device	M-Bus device → E-Meter
On-demand data message *: billing data, status	E-Meter	M-Bus device → E-Meter
Control message *: clock synchronization	E-Meter	E-Meter → M-Bus device
Unencrypted message *: set key	E-Meter	E-Meter → M-Bus device
Installation message *: broadcast and registration	M-Bus device	—
Control message *: clear alarm	E-Meter	E-Meter → M-Bus device
Control message *: FW upgrade commands and change readout list	E-Meter	E-Meter → M-Bus device

* message type applies only to bi-directional M-Bus devices

Table 106: Messages in wireless connection

10.4. Wireless M-Bus module

A wireless M-Bus module (wM-Bus module) is an M-Bus communication module integrated in the E-meter (under meter cover) and is responsible for the wireless communication according to standards EN 13757-3 and EN 13757-4. It supports two communication interfaces, a serial communication with the main microcontroller on the E-meter and a wireless M-Bus communication with a remote M-Bus device. The wM-Bus module handles unidirectional and also bidirectional communication between the E-meter and the wM-Bus device. If the wM-Bus supports only unidirectional communication, bidirectional communication is not possible.

The E-meter and the M-Bus device have the whole control on the communication process. The wM-Bus module uses a mechanism of passing-through of all received messages on both interfaces. In general, when the wM-Bus module receives a message from the E-meter or the M-Bus device, it changes the format of the message accordingly as required by receiving device and sends the message further to the destination device. When the wM-Bus module receives regular messages from the M-Bus device it just passes them through to the E-meter. If the E-meter sends a data to the wM-Bus module, messages need to be buffered in the wM-Bus module as long as new Frequent Access Cycle (FAC) is opened by the M-Bus device.

The E-meter and the M-Bus device are responsible for handling the security part of the communication, where all secure data are stored in a non-volatile memory of the E-meter (security keys, invocation counters…). The wM-Bus module has no information regarding security keys.

wM-Bus modules cannot be exchanged on the field since the module is located inside the meter, under the meter cover. The wM-Bus module uses a serial communication interface protocol between the module and the E-meter. It works as a transparent communication interface between the E-meter and the wM-Bus device.

After the E-meter startup, a wM-Bus module detection is performed (only if the M-Bus type of the E-meter is set to wireless). When the wM-Bus module is detected, an M-Bus stack initialization is performed accordingly. After that, the communication between the E-meter and the M-Bus device can be established.

The serial communication interface for wM-Bus module is set as follows:

- **Baud rate**: 115200 bauds
- **Parity**: none
- **Data bits**: 8
- **Stop bit**: 1

NOTE
The wM-Bus module is able to communicate with up to 4 wireless M-Bus devices.

NOTE
In case of bidirectional communication, the integrated wM-Bus module can store up to 2 command messages (per channel).

NOTE
In case of bidirectional communication, the E-meter can restore buffered messages in the wM-Bus module after power outage.

NOTE
In order to enable the M-Bus communication, ensure proper configuration of inputs/outputs. This is configured through objects ***Configurable IO 5*** (0-0:196.3.5*255) and ***Configurable IO 6*** (0-0:196.3.6*255). The following values shall be set:

- object ***Configurable IO 5***: value 0x2A000000
- object ***Configurable IO 6***: value 0x2B000000

NOTE
In unidirectional operation mode, some messages may get lost due to disturbances or interference among various devices.

10.5. Firmware upgrade of wM-Bus module

An Image upgrade process of a wM-Bus module consists of two steps, transmission of the image from a HES to the E-meter, and then from the E-meter to the wM-Bus module. In the first part, an Image transfer mechanism is used as described in chapter 12. FIRMWARE UPGRADE.

In the second part, the wM-Bus module uses a manufacturer specific protocol.

E-meter manufacturer digitally signs the module image, adds a pre-defined identification, and delivers the image to the customer (HES) in secure way. HES sends this image over the P3 communication interface to the E-meter, using the Image transfer mechanism. Image is stored into non-volatile memory of the E-meter. When complete image is transferred, the verification and activation of the image is performed. At this point, the upgrade process on the serial interface between E-meter and wM-Bus module is started. When complete image is transferred, wM-Bus module verifies it. If verification fails, an image is rejected, otherwise the image is accepted. When the image is accepted, module gets restarted and starts using a new image. E-meter updates the *Image transfer status* attribute of the **Image transfer** object (0-0.44.0.0*255) accordingly.

NOTE

If power outage of the E-meter occurs during block data transfer, then E-meter restarts the complete image upgrade process after power return.

If power outage of the E-meter occurs during image verification or during image re-programming on the wM-Bus module side, then bootloader in wM-Bus module ensures that after power return the image upgrade process is continued and finished successfully.

NOTE

Ongoing image upgrade process can be restarted with another start attempt of upgrade process by HES.

NOTE

Downgrading or upgrading the same image to the wM-Bus module is rejected and the Image transfer status is set to “Image transfer failed”.

NOTE

An upgrade of the wM-Bus module is only possible if no wired M-Bus devices are installed on the E-meter.

For more information about the wM-Bus module image handling, refer to chapter 12. FIRMWARE UPGRADE.

10.6. Encryption

10.6.1. Data encryption of user data

All M-Bus messages between an E-meter and wired/wireless M-Bus devices have user data encrypted.

Wired M-Bus exceptions:

Key exchange and *Set new address* command messages are exceptions and are always sent unencrypted. Also, during the installation process, there may be messages sent unencrypted until the encryption between the E-meter and the M-Bus device is established.

Wireless M-Bus exceptions:

In bidirectional communication, *Key exchange* command message is an exception, which is always sent unencrypted. Also, during binding process there may be a short period of time where some messages are not encrypted.

Encryption modes supported by the E-meter are:

- Encryption mode 0 (no encryption),
- Encryption mode 5,
- Encryption mode 7,
- Encryption mode 9.

Encryption mode 0

Encryption mode 0 represents an unencrypted message where the user data is sent right after the configuration word. The structure of unencrypted data is presented in Table 107.

Field	Configuration word	Unencrypted data
Size	2 bytes	…

Table 107: Structure of unencrypted part of the message, using encryption mode 0

Encryption mode 5

The encrypted part of the message follows right after the header part. The structure of encrypted data is presented in Table 108.

Encryption mode 5 uses the security mechanism AES-CBC-128.

Field	Configuration word	Decryption verification (encrypted)	Encrypted data	Unencrypted data (optional)
Size	2 bytes	2 bytes	16 * NNNN - 2	…

Table 108: Structure of encrypted part of the message, using encryption mode 5

Encryption mode 7

Implementation of encryption mode 7 is in accordance with Open Metering System (OMS) specification.

Encrypted part of the message is followed right after the header part. General message structure behind (and including) the Configuration field for mode 7 is presented in Table 109. Optional Key version, Message counter, TPL padding and Unencrypted data fields are not used in OMS.

Field	Conf. word	Conf. word extension	Key version (optional)	Message counter (optional)	Decryption verification (encrypted)	Encrypted data	TPL padding (optional)	Unencrypted data (optional)
Size	2 bytes	1 byte	(1 byte)	(4 bytes)	2 bytes	16 * NNNN - 2	(1 to 16)	…

Table 109: Structure of encrypted part of the message, using encryption mode 7

Encryption mode 7 uses security mechanism AES-CBC with ephemeral key of 128 bits and a static Initialisation Vector IV = 0 (16 bytes of 00h). Ephemeral key is used for one message only. Encryption mode 7 is a symmetric encryption method.

The ephemeral key is generated with a Key Derivation Function (KDF), which requires a Message counter (from AFL layer – Authentication and Fragmentation Layer).

Encryption mode 9

Encrypted part of the message is followed right after the header part. The structure of encrypted data is presented in Table 110.

Encryption mode 9 uses the security mechanism AES-GCM-128. GCM is an algorithm for authenticated encryption with associated data. It uses a symmetric key block cipher with block size of 128 bits.

Field	Configuration word	Encrypted length	Unencrypted length	Invocation counter	Encrypted data	GCM authentication tag
Size	2 bytes	1 byte	1 byte	4 bytes	N bytes	12 bytes

Table 110: Structure of encrypted part of the message, using encryption mode 9

10.6.2. Encryption key exchange procedure

The E-meter supports Key exchange procedure. However, it is used only with bidirectional M-Bus devices.

Two types of M-Bus keys are used for M-Bus communication:

- default key,
- user key.

Default key of M-Bus device is a unique key guaranteed by the supplier. It is used to decrypt a new key sent through the M-Bus (P2) interface.

User key is used to encrypt/decrypt all messages received over the M-Bus interface. New installed M-Bus devices can be either unencrypted or encrypted. In case of unencrypted device, an unencrypted communication between E-meter and M-Bus device is allowed until new user key is transferred to M-Bus device. Since then, all communication between devices is encrypted.

After installation, the M-Bus device sends data to the E-meter. The message contains unencrypted Short ID of the M-Bus device, which is stored in the E-meter and is available to central system (CS). CS then transfers a new user key to both communication devices.

User key is transferred to the E-meter through encrypted P3 communication interface as a plain octet string by invoking the *Set encryption key* method of the **M-Bus client channel *x*** object (0-*x*:24.1.0*255; *x* = 1…4). By invocation of the *Transfer key* method, the same user key is transferred over the M-Bus interface to the M-Bus device.

In mode 5, the user key is sent to M-Bus device being wrapped by the default key. In mode 9, the user key is sent to M-Bus device being encrypted and authenticated with the default key.

NOTE

Key exchange message is always sent to M-Bus device unencrypted. A key transfer of wireless M-Bus devices is supported by the E-meter.

The structure of encrypted key data is presented in Table 111.

Key ID	Key size	Key value
1 byte	1 byte	»Key size« bytes

Table 111: Key data in mode 9

User key has its own ID as defined in Table 112.

Key ID	Description
0	User key

Table 112: Key ID of the User key message

10.6.3. Encryption key exchange procedure using SITP (only for wired M-Bus)

As defined in the EN 13757-7 standard, the Security Information Transfer Protocol (SITP) is a specific application protocol, which is intended for all types of security information handling and management of security relevant services in a metering system. The main use case of the SITP is to update the key information in an M-bus device. The implemented message flow for transfer key and its activation for wired M-bus is in accordance with the IDIS specification (IDIS Interoperability Specification, Package 3, IP Profile X, Edition 1.0, 2018).

SND-UD2 is used to transport the key information data to the wired M-Bus device.

NOTE

According to the OMS (Open Metering System Specification) specification, SND-UD2 shall be used in wireless M-Bus only and not for fragmented messages. Nevertheless, our current implementation uses SND-UD2 message for the transport of key information in wired M-Bus as well (deviation from the OMS specification). The main reason for using the SND-UD2 message is that a subsequent response with status information (RSP-UD) is expected if SITP is used.

Distinguishing between the existing and the new key transfer procedure is done based on the key transfer data length. If the key transfer data length is longer than 16 bytes, then a SITP key transfer is used.

NOTE

Key exchange messages using the SITP are always sent to M-Bus using TPL (Transport layer) security. Using SITP is not bound to specific encryption mode. SITP is in current implementation used only when key transfer data is longer than 16 bytes. If key transfer data is 16 bytes long, then general DSMR key transfer procedure is used as it is described in the chapter *10.6.2. Encryption key exchange procedure*.

10.7. M-Bus binding

This chapter describes the general binding procedures for IE.x type of the meter.

Up to four wM-Bus devices can be bound to the E-meter. The E-meter allows to bind either wired or wireless M-Bus devices, but only one type of devices can be installed to the E-meter at the same time (unless using a dongle). If the first installed M-Bus device is wired, then only additional three wired devices are allowed to be installed by the E-meter. The same rules apply also for binding wireless M-Bus devices.

The E-meter supports the following binding procedures (Figure 132):

- binding without using any tool (manually with a binding button) With manual procedure, an installer controls the installation of the device by handling the binding button and the display.
- binding using a tool
    - with **HES**, the device can be installed remotely through the P3 interface of the E-meter,
    - with **PDA**, the device can be installed locally through the P0 interface of the E-meter.

Figure 132 presents possible binding procedures.

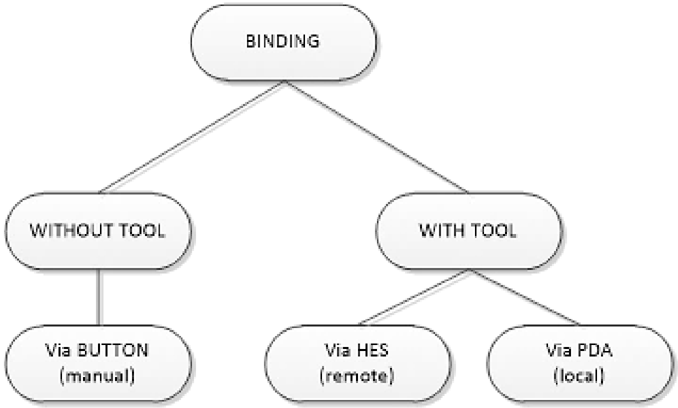


Figure 132: Diagram of supported binding procedures

10.7.1. The role of E-meter buttons and LCD in the binding procedure

The E-meter is equipped with two buttons on the front plate. Typically, the lower button is used for M-Bus binding. Optionally (by a customer request), the lower button can be sealed. For more information about buttons and their general functionalities and use, see chapter *9.3.8. Functionality of buttons and the disconnector status LED.*

ATTENTION

Due to a different meter configuration, pay attention, which button on the meter front plate is configured with a binding functionality. Typically, the lower button is configured as a binding button.

When navigating through the menus using the binding button, several messages are displayed on LCD of the E-meter. For more information about the LCD, refer to chapter *9.3. Display operation and use*.

Long press of the binding button usually means that displayed option is selected, and extra-long press means exit from the menu.

Additional help messages on LCD

In the upper left corner of display, the following messages are displayed:

- Enter – for selection of given option
- Escape – for exit from current menu

After the binding button is pressed for 2 seconds, in the upper left corner (alphanumeric field with small digits) the message “Enter” is displayed. If the button is released, displayed option (in the alphanumeric field with large digits) is selected. If the button is kept pressed, in the upper left corner the message “Escape” is displayed. If the button is released, an exit from current menu is performed.

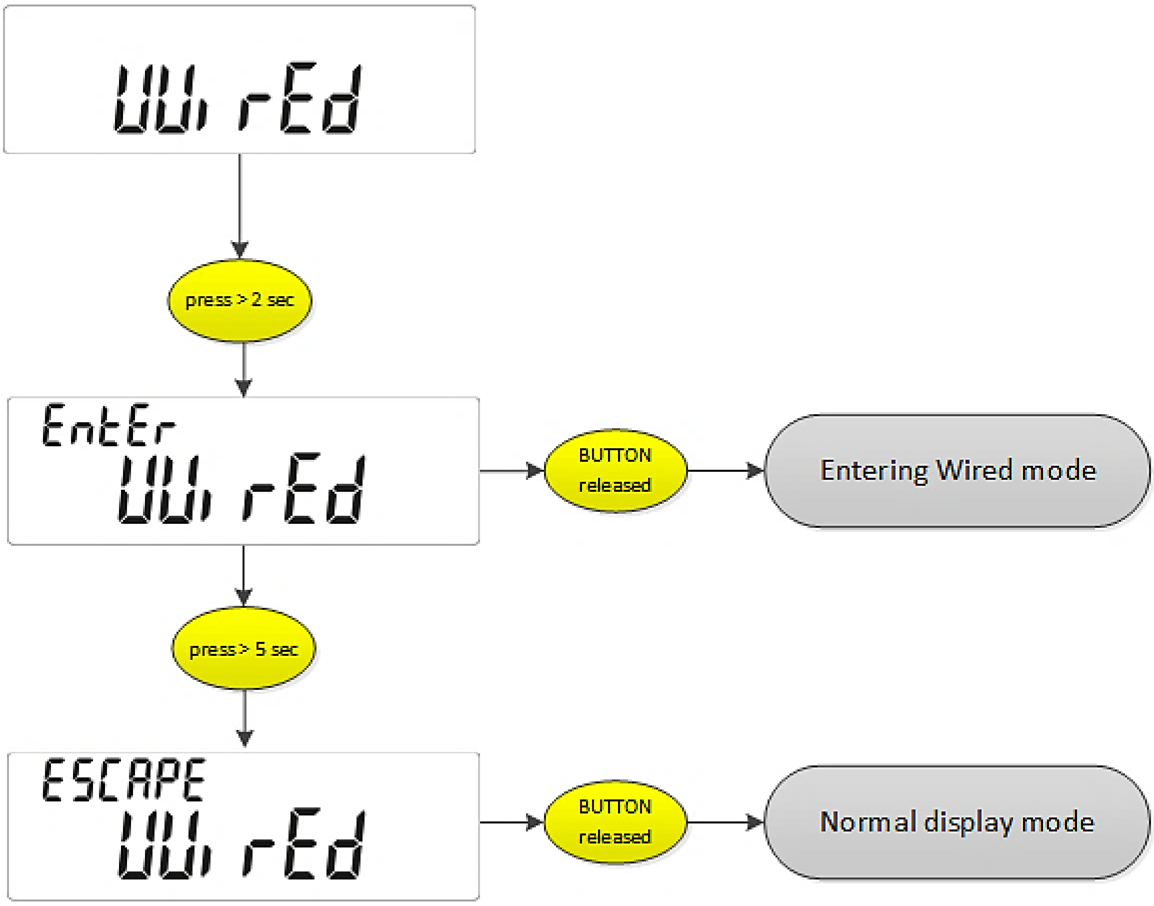


Figure 133: Additional help messages

10.7.2. Binding process

M-Bus devices can be bound to the E-meter manually with the presence of the installer. A manual binding process is started by a SHORT press of the binding button. If no M-Bus device is installed yet, then an installer first needs to decide whether to install a wired or a wireless device type. After the device type selection, a binding procedure on a wired or a wireless interface is started accordingly.

Depending on whether any of the M-Bus devices are already bound or not, the binding procedure varies.

NOTE

When all four channels are empty, **M-Bus technology type** (0-0:128.50.11*255) is by the default set to 0 (none - M-Bus type is not set). Due to this fact, the following triggers **DO NOT** start the wired binding procedure:

- E-meter power down/power up
- Execution of ***Script 1*** of **M-Bus install** object (0-0:10.50.128*255)
- Execution Slave install method on individual M-Bus channel.

Triggers for the wired binding procedure, **when no M-Bus device is bound with the E-meter,** are:

- The Manual binding with the binding button by selecting "Wired" with long press (2 s < T_p < 5 s) when shown on E-meter LCD.

- In **M-Bus technology type** object (0-0:128.50.11*255) change the value from 0 to 1 and write it to the E-meter.

Triggers for the wired binding procedure, **when one, two or three M-Bus devices are already bound,** are:

- The Manual binding with the binding button.
- Power-up of the E-meter.
- Execution of ***Script 1*** of **M-Bus install** (0-0:10.50.128*255).
- Execution of the ***Slave install*** method (with known primary address) on an M-Bus channel.

Slave install method of the object **M-Bus client channel *x*** (0-*x*:24.1.0*255; *x* = 1…4) is shown in Figure 134.

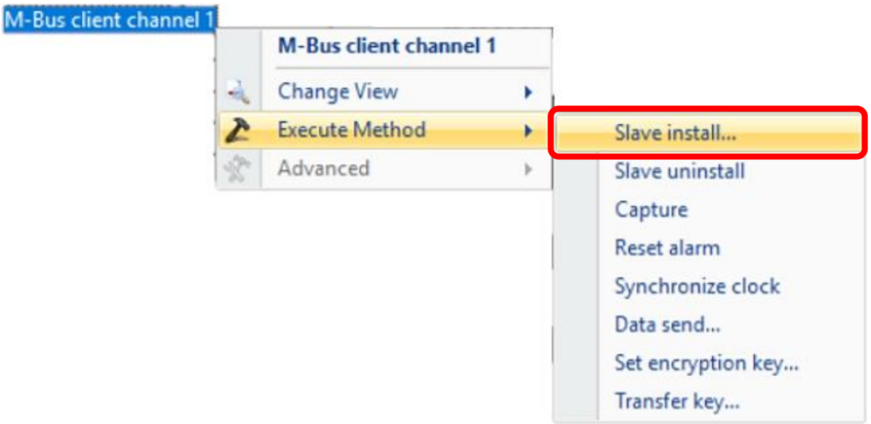


Figure 134: Slave install method of M-Bus client channel x (example)

All actions listed above start the same procedure with scanning for M-Bus devices connected to the E-meter. E-meter checks the primary addresses from 1 to 6 and also for 0, if there is still place for additional device to install (if not all M-Bus channels are already occupied). After that, it starts also with secondary search.

Primary search procedure is executed always when binding process is started. After primary search is finished, secondary search is started. It is started only under certain conditions:

- not all M-Bus channels are already occupied;
- secondary search is enabled (***bit 11*** of **M-Bus client configuration** (0-0:28.50.1*255) object).

Triggers for wireless binding procedure are:

- manual binding with the binding button
- binding via HES or locally via PDA tool

The following chapters describes all binding procedures.

10.7.2.1. Binding without a tool

10.7.2.1.1. Start manual binding procedure

10.7.2.1.1.1. M-Bus type selection mode

The precondition for this scenario is that no M-Bus device is installed on the E-meter at the moment of installation. Therefore, an installer needs to decide which device type is going to be installed (wired or wireless). The M-Bus type selection mode is entered from the *Normal display mode* with the SHORT press of the binding button. The *Normal display mode* is meant here as an *Auto scroll display mode* or a *Manual scroll display mode*.

Depending on the selected M-Bus device type, the E-meter enters to the wired or the wireless mode accordingly.

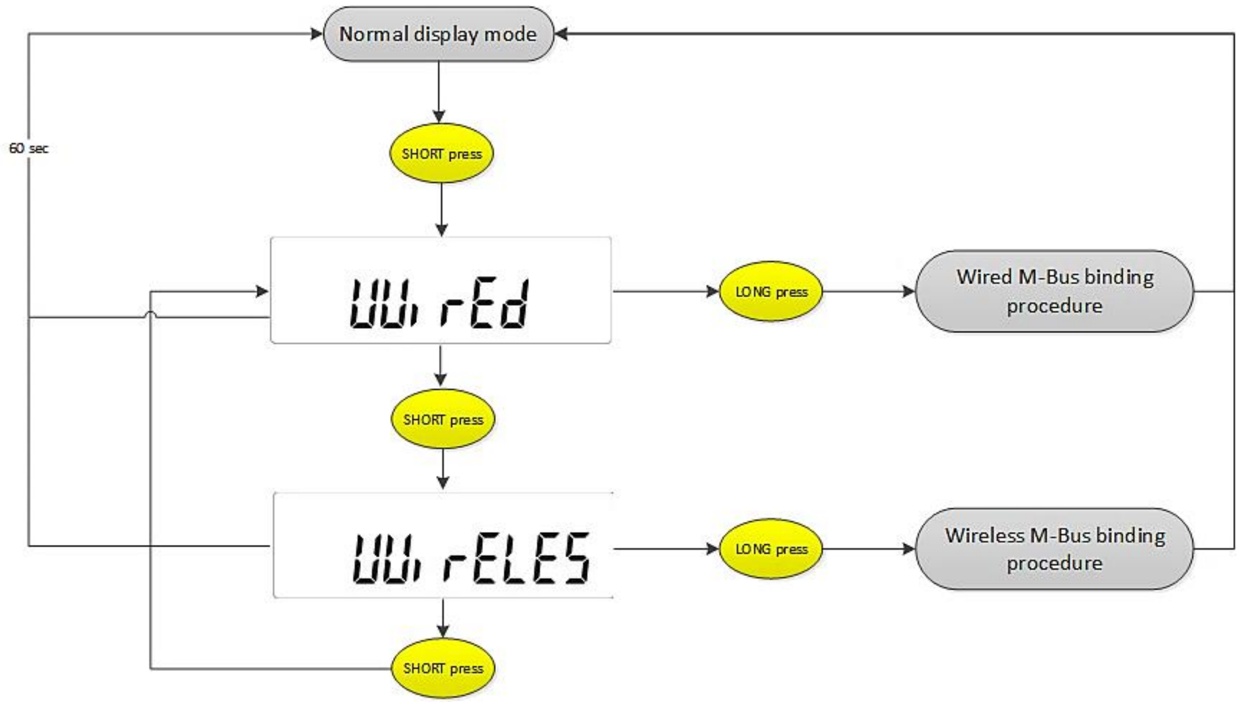


Figure 135: M-Bus type selection mode

10.7.2.1.1.2. Binding procedure in wired M-Bus mode

If there is already at least one wired device installed, the E-meter by the SHORT press of the binding button immediately starts with the wired binding procedure.

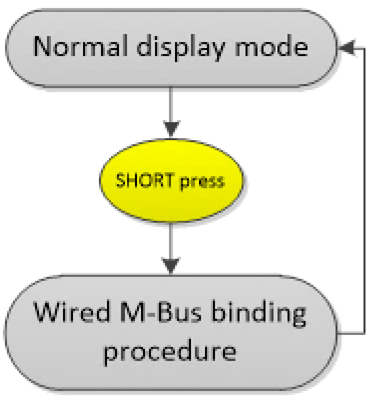


Figure 136: Start binding procedure for wired M-Bus mode

10.7.2.1.1.3. Binding procedure in wireless M-Bus mode

If there is already at least one wireless device installed, the E-meter by SHORT press of binding button immediately starts with wireless binding procedure.

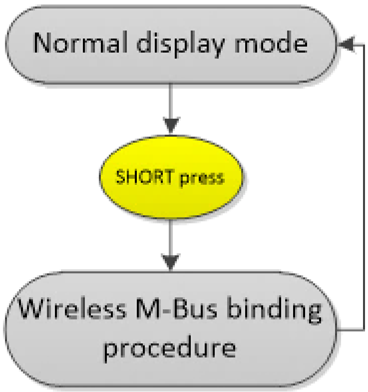


Figure 137: Start binding procedure for wireless M-Bus mode

10.7.2.1.1.4. No M-Bus channels available

If all M-Bus channels are already occupied with installed devices, then there is no possibility to install additional M-Bus device. Short press of binding button indicates “no RESourcE” on display for 2 seconds as it is presented in Figure 138 .

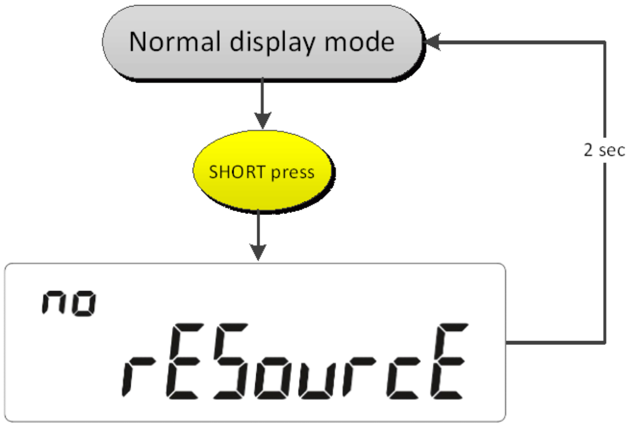


Figure 138: Start binding procedure when no free M-Bus channel available

10.7.2.1.2. Wired binding procedure

10.7.2.1.2.1. Manual binding with a button

E-meter starts to search for connected devices. During polling for the devices, a ''SEArch'' message with progress indication is displayed until the first M-Bus device is detected. After that, identification number of the installed device is displayed with corresponding channel information. If more M-Bus devices are discovered during installation procedure, all identification numbers of those devices with corresponding channel number will be automatically scrolled on the display with period of 10 seconds. After an interval of 10 minutes the pop-up list will disappear, and display mode will be changed to auto scroll mode. Auto scroll mode can be entered with EXTRA LONG button press also. The searching progress is presented with sequential increase of upper dots on the display. The Figure 139 presents whole manual binding procedure.

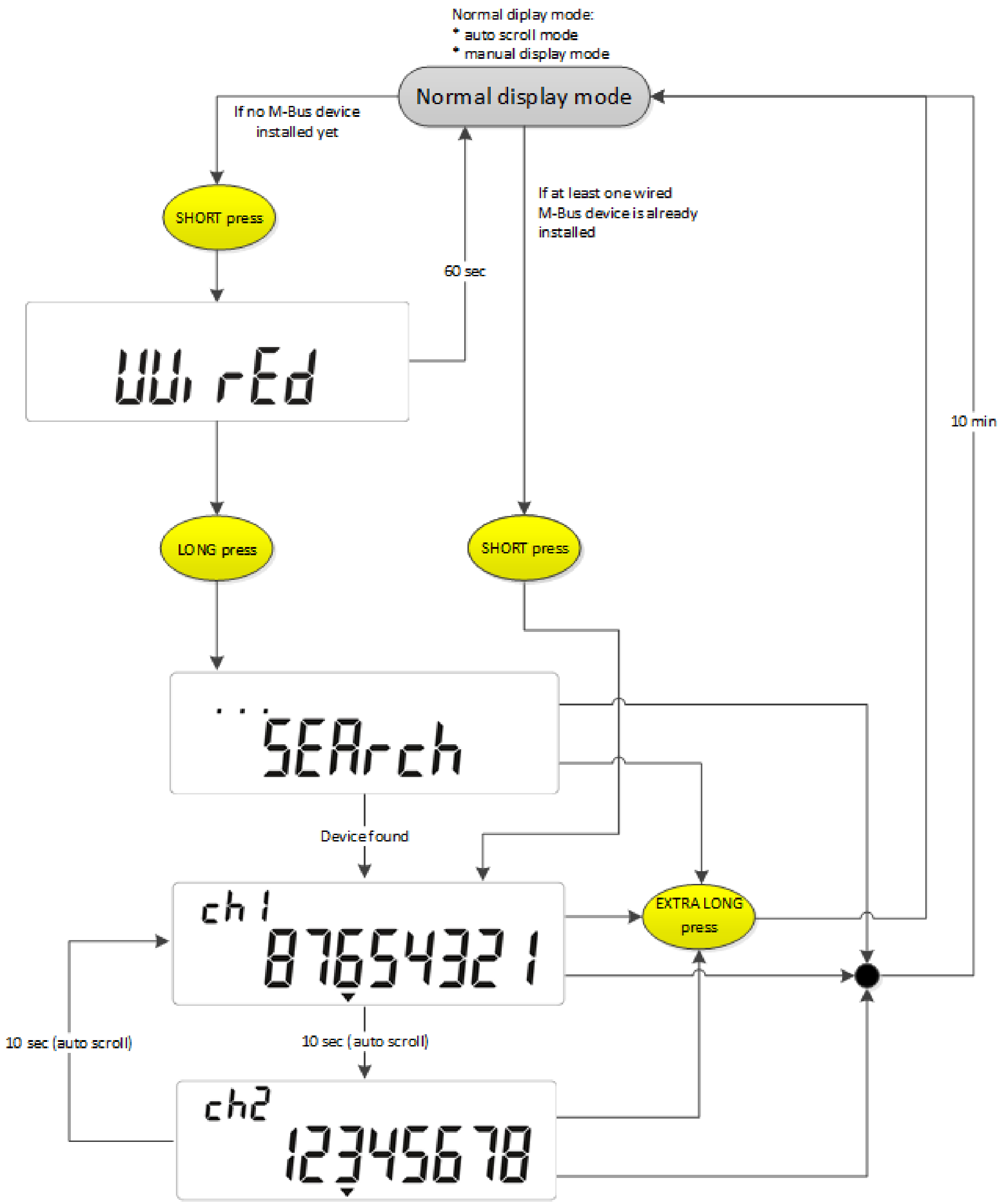


Figure 139: Wired M-Bus binding procedure

Scrolling timeout between identification numbers of each installed M-Bus device is defined with a **Display auto-scroll roll time** object (0-0:196.1.9*255). A default value for auto-scroll roll time is 10 seconds.

10.7.2.1.3. Wireless binding procedure

General binding process consists of four main steps:

1. Start the installation mode (E-meter and wireless M-Bus device). If there is already at least one wireless device installed, then E-meter immediately starts with wireless binding procedure (after short press of binding button).
1. Presentation and manual selection of M-Bus device from the list on display of the E-meter.
2. Binding of M-Bus device.
3. Exit the installation mode (E-meter and M-Bus device).

Exit from the installation mode for E-meter:

- SHORT button press after successfully/unsuccessfully binding of a M-Bus device
- EXTRA LONG button press
- 30 minutes timeout after the last interaction with button or display

10.7.2.1.3.1. M-Bus device already bound on another E-meter

If an M-Bus device is already bound to another E-meter, the LCD displays a message “bound already” after the device is selected with long button press, as shown in Figure 140.

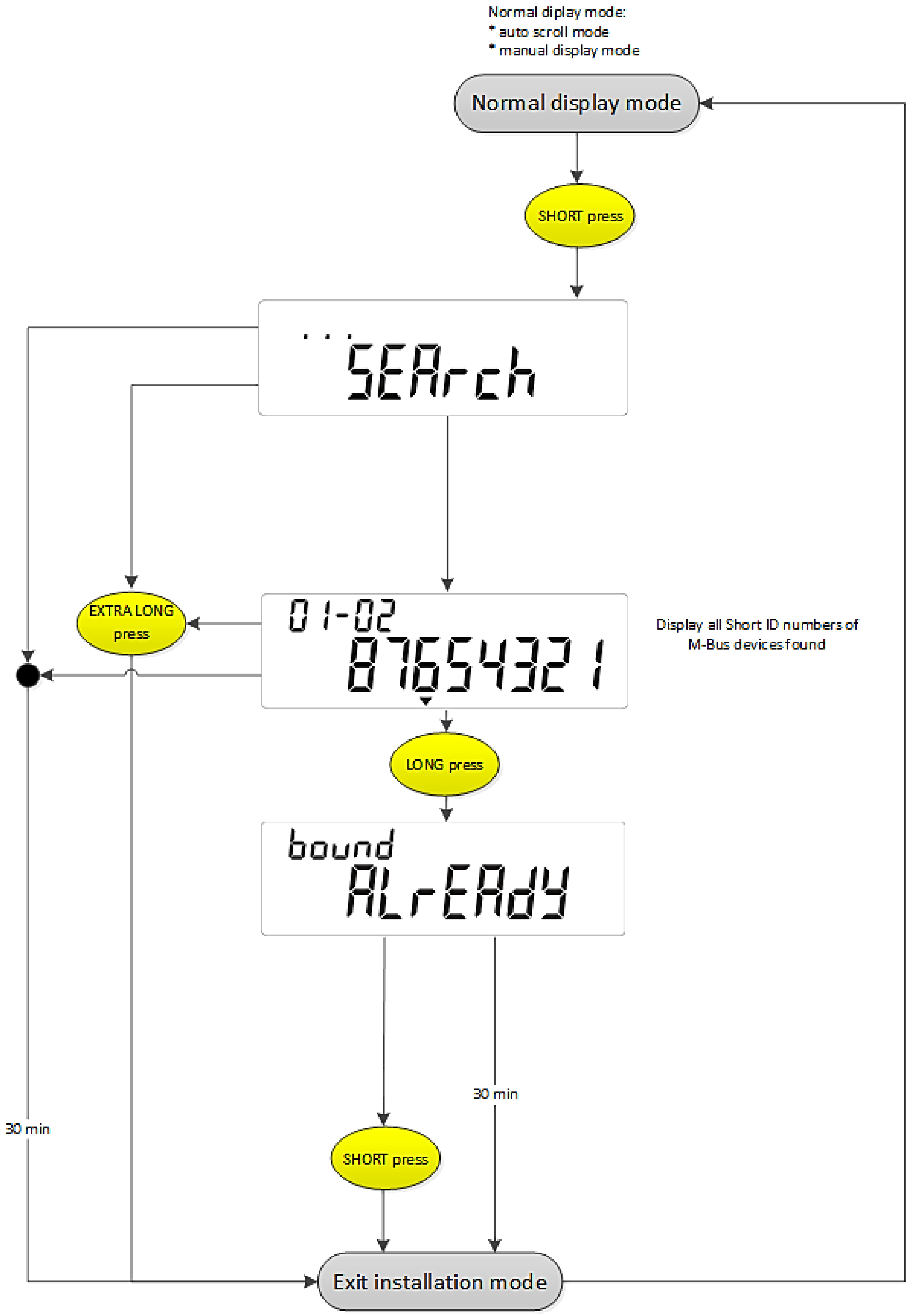


Figure 140: M-Bus device already bound to another E-meter

10.7.2.1.3.2. M-Bus device with bidirectional communication

M-Bus device with bidirectional communication for binding uses send installation message (SND_IR). After device is selected with long button press, display prints message “bind” in the upper left corner, indicating that E-meter is waiting for second SND_IR message and SND_NR message. Binding process is presented in Figure 141.

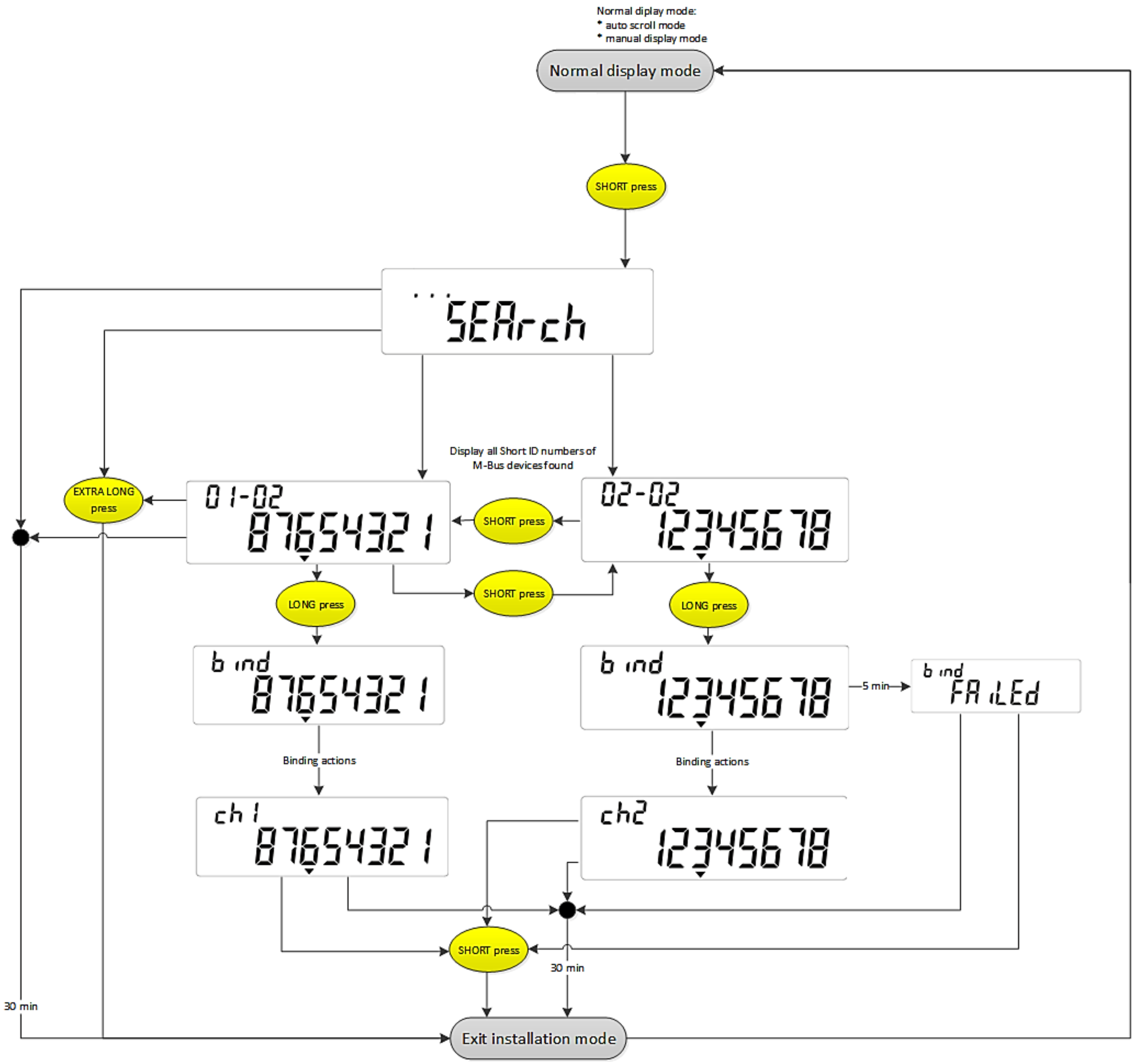


Figure 141: Wireless M-Bus binding procedure – bidirectional communication

10.7.2.1.3.3. M-Bus device with unidirectional communication

M-Bus device with unidirectional communication for binding uses SND_NR hourly message. After device is selected with long button press, display prints the channel number the device was bound to. Binding process of M-Bus device with unidirectional communication mode is presented in Figure 142.

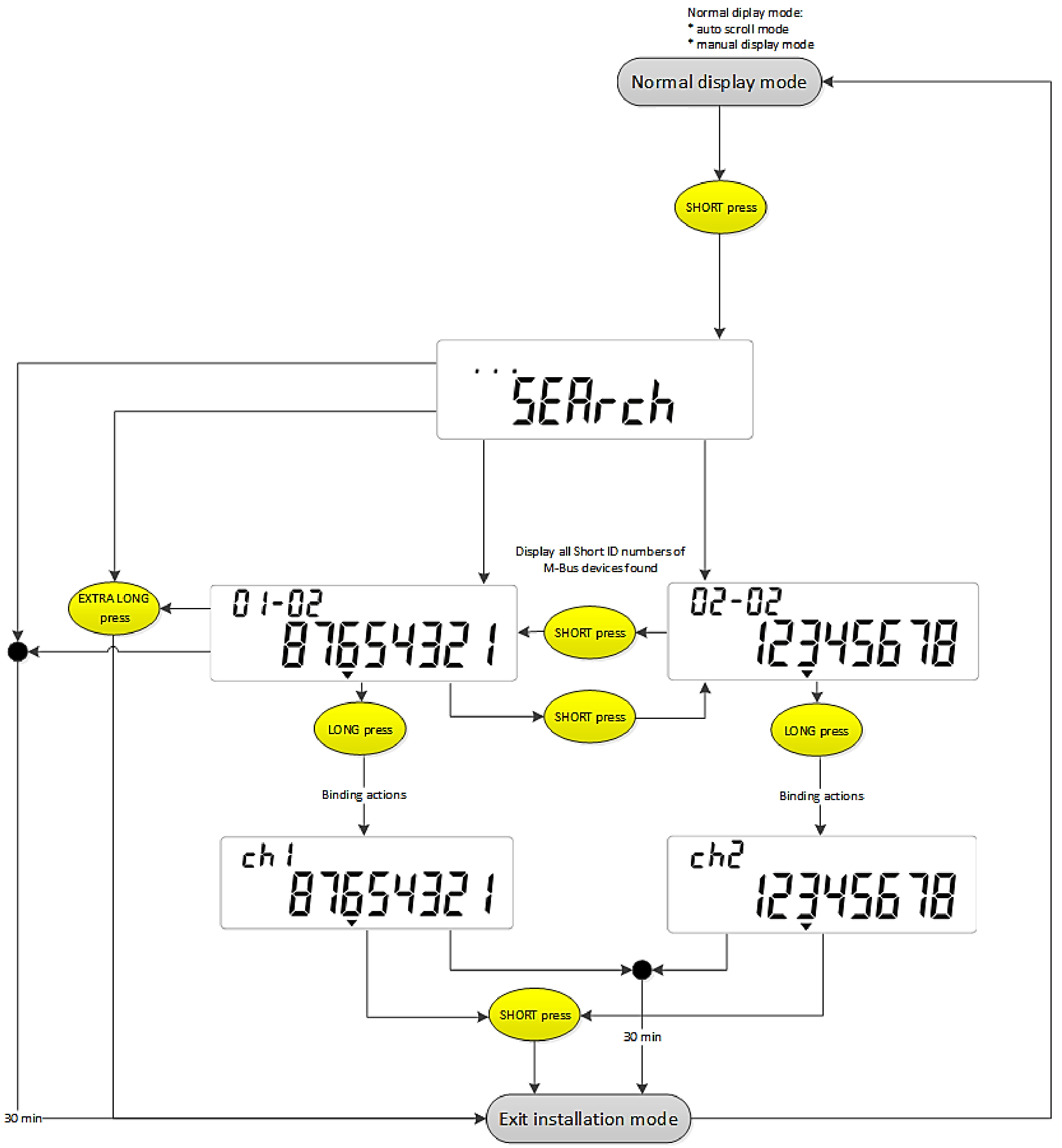


Figure 142: Wireless M-Bus binding procedure – unidirectional communication

10.7.2.2. Binding with a tool

Binding can be performed remotely using HES or locally with PDA tool. Tool is used for entering of M-Bus device identification data into E-meter (Identification number, Manufacturer ID, Version, Device type). Data are needed at installation procedure of wireless M-Bus devices. M-Bus type wireless is selected with setting of M-Bus technology type object (0-0:128.50.11*255) to value 2. If no wireless M-Bus device is installed after 5 minutes, M-Bus type is automatically changed back to none (value 0).

In general, no identification data is needed for installation of wired M-Bus devices. Primary address and capture time for wired M-Bus devices can also be entered. M-Bus type wireless is selected with setting of

M-Bus technology type object (0-0:128.50.11*255) to value 1. If no wired M-Bus device is installed after primary and secondary search, M-Bus type is automatically changed back to none (value 0).

M-Bus type can be set remotely only if no M-Bus type is selected yet. Direct change of active M-Bus type to another is not allowed. All existing M-Bus devices must be deinstalled first, in order to change the M-Bus type. M-Bus type is automatically set to none (from already set wired/wireless type) when no M-Bus devices are installed on the E-meter.

10.7.3. Deinstallation process

Deinstallation of the M-Bus devices can be performed manually with pressing binding button or using a tool.

10.7.3.1. Manual deinstallation

Manual deinstallation procedure for M-Bus devices can be triggered by EXTRA LONG press of a binding button. In this case, display shows “Enter Deinstall” message as shown in the Figure 143 and E-meter enters in the deinstall menu. A deinstallation can be triggered from any of the display modes: auto scroll mode, manual scroll mode. If no M-Bus is installed, then button press is ignored.

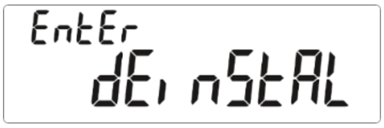


Figure 143: Enter deinstall menu

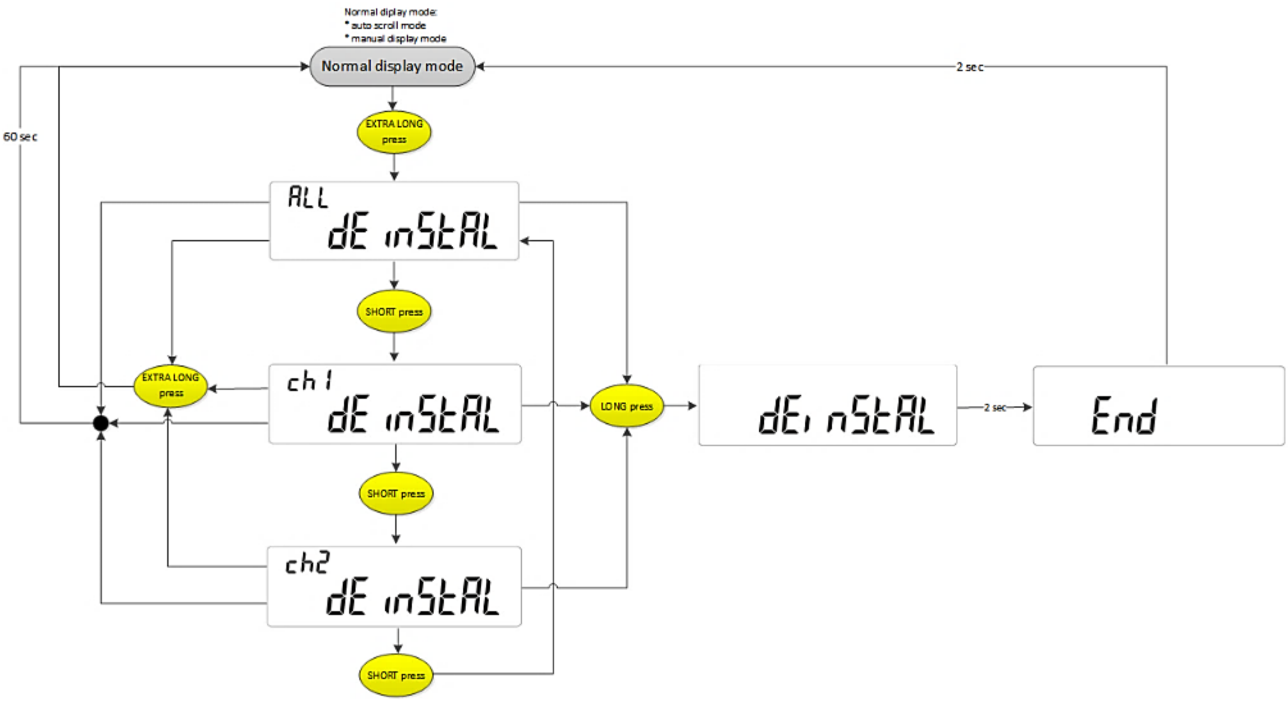


Figure 144: Manual deinstallation procedure for the M-Bus device (wired or wireless) – when 2 devices are installed

10.7.3.2. Deinstallation using the tool

Deinstallation with a tool can be performed remotely via HES or locally using PDA tool.

Remote deinstallation is performed by HES, where one device per channel can be deinstalled at the time. HES invokes the ***Slave uninstall*** method (Figure 145) of the **M-Bus client channel *x*** object (0-*x*:24.1.0*255; *x* = 1…4), which triggers deinstallation of the M-Bus device from the particular channel.

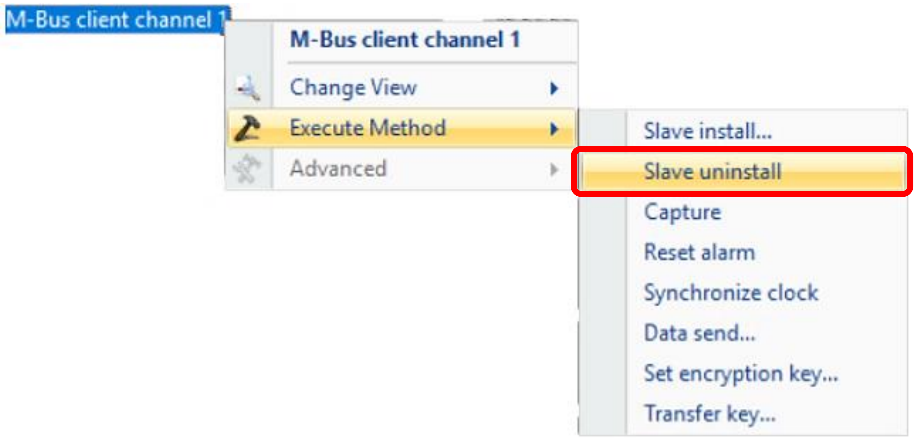


Figure 145: Slave uninstall method of M-Bus client channel x (example)

Local deinstallation can be executed with using a PDA tool (with the same method as described above).

10.7.4. M-Bus display cursor

Wired M-Bus devices

Multi-utility cursor (MU) is active on the display as long as at least one M-Bus device is physically connect-ed to the bus. If none of the devices are connected to the bus, then MU cursor turns off after first capture even if the devices are correctly installed in the e-meter.

Wireless M-Bus devices

Multi-utility cursor is active on the display as long as at least one M-Bus device is installed on E-meter.

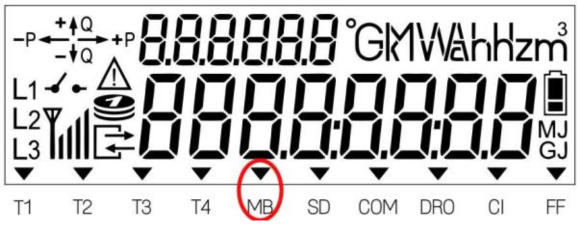


Figure 146: M-Bus display cursor

Multi-utility cursor will blink until E-meter is in search mode:

- After power-up, when searching for wired M-Bus devices. It is not possible to enter binding mode with binding button until search is in progress.
- After manually enter search mode for wired M-Bus devices (Figure 139).
- After manually enter search mode for wireless M-Bus devices (Figure 141).

NOTE

The Multi-utility cursor (MU) can be shown on the LCD only if it is defined in **Display cursors configuration** object (0-0:196.1.4*255).

10.8. Objects related to M-Bus

10.8.1. M-Bus client channel

E-meter uses four M-Bus interfaces which can be configured using instances of the **M-Bus client channel *x*** (0-*x*:24.1.0*255; (*x* = 1…4) *x* stands for a channel where corresponding M-Bus device is connected). Each M-Bus client channel object controls one M-Bus device.

M-Bus device is identified with its Short ID (Identification Number, Manufacturer ID, Version and Device type). These parameters are carried by the corresponding attributes of the **M-Bus client channel *x*** object.

Figure 147: M-Bus client channel x object (example of channel 1)

M-Bus port reference

The attribute provides reference to an ***M-Bus port setup*** object (0-0:24.6.0*255) used to configure an M-Bus port.

Capture definition

The attribute provides the array of *Data information block* (DIB) and *Value information block* (VIB) of an M-Bus device, which are stored in the E-meter. The array index of the particular DIB/VIB element represents a link to the corresponding M-Bus extended register **M-Bus value channel *x*, instance *y*** (0-*x*:24.2.*y**255; x = channel; y = index).

The elements DIB and VIB are described in EN 13757-3.

NOTE
Capture definition is cleared at the deinstall of the M-Bus device.

Capture period

This attribute applies only for wired M-Bus devices. The attribute represents the period in seconds for synchronously capturing M-Bus data.

Primary address

This attribute applies only for wired M-Bus devices. The attribute carries the *primary address* of the M-Bus slave device, in the range of 0...250. If the slave device is already configured and its primary address is different from 0, then this value shall be written to the *primary address* attribute. From this moment, the data exchange with the M-Bus slave device is possible. Otherwise, the *Slave install* method shall be used.

Identification number

The attribute is part of the Short ID. It is either a fixed fabrication number or a number changeable by the customer, coded with 8 BCD packed digits (4 bytes). The value can be within the range from 00000000 to 99999999. Short ID is retrieved from the header of every M-Bus message, which is always unencrypted.

Manufacturer ID

The attribute is part of the Short ID. It is formed from ASCII code as specified in EN 13757-3.

Version

The attribute is part of the Short ID. The attribute represents the hardware version of M-Bus device, which is fixed during its lifetime.

Device type

The attribute is part of the Short ID. The attribute represents the type of M-Bus device, according to EN 13757-3.

Access number

The attribute is part of the message header as specified in EN 13757-3. It is incremented by one after each transmission of the new message.

Status

The attribute represents a status of an M-Bus device. It is a part of the message header as specified in EN 13757-3. For all bits, logic level high means that error is present, otherwise not.

Bit	Description
0, 1	Application bit errors (for more information, see Table 114)
2	Power low (Battery replacement expected)
3	Permanent error
4	Temporary error
5	Customer specific
6	Customer specific
7	Customer specific

Table 113: M-Bus Status

Application Bits		Application Status Description
0	0	No error
0	1	Application busy
1	0	Any application error
1	1	Reserved

Table 114: M-Bus Status – Application bit errors

Alarm

The attribute is a part of the message header as specified in EN 13757-3.

NOTE

This attribute is not supported by the meter.

Specific methods

Specific methods of the **M-Bus client channel *x*** object are available by the right click on the object and selecting Execute Method; it opens a menu with available methods (Figure 148).

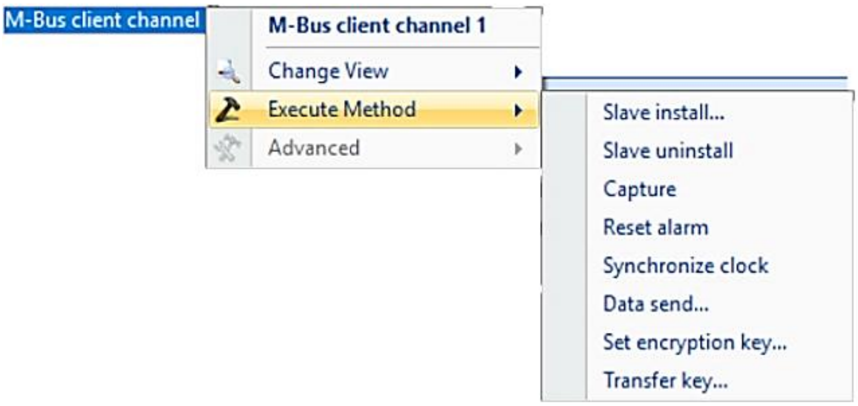
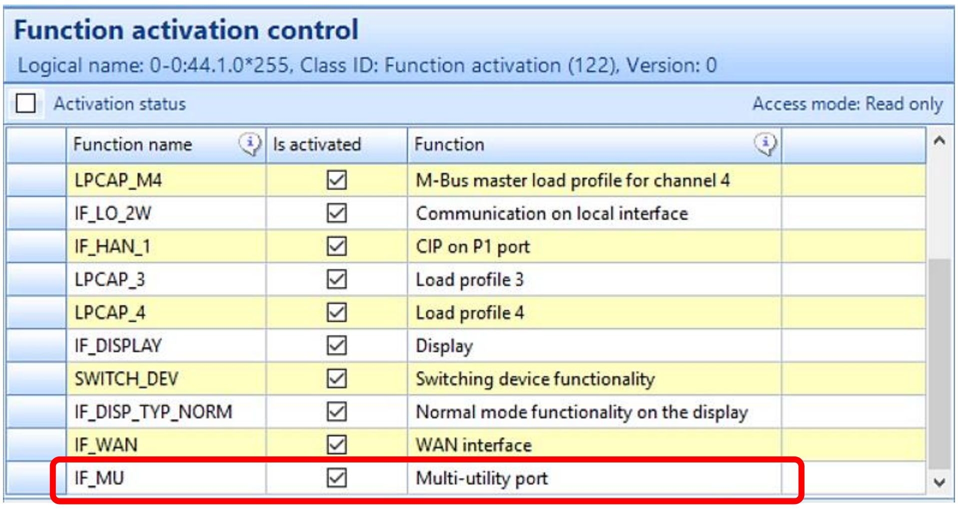


Figure 148: Access to specific methods of M-Bus client channel x object (example of channel 1)

NOTE

All methods can only be executed if function activation status for multi-utility port (**IF_MU**) is activated (**Function activation control** (0-0:44.1.0*255); see Figure 149). If it is deactivated, the executing of methods is rejected.



Function activation control

Logical name: 0-0:44.1.0*255, Class ID: Function activation (122), Version: 0

Activation status — Access mode: Read only

Function name	Is activated	Function
LPCAP_M4	☑	M-Bus master load profile for channel 4
IF_LO_2W	☑	Communication on local interface
IF_HAN_1	☑	CIP on P1 port
LPCAP_3	☑	Load profile 3
LPCAP_4	☑	Load profile 4
IF_DISPLAY	☑	Display
SWITCH_DEV	☑	Switching device functionality
IF_DISP_TYP_NORM	☑	Normal mode functionality on the display
IF_WAN	☑	WAN interface
IF_MU	☑	Multi-utility port

Figure 149: Activated Multi-utility port (IF_MU) in Function activation control object

Slave install

This method applies only for wired M-Bus devices. The method installs an M-Bus device to the E-meter. An argument of the method (data) is type of *Unsigned8* and represents primary address of the M-Bus device which is trying to be installed.

Slave de-install

The method deinstalls an M-Bus device from the E-meter. The following actions are performed:

- Short ID (identification number, manufacturer ID, version, device type) is set to 0.
- user key transferred previously to the M-Bus device is removed from E-meter memory, the default key in the M-Bus device is not affected.
- attribute configuration is set to 0.
- attributes encryption key status, access number, status, primary address, and alarm are set to 0.

According to the **M-Bus client configuration** object, also other actions can be performed on corresponding channel (*x*, where *x* = 1…4):

- reset of M-Bus value register (0-*x*:24.2.1*255),
- reset of M-Bus profile (0-*x*:24.3.0*255),
- reset of M-Bus control log (0-*x*:24.5.0*255),
- reset of M-Bus control event object (0-*x*:96.11.4*255).

Capture

This method applies only for wired M-Bus devices. The method captures values from the M-Bus devic*e.*

Reset alarm

This method applies only for wireless and bidirectional M-Bus devices. The method resets alarm state in the M-Bus device.

Synchronize clock

This method applies only for wireless bidirectional M-Bus devices. The method synchronizes the clock of the M-Bus device with the current time of the E-meter.

Data send

This method applies only for wireless bidirectional M-Bus devices. The method sends data to the M-Bus device.

Set encryption key

This method applies only for bidirectional M-Bus devices. The method sets *User key* to the E-meter. It is used for encryption and decryption of the messages between the E-meter and the M-Bus device. If the value of the key is set to zero, the encryption of M-Bus message is disabled.

NOTE

The method is rejected by the E-meter if it is invoked without the parameter (key length is 0).

Transfer key

This method applies only for bidirectional M-Bus devices. The method transfers *User key* to the M-Bus device. When the M-Bus device receives the message, it decrypts it with its own *Default key* and stores the new *User key* for further communications.

NOTE

The method is rejected by the E-meter if it is invoked without the parameter (key length is 0).

NOTE

All methods, except *Slave install*, are rejected by the E-meter if an M-Bus channel is empty.

10.8.2. M-Bus master port setup

A speed communication of an M-Bus master port can be read by the object **M-Bus master port setup 1** (0-0:24.6.0*255). Wired M-Bus communication speed is fixed to 2400 baud regardless on the value of the **M-Bus master port setup 1**.

NOTE

This object is relevant only if a wired M-Bus technology is supported by the meter.

10.8.3. M-Bus device identifier

An identification (ID) of an M-Bus device is one of the parameters, which defines uniqueness of the device. The M-Bus device identifier can be read in the object **M-Bus device ID 1, channel *x*** (0-*x*:96.1.0*255; (*x* = 1…4)), where *x* represents the M-Bus channel.

For successful reading of this identifier, M-Bus device data must be unencrypted or successfully decrypted, (the proper encryption key must be previously uploaded to the E-meter and M-Bus device).

10.8.4. M-Bus measurement value

M-Bus value channel *x*, instance *y* (0-*x*:24.2.*y**255; (*x* = 1…4; *y* = 1…10), where *x* represents the M-Bus channel, and *y* the index of a register) object holds the last captured measurement value from the last received M-Bus message. There are a total of eight such objects with following attributes:

- **Value** represents the captured value from the M-Bus device related to the correct index of the Capture definition attribute (DIB/VIB) of the *M-Bus Client channel x* object.
- **Scaler unit** represents a scaler and a unit of the captured value from the M-Bus device.
- **Status** refers only to attribute Value of this object. Two values for status are used:
  - **0** – M-Bus captured value is valid,
  - **4** – M-Bus captured value is not valid or it is disturbed (any other situation).
- **Capture time** represents the time of the captured value by the M-Bus device where the current time of the E-meter is used.

10.8.5. M-Bus master load profile

M-Bus master load profiles perform hourly interval readings of M-Bus devices. The buffer is filled monotonously, and no irregular entries are allowed. Captured objects include *clock*, *status,* and *M-Bus value* objects. To each of four channels, the dedicated object **M-Bus master load profile for channel *x*** (0-x:24.3.0*255; *x* = 1…4) is defined (Figure 150). Attributes and methods of the objects are described below.

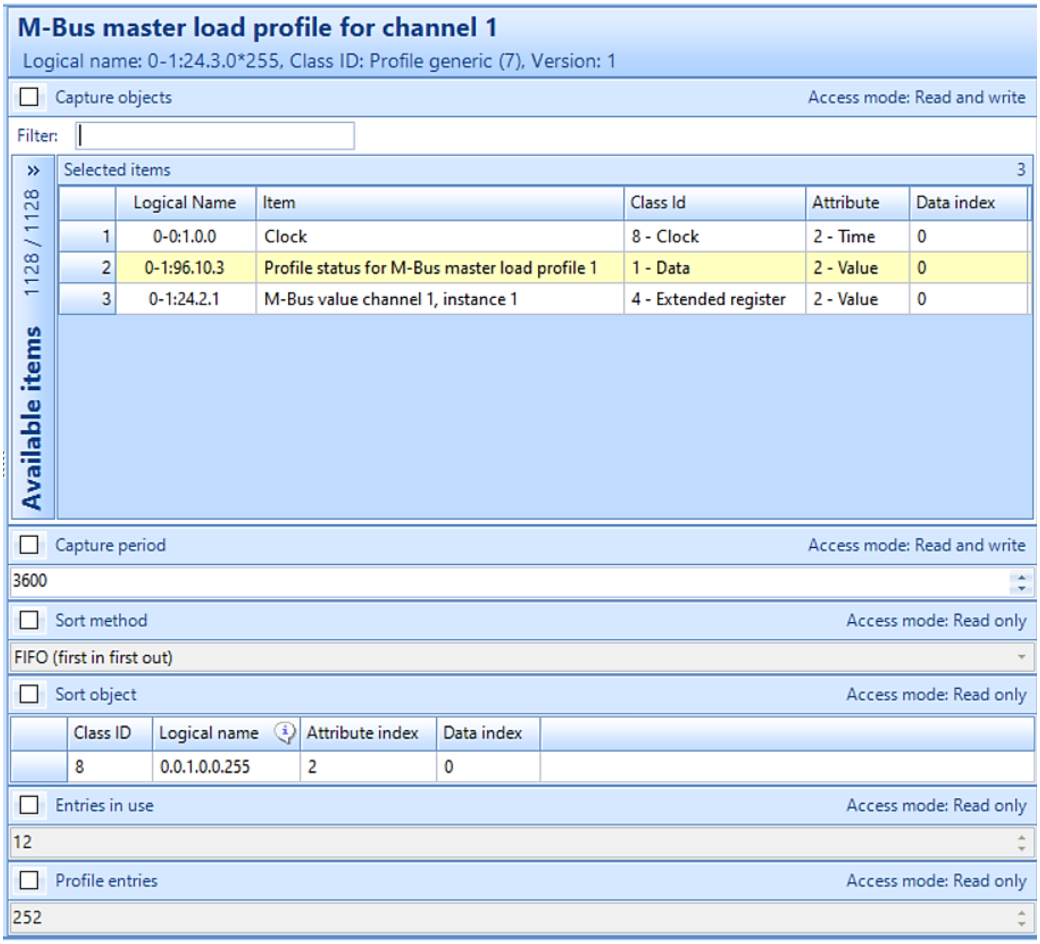


Figure 150: M-Bus master load profile for channel x

Capture objects

Besides objects *Clock* (0-0:1.0.0*255) and *Profile status for M-Bus master load profile x* (0-*x*:96.10.3*255; *x* = 1...4), the attribute can hold up to 8 additional objects.

Capture period

The attribute defines the time distance (in seconds) between two captured data. The period is synchronized with the hour; it always begins at completed hour. The default value is set to 3600.

Sort method

For sorting captured data, the sort method is fixed to FIFO (First in First Out).

Sort object

The attribute uses **Clock** (0-0:1.0.0*255) object as sort object.

Entries in use

The attribute shows how many recordings have been made and recorded (captured).

Profile entries

The attribute shows maximum number of possible recordings in the E-meter.

Reset

The method erases captured values from the profile.

Capture

The method is not available.

NOTE

The M-Bus load profile is erased when a new capture period or capture objects are set.

NOTE

In case the *M-Bus load profile* is empty (no records) and the *Reset method of M-Bus load profile* is triggered, then the *event 254 – Load profile cleared* (see *IE.x Event codes – Appendix A3*) will not be recorded to the *M-Bus event log*.

Capturing of M-Bus load profiles can be enabled or disabled by **Function activation** functionality (refer to chapter *9.17. Function activation*). It can be done on demand by the **Function activation control** object (0-0:44.1.0*255; for an example, see Figure 151) or programmed with **Function activation control scheduler** object (0-0:15.0.7*255).

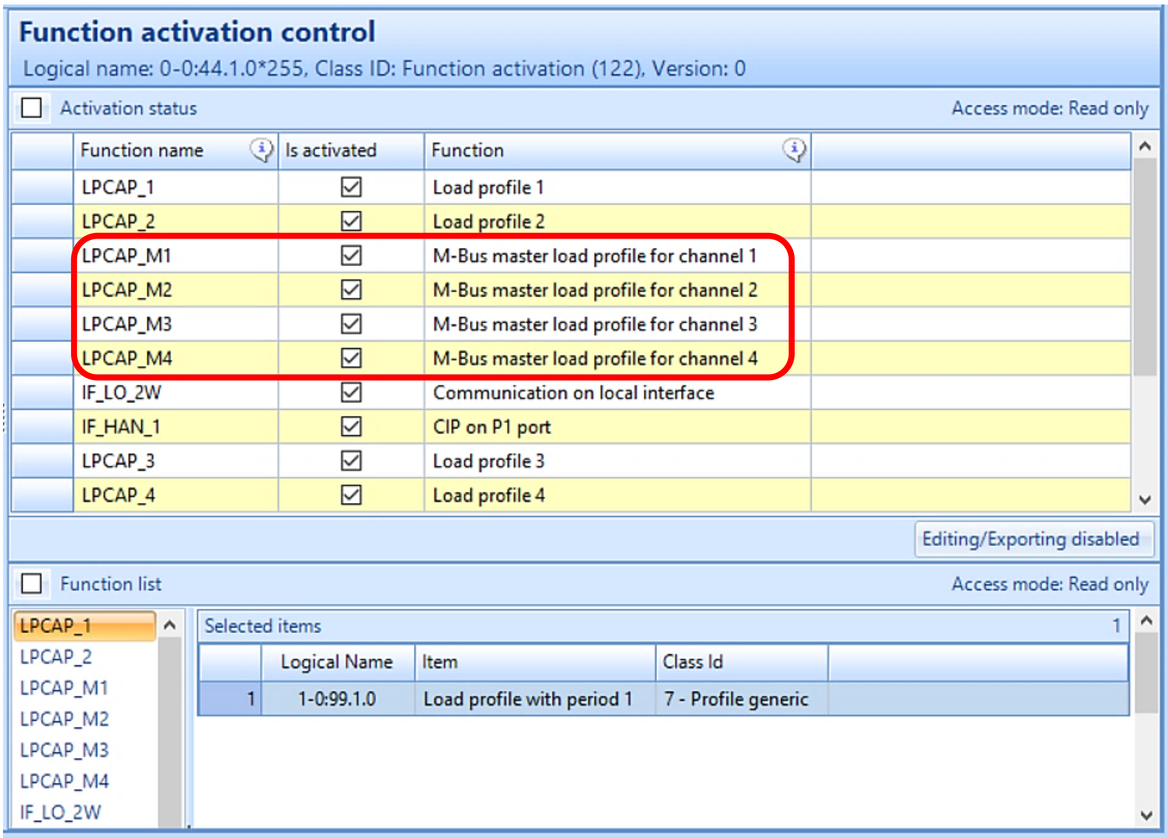


Figure 151: Activated function for capturing of all M-Bus load profiles in Function activation control

NOTE

By default, the hourly M-Bus load profile is enabled by the function activation.

NOTE

If function activation for multi-utility port (the function **IF_MU** in the **Function activation object** (0-0:44.1.0*255) is not enabled, following actions are not allowed to be executed:

- all methods on an M-Bus client channel (with tool)
- a selection of wired/wireless M-Bus type (with tool)
- an M-Bus install and M-Bus remove scripts (with tool)

- an entering a binding mode for a wired and wireless M-Bus (via button)
- a deinstall of M-Bus devices (via button)

10.8.6. M-Bus master daily load profile (optional)

M-Bus master daily load profiles perform daily interval readings of M-Bus devices. The buffer is filled monotonously, and no irregular entries are allowed. Captured objects include *clock*, *status,* and *M-Bus value* objects. To each of four channels, the dedicated object **M-Bus master daily load profile** (0-x:24.3.1*255; *x* = 1…4) is defined. For the attributes and methods of the objects, refer to chapter *10.8.5. M-Bus master load profile.*

NOTE

Unlike the M-Bus hourly load profile, the default value of the ***Capture period*** attribute of the **M-Bus master daily load profile** is set to 86400.

NOTE

M-Bus master daily load profiles is functionality available in the meter as an option.

10.8.7. M-Bus profile control script table

An object **M-Bus profile script table** (0-0:10.0.110*255) keeps ten scripts defined to control each of M-Bus (hourly) load profiles (*M-Bus master load profile for channel x*, x = 1…4).

Script ID	Description
Script 1	Execute method for function activation of M-Bus master load profile for channels 1-4.
Script 2	Execute method for function de-activation of M-Bus master load profile for channels 1-4.
Script 3	Execute method for function activation of M-Bus master load profile for channel 1.
Script 4	Execute method for function de-activation of M-Bus master load profile for channel 1.
Script 5	Execute method for function activation of M-Bus master load profile for channel 2.
Script 6	Execute method for function de-activation of M-Bus master load profile for channel 2.
Script 7	Execute method for function activation of M-Bus master load profile for channel 3.
Script 8	Execute method for function de-activation of M-Bus master load profile for channel 3.
Script 9	Execute method for function activation of M-Bus master load profile for channel 4.
Script 10	Execute method for function de-activation of M-Bus master load profile for channel 4.

Table 115: M-Bus (hourly) profile control script table – description

10.8.8. M-Bus profile status

The object **Profile status for M-Bus master load profile *x*** (0-*x*:96.10.3*255; *x* = 1…4) shows the sum of status register bits set. For each of four channels, the dedicated status object is defined.

Profile status for M-Bus master daily load profile is available by four objects (for each channel) named **Profile status for M-Bus Daily load profile (channel *x*)** (0-*x*:96.10.5*255, where *x* stands for channel 1-4). It applies only if the option “M-Bus master daily load profiles” is included in the meter configuration.

For status bit description, refer to the Table 52.

10.8.9. M-Bus event logging

Refer to chapter *9.9.2.4. M-Bus event log*.

10.8.10. M-Bus event log status codes

The **Event object – M-Bus event log** (0-0:96.11.3*255) object holds the code from the last event triggered. These codes along with timestamps are then used in M-Bus event log.

M-Bus event log status codes are listed in a separate document, *IE.x Event codes – Appendix A3*.

NOTE

Event status codes in this register are only visible in **M-Bus event log** profile readings (0-0:99.98.3*255), because they are only used as references in a profile storage.

10.8.11. M-Bus master disconnect control

This functionality applies only for bidirectional M-Bus devices, which have an integrated disconnector – valve. The **M-Bus master disconnect control object *x*** (0-*x*:24.4.0*255) controls the opening and closing of an M-Bus disconnector (e.g., gas valve). For each of four channels, the dedicated status object is defined (*x* = 1…4). Attributes and methods of the object are described below.

Output state

The attribute shows the actual physical state of the disconnect unit. The value is enumerated.

- 0 - False
- 1 - True

Control state

The attribute defines the internal state of the disconnect unit. In the state *Disconnected,* the meter disconnects a consumer. In the state *Connected,* the consumer is connected to the network (gas, water...). In the state *Ready to reconnection, the* customer can perform reconnection manually on the meter. Possible *control states* are:

- 0 - Disconnected – the consumer is disconnected
- 1 - Connected – the consumer is connected
- 2 - Ready for reconnection – the consumer is disconnected. Reconnection needs to be performed manually on the meter

Control mode

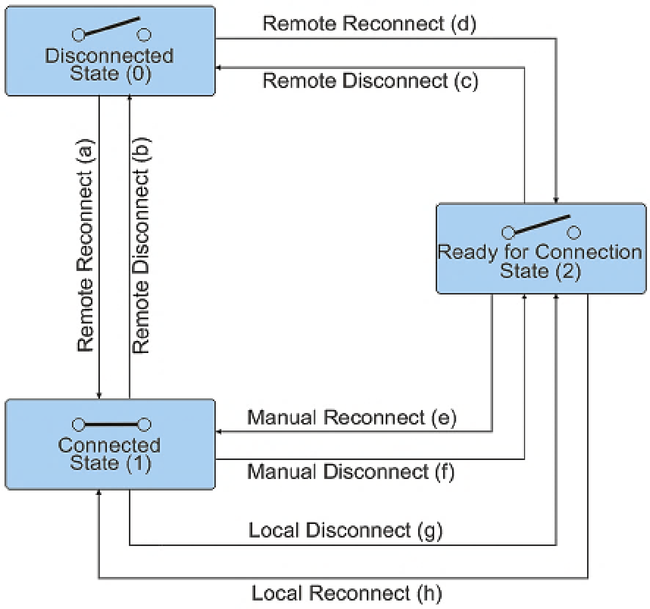


Figure 152: M-Bus disconnect state diagram

The attribute ***Control mode*** defines a mode of operation of *M-Bus master disconnect control*. Possible modes are listed in Table 116.

Mode	Description	
0	None	The disconnect control processes the command to go in 'connected' state
1	Disconnection:	Remote (b, c) Local (g)
	Reconnection:	Remote (d) Manual (e) – Press the key on M-Bus device
2	Disconnection:	Remote (b, c) Local (g)
	Reconnection:	Remote (a) Manual (e) – Press the key on M-Bus device
3	Disconnection:	Remote (b, c) Local (g)
	Reconnection:	Remote (d) Manual (e) – Press the key on M-Bus device
4	Disconnection:	Remote (b, c) Local (g)
	Reconnection:	Remote (a) Manual (e) – Press the key on M-Bus device
5	Disconnection:	Remote (b, c) Local (g)
	Reconnection:	Remote (d) Manual (e) – Press the key on M-Bus device Local (h)
6	Disconnection:	Remote (b, c) Local (g)
	Reconnection:	Remote (d) Manual (e) – Press the key on M-Bus device Local (h)

Table 116: M-Bus disconnector control modes

NOTE
Depending on the M-Bus device used, not all transitions are supported by M-Bus devices.

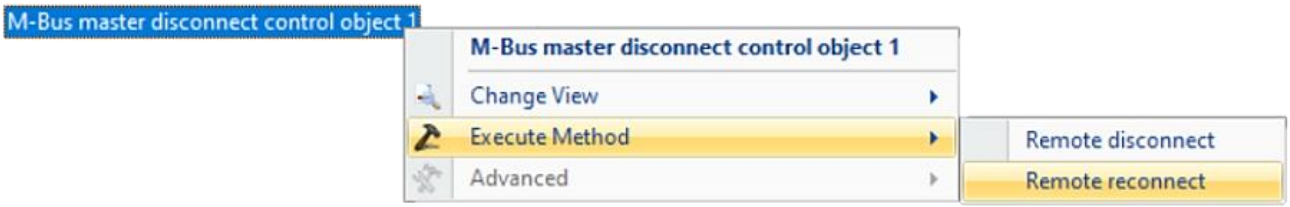


Figure 153: Methods of M-Bus master disconnect control object x

Method description

- **Remote disconnect** forces the disconnector into '*disconnected'* state if a remote disconnection is enabled (control mode > 0).
- **Remote reconnect** forces the disconnect unit into the '*ready for reconnection*' state if a direct remote reconnection is disabled (control mode = 1, 3, 5, 6), and forces it into the '*connected'* state if a direct remote reconnection is enabled (control mode = 2, 4).

NOTE

If a valveless (without a disconnector or a valve) M-Bus device is used, both attributes – *Output state* and *Control state* – are set to the value 1. Therefore, all commands for connection/disconnection are rejected by the E-meter.

10.8.12. M-Bus disconnect control schedule

This functionality applies only for bidirectional M-Bus devices, which have an integrated disconnector – valve. **M-Bus disconnect control schedule** (0-1:15.0.1*255) is intended to define a schedule for a connection or a disconnection. For all four M-Bus channels, only this one object is used. In the object, the following attributes should be defined.

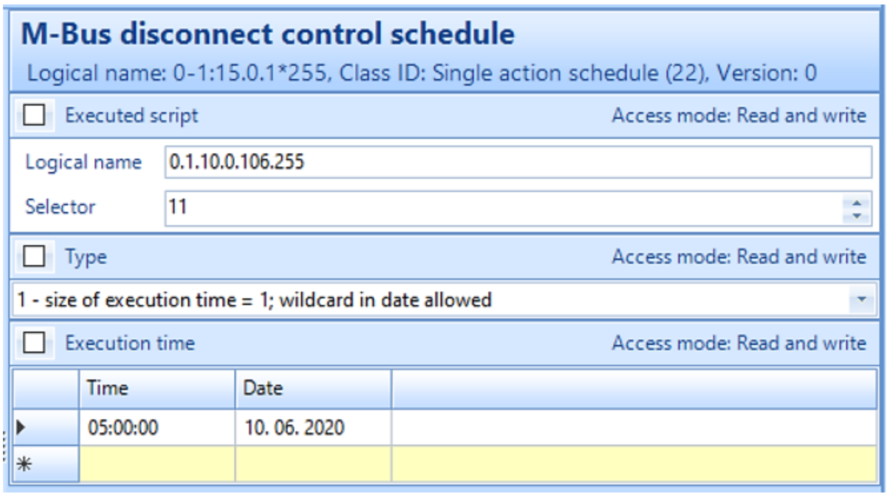


Figure 154: M-Bus disconnect control schedule - example

Executed script

For executed script *M-Bus Disconnector script table (**Logical name**: 0-1:10.0.106*255)* should be used. ***Selector*** (number of a selected Script) needs to be selected according to:

- the M-Bus channel used and
- the selected command (connect/disconnect).

For more information about the scripts, refer to chapter *10.8.13. M-Bus disconnector script table*.

Type

The type functionality is not fully supported by the meter. Type 1 is used as the default value.

Execution time

The attribute defines the time (date & time) of the script execution.

10.8.13. M-Bus disconnector script table

This functionality applies only for bidirectional M-Bus devices, which have an integrated disconnector - valve. In the object **M-Bus Disconnector script table** (0-1:10.0.106*255), sixteen scripts are defined to control each of four M-Bus channels with remote reconnect and remote disconnect service. For a user, only scripts (Script 9 – Script 16) with an executable method are usable.

Script ID	Description
Script 1	Write attribute Control state = Ready for connection of M-Bus master disconnect control object 1 (channel 1)
Script 2	Write attribute Control state = Connected of M-Bus master disconnect control object 1 (channel 1)
Script 3	Write attribute Control state = Ready for connection of M-Bus master disconnect control object 2 (channel 2)
Script 4	Write attribute Control state = Connected of M-Bus master disconnect control object 2 (channel 2)
Script 5	Write attribute Control state = Ready for connection of M-Bus master disconnect control object 3 (channel 3)
Script 6	Write attribute Control state = Connected of M-Bus master disconnect control object 3 (channel 3)
Script 7	Write attribute Control state = Ready for connection of M-Bus master disconnect control object 4 (channel 4)
Script 8	Write attribute Control state = Connected of M-Bus master disconnect control object 4 (channel 4)
Script 9	Execute method Remote disconnect of M-Bus master disconnect control object 1 (channel 1)
Script 10	Execute method Remote reconnect of M-Bus master disconnect control object 1 (channel 1)
Script 11	Execute method Remote disconnect of M-Bus master disconnect control object 2 (channel 2)
Script 12	Execute method Remote reconnect of M-Bus master disconnect control object 2 (channel 2)
Script 13	Execute method Remote disconnect of M-Bus master disconnect control object 3 (channel 3)
Script 14	Execute method Remote reconnect of M-Bus master disconnect control object 3 (channel 3)
Script 15	Execute method Remote disconnect of M-Bus master disconnect control object 4 (channel 4)
Script 16	Execute method Remote reconnect of M-Bus master disconnect control object 4 (channel 4)

Table 117: M-Bus disconnector script table – description

NOTE
Scripts listed in the Table 117 are executed directly via writing into an attribute or by calling M-Bus disconnector methods (remote disconnect, remote reconnect). Writing into attribute is not possible by a user due to a Read only access mode.

10.8.14. M-Bus master control log

This functionality applies only for bidirectional M-Bus devices which have an integrated disconnector – valve. Changes of the states (connected, disconnected, ready for connection/reconnection) related to the M-Bus disconnect control are recorded in the objects **M-Bus master control log object *x*** (0-*x*:24.5.0*255). For each of four channels, the dedicated master control log object is defined (*x* = 1…4). The objects contain all events related to an M-Bus disconnector, e.g., a gas valve (open valve, close valve). ***M-Bus master control log*** structure consists of ***Timestamp*** and ***Event code***.

Capture objects

When event is triggered, the timestamp and the event code set in this attribute are recorded.

NOTE
These attributes are fixed and not settable.

Capture period

The attribute *Capture period* is set to 0 because events are triggered and recorded as they occur.

Sort Method

The attribute for sorting captured data is fixed to FIFO (First in First Out).

Sort object

The *Clock* object (0-0:1.0.0*255) is used as a sort object.

Entries in use

This attribute shows how many recordings have been recorded (captured).

Profile entries

This attribute shows how many recordings are possible in the E-meter. This number depends on the number of capture objects set.

Specific methods

The *M-Bus master control log* has two methods implemented:

- Reset (erases captured values)
- Capture (not supported by the meter)

NOTE
The *M-Bus master control log* is erased when a new capture period or capture objects are set.

NOTE
A transition duration between two disconnect states (see Figure 152) is much longer at the M-Bus disconnector than at the electrical disconnector. In many situations, the output state is refreshed after the next capture period. Therefore, for correct state machine handling in E-meter, it is recommended that after each command (connect/disconnect) there should be no further actions within the same capture period (1 hour).

10.8.15. M-Bus control event codes

This functionality applies only for bidirectional M-Bus devices which have an integrated switching devices – valve. **Event objects - M-Bus master control log *x*** (0-*x*:96.11.4*255; *x* = 1-4, where *x* stands for a channel number). The object holds M-Bus control event code from the last event triggered. These codes along with timestamps are then used in the event log.

NOTE
Event status codes in this register are only visible in ***M-Bus control log object x*** (0-x:24.5.0*255) profile readings, because they are only used as references in a profile storage.

M-Bus control event codes are listed in chapter *9.9.3. Event codes*.

10.8.16. M-Bus client configuration

M-Bus client configuration object (0-0:128.50.1*255) is intended for additional configuration for a different kind of M-Bus functionality behaviour (Table 118). There are a lot of different scenarios of M-Bus functionality possible for some actions, for example, transferring the encryption key to the M-Bus slave, handling the M-Bus value registers, profiles, and logs in the case of decommissioning of the M-Bus slave, handling the capture actions in relation with an M-Bus device id, etc.

Bit	Name – Bit property	Enumerated value
0	Transfer key *	0 – Sent to M-Bus device without rotation. 1 – Sent to M-Bus device backwards
1	Time information *	0 – Included only in encrypted frame 1 – Included in unencrypted valve command frame
2-4	Reserved	Not used
5	Resetting of M-Bus value registers	0 – Not reset 1 – Reset at decommissioning process
6	Resetting of M-Bus profile	0 – Not reset 1 – Reset at decommissioning process
7	Resetting of M-Bus control log and M-Bus control event object **	0 – Not reset 1 – Reset at decommissioning process
8	M-Bus value capture ***	0 – Independently on M-Bus device id 1 – If device id not known, captured with “Invalid data” of Status of Profile
9	Logging of M-Bus event log, M-Bus control log, Meter fatal error register, Alarm registers	0 – Logged (and reset) regardless on M-Bus device id 1 – Logged (and reset) if M-Bus device id is already successfully captured and known
10	Sending of installed device data on P1 port	0 – Only if M-Bus device id is already successfully captured and known 1 – Regardless of M-Bus device id
11	M-Bus secondary search ***	0 – Disabled 1 – Enabled
12	Reserved	Not used
13	Resetting of M-Bus daily profile ****	0 – Not reset 1 – Reset at decommissioning process
14	M-Bus master setup Short ID attributes (6, 7, 8, 9) writable	0 – Attributes 6, 7, 8, 9 read only 1 – Attributes 6, 7, 8, 9 read write
15-31	Reserved	Not used

* This functionality applies only for bidirectional M-Bus devices.
** This functionality applies only for bidirectional M-Bus devices, which have an integrated switching devices – valve.
*** This functionality applies only for wired M-Bus devices
**** This functionality applies only if the option “M-Bus master daily load profiles” is included in the meter configuration; otherwise, the bit 13 is not in use.

Table 118: M-Bus client configuration

Bit 0 – Transfer key

An encryption key (16 bytes) can be sent to an M-Bus device by an invocation of a Transfer key method in the right byte order (without a rotation) or backwards.

- If bit is set to 1, the encryption key is sent to the M-Bus device backwards.
- If bit is set to 0, the encryption key is sent in the right order.

Bit 1 – Time information

It is possible to configure whether a time information is included in an unencrypted valve control message or not.

- If bit is set to 1, the time information is included in an unencrypted valve command frame.
- If bit is set to 2, the time information is included only in the encrypted frame.

Bit 5 – Resetting of M-Bus value registers

At a decommissioning of an M-Bus device from a specific channel, it is possible to configure whether M-Bus value register (0-*x*:24.2.1*255, *x* = 1…4) is reset or not.

- If bit is set to 1, the M-Bus value register is reset at the decommissioning process.

- If bit is set to 0, the M-Bus value register remains unchanged.

Bit 6 – Resetting of M-Bus profile

At a decommissioning of an M-Bus device from a specific channel, it is possible to configure whether the M-Bus profile (0-*x*:24.3.0*255, *x* = 1…4) is reset or not.

- If bit is set to 1, the M-Bus profile is reset at the decommissioning process.
- If bit is set to 0, the M-Bus profile remains unchanged.

Bit 7 – Resetting of M-Bus control log and M-Bus control event object

At a decommissioning of an M-Bus device from a specific channel, it is possible to configure whether the M-Bus control log (0-*x*:24.5.0*255, *x* = 1…4) is reset or not.

- If bit is set to 1, the M-Bus control log is reset at the decommissioning process. An M-Bus control event object (0-*x*:96.11.4*255, *x* = 1…4) is also reset.
- If bit is set to 0, the M-Bus profile and M-Bus control event objects remain unchanged.

Bit 8 – M-Bus value capture

It is possible to configure that an M-Bus value is hourly captured to the M-Bus profile (0-*x*:24.3.0*255, *x* = 1…4) regularly in dependence on successfully decrypted M-Bus device.

- If bit is set to 1, the M-Bus value is hourly captured to the M-Bus profile with regular Status of Profile (0-x:96.10.3*255, *x* = 1…4) only if the M-Bus device id is already successfully captured, meaning that message has been successfully decrypted. If the message has not been successfully decrypted yet, then the M-Bus value is hourly captured to the M-Bus profile with an “Invalid data” of the Status of the Profile.
- If bit is set to 0, the M-Bus value is hourly captured to the M-Bus profile with a regular Status of the Profile independently on the M-Bus device message decryption.

Similar applies for M-Bus daily profile (0-x:24.3.1) if included in the meter configuration.

Bit 9 – Logging of M-Bus event log, M-Bus control log, Meter fatal error register, Alarm registers

It is possible to configure that the M-Bus event log (0-0:99.98.3*255), the M-Bus control log (0-*x*:24.5.0*255, *x* = 1…4), the Error register (0-0:97.97.0*255) and the Alarm registers (0-0:97.98.0*255, 0-0:97.97.1*255) are logged in dependence with a successful encryption of the M-Bus device message.

- If bit is set to 1, the M-Bus event log, the M-Bus control log, the Error register and the Alarm registers are logged only if the M-Bus device message is already successfully decrypted.
- If bit is set to 0, the M-Bus event log, the M-Bus control log, the Error register and the Alarm registers are logged regardless on the M-Bus device message decryption.

Bit 10 – Sending of installed device data on P1 port

Some M-Bus devices do not contain an M-Bus device id (0-x:96.1.0*255, *x* = 1…4) in their data message, but in some cases, it is desirable to present a data of the M-Bus device on the P1 port. Therefore, it is possible to configure that all M-Bus device data (M-Bus device id (0-*x*:96.1.0*255, *x* = 1…4), M-Bus device type (0-*x*:24.1.0*255, attribute 9; *x* = 1…4), M-Bus load profile (0-*x*:24.3.0*255, *x* = 1…4), M-Bus valve position (0-*x*:24.4.0*255, *x* = 1…4) …) are sent to the P1 port in dependence on the data decryption status.

- If bit is set to 1, M-Bus data of an installed device are sent to the P1 port every 10 seconds regardless of M-Bus device decryption status, but the device needs to be already installed.
- If bit is set to 0, M-Bus data of the installed device are sent to the P1 port every 10 seconds only if the M-Bus device is installed, successfully decrypted, and an equipment identifier needs to be known. If the M-Bus device does not include the equipment identifier this condition is not fulfilled.

Bit 11 – Secondary search

When primary search of binding procedure is finished, the secondary search can be started. It can be started only when not all the M-Bus channels are already occupied and when the secondary search is enabled.

- If bit is set to 1, the secondary search is enabled.
- If bit is set to 0, the secondary search is disabled.

Bit 13 – Resetting of M-Bus daily profile

Only if the option “M-Bus daily load profiles” is included in the meter configuration, bit 13 is available, otherwise not.

At a decommissioning of an M-Bus device from a specific channel, it is possible to configure whether the M-Bus daily profile (0-*x*:24.3.1*255, *x* = 1…4) is reset or not.

- If bit is set to 1, the M-Bus daily profile is reset at the decommissioning process.
- If bit is set to 0, the M-Bus daily profile remains unchanged.

Bit 14 - M-Bus master setup Short ID attributes (6, 7, 8, 9) writable

Wired M-Bus devices require “Read only” access rights for attributes 6, 7, 8, 9. Wireless M-Bus devices require “Read/Write” access rights for these attributes during binding procedure. With the configuration, it is possible to change the access rights between “Read only” and “Read/Write”:

- If bit is set to 1, access rights for attributes 6, 7, 8, 9 are set to Read/Write.
- If bit is set to 0, access rights for attributes 6, 7, 8, 9 are set to Read only.

NOTE

When changing the M-Bus client configuration bit 14, a new read of the meter scheme shall be performed in order to make the change into account.

10.8.17. M-Bus alarms

M-Bus alarms are used for M-Bus events, which are directly related to M-Bus devices connected to the E-meter. The alarms are grouped in the following groups:

- M-Bus communication error
- M-Bus fraud attempt (customer specific *)
- M-Bus permanent error
- M-Bus low battery
- New M-Bus device installed
- M-Bus client decryption failed
- M-Bus valve alarm (customer specific *)

* See the note below.

Each group consists of four different alarms – one per channel (1–4).

Alarm	Alarm set condition	Alarm reset condition
M-Bus communication error	Condition for this error is different for wired and wireless M-Bus device: • wired – the error is set after three unsuccessful attempts to read the M-Bus device (the device is physically disconnected). • wireless – the error is set after 4 hours of no reception of any message from the M-Bus device.	• For wired, the error is cleared after the first successful reading of the M-Bus device (the device is physically connected again). • For wireless, the error is cleared after the first successfully received message from the M-Bus device.
M-Bus fraud attempt *	When the data is successfully received from the M-Bus device and bit 6 (Fraud attempt) in the Error status code of the fixed data header of the message is set.	When the data is successfully received from the M-Bus device and bit 6 (Fraud attempt) in the Error status code of the fixed data header of the message is cleared.
M-Bus permanent error	When the data is successfully received from the M-Bus device and bit 3 (Permanent error) in the Error status code of the fixed data header of the message is set. Usage of this error is M-Bus device specific.	When the data is successfully received from the M-Bus device and bit 3 (Permanent error) in the Error status code of the fixed data header of the message is cleared.
M-Bus battery low	When the data is successfully received from the M-Bus device and bit 2 (Battery low) in the Error status code of the fixed data header of the message is set. Indicates that the battery must be exchanged due to the expected end of life time. Usage of this error is M-Bus device specific.	When the data is successfully received from the M-Bus device and bit 2 (Battery low) in the Error status code of the fixed data header of the message is cleared.
M-Bus device installed	After successful installation of a new M-Bus device to a free channel.	After successful de-installation of the M-Bus device from the channel.

Alarm	Alarm set condition	Alarm reset condition
M-Bus client decryption failed	After unsuccessful decryption of the received M-Bus message.	After the first successful decryption of the received M-Bus message.
M-Bus valve alarm *	When the data is successfully received from the M-Bus device and bit 7 (Valve alarm) in the Error status code of the fixed data header of the message is set. Usage of this error is M-Bus device specific.	When the data is successfully received from the M-Bus device and bit 7 (Valve alarm) in the Error status code of the fixed data header of the message is cleared.

* See the note below.

Table 119: Set and reset conditions of M-Bus alarms

NOTE

Alarms marked with * (asterisk) are customer specific. According to the standard, there is also M-Bus temporary failure alarm defined, which is not supported by the E-meter.

For more information on M-Bus alarms, refer to chapter *9.11. Alarms*.

10.8.18. M-Bus technology type

M-Bus technology type (0-0:128.50.11*255) object holds an M-Bus technology type information of an active M-Bus on the E-meter. The parameter is settable. Valid values of this object are:

- **0** – none (M-Bus type is not set)
- **1** – wired M-Bus type is active
- **2** – wireless M-Bus type is active

M-Bus type can be set **remotely** only **if no M-Bus type has been selected yet (value 0)**. Direct change of the M-Bus type from wired to wireless or vice-versa is not allowed.

If the change of the M-Bus type is needed, firstly all existing M-Bus devices must be deinstalled from the E-meter. After that, the value of the *M-Bus technology type* automatically resets to 0. After power-up of the E-meter, the last active M-Bus type is restored.

NOTE

The M-Bus technology type can only be set if a function activation status for **Multi-utility port (IF_MU) is activated** (see Figure 149).

If the function activation status for Multi-utility port (IF_MU) is deactivated, then a setting of the M-Bus technology type is rejected (if using a tool or a button).

10.8.19. M-Bus diagnostic

M-Bus diagnostic channel x (0-*x*:24.9.0*255; *x* = 1-4, where *x* stands for a channel number) holds an additional information related to the operation of the wireless M-Bus network. Only two attributes are used:

- Received signal strength (attribute 2)
- ***Capture time*** (attribute 9).

Received signal strength (RSSI) holds the signal information of the M-Bus devices' receiver at the time of received M-Bus message from the E-meter.

There are four objects available for each of four channels (*x*=1-4).

For bidirectional wireless M-Bus devices, RSSI can be included in ***Status*** field (attribute 11 *in M-Bus client channel x* (0-*x*:24.1.0) object). In that case, RSSI is calculated (based on EN 13757-3) from the *Status* field as it is described in the Table 120.

Bit number	Value
0 ... 5	Last received RSSI value from this meter for a reception level in range: -128 ... -6 dBm Reception level is calculated by *-130 dBm + 2 × RSSI-Value* (1 ... 62) If RSSI value is: • 0 – No RSSI value or wired communication • 1 – RSSI value is -128 dBm or below • 63 – the reception level is > -6 dBm
6	Reserved (0 by default)
7	Reserved (0 by default)

Table 120: Wireless M-Bus – meaning of status field if it holds RSSI value

NOTE
An RSSI value of the *Received signal strength* is only relevant if the wM-Bus device is sending RSSI in *Status* field. Otherwise, value is displayed, but it is not relevant.

10.8.20. M-Bus modem signal strength

M-Bus channel *x* modem signal strength objects (x = 1…4) hold an information of modem signal strength (signal strength of received wM-Bus message from a wM-Bus device) of corresponding M-Bus channel on the E-meter. These objects are:

- M-Bus channel 1 modem signal strength (0-0:128.50.12)
- M-Bus channel 2 modem signal strength (0-0:128.50.13)
- M-Bus channel 3 modem signal strength (0-0:128.50.14)
- M-Bus channel 4 modem signal strength (0-0:128.50.15)

A displayed signal strength unit is dBm.

10.8.21. M-Bus message counters

This functionality applies only to wireless communication. M-Bus device can send to the E-meter two different types of messages (see chapter *10.3.1. Wireless communication modes and sub-modes*):

- T mode messages
- C mode messages

Meter supports the following counters for successfully received and decrypted messages:

- M-Bus T MSG counter channel 1 (0-0:128.50.3*255)
- M-Bus C MSG counter channel 1 (0-0:128.50.4*255)
- M-Bus T MSG counter channel 2 (0-0:128.50.5*255)
- M-Bus C MSG counter channel 2 (0-0:128.50.6*255)
- M-Bus T MSG counter channel 3 (0-0:128.50.7*255)
- M-Bus C MSG counter channel 3 (0-0:128.50.8*255)
- M-Bus T MSG counter channel 4 (0-0:128.50.9*255)
- M-Bus C MSG counter channel 4 (0-0:128.50.10*255)

11. SECURITY

The coarse partitioning of the E-Meter security is devised into:

- physical security,
- logical security.

11.1. Physical security

Physical security is comprised of:

- sealing protection (see chapter *4.5 Sealing*),
- tamper detection.

11.1.1. Sealing protection

There are different sets of seal protection:

- the first set protects the terminal cover,
- the second protects the exchangeable communication module
- the third protects the lower button (optionally).

The locations of sealing points are presented in chapter *4.5 Sealing*.

11.1.2. Tamper detection

If seals are tampered with and either of the covers is removed (terminal cover or communication module), then the corresponding tamper is detected, and events are recorded in the Fraud detection event log (see chapter *9.9.2.2. Fraud detection log*).

In case of terminal cover opening, the dedicated counter (Cover opening counter) is incremented as well.

11.2. Logical security

Logical security is divided into the following entities:

- DLMS/COSEM Security (Suite 0 level; see table below), which is divided into:
    - data access security, which controls access to the data held by a DLMS/COSEM server,
    - data transport security, which allows the sending party to apply cryptographic protection to ensure confidentiality and integrity.
- Additional Communication Security
    - There are several Iskraemeco add-ons to DLMS/COSEM security. Foremost, a “DLMS channel options” object, for every channel on which the COSEM server is present, is introduced in order to cater different market requirements.
- Secure Storage
    - Secure storage is a reserved space in the MCU memory, which is cryptographically protected. In secure storage, E-Meter stores all the necessary global-encryption, authentication, and master keys.

Security suite id	Authenticated encryption	Digital signature	Key agreement	Hash	Key transport
0	AES-GCM-128	-	-	-	AES-128 key wrap

Table 121: Security suite

11.2.1. Roles

Current Association (0-0:40.0.0*255) is an object in the meter, which contains the list of association objects and additional information of the current association on the local and/or remote interface.

Roles (additional associations) are customer-specific associations used for different access levels for managing the device and retrieving the data from the device. There are up to ten additional customer-specific associations (roles) supported in the meter.

Available roles are presented in Table 122. Their corresponding functions are listed in Table 123.

Application Associations		Client SAP	Enabled/ Disabled	Accessible meter functions (Designations described in Table 123)	L – Local/ R – Remote/ S – Specific
A 5	Role 1 – Central System Read Write	17	Enabled	a, b, c, g, t	L
A 6	Role 2 – Central System Read Only	18	Enabled	a, b, f, g, t	L
A 7	Role 3 – Installer	19	Enabled	a, b, c, d, e, f, g, h, t	L
A 8	Role 4 – Admin	20	Enabled	a, b, c, d, e, f, g, h, j, m, n, o, p, t	L + R
A 9	Role 5 – Security Officer	21	Enabled	i, j, k, q, s, t	L + R
A 10	Role 6 – Calibration and Testing	22	Enabled	a, b, c, d, e, f, g, h, m, n, o, t	L
A 11	Role 7 – Maintenance	23	Enabled	a, b, c, d, e, f, g, h, j, t	R
A 12	Role 8 – Display	24	Enabled	a, t	L
A 13	Role 9 – Customer	25	Enabled	-	L
A 14	Role 10 – not used; reserved for future use	26	Disabled	N/A	N/A

Table 122: List of available Roles

	List of available functions for Roles	Assignment of Role *n* (*n* = 1, 2, 3 … 9)
a	**Reading meter registers:** • Reading meter registers • Reading billing registers • Reading meter objects (parameter scheme) • Reading measurement registers	1, 2, 3, 4, 6, 7, 8
b	**Reading load profiles, logbooks**	1, 2, 3, 4, 6, 7
c	**Activating/deactivating display**	1, 3, 4, 6, 7
d	**Activating/deactivating load profile**	3, 4, 6, 7
e	**Activating/deactivating Consumer interface (P1)**	3, 4, 6, 7
f	**Disconnector on/off**	2, 3, 4, 6, 7
g	**Setup date and time**	1, 2, 3, 4, 6, 7
h	**Meter parameterization and configuration (including sw. device):** • Meter parameterization and configuration • Change parameters for local (P0), consumer (P1) interface • Change communication parameters • Change other meter parameters • Tariff setup • FW activation	3, 4, 6, 7
i	**Change meter security parameters**	5
j	**Parameterization of sub-metering devices:** • Pairing E-meter with G-meter	4, 7
k	**Download of meter NLRFW (Application)**	5
l	**Download of meter LRFW (Core)**	5
m	**Delete content of load profiles, logbooks**	4, 6
n	**Set meter to test mode**	4, 6
o	**Reset meter registers**	4, 6

	List of available functions for Roles	Assignment of Role *n* (*n* = 1, 2, 3 … 9)
p	**ADMIN self-exclusion**	4
q	**ADMIN unblocking**	5
r	IDIS Association self-exclusion	IDIS Management association *
s	**IDIS Association unblocking**	5
t	**Access to exclusive COSEM SAP**	1, 2, 3, 4, 5, 6, 7, 8

* IDIS Management association is disabled

Table 123: List of available functions for Roles

NOTE
If any of additional customer-specific associations (roles) are defined for use, see corresponding appendix of this document, where the roles are described.

12. FIRMWARE UPGRADE

The meter supports FW upgrade of the E-meter and communication modules. This provides the possibility to add new functionalities or patch bugs after the device is already in the field.

NOTE
Firmware upgrade of M-Bus devices (sub-meters) is not supported by the meter.

According to the COSEM/DLMS specification, the meter utilizes the Image Transfer COSEM class (class_id = 18) for transferring binary files, called **Images**, to COSEM servers (E-meter).

Image upgrade usually takes place in several steps:

Step 1: (Optional): Client checks image block size with server

Step 2: Client initiates Image transfer

Step 3: Client transfers Image blocks

Step 4: Client checks completeness of the Image

Step 5: Server verifies the Image (Initiated by the client or on its own)

Step 6: (Optional): Client checks the information on the images to activate

Step 7: Server activates the Image(s) (Initiated by the client or on its own)

The meter offers the possibility to upgrade the firmware during operation. Please note that a FW upgrade is only possible in compliance with national laws and/or regulations. For more information on disabling FW upgrade, see chapter *9.18. Factory set and locked objects (national regulations)*.

12.1. Type of images

The meter supports upgrading of the following devices:

- E-meter itself:
  - Legally Relevant FW (LRFW) part – Core
  - National Legally Relevant FW (CLRFW) - CLR
  - Legally Non-Relevant FW (LNRFW) part – Kernel
  - Legally Non-Relevant FW (LNRFW) part – Application

NOTE
These four parts are physically separate programs, placed in separate memory locations of the memory inside the meter. However, they are all stored in the flash memory of the MCU.

If necessary, more than one E-meter part can be transferred and activated at once using a composite image.

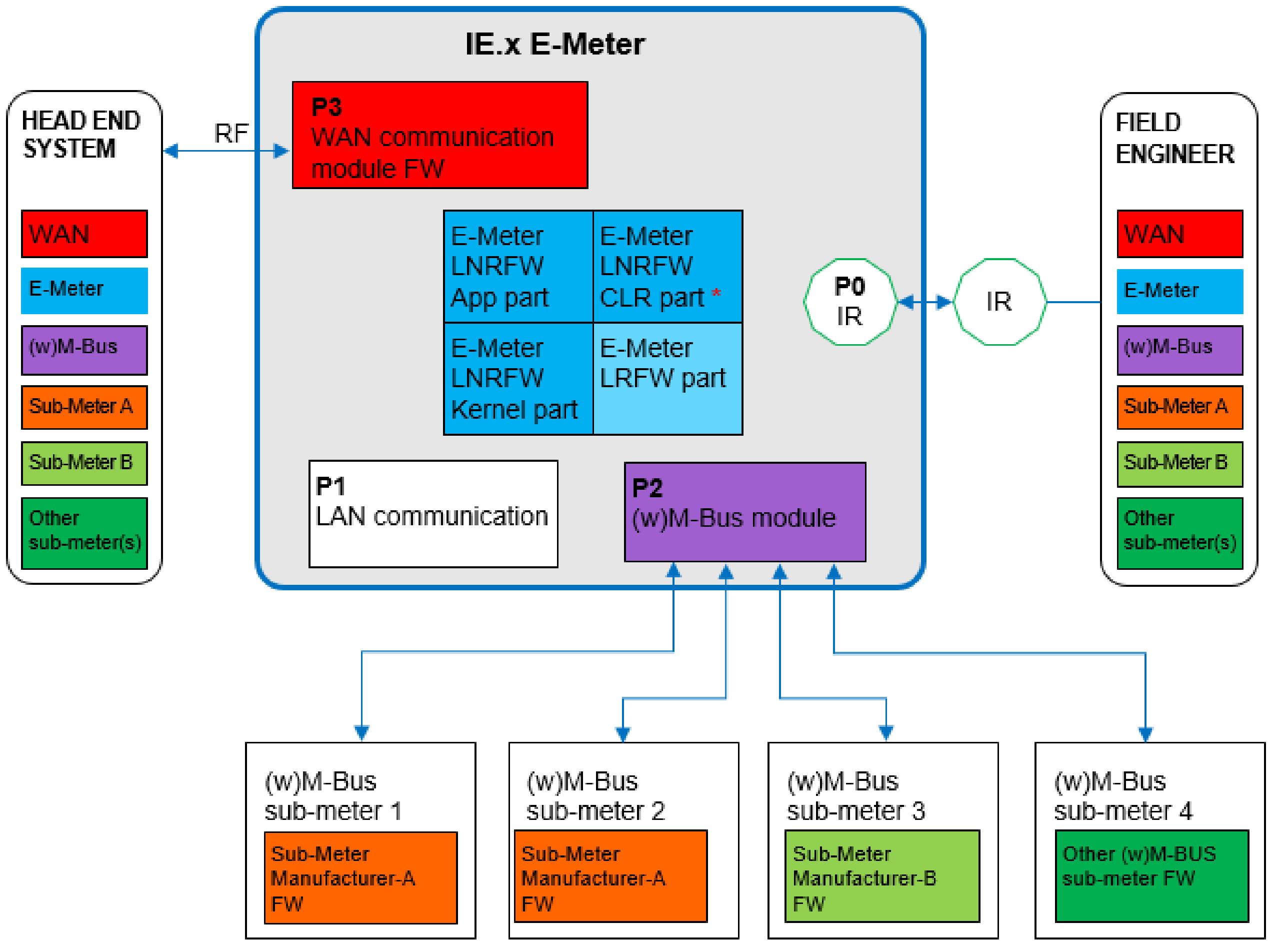
If the firmware activation process is interrupted by a power down of the E-Meter, it will be automatically continued to finish and execute at the next power up.

If the image block transfer is interrupted (step 3) by a power down of the E-Meter before the image verification method (step 5) could be executed, then image transfer needs to be repeated from the beginning.

- WAN communication module Firmware
- wMBUS communication module Firmware

In the measuring system, the following entities can be upgraded with new FW (see Figure 155):

- Electrical Meter Legally Non-Relevant Part of Firmware – **BLUE**.
- Electrical Meter Legally Relevant Part of Firmware – **LIGHT BLUE**.
- WAN communication module Firmware (or just a part of it) – **RED**.
- wM-Bus communication module Firmware inside the E-Meter (if wM-Bus exists) – **PURPLE**.
- Sub-meters (Gas, Heat, Water...) Firmware, possible form different manufacturers. – **ORANGE**, **LIGHT-GREEN**, **GREEN**



* Depending on the national legislation, the CLR part of the firmware can be handled as a LNRFW or LRFW.

Figure 155: Different approaches/options to FW Upgrade

There are two general types of images.

- Images, which are verified by the E-Meter. These images can have a source from different manufactures (E-Meter producer, communication module (e.g., NB IOT modem). Those images, together with their Identification, are then signed by the E-Meter manufacturer with an ECDSA signature for integrity checking and for authenticity.
- Sub-Meter. These images are just transferred with Image Upgrade methods to an E-Meter's temporary storage. They are not modified in any way by the E-Meter producer. Verification and activation are executed in Sub-Meter devices.

The E-Meter uses the Identification value provided at the time of the Image Transfer initiate method execution to differentiate between image types. See Table 124.

Image type	Initiate method: Image Identification	OBIS code version	ID example	OBIS code signature	Signature type
E-Meter CORE	ISK-IMG-COR-ISK	1-0:0.2.0*255	ISKIE5T**C**01100004	1-0:0.2.8*255	ECDSA over SHA2-256
E-Meter Application	ISK-IMG-COM-ISK	1-1:0.2.0*255	ISKIE5T**A**01100003	1-1:0.2.8*255	ECDSA over SHA2-256
E-Meter CLR	ISK-IMG-CLR-ISK	1-5:0.2.0*255	ISKIE5T**R**01100002	1-5:0.2.8*255	ECDSA over SHA2-256
E-Meter Kernel	ISK-IMG-KER-ISK	1-7:0.2.0*255	ISKIE5T**K**01100002	1-7:0.2.8*255	ECDSA over SHA2-256
WAN communication module	ISK-IMG-MOD-ISK	1-2:0.2.0*255	ISK**MO**6BG95-M006.01	1-2:0.2.8*255	ECDSA over SHA2-256
wMBUS module	ISK-IMG-MOD-ISK	1-4:0.2.0*255	ISK**MO**700405AC3204		ECDSA over SHA2-256

Table 124: Image types

13. ASSOCIATION

The communication between two devices can be established on several peer protocol layers. This section presents different Application associations between the E-meter (the server) and the COSEM client.

To effectively exchange information within an Application association, the pair of AE-invocations shall be mutually aware of and follow a common set of rules that govern the exchange. This common set of rules is called the application context of the application association.

Objects that contain the information about the current application association with the application context are described in detail.

Within the current application association, different parameters may be changed, thus the number of programming accesses is registered along with the timestamp of the last attempt.

13.1. SAP assignment

The SAP assignment list contains the list of all logical devices and their SAP addresses within the physical device. The interface class "SAP assignment list" contains the information about the assignment of the logical devices in the physical device.

Example:

Iskraemeco meter with the "Logical device name" ISK1030712345678 has the SAP assignment shown in Table 125.

SAP Assignment	Physical device name
1	ISK1030712345678

Table 125: SAP assignment example

Device ID is used in the last part of the Logical device name, thus guaranteeing uniqueness of the name. The Logical device name is used to construct the System Title, which is used in COSEM security.

The Client dictates the type of the association because Server SAP is always 1. The next section briefly encapsulates the core features of the respective association.

The firmware inside the meter supports Application Associations, indicated in Table 126.

COSEM Application Associations		**Client SAP**	**Enabled /Disabled**	**Interface Local/Remote/Specific**
A 0	IDIS CIP Association	103	Enabled	P1 CIP specific
A 1	IDIS Public Association	16	Enabled	Local + Remote
A 2	IDIS Management Association	1	Enabled	Local + Remote
A 3	IDIS Pre-established Association	102	Enabled	Pre-established push specific
A 5 – A 14	*Roles (additional associations)* – (OPTION)	For more information, see chapter *11.2.1. Roles.*		

Table 126: COSEM Application Associations

CIP association supports the CIP functionality. (For more information, see chapter *9.5. Push.*)

Public association is used for reading basic device configuration information (e.g., SAP, logical device name, association, serial numbers ...). It is not strongly secured. The Public association is available on remote communication and as well on local interface. Public association is also used to read the invocation counter.

Management association is used for management of the device, retrieving the data from the device and authorizing actions in the meter. The Management association is available on remote communication as well as on local interface i.e., optical port.

Pre-established association is used for PUSH notifications via data-notification service.

14. TECHNICAL CHARACTERISTICS

14.1. Single-phase meter

Model type	IE.5-ED1	IE.5-EB2
Reference voltage	230 V	230 V, 240 V
Extended operating voltage range	-20% to +15% U_n	
Reference frequency	50 Hz	50 Hz, 60 Hz
Reference current	5 A	
Maximum current	85 A	100 A
Thermal current	120% I_{max}	
Start-up current	< 0.4% of reference current	
Short circuit current	30 × I_{max}	
Utilization category (EN 62052-31)	UC2	
Active energy (IEC 62053-21 / EN 50470)	Class 1/Class B	
Reactive energy (IEC 62053-23)	Class 2	
Meter shutdown voltage	< 165 V	
Meter restoration voltage	176 V	
Power consumption in voltage circuit (meter with all integrated components)	1.25 W and 3 VA	1.30 W and 2.5 VA
Additional consumption - Backlight	0.2 W / 0.4 VA	0.2 W / 0.4 VA
Power consumption in current circuit (meter with all integrated components)	0.020 VA (I_{ref} = 5 A)	0.035 VA (I_{ref} = 5 A)
Operating temperature of meter	-40 °C to +70 °C	
Operating temperature of LCD display	-25 °C to +70 °C	
Storage temperature	-40 °C to +80 °C	
Temperature coefficient	-40 °C to +70 °C < ± 0.05% per K	
Protection class	Double insulation	
Ingress protection (IEC 60529)	IP54	
Electrostatic discharges (IEC 61000-4-2)	Contact: 8 kV, air: 15 kV	
Electromagnetic RF fields (IEC 61000-4-3)	Active: 10 V/m, passive: 30 V/m	
Radio interference suppression	Class B	
Fast transient burst (IEC 61000-4-4)	4 kV into voltage circuit / 2 kV into other	
Overvoltage category (IEC 60664-1)	OVC III	
Surge (IEC 61000-4-5)	4 kV into voltage measuring circuit / 1 kV into other	
Immunity to conducted disturbances (IEC 61000-4-6)	10 V	
Insulation strength	4 kV_{rms}, 50 Hz, 1 min	
Impulse voltage 1.2/50µs (EN 50470-1)	12 kV into voltage measuring circuit, 6 kV into other	
Internal clock accuracy; at +23 °C (IEC 62054-21)	0.5 s/day	
Backup with supercap	7 days	
Case	Antistatic polycarbonate plastic	
Mechanical conditions	• Shock test according to IEC 60068-2-27 • Vibration test according to IEC 60068-2-6	
Mechanical environment	M2	
Humidity	Up to 95%	
Altitude	Up to 2000 m	
Pollution degree	2	
Type of meter	Indoor/outdoor	

Model type	IE.5-ED1	IE.5-EB2
Weight (without inserted FEM modules)	Ca. 0.8 kg	
Height/Width/Depth (in mm)	• With standard terminal cover: 209/130/67 • With short terminal cover: 169/130/67	
Integrated disconnector (Supply control switch)		
Insulation strength contact to contact	1 kV_{rms}, 50 Hz, 1 min	
Mechanical life of contacts (number of mechanical switching operations)	1,000,000	
Switching capacity at I_{max}	• 5,000 at cosΦ = 1 • 5,000 at cosΦ = 0.5	
Utilization category of integrated disconnector (EN 62052-31)	UC3	

14.2. Three-phase direct connected meter

Model type	IE.5-TD1	IE.5-TD2	IE.5-TD3	IE.5-PD2
Connection type	• 3P4W • 3P3W • 1P2W	• 3P4W • 3P3W • 1P2W	3P4W	3P3W
Reference voltage	• 3×240/415 V • 3×230/400 V • 3×230 V • 230 V (L3)	• 3×240/415 V • 3×230/400 V • 3×230 V • 230 V (L3)	3×230/400 V	3×230 V
Extended operating voltage range	-20% to +15% U_n			
Reference frequency	50 Hz			
Reference current	5 A	5 A	5A, 10 A	5 A
Maximum current	85 A	100 A	120 A	100 A
Thermal current	120% I_{max}			
Start-up current	< 0.4% of reference current			
Short circuit current	30 × I_{max}			
Utilization category (EN 62052-31)	UC2	UC2	UC3	UC2
Active energy (IEC 62053-21/ EN 50470)	Class 1 / Class B			
Reactive energy (IEC 62053-23)	Class 2			
Meter shutdown voltage	< 165 V			
Meter restoration voltage	176 V			
Power consumption in voltage circuit (meter with all integrated components)	0.52 W / 1.24 VA (L1, L2 and L3)	0.52 W / 1.24 VA (L1, L2 and L3)	0.52 W / 1.24 VA (L1, L2 and L3)	0.41 W / 0.94 VA (L1, L2 and L3)
Additional consumption – backlight	0.2 W / 0.4 VA			
Power consumption in current circuit (meter with all integrated components)	0.02–0.04 VA (I_{ref} = 5 A) / phase			
Operating temperature of meter	-40 °C to +70 °C			
Operating temperature of LCD display	-25 °C to +70 °C			
Storage temperature	-40 °C to +80 °C			
Temperature coefficient	-40 °C to +70 °C < ± 0.05% per K			
Protection class	Double insulation			
Ingress protection (IEC 60529)	IP54			
Electrostatic discharges (IEC 61000-4-2)	Contact: 8 kV, air: 15 kV			
Electromagnetic RF fields (IEC 61000-4-3)	Active: 10 V/m, passive: 30 V/m			

Model type	**IE.5-TD1**	**IE.5-TD2**	**IE.5-TD3**	**IE.5-PD2**
Radio interference suppression	Class B			
Fast transient burst (IEC 61000-4-4)	4 kV, into voltage measuring circuit / 2 kV into other			
Overvoltage category (IEC 60664-1)	OVC III			
Surge (IEC 61000-4-5)	4 kV into voltage measuring circuit / 1 kV into other			
Immunity to conducted disturbances (IEC 61000-4-6)	10 V			
Insulation strength	4 kV_{rms}, 50 Hz, 1 min			
Impulse voltage 1.2/50µs (EN 50470-1)	12 kV into voltage measuring circuit / 6 kV into other			
Internal Clock Accuracy; at +23 °C (IEC 62054-21)	0.5 s/day			
Backup with supercap	7 days			
Case	Antistatic polycarbonate plastic			
Mechanical conditions	• Shock test according to IEC 60068-2-27 • Vibration test according to IEC 60068-2-6			
Mechanical environment	M2			
Humidity	Up to 95%			
Altitude	Up to 2000 m			
Pollution degree	2			
Type of meter	Indoor/outdoor			
Weight (without inserted FEM modules)	Ca. 1.3 kg			
Height/Width/Depth (in mm)	• With standard terminal cover: 244/177/79 • With short terminal cover: 184/177/79			
Integrated disconnector (Supply control switch) *				
Insulation strength contact to contact	1 kV_{rms}, 50 Hz, 1 min			
Mechanical life of contacts (number of mechanical switching operations)	1,000,000			
Switching capacity at I_{max}	5,000 at cosΦ = 1 5,000 at cosΦ = 0.5			
Utilization category of integrated disconnector (EN 62052-31)	UC3			

* IE.5-TD3 is not equipped with an integrated disconnector (supply control switch).

14.3. Indirect connected meter

Model type	IE.7-TT2	IE.7-PT2	IE.7-TV2
Connection type	• 3P4W • 3P3W	3P3W	• 3P4W • 3P3W
Reference voltage	• 3×230/400 V • 3×230 V • 3×63.5/110 V • 3×110 V	3×230 V	• 3×63.5/110 V • 3×57.7/100 V • 3×110 V • 3×100 V
Extended operating voltage range	-20% to +15% U_n		
Reference frequency	• 50 Hz • 60 Hz	50 Hz	50 Hz
Reference current	1 A		
Maximum current	10 A		
Thermal current	120% I_{max}		
Start-up current	< 0.1% of reference current		
Short circuit current	20 × I_{max}		
Utilization category (EN 62052-31)	N/A		
Active energy (IEC 62053-22/ EN 50470)	Class 0.5 S / Class C		
Reactive energy (IEC 62053-24)	Class 1		
Meter shutdown voltage	< 75 V		
Meter restoration voltage	80 V		
Power consumption in voltage circuit (meter with all integrated components)	0.4–0.5W / 0.8–0.94VA		
Additional consumption – backlight	0.2 W / 0.4 VA		
Power consumption in current circuit (meter with all integrated components)	0.03 VA (I_{ref} = 1 A) / phase		
Operating temperature of meter	-40 °C to +70 °C		
Operating temperature of LCD display	-25 °C to +70 °C		
Storage temperature	-40 °C to +80 °C		
Temperature coefficient	-40 °C to +70 °C < ± 0.05% per K		
Protection class	Double insulation		
Ingress protection (IEC 60529)	IP54		
Electrostatic discharges (IEC 61000-4-2)	Contact: 8 kV, air: 15 kV		
Electromagnetic RF fields (IEC 61000-4-3)	10 V/m active, 30 V/m passive		
Radio interference suppression	Class B		
Fast transient burst (IEC 61000-4-4)	4 kV into voltage measuring circuit / 2 kV into other		
Overvoltage category (IEC 60664-1)	OVC III		
Surge (IEC 61000-4-5)	4 kV into voltage measuring circuit / 1 kV into other		
Immunity to conducted disturbances (IEC 61000-4-6)	10 V		
Insulation strength	4 kV_{rms}, 50 Hz, 1 min		
Impulse voltage 1.2/50µs (EN 50470-1)	12 kV into voltage measuring circuit, 6 kV into other		
Internal Clock Accuracy; at +23 °C (IEC 62054-21)	0.5 s/day		
Backup with supercap	7 days		
Case	Antistatic polycarbonate plastic		
Mechanical conditions	• Shock test according to IEC 60068-2-27 • Vibration test according to IEC 60068-2-6		
Mechanical environment	M2		

Model type	IE.7-TT2	IE.7-PT2	IE.7-TV2
Humidity	Up to 95%		
Altitude	Up to 2000 m		
Pollution degree	2		
Type of meter	Indoor/outdoor		
Weight (without inserted FEM modules)	Ca. 1.1 kg		
Height/Width/Depth (in mm)	• With standard terminal cover: 244/177/79 • With short terminal cover: 184/177/79		

Owing to periodic improvements of our products, the supplied products can differ in some details from the information stated in this document. The information is subject to alteration without notice.

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