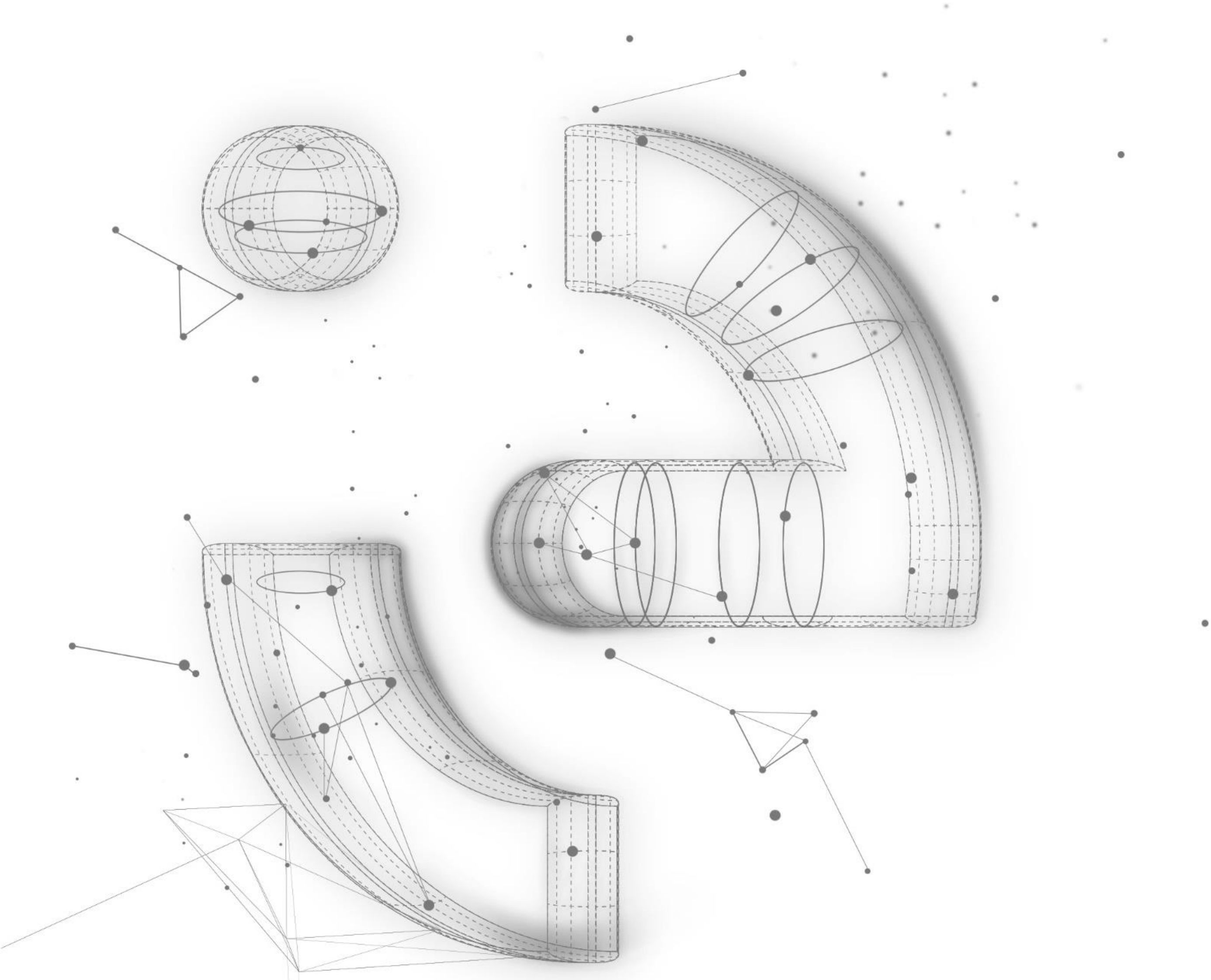
MT880

User manual



ISKRAEMECO, d.d.
Savska loka 4, 4000 Kranj

+386 4 206 4000

info@iskraemeco.com

www.iskraemeco.com

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BY ELSEWEDY ELECTRIC

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i. About the User manual

The User manual:

- is intended to present the MT880 meters;
- represents the purpose of the MT880 meters, meter construction, the way of deriving the measured quantities and meter functionalities;
- is written for technically qualified personnel at energy supply companies, responsible for system planning and system operation.

ii. Definitions, Acronyms and Abbreviations

AA	Application Association
ABS	Absolute IA+I + IA-I
AC	Alternating Current
AC	Application Core
AM	Application Module
AMI	Advanced Metering Infrastructure
APDU	Application Protocol Data Unit
APN	Access Point Name
ASCII	American Standard Code for Information Interchange
AT	Attention (modem commands used with the AT prefix)
BER	Bit Error Rate
bps	bits per second
CIP	Consumer Information Programme
CLIP	Calling Line Identification Presentation
COSEM	COmpanion Specification for Energy Metering
CM	Communication Module
CSD	Circuit-Switched Data
CT	Current Transformer
DC	Direct current
DHCP	Dynamic Host Control Protocol
DIN	Deutsches Institut für Normung (English: German Institute for Standardization)
DL	Data Link
DLMS	Device Language Message Specification
DNS	Domain Name Server
EMC	ElectroMagnetic Compatibility
FIFO	First-In First-Out
FW	FirmWare
GCM	Galois/Counter Mode
GMAC	Galois Message Authentication Code
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HDLC	High-Level Data Link Control
HES	Head End System
HHU	Hand Held Unit
HLS	High Level Security
HW	HardWare
ICCID	Integrated Circuit Card IDentifier
IDIS	Interoperable Device Interface Specifications
IEC	International Electrotechnical Commission
IMEI	International Mobile station Equipment Identity
IO	Input Output
IP	Internet Protocol
IPCP	Internet Protocol Control Protocol

LCD	Liquid Crystal Display
LCP	Link Control Protocol
LED	Light Emitting Diode
LLS	Low Level Security
LMN	Local Metrological Network
LN	Logical Name
MCO	Meter Cover Opening
MID	Measuring Instruments Directive
MP	Measurement period
MPA	Measurement period output
MPE	Measurement period input
MRA	External billing reset output
MRE	External billing reset input
MZA	Output for disabling demand measurement
MZE	Input for disabling demand measurement
NCT	No Connection Timeout
NET	IA+I – IA-I
NV	Non-Volatile
OBIS	OBject Identification System
OIML	Organisation Internationale de Métrologie Légale (English: International Organization of Legal Metrology)
OVC	OverVoltage Category
PAP	Password Authentication Protocol
PDP	Packed Data Protocol
PHY	PHYsical
PIN	Personal Identification Number
PPP	Point-to-Point Protocol
PQM	Power Quality Management
PUK	PIN Unlock Key
RAM	Random-Access Memory
RMS	Root Mean Square
RTC	Real Time Clock
SAP	Service Access Point
SIM	Subscriber Identification Module
SMA	SMA (SubMiniature version A) connector - type of Coaxial RF antenna connector
SMS	Short Message Service
SN	Serial Number
SW	SoftWare
TCO	Terminal Cover Opening
TCP	Transmission Control Protocol
THD	Total Harmonic Distortion
THR	THReshold value
TOU	Time Of Use
UART	Universal Asynchronous Receiver-Transmitter
UC	Utilization Category
UDP	User Datagram Protocol
UI	Unnumbered Information
UNIPEDE	Union internationale des producteurs et distributeurs d'énergie électrique (English: International Union of Producers and Distributors of Electrical Energy)
UMTS	Universal Mobile Telecommunications System
UTRAN	Universal Terrestrial Radio Access Network
VDEW	Verband Der ElektrizitätsWirtschaft (English: German Electricity Association)
VT	Voltage Transformer
WELMEC	Western European Legal MEtrology Cooperation
WPDU	Wrapper Protocol Data Unit

iii. Reference documents

- Installation and maintenance manual
- Technical descriptions of communication modules

iv. Versioning

Date	Version	Update
27.03.2013	V1.00	First version of the document
29.10.2013	V1.01	Annex 1 (MT880 object list) added to the end of the document
28.11.2013	V1.02	Note regarding RS485 communication ports termination added
23.01.2014	V1.03	• Error register explained in detail • Wrong phase sequence case explained • Information about ARON connection added • No power reading information added • Meter type designation corrected
12.01.2015	V1.04	• Extended voltage range added • Extended current range added
20.02.2015	V2.00	• FW module version 13 & 14 related changes updated: - System access configuration chapter added - TOU identifier added - Recording interval 1 & 2 objects added • 2G/3G related description fixed, communication speed values updated • Display cursor definition table updated
10.09.2015	V2.10	• Chapter *6.15.12. Operation time, non-operation time, TOU timers* was added • Object list in chapter *11. ANNEX 1* was added
28.06.2016	V3.00	• In subchapter *3.4. Meter connection*: - information about the identification number of connection diagram (ISXXXXX) was added - ISXXXXX marks on the connection diagrams were added • Subchapter *4.2.1.3.U-I link* was added • In subchapter *4.3. Nameplate*, excerpts of the nameplates with descriptions were added • In subchapter *5.1.6. Cursors:* - *Table 41*, *Display cursors definition* was updated - *Figure 35, Display cursors legend* was rearranged (with new designations) • In subchapter *5.3.2.1. Data menu*, example of the registers value reading on the LCD was added • In subchapter *6.2.4. Pulse outputs*, NOTE related to FW core version 5 was added • Subchapter *6.8.1. Alarm monitors* was added • In subchapter *6.8.3. Alarm bit assignment*, fraud attempt alarm cases were added • In subchapter *6.9.2. Error types*, fraud attempt errors were removed from subchapter • NOTE in subchapter *6.9.3.1. Description of errors and required actions* was added • Subchapter *6.11.4 Calendar type* was added • System access rights options in subchapter *6.16. System access configuration* were added • In chapter *11. ANNEX 1* - firmware versions were added and - MT880 object list was replaced.
19.10.2016	V3.10	• In subchapter *6.7.1. Billing reset enabling/disabling*, Table 57 was updated • Subchapter *6.7.5.2. Special previous values registers for display* was added • Subchapter *6.12.5. Manual tariffication script activation* was added • In subchapter *6.12.6. Tariff switch source*, option 4 was added • In subchapter *6.14.4. Load control output script table*, Table 74 was updated

		• Subchapter *7.2.2. Additional communication security* was supplemented with the description of the **HDLC channel options** object • In chapter *11. ANNEX 1* - firmware versions were updated and - MT880 object list was updated
18.07.2018	V4.00	• In chapter *1.2. Safety instructions*, caution text about overcurrent and overvoltage protection, and warning about radio interference in residential environments were added • As an option, External power supply was added – chapter *6.3. External power supply (option)* • Added Measurement period 2 – chapter *3.5.12.2. Average demand* • Maximum records number of Load profile 1 and Load profile 2 were changed (*6.6. Load profile*). • *6.6.1. Profile objects*: added Power Quality profile • Chapter *6.15.1.* was renamed (*Power quality → Power quality monitoring*) • In chapter *10. TECHNICAL CHARACTERISTICS*, utilization categories and overvoltage category were added. • Upgraded firmware version and object list (*11. ANNEX 1*) • Added chapters: - *3.5.5.4. Last average voltage* - *3.5.5.5. Last average voltage THD* - *3.5.6.2. Last average current* - *3.5.6.3. Last average current THD* - *3.5.7.2. Instantaneous phase angles between voltage and current* - *6.15.1.8. Voltage fail* - *6.15.2. Power quality indicators* - *6.15.4. THD monitoring* - *6.15.5. Frequency monitoring* - *6.17. Transformer and line losses* - *8.7.2. Push over Ethernet* • Improvements of the document
12.04.2019	V4.10	• Updated connection diagrams (Figure 3, Figure 5, Figure 6, Figure 7, Figure 9) • Added - Additional objects for phase angles between current and voltage - Output toggles - LMN communication module - Display lock 2 indicator - Horizontal scroll - Capture object data index value defined in display readout list - Status word – meter state information - “Ready for reconnection” state in Load management relay control - Relay logic selection (inverting) • Improvements of the document
10.09.2019	V4.20	• Added - in chapter *3.5.9.1. Instantaneous power*, objects “Instantaneous reactive power total” (1-0:130.7.0*255) and “Instantaneous apparent power total” (1-0:131.7.0*255) - in Table 61, alarms 16–24 - Push over RS-485 (chapter *8.7.3.*) • Updated chapter *8.7. Push* – changed structure of subchapters • Removed chapter *11: Annex 1*

NOTE

OBIS (Object Identification System) code (according to DLMS UA 1000-1:2001 standard) is composed of 6 groups of digits (A-B:C.D.E*F; i.e. 0-0:1.0.0*255). In a case where the last group of digits (group F) is not written, means the value of F is 255.

TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF TABLES

1. SAFETY INFORMATION

Safety information used in this User Manual is described with the following symbols and pictographs:

DANGER: for a possibly dangerous situation, which could result in severe physical injury or fatality – attention to a high-risk hazards.

WARNING: attention to a medium risk hazards.

CAUTION: for a possibly dangerous situation, which could result in minor physical injury or material damage - attention to a low risk hazards.

NOTE (Operating instruction): for general details and other useful information.

All safety information in this user manual describes the type and source of danger, its possible consequences, and measures to avoid the danger.

1.1. Responsibilities

The owner of the meter is responsible to assure that all authorized persons who work with the meter read and understand the parts of the User Manual and Installation and Maintenance Manual that explains the safe handling with the meter.

The personnel must be sufficiently qualified for the work that will be performed. The installation personnel must possess the required electrical knowledge and skills, and must be authorised by the utility to perform the installation procedure.

The personnel must strictly follow the safety regulations and operating instructions, written in the individual chapters in this User Manual and in the Installation and Maintenance Manual.

The owner of the meter responds specially for the protection of the persons, for prevention of material damage and for training of personnel.

1.2. Safety instructions

CAUTION: At the beginning of handling with the meter, the meter should be carefully taken out of the box where it was packed. This should prevent the meter from falling as well as any other external or internal damage to the device and personal injuries. Should such an incident occur despite all precautions, the meter must not be installed at the metering point as such damage may result in different hazards. In such case, the meter needs to be sent back to the manufacturer for examination and testing.

CAUTION: The edges of the seal wires are sharp.

WARNING: Safety measures should be observed at all times. Do not break the seals or open the meter at any time!

The content of this User manual provides all information necessary for safe selection of MT880 meter.

It must be consulted in all cases where symbol ⚠ is marked in order to find out the nature of the potential hazards and any actions, which have to be taken to avoid them.

The meter installation procedure is described in detail in the Installation and Maintenance Manual.
For safety reasons, the following instructions should be followed.

DANGER: Any unauthorized manipulation of the device is dangerous for life and prohibited according to the applicable legislation. Any attempt to damage the seals as well as any unauthorized opening of the terminal or meter cover is not allowed according to the national legislation.

CAUTION: On the supply side of installation where the meter is installed, the installer must provide environment according to requirements for OVC III or lower, so proper overvoltage protection must be installed (max. overvoltage <4kV). The protection must be done according to local regulation.

The installer must provide overcurrent protection on the supply side of installation. The cut-off current of protection must not be higher than meter maximum current (I_{max}). The current capability of overcurrent protection must be according to UC rating of the meter equipment (only for direct connected meter). The overcurrent protection must be done according to local regulation as well.

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

The installer must consult and comply with local regulations and read the installation instructions written in the Installation and maintenance manual.

WARNING: Meter installation may not be performed by unauthorised and untrained personnel. Such persons are not allowed to cut the seals and open the terminal or meter cover as contact with the live parts of the meter is dangerous for life.

DANGER: Opening the terminal or meter cover is dangerous for life because there are live parts inside.

CAUTION: The installer is expected to fully understanding the risks and safety issues involved in electrical installations. The installer shall be aware at all times of the potential hazard of electrical shock and shall exercise due to caution in completing the task!

Installation personnel must possess the required electrical knowledge and skills and must be authorised by the utility to perform the installation procedure.

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

CAUTION: The temperature of the terminal block of the connected and operating meter may rise; therefore, the temperature of the terminal cover may rise as well.

DANGER: In case of any damage inside the meter (fire, explosion...) do not open the meter.

CAUTION: The meter may be used only for the purpose of measurement for which it was produced. Any misuse of the meter will lead to potential hazards.

No maintenance is required during the meter's lifetime. The implemented metering technique, built-in components, and manufacturing process ensure high long-term stability of meters, so that there is no need for their recalibration during their lifetime.

The capacity of the built in battery is sufficient to backup meter functions like RTC and tampering functions for its entire lifetime.

Cleaning of the meter is allowed only with a soft dry cloth. Cleaning is allowed only in upper part of the meter – in region of the LCD. Cleaning is forbidden in the region of terminal cover. Cleaning can be performed only by the personnel, responsible for meter maintenance.

CAUTION: Do not try to erase the markings, laser printed on the nameplate.

DANGER: Never clean soiled meters under running water or with high-pressure devices. Penetrating water can cause short circuits. A damp cleaning cloth is sufficient to remove normal dirt such as dust. If the meter is more heavily soiled, it should be dismounted and sent to the responsible service or repair centre.
While dismounting the meter observe and follow the same safety regulations and instructions as for installation of the meter.

CAUTION: Visible signs of fraud attempt (mechanical damages, presence of a liquid, etc.) must be regularly checked. The quality of seals and the state of the terminals and connecting cables must be regularly checked.
If there exist a suspicion of incorrect operation of the meter, the local utility must be informed immediately.

After the end of the meter's lifetime, the meter should be treated according to the Waste Electric and Electronic Directive (WEEE).

WARNING: **Possible radio interference in residential environments**
This is a class A product. In combination with some communication modules it may cause radio interference in which case the user may be required to take adequate measures.

2. ENERGY METERING

MT880 meter is designed for industrial and commercial applications with accuracy class up to 0,5S (MID C) and is intended for more precise energy measurements. It measures active, reactive, and apparent energy/demand in two directions and in four quadrants. The meter measures consumed energy in three-phase four-wire, or three-phase three-wire networks. It can be connected directly or indirectly through measurement transformers.

Measuring and technical characteristics of the meter comply with the IEC 62052-11, IEC 62053-21, IEC 62053-22, IEC 62053-23, EN 50470-1, EN 50470-3 standards.

Meters are designed and manufactured in compliance with the standards and ISO 9001, as well as Iskraemeco standards.

Meter utilizes the DLMS communication protocol in compliance with the IEC 62056-46 standard.
Also, IEC 62056-21 (former IEC 1107) mode C protocol is supported with limited, manufacturer specific implementation.

3. MT880 METERS INTRODUCTION

3.1. Standards and references

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 61000-4-6	Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields
IEC 61000-4-15	Electromagnetic compatibility (EMC) – Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications
IEC 62052-11	Electricity metering equipment (AC) – General requirements, tests and test conditions – Metering equipment
IEC 62053-21	Electricity metering equipment (a.c.) – static meters for active energy (classes 1 and 2)
IEC 62053-22	Electricity metering equipment (a.c.) – static meters for active energy (classes 0.2 and 0.5)
IEC 62053-23	Electricity metering equipment (a.c.) – static meters for reactive energy (classes 2 and 3)
IEC 62053-24	Part 24: Static meters for fundamental component reactive energy (classes 0,5 S, 1S and 1)
IEC 62054-21	Electricity metering (a.c.) – Tariff and load control – Particular requirements for time switches
IEC 62056-21	Electricity metering – Data exchange for meter reading, tariff and load control – Direct local data exchange
IEC 62056-42	Electricity metering – Data exchange for meter reading, tariff and load control –Physical layer
IEC 62056-46	Electricity metering – Data exchange for meter reading, tariff and load control – Data link layer
IEC 62056-47	Electricity metering – Data exchange for meter reading, tariff and load control –COSEM transport layers for IP networks
IEC 62056-53	Electricity metering – Data exchange for meter reading, tariff and load control –COSEM Application layer
IEC 62056-61	Electricity metering – Data exchange for meter reading, tariff and load control – Object identification system (OBIS)
IEC 62056-62	Electricity metering – Data exchange for meter reading, tariff and load control –Interface classes
IEC 62059-41	Electricity metering equipment – Dependability – Reliability prediction
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)
CLC/TR 50579	Electricity metering equipment (A.C.). Severity levels, immunity requirements and test methods for conducted disturbances in the frequency range 2 kHz-150 kHz
IEC 60664-1:2007	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests

3.2. Meter description

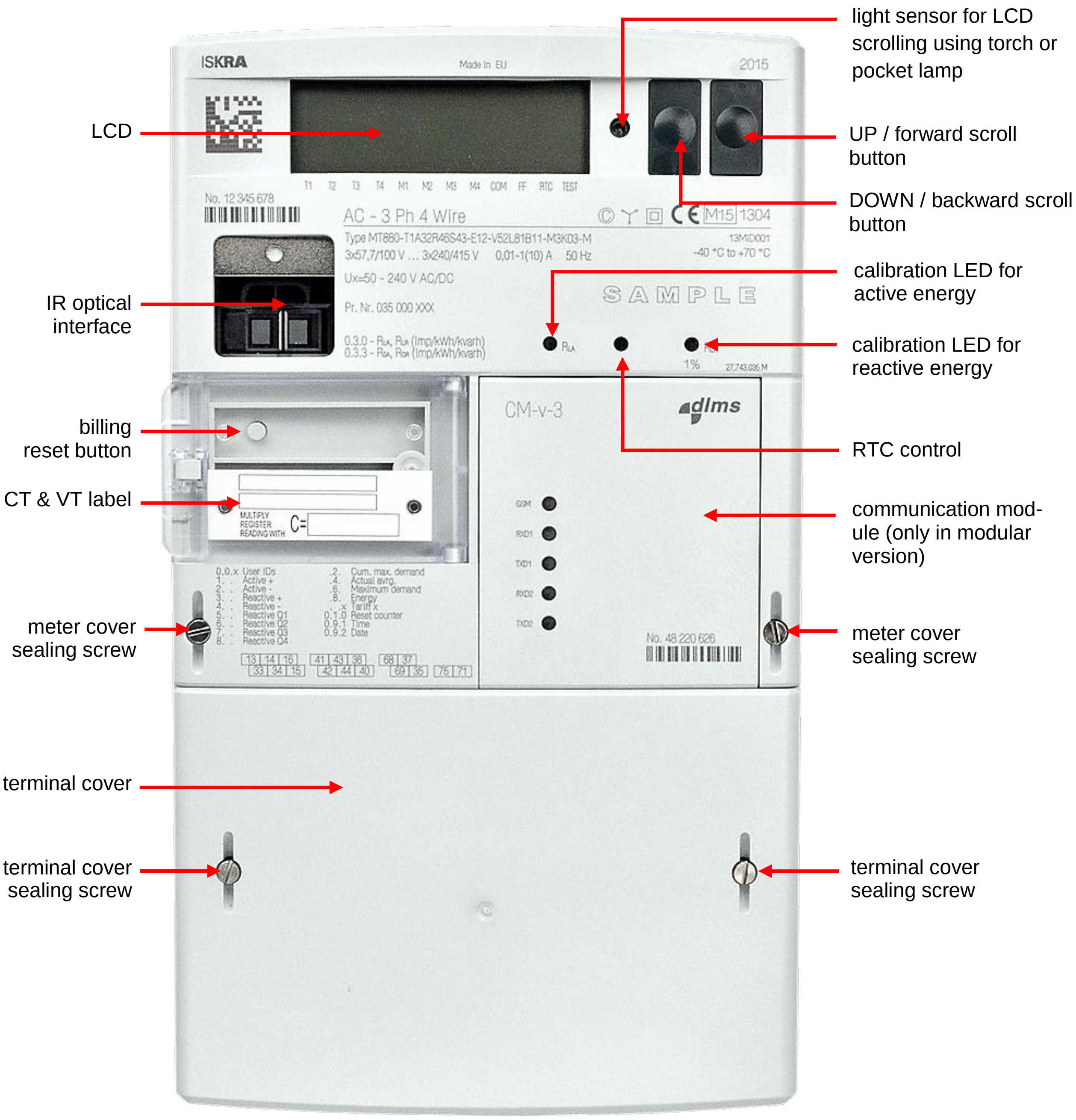


Figure 1: MT880 – modular version – front view

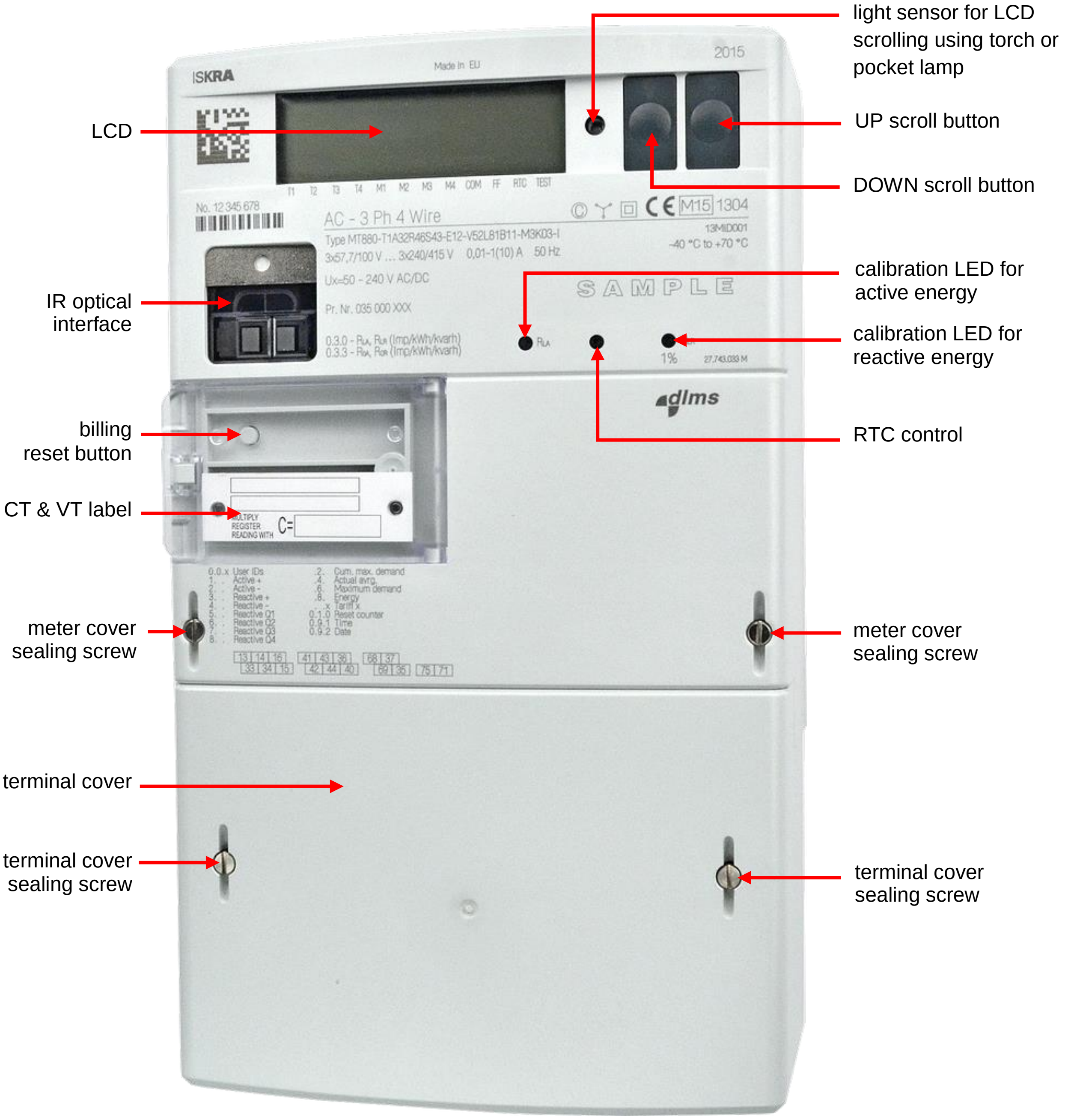


Figure 2: MT880 – integrated version – front view

3.3. Main meter properties

Measuring of:

- Active energy and demand of accuracy class up to 0.5S (MID C)
  (in compliance with IEC 62053-22, EN 50470-3).
- Reactive energy of accuracy class up to 1 (in compliance with IEC 62053-24).
- Two-way energy flow direction.
- Reactive energy per quadrant measurement.

Energy registration modes:

- Two-way energy flow direction, three-phase energy registered as arithmetic sum of phase energies.
- Two-way energy flow direction, three-phase energy registered as vector sum of phase energies.

Meter connection:

- Direct or transformer connection of the meter.
- 3-phase 4-wire or 3-phase 3-wire connection.
- The three-phase meter can function as a single-phase or a two-phase meter as well.

Meter benefits:

- No meter re-calibration over its lifetime required.
- High meter reliability.
- EMC compatibility better as required by IEC 62052-11 standard.
- Higher voltage input “surge” protection and Impulse voltage according to EN 50470-1 and IEC 62052-11.
- Shielded measurement part.

Additional meter functions:

- Power Quality Measurements.
- Power Quality Measurements data available as instantaneous or average data.
- Harmonic components for currents and voltages (up to the 31st), THD factor.
- Voltage sags & swells.
- Under – over voltage.
- UNIPEDE voltage tolerance table.
- Detection of minimum and maximum voltage for present and previous day.
- Detection of minimum and maximum current for present and previous day.
- Detection of minimum, maximum, instantaneous and average Power factor; registered per phase and three-phase.
- Detection of phase angles between phase voltages and phase angles between voltages and currents.
- Registration of long and short power downs and duration per phase and three phase.

Time-of-use registration:

- Up to 8 tariffs.
- Up to 16 masks for configuring different combinations of tariff registers.
- Up to 16 seasons tariff programs.
- Up to 16 weekly rules.
- Up to 32 daily rules.
- Up to 16 actions per day tariff program.
- Up to 128 special day definitions (holidays ...).
- Separate energy and demand tariff switching.
- Tariff switching driven by internal RTC (by IEC 61038).
- Tariff switching via inputs (separately for energy and demand).

Load-profile recorder:

- Two load profiles.
- Up to 32 free configurable capture objects per profile.

Communication interfaces (up to three independent communication interfaces in integrated meter version and up to four independent communication interfaces in modular meter version):

- infrared optical port (IEC 62056-21) for local meter programming and data downloading,
- optional built-in RS232 communication interface or
- optional built-in RS485 communication interface.

Additional communication interfaces are available through exchangeable communication modules only at modular meter version. (For more information, see chapter 8.5. *Exchangeable communication modules.*)

LCD: In compliance with the VDEW specification.

Data display modes:

- Autoscroll with configurable appearance time.
- Manual scroll:
  - Standard data display mode.
  - Load profile (P.01 and P.02) display mode.
  - Service log (P.99) display mode.
  - Grid quality display mode.

Console push-buttons:

- Up scroll push-button.
- Down scroll push-button.
- Optical scroll button.
- Billing reset push-button.

Indicators:

- LCD:
  - Presence of phase voltages L1, L2, L3.
  - Presence of phase currents and phase energy flow direction.
  - Power flow directions.
  - Notification field.
  - Physical unit field.
  - Alphanumeric field 1 - OBIS identification code presentation.
  - Alphanumeric field 2 - Data value presentation.
- LED1: Metrological LED 1 – active energy (left).
- LED2: RTC test LED (middle).
- LED3: Metrological LED 2 – reactive energy (right).

Communication protocols:

- DLMS/COSEM,
- IEC 62056-21, mode E,
- MODBUS.

OBIS data identification code according to IEC 62056–61 standard.

Auxiliary inputs/outputs:

- up to 5 high voltage programmable inputs,
- up to 8 non-voltage (OptoMOS) programmable outputs, divided in two different groups (5 + 3),
- bistable 5 A relay,
- alarm input,
- analog output (4 mA – 20 mA) for direct connection to SCADA on the MODBUS module.

Meter programming as well as FW upgrade can be done locally or remotely in compliance with the predefined security policy and specific national regulations.

Two variants of the U-I link are available only for direct connected meters:

- under the terminal cover,
- under the meter cover.

Construction:

- Made of high quality self-extinguishing UV stabilized material that can be recycled.
- Ingress protection IP54 against dust and water penetration (by IEC 60529).

Fraud detection:

- registration of magnet tampering,
- registration of meter and terminal cover opening,
- registration of inverted energy flow direction,
- registration of current and voltage asymmetry,
- registration of minimum power factor,
- two alarm inputs,
- missing voltage,
- wrong phase sequence,
- current without voltage.

Event logs:

- Standard event log – 255 entries.
- Fraud event log – 255 entries.
- Power quality event log – 255 entries.
- Power down event log – 64 entries.
- Communication event log – 255 entries.
- Meter Cover Opening & Terminal Cover Opening event log – 20 entries.
- Magnetic tamper event log – 20 entries.
- Certification data log – 100 entries.
- Power failure event log (records duration of long power failure in any phase) – 10 entries.

Alarming and monitoring is presented via:

- LCD special characters and statuses,
- up to two alarm outputs,
- remote communication channel GPRS or SMS,
- specific alarm registers (IDIS, ISKRAEMECO),
- load control functionality (three independent channels).

Power supply:

- Primary power supply of the meter
- External power supply of the meter (Optional)

Push:

- on alarm,
- on wake-up (for handling dynamic GPRS addresses),
- on installation (when meter first put into mobile network),
- on interval (up to three different time intervals possible.

3.4. Meter connection

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

MT880 meters can be connected to the 3-phase 4-wire or 3-phase 3-wire networks (Aron connection).
All, semi-direct (CT) indirect (CT/VT) as well as direct connections are supported. Connection diagram is usually located in the inner side of the terminal cover (see Figure 24).

To each connection diagram, corresponding identification number is assigned. It is generated by Iskraemeco and looks like **ISXXXXX**, where x represents any number from 0 to 9. On the nameplate of each meter, corresponding identification number of the connection diagram is printed, and it can be found as
Conn.: ISXXXXX (see Figure 29 – Figure 32).

The meter with the connection diagram identification number IS26727 (Figure 3) can also be connected according to the following connection diagrams:

- IS26722 (modular version, Aron external connection diagram, grounded "L" terminal) - Figure 7
- IS26723 (modular version, external Aron connection diagram, grounded "K" terminal) - Figure 5

The meter with the connection diagram identification number IS26729 (Figure 4) can also be connected according to the following connection diagrams:

- IS26724 (integrated version, external Aron connection diagram, grounded "L" terminal) - Figure 8
- IS26725 (integrated version, Aron external connection diagram, grounded "K" terminal) - Figure 6

3.4.1. Indirect connected meters

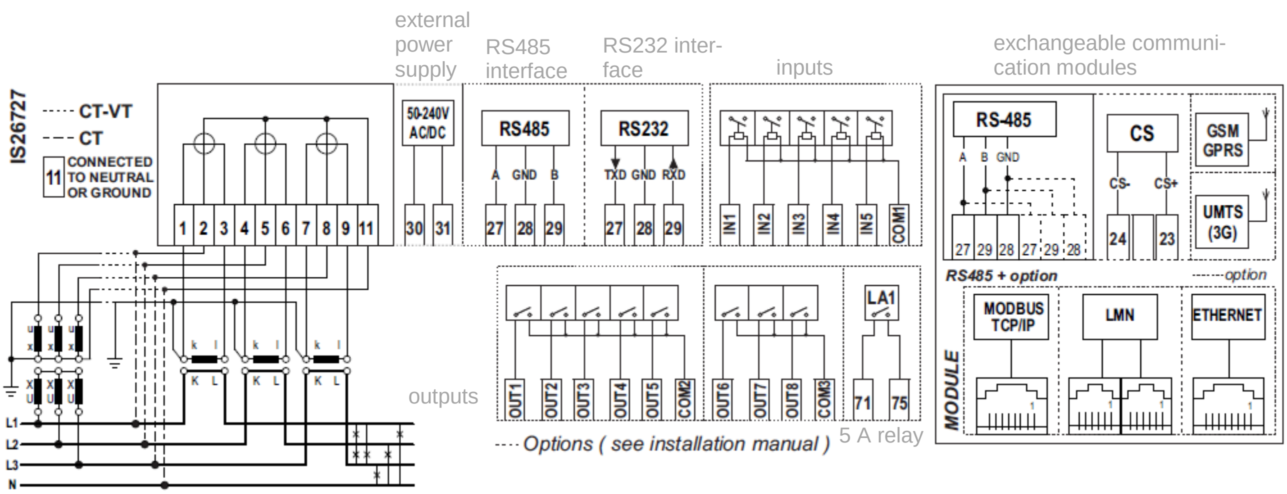


Figure 3: Meter connection diagram – CT, CT/VT connection, 3-phase 4-wire system, modular version

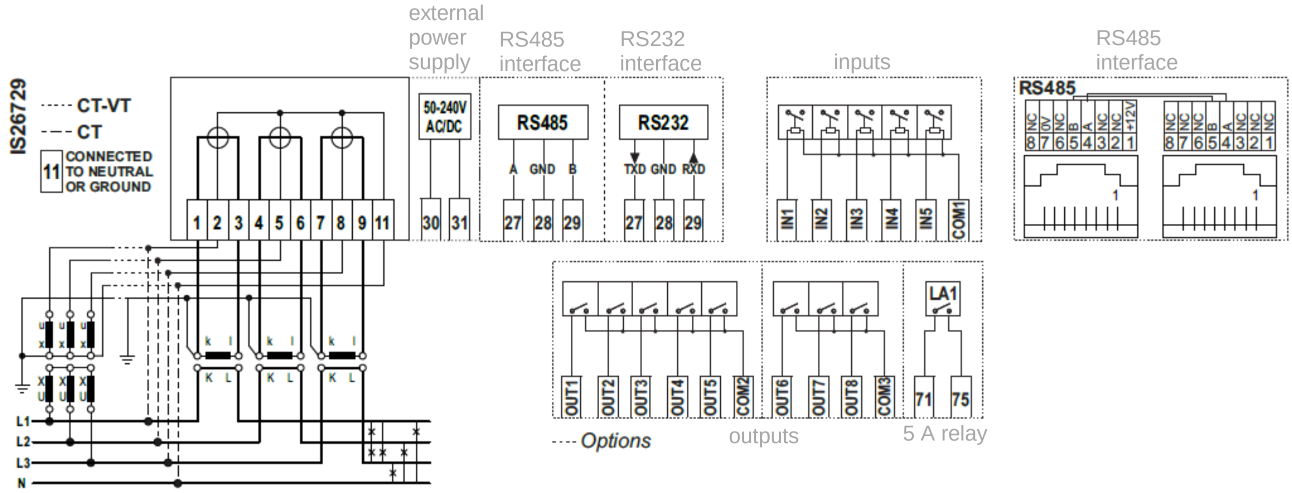


Figure 4: Meter connection diagram – CT, CT/VT connection, 3-phase 4-wire system, integrated version

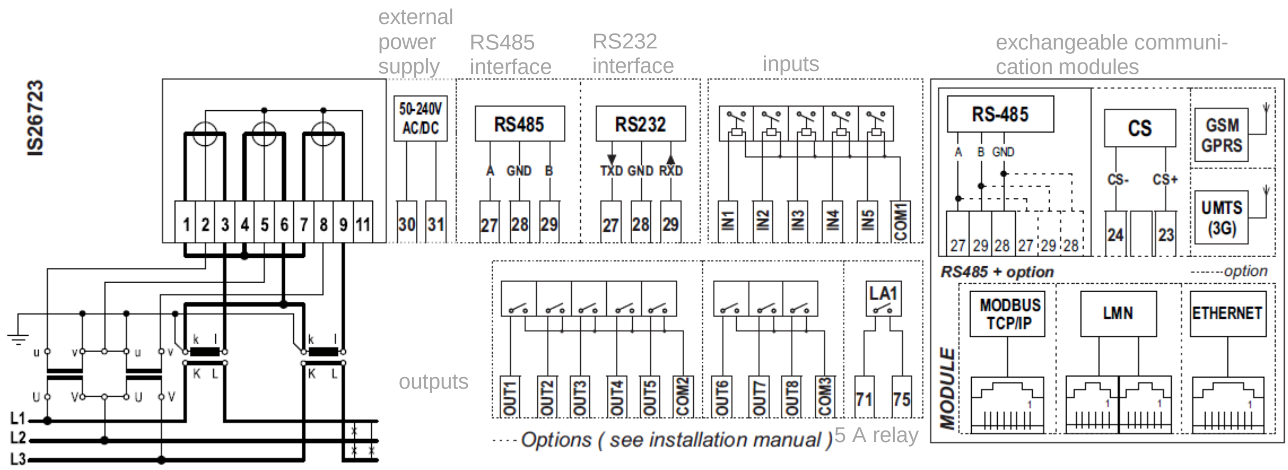


Figure 5: 3-phase 3-wire indirect external Aron connection diagram, “k” terminal grounded, modular version

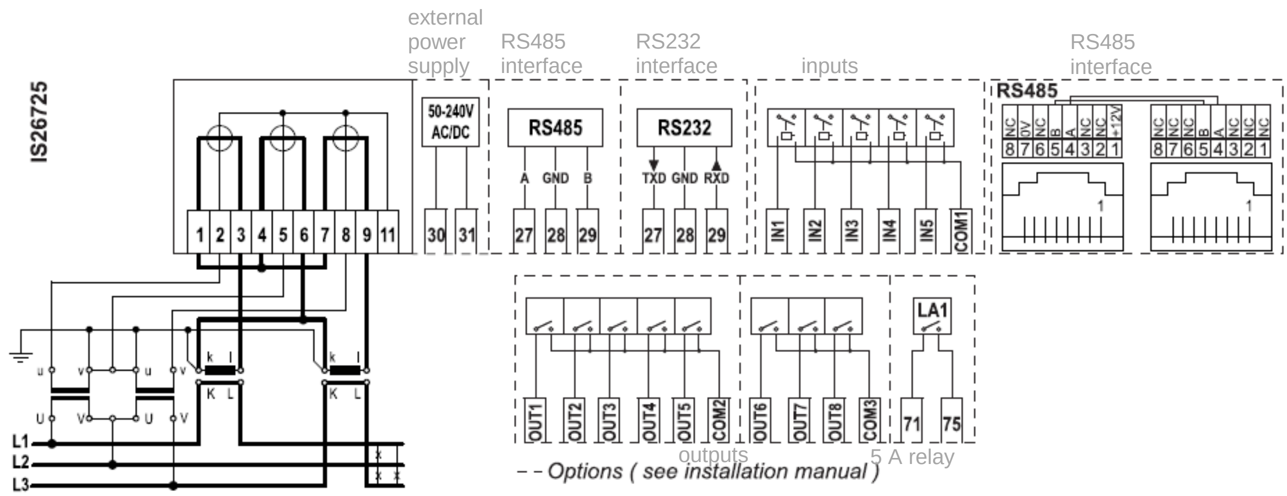


Figure 6: 3-phase 3-wire indirect external Aron connection diagram, “k” terminal grounded, integrated version

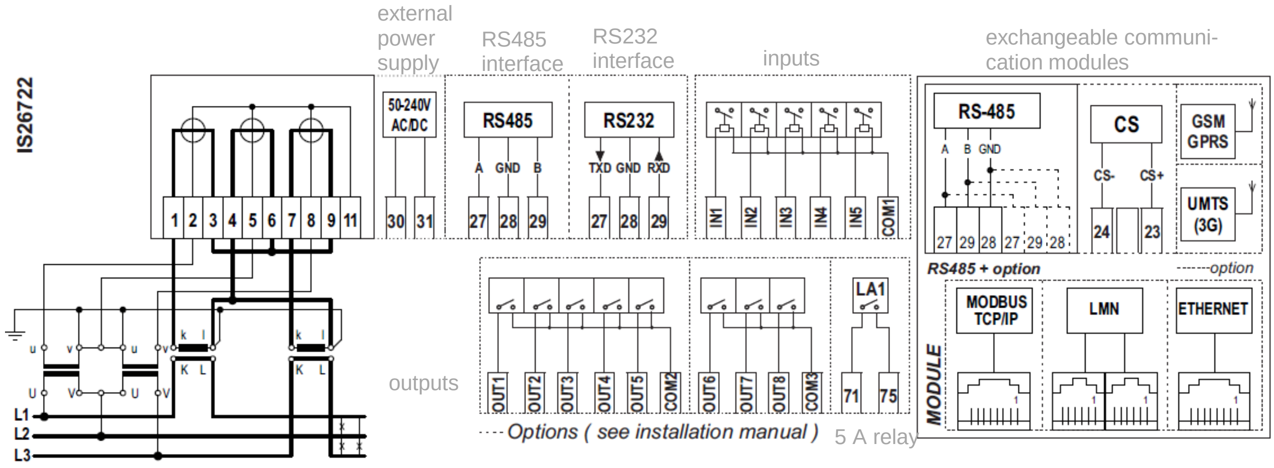


Figure 7: 3-phase 3-wire indirect external Aron connection diagram, "I" terminal grounded, modular version

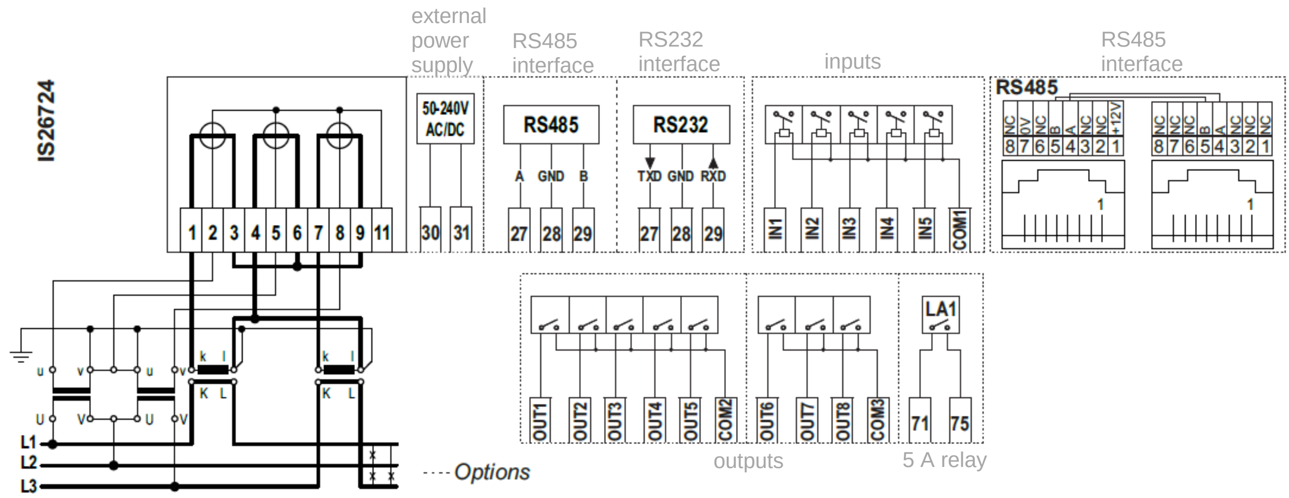


Figure 8: 3-phase 3-wire indirect external Aron connection diagram, "I" terminal grounded, integrated version

3.4.2. Direct connected meters

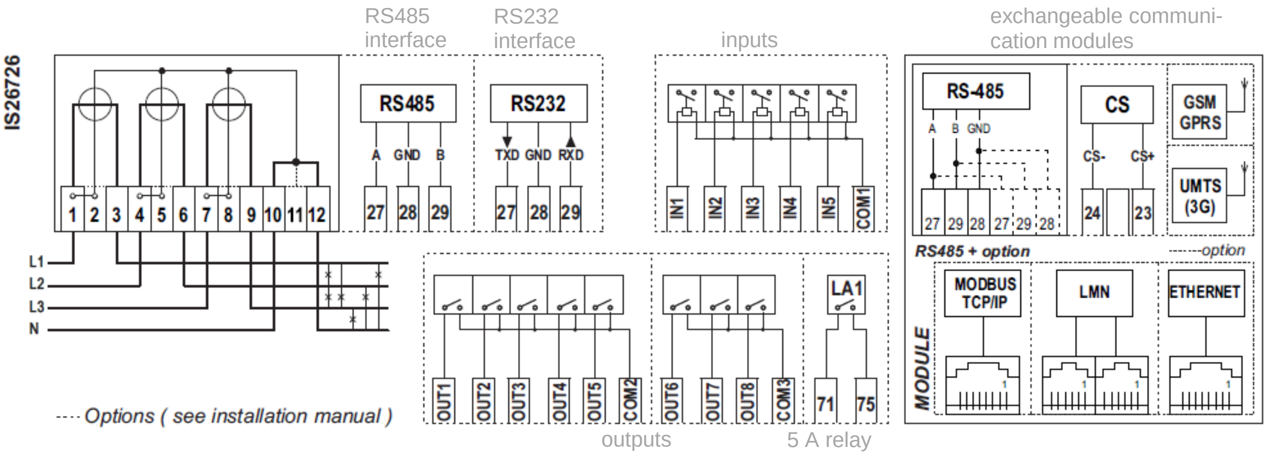


Figure 9: 3-phase 4-wire connection diagram for direct connected meter, modular version

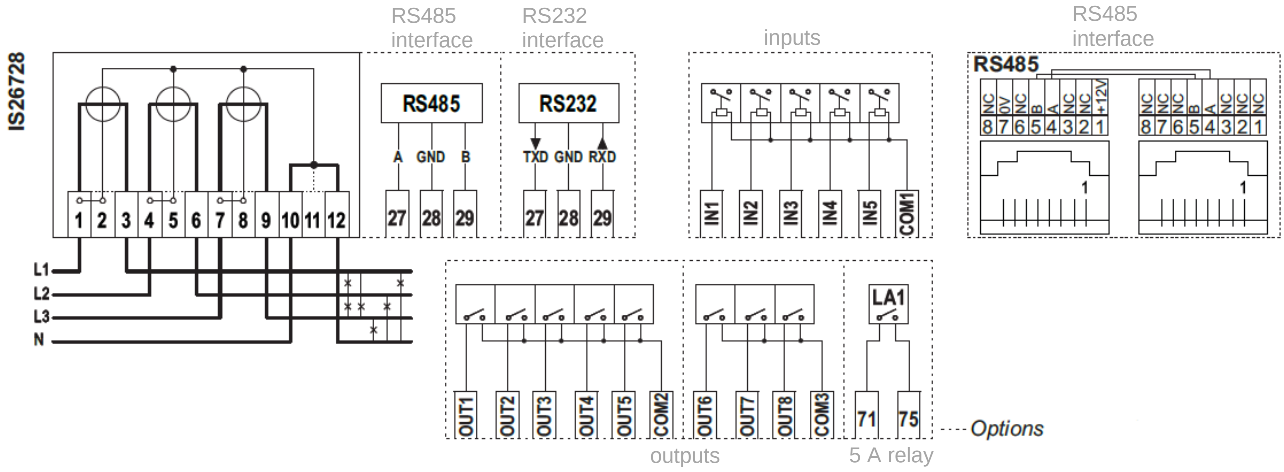


Figure 10: 3-phase 4-wire connection diagram for direct connected meter, integrated version

3.5. Measuring of basic quantities

3.5.1. Measurement system

The measurement systems consist of shielded measurement current transformers. The shield ensures protection from external magnetic field influence. Measurement system complies with OIML (International Organization of Legal Metrology) requirements and is resistant to the influence of harmonic disturbances. Long-term stability ensures no need of recalibration during entire meter lifetime.

Available three-meter variants are:

- I_{max} = 10 A - CT, CT/VT connected meter, 3x57,7/100 V ... 3x240/415 V,
- I_{max} = 20 A - CT, CT/VT connected meter, 3x57,7/100 V ... 3x290/500 V,
- I_{max} = 120 A - direct connected meter, 3x110/190 V ... 3x240/415 V.

NOTE!
Meter nominal voltage parameter has to be properly set to operate correctly in terms of PQM (Power Quality Management) and voltage event detection.

Measured quantities:

- active energy/demand: nominal frequency with included harmonics,
- reactive energy/demand: nominal frequency only (natural connection is used),
- apparent energy/demand, measured according to RMS values of voltage and current – includes harmonic values, in 2 system connection P-Q method is used,
- RMS phase voltages and phase currents,
- phase angles between voltages, phase angles between phase voltages and phase currents,
- network frequency,
- harmonic components in phase voltage and phase current (up to 31st harmonic),
- THD (Total Harmonic Distortion) per phase voltage and phase current,
- power factor per phase and total.

3.5.2. Analyse of measured data

3.5.2.1. Active Energy registration method

Vector registration method (∑ Li)
By vector method, the vectors of each phase L1, L2 and L3 are summed:

- When the vector sum of energies is positive, the meter registers A+ energy.
- When the vector sum of energies is negative, the meter registers A- energy.

Example (phase load is the same):

Phase:	L1	L2	L3
Load:	+A	-A	+A

Total registration (1-0:1.8.0*255): (+A) + (-A) + (+A) = +A
Meter registers +A (one-phase load).

Arithmetic registration method
The meter can register energy import (A+) and export (A-) in the same time with arithmetic registration method.

Example (phase load is the same):

Phase:	L1	L2	L3
Load:	+A	-A	+A

Total registration — Energy import (1-0:1.8.0*255): (+A) + (+A) = 2*(+A)
Energy export (1-0:2.8.0*255): -A

3.5.2.2. Reactive Energy registration method

Meter can be configured to register positive and negative reactive energy in two ways:

- 0: the sign of the reactive phase energy/power is the sign of that reactive energy itself,
- 1: the sign of the reactive phase energy/power is the sign of the corresponding phase active energy.

Then the reactive phase energies are summed into total values according to the desired energy registration method.

Which quadrants are summed in Q+ and Q- can be defined in the **Reactive energy registration method** (0-0:196.0.11) object. According to this object, instantaneous reactive import/export powers can be calculated as:

- Q+ = QI + QII and Q- = QIII + QIV, when parameter value is 0 or,
- Q+ = QI + QIV and Q- = QII + QIII, when parameter value is 1.

3.5.3. Transformer configuration

At CT or CT/VT transformer meter could register energy/demand as well as voltage/current values as primary or secondary. Type of parameterisation is defined via meter parameter and it is under factory protection level.

NOTE!
If we switch between primary and secondary registration and data presentation on the already connected and operating meter, meter does not recalculate data to the new CT or CT/VT ratio. Already saved meter data remains as they are.

Transformer ratios are separately configured for voltage and current transformers. Both ratios are defined with numerator and denominator. In such a way, also non-integer ratios can be achieved.

Primary energy and power values are calculated as:

$$EP(PRIM) = \frac{VT_{NUM}}{VT_{DEN}} \times \frac{CT_{NUM}}{CT_{DEN}} \times EP(SEC)$$

Where symbols in equation are explained as:

- EP(PRIM) – energy/power primary value
- EP(SEC) – energy/power secondary value
- VT_{NUM} – voltage transformer numerator
- VT_{DEN} – voltage transformer denominator
- CT_{NUM} – current transformer numerator
- CT_{DEN} – current transformer denominator

If meter is configured for primary measurement and denominator is set to 0, corresponding values will be registered as secondary values.

3.5.4. Measurement of different related values

3.5.4.1. Instantaneous values

- Instantaneous voltage,
- Instantaneous voltage harmonics,
- Instantaneous voltage THD,
- Instantaneous current,
- Instantaneous current harmonics,
- Instantaneous current THD,
- Instantaneous current – sum of all three phases,
- Instantaneous phase angle,
- Instantaneous net frequency,
- Instantaneous power,
- Instantaneous power factor import total and per phase,
- Instantaneous power factor export total and per phase,
- Instantaneous active import power total and per phase,
- Instantaneous active export power total and per phase,
- Instantaneous active absolute power,
- Instantaneous reactive import power total and per phase,
- Instantaneous reactive export power total and per phase,
- Instantaneous reactive power per quadrant total and per phase,
- Instantaneous apparent import power total and per phase,
- Instantaneous apparent export power total and per phase,
- Instantaneous active absolute power total and per phase,
- Instantaneous active net presented power total and per phase,
- Phase angles U – U,
- Phase angles U – I,
- Phase angles I – U.

3.5.4.2. Min/max values

- Minimum and maximum voltage,
- Daily maximum and minimum voltage,
- Previous day maximum and minimum voltage,
- Minimum and maximum current,
- Minimum and maximum net frequency,
- Minimum and maximum power factor total and per phase,
- Cumulative maximum demand active import total and per phase,
- Maximum demand active import total and per phase,
- Cumulative maximum demand active export total and per phase,
- Maximum demand active export total and per phase,
- Cumulative maximum demand reactive import total and per phase,
- Maximum demand reactive import total and per phase,
- Cumulative maximum demand reactive export total and per phase,
- Maximum demand reactive export total and per phase,
- Cumulative maximum demand apparent export total and per phase,
- Maximum demand apparent export total and per phase,
- Cumulative maximum demand absolute,
- Maximum demand absolute,
- Cumulative maximum demand net presented,
- Maximum demand net presented,
- Cumulative maximum demand reactive per quadrant,
- Maximum demand reactive per quadrant.

3.5.5. Voltage

3.5.5.1. Instantaneous voltage, voltage harmonics and THD values

Phase voltage is measured and presented in corresponded DLMS/COSEM objects for each phase separately. Internally voltages are always measured in mV. According to measurement transformer parameters, the measured values are presented as:

- mV values when meter is configured for secondary voltage/current measurement,
- V values when meter is configured for primary voltage/current measurement.

Harmonics and THD values are presented in % of fundamental value.
Instantaneous voltage harmonics are measured up to 31st harmonics. Meter also measures voltage THD.
Instantaneous voltage is measured in the meter every 100 ms.

	L1	L2	L3	Any phase
Instantaneous voltage	32.7.0	52.7.0	72.7.0	12.7.0
Instantaneous voltage harmonics (h=1...31)	32.7.h	52.7.h	72.7.h	x
Instantaneous voltage THD	32.7.124	52.7.124	72.7.124	12.7.124

Table 1: Instantaneous voltage objects in the MT880 meter

3.5.5.2. Daily (current/previous) peak and minimum values

MT880 meter represents daily peak and minimum values of voltage for current day and for previous day in special objects.

	L1	L2	L3
Daily peak voltage (current)	128.8.10	128.8.20	128.8.30
Daily peak voltage (previous)	128.8.11	128.8.21	128.8.31
Daily minimum voltage (current)	128.8.12	128.8.22	128.8.32
Daily minimum voltage (previous)	128.8.13	128.8.23	128.8.33

Table 2: Peak and minimum values of voltage

3.5.5.3. Average voltage

For each period defined in the object **Voltage peak and minimum aggregation period [s]** (0-0:128.8.50*255), the average voltage is calculated and stored in corresponding objects.

	L1	L2	L3
Average voltage	32.24.0	52.24.0	72.24.0

Table 3: Average values of voltage

3.5.5.4. Last average voltage

Average values of voltages are applied to meter terminals on each phase. Aggregation period is defined with the **Measurement period 1** (1-0:0.8.0*255). The measured values are presented in corresponding objects for each phase separately. Object value is the last period average value.

	L1	L2	L3
Last average voltage period *[phase]*	32.5.0	52.5.0	72.5.0

Table 4: Last average voltage (per phase) – period 1

3.5.5.5. Last average voltage THD

Average values of voltage THD are applied to meter terminals on each phase. Aggregation period is defined by **Measurement period 2** (1-0:0.8.1.*255). The measured values are presented in corresponding objects for each phase separately. Object value is the last period average value.

	L1	L2	L3
Last average voltage THD *[phase]*	32.15.124	52.15.124	72.15.124

Table 5: Last average voltage THD (per phase) – period 2

3.5.6. Current

3.5.6.1. Instantaneous current, current harmonics and THD values

Phase current is measured and presented in corresponded DLMS/COSEM objects for each phase separately. Internally currents are always measured in mA. According to measurement transformer parameters, the measured values are presented as:

- mA values when meter is configured for secondary voltage/current measurement,
- values when meter is configured for primary voltage/current measurement.

Harmonics and THD values are presented in % of fundamental value.

Current harmonics are measured up to 31st harmonics. Meter also measures current THD.

Instantaneous current is measured in the meter every 100 ms.

	SUM	L1	L2	L3	Any phase
Instantaneous current	90.7.0	31.7.0	51.7.0	71.7.0	11.7.0
Instantaneous current harmonics (h=1…31)	x	31.7.h	51.7.h	71.7.h	x
Instantaneous current THD	x	31.7.124	51.7.124	71.7.124	x

Table 6: Instantaneous current objects in the MT880 meter

3.5.6.2. Last average current

Average values of current are applied to meter terminals on each phase. Aggregation period is defined by **Measurement period 1** (1-0:0.8.0*255). The measured values are presented in corresponding objects for each phase separately. Object value is the last period average value.

	L1	L2	L3
Last average current period *[phase]*	31.5.0	51.5.0	71.5.0

Table 7: Last average current (per phase) – period 1

3.5.6.3. Last average current THD

Average values of current THD are applied to meter terminals on each phase. Aggregation period is defined by **Measurement period 2** (1-0:0.8.1.*255). The measured values are presented in corresponding objects for each phase separately. Object value is the last period average value.

	L1	L2	L3
Last average current THD *[phase]*	31.15.124	51.15.124	71.15.124

Table 8: Last average current THD (per phase) – period 2

3.5.7. Phase angles

3.5.7.1. Instantaneous phase angles between voltages

MT880 meter provides measurement of phase angles between voltages of different phases.

	Phase angle
U(L1) – U(L1)	81.7.0
U(L2) – U(L1)	81.7.1
U(L3) – U(L1)	81.7.2
U(L3) – U(L2)	81.7.12

Table 9: Phase angles between voltages objects

3.5.7.2. Instantaneous phase angles between voltage and current

MT880 meter provides also measurement of phase angles between voltages and currents for every phase.

	Phase angle
U(L1) – I(L1)	81.7.40
U(L2) – I(L2)	81.7.51
U(L3) – I(L3)	81.7.62

Table 10: Phase angles between voltage and current objects

3.5.7.3. Instantaneous phase angles between current and voltage

MT880 meter provides also measurement of phase angles between currents and voltages for every phase.

	Phase angle
I(L1) – U(L1)	81.7.4
I(L2) – U(L1)	81.7.5
I(L3) – U(L1)	81.7.6
I(L2) – U(L2)	81.7.15
I(L3) – U(L3)	81.7.26

Table 11: Phase angles between current and voltage objects

3.5.8. Net frequency

3.5.8.1. Instantaneous net frequency

Meter presents information about supply network frequency in the corresponding object. Frequency is always measured on one of the connected phase voltages.

	Any phase
Instantaneous net frequency	14.7.0

Table 12: Instantaneous net frequency object

3.5.9. Power

3.5.9.1. Instantaneous power

The measurement microcontroller sends measured values to the main microcontroller every 100 ms.

Every instantaneous power value (except Instantaneous reactive power total (130.7.0) and Instantaneous apparent power total (131.7.0)) is available per phase and as sum over all phases (Table 13).

All phase instantaneous power values can be measured by vector or arithmetic method.

	SUM	L1	L2	L3
A+	1.7.0	21.7.0	41.7.0	61.7.0
A-	2.7.0	22.7.0	42.7.0	62.7.0
Q+	3.7.0	23.7.0	43.7.0	63.7.0
Q-	4.7.0	24.7.0	44.7.0	64.7.0
QI	5.7.0	25.7.0	45.7.0	65.7.0
QII	6.7.0	26.7.0	46.7.0	66.7.0
QIII	7.7.0	27.7.0	47.7.0	67.7.0
QIV	8.7.0	28.7.0	48.7.0	68.7.0
S+	9.7.0	29.7.0	49.7.0	69.7.0
S-	10.7.0	30.7.0	50.7.0	70.7.0
ABS	15.7.0	35.7.0	55.7.0	75.7.0
NET	16.7.0	36.7.0	56.7.0	76.7.0
Reactive Total	130.7.0	N/A	N/A	N/A
Apparent Total	131.7.0	N/A	N/A	N/A

Table 13: Instantaneous power objects

NOTE!
Abbreviation ABS in this user manual means absolute active energy |A+| + |A-|.
Abbreviation NET in this user manual means net active energy |A+| – |A-|.

Instantaneous reactive power total (1-0:130.7.0*255) is sum of quadrant instantaneous reactive power values (Q1 + Q2 + Q3 + Q4).

Instantaneous apparent power total (1-0:131.7.0*255) is sum of apparent instantaneous power S+ and S-.

3.5.10. Power factor

According to DLMS/COSEM structure, power factor is calculated separately for import and export power.

Meter provides information about instantaneous power factor as:

- Power factor positive = active energy positive / apparent energy positive
- Power factor negative = active energy negative / apparent energy negative

NOTE!
The power factor is always calculated using the arithmetic method. Therefore, the instantaneous power factors for all phases, for the positive and the negative direction, are both valid at the same time, while the power is registered separately for both directions.

Because specific phase energy can flow only in one direction at certain time, per phase instantaneous power factors are valid only for one direction (either positive or negative) and the value for other direction is set to 0.

	SUM	L1	L2	L3
Instantaneous power factor +	13.7.0	33.7.0	53.7.0	73.7.0
Instantaneous power factor -	84.7.0	85.7.0	86.7.0	87.7.0

Table 14: Instantaneous power factor objects

3.5.10.1. Minimum and maximum power factor

MT880 meter presents also minimum and maximum value of power factor in the measurement period in special objects.

	SUM	L1	L2	L3
Minimum power factor +	13.3.0	33.3.0	53.3.0	73.3.0
Minimum power factor -	84.3.0	85.3.0	86.3.0	87.3.0
Maximum power factor +	13.6.0	33.6.0	53.6.0	73.6.0
Maximum power factor -	84.6.0	85.6.0	86.6.0	87.6.0

Table 15: Minimum and maximum power factor objects

3.5.10.2. Last average power factor

Last average power factor in the measurement period is calculated and stored in corresponding objects.

	SUM	L1	L2	L3
Last average power factor +	13.5.0	33.5.0	53.5.0	73.5.0
Last average power factor -	84.5.0	85.5.0	86.5.0	87.5.0

Table 16: Last average power factor objects

3.5.11. Energy

MT880 meter provides following energy values:

- positive and negative active energy (A+, A-), sum of all phases and per phase,
- positive and negative reactive energy (R+, R-), sum of all phases and per phase,
- reactive energy (QI, QII, QIII, QIV), sum of all phases and per phase,
- positive and negative apparent energy (S+, S-), sum of all phase and per phase,
- ABS (absolute) active energy (|A+| + |A-|), sum of all phases and per phase,
- NET active energy (|A+| - |A-|), sum of all phases and per phase.

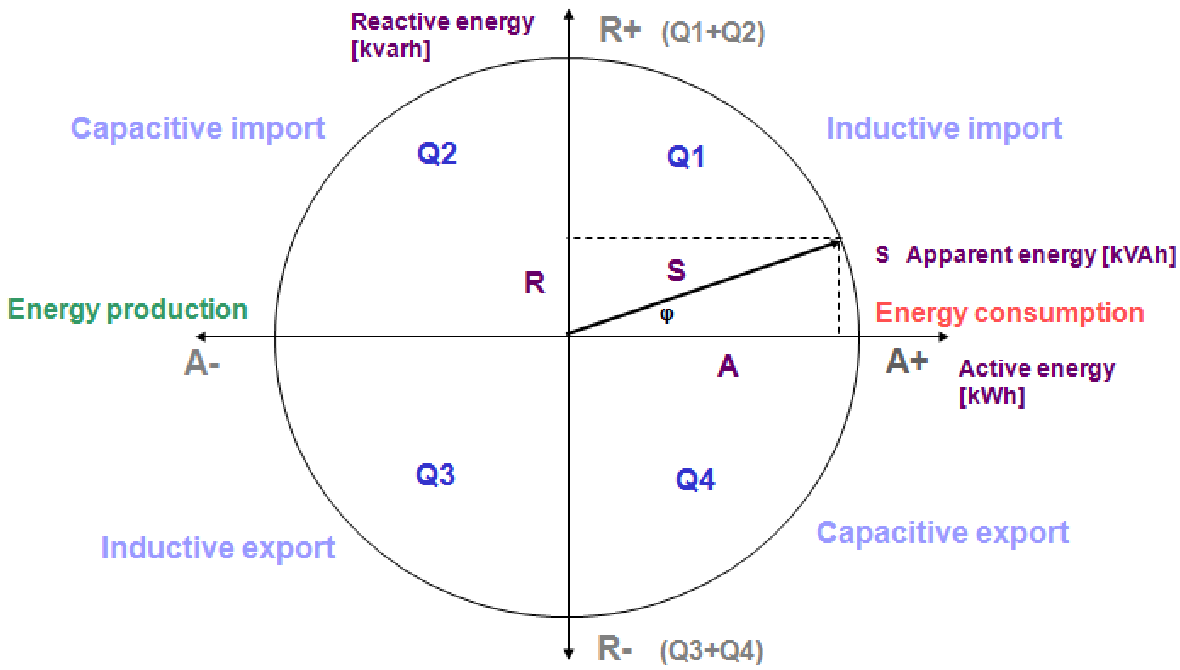


Figure 11: Quadrant cross

Reactive energy/power can be registered by vector or arithmetic method, positive and negative reactive energy/power can be registered as sum of different quadrant components:

- Q+ = QI + QII and Q- = QIII + QIV or
- Q+ = QI + QIV and Q- = QII + QIII

Besides total registration, MT880 meter provides up to 8 tariffs for energy and demand registration.

MT880 meter provides the following energy values:

- total values,
- Billing period values - time integral 2 values,
- Load profile 1 period values - time integral 5 values,
- Load profile 2 period values - time integral 6 values,
- tariff values.

3.5.11.1. Total energy values

Supported total energy values in the MT880 meters are presented in Table 17. Different energy types (A+, A-, Q+, Q-, QI, QII, QIII, QIV, S+, S-, ABS and NET) are registered as three phase values as well as per phase values.

	SUM	L1	L2	L3
A+	1.8.0	21.8.0	41.8.0	61.8.0
A-	2.8.0	22.8.0	42.8.0	62.8.0
Q+	3.8.0	23.8.0	43.8.0	63.8.0
Q-	4.8.0	24.8.0	44.8.0	64.8.0
QI	5.8.0	25.8.0	45.8.0	65.8.0
QII	6.8.0	26.8.0	46.8.0	66.8.0
QIII	7.8.0	27.8.0	47.8.0	67.8.0
QIV	8.8.0	28.8.0	48.8.0	68.8.0
S+	9.8.0	29.8.0	49.8.0	69.8.0
S-	10.8.0	30.8.0	50.8.0	70.8.0
ABS	15.8.0	35.8.0	55.8.0	75.8.0
NET	16.8.0	36.8.0	56.8.0	76.8.0

Table 17: Total energy objects

3.5.11.2. Tariff energy values

Activation of specific tariff is done by tariff program. Tariff scheme is implemented in the MT880 meter and it includes only three phase values – there are no tariff registers for per phase energy values.

	Total tariff
A+	1.8.e
A-	2.8.e
Q+	3.8.e
Q-	4.8.e
QI	5.8.e
QII	6.8.e
QIII	7.8.e
QIV	8.8.e
S+	9.8.e
S-	10.8.e
ABS	15.8.e
NET	16.8.e

<e> is used as tariff index from 1 to 8

Table 18: Tariff energy registers

3.5.12. Demand

The MT880 meters calculates instantaneous values of demands in the demand period and register the maximum ones in a billing period for both, per each phase and three-phase.

Demand P_d is calculated as a quotient of energy integrated over a period of time and the time period. Therefore, it is an average value. The period of energy integration is called a demand period T_{dp}. Maximum demand is the largest demand in a billing period (a time span between two billing resets of the meter).

The MT880 meters calculate momentary value of demand P_{cd} over elapsed time in a current demand period. At the end of the demand period the momentary value of demand is equal to the demand, i.e. $P_{cd} = P_d$.

At the end of each demand period, a new demand $\mathbf{P_d}$ is compared with a current maximum demand $\mathbf{P_{md}}$ stored in a corresponding register of a maximum demand for a current billing period. If it is higher, it is stored in the register; otherwise, it is neglected. If it is stored in the maximum demand register then date and time when the demand period has ended are stored in corresponding registers too. In such a way in the register is stored a maximum demand at the end of a billing period as well as date and time when the demand period has ended.

At the billing reset, maximum demand for a current billing period is transferred into the corresponding register for a previous billing period and the register of maximum demand in a current billing period is cleared.
A routine of maxim demand calculation for a new billing period is started from the beginning.

Date and time of the end of maximum demand (so called time stamp) are stated by each maximum demand.

Demand period types

There are two basic demand period types:

- fixed demand period,
- rolling demand period.

Demand measurement in a fixed demand period

At fixed demand measurement, a new demand period starts when the previous one is ended.

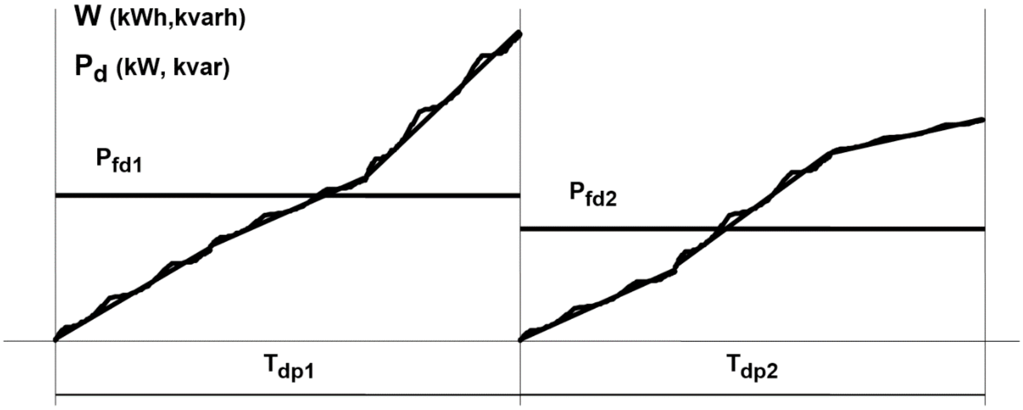
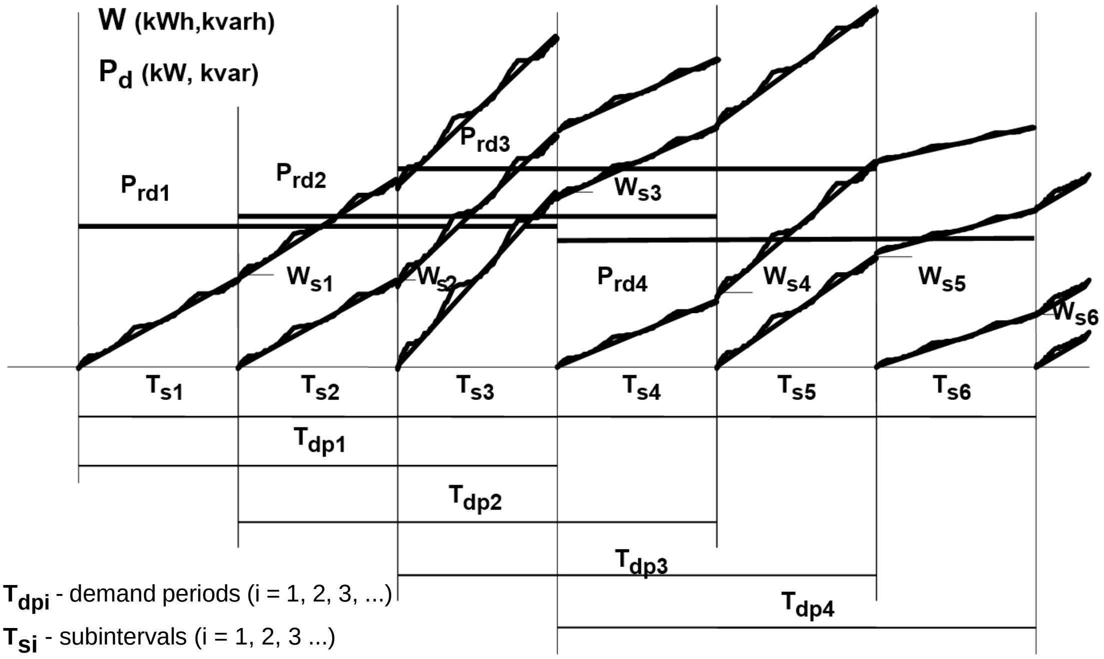


Figure 12: Demand measurement in a fixed demand period

Demand measurement in a rolling demand period

At rolling demand measurement, a demand period $\mathbf{T_{dp}}$ is divided into subintervals $\mathbf{T_S}$.

At the end of each subinterval starts a new demand period. Each measurement period T can be divided into up to 15 sub periods.



$\mathbf{T_{dpi}}$ - demand periods (i = 1, 2, 3, ...)

$\mathbf{T_{Si}}$ - subintervals (i = 1, 2, 3 ...)

Figure 13: Demand measurement in a rolling demand period

Routines of demand calculation

In a case of fixed demand period, demand $\mathbf{P_{fdi}}$ is calculated as a quotient of energy integrated over demand period $\mathbf{T_{dpi}}$ and the demand period, i.e.:

$$\mathbf{P_{fdi}} = \frac{\mathbf{W_i}}{\mathbf{T_{dpi}}}$$

where:

$\mathbf{P_{fdi}}$ - fixed demand in the i-th demand period $\mathbf{T_{dpi}}$ (i = 1, 2, 3 ...)

$\mathbf{W_i}$ - energy integrated over the i-th demand period $\mathbf{T_{dpi}}$ (i = 1, 2, 3 ...)

In a case of rolling demand period, demand $\mathbf{P_{rdi}}$ is calculated from the following equation:

$$\mathbf{P_{rdi}} = \frac{\sum_{i=1}^{i+n-1} \mathbf{W_{si}}}{\mathbf{T_{dp}}}$$

where:

$\mathbf{P_{rdi}}$ - rolling demand registered in the i-th demand period (i = 1, 2, 3, ...)

$\mathbf{W_{si}}$ - energy integrated over the i-th subinterval (i = 1, 2, 3,...)

n - a number of subintervals in the demand period $\mathbf{T_{dp}}$

Meter calculates an average demand in time interval s a quotient of registered energy during measurement period and elapsed time Td: Demand = ($E_{(n)}$ – $E_{(n-1)}$) / Td.

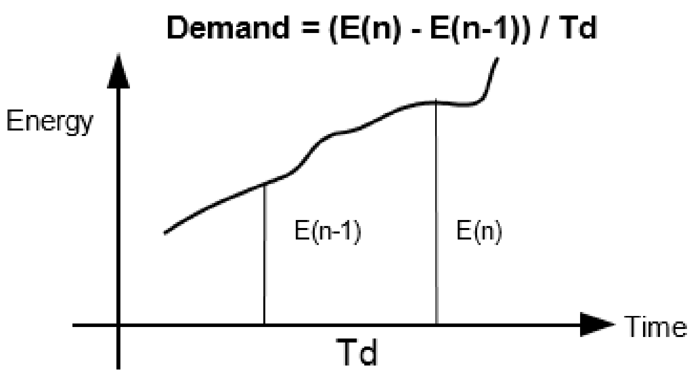


Figure 14: Demand calculation sample

3.5.12.1. Demand measurement resolution

The MT880 can registries primary or secondary values. The meter measuring resolution is programmable. Demand registers are 32 bit long, so the maximum value in each demand register can be 2^{32} = 4294967296. The value of the product CT*VT at certain combination of U_{nom} and I_{max} is important. Table 19 represents maximum value of CT*VT for specific measurement resolution at specific U_n = 57,7 V and I_{max} = 6 A.

Resolution	1 W	100 mW	10 mW	1 mW
CT * VT max	4100000	410000	41000	4100

*Table 19: Maximum value of CT*VT*

Iskraemeco’s proposal: maximum measurement resolution for primary presentation at CT connected meter is 100 mW.

3.5.12.2. Average demand

Measurement period 1 (1-0:0.8.0*255) object is related to measuring and calculating the average demand values. Available measurement periods are 1, 5, 10, 15, 30, 60 minutes. Values must be entered in seconds.

Values related to measurement period:

- Demand measurements,
- Power factor measurement.

Measurement period 2 (1-0:0.8.1*255) is used for basic time related measurements, such as THD average values registration. Possible length of measurement period is 1, 5, 10, 15, 30 or 60 minutes – value entered in seconds can therefore be 60, 300, 600, 900, 1800 or 3600. Other values will be rejected by meter.

NOTE!
If Measurement period is changed, the previous period is still active until it ends and after that the new set period becomes active.

Average demand objects 1-0:**x**.4.0 (where "**x**" represents the first number of codes in Table 20) are objects, measured with block or sliding measurement period. MT880 meter implements 30 average demand registers.

	SUM	L1	L2	L3	tariff 1...8
A+	1.4.0	21.4.0	41.4.0	61.4.0	-
A-	2.4.0	22.4.0	42.4.0	62.4.0	-
Q+	3.4.0	23.4.0	43.4.0	63.4.0	-
Q-	4.4.0	24.4.0	44.4.0	64.4.0	-
QI	5.4.0	-	-	-	-
QII	6.4.0	-	-	-	-
QIII	7.4.0	-	-	-	-
QIV	8.4.0	-	-	-	-
S+	9.4.0	29.4.0	49.4.0	69.4.0	-
S-	10.4.0	30.4.0	50.4.0	70.4.0	-
ABS	15.4.0	-	-	-	-
NET	16.4.0	-	-	-	-

Table 20: Average demand objects

3.5.12.3. Last average demand

Last average demand objects 1-0:**x**.5.0 (where "**x**" represents the first number of codes in Table 21) are stored as separate objects for possible display on LCD. MT880 meter implements 30 last demand registers.

	SUM	L1	L2	L3	tariff 1...8
A+	1.5.0	21.5.0	41.5.0	61.5.0	-
A-	2.5.0	22.5.0	42.5.0	62.5.0	-
Q+	3.5.0	23.5.0	43.5.0	63.5.0	-
Q-	4.5.0	24.5.0	44.5.0	64.5.0	-
QI	5.5.0	-	-	-	-
QII	6.5.0	-	-	-	-
QIII	7.5.0	-	-	-	-
QIV	8.5.0	-	-	-	-
S+	9.5.0	29.5.0	49.5.0	69.5.0	-
S-	10.5.0	30.5.0	50.5.0	70.5.0	-
ABS	15.5.0	-	-	-	-
NET	16.5.0	-	-	-	-

Table 21: Last demand objects

3.5.12.4. Maximum demand

Maximum demand registers represent the biggest current average value of values in average demand objects measured in each measurement period. At the end of each measurement period, current average value from 1-0:x.4.0*255 register is compared to maximum demand value. If current average value is bigger than maximum demand value, it replaces the value stored in maximum demand register. Maximum demand values are set to zero value at the end of each billing period.

Maximum demand can be measured with block or sliding measurement period.

It is possible to measure and calculate maximum demand for

- Active energy in both flow directions,
- Reactive energy per quadrants and as sum of two quadrants,
- Apparent energy in both flow directions.

Maximum demands are registered by individual tariffs and cumulatively.

The measurement and calculation of maximum demand for certain time that follows a period of network voltage failure can be blocked with parameter.

Maximum demand objects 1-0:**x**.6.0, (where “**x**” represents the first number of codes in the table) are listed in Table 22.

	SUM	L1	L2	L3	tariff 1...8
A+	1.6.0	21.6.0	41.6.0	61.6.0	1.6.1...8
A-	2.6.0	22.6.0	42.6.0	62.6.0	2.6.1...8
Q+	3.6.0	23.6.0	43.6.0	63.6.0	3.6.1...8
Q-	4.6.0	24.6.0	44.6.0	64.6.0	4.6.1...8
QI	5.6.0	-	-	-	5.6.1...8
QII	6.6.0	-	-	-	6.6.1...8
QIII	7.6.0	-	-	-	7.6.1...8
QIV	8.6.0	-	-	-	8.6.1...8
S+	9.6.0	29.6.0	49.6.0	69.6.0	9.6.1...8
S-	10.6.0	30.6.0	50.6.0	70.6.0	10.6.1...8
ABS	15.6.0	-	-	-	15.6.1...8
NET	16.6.0	-	-	-	16.6.1...8

Table 22: Maximum demand objects

3.5.12.5. Cumulative maximum demand

Cumulative maximum demand objects represent the sum of all maximum demand register values 1-0:x.6.y*255 at the end of billing period. Before the values in maximum demand objects are cleared, they are added to the appropriate cumulative maximum demand register 1-0:x.2.y*255.

MT880 meter implements 126 cumulative maximum demand registers (Table 23).

	SUM	R	S	T	tariff 1...8
A+	1.2.0	21.2.0	41.2.0	61.2.0	1.2.1...8
A-	2.2.0	22.2.0	42.2.0	62.2.0	2.2.1...8
Q+	3.2.0	23.2.0	43.2.0	63.2.0	3.2.1...8
Q-	4.2.0	24.2.0	44.2.0	64.2.0	4.2.1...8
QI	5.2.0	-	-	-	5.2.1...8
QII	6.2.0	-	-	-	6.2.1...8
QIII	7.2.0	-	-	-	7.2.1...8
QIV	8.2.0	-	-	-	8.2.1...8
S+	9.2.0	29.2.0	49.2.0	69.2.0	9.2.1...8
S-	10.2.0	30.2.0	50.2.0	70.2.0	10.2.1...8
ABS	15.2.0	-	-	-	15.2.1...8
NET	16.2.0	-	-	-	16.2.1...8

Table 23: Cumulative maximum demand registers

3.5.12.6. Measurement period parameterization

Measurement period (MP) can be manipulated with settings in measurement period parameterization object (Table 24).

Bit	Option	Value 0	Value 1
0	MP type	Synchronous	Asynchronous
1	Power down/up behaviour	No new MP	New MP
2	Demand tariff switch behaviour	No new MP	New MP
3	Billing reset behaviour	No new MP	New MP
4 - 7	Not used	/	/

Table 24: Measurement period configuration object settings

Measurement period configuration explanation:

- **Asynchronous** MP type is not supported in MT880.
- **Power down/up behaviour** can force conclusion of current demand MP and start of new one in case of power down, even if power down does not go over MP end.
- **Demand tariff switch behaviour** will force new PM when demand tariff changes.
- **Billing reset behaviour** can be set to end current MP and start new one when billing reset is executed.

3.5.13. Billing profile values (Time integral 2)

Billing reset is executed at the end of billing period. At billing reset the current value of the objects selected in Billing profile are transferred into corresponding previous values objects and values in current objects are reset to zero value. Supported billing objects in the MT880 meters are presented in Table 25 – Table 30.

Different energy types (A+, A-, Q+, Q-, QI, QII, QIII, QIV, S+, S-, ABS and NET) are registered as three phase values (SUM) as well as per phase values.

3.5.13.1. Voltage objects related to billing period

	L1	L2	L3
Minimum voltage	32.3.0	52.3.0	72.3.0
Maximum voltage	32.6.0	52.6.0	72.6.0

Table 25: Voltage objects related to billing period

3.5.13.2. Current objects related to billing period

	L1	L2	L3
Minimum current	31.3.0	51.3.0	71.3.0
Maximum current	31.6.0	51.6.0	71.6.0

Table 26: Current objects related to billing period

3.5.13.3. Net frequency object related to billing period

	Any phase
Minimum net frequency	14.3.0
Maximum net frequency	14.6.0

Table 27: Net frequency objects related to billing period

3.5.13.4. Power factor objects related to billing period

	SUM	L1	L2	L3
Average power factor +	13.14.0	33.14.0	53.14.0	73.14.0
Average power factor -	84.14.0	85.14.0	86.14.0	87.14.0
Minimum power factor +	13.3.0	33.3.0	53.3.0	73.3.0
Maximum power factor +	13.6.0	33.6.0	53.6.0	73.6.0
Minimum power factor -	84.3.0	85.3.0	86.3.0	86.3.0
Maximum power factor -	84.6.0	85.6.0	86.6.0	86.6.0

Table 28: Power factor objects related to billing period

3.5.13.5. Total energy objects related to billing period

	SUM	L1	L2	L3
A+	1.9.0	21.9.0	41.9.0	61.9.0
A-	2.9.0	22.9.0	42.9.0	62.9.0
Q+	3.9.0	23.9.0	43.9.0	63.9.0
Q-	4.9.0	24.9.0	44.9.0	64.9.0
QI	5.9.0	25.9.0	45.9.0	65.9.0
QII	6.9.0	26.9.0	46.9.0	66.9.0
QIII	7.9.0	27.9.0	47.9.0	67.9.0
QIV	8.9.0	28.9.0	48.9.0	68.9.0
S+	9.9.0	29.9.0	49.9.0	69.9.0
S-	10.9.0	30.9.0	50.9.0	70.9.0
ABS	15.9.0	35.9.0	55.9.0	75.9.0
NET	16.9.0	36.9.0	56.9.0	76.9.0

Table 29: Total energy objects related to billing period

3.5.13.6. Tariff energy objects related to billing period

	Tariff
A+	1.9.e
A-	2.9.e
Q+	3.9.e
Q-	4.9.e
QI	5.9.e
QII	6.9.e
QIII	7.9.e
QIV	8.9.e
S+	9.9.e
S-	10.9.e
ABS	15.9.e
NET	16.9.e

<e> is used as tariff index from 1 to 8

Table 30: Tariff energy objects related to billing period

3.5.14.Load profile 1 (Time integral 5) and Load profile 2 (Time integral 6) objects

Supported load profile objects in MT880 meters are presented in Table 31 – Table 34. Different energy types (A+, A-, Q+, Q-, QI, QII, QIII, QIV, S+, S-, ABS and NET) are registered as three phase values as well as per phase values.

3.5.14.1. Voltage

Average voltage

	L1	L2	L3
Average voltage related to LP1	32.27.0	52.27.0	72.27.0
Average voltage related to LP2	32.28.0	52.28.0	72.28.0

Table 31: Load profile 1 and Load profile 2 voltage objects

3.5.14.2. Current

Average current

	L1	L2	L3
Average current related to LP1	31.27.0	51.27.0	71.27.0
Average current related to LP2	31.28.0	51.28.0	71.28.0

Table 32: Load profile 1 and Load profile 2 current objects

3.5.14.3. Power factor

Average power factor

	SUM	L1	L2	L3
Average power factor + related to LP1	13.27.0	33.27.0	53.27.0	73.27.0
Average power factor + related to LP2	13.28.0	33.28.0	53.28.0	73.28.0
Average power factor – related to LP1	84.27.0	85.27.0	86.27.0	87.27.0
Average power factor – related to LP2	84.28.0	85.28.0	86.28.0	87.28.0

Table 33: Load profile 1 and Load profile 2 power factor objects

3.5.14.4. Energy

Total values

	SUM	L1	L2	L3
A+	1.d.0	21.d.0	41.d.0	61.d.0
A-	2.d.0	22.d.0	42.d.0	62.d.0
Q+	3.d.0	23.d.0	43.d.0	63.d.0
Q-	4.d.0	24.d.0	44.d.0	64.d.0
QI	5.d.0	25.d.0	45.d.0	65.d.0
QII	6.d.0	26.d.0	46.d.0	66.d.0
QIII	7.d.0	27.d.0	47.d.0	67.d.0
QIV	8.d.0	28.d.0	48.d.0	68.d.0
S+	9.d.0	29.d.0	49.d.0	69.d.0
S-	10.d.0	30.d.0	50.d.0	70.d.0
ABS	15.d.0	35.d.0	55.d.0	75.d.0
NET	16.d.0	36.d.0	56.d.0	76.d.0

Field <d> in object codes is used as:

- 29 – for Load profile 1 energy objects,
- 30 – for Load profile 2 energy objects.

Table 34: Load profile 1 and Load profile 2 total energy objects

4. METER CONSTRUCTION

4.1. Technical figures and dimensions

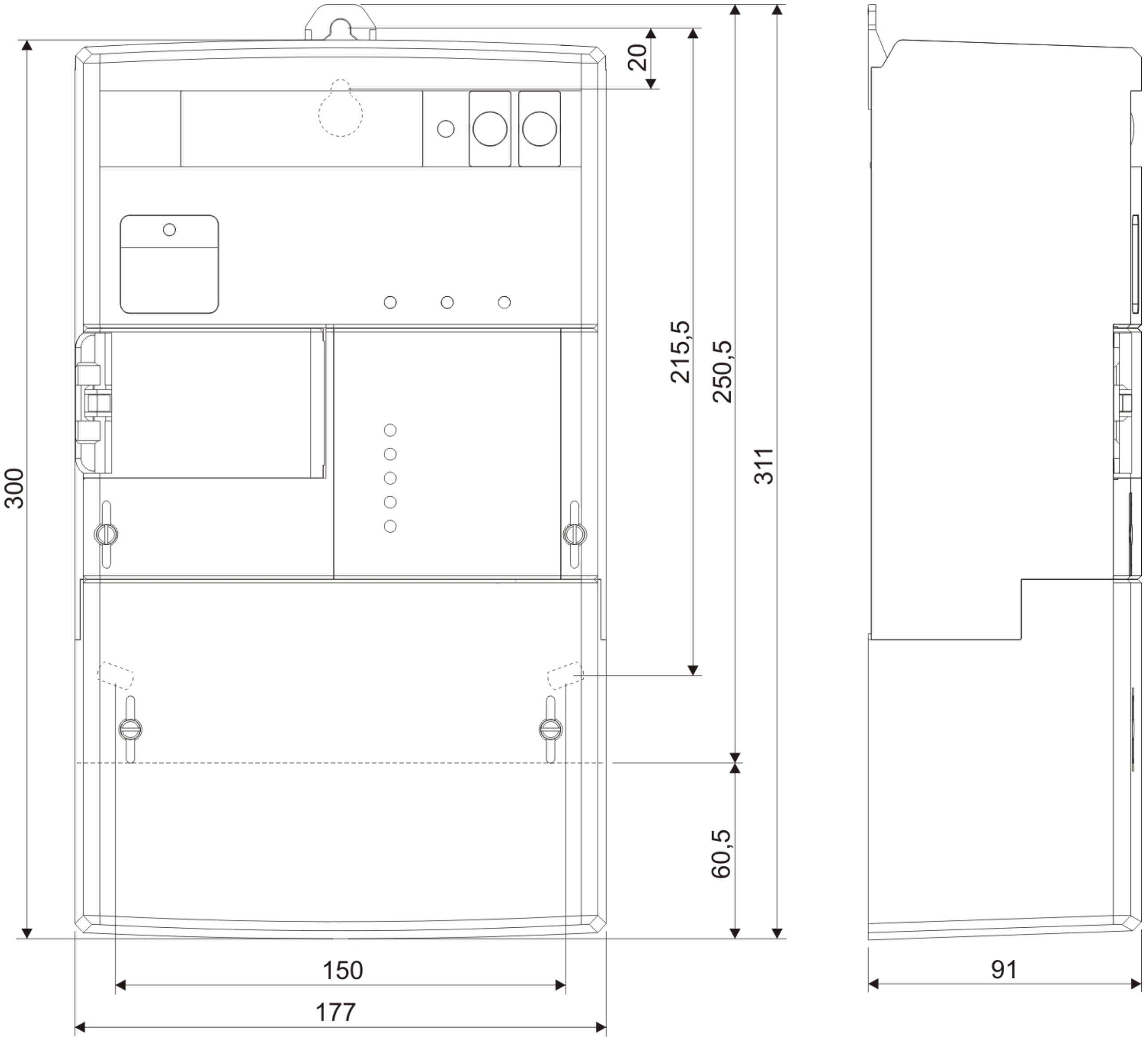


Figure 15: Overall and fixing dimensions of MT880 meter

4.2. Meter case

A compact meter case consists of:

- a meter base with a terminal block and fixing elements for mounting the meter,
- a meter cover and
- a terminal cover.

The meter case is made of high quality self-extinguishing UV stabilized polycarbonate that can be recycled. The case ensures double insulation and IP54 protection level against dust and water penetration.

The movable top hanger is provided on the backside of the meter base under the top edge. The top hanger ensures the upper fixing hole, height of 215.5 mm above the line connecting the bottom fixing holes (DIN 43857).

On the front side of the meter, there is a transparent window, which is fixed to the meter cover with a hinge. The window covers the billing reset button and it can be sealed. On the inner side, under the window there is a space for two CT/VT labels.
The optical port is designed in accordance with IEC 62056-21 standard, with addition functionality of no power reading.

The meter connection diagram is placed on the inner side of the terminal cover.
Different versions of terminal cover exist:

- Standard one with 60mm free space between meter bottom and cover:
  - terminal cover in colour RAL7035.
  - transparent terminal cover.
- COP5 terminal cover, which covers only current and voltage terminals, and it has provision for sealing (for more information see chapter *4.2.5. COP5 terminal cover*).

A terminal block complies with the DIN 43857 standard. It is made of self-extinguishing high quality polycarbonate.
Current terminals for indirect connected meters are made of nickel-plated brass, at direct connected meters they are made of zinc-plated iron and have two screws. Clamping terminals at direct connected meters assure the same quality of the contact irrespective of the shape of the connection conductor (a compact wire, a stranded wire, of greater or smaller cross-sections).
Current terminals:

- direct connected meter – 9,5 mm hole diameter,
- indirect connected meters – 5 mm hole diameter.

The meter is equipped with four additional auxiliary voltage terminals – 2 (L1), 5 (L2), 8 (L3) and 11 (N). They enable simple connection of additional external devices.

4.2.1. Terminal block

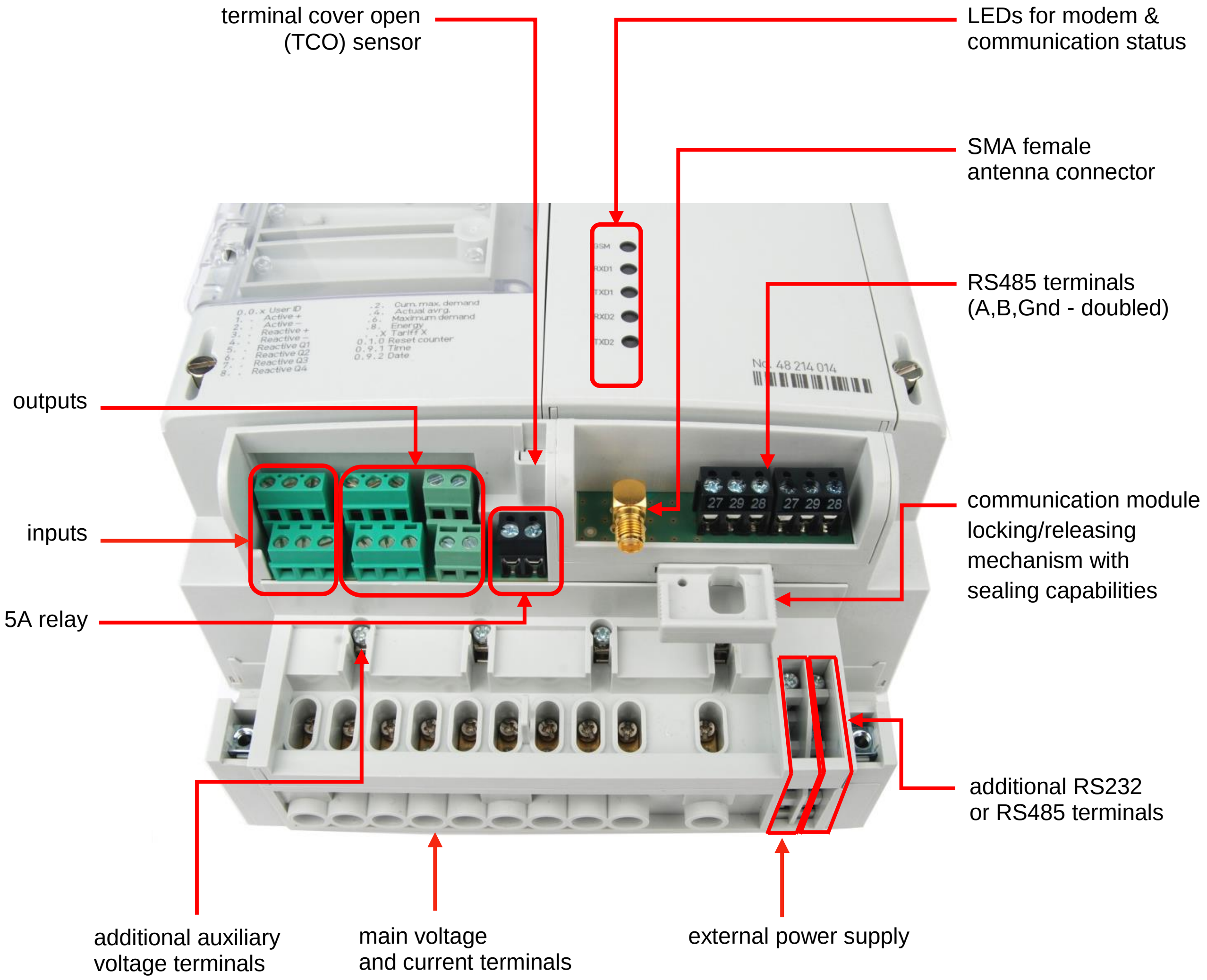


Figure 16: Terminal block – modular version

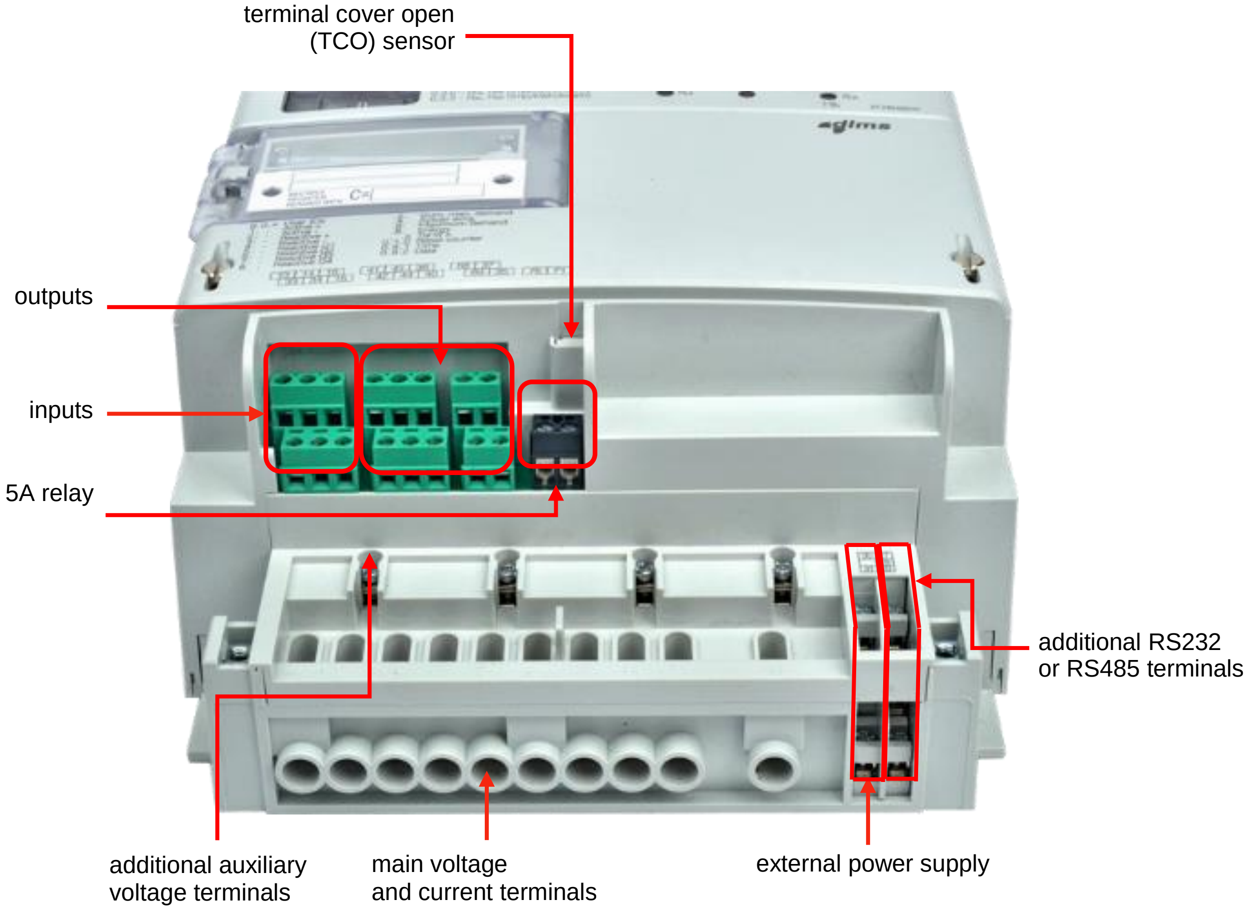


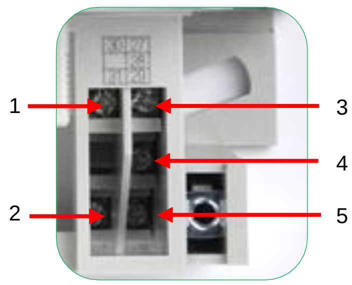
Figure 17: Meter appearance of integrated version – terminal block view

- **Main voltage and current terminals:**
  Current terminals at indirect connected meters are made of brass or nickel-plated brass, at direct connected meters they are made of zinc-plated iron and have two screws. Terminals at direct connected meters assure the same quality of the contact irrespective of the shape of the connection conductor (a compact wire, a stranded wire, greater or smaller cross-sections). Current terminals at direct connected meters have 9.5 mm hole diameter, while current terminals at indirect connected meters have 5 mm hole diameter.

- **Auxiliary voltage terminals:**
  The meter is equipped with four additional voltage terminals. They enable simple connection of external devices.

- **Additional terminals**:

a) External power supply and RS485/RS232



meter equipped with external power supply and RS485

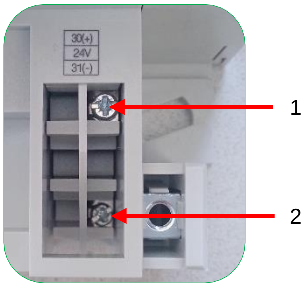
1 → 30 L
2 → 31 N
3 → 27 A (transmission)
4 → 28 GND
5 → 29 B (receiving)

meter equipped with external power supply and RS232

1 → 30 L
2 → 31 N
3 → 27 Tx (transmission)
4 → 28 GND
5 → 29 Rx (receiving)

Figure 18: Additional terminals – external power supply and RS458/RS232

b) External power supply (option)



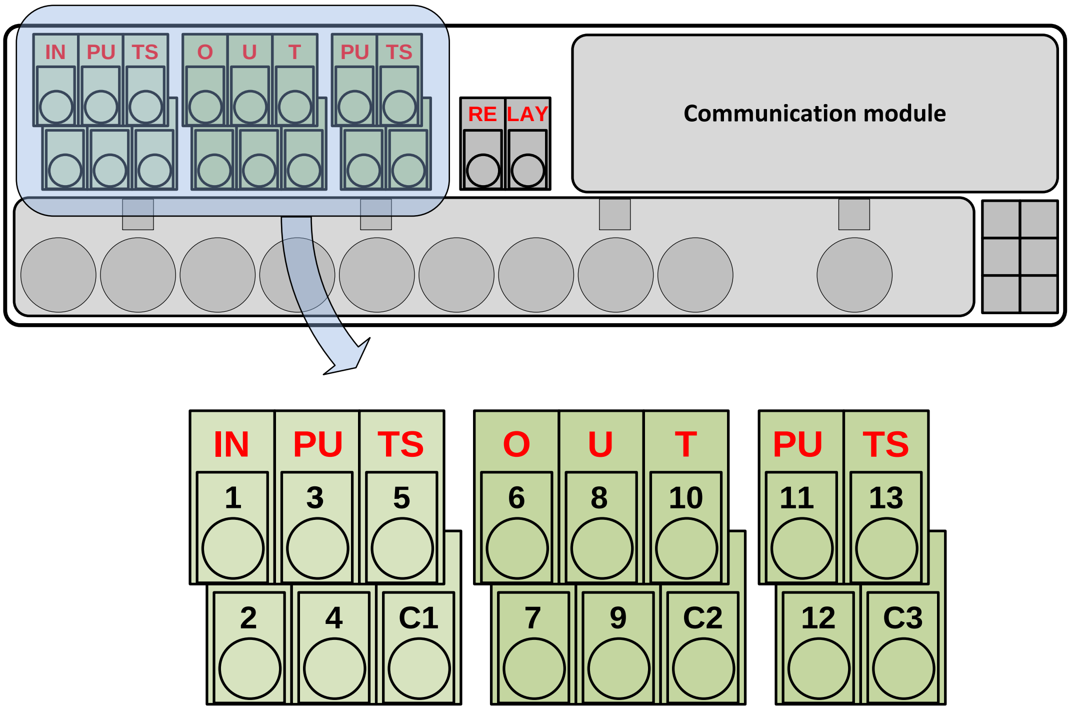
meter equipped with external power supply

1 → 30 L
2 → 31 N

Figure 19: Additional terminals – external power supply (option)

4.2.1.1. Inputs and outputs

Meter supports 5 high voltage configurable inputs, 8 voltage free (OptoMOS) configurable outputs, divided in two different groups (5 and 3) depending on meter hardware configuration and bistable 5 A relay.



INPUTS

1 – input 1
2 – input 2
3 – input 3
4 – input 4
5 – input 5
C1 – common terminal for inputs 1-5

OUTPUTS

6 – output 6
7 – output 7
8 – output 8
9 – output 9
10 – output 10
C2 – common terminal for outputs 6-10

11 – output 11
12 – output 12
13 – output 13
C3 – common terminal for outputs 11-13

Figure 20: Configurable I/O ports

Function	Description
NC	No function is assigned to the terminal
INPUTS	
TE1/2	Energy tariff input T1 – T4
TE3/4	
ME1/2	Demand tariff input M1 – M4
ME3/4	
MPE	External time/measurement period synchronization input
MZE	External input for disabling of demand measurement
MREa	Input a for external billing reset
MREb	Input b for external billing reset
MRE	External billing reset via one input
MKE1	Alarm input 1
MKE2	Alarm input 2
OUTPUTS	
MKA1	Alarm output 1
MKA2	Alarm output 2
MPA	Measurement period output
ER+A	Energy flow direction +A
ER+R	Energy flow direction +R
+AA	Pulse output for +A
-AA	Pulse output for -A
|AA|	Pulse output for absolute A
+RA	Pulse output for +R
-RA	Pulse output for –R
|RA|	Pulse output for absolute R
RA1	Pulse output for RA1
RA2	Pulse output for RA2
RA3	Pulse output for RA3
RA4	Pulse output for RA4
+SA	Pulse output for +S
-SA	Pulse output for -S
|SA|	Pulse output for absolute S
TA1/2	Energy tariff outputs T1 – T4
TA3/4	
MA1/2	Demand tariff outputs M1 – M4
MA3/4	
MZA	Output for disabled max. demand measurement
MRAa	Output for external billing reset a
MRAb	Output for external billing reset b
LA1	Load control output 1
LA2	Load control output 2
LA3	Load control output 3
TGL1	Output toggle 1
TGL2	Output toggle 2
TGL3	Output toggle 3

Table 35: List of input and output functions

4.2.1.2. 5 A relay

Meter is equipped with 5 A bistable relay, which can be used for different purposes:

- controlling of external circuit breaker,
- alarm output,
- load control output.

For controlling 5 A bistable relay, predefined scripts are prepared in the programming software SEP2 Meter-View (remote connect/disconnect). For specific functionality of 5 A bistable relay, customer can also provide specific customer related scripts.

4.2.1.3. U-I link

A sliding U-I link is a mechanical device (used only on direct connected meters) intended for fast and simple separation of meter current and voltage circuit, used for calibration or accuracy testing. The U-I link can be integrated into the meter or can be optionally a part of the meter terminal block. In this case, a special slider is built in each phase of the connection terminal and is accessible by using the sliding button. The sliding button can be shifted left and right with a screwdriver. When the sliding button is in position “left” (see Figure 21), U-I splitter (see Figure 22) can be inserted to separate meter’s current part from the voltage part. The sliding button can be locked in the “right” position to prevent its moving.

For additional information, see the Installation and maintenance manual (chapter *3.3.Terminal block of direct connected meter D2*).

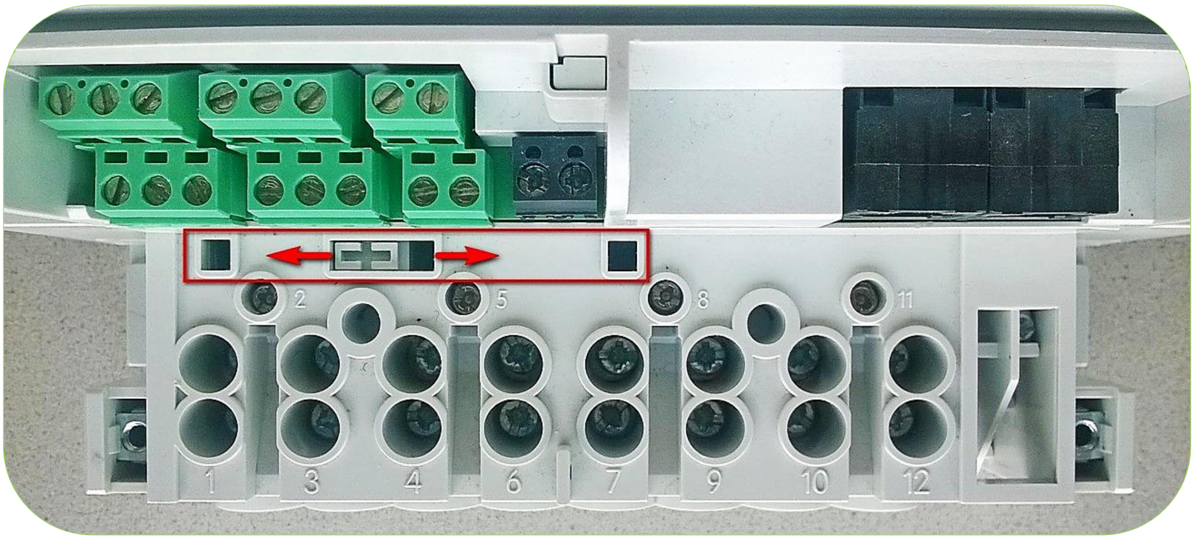


Figure 21: U-I link

Special tool named U-I splitter, designed and manufactured by Iskraemeco, is intended for current and voltage circuit separation. See Figure 22.

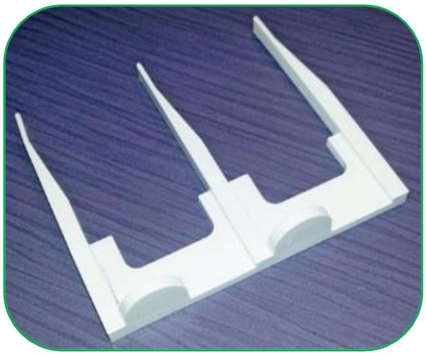


Figure 22: U-I splitter

4.2.2. Meter cover

Meter cover is made of high quality self-extinguishing UV stabilized polycarbonate that can be recycled. It is also used as the nameplate, which is laser printed and cannot be erased. On the nameplate are all metrological data in accordance with IEC standard.

Two different meter cover exist for integrated and for modular version of the meter. The integrated version of meter cover is compact while modular version has a place for exchangeable communication module.

The MT880 meter is equipped with the meter cover opening (MCO).

4.2.3. Terminal cover

The meter terminal is made of high quality self-extinguishing UV stabilized polycarbonate that can be recycled. It can be non-transparent or transparent. The MT880 meter is equipped with the terminal cover opening (TCO) detector. On the inner side of the terminal cover, there is the place for the connection diagram. (See Figure 24.)

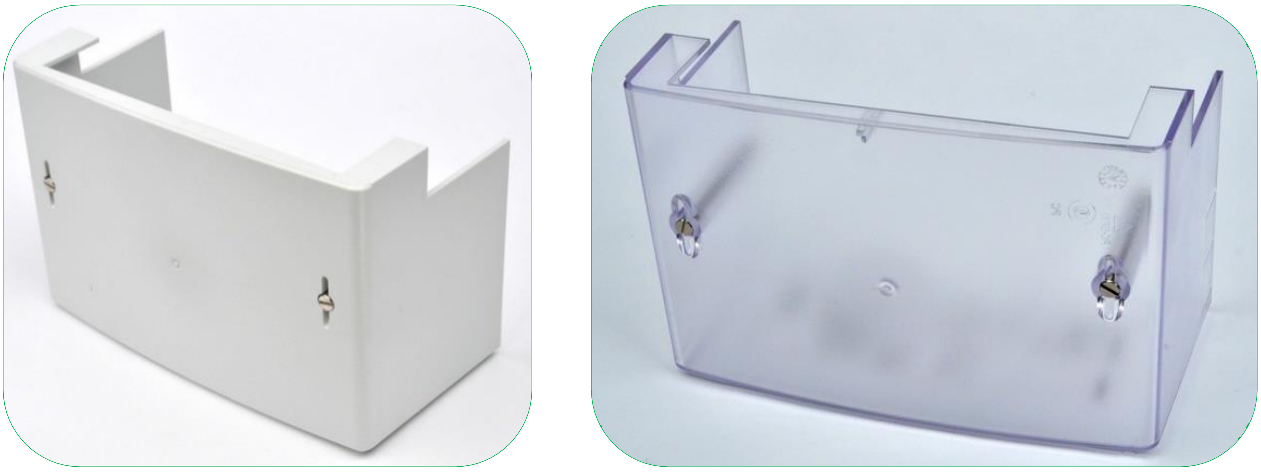


Figure 23: Terminal cover – non-transparent (left) and transparent (right)

Figure 24: Meter connection diagram on the inner side of the non-transparent (left) and transparent (right) terminal cover

NOTE!
For more information about the opening detectors, see chapter *6.4.1. Meter cover and terminal cover opening detection*.

4.2.4. Meter connection diagram position

The meter connection diagram is in the form of label, which is stuck on the inner side of the terminal cover of the meter (see Figure 24). An example of the connection diagram is shown in Figure 25.

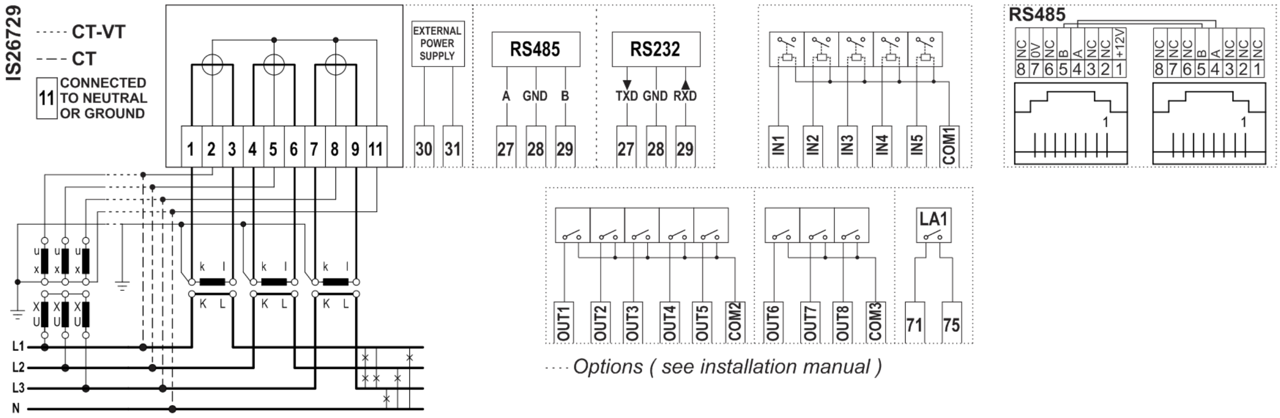


Figure 25: Example of the meter connection diagram

4.2.5. COP5 terminal cover

Optionally, it is possible to cover and seal the main voltage and current terminals with the COP5 cover. In this way, it is prevented unauthorized access to the main terminals; however, inputs, outputs, communication module (at modular version of the meter), and external power supply terminals are still accessible. (See Figure 26.)

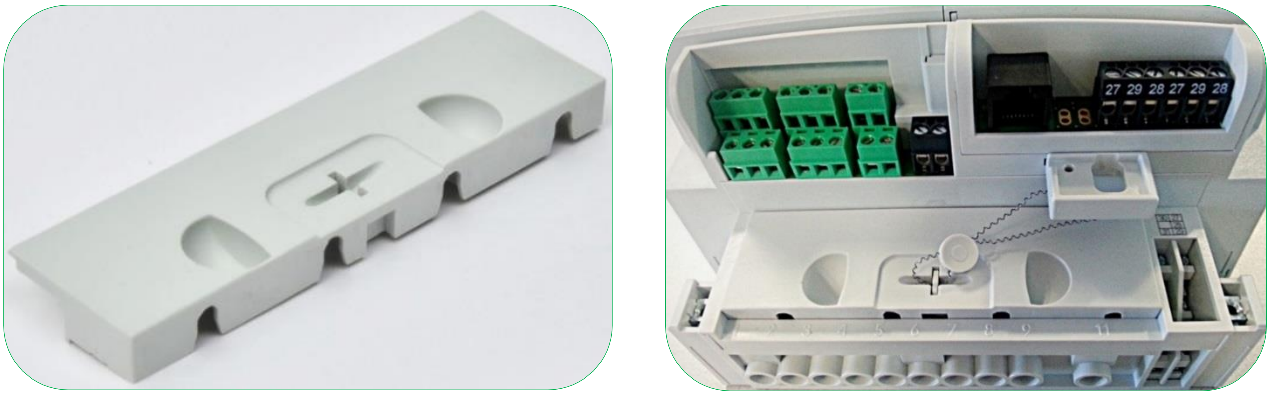
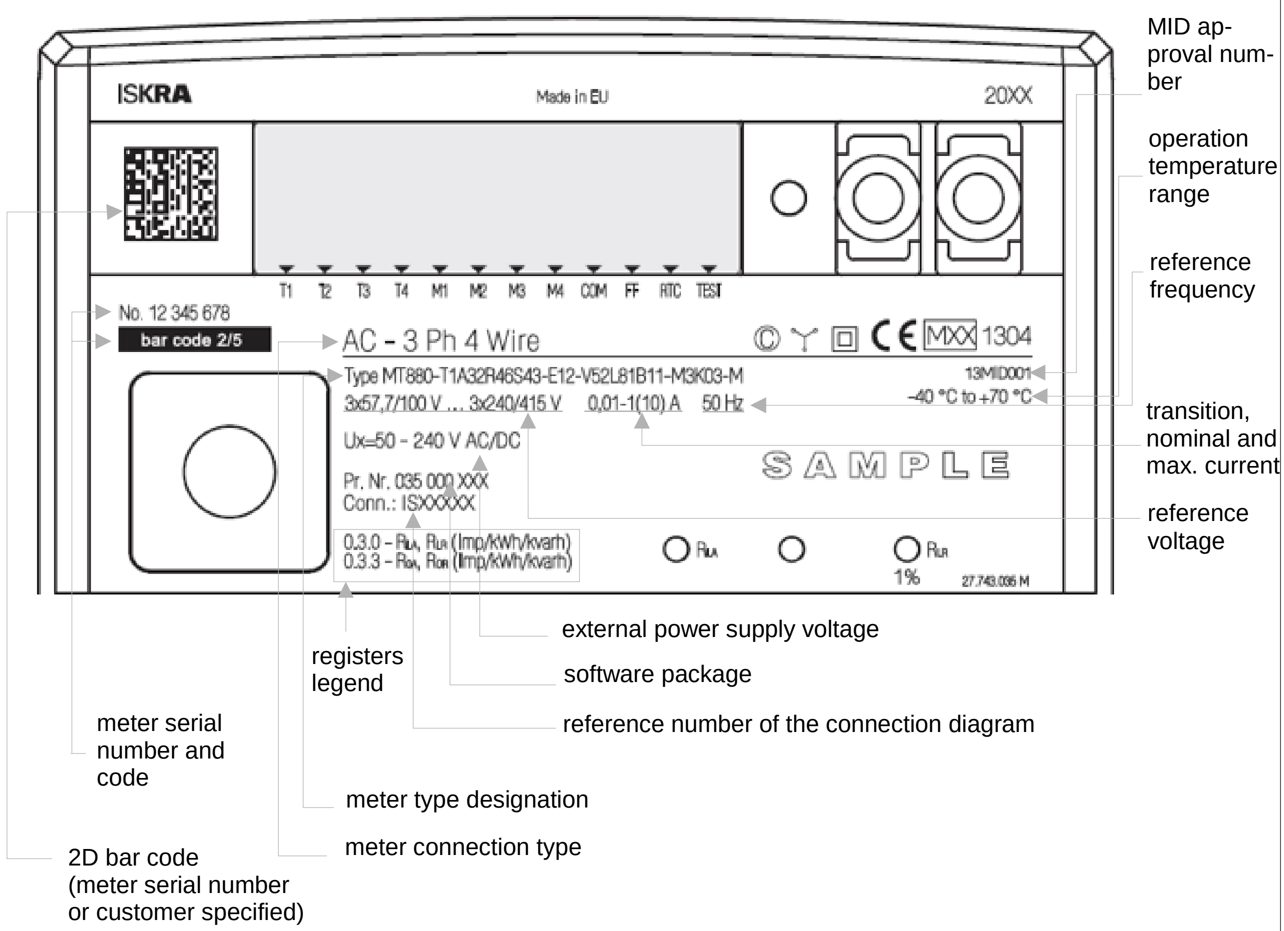


Figure 26: COP5 cover (left), fitted and sealed COP5 cover on the MT880 meter (right)

NOTE!
Only upon a special request by customer order, COP5 cover can be delivered.

4.3. Nameplate

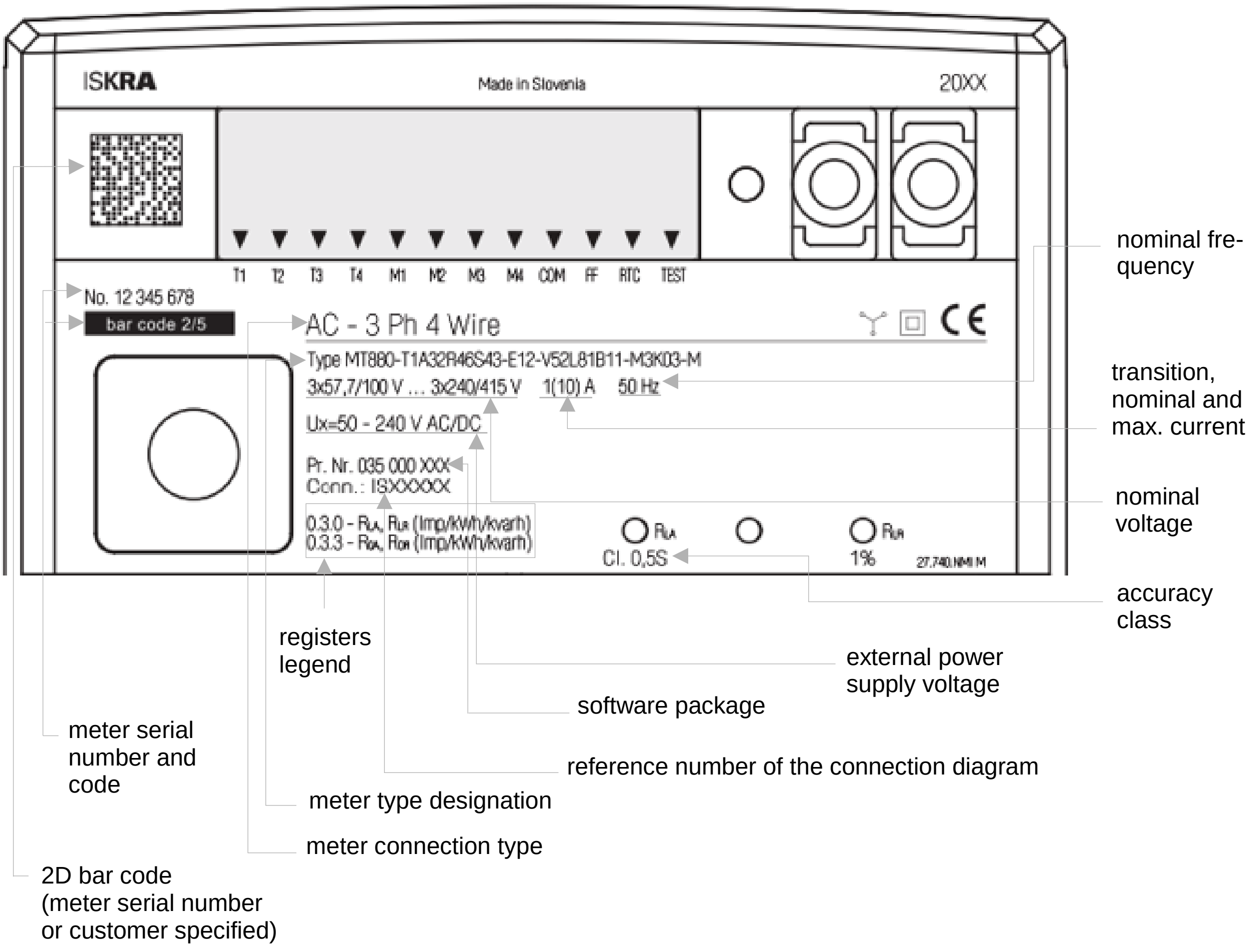
The MT880 meter nameplate is laser printed on the meter's cover. On a nameplate, it can be found the basic data and the type designation of the meter. (See Figure 27 and Figure 28.)



Legend of Symbols and Markings

Ⓒ accuracy class 0,5	CE CE (Conformité Européenne) mark
3-phase 4-wire connection	M13 year of approval
⧈ protection class IEC 62052-11	1304 code of approval body

Figure 27: Nameplate of modular version MT880 meter (MID)



Legend of Symbols and Markings

Y	3-phase 4-wire connection
▢	Protection class IEC 62052-11
CE	CE (Conformité Européenne) mark

Figure 28: Nameplate of modular version MT880 meter (IEC)

4.3.1. Nameplate examples

The examples of the meter nameplate are shown in Figure 29 – Figure 32.

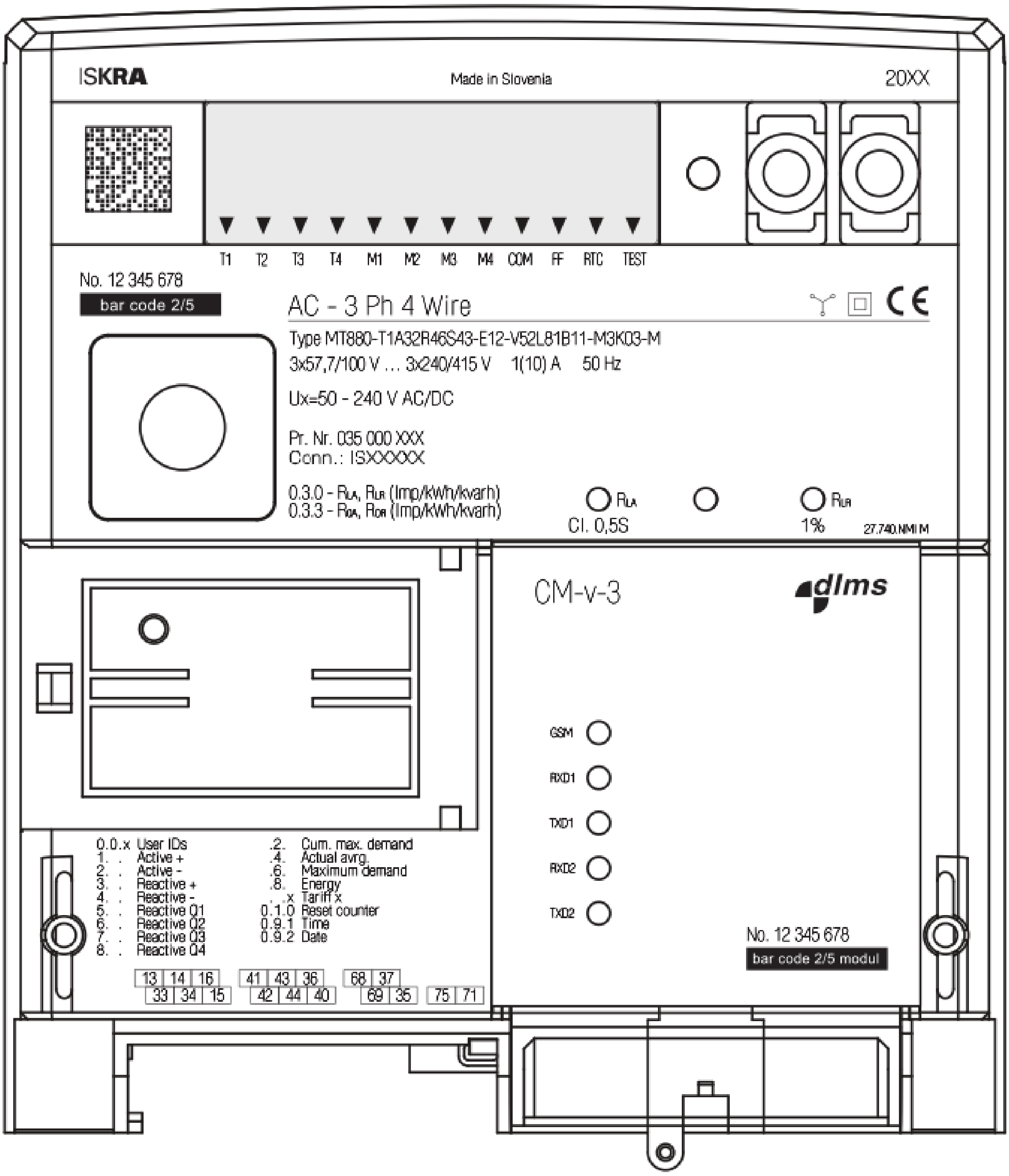


Figure 29: MT880 – Modular version meter nameplate (IEC)

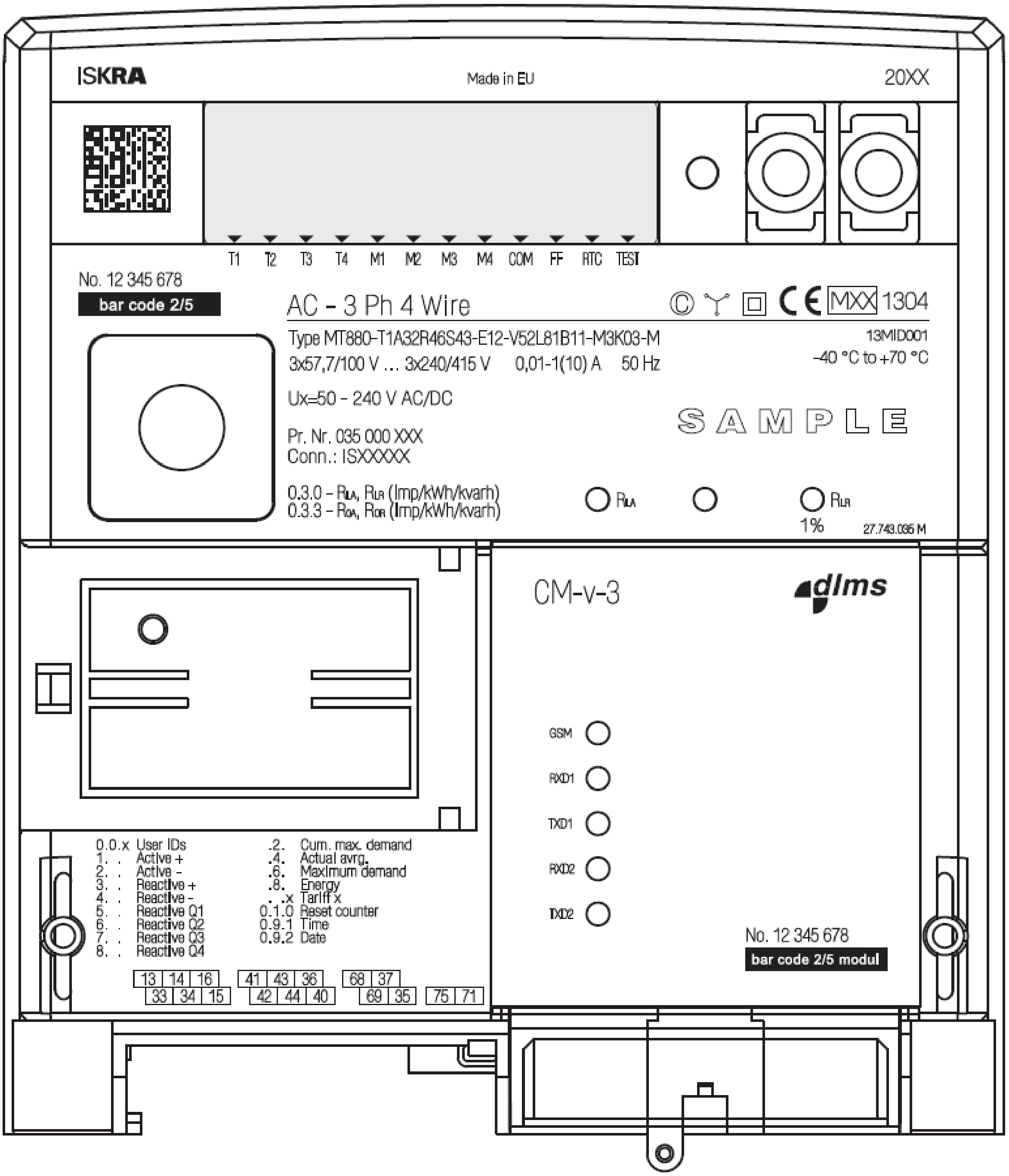


Figure 30: MT880 – Modular version meter nameplate (MID)

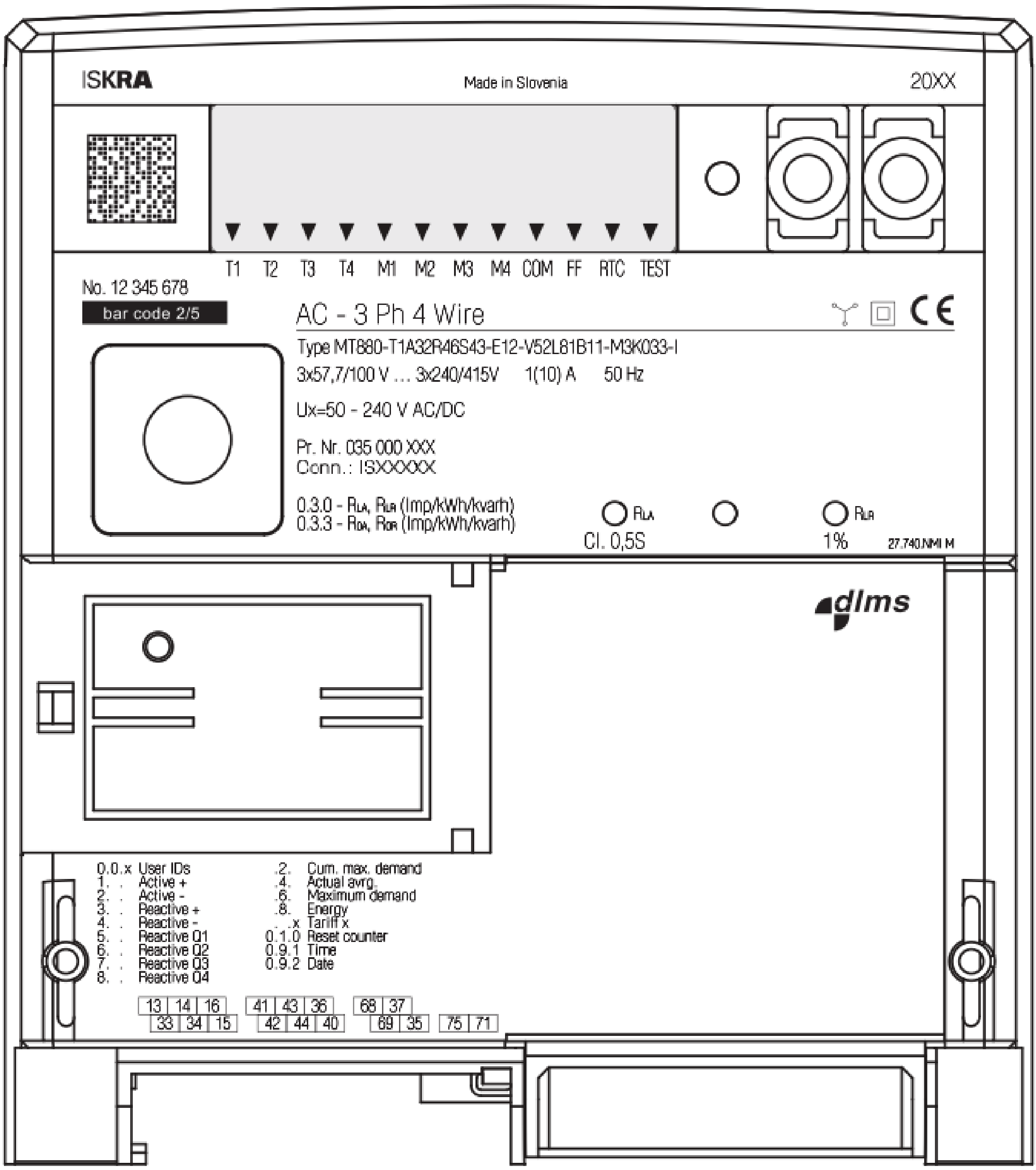


Figure 31: MT880 – Integrated version meter nameplate (IEC)

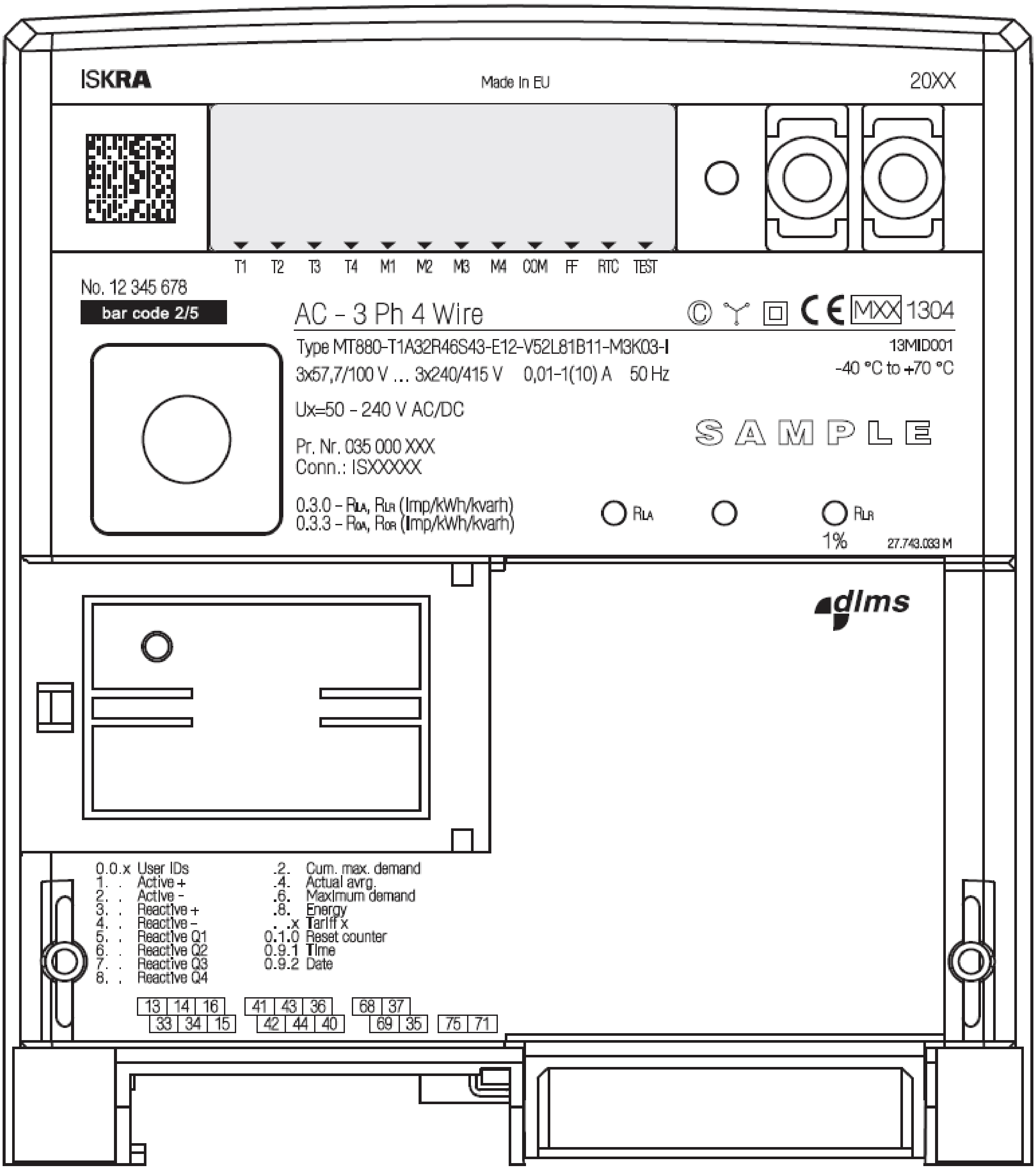


Figure 32: MT880 – Integrated version meter nameplate (MID)

4.4. Type designation

4.4.1. MT880 meters

MT880–XX**A**nm**R**nm**S**nm**–E**n**V**n**2L**nm**B11–MxK0x–Y-H**xx

MT880			three-phase multi-function four-quadrant electronic meter with three measuring systems
XX			type of connection
	D2		direct connected meter
	T1		transformer connected meter
A			active energy
	n = **3**		class 0.5S, C
	n = **4**		class 1, B
		m = **1**	one energy flow direction
		m = **2**	two energy flow directions
R			reactive energy
	n = **4**		calibrated to 1%
	n = **5**		class 2 (IEC 62053 – 23)
		m = **1**	reactive energy flow in one direction (Q+)
		m = **2**	reactive energy flow in two directions (Q+, Q-)
		m = **3**	inductive reactive energy - reception, capacitive reactive energy transmission (Q1 and Q4)
		m = **4**	inductive reactive energy in two directions (Q1 in Q3)
		m = **5**	measurement of reactive energy in four quadrants (Q1, Q2, Q3 and Q4)
		m = **6**	measurement of reactive energy in four quadrants, reception and transmission (Q1, Q2, Q3, Q4 Q+ and Q-)
S			apparent energy
	n = **4**		adjusted to 1%
	n = **5**		adjusted to 2%
		m = **3**	apparent energy → U x I
E			external power supply
	n = **1**		power supply of the whole meter
	n = 2		no power supply via the optical probe (reading if measuring voltages are absent)
V			control inputs
	n = **1..5**		a number of inputs
		2	control voltage is phase voltage
L			OptoMOS relay outputs
	n = **1..8**		a number of outputs
		m = **1**	OptoMOS relay output
B11			5A bistable relay
M			additional device
	x = **2**		Super capacitor back up for RTC and intrusions detection (meter and teminal cover openning, presence of high magnetic field)
	x = **3**		Li battery back up for RTC and intrusions detection (meter and teminal cover openning, presence of high magnetic field)
K			communication interface
	0		meter interface one: IR – optical interface
	x = **2**		meter interface two: RS-232 or
	x = **3**		meter interface two: RS-485
Y			meter version
	M		modular
	I		integrated
H			hardware version *
	xx		versioning number defines specific version of HW (numbers go from 01 to 99)

* The type designation of first version of HW at specific meter type does not contain this index. Each HW that differs from the initial one gets its own index. For each new modification of HW the index rises by 1.

Table 36: Meter type designation

4.4.2. Communication modules

CM				Communication module for MT880 - M meter
	n			the first communication interface
		1		passive CS- interface (20 mA current loop)
		e		Ethernet
		LMN		LMN
		f3e*		MODBUS : analogue output (active CS- interface (20 mA active current loop)) + RS485 + Ethernet
		u		3G (UMTS) modem
		v		2.5G (EDGE) modem
			3	the second communication interface – passive RS485

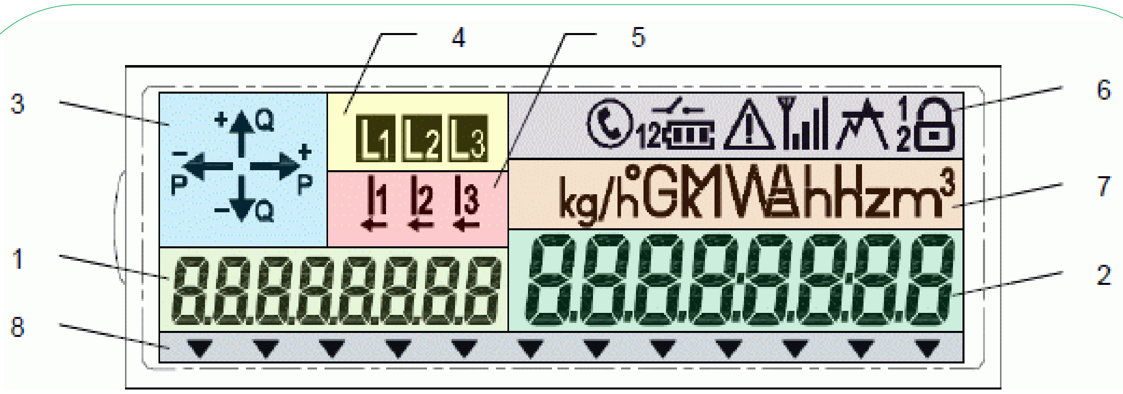
* CM-f3e module – all 3 communications (f+3+e) are combined on the same level

Table 37: Communication modules designation

5. CONSOLE

5.1. LCD

In the MT880 meter the 198-segment liquid crystal display (LCD) is used. Display complies with the VDEW requirements.



1	alphanumeric field 1 – small seven-segment digits – OBIS identification code presentation
2	alphanumeric field 2 – large seven-segment digits – data value presentation
3	energy flow direction cursors
4	voltage indicators by phases
5	current indicators by phases
6	notification field
7	physical unit field of the currently displayed data
8	cursors

Figure 33: MT880 display fields

LCD data:

- Dimensions (visible area): 80.6 x 25.1 mm
- View direction: 6:00
- Number of digits: 8 + 8 (code + value)
- Digit dimension – code: 3 x 6 mm
- Digit dimension – value: 4 x 8 mm

5.1.1. Alphanumeric field

LCD has 16 seven-segment alphanumeric digits. The first eight digits from the left are smaller and are used for presentation the OBIS identification codes of the displayed data (in accordance with DIN 43863-3). The last eight digits are larger and are used for presentation the data value. The character size is 6 mm for small digits and 8 mm for large digits. See Figure 33.

5.1.2. Display test state

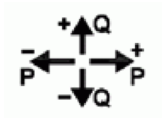
In display test state, all segments are displayed. Display test state is performed in three ways:

- At meter start-up, for five seconds.
- At short press on *Forward-scroll* button in *Auto-scroll mode* (before entering the *Data/Set menu*).
- By entering the *LCD test mode* from *Set menu*.

5.1.3. Energy flow direction cursors

There are four energy flow direction cursors on the display:

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



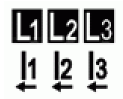
Significance of the energy flow direction cursors:

- Active cursor indicates major energy flow direction.
- Blinking cursor indicates minor energy flow direction.
- If all cursors are blinking, the value of current is under the start-up measurement threshold

5.1.4. Phase indicators

There are two types of phase indicators on the display:

- Phase presence indicators (L_1, L_2, L_3),
- Phase current indicators (I_1, I_2, I_3).



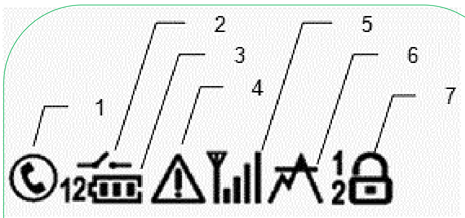
Phase presence indicators:

- Phase presence indicators (L_1, L_2, L_3) indicate the presence of voltage in particular phase.
- If all phase presence indicators are blinking, the sequence of the connected phases is incorrect. Correct phase sequences: $L_1L_2L_3$ or $L_2L_3L_1$ or $L_3L_1L_2$

Phase current indicators:

- Phase current indicators (I_1, I_2, I_3) indicate the presence of current in particular phase.
- An arrow (←) below the phase current indicator (I_1, I_2, I_3) indicates the reverse flow energy in particular phase.
- If the phase current is below the defined current threshold, than the phase current indicator is off. In case of connection via transformer, the current threshold value is recalculated with the current transformer ratio, to correspond the current on the primary side of transformer.

5.1.5. Notification field



1 In call indicator
2 Disconnect control indicator
3 Battery status
4 Alarm indicator
5 GSM signal status
6 Load control indicator
7 Authentication/decryption failure indicator

Figure 34: Notification field on display

5.1.5.1. In Call Indicator

The *In call indicator* (✆) is activated, when GSM/GPRS communication is active. That is when:

- GSM call is in progress, or
- PDP context is established on GPRS.

When GSM connection is starting or ending, the *In call indicator* is blinking.

5.1.5.2. Disconnect control indicator

The *Disconnect control indicator* (⌐/–) is activated, when load control relay is disconnected.

5.1.5.3. Battery status

The *Battery status* (▮▮▮) on display is activated only if the **RTC backup type** (0-0:128.1.2) object is set to *Battery*. Otherwise, there is no battery status presented on the display. *Battery status* can show five stages of battery remaining capacity, as is defined in Table 38.

Battery status	Battery remaining capacity in %
3 bars (Battery full)	100% – 71%
2 bars	70% – 41%
1 bar	40% – 11%
Blank battery (Battery low)	10% – 1%
Blank battery blinks (Battery empty)	0%

Table 38: Battery status

5.1.5.4. Alarm indicator

The *Alarm indicator* (⚠) is activated, when the system alarm status is set. That is, when any alarm bit is set in either of two alarm registers:

- Alarm register 1,
- Alarm register 2.

5.1.5.5. GSM signal status

The *GSM signal status* (Ỵ.ıll) bars present the strength of GSM signal, which is obtained from the **GSM signal quality** (0-0:128.20.0) object, as is defined in Table 39 and Table 40.

GSM signal status bars	***GSM signal quality* object value**
4 bars	≥ 27
3 bars	21 – 26
2 bars	15 – 20
1 bar	9 – 14
None	0 – 8; 99

Table 39: GSM signal status

Signal strength [dBm]	***GSM signal quality* object value**
-113 dBm or less	0
-111 dBm	1
-109 dBm…-53 dBm	2 – 30
-51 dBm or greater	31
not known or not detectable	99

Table 40: GSM signal quality object value definition

The antenna segment in front of *GSM signal status* bars presents the information about GSM communication modem registration status, obtained from the **GSM status** (0-0:128.20.1) object:

- Antenna segment is blinking – Status: Modem registered to GSM network (home or roaming).
- Antenna segment is active – Status: Modem registered in the system.

5.1.5.6. Load control indicator

The *Load control indicator* ( ) is activated, when any of load control activation scripts is executed (normally from register monitor). There are three load control channels implemented in the meter, and each having its corresponding script to activate or deactivate load control. Scripts are listed in the **Load control output script table** (0-0:10.1.250) object.

5.1.5.7. Authentication/decryption failure indicator

The *Authentication / decryption failure indicator* ( ) is activated, when authentication or decryption error blocks the communication interfaces. The communication is blocked when authentication or decryption error counter achieve the value defined in **Decryption and authentication failure count limit** (0-0:196.98.2.255). . The duration of blockade is internally set to 60 seconds.

5.1.5.8. Display lock 2 indicator

This meter feature can be used when the meter is equipped with the CM-LMN-e3 module.

The Display lock 2 indicator ( ) is displayed (**Display lock 2 status** (0-0:196.1.30*255) value is “True”) when the communication between LMN module and gateway is encrypted.

5.1.6. Cursors

Meter has laser printed markings on the nameplate below the LCD display. These markings are related to the cursors on the LCD. Depending on the meter configuration, these cursors have different meaning. At the bottom of the display are 12 triangular cursor segments; they are freely configurable. See example in Figure 35.

Cursor name	Cursor function	Displayed cursor meaning	Blinking cursor meaning
T1	Energy Tariff 1 indicator	Energy Tariff 1 active	Energy Tariff 5 active
T2	Energy Tariff 2 indicator	Energy Tariff 2 active	Energy Tariff 6 active
T3	Energy Tariff 3 indicator	Energy Tariff 3 active	Energy Tariff 7 active
T4	Energy Tariff 4 indicator	Energy Tariff 4 active	Energy Tariff 8 active
T5	Energy Tariff 5 indicator	Energy Tariff 5 active	*
T6	Energy Tariff 6 indicator	Energy Tariff 6 active	*
T7	Energy Tariff 7 indicator	Energy Tariff 7 active	*
T8	Energy Tariff 8 indicator	Energy Tariff 8 active	*
SQ	Signal Quality indicator (GSM/GPRS/UMTS option)	GSM signal present	GSM signal weak
COM	Network login (GSM/GPRS option)	Meter logged in the network (GSM/GPRS), installation call made or not enabled	GSM/GPRS modem registered but installation call wasn't made
DRO	Data Read Out indicator	Meter data reading active	
FF	Fatal Failure indicator	Fatal Failure	
SET	Set mode indicator	Set mode active	
EXM	External Module indicator	External Module installed	External Module detected but not recognized
GPRS	GPRS status indicator (GSM/GPRS option)	GPRS registered PDP context active	GPRS registered PDP context not active
TEST	Test mode indicator	Test mode active	
TCO	Terminal Cover indicator	Terminal Cover opened alarm	
MCO	Meter Cover indicator	Meter Cover opened alarm	
VA	Voltage Alarm indicator	Under-voltage, over-voltage alarm	
BB	Billing Blocked indicator	Billing blockade active	
RTC	RTC tariff indicator	Tarff control via activity calendar	
DT1	Demand Tariff 1 indicator	Demand Tariff 1 active	Demand Tariff 5 active
DT2	Demand Tariff 2 indicator	Demand Tariff 2 active	Demand Tariff 6 active
DT3	Demand Tariff 3 indicator	Demand Tariff 3 active	Demand Tariff 7 active
DT4	Demand Tariff 4 indicator	Demand Tariff 4 active	Demand Tariff 8 active
DT5	Demand Tariff 5 indicator	Demand Tariff 5 active	*
DT6	Demand Tariff 6 indicator	Demand Tariff 6 active	*
DT7	Demand Tariff 7 indicator	Demand Tariff 7 active	*
DT8	Demand Tariff 8 indicator	Demand Tariff 8 active	*
AIN1	Alarm Input 1 indicator	Alarm input 1 active	
AIN2	Alarm Input 2 indicator	Alarm input 2 active	
MZE	MZE Input indicator	MZE input active – demand measurement disabled.	

* depends on the tariff programming, see subchapter *5.1.6.1. Energy/demand tariff cursors*

Table 41: Display cursors definition

Example:

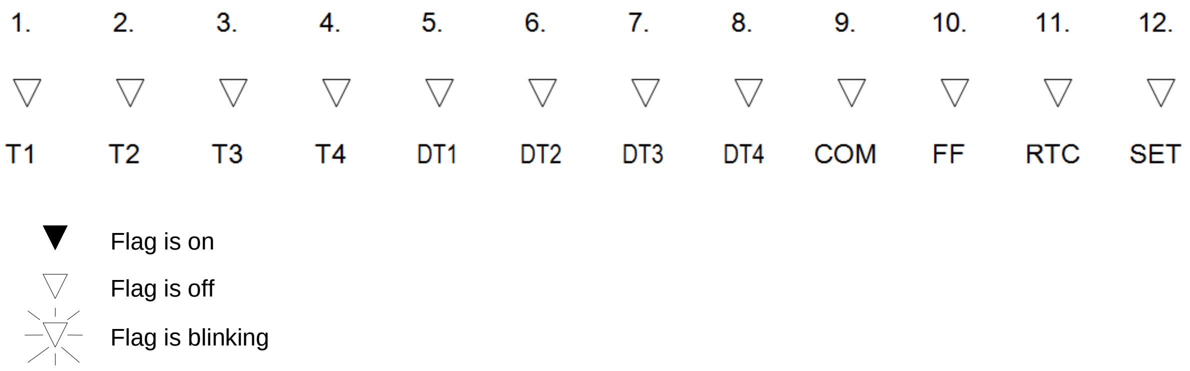


Figure 35: Display cursors legend

Cursors could have different meaning. The meaning of each cursor can be configured by parameter **Display cursors configuration** (0-0:196.1.4*255).

5.1.6.1. Energy/demand tariff cursors

- Up to eight energy-tariff cursors are supported (T1, T2… T8).
- Up to eight demand-tariff cursors are supported (DT1, DT2… DT8).
- Each of the 12 triangle LCD cursors segments (▽) can be assigned to one of the eight tariff cursors.
- If the active tariff is greater than the greatest parameterized tariff cursor, the active tariff indication on display is represented by blinking the tariff cursor which is defined by expression:

blinking tariff cursor = active tariff – greatest parameterized tariff cursor

Example:

active tariff:	*T7*
greatest parameterized tariff cursor:	*T4*
active tariff > greatest parameterized tariff cursor:	*T7 > T4*
tariff indication by blinking tariff cursor:	*T7 – T4 = T3 blinking*

- If there is no corresponding tariff cursor parameterized for an active tariff, the active tariff is not indicated on display.

5.1.7. Display format

Several display format objects are used to configure format for energy, demand, voltage, and current presentation on display. Up to eight digits are used to display a value, and up to seven of them can be used for decimal precision. The unit for energy and demand can be configured as well.

5.1.7.1. Display format for energy

Display format for energy is programmable by the **Display format for energy** (0-0:196.1.0) object. The value of energy objects is displayed with eight numbers; number of decimal places is programmable. The unit of displayed quantities is also programmable and can be either Wh or kWh or MWh or GWh. Displayed values can be primary or secondary (related to energy and demand). In the test mode, the number of additional decimal places is programmable.

5.1.7.2. Display format for demand

Display format for demand is programmable as well, by the **Display format for demand** (0-0:196.1.1) object. The value of demand objects is displayed with up to eight numbers, the format for demand and number of decimal places is programmable. The unit of displayed quantities is also programmable and can be either W or kW or MW or GW (var or kvar or Mvar or Gvar; VA or kVA or MVA or GVA). Displayed values can be primary or secondary (related to energy and demand). In the test mode, the number of additional decimal places is programmable.

5.1.7.3. Display precision for voltage and current

When meter is configured for secondary registration of voltage/current, the measured voltages are stored in mV/mA. Differently when meter is configured for primary registration of voltage/current, voltage values are stored in V/A. Format for voltage and current display is programmable. We can set the numbers of decimal places for voltage and current display by the parameter (valid only for secondary presentation).

5.1.8. OBIS data name presentation on display

There are 8 digits reserved for OBIS name presentation on the left side of the display. OBIS name is always displayed from the first digit on the left. See Figure 33.

There are two types of OBIS name format supported on display:

- short OBIS name format: C.D.E.(F),
- full OBIS name format: A-B:C.D.E.(F).

OBIS name format is set as a bit–parameter in the **Display configuration** (0-0:196.1.3) object. By default, the short OBIS name format is used. There is an exception for OBIS names with field B ≠ 0; in this case, the full OBIS name format is used. Field F is optional and is used as index of previous values.

Up to eight characters of OBIS name can be displayed. There are some abbreviation characters, used for the specific multi-character fields of OBIS name (Table 42).

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

Table 42: OBIS name abbreviation characters

5.1.9. Error codes on display

In certain cases, an error message can appear on display. The error codes that can be seen on display are listed in Table 43.

Error code	Error description
Error 11	Ident format failed
Error 23	Ident not existing
Error 31	Value format failed

Table 43: Error codes on display

5.1.10. Horizontal scroll

Some data/string, which are displayed on the LCD, may be larger than 8-character size of alphanumeric field on LCD. In this case, at the same time whole data could not be displayed on LCD.

Horizontal scroll functionality enables LCD fully presenting of data/strings larger than 8 characters by horizontal scrolling. The functionality is available for data of following objects:

- Active firmware module signature object: 1-1:0.2.8
- Active firmware core signature object: 1-0:0.2.8
- Activity calendar: 0-0:13.0.0
- GSM IMEI: 0-0:128.20.4
- Load control monitor 1: 0-1:16.0.0
- Load control monitor 2: 0-2:16.0.0
- Load control monitor 3: 0-3:16.0.0

Horizontal scroll shift period is one second.

For Active firmware module/core signature objects, full OBIS code presentation is used.

The horizontal scroll is used for threshold values (*Thresholds*) of the objects Load control monitor 1,2,3 (0-*x*:16.0.0*255; where x stands for 1, 2 or 3).

5.2. Console timers

There are four generally used console timers that use the timeouts, which can be configured via configuration objects. When the timeout for the particular timer elapsed, the corresponding action is triggered:

- LCD backlight timer,
- Auto-scroll timer,
- Menu exit timer,
- Test mode exit timer.

5.2.1. LCD backlight timer

- Turn off the LCD backlight after timeout elapsed.
- Timeout is defined in seconds in the **Display backlight timeout** (0-0:196.1.8) object.

5.2.2. Auto-scroll timer

- Scroll to the next item from *General display readout* list in *Auto-scroll mode* after timeout elapsed.
- Timeout is defined in seconds in **Display autoscroll roll time** (0-0:196.1.9) object.

5.2.3. Menu exit timer

- Exit from specific menu/mode into *Auto-scroll mode* after timeout elapsed.
- Timeout is defined in seconds in **Display exit from specific mode timeout** object (0-0:196.1.11).

5.2.4. Test mode exit timer

- Exit from the *Test mode* into *Auto-scroll mode* after timeout elapsed.
- Timeout is defined in seconds in **Test mode exit time** (0-0:196.1.20) object.
- Timeout default value: 3600 s.

5.3. Buttons

- Forward scroll button – right button for general use.
- Backward scroll button – left button for general use.
- Optical scroll button
- Set button – under the sealed transparent window.

While the *Backward-scroll* button and the *Set* button are not sensitive to various button press duration, the *Forward-scroll* button distinguishes three different types of button press, depending on press duration:

- Short button press – press durations shorter than 2 s.
- Long button press – press durations longer than 2 s or equal, and shorter than 5 s.
- Extended button press – press durations longer than 5 s or equal.

Use of buttons and meaning of different button press is described in Table 44.

Button press	Press duration	Triggering event	Tip on display
Forward-scroll button			
Short	t < 2 s	Scroll forward / Go to the next item	/
		Cancel meter reset in *Reset mode*	/
Long	2 s ≤ t < 5 s	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 *Auto-scroll mode* at the end of list in *Set menu / Data menu*	ESC
Extended	t ≥ 5 s	Escape into the *Auto-scroll mode*	ESC
Backward-scroll button			
Short	/	Scroll backward / Go to the previous item	/
Set button			
Short	/	Enter into the *Set menu* from the display test state	/
		Execute billing reset	donE rEJEctEd
		Confirm the setting in *Set mode*	/
		Execute meter reset in *Reset mode*	donE rEJEctEd

Table 44: Use of buttons

Button label	Button	Press
FS	Forward-scroll button	Short press
FL	Forward-scroll button	Long press
FE	Forward-scroll button	Extended press
BS	Backward-scroll button	Short press
SS	Set button	Short press

Table 45: Button labels

5.3.1. Optical scroll button

Meter is equipped with optical scroll button (Figure 36). The functionality is the same as for forward scroll button. Functionality (enabled/disabled) of optical scroll button is programmable.

Figure 36: Optical scroll button on the meter

5.3.2. Menu navigation

The console user interface has two menus that are accessible from the display test state, which is entered from the *Auto-scroll mode* by a short press on *Forward-scroll* button (Figure 37).

- *Data menu* (general use)
- *Set menu* (limited use)

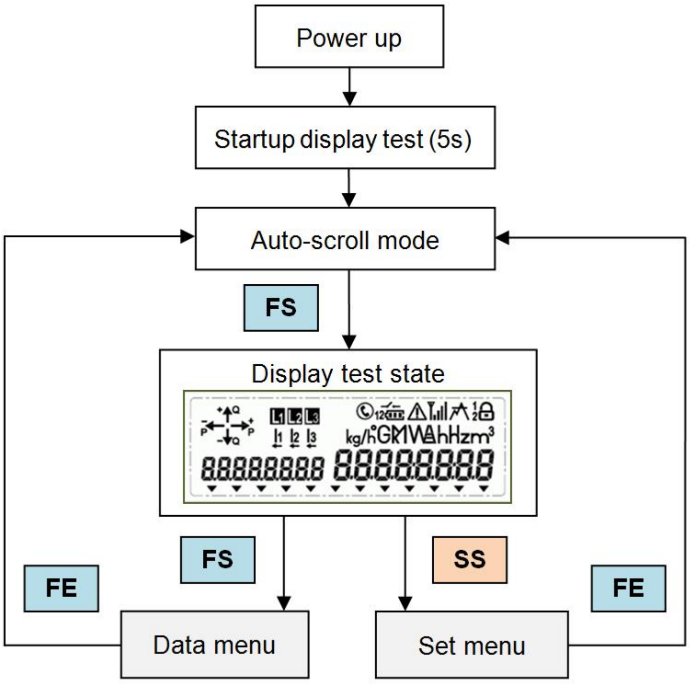


Figure 37: Entering the Data/Set menu

5.3.2.1. Data menu

Data menu is accessible from the display test state by a short press on *Forward-scroll* button. In *Data menu*, five items are supported for presentation on display. The first item is *Manual-scroll mode* (Std data).
It is fixed and cannot be disabled. Other four items are optional and can be configured by the **Display configuration** object (0-0:196.1.3). In *Data menu,* the following items are listed in next order:

- Std data – Manual-scroll mode,
- P.01 – Load profile with period 1 (optional),
- P.02 – Load profile with period 2 (optional),
- P.99 – Certification data log (optional),
- Grid – Grid mode (optional),
- End – end of list.

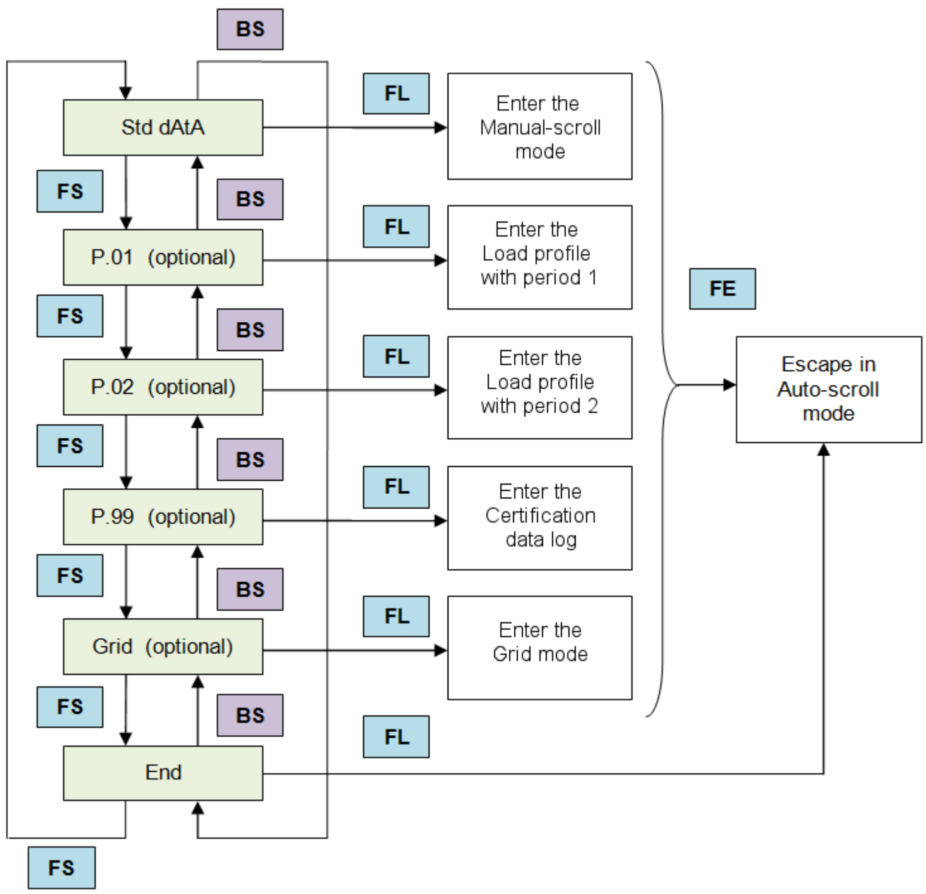


Figure 38: Data menu navigation

Example

Q:

How to read the **Active firmware version** and **Active firmware core signature** value on the LCD?

A:

Active firmware version can be found by the register **1.0.0.2.0**.
Active firmware core signature can be found by the register **1.0.0.2.8**.

Follow the next steps to show data on the LCD:

1. Short press the forward scroll button (< 1 s); the LCD test mode displays.
2. Short press the forward scroll button; *Std dAtA* appears.
3. To enter the *Std dAtA* menu press the forward scroll button for 2 s until *EntEr* shows. By short pressing the forward scroll button, manually listing between registers is now available. Manually listing is also possible with the backward scroll button.
4. Press the forward scroll button repeatedly until the register **1.0.0.2.0** can be seen on the left side of the LCD.
5. Read the registers value on the right side of the LCD.
6. By next short press on the forward scroll button, the value for the register **1.0.0.2.8** appears. Read its value.
7. If there is no need to read a value of any other register exit the Manual scroll mode by extended press (≥ 5 s < 8 s) on the forward scroll button until *ESC* is shown. The transition from Manual to Auto scroll mode can also be done automatically; the transition time is configurable.

NOTE!
The displayed items listed in General display readout mode (Auto scroll mode) or Alternate display readout mode (Manual scroll mode) sequence list is defined in objects **General display readout** (0-0:21.0.1) and **Alternate display readout** (0-0:21.0.2).

NOTE!
The object name **Active firmware core signature** has the same meaning as the object name **Checksum** in the older meter versions.

NOTE!
A place number of the register in the *Std dAtA* menu is already set and it can be changed.

5.3.2.2. Set menu

Set menu is accessible from the display test state by a short press on *Set* button, which is protected with a seal. In *Set menu* there are four items listed in next order:

- Set – *Set mode* – date and time setting,
- Test – *Test mode* – high precision for energy and demand,
- Lcd test – *Lcd test mode* – display unit test,
- Reset – *Reset mode* – meter reset execution,
- End – end of list.

NOTE!
Reset mode is protected with the highest protection level.

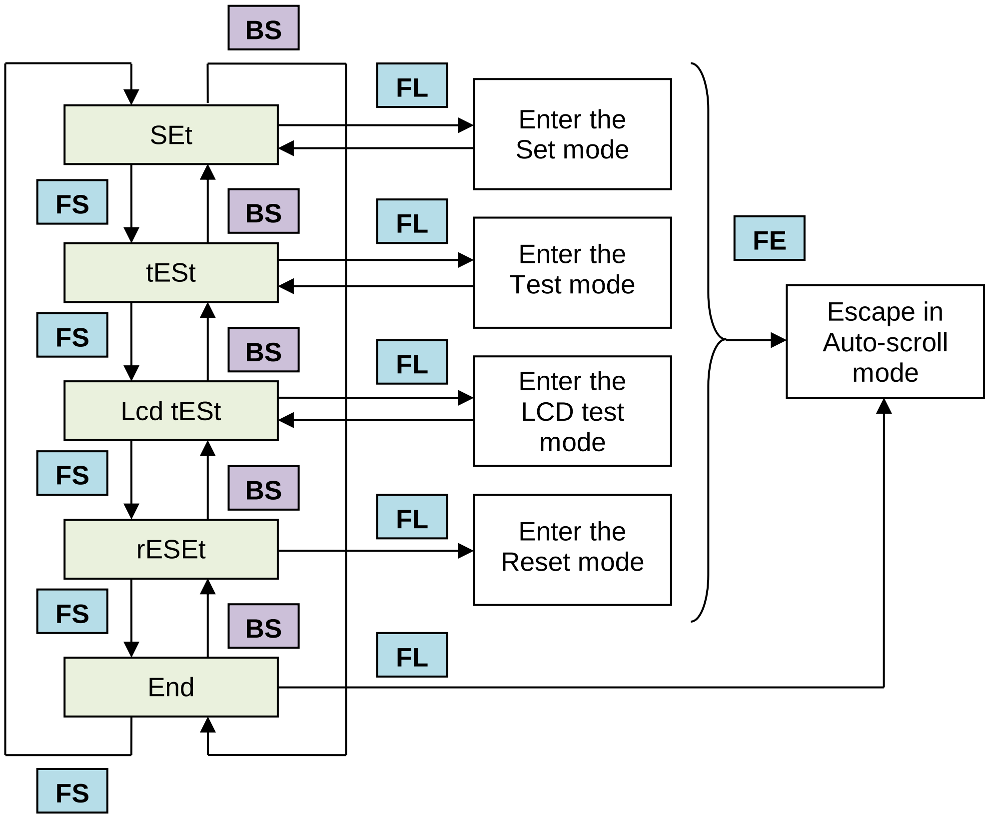


Figure 39: Set menu navigation

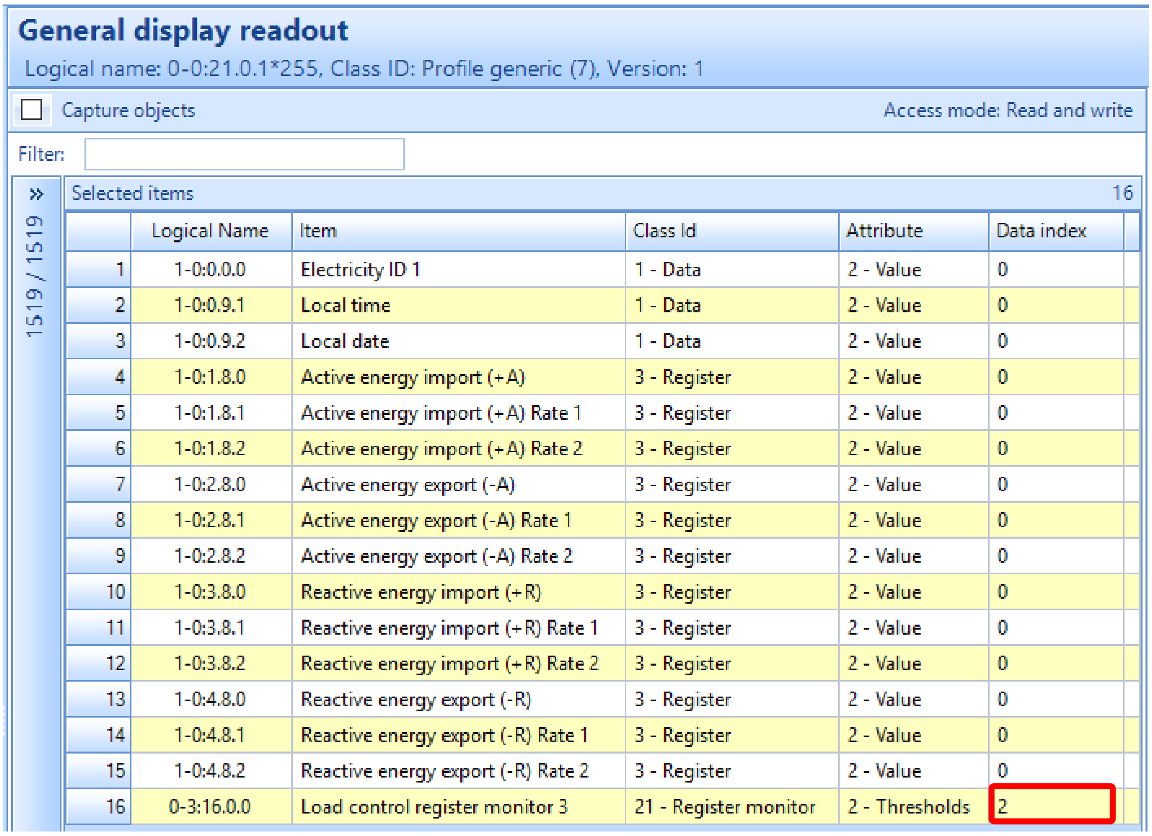
5.3.3. Auto-scroll, Manual-scroll mode

Auto-scroll mode and *Manual-scroll mode* are used for data presentation on display, intended for user. Data that appear on display are listed in sequence lists, defined by objects:

- **General display readout** (0-0:21.0.1) object → *Auto-scroll mode* sequence list
- **Alternate display readout** (0-0:21.0.2) object → *Manual-scroll mode* sequence list

The meter enables show more-complex data types as are structure and array on the meter display. For this reason, capture object data index is used. Capture object data index defines element of the structure or element of the array which value is presented on the meter's display.

Up to 6 capture object data index value can be defined in each display readout list.


General display readout
Logical name: 0-0:21.0.1*255, Class ID: Profile generic (7), Version: 1
Capture objects — Access mode: Read and write
Filter:
Selected items 16
1519 / 1519

	Logical Name	Item	Class Id	Attribute	Data index
1	1-0:0.0.0	Electricity ID 1	1 - Data	2 - Value	0
2	1-0:0.9.1	Local time	1 - Data	2 - Value	0
3	1-0:0.9.2	Local date	1 - Data	2 - Value	0
4	1-0:1.8.0	Active energy import (+A)	3 - Register	2 - Value	0
5	1-0:1.8.1	Active energy import (+A) Rate 1	3 - Register	2 - Value	0
6	1-0:1.8.2	Active energy import (+A) Rate 2	3 - Register	2 - Value	0
7	1-0:2.8.0	Active energy export (-A)	3 - Register	2 - Value	0
8	1-0:2.8.1	Active energy export (-A) Rate 1	3 - Register	2 - Value	0
9	1-0:2.8.2	Active energy export (-A) Rate 2	3 - Register	2 - Value	0
10	1-0:3.8.0	Reactive energy import (+R)	3 - Register	2 - Value	0
11	1-0:3.8.1	Reactive energy import (+R) Rate 1	3 - Register	2 - Value	0
12	1-0:3.8.2	Reactive energy import (+R) Rate 2	3 - Register	2 - Value	0
13	1-0:4.8.0	Reactive energy export (-R)	3 - Register	2 - Value	0
14	1-0:4.8.1	Reactive energy export (-R) Rate 1	3 - Register	2 - Value	0
15	1-0:4.8.2	Reactive energy export (-R) Rate 2	3 - Register	2 - Value	0
16	0-3:16.0.0	Load control register monitor 3	21 - Register monitor	2 - Thresholds	2

Figure 40: Example – defined data index value of Load control register monitor 3

NOTE!
Displaying value of the array element is available only for second attributes of the Load control register monitor 1,2,3 objects.

5.3.3.1. Auto-scroll mode

Auto-scroll mode is implemented in the following way:

- *Auto-scroll mode* is general meter mode, where the items listed in the **General display readout** object are cyclically displayed on LCD.
- Each item is displayed for a time defined in seconds in **Display autoscroll roll time** (0-0:196.1.9) object.
- Default auto-scroll time is 10 seconds.

In **General display readout** object, up to 128 capture objects can be configured; it means that the same amount of objects can be displayed in Auto-scroll mode.

5.3.3.2. Manual-scroll mode

Manual-scroll mode is implemented in the following way:

- *Manual-scroll* mode is used for manual data review on display.
- Displayed items are listed in *Manual-scroll* mode sequence list, defined by the **Alternate display readout** object.
- *Manual-scroll mode* is accessible from the *Data menu* by a long press on *Forward-scroll* button at the *Std data* item, when tip ***EntEr*** is shown. Then the first item from the sequence list is displayed.
- The next item from the sequence list is displayed by a short press on the *Forward-scroll* button.
- The previous item from the sequence list is displayed by a short press on the *Backward-scroll* button.
- At the end of sequence, the ***End*** notice is displayed.
- Return to the *Data menu* is performed by a long press on the *Forward-scroll* button, when tip ***Layer up*** is shown.
- Escape in *Auto-scroll* mode is performed by an extended press on *Forward-scroll* button, when tip ***Esc*** is shown.

In **Alternate display readout** object, up to 128 capture objects can be configured.

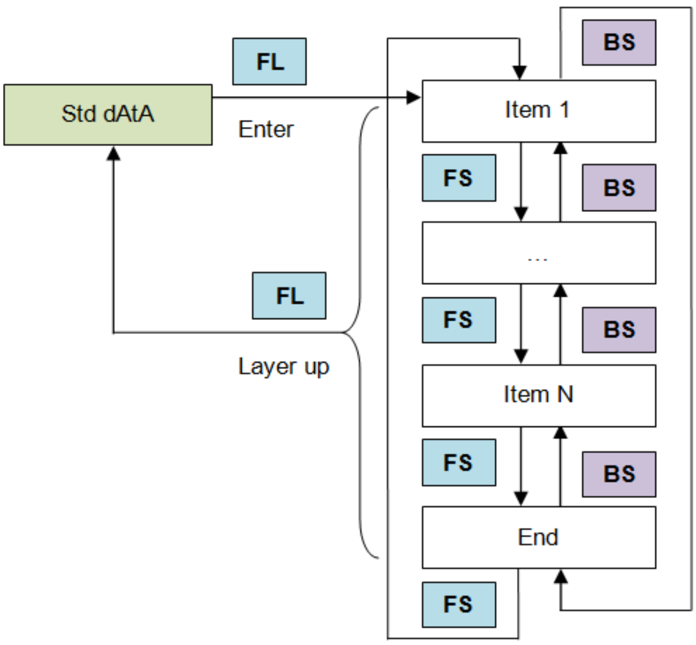


Figure 41: Manual-scroll mode navigation

5.3.4. Load profile on display

Presentation of Load profile on display is optional and can be enabled by a parameter in the **Display configuration** object. Load profile presentation is accessible from the *Data menu,* by a long press on *Forward-scroll* button at the *P.01 / P.02* item, when tip ***EntEr*** is shown:

- P.01 – Load profile with period 1,
- P.02 – Load profile with period 2.

Load profile presentation on display follows VDEW specifications. Load profile is presented on display in three layers:

- layer DATE (upper layer),
- layer TIME (middle layer),
- layer ATTR (lower layer).

Layer DATE:

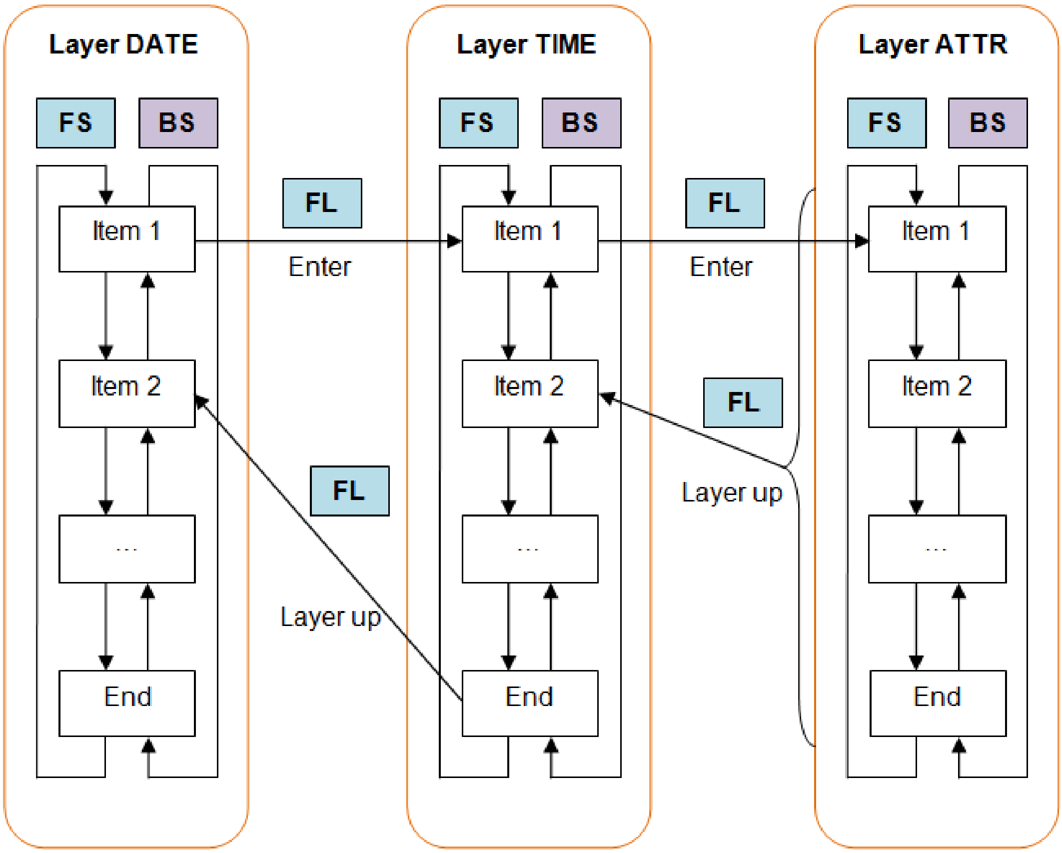
- List of dates of Load profile records.
- Format: P.0X YY.MM.DD (legend: X = period 1 or 2 of Load profile, YY = year, MM = month, DD = day).
- First item is the youngest date of Load profile records.
- Last item is the oldest date of Load profile records.
- At the end of list, the ***End*** notice is displayed.
- Short press on *Forward-scroll* button to scroll to the next date.
- Short press on *Backward-scroll* button to scroll to the previous date.
- Long press on *Forward-scroll* button to enter the *Layer TIME*, to the first period in selected day.
- Long press on *Forward-scroll* button at the end of list to return into *Data menu*.
- Extended press on *Forward-scroll* button to escape into *Auto-scroll* mode.

Layer TIME:

- List of periods of Load profile records in selected day.
- Format: P.0X MM.DD.hh:mm (legend: X = period 1 or 2 of Load profile, MM = month, DD = day, hh = hours, mm = minutes).
- First item is the period of the first record in selected day (after time 00:00:00).
- Last item is the period of the last record in selected day (including time 00:00:00 on next day).
- Period ended at 00:00:00 (on next day) belongs to the previous day.
- At the end of list, the ***End*** notice is displayed.
- Short press on *Forward-scroll* button to scroll to the next period.
- Short press on *Backward-scroll* button to scroll to the previous period.
- Long press on *Forward-scroll* button to enter the *Layer ATTR*, to the first object in selected period.
- Long press on *Forward-scroll* button at the end of list to return into *Layer DATE*, to the next date.
- Extended press on *Forward-scroll* button to escape into *Auto-scroll* mode.

Layer ATTR:

- List of captured objects of the current record:
  - **Load profile with period 1** (1-0:99.1.0) object,
  - **Load profile with period 2** (1-0:99.2.0) object.
- First item is the first object from the capture objects list, except *Clock* object.
- Last item is the last object from the capture objects list.
- At the end of list, the ***End*** notice is displayed.
- Short press on *Forward-scroll* button to scroll to the next object from the list.
- Short press on *Backward-scroll* button to scroll to the previous object from the list.
- Long press on *Forward-scroll* button to return into *Layer TIME*, to the next period.
- Extended press on *Forward-scroll* button to escape into *Auto-scroll* mode.



Display forms by layers:

P.0X YY.MM.DD

P.0X MM.DD.hh:mm

C.10.1 1
1.8.0 000000
...

Legend:

YY	→ Year	hh	→ hours
MM	→ Month	mm	→ minutes
DD	→ Day	X	→ Load profile period 1 or 2

Figure 42: Load profile on display navigation

5.3.5. Certification data log on display

Presentation of Certification data log on display is optional and can be enabled by a parameter in the **Display configuration** object. Certification data log presentation is accessible from the *Data menu,* by a long press on *Forward-scroll* button at the *P.99* item, when tip ***EntEr*** is shown.

Certification datalog is presented on display in two layers:

- layer DATE (upper layer),
- layer TIME (lower layer).

Layer DATE:

- List of Certification data log records, sorted by indexes in descending order.
  - Identifier: P.99.XX (XX = index of the current record).
  - Value: Date of the current record.
- The first item is a record with the last (greatest) index.
- The last item is a record with the first (lowest) index. Counting of indexes is started with 1.
- At the end of list, the ***End*** notice is displayed.
- Short press on *Forward-scroll* button to scroll to the next record (decrement index).
- Short press on *Backward-scroll* button to scroll to the previous record (increment index).
- Long press on *Forward-scroll* button to enter the *Layer TIME*.
- Long press on *Forward-scroll* button at the end of list to return into *Data menu*.
- Extended press on *Forward-scroll* button to escape into *Auto-scroll* mode.

Layer TIME:

- List of recorded time and captured objects of the current record.
- Capture objects list is defined by **Certification data log** object as:
  - Clock,
  - Last modified secure parameter,
  - Last modified secure parameter old value,
  - Last modified secure parameter new value.
- First displayed item is a recorded time of the current record:
  - Identifier: P.99.XX (XX = index of the current record).
  - Value: Time of the current record.
- Second displayed item is an old value of the modified secure parameter:
  - Identifier: Modified secure parameter identifier.
  - Value: Modified secure parameter old value.
- Third displayed item is a new value of the modified secure parameter:
  - Identifier: Modified secure parameter identifier.
  - Value: Modified secure parameter new value.
- At the end of list, the ***End*** notice is displayed.
- Short press on *Forward-scroll* button to scroll to the next item.
- Short press on *Backward-scroll* button to scroll to the previous item.
- Long press on *Forward-scroll* button to return into *Layer DATE*, to the next record (decrement index).
- Extended press on *Forward-scroll* button to escape into *Auto-scroll* mode*.*

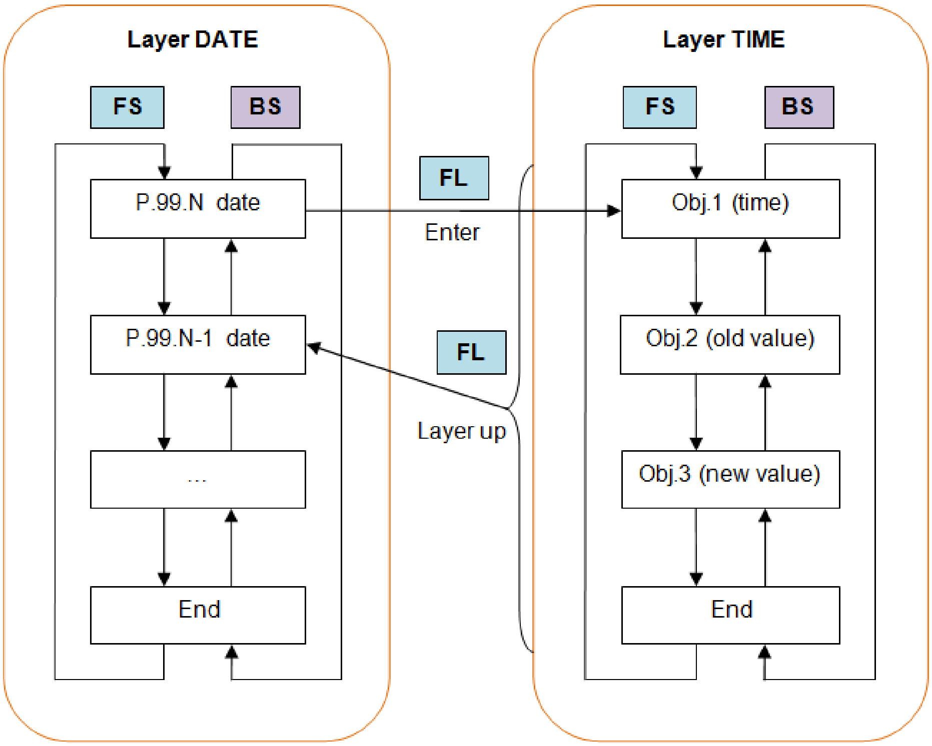


Figure 43: Certification data log on display navigation

5.3.6. Grid mode on display

Grid mode is used for manual review of data related to the main electricity values on display. Grid mode is optional and can be enabled by a bit–parameter in the **Display configuration** object. Grid mode is accessible from the *Data menu,* by a long press on *Forward-scroll* button at the Grid item, when tip ***EntEr*** is shown. Then the first item from the Grid mode sequence list is displayed.

- Grid mode sequence list is defined by **Grid display readout** (0-0:21.0.5) object.
- The next item from the sequence list is displayed by a short press on *Forward-scroll* button.
- The previous item from the sequence list is displayed by a short press on *Backward-scroll* button.
- At the end of the sequence, the ***End*** notice is displayed.
- Return to the *Data menu* is performed by a long press on *Forward-scroll* button, when tip ***Layer up*** is shown.
- Escape in *Auto-scroll mode* is performed by an extended press on *Forward-scroll* button, when tip ***Esc*** is shown.

In **Grid mode**, up to 32 capture objects can be configured.

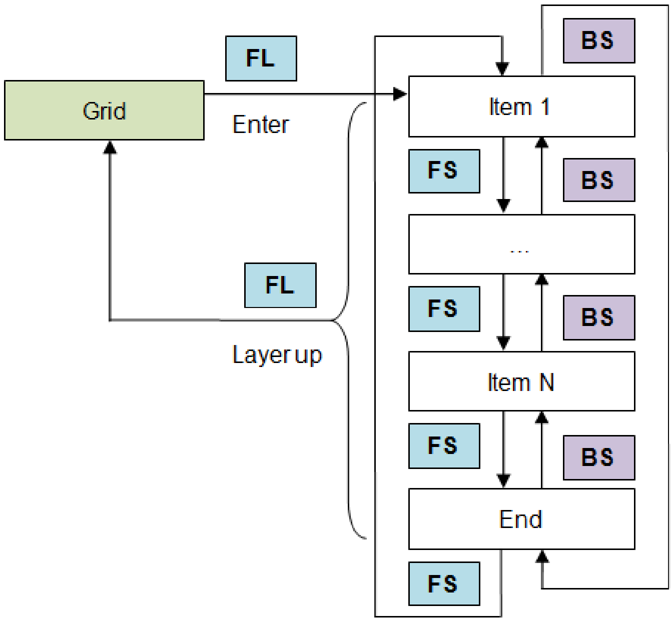


Figure 44: Grid mode navigation

5.3.7. SET mode on display

Set mode is used for setting the system date and time via console buttons. It follows VDEW specification. Set mode is the first item listed in *Set menu*. It is accessible by a long press on *Forward-scroll* button at the Set item, when tip ***EntEr*** is shown.

- First item listed in Set mode is system date (format: YYYY.MM.DD).
- Second item listed in Set mode is system time (format: hh:mm:ss).
- Scroll the list forward / backward by a short press on *Forward-scroll* button / *Backward-scroll* button.
- At the end of list, the ***End*** notice is displayed.
- Setting of the displayed item (date, time) is performed by editing the digits, one by one from left to right.
- Enter the setting of the displayed item by a short press on the Set button. The first digit starts blinking.
- Blinking digit is enabled to edit by a short press on *Forward-scroll* button / *Backward-scroll* button.
- Setting is confirmed by a short press on Set button. Next digit starts blinking.
- When the last digit is set, all digits start blinking. Confirm the setting of the displayed item by a short press on Set button.
- When the Set mode is active, it is indicated with the Set mode indicator cursor (SET). See Figure 35.

5.3.8. Test mode on display

Test mode is used for testing purposes to review the energy and demand registers with higher precision. Test mode can be entered in two ways:

- by the script execution via communication,
- by buttons.

Via buttons, the Test mode is accessible from the *Set menu,* by a long press on *Forward-scroll* button at the Test item, when tip ***EntEr*** is shown:

- Displayed items are listed in sequence list, defined by Auto-scroll sequence.
- Energy and demand registers are displayed with higher precision.
- Test mode precision for energy and demand registers is defined by **Display test mode precision for energy and demand** (0-0:196.1.6) object.
- Previous values are skipped and are not shown.
- When the Test mode is active, it is indicated with the Test mode indicator cursor (TEST).
- Test mode is active for a time defined by **Test mode exit time** (0-0:196.1.20) object.
- The next item from the sequence list is displayed by a short press on *Forward-scroll* button.
- The previous item from the sequence list is displayed by a short press on *Backward-scroll* button.
- At the end of sequence, the ***End*** notice is displayed.
- Return to the Set menu is performed by a long press on *Forward-scroll* button*,* when tip ***Layer up*** is shown.
- Escape into the *Auto-scroll mode* is performed by extended press on *Forward-scroll* button, when tip ***Esc*** is shown.

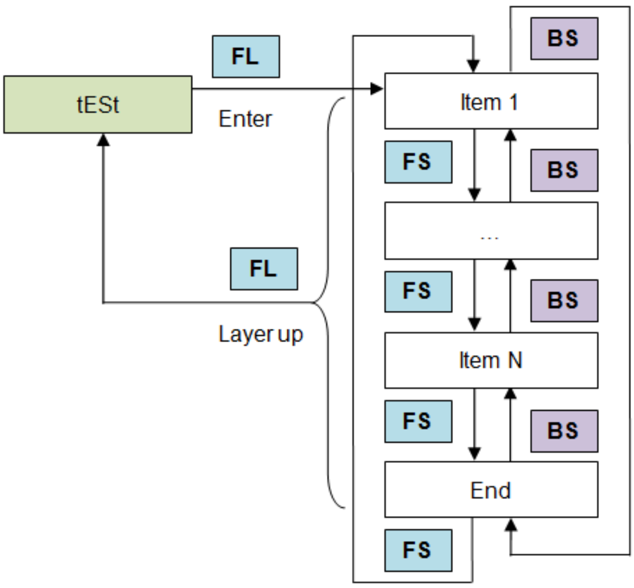


Figure 45: Test mode navigation

5.3.9. LCD test mode

LCD test mode is used for testing purposes to perform LCD unit test. LCD test mode is accessible from the Set menu by a long press on *Forward-scroll* button at the *Lcd test* item, when tip ***EntEr*** is shown:

- There are four LCD test conditions (full, odd, even, none) among which can be scrolled forward/backward by a short press on *Forward-scroll* button / *Backward-scroll* button.
- At the end of test sequence, the ***End*** notice is displayed.
- Return to the Set menu is performed by a long press on *Forward-scroll* button*,* when tip ***Layer up*** is shown.
- Escape into the *Auto-scroll mode* is performed by an extended press on *Forward-scroll* button*,* when tip ***Esc*** is shown.

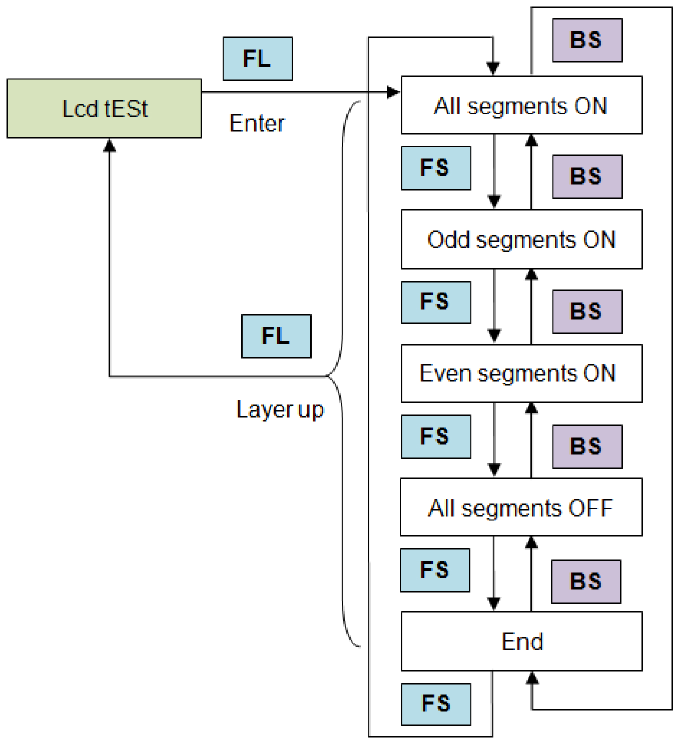


Figure 46: LCD test mode navigation

5.4. Metrological pulse generation

5.4.1. Metrological LEDs

The meter is provided with three red LEDs on the nameplate (see Figure 47). They are intended for checking the measurement and RTC accuracy.

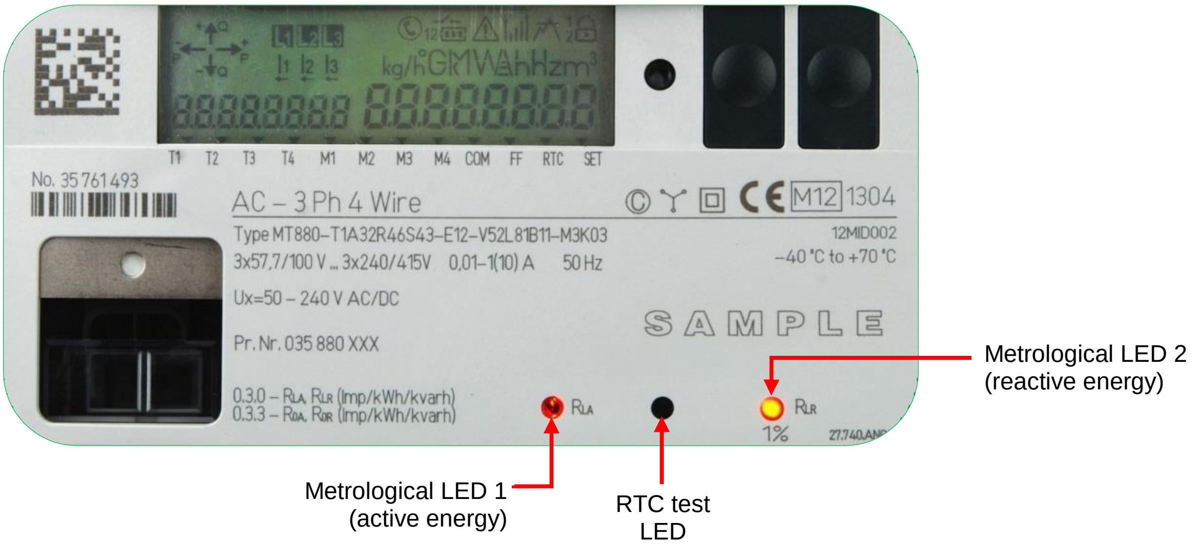


Figure 47: Metrological LEDs

LEDs definition:

- **Metrological LED 1** (left): default programmed for active energy, other functionalities can be parameterized on request.
- **RTC LED** (middle): it is intended for checking the RTC accuracy.
- **Metrological LED 2** (right) default programmed for reactive energy, other functionalities can be parameterized on request.

In special meter test mode (activated by the script execution via communication), the metrological LED constant is 10 times higher than in the normal mode.

Change of the LED impulse constant is written in the Certification data log:

- in the **Active energy metrological LED** (1-0:0.3.0) object for active energy, entered as impulses/kWh,
- in the **Reactive energy metrological LED** (1-0:0.3.1) object for reactive energy, entered as impulses/kvarh and
- in the **Apparent energy metrological LED** (1-0:0.3.2) object for apparent energy, entered as impulses/kVAh .

In normal meter operation mode, the metrological LEDs emit pulses with frequency that is proportional to the measured energy and is intended for the meter calibration and testing. The LEDs are turned-on and glow steadily if load is lower than the meter starting current.

Metrological LEDs can be configured for any type of energy measured by the meter. Any value in range from 500 to 100000 impulses can be used.

5.4.2. Impulse outputs

Up to four general-purpose outputs can be configured as impulse outputs. Each of up to four impulse outputs can be configured for any type of energy or different combination of energy.

Constants used for impulse outputs for active, reactive, and apparent energy are separately configurable. Constants can be applied to any of impulse outputs that are configured for the specific energy type.

Change of the constant is written in the Certification data log:

- in the **Active energy, output pulse meter constant** (1-0:0.3.3*255) object for active energy, entered as impulses/kWh,
- in the **Reactive energy, output pulse meter constant** (1-0:0.3.4*255) object for reactive energy, entered as impulses/kvarh and
- in the **Apparent energy, output pulse meter constant** (1-0:0.3.5*255) object for apparent energy, entered as impulses/kVAh.

The length of impulse as well as impulse polarity is programmable. Pulse length could be programmed from 20 to 65535 ms.

6. MAIN METER FUNCTIONALITIES

6.1. Inputs

Five (5) terminals can be defined as inputs. See Figure 20. Eleven (11) different input functions can be assigned to the input terminals (see Inputs in Table 35). Relations between input signals and triggered functions in dependence on idle state of the input are presented in following figures. Control input voltage can be AC or DC. The type of voltage has to be programmed in the meter. The state of control voltage can be high or low (see Figure 48 and Figure 49).

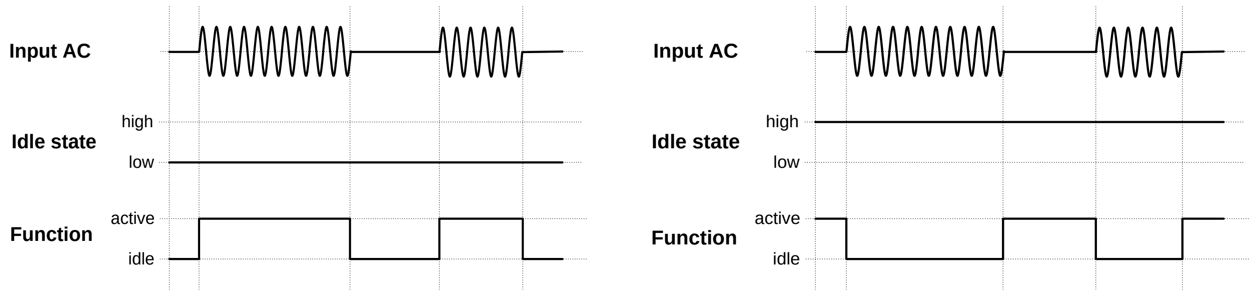


Figure 48: Correlation between AC input and function according to idle state

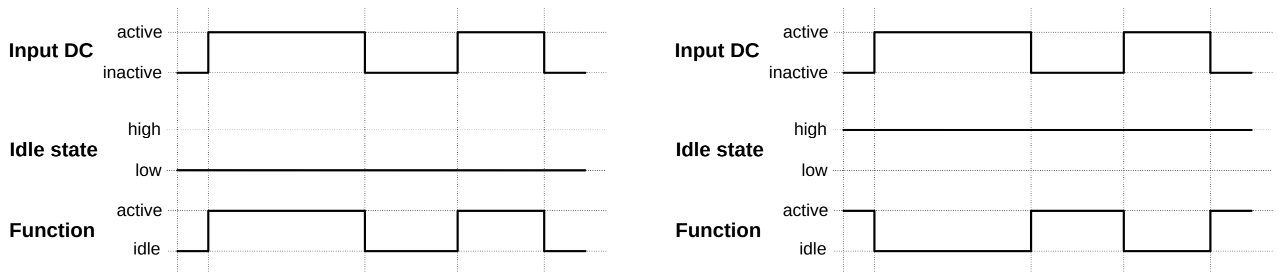


Figure 49: Correlation between DC input and function according to idle state

6.1.1. Input for disabling demand measurement (MZE)

Input for disabling of demand measurement (MZE) can be configured in the meter. If input is configured and active, all demand register values for current period are not measured.

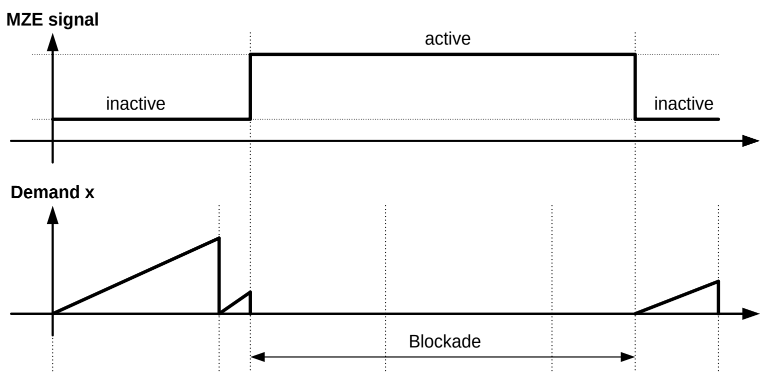


Figure 50: MZE input and demand measurement

6.1.2. Alarm inputs

Two alarm inputs (MKE1, MKE2) can be configured in the meter.

6.2. Outputs

Eight (8) terminals divided into two groups (5 +3) can be defined as outputs (see Figure 20). Twenty-eight (28) different output functions can be assigned to those outputs (see Outputs in Table 35). Different kind of actions in the meter drives the configured output states. Relations between triggering function and outputs in dependence on idle state of the output are presented in Figure 51.

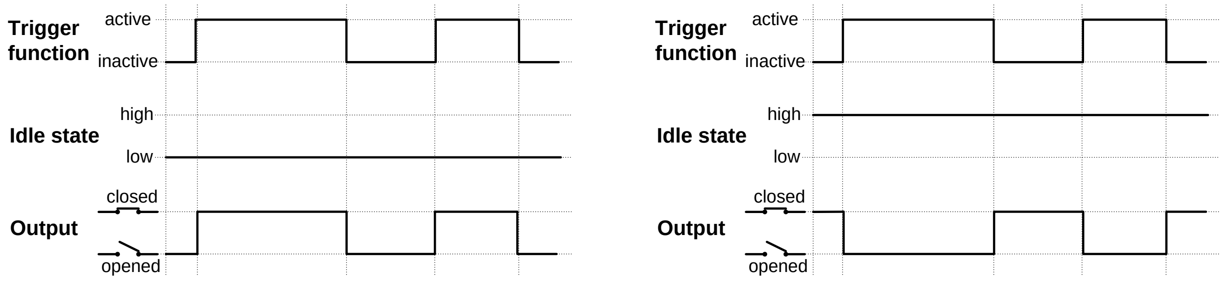


Figure 51: Correlation between trigger function and output according to idle state

6.2.1. Alarm outputs

Two alarm outputs (MKA1, MKA2) can be configured in the meter for signalling alarm condition to external connected devices. Different or same meter statuses can activate this two alarm outputs.

6.2.2. Measurement period output

Measurement period output (MPA) can be configured in meter for indication of start of new measurement period. Duration of MPA output is programmable. Default value is 1% of measurement period.

Example: if measurement period is 15 minutes (900 seconds) long, the MPA length is 9 seconds.

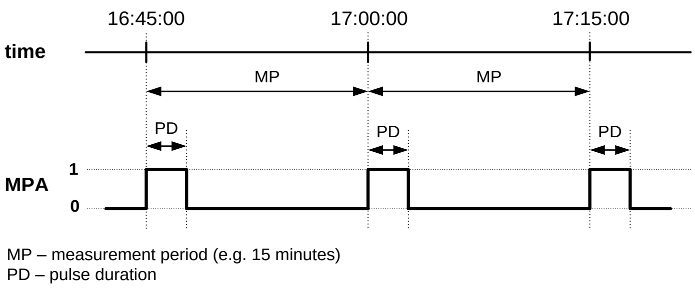


Figure 52: MPA output signal

6.2.3. Energy direction output

Two outputs for energy flow direction for active (ER+A) and reactive (ER+R) energy can be configured in the meter. Application is capturing the information about energy flow from the measurement part, and it drives the configured output to the proper state. If positive active energy flow is detected, the output state goes to active, otherwise goes to inactive.

6.2.4. Pulse outputs

Pulse outputs, which can be defined: +AA, -AA, |AA|, +RA, -RA, |RA|, RA1, RA2, RA3, RA4, +SA, -SA, |SA|.
Up to four (up to six *) outputs can be configured at the same time.

NOTE!
Up to four outputs can be configured as metrological pulse outputs at the same time. If more ports are tried to be configured as metrological pulse outputs, then configuration is rejected by the meter. Several impulse outputs can be configured with the same energy type (same function).

NOTE! *
Valid from FW core version 5 onwards: Up to six outputs can be configured as metrological pulse outputs at the same time. If more ports are tried to be configured as metrological pulse outputs, then configuration is rejected by the meter. Several impulse outputs can be configured with the same energy type (same function).

6.2.5. Output for disabling demand measurement (MZA)

Output for disabling demand measurement functionality (MZA) can be configured in the meter. If input state for disabling of demand measurement (MZE) is active, then also MZA output state is active, otherwise it is inactive. MZA output is correlated with input MZE.

6.2.6. Load control outputs

Up to three load control outputs (LA1, LA2, LA3) can be configured in the meter.

Information about all input and output statuses (activity) are stored in meter in specific status registers (0-0:96.3.x*255 (x=0…3)). All of them are read only registers.

6.3. External power supply (option)

The meter can be optionally equipped with additional power supply for supplying the meter, energized from separate energy source (see Table 46). If external power supply is equipped and energized, the meter is supplied from this source and the main power supply in this case is just a reserve. On this way, the influence on voltage inputs is minimized.

Terminal	Terminal functionality
30	• 50 – 240 V AC/DC • 50 – 290 V AC/DC • 24 V DC (+)
31	• 50 – 240 V AC/DC • 50 – 290 V AC/DC • 24 V DC (-)

Table 46: External power supply

6.4. Fraud detection

6.4.1. Meter cover and terminal cover opening detection

All accesses (opening and closing the meter and terminal cover) to the meter are detected and corresponding events are recorded and stored in a fraud detection event log as well as in a MCO & TCO (MCO – meter cover opening, TCO – terminal cover opening) event log.

Meter detects cover opening and closing in no-power state, too. The event is registered by the first next power up.

When MCO and TCO alarm is generated on the LCD, it could be cleared by the system operator only.

6.4.2. Magnetic field detection

MT880 meter is equipped with shielded measurement system, so magnetic fields has no influence to the meter accuracy measurements, however presence of magnetic fields are detected. Events are recorded in the fraud detection event log and in the magnetic tamper event log. Meter detects magnetic field also in no power state. The event is registered by the first next power up.

When magnet field detection alarm is generated on the LCD, it could be cleared by the system operator only.

6.5. Event logs

Event logs are organized as FIFO object. There are more event logs with different size available. See Table 47.

Event log object	Logical name	Event log depth (number of records)
Standard event log	0-0:99.98.0.255	255
Fraud detection log	0-0:99.98.1.255	255
Power quality log	0-0:99.98.4.255	255
Power down event log	0-0:99.98.5.255	64
Communication event log	0-0:99.98.6.255	255
MCO & TCO event log	0-0:99.98.7.255	20
Magnetic tamper event log	0-0:99.98.8.255	20
Power failure event log	1-0:99.97.0.255	10
Certification data log	1-0:99.99.0.255	100

Table 47: List of event logs with corresponding logical names and their capacity

6.5.1. Standard event log

List of events in the **Standard event log** (0-0:99.98.0) is shown in Table 48.

VDEW event code	Event name
0x0001	Fatal error
0x0002	Replace Battery
0x0004	Value corrupt
0x0008	DST enabled or disabled
0x0010	Billing reset
0x0020	Clock adjusted (old date/time)
0x0040	Power Up
0x0080	Power Down
0x2000	Event log cleared
0x4000	Load profile cleared
0x8001	Power down phase L1
0x8002	Power down phase L2
0x8003	Power down phase L3
0x8004	Power restored phase L1
0x8005	Power restored phase L2
0x8006	Power restored phase L3
0x8012	No connection timeout
0x8040	Clock adjusted (new date/time)
0x8041	One or more parameters changed
0x8042	Meter master reset
0x8043	Error register cleared
0x8044	Alarm register cleared
0x8045	Passive TOU programmed
0x8046	TOU activated
0x8047	Global key(s) changed
0x8048	Meter unlocked
0x8049	Meter locked
0x8050	Program memory error
0x8051	RAM error
0x8052	NV memory error
0x8053	Watchdog error
0x8054	Measurement system error
0x8055	Clock invalid
0x8060	Firmware ready for activation
0x8061	Firmware activated
0x8062	FW verification failed
0x8070	Previous values reset
0x8071	Wrong phase sequence
0x8072	Missing neutral
0x8073	Register rollover
0x8074	Certification data log full

VDEW event code	Event name
0x8075	Result reset
0x8130	Alarm input 1 activated
0x8131	Alarm input 2 activated
0x8132	Alarm output 1 activated
0x8133	Alarm output 2 activated
0x8140	Load control 1 activated
0x8141	Load control 1 deactivated
0x8142	Load control 2 activated
0x8143	Load control 2 deactivated
0x8144	Load control 3 activated
0x8145	Load control 3 deactivated

Table 48: List of events in the Standard event log

6.5.2. Fraud detection log

Fraud detection log (0-0:99.98.1) is used to log various events related to possible fraud attempts. List of events in the Fraud detection log is presented in Table 49.

VDEW event code	Event name
0x2000	Event log cleared
0x800E	Meter cover closed
0x800F	Terminal cover closed
0x8010	Meter cover removed
0x8011	Terminal cover removed
0x804A	Association authentication failure (n time failed authentication)
0x804B	Decryption or authentication failure (n time failure)
0x804C	Replay attack
0x8080	Current without Voltage phase L1 - start
0x8081	Current without Voltage phase L2 - start
0x8082	Current without Voltage phase L3 - start
0x8083	Current without Voltage phase L1 - end
0x8084	Current without Voltage phase L2 - end
0x8085	Current without Voltage phase L3 - end
0x8086	Missing current L1 - start
0x8087	Missing current L2 - start
0x8088	Missing current L3 - start
0x8089	Missing current L1 - end
0x808A	Missing current L2 - end
0x808B	Missing current L3 - end
0x808C	Over current L1 - start
0x808D	Over current L2 - start
0x808E	Over current L3 - start
0x808F	Over current L1 - end
0x8090	Over current L2 - end
0x8091	Over current L3 - end
0x8094	Asymmetrical current - start
0x8095	Asymmetrical current - end
0x8100	Asymmetrical voltage - start
0x8101	Asymmetrical voltage - end
0x8120	Reverse power flow - start
0x8121	Reverse power flow - end
0x8122	Low power factor - start
0x8123	Low power factor - end
0x8124	Strong DC field detected
0x8125	No strong DC field anymore

Table 49: List of events in the Fraud detection event log

6.5.3. Power quality log

Power quality log (0-0:99.98.4) stores events related to quality of supplied power. List of events in the Power quality log is given in Table 50.

VDEW event code	Event name
0x2000	Event log cleared
0x8001	Power down phase L1
0x8002	Power down phase L2
0x8003	Power down phase L3
0x8004	Power restored phase L1
0x8005	Power restored phase L2
0x8006	Power restored phase L3
0x8020	Voltage sag phase L1
0x8021	Voltage sag phase L2
0x8022	Voltage sag phase L3
0x8023	Voltage swell phase L1
0x8024	Voltage swell phase L2
0x8025	Voltage swell phase L3
0x8102	Over-voltage phase L1
0x8103	Over-voltage phase L2
0x8104	Over-voltage phase L3
0x8105	Voltage normal phase L1
0x8106	Voltage normal phase L2
0x8107	Voltage normal phase L3
0x8108	Under-voltage phase L1
0x8109	Under-voltage phase L2
0x810A	Under-voltage phase L3
0x810B	Missing-voltage L1
0x810C	Missing-voltage L2
0x810D	Missing-voltage L3
0x810E	THD voltage over limit L1 - start
0x810F	THD voltage over limit L2 - start
0x8110	THD voltage over limit L3 - start
0x8111	THD voltage over limit L1 - stop
0x8112	THD voltage over limit L2 - stop
0x8113	THD voltage over limit L3 - stop
0x8114	THD current over limit L1 - start
0x8115	THD current over limit L2 - start
0x8116	THD current over limit L3 - start
0x8117	THD current over limit L1 - stop
0x8118	THD current over limit L2 - stop
0x8119	THD current over limit L3 - stop
0x811A	Frequency over limit
0x811B	Frequency under limit
0x811C	Frequency normal

Table 50: List of events in the Power quality event log

6.5.4. Powerdown event log

Powerdown event log (0-0:99.98.5) contains events related to the presence of phase and three phase voltages. List of events in the Powerdown event log is shown in Table 51.

VDEW event code	Event name
0x0040	Power Up
0x0080	Power Down
0x2000	Event log cleared
0x8001	Power down phase L1
0x8002	Power down phase L2
0x8003	Power down phase L3
0x8004	Power restored phase L1
0x8005	Power restored phase L2
0x8006	Power restored phase L3

Table 51: List of events in the Power down event log

6.5.5. Communication event log

Communication event log (0-0:99.98.6) is used for storing events related to communication, specially related to the 2G/3G modem behaviour. List of events in the Communication event log is presented in Table 52.

VDEW event code	Event name
0x2000	Event log cleared
0x8012	No connection timeout
0x8150	Initialization failure
0x8151	SIM failure
0x8152	GSM registration failure
0x8153	GPRS registration failure
0x8154	PDP context established
0x8155	PDP context destroyed
0x8156	Modem SW reset
0x8157	Modem HW reset
0x8158	GSM outgoing connection
0x8159	GSM incoming connection
0x815A	GSM hangup
0x815B	Diagnostic failure
0x815C	User initialization failure
0x815D	Signal quality failure
0x815E	PDP context failure
0x8160	Auto Answer
0x8170	No connection timeout channel 1
0x8171	No connection timeout channel 2
0x8172	No connection timeout channel 3

Table 52: List of events in the Communication event log

6.5.6. MCO & TCO event log

Meter Cover Opening & Terminal Cover Opening event log (0-0:99.98.7) is intended for logging events related to meter and terminal cover openings. List of events in the MCO & TCO event log is given in Table 53.

VDEW event code	Event name
0x2000	Event log cleared
0x800E	Meter cover closed
0x800F	Terminal cover closed
0x8010	Meter cover removed
0x8011	Terminal cover removed

Table 53: List of events in the MCO & TCO event log

6.5.7. Magnetic tamper event log

List of events in the **Magnetic tamper event log** (0-0:99.98.8) is shown in Table 54.

VDEW event code	Event name
0x2000	Event log cleared
0x8124	Strong DC field detected
0x8125	No strong DC field anymore

Table 54: List of events in the Magnetic tamper event log

6.5.8. Power failure event log

Power failure event log (1-0:99.97.0) contains all events related to long power outages. In the event log only the power up time stamp and the duration of long power failures in any phase are stored. No special code is defined to logging of power failure events. Separately the duration of last long power failure is recorded.

Each entry recorded in this event log contains:

- time of power up after long power failure,
- duration of long power failure.

6.5.9. Certification data log (Technical data log)

Certification data log (1-0:99.99.0) is used to log modifications of metrological parameters. The data log contains time stamp, Last modified secure parameter identifier, old and new parameter value.

Values of the following objects are registered:

- **Active energy metrological LED** (1-0:0.3.0)
- **Reactive energy metrological LED** (1-0:0.3.1)
- **Apparent energy metrological LED** (1-0:0.3.2)
- **Transformer ratio – current (numerator)** (1-0:0.4.2)
- **Transformer ratio – current (denominator)** (1-0:0.4.5)
- **Transformer ratio – voltage (numerator)** (1-0:0.4.3)
- **Transformer ratio – voltage (denominator)** (1-0:0.4.6)
- **Measurement period 1, for average value 1** (1-0:0.8.0)
- **Recording interval 1, for load profile** (1-0:0.8.4)
- **Recording interval 2, for load profile** (1-0:0.8.5)
- **Active output constant** (1-0:0.3.3)
- **Reactive output constant** (1-0:0.3.4)
- **Apparent output constant** (1-0:0.3.5)
- **Output pulse duration** (1-0:0.9.8)
- **Nominal voltage** (1-0:0.6.0)

NOTE!
The capacity of Certification data log is set to 100 entries. There is not possible to change any parameter, when event log is full. The log can only be erased when meter is in unlocked state.

6.6. Load profile

Two general-purpose load profiles are available in the MT880 meter. Each of two can capture any of the basic type object value present in the meter:

- **Load profile with period 1** (1-0:99.1.0),
- **Load profile with period 2** (1-0:99.2.0).

Number of available records are calculated, when load profiles are pre-programmed, related to the type of the object, which is defined for load profile, number of objects defined for load profile and registration period.

Profiles are implemented as FIFO buffers. Each record has associated a unique record number. Within one load profile, more records can have the same time stamp (in case time is shifted back) but all have different record number.

Load profiles are dynamically organized – the less channels are chosen the higher is roll over time and vice versa.

6.6.1. Profile objects

Capture objects

Up to 32 capture objects can be defined for each load profile. Number of capture objects directly defines number of profile entries. Minimum and maximum profile capacity depends on the capture period selected and number of capture objects set.

Capture period

Capture period is variable which defines the time distance between two captured data (in seconds).
It can be set to next values:

- 0 No registration is performed
- 300 5 minute recording period (the minimum recording period)
- 900 15 minutes recording period
- 1800 30 minutes recording period
- 3600 1 hour recording period
- 86400 1 day recording period

The period is synchronized with the hour; it always begins at completed hour.

Sort method

This attribute is used for sorting the captured data, only FIFO method is supported.

Sort Object

Clock object is used as sort object.

Entries in use

This attribute shows how many records have been captured.

Profile Entries

This attribute shows how many records are possible in the meter. This number depends on the capture period selected and number of capture objects set.

NOTE!
Load profile is erased when new capture period is set or capture objects changed.

Power Quality profile

The meter has one power quality profile (**Power quality profile** – 1-0:99.14.0*255), which stores the power quality related objects. Maximum number of available records is 3196.

6.6.2. Profile status

The meter has two status registers enabled:

- **Profile status – Load profile with period 1** (0-0:96.10.1),
- **Profile status – Load profile with period 2** (0-0:96.10.2).

The MT880 meter provides extended status information for profile records. Status information is organized as 16-bit value; each bit is carrying specific information. See Table 55.

Status	**Bit**	**Description**
None		No event.
Critical error	0	A serious error such as a hardware failure or a checksum error has occurred.
Clock invalid	1	RTC backup has been discharged. The time is declared as invalid.
Data not valid	2	It indicates that the current entry may not be used for billing purposes without further validation because a special event has occurred. The reason may be found in the other status bits.
Daylight saving	3	It indicates whether or not the daylight saving time is currently active. The bit is set if the daylight saving time is active (summer) and cleared in winter.
Billing reset	4	The bit is set to indicate that billing reset was executed in recording period.
Clock adjusted	5	The bit is set when clock has been adjusted more than the synchronisation limit.
Power up	6	This bit is set to indicate that any-phase power up.
Power down	7	This bit is set to indicate that an all-phase power failure occurred.
Power down L1	8	This bit is set to indicate that phase L1 voltage was disconnected during recording period.
Power down L2	9	This bit is set to indicate that phase L2 voltage was disconnected during recording period.
Power down L3	10	This bit is set to indicate that phase L3 voltage was disconnected during recording period.
Power up L1	11	This bit is set to indicate that phase L1 voltage was reconnected during recording period.
Power up L2	12	This bit is set to indicate that phase L2 voltage was reconnected during recording period.
Power up L3	13	This bit is set to indicate that phase L3 voltage was reconnected during recording period.
Parameter changed	14	This bit is set to indicate that at least one parameter was changed during recording period.
Clock synchronized	15	This bit is set to indicate that meter clock was synchronized during recording period.

Table 55: List of profile statuses

6.7. Billing

Billing functionality provides process and storage for managing billing data, which is recorded in billing profile. Up to 32 different objects can be stored in billing profile. By default, the first data in billing profile entries is time mark (object **Clock,** 0-0:1.0.0*255).

Billing profile itself does not have a capture period defined. Storing into billing profile can be triggered by different sources (periodically or aperiodically):

- by RTC via single-action schedule – end of billing object,
- via Billing inputs,
- via Billing reset button,
- via Communication interfaces directly invoking script execution.

6.7.1. Billing reset enabling/disabling

In order to allow different triggers for billing reset, execution bitmask **Billing reset trigger selection** (0-0:128.11.0*255) object is implemented. It allows selection of different billing reset triggers to be enabled in parallel. See Table 56.

Bit index	Bit assignment	Value definitions
0	Reset button	0 – disabled 1 – enabled
1	Billing script execution via communication interface	0 – disabled 1 – enabled
2	Single-action schedule	0 – disabled 1 – enabled
3	MREa/MREb or MRE input	0 – disabled 1 – enabled

Table 56: Bitmask object for billing reset

Billing reset functionality is implemented with various options. Following configuration options are provided in the meter by the **Billing reset configuration options** (0-0:128.11.1) object (Table 57).

Bit index	Bit assignment	Value definitions
0,1	Previous value presentation mode	0 – Linear 1 – Circular modulo 99 2 – Circular modulo 12
2	Billing reset during power down disabled	0 – Billing reset enabled 1 – Billing reset disabled
3	Billing reset waits end of MP	0 – NOT active 1 – Active

Table 57: Configuration options

6.7.1.1. Billing reset related to power down

Scheduled billing execution time can coincides with power down. When meter powers up there are two options, configured with *Billing reset during power down* configuration bit in the **Billing reset configuration options** object:

- Enabled (**1**): billing reset performs immediately after meters power up. Billing reset timestamp stored in billing profile is the actual billing execution time stamp (not the time that is set in single-action schedule object).
- Disabled (**0**): billing reset is not executed when meter is powered up. Billing reset is postponed until next scheduled (or otherwise triggered) billing reset.

6.7.1.2. Billing reset related to MP

When *Billing reset waits end of MP* property bit in the **Billing reset configuration options** object is set to:

- Active (**1**): every triggered billing waits first end of measurement period (MP) and executes immediately after MP ends.
- NOT active (**0**): billing reset executes immediately when triggered.

6.7.2. Billing reset triggering

6.7.2.1. Billing reset via reset button

Billing reset via reset button is performed by short press on the reset button, located under the transparent window (see Figure 53), when the meter is in the auto-scroll mode.

Reset button can be disabled:

- by clearing bit 0 in the **Billing reset secured configuration options** (0-0:128.11.2) object (configuration can be changed on unlocked meter only).
- by clearing bit 0 in the **Billing reset trigger selection** (0-0:128.11.0) object (configuration can be changed by using password 4).

To assure that reset button triggers billing reset, in both objects bit 0 parameters *Billing reset key enabled* and *Reset button* must be enabled (set to ON).

Figure 53: Billing reset button under the transparent window

6.7.2.2. External billing reset via MREa & MREb, MRE input

External billing reset functionality can be performed in two ways:

- with synchronous change on two inputs (MREa and MREb) or
- with pulse signal on one single input (MRE).

Billing reset via MREa and MREb inputs is triggered when both inputs change state and the two states are negated. Meter also executes billing reset when input states change during power down. In this case, billing is triggered immediately after power up.

When MREa and MREb inputs change during power down and single action schedule execution time is passed during power down, too, only one billing is executed immediately after next power up.

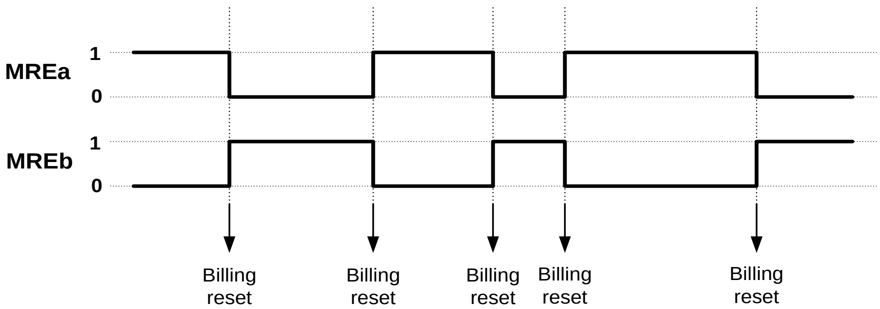


Figure 54: MREa and MREb inputs and external billing reset

Billing reset via MRE input is triggered when signal changes from inactive to active state for time duration in range from 100 ms to 2500 ms.

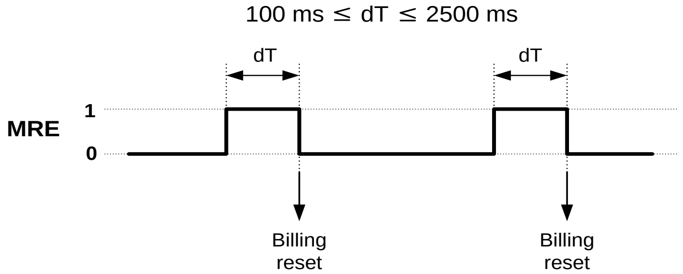


Figure 55: MRE input and external billing reset

6.7.2.3. Billing reset output

Meter can be configured to drive billing reset outputs (MRAa/MRAb) according to VDEW specification. Output functions billing outputs configuration are enumerated as follows:

- MRAa (Output for external billing reset a),
- MRAb (Output for external billing reset b).

At the time when billing reset is performed, billing reset outputs simultaneously change states. Last states are remembered and restored after power down.

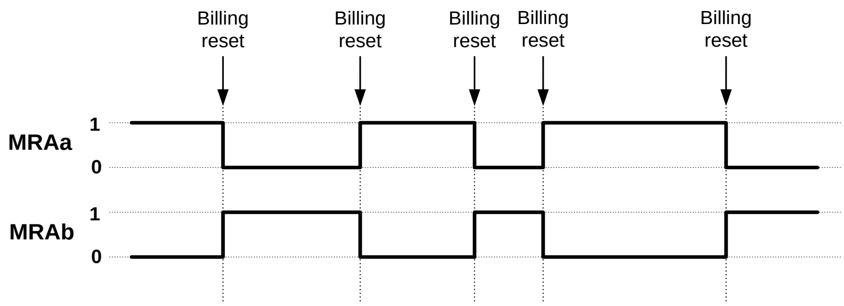


Figure 56: MRAa and MRAb outputs at billing reset

6.7.3. Billing reset lockout functionality

Billing reset trigger lockout matrix

After certain trigger executes billing reset, further billing resets can be blocked for a predefined time delay. Each trigger can lockout any combination of available triggers. This can be configured by using the **Billing reset trigger lockout matrix** object (0-0:128.11.3). Object is implemented as octet string of 4 octets, each octet corresponding to one specific billing reset trigger.

Each octet carries bitmask, which defines triggers that are locked out with the trigger that specific octet represents (Table 58).

Trigger	Reset key	Com	Schedule	Input
Reset key	Enabled/Disabled	Enabled/Disabled	Enabled/Disabled	Enabled/Disabled
Communication interface (Com)	Enabled/Disabled	Enabled/Disabled	Enabled/Disabled	Enabled/Disabled
Schedule	Enabled/Disabled	Enabled/Disabled	Enabled/Disabled	Enabled/Disabled
Input	Enabled/Disabled	Enabled/Disabled	Enabled/Disabled	Enabled/Disabled

Table 58: Billing reset lockout matrix

Billing period reset lockout time

Time for which further billing resets are disabled can be set in seconds via **Billing period reset lockout time** (1-0:0.9.12) object. Billing reset lockout time could be set up to 28 days. If there is a value greater than 28 days, the actual lockout time will be 28 days. Lockout timer starts running when billing reset actually executes (this can be delayed from actual triggering to end of MP if configured so). Each trigger lockout runs on its own timer.

Power down deactivates any active billing reset lockout.

6.7.4. Billing reset execution information

For each billing reset execution, the meter provides the time stamp – date and time of the moment of billing reset execution. In relation to billing execution, meter also provides information about time that elapsed from last billing reset. This information is presented as number of days and it is available in the **Time expired since last end of billing** object (1-0:0.9.0). Number of days is incremented with each 24 hours passed from last billing. With each executed billing reset, the value is reset to 0.

6.7.5. Billing profile

Billing profile is the storage for billing data, captured by execution of billing actions in the **Data of billing period 1** (0-0:98.1.0) object. Billing profile buffer is organized as an array of entries. Each entry is a snapshot of capture object values at the moment of capture time. By default, the first data in billing profile entries is time mark in the **Clock** (0-0:1.0.0) object.

Buffer

Storage for billing data captured with every billing reset execution. It enables selective access per range and entry.

Capture objects: up to 32 objects can be set to be captured according to capture period. By default, capture objects are set to:

- **Clock** (0-0:1.0.0), attribute 2 - Time
- **Active energy import, rate 1** (1-0:1.8.1), attribute 2 - Value
- **Active energy import, rate 2** (1-0:1.8.2), attribute 2 - Value
- **Maximum demand register – Active energy import, rate 1** (1-0:1.6.1), attribute 2 - Value
- **Maximum demand register – Active energy import, rate 2** (1-0:1.6.2), attribute 2 - Value

Capture period is set to 0 because records are recorded according to end of billing period. In unlocked mode, user has also write access. Maximum capture period can be set to 86400 seconds (1 day).

Sort method: contains attribute for sorting captured data. It is fixed to FIFO (First in First Out).

Sort object: as sort object is used object **Clock** (0-0:1.0.0).

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 number of capture objects set.

Specific methods

This method is accessible with right mouse click on the Data of billing period 1 object: *Execute method – Reset*. This action erases captured values.

NOTE!
Billing profile is erased when capture objects are changed.

6.7.5.1. Previous values of billing registers

Previous values of billing registers are stored in billing profile. Previous values can also be presented on display. Two variants of presentation are supported:

- Linear presentation of previous values,
- Circular presentation of previous values.

The number of previous values that are shown on display is configurable via **Previous values readout count** (0-0:128.11.4) object, with different numbers of presented previous values:

- in the Auto scroll sequence,
- in the Manual scroll sequence and
- in the Local port readout sequence.

Pervious values OBIS address is formatted as: A-B:C.D.E*F. **F** is formatted as two digits number. It means previous value index.

Example data readout of the register 1-0:1.8.1 (active energy import, rate 1) with following previous values:

`1-0:1.8.1(2194305.3*kWh)`	current value
`1-0:1.8.1*01(1688219.1*kWh)`	previous value 1
`1-0:1.8.1*02(1637426.3*kWh`	previous value 2
`1-0:1.8.1*03(1613504.6*kWh)`	previous value 3
`1-0:1.8.1*04(1304619.3*kWh)`	previous value 4
`1-0:1.8.1*05()`	no more billing values available

NOTE!
Not all object available in meter COSEM model are supported in IEC 62056-21 (IEC 1107). In this case ER23 or () is returned.

6.7.5.2. Special previous values registers for display

Normally previous values on display are scrolled immediately after its current values.

For some special request here are some special previous value registers which can be presented anywhere on LCD sequence list. Previous value registers are excluded from object model.

Available registers for last billing values are listed in Table 59.

SUM	Tariff 1	Tariff 2
1.0.1.6.0.1	1.0.1.6.1.1	1.0.1.6.2.1
1.0.1.8.0.1	1.0.1.8.1.1	1.0.1.8.2.1
1.0.5.8.0.1		

Table 59: Available special previous value registers

Each of these previous register could be placed anywhere in display sequence list.

For that purpose, parameter in the **Previous values readout count** (0.0.128.11.4) object should be properly set. Maximum number of previous value for proper display sequence should be set to 0.

If no billing has been done yet, previous values registers show zero values.

NOTE!
Until register are not added to billing capture objects, Error11 is shown on display.
Example: if 1.0.1.8.0.255 is not included to billing profile capture objects list, register 1.0.1.8.0.1 cannot be shown on display, so Error11 is shown.

6.7.5.3. Profile status

The status register in the **Profile status – Billing profile** (0-0:96.10.3) object is used to show additional information concerning the stored entry. With this information, the HES (Head End System) may decide whether the captured registers can be used for billing or not. The value of the status register is stored for every entry. The value of the status register of billing profile has a size of 2 bytes. The status information is encoded into the 16 bits.

Status	Bit	Description
None		No event.
Critical error	0	A serious error such as a hardware failure or a checksum error has occurred.
Clock invalid	1	The power reserve of the clock has been exhausted. The time is declared as invalid.
Data not valid	2	It indicates that the current entry may not be used for billing purposes without further validation, because a special event has occurred. The reason may be found in the other status bits.*
Daylight saving	3	It indicates whether or not the daylight saving time is currently active. The bit is set if the daylight saving time is active (summer) and cleared in winter.
Billing reset	4	The bit is set to indicate that billing reset was executed in recording period.
Clock adjusted	5	The bit is set when clock has been adjusted more than the synchronisation limit.
Power up	6	This bit is set to indicate that any-phase power connection occurred.
Power down	7	This bit is set to indicate that an all-phase power failure occurred.
Power down L1	8	This bit is set to indicate that phase L1 voltage was disconnected during recording period.
Power down L2	9	This bit is set to indicate that phase L2 voltage was disconnected during recording period.
Power down L3	10	This bit is set to indicate that phase L3 voltage was disconnected during recording period.
Power up L1	11	This bit is set to indicate that phase L1 voltage was reconnected during recording period.
Power up L2	12	This bit is set to indicate that phase L2 voltage was reconnected during recording period.
Power up L3	13	This bit is set to indicate that phase L3 voltage was reconnected during recording period.
Parameter changed	14	This bit is set to indicate that at least one parameter was changed during recording period.
Clock synchronized	15	This bit is set to indicate that meter clock was synchronized during recording period.

* In the case of *Data not valid* bit set in profile status captured data need additional validation in HES

Table 60: Billing profile status - Bit assignment

6.8. Alarms

In addition to events, described in chapter *6.5. Event logs* and based on constant monitoring, meter enables alarm handling as well. Alarms are information about presence or occurrence of some special events detected by the meter. Different events can have their source inside or outside of the meter. Alarms do not carry any additional time information, like events in event log. Alarms are mostly used for presentation of detected special condition to the user:

- via the meter display,
- via dedicated alarm outputs,
- via communication interfaces (by “push On Alarm” functionality via SMS or TCP/IP).

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 policy of the utility, not all supported alarms are wanted. Therefore, the alarm filters can be configured by the user to hide 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.

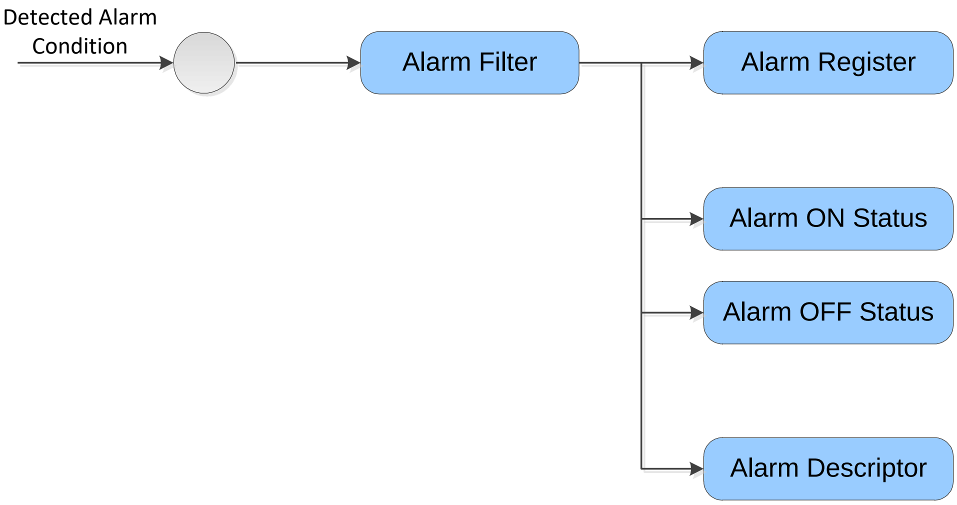


Figure 57: Basic alarming object set

All alarm objects mentioned in Figure 57 are bit-organized, where each single bit is related to specific alarm condition.

6.8.1. Alarm monitors

For the purpose of triggering alarm reporting via remote communication, each set of alarm objects includes dedicated alarm monitor object. Consequently, there are two alarm monitor objects in the meter, one for each alarm set:

- **Alarm monitor 1** (0-0:16.1.0) object,
- **Alarm monitor 2** (0-0:16.1.0) object.

Alarm monitors are bit monitors, 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 1** (0-0:97.98.20) or **Alarm descriptor 2** (0-0:97.98.21) 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 as described in chapter *8.7.1.2. 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.

6.8.2. Alarm registers

Alarm register is basic alarm object carrying information about active alarms. This register normally presents currently active alarm state. Two alarm register objects are implemented:

- **Alarm register 1** (0-0:97.98.0), (related to the IDIS specification) and
- **Alarm register 2** (0-0:97.98.1), (related to the meter specific statuses).

The attribute value of both alarm registers is 32 bit long, where each bit represents different alarm.

Specific bits of alarm registers may be automatically cleared - reset by the meter, if the condition for alarm has disappeared (except for Watchdog error, Fraud attempts, Meter cover opened, Terminal cover opened, Strong DC field detected and Fatal fault). See Table 61 and Table 62.

Alternatively, all bits may be externally reset via communication channels.

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 occur once again.

6.8.3. Alarm bit assignment

Table 61 and Table 62 provide a list of the supported alarms in the corresponding alarm register objects.

Bit	Alarm	Description	ON	OFF
0	Clock invalid	Current clock is compared with internal clock structure and if there is any deviation the bit is set.	✓	✓
1	Replace battery	Clock battery or backup capacitor is discharged.	✓	✓
2 - 7	Unused		-	-
8	Program memory error	Set whenever a program memory error bit in error register is set.	✓	✓
9	RAM error	Set whenever a RAM error bit in error register is set.	✓	✓
10	NV memory error	Set whenever a NV memory error bit in error register is set.	✓	✓
11	Measurement system error	Set whenever a measurement system error bit in error register is set.	✓	✓
12	Watchdog error	Set whenever a watchdog error bit in error register is set.	✓	×
13	Fraud attempts	Alarm is raised whenever a fraud attempt is detected.	✓	×
14-15	Unused		-	-
16	Voltage sag L1	Indicates voltage sag on phase L1 is detected	✓	×
17	Voltage sag L2	Indicates voltage sag on phase L2 is detected	✓	×
18	Voltage sag L3	Indicates voltage sag on phase L3 is detected	✓	×
19	Voltage swell L1	Indicates voltage swell on phase L1 is detected	✓	×
20	Voltage swell L2	Indicates voltage swell on phase L2 is detected	✓	×
21	Voltage swell L3	Indicates voltage swell on phase L3 is detected	✓	×
22	Voltage normal L1	Indicates that voltage L1 is back to within normal values after sag/swell has been detected.	✓	×
23	Voltage normal L2	Indicates that voltage L2 is back to within normal values after sag/swell has been detected.	✓	×
24	Voltage normal L3	Indicates that voltage L3 is back to within normal values after sag/swell has been detected.	✓	×
25-31	Unused		-	-

Table 61: Alarm bits of the Alarm register 1 object

Fraud attempts alarm (Table 61, bit 13) is generated in the following cases:

- meter cover is removed,
- terminal cover is removed,
- strong DC field is detected,
- authentication on communication fails more than **N** times*,
- decryption on communication fails more than **N** times*,
- replay attack on communication is detected.

* variable **N** is configurable in the **Decryption and authentication failure count limit** (0-0:196.98.2) object

Bit	Alarm	Description	ON	OFF
0	Alarm input 1 active	Indicates that alarm input 1 toggled into active state.	✓	✓
1	Alarm input 2 active	Indicates that alarm input 2 toggled into active state.	✓	✓
2	Current over limit L1	Indicates that L1 current value is over limit. Current threshold and time period are set as parameters.	✓	✓
3	Current over limit L2	Indicates that L2 current value is over limit. Current threshold and time period are set as parameters.	✓	✓
4	Current over limit L3	Indicates that L3 current value is over limit. Current threshold and time period are set as parameters.	✓	✓
5	Strong DC field detected	Indicates that strong magnetic field is or was detected. Bit can only be cleared manually.	✓	×
6	Terminal cover opened (TCO)	Indicates that terminal cover is or was opened. Bit can only be cleared manually.	✓	×
7	Meter cover opened (MCO)	Indicates that meter cover is or was opened. Bit can only be cleared manually.	✓	×
8	Missing voltage L1	Indicates missing voltage on phase L1.	✓	✓
9	Missing voltage L2	Indicates missing voltage on phase L2.	✓	✓
10	Missing voltage L3	Indicates missing voltage on phase L3.	✓	✓
11	Voltage under limit L1	Indicates that voltage L1 is under the limit. Voltage threshold and time period are set as parameters.	✓	✓
12	Voltage under limit L2	Indicates that voltage L2 is under the limit. Voltage threshold and time period are set as parameters.	✓	✓
13	Voltage under limit L3	Indicates that voltage L3 is under the limit. Voltage threshold and time period are set as parameters.	✓	✓
14	Asymmetrical voltage	Indicates asymmetrical voltage condition. See power quality.	✓	✓
15	Wrong phase sequence	Indicates that phase sequence is not normal.	✓	✓
16	Neutral line disturbed	Indicates that neutral line is disturbed.	✓	✓
17	Current without voltage L1	Indicates that there is current flowing on phase L1 even though voltage level L1 is not sufficient. Current threshold, voltage threshold and time period are set as parameters.	✓	✓
18	Current without voltage L2	Indicates that there is current flowing on phase L2 even though voltage level L2 is not sufficient. Current threshold, voltage threshold and time period are set as parameters.	✓	✓
19	Current without voltage L3	Indicates that there is current flowing on phase L3 even though voltage level L3 is not sufficient. Current threshold, voltage threshold and time period are set as parameters.	✓	✓
20	Asymmetrical current	Indicates that phase currents are not symmetrical	✓	✓
21	Negative power L1	Indicates that current is flowing in negative direction on phase L1.	✓	✓
22	Negative power L2	Indicates that current is flowing in negative direction on phase L2.	✓	✓
23	Negative power L3	Indicates that current is flowing in negative direction on phase L3.	✓	✓
24	Manual trigger *	Can be used for manual triggering of alarm output.	×	×
25	Load control channel 1 active	Indicates that load control 1 is activated.	✓	✓
26	Load control channel 2 active	Indicates that load control 2 is activated.	✓	✓
27	Load control channel 3 active	Indicates that load control 3 is activated.	✓	✓
28	Voltage over limit L1	Indicates that voltage on phase L1 is over the limit. Voltage threshold and time period can be set as parameters.	✓	✓
29	Voltage over limit L2	Indicates that voltage on phase L2 is over the limit. Voltage threshold and time period can be set as parameters.	✓	✓
30	Voltage over limit L3	Indicates that voltage on phase L3 is over the limit. Voltage threshold and time period can be set as parameters.	✓	✓
31	Fatal fault	Indicates that fatal fault condition is or was detected by the meter.	✓	×

* alarm is not used in the meter

Table 62: Alarm bits of Alarm register 2 object

All alarms with checked ON and OFF columns are automatically set and cleared by the meter according to alarm condition occurrence. Alarms where OFF column is not checked, can only be cleared by the user with admin authorization.

6.8.4. Alarm filters

Alarm filter objects are used to hide unwanted alarms. The structure of the filters is the same as of the corresponding alarm register objects. Two alarm filter objects are implemented:

- **Alarm filter 1** (0-0.97.98.10),
- **Alarm filter 2** (0-0.97.98.11).

To hide an unwanted alarm a corresponding bit in the alarm filter should be cleared. By default all bits in the alarm filters are cleared, which means that all alarms are hidden.

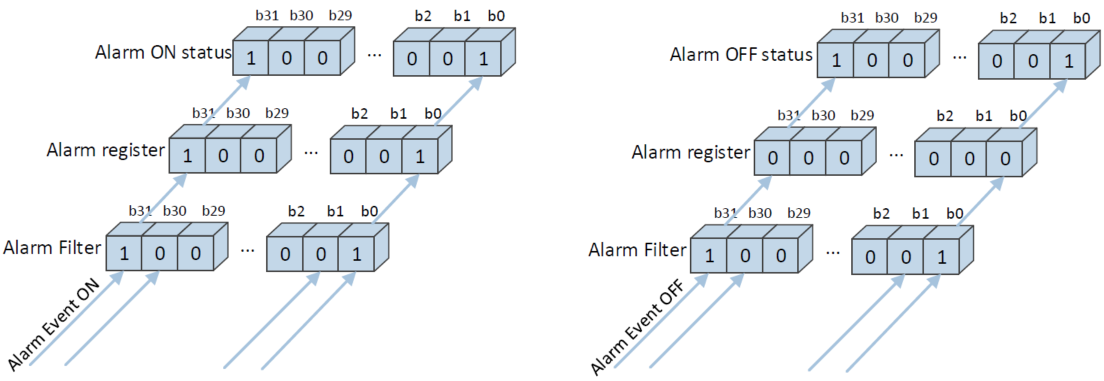


Figure 58: Alarm filtering principle

Bits in the **Alarm filter 1** object represent alarms according to **Alarm register 1** object and bits in the **Alarm filter 2** object represent alarms according to **Alarm register 2** object.

6.8.5. Alarm descriptors

The alarm descriptor has exactly the same structure as the alarm register. Whenever a bit in the alarm register changes from 0 to 1, the corresponding bit of the alarm descriptor is set to 1. Resetting the alarm register does not affect the alarm descriptor. The bits of the alarm descriptor can be manually reset by the client system.

For the purpose of monitoring alarm, register's bit transition changes from 0 to 1, the following alarm descriptor objects are implemented:

- **Alarm descriptor 1** (0-0:97.98.20),
- **Alarm descriptor 2** (0-0:97.98.21).

Bits in **Alarm descriptor 1** object represent alarms according to **Alarm register 1** object and bits in **Alarm descriptor 2** object represent alarms according to **Alarm register 2** object.

6.8.6. Alarm statuses

Alarm status is a 32-bit register indicating which alarm has been set/cleared. A separate register for ON and OFF statuses is implemented. The bits of every alarm status are never automatically cleared by the meter and must therefore be manually cleared by the client system (e.g. SEP2 MeterView).

The following Alarm on status objects are:

- **Alarm on status 1** (1-0:96.242.0),
- **Alarm on status 2** (1-0:96.242.10).

The following Alarm off status objects are:

- **Alarm off status 1** (1-0:96.243.0),
- **Alarm off status 2** (1-0:96.243.10).

6.8.7. Alarm signalling

6.8.7.1. Alarm signaling on display

Presence of alarm is presented on display via dedicated alarm segment. Alarm segment on display is activated, when at least one alarm bit is set in any of the alarm registers.

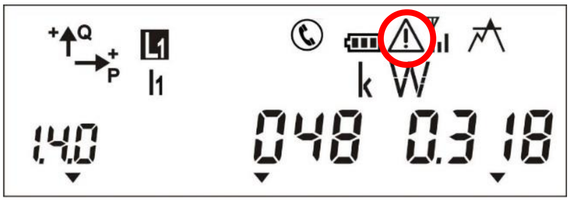


Figure 59: Alarm segment shown on LCD

6.8.7.2. Alarm signaling via output

From generated alarm register, the meter can also drive up to 2 alarm outputs, which can be used as a signal for 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:

- **Alarm output 1 mask 1** (1-0:96.244.2),
- **Alarm output 1 mask 2** (1-0:96.244.12),
- **Alarm output 2 mask 1** (1-0:96.244.3),
- **Alarm output 2 mask 2** (1-0:96.244.13).

Each alarm output is activated (output state goes to active) when at least one alarm bit in any of the alarm registers is set and when the same corresponding bit in any of the alarm output mask objects is set (Figure 60).

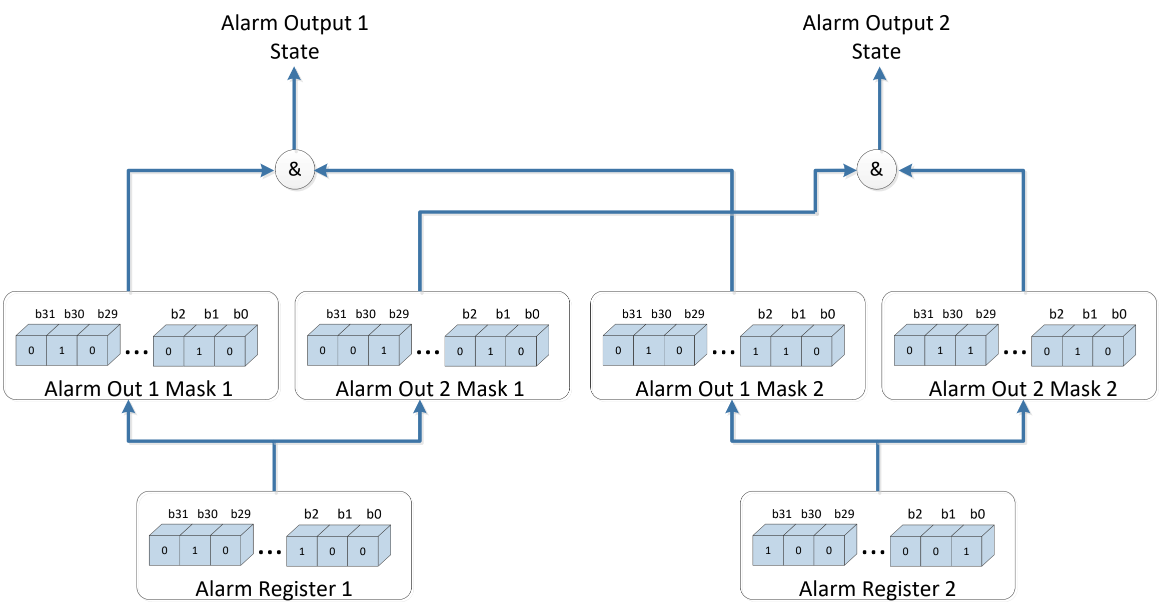


Figure 60: Alarm outputs generation

6.9. Errors

Common internal supervising mechanisms, which meter uses to generate events and alarms, are also used for generating error information. When a condition that might indicate malfunction in meter operation is detected, the appropriate flag in *error register* is set by the meter. Similar to alarms, also error registration is implemented with possible filtering.

6.9.1. Error register

Similar to alarm registers, also error register is bit organized. **Error register** object (0-0:97.97.0) is a 32 bit value but not all bits are used to signal error conditions.

Once a flag in the **Error register** object is set, it remains active even after the corresponding error condition has disappeared. The **Error register** object has to be cleared by the user, using supported communication interfaces. 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 to active by the meter.

The meaning of the error register bits is the same as for the **Alarm register** object. See Table 63.

Bit	Error	Description
0	Clock invalid	Current clock is compared with internal clock structure and if there is any deviation, the bit is set.
1	Replace battery	Clock battery or backup capacitor is discharged.
2-7	Unused	
8	Program memory error	Set whenever a program memory error bit in error register is set.
9	RAM error	Set whenever a RAM error bit in error register is set.
10	NV memory error	Set whenever a NV memory error bit in error register is set.
11	Measurement system error	Set whenever a measurement system error bit in error register is set.
12	Watchdog error	Set whenever a watchdog error bit in error register is set.
13-31	Unused	

Table 63: Error register bit explanation

The data in the **Error register** object is by default visible on the display as part of the *Auto-scroll mode* sequence list. The errors are displayed in hexadecimal code, where each digit of the error code represents four bits of the error register.

6.9.2. Error types

Errors recorded in the **Error register** object fall into one of four categories:

- Clock errors
- Memory errors
- Measurement system error
- Watchdog error

Clock errors

Invalid clock error

If the meter detects that the clock may be invalid, i.e. if the power reserve of the clock has exhausted, the corresponding flag (Clock invalid, bit 0) in the **Error register** object is set.

Check battery state error

By continuously monitoring the state of the battery or of the capacitor, the meter is able to provide information on remaining battery capacity percentage. When the remaining battery capacity falls under the critical limit, the corresponding flag (Replace battery, bit 1) in the **Error register** object is set.

Memory errors

Program memory error

During build time, the MD5 signature of the whole generated program code of the Core and of the Module part of the firmware is stored together with the generated program code into the program memory. To ensure that a valid firmware is being executed on the meter, both MD5 checksums (core and module) are constantly recalculated during program execution and compared against the respective MD5 checksums stored in the program memory. An MD5 checksum mismatch indicates that an invalid firmware is running on the meter, possibly due to bad memory cells, or even due to an unauthorized modification attempt of the meter's firmware.

If a MD5 mismatch is detected, a corresponding flag (Program memory error, bit 8) in the **Error register** object is set.

RAM error

Every time a meter power-up or a firmware upgrade is performed, an initialization process is executed, resulting in a complete internal program memory (RAM) check. RAM is tested through its whole address range using a non-destructive RAM test. If the RAM test fails, a corresponding flag (RAM error, bit 9) in the **Error register** object is set.

Additionally, during a normal meter operation, the integrity check of individual RAM parts containing critical data is performed. Each time when a critical data is intentionally changed, the new signature is re-calculated and stored so that it can be compared against the calculated signature of the respective RAM data, when needed. In case of a mismatch, a RAM error flag in the **Error register** object is set.

Non-Volatile memory error

The non-volatile memory is used as a long-term persistent storage for periodical data history, billing data, event logs, register back-ups, parameters and any other data needed by the meter during a normal start up.

Data integrity checking is performed periodically or randomly, during data access. Integrity checking of the data, which intercepts with the meter process itself, and is subjected to changing frequently, is performed randomly. The validity of the meter's configuration parameters on the other hand, is inspected periodically, with a period set to one hour. If the described data integrity checking fails, a corresponding flag (NV memory error, bit 10) in the **Error register** object is set.

Measurement system error

The meter performs certain self-diagnostic tests to ensure undisturbed operation and the required measuring accuracy. If any kind of excessive deviation is detected, the corresponding flag (Measurement system error, bit 11) in the **Error register** object is set.

Watchdog error

Whenever 10 or more watchdog resets are detected within 2-hour period, the corresponding flag (Watchdog error, bit 12) in the **Error register** object is set.

6.9.3. Errors classified by severity and required actions

Errors are classified by severity on:

- Fatal errors
- Critical errors
- Non-critical errors

Fatal errors — A fatal error indicates a severe problem, which prevents the meter maintaining measurement operation, e.g. defective hardware component.

The meter stops its operation and the error code is displayed permanently.

Action: The meter must be replaced.

Critical errors — A critical error indicates a severe problem, but with which the meter continues to function and measurement is still possible. The data are stored in the memory and suitably marked in case of doubt. After a critical error the error code is displayed until acknowledged with the display button or the error register is reset, e.g. via the electrical interface. Depending on the type of the error, this can cyclically occur again, since with the acknowledgement the error cause in not repaired.

Action: If the error reoccurs, the meter must be replaced as soon as possible.

Non-critical errors Non-critical errors can influence the meter functions (temporarily or permanent). These errors are recorded in the error register.

Action: The meter remains serviceable and normally not need to be replaced.

6.9.3.1. Description of errors and required actions

F.F.0 xx xx xx x1 (bit0) Clock invalid

Severity → Non-critical

Description → Indicates clock is invalid. If the meter detects that the clock may be invalid, i.e. if the power reserve of the clock has exhausted, the flag is set.

When the meter clock is set, the meter will reset invalid time bit in error register, if the reason for “Clock invalid” error (empty clock battery or backup capacitor) is removed. The energy registers are not affected by “Clock invalid” error.

The same error applies to messages: F.F.0 .. x3/x5/x7/x9/xB/xD/xF (combinations if other 3 bits are also set in the corresponding nibble).

Required Action → First, check if Replace battery error is also set. If yes, take actions of that error. Finally, set the clock via communication channels.

F.F.0 xx xx xx x2 (bit1) Replace battery (discharged)

Severity → Non-critical

Description → Clock battery or backup capacitor is discharged.

By continuously monitoring the state of the battery or of the capacitor, the meter is able to provide information on remaining battery capacity percentage. When the remaining battery capacity falls under the critical limit, the flag is set.

The same error applies to messages: F.F.0 .. x3/x6/x7/xA/xB/xE/xF (combinations if other 3 bits are also set in the corresponding nibble).

Required Action → Replace the battery (valid for meters with the Li-battery only); leave the meter powered up at nominal voltage to charge the super capacitor (valid for meters with the backup super capacitor only). Set the clock via communication. Clear the error via communication.

F.F.0 xx xx x1 xx (bit8) Program memory error

Severity → Fatal

Description → Indicates error in the meters program space (internal flash memory) when the behaviour of meter is unpredictable.

MD5 checksum of the Core and/or of the Module part mismatch with the build time MD5 checksum. That indicates an invalid firmware is running on the meter, possibly due to bad memory cells, an error in transfer of the new firmware during the update process, or even due to an unauthorized modification attempt of the meter’s firmware.

The same error applies to messages: F.F.0 .. x3/x5/x7/x9/xB/xD/xF (combinations if other 3 bits are also set in the corresponding nibble).

Required Action → The meter should be replaced. The results stored in the meter should be inspected and validated.

F.F.0 xx xx x2 xx (bit9) RAM error

Severity → Critical

Description → Error detected in RAM (data) memory.

Every time a meter power-up or a firmware upgrade is performed, an initialization process is executed, resulting in a complete internal program memory (RAM) check. RAM is tested through its whole address range using a non-destructive RAM test. If the RAM test fails, the flag is set.

Additionally, during a normal meter operation, the integrity check of individual RAM parts containing critical data is performed. Each time a critical data is intentionally changed; the new signature is re-calculated and stored so that it can be compared against the calculated signature of the respective RAM data, when needed. In case of a mismatch, the flag is also set. The meter can operate irregularly.

The same error applies to messages: F.F.0 .. x3/x6/x7/xA/xB/xE/xF (combinations if other 3 bits are also set in the corresponding nibble).

Required Action → Clear the error via communication. Power-up the meter and wait for a short time. If the error reoccurs, replace the meter.

F.F.0 xx xx x4 xx (bit10) NV memory error

Severity → Critical

Description → Error detected in non-volatile memory.

The non-volatile memory is used as a long-term persistent storage for periodical data history, billing data, event logs, register back-ups, parameters and any other data needed by the meter during a normal start up.

Data integrity checking is performed periodically or randomly, during data access. If the data integrity checking fails, the flag is set. The meter can operate irregularly.

The same error applies to messages: F.F.0 .. x5/x6/x7/xC/xD/xE/xF (combinations if other 3 bits are also set in the corresponding nibble).

Required Action → Check validity of data and parameters. Compare the parameter objects in the meter with the values originally stored in the meter at installation time. If there is difference, replace the meter. If there is no difference, clear the error via communication and observe if the error reoccur after short period of time. If the error reoccurs, replace the meter.

F.F.0 xx xx x8 xx (bit11) Measurement system error

Severity → Fatal/Critical

Description → Error detected in measurement system.

The meter performs certain self-diagnostic tests to ensure undisturbed operation and the required measuring accuracy. If any kind of excessive deviation is detected within several minutes time interval, the flag is set. The measurement could be inaccurate.

The same error applies to messages: F.F.0 .. x9/xA/xB/xC/xD/xE/xF (combinations if other 3 bits are also set in the corresponding nibble).

Required Action → Check the energy measurements results. If the measurements are correct, clear the error via communication. If the error reoccurs repeatedly after several minutes, replace the meter (Critical). If the measurements are not correct, replace the meter (Fatal).

F.F.0 xx xx 1x xx (bit12) Watchdog error

Severity → Critical

Description → Meter has been restarted by watchdog circuitry.

Whenever a watchdog reset or a hardware reset of the microcontroller is performed, the flag is set.

The same error applies to messages: F.F.0 .. 3x/5x/7x/9x/Bx/Dx/Fx (combinations if other 3 bits are also set in the corresponding nibble).

Required Action → Check the energy measurements results. If the results are significantly different from expected results, replace the meter. Check the Watchdog resets object (0-0:128.6.0*255). If the value is increasing during one-day period of time, replace the meter.

NOTE!

When an error occurs, the warning in the form of **F.F.0 xx xx xx xx** is presented on the LCD display.

Each **x** represents values of the bits, which meanings are described above this note.

Sign **x** as such is not presented on the display!

6.9.4. Error filter

The **Error 1 filter** (0-0:196.97.0) object can be programmed to hide unwanted errors. To hide unwanted errors the corresponding bits in the error filter should be set to logical 1.

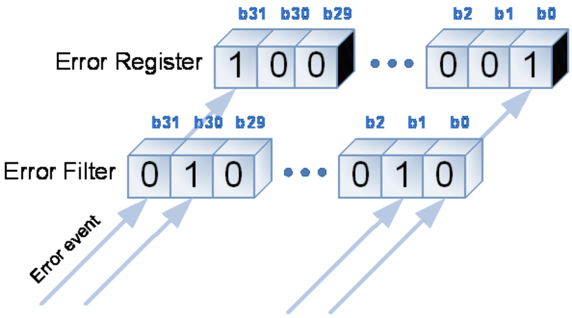


Figure 61: Error filtering

6.9.5. Error display filter

The **Error 1 display filter** (0-0:196.97.10) object can be used to hide the errors that are not intended to cause the FF indicator cursor to be displayed. The structure of the **Error 1 display filter** object is the same as the structure of the **Error register** object. By setting the **Error 1 display filter** object to 0, every error flag set in the **Error register** object causes the FF indicator cursor to be displayed. On the contrary, setting specific error display filter bit to 1, will prevent the corresponding error to activate FF cursor on display.

6.10. Status word

The **Status word** (0-0:196.5.0*255) object value contains information about the meter state (Table 64).

Bit	Status word	Description
0 – 1	Status word identification bit 0	Always 0
2	Status word identification bit 0	Always 1
3 – 7	Status word identification bit 0	Always 0
8	Idleness/starting in the active power unit of the measuring element	0 - Measurement is inactive 1 -Measurement is active
9	Manipulation magnetic interference	0 - Magnetic field is not detected * 1 - Magnetic field is detected
10	Manipulation Terminal cover (3.HZ) or Locking pin (eHZ)	0 -Terminal cover is not opened * 1 -Terminal cover is opened
11	Energy direction, sum	0 - A+ energy direction 1 - A- energy direction
12	Energy direction L1	0 - A+ energy direction 1 - A- energy direction
13	Energy direction L2	0 - A+ energy direction 1 - A- energy direction
14	Energy direction L3	0 - A+ energy direction 1 - A- energy direction
15	Rotating field	0 - Correct phase sequence 1 - Wrong phase sequence
16	Return stop	Unused
17	Error relevant for calibration purposes	0 - Measurement system ready 1 - Measure system error
18	Line voltage L1	0 - Phase missing ** 1 - Phase presence ***
19	Line voltage L2	0 - Phase missing ** 1 - Phase presence ***
20	Line voltage L3	0 - Phase missing ** 1 - Phase presence ***
21 – 31	Reserved	Always 0

* The value is set 24 hour after the condition is disappeared
** The value is set when phase voltage drops below 60% U_n
*** The value is set when phase voltage increases above 80% U_n

Table 64: Status word

NOTE!
The Status word object has been added to the meter object list to support LMN module.

6.11. Clock

These objects, set in the **Clock** (0-0:1.0.0) object, are used for all date and time related information settings in the meter, including deviation of local time to a generalized time reference (Coordinated Universal Time, UTC), due to time zones and daylight saving time schemes.

6.11.1.Local time and date

These two objects are used to access system clock and show date and time separately. Date and time are represented on the meter display like this:

- Time: hh:mm:ss (hours:minutes:seconds),
- Date: four date formats are supported for presentation of date on display:
  - YY.MM.DD (year.month.day)
  - DD.MM.YY (day.month.year)
  - YYYY.MM.DD (year.month.day)
  - DD.MM.YYYY (day.month.year)

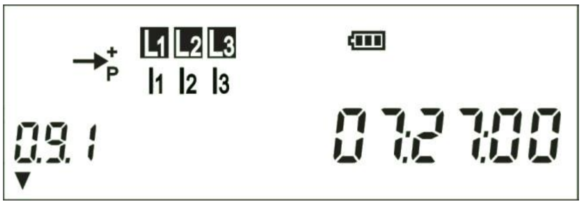


Figure 62: Display time presentation (hh:mm:ss)

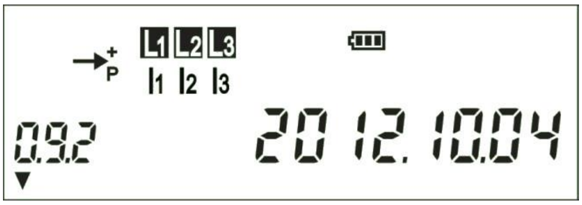


Figure 63: Display date presentation (yyyy.mm.dd)

Local time and date can be set locally/remotely via SEP2 MeterView or manually via console (with buttons).

6.11.2.Clock synchronization

Clock synchronization can be done via synchronization input – MPE (see Figure 20 and Table 35) or remotely/locally via communication interface, set in the **Clock synchronisation method** (1-0:0.9.10) object.

Different types of synchronization are available:

- once per minute,
- once per measurement period,
- once per day.

6.11.2.1. Clock time shift limit

Clock time shift limit is a parameter in the **Clock time shift limit** (1-0:0.9.11) object, which define difference between time synchronisation and time setting. If difference between system and meter clock is larger than time synchronisation limit, then meter records this event as time setting.

6.11.3.Real time clock

Real Time Clock (RTC) integrated circuit with digital calibration provides information about the year, month, day, day in a week, hour, minute, second and leap year for the meter. It includes also deviation from UTC (Coordinated Universal Time). Built-in super capacitor (SuperCap) or lithium battery is used for RTC backup. To retain accurate clock during power loss, the super capacitor holds data up to 7 days when is charged more than 24 hours at nominal voltage. If it is charged for 1 h, it holds data for 24 h. Lithium battery holds data for longer period. It ensures 10 years of back up and 20 years of lifetime. Integrated lithium battery does not need replacement during entire meter lifetime. It ensures the back-up power supply for RTC and tampering functions (detection of external magnetic field, MCO, TCO) during entire meter lifetime. All other parameters as well as measured data are securely saved in the non-volatile memory.

The **RTC mode** (0-0:128.1.0) object determines RTC operation function:

- 0 – Normal - for normal use,
- 1 – Test - for calibration - test purposes.

6.11.3.1. RTC backup type

With **RTC Backup Type** (0-0:128.1.2) object, type of RTC backup is selected. Available options are:

- 0 – SuperCap
- 1 – Battery
- 255 – Not defined

6.11.3.2. RTC Backup Duration

The object **RTC Backup Duration** (0-0:128.1.3*255) is in use only if the **RTC backup type** object is set to 0 – SuperCap.

Object RTC Backup Duration defines the time interval after the last power down when time/date is valid.

At power up, the difference between power up time and last power down time is calculated. If the difference is larger than RTC Backup Duration value, clock_status invalid flag is set.

6.11.3.3. Battery Use Time Counter

Battery use time counter (0-0:96.6.0*255) object shows battery use time. The value is a sum of meter power down and power up time.

6.11.3.4. Battery installation date and time

Date and time of battery installation, shown in the **RTC battery installation date and time** (0-0:96.6.5*255) object, is entered in the meter during the production process. Due to the high capacity of the battery, meter does not need replacement of battery during entire meter lifetime.

6.11.3.5. Battery Estimated Remaining Use Time Counter

Counter, presented in the **Battery estimated remaining use time** (0-0:96.6.6*255) object, shows remaining battery use time. Estimation is calculated from battery default lifetime (20 years) minus battery use time. When meter is unlocked, we can change default lifetime with writing the **Battery use time counter** or the **Battery estimated remaining use time** counter object. In such case, default lifetime is sum of battery use time and battery estimated remaining use time.

When this counter reaches 0, replace battery (bit 1) alarm event is triggered (Table 61).

In a case the battery status reaches critical value, the status for battery replacement on LCD is present (blank battery blinks; see Table 38).

6.11.4. Calendar type

The meter MT880 has implemented the **Calendar type** (0-0.128.10.20) object. Its value defines which calendar is showed on the meter display. In Table 65 currently, two possibilities are presented:

- Gregorian calendar,
- Persian (Jalali) calendar.

Bit	Description
0	Gregorian calendar
1	Persian (Jalali) calendar
2 … 15	*Unused*

Table 65: Calendar type bit field definition

6.12. Tariff program

Tariff program is implemented with set of objects that are used to configure different seasons or weekly and daily programs, to define which certain tariffs should be active. Different actions can be performed with tariff switching as well (e.g. registering energy values in different tariffs or switching on/off bistable relay).

6.12.1. Activity calendar

Activity calendar (0-0:13.0.0*255) object allows creating various tariff structures in the meter. Activity calendar is used to control storing of energy and demand registers according to tariff rate schedule.

Activity calendar consists of two calendars – active and passive. Passive calendar can be activated at predefined time. Changes can be made only to passive calendar, and with the activation, it becomes active one.

Each calendar has following attributes:

- Calendar name (active/passive),
- Season profile (active/passive),
- Week profile table (active/passive),
- Day profile table (active/passive).

Calendar name identifies the active/passive calendar.

Season table in the **season profile** consist of up to 16 seasons, during which different week tables can be applied. Season profile consists of:

- Season profile name,
- Season start date & time,
- Week name.

Week profile table determines the day profile table applied for particular week. 16 week tables are available – one week profile per season. Week tables are divided into days from Monday to Sunday without time data; they are repeated every week while they are valid according to season profile. Week profile consists of:

- Week name,
- Weekdays.

Day profile table: up to 32-day profile tables are available in the meter to cover weekdays and special days. Day profile tables are divided into day actions, which define individual tariff switching times for energy and power. Each of these day actions is defined by the entry of start time. Up to 16 daily actions (switching points) can be defined per one-day profile table.

6.12.2.Special days

Date definition in the **Special days table** (0-0:11.0.0) object can be:

- Fixed dates (occur only once),
- Periodic dates.

The **Special days table** object implementation in the MT880 meter allows configuring up to 128 special day dates. It is possible to define different special days.

6.12.3.Register activation

MT880 meter implements two register activation objects:

- **Register activation – energy** (0-0:14.0.1) object and
- **Register activation – maximum demand** (0-0:14.0.2) object.

The complete set consists of 12 energy types (A+, A-, Q+, Q-, Q1, Q2, Q3, Q4, S+, S-, absolute active energy, net presented active energy), each having 4 or 8 tariff registers (depending on meter configuration).

In total 96 objects are included in register assignment attribute of energy register activation object.

For those objects in register assignment, 16 masks are available.

6.12.4.Tariffication script table

The tariffication script table provides a way for activating different masks for energy and demand.
Up to 32 scripts can be defined in the **Tariffication script table** (0-0:10.0.100*255) object. Each script can execute up to 4 actions.

6.12.5.Manual tariffication script activation

Manual tariffication script activation activate script from the **Tariffication script table** (0-0:10.0.100) object.

By setting the **Manual Tariffication Script Activation** (0-0:96.14.11) object attribute to value x, script x is executed immediately and value of attribute is cleared. Active tariffs changed as defined in executed script.

Active tariffs remain unchanged until next script is executed by internal tariff program (activity calendar) or another manual request.

To enable manual tariffication, set **Tariff switch source energy** (0-0:128.10.0) object to option 4 - Internal clock and manual request. However, tariff program (activity calendar) must be defined.

6.12.6.Tariff switch source

Tariff switch source determines tariff triggering. Meter supports three options of tariff switching by the **Tariff switch source energy** (0-0:128.10.0) object:

- 0 – tariff control via tariff input ,
- 1 – tariff control via internal clock (tariffs are controlled by activity calendar).
- 4 – tariff control via internal clock (tariffs are controlled by activity calendar) and manual request.

Tariff changeover can be done immediately or can be synchronized with measurement period.

6.12.7. Currently active tariff

Currently active tariff shows the tariff that is currently active and is presented with activated status on the LCD display or:

- via the **Currently active energy tariff** (0-0:96.14.0) object,
- via the **Currently active demand tariff** (0-0:96.14.1) object.

Active tariff presentation on the LCD is shown in Table 66. See also Figure 35.

Tariff	Display Flag
No Tariff	None
1	Flag 1 ON
2	Flag 2 ON
3	Flag 3 ON
4	Flag 4 ON
5	Flag 1 flashing
6	Flag 2 flashing
7	Flag 3 flashing
8	Flag 4 flashing

Table 66: Active tariff

6.12.8. Tariff inputs

Two tariff inputs (TE1, TE2) for energy and two tariff inputs for demand tariffs (ME1, ME2) can be configured. For each pair of tariff inputs (energy and demand) there is a coding table, which defines specific script from tariff script table, which shall be executed on certain combination of input signals. Based on this a required mask in register activation becomes active at specific combination of two inputs. For two register activation objects, two input control objects are implemented to correctly switching tariffs with inputs:

- **Energy tariff inputs control** (0-0:128.10.2) object
- **Demand tariff inputs control** (0-0:128.10.12) object

NOTE!
With all state combinations of two tariff inputs (energy or demand), 4 different scripts out of 32 supported by meter can be executed.

Tariff inputs control parameters are defined as octet-string with length of four (4), where each octet corresponds to *script id* in the tariff script table. Up to 32 programmable scripts are supported by the meter. Each tariff input state combination (energy or demand) refers to script id index, which activates corresponding register activation active mask (energy or demand) to switch the tariff (Table 67).

Tariff input combination	11	10	01	00
Tariff input control object	octet 3 (script id)	octet 2 (script id)	octet 1 (script id)	octet 0 (script id)

Table 67: Relation between tariff input combination and tariff input control object

Example:

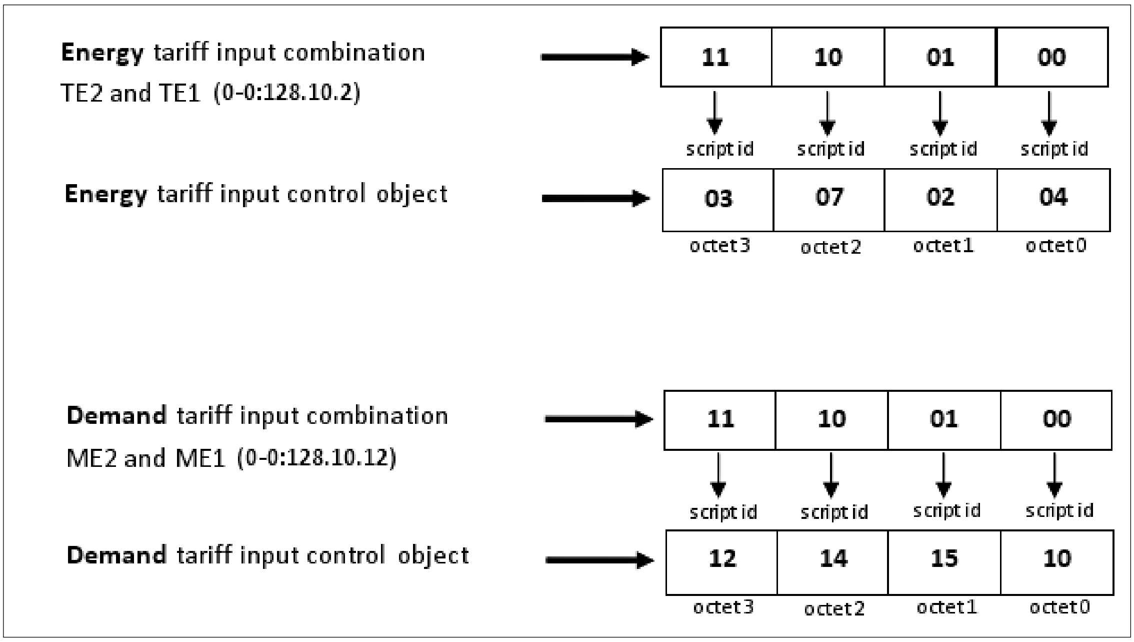


Figure 64: Relation between two tariff inputs combination and tariff input control object

TE2	TE1	Energy tariff input control object (0-0:128.10.2)	Action
0	0	04 *(octet 0)*	script 4 is executed
0	1	02 *(octet 1)*	script 2 is executed
1	0	07 *(octet 2)*	script 7 is executed
1	1	03 *(octet 3)*	script 3 is executed

Table 68: Script actions according to energy tariff input combination

ME2	ME1	Demand tariff input control object (0-0:128.10.12)	Action
0	0	10 *(octet 0)*	script 10 is executed
0	1	15 *(octet 1)*	script 15 is executed
1	0	14 *(octet 2)*	script 14 is executed
1	1	12 *(octet 3)*	script 12 is executed

Table 69: Script actions according to demand tariff input combination

NOTE!
If the **Tariff switch source energy** (0-0:128.10.0*255) is set to **0** (as tariff input) and if ports for tariff inputs (energy or demand) are not configured yet, then script id 1 is executed as default script. If ports for tariff inputs (energy or demand) are configured correctly but tariff input control object is not configured yet (octet-string value = 00000000), then script id 1 is also executed as default script.

6.12.9.Tariff outputs

Two tariff outputs (TA1, TA2) and two demand outputs (MA1, MA2) can be configured in the meter. For each pair of tariff outputs (energy and demand) there is a coding table implemented. The coding tables define which tariff output combination is activated according to the current active tariff mask in register monitor object. When active mask is equal to one of the masks set in tariff outputs control object, then outputs are set to state combination, which corresponds to the position of the mask within tariff output control object.

Two sets of output control COSEM objects are implemented:

- **Energy tariff outputs control** (0-0:128.10.3*255) object
- **Demand tariff outputs control** (0-0:128.10.13*255) object

Tariff outputs control parameters are defined as octet-string with length of four (4) where each octet represents tariff mask id. If active tariff mask equals to one of the masks in tariff outputs control object, then outputs are set to states, which correspond to the position of mask id within tariff output control object (Table 70).

Tariff output combination	11	10	01	00
Tariff output control object	octet 3 (tariff mask id)	octet 2 (tariff mask id)	octet 1 (tariff mask id)	octet 0 (tariff mask id)

Table 70: Relation between tariff output combination and tariff output control object

Example:

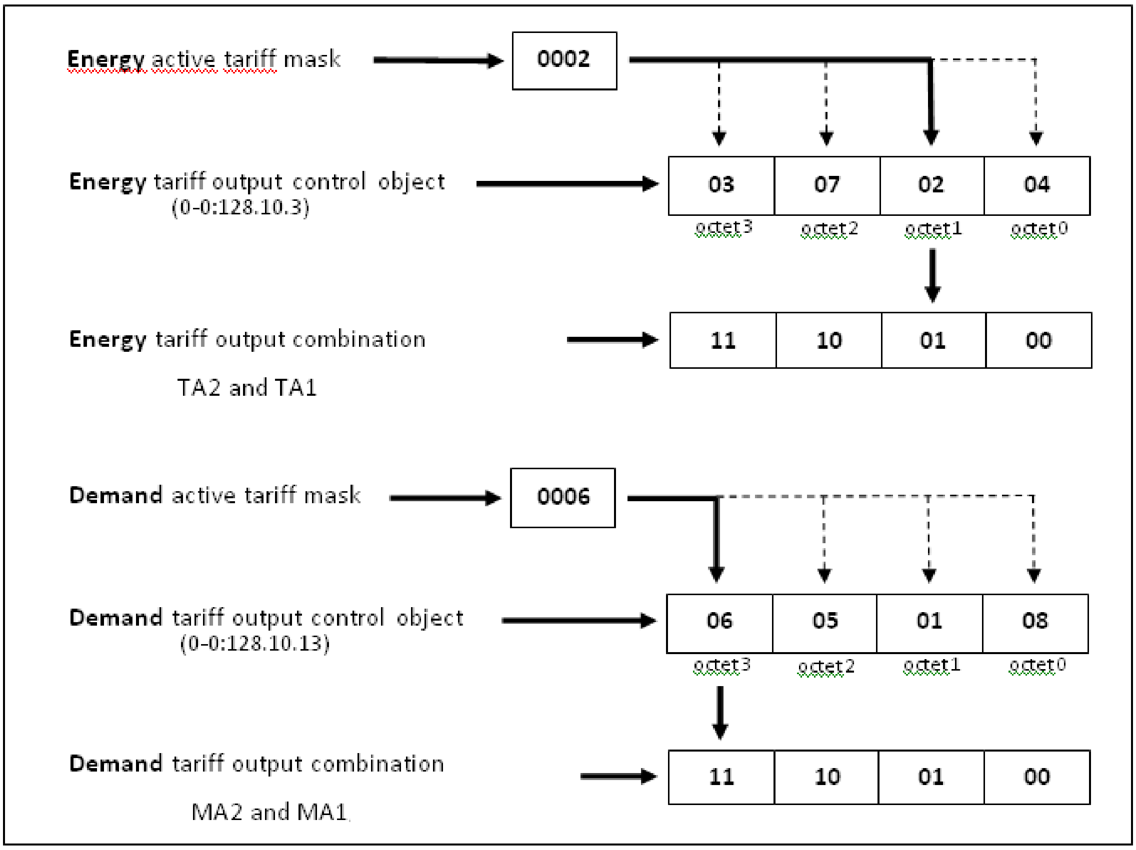


Figure 65: Relation between active tariff mask, tariff output control object and output combination

TA2	TA1	Energy tariff output control object (0-0:128.10.3)	Action
0	0	04 *(octet 0)*	tariff active mask 4 sets outputs to state 00
0	1	02 *(octet 1)*	tariff active mask 2 sets outputs to state 01
1	0	07 *(octet 2)*	tariff active mask 7 sets outputs to state 10
1	1	03 *(octet 3)*	tariff active mask 3 sets outputs to state 11

Table 71: Relation between currently active tariff mask and energy tariff output combination

MA2	MA1	Demand tariff output control object (0-0:128.10.13)	Action
0	0	08 *(octet 0)*	tariff active mask 8 sets outputs to state 00
0	1	01 *(octet 1)*	tariff active mask 1 sets outputs to state 01
1	0	05 *(octet 2)*	tariff active mask 5 sets outputs to state 10
1	1	06 *(octet 3)*	tariff active mask 6 sets outputs to state 11

Table 72: Relation between currently active tariff mask and demand tariff output combination

6.12.10. Time switch program number

Time switch program number (1-0:0.2.2) object holds a TOU identifier value. The value is written and read in alphanumeric format. The length of the ID is limited to maximum 48 characters.

6.13. Software

6.13.1. Meter programming

Programming of the meter as well as application part of FW upgrade can be done locally or remotely in compliance with the predefined security levels. The objects in the meter are protected with four authentication levels (passwords) and with PARAM key, which can be found under the meter cover. Firmware update procedure is made in accordance with WELMEC recommendation.

6.14. Load management

Meter is equipped with 5A bistable relay, which can be used for load limitation. Relay output can be controlled by several meter functions:

- through communication interfaces by invoking disconnect/reconnect methods on the **Load management – Relay control 1** (0-1:96.3.10) object or interfaces by executing scripts of the **Load management script table** (0-0:10.0.103) object,
- By the **Load control register monitor 1-3** (0-1:16.0.0, 0-2:16.0.0 and 0-3:16.0.0) objects, which can be configured to execute *Load management script table* scripts when crossing thresholds,
- By the tariffication program, which executes disconnect/reconnect methods of the **Load management – Relay control 1** object.

Additionally meter can be configured to drive up to three load control outputs, selected from available OptoMOS outputs in order to signal load control state. Load control information (number of activations and duration of activations) are also registered by the meter.

6.14.1.Load management relay control

Dedicated disconnect control **Load management – Relay control 1** object (0-1:96.3.10*255) is implemented in the meter for controlling the relay.

Relay state could be read out from the meter via *Output state* and shows actual physical state of disconnect unit:

- 0 – Disconnected,
- 1 – Connected.

Control state defines state of the disconnect unit. States are:

- 0 – Disconnected – relay is open,
- 1 – Connected – relay is closed.
- 2 – Ready for reconnection

When the disconnector unit is in "*Ready for reconnection*" control state, it is possible to perform manual connection on the meter. It can be performed by holding the right button 8 seconds until the display symbol for relay connection on the meter's display stops blinking.

NOTE!
When delay is used (refer to chapter *6.14.3. Load management delay*), control state is switched immediately with command execution, but relay actually switches after the delay expires.

Control Mode

Control mode defines the mode of operation for disconnect control object. See Figure 66.
Possible modes are listed in Table 73.

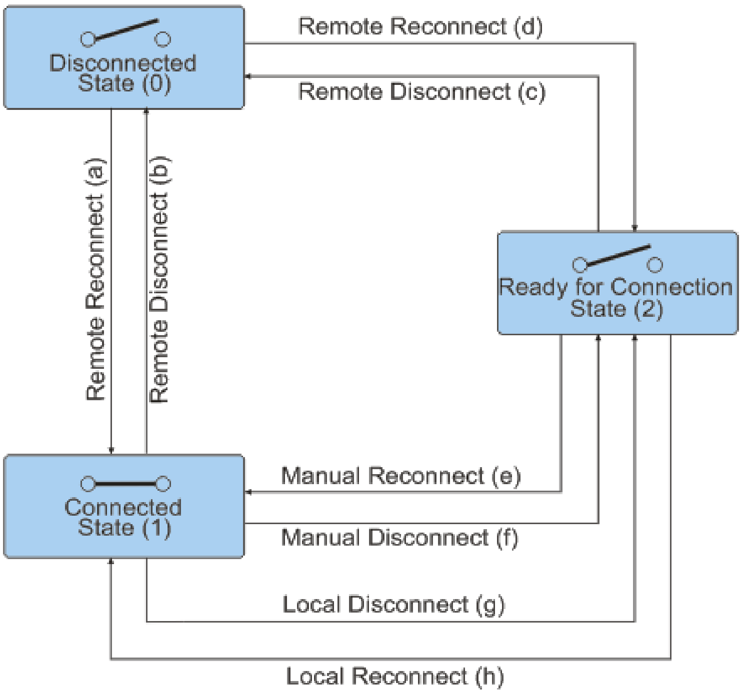


Figure 66: Operation of disconnect control object

Mode	Description	
0	None. The disconnect control object is always in 'Connected' state	
1	Disconnection:	• Remote (b, c) • Manual (f) – Press and hold right button until appears, and release the button • Local (g)
	Reconnection:	• Remote (d) • Manual (e) – Press and hold right button until disappears and release the button
2	Disconnection:	• Remote (b, c) • Manual (f) – Press and hold right button until appears, and release the button • Local (g)
	Reconnection:	• Remote (a) • Manual (e) – Press and hold right button until disappears and release the button
3	Disconnection:	• Remote (b, c) • Local (g)
	Reconnection:	• Remote (d) • Manual (e) – Press and hold right button until disappears and release the button
4	Disconnection:	• Remote (b, c) • Local (g)
	Reconnection:	• Remote (a) • Manual (e) – Press and hold right button until disappears and release the button
5	Disconnection:	• Remote (b, c) • Manual (f) – Press and hold right button until appears an release the button • Local (g)
	Reconnection:	• Remote (d) • Manual (e) – Press and hold right button until disappears and release the button • local (h)
6	Disconnection:	• Remote (b, c) • Local (g)
	Reconnection:	• Remote (d) • Manual (e) – Press and hold right button until disappears and release the button • Local (h)

 – Disconnect control indicator in Notification field of LCD (see chapter *5.1.5. Notification field*)

Table 73: Disconnect modes of load management disconnect control

NOTE!
For the switchover to be made, methods below should be executed (remotely or locally). Manual transitions are not possible.

Depending on the selected mode, manual reconnection and disconnection is possible by pressing the right button:

- **Manual reconnection**:
  On the LCD, the indicator (disconnect control indicator) is blinking.
  Press the button for 8 seconds until disappears and then release it.
- **Manual disconnection**:
  Press the button for 10 seconds.
  The indicator starts blinking and then release the button.

Method description

- *Remote disconnect* forces the relay into 'disconnected' state if remote disconnection is enabled (control mode > 0),

- *Remote reconnect* forces the relay:
  - into the “Ready for reconnection” state if a direct remote reconnection is disabled (control mode = 1, 3, 5, 6), or
  - into the ‘Connected’ state’ if a direct remote reconnection is enabled (control mode = 2, 4).

NOTE!
Relay reconnection through communication interfaces is only possible if modes 2 or 4 are selected.
In order to switch relay using register monitors or tariff program, modes 5 or 6 should be used.

6.14.2.Load management script table

In order to be able to configure the meter for driving relay locally, a dedicated **Load management script table** (0-0:10.0.103) object is implemented in the meter. Two script tables are fixed:

- Script 1 – disconnect script,
- Script 2 – reconnect script.

6.14.3.Load management delay

Via the dedicated **Load management delay mode** (0-0:128.30.0) object, relay switching can be configured for different operation modes, which are related to delay switching.

Available modes for relay switching are:

- 0 – Normal (no switching delays are activated),
- 1 – Switch on delayed,
- 2 – Switch on random delayed,
- 3 – Switch on delayed with power on delay,
- 4 – Switch on delayed with power on random delay,
- 5 – Switch on random delayed with power on delay,
- 6 – Switch on random delayed with power on random delay.

The **Load management power on delay** (0-0:128.30.2) object can be used to configure time delay (in seconds) for relay to switch on at power up. When power down occurs and relay state is connected with power on delay mode configured, next power up causes the relay to disconnect for the time set in **Load management power on delay** before it is reconnected. During the power on delay time, *Control state* remains connected, however *Output state* is changed to state disconnected. According to configured mode, the delay time can be constant or random within the configured range.

The **Load management switch on delay** (0-0:128.30.3) object can be used to configure time delay (in seconds) for relay to switch on when *Control state* is changed to connected by invoking Reconnect action. During the switch on delay time, *Control state* changes to connected, however *Output state* remains set to disconnected. According to configured mode, the delay time can be constant or random within the configured range.

6.14.4.Load control output script table

In order to drive load control outputs, meter has special script table implemented, used by **Load control output script table** (0-0:10.1.250) object. This script table provides 6 scripts to support driving of 3 load control outputs, where two scripts are used for one load control output (one script for activation and the other for deactivation). See Table 74.

Script number	Action	Load control output	Log book event	Alarm 2 bit
1	Activate	LA1	Load control channel 1 active	Set: B25 Load control channel 1 active
2	Deactivate	LA1	Load control channel 1 deactivated	Clear: B25 Load control channel 1 active
3	Activate	LA2	Load control channel 2 active	Set: B26 Load control channel 2 active
4	Deactivate	LA2	Load control channel 2 deactivated	Clear: B26 Load control channel 2 active
5	Activate	LA3	Load control channel 3 active	Set: B27 Load control channel 3 active
6	Deactivate	LA3	Load control channel 3 deactivated	Clear: B27 Load control channel 3 active

Table 74: Load control output script table available scripts

Load control output activations are registered in dedicated information objects as:

- counter of load control activations in billing period per load control channel,
- duration (in seconds) of active load control output state in billing period per load control channel,
- cumulative duration (in seconds) of active load control state per load control channel.

Counter objects are incremented with every execution of dedicated load control output activation script in the **Load control output activated count** (0-0:128.6.**e**) objects. Values for **e** are 10, 13, and 16. See Table 75.

Duration objects register time elapsed between each execution of activation and deactivation script. For each load control output channel, duration is separately accumulated in billing period and as total cumulative duration in the **Load control output activated duration** (0-0:128.6.**e**) objects. Values for **e** are 11, 12, 14, 15, 17, and 18. Duration is registered in seconds. See Table 75.

Logical name	Description
0-0:128.6.10	Load control 1 activated count in billing period
0-0:128.6.11	Load control 1 activated duration in billing period
0-0:128.6.12	Load control 1 activated duration cumulative
0-0:128.6.13	Load control 2 activated count in billing period
0-0:128.6.14	Load control 2 activated duration in billing period
0-0:128.6.15	Load control 2 activated duration cumulative
0-0:128.6.16	Load control 3 activated count in billing period
0-0:128.6.17	Load control 3 activated duration in billing period
0-0:128.6.18	Load control 3 activated duration cumulative

Table 75: Load control output information objects

6.14.5.Load control register monitors

Three register monitors are implemented in MT880 meter for control functionality with **Load control register monitor 1-3** object (0-b:16.0.0), where **b** is used for indexation of register monitors. Values are 1, 2, and 3.

Thresholds

Provides the threshold values to which the monitored attribute of the referenced object is compared. The threshold is of the same type as the monitored attribute of the referenced object. Up to 2 thresholds can be configured.

Monitored Value

Defines an object, which will be monitored.

Actions

Defines the scripts to be executed, when the monitored attribute of the referenced object crosses the corresponding threshold. The attribute “actions” has exactly the same number of elements as the attribute “thresholds”. The ordering of the action items corresponds to the ordering of the thresholds. Each action element in array has action up and action down, where:

- *Action Up* defines the action, when the attribute value of the monitored register crosses the threshold in upwards direction,
- *Action Down* defines the action, when the attribute value of the monitored register crosses the threshold in downwards direction.

Examples:

Example 1 – monitoring value with constant single threshold parameter

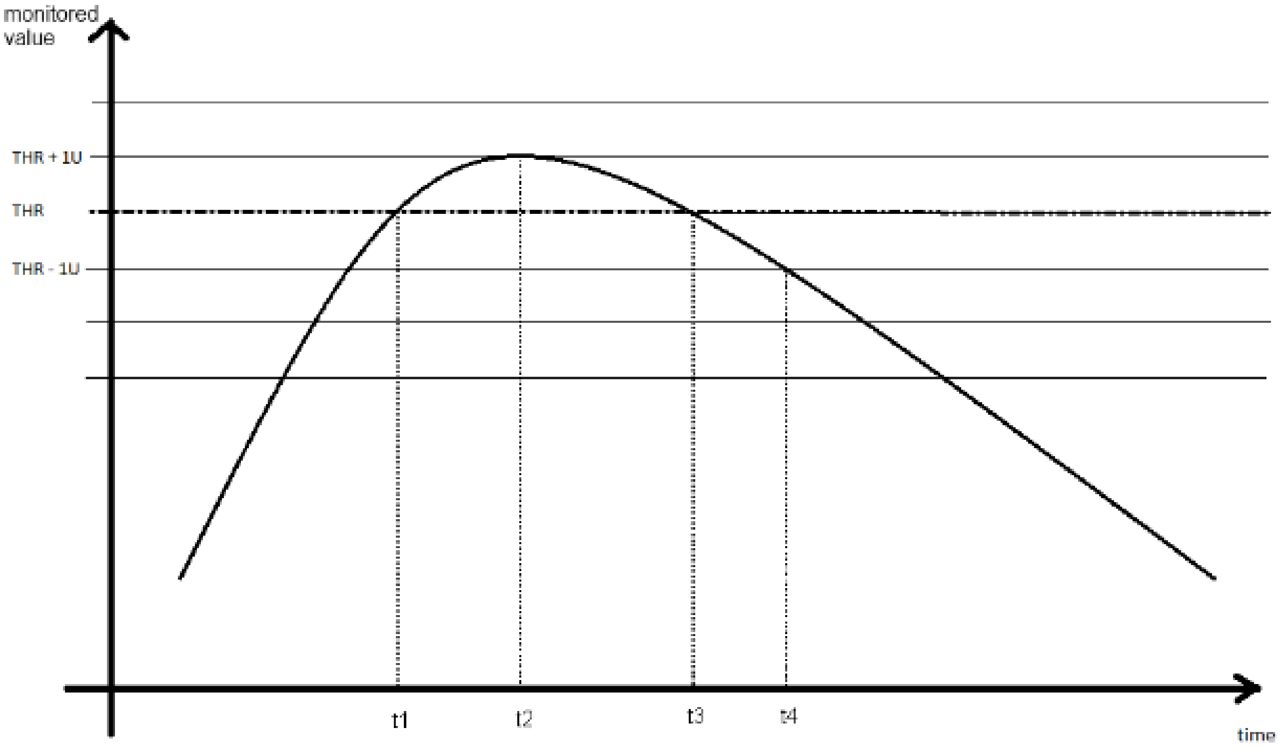


Figure 67: Register monitor normal operation

Register monitor threshold value is set to THR value:

- [t1] – Register monitored value hits threshold level. No action is taken.
- [t2] – Register monitored value passes threshold level for at least one unit (THR + 1U). Action up is executed
- [t3] – Register monitored value hits threshold level. No action is taken.
- [t4] – Register monitored value passes threshold level for at least one unit (THR – 1U). Action down is executed

See Figure 67.

Example 2 – monitoring value with changing single threshold parameter

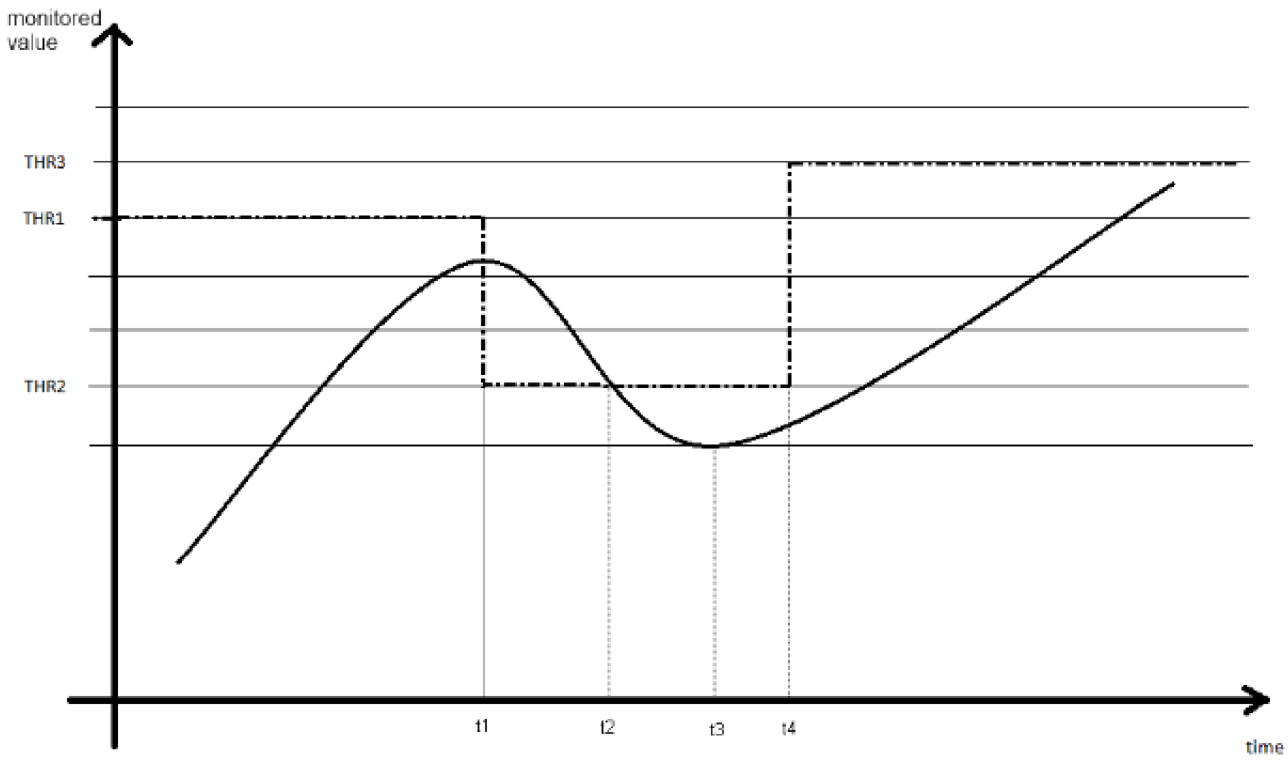


Figure 68: Register monitor operation when parameter changes in runtime

At the beginning, monitored threshold value is set to THR1. Threshold is changed in runtime:

- [t1] – Register monitored value increases; however, threshold value is lowered. Action up is called.
- [t2] – Register monitored value decreases and reaches new threshold. No action is taken.
- [t3] – Register monitored value passes threshold value for at least one unit (THR2-1U). Action down is executed.
- [t4] – Register monitored threshold parameter value is raised. Monitored value increases but no action is taken because no threshold is passed.

See Figure 68.

The examples above illustrate single register monitor operation. When all three register monitors are used, each of them works independently.

NOTE!
If all three register monitors are configured to control relay through **Load management script table** object, relay remains disconnected when at least one register monitor requires disconnected state. Only when all three register monitors allow, relay will be connected.

6.14.6.Sliding average current

For the purpose of controlling the load, **Sliding average current** (1-0:**c**.4.0) objects are available per each phase (mark **c** in OBIS code represents phases: 31 for L1, 51 for L2 and 71 for L3). Those objects do not contain directly measured phase current RMS, but the averaged value over the number of periods. Phase RMS current is averaged with period (1 second by default) over number of periods (90 seconds by default) to provide result of sliding average current.

Each sliding average current object works independently and can have different settings for period and number of periods.

6.14.7.Output toggle

For controlling third-party disconnect unit by the meter, *output toggle* is available.

In the meter, up to three output-toggle outputs (TGL1, TGL2, TGL3) can be integrated (see Table 35).

Toggle pulse is performed on the appropriate output by execution appropriate script from script table of **Output toggle** (0-0:10.0.251*255); see Table 76.

Pulse duration is defined in the **IO configuration port** parameters.

Script number	Action	Output toggle	Description
1	Activate	TGL1	Activate toggle pulse on TGL1
2	Activate	TGL2	Activate toggle pulse on TGL2
3	Activate	TGL3	Activate toggle pulse on TGL2

Table 76: Available scripts of Output toggle script table

6.14.8.Relay logic selection

Logic for relay connect and relay disconnect can be inverted and is settable by object **Load control relay logic selection** (0-0:128.30.9*255). Available options are:

- 0 - Relay logic is not inverted
- 1 - Relay logic is inverted

6.15. Monitoring functions

6.15.1.Power quality monitoring

Meter power quality module provides measurements and analysis of grid values. The basic power quality measurements consist of:

- voltage level, sag, swell, cut detection and registration, under and over limit
- voltage maximum and minimum of present day and previous day
- voltage asymmetry detection,
- phase voltage failure registration.

All power quality measurements are based on phase U_{rms} measurement. The basic measurement time interval for mains supply voltage is 200 ms, which is a 10-cycle time interval for 50Hz power systems.
Basic time interval values are aggregated over recording time interval (aggregation time interval), which is 10 minutes by the default.

All power quality measurements related to voltage use values stored in instantaneous voltage objects, which are calculated according to voltage transformer settings as primary or secondary values. In order to assure proper voltage quality operation, nominal voltage in the **Nominal voltage** (1-0:0.6.0*255) object must be set such that it will correspond with measured instantaneous voltages.

NOTE!
Nominal voltage can be set in volts (V). Because nominal voltage is set as 16-bit value, it is not possible to set values of nominal voltage higher than 65535 volts. For higher voltages applied on primary side, meter must be configured for secondary voltage registration.

NOTE!
During the installation check the **Nominal voltage** object and set it accordingly.

NOTE!
Nominal voltage value is set to 230 volts by default.

6.15.1.1. Voltage level (UNIPEDE tables)

Voltage level monitoring is based on several predefined voltage thresholds set as percentage of U_{rms} nominal. At the start of aggregation interval, meter starts to sample phase U_{rms} voltages with basic time interval, and it averages them. At the end of aggregation period, calculated average phase voltage is compared to predefined thresholds. The voltage depth value obtained at the end of aggregation time interval is checked to fall inside one of the threshold levels presented in Table 77 and the counter for the matched threshold level is incremented. The depth is the difference between the reference voltage (nominal phase voltage) and the average U_{rms} value measured on particular phase during the aggregation interval.

Threshold levels	Threshold voltages depths	Threshold level counters
Level 1	U > +10%	Counter 1 over voltage
Level 2	+5% < U < +10%	Counter 2 over voltage
Level 3	0% < U < +5%	Counter 3 over voltage
Level 4	-5% < U < 0%	Counter 4 under voltage
Level 5	-10% < U < -5%	Counter 5 under voltage
Level 6	-15% < U > -10%	Counter 6 under voltage
Level 7	U < -15%	Counter 7 under voltage

Table 77: Voltage level Detection Model

In a case of simultaneous occurrence of different voltage levels on different phases, all the corresponding phase threshold level counters are incremented, When voltage depths measured on multiple phases are in the same voltage level range, the corresponding ANY counter is incremented only by 1.

Over and under voltage threshold level objects (0-0:128.7.**e***) are listed in Table 78.

Over voltage threshold level objects	value e*	Under voltage threshold level objects	value e*
L1 level 1 counter	**11**	L1 level 4 counter	**14**
L1 level 2 counter	**12**	L1 level 5 counter	**15**
L1 level 3 counter	**13**	L1 level 6 counter	**16**
L2 level 1 counter	**21**	L1 level 7 counter	**17**
L2 level 2 counter	**22**	L2 level 4 counter	**24**
L2 level 3 counter	**23**	L2 level 5 counter	**25**
L3 level 1 counter	**31**	L2 level 6 counter	**26**
L3 level 2 counter	**32**	L2 level 7 counter	**27**
L3 level 3 counter	**33**	L3 level 4 counter	**34**
ANY level 1 counter	**41**	L3 level 5 counter	**35**
ANY level 2 counter	**42**	L3 level 6 counter	**36**
ANY level 3 counter	**43**	L3 level 7 counter	**37**
		ANY level 4 counter	**44**
		ANY level 5 counter	**45**
		ANY level 6 counter	**46**
		ANY level 7 counter	**47**

Table 78: List of over and under voltage threshold level objects

6.15.1.2. Voltage sag

Voltage sags starts when instantaneous voltage of specific phase drops below threshold for voltage sag (U_{thr}) for longer than the time set in the **Time threshold for voltage sag** (1-0:12.43.0) object. Voltage sag ends when the same instantaneous voltage rises above threshold. Voltage sag detection involves 2% hysteresis, which means that once voltage drops below threshold U_{thr}, it must rise 2% above U_{thr} in order to come out of voltage sag condition.

The following information is recorded when voltage sag is detected:

- voltage sag counter is incremented by 1,
- magnitude of voltage sag is stored,
- duration of voltage sag is stored,
- event is recorded in the **Power quality log** (0-0:99.98.4) object
- alarm is set.

Voltage Sag Parameters

Threshold for voltage sag (1-0:12.31.0) is parameter that defines threshold under which voltage sag condition is detected, defined as percentage of nominal voltage.

Time threshold for voltage sag (1-0:12.43.0.0) specifies the required duration (in seconds) for which specific voltage must drop below threshold for voltage sag, set in the **Threshold for voltage sag** object.

Voltage Sag Information

Each detected voltage sag on specific phase voltage results in increment of corresponding phase voltage sag counter by the **Counter for voltage sag** (1-0:12.32.0) and the **Number of voltage sags in phase L1/L2/L3** (1-0:**c**.32.0) objects, where "**c"** values are: 32 for L1, 52 for L2 and 72 for L3. The counter for any phase voltage sag is only incremented when all phase voltages come out of voltage sag condition.

Information on voltage magnitude for last occurred voltage sag on specific phase is stored in the corresponding **Magnitude for voltage sag** (1-0:12.34.0) register object for any phase and in the **Magnitude of last voltage sag in phase L1/L2/L3** (1-0:**c**.34.0) objects, where "**c"** values are: 32 for L1, 52 for L2 and 72 for L3. For each phase meter records the minimum value of instantaneous phase voltages during voltage sag condition on that specific phase. The any phase voltage sag magnitude is registered when all phase voltages come out of voltage sag condition. The registered magnitude is the minimum measured instantaneous voltage in any phase during any phase voltage sag condition.

With each new occurrence of specific voltage sag, previous voltage sag information is rewritten with new information.

In parallel with voltage sag magnitude, also voltage sag duration is recorded (for any phase and per specific phase) by the **Under limit duration** (1-0:12.33.0) and the **Duration of last voltage sag in phase L1/L2/L3** (1-0:**c**.33.0) objects, where "**c"** values are: 32 for L1, 52 for L2 and 72 for L3. Duration records the time from the point that voltage level drops below U_{thr} to the point when it rises above U_{thr} including 2% hysteresis.

6.15.1.3. Voltage swell

Voltage swell starts when instantaneous voltage of specific phase rises above threshold for voltage swell U_{thr} for longer than the time set in the **Time threshold for voltage swell** (1-0:12.44.0) object. Voltage swell ends when the same instantaneous voltage drops below threshold. Voltage swell detection involves 2% hysteresis, which means that once voltage rises above threshold U_{thr}, it must drop 2% below U_{thr} in order to come out of voltage swell condition.

The following information is recorded when voltage swell is detected:

- voltage swell counter is incremented by 1,
- magnitude of voltage swell is stored,
- duration of voltage swell is stored,
- event is recorded in the **Power quality log** (0-0:99.98.4) object
- alarm is set.

Voltage Swell Parameters

Threshold for voltage swell (1-0:12.35.0) is parameter that defines threshold above which voltage swell condition is detected, defined as percentage of nominal voltage.

Time threshold for voltage swell (1-0:12.44.0*0) specifies the required duration (in seconds) for which specific voltage must rise above threshold for voltage swell, set in the **Threshold for voltage swell** object.

Voltage Swell Information

Each detected voltage swell on specific phase voltage results in increment of corresponding phase voltage swell counter by the **Counter for voltage swell** (1-0:12.36.0) and the **Number of voltage swells in phase L1/L2/L3** (1-0:**c**.36.0) objects, where "**c"** values are: 32 for L1, 52 for L2, and 72 for L3. The counter for any phase voltage swell is only incremented when all phase voltages come out of voltage swell condition.

Information on voltage magnitude for last occurred voltage swell on specific phase is stored in the corresponding **Magnitude for voltage swell** (1-0:12.38.0) register object for any phase and in the **Magnitude of last voltage swell in phase L1/L2/L3** (1-0:**c**.38.0) objects, where "**c"** values are 32 for L1, 52 for L2, and 72 for L3. For each phase meter records the maximum value of instantaneous phase voltages during voltage swell condition on that specific phase. The any phase voltage swell magnitude is registered when all phase voltages come out of voltage swell condition. The registered magnitude is the maximum measured instantaneous voltage in any phase during any phase voltage swell condition.

With each new occurrence of specific voltage swell, previous voltage swell information is rewritten with new information.

In parallel with voltage swell magnitude, also voltage swell duration is recorded (for any phase and per specific phase) by the **Over limit duration** (1-0:12.37.0) and the **Duration of last voltage swell in phase L1/L2/L3** (1-0:**c**.37.0) objects, where "**c"** values are 32 for L1, 52 for L2, and 72 for L3. Duration records the time from the point that voltage level rises above U_{thr} to the point when it drops below U_{thr} including 2% hysteresis.

6.15.1.4. Voltage cut

Voltage cut starts when instantaneous voltage of specific phase drops below threshold for voltage cut for longer than the time set in the **Time threshold for voltage cut** (1-0:12.45.0) object. Voltage cut ends when the same instantaneous voltage rises above threshold. Voltage cut detection involves 2% hysteresis. Voltage cut is recorded in the meter as event in the **Power quality log** (0-0:99.98.4) object.

Voltage cut parameters

Threshold for voltage cut (1-0:12.39.0) is parameter that defines threshold below which voltage cut condition is detected, defined as percentage of nominal voltage.

Time threshold for voltage cut specifies the required duration (in seconds) for which specific voltage must drop below threshold for voltage cut, set in the **Threshold for missing voltage (voltage cut)** (1-0:12.39.0) object, until voltage cut condition is detected.

6.15.1.5. Voltage under/over limit

In addition to voltage sags, swells and cut, MT880 meter also provides additional mechanism to detect condition, when phase voltage rises above or drops below certain threshold levels. Such conditions are categorized as over-voltage or under-voltage. From samples of phase voltages, meter calculates average values over time period. This time period is synchronized with the meter clock. At the end of time period, each value of average phase voltage is compared to the overlimit and underlimit thresholds set as parameters. When specific phase voltage value rises above overlimit threshold, an event for voltage overlimit is generated. In addition, when certain phase voltage drops below underlimit threshold, an event for voltage underlimit is recorded.

The meter also records end of voltage under/over limit condition (voltage normal event), when phase voltage returns between the two threshold levels. In order to prevent several events when phase voltage is exactly on the level of thresholds, the 2% hysteresis is implemented. This means that in order to detect normal voltage, phase voltage must rise additional 2% above parameterized underlimit threshold, or drop additional 2% below parameterized overlimit threshold.

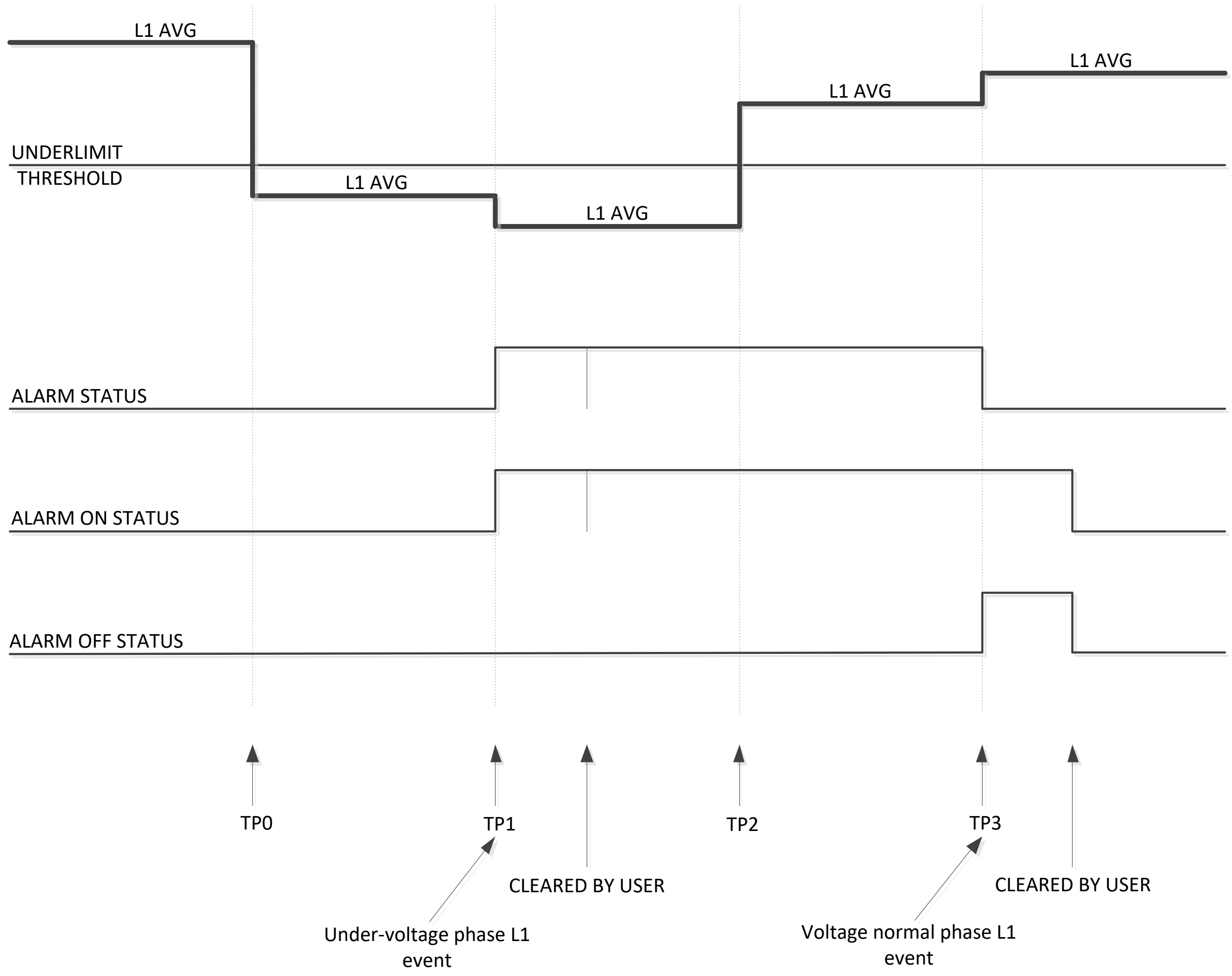


Figure 69: Under-voltage/Over-voltage alarm and event generation

Events for voltage asymmetry are always generated at the end of each specific time period, when the meter checks average phase voltage values.

In addition to events, voltage overlimit and underlimit conditions for specific phase voltages are also presented by dedicated bits in alarm registers. When phase voltage enters overlimit or underlimit condition, dedicated alarm bits in **Alarm register 2** (0-0:97.98.1) and **Alarm ON status 2** (1-0:96.242.10) registers are set. Later when phase voltage exits overlimit or underlimit condition, the same alarm bit in **Alarm register 2** is cleared, and alarm bit in **Alarm OFF status 2** (1-0:96.243.10) register is set but **Alarm ON status 2** register keeps the old information. If specific voltage overlimit or underlimit alarm bit in **Alarm register 2** or **Alarm ON status 2** register is cleared by the user before meter detects normal voltage condition (which can only happen at the end of next time period), alarm bit is immediately set back by the meter.

The **Time Threshold for Voltage Underlimit** (1-0:12.43.0*1) and the **Time Threshold for Voltage Overlimit** (1-0:12.44.0*1) are addressing the same parameter because under/over voltage detection process runs with a single time period. Both thresholds are set as percentage of nominal voltage, with the 0.1% resolution.

NOTE!

When the **Time threshold for voltage underlimit** and the **Time Threshold for Voltage Overlimit** object parameters are set to 0 it means that under/over voltage detection is disabled.

6.15.1.6. Voltage daily / previous day peak and minimum

MT880 meter records daily peak and minimum values of phase voltages and averaged three-phase voltage. Samples of instantaneous phase voltages are taken every 200 ms, and averaged during settable aggregation period. At the end of aggregation period average values are compared to values stored in the current registers and if new values are found to be greater or lower than existing values, those existing values are overwritten with new extreme values. At the end of the day, peak and minimum values are copied from current registers into previous registers and current registers are reset.

Average voltage for daily peak and minimum calculation

Values of average phase voltages in settable aggregation period for voltage peak and minimum calculation are available as **Average voltage L1/L2/L3** (1-0:**c**.24.0) COSEM objects (values for "**c"** are 32 for L1, 52 for L2, and 72 for L3). Values in those objects are refreshed at the end of aggregation period, and the same values are kept until next period ends.

Voltage daily peak/minimum / current/previous voltage (0-0:128.8.**e***) objects are listed in Table 79.

Object	value e*
ALL phases average voltage daily peak – current	**0**
ALL phases average voltage daily peak – previous	**1**
ALL phases average voltage daily minimum – current	**2**
ALL phases average voltage daily minimum – previous	**3**
Daily peak voltage – current L1	**10**
Daily peak voltage – previous L1	**11**
Daily minimum voltage – current L1	**12**
Daily minimum voltage – previous L1	**13**
Daily peak voltage – current L2	**20**
Daily peak voltage – previous L2	**21**
Daily minimum voltage – current L2	**22**
Daily minimum voltage – previous L2	**23**
Daily peak voltage – current L3	**30**
Daily peak voltage – previous L3	**31**
Daily minimum voltage – current L3	**32**
Daily minimum voltage – previous L3	**33**

Table 79: Voltage daily peak/minimum / current/previous voltage objects

Voltage peak and minimum aggregation period

Aggregation period for calculating average voltages that are used in process of voltage daily peak and minimum registration can be set as parameter in the **Voltage peak and minimum aggregation period** (0-0:128.8.50) object. The value is entered in seconds.

6.15.1.7. Voltage asymmetry

Voltage asymmetry is condition when at least one phase voltage deviates from average three-phase voltage for more than a defined threshold. With the period of 200 ms, meter takes samples of instantaneous phase voltages from which it calculates average values over longer aggregation period. At the end of aggregation period, the calculated average values of phase voltages are compared with average three-phase voltage (Σ Uphase / 3). Any average phase voltage that deviates from average three-phase voltage for more than defined threshold, results in registration of voltage asymmetry (alarm and event).

Asymmetrical voltage detection is always synchronized with internal meter clock and is always executed on multiples of aggregation period.

The upper and lower threshold for voltage asymmetry detection can be set as parameters in the **Asymmetrical voltages upper threshold** (0-0:128.7.50) and in the **Asymmetrical voltages lower threshold** (0-0:128.7.51) objects in percentage with 0.1% resolution.

Aggregation period for asymmetrical voltage detection can also be set as parameter in seconds in the **Asymmetrical voltages time threshold** (0-0:128.7.52) object.

Events for voltage asymmetry are always generated at the end of aggregation period, when the meter checks average phase voltage values. At the same time, also dedicated alarm is set or cleared. However, if alarm bit is cleared by the user, before the meter detects normal voltage condition (which can only happen at the end of next aggregation period), alarm is immediately set back.

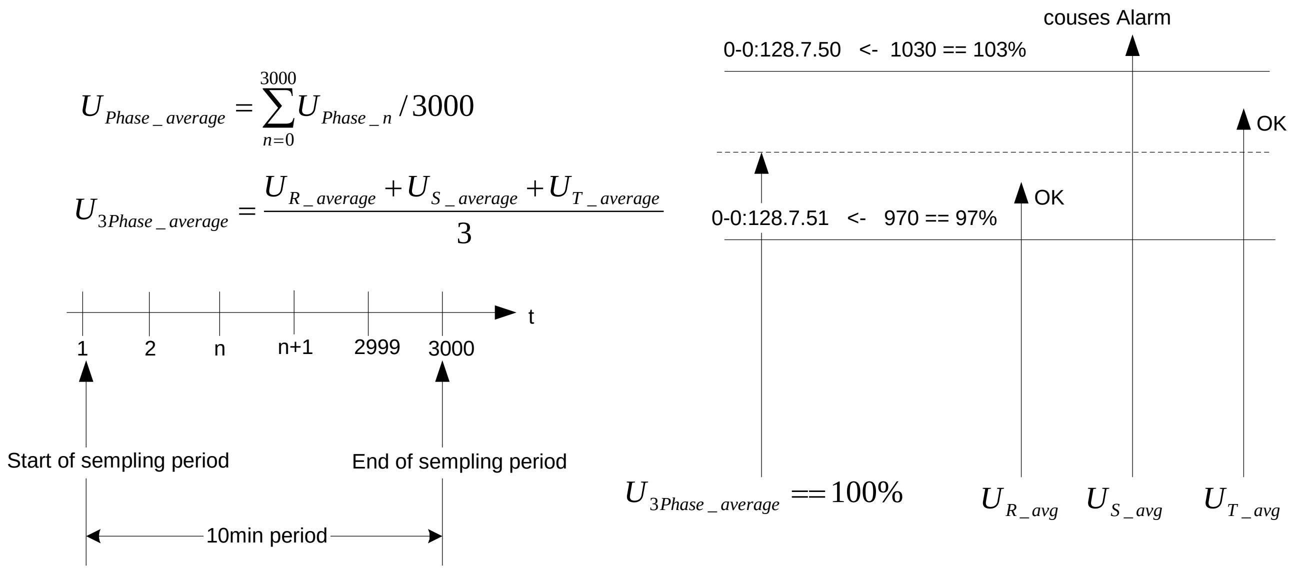


Figure 70: Voltage Asymmetry Calculation

NOTE!
In order to record the voltage asymmetry in alarm registers, IE alarm system needs to be selected!

6.15.1.8. Voltage fail

Voltage fail status is detected when voltage average value of specific phase drops below value defined with »*Threshold for Voltage fail*« over one second, and the power down event per phase is recorded. Voltage fail status ends when the same voltage rises above the threshold, and the power-restored event per phase is recorded.

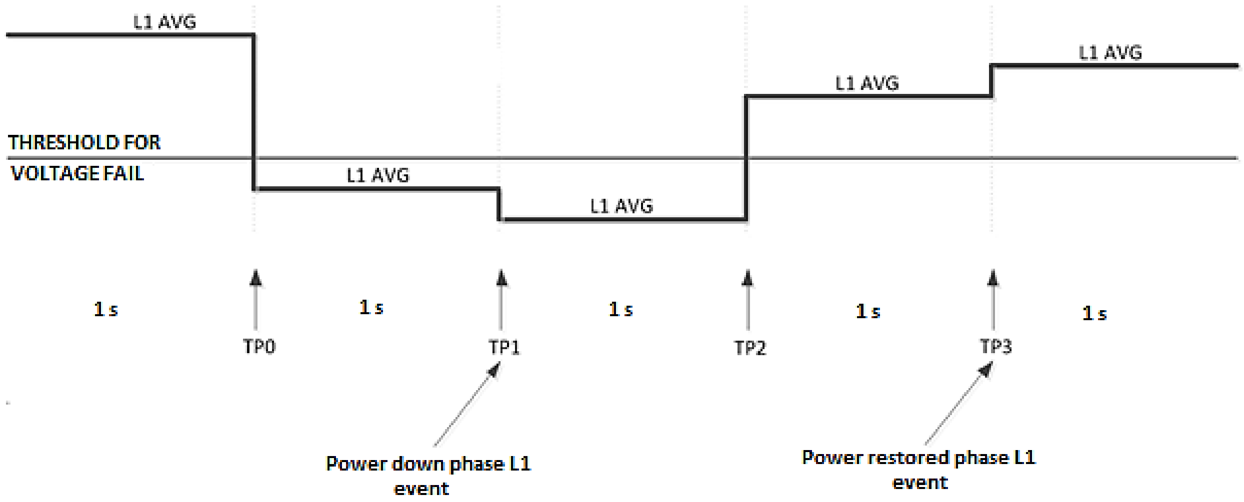


Figure 71: Voltage fail

Voltage fail parameters

Threshold for voltage fail is parameter. It defines threshold below which voltage fail condition is detected. Threshold is defined as percentage of nominal voltage.

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	0-0:128.6.2*255	R			
2. Value	Unsigned16			R/W	0	65535	650
3. Scaler unit	Structure			R			10^-1 %

Table 80: Threshold for voltage fail

NOTE!
If threshold for voltage value is set to 0, then this functionality works on the phase presence information from the measurement chip (voltage level approx. 4.5 V).

6.15.1.9. Power failure

Meter detects and registers power failures per phase, for any phase and for all phases. Registration of power failures is done by:

- incrementing dedicated counters,
- setting alarms,
- storing events in Standard and Power down event logs.

Number of power failures

Every phase failure or all three-phase failure occurrence, regardless of its duration, is counted in dedicated register in the **Number of power failures** (0-0:96.7.**e**) object. Values for "**e"** are 0 for all three phases, 1 for phase L1, 2 for phase L2, and 3 for phase L3.

Time of power failure

Every last occurred power failure is also registered with time in dedicated registers in the **Time of power failure** (0-0:96.7.**e**) object. . Values for "**e"** are 10 for all three phases, 11 for phase L1, 12 for phase L2, 13 for phase L3, and 14 for any phase.

Number of long power failures

Power failures with duration longer than defined time threshold are additionally counted in separate registers in the **Number of long power failures** (0-0:96.7.**e**) object. Values for "**e"** are 5 for all three phases, 6 for phase L1, 7 for phase L2, 8 for phase L3, and 9 for any phase.

The time threshold for long power failure detection can be set in seconds via **Time threshold for long power failure** (0-0:96.7.20) object.

Duration of last long power failure

For each detected and ended long power failure there is information about its last time duration, recorded in the **Duration of last long power failure** (0-0:96.7.**e**) object. Values for "**e**" are 15 for all three phases, 16 for phase L1, 17 for phase L2, 18 for phase L3, and 19 for any phase.

NOTE!
ANY phase counters are not changed or incremented until all phases are restored and present on the meter.

Number of short power failures

Number of short power failures, with duration less than set in the **Time threshold for long power failure** object is registered in the separate **Number of short power failures** (0-0:128.6.1) object.

6.15.2.Power quality indicators (option)

As far as power supply quality assessment is concerned, the meter registers power supply quality irregularities in the metering point, and calculate values of quality indicators.

The meter supports following power quality indicators:

- Slow voltage variation indicator – W1
- Voltage distortion indicator – W2
- Voltage unbalance indicator – W3
- Voltage fluctuations indicator (Plt) – W4

The power quality indicators can be disabled or enabled by object **System functionality manage** (0-0:128.7.130*255); see Figure 72. The functionality is enabled when the bit (B0 – B3) is set.

System functionality manage
Logical name: 0-0:128.7.130*255, Class ID: Data (1), Version: 0

☐ Value : Unsigned — Access mode: Read and write

	Description	ON/OFF
B0	Slow voltage variation indicator	☑
B1	Voltage distortion indicator	☑
B2	Voltage unbalance indicator	☑
B3	Voltage fluctuations indicator (Plt)	☑

Figure 72: Disabling/enabling power quality indicators

Calculated values of power quality indicators are recorded to log (**Data of billing period 2** – 0-0:98.2.0*255) as it is defined in *Execution time* of object **End of billing period 2 scheduler** (0-0:15.1.0*255), e.g. on every Monday at 00:00 local time (it means one week period).

In the log, n-places (n = 1…13) are reserved for the records (number of places is defined in attribute *Profile entries* of object Data of billing period 2).

Object **Data of billing period 2** (0-0:98.2.0*255) is introduced to manage saved records (see Figure 73 and Table 81).

Data of billing period 2
Logical name: 0-0:98.2.0*255, Class ID: Profile generic (7), Version: 1

☐ Capture objects — Access mode: Read and write

Filter:

1583 / 1583 — Selected items 10

	Logical Name	Item	Class Id	Attribute	Data index
1	0-0:1.0.0	Clock	8 - Clock	2 - Time	0
2	0-0:128.7.134	Measurement value W1	3 - Register	2 - Value	0
3	0-0:128.7.137	Measurement value W2	3 - Register	2 - Value	0
4	0-0:128.7.141	Measurement value W3	3 - Register	2 - Value	0
5	0-0:128.7.145	Measurement value W4	3 - Register	2 - Value	0
6	0-0:128.7.135	Evaluated value ΔW1	3 - Register	2 - Value	0
7	0-0:128.7.138	Evaluated value ΔW2	3 - Register	2 - Value	0
8	0-0:128.7.142	Evaluated value ΔW3	3 - Register	2 - Value	0
9	0-0:128.7.146	Evaluated value ΔW4	3 - Register	2 - Value	0
10	0-0:128.55.40	Total number of events during measuring period	1 - Data	2 - Value	0

Figure 73: Data of billing period 2 (example)

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	7	0-0:98.2.0	R			
2. Buffer	Array			R			
3. Capture objects	Array			R	1	32	6
4. Capture period	DoubleLongUnsigned			R	0	86400	0
5. Sort method	Enum			R	1	1	1-FIFO
6. Sort object	Structure			R			Clock
7. Entries in use	DoubleLongUnsigned			R	0	13	0
8. Profile entries	DoubleLongUnsigned			R	0	13	13
Specific Methods							
1. Reset							
2. Capture							

Table 81: Data of billing period 2

Buffer
Storage for power-quality-indicator data captured with every capture execution. Buffer enables selective access per range and entry.

Capture objects
Up to 32 objects can be set to be captured according to *capture period*. Capture objects are set to:

- 0-0:1.0.0, attribute 2 (system time)
- 0-0:128.7.134, attribute 2 (Measurement value W1)
- 0-0:128.7.137, attribute 2 (Measurement value W2)
- 0-0:128.7.141, attribute 2 (Measurement value W3)
- 0-0:128.7.145, attribute 2 (Measurement value W4)
- 0-0:128.7.135, attribute 2 (Evaluated value ΔW1)
- 0-0:128.7.138, attribute 2 (Evaluated value ΔW2)
- 0-0:128.7.142, attribute 2 (Evaluated value ΔW3)
- 0-0:128.7.146, attribute 2 (Evaluated value ΔW4)
- 0-0:128.55.40, attribute 2 (Total number of events during measuring period)

Capture period
Capture period is set to 0 because records are captured according to *End of billing period 2 scheduler*.

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 records are possible in the meter.

Specific methods
Reset – Erases captured values.

Capture – Capture of the record.

The calculation of the evaluated indicator values and saving of the power-quality indicator results are triggered with the scheduler and are defined with the time in the attribute *Execution time*. The trigger period can be set by object **End of billing period 2 scheduler** (0-0:15.1.0*255).

Power-quality-indicator scheduler invokes Script 2 of **MDI reset / End of billing period** (0-0:10.0.1*255). The script calculates indicator evaluated values, then saves the results and measurement values of power quality indicators to the **Data of billing period 2** (0-0:98.2.0*255).

6.15.2.1. Power quality indicator ranges and uncertainty

The values (RMS voltage value, TTHD, Unbalance, P_{st}) are within the uncertainty limits specified in column *Uncertainty* of tables (see Table 82, Table 83, Table 84, Table 85) if:

- the measured phase voltage is within the range defined in the column *Voltage Range*, and
- the values are within the range defined in the column *Output Range*.

If the phase voltage is outside the voltage range specified in column *Voltage range*, the sampled values of RMS voltage value, TTHD, Unbalance are not used for the calculation of the indicators W1, W2, W3. However, W4 is still calculated under these conditions.

If the phase voltage is outside the voltage range specified in column *Voltage range* for the whole averaging period (10 minutes), the output values (RMS voltage value, TTHD, Unbalance) are set to 0. Under these conditions, P_{st} is still calculated.

Value	Voltage range	Output Range	Uncertainty
RMS voltage value	35V – 290V	35V - 290 V	+/- 1%

Table 82: Slow voltage variation indicator W1

Value	Voltage range	Output Range	Uncertainty
TTHD	150V – 290V	0 – 300%	+/- 2%

Table 83: Voltage distortion indicator W2

Value	Voltage range	Output Range	Uncertainty
Unbalance	150V – 290V	0 – 20%	+/- 0,3%

Table 84: Voltage unbalance indicator W3

Value	Voltage range	Output Range	Uncertainty
P_{st}	150V – 290V	0.5 – 8%	+/- 10%

Table 85: Voltage floctuation indicator W4

6.15.2.1.1. Slow voltage variation indicator – W1

Slow voltage variation indicator is implemented in the meter for presenting RMS voltage value behaviour in one period (defined in **End billing period 2 scheduler** (0-0:15.1.0*255)). The meter measures RMS voltage value and calculates average voltage value of 10 minutes (for each phase separately). The calculated average value is compared with value defined in **Nominal voltage** (1-0:0.6.0*255). The comparison result is voltage deviation ratio. The voltage deviation ratio value is then used in calculation with the values of **Maximum allowed over voltage deviation** (0-0:128.7.131*255) and **Maximum allowed under voltage deviation** (0-0:128.7.132*255) to get relative voltage deviation.

Based on defined value in **Input parameter CPW1** (0-0:128.7.133*255) and the relative voltage deviation, maximum value within period defined in **End billing period 2 scheduler** (0-0:15.1.0*255) is recorded in object **Measurement value W1** (0-0:128.7.134*255). Evaluated value ΔW1 is calculated at the end of the period, and recorded in object **Evaluated value ΔW1** (0-0:128.7.135*255). The valuated value ΔW1 represents RMS voltage value behaviour in one period (defined in End billing period 2 scheduler) and evaluation if the RMS voltage value was within definable range.

NOTE!
Maximum allowed increment of over/under voltage deviation object's value is 0.5%.

6.15.2.1.2. Voltage distortion indicator – W2

Voltage distortion indicator represents maximum voltage THD value within one period (defined in **End billing period 2 scheduler** (0-0:15.1.0*255)). The meter continuously measures voltage THD value per phase. Averaging time for THD is 10 minutes. Actual maximum 10-minutes average value of all phases within period is recorded. At the end of the period, the saved maximum value is compared with the value defined in object **Input parameter THD (allowed)** (0-0:128.7.136*255).

Result of the comparison is the ratio; the maximum ratio value is recorded in **Measurement value W2** (0-0:128.7.137*255). Evaluated value ΔW2 is calculated at the end of the period, and recorded in object **Evaluated value ΔW2** (0-0:128.7.138*255). The value of object Evaluated value ΔW2 is assessment of the measured voltage THD value within one period (defined in **End billing period 2 scheduler** (0-0:15.1.0*255)) according to definable range.

6.15.2.1.3. Voltage unbalance indicator – W3

The supply voltage unbalance is evaluated using the method of symmetrical components. The meter measures phase voltages and phase angles, and calculate voltage unbalance. Average value of voltage unbalance is calculated within 10-minutes period and the value is saved. Current calculated value is represented in object **Voltage unbalance K** (0-0:128.7.154*255). **Measurement value W3** (0-0:128.7.141*255) is calculated ratio of the n-percentile voltage unbalance average defined in object **Input parameter CPW3** (0-0:128.7.139*255) and allowed unbalance value in object **Input parameter K (allowed)** (0-0:128.7.140*255).

At the end of the period (defined in **End billing period 2 scheduler** (0-0:15.1.0*255)), a value of **Evaluated value ΔW3** (0-0:128.7.142) is calculated.

The value in object **Evaluated value ΔW3** represents assessments of voltage unbalance value in one period (defined in **End billing period 2 scheduler** (0-0:15.1.0*255)) according to allowed unbalance value.

6.15.2.1.4. Voltage fluctuations indicator (P_{lt}) – W4

Voltage fluctuations indicator (P_{lt}) W4 is calculated from the per-phase long-term flicker severity P_{lt}, which in turn is calculated from the short-term flicker severity P_{st} (where long-term period - P_{lt} is 2 hours and short-term period – P_{st} is 10 minutes). Both values are calculated as specified in standard IEC 61000-4-15.

The P_{lt} value is saved every 2 hours. At the end of period defined in **End billing period 2 scheduler** (0-0:15.1.0*255), the voltage fluctuations indicator is calculated. This value is ratio between n-percentile (defined in **Input parameter CPW4** (0-0:128.7.143*255), of the saved P_{lt} values and the allowed P_{lt} defined in **Input parameter Plt (allowed)** (0-0:128.7.144*255). The voltage fluctuation indicator is represented in object **Measurement value W4** (0-0:128.7.145*255).

At the same time, at the end of period defined in **End billing period 2 scheduler** (0-0:15.1.0*255), **Evaluated value ΔW4** (0-0:128.7.146*255) is also calculated. The value is assessment of the P_{lt} values during the entire period (defined in **End billing period 2 scheduler** (0-0:15.1.0*255)) if the value was in allowed range.

Instantaneous values of P_{st} (10-minutes period) and instantaneous values of P_{lt} (2 hours period) are available as well:

- **Pst value in last short-term period L1** (0-0:128.7.148*255)
- **Pst value in last short-term period L2** (0-0:128.7.149*255)
- **Pst value in last short-term period L3** (0-0:128.7.150*255)
- **Pst value in last long-term period L1** (0-0:128.7.151*255)
- **Pst value in last long-term period L2** (0-0:128.7.152*255)
- **Pst value in last long-term period L2** (0-0:128.7.153*255)

6.15.3.Current monitoring

6.15.3.1. Asymmetric current

Meter samples phase currents instantaneous values every 200 ms and calculates average values of phase currents over monitoring time period set in the **Asymmetric currents time threshold** (0-0:128.7.60) object. This time period is synchronized with meter clock. At the end of time period, each value of average phase current is compared to average value of all phase currents. When any of phase currents goes below asymmetric currents lower threshold set in **Asymmetric currents lower threshold** (0-0:128.7.61) object or above asymmetric currents upper threshold, set in the **Asymmetric currents upper threshold** (0-0:128.7.62) object, asymmetrical condition is detected. Both thresholds are set as percentage with scaler set to -1, which means that thresholds can be set to 0.1% resolution.

Based on asymmetric currents condition, the meter drives corresponding alarm in the alarm register.

6.15.3.2. Phase current missing

Meter samples phase currents instantaneous values every 200 ms and calculates average values of phase currents over monitoring time period set in the **Current missing time threshold** (1-0:11.45.0) object. This time period is synchronized with the meter clock, meaning that each period can end only on certain time points, which correspond to multiples of time period. In addition, if certain period does not accumulate enough samples for valid averaging (due to power down or clock setting), no checking of missing current is executed. Averaging is considered as valid when number of samples lies between 98% and 102% of required samples (calculated as *Current missing time threshold/Sampling period*). At the end of monitoring time period, each value of average phase current is compared to value set in the **Current missing threshold** (1-0:11.39.0) object – I_{min}. When any of phase currents goes below I_{min}, missing current condition is detected. In order to go out of missing current state, average value of phase current must rise above I_{min} + 2% (I_{min}). The hysteresis of 2% is built in to avoid jumping into and out of missing current condition when phase current is near the threshold value. The 2% hysteresis is fixed.

When phase current is detected as missing or when sufficient current is detected, meter logs dedicated events in the event log.

NOTE!
Missing current detection can be disabled by setting the **Current missing time threshold** object parameter to 0.

6.15.3.3. Phase current overlimit

From samples of phase currents instantaneous values meter calculates average values of phase currents over time period set in the **Current overlimit time threshold** (1-0:11.44.0) object. This time period is synchronized with meter clock, meaning that each period can end only on certain time points, which correspond to multiples of time period. In addition, if certain period does not accumulate enough samples for valid averaging (due to power down or clock setting), no checking of missing current is executed.

At the end of time period, each value of average phase current is compared to value set in the **Current overlimit threshold** (1-0:11.35.0) object – I_{max}. When any of phase currents goes above I_{max}, over current condition is detected. In order to go out of over current state, average value of phase current must fall below I_{max} - 2% (I_{max}). The hysteresis of 2% is built in to avoid jumping into and out of over current condition when phase current is near the threshold value. The 2% hysteresis is fixed.

When phase current is detected as overlimit or when current below threshold is detected, meter logs dedicated events in the event log.

6.15.3.4. Current without voltage

From samples of phase currents and phase voltages meter calculates average values over time period set in the **Current without voltage time threshold** (0-0:128.7.70) object. This time period is synchronized with the meter clock. At the end of time period, each value of average phase current is compared to a threshold set in the **Current without voltage – current threshold** (0-0:128.7.71) object and each value of average phase voltage is compared to a threshold set in the **Current without voltage – voltage threshold** (0-0:128.7.72) object. When specific phase current value is above current threshold and corresponding phase voltage is below voltage threshold, condition for current without voltage is detected. This situation is recorded with dedicated event in the fraud event log, and dedicated alarm in the alarm register.

When phase current drops below threshold or phase voltage rises above threshold, the meter will record end of current without voltage condition. In order to prevent several events when phase currents or phase voltages are right on the level of thresholds, the 2% hysteresis is implemented. This means that in order to detect current without voltage condition end, phase current must drop additional 2% below or phase voltage must rise additional 2% above parameterized thresholds.

The thresholds for current and voltage as well as averaging time period can be set as parameters via dedicated COSEM objects.

Current threshold must be set in mA, and voltage threshold must be set as percentage of nominal voltage, with scaler set to -1, which means that threshold can be set to 0.1% resolution.

NOTE!
When the **Current without voltage time threshold** object parameter is set to 0, means that current without voltage detection is disabled.

6.15.3.5. Negative energy flow

Meter constantly monitors direction of current flowing through each phase terminal. When specific phase current is found to be flowing out of phase terminal (energy generation), alarm for negative phase energy flow is set. There is specific alarm for each phase.

Additionally when energy direction in one phase is different from energy direction of two other phases and all energies are above current threshold (set as parameter), meter starts running a timer. If such condition stays for a time period longer than is set in the **Reverse power flow time threshold** (0-0:128.7.80) object, the meter detects reverse energy flow condition. When later all energies start flowing in same direction or at least one of the energy falls below threshold, meters starts running a timer again. If same condition stays for a time period longer than is set in the **Reverse power flow time threshold** object, the meter detects normal phase sequence condition. Reverse energy flow condition is registered via dedicated events in the **Fraud detection log** (0-0:99.98.1) object.

Reverse energy flow condition can only be detected if current values of all three phases are above threshold level which is set as parameter in mA.

NOTE!
Reverse energy flow is disabled when the **Reverse power flow time threshold** object parameter is set to 0.

6.15.4. THD monitoring

Total harmonic distortion (THD) of a signal is a measurement of the harmonic distortion present, and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. Per phase THD value for voltage and current are obtained from the measurement chip. The number of harmonics that measurement chip analyses is 63.

Meter constantly monitors THD values on each phase. When value on any phase increase above threshold for voltage/current THD after time threshold for voltage/current THD, proper start event is recorded (see event code tables in chapter *6.5. Event logs* and its subchapters). Otherwise, when THD value fall below defined threshold, stop event is recorded.

NOTE!
Measuring the THD value takes up to three seconds.

6.15.4.1. THD for voltage

Threshold for voltage THD (0-0:128.7.110*255) is a parameter that defines threshold, above which voltage THD condition is detected. Threshold is defined as percentage of nominal THD for voltage.

Time threshold for voltage THD (0-0:128.7.111*255) is a parameter that specifies the required duration (in seconds), for which specific voltage THD must rise above »Threshold for voltage THD« until voltage THD condition is detected.

6.15.4.2. THD for current

Threshold for current THD (0-0:128.7.120*255) is a parameter that defines threshold, above which current THD condition is detected. Threshold is defined as percentage of nominal THD for current.

Time threshold for current THD (0-0:128.7.121*255) is a parameter that specifies the required duration (in seconds), for which specific current THD must rise above »Threshold for current THD« until current THD condition is detected.

6.15.5. Frequency monitoring

The MT880 meter measures frequency and monitors the frequency value. The nominal frequency is defined as parameter in the object Measurement system configuration (0-0:196.0.0.255). Default value is 50 Hz. The frequency value is monitored by frequency-monitoring functionality.

6.15.5.1. Over/under frequency

Over or under frequency status is detected when the frequency value drops below / rise above the values defined in object **Under frequency threshold** (0-0:128.7.162*255) / object **Over frequency threshold** (0-0:128.7.161*255) over time defined in object **Under and over frequency time threshold** (0-0:128.7.164*255) and the *Frequency over limit* or *Frequency under limit* event is recorded (see chapter *6.5.3. Power quality log*). Over or under frequency status ends when the frequency value is returned back into range between thresholds; the *Frequency normal* event is recorded.

NOTE!
If **Under and over frequency time threshold** value is set to 0, then the frequency monitoring functionality is disabled.

6.15.6.Wrong phase sequence

Measurement circuit constantly monitors zero crossing on all phase voltages. When sequence of zero crossing transitions does not follow correct order (L_1 L_2 L_3 or L_2 L_3 L_1 or L_3 L_1 L_2), measurement circuit detects incorrect phase sequence. This information is sampled every 200 ms and aggregated over longer aggregation time period. If measurement circuit reports incorrect phase sequence for longer than defined aggregation period, meter records wrong phase sequence condition as alarm and event.
Aggregation period for wrong phase sequence detection is configurable via the dedicated **Wrong phase sequence time threshold** (0-0:128.7.90) object.

Wrong phase sequence is registered in the **Standard event log** (0-0:99.98.0) object.

NOTE!
When voltage phase sequence does not follow correct order (L_1 L_2 L_3 or L_2 L_3 L_1 or L_3 L_1 L_2), measurements of the active and reactive energy are correct despite the recorded alarm and event.

6.15.7.Low power factor

Meter is able to detect condition when three phase power factor drops below certain threshold.
From samples of three-phase power factor (positive and negative) and three-phase apparent power, the meter calculates average value over time period set in the **Low power factor time threshold** (1-0:13.43.0) object. This time period is synchronized with meter clock. At the end of time period, each value of average three phase power factor is compared to a threshold set in **Low power factor threshold** (1-0:13.31.0) object. When three phase power factor value is below threshold and three phase apparent power is above value set in the **Low power factor apparent power threshold** (0-0:128.7.100) object, condition for low power factor is fulfilled.
This situation is registered with dedicated event in the **Fraud detection log** (0-0:99.98.1) object.

Meter will also record end of low power factor condition when three-phase power factor rises above threshold or three phase apparent power drops below threshold. In order to prevent several events when three phase power factor or three-phase apparent power are right on the level of thresholds, the 2% hysteresis is implemented. Low-power factor detection includes three phase power factor positive and negative values.

6.15.8.Tampering

6.15.8.1. Meter cover and terminal cover opening

Possible unauthorized access to the meter (opening and closing the meter or terminal cover) is detected by the meter. Events are stored in fraud attempt status and in a MCO & TCO event log (see chapter *6.5.6. MCO & TCO event log*).

In order to avoid multiple increments of the meter of openings (rebounds), a timeout of 5 seconds is set up at the closing of the covers. During this timeout, no new openings are detected.

If meter is in a power down mode, only the first opening of each cover is detected. The event is logged at power up with date and time of power up. When the meter is in a power down state, the monitoring of covers opening is active so long as backup supply is present.

6.15.8.1.1. Cover Opening Counter

Cover opening counter in the **Cover opening counter** (0-0:96.15.0) object represents number of terminal cover openings.

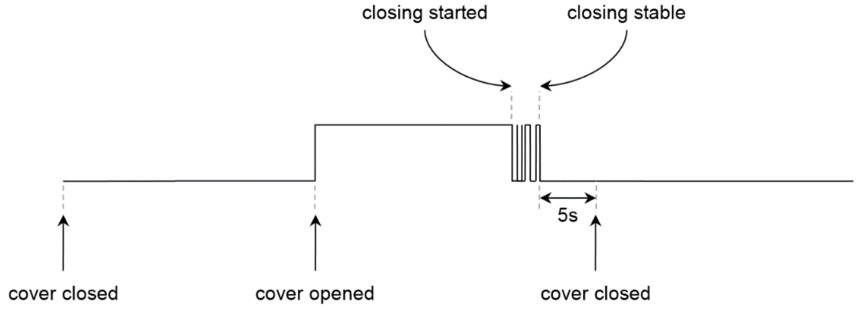


Figure 74: Cover Opening/Closing Detection

6.15.8.2. Magnetic field detection

Meter has integrated magnets sensor, which detects presence and removal of the external magnetic fields. Events are detected as the fraud attempt status and are recorded in the magnetic tamper event log (see chapter *6.5.7. Magnetic tamper event log).*

Detection of the magnetic field is possible also when meter is in a power down mode. If backup supply is not present or discharged, then magnetic field detection does not operate.

Status of magnetic field presence/absence is updated every 1.5 seconds. Events are recorded with date and time of occurrence. If strong magnetic field is detected during power down this event is recorded with date and time of next meter power up.

6.15.9. Meter parameterization monitoring

Meter parameters can be changed via different communication interfaces. Each parameterization is being registered by the meter with the following information:

- parameterization counter – the **Number of configuration program changes** (0-0:96.2.0) object is incremented,
- date and time of last parameterization – the **Date of last configuration program change** (0-0:96.2.1) object is refreshed with current time,
- if parameter being changed is on the list of certified parameters, timestamp, parameter identification, old value and new value are stored in certification log.

6.15.10. Watchdog counter

Meter is equipped with watchdog protection circuit, which would reset main microcontroller in case of undesired processing delay or program flow. Each watchdog reset event is counted in the dedicated **Watchdog resets** (0-0:128.6.0) counter object and logged in standard event log.

Watchdog counter is incremented by one, at system restart after every watchdog reset. Special timer is used to monitor number of watchdog resets within time period. Only when 10 or more watchdog resets are detected within 2-hour period, the watchdog error is generated on the corresponding bit in error register.

6.15.11. Internal status presentation

6.15.11.1. Internal control signal status C.4

Specific objects are implemented to present the states of the internal control signals. Table 86 explains in detail the meaning of the value attribute derived from a particular COSEM object.

Ob-jects	**Internal control signal status** (0-0.96.4.0)			
	Internal control signal status 4 (0-0.96.4.4)	**Internal control signal status 3** (0-0.96.4.3)	**Internal control signal status 2** (0-0.96.4.2)	**Internal control signal status 1** (0-0.96.4.1)
Bit	**4th octet**	**3rd octet**	**2nd octet**	**1st octet**
b7	Load control activation	Active energy flow+	reserved	Tariff 1
b6	reserved	Reactive energy flow+	reserved	Tariff 2
b5	reserved	Apparent energy flow+	reserved	Tariff 3
b4	reserved	reserved	reserved	Tariff 4
b3	reserved	reserved	reserved	Tariff 5
b2	reserved	reserved	reserved	Tariff 6
b1	reserved	reserved	reserved	Tariff 7
b0	reserved	reserved	reserved	Tariff 8

Table 86: Internal control signal status content explanation (C.4)

6.15.11.2. Internal device state status C.5

To monitor the internal states of the device, specific objects are implemented. Table 87 explains the meaning of the value attribute derived from a particular COSEM object.

Ob-jects	**Internal state status** (0-0.96.5.0)			
	Internal state status 4 (0-0.96.5.4)	**Internal state status 3** (0-0.96.5.3)	**Internal state status 2** (0-0.96.5.2)	**Internal state status 1** (0-0.96.5.1)
Bit	**4th octet**	**3rd octet**	**2nd octet**	**1st octet**
b7	Billing lockout – key	Parameterized state	Active energy start-up	Voltage phase L1
b6	Billing lockout – optical interface	Set state	Reactive energy start-up	Voltage phase L2
b5	Billing lockout – electrical interface	Tariff time switches tariffs	Apparent energy start-up	Voltage phase L3
b4	reserved	reserved	reserved	Valid rotating field
b3	reserved	reserved	reserved	reserved
b2	reserved	reserved	reserved	reserved
b1	reserved	reserved	reserved	reserved
b0	reserved	reserved	reserved	reserved

Table 87: Internal device status content explanation (C.5)

6.15.12. Operation time, non-operation time, TOU timers

MT880 meter provides information of meter in operation time and operation time by tariffs with integrated timer. Obtained data are accessible by MeterView in **Time of operation** (0-0:96.8.0) and in **Time of registration rate** object (0-0:96.8.**t**). Label "**t**" represents tariffs from 1 to 8.

Meter has also functionality to calculate time of non-operation state, which data are accessible in **Time of non-operation** (0-0:196.8.0) object.

NOTE!
Operation time, non-operation time, and TOU timers registers represent values in seconds. On the LCD, those values are represented in minute.

NOTE!
If the meter is powered through auxiliary supply, the meter counts time of non-operation.

6.16. System access configuration

System access options object (0-0:128.90.0) is implemented to support various runtime configurations, protected with parameterisation key, for special customer requests.

Object can be modified in higher parameterisation mode only – PARAM key must be locked (Table 88).

Bit	Description
0	Load profile restrictions enabled
1	Image transfer restrictions enabled
2 … 15	*Unused*

Table 88: Bit field definition for restrictions

System access rights options object (0-0:128.90.1) holds system access rights which can be either read only or read and write. Restrictions are active only when parameter key is locked. See Table 89.

Bit	Description
0	General level access
1	Three-level access *
2 … 15	*Unused*

* Three-level access specification:

- Level 1 – READ access only
- Level 2 – READ access only + time & date settings
- Level 3 – READ and WRITE access

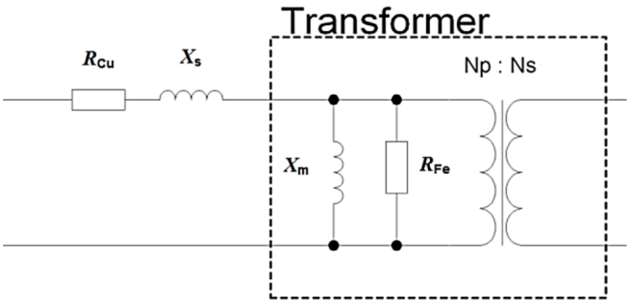
Table 89: Bit field definition for system access rights

6.17. Transformer and line losses

The meter performs measurements of losses in a grid, which are generated by all energy transfers in the grid.

6.17.1. Transformer energy losses

The model of the line and the transformer used for loss calculation is shown in Figure 75.



Legend:
R_{Cu} – Line resistance losses
X_s – Line reactance losses
X_m – Transformer magnetic losses
R_{Fe} – Transformer iron losses
Np – Number of turns on the primary side of the transformer
Ns – Number of turns on the secondary side of the transformer

Figure 75: Model of line and transformer for calculation of loss quantities

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:0.10.1*255	R			
2. Value	Unsigned32			R/W	0	4294967295	0
3. Scaler unit	Structure			R			10^0 Ohm

Table 90: Transformer iron losses R_{Fe}

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:0.10.2*255	R			
2. Value	Unsigned32			R/W	0	4294967295	0
3. Scaler unit	Structure			R			10^-3 Ohm

Table 91: Line resistance losses R_{Cu}

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:83.8.4*255	R			
2. Value	Unsigned64			R	0	2^64 -1	0
3. Scaler unit	Structure			R			10^0 Wh

Table 92: Active transformer losses +

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:83.8.5*255	R			
2. Value	Unsigned64			R/W	0	2^64 -1	0
3. Scaler unit	Structure			R			10^0 Wh

Table 93: Active transformer losses –

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:83.8.1*255	R			
2. Value	Unsigned64			R	0	2^64 -1	0
3. Scaler unit	Structure			R			10^0 Wh

Table 94: Active line losses +

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:83.8.2*255	R			
2. Value	Unsigned64			R/W	0	2^64 -1	0
3. Scaler unit	Structure			R			10^0 Wh

Table 95: Active line losses –

6.17.2.Coil and Winding losses

A meter makes a measurement of two types of losses, related to voltage (Iron) and current (Copper):

- **U^2t** – Coil (Iron) losses (related to voltage)
- **I^2t** – Winding (Copper) losses (related to current)

The meter measures and calculates losses values of I^2t and U^2t with detection of current direction flow, respectively as it is presented in Table 96.

	Energy flow direction	Related to	Type of losses	Registered in OBJECT
$+I^2t$	Positive	Current	Winding (Copper) losses	**1-0:88.8.1*255 (Ampere-squared hours +)**
$-I^2t$	Negative	Current	Winding (Copper) losses	**1-0:88.8.2*255 (Ampere-squared hours -)**
$+U^2t$	Positive	Voltage	Coil (Iron) losses	**1-0:89.8.1*255 (Voltage-squared hours +)**
$-U^2t$	Negative	Voltage	Coil (Iron) losses	**1-0:89.8.2*255 (Voltage-squared hours -)**

Table 96: Coil and Winding losses

NOTE!
When a meter is in No Load condition, positive Coil (Iron) losses are registered.

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:88.8.1*255	R			
2. Value	Unsigned64			R	0	2^64 -1	0
3. Scaler unit	Structure			R			10^0 A^2h

Table 97: Positive Winding (Copper) losses

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:88.8.2*255	R			
2. Value	Unsigned64			R	0	2^64 -1	0
3. Scaler unit	Structure			R			10^0 A^2h

Table 98: Negative Winding (Copper) losses

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:89.8.1*255	R			
2. Value	Unsigned64			R	0	2^64 -1	0
3. Scaler unit	Structure			R			10^2 V^2h

Table 99: Positive Coil (Iron) losses

Attributes	Data type	Class ID	Code	Access	Min.	Max.	Default
1. Logical name	Octet-string	3	1-0:89.8.2*255	R			
2. Value	Unsigned64			R	0	2^64 -1	0
3. Scaler unit	Structure			R			10^2 V^2h

Table 100: Negative Coil (Iron) losses

6.17.3. Console format

Console presentation of losses objects is defined by separate formatting system with following default presentation:

- Registers 1-0:89.8.1*255 and 1-0:89.8.2*255 are presented with 7 whole digits and 1 decimal digit (7+1 format) in units kV^2h.
- Registers 1-0:88.8.1*255 and 1-0:88.8.2*255 are presented with 5 whole digits and 3 decimal digits (5+3 format) in units kA^2h.

6.17.3.1. Display format for Voltage-squared hours

Display format for Voltage-squared hours COSEM object (0-0:196.1.17*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).
- P = Precision:
  - Precision is a number of decimal digits for energy presentation on display.
  - Last nibble of object's value (lower half of byte).
- Default value: 81
  - Width: 8 digits
  - Precision: 1 digit
  - Format form: 0000000.0
- Precision value should be lower than the width value.
- Maximum width value is 8 digits (number of large digits on LCD).
- Otherwise the »Error 31« (value format failed) message is displayed.

6.17.3.2. Display format for Ampere-squared hours

Display format for Ampere-squared hours COSEM object (0-0:196.1.18*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).
- P = Precision:
  - Precision is a number of decimal digits for demand presentation on display.
  - Last nibble of object's value (lower half of byte).
- Default value: 83
  - Width: 8 digits
  - Precision: 3 digits
  - Format form: 00000.000
- Precision value should be lower than the width value.
- Maximum width value is 8 digits (number of large digits on LCD).
- Otherwise the »Error 31« (value format failed) message is displayed

NOTE!
Units are not displayed because meter does not have a capability to display V^2h or A^2h

6.17.4. Profile format

All registers related to losses are presented in profile as objects presented in chapter *6.17. Transformer and line losses*. This presentation is according to the COSEM specification and is independent from console presentation (described in chapter *6.17.3. Console format*). Scaler unit attribute defines the presentation of the registers.

7. SECURITY

MT880 meter security is divided into:

- **physical security**,
- **logical security**.

The physical security protects the meter from different tampering attempts and unauthorized accesses. With the increase of smart metering and the rise of AMI infrastructures, also the logical security was introduced in the MT880 meter.

7.1. Physical security

Physical security is comprised of:

- **seal protection** and
- **parameters protection button** (PARAM key).

7.1.1. Seal protection

There are different sealing places on the meter (see Figure 76):

- The meter cover is sealed with two metrological seals, which could be removed only by authorized person.
- The terminal cover is sealed with two utility seals.
- The transparent window on the meter cover, which covers the billing reset button, could be sealed with utility seal.
- The communication module could be sealed with one utility seal (see Figure 77).
- The COP5 terminal cover could be sealed with one utility seal (see Figure 77).

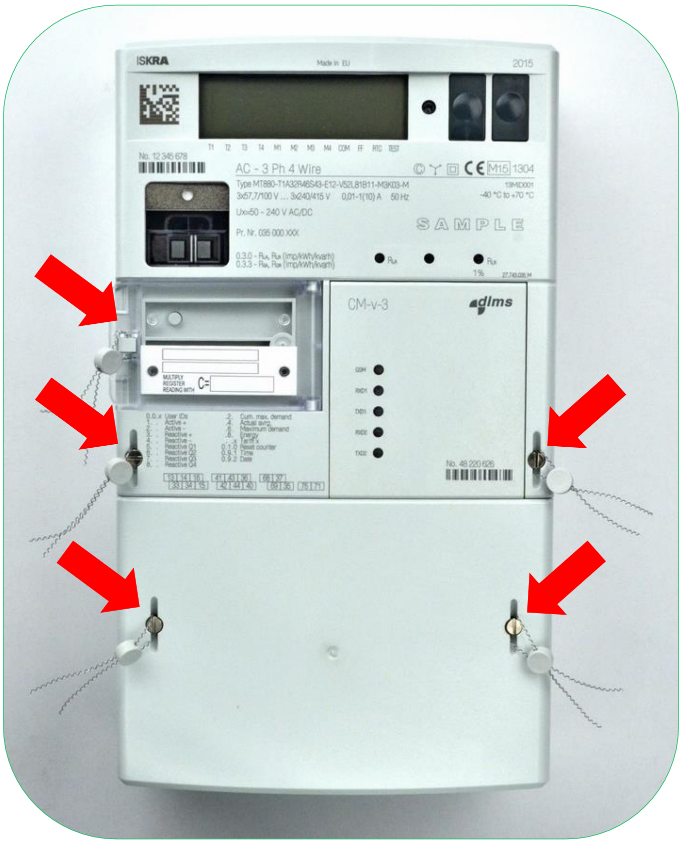


Figure 76: Meter and a terminal cover seal positions

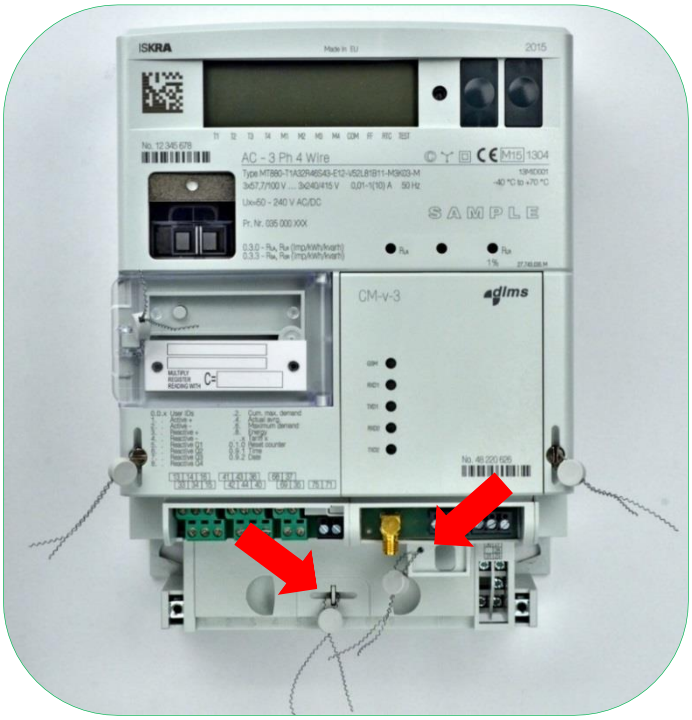


Figure 77: COP5 and a communication module seal positions

7.1.2. Parameters protection button

In order to prevent unauthorized access to the specific meter parameters or execution specific scripts parameterisation, the parameters protection button is located under the meter cover. To access the parameters protection button, the meter cover has to be opened (metrological seals must be removed) and the parameters protection button (PARAM key) could be pressed. The meter will be hardware unlocked, in so-called parameterization mode for 5 minutes or until the first power down.

Parameterization mode is visible via the meter LCD by flashing of first six flags on the LCD (see Figure 33).

7.2. Logical security

Logical security in MT880 meter is divided into two separate entities:

- DLMS/COSEM Security,
- Secure Storage.

7.2.1. DLMS/COSEM security

DLMS/COSEM provides two main information security features for accessing and transporting data**:**

- **data access security** controls access to the data held by a DLMS/COSEM server,
- **data transport security** allows the sending party to apply cryptographic protection to the xDLMS APDUs to ensure confidentiality and integrity. This requires ciphered ADPUs.

The information is given partly at the beginning of the application association establishment with two services:

- **application context** (are ciphered APDUs allowed or not),
- **authentication context** (the level of data access security),

and partly by COSEM objects which define access to specific attributes.

Data access security

Data access security is managed by the Association LN object. Each COSEM server i.e. a logical device may support Application Associations with various clients, each having a different role, and with this, different access rights. Each Association object provides a list of objects visible in that particular Application Association and also the access rights to objects' attributes and methods.

To be able to access data, the client must be properly authenticated. Upon Application Association establishment, an authentication context is negotiated between the client and the server. This specifies the required authentication of the peers, and, where needed, the security algorithm to verify the authentication. Three data access security levels are provided:

- Lowest level security (no security),
- Low Level Security (LLS),
- High Level Security (HLS).

The MT880 meter supports three different clients with three different behaviours regarding authentication minimal requirements, as shown in Table 101.

Client name	Client L-SAP	Minimal Security Requirements
Public	16	Lowest level security (no security)
Management	1	HLS (LLS as a backup)
Pre-established	102	No HLS nor LLS

Table 101: Set of supported clients

For every security level, different authentication procedures are required. Authentication context and specifically the COSEM Authentication Mechanism Name are presented in Table 102.

Authentication Mechanism Name	ID
COSEM lowest level security mechanism name	0
COSEM low level security mechanism name	1
COSEM high level security mechanism name using MD5	3
COSEM high level security mechanism name using SHA-1	4
COSEM high level security mechanism name using GMAC	5

Table 102: Supported authentication mechanism names

Lowest Level Security

This authentication context does not require any peer authentication; it allows direct access to the data in the server, within the access rights available in the given Application Association.

Authentication mechanism name is therefore not present in Application Association Request.

Low Level Security (LLS)

The purpose of Low Level Security is to allow the authentication of clients by verifying the password supplied. The server is not authenticated. The client has to supply the correct password during the process of Application Association establishment. If the password is accepted, the Application Association is established and the client can access data within the access rights available in the given Application Association. Otherwise, the Application Association is not established.

High Level Security (HLS)

The purpose of High Level Security is to allow mutual authentication of the client and the server participating in an association.

This is a 4-pass process, involving the exchange of challenges during Application Association establishment, which is followed by exchanging the results of processing these challenges, using cryptographic methods. If the authentication takes place, the client can proceed to access data within the access rights available in the given Application Association, and it accepts data coming from the server. Otherwise, the Application Association is not established. When the number of unauthorized accesses (Authentication Failure Count) is bigger than predefined limit (Authentication Failure Count Limit), the meter logs a respective event and rejects every subsequent application request for a predefined amount of time (60s). With this mechanism, the risk of brute force attacks is mitigated. The last unauthorized access is time stamped (Authentication Failure Stamp).

According to secure meter communication, it is possible to access the MT880 meter only with Application Association, which is currently active in the meter. If user wants to access the meter with different Application Association, new authentication mechanism name has to be written in the currently active Application Association's *Authentication mechanism name* attribute (*Authentication mechanism id*) of the *Current association* object. The meter can now be accessed with the new Application Association.

Data transport security

Data transport security relies on applying cryptographic protection to xDLMS APDUs. This is achieved via several security mechanisms. The first mechanism is incorporated in application association request with two application service elements:

- The COSEM application context,
- User information filled with Initiate Request primitive.

ASEs involved in security

Table 103 shows Different application context names and the relation between those names and allowed types of xDLMS APDUs. Ciphered APDUs are allowed only in Application context name with ciphering.

Application Context Name	ID	Unciphered APDUs	Ciphered APDUs
Logical Name Referencing no ciphering	1	Yes	No
Short Name Referencing no ciphering	2	Yes	No
Logical Name Referencing with ciphering	3	Yes	Yes
Short Name Referencing with ciphering	4	Yes	Yes

Table 103: Application context names

Security context

The second mechanism is called the security context. The security context defines security attributes relevant for the data transport security process of ciphering/deciphering. The elements are:

- Security policy (determining what kind of protection to be used),
- Security suite (specifying the security algorithm),
- Security material relevant for the given security suite
- Encryption keys,
- Authentication keys,
- Initialization vectors (comprised of System title and current frame counter).

Usage
Encryption/decryption

GCM and its authentication derivate GMAC are used to encrypt and authenticate xDLMS APDUs as presented in Figure 78.

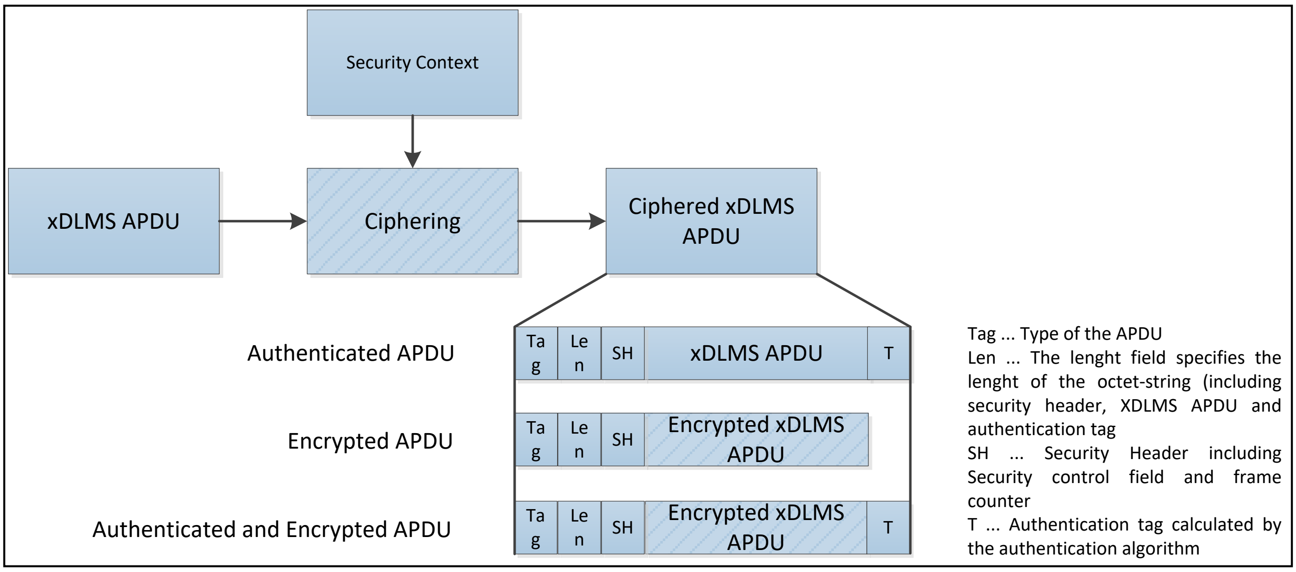


Figure 78: Procedure for ciphering xDLMS APDU

If the authentication and decryption fails at the DLMS/COSEM server, several indications are logged. If the authentication or decryption of the xDLMS APDU is not confirmed and properly restored then respective informative objects are updated (Decryption/Authentication Failure Count, Decryption/Authentication Failure Stamp).

Key Changing

All global keys are changed by using the security_setup global_key_transfer method.
Possible responses from the meter:

- If the “new” key is accepted, then the meter sends Action Response (same invoke_id and priority as the request): SUCCESS ciphered with “currently used” key. From this point on, meter uses the “new” key (replacing the “currently used” key with “new” key) and resets FC,
- If the type of the data in the Action Request is not correct then the meter answers with Action Response(same invoke_id and priority as the request): Data_Access_Error=Type unmatched,
- If the meter cannot decrypt the pdu (request encrypted with invalid key) Response (state-error=service-not-allowed, service-error=operation-not-possible).

Security Policy Changing

The Security Policy may be changed by invoking the security_activate method of the security setup object, or by setting the security_policy attribute of the security setup object.

Putting the meter into the field

The following process is performed:

- in the factory, the security policy is set to zero (if it is not requested by the customer),
- commissioning is performed during installation via the local port using HLS (mechanism_id 3 or 4) or LLS (without using any encryption key). In this case, it is assumed that the ”HLS secret” is set in the factory into the meter and that the ”HLS secret” is known to the client at the local port. Alternatively, HLS (mechanism_id 5) might be used but in this case the default keys (set in the factory) have to be exposed and need therefore to be changed (remotely) after commissioning,
- securing the meter: The security policy is set to >0 either locally or remotely after commissioning of the meter,
- if keys are used in step 2 then they have to be exchanged remotely.

7.2.1.1. Authentication failure settings

If authentication failed (wrong password), time stamp in object **Decryption failure stamp** (0-0:196.98.4*255) / **Decryption failure stamp (2) (**0-1:196.98.4*255) is recorded. Every failed authentication is recorded (incremented by 1) in object **Authentication failure count** (0-0:196.98.1*255) / **Authentication failure count (2)** (0-1:196.98.1*255). When counter value of failed authentications increased to the limit set in object **Decryption and authentication failure count limit** (0-0:196.98.2*255) / **Decryption and authentication failure count limit (2)** (0-1:196.98.2*255), authentication attempt is blocked for time defined in object **Time of login after blocking** (0-0:128.100.75*255). The time is defined in minutes. It can be set from 10 to 60 minutes (incremented by 10 minutes).

7.2.2. Additional communication security

There are several Iskraemeco add-ons to DLMS/COSEM security.

DLMS options channel (0-**c**:128.70.0) object, where **"c"** stands for the channel 0, 1, 2 or 3.
With this object, different settings can be introduced and technology shortcomings can be solved. This object (for every channel on which COSEM server is present) is introduced in order to cater different market requirements. Option bits are:

- Bit 0 – Ignore HDLC service class (need to be set for those E-meters that have external modem communicating with microprocessor via HDLC),
- Bit 1 – Security replay attack prevention (frame counter checking),
- Bit 2 – Association Establishment with AARQ/AARE and Association Release follows diction in [2]. Setting this bit means that Request for Unciphered Application Association cannot use ciphered context.
- Bit 3 – When bit is set, the corresponding communication channel is read-only (any write or action operation is rejected by the meter). The read-only configuration is active only when meter is locked.

DLMS association restrictions channel (0-c:128.70.1) object, where **"c"** stands for the channel 0, 1, 2 or 3.
With this object, different associations can be prohibited on the same server running on one communication channel. One can disable public, management, pre-established or combination of those Application Associations by writing proper value in this object.

HDLC Channel options (0-c:128.75.0) object, where **"c"** stands for the channel 0, 1, 2 or 3.
With this object, different options can be set:

- Bit 0 – Enable response delay for HDLC; response delay is set in IEC Local port object - attribute 5. It is time between last received and first transmit byte.

7.2.3. Secure storage

Secure storage is a reserved space in non-volatile memory, which is cryptographically protected. In secure storage meter stores all the necessary global encryption, authentication, and master keys.

The main characteristics of this mode are:

- provide security for storage data at rest (not in transit),
- tweakable block cipher encryption mode ("non-malleable"),
- usage of two keys (in process of encryption/decryption) derived from cryptographic salt and hidden passwords.

8. COMMUNICATION

8.1. Communication variants

Beside of the meter variant with communication interfaces, integrated on the meter's main board, there is a modular variant with the exchangeable communication interfaces.

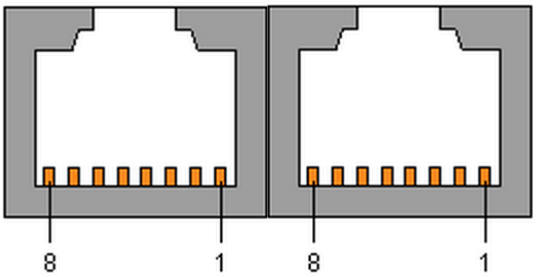
NOTE!
The communication response of the meter is slower when the meter communicates over the several ports at the same time. This meter behaviour need to be taken into account the time critical system, which communicate with the meter (LMN module).

8.1.1. Integrated variant

Meter has up to three independent communication interfaces in integrated meter variant:

1. optical communication interface;
2. RS232/RS485 communication interface on the main meter board;
3. additional RS485 communication interface is placed on the upper PCB and is accessible via RJ45 connector. RJ45 connector enables also power supply for the modem (2.5 W, 12 V DC).
(See Figure 79 and Figure 80.)

Figure 79: RJ45 connectors for RS485 interface connection (for integrated variant only)



Left:	Right:
1 – Vdc +12 V	**1 –** NC
2 – NC	**2 –** NC
3 – NC	**3 –** NC
4 – A	**4 –** A
5 – B	**5 –** B
6 – NC	**6 –** NC
7 – Vdc -0 V	**7 –** NC
8 – NC	**8 –** NC

Figure 80: Description of RJ45 (8 pins) for RS485 interface connection

8.1.2. Modular variant

Meter has up to four independent communication interfaces in modular meter variant:

1. optical communication interface
2. RS232/RS485 communication interface on the main meter board
3. exchangeable communication module with two-/three-communication interfaces

A single port can run on various physical interfaces using different protocols. Since different physical interfaces are also related to hardware configuration, an individual port can only support a limited amount of interface variants.

Port	Physical	Protocol	Meter type
P0	Optical	IEC 62056-46 (DLMS/HDLC) IEC 62056-21	Modular, Integrated
P1	RS485 or RS232	IEC 62056-46 (DLMS/HDLC) IEC 62056-21	Modular, Integrated
P2	CS	IEC 62056-46 (DLMS/HDLC) IEC 62056-21	Modular
	GSM/ GPRS/UMTS	IEC 62056-46 (DLMS/HDLC) IEC 62056-21	Modular
	Ethernet	IEC 62056-46 (DLMS/HDLC) via Consereth IEC 62056-47 IEC 62056-21	Modular
	MODBUS	Modbus/TCP Modbus/RTU	Modular
	LMN	VDE/FNN Lastenheft leitungsgebundene LMN-Protokolle	Modular
P3	RS485	IEC 62056-46 (DLMS/HDLC) IEC 62056-21	Modular, Integrated (via RJ45)

Table 104: Communication interfaces and protocols

8.1.3. Variant configuration

The configuration of integrated/modular communication variant can be configured via the dedicated **Communication variant configuration** (0-0:128.21.1) object.

Parameter value	Description
0	Modular communication
1	Integrated communication

Table 105: Communication variant configuration enumeration

On the integrated meter version (parameter value 1), communication port 2 is unused and communication port 3 is used for upper RS485 interface.

8.2. Settings

Each communication port can be configured using **IEC local port setup** (0-**b**:20.0.0) and **IEC HDLC setup** (0-**b**:22.0.0) objects, presented in Table 106. Value "**b"** presents dedicated channel (0, 1, 2, or 3).
Certain communication profiles rely on additional objects for full configuration setup. The configurations are hardware and protocol specific and are presented in detail in subsequent chapters.

Port	Object
P0	IEC local port setup – channel 0 (0-0:20.0.0) IEC HDLC setup - channel 0 (0-0:22.0.0)
P1	IEC local port setup – channel 1 (0-1:20.0.0) IEC HDLC setup - channel 1 (0-1:22.0.0)
P2	IEC local port setup – channel 2 (0-2:20.0.0) IEC HDLC setup - channel 2 (0-2:22.0.0)
P3	IEC local port setup – channel 3 (0-3:20.0.0) IEC HDLC setup - channel 3 (0-3:22.0.0)

Table 106: Communication ports and related COSEM objects

8.2.1. IEC local port setup object attributes

Communication mode defines the communication protocol used by the meter on a specific port:

- 0 – protocol according to IEC 62056-21 (1107, limited and manufacturer specific functionality),
- 1 – protocol according to IEC 62056-46 (DLMS UA).

Default baud rate is the baud rate used by the corresponding communication interface. The following baud rates can be applied for IEC local port setup:

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

Due to port and interface related hardware limitations, a specific communication interface can only support a limited set of baud rates:

- Optical interface enables maximum baud rate up to 57600 baud, in no power state up to 19200 baud,
- RS232 and RS485 on the meter maximum baud rate up to 38400 baud,
- CS interface up to 19200 baud,
- RS485 interface on module and the 2G, 3G and Ethernet communication module enables baud rate up to 115200 baud.

Propose baud rate defines the baud rate to be proposed by the meter. Default and proposed baud rates can only differ when default mode 0 (protocol according to IEC 62056-21) is configured

Response time defines the minimum time between the reception of the request (end of the request telegram) and the transmission of the response (beginning of the response telegram). The following options are available:

- 0 – 0-20 ms,
- 1 – 0-200 ms.

Device address is intended to identify the meter in the group of meters using an eight-digit number.
The attribute is of no relevance when the communication interface is configured using protocol according to IEC 62056-46 (DLMS UA).

Settings password is used only in conjunction with communication protocols according to 62056-21 during a connection establishment process. If using protocol according to 62056-46, the attribute has no relevance.

Parameterisation password and *W5 password* are currently not in use.

8.2.2. IEC HDLC setup object attributes

Communication speed attribute defines communication speed. Communication speed values are the same as at the **IEC local port setup** object attribute *Default baud rate*. See chapter *8.2.1. IEC local port setup object attributes*.

The use of communication speed attribute is deprecated and has no impact on setting the port's baud rate.

Windows size transmit attribute defines the maximum number of frames that a device or a system can transmit before it needs to receive an acknowledgement from the corresponding station. Another value can be negotiated during a connection establishment process.

Window size receive defines the maximum number of frames that a device or system can receive before it needs to transmit an acknowledgement to the corresponding station. Another (lower) value can be negotiated during a connection establishment process

Max info field length transmit attribute defines the maximum information field length of HDLC frames that a device can transmit. Another (lower) value can be negotiated during a connection establishment process.

Max info field length receive attribute defines the maximum information field length that a device can receive. Another (lower) value can be negotiated during a connection establishment process.

Inter octet time out defines the time (in milliseconds) during which the next octet of a frame must be received. Whenever this time out occurs in the receiver, the end of the actually received frame is assumed.

Inactivity time out defines the time (in seconds) during which a frame/octet must be received in order to keep connection alive. When inactivity timeout elapses, active HDLC connection is dropped.

Device address attribute contains the physical address (i.e. lower HDLC address) of the device.

MT880 meters support single byte HDLC addressing:

- 00 No Station Address,
- 01… 0F Reserved for future use,
- 10... 7D Usable address space,
- 7E 'Calling' device address,
- 7F Broadcast address.

Factory-address settings:

- Optical port: communication protocol is set to IEC 62056-21 mode E, HDLC address = 17
- Other communication ports: communication protocol IEC 62056-46, HDLC address related to the meter serial number, calculated according the algorithm.

HDLC address = Last two digits from meter serial number + 16

Example:

Meter serial number:	35623756
Last two digits:	56
HDLC meter address:	56 + 16 = 72

NOTE!
The HDLC meter address must be unique. In a case, that two meters have the same one, address on one meter must be changed.

8.3. Optical interface

Optical interface enables a bi-directional local communication for data readout and parameterization.

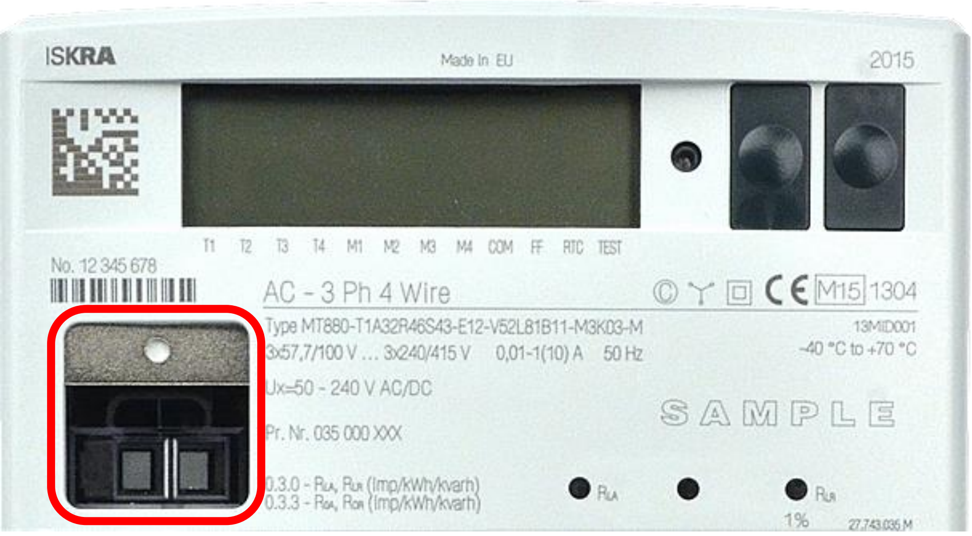


Figure 81: Optical interface

Physical properties of the optical interface are implemented according to the IEC 62056-21 (1107) standard. The local meter data exchange is performed by a hand-held unit (HHU) or a PC using an optical probe. The interface implements a COSEM 3-layer, connection-oriented (CO), HDLC based communication profile. The profile comprises of COSEM AL, HDLC based data link layer and of physical layer for CO connection oriented data exchange.

Application layer	according to IEC 62056-53
Data link layer	according to IEC 62056-46
Physical layer	according to IEC 62056-42

Table 107: Three-layer communication profile

The optical interface can be configured using the following objects:

- **IEC local port setup – channel 0** (0-0:20.0.0),
- **IEC HDLC setup - channel 0** (0-0:22.0.0).

Maximum baud rate on optical interface is limited to 57600 bps.

8.4. RS232 or RS485 interface – accessible via additional terminals

The RS232/RS485 interface can be configured using the following objects:

- **IEC local port setup - channel 1** (0-1:20.0.0),
- **IEC HDLC setup - channel 1** (0-1:22.0.0).

Both communication interfaces have a baud rate limited to 38400 bps and implement a COSEM 3-layer, connection oriented (CO), HDLC based communication profile.

8.5. Exchangeable communication modules

Communication ports 2 and 3 are used for exchangeable communication.
Communication port 2 can be used as one of available type of communication interfaces:

- 2G/3G modem communication interface,
- Ethernet communication interface,
- LMN communication interface,
- Modbus communication interface,
- CS communication interface.

Communication port 3 is used for an RS485 communication interface.

The described communication interfaces implement a COSEM 3-layer, connection oriented (CO), HDLC based communication profile.

Configuration of communication port 2 uses the following objects:

- **IEC local port setup - channel 2** (0-2:20.0.0),
- **IEC HDLC setup - channel 2** (0-2:22.0.0).

Similarly, communication port 3 can be configured using the objects:

- **IEC local port setup - channel 3** (0-3:20.0.0),
- **IEC HDLC setup - channel 3** (0-3:22.0.0).

Module	**Baud rate limitation** [bps]	
	P2	**P3**
2G/3G/Ethernet/LMN MODEM + RS485	115200	115200
CS + RS485	19200	38400

Table 108: HW limitations of communication modules

If a module equipped with a 2G/3G modem is inserted in the meter, the communication port 2 is operating in the following manner:

- internal baud rate is fixed to 115200 bps,
- consequently, setting baud rate attributes of IEC Local Port Setup – channel 2 object has no relevance,
- the meter's firmware is executing modem specific protocol stack on the corresponding communication port.

8.5.1. Module detection

Meter provides the ability to use different communication modules, which could be exchanged during meter operation. The meter can also operate without inserted module. To assure such functionality, the meter supports a special detection mechanism. The detection process constantly runs on the meter when connected to main power.

Information about communication module inserted in the meter can be retrieved using the **Communication module info** (0-0:128.21.0) object. The content of this object carries the following information:

- module status:
  - 00 – not detected,
  - 01 – detected but not recognized,
  - 02 – recognized and running.
- module type:
  - 01 – 2G + RS485 module,
  - 02 – 3G +RS485 module,
  - 03 – CS + RS485 module,
  - 04 – MODBUS module,
  - 05 – Ethernet module
  - 06 – LMN module
  - FF – integrated communication.
- module version, version numbering starts with 01.

Information about detected communication module can be presented on the display.

8.5.2. GSM / GPRS communication module

A GSM/GPRS module supports communication over a cellular network using a modem, controlled by the meter.

8.5.2.1. Modem initialization

During a modem initialization phase a series of preset AT (attention) commands is sent to the modem to ensure proper modem configuration. An invalid response or no response to any of these commands can result in a modem reset when a valid response to at least one initialization command is not received within a 60-second limit. The commands are set with attributes using the **Modem configuration** (0-0:2.0.0) object.

Communication speed is the speed between the device and the modem (not necessarily the communication speed of the WAN):

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

Initialization string contains all the necessary initialization commands to be sent to the modem in order to configure it properly. If the array contains of more than one initialization string element, the *requests* are sent in a sequence. The next request is sent after the expected *response* matching the previous request and waiting a *delay after response* time (in ms), to allow the modem to execute the request.

Modem profile: the attribute is not used by the meter

8.5.2.2. GSM/GPRS network diagnostic

The modem initialization service is followed by the network diagnostic service. It produces a sequence of diagnostic commands, which are sent to the modem every 10 seconds.

One diagnostic sequence contains the following set of commands:

- AT+CPIN? (request SIM status)
- AT+CSQ (request signal quality)
- AT+CREG? (request GSM registration status)
- AT+CGREG? (request GPRS registration status)
- AT+COPS? (request network operator name)
- AT+CGACT? (request PDP context activation status)

To provide information about modem operation and its registration to different networks several diagnostics COSEM objects are implemented (Table 109).

Logical name	Object name	Access mode
0-0:128.20.0	GSM signal quality	Read and write
0-0:128.20.1	GSM Status	Read and write
0-0:128.20.2	ID GSM ICCID	Read only
0-0:128.20.3	GSM program version	Read only
0-0:128.20.4	GSM IMEI	Read only
0-0:128.20.5	GSM network name	Read only
0-0:128.20.6	GSM WIPsoft program version	Read only
0-0:128.20.7	Extended network diagnostic – Network list	Read only
0-0:128.20.8	Extended network diagnostic – Cell environment	Read only
0-0:128.20.9	GSM BER (Bit Error Rate)	Read only
0-0:128.20.11	GSM signal strength indication limit 1	Read and write
0-0:128.20.12	GSM signal strength indication limit 2	Read and write

Table 109: GSM/GPRS modem diagnostics objects

GSM signal quality (0-0:128.20.0) object value presents network signal strength. The retrieved values (as defined in 3GPP TS 27.007) have the following meaning, described in Table 110.

GSM signal quality object value	Signal strength [dBm]
0	-113 dBm or less
1	-111 dBm
2 – 30	-109 dBm…-53 dBm
31	-51 dBm or greater
99	not known, or not detectable
255	no valid response to the last AT+CSQ command was received from the modem

Table 110: GSM signal strength

GSM status (0-0:128.20.1) object contains bit-organized information about modem operation. The detailed bit description is presented in Figure 82.

Bit	Bit description
0	Modem registered to GSM network (home or roaming)
1	Modem registered in the system (installation call done or not active)
2	Modem registered in GPRS network (home or roaming)
3	Modem has active PDP context
4-7	Reserved for future use
8	SIM card not detected or giving error response
9	SIM card requires PIN or PUK code
10	Modem reset pending
11	Installation call failed
12-15	Reserved for future use

Figure 82: GSM status object bit assignment

ID GSM ICCID (0-0:128.20.2) object contains SIM identification number which is a 20-digit long number used for physical SIM card identification.

GSM program version (0-0:128.20.3) object contains a special string to identify firmware of the integrated modem. Version should be 7.46 or above.

GSM IMEI (0-0:128.20.4) object contains the IMEI number of the integrated modem. IMEI is a unique identification of every device that communicates in mobile networks.

GSM network name (0-0:128.20.5) object presents the name (in alphanumeric format) of the currently registered mobile network. If modem is not yet registered to the mobile network, the object's value field is empty.

GSM WIPsoft program version (0-0:128.20.6) object contains a special string to identify WIPsoft program version of integrated modem. Version should be 5.42 or above.

GSM signal strength indication limit 1 (0-0:128.20.11) and **GSM signal strength indication limit 2** (0-0:128.20.12) objects are used in conjunction with console's triangular cursor segments. If any of the cursors available is defined as a Signal Quality Indicator (SQ), the GSM signal strength indication limit 2 object represents the threshold after which the network signal is considered sufficient (resulting in SQ cursor being displayed). If the received network signal strength is below the value specified in GSM signal strength indication limit 1 object, SQ cursor is not displayed at all. Lastly, if the received network signal strength is between the values specified by both objects, the SQ cursor blinks.

At start-up or after every modem reset the value attribute of ID GSM ICCID, GSM IMEI and GSM network name diagnostic objects contains "Reading ..." if the specific information has not been yet retrieved from the modem.

8.5.2.3. Extended network diagnostics

The meter provides support for efficient installation into 2G/3G mobile networks in order to successfully communicate with remote clients. This support functionality is called “Extended network diagnostics“ and it consists of two features:

- Providing information about available 2G/3G networks,
- Providing information about cells of selected 2G/3G network.

Because of relatively time-consuming operation, capturing of above described information does not run automatically but only on request. User can initiate request for extended diagnostic execution via any of available communication interfaces by specific script of the dedicated **Extended network diagnostics script table** (0-0:10.5.101) object. Several scripts are available (see Table 111).

Script ID	Function
0	Capture available 2G/3G networks information and cell environment information of selected 2G/3G network.
1	Capture available 2G/3G networks information only.
2	Capture cell environment information of selected 2G/3G network.

Table 111: Supported scripts of extended network diagnostics script table object

Captured information is stored in two dedicated objects, formatted as visible strings:

- the **Extended network diagnostic – Network list** (0-0:128.20.7) object contains a list of available 2G/3G networks,
- the **Extended network diagnostic – Cell environment** (0-0:128.20.8) object contains cell environment information of selected 2G/3G network.

Network list status is formatted as number defining specific network status (see Table 112).

Status	Meaning
0	unknown
1	available
2	current
3	forbidden

Table 112: Network list status field explanation

Long alphanumeric name is descriptive network name of up to 16 characters.

Numeric name is numeric name of the network.

Network type is formatted as a number defining 2G or 3G network type (see Table 113).

Type	Meaning
0	GSM (2G)
2	UTRAN (3G)

Table 113: Network type field explanation

When meter is powered up or after modem is reset, both information objects present strings: "**Unavailable**". When user executes specific extended network diagnostics script, the corresponding object(s) contents are changed to "**Reading …**" until capturing is successfully ended or modem is reset. If error is detected in the process of information capturing, "**Error!**" string is returned in objects.

Capturing network list can take some time, even 30 seconds or more. Capture of cell environment information easily takes more than 5 seconds as well.

8.5.2.4. Modem reset

MT880 meters implement modem reset mechanism, which enables the automatic restart and re-initialization of the 2G/3G communication module, thus restoring it back to the full operational mode.

Each time a modem reset is required, the meter attempts to perform a software reset (using corresponding AT commands) first. If a software reset proves to be unsuccessful, a hardware reset is performed by triggering modem HW reset signal. The occurrence of modem reset events is recorded in the **Communication event log** object under "*Modem SW reset*" (0x8156) or "*Modem HW reset*" (0x8157) events.

The following scenarios can cause the modem reset to occur:

- error in modem initialization,
- error in modem diagnostic,
- error during a CSD/GPRS connection,
- no-connection timeout has expired.

Each communication port has a separate timer, which records the time duration since the last successful communication over that particular port. A common timer for recording the time duration since the last successful communication over any of the available ports is also implemented. When the timer expires, the ports affected are re-initialized. If the port to be re-initialized is used as a 2G/3G communication interface, additionally a modem reset is performed prior to any port re-initialization.

The **No connection timeout** (0-0:128.20.30) object is used to configure timeout parameter for the timers described above. The object is set to 30 hours by default. Setting the **No connection timeout** object parameter to 0 disables the described monitoring functionality, hence no resets due to lack of communication are performed.

The actual value used by the meter to monitor communication inactivity is calculated from the *No connection timeout* (NCT) parameter and is therefore different. The actual value used is random value between NCT and NCT + NCT/3. This is to prevent an excessive number of simultaneous 2G/3G de-registrations performed by different meters when common source of error occurs in the network.

Whenever a request to restart the modem is issued, the meter enters a special modem restart procedure. The following actions are executed:

- IMSI detach is requested,
- multiplexing mode on modem is closed,
- modem software reset is requested,
- in case of unsuccessful SW reset, modem HW reset is requested,
- reset procedure finishes and reinitializes modem communication.

The entire modem reset procedure takes approximately 3 to 4 minutes to complete. Whether or not a modem reset procedure is currently in progress can be observed using the GSM status object. If the 11th bit of the object's value attribute (Modem reset pending) is set to high, the modem reset procedure is being executed.

8.5.3. GSM / GPRS connection management

GSM/GPRS connection management functionality is achieved through the implementation of several COSEM classes:

- GPRS modem setup,
- PPP Setup,
- IPv4 Setup,
- Auto Connect,
- Auto Answer.

In order to be visible within a GPRS network, the meters must establish connection to GPRS network first. Using special connection management functionality, meter can either be always connected to the GPRS network or only on request. This functionality is described later.

When meter starts up, modem is not connect to GPRS network by default, but depends on mode of connection. The meter first requests the modem to attach to GPRS network. When attach is confirmed, PDP context activation is requested by the meter using configured APN, username and password. Dedicated object called **GPRS modem setup** (0-0:25.4.0) is used for configuration of APN.

GPRS modem setup object attributes are used in the following way:

- *APN*: defines the access point name of the network.
  The size of the APN string is limited to maximum 40 characters.
- *PIN code*: 4-digit PIN code for unlocking the SIM card. The meter is able to unlock SIM access on the inserted 2G/3G communication module if PIN code is configured. Meter implements only 4-digit PIN codes.
- *Quality of service*: Not used by the meter.

CAUTION!
When modem requires PIN code and the PIN code parameter is valid as described above, the meter will send the PIN code to the modem unconditionally. This means that if PIN code parameter is incorrect, the SIM card will eventually become locked for PUK code, which must be entered outside of meter environment (e.g. in a separate modem or cell phone).

NOTE!
Although PIN code parameter is stored within **GPRS modem setup** object, it is also used when meter is working in GSM only mode.

Username and password for GPRS PDP context activation must be configured in object **PPP setup** (0-0:25.3.0).

PPP Setup object attributes are used in the following way:

- *PHY reference*: references another object by its logical_name. The object referenced contains information about the specific physical layer interface, supporting the PPP layer.
  GPRS modem setup object is referenced by default.
- *LCP options*: this attribute contains the parameters for the Link Control Protocol options.
  From the whole set of available options, only Authentication protocol is used.
  Authentication protocol option must be configured for PAP protocol.
- *IPCP options*: Not used by the meter!
- *PPP authentication*: contains the parameters required by the PPP authentication procedure used.
  PPP authentication must be configured with appropriate PAP username and password, which will be accepted by the network when PDP activation request is sent. The size of the username and password strings is limited to maximum 32 characters.

NOTE!
GSM/GPRS communication module used on MT880 meter supports only PAP authentication for PDP context activation.

When connection manager in the meter requests disconnection from GPRS network, meter sends PDP deactivation request to the modem, followed by a detach request. After this, meter is completely disconnected from GPRS network (also not attached), being only registered to GSM network.

In the process of PDP context activation, modem connected to GPRS gets its IP address assigned by the network. The assigned IP address can be seen in **IPv4 Setup** (0-0:25.1.0) object.

IPv4 Setup object attributes are used in the following way:

- *DL reference*: references a Data link layer (e.g. Ethernet or PPP) setup object by its logical name. The referenced object contains information about the specific settings of the data link layer supporting the IP layer, *PPP Setup* object is referenced by default.
- *IP address*: carries the value of the IP address (IPv4) of the meter when connected to GPRS network. If no IP address is assigned, the value is 0.
- *Multicast IP address***:** not used by the meter!
- *Parameters to support the selected IP options*: not used by the meter!
- *Subnet mask*: not used by the meter!
- *Gateway IP address*: not used by the meter!
- *Use DHCP flag*: not used by the meter!
- *Primary DNS address*: Not used by the meter!
- *Secondary DNS address*: not used by the meter!

In a case of unsuccessful GPRS connection establishment, connection manager takes care of possible retries if configured.

8.5.3.1. Auto connect

The meter implements **Auto connect** (0.0.2.1.0) object in order to be able to control the operation of auto connect functionality.

The attributes of the **Auto connect** object are used in the following way:

- *Mode***:** controls the auto connect functionality in terms of the timing, the message type and the infrastructure to be used.

(0…99)	reserved.
101	always on; the device is permanently connected to the communication network.
102	always on within the time validity time of the calling window. The device is disconnected from the communication network outside the calling window. No connection possible outside the calling window.
103	always on within the validity time of the calling window. The device is disconnected from the communication network outside the calling window, but it connects to the communication network as soon as the connect method is invoked.
104	wake up mode: the device is usually disconnected. It connects to the communication network as soon as the connect method is invoked.
(105…199)	reserved.
(200…255)	manufacturer specific modes.

NOTE!
Meter connects to GPRS network only if one of modes (101) to (104) is configured.

- *Repetitions***:** the maximum number of retrials in case of unsuccessful connection attempts.
- *Repetitions delay***:** the time delay, expressed in seconds until an unsuccessful connection attempt can be repeated.
  If value is 0, repetitions delay is not specified.
- *Calling window:* contains the time points when the window becomes active (start_time), and inactive (end_time). The start_time implicitly defines the period.
- *Destination list***:** NOT used by the meter!

When a connect method is invoked, the auto connect attempts to connect to the network if not already connected. When successful, the meter remains connected to the network until a specific condition is met or network error occurs. If a connection attempt is unsuccessful, the auto connect re-attempts to connect to the network. The number of re-attempts is limited by the repetitions attribute. A connect method can only be invoked if the mode attribute is set to 103 (while outside of the defined calling window) or to 104.

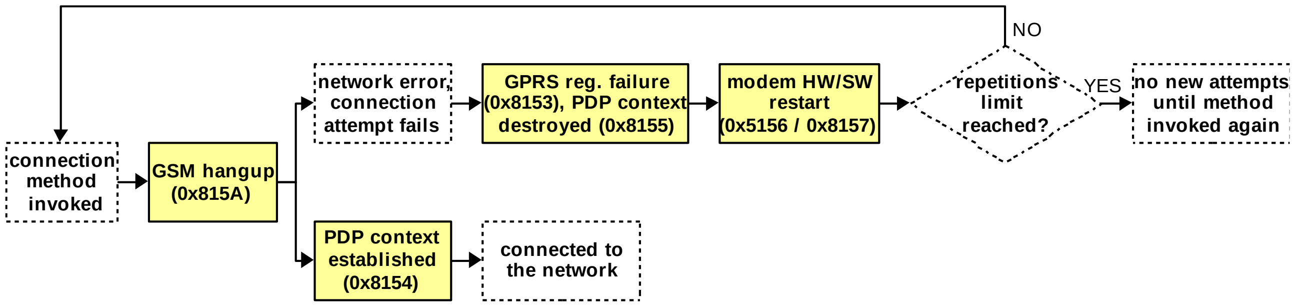


Figure 83: Auto connect operation in modes 103 and 104 when a connection method is invoked

Changes in any of the above COSEM objects causes the Auto connect to re-initialize: the meter waits for any active IP communication to finish and afterwards requests a disconnection from the IP network, which is followed by Auto connect re-initialization. If necessary, a reconnection to the IP network is performed. Special consideration applies to the Consereth timeout object and the Inactivity attribute of the TCP-UDP Setup object: the Auto connect is re-initialized only when a change in either of the previously specified objects results in a new maximum value of both.

Additional explanation of Auto connect characteristics:

- With mode set to 103 and the calling window not defined, the wake-up request can nevertheless be performed.
- When the mode is set to 103 and a connection to the IP network is established using a wake-up request and a transition from outside to inside of the calling window occurs, the meter remains connected to the IP network until the validity time of the calling window.
- If the data exchange over the IP network is unexpectedly interrupted or no valid disconnect request is received, two distinct outcomes are possible:
    1. The data exchange is interrupted after a request was received by the meter but before the corresponding response could be sent:

       The meter attempts to send a response to the allegedly connected peer, however, the peer is no longer accessible and therefore no acknowledgment can be received on the meter's side. After the round trip time has expired, the meter retransmits the response and again waits for an acknowledgement. The round trip time is preset to 8 s and the number of retransmissions is limited to 12. If the number of retransmissions is reached, the timeout period expires (after approximately 8 * 12 = 96 s) and the socket is closed. After that, new data exchange using the same server socket is again possible.
    2. The data exchange is interrupted after a proper response was sent and acknowledged but before a new request could be sent by the client peer:

       The meter is not aware that the peer socket has disconnected and therefore expects new data to arrive. If no data is received within the inactivity timeout (Consereth timeout object or TCP-UDP Setup object, depending on the active server socket), the socket is closed. After that, new data exchange using the same server socket is again possible.
- When the meter is connected to the IP network using a wake-up request (applicable to modes 103 and 104) the following principles apply:
    1. If the data exchange over the IP network does not occur within the valid timeout (the maximum value of the inactivity timeout attribute (no. 6) of the TCP-UDP Setup object and the Consereth timeout object), the meter automatically disconnects from the IP network.
    2. If the data exchange over the IP network is successfully finished (disconnect requests are properly acknowledged), the meter immediately disconnects from the IP network.

3. If any of the previously stated Auto connect specific COSEM objects or respective attributes is changed, the re-initialization of Auto connect is not followed by a reconnection to the IP network.

8.5.3.2. Auto answer

The meter provides an **Auto answer** (0-0:2.2.0) object intended to manage the following functionality of the exchangeable GSM/GPRS module:

- answering to incoming calls,
- handling GPRS wake-up requests.

The attributes of the **Auto Answer** object have the following meaning:

- *Mode:* defines the working mode of the modem line when the meter is auto answering.
  Parameter value is enumerated:

0	line dedicated to the device.
1	shared line management with a limited number of calls allowed. Once the number of calls is reached, the window status becomes inactive until the next start date, whatever the result of the call.
2	shared line management with a limited number of successful calls allowed. Once the number of successful communications is reached, the window status becomes inactive until the next start date.
3	currently no modem connected.
(200...255)	manufacturer specific modes.

- *Listening window: d*efines the time points when the communication window(s) become active (start_time) and inactive (end_time).

- *Status*: here the status of the window is defined as:
  - 0 – Inactive: the device will manage no new incoming call. This status is automatically reset to active when the next listening window starts.
  - 1 – Active: the device can answer to the next incoming call.
  - 2 – Locked: this value can be set automatically by the device, or by a specific client, when this client has completed its reading session and wants to give the line back to the customer before the end of the window duration. This status is automatically reset to active when the next listening window starts.

- *Number of calls*: this number is the reference used in modes 1 and 2. When set to 0, this means there is no limit.

- *Number of rings:* defines the number of rings before the meter connects the modem. Two cases are distinguished:
  - the number of rings within the window defined by the attribute “listening_window”,
  - the number of rings outside the “listening_window”.

- *List of callers:* contains an optional list of calling numbers, which further limits the connectivity of the modem based on the calling number. It also controls the acceptance of wake-up requests from a calling number. Each calling number in the list is associated with call type, defined as:
  - (0) normal CSD call; the modem only connects if the calling number matches this entry in the list. This is tested in addition to all other attributes, e.g. *number of rings, listening windows*, etc.
  - (1) wake-up request; calls or messages from this calling number are handled as wake-up requests. The wake-up request is processed immediately regardless of *number of rings*.

Calling number (caller_id):

The caller_id identifies a calling number from which calls are accepted. The wild-card characters '?' and '*' are supported. With '?' any single character matches, with '*' any character string matches. '*' can only be used at the beginning or at the end of a number, but neither in between nor alone.

Example 1: "+994193500" = only calls from "+994193500" are accepted.

Example 2: "+9941935????" = calls from all numbers in the range of "+99419350000" to "+99419359999" are accepted.

Example 3: "7777*" = calls from all numbers starting with "7777" are accepted.

Example 4: "*9000" = calls from all numbers ending with "9000" are accepted.

Example 5: "?*" = calls from all numbers with at least one digit are accepted.

NOTE!
If the same calling number is defined as a normal CSD call and as a wake-up request, the type of action, which is defined first in the list, is allowed to execute.

8.5.3.3. Answering to incoming calls

The client system may initiate communication to the meter via circuit-switched-data (CSD) connection using GSM network. In order to support this **Auto Answer** object in the meter, it must be configured appropriately. Functionality of answering incoming calls is based on caller recognition, which is achieved by using GSM network CLIP service.

In order to be able to accept incoming call, the meter must have **Auto answer** object configured in one of the following way:

- List of allowed callers is empty so meter answers incoming calls regardless of calling number.
- Calling number reported with CLIP matches one of the calling numbers in list of allowed callers, which is associated with caller type for normal CSD call.

In addition to calling number checking, meter also answers incoming calls according to other parameters (listening window, number of rings, etc.).

8.5.3.4. Managing wake-up requests via CSD

In addition to "Always ON" modes, where GPRS connection is permanently activated during defined time period, the meter also supports GPRS connection establishment on request, so called wake-up. Wake-up is based on receiving CSD call notification (RING, +CLIP). Upon receiving the wake-up call from the HES, the meter verifies the calling number according to configuration of the **Auto answer** object. If the call type of the calling number is set to (1) "wake-up request" in the *List of callers* the meter rejects incoming CSD call and immediately triggers GPRS connection request to the modem. The GPRS connection request is only triggered if appropriate mode (103 or 104) is configured in *Auto Connect* object. If mode 104 is configured in **Auto connect** object, also *Calling window* is checked.

When **Auto Answer** *Mode* is set to 0, meter does not check any other parameters of **Auto Answer** object, except *List of callers* when managing wake-up request. When **Auto Answer** *Mode* is set to 1 or 2, meter also takes *Listening window*, and *Number of calls* into account when managing wake-up request.

8.5.4. CS / RS485 communication module

The module equipped with CS and RS485 communication interfaces communicates with the meter using ports 2 and 3 respectively. Both communication interfaces operate according to protocol IEC62056-46 or IEC 62056-21 (former 1107).

NOTE!
Unused RS485 meter interfaces have to be terminated with 120 Ω resistors.

8.5.5. Ethernet communication module

See technical description of the module.

8.5.6. LMN/Ethernet communication module

See technical description of the module.

8.6. Communication profiles

Several communications profiles are used in the meter:

- COSEM/DLMS over TCP/IP (using GPRS network)
- COSEM/DLMS over IEC 62056-46 (using local port, GSM CSD or CONSERETH over TCP/IP)
- IEC 62056-21 (using local port or CONSERETH over TCP/IP)

COSEM communication profiles

Three different communication profiles can be seen. Figure 84 presents COSEM communication profiles implemented in the meter.

COSEM 3-layer, connection oriented, HDLC based communication profile runs on local communication interfaces (optical, RS485, RS232, CS) and on the GSM interface (see left side of Figure 84).

TCP/IP based COSEM communication profile is implemented for use in conjunction with a GPRS/UMTS communication interface (see right side of Figure 84).

Consereth protocol, which is based on TCP/IP protocols and enables transparent sending of any sort of messages from TCP/IP networks to serial interfaces and vice versa. The implemented Consereth protocol is COSEM based and it is used to transfer HDLC packets (see the middle of Figure 84).

Capital letter **C** presents levels in communication profiles where cascading functionality can be implemented.

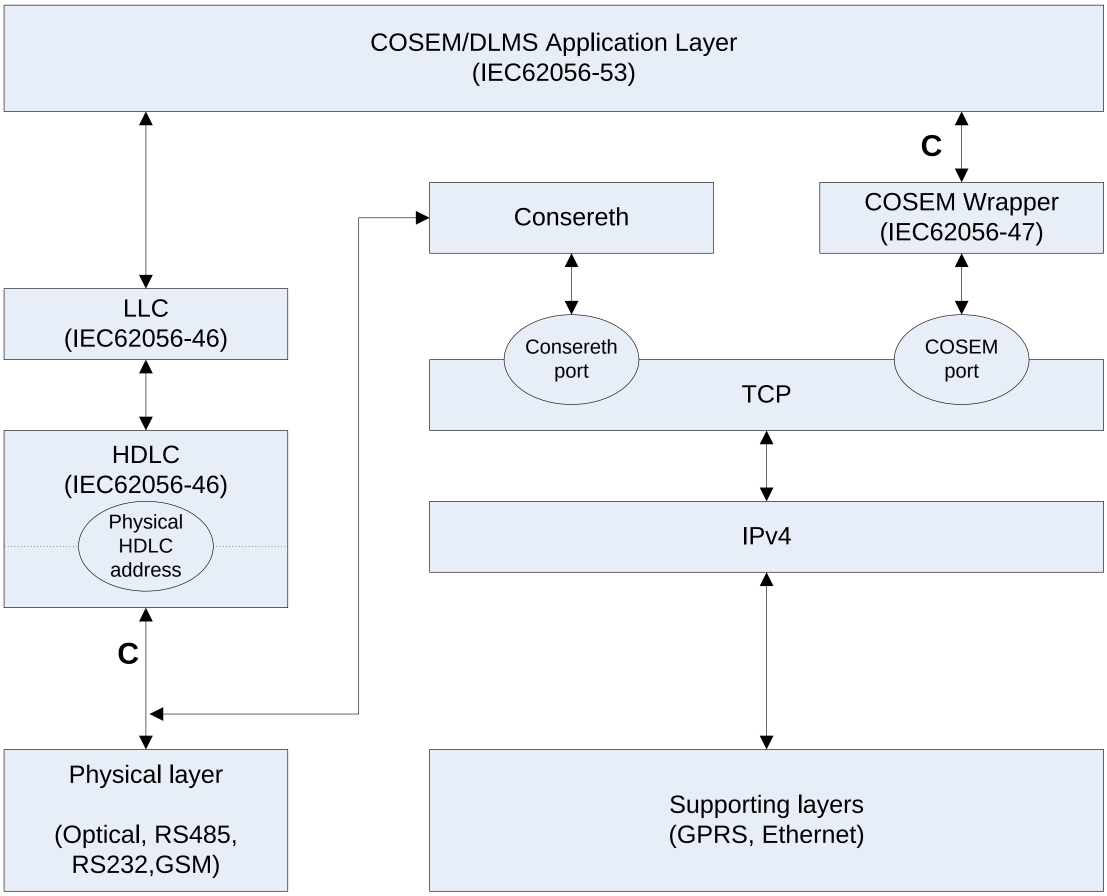


Figure 84: COSEM communication profiles

IEC 62056-21 (IEC 1107) communication profile

Also IEC 62056-21 (formerly known as IEC 1107) communication protocol is implemented in the meter. Communication profile shown on the right side of Figure 85 is a TCP/IP based IEC1107 communication profile using Consereth protocol. The implementation of Consereth protocol for IEC1107 communication profile is completely the same as for COSEM profile, with only difference, that in case of IEC1107 profile Consereth carries IEC1107 messages.

Capital letter C presents levels in communication profiles where cascading functionality can be implemented.

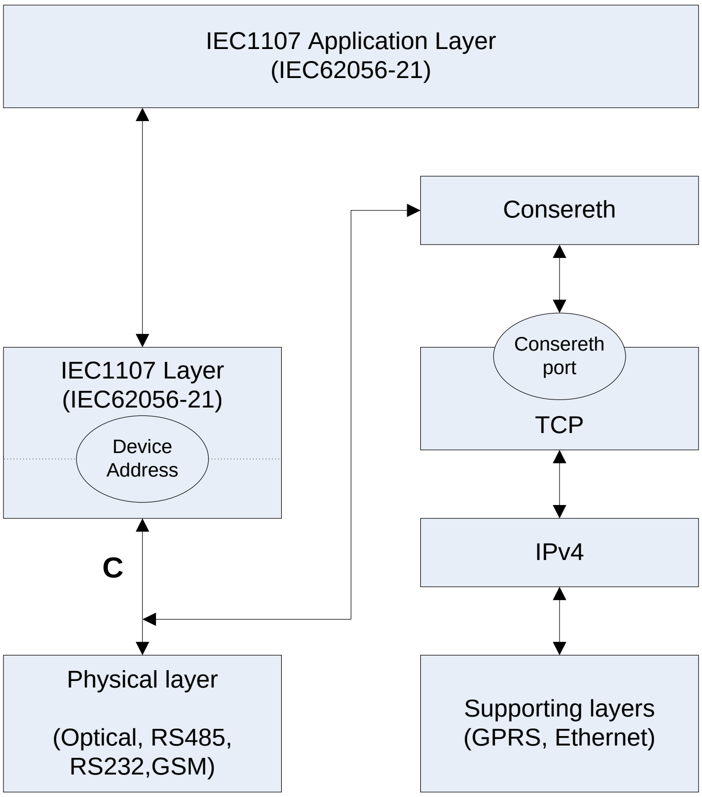


Figure 85: IEC 62056-21 (IEC 1107) communication profiles

NOTE!

When Consereth protocol is used for accessing meters over cascading channels, all connected meters must be set to fixed baud rate.

8.6.1. Communication servers

The meter is COSEM DLMS based. That server handles the needed services in order to provide access to COSEM objects implemented as COSEM classes.

Meter equipped with four communication ports, where each of them is running its own server(s). In order to access all running servers several communication profiles can be used. The use of specific server and communication profile on certain communication port is limited by HW configuration and parameter settings.

In addition to the four server sets presented in Figure 86, there is also a separate COSEM server running in the meter just for the purpose of COSEM Wrapper communication.

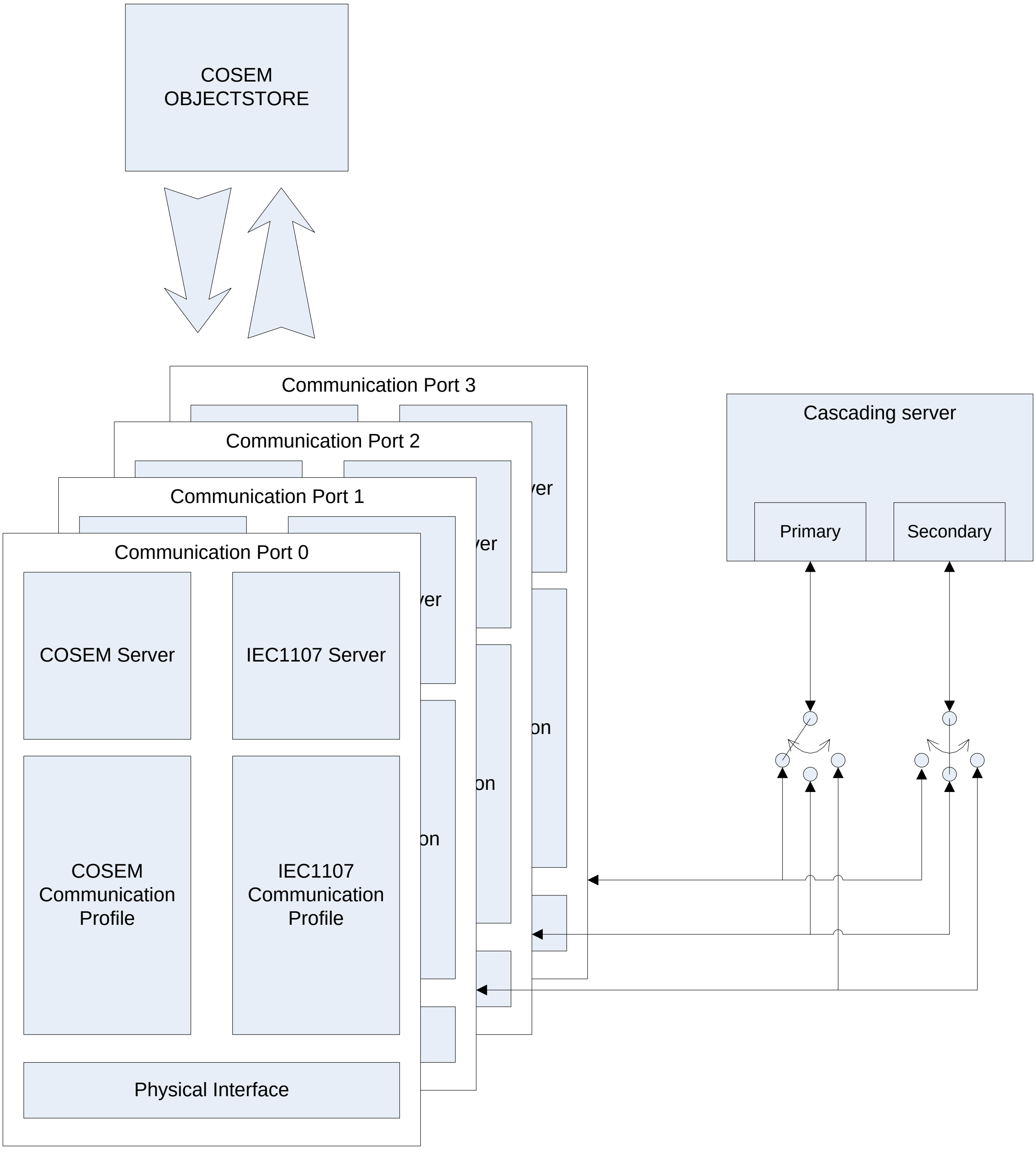


Figure 86: Meter communication model

8.6.2. COSEM wrapper

COSEM Wrapper protocol is a part of COSEM specification used for COSEM communication over IP networks. The COSEM wrapper layer adds 8 bytes long header to the original COSEM message. The wrapper header includes information about version, source wrapper port, destination wrapper port, and length. COSEM Wrapper header is followed by COSEM application data (APDU).

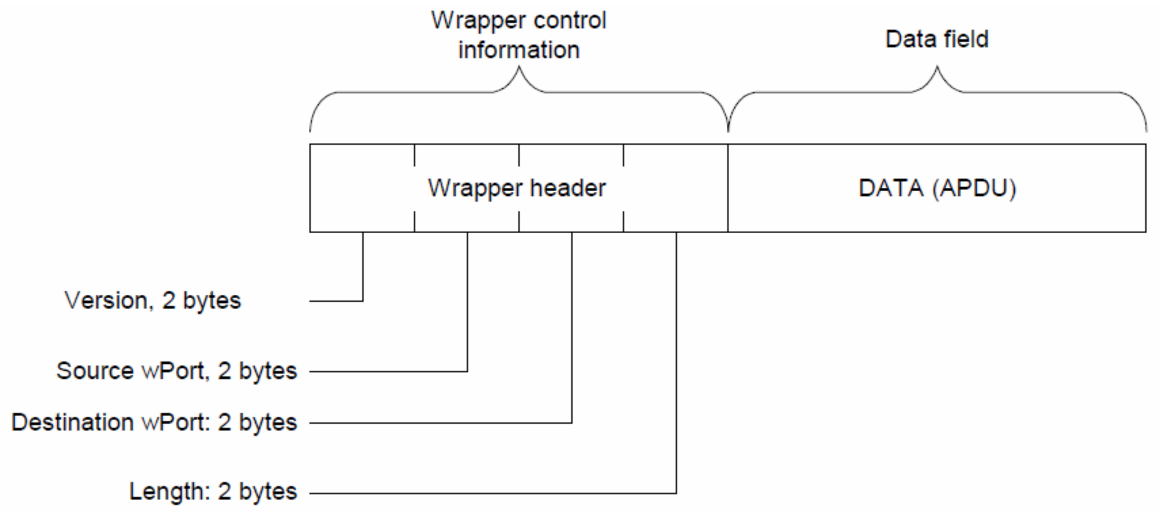


Figure 87: The COSEM wrapper protocol data unit (WPDU)

When receiving COSEM Wrapper messages, the meter checks version number and length fields of the incoming TCP packet. If the version is not 1 (fixed value) or if the length of data APDU is not equal to Length field, the packet is discarded and the active connection is closed. When the header is verified, the data APDU with additional parameters is passed to the DLMS server.

When DLMS server in the meter responds to the request, the frame is passed through the COSEM Wrapper layer, which adds the COSEM wrapper header and send the message active socket connection to the client.

When no data is exchanged for the time out period, configured in the dedicated object, the meter closes the incoming connection. Meter still keeps listening for new connections on configured port.

8.6.3. Consereth

Consereth protocol runs over TCP/IP protocol and enables transparent sending of any sort of messages through TCP/IP networks. In the meter, Consereth is used to transfer HDLC and IEC62056-21 packets. Consereth message consists of 3-byte header and payload message.

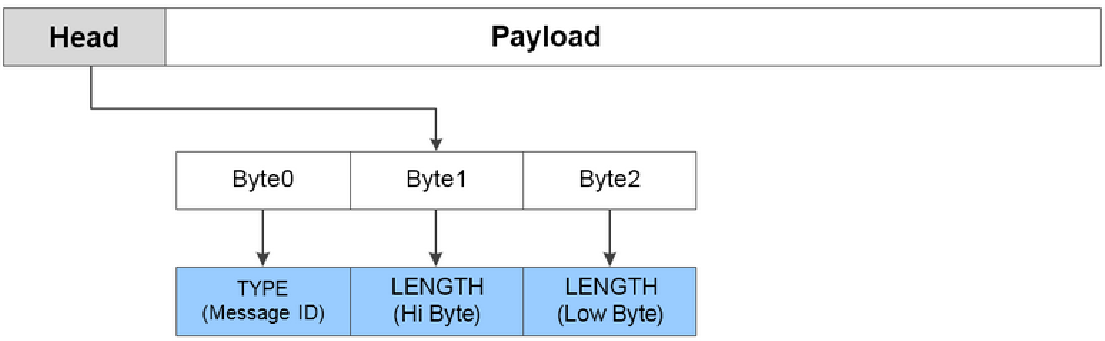


Figure 88: Consereth message structure

The 1st byte of header contains TYPE (Message_ID) value, which is encoded as presented in Table 114. The meter only supports “Data” type messages.

Message_ID	Message Type	Description
1	Request	Message is interpreted. Sender receives response (not implemented).
2	Respond	Response to the request (not implemented).
3	Data	Message is not interpreted – data is transferred to internal servers (RX) / transferred to the socket (TX)

Table 114: TYPE (Message_ID) options

The 2nd byte of header carries High Byte of the length and together with the 3rd byte of header which carries Low Byte determine the length of the payload message. Length of the payload message is limited to 200 bytes.

If the message to be transmitted is larger than 200 bytes, the message is fragmented to several Consereth packets, each containing maximum 200 bytes of text message.

When receiving Consereth messages, meter checks header message type. Only Data message type is supported. Then Data length is parsed from the header. If data length is not larger than 200 bytes, data message is passed to upper HDLC or IEC 62056-21 server.

When HDLC or IEC 62056-21 server responds to the request, the response frame is given to a Consereth header, and sent through TCP/IP socket. Meter always cumulates data to be sent until the message is not larger than 200 bytes or until 30 ms timeout elapses from last sending request. If more than 200 bytes need to be sent within 30 ms timeout, message is divided to fragments of maximum size 200 bytes.

When no data is exchanged within the time out period configured in dedicated object, the meter closes the active Consereth connection. Meter still keeps listening for new connections on configured port.

Two dedicated objects are used to configure Consereth communication parameters:

- Consereth port,
- Consereth timeout.

Consereth port (0-0:128.23.0) object contains the TCP port number on which the server listens for new socket connections. When the Consereth port is set to 0, the Consereth Server is disabled. Valid values for Consereth port for operational server are between 1 and 65535.

When the port number is changed, the meter waits the client to close the connection. After that, the meter closes the listening socket on old port number, waits for 5 seconds, and opens the listening socket on the new port number.

Consereth timeout (0-0:128.23.1) object is timeout expressed in seconds. This is the time, after which the incoming connection will be closed if no activity (exchange of data) is present on the socket.

Valid values for the Consereth timeout are between 1 and 3600 s. When 0 s or values larger than 3600 s are set, the Consereth Server operates with a 3600 s timeout.

Number of simultaneous Consereth connections is limited to 1, which means that only one Consereth client can communicate with the meter at a time.

8.6.4. Cascade

Cascading server is a functionality that gives the meter the possibility to act as a gateway to other meters. Cascading server has its primary and secondary communication ports defined as parameters. The function of cascading server is to transfer all protocol messages received on primary port to the secondary port and vice versa. Which meter port is defined as primary and/or secondary ports is programmed in the meter.

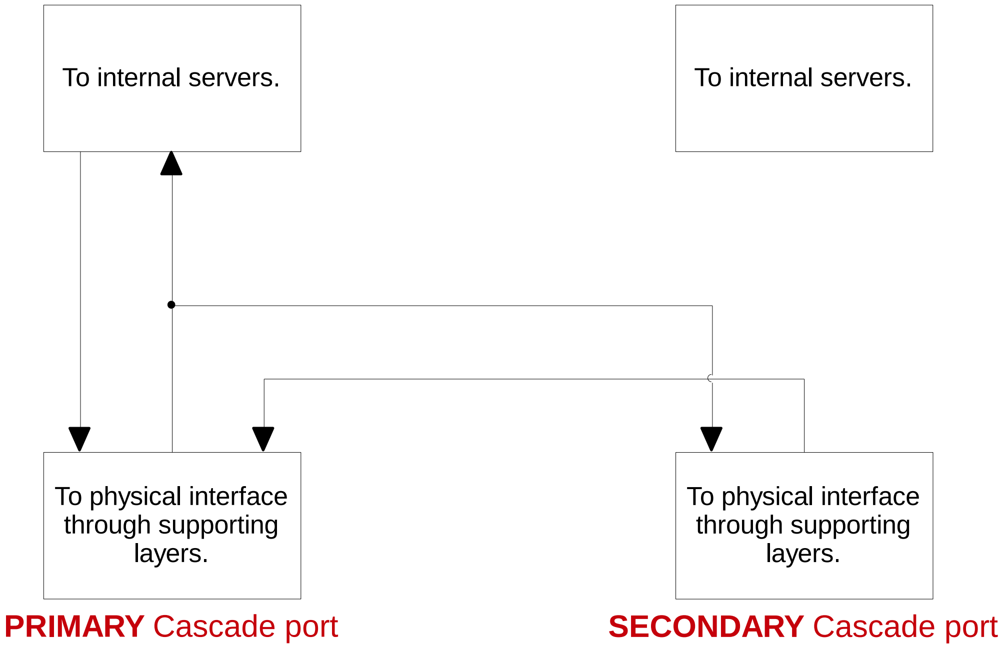


Figure 89: A typical cascade implementation

All messages received on primary cascading port from remote clients are also transferred to internal servers running on those ports. However, this is not the case for the secondary cascading port, where messages to internal servers are never delivered. Only a primary cascading port is allowed to begin a message transfer over a cascade.

The cascading server introduces two new COSEM objects:

- **Primary cascading port** (0-0:128.22.0),
- **Secondary cascading port** (0-0:128.22.1).

In order for the cascade to operate, both cascading port COSEM objects must be properly configured. Configuring invalid values into described cascading port objects is rejected by the meter. The following port limitations apply when configuring the value attributes of cascading port objects. See Table 115.

Primary cascading port		Secondary cascading port	
0-1:20.0.0*255	(IEC local port setup – channel 1)	0-1:20.0.0*255	(IEC local port setup – channel 1)
0-2:20.0.0*255	(IEC local port setup – channel 2)	0-2:20.0.0*255	(IEC local port setup – channel 2)*
0-3:20.0.0*255	(IEC local port setup – channel 3)	0-3:20.0.0*255	(IEC local port setup – channel 3)
0-0:128.23.0*255	(Consereth port)		

* Setting the IEC local port setup – channel 2 object as a secondary cascading port is only valid when communication port 2 is not used as GSM/GPRS communication interface.

Table 115: Limitations of cascade configuration

The changes to cascading parameters are applied instantly if no active cascade transfer is currently in progress or only after the message transfer over a cascade server ends (i.e. cascade server connection is not active for a period of 10 seconds or more).

An active cascade transfer can be observed in the corresponding port's **ID serial process status channel** (0-**b**:96.10.128) object, where "**b**" can be of values 0, 1, 2, or 3. Whenever a bit 17 is set, an active message transfer over the cascade is in progress.

Bit index	Description
B0	Phy IEC local port PKT
B1	Phy IEC local port HDLC mode
B2, B3	Unused
B4…B7	Reserved
B8	Appl IEC 1107 connected
B9…B11	Unused
B12	Appl COSEM connected
B13	Appl COSEM associated
B14…B15	Unused
B16	Cascade activity on secondary port
B17	Cascade activity
B18 – B31	Unused

Table 116: Serial process status bit explanation

The message transfer over a cascade can only be successful if the protocol used by the client is the same as the one used by the meter to which the messages are intended to be sent. Both communication protocols are supported: DLMS/COSEM and IEC 62056-21.

8.7. Push

8.7.1. General

Push functionality is implemented to provide a way of autonomous sending of data from the meter to the HES, following some predefined triggers.

Push method activates push process leading to the elaboration and the sending configured push data. Following push objects are implemented:

- **Push setup - On connectivity** (0-0:25.9.0),
- **Push setup - Interval 1** (0-1:25.9.0),
- **Push setup - Interval 2** (0-2:25.9.0),
- **Push setup - Interval 3** (0-3:25.9.0),
- **Push setup - On alarm** (0-4:25.9.0),
- **Push setup - On installation** (0-7:25.9.0).

Push setup supports:

- Object list:
  - All COSEM objects in meter with the read access.
- Service type:
  - 0 – TCP/IP,
  - 4 – SMS.
- Destination:
  - IP address including the port number (ex: 10.253.49.30:10000) for service type TCP/IP,
  - Phone number (ex: 0038641123456, +38641123456, 041123456) for service type SMS.
- Message type:
  - 0 – COSEM APDU.

Push can be triggered:

- Internally:
  - from the **Push script table** (0-0:10.0.108):

if a monitor threshold is exceeded (alarm);

on time base with schedulers:

- ❖ **Push action scheduler – Interval 1** (0-1:15.0.4),
- ❖ **Push action scheduler – Interval 2** (0-2:15.0.4),
- ❖ **Push action scheduler – Interval 3** (0-3:15.0.4).

  - by an event (installation, established PDP context).
- From client (HES):
  - wake-up call (established PDP context),
  - executing the method Push (0),
  - executing the script from the **Push script table** (0-0:10.0.108),
  - executing the meter registration procedure.

In a case of missing data, a null-data-element needs to be sent instead of the actual attribute value. Push process takes place in a pre-established association context. Since there is only one logical device the meter's system title is always the same for all associations. Only one-way communication link is established between the meter and the HES with push data-notification services.

A variety of use cases provide using of data_notification service:

- Meter Reading on Demand (missing data from the last reading periods),
- Meter Reading for Billing (total registers, rated registers, profiles and event logs),
- Quality of Supply Reporting,
- Meter Supervision (Alarms, Events, etc.),

<u>Push setup object overview:</u>

Push object list:	defines a list of attributes to be pushed.
Send destination and method:	contains destination address (e.g. phone number, IP address) where the data specified by the push_object_list has to be sent, as well as the sending method.
Communication window:	defines time points for active (start_time) and inactive (end_time) communication window.
Randomization start interval:	push operation is not started immediately after the invocation of the push method but randomly delayed (in seconds) to avoid data traffic peak.
Number of retries:	defines maximum number of retries in case of unsuccessful or skipped push attempts.
Repetition delay:	time delay (in seconds) until the next push attempt is started after an unsuccessful push.

8.7.1.1. Push setup

Push setup

Push setup – On connectivity: when there is PDP context established, meter sends its IP address and system title using data_notification service to the HES.

Push setup – Interval 1, 2, 3 can be used for various periodical data reporting (profiles, billing, etc.).

Push setup – On alarm is called from alarm monitor objects to report alarm registers.

Push setup – On installation 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).

Push action scheduler

Push action scheduler – Interval (0:**i**-15.0.4), where "**i**" represents interval 1, 2 or 3, is used to periodically invoke the **Push script table** (0-0:10.0.108) with a predefined selector to trigger push method on dedicated Push setup object.

Push script table

Push script table (0-0:10.0.108) object contain scripts, which are used to trigger push method on configured Push setup objects.

8.7.1.2. Push process

Push process is implemented through the data_notification process, which takes care of processing requested push objects, checking for successful communication, and preparing data to build proper COSEM_APDU message.

Only one Push setup object is processed at once. Multiple Push requests are resolved through executing one by one according to the COSEM logical name until at least one object is active.

In a case of a delay (randomisation_start_interval, repetition_delay) another Push object is treated, if it is triggered. If triggered Push object has no delay at first attempt or the delay expires and communication window is active, then Push process continues to establish connection. If communication window is not active then first attempt is started in next active Window element and another Push object is treated if it is triggered. If communication window reaches end, Push process is finished. If there is no destination set, then Push process is finished as well.

When using **TCP/IP** as service type, registration in GPRS network must be established in maximum delay of 330 seconds. If error occurs, or delay expires, new push attempt is started. When registration in GPRS network is established, then connection to the destination is started. If error occurred or connection is not established in 60 seconds, new push attempt is started. If Push object list is empty, then process is finished. At the end of sending Data_notification waiting for server to close socket is made. If server does not close socket in 60 seconds and connection to the same destination is no more active, push is treated as failed and new push attempt is started. If power down occurred at the end of sending data_notification, waiting for the server to close socket is not made and push is always treated as successful.

When using **SMS** as service type, the check if previous SMS was sent is made. If error occurred or previous SMS was not sent in 50 seconds, new push attempt is started, otherwise the phone number is checked if it is in proper format. If object list is empty then Push process is finished at this point. After last block is prepared, wait and check if it was sent is made. If SMS is not sent in 50 seconds, new push attempt is started, otherwise push is finished successfully. If power down occurred, check if SMS was sent is not made.

For information about using **RS-485** as service type, refer to chapter *8.7.3. Push over RS-485*.

8.7.1.3. Push related functionality

Security Setup

Object **Security setup** (0-0:43.0.0) is used to secure data_notification when pushing data using pre-established association. The "Management Client association" and the "Pre-established Client association" share the same security context. Therefore, there is only one security setup object through which this security context is configured.

Alarms

Alarm monitor 1 (0-0:16.1.0) and **Alarm monitor 2** (0-0:16.1.1) objects are used to monitor predefined monitored value and execute action on predefined script.

Alarm descriptor 1 (0-0:97.98.20) and **Alarm descriptor 2** (0-0:97.98.21) objects are used for monitored value in the objects **Alarm monitor 1,** or **Alarm monitor 2**.

NOTE!
Wildcards are allowed in date and in time up to a hundredths of seconds. This is a deviation from the current standard (COSEM Blue Book 10th Edition) where wildcards in time are not allowed.

NOTE!
Execution time is customized up to a millisecond. This is a deviation from the current standard (COSEM Blue Book 10^{th} Edition) where seconds and hundredths of seconds must be zero.

NOTE!
Push script table contains more scripts that the number of push setup objects. This is because not all push objects are implemented in the MT880 meter.

NOTE!
Push uses Pre-established association.

NOTE!
Push process on a specific push setup object is stopped if no destination is defined, if push retries exceeded maximum number or if end of a communication window is reached.

NOTE!
If error occurred during internal reading of an object that needs to be pushed, then missing values are filled with zeroes. Other errors during push process are handled with push retries.

NOTE!
If end_time of communication window element is smaller than start_time, this window element parameter is stored in the meter but ignored during execution of push process.

NOTE!
Objects that have special access rights could not be sent with push process and therefore missing values are filled with zeroes

NOTE!
When TCP service type is used for push, the meter keeps TCP session open after pushing the data. This allows, the HES to close the session and in this way confirm the reception of the push data. However, if HES does not request closing in 60 s, the meter closes the TCP session and considers push operation as failed.

NOTE!
When GPRS is used (TCP as service type), the maximum length of sending data should not exceeded *5* kB due to limitation of GSM/GPRS modem.

NOTE!
When master reset is performed, push setup objects, push script table and push schedulers attributes are erased.

NOTE!
If GPRS communication (PDP context) needs to be established for execution of push operation, then **Push Setup – On connectivity** is executed before any other Push Setup object that is triggered.

8.7.2. Push over Ethernet

When trigger for specific push-setup object appears inside the meter, the push action is executed. This means that proper data-notification message is prepared and sent to a destination defined in the corresponding push-setup object. When defining push over Ethernet, the destination attribute in the specific push-setup object (e.g. Push setup – On alarm) must be set to the following values:

- Service_type: (5) - HDLC
- Destination: 0-2:22.0.0.255
- Message Type: (0) - COSEM APDU

With such parameterisation, the hosting meter sends **HDLC UI frame** containing data-notification COSEM APDU on UART interface toward Ethernet communication module when push is triggered. Such push HDLC-message carries the following HDLC addresses:

- Client SAP: **102** (Client HDLC address)
- Server SAP: **1** (Server upper HDLC address)
- Server physical address: **17** (Server lower HDLC address)

The HDLC destination defined in the push setup object is only part of destination specification. In order to be able to send the push message out of the meter via Ethernet, the Ethernet communication module needs definition of destination IP, port and protocol type. These parameters are defined as COSEM objects in the meter:

- **Ethernet push destination IP address** (0-0:128.24.0*255) – push destination IPv4 address
- **Ethernet push destination IP port** (0-0:128.24.1*255) – defines the port (TCP/UDP) – in addition to IP address – where remote peer is listening for push messages coming from the meters.
- **Ethernet push protocol type** (0-0:128.24.2*255) – specifies, which transport protocol is used for sending the push message towards the listening server

Ethernet communication module must read these parameters from the hosting meter by using well known HDLC services already used for reading other parameters of communication module.

When Ethernet communication module receives the push message from the hosting meter, the module adds Consereth header in front of the received HDLC frame and sends it over Ethernet/IP network to a specified port using defined TCP/UDP protocol.

In a case, when the push is triggered just in time, when the module is communicating with the meter (regularly, module communicates with meter every ten seconds), the push message will not be transferred. In order to avoid such a case, in the push parameters, set the attribute "Number of retries" to 1, and "Repetition delay" to 5 seconds.

In a case, when the push is triggered at a moment, when HES reads the meter via Ethernet, and it takes more than 5 seconds from triggering the push, the push message will not be transferred. In this case, HES can read the status of "triggers" for push (alarms ...), which needs to be add to HES reading list.

NOTE!
If object **Ethernet push destination IP address** (0-0:128.24.0*255) is not available, then push over Ethernet is disabled.

8.7.3. Push over RS-485

Push over RS-485 functionality enables transferring push messages from meters towards HES via RS-485 and WAN communication. Figure 90 presents a flow concept of the push over RS-485.

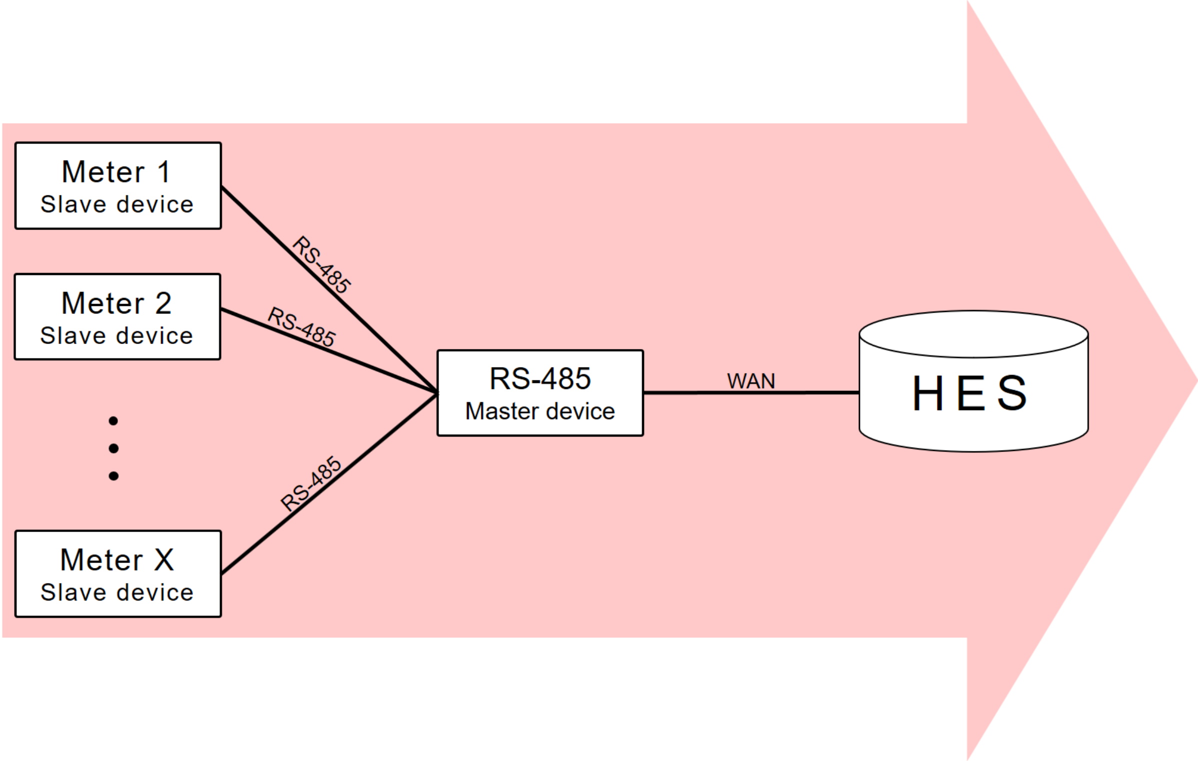


Figure 90: Flow direction of push messages over RS-485

The functionality is based on DLMS specification, which defines unbalanced connection-mode datalink operation. By definition, an unbalanced data link involves one primary station and one or more secondary station(s). This means when meters are connected to the same RS-485 bus, only one meter can act as a primary station (master) and all other must act as secondary stations (slaves). In such a configuration, slave meters are only allowed to transmit on the RS-485 bus if they are addressed by the master meter. The master meter in such a configuration also provides WAN connectivity.

When push message is triggered by a slave meter, it is sent to the master meter.
After master meter receives complete push message from sub-meter, it triggers push method of “sub-meter push setup” object. Push process then proceeds in normal way as implemented for other push setup objects in master meter. Master meter executes WAN communication retries according to parameters in sub-meter push setup and other related objects.

The whole functionality around push in a system of meters connected via a RS-485 bus is divided in the functionality of slave meters and the functionality of master meters. Therefore, the master meter and all its slave meters must be properly configured.

In the master meter **Sub-meter address list** (0-0:128.22.2*255) must be fulfilled with HDLC addresses of all slave meters (maximum 30 slave meters), which are physically connected to the master meter via RS-485 bus. In all slave meters HDLC address must be defined (**IEC HDLC setup channel *x*** (0-*x*:22.0.0*255), where *x* is 0, 1, 2 or 3).

For configuring objects related to push messages process, refer to the chapter *8.7.1. General*.

NOTE
If some of slave meters is not presented in defined RS-485 network, the master meter triggers a push and **an empty message** is sent to the HES.

8.8. No power reading

No power reading functionality is used to access the meter data through active optical probe even when meter has no other power supply connected. Active optical probe is powered by a computer USB port. Because active optical probe is able to supply only a limited amount of power, meter operates in a special low power mode, also blocking all eventual changes of meter parameters. When meter runs in *No power reading* mode, the following applies:

- Optical interface is the only active communication port.
- The maximum baud rate of optical interface is 19200 bps. In this case, only reading (COSEM-GET) actions are allowed (no SET and ACTION).
- Sequence of displayed data is the same as in normal mode.
- The meter runs in read-only mode. All events occurred in that time will be recorded when main supply is reconnected.
- The RTC could be lost, the meter will not show invalid clock error or alarm until main power is applied, though the date time value might be incorrect.

Figure 91: No power reading with SEP2 MeterView – meter supplied by laptop via optical probe

Figure 92: No power reading – meter supplied by power bank via optical probe

NOTE!
Different power supply capabilities of computer's USB ports may cause unsuccessful No power reading. If such error occurs, remove communication module from the meter.
For communication module removing procedure, see the Installation and maintenance manual, chapter *3.1.5. Communication module inserting/removing*.

NOTE!
For no power reading, only an active optical probe **SONDA 6** can be used.

9. IDENTIFICATION

In order to identify each meter, its functionalities, and capabilities, several identification objects are implemented. While some of them are fixed by the meter, some can also be defined by the user.

To access the meter via DLMS/COSEM protocol, the usage of device address is mandatory. Device address is structured in the following way:

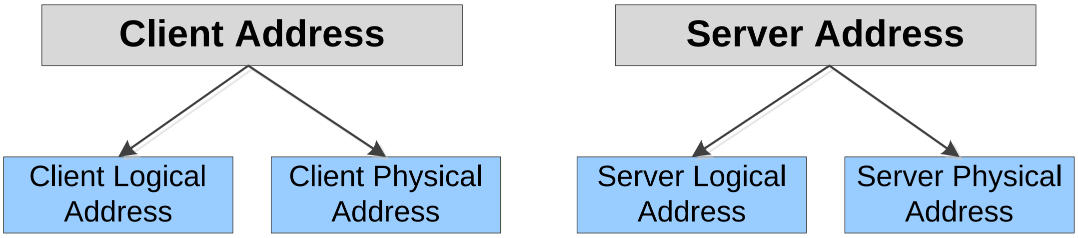


Figure 93: DLMS/COSEM addressing

Where:

- Logical addresses are dedicated specifically to COSEM/DLMS protocol
- Client logical address is the logical address of the client accessing the meter
- Server logical address is the address of the specific logical device inside physical device – meter
- Pair of logical addresses determines association establishment between the server and the client. Different access rights may be granted by the server. Which assignments are available can be read in SAP assignment object
- Physical addresses depend on communication interface used for accessing the meter (HDLC addresses, phone numbers, IP addresses, TCP ports, etc.). In some cases, specific physical address can also be omitted (e.g. Client physical address in HDLC protocol).

Based on pairs of logical addresses, the meter supports COSEM Application Associations according to Table 117. Only one logical device is identified with server logical address 1 is implemented in the meter.

COSEM Application Associations	Client SAP	Server SAP
Public Association	16	1
Management Association	1	1
Management Association 2	2	1
Preestablished Association	102	1

Table 117: COSEM Application Associations

Management Association (2) is to be 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 e.g. GPRS as well as on local interface i.e. optical port.

9.1. SAP assignment

SAP assignment list in **SAP assignment** (0-0:41.0.0) object contains the list of all logical devices and their SAP addresses within the physical device – meter.

The interface class “SAP assignment list” contains the information on the assignment of the logical devices in the physical device. Information is presented as pairs of logical device address associated with a COSEM logical device name. Only one logical device is implemented in the meter.

9.2. Current association

The **Current association** (0-0:40.0.0) object is a list of associated objects in the meter and some additional information.

Object list contains the list of visible COSEM objects with their class id, class name, version, logical name and the access rights to their attributes and methods within the given application association.

Associated Partners ID contains the identifiers of the COSEM client and server (logical device) application processes within the physical devices hosting these processes, which belong to the Application Association (AA) modelled by the Association LN object.

- Client SAP (1),
- Server SAP (1).

Application context name: in the COSEM environment, it is intended that an application context pre-exists and it is referenced by its name during the establishment of an AA. This attribute contains the name of the application context for that association. It includes these elements:

- joint-iso-ctt (2),
- country (16),
- country-name (756),
- identified-organization (5),
- DLMS-UA (8),
- application-context (1),
- context-id (x).

Context-id (x) can be (where **x** stands for 0 to 3):

- 0 – Logical Name Referencing No Ciphering,
- 1 – Short Name Referencing No Ciphering,
- 2 – Logical Name Referencing With Ciphering,
- 3 – Short Name Referencing With Ciphering.

xDLMS context info contains all the necessary information on the xDLMS context for the given association, where:

- the *conformance* element contains the xDLMS conformance block supported by the server;
- the *max-receive-pdu-size* element contains the max. length for an xDLMS APDU, expressed in bytes that the client may send. This is the same as the *server max receive pdu size* parameter of the DLMSInitiate. response pdu (see Green Book Clause 9.4.4.);
- the *max-send-pdu-size*, in an active association contains the max. length for an xDLMS APDU, expressed in bytes that the server may send. This is the same as the *client max receive pdu size* parameter of the DLMS User Association, COSEM Identification System and Interface Classes, Ed. 9 draft 0.5 DLMS User Association V0.5 2008-12-01 DLMS UA 1000-1 ed. 9.0 54/255 © Copyright 1997-2008 DLMS User Association DLMS-Initiate.request pdu (see Green Book Clause 9.4.4);
- the *dlms-version-number* element contains the DLMS version number supported by the server;
- the *quality-of-service* element is not used;
- the *cyphering-info*, in an active association, contains the dedicated key parameter of the DLMS-Initiate request pdu (See Green Book Clause 9.4.4).

Authentication mechanism name contains the name of the authentication mechanism for the association. It includes these elements:

- joint-iso-ctt (2),
- country (16),
- country-name (756),
- identified-organization (5),
- DLMS-UA (8),
- authentication-mechanism-name (2),
- mechanism-id (x).

Mechanism-id can be (where **x** stands for 0 to 5):

- COSEM lowest level security mechanism name – (0),
- COSEM low level security mechanism name – (1),
- COSEM high level security mechanism name – (2),
- COSEM high level security mechanism name using MD5 – (3),
- COSEM high level security mechanism name using SHA-1 – (4),
- COSEM high level security mechanism name using GMAC – (5).

LLS Secret contains the authentication value for the LLS authentication process.

Association status indicates the current status of the association, which is modelled by the object. These can be:

- non-associated – (0),
- association-pending – (1),
- associated – (2).

Security setup reference references the **Security setup** (0-0:43.0.0) object by its logical name. The referenced object manages security for a given **Current association** object instance.

Method Description

This method is accessible with right mouse click on the Current association object: *Execute method - Change HLS secret.* This method changes *HLS secret*, where *master key* needs also to be known.

9.3. COSEM logical device name

The COSEM logical device can be identified by its unique COSEM logical device name. This name can be retrieved from an instance of IC “SAP assignment”, or of a **COSEM logical device name** (0-0:42.0.0) COSEM object. This name is defined as an octet-string of up to 16 octets. The first three octets uniquely identify the manufacturer of the device 2. The manufacturer is responsible for guaranteeing the uniqueness of the octets that follow (up to 13 octets).

COSEM device logical name consists of the following information and it is represented in ASCII format, e.g. ISKT880M00000001:

- Manufacturer code
  MC (3 bytes): ISK
- Meter type
  MT (4 bytes): T880 - three phase, type 880
- Meter server restriction/access
  R (1 byte): M – management, P – public, E – Pre-establishment
- Manufacturer specific serial number ASCII encoded (SN)
  SN (8 bytes): Serial Number **Device ID 1, manufacturing number** (0-0:96.1.0)

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10	Byte 11	Byte 12	Byte 13	Byte 14	Byte 15	Byte 16
MC			**MT**				**R**	**SN**							

Figure 94: COSEM logical device name structure

9.4. Electricity ID 1

Electricity ID 1 is unique meter number in certain group of meters. The number is written and read in alpha-numeric format (in the **Electricity ID 1** (1-0:0.0.0) object). The length of the ID must be 8 characters.

The number is copied into the **IEC local port setup channel 0** (0-0:20.0.0) object and is used when accessing the meter through IEC 62056-21 (former 1107) protocol (through the optical interface).

9.5. Device ID

Meter provides 9 different device identification strings, set in the **Device ID** (0-0:96.1.**e***) objects (Table 118).

Device ID	description	value e*
Device ID 1	manufacturing number	0
Device ID 2	meter equipment ID	1
Device ID 3	function location	2
Device ID 4	location information	3
Device ID 5	general purpose	4
Device ID 6		5
Device ID 7		6
Device ID 8		7
Device ID 9	meter ID	8

Table 118: Device IDs

Device ID 1

Device ID1 is meters manufacturing serial number (also reflected in a *COSEM logical device name*). The number is written and read in alphanumeric format. The length of the ID must be 8 characters.

Device ID 2

Device ID2 is customer ID. The number is written and read in alphanumeric format. The length of the ID is limited to maximum 48 characters.

Device ID 3 ... Device ID 9

Device ID's have no special meaning forced by the meter. They are general purpose IDs for any identification purposes. The numbers are written and read in alphanumeric format. The length of the ID's is limited to maximum 48 characters.

9.6. Meter firmware identification

Identification of the firmware running in the meter is available via dedicated COSEM objects.

9.6.1. Firmware architecture

Whole meter application is divided in two parts: core and module. Each part includes specific firmware components. Both parts of firmware (core and module), use the same structure of identification. Identification is 16 characters long.

Firmware Identification Structure

Core and module identifications are separated in different objects; however, they both follow the same structure.

Firmware identification (e.g. **ISKACMT880100500**) consists of the following fields (see Figure 95):

- Manufacturer tag (3 characters) ISK stands for Iskraemeco,
- FW tag (2 characters) AC – application core, AM – application module,
- Device type (5 characters) Type of meter i.e. MT880,
- Revision (6 characters) Revision of application core or application module.

Revisions number (RRRRRR) is structured as presented in Figure 96.

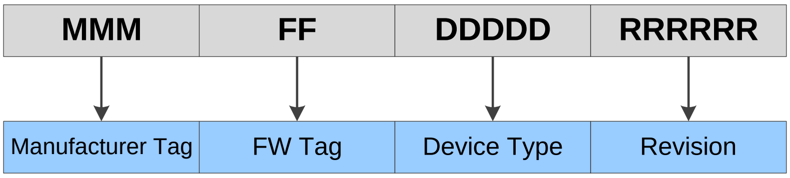


Figure 95: Firmware Identification Structure

Firmware Revision Number Structure

The firmware revision number (e.g. ISKACMT880**100500,** the last 6 characters) is structured in three levels:

- Major revision number (M),
- Minor revision number (mmm),
- Build number (bb).

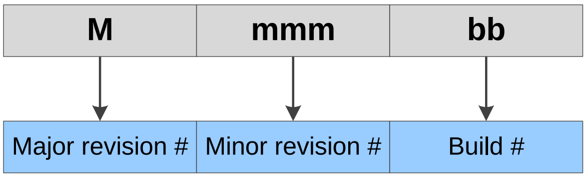


Figure 96: Revision Number Structure

9.6.2. Active FW core version

Active firmware version (1-0:0.2.0) object identifies application core of the metering firmware.
The data is stored as 16-character ASCII value. See Figure 95.

9.6.3. Active FW module version

Active firmware version 1 (1-1:0.2.0) object identifies application module of the metering firmware.
The data is stored as 16-character ASCII value. See Figure 95.

9.6.4. Active FW core signature

Signature in the **Active firmware core signature** (1-0:0.2.8) object is used to check integrity of core firmware. It is calculated using MD5 algorithm.
(Message-Digest algorithm 5) and its length is 16 characters.

9.6.5. Active FW module signature

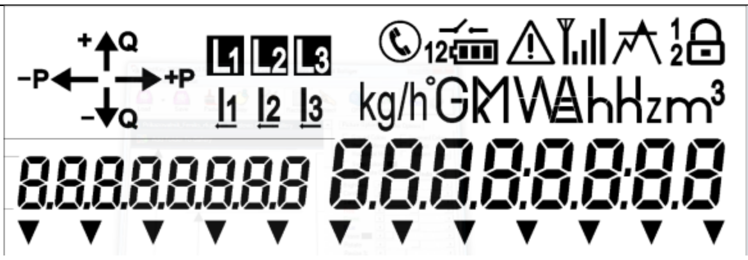
Signature in the **Active firmware module signature** (1-1:0.2.8) object is used to check integrity of module firmware. It is calculated using MD5 algorithm.
(Message-Digest algorithm 5) and its length is 16 characters.

10. TECHNICAL CHARACTERISTICS

Reference voltage	
Indirect connection (HW version up to 3x240/415 V)	3x57.7/100 V ... 3x240/415 V 3x100 V … 3x230 V (3P3W connection) 0.8 - 1.15 U_n List of reference voltages: 3x63.5/110 V, 3x69/120 V, 3x115/200 V, 3x120/208 V, 3x127/220 V, 3x220/380 V, 3x230/400 V, 3x240/415 V, 3x57.7/100 V…3x230/400 V, 3x57.7/100 V…3x240/415 V, 3x63.5/110 V…3x230/400 V, 3x63.5/110 V…3x240/415 V, 3x100 V, 3x110 V, 3x120 V, 3x200 V, 3x230 V
Indirect connection (HW version up to 3x290/500 V)	3x57.7/100 V ... 3x290/500 V 3x100 V … 3x290 V (3P3W connection) 0.8 - 1.15 U_n List of reference voltages: 3x63.5/110 V, 3x69/120 V, 3x115/200 V, 3x120/208 V, 3x127/220 V, 3x220/380 V, 3x230/400 V, 3x240/415 V, 3x277/480V, 3x290/500V, 3x57.7/100 V…3x290/500 V, 3x63.5/110 V…3x277/480 V, 3x63.5/110 V…3x290/500 V, 3x100 V, 3x110 V, 3x120 V, 3x200 V, 3x230 V, 3x290V
Direct connection	3x120/208 V ... 3x240/415 V 0.8 - 1.15 U_n List of reference voltages: 3x120/208 V, 3x127/220 V, 3x220/380 V, 3x230/400 V, 3x240/415 V
Reference frequency	50 Hz ±2% or 60Hz ±2%
Currents (A)	
Indirect connection	
Rated current (HW version up to 3x240/415 V)	1 A, 1.5 A, 2 A, 5 A, 5//1 A
Maximal current (HW version up to 3x240/415 V)	6 A, 10 A
Rated current (HW version up to 3x290/500 V)	2.5 A, 5 A, 10 A
Maximal current (HW version up to 3x290/500 V)	10 A, 15 A, 20 A
Thermal current	120% I_{max}
Short circuit current	0,5 sec 20 × I_{max}
Start-up current	0.1% of rated current (1 A) for class C (0,5S)
Direct connection	
Basic current	5 A, 10 A
Maximal current	60 A, 80 A, 100 A, 120 A
Thermal current	120% I_{max}
Short circuit current	half cycle at rated frequency, 30 × I_{max}
Utilization category	UC1 (60 A), UC2 (80 A), UC2 (100 A), UC3 (120 A)
Start-up current	0.4% of basic current for class 0,5S
Accuracy class	
Indirect connection	
Active energy	B or C (EN 50470-3) Class 1 (IEC 62053-21) Class 0.5S (IEC 62053-22)
Reactive energy	Class 1 (IEC 62053-24) Class 2 (IEC 62053-23)
Apparent energy	Calibrated up to 1%
Direct connection	
Active energy	B or C (EN 50470-3) Class 1 (IEC 62053-21) Class 0.5S (IEC 62053-22)

Reactive energy	Class 1 (IEC 62053-24) Class 2 (IEC 62053-23)
Apparent energy	Calibrated up to 1%
Outputs	
Type - OPTO-MOS relay	
Contact	Make or break contact
Permitted load	100 mA
Voltage	12–275 V
Pulse length	From 20 ms to 2400 ms (adjustable in steps by 20 ms)
Transmission distance	Up to 1 km
Inputs	
Voltage level (HW version up to 3x240/415 V)	100–240 V AC/DC ON: U ≥ 80 V OFF: U < 20 V
Voltage level (HW version up to 3x290/500 V)	100–290 V AC/DC ON: U ≥ 80 V OFF: U < 20 V
Current consumption	< 2 mA @ 50 V < 10 mA @ 240 V < 12 mA @ 290 V
Self-consumption	
Self-consumption of current circuit per phase	0.01 VA by nominal current 1 A
Self-consumption of voltage circuits	
Nominal voltage 57.7 V	0.6 W / 1.1 VA (self consumption of voltage circuits, when meter is supplied from the measuring voltages) - per phase
	0.4 W / 0.1 VA (self consumption of voltage circuits, when meter is supplied from the external voltage) - per phase
	2.1 W / 3.2 VA (self consumption of the external power supply, when meter is supplied from the external voltage)
	0.9 W / 1.4 VA (GSM module)
Nominal voltage 240 V	1 W / 2.1 VA (self consumption of voltage circuits, when meter is supplied from the measuring voltages) - per phase
	0.4 W / 0.6 VA (self consumption of voltage circuits, when meter is supplied from the external voltage) - per phase
	2.1 W / 3.2 VA (self consumption of the external power supply, when meter is supplied from the external voltage)
	1.1 W / 2.3 VA (GSM module)
Nominal voltage 290 V	1.1 W / 2.1 VA (self consumption of voltage circuits, when meter is supplied from the measuring voltages) - per phase
	0.5 W / 0.6 VA (self consumption of voltage circuits, when meter is supplied from the external voltage) - per phase
	2.5 W / 3.7 VA (self consumption of the external power supply, when meter is supplied from the external voltage)
	1.4 W / 2.4 VA (GSM module)
Communication	
Port 0 – Optical interface Port 1 – RS232 or RS485 (on the meter board)	Max. 57600 Baud (IEC62056-21 mode E and/or DLMS) Max. 38400 Baud (IEC62056-21 mode E and/or DLMS)
Port 2 – Communication port in the module	CS interface: max. 9600 Baud (IEC62056-21 mode E and/or DLMS) 2.5G/3G modem: max. 115200 Baud (IEC62056-21 mode E and/or DLMS) Ethernet: 10/100 Mbit/s LMN: 921600 Baud
Port 3 - Communication port in the module	RS485: max. 115200 Baud (IEC62056-21 mode E and/or DLMS)
LED output	
Type	LED – red
Number	2, function kWh/kvarh, kWh/kVA – programmable

Impulse frequency	≤ 2.5 kHz
Impulse length	8 ms
Constant	Programmable
Real time clock	
Accuracy	Crystal: < 5 ppm = ≤ ±3 min./year (at Top = +25 °C)
Back-up power supply	SuperCap: > 7 days, charging time 24 hours at nominal voltage Lithium battery: 10 years; battery type: ER14250
External power supply	
Value – meter HW up to 3x240/415 V	50–240 V AC/DC
Value – 290/500 V	50– 290 V AC/DC
Tolerance	0.8–1.15 U_n
Frequency (only for AC)	50 Hz or 60 Hz
Load control switches	5 A bistable relay
Switching voltage	250 V AC
Maximum switching current	8 A
Switching power	2000 VA
Auxiliary control switches	OptoMOS relay output
EMC	
Electrostatic discharge	Contact 8 kV, air 15 kV (IEC 61000-4-2)
VF magnetic field (80 MHz – 2 GHz)	20 V/m active and 30 V/m passive (IEC 61000-4-3)
Transient test	
- Current and voltage circuit not under load	5 kV (IEC 61000-4-4)
- Auxiliary circuits > 40 V	2 kV
Overvoltage category	OVC III (IEC 60664-1:2007)
Surge test	
- Current and voltage circuits	4 kV (IEC 61000-4-5)
- Auxiliary circuits > 40 V	1 kV
Insulation strength	4 kV_{rms}, 50 Hz, 1 min
Impulse voltage	
- Current and voltage circuits	12 kV voltage circuit,10 kV current circuit, 6 kV other 1.2/50 µs (IEC 62052-11)
- Auxiliary circuits	6 kV, 1.2/50 µs
Radio interference suppression	Class B (EN 50022)
Immunity to conducted disturbances	20 V (EN 61000-4-6)
Immunity to damped oscillatory waves (Indirect connection)	2.5 kV (common mode) (EN 61000-4-18 slow damped) 1 kV (differential mode)
Glow wire test	IEC 695-2-1
Spring hammer test	IEC 60068-2-75
Temperature ranges (IEC 62052-11)	
Operation	-40 °C ... +70 °C
LCD operation	-25 °C ... +70 °C
Storing	-40 °C ... +85 °C
Temperature coefficient	

(IEC 62052-11)	
Range	-40 °C ... +70 °C less than ±0.015% / K
Ingress protection (IEC 60529)	IP 54
Protection class (IEC 62052-11)	
Liquid Crystal Display	 Number of digits for index: 8 Index digit size: 3 x 6 mm Number of digits for index: 8 Index digit size: 4 x 8 mm
Climatic conditions	
Type of meter	Indoor meter
Humidity	max. 95%
Altitude	max. 2000 m
Mechanical conditions	Meter passed all mechanical tests like shock and vibration tests.
Terminals (diameter)	
Indirect connected meter	
Screw type	Combi Pozidrive
Diameter	5 mm
Material	Brass or Nickel plated brass
Tightening torque	1.5–1.7 N m
Direct connected meter	
Screw type	Combi Pozidrive
Diameter	9.5 mm
Material	Nickel plated steel
Tightening torque	2.6–3.0 N m
Mechanical environment	M1
Electromagnetic environment	E2
Climatic class	3K7
Dimensions	311 × 177 × 91 mm (standard terminal cover) 255 × 177 × 91 mm (short terminal cover)
Mass	
Transformer operated meter, modular version	Approx. 1.68 kg
Direct operated meter, modular version	Approx. 2,05 kg

Owing to periodic improvements of our products, the supplied products can differ in some details from data stated in this manual.

Iskraemeco d.d., Merjenje in upravljanje energije
4000 Kranj, Savska loka 4, Slovenia
Telephone (+386 4) 206 40 00, Fax: (+386 4) 206 43 76
http://www.iskraemeco.com, E-mail: info@iskraemeco.com
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