

SM401 Smart electricity meter

Technical description



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1 General description

The SM401 generation of smart meters complies with the latest requirements in the field of implementation of multifunctional “smart” meters and “smart” AMM networks for remote reading and control. The meters are designed according to the newest functional and technology requests in the field of smart metering and requests of the market as well.

The SM401 meters are designed for 2 wire single phase, direct or transformer connection to the mains. It measures active and optionally reactive and apparent energy for residential and commercial customers.

In basic variant, the meter is equipped with integrated switching device, and with integrated communication device – G3-PLC modem.

The functions of the SM401 meters are in compliance with relevant international standards and certification bodies – IEC, EN, VDEW, DLMS, IDIS, M-Bus.

The meter measure active and reactive energies in both directions, absolute energy, and register them in 8 tariffs.

Accuracy classes are 1 and 2 according to IEC, and A and B according to EN for direct connected meters.

For reactive energy, accuracy classes are 2 or 3 per IEC.

The meter has real time clock, integrated, backed up with battery or super capacitor.

The measured values are shown on LCD display. The scroll sequence is programmable, and review of the other values is possible by using press-key on the front plate of the meter.

The communication interfaces that meter is equipped with are: M-Bus, Wireless M-Bus, IR port, RS485 and one of the communication modems – GPRS/3G/LTE.

1.1 Short technical overview

The SM401 meter complies with the latest requirements in the field of implementation of multifunctional “smart” meters and “smart” AMM networks for remote reading and control.

The main characteristics of the meter are:

- High precision and long term stability
- Communication module G3-PLC or RS485 port, and disconnecter
- Internal and external tariff management (tariffs 1 – 8)
- Wide range of measurement: from 25 mA to 100 A
- No-power reading (using LCD and optical port)
- Strong magnetic field detection and terminal block cover or cover of the measuring part removal detection
- Adjustable input power threshold which will switch off a consumer that has exceeded given limit.
- During the lifetime of the meter recalibration is not necessary
- EMC compliance according to IEC and EN standards

Energy and power measuring:

- Active energy measurement (received, delivered and absolute) in accordance with IEC 62053-21/22 standards (class 1 or 2) or EN 50470-3 standard (class index A or B)
- Reactive energy measuring (in four quadrants) in accordance with IEC 62053-23 standard, class 2 or 3 (optional)
- The registers of active energy are in compliance with EN 62056-61 (1.8.x – received active energy, 2.8.x – delivered active energy, 15.8.x – absolute active energy)
- The meter measures and displays the RMS values of voltages and currents
- Single-phase two-wire connection to a 230 V/110 V mains.
- Wide measuring range for measuring of current 0,025 – 5(100) A
- Current active demand and maximum average demand measuring in both directions
- Power quality supervision and diagnostics of the mains
- Software adjustment of meter's functionalities (parameterization per customer needs)

Other characteristics:

- Wide temperature range from -40°C to +70°C. As an option tropicalized version adjusted to operation in regions with high moisture and temperature is also available.
- High level of protection against infiltration of water and dust – IP54 protection in accordance with IEC60529
- Precision of the real time clock is controlled by the oscillator 32768Hz with reserve battery power supply; precision of the clock is ± 3 min per year at ambient temperature, with a cumulative error
- The installed calendar allows automatic DST clock shifts
- A lithium battery provides reserve power supply of the clock for more than 15 years
- The meter monitors the voltage of the lithium battery and indicates if the battery is discharged

2 Meter faceplate

The following figure represents 1-phase meter faceplate:



Fig. 2 - Meter faceplate representing important exterior elements of the meter

1. Meter cover
2. Meter cover screws (meter sealing points)
3. Left button sealing door
4. Display button
5. LCD display
6. LED imp/kwh
7. LED imp/kvarh (optional)
8. Optical port
9. Terminal block cover
10. Terminal block cover screws (sealing points for the meter terminal block)

2.1 Meter case

All parts of the meter are made of high quality, certified materials.

Plastic parts are made of polycarbonate or polycarbonate with 10% of glass fibres. Terminal block is made of polycarbonates with glass fibers. The meter case complies with mechanical requirements as specified in the relevant standards IEC 62052-21 and IEC 62052-11 and EN 50470-1.

The case is made of high quality UV resistant, polycarbonate self-extinguishing material. The meter case consists of a housing, meter chassis, meter cover and terminal block cover. Measuring part of the meter and terminal block are inside the housing. Meter cover is sealed and it cannot be removed without damaging the seal. The level of protection of the meter against infiltration of water and dust is IP54 according to the IEC 60529. The main meter data are indicated on its face plate according to the IEC 62052-11 and EN 50470-1 standard.

Adjustable hanger is placed at the back side of the casing. This steel hanger allows three different height levels of meter mounting.

Removal of the meter cover and/or terminal block cover is detected by a micro-switch.

Current terminals are made of brass (or steel) and provided with high quality M6 screws. In order to ensure a reliable cable fixing the use of a screwdriver with PZ2 type top is recommended.

All current conduction parts are made from electrolytic copper and have large enough cross-sections to enable uniform distribution of heat without "hot points".

2.2 Overall and fixing dimensions of the case

The meter's dimensions, its shape and high quality packaging guarantee easy and optimal transport conditions. Adjustable hanger and fixing holes guarantee reliably and easy fixing of the meter during mounting.

Meter case dimensions comply with DIN 43857. The dimensions of the meter are shown in the following Figures:

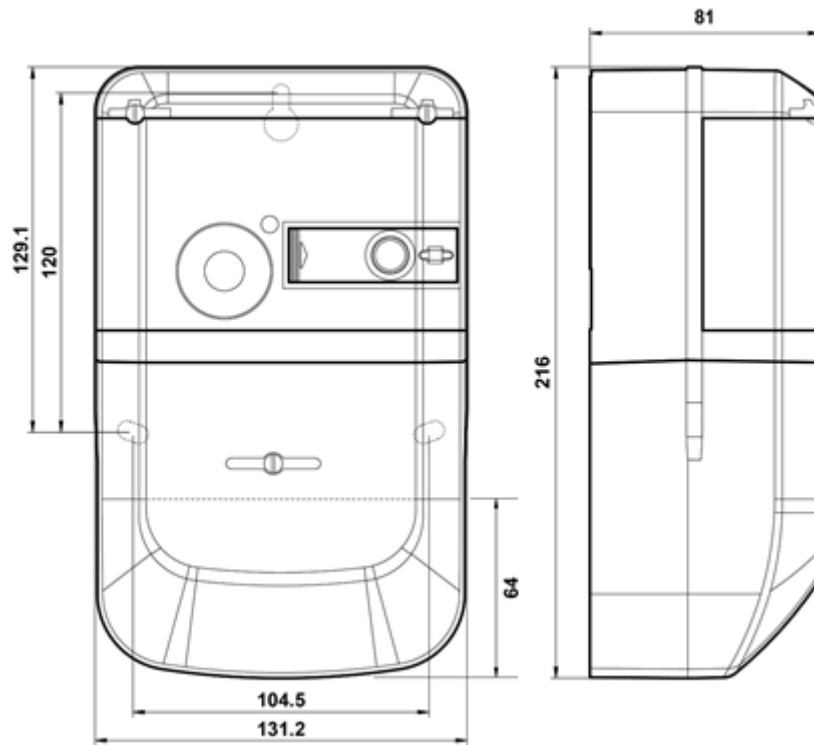


Fig. 4 - Exterior dimensions of the 1-phase meter

2.3 Name plate layout

The following figures show meter's name plate with its marking. It is in accordance with IEC 62052-11 and EN 50470-1:

1. Meter type with ordering designation
2. Company logo – manufacturer name
3. General purpose arrows
4. Reference voltage
5. Rated frequency
6. Basic and maximum current
7. Number of phases
8. Operating temperature range
9. Accuracy class
10. Meter's approval mark
11. Country and year of production
12. LED pulse constant
13. Serial number
14. Pulse output constant
15. OBIS codes description (codes on LCD)
16. Meter's certificate marks
17. Insulation level label

18. Communication protocol
19. Protection class label
20. Barcode (meter type and serial number)

The wiring diagram is placed under terminal cover.

The data are indelible in normal use of the meter.

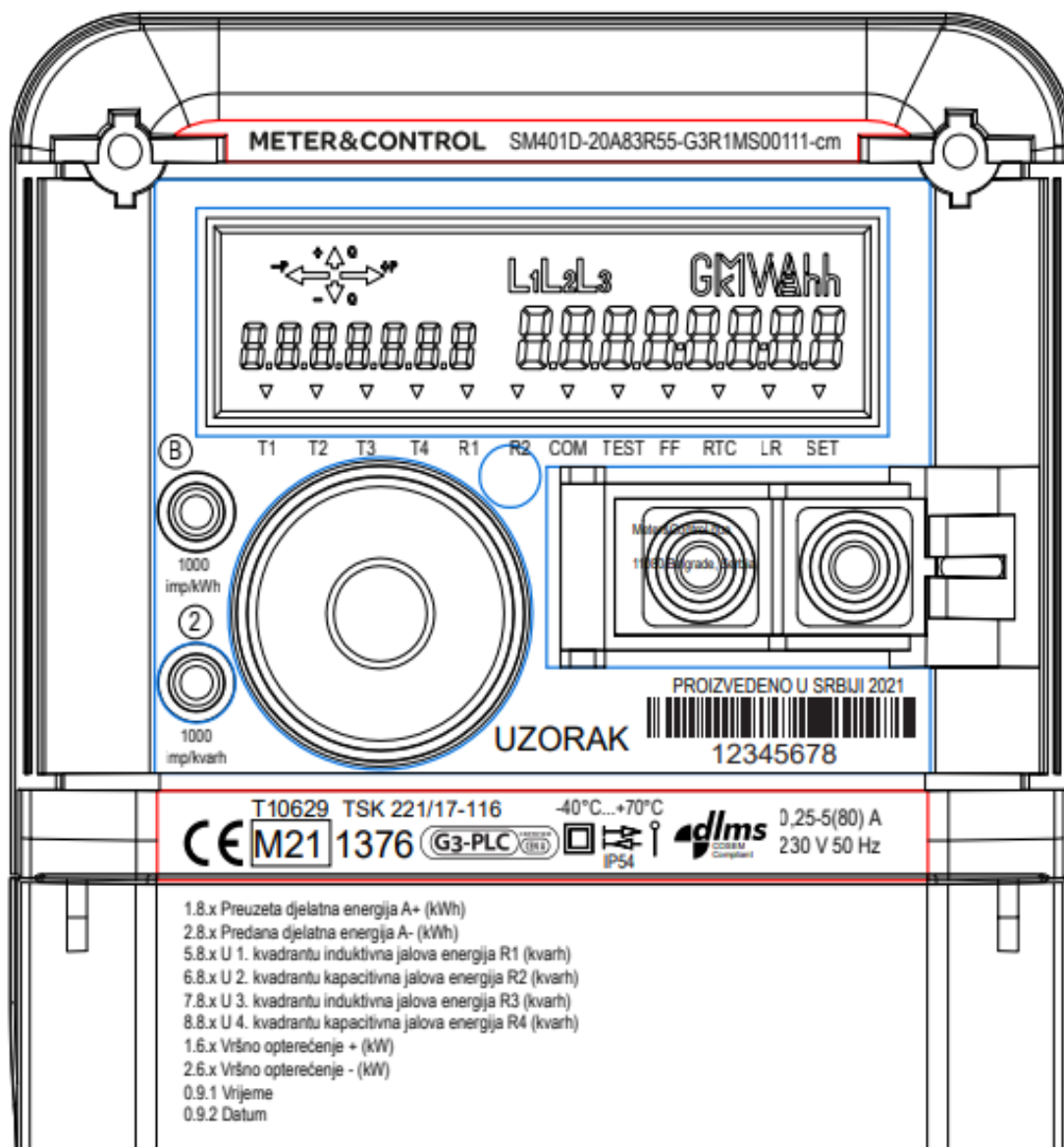


Fig. 6 - 1-phase meter front panel layout

2.4 Sealing of the meter

Sealing of the meter is applied through the sealing screws – 2 screws for meter cover, and 2 (1 for single phase) screws for terminal cover.

The left button door also could be sealed.

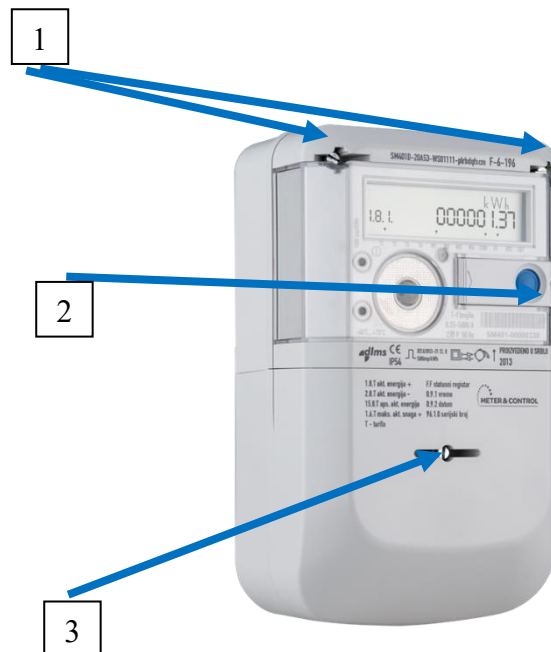


Fig. 7 - Sealing of the 1-phase meter

1. Sealing screws for meter cover
2. Sealing of the left button door
3. Sealing of the terminal cover

2.5 Terminal block SM401

The terminal is designed in accordance with IEC 62052-11 and EN 50470-1. It is modular type, and could be easily changed during service.

The same contact quality is approved, no matter if Al or Cu conductor are uses, stranded or solid types.

The material used for terminal block is polycarbonate with 10% of fibre glass, and it is in accordance with ISO 75-2, 135°C (1.8 Mpa, method A).

The main current terminal blocks for direct connection meters are made of brass (steel) shells provided with two M6 screws. Both solid and stranded wire with a cross section from 4 mm² to 35 mm² can be used for connection. Maximum applicable current is 100 A, and for basic configuration the maximum current is 80 A.

When conductors with small cross-sections are used (less than 4 mm²), they are placed in a special indentation (stamping) of the copper bus bar preventing the wire shift sideways when

tightening (Fig. 16).

The current terminals provide the minimum time needed for meter wiring on the measuring point. The wiring diagram is placed under terminal cover.

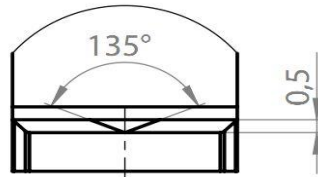


Fig. 16 - Indentation (stamping) for conductors with smaller cross sections



Fig. 17 - SM401 meter terminals

Figure 18 shows the layout of the terminal block with screws in maximum open position.

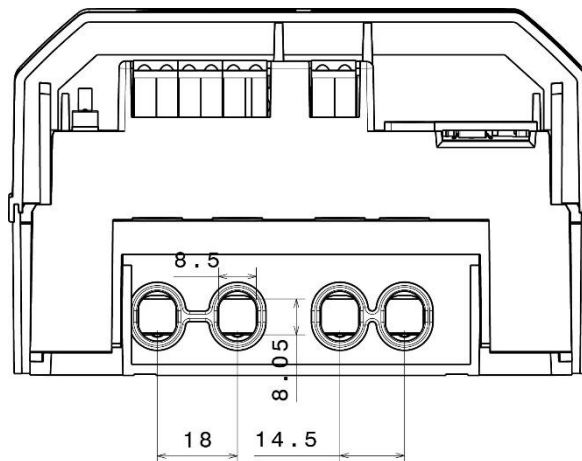


Fig. 18 - Layout of the meter terminal block opening

2.5.1 Auxiliary terminals

Auxiliary terminals are divided in two groups: mains voltage terminals and low voltage

terminals (with galvanic insulation). The same auxiliary terminals are used both for direct connection meters and transformer meters. All auxiliary terminals are based on 'PLUG IN' principle.

Mains voltage terminals, depending on the assembly, can be:

- Tariff inputs
- Relay outputs
- Optomos output

Low voltage terminals, depending on the assembly, can be:

- Impulse outputs
- Alarm inputs
- MBUS output
- RS485 port

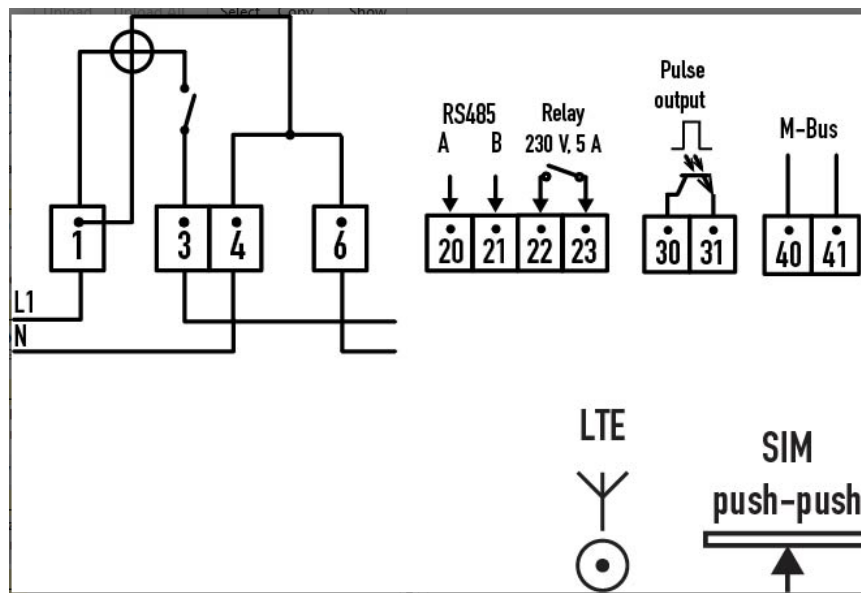


Fig. 19 – Example of auxiliary terminals

2.5.1.1 High-voltage terminals

High voltage terminals are intended for connection to the 230 VAC and are not galvanic isolated.

They are in category of terminals with voltage over the 40 V.

The meter has three types of high voltage terminals: tariff inputs, optomos output and relay outputs.

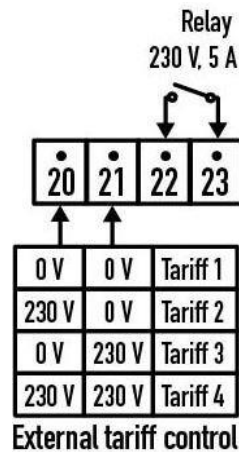


Fig. 20 - Tariff inputs and relay output for SM401 meter type

2.5.1.2 Low-voltage terminals

Low voltage terminals are intended for connection with other devices. Nominal voltage is under the 40 V, and they are galvanic isolated.

The meter has M-Bus micro-master communication interface for collecting data from other measuring devices – gas meters, water meters, and other devices that support M-Bus interface.

2.5.1.3 The auxiliary terminal functions (inputs/outputs)

The meter has the following possible terminal configuration:

- Relay output 230/120 V AC, 5 A or two tariff inputs 230/120 V AC, on terminals 20, 21
- Relay output 230/120 V AC, 5 A or OPTOMOS output 230/120 V/0,1 A, on terminals 22, 23
- S0 input or electrical pulse output, on terminals 30, 31
- S0 input, on terminals 32, 33

The usage of inputs/outputs:

- 230/120 V AC inputs are used for external tariff control.
- S0 inputs are used as control inputs – alarms, external switch for reconnection the switching device...
- The relay output could be used as a tariff indicator, or for independent current circuit management.
- The OPTOMOS output could be used as a tariff indicator, or for independent current circuit management.

The electrical pulse output could be realized via OPTOMOS or via low-voltage pulse output.

2.5.1.3.1 Electrical pulse output

The meter has one passive electrical pulse output for meter testing, which is galvanic isolated.

Electrical characteristics of this output are in line with IEC 62053-31, B class.

Electrical impulse outputs are located at the connectors 30 and 31 (Fig. 19).

The constant at this output is configurable. By default it is set to:

- Active energy constant is 500 pulse/kWh
- Reactive energy constant is 500 pulse/kvarh

2.5.1.3.2 Impuls S0 input

The impulse S0 input can be used as a control input, i.e. as alarm or external switch for activation of the disconnecter module.

2.5.1.3.3 Bistable relays

The bistable relay output for the current of 5 A uses for direct control of individual consumer circuits. The output could be remotely controlled or set to indicate the active tariff.

2.5.1.3.4 Tariff inputs

The meter is provided with two tariff inputs which are operated with 230/120 V AC. They are used for external tariff control. As an option, tariff input can be used for activation of special tariff active during special conditions in the network.

3 Functional description of the meter

3.1 Meter configuration and functional description

The meter consists of the following units:

- Power supply
- Microcontroller with measuring unit in charge of measurement part firmware
- Separate microcontroller in charge for applicative part of the firmware
- FRAM memory
- Flash memory
- Display
- Buttons
- Analog part (AFE – voltage and current sensors)
- Communication (2G/3G/4G or G3 PLC) module or RS485 port
- Disconnecter module (latching relays) – only for direct connection meter type
- Detector of unauthorised access to the meter
- Inputs and outputs

The meters have enough spare capacity of FRAM and FLASH memory as well as uController power to support future upgrade of firmware.

Retention time is 100 years.

3.2 Analog part (AFE – Voltage and current sensors)

AFE consists of a voltage dividers, current transformers and appropriate shunts. The microcontroller is provided with A/D converters for conversion of phase voltages and currents into digital values.

Measurement systems allow, beside precise measurement of the active energy and demand in a wide measuring and temperature range, measuring of the phase voltages and currents, as well as measuring of the phase angles between voltages and between the voltage and current of each phase.

Analog signals representing a scaled voltage value (VA, VB or VC) or current value (IA, IB, IC) in each of the phases are brought to analog input pins of the measuring chip. Analog signals are then brought to the multiplexer input making a circular selection of input voltages and forwarding them to the output of the analog-digital converter (ADC) where the selection is made. Besides the scaled current and voltage values, voltage from RTC battery and temperature sensor is also brought to the AC converter.

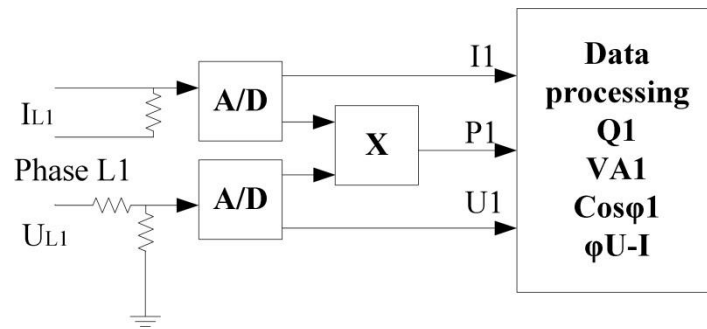


Fig. 25 – Analog part – AFE for 1-phase meters

3.3 Microcontroller

The meters have two microcontrollers, one intended for measurement functions and other intended for applicative functions in order to achieve code separation to WELMEC 7.2 directive. This allows easy and safe firmware update of applicative part of the firmware without affecting metrology functions and need for new meter verification in case of firmware update.

3.4 Power supply

The power supply is designed to operate in the required voltage range 58 V- 230 V(+15%,- 20%). The power supply generates the voltages of +7 VDC and + 11 VDC.

The voltage of +7 VDC is used as a power supply for the whole measuring, microcontroller and disconnecter part. The voltage is later set to +3.6 V and +3.3 V by linear regulators, while it is put up to +36 VDC by the DC-DC converter in order to be used for power supply of the bistable switch.

The + 11 VDC voltage has a galvanic insulation and it is used for the supply of communication ports. The voltage is put up to +36 VDC by the DC-DC convertor and it is used for power supply of the M-Bus master.

4 Data exchange

4.1 Communication with the meter

Communication with the meter could be established in few ways.

There are 4 levels of parameterization of the meter, and each level is password secured.

Local data exchange could be via:

- Visual communication (LCD display, LED diodes)
- Optical, IR port
- Wired M-Bus interface (optional)
- Wireless M-Bus interface (optional)
- RS485 interface (optional)

Remote data exchange is supported via:

- PLC modem, meter type Sx401

Wired M-Bus is used for connection other measuring devices, and is isolated.

The meter support simultaneously communication of all ports.

Communication do not influence measuring part of the meter, neither on exceeding self power consumption.

The communication is in accordance with DLMS/COSEM protocol and standard.

The meter has the DLMS/COSEM certificate.

4.1.1 Visual communication

4.1.1.1 LCD display

The meter has multifunctional display in accordance with VDEW specification. Display shows the following:

- Eight digits (in lower right part) for showing numerous measurement results, and measurement unit is in the upper right part
- In lower left corner OBIS code of measurement value is shown
- At the very bottom of display there are 12 flags – indicators
- In the middle of the upper part of display, there is a phase indicator
- In the upper left corner, there are indicators of quadrant where there is instantaneous, apparent, active and reactive demand (and energy)

There are two display sequences: auto display and manual display. Manual display sequence is accessed by pressing the buttons on the meter. The values to be monitored in both manual and auto display sequences are adjustable. After a programmed (and programmable) interval the display returns to Auto display sequence.

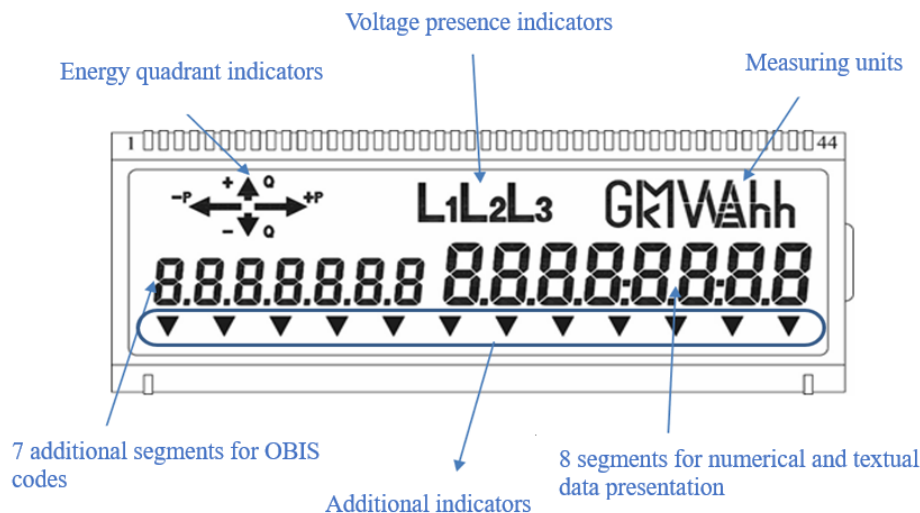


Fig. 26 – All segments of the LCD display

Additional indicators refer to:

- T1 – T4: They indicate the tariff in which the current consumption is recorded
- M1 – M4: Tariff in which the maximum 15-minute power is currently being recorded
- R1: Relay 1 is on
- R2: Relay 2 is on
- COM: Off –not connected to the cellular network. On –connected to the cellular network. Blinking – TCP / IP communication is in progress, via mobile network.
- TEST: Test mode activated (increased number of decimals in energy display)
- FF: If on , there is an error on the meter or fraud occurred, it is necessary to read the error register (OBIS code: 97.97.0 and /or 97.97.1) to accurately identify the error, it is advisable to read the event logs as well.
- CI: It signals that the meter is sending the data to the user interface (push on RS485 port)
- CLK: It blinks when the meters clock time is invalid. Time synchronization required.
- LR: Indicates whether the value shown on the display comes from a metrologically relevant or legally irrelevant (applicative) part of the firmware.
- SET: signals the status of the switch. If the switch is on, then the indicator is on and vice versa. If the indicator is blinking, the switch should be turned on manually by pressing and holding the unsealed button.

Presentation of meter values and characteristic codes are easily readable even in badly lit environments, as well as under direct lighting.

The meter shows phase presence on the display. If the phase voltage is 50% of nominal value, the meter detect absence of phase. The percentage value at which meter detect absence of the phase could be programmed (50% is default value).

Displaying data is in formats of:

1. Direct connection
 - a. Energy – 6 integers, 2 decimal places
 - b. Power – 6 integers, 2 decimal places
 - c. Energy – 8 integers, 0 decimal places
2. Transformer connection
 - a. Energy – 6 integers, 2 decimal places
 - b. Power – 5 integers, 3 decimal places

Number of decimal places is adjusted separately for energy, power, current and voltage.

Obis codes for those objects are:

1.0.129.1.51.255 (energy);
 1.0.129.1.52.255 (power);
 1.0.129.1.61.255 (voltage);
 1.0.129.1.62.255 (current).

Currently, the test mode is activated locally via the optical port and is also deactivated via the port by entering a certain value in object 1.0.129.1.41.255.

If necessary it is possible to add test mode activation through the display menu.

The current test mode duration in seconds can be set in object 1.0.129.1.40.255. After this time, the test mode ends and the normal resolution on the display returns.

OBIS codes are displayed on 6 digits and are in accordance with IEC 62056-61 (OBIS).

Size of the digits on the display:

For measuring values **7.5 X 3.75 mm**
 For OBIS codes **5.5 X 2.75 mm**

The frequency of blinking some of the display element is 1 Hz.

The default display language is English.

4.1.1.1.1.1 OBIS codes

OBIS codes on the meter display:

CODE	DATA DESCRIPTION
96.1.0	Meter serial number
96.1.1	Utility ID (utility serial number)
0.9.1	Time
0.9.2	Date
1.8.0	Total received active energy (A+)
15.8.0	Total absolute active energy A
1.8.T	Received active energy in tariff T (T=1,2,3,4)
15.8.T	Absolute active energy in tariff T (T=1,2,3,4)
2.8.0	Total transferred active energy (A-)
2.8.T	Transferred active energy in tariff T (T=1,2,3,4)
1.6.1	A+ received max demand in the first phase (T1)
1.6.2	A+ received max demand in the second phase (T2)
1.6.3	A+ received max demand in the third phase (T3)
1.6.4	A+ received max demand in the fourth phase (T4)
2.6.1	A- transferred max demand in the first phase (T1)
2.6.2	A- transferred max demand in the second phase (T2)

CODE	DATA DESCRIPTION
2.6.3	A- transferred max demand in the third phase (T3)
2.6.4	A- transferred max demand in the fourth phase (T4)
32.7.0	Effective value of voltage phase 1
31.7.0	Effective current value of phase 1
33.7.0	Demand factor in phase 1
3.8.0	Total received reactive energy
3.8.T	Received reactive energy in tariff T (T=1,2,3,4)
4.8.0	Total transferred reactive energy
4.8.T	Transferred reactive energy in tariff T (T=1,2,3,4)
5.8.0	Received inductive reactive energy (Q1) total
5.8.T	Received inductive reactive energy (Q1) in tariff T (T=1,2,3,4)
6.8.0	Transferred capacity reactive energy (Q2) total
6.8.T	Transferred capacity reactive energy (Q2) in tariff T (T=1,2,3,4)
7.8.0	Transferred inductive reactive energy (Q3) total
7.8.T	Transferred inductive reactive energy (Q3) in tariff T (T=1,2,3,4)
8.8.0	Received capacity reactive energy (Q4) total
8.8.T	Received capacity reactive energy (Q4) in tariff T (T=1,2,3,4)
34.7.0	Voltage frequency in phase 1
96.6.3	Battery voltage for backup supply of the clock
1.7.0	Positive active instantaneous demand A+
2.7.0	Negative active instantaneous demand A-
3.7.0	Reactive instantaneous demand R+
4.7.0	Reactive instantaneous demand R-
97.97.0	Status and error register
25.6.0	Communication Signal Quality

4.1.1.1.2 Status and error register

Condition of status and error register may be shown on the display, besides measurement values. In that case F.F is written instead of Obis code in the lower left corner of the display. Condition of the register on display is shown in the hex code. Meanings of specific bits of this register controlled by legally relevant software are as follows:

Clock error	0x00000001
Calibration error	0x00000008
Phase L1 no voltage	0x00000100
Measuring part operating error (CE)	0x00000800
Flash memory legally relevant error	0x00010000
Initialization error	0x00040000
Season errors not defined	0x00100000
Possibility of wrong clock due to weak battery	0x00200000
Battery must be changed	0x00800000
Removed terminal block cover	0x01000000
Removed meter cover	0x02000000
Low battery voltage	0x04000000
Strong magnetic field	0x08000000

Reset WDT legally relevant	0x10000000
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Bits controlled by legally non-relevant software are:

FRAM energy CRC error	0x00000002
MAX average demand CRC error	0x00000004
Reset WDT legally non-relevant	0x00004000
Flash memory legally-non relevant error	0x00008000
Initialization error	0x00040000
Tariff errors not defined	0x00080000
Inverse energy direction in phase L1	0x20000000

FRAM energy CRC error and MAX average demand CRC error bits are set by legally non-relevant software, when legally relevant software detects checksum error and sends corresponding message via communication channel.

Possible values in error register 0.0.97.97.0.255 is defined by IDIS and it is stated below:

Clock invalid	0x00000001
Battery replace	0x00000002
Program memory error	0x00000100
RAM error	0x00000200
NV memory error	0x00000400
Measurement system error	0x00000800
Watchdog error	0x00001000
Fraud attempt	0x00002000
M-Bus communication error ch 1	0x00010000
M-Bus communication error ch 2	0x00020000
M-Bus communication error ch 3	0x00040000
M-Bus communication error ch 4	0x00080000
M-Bus fraud attempt ch 1	0x00100000
M-Bus fraud attempt ch 2	0x00200000
M-Bus fraud attempt ch 3	0x00400000
M-Bus fraud attempt ch 4	0x00800000
Permanent error M-Bus ch1	0x01000000
Permanent error M-Bus ch2	0x02000000
Permanent error M-Bus ch3	0x04000000

Permanent error M-Bus ch4	0x08000000
Battery low on M-Bus ch1	0x10000000
Battery low on M-Bus ch2	0x20000000
Battery low on M-Bus ch3	0x40000000
Battery low on M-Bus ch4	0x80000000

4.1.1.2 Use of display and keyboard

The meter SM401 shows information on display in accordance with the VDEW specification and parameters and measurement results are implemented as in a device in compliance with the DLMS/COSEM recommendations and also adequate OBIS codes are allocated.

The meter is in automatic display mode upon autonomous operating mode and it shows on the display the values of devices selected in the device *General display readout* (OBIS code: 0.0.21.0.1.255). Data is changed in intervals of 8s (or other value upon consumer selection, obis code: 1.0.129.1.10.255) and typically shows: date and time obtained from RTC, status register, consumption per tariffs. One can enter the manual display mode through which the consumer obtains different data collected during operating mode of the meter by activating the keyboard by consumer. The return to manual display mode from automatic mode is achieved by pressing the right button longer than 7 s, or it is returned automatically if the button was not pressed for a certain (configurable) number of seconds.

The meter has implemented the auto diagnostic display mode, which serves for visual verifying the validity of display characters. This mode is applied in the process of implementing the auto diagnostic function.

General view of the display with description is shown in Figure 27.

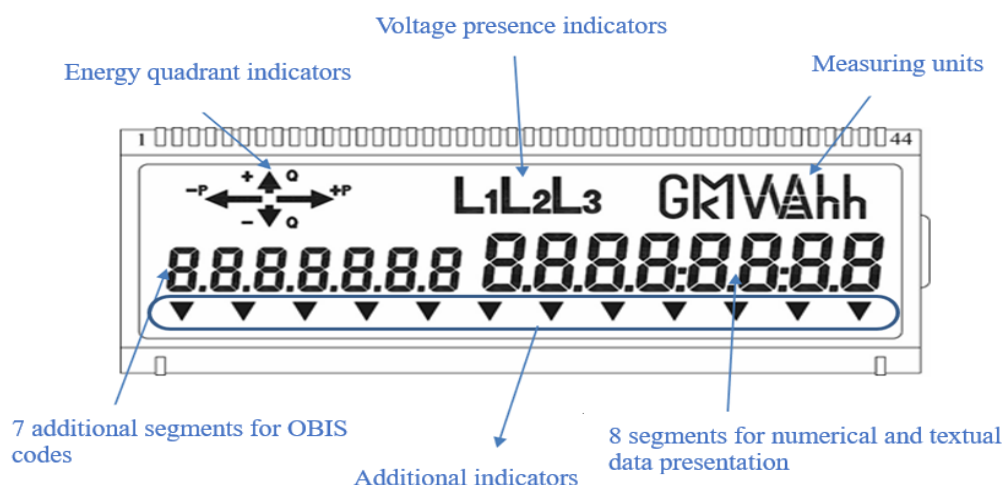


Fig. 27 - Different part of the display

Display is controlled by legally relevant software, but it gives certain freedom to legally non-relevant software to show all kind of data but with certain control. Display segments can be divided in couple groups which are:

- *Energy quadrant indicators.* They are controlled by legally relevant software.
- *Voltage presence indicator L1.* On turn on of the meter this indicator is controlled by legally relevant software. If indicator is turned on that means presence of certain phase voltage. If phase voltage has value below certain threshold appropriate phase indicator will be turned off. In order to make it possible for legally non-relevant software to signalize some special states it can take control over these indicators. Using this method legally non-relevant part can use these indicators to signalize inverse energy direction or some similar states. During manufacturing process is configurable behaviour of phase indicators in case of inverse energy flow.
- *Triangle indicators on the bottom of the display.* These indicators can be used for different purposes. They all are controlled by legally non-relevant software except the next-to-last one which is always controlled by legally relevant software. That indicator gives information if value currently shown on display, on value and unit field, is coming from legally relevant or legally non-relevant software. This indicator is named LR/LNR indicator and when turned on shows that value shown on value field is coming from legally relevant software, and when turned off shows that value shown on value field is coming from legally non-relevant software.
- *Group of segments which include OBIS field, Value field and field for unit representation.*

The meter possesses 2 buttons which are located in the upper right part – unsealed and sealed button. Unsealed button is always available and it is used for scrolling through the meter menu.

Functions of the unsealed button are as follows:

- Scrolling (S - Scroll), press unsealed button in duration of up to 2 s
- Enter (E - Enter), press unsealed button in duration from 2 s to 5 s
- F - Pressure on unsealed button in duration of 2s to 5s when the lower cover of the meter has been opened
- Back (B - Back), press unsealed button in duration from 5 s to 7 s
- Master Back (MB –Master Back), press unsealed button in duration longer than 7 s (Master Back is done when the pressure on the right button lasts minimum 7 s)
- Manual Reconnect (MR - Manual Reconnect), press unsealed button longer than 10 s
- When the meter is without supply, by pressing unsealed button in duration of minimum 4 s, we switch-on the meter under battery supply
- Enter when the lower cover of the meter has been opened (F), press unsealed button in duration from 2 s to 5 s, when lower cover of the meter has been opened.

Typically, command “S” is used for listing options in menu and parameters in the list, whereas command “E” is used as confirmation of a source or entry into menu option, whereas command “B” is used for exit from some sub-menus or some parameter lists. With command “MB” the meter is normally put into autoscroll mode. Command “MR” is used for annual switch-on of bistable interlock.

Below, the general menu system as well as the manner how to obtain different specific data in the meter is described in details.

4.1.1.2.1 Menu tree

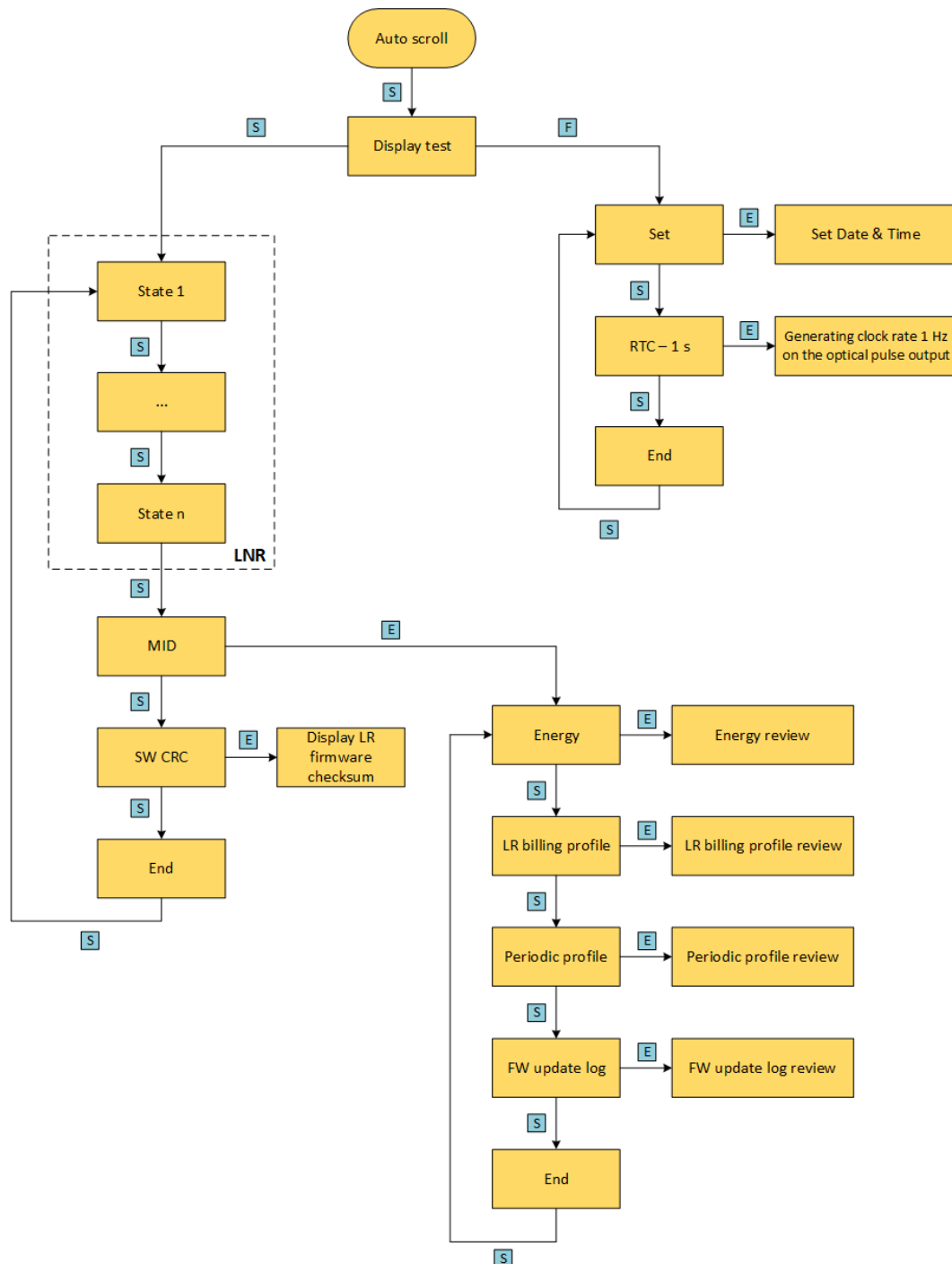


Fig. 28 – Menu tree for SM401 meters

4.1.1.2.2 Review of standard data

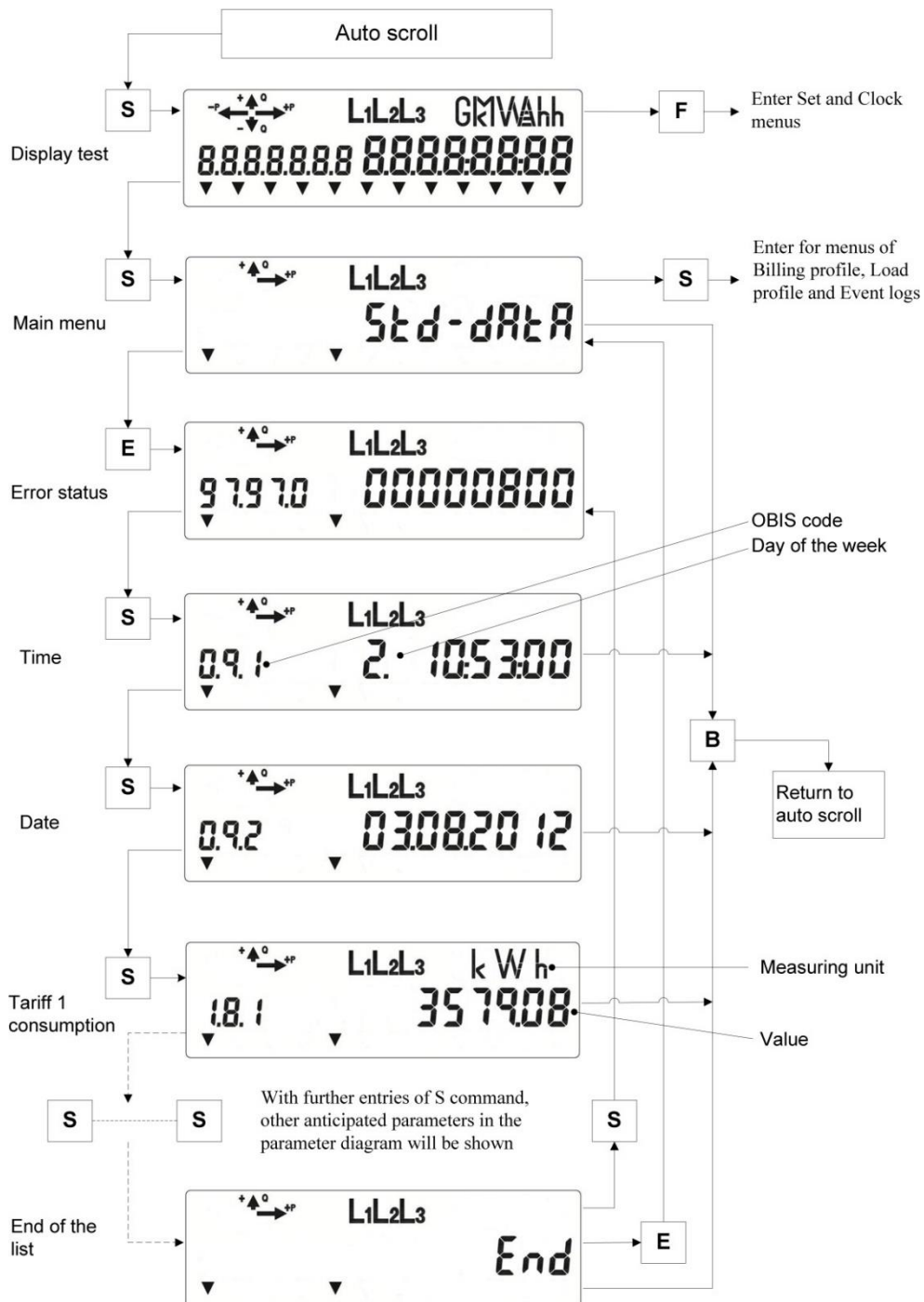


Fig. 29 – Standard data review on SM40X2 meters

Selection of values, which are shown as standard data, is done through the object Alternate display readout (OBIS code. 0.0.21.0.2.255)

4.1.1.2.3 Review of the billing profile

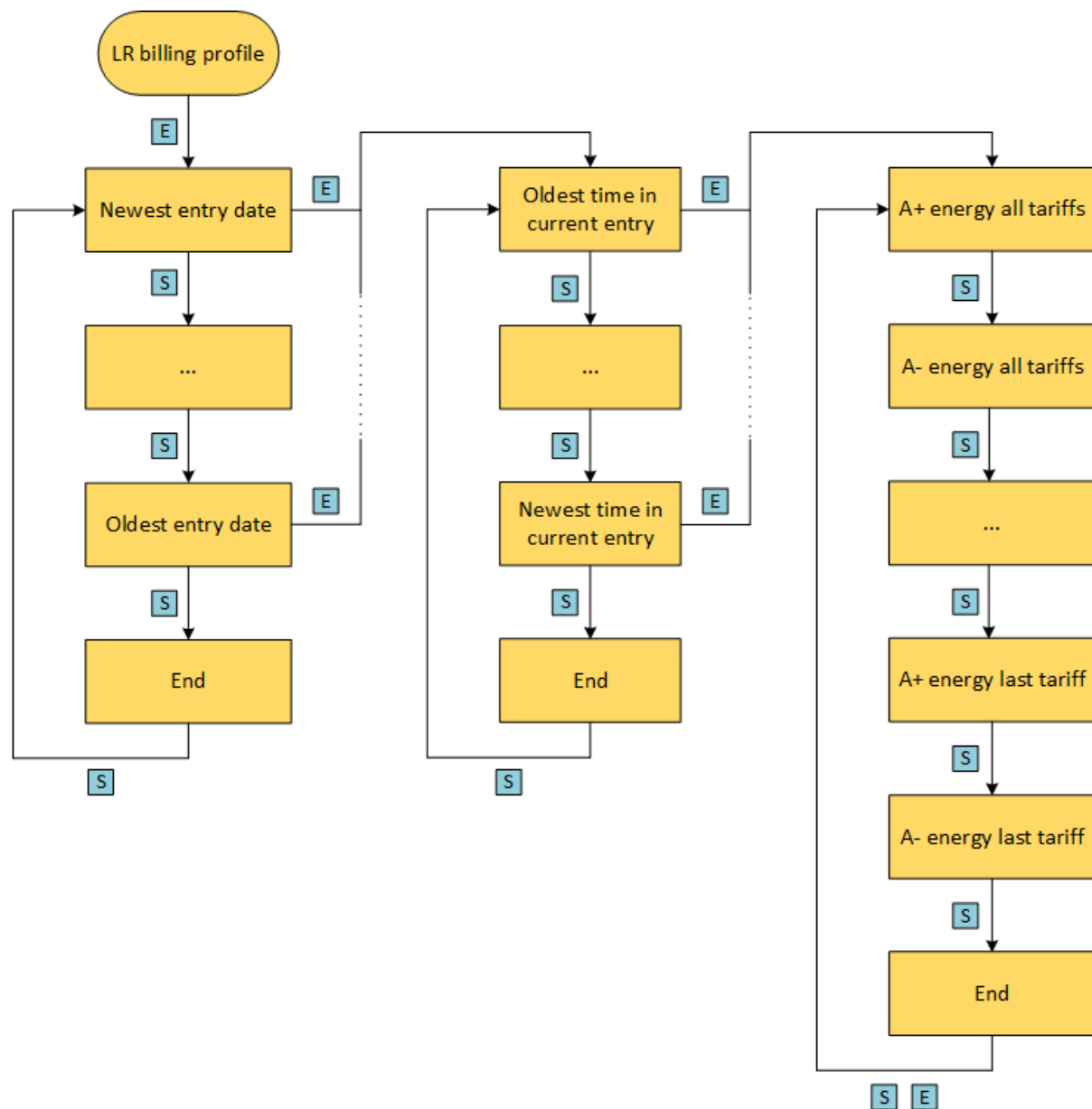


Fig. 30 – Billing profile on the SM401 meter

Selection of values memorized in the billing profile is done through the object Data of billing period 1 (OBIS code. 0.0.98.1.0.255). The all records written in billing profiles could be accessed and displayed in the LCD. The data are in reverse chronological order.

4.1.1.2.4 Review of the load profile (example of the profile 1)

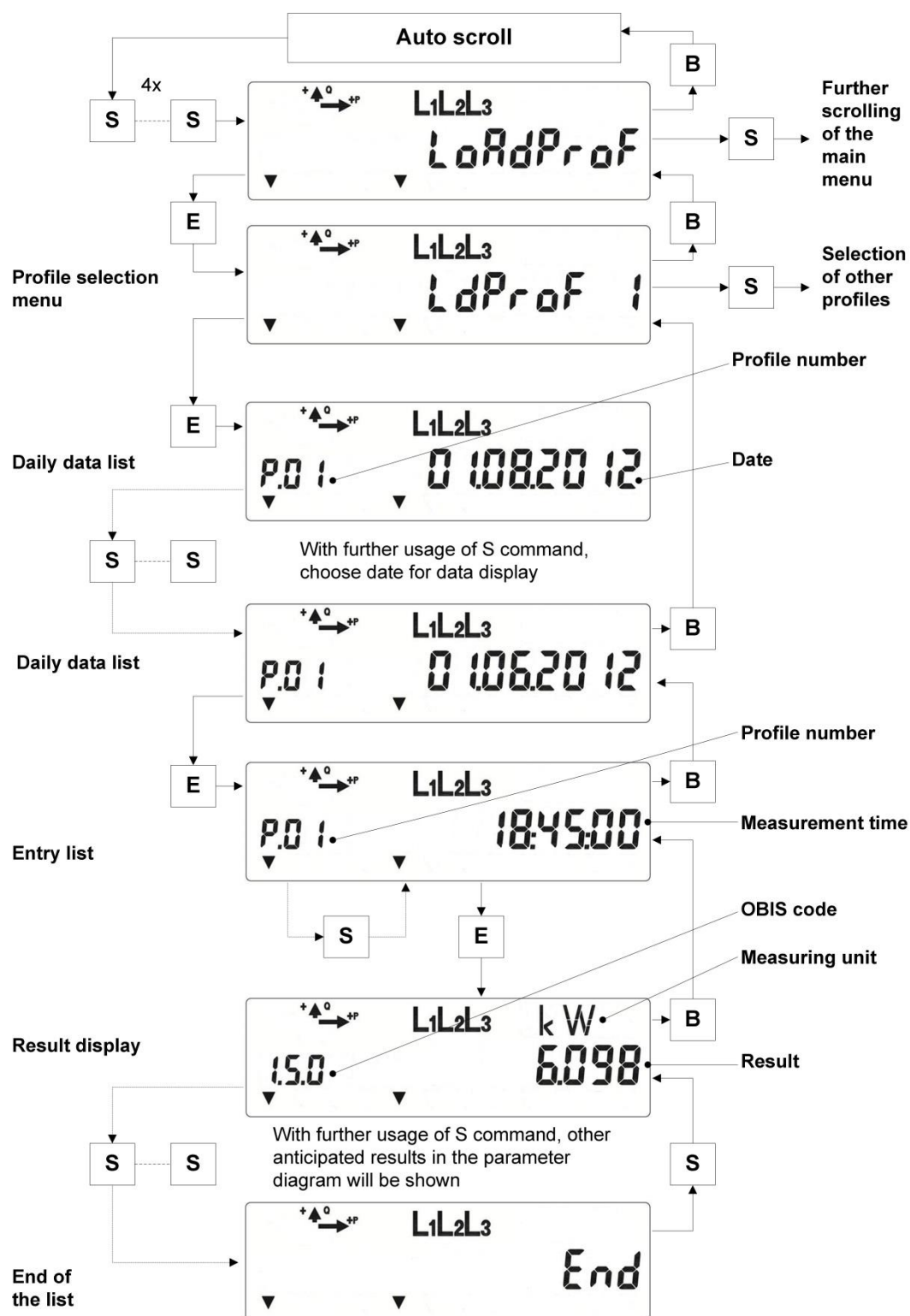
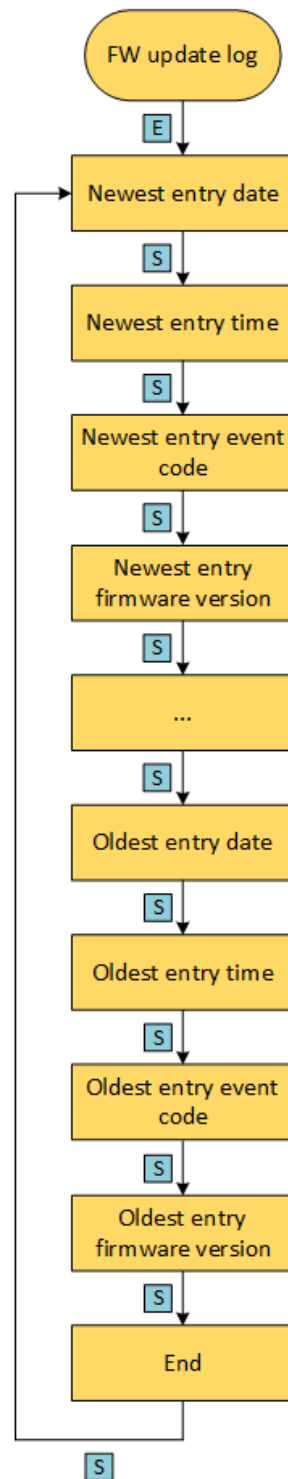


Fig. 31 – Review of the load profile on the display of the SM401 meter

- Selection of values, which are stored in load profile, is done through the object Load profile (OBIS codes consecutively):
- 1.0.99.1.0.255 – Load Profile 1.
- 1.0.99.2.0.255 – Load Profile 2.
- 1.0.99.3.0.255 – Load Profile 3.
- 1.0.99.129.0.255 – Load Profile 4.
- 1.0.99.130.0.255).

4.1.1.2.6 Review of the firmware update log



Review of firmware update log part of menu

4.1.1.3 **Optical LED pulse outputs**

On the meter front plate there are two red LED diodes, which are using for meter accuracy testing – optical LED pulse output.

Optical LED pulse output is in accordance with IEC 62052-11 and EN 50470-1. The LED blinking frequency depends on the load which meter measure and meter constant (pulse/kWh for active and pulse/kvarh for reactive energy).

The meter constant is in accordance with IEC 62053-21/22 and EN 50470-3. Constant is configurable and its usual values are:

- The 1.000 pulse/kwh, 3.200 pulse/kwh or 4.000 pulse/kwh for active energy
- The 1.000 pulse/kvarh, 3.200 pulse/kwh or 4.000 pulse/kvarh for reactive energy

4.1.2 **RS 485 port**

The SM401 meter optionally has one RS485 port which allows local communication with the meter, reading data and meter parameterisation. The RS485 bus is half-duplex with A and B connectors. Supported communication protocol is DLMS, and communication speed is 9600 bit/sec. Optionally RS485 port can be used for one way communication with In Home Display in accordance to IDIS specification.

4.1.3 **G3-PLC modem**

The meter type SM401 has integrated PLC modem. Integrated modem is placed on the meter PCB.

The PLC (Power Line Carrier) enables creation of a communication channel through a low voltage network (mains). The main advantage of the PLC communication is usage of the existing infrastructure.

The communication protocol with data concentrator is in accordance to DLMS and IDIS Package 2 specification.

The communication module (modem) is designed to be resistant to overvoltages, atmospheric discharge, irregular wiring, neutral disconnection as well as missing of one or more phases. After irregular events modem returns to operating mode automatically without operator intervention required. Modem has a watchdog function that allows reset the modem if it has been inactive for a certain period of time.

The G3 PLC modem is using OFDM modulation, and is in accordance with the following standards/specifications:

- G3-PLC, CENELEC A bandwidth (including PHY, MAC 6LoWPAN, LOADng routing protocol). FCC bandwidth is also supported.
- IEEE1901.2, FCC/ARIB bandwidth
- In accordance with CENELEC, FCC i ARIB specifications
- Support for IPv6 full stack (including IPv6 addressing)
- PLC communication in application layer is in accordance with DLMS/COSEM

specification

- The modem support communication standard change through the firmware update and setting new communication parameters.

The modem is using one phase for PLC communication. Total power consumption of the meter with the communication function is in the level of allowed self-consumption of the meter.

The figure 33 presents the layers of G3 PLC modem – from physical (PHY) to application layer:

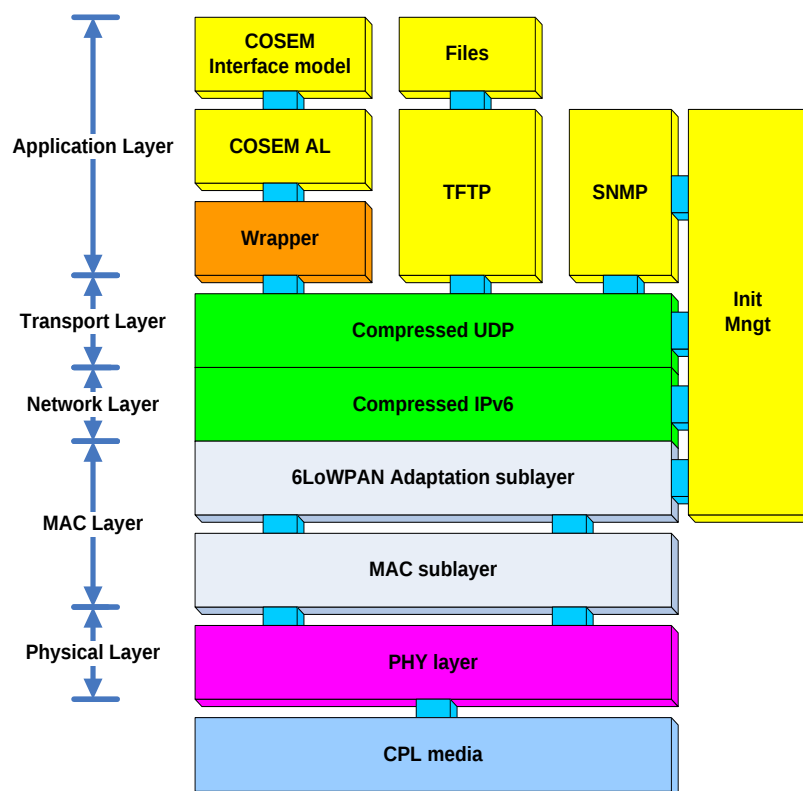


Fig. 33 – Communication layer of G3 PLC modem

The physical layer characteristics (PHY):

- Support of internationally accepted bands from 10kHz - 490kHz (FCC, CENELEC, ARIB). The signal spectrum of G3 PLC is shown on the figure 34.
- Multi-layer error encoding/decoding, algorithms: CRC16, Viterbi, Reed Solomon convolution.
- Auto adapt to channel conditions – modulations 8PSK, QPSK, BPSK, ROBO. Transfer rate depend of modulation type is shown on Fig. 35.
- Adaptive tone mapping – adapting to channel conditions to increase robustness and data rate.
- Bandwidth notching for guaranteeing coexistence with other technologies in the same physical network.

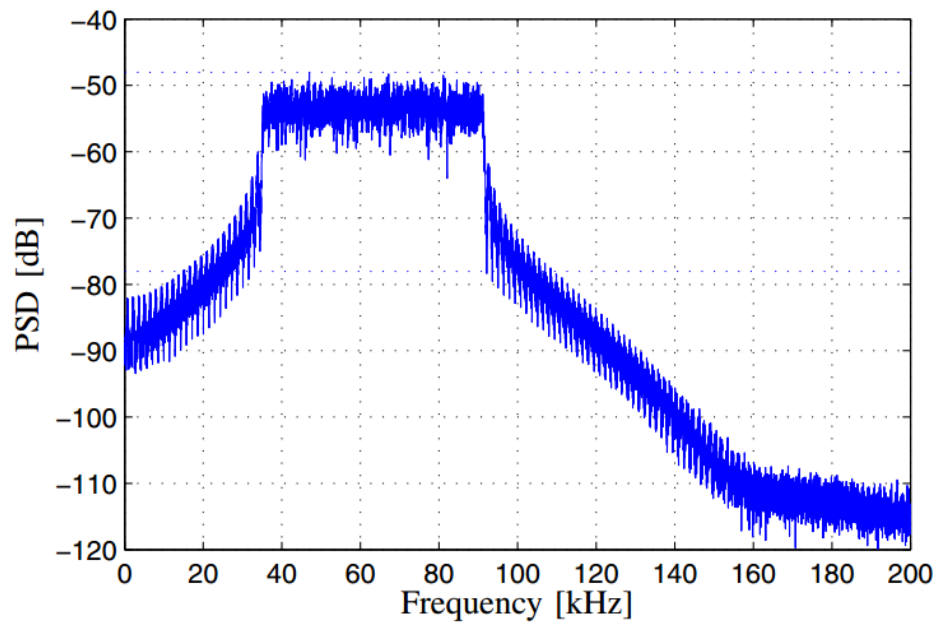


Fig. 34 – Signal spectrum of G3 PLC in CENELEC A bandwidth – from 36 kHz to 91 kHz

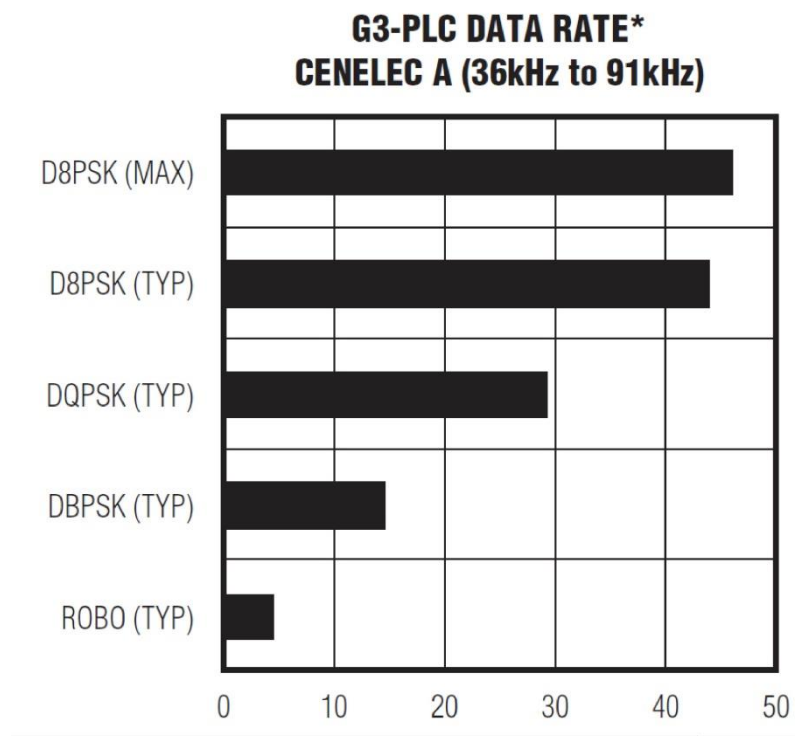


Fig. 35 – Data transfer rate in CENELEC A bandwidth

Application layer characteristics:

- In accordance with ANSI C12.19/C12.22 i IEC 62056-61/62 (DLMS/COSEM)

Transport and network layer characteristics:

- Protocol Ipv6 enables potential services: SNMP (Simple Network Management Protocol), TFPT (Trivial File Transfer Protocol), etc.
- Adaptation layer 6LowPan associates MAC layer 802.15.4 with Ipv6 – compression of IP header, fragmentation, routing and authentication.

MAC (Media Access Control) layer characteristics:

- Full „mesh“ network support – *plug-and-play* network management to choose „best path“
- Time domain and collision management
- MAC layer in accordance with IEEE 802.15.4-2006
- Carrier sense multiple access with automatic repeat request scheme – CSMA/ARQ

4.1.4 Optical port

Optical port enables local communication with the meter, including data reading and parameterization of the meter. It is located in the central part of the upper cover of the meter, directly under the LCD display. DLMS is the supported communication protocol at the optical port. The communication is realized at the speed of 9600 bit/sec. The port is in accordance with SRPS EN 62056-21. The connection to the optical port is realized through the optical probe. It allows for the simultaneous and reliable communication over optical and electrical interface on the meter.

4.1.5 Wired M-Bus

The port has been designed as a wired MBUS (according to the standards EN 13757-2, EN 13757-4 and EN 13757-3). It is used for data collection from the water meter, gas meter and heat meter. In case when wired M-Bus is present in the meter, meter can have maximum one additional RS485 port.

4.1.6 Wireless M-Bus (WMBUS)

Wireless M-Bus is available as optional module integrated on meter PCB. It is used for data collection from the water meter, gas meter and heat meter. Besides that, the meter sends calculation and service data to the wireless display (HAN communication) situated inside the consumer's apartment through the WMBUS port. It has been designed according to the standard EN13757-4.

5 Meter functions

5.1 Billing profiles

Billing profile (registered energy and demand values per tariffs, obis code 0-0:98.1.255) is generated and kept for maximum 310 billing periods (months) depending on number of values (channels followed). The billing profile is FIFO organised. Selection of billing values is configurable and it is possible to monitor up to 40 different billing values (channels). They are recorded every month; entry date and time are configurable. Billing data are stored in Flash memory. Measured values of billing periods may be readout on the display locally, using personal computer, or remotely from AMM centre.

There are 2 billing profiles :

- Billing profile 1 (*billing profile* – obis 0.0.98.1.0.255) –The values stored in billing profile are chronologically ordered, started from the last billing period.

The purpose of this profile is to record billing data at the end of billing period with automatic reset of maximum demand indicator. Manual reset maximum demand indicator is not allowed.

- Billing profile 2 (*load profile 5* – obis 1.0.99.130.0.255) – capacity for example recording timestamp, A+ in two tariff i Pmax with timestamp) is 850 records

The purpose of this billing period is to record billing data in case of fraud of the meters, without reset of the maximum demand indicator.

5.2 Load profile

The load profile represents recorded measuring values in memory during certain period of time.

The meter support recording 4 load profiles.

The period of registration for 4 load profiles are independent and programmable, and could take one of the following values: 1, 5, 10, 15, 30, 60 minutes or 24 h. Each of 4 load profiles can be set to any of the mentioned capture periods.

All profiles are FIFO organized.

Values that may be registered in load profile are as follows:

- Date and time
- Average demand
- Energy counters
- Maximum demand measurement and origin time
- Voltage and current instantaneous values
- Demand factor for all three phase conductors
- Frequencies for all three phase conductors
- THD for voltages and currents
- Error object

- Profile status register
- RTC battery voltage

Profile status is 1 byte where each bit has following meaning:

Bit 7 - PDN	Power down: Indicate that total power outage has been detected during the affected capture period
Bit 6	Reserved bit, always set to 0.
Bit 5 – CAD	Clock adjusted: Indicates that clock has been adjusted by more than the synchronisation limit
Bit 4	Reserved bit, always set to 0.
Bit 3 – DST	Daylight saving> Indicates whether or not daylight saving time is currently active. Set for active DST (summer) or cleared for normal time (winter)
Bit 2 – DNV	Data not valid: Indicates that current entry may not be used for billing purposes without further validation because a special event has occurred
Bit 1 – CIV	The power reserve of the calendar clock has been exhausted. The time is declared as invalid. At the same time DNV bit is set
Bit 0 - ERR	Critical error> A serious error such as a hardware failure or a checksum error has occurred. If the ERR bit is set also the DNV bit is set.

Following is the list of all profiles, and their OBIS codes:

- Load profile 1 (0-0:99.1.0.255)
Load profile 1 captures energy values in 10 channels (A+, A-, R1, R2, R3, R4, average 15 minute power, timestamp, communication signal quality...).
Load profile stores the last 5762 entries with data registration of 60 days (in the case of 10 channels and a 15-minute recording period).
Default period of load profile 1 is 15 minutes. For default period of 15 minutes load profile will capture new entry at xy:00, xy:15, xy:30 and xy:45 min.
- Load profile 2 (0-0:99.2.0.255) – default period of load profile 2 is an hour and so it records 3484 entries in the case of recording in 10 channels. As with other profiles, it can be set with other period recording value (daily, 15 minute, 10 minute...) and in this case the maximum number of records changes proportionally. All energies, powers,

profile status including active energy combined (15.8.0) and active energy net (16.8.0) can be recorded in LP2.

- Load profile 3 (1-0:99.3.0.255)– is usually used as daily profile and it records 5762 entries in the case of recording in 10 channels. As with other profiles, it can be set that the recording period has other values (daily, 15 minute, 10 minute...) and in that case the maximum number of records changes proportionally.
- Load profile 4 (1-0:99.129.0.255)- is usually used as 10 minute profile for recording phase currents and voltages. It is usually recorded in 7 channels, which means that it has the ability to record 1080 records in 7 channels or values for 7.5 days.

Every profile can record up to 20 channels, but in that case the maximum number of recorded values is reduced proportionally.

5.3 Power management

The SM401 meter has power management feature realized in two ways:

1. By integrated disconnecter
2. By bistable relay for management individual power circuits

5.3.1 Integrated disconnecter module

The meter, intended for direct connection to power supply network, has the disconnecter installed, enabling switch-off of consumers from the electric distribution network. Switch-off and disconnecter switch-on is possible by using remote or local communication with the meter, depending on meter adjustments. Depending on adjustments, meter has the possibility to switch-off a consumer in the case of exceeding allowed demand limit as well as to allow switch-on upon expiry of penalty time. It is possible to alter allowed demand limits remotely with a resolution of 1W.

As an option, meter can check if there is a voltage present on a load side in case disconnecter is in open state (disconnected) and report a fraud event.

Disconnecter switches-off/switches-on all three phase conductors simultaneously (i.e. one phase for SM401), without neutral. Safe cut-off is provided by three (one for SM401) separate disconnectors, which may cut off current up to 100 A with guaranteed number of up to 1.000.000 commutations Time of switch-off/switch-on is less than 15 ms. Disconnecter characteristics are in compliance with the standard IEC 62055-31 Annex C UC3 category.

The relays are immune to external DC magnetic field, which could cause changeover of the switch. If the changeover influenced by external magnet is done, that event is recorded in measuring integrity log book. After the magnet is removed, the relays are return to the previous connection state.

There is a few ways to activate (switch-on or switch-off) the disconnecter:

- Remotely – by sending the command from AMM centre
- Locally – as a result of:

- Power limit activation
- Code red activation

The meter support creating a power management category (group) in which it belongs to. All meters belong to one group could be simultaneously adjust to power limit, or disconnectors of all meters in same group could be switched-off or switched-on.

The meters within same group could be set as a red code, or return to normal operation.

If consumer is switched-off from the electrical power network locally, repeated switch-on of the electrical power network (closure of the disconnector contacts) is done manually, depending on disconnector operating mode: by pressing the button on the front panel of measuring part (the pressing longer than 10 s) or using external switch connected to S0 meter input (this is usual way when the meter is in long distance measuring point, so it is impossible to open the measuring cabinet). If consumer is switched-off from the electrical power network remotely by sending command for switch-off of disconnector from the AMM centre, the switch-on of consumer is done automatically upon the receipt of remote command for switching-on (closure of the disconnector contacts) or manually, depending on the selected limiter mode.

Operating of the disconnector is realized as a machine with three possible conditions, as shown in figure Fig 41. The conditions are as follows:

1. Connected
2. Ready for reconnection
3. Disconnected

In *Connected* condition buyer is connected to electric power distribution network, whereas in condition *Disconnected* and *Ready for reconnection* is not connected. Transition between conditions is done through 8 possible transitions (from a to h) shown in figure 41.

Disconnector control may be done in three manners:

- Locally with transitions: g and h
- Remotely with transitions: a, b, c and d
- Manually with transitions: e and f

Disconnector may be regulated remotely through any communication channel (optical port, GPRS). Disconnector is manually regulated by usage of unsealed button of the meter.

Disconnector may operate within total of 7 different modes. Depending on the mode, some transitions are supported and some are not supported.

Mode (0) : Disconnector is always in *Connected* condition, there are no supported transitions

Mode (1) : Supported transitions b, c, d, e, f, g

Mode (2) : Supported transitions a, b, c, e, f, g

Mode (3) : Supported transitions b, c, d, e, g

Mode (4) : Supported transitions a, b, c, e, g

Mode (5) : Supported transitions b, c, d, e, f, g, h

Mode (6) : Supported transitions b, c, d, e, g, h.

In the case of a power failure, storing of disconnector instantaneous condition is done in permanent memory (FRAM). Upon meter reset, the condition of disconnector upon power failure can be read from permanent memory and disconnector initiation is done in accordance with that condition.

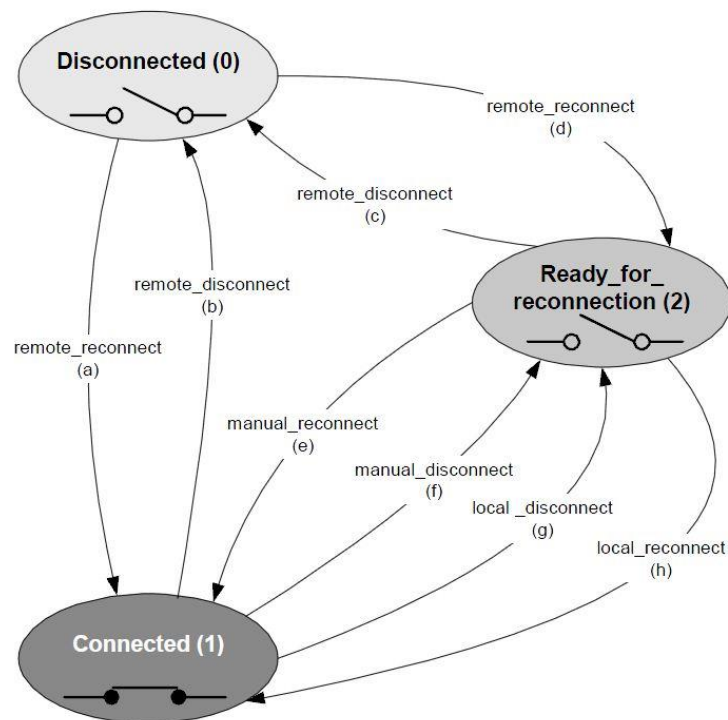


Fig. 41 – Machine showing disconnector condition

If the command for disconnection is sent remotely from AMM centre, the reconnection is done automatically by sending remote command, or manually, depend on mode of disconnector.

Figure 42 shows display in case where the command for disconnection is sent remotely from AMM centre:

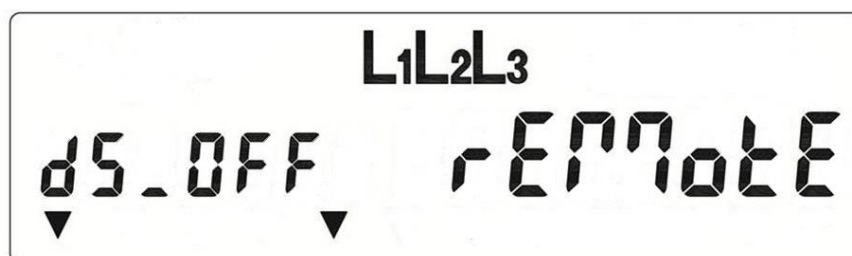


Fig. 42 – Display when the meter is disconnected remotely

The most common working mode for disconnectors are – Automatic connection, and Conditional connection.

In first case, the disconnector is automatically reconnected after receiving the command from AMM centre, or after expiration of penalty period (if the power limit cause disconnection).

In the second case, beside reconnection condition (command from AMM centre, or set action after expiration of penalty period), it is necessary to locally confirm the reconnection.

In this case, on the display is showed message that exist condition for reconnection:

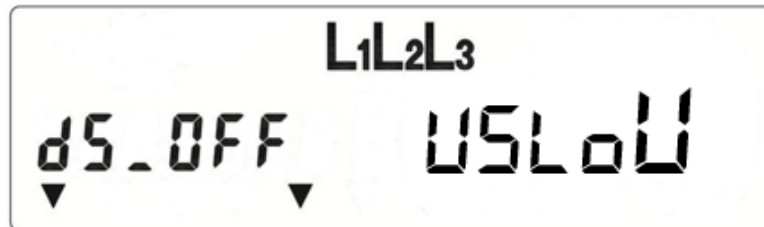


Fig. 43 – Message on the display that exist message for reconnection

For automatic reconnection, the mode 2 or 4 are used, while for conditional reconnection modes 1, 3, 5 or 6 are used.

The modes are selected depending of way of disconnection: remotely, manual, or by limiter.

5.3.2 Bistable relay output

The meter may optionally include bistable relays which are used for management of individual power circuits with consumers. Only loads that have currents up to 5 A and normal voltage of 230 V/120 V can be connected to bistable relay.

Relay management with 230 V, 5 A relays may be done on command or according to change of tariff depending on selected control mode.

Obis code 0.1.96.3.10.255 is used for selecting control mode for relay one and 0.2.96.3.10.255 for relay 2. Mode 4 is used for operation on command, while mode 6 is used for operation according to tariff table. Supported transitions (local, remote...) in these modes are according to DLMS specification for load control management.

Class name: Disconnect control, Class id: 70, Version: 0

Attributes

Logical Name:

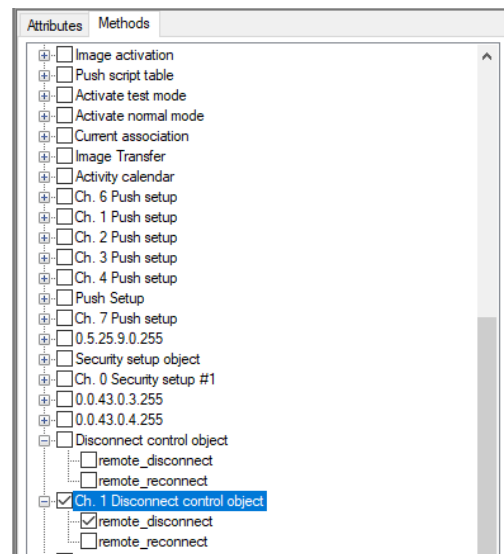
A	B	C	D	E	F
0	1	96	3	10	255

Output state: ☐ Closed ☒ Open

Control state: Ready for reconnection ▾

Control mode: 4 ▾

- When mode 4 is activated, change of state of relays is done through methods of object 0.1.96.3.10.255.



- When mode 6 is activated (operation according to change of tariff), definition of operation of relays in different tariffs is done through Tariffication script table (obis code 0-0:10.0.100.255). User can choose if relay should be open or closed during each of the defined tariffs.

	0	0	10	0	100	255
Script Id	Service	Object	Index	Parameter	Type	
1	write attribute	(Register Activation) Register activation - Energy {0.0.14.0.1.255}	4	0001	octet-string	
1	write attribute	(Register Activation) Register activation - Maximum Demand {0.0.14.0.2.255}	4	0001	octet-string	
1	write attribute	(Disconnect control) Ch. 1 Disconnect control object {0.1.96.3.10.255}	3	2	enum	
2	write attribute	(Register Activation) Register activation - Energy {0.0.14.0.1.255}	4	0002	octet-string	
2	write attribute	(Register Activation) Register activation - Maximum Demand {0.0.14.0.2.255}	4	0002	octet-string	
2	write attribute	(Disconnect control) Ch. 1 Disconnect control object {0.1.96.3.10.255}	3	1	enum	
3	write attribute	(Register Activation) Register activation - Energy {0.0.14.0.1.255}	4	0003	octet-string	
3	write attribute	(Register Activation) Register activation - Maximum Demand {0.0.14.0.2.255}	4	0003	octet-string	
3	write attribute	(Disconnect control) Ch. 1 Disconnect control object {0.1.96.3.10.255}	3	2	enum	
4	write attribute	(Register Activation) Register activation - Energy {0.0.14.0.1.255}	4	0004	octet-string	
4	write attribute	(Register Activation) Register activation - Maximum Demand {0.0.14.0.2.255}	4	0004	octet-string	
4	write attribute	(Disconnect control) Ch. 1 Disconnect control object {0.1.96.3.10.255}	3	1	enum	

Parameter 1 in Tariffication script table means that relay will be on (connected) during specified tariff, while parameter 2 means it will off (disconnected during specific tariff). Script id defines desired tariff (1-8)

- Change of state of relay on command can be even done when relay is in mode 6 (work according to tariff) but if command for disconnection of relay is sent while relay is in mode 6 and after that user wants to reconnect the relay, relay has to be returned to mode 4 first since remote reconnect command is not allowed in mode 6 according to DLMS supported transitions.

5.3.3 Limiter

Besides (hardware) current limitation per voltage phases, which is done by fuses, the meter SM401 optionally possesses software possibility to limit current.

Limitation power value and time period for that load are entered into the dedicated object of the meter memory to be supervised by the meter.

The disconnecter will switch-off consumer (open the contacts) if the supervised average power value during time interval A is higher than posted power limit values B (kW), where

- A is programmable and may take the value from 30 seconds to 3600 seconds with resolution of 1 second.
- B is programmable from 1 to 75 kWh with resolution of 1 W.

Setting of A and B values can be done locally, through local communication port or remotely from the AMM centre, if the meter is equipped with the communication module.

After consumer is switched-off due to current over limit, contacts of the disconnecter device stay in the open condition during time period C where:

- C is programmable and may take the value from 30 seconds to 3600 seconds with resolution of 1 second.

After penalty period C has expired and after consumption correction by consumer has been done, manual/automatic switching-on of disconnecter is enabled, or disconnecter is automatically is switched on (depends on working mode).

Beside the power, the limitation could be done by current, on the same way.

The meter has special log book with timestamp i disconnecter status where are stored the records of at least 315 last power-offs, power-on as a result of limitator, code red function or disconnecter activation by remote AMM center.

The OBIS code for limitation power object (Limiter) is 0-:0.17.0.0.255.

The following figure represent display message when the limitation is active (by power or by current):

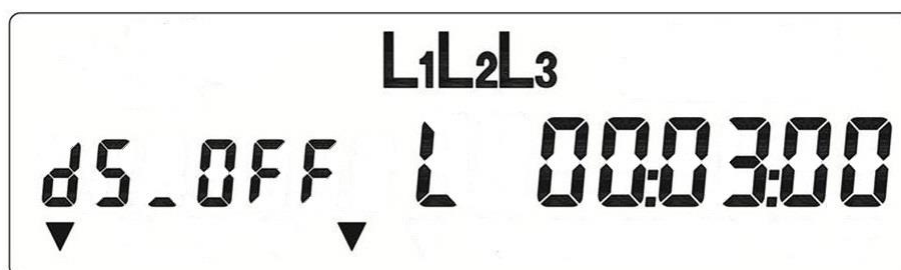


Fig. 44 – The meter display message during power/current limitation when disconnecter is off

5.3.4 Code red

The meter ST40x optionally has *Code red* function. *Code red* is realized through limiter object and it enables consumption management during consumption reduction of the larger group of consumers (e.g. during summer period due to higher load for using air conditioning devices or during winter period due to electrical heating or the like). Usage of *Code red* functionality is available after the meter integration in the AMM system, i.e. after instalment of communication modem and connection of the meter with the AMM centre.

Code red functionality is realized by broadcasting message to all meters, whereas only the meters that belong to that group (based on the consumption category or contract) will respond to the message with the adequate action. During *Code red* situation, control of the particular group of consumer category total consumption is limited by posting the new demand limit for consumer groups or individual meters on lower value (*Threshold Emergency*). In that case, demand limit is determined by *code red* message and it has priority over demand limit which is applicable in normal consumption mode.

Upon activation of *code red* situation and broadcasting *code red* message to the meters, the disconnector will switch-off consumers if the average measured demand value (kW) during X time interval is higher than *code red* demand limit Y (kW), where

- X is programmable and may take the value from 0 seconds to 130 years with resolution of 1 second.
- Y is programmable from 1 to 100 kW with a resolution of 1 W.

If disconnector is activated and switches-off consumer due to over *code red* demand limit, the contacts of disconnector stay open during time period Z, where

- Z is programmable and may take the value from 0 seconds to 130 years with resolution of 1 second.

After time period Z has expired and after consumption correction by consumer has been done, the disconnector switching-on is enabled. Beside the power, the code red limitation could be done by current, on the same way.

5.4 Event log

The meter has permanent memory (FLASH) where event list is recorded, for measurement, adjustment and meter management. For each event, the entry is generated in memory, referring to the type of event, timestamp and meter status when the event occurred. Each record is protected with checksum which guarantees the validity of the data.

The meter could record up to 227 events and meter status into standard log book.

The meter possesses the following event logs:

- *Standard event log* (obis: 0-0:99.98.0.255; records number: 227)
- *Disconnector control log* (obis: 0-0:99.98.2.255; records number: 178)
- *Power failure event log* (obis: 1-0:99.97.0.255; records number: 195)

- *Fraud detection log* (obis: 0-0:99.98.1.255; records number: 227)
- *Firmware update log* (obis: 0-0:99.98.6.255; records number: 178)
- *M-Bus event log* (obis: 0-0:99.98.3.255; records number: 227)
- *Power quality event log* (obis: 0-0:99.98.4.255; records number: 227)
- *MBUS control log 1* (obis: 0-1:24.5.0.255; records number: 227)
- *MBUS control log 2* (obis: 0-2:24.5.0.255; records number: 227)
- *MBUS control log 3* (obis: 0-3:24.5.0.255; records number: 227)
- *MBUS control log 4* (obis: 0-4:24.5.0.255; records number: 227)

In M-Bus log books are stored data from other types of measuring devices connected to the M-Bus port on the meter.

Events recorded in the standard event log are as follows:

- Power down
- Power up
- DST enabled or disabled
- Clock adjusted
- Clock invalid
- Battery replace
- Battery voltage low
- TOU activated
- Error register cleared
- Alarm register cleared
- Program memory error
- RAM memory error
- Non-volatile memory error
- Watchdog error
- Measurement system error
- Firmware ready for activation
- Firmware activated
- Passive TOU programmed
- External alert detected

Recorded events of the specific event logs (events regarding voltage quality, measurement integrity, demand limit, etc.) are not recorded in the standard event log.

Log books are protected and can't be deleted without authorization. All log books are organized as a FIFO stack.

Firmware update event log is intended to measurement part of firmware and it captures following values:

- Timestamp
- Event code
- FW version

For each event, the entry is generated in memory, referring to the type of event, timestamp

and firmware version when the event occurred. Each record is protected with checksum which guarantees the validity of the data. Event log codes for Firmware update log are given in table below:

17	Firmware ready for activation	Signalling that the new software is successfully accepted and verified, i.e. ready for activation
18	Firmware activated	Signalling that the new software is activated
51	FW verification failed	Failed software verification
204	Image transfer aborted	Attempt to image transfer while image transfer already occurs
205	Image transfer aborted via optical port	Attempt to image transfer via optical port while image transfer already occurs
240	Update attempt with firmware for another type of meter	Marks that the firmware which was sent for update, is not for this type of meter
241	Firmware image incorrect signature	Marks that firmware was sent for update, has incorrect signature
242	Firmware ready for activation via optical port	Signalling that the new software is successfully accepted via optical port and verified, i.e. ready for activation
243	Firmware activated via optical port	Signalling that the new software is activated via optical port
244	FW verification failed via optical port	Failed software verification via optical port
245	Update attempt with firmware for another type of meter via optical port	Marks that the firmware which was sent for update via optical port, is not for this type of meter
246	Firmware image incorrect signature via optical port	Marks that firmware was sent for update via optical port, has incorrect signature
255	Event log cleared	Marks that it is first event in meter

Table 1 – Event Codes in Firmware update event log

5.5 Time of use (tariff program)

Internal clock enables application of complex daily and weekly tariff structures and several seasons during a year (*Time of use*):

- Up to 8 seasons during a year
- Up to 8 weekly programs
- Up to 24 types of days
- Up to 31 holidays
- Up to 48 tariff changes during a day

The meter supports activation of special tariff during critical conditions in network. This tariff is activated by detection of low frequency due to bad network conditions.

5.6 Daylight saving time (DST)

DST (*Daylight Saving Time*) is a functionality which provides automatic transition from winter to summer time calculation, and vice versa. Transition is possible by:

- Algorithm, every year in the last week of the selected month and hour
- Fixed date of the stated date in the table form
- DST functionality can be active or inactive.

The E-meter autonomously switches to daylight savings time according to Directive 2000/84/EC.

5.7 Power quality supervision

In accordance with the standard EN 50160, the meter supervises power quality.

5.7.1 Voltage levels

The meter registers quality parameters of power and their duration (voltage level). Voltage levels are registered in a way that the meter follows voltage per each phase with the period of 1s sampling. Based on this value belonging to one of 7 defined levels, it increments the corresponding register. On basis of registered voltage values per levels and their duration, we may have an insight into voltage levels for the previous period.

5.7.2 Registering of voltage cuts

The meter has specific registers for registering number and total duration of voltage cut. There are specific registers for recording long (longer than 3 min – default value, may be configured) and short voltage cuts (shorter than 3 min – default value, may be configured) for each individual phase, for any phase and for all three phases.

The meter possesses event log which records long voltage cuts (which are longer than 3

minutes as default and may be configured) in any phase. This event log can store last 227 long voltage cuts with timestamp, when voltage cut occurred (i.e. when it ended) and its duration. There is a separate object within the meter which defines value in volts when the voltage cut is announced in every phase (1-0:12.39.0.255). The same device impacts switch-on and switch off of the phase indicator (L1, L2, L3) on the meter display. Registering of voltage sags and swells (maximum and minimum voltage values)

Adjusting voltage threshold is configurable (devices 1-0:12.35.0.255 and 1-0:12.31.0.255) for registering voltage sags and swells. Initial values are $0,8U_n$ for sags and $1,15U_n$ for swells. If voltage swell, i.e. voltage sag duration reaches anticipated and defined period, an entry is generated in the special event log (power quality log) with timestamp (date and time of voltage swell/sag condition) and code on basis of which we may see in which phase the voltage swell/sag occurred.

The codes that are recorded along with timestamps into *power quality log* are shown below:

- 255 - Event log cleared (The first record into log book)
- 76 - Undervoltage L1
- 79 - Overvoltage L1
- 82 - Missing voltage L1 (under U_{min} value longer that time threshold)
- 85 - Voltage L1 normal
- 92 – 7 days bad voltage L1

5.7.3 Registering of monthly minimum, maximum and average values

The meter has objects that store monthly maximum values of voltage and current per phases. Also, there are objects that record voltage minimum. All these devices are duplicated so that there are objects which store conditions for the current month (current billing period) and objects for the previous billing period.

The meter has objects that store average 10 minutes voltage values.

5.8 Detection of unauthorized access to the meter (integrity of measuring)

The meter enables realization of the following functions: recording, memorizing and signalling unauthorized access to the meter – fraud detection, as an option:

Detection of meter measuring part cover opening

Detection of terminal block cover opening

Detection of an unauthorised access attempt

Event log and fraud event counter

Impact of strong magnetic field on the meter

Detectors for opening of the meter measuring part cover and terminal block cover are realized in the form of two micro switches which generate signal upon the cover opening. This event is registered with timestamp in the event log, and the indication for fraud detection is shown on display in FF register. Record for opening of the meter measuring part cover and terminal

block cover is generated and stored in the event log even when the meter is in non-voltage mode.

In case of entering wrong password upon attempt of the meter parameters change, record with timestamp is registered in event log.

The meter is resistant to the impact of magnetic field of “normal” magnet. If the level of magnetic field (to which the meter is exposed) is high (according with the standard IEC 62052-11 or EN50470-1) entry about this event is registered in event log with timestamp and duration time of the magnetic field impact.

For each of those stated and described events, entry with timestamp when the event occurred is recorded in the special event log (fraud event log).

The meter could register up to 227 events into log book. The OBIS code for fraud log is 0-0:99.98.1.255.

Codes are always record with time stamp. Here is the list of codes:

- 255 - Event log cleared (The first record in the log book)
- 40 - Terminal cover removed
- 41 - Terminal cover closed
- 42 - Strong DC field detected
- 43 - No strong DC field anymore
- 44 - Meter cover removed
- 45 - Meter cover closed
- 46 - Association authentication failure (Access with bad password)
- 49 – Decryption or authentication failure
- 50 – Replay attack
- 203 - Consumption detected while disconnecter is turned off

5.9 Push mechanism

The meter can be configured to send certain data to HES if some trigger occurs. This mechanism is called push mechanism and there are several triggers. The triggers can be: expiration of specified interval, alarm, modem connectivity to PLC network, meter installation. User can configure list of values to be sent to HES if such trigger occurs for each trigger independently. The list can store up to 32 object attributes. Objects which are used for configuration are:

- Push setup – Interval 1 (0.1.25.9.0.255)
- Push setup – Interval 2 (0.2.25.9.0.255)
- Push setup – Interval 3 (0.3.25.9.0.255)
- Push setup – On Alarm (0.4.25.9.0.255)
- Push setup – On Connectivity (0.0.25.9.0.255)
- Push setup – On Installation (0.7.25.9.0.255)

Objects:

- Push action scheduler – Interval 1 (0.1.15.0.4.255)
- Push action scheduler – Interval 2 (0.2.15.0.4.255)

Push action scheduler – Interval 3 (0.3.15.0.4.255)

are used to set up interval for triggering push mechanism for related push setup objects.

Push setup – On Alarm will be triggered if some alarm occurs.

Push setup – On connectivity will be triggered when G3-PLC modem connects to the power network and is ready to transfer data.

Push setup – On installation is intended to be triggered after setting up the meter on the field by invoking push action of corresponding push setup object.

Some of the alarms can be forwarded, including:

- Voltage loss L1;
- Voltage, below the limit L1;
- Fatal error (memory, switch, clock);
- Fraud alarm (terminal cover removal detection, meter cover removal detection, meter communication)

Besides push data via PLC network toward data concentrator data can be pushed and to customer LCD or similar device. The data will be sent using the same format as in case push via cellular network. Attribute list to be pushed is configured via object:

Push setup – Consumer information (0.0.43.0.1.255)

5.10 Alarms

Some of the events can trigger alarms. If one of these events occurs, the corresponding flag in the alarm registers are set and an alarm is then raised via communication channel. All alarm flags in the alarm registers remain active until the alarm registers are cleared.

Each bit in the alarm registers represents a different alarm. If the bit is set (logical 1) the alarm (corresponding to position of the set bit) was recorded. The value in the Alarm Registers is a summary of all active and inactive alarms at that time.

The Alarm Filters can be programmed to mask out unwanted alarms. The structure of the filter is the same as the structure of the Alarm Registers. To mask out unwanted alarms the corresponding bits in Alarm Filters should be set to logical 0.

Alarming process is as it is described in IDIS package 2.

COSEM objects supporting Alarms are:

Alarm Register 1 (0.0.97.98.0.255)

Alarm Register 2 (0.0.97.98.1.255)

Alarm Filter 1 (0.0.97.98.10.255)

Alarm Filter 2 (0.0.97.98.11.255)

Alarm Descriptor 1 (0.0.97.98.20.255)

Alarm Descriptor 2 (0.0.97.98.21.255)

Alarm monitor 1 (0.0.16.1.0.255)

Alarm monitor 2 (0.0.16.1.1.255)

Some of the alarms can be forwarded, including:

- Voltage loss L1;

- Voltage, below the limit L1;
- Fatal error (memory, switch, clock);
- Fraud alarm (terminal cover removal detection, meter cover removal detection, meter communication)

5.11 No-power reading (optional)

Reading option and parameterizing of the meter in non-voltage mode is realized with integrated battery supply.

Lithium battery of high capacity enables communication through optical probe (recommended to use OS30, produced by Meter&Control), operating mode of LCD display and control with buttons in duration of at least 50 hours.

In order to prevent excessive consumption of the battery, the meter limits time duration of non-voltage reading to max 2 minutes.

No power reading is automatically switched-off after inactivity longer than 15 seconds. In this battery mode we enter reading and parameterizing of the meter by long pressing of the unsealed button.

5.12 Internal clock

Purpose of internal clock is tariff switching, realization of integration period for registering peak load as well as enabling flexible tariff policies in terms of *Time of use* functionality.

Operating mode of internal clock (*Real Time Clock* – RTC) is managed by crystal oscillator 32.768 kHz. Accuracy and other characteristics of internal clock are realized in compliance with the standard IEC 62052-21 and IEC 62054-21. Setting the time and time correction of internal clock are realized in the same manner as in case of parameterizing electrical values and through communication ports. Internal clock enables realization of internal calendar which provides data on year, month, day, day in a month, hour, minute, second and leap year.

Basic supply comes from the mains.

Backup supply is provided from lithium battery or supercap. Lithium battery for backup of the clock has life expectancy minimum 15 years. On power up and on every midnight battery testing is performed. If battery voltage is low the corresponding bit in FF register is set and record with timestamp is registered in event log. Instead of lithium battery, as an option, it is possible to use supercap which provide 168 hours of work in non-voltage mode.

5.13 Measuring and displaying active power

The meter measure and on demand display the current active power on the LCD.

The meter also measure and on demand display maximum demand per tariff.

The codes for maximum demand registers are in accordance with SRPS EN 62056-61 (registers 1.6.x).

The integration period is programmable and could be review on the LCD display, and via

remote meter reading. The default value of integration period is 15 min.

The hand reset of the maximum demand value is not possible using unsealed button. As an option it is possible to do reset of maximum demand using sealed button. This option is user configurable.

5.14 Prepaid features

All meters support option of prepaid. Activation of prepaid is done by setting attribute 2 of 0.0.19.0.0.255 object to 020216021602 value.

All prepaid features and obis codes are implemented according to DLMS/COSEM prepaid definitions. Recharge of credit is done through remote communication with HES. Recharge of credit using keyboard or cards is not supported.

Client has option of defining different pricing for different tariffs. This is done by setting attribute 6 of class 113. Obis code for tariff 1 price is 0.0.19.20.0.255 and 0.0.19.20.1.255 for tariff 2.

The time for activation of these prices is defined in attribute 7 of the same objects while in attribute 5 of the same objects is presented currently applied (active) price.

When credit is low appropriate warning is presented on meter display e.g. Alert Low cre Threshold for Low credit warning is set over attribute 5 of the 0.0.19.10.0.255 object, class 112 Credit.

Prepaid also allows activation of emergency credit. Following message appears on the screen and user is able to activate emergency credit by pressing right meter button positioned below the lever next to the left meter button. User should press button in duration of less than 5 seconds.



Figure 1 – Message on meter display for manual activation of emergency credit



Figure 2 – Left button for activation of emergency credit

When emergency credit is activated, following message appears on the meter display:



Figure 3 – Message on display after emergency credit is selected (activated)

Change of value of available emergency credit can be set by writing appropriate value of the attribute 9 of the object 0.0.19.10.1.255, class 112 Credit

Threshold for activation of the emergency credit can be set by writing appropriate value in the attribute 10 of the same object 0.0.19.10.1.255.

In case emergency credit is activated and used by client, client can see the debt which needs to be settled in order to return credit status to 0. It is presented in object 129.0.5 and visible on meter display.

6 Meter security system

The meter has particular security measures from the unauthorized access and fraud detection. Security measures include the following:

Detection of measuring part cover and terminal block cover opening

Detection of strong magnetic field

Security from the unauthorized access and parameterizing

Detection of measuring part cover and terminal block cover opening is done with two micro switches which generate signals in case when some of the covers are opened. This event is registered in event log with the code and timestamp when the cover is removed. Also, byte in the status register is set and may be shown on LCD display.

The meter detects presence of strong magnetic field (stronger than 200 mT) with sensor and this event is registered in event log with the code and timestamp. Also, presence of high frequency electromagnetic field is detected as fraud event as well. Byte setting in status register is also done in this case and it may be shown on LCD display.

Protection from unauthorized access and parameterizing

The meter has particular mechanisms to ban unauthorized communication - locally and by remote system for compilation of data. Data that are locally accessed (via optical probe) are protected by checking the rights of access on three levels, depending on the fact whether parameters are readout or entered and depending on whether terminal block cover was closed or not.

The meter has protection from the unauthorized readout of data via optical port. This protection is provided by checking the password which the meter obtains from software for local readout.

The second level of protection is protection from the unauthorized change of the meter parameters without removing meter terminal cover. Most parameters on the meter cannot be changed, even in case when the meter password was accepted, but terminal block cover is not removed.

The non-volatile memory is encrypted and protected to guarantee the authenticity of the data and to prevent unauthorized access.

In case that terminal block cover is removed, parameters entry, software change and local switch-on/switch-off of disconnecter are possible only when the password has been checked.

The meter supports work with 5 different clients: Public (Client address 16), Pre-Establish (Client address 102) Management (Client address 1) according to IDIS specification and additional 2 clients for communication via optical port Data Collection (Client Address 32) and Utility Field Service (Client Address 48).

The public client accesses the meter without a password, but has limited access rights. It can read basic parameters which are precondition for starting HLS like Logical Device Name, Framecounters... Purpose of Public client is to collect afore mentioned necessary data before starting HLS with other clients.

The pre-established client is used for sending broadcast messages e.g. set clock on all meters. and has no right for closing or opening of the COSEM connection. It shares the security context with the Management customer.

The Management client possesses the highest access authorization. It has local and remote access, authorization to read and write all the objects, except the ones that were set during the manufacturing process and can't be changed during the meter lifetime like serial number. Firmware update procedure is done using Management client in a way described in chapter Firmware update (upgrade) according to IDIS specification.

In case of an LLS (Low Level Security) during the opening of the COSEM connection, an LLS password is used. In case of an HLS (High Level Security), the meter supports different security policies. The security policy can be set via the attribute „Security policy“ of the object "Security Setup" to one of these values:

- No Security
- All messages are authorized
- All messages are encrypted
- All messages are authorized and encrypted

The meter does not accept messages whose security policy/guidelines are lower than the ones required by the attribute in meter, but it do accepts higher security policy/guidelines than the ones which are currently set (required) by this attribute in the meter.

These security guidelines are also used by the radio communication.

Data Collection and Utility Field Service clients are clients for local access to the meter over optical port for purpose of local readout of data and meter setup and maintenance.

The meter is in accordance in full range with DLMS Security, DLMS/COSEM Green Book 7th ed. Section 9.2 (Niveas 7 des OSI Models). DLMS Security Suite 0 is supported while DLMS Security Suite 1 is under development.

The following encryption is supported in advance: AES 128 GMAC (Advanced Encryption Standard block cipher length 128).

As can be seen from these options data transport security can be authentication and/or encryption according to AES-128 GMAC (DLMS Security Suite 0).

Data transport security options **for communication over optical port and for communication with HES** are defined in object 0.0.43.0.0.255, class id 64.

Data transport security options **for communication with consumer information display via RS485 port** are defined in object 0.0.43.0.1.255, class id 64.

The meter saves and exchanges keys in a safe way; the new key is packaged via the use of the key for key encryption.

The meter allows the configuration of the attribute “Authentication_mechanism_name” for the object „Current Association” on values 1 or 5. Through the setting of the value of this attribute to 5, the meter will accept messages for opening the COSEM connection only when an HLS message is used.

By resetting the value of this attribute to 1, the meter will accept both LLS and HLS messages for opening the COSEM connection.

1 – LLS

5 – HLS GMAC

Access rights for customers: Public, Pre-Established and Management client are defined by IDIS. The content is encrypted so even the client do not knows the keys.

In order to prevent reply/attach threats or unauthorized massive disconnection of the meters each message exchanged with meter has frame counter. For each message, frame counter is increased so if the meter receives the message which frame counter is not increased by one compared to the last message received, the message will be discarded.

All messages related to disconnection/reconnection can not be sent by pre-established client which means that they can not be encrypted with broadcast, but only with unicast key which may be different for each meter.

All meters has xDLMS structure of messages.

7 Procedure of connecting meter on the mains and checking the status

7.1 Procedure of connecting SM401 to the mains and checking the status

The direct connection meter is connected to the low voltage mains directly. The wiring scheme is located on the inside of the terminal block cover (Fig. 47). The screws shall be fixed with 2.5 Nm torque.

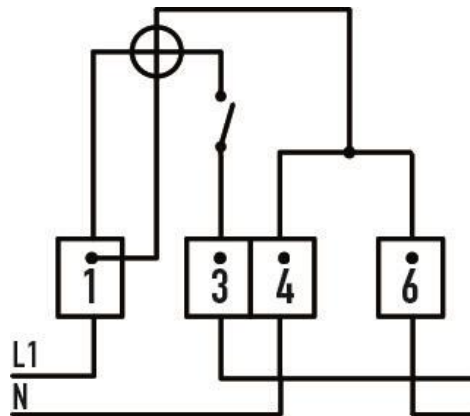


Fig. 47 – Connection diagram for 1-phase meter

The phase connection order (input - output) do not influence the measuring accuracy.

If some of the phase is irregular connected, phase indicator on the display will blink with 1 Hz frequency.

The meter will measure and record energy no matter of energy direction.

Mounting of the meter is in accordance with DIN 43857-2.

- Meter enclosure is fixed using 3 screws.
- Connection of the meter to the mains is as showed on wiring diagram on the terminal cover. The screws are fixed with 2.5 Nm torque.

Checking L1 indicator on the LCD display:

- Indicator is shown on the display - L1 – the phase is presence.
- Indicator L1 is missing – the phase voltage is missing on that phase and meter is off. In that case should be checked if phase conductors of missing phase is connected to the meter.
- Indicator L1 is blinking:
 - ✓ Input and output are interchanged (reverse energy flow).
- The next step is to check the date and time, and setting up if needed. If the internal clock shows year 2001, that mean it was not set up before. In this case, status flag is changed.

- Check if push buttons is working.
- If everything is OK, operator should seal the terminal cover.

8 Equipment for meter reading and meter parameterization

For the purposes of parameterization and maintenance of the meters the manufacturer recommends the following equipment:

8.1 Service meter programming and data reading

For the service programming of the meter, and reading data, the manufacturer recommend the following tools:

- PaMet application developed by Meter&Control which is used for data exchange and parameterization. Supported OS are Windows XP / Windows Vista / Windows 7 / Windows 8 / Windows 10.
- Optical probe – to read the data via IR port (recommended optical probe type is OS30, produced by Meter&Control)
- PC, laptop

This equipment is mostly used by authorized persons on the field and in testing laboratories.

8.2 Reading of the meter and parametrization on the field

For the meter reading and parametrization on the field, the manufacturer recommends:

- uPaMet (internal application for parametrization of the meter) for all types of hand-held terminals (Palmtop PC), which are using Windows CE
- PaMet (internal application) and laptop with Windows 7 / Vista / XP
- Optical probe (type OS30)

9 Maintenance of the meter

The meter do not need any maintenance during lifetime. Standard meter lifetime is 15 years. The applied measuring technique, built components, and highly controlled production process guarantee long term stability, so the recalibration is not needed during lifetime. Operating temperature range is from -40°C to +70°C. Storage temperature is from -40°C to +80°C.

Failure rate is less then 2% in first year of using, and less then 1% for each next year of using of the meter.

Periodically is good to check the following:

Does the meter dry and clean – take care about display and optical port?

Does it meter under normal function?

Does the sealing are in good condition and without damages?

Does the internal auto diagnostic records some errors in status register (F.F register)?

Does energy counters works and record logical change in energy amount?

10 Table review of technical characteristics of the meter

The meter type SM401:

BASIC MEASURING CHARACTERISTICS	
Accuracy class	
▪ Active energy	1 or 2 (IEC 62053-21); A or B (EN50470-3)
▪ Reactive energy	2 or 3 (IEC 62053-23)
Nominal current I_n	5 A for max current 80A to 100 A
Minimal current I_{min}	0,04 I_n
Nominal voltage, U_n	120/230 V
Voltage range	0,8 U_n – 1,15 U_n
Frequency	50 Hz
Meter constant (LED)	1.000, 3.200 or 4.000 imp/kWh/kVAh
Working temperature range	-40°C to +70°C
Relative humidity operation	95 % in period 24h
Storage temperature	-40°C to +80°C
Internal RTC	
▪ standard	Physical layer according to IEC 62054-21
▪ Frequency of the quartz	32.768 kHz
EXCHANGE DATA WITH THE METER	
LCD	in accordance with VDEW
Interfaces (PHY)	
• Optical port	IEC 62056-21
• Wired M-Bus	EN 13757-2
• RS485 port - meter type SM405	RS485
• PLC – meter type SM401	G3-PLC, S-FSK
Communication protocols	
• Optical port	IEC 62056-46 (DLMS)
• Wired M-Bus	EN 13757-3
• RS485 port - meter type SM405	RS485
• PLC – meter type SM401	DLMS/COSEM, EN 61334-4-511, EN 61334-4-32, EN 61334-5-1
SWITCHING DEVICE (INTEGRATED)	
• Max switching current	100A
• Short circuit current	30 I_{max}
• Utilization category	IEC 62055-31, UC3
• Mechanical lifetime	1.000.000
INPUTS	
control inputs, for tariff control	Tariff inputs, 230 V or 120V
SO input	Alarm input, relay control by switch
OUTPUTS	
Relay outputs	Outputs with bistable relay (230 V or 120 V, 5 A)
Solid state relay	Transistor (Opto MOS) output (230 V or 120V, 0,1A)
Electromagnetic compatibility (EMC)	
Self consumption (voltage circuit)	According to IEC/EN 62053-21/22/23, IEC/EN 62053-61, EN 50470-3
Self consumption (current circuit)	According to IEC/EN 62053-21/22/23, IEC/EN 62053-61, EN 50470-3
AC test	4 kV, 50 Hz, 1 min.
Surge voltage	6 kV, 1,2/50µs, according to IEC 62052-11, EN 50470-1
METER ENCLOSURE	
Dimensions (mm)	216x131,2x81
Weight	0,83 kg
Ingress protection	IP54 according to IEC 60529

11 Firmware update (upgrade)

11.1 Firmware signature calculation

Meter SM401 supports code separation, which means that meter contains two software legally relevant and legally non-relevant software. Both these software have their own signature.

Firmware Signature presents 4-bytes value which is actually program checksum (Flash) memory of microcontroller where the program, i.e. the meter firmware is situated. Checksum (CRC) is calculated after every meter power up and its value is placed in the RAM of the microcontroller. Calculation lasts around 1 minute and if during calculation checksum need to be read via communication port, read value will be 0. If during calculation checksum wants to be shown on the display, instead of checksum value message CALC and xx (where xx represents percentage of total firmware checksum calculation) is displayed.

Checksum may be read from the meter using communication protocol and its Obis code is: 1.0.0.2.8.255.

Also, checksum is shown in autonomous regime auto scroll sequence and may be shown in separate part of the display menu.

11.2 Firmware version

Firmware identification in electricity meter is implemented in accordance with IDIS specification and it has following format:

V03xxyy where

V – represents Version

03 – represents IDIS three phase meter

xx – represents two digits of the major firmware release

yy – represents two digits of the minor firmware release

Example: V030202.

Legally relevant firmware version is kept in object: 1.0.0.2.0.255 and it can be shown on the display.

Legally non-relevant firmware version is kept in object: 1.1.0.2.0.255.

11.3 Firmware update procedure

The meter supports the options for change of its own software during its operating mode (*firmware update*) through *DLMS* protocol, and is in accordance with WELMEC 7.2.

Firmware update in the meter is realized so that measurement characteristics of the meter

are not compromised, as well as data memorized in the meter and configurational or operational parameters of the meter. Entry of the new software in the meter may be done locally (though optical port) or remotely (through remote management system).

Firmware download is initiated by sending image identifier to the electricity meter. Image identifier value depends of the meter type and it is represented in following format:

MAC-ST40xy-LR-HWz.k-FWu.v.w where

x – represents meter communication module (1, 2 or 5): 1 – PLC, 2 – GPRS, 5 – RS485

y – represents meter connection type (D or C): D – direct connection; C – transformer connection

z.k – represents meter hardware version

u.v.w – represents legally relevant firmware version

Example: Image identifier for direct meter with Cellular modem and hardware version 1.1 would be:

MAC-ST402D-LR-HW1.1-FW1.1.0

If image identifier is correct, then firmware update event log capacity is checked. If event log is full, firmware update procedure is discarded. Otherwise, firmware download is initiated and meter will accept following data as defined in DLMS standard. Firmware is sent to the meter in segments which are stored in non-volatile memory. That enables the meter to operate easily, to collect (i.e. measure and record) all necessary data. After reception of complete firmware, its validity is checked. The validity of firmware is reflected in calculation of firmware checksum. Checksum represents 4 byte sum of the downloaded firmware (image file + digital signature). Calculated checksum is compared with checksum that was sent upon firmware download. If the checksum is correct, next step is to verify whether downloaded firmware (to which the meter is to be updated) has proper digital signature. If there is any discrepancy in checksum or the type of firmware meter, the meter will not be updated.

The meter has an option of *delayed update of firmware*. The new software is sent to the meter with parameters on date and time when the firmware update should be done. When the given parameter has been obtained, the meter will do the *update*, and then it will start executing the new software. If the parameter on delayed upgrading of software is not defined, the meter will start with upgrading immediately after dispatch of the new software version.

After update, calculation of measuring part of the firmware checksum is performed and it is compared to the value of old version which is stored in permanent memory. If checksum is incorrect new firmware is discarded and old firmware remains active.

Firmware update option may be accessed only by *management* client.

12 Auto diagnostic function (self-check)

The meter has implemented function of auto diagnostic (self-check), which mean that key parameters of the meters are checked and proved.

The key parameters that are checked are: memory integrity, status and alarms, display, battery status, communication status, presence of the phase voltages, etc.

Auto diagnostic is performed each time when meter is initialized: connection to the mains and after firmware download/update.

Also, monitoring of meter's parameters is continually performed during the meter operation. Auto diagnostic could be started locally, on the authorized demand.

The self-check of meter software (each software version has unique check-sum) is performed each time the meter is connected to the mains, after return to the power, and after firmware download/update.

The diagnostic results are stored into standard log book, and into integrity book, and could be accessed locally or remotely.

The results could be shown into display, when the F.F register is set to be shown during meter parametrization.

The F.F register is status register where each error has it unique code.

The code list is presented in chapter 4.1.1.1.1 of this manual.

13 Support for the connection of water meters, gas meters and calorimeters (Multi-utility metering)

The meter is equipped with interface (wired M-Bus or optionally wireless M-Bus) for connecting other measuring devices which are installed at the customer – water meter, gas meter and heat meter (calorimeter).

The meter has a reserved memory register to save billing profiles for each of these devices. The billing period is 5, 10, 15, 30, 60 minutes or once a day.

The memory capacity is 300 records for each device, and is organized as a FIFO stack. All data are stored into the profiles associated with M-Bus devices.

There are 4 load profiles:

M BUS load profile 1 (obis – 0.1.24.3.0.255) – capacity to 680 records

M BUS load profile 2 (obis – 0.2.24.3.0.255) – capacity to 680 records

M BUS load profile 3 (obis – 0.3.24.3.0.255) – capacity to 680 records

M BUS load profile 4 (obis – 0.4.24.3.0.255) – capacity to 680 records

There are event log for M-Bus devices, where the similar event as for meters are stored:

M BUS event log (obis – 0.0.99.98.3.255) – capacity to 340 records

M BUS event log 1 (obis – 0.1.24.5.0.255) – capacity to 340 records

M BUS event log 2 (obis – 0.2.24.5.0.255) – capacity to 340 records

M BUS event log 3 (obis – 0.3.24.5.0.255) – capacity to 340 records

M BUS event log 4 (obis – 0.4.24.5.0.255) – capacity to 340 records

The meter has implemented algorithms for reading the measuring devices and for storing their data.

As was mentioned above, all data from these devices are stored into profiles associated with M-Bus.

This function could be adapt as per utility requests.

14 Type designations

SM401D – 20A51R56 – G3MS20111 – wscmgmbzv

(The meter type – measuring – interfaces – functions)

- **Meter types :**

ST – 3-phase meter

SM – 1-phase meter

401 – meter with PLC modem

402 – meter with cellular modem

405 – meter with RS485 port

D – direct connection

C – transformer connection (via current transformers)

- **Measuring characteristics**

10 – $I_n = 1A$, $I_{max} = 10A$

15 – $I_n = 5A$, $I_{max} = 6A$

19 – $I_n = 5A$, $I_{max} = 60 A$

20 – $I_n = 5A$, $I_{max} = 80 A$

22 – $I_n = 5A$, $I_{max} = 100 A$

23 – $I_n = 5A$, $I_{max} = 120 A$

A – active energy

R – reactive energy

3 – accuracy class 0.5S

4 – accuracy class 1

5 – accuracy class 2

6 – accuracy class 3

7 – accuracy class MID A

8 – accuracy class MID B

9 – accuracy class MID C

1 – measuring A+

3 – measuring A+, A- and |A|

5 – measuring R+, R-, R1, R2, R3, R4

6 – measuring R1

- **Interfaces**

G2 – PLC S-FSK (PLAN+) modem

G3 – PLC G3 modem

R1 – One RS485 port

R2 – Two RS485 ports

O – Optical port

M – Optical port, wired M-Bus

S – Integrated switching device

V – 230 V or 120 V power supply output for external modem

W – Wireless M-Bus

C – Current Loop interface

11322 – no of tariff inputs 230 V or 120V, no of OPTOMOS outputs, no of pulse outputs, no of relays 5A, no of SO inputs

- **Functions**

w – “no poWer” reading battery

s – Supercap for RTC backup

- c** – Support for **C**ustomer information unit
- m** –**M**ulti-utility metering
- g** – Last **g**asp functionality
- n** – Measurment element for measuring **n**eutral current (bypass detection)
- b** – Display backlight
- z** – Detection of impedance downstream of meter switching device (disconnecter)
- v** – Detection of voltage downstream of meter switching device (disconnecter)

15 Safety

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 authorized 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 respond specially for the protection of the persons, for prevention of material damage and for training of personnel.

15.1 Safety regulations

The following safety regulations must be observed at all times:

- a) The meter connections must not be under voltage during installation or when opening. Contact with live parts is dangerous to life. The relevant main fuses should therefore be removed and kept in a safe place until the work is completed, so that other persons cannot replace them unnoticed.
- b) Local safety regulations must be observed. Only technically qualified and suitably trained personnel is authorized to install the meters.
- c) The meters must be held securely during installation. They can cause injuries if dropped.
- d) Meters, which have fallen, must not be installed, even if no damage is apparent, but must be returned for testing to the service and repair department responsible (or the manufacturer). Internal damage can result in functional disorders or short-circuits.

The meters must not be cleaned with running water or with compressed air devices. Water penetrating can cause short circuits.

16 Standards

The meter is designed in accordance with the following international standards:

- IEC 62056-21 (mod C), Electricity metering - data exchange meter reading, tariff and load control (part 21: Direct local area exchange)
- IEC 60529, Degrees of protection provided by enclosures (IP code), IP54
- IEC 62052-11 Electricity metering equipment (a.c.) - general requirements, test and test conditions (part 11: Metering equipment)
- IEC 62052-11 Electricity metering equipment (ac) - General requirements, testing and test conditions (Part 11: Measuring equipment), Class II indirect contact protection, Class B radio interference limits
- 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 50470-1 Electrical meters (ac) - Part 1: General requirements, tests and test conditions - Measuring equipment (accuracy classes A, B and C), resistance to shock wave voltage 1.2 / 50 μ s, 6kV
- EN 50470-3 Electricity metering equipment (a.c.) — Part 3: Particular requirements — Static meters for active energy (class indexes A, B and C)
- EN 50470-3 Electrical meters (ac) - Part 3: Particular requirements - Static meters of active energy (index classes A, B and C), Insulation strength test of 4 kV meters, 50 Hz, 1 minute
- IEC 62053-21, Electricity metering equipment (a.c.) - Particular requirements (part 21: Static meters for active energy (classes 1 and 2))
- IEC 62053-22, Electricity metering equipment (a.c.) - Particular requirements (part 21: Static meters for active energy (classes 0.2S and 0.5S))
- IEC 62053-23, Electricity metering equipment (a.c.) - Particular requirements (part 23: Static meters for reactive energy (classes 2 and 3))
- IEC 62053-24, Electricity metering equipment (a.c.) - Particular requirements (part 24: Static meters for reactive energy (classes 0,5 and 1))
- IEC 62053-31, Electricity metering equipment (a.c.) - Particular requirements (part 31: Pulse output devices for electromechanical and electronic meters (two wires only))
- IEC 62054-11, Electricity metering (a.c.) - Tariff and load control (part 11: Particular requirements for electronic ripple control receivers)
- IEC 62054-21, Electricity metering (a.c.) - Tariff and load control (part 21: Particular requirements for time switches)
- IEC 61000, Electromagnetic compatibility (test and measurement methods), Part 4-2 - Electrostatic discharge test
- IEC 61000, Electromagnetic compatibility (test and measurement methods), Part 4-3 - Resistance test to radiated radio frequency electromagnetic fields
- IEC 61000, Electromagnetic compatibility (test and measurement methods), Part 4-4 - Resistance test to electrical fast burst transients
- IEC 61000, Electromagnetic compatibility (test and measurement methods), Part 4-5 - Burst surge resistance test
- IEC 61000, Electromagnetic compatibility (test and measurement methods), Part 4-6 - Resistance test to guided interference by radio frequency fields
- EN 60695-2-11, Fire hazard testing - Part 2-11: Glow / hot wire test methods
- RoHS 2 Directive 2011/65 / EU banning the use of certain hazardous substances in electrical and electronic equipment
- DIN 43857-2, Watt-hour meters in moulded insulation case without instrument transformers,

- up to 60 A rated maximum current; principal dimensions for poly-phase meters*
- *BS EN 13757 – 3 : 2004 Communication system for and remote reading of meter; Part 3: Dedicated application layer*
- *BS EN 13757 – 2 : 2004 Communication system for and remote reading of meter; Part 2: Physical and link layer*
- *BS EN 13757 – 4 Communication systems for meters and remote reading of meters. Wireless meter readout (radio meter reading for operation in the 868-870 MHz SRD band*
- *EN 50065 - 1: Signal transmission over low voltage electrical installations in the frequency range 3kHz to 148.5kHz - Part 1: General requirements, frequency ranges and electromagnetic interference*
- *EN 62056-8-5: Electricity metering data exchange - DLMS / COSEM set - Part 8-5: Narrowband OFDM G3-PLC communication profile for nearby networks*
- *ITU-T G.9903: Narrowband communication transceivers of orthogonal frequency multiplex power lines for G3-PLC networks, Orthogonal frequency multiplex (OFDM) Protocol for communication through power lines (PLC).*