User 's Manual

EN

Three-phase electrical energy meters for charging stations

WM3M4 & WM3M4C

September 2024 • Version 2.13• valid from FW version 2.12

Three-phase electrical energy meters for charging stations

WM3M4 & WM3M4C

User and Installation manual

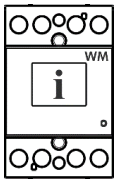
Security Advices and Warnings

Please read this chapter carefully and examine the equipment carefully for potential damages which might arise during transport and to become familiar with it before continue to install, energize and work with *the WM3M4 & WM3M4C three-phase energy meters*.

This chapter deals with important information and warnings that should be considered for safe installation and handling with a device in order to assure its correct use and continuous operation.

Everyone using the product should become familiar with the contents of chapter »Security Advices and Warnings«.

If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.



PLEASE NOTE

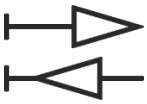
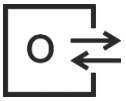
This booklet contains instructions for installation and use of a three-phase energy meters WM3M4 & WM3M4C. Installation and use of a device also includes handling with dangerous currents and voltages therefore should be installed, operated, serviced and maintained by qualified personnel only. ISKRA Company assumes no responsibility in connection with installation and use of the product. If there is any doubt regarding installation and use of the system in which the device is used for measuring or supervision, please contact a person who is responsible for installation of such system.

Before installing

Check the following before installing:

- Nominal voltage.
- Terminals integrity.
- Protection fuse for voltage inputs (recommended maximum external fuse size is 40 A).
- External switch or circuit breaker must be included in the installation for disconnection of the devices' power supply. It must be suitably located and properly marked for reliable disconnection of the device when needed.
- Proper connection of communication terminals.

Used symbols on devices' housing and labels

SYMBOL	EXPLANATION
	**DANGER** Indicates proximity of hazardous high voltage, which might result in serious injury or death if not handled with care.
	**WARNING** Indicates situations where careful reading of this manual is required and following requested steps to avoid potential injury is advised.
	Compliance of the product with directive 2002/96/EC, as first priority, the prevention of waste electrical and electronic equipment (WEEE), and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment.
	Compliance of the product with European CE directives.
	Double insulation.
	Three-phase connection.
	Single-phase connection.
	Bidirectional energy measurement.
	IR optical communication.
	Read user's manual.

UK CA	Compliance of the product with UK Conformity Assessed (UKCA) directives.

Disposal

It is strongly recommended that electrical and electronic equipment (WEEE) is not deposit as municipal waste. The manufacturer or provider shall take waste electrical and electronic equipment free of charge. The complete procedure after lifetime should comply with the Directive 2002/96/EC about restriction on the use of certain hazardous substances in electrical and electronic equipment.

Table of contents

1 BASIC DESCRIPTION AND OPERATION

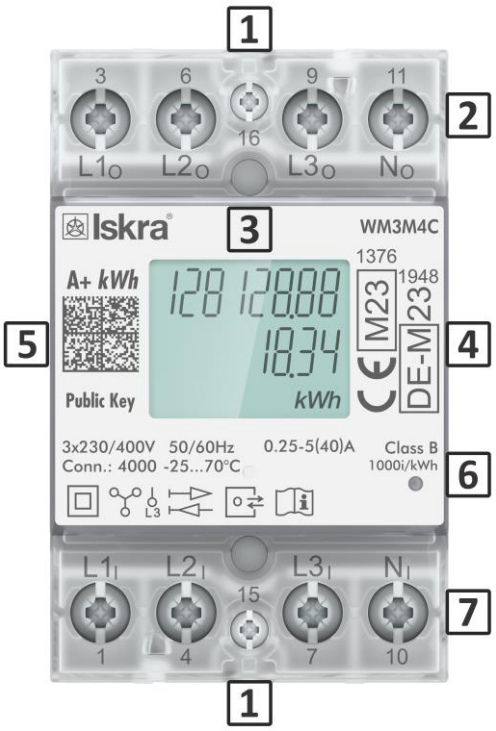
The following chapter presents basic information about *WM3M4 & WM3M4C three-phase energy meters* required to understand its purpose, applicability and basic features connected to its operation. In this chapter you will find:

1.1 Description of the device

1.1.1 Functionality of WM3M4 & WM3M4C

The *WM3M4 & WM3M4C energy meters* are MID certified meters, intended for energy measurements in the three-phase and single-phase electrical charger stations. The WM3M4C energy meter features high temperature operation and digital signing for a charging event, whereas WM3M4 features only high temperature operation. Both meters measure energy directly in 4-wire networks according to the principle of fast sampling of voltage and current signals. A built-in microprocessor calculates power, energy, current, voltage, power factor, power angle, frequency, harmonics of THD voltage and THD current harmonics. WM3M4C meter can detect and log events relevant for charging via RS485 communication. Thus the meter can produce relevant digital signature for charging event.

1.1.2 Appearance



1. **RS485 terminals**
2. **Current terminals to load**
3. **LCD display**
4. **IR COMM PORT** (on side)
5. **Public key as Data Matrix code** (valid only for WM3M4C)
6. **LED indicator** (1000 imp/kWh)
7. **Current terminal – source** (max 40 A)

LCD

Number of digits:	8 (6+2)
Height of digits:	6.52 mm

LED

Colour:	red
Pulse rate:	1000 imp/kWh
LED on:	no load indication

Figure 1: *Appearance of a three-phase electrical energy meter WM3M4C*

The energy meters have a built-in optical (IR) communication port on the side as a standard. A special WM-USB adapter (size 1 DIN module) can easily be attached to it. It can be used for direct communication with a PC to change settings of devices without any communication installed.

On the housing there are two terminals, A(16) and B(15) for RS485 communication.

Terminals can be sealed with a protective cover to prevent unauthorized access. The meters are mounted in accordance with EN 60715.

1.2 Hardware description

The whole system of the *WM3M4 & WM3M4C energy meters* is equipped with the following units:

- Stand-alone unit.
- Power supply unit.
- Process unit (MCU microcontroller) with IR communication, LED display, LCD support, and EEPROM.
- Additional unit for RS485 communication.

Communication:

- Every meter is equipped with **IR optical communication** and **RS485 communication.** Both use the MODBUS protocol. It is used for setting and reading a meter with the WM-USB adapter or RS485 adapter. The *WM3M4 & WM3M4C energy meters* can also be connected to SG (smart gateway). It is intended to connect various equipment into the communication network.
- **The LED** shows the state of active energy. It flashes in proportion to the received active energy. When there is no load, the LED lights up.

1.3 Main features

- **3 DIN modules width** three-phase direct connected DIN-rail mounting meter**.**
- **Class 1** for active energy according to EN **62053-21**.
- MID approval WM3M4 & WM3M4C for **class B** according to EN 50470-3.
- PTB approval for EV charging stations (according to PTB-A 20.1. and PTB-A 50.7, *valid only for WM3M4C*).
- Reference frequency **50 Hz or 60 Hz.**
- Maximum current ($\mathbf{I_{max}}$) **40 A.**
- Reference current **5 A ($\mathbf{I_{ref}}$).**
- Reference voltage **3x230 V/400 V ($\mathbf{U_n}$).**
- Voltage **operating range** (-20 % ... +15 %) U_n.
- Two row display **6+2** digit (**10 Wh** resolution) with backlight.
- **Multifunctional** front LED.
- **IR** Serial communication.
- **RS485** Serial communication.
- Measurement of
    - Power (active/reactive/apparent for each phase and total).
    - Active energy (bidirectional).
    - Voltage (each phase).
    - Current (each phase).
    - Phase to phase voltage.
    - Phase to phase angle.
    - Frequency.
    - Power factor (each phase and total).
    - Power angle (each phase and total).
    - THD of voltage.
    - THD of current.
- **Crypto engine (Hash, signature)** for generation of secure datasets (*valid only for WM3M4C*).
- **Cable losses** are taken into account
- Possibility to connect as a single phase **(on L3)**.
- Remote control for **backlight LCD**.
- Secure data transfer (**digital signature**, *valid only for WM3M4C*).
- **70°C** ambient operation temperature.
- **Sealable** terminal cover.

2 CONNECTION

This chapter deals with the instructions for connection of *the WM3M4 & WM3M4C energy meters*. Both the use and connection of the device include handling with dangerous currents and voltages. The connection shall thus be performed ONLY by a qualified person using appropriate equipment. ISKRA, d.o.o. does not take any responsibility regarding the use and connection. If any doubt occurs regarding connection and the use in the system which device is intended for, please contact a person who is responsible for such installations.

IN THIS CHAPTER, YOU WILL FIND:

2.1 Mounting

The WM3M4 & WM3M4C energy meters are intended for DIN-rail mounting. In the case of using the stranded wire, the ferrule must be attached before the mounting.

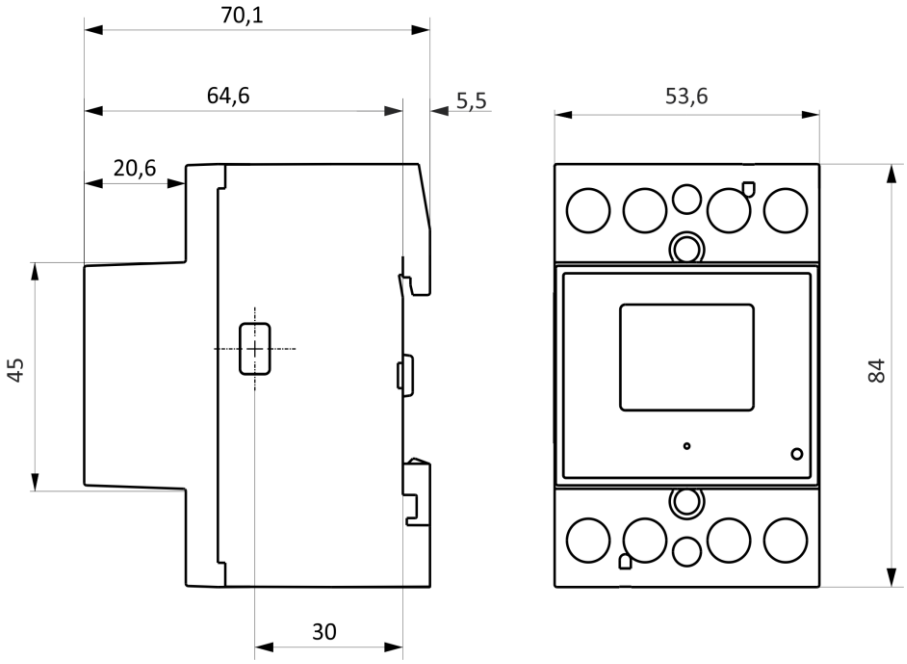
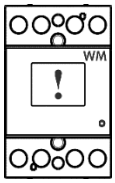


Figure 2: *Dimensional drawing and rear DIN rail mounting position*

2.2 Electrical connection



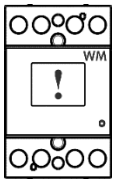
WARNING

Wrong or incomplete connection of voltage or other terminals can cause non-operation or damage to the device.

The meters are used for direct connection into the four-wire networks or single-phase (L3) operation. They are also equipped with communication terminals. Pictures below are showing equipped combination.

Recommended installation:

1 Mounting to DIN rail according to DIN EN60715.
2 Main inputs:
   a. Contacts capacity: rigid (flexible) 2.5 mm^2 … 25 (16) mm^2.
   b. Connection screws: M5.
   c. Recommended / Maximum torque: 3/3.5 Nm (PZ2).
   d. Length or removed isolation: 10 mm.
3 Communication terminals:
   a. Contact capacity: 1 mm^2 … 2.5 mm^2.
   b. Connection screws: M3.
   c. Recommended / Maximum torque: 0.7/0.8 Nm (PZ1).
   d. Length or removed isolation: 8 mm.



PLEASE NOTE

Neutral wire must be connected to the meter.

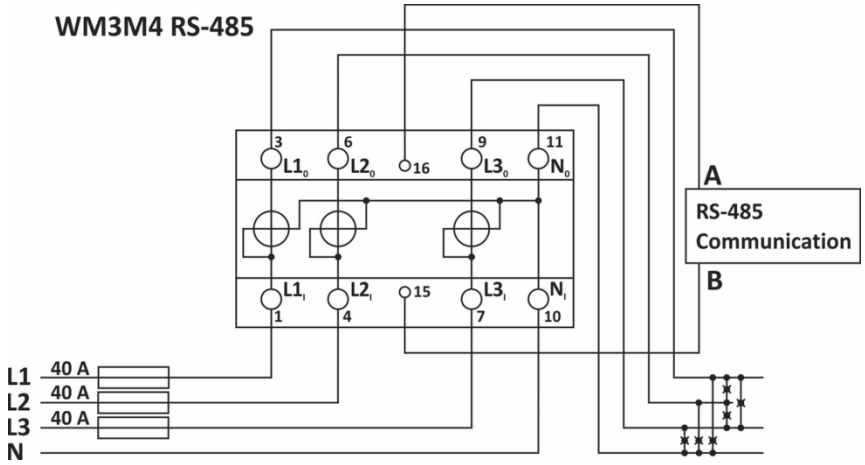


Figure 3: *Three - phase connection diagram*

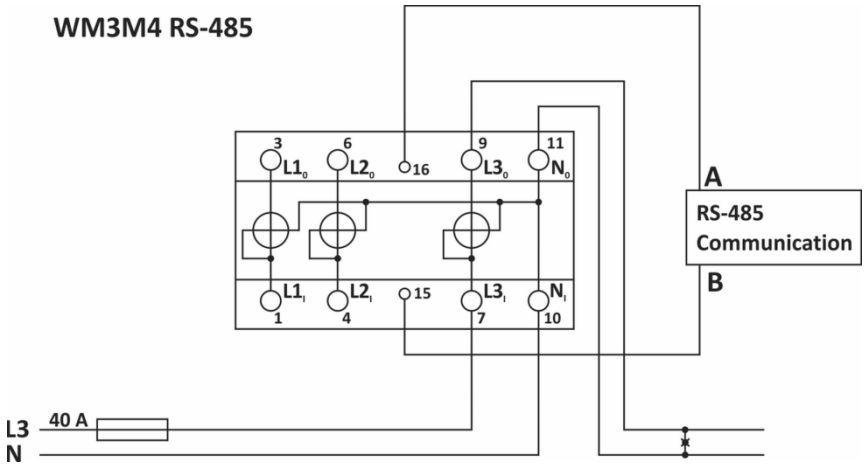


Figure 4: *Single-phase connection diagram*

3 FIRST STEPS

Programming *WM3M4 & WM3M4C energy meters* is very transparent and user-friendly. Numerous settings are organized in groups according to their functionality.

IN THIS CHAPTER YOU WILL FIND BASIC PROGRAMMING STEPS:

3.1 Display of device info

Energy meters have LCD display with following layout.

Layout of LCD:

1 Total kWh import
2 User settable line
3 4 digit label
4 kWVA display
5 kWh display

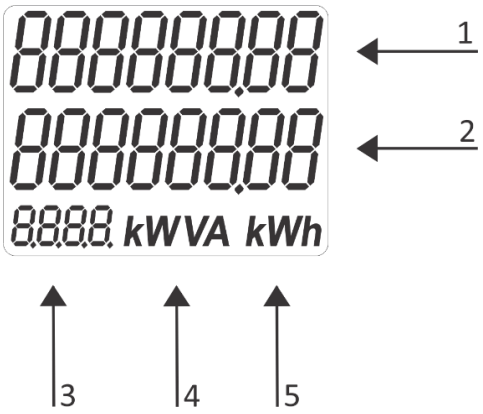


Figure 5: *Layout of LCD*

3.2 Welcome screens

LCD segment test

Figure 6: *LCD segment test*

FW identification window:

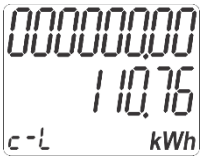
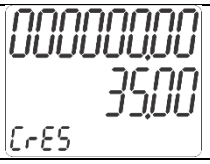
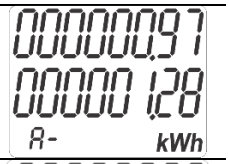
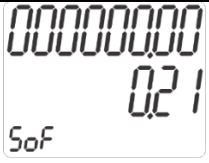
1 CRC of main FW MCU
2 CRC of measuring modules FW
3 Main FW version

Figure 7: *FW identification window*

3.3 LCD Display information

LCD Display has 2 rows with 8 digits each and 4 digit label. Display scrolls automatically. Displayed quantities and scroll time can be set via communication by MiQen software. Top row always displays imported active energy consumption. The LCD display shows the values of the counters Modbus registers.

Row 2 is configurable to display following values:

BITS	*ROW 2 DESCRIPTION*	*ROW 3 DESCRIPTION/ABBREVIATION*	*LCD EXAMPLES*
BIT 14	**Consumption 2 (A-) + Cable loss 2 (A-)** - of last charging (in idle state) - of actual charging event (during charging)	c-L- Unit: kWh	
BIT 13	**Consumption (A+) - Cable Loss (A+)** - of last charging (in idle state) - of actual charging event (during charging)2 (A+)	c-L Unit: kWh	
BIT 12	**Cable Loss 2 (A-)** - of last charging (in idle state) - of actual charging event (during charging)	LoS- Unit: kWh	
BIT 11	**Cable Loss (A+)** - of last charging (in idle state) - of actual charging event (during charging)	LoSS Unit: kWh	
BIT 10	**Cable Resistance setting (mOhm)**	CrES Unit mOhm is not shown.	
BIT 9	**Energy consumption 2 (A-) of charging** **End:** Consumption 2 (A-) of last charging in idle state. **Run:** Consumption 2 (A-) of actual charging event (during charging).	cA- Unit: kWh	
BIT 8	**Export active energy counter**	A- Unit: kWh	
BIT 7	**SW version**	SoF	

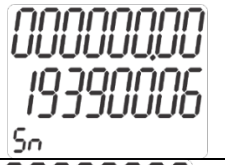
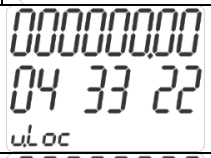
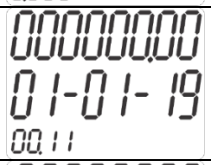
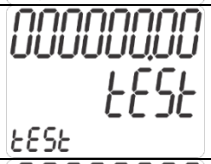
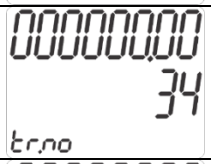
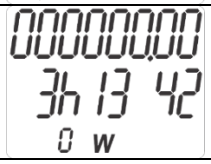
BIT 6	**Serial number**	Sn	
BIT 5	**Time**	1st digit: Clock status (see Table 5) Digits after dot: • Loc (Local time), or • Utc (UTC time)	
BIT 4	**Date** (e.g.: day, month, year)	hh.mm (hour.minutes) (time - e.g.: 00 (hour).11 (minutes))	
BIT 3	**Custom String**	LCD Custom string label (see Table 3); Available characters (see chapter 3.3.3)	
BIT 2	**Transaction number**	tr.no	
BIT 1	**Duration** (e.g.: 3 h 13 min 42 s)	Charging power (e.g.: 0 W)	
BIT 0	**Energy consumption of charging** **End:** Consumption of last charging in idle state. **Run:** Consumption of actual charging event (during charging).	1st digit: Clock status (see Table 5) 2nd digit: Charging status (see Table 6)	

***Table 1**: LCD ROW2 Configuration*

Default state is Energy consumption.

If multiple bits are selected, then values are cycling with period defined in MODBUS register 40174.

40174	LCD cycling period	Cycling time in Seconds

***Table 2**: LCD cycling period*

Custom string is defined in register 47063:

47063	LCD Custom string	8 bytes to display on 7-segment LCD (non printable values are replaced with empty space)

***Table 3**: LCD Custom string*

Custom string label has configurable label in register 47064:

47064	LCD Custom string label	4 bytes to display on 7-segment LCD (non printable values are replaced with empty space)

***Table 4**: LCD custom string label*

Value	Clock status	LCD status
0	Not sync (U)	u
1	Informative clock	i
2	Synchronized clock	S
3	Relative clock	r

***Table 5**: Clock sync status*

Register 47000

Value	Charging Status	LCD status
0	Not charging (Idle)	I
1	Charging	C
2	Charging after power down	P
3	Charging after meter reset	d

***Table 6**: Charging status*

3.3.1 LCD Error display

Errors are displayed on row 2 and have priority over other messages.

Error format is: Err 1234.

Number represents hexadecimal value of 16 bits error state.

Bit 0	Error Parameter CRC
Bit 1	Error Firmware CRC
Bit 2	Error MID-lock
Bit 3	Error phase module 1 CheckSum
Bit 4	Error phase module 2 CheckSum
Bit 5	Error phase module 3 CheckSum
Bit 6	Error Main FW CheckSum
Bit 7	Error Software Checksum
Bit 8	Error Calibration Data CheckSum
Bit 9	Error MID Setting Data CheckSum
Bit 10	Error Setting Data CheckSum
Bit 11	Error phase module 1 cal. data CheckSum
Bit 12	Error phase module 2 cal. data CheckSum
Bit 13	Error phase module 3 cal. data CheckSum
Bit 14	Error Crypto data CheckSum
Bit 15	Error Crypto chip failure

***Table 7**: Error bits*

Example:

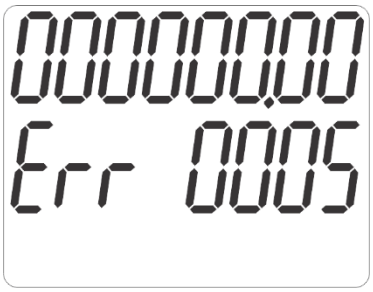


***Figure 8:** Error display*

Err 0005 (binary representation: 0000 0000 0000 0101).

BIT0 and BIT2 are set, so we have Parameter CRC Error and MID-lock Error.

In case the meter is in Error state the start of charging process with digital signature is blocked and the meter needs to be replaced.

3.3.2 LCD Warning display

Warning is displayed on row 2 and have priority over other messages.

If the MODBUS register 47097 for „Change Lock control“ is not set, the warning is displayed. See chapter 6.5.6.1Change Lock control.

Example:

Figure 9: *Warning display*

3.3.3 List of available characters on LCD

0,O,1,I,l,2,3,4,5,S,6,G,7,8,9,A,B,b,C,D,d,E,F,H,L,J,N,P,R,U,V,c,h,i,r,n,o,v,u,t,-

4 SETTINGS

Settings of *the WM3M4 & WM3M4C energy meters* can be done via MiQen software. A setting structure, which is similar to a file structure in an explorer, is displayed in the left part of the MiQen setting window. Available settings of that segment are displayed in the right part by clicking any of the stated parameters.

IN THIS CHAPTER, YOU WILL FIND A DETAILED DESCRIPTION OF ALL *WM3M4 & WM3M4C ENERGY METERS* FEATURES AND SETTINGS. THE CHAPTER IS ORGANIZED IN A WAY TO FOLLOW SETTINGS ORGANIZATION AS IN SETTING SOFTWARE MIQEN.

4.1 Introduction

Parameterization can be modified by serial communication (RS485) or by a special WM-USB adapter (size 1 DIN module) and MiQen software.

4.2 MiQen software

MiQen software is a tool for complete programming and monitoring of ISKRA measuring instruments, connected to a PC via serial communication or by a special WM-USB adapter. A user-friendly interface consists of six segments: devices management (Connection), instrument settings (Settings), real-time measurements (Measurements), data analysis (Analysis), saved preffered devices (My Devices – this action is not supported by this meter) and software upgrading (Upgrades – this action is not supported by this meter). These segments are easily accessed utilizing icons on the left side (see Figure 9).

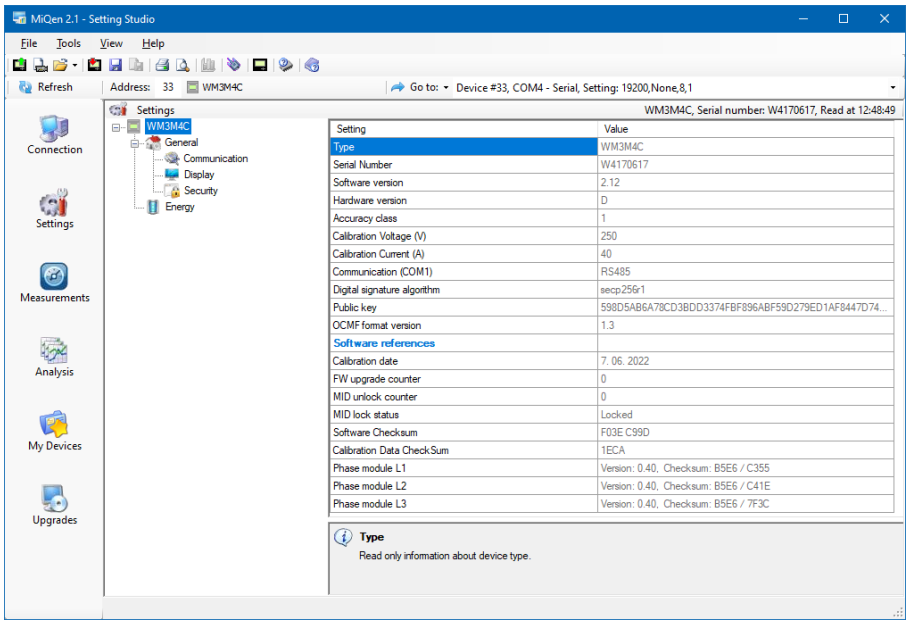


Figure 10: *MiQen programming and monitoring software*

For further managing those segments, icons on the top bar can be utilised.:

- READ SETTINGS : reads and displays all device's settings.
- READ MEMORY : data is read directly from a device's internal memory (not supported by this meter).
- OPEN : data is read from a local database.
- DOWNLOAD SETTINGS : changes should be downloaded to the device by pressing this button when programming is finished.
- SAVE : the file settings will be saved.
- EXPORT : data can be exported to an Access data base, Excel worksheets or as a text file (not supported by this meter).
- PRINT : data listing can be exported into PDF file or printed on a paper.

- PRINT PREVIEW : preview of a PDF file.
- GRAPHICAL ANALYSIS : measurements can be shown in a graphical form (not supported by this meter).
- COMMUNICATION PORT SETTING : opens window for communication port settings.
- INTERACTIVE INSTRUMENT : additional communication feature of a device allows interactive handling with a dislocated device as if it would be operational in front of a user (not supported by this meter).
- MEMORY INFO : shows available memory since last official data transfer (not supported by this meter).
- HELP : for more detailed information how to handle a device.

MiQen software is required for programming and monitoring *the WM3M4 & WM3M4C energy meters*. Software installation can be downloaded from https://www.iskra.eu/en/Iskra-Software/MiQen-Settings-Studio/

PLEASE NOTE

MiQen has very intuitive help system. All functions and settings are described in Info window on the bottom of MiQen window.

4.3 Connection

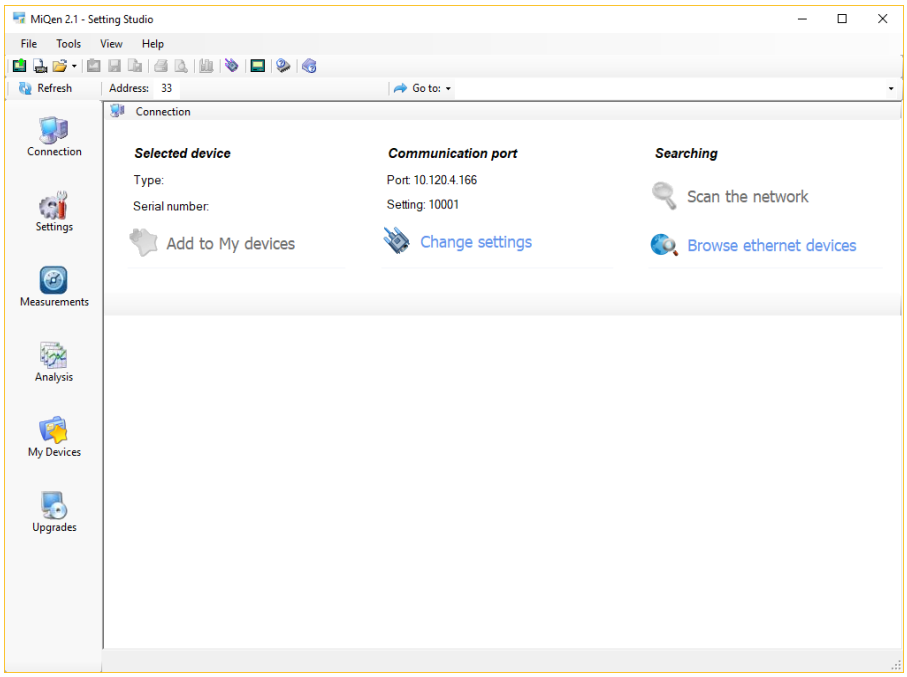


Figure 11: *MiQen Device Management window*

With MiQen it is very easy to manage devices. If dealing with the same device that has been accessed before it can be easily selected from a favourite's line.

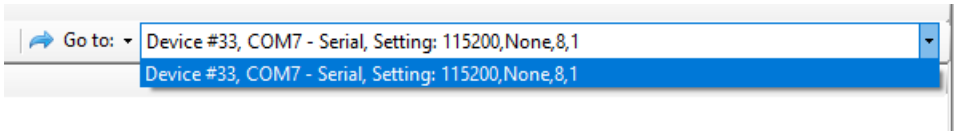
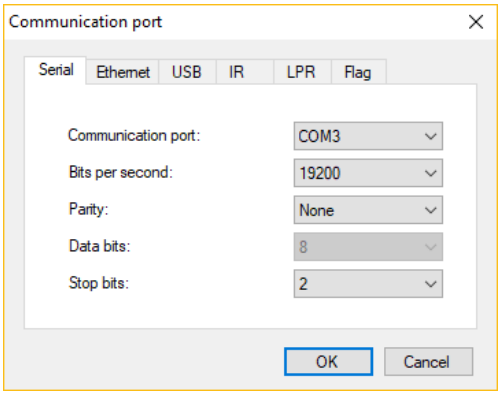


Figure 12: *Favourite's line*

This way is Communication port set automatically as it was during last access.
To communicate with new device, following steps should be followed:

Connect a device to a communication interface

Set Communication port parameters



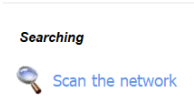
Under the *Communication port,* current communication parameters are displayed. To change those parameters click on the Change settings button. A Communication port window opens with different communication interfaces.

The WM3M4 & WM3M4C energy meters supports only serial communication, so only serial communication parameters can be set.

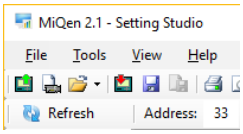
Figure 13: *Communication port window*

Start communicating with a device

Click on the REFRESH button and devices information will be displayed.



When a device is connected to a network and a certain device is required, it is possible to browse a network for devices. For this purpose choose ***Scan the network***.



Factory default **MODBUS address** for all devices is 33. Therefore it is required to change MODBUS address number of the devices if they are connected in the network so each device will have its unique address number.

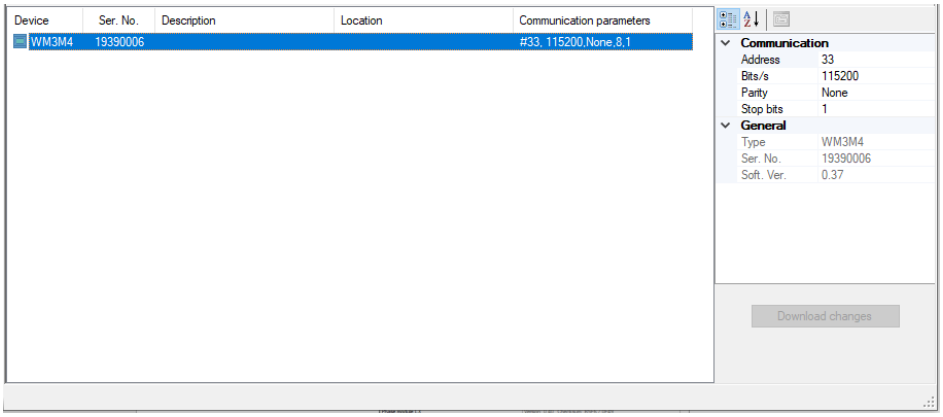


Figure 14: *Display of device's adress settings in the MiQen software*

4.4 Settings

After communication with a device is established, choose icon Settings from a list of MiQen functions on a left side.

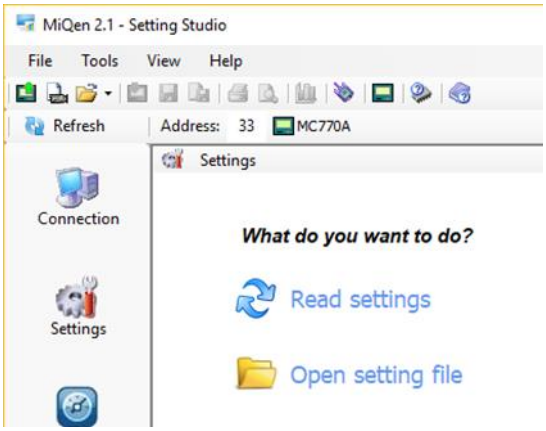


Figure 15: *MiQen Device Setting window*

Choose Read settings button to display all device's settings and begin adjusting them according to project requirement.

Settings are shown in the Settings set – the left part shows the hierarchical tree structure of settings, in the right part, the parameter values of the selected set of parameters are displayed. In addition to transferring the settings to the meter, there is a possibility of saving and reading from the set files. This can be done with a right click on a mouse on a certain parameter. Afterwards, a window is shown with a save and a read icon.

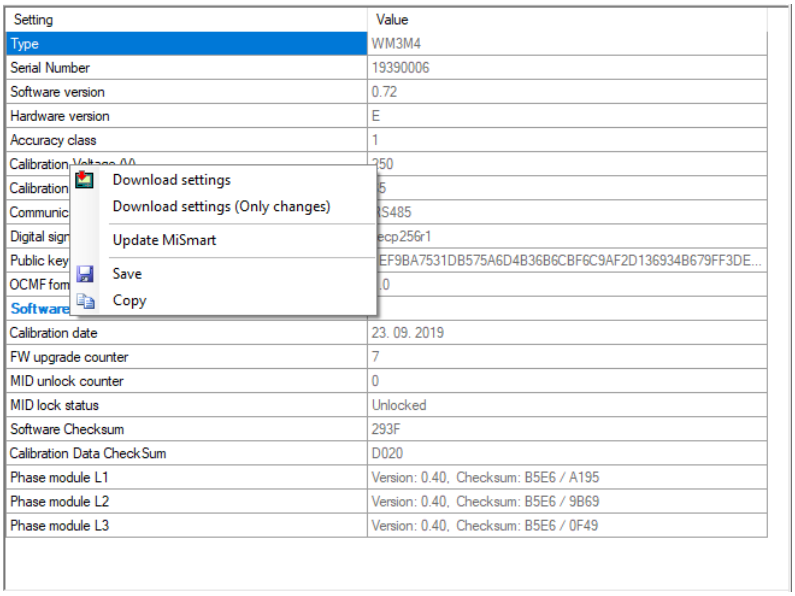


Figure 16: *Save and read parameters window*

Those icons can also be found on a top bar.

Settings values colored in gray are informative nature only.

Identification window:

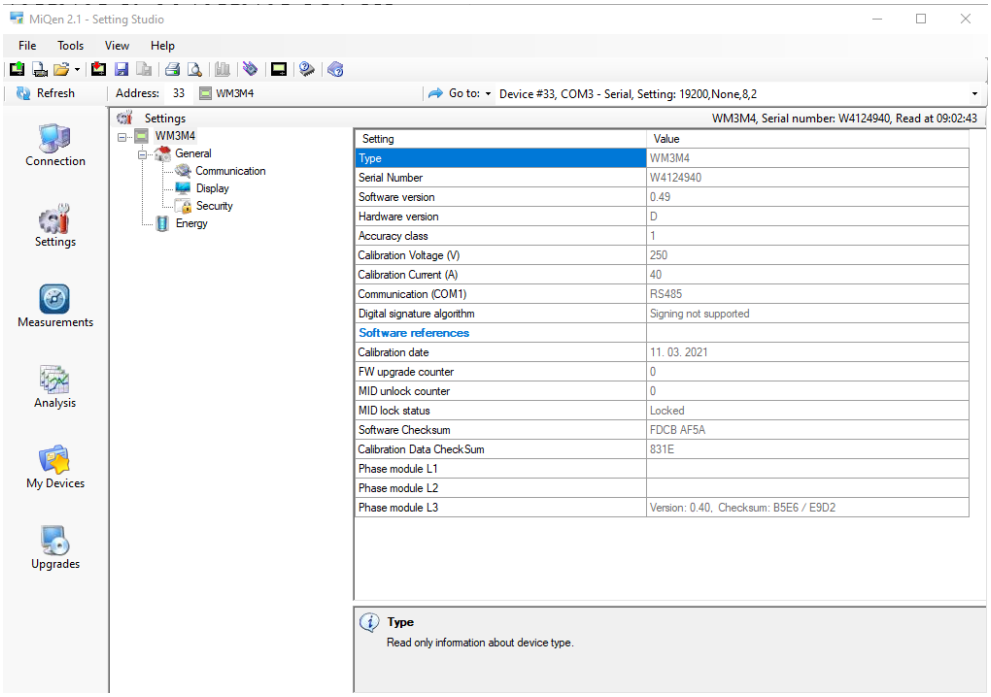


Figure 17: *WM3M4 Identification window*

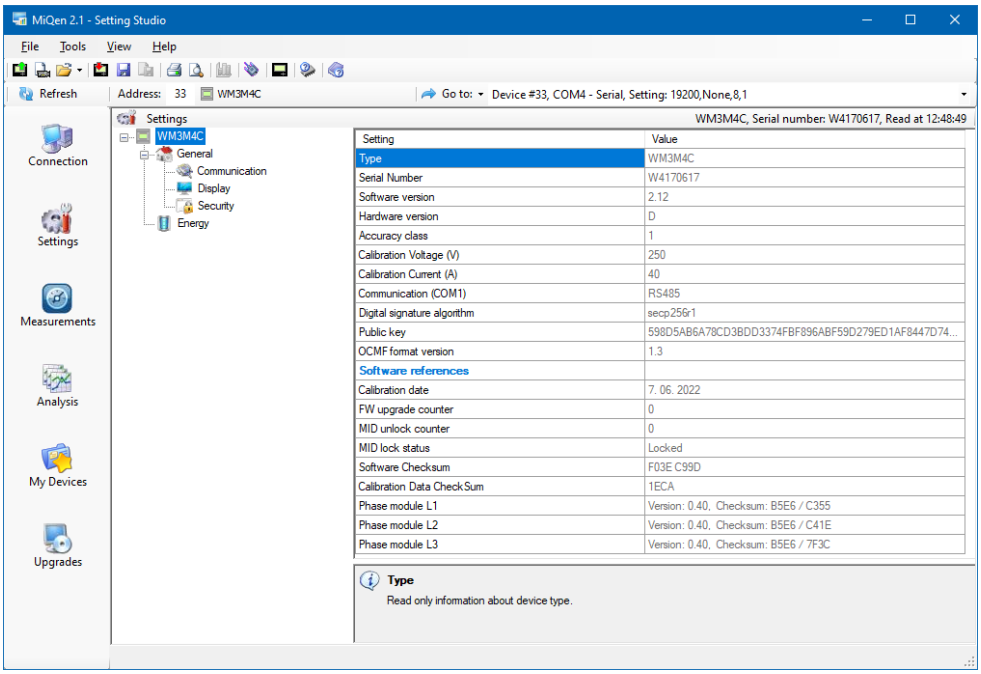


Figure 18: *WM3M4C Identification window*

- **Type.**
- **Serial number.**
- **Software version.**
- **Hardware version.**
- **Accuracy class.**
- **Calibration voltage.**
- **Calibration current.**
- **Communication.**
- **Digital signature algorithm** (supported only for WM3M4C).
- **Public key:** for further description see chapter *6.3.1. Generation of private/public key pair on page 37* (valid only for WM3M4C).
- **OCMF format version** (*valid only for WM3M4C*)**.**

Software references:

- **Calibration date.**
- **FW upgrade counter – applicable only up to version 2.03.**
- **MID unlock counter– applicable only up to version 2.03.**
- **MID lock status.**
- **Software Checksum – Main FW .**
- **Calibration Data Checksum –** CRC of calibration parameters.
- **Phase module L1** – version of FW, CRC of FW and CRC of calibration parameters.
- **Phase module L2** – version of FW, CRC of FW and CRC of calibration parameters.
- **Phase module L3** – version of FW, CRC of FW and CRC of calibration parameters.

4.4.1 General settings

General settings set communication, display and security settings (passwords).

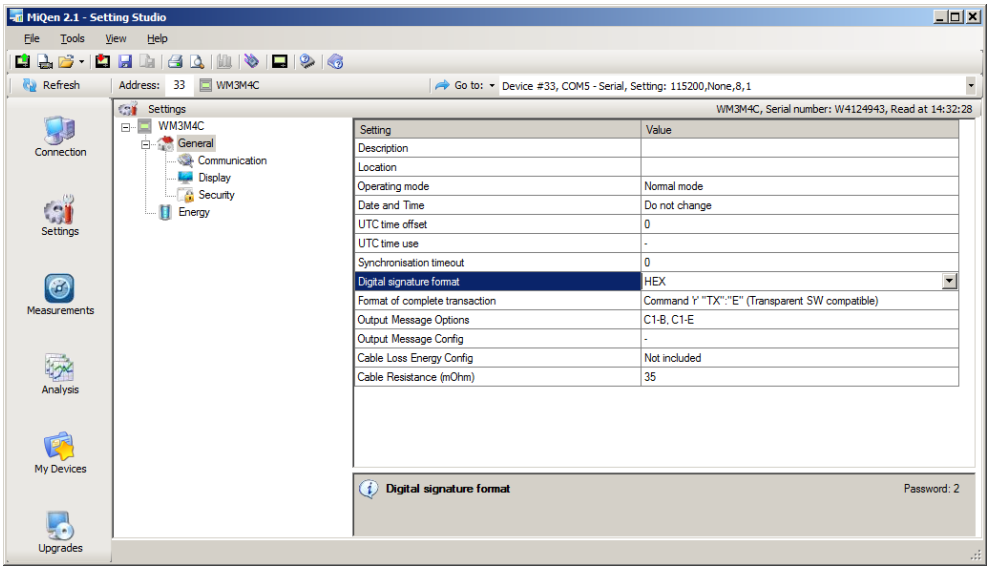


Figure 19: *General settings window*

- **The description and location** segment is intended for easier recognition of a certain unit. They are specially used for identification of the device or location on which measurements are performed.
- **Operating mode**: the test mode is used for meter testing and is designed to increase resolution of the energy counter and reduce the time required for testing.

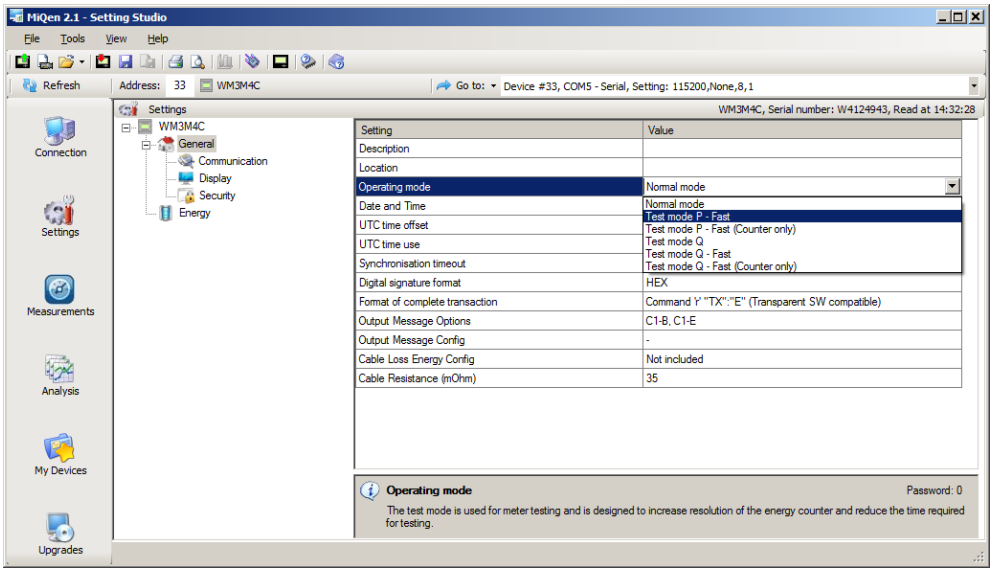


Figure 20: *Operating mode window*

- **Date and time**: date and time used only for time synchronisation.
- **UTC time offset**: it is the difference in hours and minutes from Coordinated Universal Time (UTC) for a particular place and date.

- **UTC time use:** Energy meter has three time presentations: RS485 communication (MODBUS registers type T_unix), LCD display, JSON transaction.

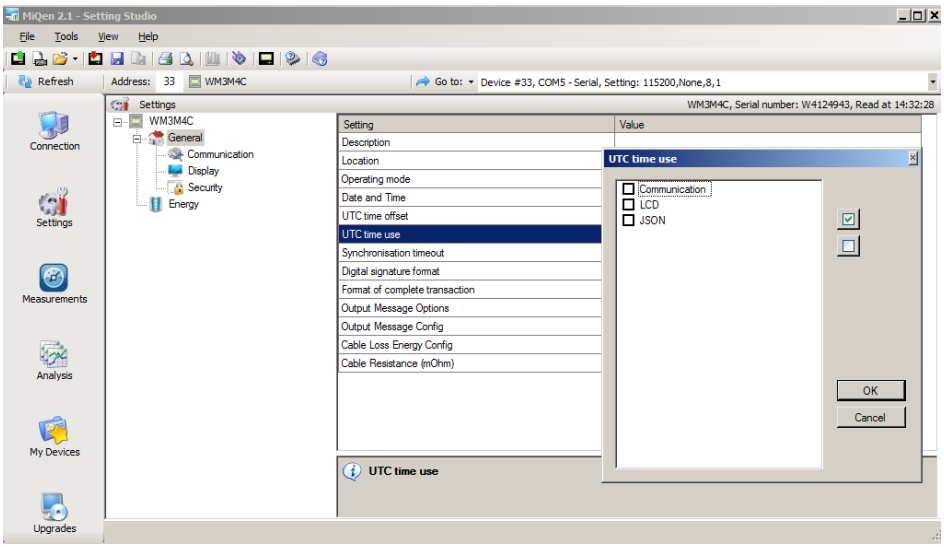


Figure 21: *UTC time use*

- **Synchronisation timeout**: clock status changes to “Unsynchronized “ after timeout (in minutes).
- **Digital signature format**: the energy meter supports ASN.1 HEX and Base 64 signature format (valid only for WM3M4C).

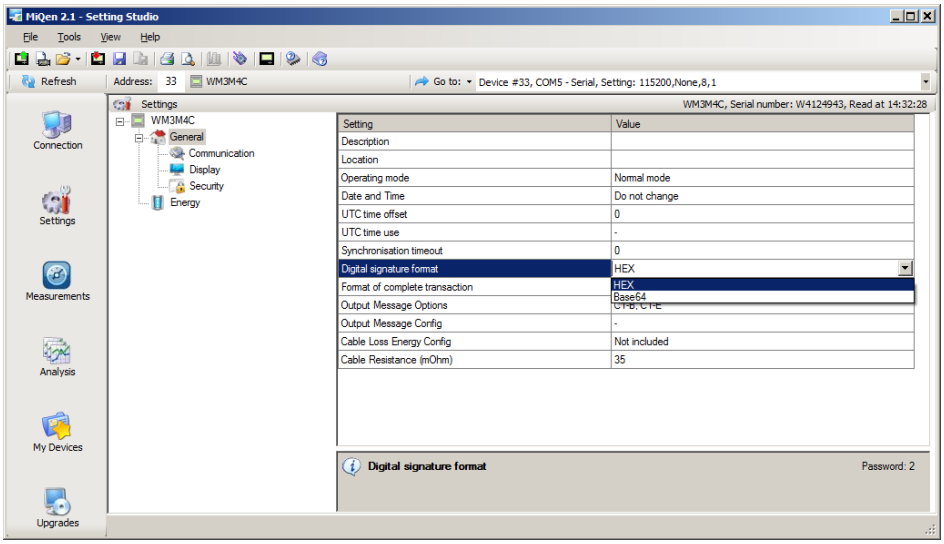


Figure 22: *Digital signature format window*

4.4.1.1 Communication

The communication segment is intended for setting the serial communication parameters (RS485).

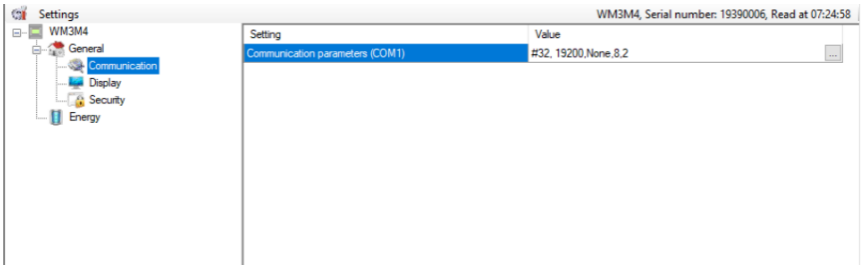


Figure 23: *Display of device's communication settings in the MiQen software*

4.4.1.2 Display

- **Backlight:** is possible to turn on/off via serial communication.

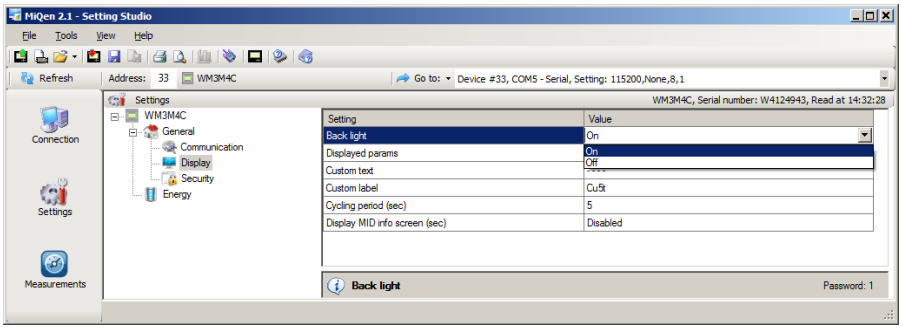


Figure 24: *Backlight window*

- **Display params** set the parameters displayed on the LCD.

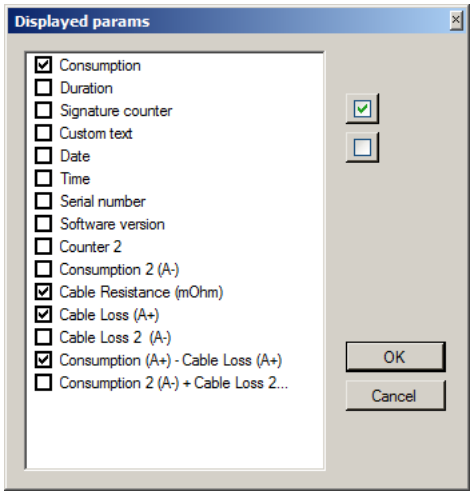


Figure 25: *Display params window*

- **Custom text** (Table 3 – for list of available characters see chapter 3.3.3).
- **Custom label (**Table 3: LCD Custom string**).**
- **Cycling period** defines the cycling period for measurements on LCD display, valid values from 5 s to 60 s.
- **Display FW identification:** displays FW identification screen on LCD for a chosen period of time up to 60 seconds (see chapter *Welcome screens and item 6.5.16*).

4.4.1.3 Security

A password consists of four letters taken from the British alphabet from A to Z. When setting a password, only the letter being set is visible while the others are covered with●.

Settings parameters are divided into three groups regarding security level: PL1 >password level 1, PL2 >password level 2 and BP >a backup password.

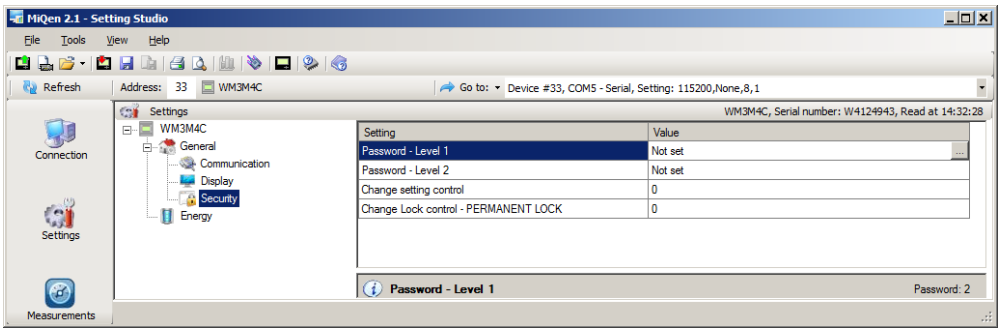


Figure 26: *Security window*

PLEASE NOTE

A serial number of the device is stated on the label and is also accessible with MiQen software.

Password-Level 1 >PL1

There are no settings in these meters protected by Password-level 1.

Password-Level 2 >PL2

With level 2 password you can change all supported settings. The settings cannot be saved in the settings file.

A Backup Password->BP

A backup password >BP) is used if passwords at levels 1 >PL1) and 2 >PL2) have been forgotten, and it is different for each device >depending on a serial number of the device). The BP password is available in the user support department in ISKRA d.o.o., and is entered instead of the password PL1 or/and PL2. Do not forget to state the device serial number when contacting the personnel in ISKRA d.o.o.

Password modification

A password is optionally modified; however, only that password can be modified to which the access is unlocked at the moment.

Password disabling

A password is disabled by setting the "AAAA" password.

PLEASE NOTE

A factory set password is "AAAA" at both access levels >PL1 and PL2. This password does not limit access.

4.4.2 Energy

4.4.2.1 Counters

The WM3M4 & WM3M4C energy meters have four nonresettable counters for which MID approval is valid. The setting of these counters is fixed in the production and the setting parameters cannot be modified during use and counters cannot be reset.

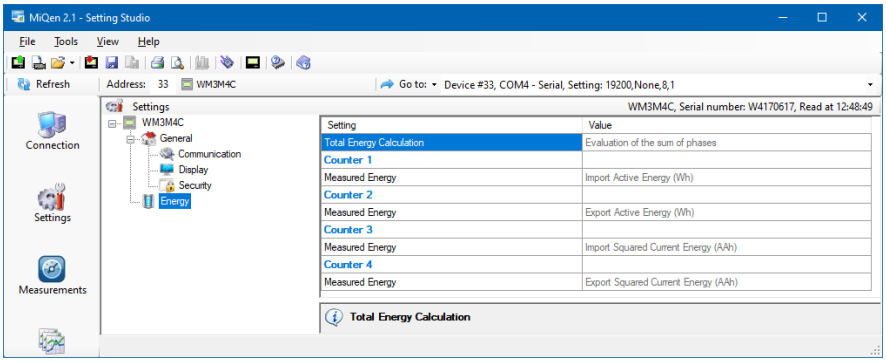


Figure 27: *MiQen energy counters*

Counter 1 displays imported active energy.

Counter 2 displays exported active energy.

Counter 3 displays imported squared current accumulation (for calculation of cable loss).

Counter 4 displays exported squared current accumulation (for calculation of cable loss).

4.5 Measurements

Measurements can be seen ONLINE when a device is connected to power supply and is communicating with MiQen. When a device is not connected it is possible to see OFFLINE measurements simulation. The latter is useful for presentations and visualization of measurements without the presence of an actual device.

In ONLINE mode all supported measurements and alarms can be seen in real-time in a tabular (Table view) or graphical form (Graphic view). All data can be exported to an Access database, Excel worksheets or as a text file.

Measurements window can be selected by clicking this tab: Charge control | Measurements

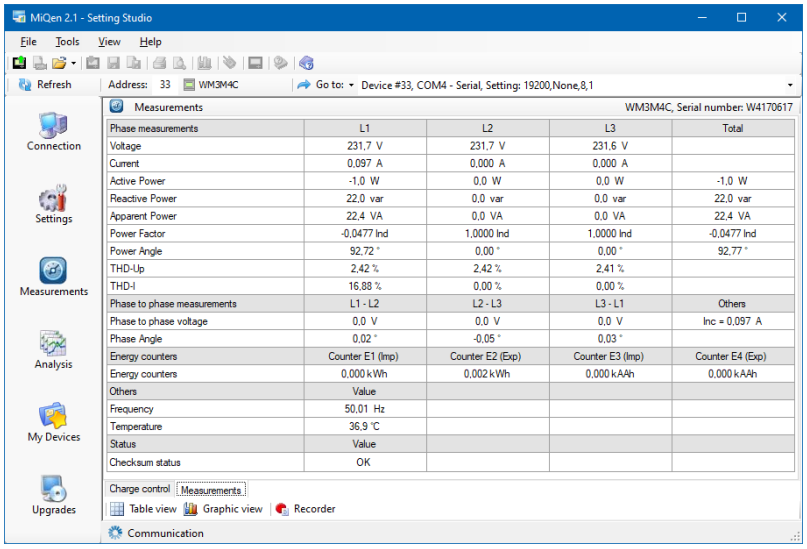


Figure 28: *Measurements window*

Charge control window can be selected by clicking this tab: Charge control | Measurements

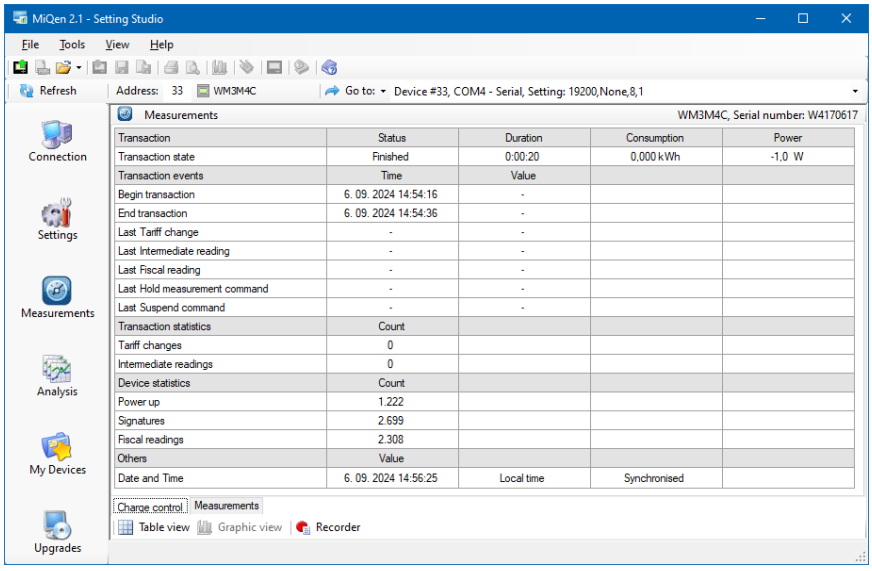


Figure 29: *Charge control window*

For further processing of the results of measurements, it is possible to set a recorder (Recorder button) on the active device that will record and save selected measurements to MS Excel .csv file format.

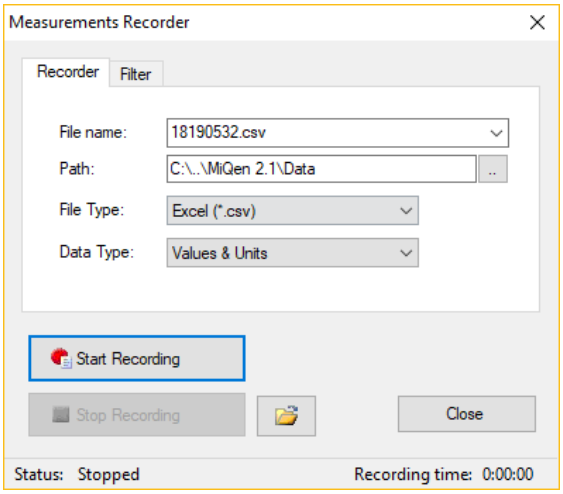


Figure 30: *Measurements Recorder*

5 MEASUREMENTS

The WM3M4 & WM3M4C energy meters ensure active energy measurement and actual measurements of other parameters of three phase network. *The meters* perform measurements with a constant sampling frequency of 3906.25 Hz.

5.1 Online measurements

Online measurements are available on display or can be monitored with setting and monitoring software MiQen.

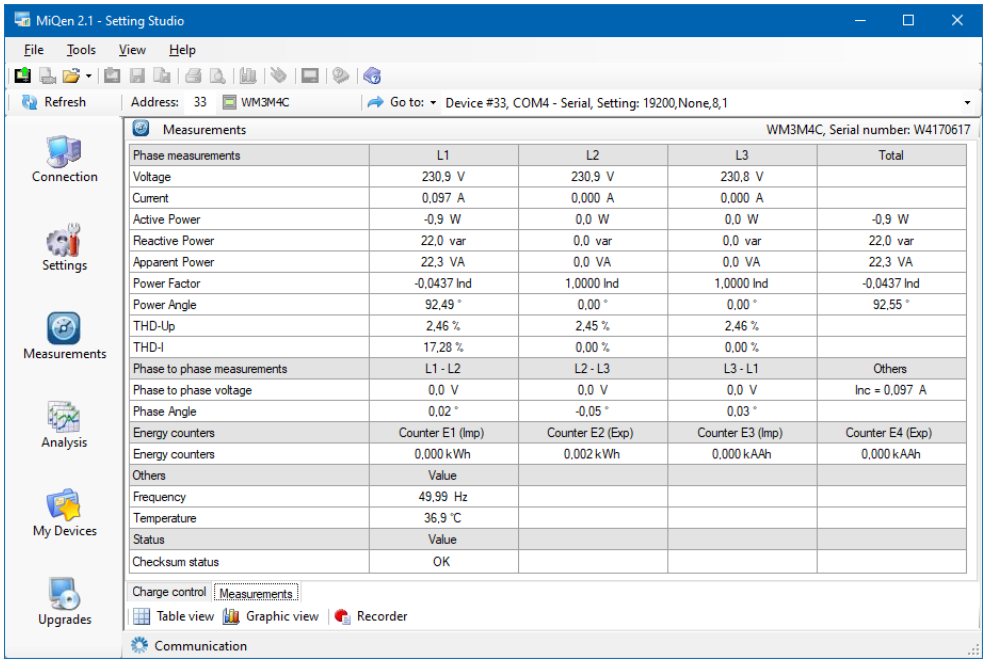


***Figure 31**: Online measurements window.*

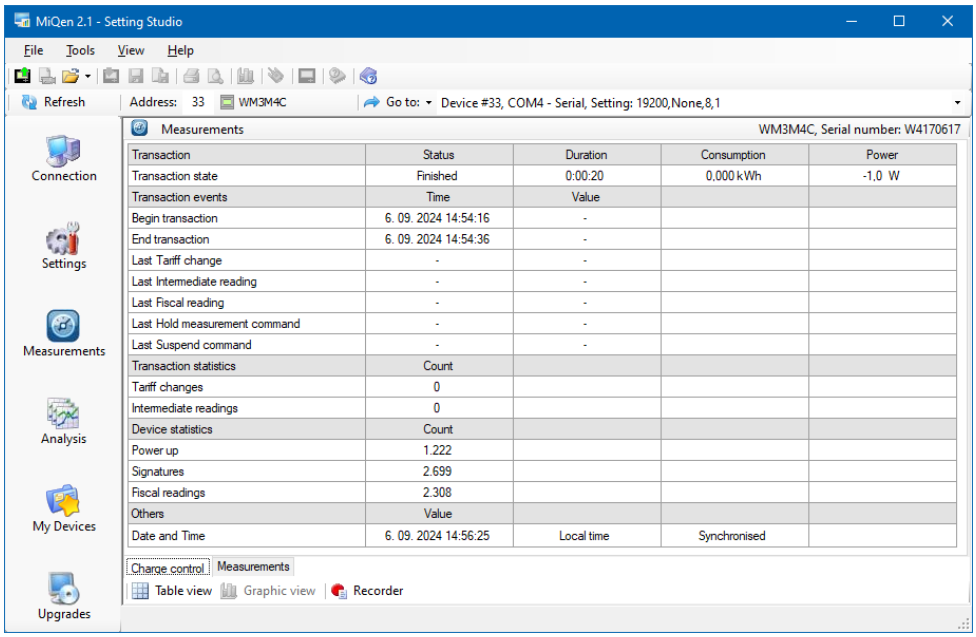


***Figure 32**: Charge control window.*

5.2 Selection of available quantities

Microprocessor calculates the TRMS voltage, TRMS current, active, reactive and apparent power, U-I phase angle, first harmonic of voltage, first harmonic of current, peak to peak voltage, THD of voltage and THD of current. Complete selection of available online measuring quantities is shown in a table below.

Meas. type	Measurement	Single-phase	3-phase	comments
Phase measurements	Voltage			
	U_{1-3}	☑	☑	
	Current			
	I_{1-3}	☑	☑	
	I_{NC}		☑	Calculated neutral current
	Power			
	P_{1-3}	☑	☑	
	P_{TOT}	☑	☑	
	Q_{1-3}	☑	☑📖	
	Q_{TOT}	☑	☑	
	S_{1-3}	☑	☑	
	S_{TOT}	☑	☑	
	PF_{1-3}	☑	☑	
	PF_{TOT}	☑	☑	
	φ_{1-3}	☑	☑	
	φ_{TOT}	☑	☑	
	Harmonic analysis			
	$THD\text{-}U_{1-3}$	☑	☑	
	$THD\text{-}I_{1-3}$	☑	☑	
Phase to phase measurements	Voltage			
	Upp_{1-3}		☑	
	φ_{x-y}		☑	Phase-to-phase angle
Metering	Energy		☑	
	Counter E_1	☑	☑	
Other measurements	Miscellaneous			
	Frequency	☑	☑	
	Temperature	☑	☑	
Status	Checksum status	☑	☑	

📖 Further description is available in following subchapters

Table 8: Selection of available measurement quantities

5.3 Calculation and display of measurements

This chapter deals with capture, calculation and display of all supported measurement quantities. The LCD display shows the values of the counters Modbus registers.

5.3.1 Voltage

Voltage related measurements are listed below:

- Real effective (TRMS) value of all phase voltages (U_1, U_2, U_3) and phase-to-phase voltages (U_{12}, U_{23}, U_{31}).
- Phase and phase-to-phase voltage angles (φ_{12}, φ_{23}, φ_{31}).

$$U_f = \sqrt{\frac{\sum_{n=1}^{N} u_n^2}{N}}$$

$$U_{xy} = \sqrt{\frac{\sum_{n=1}^{N} \left(u_{xn} - u_{yn}\right)^2}{N}}$$

***Figure 33**: Voltage equations*

All voltage measurements are available through communication.

5.3.2 Current

WM3M4 & WM3M4C energy meter measures:

- real effective (TRMS) value of phase currents

$$I_{RMS} = \sqrt{\frac{\sum_{n=1}^{N} i_n^2}{N}}$$

***Figure 33**: Current equation*

All current measurements are available on communication.

5.3.3 Active, reactive and apparent power

Active power is calculated from instantaneous phase voltages and currents. All measurements are seen on communication. Reactive power is calculated with the method of 90 degrees displacement of current samples.

5.3.4 Power factor (PF) and power angle

PF or distortion power factor is calculated as the quotient of active and apparent power for each phase separately and total power angle. It is called distortion power factor since true (distorted) signals are using in equation. A symbol for a coil (positive sign) represents inductive load and a symbol for a capacitor (negative sign) represents capacitive load.

5.3.5 Frequency

Network frequency is calculated from time periods of measured voltage. Instrument uses synchronization method, which is highly immune to harmonic disturbances.

5.3.6 Energy counters

Energy counters are displayed on LCD and in data signature with resolution 10 Wh. In the MODBUS registers the resolution of energy counters and consumption of charging process is increased to 1 Wh.

5.3.7 Harmonic distortion

The *WM3M4 & WM3M4C energy meters* calculate THD for phase currents and phase voltages and are expressed as percent of high harmonic components regarding to fundamental harmonic.

5.3.8 Cable losses

Losses in cables are calculated according to the equation:

$$E_{LOSS} = \mathrm{R} \sum_{x=1}^{4} {I_x}^2 dt$$

***Figure 34**: Cable losses equation*

I_x current in individual cable
R cable resistance
dt time period of calculation

Counters 3 and 4 are added to the instrument (counter 3 for import and counter 4 for export), which time integrate the sum of squared phase currents and the squared zero current. Zero current is calculated as vector sum of phase currents.

Cable resistance R is entered as a parameter in MODBUS register 47080 in hundredths mOhm (mV/A) from 0.00mOhm up to 650.00mOhm. The resistances of all phase conductors and the neutral conductor must be equal.

Counter 3 is active when the total real power is positive (import A+). Counter 4 is active when the total real power is negative (export A-).

Cable losses during charging are calculated as the difference between AAh counter values at the end and start of charging multiplied by the resistance R.
At the start of charging, the set value from the MODBUS register 47080 is transferred into the MODBUS register 46999 (Cable Resistance during Charging), which is stored into the permanent memory (EEPROM) together with the time of the start of charging and the values of the energy counters at the start of charging. All calculations take into account the saved cable resistance value R from MODBUS register 46999. Writing into the MODBUS register 46999 is not possible.

5.3.8.1 Example of cable losses calculation (3 phase load)

A symmetrical load I_L=10A is assumed. In the case of a symmetrical load, no current flows through the neutral conductor (I_{nc}=0A). Resistance of cable conductors R=35mOhm, charging time dt=1 hour.

E_{LOSS} = 0.035 * 3*10*10*1 Wh = 10.5 Wh

5.3.8.2 Example of cable losses calculation (1 phase load)

A load I=16A is assumed. In the case of a single-phase load, the current of the neutral conductor is equal to that of the phase conductor (I_{nc}=16A). Resistance of cable conductors R=35mOhm, charging time dt=1 hour.

E_{LOSS} = 0.035 * 2*16*16*1 Wh = 17.92 Wh

6 DIGITAL SIGNATURE (VALID ONLY FOR WM3M4C)

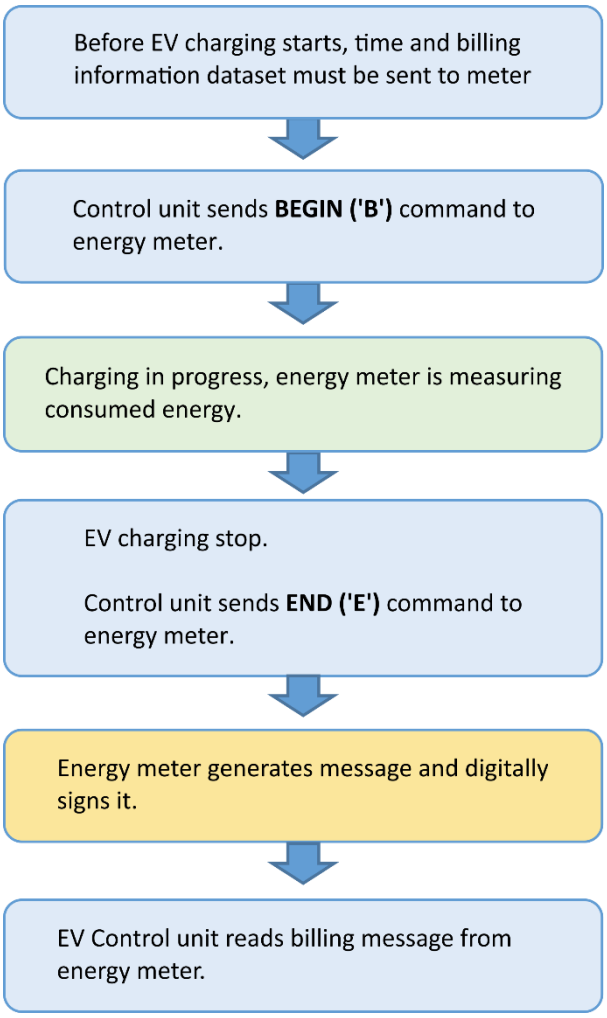
The WM3M4C energy meters support digital signature. In this chapter, you will find:

6.1 Introduction

Energy meter supports digital signing of billing information to ensure integrity of data for end customer. All digital signing procedures are HW based with dedicated crypto chip, which supports ECDSA FIPS186-3 Elliptic Curve Digital Signature. Energy meter supports MODBUS over RS485 for communication with EV control unit.

6.2 Digital signing procedure

EV charger control unit is responsible to send start and stop command to energy meter. Energy meter measures consumed energy during charging. When charging is finished, EV control unit provides billing dataset (customer info, time, etc.) to energy meter via MODBUS communication. Energy meter adds measured energy and generates final billing message with digital signature. EV charger control unit then reads complete billing information with measured energy consumption and digital signature.



6.3 Energy meter cryptographic functions explanation

Energy meter has HW based cryptographic unit for digital signing of billing dataset.

6.3.1 Generation of private/public key par

This is one-time procedure made at production of energy meter. Generation of key pair is HW based with dedicated crypto chip. Private key is stored internally within the crypto chip and there is no way of reading it.

6.3.2 Public Key as Data Matrix-code on front of enclosure and readable via MODBUS

Public key is available to end user for verification of digital signature. Therefore, public key is readable through MODBUS communication and printed with Data Matrix code on front of the meter.

6.3.3 Generation of billing dataset using internal energy meter value

Energy meter has MODBUS registers to store users billing dataset. Main EV charger SW must write billing dataset to energy meter. Energy meter will fill in measured energy and timestamp to complete billing information. Billing dataset is compatible with OCMF 1.0.

6.3.4 Generation of hash (SHA256) for billing dataset

After completing billing dataset, meter calculates hash of complete message with SHA-256 algorithm documented in the following site: http://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.180-4.pdf. Hash is 32 bytes long identification of message and is used as an input for signature generation.

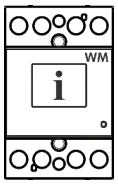
6.3.5 Generation of signature for billing dataset

Signing of previously prepared hash is cryptographic procedure with ECDSA NIST P256 prime curve. Crypto chip generates signature in less than a second. Algorithm is documented in:

FIPS 186-4 specification http://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.186-4.pdf

6.3.6 Exporting billing dataset including signature

Complete billing dataset and digital signature are available for readout via MODBUS communication.



PLEASE NOTE

Dataset and corresponding signature are available in more then 120 registers and they can not be read with single MODBUS command. Both should be read in sequence and stored together before new transaction command is executed.

6.4 Consumption measuring and digital signing procedure

EV charger control unit must use following procedure to measure charging consumption and sign billing dataset:

1. Set time, time zone, signature format.
2. Enter billing dataset.
3. Enter dataset size.
4. Send Begin command.
5. Send intermediate reading commands (optional).
6. Send fiscal reading (optional).
7. Send tariff change command (optional).
8. Send End command (triggers signing process).
9. Check signature status register until signature is ready.
10. Read Output message length.
11. Read Output message.
12. Read signature length.
13. Read signature.
14. Read public key.

6.5 Crypto Register Definitions

6.5.1 Operator Command Register

40012		Operator Command Register	T1	1	Save Settings
				2	Abort Settings

Table 9 *Operator Command Register*

Operator Command 1 (Save Settings) must be used to store all settings changes into the permanent memory (EEPROM).
Operator Command 2 (Abort Settings) can be used to restore all settings from the permanent memory (EEPROM) as at power up.

If the "save setting" command is not sent at the end of changing settings, the changes are not written into the EEPROM.

6.5.2 Communication parameter

MODBUS register	Description	Format	Value	
40203	Baud Rate	T1	0	Baud rate 1200
			1	Baud rate 2400
			2	Baud rate 4800
			3	Baud rate 9600
			4	Baud rate 19200
			5	Baud rate 38400
			6	Baud rate 57600
			7	Baud rate 115200
40204	Stop Bit	T1	0	1 Stop bit
			1	2 Stop bits
40205	Parity	T1	0	No parity
			1	Odd parity
			2	Even parity
40206	Data Bits	T1	0	8 bits

Table 10: *RS485 communication parameters table*

Default settings:

Baud rate: 115200
Parity: None
Stop bits: 1

6.5.3 Cryptographic control registers

MODBUS Address	Size in bytes	Access Type	Description
47051	2	R/W	Command Register (see ***Table 15***)
47052	2	R	Signature Status Register (see ***Table 12***)
47053	2	R/W	Time zone Offset
47054 - 47055	4	R/W	Date and Time Synchronization
47056	2	R	Input Message Length
47057	2	R	Output Message Length
47058	2	R	Signature Length
47059	2	R/W	Signature Format (see ***Table* 14**)
47060	2	R	Signature Algorithm
47061	2	R/W	LCD Backlight
47062	2	R/W	LCD Display 2nd Row Mode (see ***Table 1***)
47063 - 47066	8	R/W	LCD Display Custom String
47067 - 47068	4	R/W	LCD Display Custom String Label
47069	2	R	OCMF format version (upper 8 bits Major, lower 8 bits Minor, currently 1.0)
47070	2	W	Consumption and duration Reset register. Control unit can reset last charging values by setting BIT 0.
47071	2	R/W	Clock synchronization status (see ***Table 5***)
47072	2	R/W	Clock synchronization timeout
47073	2	R/W	UTC / local time format
47074	2	W	Time adjustment (-3 seconds to +3 seconds)
47075	2	W	FW identification screen on LCD
47076	2	R/W	End transaction specification in data set (format of complete transaction)

***Table 11**: Cryptographic control registers*

6.5.4 Signature status register (47052)

Value	Description
0	Not initialised
1	Idle
2	Signature in progress
15	Signature OK
128	Invalid date time
129	CheckSum error
130	Invalid command
131	Invalid state
132	Invalid measurement
133	Test mode error
243	Verify state error
244	Signature state error
245	Keypair generation Error
246	SHA failed
247	Init failed
248	Data not locked
249	Config not locked
250	Verify error
251	Public key error
252	Invalid message format
253	Invalid message size
254	Signature error
255	Undefined error

***Table 12**: Signature status register*

6.5.5 Setting time related registers

Control unit can set time, time sync status, time sync status timeout, UTC offset and UTC / local time presentation.

Time changing is not possible during charging!

One time adjustment (+-3 seconds) is permitted during charging.

6.5.5.1 Setting time

Write unix timestamp to MODBUS registers 47054 - 47055.

47054 : high 16 bits

47055 : low 16 bits

If BIT 0 is set in register 47073 (UTC / local time setting), UTC time must be written. If BIT 0 is not set, the local time must be written.

Example:

Unix time: 1570096309 hex:0x5D95C4B5

Write 0x5D95 to 47054

Write 0x C4B5 to 47055

The best practice is to set time at start of every charging procedure.

6.5.5.2 Time status

Control unit must also set the status of clock in register 47071. Statuses are defined in ***Table 5***.

6.5.5.3 Time status timeout

Clock status changes to Unsynchronized after timeout (in minutes), which is set in register 47072.

6.5.5.4 Time zone

Write offset (in minutes) from UTC time to 47053.

Warning:

Energy meter does not support DST, so the current offset from UTC must be written.

Example:

Slovenia is UTC + 1:00, but in summer time write 120 to 47053.

6.5.5.5 UTC / local time presentation

Time representation on LCD and in signature (JSON) can be displayed differently with UTC/local time setting.

For example, time is set in UTC format, but you want to have local time on LCD and in signature. Then UTC/local time setting should be set to 0x1 (BIT 0). It means that time on communication is in UTC format and time on LCD and JSON is in local time.

Energy meter has 3 time presentations:

1. RS485 communication (MODBUS registers type T_unix)
2. LCD display
3. Timestamp in JSON transaction

Every one of them can be set to UTC or local time. Default state for all is local time.

Register 47073 UTC / local time setting (0 = local time, 1 = UTC)

BIT 2	BIT 1	BIT 0
JSON	LCD	RS485

***Table 13**: UTC / local time register*

If BIT 0 is set, UTC time must be written to MODBUS registers 47054 - 47055. If BIT 0 is not set, local time must be written.

6.5.5.6 Time adjusting

Fine time adjusting is a way to compensate clock drift during charging. Up to +- 3 seconds adjusting is permitted in register 47074.

6.5.6 Cable losses

Losses in cables are calculated according to the equation:

$$E_{LOSS} = \mathrm{R} \sum_{x=1}^{4} {I_x}^2 dt$$

***Figure 35**: Cable losses equation*

I_x current in individual cable
R cable resistance
dt time period of calculation

Two counters are added to the instrument (counter 3 for import and counter 4 for export), which time integrate the sum of squared phase currents and the squared zero current. Zero current is calculated as vector sum of phase currents. Cable resistance R is entered as a parameter in MODBUS register 47080 in hundredths mOhm (mV/A) from 0.00mOhm up to 650.00mOhm. Changing the register 47080 is allowed only if „Change Lock control“ is not locked! Changing the register 47080 is not possible during charging. To save the changed value into the permanent memory (EPROM), the "Save Settings" command is also required (writing value 1 into the MODBUS register 40012).

The resistances of all phase conductors and the neutral conductor must be equal. Counter 3 is active when the total real power is positive (import A+). Counter 4 is active when the total real power is negative (export A-).

Cable losses during charging are calculated as the difference between AAh counter values at the end and start of charging multiplied by the resistance R.
At the start of charging, the set value from the MODBUS register 47080 is transferred into the MODBUS register 46999 (Cable Resistance during Charging), which is stored into the permanent memory (EEPROM) together with the time of the start of charging and the values of the energy counters at the start of charging. All calculations take into account the saved cable resistance value R from MODBUS register 46999. Writing into the MODBUS register 46999 is not possible.

Cable losses and resistance R data used to calculate the losses can be added to the signed billing dataset, depending on the settings in registers 47077 and 47078.
The resistance R is given in mOhm.

The "RV" values of the MID energy counters in the signed billing dataset can remain unchanged (Reg. 47079 = 0).

Using the setting register 47079, the "RV" values can be modified according to the cable losses:
1. The energy of the cable losses is added to the "RV" value at the start of the charge, the "XV" consumption value is calculated from the difference of the modified "RV" values
2. The energy of the cable losses is subtracted from the "RV" value at the end of the charge, the "XV" consumption value is calculated from the difference of the modified 'RV' values

For the exported energy (energy counter 2 for A-), the cable losses are taken into account with the opposite sign:
1. The energy of the cable losses is subtracted from the "RV" value at the end of the charge,, the 'XV' value of the consumption is calculated from the difference of the modified "RV" values
2. The energy of the cable losses is added to the "RV" value at the start of the charge, the 'XV' consumption value is calculated from the difference of the modified 'RV' values

All settings MODBUS registers are valid and operational as soon as they are written. To store them into the permanent memory (EPROM), the "Save Settings" command is required (writing value 1 into the MODBUS register 40012).
Setting parameters cannot be changed by themselves.

Changing the registers 47079 and 47080 is allowed only if „Change Lock control“ is not locked!
The entry of an unchanged value in register 47080 (Cable Resistance) and 47079 (Cable Loss Energy Config) is allowed without restrictions.
During charging (from command “B” to one of the commands to end charging) changing register 47080 (Cable Resistance) and 47079 (Cable Loss Energy Config) is not possible.

6.5.6.1 *Change Lock control*

The MODBUS register for „Change Lock control“:

47097		Change Lock control	T1	0	not set (LCD warning)	0	1	0	R/W*
				1	Permanent Locked (if set 1, can not be changed)				

0. not set – the default value. In this case the warning „not set“ is shown on the second line of the LCD every 3 seconds and the error flag „E“ is included in the „EF“ field of the signed billing dataset

Figure 36: *Warning display*

1. Permanent Locked. **When „Change Lock control“ is set to 1, it cannot be changed anymore!** The changes of registers 47062, 47076, 47077, 47078, 47079, 47080, 47097 and 47099 is not possible. **Before „Change Lock control“ is set to 1, it is recommended to check the values in all registers, which will no longer be possible to change after "Permanent Locked".**

The changed value, entered in register 47097 (Change Lock control) is immediately stored in the permanent memory (EEPROM). Also, the registers 47079, 47080 and 47099 are stored in the permanent memory (EEPROM). **The other registers are NOT immediately stored in the permanent memory.** To store them into the permanent memory (EPROM), the **"Save Settings" command is required** (writing value 1 into the MODBUS register 40012).
The entry of an unchanged value in register 47097 (Change Lock control) is allowed without restrictions. During charging (from command “B” to one of the commands to end charging) changing register 47097 (Change Lock control) is not possible.
The MODBUS register for special password:

3,6,16	47098		Change setting control	T1	12345	Enable changes for 60s		0	RW

For a special password (condition for entering a change of register 47097 (Change Lock control)), it is necessary to enter the value 12345 in the MODBUS register 47098 (Change setting control). Reading from register 47098 returns the time in seconds until the end of the write change permission. The read value 0 from the register 47098 means that the entry of changes is not allowed.
Entering a special password in the MiQen program:

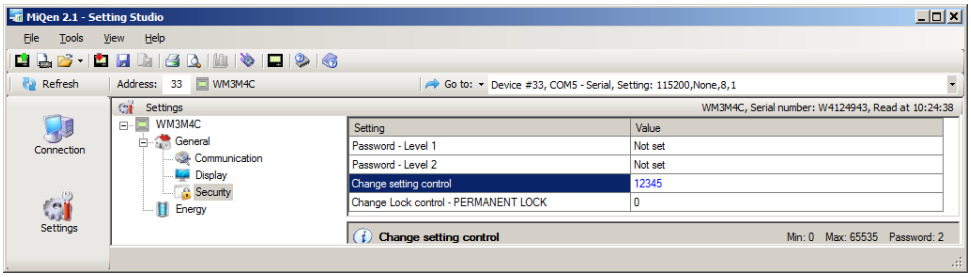


Figure 37: *Security window*

6.5.6.2 Measurements of the cable losses

Registers for additional measurements of the cable losses:

46979	46980	Start Counter 4 Squared Current (A-)	T3u		Squared Current (AAh)
46981	46982	Stop Counter 4 Squared Current (A-)	T3u		Squared Current (AAh)
46983	46984	Consumption 4 Squared Current (A-)	T3u		Squared Current (AAh)
46985	46986	Cable Loss (A-)	T3u		Wh
46987	46988	Consumption (A-) + Cable Loss	T3u		Wh
46989	46990	Start Counter 3 Squared Current (A+)	T3u		Squared Current (AAh)
46991	46992	Stop Counter 3 Squared Current (A+)	T3u		Squared Current (AAh)
46993	46994	Consumption 3 Squared Current (A+)	T3u		Squared Current (AAh)
46995	46996	Cable Loss (A+)	T3u		Wh
46997	46998	Consumption (A+) - Cable Loss	T3u		Wh
46999		Cable Resistance during Charging	T16		mOhm

Register 46999 contains the set value of the cable resistance during the last (current) charge. At the start of the charge, the value is transferred from the setup register 47080. It remains unchanged until the next start of charging.
Writing into the measurements MODBUS registers 46979 to 49999 is not possible.

6.5.6.3 Dataset example

An example of input billing dataset:

{"FV":"1.0","GI":"Gateway1","GS":"123456789","GV":"1.0","PG":"","MV":"","MM":"","MS":"","MF":"","IS":true,"IL": "VERIFIED","IF":[],"IT":"NONE","ID":"","CT":"EVSEID","CI":"Charge-Box-ID","TT": "Tarif 1","LC": {"LN": "cable_name","LI": 1,"LR": ,"LU": ""},"RD":[]}

{
"FV":"1.0",
"GI":"Gateway1",
"GS":"123456789",
"GV":"1.0",
"PG":"",
"MV":"",
"MM":"",
"MS":"",
"MF":"",
"IS":true,
"IL": "VERIFIED",
"IF":[],
"IT":"NONE",
"ID":"",
"CT":"EVSEID",
"CI":"Charge-Box-ID",
"TT": "Tarif 1",
"LC": {
"LN": "cable_name",
"LI": 1,
"LR": ,
"LU": ""
},
"RD":[]
}

An example of a signed billing dataset (data added by the instrument is colored):


```
{
"FV": "1.0"
"GI": "Gateway1"
"GS": "123456789"
"GV": "1.0"
"PG": "T28"
"MV": "Iskra"
"MM": "WM3M4C"
"MS": "W4124943"
"MF": "2.11"
"IS": true
"IL": "VERIFIED"
"IF": []
"IT": "NONE"
"ID": ""
"CT": "EVSEID"
"CI": "Charge-Box-ID"
"TT": "Tarif 1"
"LC": {
  "LN": "cable_name",
  "LI": 1,
  "LR": 35.0,
  "LU": "mOhm"
}
"RD": [
  {
    "TM": "2024-02-19T11:59:32,000+0000 S",
    "TX": "B",
    "RV": 234.56,
    "RI": "1-b:1.8.0",
    "RU": "kWh",
    "RT": "AC",
    "EF": "",
    "ST": "G"
  },
  {
    "TM": "2024-02-19T12:02:51,000+0000 S",
    "TX": "E",
    "RV": 234.56,
    "CL": 0.0,
    "RI": "1-b:1.8.0*255",
    "RU": "kWh",
    "RT": "AC",
    "EF": "",
    "ST": "G"
  }
]
}
```


The version 2.11 adds blue colored data.

6.5.7 Signature format

Energy meter supports hex (ASN.1) and Base 64 signature format in register 48188. Format can be set in register 47059:

Value	Signature format
0	HEX (ASN.1)
1	Base64

Table 14: *Signature format*

6.5.8 Signature algorithm

Energy meter currently supports only ECDSA-secp256r1-SHA256 algorithm. This parameter is not settable using MODBUS communication. It is a constant depending on the type of instrument (with or without crypto function). It is used only as information if the crypto function is implemented.

Register 47060:

Value	Signature format
0	Without signature
4	ECDSA-secp256r1-SHA256

Table 15*: Signature algorithm*

6.5.9 Entering billing dataset

Dataset register is at MODBUS address 47100. Only 120 MODBUS registers (240 bytes) can be entered in one write command. Maximum size of billing dataset is 1024 bytes. Format is defined in ***Dataset format*** *paragraph*.

Example:

If 300 bytes need to be written:

- write 120 MODBUS registers to MODBUS address 47100
- write 30 registers to MODBUS address 47220 (47100 + 120).

After writing dataset, length (in bytes) must be written to MODBUS address 47056.

6.5.10 Transaction commands

Command register for transactions is at MODBUS address 47051. High 8 bits is command, lower 8 bits are reserved.

It is very important to check measurement status register (47000) before sending command, because energy meter accepts only commands which are valid for current state.

Time, input message and input message length must be set before sending command.

After sending command, check result of operation in control status register (47052).

Register 47051

Value	Command	Valid charging states (47000)
'B' (0x42)	Begin transaction	Idle state (0)
'E' (0x45) 'L' (0x4C) 'R' (0x52) 'A' (0x41) 'P' (0x50)	End transaction	Active state
'C' (0x43)	Intermediate Reading	Active state
'X' (0x58)	Exception	Active state
'T' (0x54)	Tariff Change	Active state
'S' (0x53)	Suspended command	Active state
'r' (0x72)	End transaction (with begin and end)	Active state
'f' (0x66)	Fiscal Reading	Any state
'h' (0x68)	Hold command	Active state
'i' (0x69)	Last charge reading (with begin and end)	Idle state

***Table 16**: Transaction commands*

Signature process starts after every command. Control unit can read out signed dataset with current time and energy meter value reading.

Meter stores one value (timestamp and counter value) for each command. Registers are defined in measurements table (Table 16).

If 'r' command is sent, array with begin and end reading is generated and signed.

Hold command is used for read and sign later procedure. Every energy value reading is stored by default. When 'h' command is sent, stored value is used for next signature instead of actual energy counter value.

If 'i' command is sent, array with begin and end reading of the last charge is generated and signed (added in the SW version 2.08).

6.5.11 Signature status

Control unit must check signature status before reading signed dataset and signature. Signing process takes up to 1 second, so control unit must check status few times with some delay.

MODBUS register address is 47052. Signature OK value is 15.

6.5.12 Output billing dataset

Signature process modifies original billing dataset, which was entered at start of measuring. Output billing dataset contains meter information (meter vendor, meter model, meter serial number and firmware version), measured value and unique pagination value (PG). Output billing dataset is available until next signature request or power down.

JSON and binary output are supported.

Only 120 MODBUS registers (240 bytes) can be read in one MODBUS read command.

6.5.13 JSON output

Size of JSON output billing dataset is at MODBUS address 47057.

JSON output billing dataset is at MODBUS address 47612.

6.5.14 Binary output

Size of binary output billing dataset is at MODBUS address 48316.

Binary output billing dataset is at MODBUS address 48317.

6.5.15 Signature

After successful signature process, control unit can read signature in specified signature format.

Signature length register is at MODBUS address 47058.

Signature register is at 48188.

6.5.16 Public key

Public key is stored in 64 bytes raw format at MODBUS address 48124.

For **Transparenz Software** check, public key header should be prepended:

3059301306072A8648CE3D020106082A8648CE3D03010703420004

For checking with ECDSA, public key header is: 04.

6.5.17 Dataset format

Format is compliant with OCMF v1.0.
Energy meter requires following fields in dataset:

```
{
"FV":"1.0",
"GI":"",
"GS":"",
"PG":"",
"MV":"",
"MM":"",
"MS":"",
"MF":"",
"IS":true,
"IF":[],
"IT":"NONE",
"ID":"",
"CT":"EVSEID",
"CI":"",
"RD":[]
}
```

Warning: JSON names must be in specified order and without whitespaces. Downloaded message should look like:

{"FV":"1.0","GI":"","GS":"","PG":"","MV":"","MM":"","MS":"","MF":"","IS":true,"IF":[],"IT":"NONE","ID":"","CT":"EVSEID","CI":"","RD":[]}

Example of valid JSON dataset (**newlines are added for better readability**):

```
{
"FV":"1.0",
"GI":"Gateway1",
"GS":"123456789",
"GV":"1.0",
"PG":"",
"MV":"",
"MM":"",
"MS":"",
"MF":"",
"IS":true,
"IL": "VERIFIED",
"IF":[],
"IT":"NONE",
"ID":"",
"CT":"EVSEID",
"CI":"Charge-Box-ID",
"TT": "Tarif 1",
"LC": {
        "LN": "cable_name",
        "LI": 1,
        "LR": ,
        "LU": ""
},
"RD":[]
}
```

Energy meter fills following values:
PG:”T<signature counter>” or “F<fiscal counter>” for fiscal readings
MV:“meter manufacturer”
MM:”meter model”
MS:”meter serial number”
MF:”meter firmware version”
LR:“cable resistance“
LU:“resistance unit“
RD: meter generates complete array of readings data

Example of modified dataset:

```
{
"FV": "1.0",  //Firmware: provided by charging controller
"GI": " Gateway1", //Gateway ID: provided by charging controller
"GS": "123456789", //Gateway serial: provided by charging controller
"GV": "1.0", //Gateway version: provided by charging controller
"PG": "T28", //transaction number (unique)
"MV": "Iskra",  //Meter manufacturer
"MM": "WM3M4C",  //Meter model
"MS": "W4124943",  //Meter serial number
"MF": "2.11",  //Meter Firmware version
"IS": true, // Provided by charging controller
"IL": " VERIFIED", // Provided by charging controller
"IF": [],  // Provided by charging controller
"IT": "NONE", // Provided by charging controller
"ID": "", // Provided by charging controller
"CT": "EVSEID", // Provided by charging controller
"CI": "Charge-Box-ID",  // Provided by charging controller
"TT": "Tarif 1",  // Provided by charging controller
"LC": {
  "LN": "cable_name",  // Provided by charging controller
  "LI": 1,  // Provided by charging controller
  "LR": 35.0,  // Cable resistance
  "LU": "mOhm" // Resistance unit
}
"RD": [ //measuring data array
  { //start charging block
    "TM": "2024-02-19T11:59:32,000+0000 S",  //timestamp
    "TX": "B", //begin command
    "RV": 234.56, //energy counter value
    "RI": "1-b:1.8.0*255", //value ID
    "RU": "kWh", //unit
    "RT": "AC", //current type
    "EF": "", //error flag
    "ST": "G" //status
  },
```

```
 {//end charging block
  "TM": "2024-02-19T12:02:51,000+0000 S", //timestamp
  "TX": "E", //end command
  "RV": 234.56, //energy counter value
  "CL": 0.0, //cable losses energy
  "RI": "1-b:1.8.0", //value ID
  "RU": "kWh", //unit
  "RT": "AC", //current type
  "EF": "", //error flag
  "ST": "G" //status
 }
]
}
```


Green highlighted data is generated by energy meter. Data is without whitespaces (**newline characters are added in this document for better readability).**

6.5.18 FW Identification display

FW Identification is displayed on LCD for number of seconds written to register 47075.

Displayed info are presented in three rows on LCD display:

Main Firmware CRC (8digits) in row 1
Phase module CRC (4 digits) in row 2
Main FW version in row 3

***Figure 38**: FW Identification screen*

BF34 is the check sum of the SW in the measuring modules – each phase module has its own processor from which the measuring results are transferred to main processor for further processing. This FW cannot be modified using interfaces but is part of CRC approval and is also checked during operation.

6.5.19 Measurements table

Control unit can check measurements and statuses during the charging process.

47000		Measurement status	T1	0	Idle
				1	Active
				2	Active after power failure
				3	Active after reset
47001	47002	Duration	T3u		Seconds
47003	47004	Consumption	T_32U		Wh
47005	47006	Active Power Total (Pt)	T6		Reg (30140-30141)
47007	47008	Date and Time	T_Unix		
47009		Tarrif changes count	T1		Command T
47010		Intermediate readings count	T1		Command C
47011	47012	Fiscal Readings count	T3u		Command f
47013	47014	Signatures count (pagination)	T3		
47015	47016	Start Timestamp	T_Unix		
47017	47018	Start Counter value	T_32U		Wh
47019	47020	Stop Timestamp	T_Unix		
47021	47022	Stop Counter value	T_32U		Wh
47023	47024	Tariff change Timestamp	T_Unix		
47025	47026	Tariff change Counter value	T_32U		Wh
47027	47028	Intermediate Reading Timestamp	T_Unix		
47029	47030	Intermediate Reading Counter value	T_32U		Wh
47031	47032	Fiscal Reading Timestamp	T_Unix		
47033	47034	Fiscal Reading Counter value	T_32U		Wh
47035	47036	Hold measurement Timestamp	T_Unix		
47037	47038	Hold measurement Counter value	T_32U		Wh
47039	47040	Suspend Timestamp	T_Unix		
47041	47042	Suspend Counter value	T_32U		Wh

***Table 17**: Measurements table*

6.5.20 Input / Output Data Table

47100	47611	Input Message (JSON/Binary)
47612	48123	Output Message (JSON)
48124	48155	Public Key (raw)
48156	48187	Signature (raw)
48188	48315	Signature ASN.1
48316		Binary Output Message Lenght
48317		Binary Output Message

***Table 18**: Input/Output table*

6.5.19 End transaction specification in data set

In the SW version 2.05 MODBUS parameter 47076 is implemented. It defines the value TX in the end transaction block of data set in case 'r' command is used. Value "E" specifies basic end transaction and provides better presentation of output data in Transparenz software. Value "r" was used in initial version and with this setting it can be still used in actual applications.

Register 47076:

Value	TX value in end transaction block	Description
0	"TX": "r"	The same operation as in version 2.03
1	"TX": "E"	Improves presentation of data in the Transparenz software
2	"TX": "E" Command 'E' generates begin and end transaction	Allows compatibility with other devices in case of different approach to OCMF specification

***Table 19**: End transaction specification in data set*

6.6 Power loss behaviour

If power loss happens during charging, meter continues to measure energy and duration after power is restored. All events are saved (begin and tariff changes) but meter does not save time, because it is not relevant anymore (meter is without battery). Meter detects this irregular state and reports it with measurement status 2 in register 47000.

Control unit must set time and billing dataset to continue. Then End transaction command can be send. Meter will generate and sign complete transaction with time error flag ("EF": "t").

6.7 Unexpected reset behaviour

Meter will set Energy error flag ("EF": "E") if unexpected reset happens during charging. Measured energy consumption is **not valid**.

7 TECHNICAL DATA

In following chapter all technical data regarding operation of *WM3M4 & WM3M4C energy meters* are presented.

7.1 Accuracy

Measured values	Accuracy class
Active energy:	class 1 EN 62053-21
	class B EN 50470-3
	±1.5% from I_{min} to I_{tr}
	±1% from I_{tr} to I_{max}
Voltage:	±1% of measured value
Current:	±1% of I_{ref} from I_{st} to I_{ref}
	±1% of measured value from I_{ref} to I_{max}
Active Power:	±1% of nominal power ($U_n * I_{ref}$) from I_{st} to I_{ref}
	±1% of measured value from I_{ref} to I_{max}
Reactive, Apparent power:	±2% of nominal power from I_{st} to I_{ref}
	±2% of measured value from I_{ref} to I_{max}
Frequency:	±0.5% of measured value

7.2 Mechanical characteristics of input

Rail mounting according to DIN EN 60715. In case of using the stranded wire, the ferrule must be attached before the mounting.

Terminals		Maximum conductor cross-sections
Main inputs	Contacts capacity:	Rigid (flexible) 2.5 mm^2... 25 (16) mm^2
	Connection screws:	M5
	Recommended / Max torque:	3/3.5 Nm (PZ2)
	Length of removed isolation:	10 mm
Communication terminals	Contacts capacity:	1 mm^2... 2.5 mm^2
	Connection screws:	M3
	Recommended / Max torque:	0.7/0.8 Nm (PZ1)
	Length or removed isolation:	8 mm

7.3 Electrical characteristics of input

Inputs and outputs		
Measuring input	*Type (connection):*	*three-phase (4u)*
	Reference current (I_{ref}):	*5 A*
	Maximum current (I_{max}):	*40 A*
	Minimum current (I_{min}):	*0.25 A*
	Transitional current (I_{tr}):	*0.5 A*
	Starting current:	*20 mA*
	Power consumption at I_{ref}	*< 0.05 VA*
	Nominal voltage (U_n):	*3x230 V/400 V (-20 %...+15 %)*
	Power consumption per phase at U_n:	*< 8 VA, 0.6 W*
	Nominal frequency (f_n):	*50 Hz and 60 Hz*
	Minimum measuring time:	*10 s*
Security *(valid only for WM3M4C)*	*Hash generation:*	*SHA256*
RS485 Serial communication	*Type:*	*RS485*
	Speed:	*1200 bit/s to 115200 bit/s (default 115200 bit/s)*
	Frame:	*8, N, 1*
	Protocol:	*MODBUS RTU*
	Address:	*33 – (default)*
Optical communication	*Type:*	*IR*
	Connection:	*via WM-USB adapter*
	Speed:	*19200 bit/s*
	Frame:	*8, N, 1*
	Protocol:	*MODBUS RTU*
	Address:	*33 – (locked)*
	Remark:	*All settings are fixed*

7.4 Safety and ambient conditions

According to standards for indoor active energy meters.

Temperature and climatic condition according to EN 62052-11.

Dust/water protection	*IP50**
Operating temperature:	*-25 °C - +70 °C*
Storage temperature:	*-30 °C - + 80 °C*
Enclosure:	*self-extinguish, complying UL94-V*
Indoor meter:	*Yes*
Degree of pollution:	*2*
Protection class:	*II*
Installation category	*300 Vrms CAT III*
Standard:	*IEC 62052-31*
Mechanical environment:	*M1*
Electromagnetic environment:	*E2*
Humidity:	*non condensing*
Weight (with packaging):	*228 g (248 g)*
Installation:	*DIN rail 35 mm*
Dimensions (W x H x D):	*53,6 mm x 84 mm x 69,4 mm*
Package dimensions (W x H x D):	*57 mm x 93 mm x 85 mm*
Colour:	*RAL 7035*

Note *: To fulfil the requirements for IP51 protection according to EN 50470-1 the meters should be mounted in the cabinet with IP51 specification.

7.5 EU Directives conformity

EU Directive on Measuring instruments MID **2014/32/EU.**

EU Directive on EMC **2014/30/EU.**

EU Directive on Low Voltage **2014/35/EU.**

EU Directive WEEE **2002/96/EC.**

List of considered harmonized standards confirming appliance with the essential requirements of the Regulation:

EN 50470-1:2006 Electricity metering equipment (ac) - Part 1: General requirements, tests and test conditions - Metering equipment (class indexes A, B and C).
EN 50470-3:2006 Electricity metering equipment (ac) - Part 3: Particular requirements - Static meters for active energy (class indexes A, B and C).

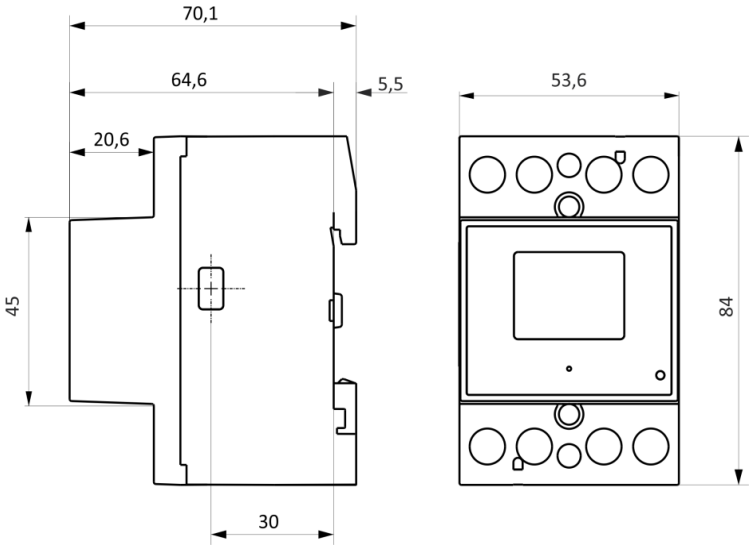
Other standards taken into account in the design and testing of the meter:

EN 62052-11:2003, EN 62052-11:2003/A1:2017 Electricity metering equipment (ac) - General requirements, tests and test conditions - Part 11: Metering equipment.
EN 62053-21:2003, EN 62053-21:2003/A1:2017 Electricity metering equipment (ac) - Particular requirements - Part 21: Static meters for active energy (classes1 and 2).
EN 62053-23:2003, EN 62053-23:2003/A1:2017 Electricity metering equipment (ac) - Particular requirements - Part 23: Static meters for reactive energy (classes 2 and 3).
EN 62053-31:1998 Electricity metering equipment (a.c.) - Particular requirements - Part 31: Pulse output devices for electromechanical and electronic meters (two wires only).
EN 62052-31:2016 Electricity metering equipment (a.c.) - General requirements, tests and test conditions - Part 31: Safety requirements and tests.
EN 62059-32-1:2012 Electricity metering equipment - Dependability - Part 32-1: Durability - Testing of the stability of metrological characteristics by applying elevated temperature.
CLC/TR 50579:2012 Electricity metering equipment - Severity levels, immunity requirements and test methods for conducted disturbances in the frequency range 2 -150 kHz.

PTB-A50.7 Anforderungen an elektronische und software-gesteuerte Messgeräte und Zusatzeinrichtungen für Elektrizität, Gas, Wasser und Wärme
PTB-A 20.1 Messgeräte für Elektrizität; Elektrizitätszähler und deren Zusatzeinrichtungen
DIN EN 50470-1:2019 Wechselstrom-Elektrizitätszähler - Teil 1: allgemeine Anforderungen, Prüfungen und Prüfbedingungen - Messeinrichtungen (Genauigkeitsklassen A, B und C)
DIN EN 50470-3:2020 Wechselstrom-Elektrizitätszähler - Teil 3: Besondere Anforderungen – Elektronische Wirkverbrauchzähler der Genauigkeitsklassen A, B und C

7.6 Dimensions

7.6.1 Dimensional drawing

Construction	*Appearance*
Dimensions	All dimensions are in mm 

8 ABBREVIATION/GLOSSARY

Abbreviations are explained within the text where they appear the first time. Most common abbreviations and expressions are explained in the following table:

Term	***Explanation***
MODBUS / DNP3	*Industrial protocol for data transmission*
MiQen	*Setting Software for ISKRA instruments*
AC	*Alternating*
IR	*Infrared (optical) communication*
RMS	*Root Mean Square*
TRMS	*True Root Mean Square*
PA	*Power angle (between current and voltage)*
PF	*Power factor*
THD	*Total harmonic distortion*
EV	*Electrical vehicle*
PTB	*Physikalisch-Technische Bundesanstalt*
OCMF	*Open Charge Metering Format*
VDE	*Verband der Elektrotechnik*

List of common abbreviations and expressions

9 APPENDIX

Modbus tables

Info:

Address		Contents Input Registers	Data	Ind	Values / Dependencies
30000		Memory Reference			
		READ ONLY INFO			
30000		Device group	T1	4	WM
30001	30008	Model Number	T_Str16		WM3M4C
30009	30012	Serial Number	T_Str8		WM41####
30013		Software Reference	T1		100=1.00
30014		Hardware Reference	T_Str2		A (B,C,D…)
30015		Calibration voltage	T4		250000 mV
30017		Calibration current	T4		40000 mA
30019		Accuracy class	T17		100=1,0
30024		COM1: Communication Type	T1	2	RS485
				9	Infra red
30047	30048	Calibration Time Stamp	T10		
30076		MID lock status	T1	0	unlocked
				1	locked
30079		MID unlock counter	T1	0	Operational only up to Ver. 2.03
30080		FW upgrade counter	T1	0	Operational only up to Ver. 2.03
30081		Software CheckSum HI	T1		
30087		phase module 1 Software reference	T1		100=1,0
30088		phase module 2 Software reference	T1		100=1,0
30089		phase module 3 Software reference	T1		100=1,0
30090		phase module 1 CheckSum	T1		
30091		phase module 2 CheckSum	T1		
30092		phase module 3 CheckSum	T1		
30093		phase module 1 calibration data CheckSum	T1		
30094		phase module 2 calibration data CheckSum	T1		
30095		phase module 3 calibration data CheckSum	T1		
30096		CheckSum Params	T1		
30097		CheckSum Main Firmware	T1		
30098		Active Communication Port	T1	0	IR
				1	COM1
30099		Modbus Max. Register Read at Once	T1		

Measurements:

Address		Contents	Data	Ind	Values / Dependencies
		Input Registers			
30000		Memory Reference			
		ACTUAL MEASUREMENTS			
30101		Phase valid measurement	T1	Bit 0	Invalid measurement phase 1
				Bit 1	Invalid measurement phase 2

				Bit 2	Invalid measurement phase 3
30102	30104	Reserved			
30105	30106	Frequency	T5		
30107	30108	U1	T5		
30109	30110	U2	T5		
30111	30112	U3	T5		
30113	30114	Uavg (phase to neutral)	T5		
30115		j12 (angle between U1 and U2)	T17		
30116		j23 (angle between U2 and U3)	T17		
30117		j31 (angle between U3 and U1)	T17		
30118	30119	U12	T5		
30120	30121	U23	T5		
30122	30123	U31	T5		
30124	30125	Uavg (phase to phase)	T5		
30126	30127	I1	T5		Valid: Reg 30001<7
30128	30129	I2	T5		Valid: Reg 30001<7
30130	30131	I3	T5		Valid: Reg 30001<7
30132	30133	Inc	T5		
30134	30135	Reserved: Inm	T5		
30136	30137	Iavg	T5		
30138	30139	S I	T5		
30140	30141	Active Power Total (Pt)	T6		
30142	30143	Active Power Phase L1 (P1)	T6		Valid: Reg 30001<7
30144	30145	Active Power Phase L2 (P2)	T6		Valid: Reg 30001<7
30146	30147	Active Power Phase L3 (P3)	T6		Valid: Reg 30001<7
30148	30149	Reactive Power Total (Qt)	T6		
30150	30151	Reactive Power Phase L1 (Q1)	T6		Valid: Reg 30001<7
30152	30153	Reactive Power Phase L2 (Q2)	T6		Valid: Reg 30001<7
30154	30155	Reactive Power Phase L3 (Q3)	T6		Valid: Reg 30001<7
30156	30157	Apparent Power Total (St)	T5		
30158	30159	Apparent Power Phase L1 (S1)	T5		Valid: Reg 30001<7
30160	30161	Apparent Power Phase L2 (S2)	T5		Valid: Reg 30001<7
30162	30163	Apparent Power Phase L3 (S3)	T5		Valid: Reg 30001<7
30164	30165	Power Factor Total (PFt)	T7		
30166	30167	Power Factor Phase 1 (PF1)	T7		Valid: Reg 30001<7
30168	30169	Power Factor Phase 2 (PF2)	T7		Valid: Reg 30001<7
30170	30171	Power Factor Phase 3 (PF3)	T7		Valid: Reg 30001<7
30172		Power Angle Total (atan2(Pt,Qt))	T17		
30173		j1 (angle between U1 and I1)	T17		Valid: Reg 30001<7
30174		j2 (angle between U2 and I2)	T17		Valid: Reg 30001<7
30175		j3 (angle between U3 and I3)	T17		Valid: Reg 30001<7
30176	30180	Reserved			
30181		Internal Temperature	T17		
		THD HARMONIC DATA			
30182		U1 THD%	T16		
30183		U2 THD%	T16		
30184		U3 THD%	T16		
30185		Reserved: U12 THD%	T16		
30186		Reserved: U23 THD%	T16		

30187		Reserved: U31 THD%	T16		
30188		I1 THD%	T16		
30189		I2 THD%	T16		
30190		I3 THD%	T16		
		ENERGY			
30400		CheckSum Status	T1	0	No Error (OK)
				Bit 0	Error Parameter CRC
				Bit 1	Error Firmware CRC
				Bit 2	Error MID-lock
				Bit 3	Error phase module 1 CheckSum
				Bit 4	Error phase module 2 CheckSum
				Bit 5	Error phase module 3 CheckSum
				Bit 6	Error Main FW CheckSum
				Bit 7	Error Software Checksum
				Bit 8	Error Calibration Data CheckSum
				Bit 9	Error MID Setting Data CheckSum
				Bit 10	Error Setting Data CheckSum
				Bit 11	Error phase module 1 cal. data CheckSum
				Bit 12	Error phase module 2 cal. data CheckSum
				Bit 13	Error phase module 3 cal. data CheckSum
				Bit 14	Error Crypto data CheckSum
				Bit 15	Error Crypto chip failure
30405		Current Active Tariff	T1		
30405		Current Active Tariff	T1		
30414		Energy Counter 1 Exponent (Non-reset)	T2		
30415		Energy Counter 2 Exponent (Non-reset)	T2		
30416		Energy Counter 3 Exponent (Non-reset)	T2		
30417		Energy Counter 4 Exponent (Non-reset)	T2		
30418	30419	Energy Counter 1 (Non-reset)	T3		
30420	30421	Energy Counter 2 (Non-reset)	T3		seconds
30422	30423	Energy Counter 3 (Non-reset)			
30424	30425	Energy Counter 4 (Non-reset)			
30434	30435	1000x Energy Counter 1 (Non-reset)			
30436	30437	1000x Energy Counter 2 (Non-reset)			
30438	30439	1000x Energy Counter 3 (Non-reset)			
30440	30441	1000x Energy Counter 4 (Non-reset)			
30442	34998	Reserved			
34999	35000	Run time			
35001	35499	Reserved			
		INTERVAL MEASUREMENTS			
		AVERAGE MEASUREMENTS			
35500		The last Average interval duration	T1		Seconds/10
35501		Time since the last average measurements	T1		Seconds/10
35502		Average measurements counter	T1		
35503	35504	Timestamp (Run time)	T3		'= 0 after reset
35505	35506	Frequency	T5		
35507	35508	U1	T5		

35509	35510	U2	T5		
35511	35512	U3	T5		
35513	35514	Uavg (phase to neutral)	T5		
35515		j12 (angle between U1 and U2)	T17		
35516		j23 (angle between U2 and U3)	T17		
35517		j31 (angle between U3 and U1)	T17		
35518	35519	U12	T5		
35520	35521	U23	T5		
35522	35523	U31	T5		
35524	35525	Uavg (phase to phase)	T5		
35526	35527	I1	T5		
35528	35529	I2	T5		
35530	35531	I3	T5		
35532	35533	Reserved: Inc	T5		
35534	35535	Reserved: Inm	T5		
35536	35537	Iavg	T5		
35538	35539	Reserved: S I	T5		
35540	35541	Active Power Total (Pt)	T6		
35542	35543	Active Power Phase L1 (P1)	T6		
35544	35545	Active Power Phase L2 (P2)	T6		
35546	35547	Active Power Phase L3 (P3)	T6		
35548	35549	Reactive Power Total (Qt)	T6		
35550	35551	Reactive Power Phase L1 (Q1)	T6		
35552	35553	Reactive Power Phase L2 (Q2)	T6		
35554	35555	Reactive Power Phase L3 (Q3)	T6		
35556	35557	Apparent Power Total (St)	T5		
35558	35559	Apparent Power Phase L1 (S1)	T5		
35560	35561	Apparent Power Phase L2 (S2)	T5		
35562	35563	Apparent Power Phase L3 (S3)	T5		
35564	35565	Power Factor Total (PFt)	T7		
35566	35567	Power Factor Phase 1 (PF1)	T7		
35568	35569	Power Factor Phase 2 (PF2)	T7		
35570	35571	Power Factor Phase 3 (PF3)	T7		
35572		Power Angle Total (atan2(Pt,Qt))	T17		
35573		j1 (angle between U1 and I1)	T17		
35574		j2 (angle between U2 and I2)	T17		
35575		j3 (angle between U3 and I3)	T17		
35576	35580	Reserved			
35581		Internal Temperature	T17		
		THD HARMONIC DATA			
35582		U1 THD%	T16		
35583		U2 THD%	T16		
35584		U3 THD%	T16		
35585		Reserved: U12 THD%	T16		
35586		Reserved: U23 THD%	T16		
35587		Reserved: U31 THD%	T16		
35588		I1 THD%	T16		
35589		I2 THD%	T16		
35590		I3 THD%	T16		

35591	35599	Reserved			
		MAXIMUM MEASUREMENTS			
35600	35604	Reserved			
35605	35606	Frequency	T5		
35607	35608	U1	T5		
35609	35610	U2	T5		
35611	35612	U3	T5		
35613	35614	Uavg (phase to neutral)	T5		
35615		j12 (angle between U1 and U2)	T17		
35616		j23 (angle between U2 and U3)	T17		
35617		j31 (angle between U3 and U1)	T17		
35618	35619	U12	T5		
35620	35621	U23	T5		
35622	35623	U31	T5		
35624	35625	Uavg (phase to phase)	T5		
35626	35627	I1	T5		
35628	35629	I2	T5		
35630	35631	I3	T5		
35632	35633	Reserved: Inc	T5		
35634	35635	Reserved: Inm	T5		
35636	35637	Iavg	T5		
35638	35639	S I	T5		
35640	35641	Active Power Total (Pt)	T6		
35642	35643	Active Power Phase L1 (P1)	T6		
35644	35645	Active Power Phase L2 (P2)	T6		
35646	35647	Active Power Phase L3 (P3)	T6		
35648	35649	Reactive Power Total (Qt)	T6		
35650	35651	Reactive Power Phase L1 (Q1)	T6		
35652	35653	Reactive Power Phase L2 (Q2)	T6		
35654	35655	Reactive Power Phase L3 (Q3)	T6		
35656	35657	Apparent Power Total (St)	T5		
35658	35659	Apparent Power Phase L1 (S1)	T5		
35660	35661	Apparent Power Phase L2 (S2)	T5		
35662	35663	Apparent Power Phase L3 (S3)	T5		
35664	35665	Power Factor Total (PFt)	T7		
35666	35667	Power Factor Phase 1 (PF1)	T7		
35668	35669	Power Factor Phase 2 (PF2)	T7		
35670	35671	Power Factor Phase 3 (PF3)	T7		
35672		Power Angle Total (atan2(Pt,Qt))	T17		
35673		j1 (angle between U1 and I1)	T17		
35674		j2 (angle between U2 and I2)	T17		
35675		j3 (angle between U3 and I3)	T17		
35676	35680	Reserved			
35681		Internal Temperature	T17		
		THD HARMONIC DATA			
35682		U1 THD%	T16		
35683		U2 THD%	T16		
35684		U3 THD%	T16		

35685		Reserved: U12 THD%	T16		
35686		Reserved: U23 THD%	T16		
35687		Reserved: U31 THD%	T16		
35688		I1 THD%	T16		
35689		I2 THD%	T16		
35690		I3 THD%	T16		
35691	35699	Reserved			
		MINIMUM MEASUREMENTS			
35700	35704	Reserved			
35705	35706	Frequency	T5		
35707	35708	U1	T5		
35709	35710	U2	T5		
35711	35712	U3	T5		
35713	35714	Uavg (phase to neutral)	T5		
35715		j12 (angle between U1 and U2)	T17		
35716		j23 (angle between U2 and U3)	T17		
35717		j31 (angle between U3 and U1)	T17		
35718	35719	U12	T5		
35720	35721	U23	T5		
35722	35723	U31	T5		
35724	35725	Uavg (phase to phase)	T5		
35726	35727	I1	T5		
35728	35729	I2	T5		
35730	35731	I3	T5		
35732	35733	Reserved: Inc	T5		
35734	35735	Reserved: Inm	T5		
35736	35737	Iavg	T5		
35738	35739	S I	T5		
35740	35741	Active Power Total (Pt)	T6		
35742	35743	Active Power Phase L1 (P1)	T6		
35744	35745	Active Power Phase L2 (P2)	T6		
35746	35747	Active Power Phase L3 (P3)	T6		
35748	35749	Reactive Power Total (Qt)	T6		
35750	35751	Reactive Power Phase L1 (Q1)	T6		
35752	35753	Reactive Power Phase L2 (Q2)	T6		
35754	35755	Reactive Power Phase L3 (Q3)	T6		
35756	35757	Apparent Power Total (St)	T5		
35758	35759	Apparent Power Phase L1 (S1)	T5		
35760	35761	Apparent Power Phase L2 (S2)	T5		
35762	35763	Apparent Power Phase L3 (S3)	T5		
35764	35765	Power Factor Total (PFt)	T7		
35766	35767	Power Factor Phase 1 (PF1)	T7		
35768	35769	Power Factor Phase 2 (PF2)	T7		
35770	35771	Power Factor Phase 3 (PF3)	T7		
35772		Power Angle Total (atan2(Pt,Qt))	T17		
35773		j1 (angle between U1 and I1)	T17		
35774		j2 (angle between U2 and I2)	T17		
35775		j3 (angle between U3 and I3)	T17		

35776	35780	Reserved			
35781		Internal Temperature	T17		
		THD HARMONIC DATA			
35782		U1 THD%	T16		
35783		U2 THD%	T16		
35784		U3 THD%	T16		
35785		Reserved: U12 THD%	T16		
35786		Reserved: U23 THD%	T16		
35787		Reserved: U31 THD%	T16		
35788		I1 THD%	T16		
35789		I2 THD%	T16		
35790		I3 THD%	T16		
35791	35799	Reserved			
35800	35901	Reserved			
		RAM logger			
36000		Measurement parameter	T1		See OutTypes
36001		Time interval	T1		minutes
36002		Number of valid results	T1		
36003		Time stamp of last result	T2		minutes since midnight (<0 if no time)
36004	36515	Logger table (newest to oldest)	T17		Normalised values
36516	36771	Reserved for more memory			

Settings:

40012		Operator Command Register	T1	1	Save Settings
				2	Abort Settings

Table 20 *Operator Command Register*

Operator Command 1 (Save Settings) must be used to store all settings changes into the permanent memory (EEPROM).
Operator Command 2 (Abort Settings) can be used to restore all settings from the permanent memory (EEPROM) as at power up.

If the "save setting" command is not sent at the end of changing settings, the changes are not written into the EEPROM.

Function code	Address		Contents	Data	Ind	Values / Dependencies	Min	Max	P. Level	RW	MID
			Holding Registers								
	40000		**Memory Reference**								
			SYSTEM COMMANDS								
16	40001	40002	User Password (L1, L2, BP)	T_Str4	A...Z	Password to attempt user access level upgrade			0	W	no
16	40006	40007	Lavel 1 - User password	T_Str4	A...Z				1	W	no
16	40008	40009	Lavel 2 - User password	T_Str4	A...Z				2	W	no
3, 6	40010		Active Acces Level	T1	0	Full protection	0	0	0	RW	no
					1	Access up to level 1 user password					
					2	Access up to level 2 user password					
					3	Access up to level 2 (backup pass.)					
6	40011		Manual password activation	T1	1	Lock instrument			0	W	no
6	40012		Operator Command Register	T1	1	Save Settings			1	W	no
					2	Abort Settings					
6	40013		Reset command register 1	T1	Bit-0	Reset counter 1			1	W	no
					Bit-1	Reset counter 2					
					Bit-2	Reset counter 3					
					Bit-3	Reset counter 4					
3, 6	40016		Digital Output state		0	Off	0	1	0	RW	no
					1	On					
			GENERAL SETTINGS								
3, 6 , 16	40101	40120	Description	T_Str40					2	RW	no
3, 6 , 16	40121	40140	Location	T_Str40					2	RW	no
3, 6	40174		LCD cycling period	T1		Seconds	5	60	2	RW	no
3, 6	40185		Operation mode		0	Normal mode	0	16	0	RW	no
					1	Test mode P - Fast	Only when charging not active				
					2	Test mode P - Fast (Counter only)	Only when charging not active				
					4	Test mode Q	Only when charging not active				
					5	Test mode Q - Fast	Only when charging not active				
					6	Test mode Q - Fast (Counter only)	Only when charging not active				
					8	Test mode P – Fast LED x 1000	Only when charging not active				
					16	Test mode P – Fast LED x 10000	Only when charging not active				
			COMMUNICATION								
3, 6	40202		Port 1: Device Adress (Modbus)	T1			1	247	2	RW	no
3, 6	40203		Port 1: Baud Rate	T1	0	Baud rate 1200	1	7	2	RW	no
					1	Baud rate 2400					
					2	Baud rate 4800					
					3	Baud rate 9600					
					4	Baud rate 19200					
					5	Baud rate 38400					
					6	Baud rate 57600					
					7	Baud rate 115200					
3, 6	40204		Port 1: Stop Bit	T1	0	1 Stop bit	0	1	2	RW	no
					1	2 Stop bits					
3, 6	40205		Port 1: Parity	T1	0	No parity	0	2	2	RW	no
					1	Odd parity					
					2	Even parity					
3, 6	40206		Port 1: Data Bits	T1	0	8 bits	0	0	2	RW	no
			ENERGY								
3, 6	40401		Active Tariff	T1	0	Tariff input	0	2	1	R	yes
					1	Tariff 1					
					2	Tariff 2					
3	40402		Common Energy Counter Exponent	T2			-3	4	2	R	yes
	40403	40418	Reserved								
3, 6	40419		Total Energy Calculation	T1	0	Evaluation of the sum of phases	0	1	2	R	yes
					1	Evaluation of individual phases					
3, 6	40421		Energy Counter 1 Parameter	T1	1	Active Power	0	35	2	R	yes
					2	Reactive Power					
					3	Apparent Power					
					5	Active Power Phase 1					
					6	Reactive Power Phase 1					
					7	Apparent Power Phase 1					
					9	Active Power Phase 2					
					10	Reactive Power Phase 2					
					11	Apparent Power Phase 2					
					13	Active Power Phase 3					
					14	Reactive Power Phase 3					
					15	Apparent Power Phase 3					
					32	Squared Current (AAh)					
					33	Active Power individual phases					
					34	Reactive Power individual phases					
					35	Apparent Power individual phases					

3, 6	40422		Energy Counter 1 Configuration	T1	Bit-0	Quadrant I Enabled	0	63	2	R	yes
					Bit-1	Quadrant II Enabled					
					Bit-2	Quadrant III Enabled					
					Bit-3	Quadrant IIII Enabled					
					Bit-4	Absolute Value					
					Bit-5	Invert Value					
3	40423		Energy Counter 1 Divider	T1	0	1	0	4	2	R	yes
					1	10					
					2	100					
					3	1000					
					4	10000					
3, 6	40424		Energy Counter 1 Tarif Selector	T1	Bit-0	Tarif 1 Enabled	0	15	2	R	yes
					Bit-1	Tarif 2 Enabled					
					Bit-2	Tarif 3 Enabled					
					Bit-3	Tarif 4 Enabled					
	40425	40430	Reserved								
3, 6	40431		Energy Counter 2 Parameter	T1		see Energy Counter 1 Parameter	0	15	2	R	yes
3, 6	40432		Energy Counter 2 Configuration	T1		see Energy Counter 1 Configuration	0	63	2	R	yes
3	40433		Energy Counter 2 Divider	T1		see Energy Counter 1 Divider	0	4	2	R	yes
3, 6	40434		Energy Counter 2 Tarif Selector	T1		see Energy Counter 1 Tarif Selector	0	15	2	R	yes
3	40435	40440	Reserved								
3, 6	40441		Energy Counter 3 Parameter	T1		see Energy Counter 1 Parameter	0	15	2		yes
3, 6	40442		Energy Counter 3 Configuration	T1		see Energy Counter 1 Configuration	0	63	2		yes
3	40443		Energy Counter 3 Divider	T1		see Energy Counter 1 Divider	0	4	2		
3, 6	40444		Energy Counter 3 Tarif Selector	T1		see Energy Counter 1 Tarif Selector	0	15	2		yes
3	40445	40450	Reserved								
3, 6	40451		Energy Counter 4 Parameter	T1		see Energy Counter 1 Parameter	0	15	2		yes
3, 6	40452		Energy Counter 4 Configuration	T1		see Energy Counter 1 Configuration	0	63	2		yes
3	40453		Energy Counter 4 Divider	T1		see Energy Counter 1 Divider	0	4	2		
3, 6	40454		Energy Counter 4 Tarif Selector	T1		see Energy Counter 1 Tarif Selector	0	15	2		yes
3	40462		Pulse LED No. Of pulses	T1			1	65535	2	R	yes
3	40463		Pulse LED Energy unit	T1		* 10^(Common Energy Counter Exponent)	1	65535	2	R	yes
3	40464		Pulse LED Pulse lenght	T1		ms	2	1000	2	R	yes
			ENERGY snapshot registers								
3, 6	41901		Auto freeze interval [minutes]	T1			0	65536	0	RW	no
3, 6	41902		time to freeze [s]	T1			0	65536	0	RW	no
3, 6	41903	41904	time from freeze [s]	T3u							
3, 6	41905		Freeze status	T1	0	at reset	1	65533	0	RW	no
					65534	at interval					
					65535	at time to freeze					
3	41906		Current Active Tariff	T1						R	no
3	41915	41916	Energy Counter 1 (Non-reset)	T3						R	no
3	41917	41918	Energy Counter 2 (Non-reset)	T3						R	no
3	41931	41932	1000x Energy Counter 1 (Non-reset)	T3						R	no
3	41933	41934	1000x Energy Counter 2 (Non-reset)	T3						R	no
	41939	41989	Reserved								
			INTERVAL MEASUREMENTS								
3, 6	41990		Interval duration [s/10]	T1		600=60,0 sec	0,1	3600	0	RW	no
3, 6	41991		Time to calculate interval meas. [s/10]	T1			0,1	3600	0	RW	no
	41992	41999	Reserved								
	42000	42749	Reserved								

Signature:

Function code	Address		Contents	Data	Ind	Values / Dependencies	Min	Max	P. Level	RW
			Holding Registers							
	40000		**Memory Reference**							
	47000		**DIGITAL SIGNATURE**							
			Changes Log of Cable Resistance (Reg. 47080)							
3	46500		Log Table size	T1						R
3	46501		Log Table used	T1						R
3	46502	46503	Log 1 timestamp	T_Unix						R
3	46504		Log 1 new value of Cable Resistance	T16						R
3	46505		Log 1 old value of Cable Resistance	T16						R
3	46506	46629	Log 2 to Log 32							R
3	46630	46699	reserved							
			Changes Log of Cable Loss Energy Config (Reg. 47079)							
3	46700		Log Table size	T1						R
3	46701		Log Table used	T1						R
3	46702	46703	Log 1 timestamp	T_Unix						R
3	46704		Log 1 new value of Cable Loss Energy Config	T1						R
3	46705		Log 1 old value of Cable Loss Energy Config	T1						R
3	46706	46829	Log 2 to Log 32							R
3	46830	46978	reserved							
			Measurements							
3	46979	46980	Start Counter 4 Squared Current (A-)	T3u		Squared Current (AAh)			0	R
3	46981	46982	Stop Counter 4 Squared Current (A-)	T3u		Squared Current (AAh)			0	R
3	46983	46984	Consumption 4 Squared Current (A-)	T3u		Squared Current (AAh)			0	R
3	46985	46986	Cable Loss (A-)	T3u		Wh			0	R
3	46987	46988	Consumption (A-) + Cable Loss	T3u		Wh			0	R
3	46989	46990	Start Counter 3 Squared Current (A+)	T3u		Squared Current (AAh)			0	R
3	46991	46992	Stop Counter 3 Squared Current (A+)	T3u		Squared Current (AAh)			0	R
3	46993	46994	Consumption 3 Squared Current (A+)	T3u		Squared Current (AAh)			0	R
3	46995	46996	Cable Loss (A+)	T3u		Wh			0	R
3	46997	46998	Consumption (A+) - Cable Loss	T3u		Wh			0	R
3	46999		Cable Resistance during Charging	T16		mOhm			0	R
			DIGITAL SIGNATURE							
3	47000		Measurement status	T1	0	Finished			0	R
					1	Active				
					2	Active, Error DTM (Date, Time, Message)				
					3	Active, Error WDR (WD reset)				
3	47001	47002	Duration	T3u		Seconds			0	R
3	47003	47004	Consumption (A+)	T3u		Wh			0	R
3	47005	47006	Active Power Total (Pt)	T6		Reg (30140-30141)			0	R

3	47007	47008	Date and Time	T_Unix					0	R
3	47009		Tariff changes count	T1		Command T			0	R
3	47010		Intermediate readings count	T1		Command C			0	R
3	47011	47012	Fiscal readings count (total)	T3u		Command f			0	R
3	47013	47014	Signatures count (Total)	T3u					0	R
3	47015	47016	Start Timestamp	T_Unix					0	R
3	47017	47018	Start Counter value (A+)	T3u		Wh			0	R
3	47019	47020	Stop Timestamp	T_Unix					0	R
3	47021	47022	Stop Counter value (A+)	T3u		Wh			0	R
3	47023	47024	Tariff change Timestamp	T_Unix					0	R
3	47025	47026	Tariff change Counter value (A+)	T3u		Wh			0	R
3	47027	47028	Intermediate reading Timestamp	T_Unix					0	R
3	47029	47030	Intermediate reading Counter value (A+)	T3u		Wh			0	R
3	47031	47032	Fiscal reading Timestamp	T_Unix					0	R
3	47033	47034	Fiscal reading Counter value (A+)	T3u		Wh			0	R
3	47035	47036	Hold measurements Timestamp	T_Unix					0	R
3	47037	47038	Hold measurements Counter value (A+)	T3u		Wh			0	R
3	47039	47040	Suspend Timestamp	T_Unix					0	R
3	47041	47042	Suspend Counter value (A+)	T3u		Wh			0	R
3	47043	47044	Start Counter 2 value (A-)	T3u		Wh			0	R
3	47045	47046	Stop Counter 2 value (A-)	T3u		Wh			0	R
3	47047	47048	Consumption 2 (A-)	T3u		Wh			0	R
3	47049		Reserved							
3	47050		Power up count (Total)	T1					0	R
			Control							
3,6,16	47051		Command register	Str_2	'B' (0x42)	Begin measurement	Null	Chr A…Z	0	W
					'E' (0x45)	End measurement				
					'L' (0x4C)	End measurement				
					'R' (0x52)	End measurement				
					'A' (0x41)	End measurement				
					'P' (0x50)	End measurement				
					'C' (0x43)	Intermediate Reading				
					'X' (0x58)	eXception				
					'T' (0x54)	Tariff Change				
					'S' (0x53)	Suspended command				
					'r' (0x72)	End measurement (with begin and end)				
					'f' (0x66)	Fiscal Reading				
					'h' (0x68)	Hold command				

					'i' (0x69)	last charge reading (with begin and end)				
3	47052		Signature status	T1	0	Not initialized			0	R
					1	Idle (Time sync)				
					2	Signature in progress				
					15	Signature / Command OK				
					20	Key generated				
					128	Invalid date time				
					129	CheckSum error				
					130	Invalid command				
					131	Invalid state				
					132	Invalid measurements				
					133	Test mode error				
					243	Verify state error				
					244	Signature state error				
					245	Key generation error				
					246	Sha failed				
					247	Init failed				
					248	Data Not locked				
					249	Config Not locked				
					250	Verify error				
					251	Public key error				
					252	Invalid message format				
					253	Invalid message size				
					254	Signature error				
					255	Undefined error				
3,6,16	47053		UTC Time offset	T2		Minutes relative to GMT	-719	720	0	R/W
3,6,16	47054	47055	Set Date and Time	T_Unix					0	W
3,6,16	47056		Input Message Length	T1					0	R/W
3	47057		Output Message Length (Json)	T1					0	R
3	47058		Signature Length	T1					0	R
3,6,16	47059		Signature Format	T1	0	ASN.1			0	R/W
					1	Base64				
3	47060		Signature algorithm	T1	0	Signing not supported			0	R
					4	secp256r1				
3,6,16	47061		Backlight	T1	0	Off			0	R/W
					1	On				
3,6,16	47062		LCD parameters	T1	Bit-0	Consumption (A+)			0	R/W*
					Bit-1	Duration				

					Bit-2	Transaction number				
					Bit-3	Custom				
					Bit-4	Date				
					Bit-5	Time				
					Bit-6	Serial number				
					Bit-7	Software version				
					Bit-8	Counter 2 (A-)				
					Bit-9	Consumption 2 (A-)				
					Bit-10	Cable Resistance (mOhm)				
					Bit-11	Cable Loss (A+)				
					Bit-12	Cable Loss 2 (A-)				
					Bit-13	Consumption (A+) - Cable Loss (A+)				
					Bit-14	Consumption 2 (A-) + Cable Loss 2 (A-)				
3,6,16	47063	47066	LCD Custom string	T_Str8					0	R/W
3,6,16	47067	47068	LCD Custom label	T_Str4					0	R/W
3	47069		OCMF format version	T1		Ma/Mi (255.255)			0	R
3,6,16	47070		Reset command register	T1	Bit-0	Transaction values (Reg 47000=0; else invalid value)			0	R/W
3,6,16	47071		Synchronisation status	T1	0	Unsynchronised	0	3	0	R/W
					1	Info				
					2	Synchronised				
					3	Relative				
3,6,16	47072		Synchronisation timeout	T1		minutes, 0=disabled	0	60000	0	R/W
3,6,16	47073		UTC time use	T1	Bit-n	0=Local, 1=UTC	0	7	0	R/W
					Bit-0	Communication				
					Bit-1	LCD				
					Bit-2	JSON/Binary				
3,6,16	47074		Time adjustement	T2		Seconds	-3	3	0	R/W
3,6,16	47075		Display MID info screen	T1		Seconds (0=Disabled)	0	60	0	W
3,6,16	47076		TX value in end transaction block	T1	0	"TX": "r" (The same operation as v 2.03)	0	2	0	R/W*
					1	"TX": "E"				
					2	"TX": "E" Command 'E' has the function of command 'r'				
3,6,16	47077		Output Message Options	T1	Bit-0	Counter 1 begin	1	63	0	R/W*
					Bit-1	Counter 1 end				
					Bit-2	Counter 1 consumption				

					Bit-3	Counter 1 cable loss				
					Bit-4	Counter 2 begin				
					Bit-5	Counter 2 end				
					Bit-6	Counter 2 consumption				
					Bit-7	Counter 2 cable loss				
3,6,16	47078		Output Message Config	T1	Bit-0	add cable resistance after SW version	0	1	0	R/W*
3,6,16	47079		Cable Loss Energy Config	T1	0	not included ((write when Reg 47000=0)	0	2	0	R/W*
					1	add to Counter Start value				
					2	subtract from Counter End value				
3,6,16	47080		Cable Resistance	T16		mOhm ((write when Reg 47000=0)	0,00	650,00	0	R/W*
	47081	47095	Reserved							
3,6,16	47096		OBIS control	T1	255	RI extension	0	255	0	R
3,6,16	47097		Change Lock control	T1	0	not set (LCD warning)	0	1	0	R/W*
					1	Permanent Locked (if set 1, can not be changed)				
3,6,16	47098		Change setting control	T1	12345	Enable changes for 60s			0	RW
3,6,16	47099		Energy counters resolution	T1	0	1Wh	0	1	0	R/W*
					1	10Wh				
			Data							
3, 16	47100	47611	Input Message (JSON/Binary)						0	R/W
3	47612	48123	Output Message (JSON)						0	R
3	48124	48155	Public Key (raw)						0	R
3	48156	48187	Signature (raw)						0	R
3	48188	48315	Signature ASN.1						0	R
3	48316		Binary Output Message Length	T1					0	R
3	48317		Binary Output Message						0	R

* - mark indicates that the register can only be set once; after locking, changing the register is not possible.

Out Types:

Code	Ident	Parameter		Limit	WM1-	WM3-	Value 100%
1	U	U	U	*	*		Un
2	U1	U1	U1	*		*	Un
3	U2	U2	U2	*		*	Un
4	U3	U3	U3	*		*	Un
5	U12	U12	U12	*		*	Un
6	U23	U23	U23	*		*	Un
7	U31	U31	U31	*		*	Un
9	I	I	I	*	*		In
10	I1	I1	I1	*		*	In
11	I2	I2	I2	*		*	In
12	I3	I3	I3	*		*	In
16	P	P	Active Power P	*	*	*	Pn
17	P1	P1	Active Power Phase L1 (P1)	*		*	Pn
18	P2	P2	Active Power Phase L2 (P2)	*		*	Pn
19	P3	P3	Active Power Phase L3 (P3)	*		*	Pn
20	Q	Q	Reactive Power Q	*	*	*	Pn
21	Q1	Q1	Reactive Power Phase L1 (Q1)	*		*	Pn
22	Q2	Q2	Reactive Power Phase L2 (Q2)	*		*	Pn
23	Q3	Q3	Reactive Power Phase L3 (Q3)	*		*	Pn
24	S	S	Apparent Power S	*	*	*	Pn
25	S1	S1	Apparent Power Phase L1 (S1)	*		*	Pn
26	S2	S2	Apparent Power Phase L2 (S2)	*		*	Pn
27	S3	S3	Apparent Power Phase L3 (S3)	*		*	Pn
28	PF	PF	Power Factor PF	*	*	*	1
29	PF1	PF1	Power Factor Phase 1 (PF1)	*		*	Pn
30	PF2	PF2	Power Factor Phase 2 (PF2)	*		*	Pn
31	PF3	PF3	Power Factor Phase 3 (PF3)	*		*	Pn
36	PA	PA	Power angle PA (angle between U and I)	*	*	*	100°
37	PA1	PA1	j1 (angle between U1 and I1)	*		*	1
38	PA2	PA2	j2 (angle between U2 and I2)	*		*	1
39	PA3	PA3	j3 (angle between U3 and I3)	*		*	1
40	A12	fi U12	j12 (angle between U1 and U2)	*		*	100°
41	A23	fi U23	j23 (angle between U2 and U3)	*		*	100°
42	A31	fi U31	j31 (angle between U3 and U1)	*		*	100°
43	f	f	Frequency	*	*	*	100%=Fn+10Hz, 0%=Fn, -100%=Fn-10Hz
70	E1	E1	Energy Counter 1 (resetable)	*	*	*	(32-bit value) MOD 20000
71	E2	E2	Energy Counter 2 (resetable)	*	*	*	(32-bit value) MOD 20000

Un =	R30015
In =	R30017
Pn =	Un*In
Fn =	55
30015	Calibration voltage
30017	Calibration current

Modbus data types:

Type	Value / Bit Mask	Description
T1		Unsigned Value (16 bit) Example: 12345 stored as 12345 = 3039(16)
T2		Signed Value (16 bit) Example: -12345 stored as -12345 = CFC7(16)
T3		Signed Long Value (32 bit) Example: 123456789 stored as 123456789 = 075B CD15(16)
T3u		Unsigned Long Value (32 bit) Example: 123456789 stored as 123456789 = 075B CD15(16)
T4	bits # 15..14 bits # 13..00	Short Unsigned float (16 bit) Decade Exponent(Unsigned 2 bit) Binary Unsigned Value (14 bit) Example: $10000*10^{2}$ stored as A710(16)
T5	bits # 31..24 bits # 23..00	Unsigned Measurement (32 bit) Decade Exponent(Signed 8 bit) Binary Unsigned Value (24 bit) Example: $123456*10^{-3}$ stored as FD01 E240(16)
T6	bits # 31..24 bits # 23..00	Signed Measurement (32 bit) Decade Exponent (Signed 8 bit) Binary Signed value (24 bit) Example: - $123456*10^{-3}$ stored as FDFE 1DC0(16)
T7	bits # 31..24 bits # 23..16 bits # 15..00	Power Factor (32 bit) Sign: Import/Export (00/FF) Sign: Inductive/Capacitive (00/FF) Unsigned Value (16 bit), 4 decimal places Example: 0.9876 CAP stored as 00FF 2694(16)
T8	bits # 31..24 bits # 23..16 bits # 15..08 bits # 07..00	Time stamp (32 bit) Minutes 00 - 59 (BCD) Hours 00 - 23 (BCD) Day of month 01 - 31 (BCD) Month of year 01 - 12 (BCD) Example: 15:42, 1. SEP stored as 4215 0109(16)
T9	bits # 31..24 bits # 23..16 bits # 15..08 bits # 07..00	Time (32 bit) 1/100s 00 - 99 (BCD) Seconds 00 - 59 (BCD) Minutes 00 - 59 (BCD) Hours 00 - 24 (BCD) Example: 15:42:03.75 stored as 7503 4215(16)
T10	bits # 31..24 bits # 23..16 bits # 15..00	Date (32 bit) Day of month 01 - 31 (BCD) Month of year 01 - 12 (BCD) Year (unsigned integer) 1998..4095 Example: 10, SEP 2000 stored as 1009 07D0(16)
T_Str4 (T11)		Text String 4 characters Two characters per 16 bit register
T_Str6 (T12)		Text String 6 characters Two charcters per 16 bit register

T_Str8		Text String 8 characters Two characters per 16 bit register.
T_Str16		Text String 16 characters Two characters per 16 bit register.
T_Str20		Text String 20 characters Two characters per 16 bit register.
T16		Unsigned Value (16 bit), 2 decimal places Example: 123.45 stored as 123.45 = 3039(16)
T17		Signed Value (16 bit), 2 decimal places Example: -123.45 stored as -123.45 = CFC7(16)
T_Time	bits # 63..56 bits # 55..48 bits # 47..40 bits # 39..32 bits # 31..24 bits # 23..16 bits # 15..00	Time and Date (64 bit) 1/100s 00 - 99 (BCD) Seconds 00 - 59 (BCD) Minutes 00 - 59 (BCD) Hours 00 - 24 (BCD) Day of month 01 - 31 (BCD) Month of year 01 - 12 (BCD) Year (unsigned integer) 1998..4095 Example: 15:42:03.75, 10. SEP 2000 stored as 7503 4215 1009 07D0(16)
T_TimeIEC	bits # 63..55	Time and Date (64 bit) = IEC870-5-4 "Binary Time 2a" Reserved
	bits # 54..48 bits # 47..44 bits # 43..40 bits # 39..37 bits # 36..32 bit # 31 bits # 30..29 bits # 28..24 bit # 23 bit # 22 bits # 21..16 bits # 15..00	Years (0 .. 99) Reserved Months (1 .. 12) Day of Week (1 .. 7) Day of Month (1 .. 31) Summer Time (0 .. 1): Summer time (1), Standard time (0) Reserved Hours (0 .. 23) Invalid (0 .. 1): Invalid (1), Valid (0) Reserved Minutes (0 .. 59) Miliseconds (0 .. 59999) Example: 15:42, 1. SEP stored as 4215 0109(16)
T_Data		Record Data Size and SubTypes depends on the Actual Memory Part
T_Str40		Text String 40 characters Two characters per 16 bit register.
T_float	bits # 31 bits # 30..23 bits # 22..0	IEEE 754 Floating-Point Single Precision Value (32 bit) Sign Bit (1 bit) Exponent Field (8 bit) Significand (23 bit) Example: 123.45 stored as 123.45000 = 42F6 E666(16)
T9A	bits # 15..08 bits # 07..00	Time (16 bit) Minutes 00 - 59 (BCD) Hours 00 - 24 (BCD) Example: 15:42 stored as 4215(16)

T10A	bits # 15..08 bits # 07..00	Date (16 bit) Day of month 00 - 31 (BCD) Month of year 00 - 12 (BCD) Example: 30, SEP stored as 3009(16)
T18		Signed Value (16 bit), 4 decimal places Example: -0.2345 stored as -2345 = F6D7(16)
T_DSK		HEX value 16 bytes
T_unix	Bits # 31..00	Unix time (32 bit) Seconds since January 1, 1970 Example: 16 May 2012 10:36:46 GMT stored as 4FB3 833E(16)

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Published by Iskra, d.o.o. • Subject to change without notice • Version 2.13 September 2024 • EN K22.433.950/951