

User 's Manual



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.	
CE	Compliance of the product with European CE directives.	
	Double insulation.	
$\frac{1}{2}$	Three-phase connection.	
ļ	Single-phase connection.	
ΔŢ	Bidirectional energy measurement.	
	IR optical communication.	
i	Read user's manual.	





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.



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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	2
1.2	HARDWARE DESCRIPTION	3
1.3	Main features	4

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



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 (I_{max}) 40 A.
- Reference current 5 A (I_{ref}).
- Reference voltage 3x230 V/400 V (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).
 - \circ 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	6
2.2	ELECTRICAL CONNECTION	7

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 mm² ... 25 (16) mm².
 - 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 mm² ... 2.5 mm².
 - 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	10
3.2	WELCOME SCREENS	10
3.3	LCD DISPLAY INFORMATION	11

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

 $\begin{array}{c}1\\\hline\\2\\\hline\\3\\\hline\\2\\\hline\\3\\\hline\\200\end{array}$

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	00000000 12:40 c-L- 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	00000000 1 10,76 c-l kWh
BIT 12	Cable Loss 2 (A-) - of last charging (in idle state) - of actual charging event (during charging)	LoS- Unit: kWh	0000000 005 Los- kwh
BIT 11	Cable Loss (A+) - of last charging (in idle state) - of actual charging event (during charging)	LoSS Unit: kWh	0000000 035 Loss кwh
BIT 10	Cable Resistance setting (mOhm)	CrES Unit mOhm is not shown.	00000000 35,00 cres
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	00000000 1234 c ^{r.} kwh
BIT 8	Export active energy counter	A- Unit: kWh	00000097 00000 i28 8- kwb
BIT 7	SW version	Sof	00000000 0,2 1 50F

BIT 6	Serial number	Sn	00000000 19390006 so
BIT 5	Time	1 st digit: Clock status (see Table 5) Digits after dot: Loc (Local time), or Utc (UTC time)	00000000 04 33 22 400
BIT 4	Date (e.g.: day, month, year)	hh.mm (hour.minutes) (time - e.g.: 00 (hour).11 (minutes))	00000000 0 1-0 1- 19
BIT 3	Custom String	LCD Custom string label (see Table 3); Available characters (see chapter 3.3.3)	00000000 ŁĖŚŁ ŁEŚŁ
BIT 2	Transaction number	tr.no	00000000 34
BIT 1	Duration (e.g.: 3 h 13 min 42 s)	Charging power (e.g.: 0 W)	00000000 3h 13 42 ° w
BIT O	Energy consumption of charging End: Consumption of last charging in idle state. Run: Consumption of actual charging event (during charging).	1 st digit: Clock status (see Table 5) 2 nd digit: Charging status (see Table 6)	00000000 Run 000 u ^p kwh

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: Lo	CD cycling period	

Custom string is defined in register 47063:

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	С
2	Charging after power down	Р
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: E	Error bits

Example:



Figure 8: Error display

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

BITO 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 6.5.6.1 Change Lock control.

Example:



Figure 9: Warning display

3.3.3 List of available characters on LCD

0,0,1,I,I,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.

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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).

Refresh	Address: 33 🔄 WM3M4C	A Go to: 👻 Device #33, CC	0M4 - Serial, Setting: 19200,None,8,1
	Settings	Coming	WM3M4C, Serial number: W4170617, Read at 12:48:4
_ <u>_</u>	- Ceneral	Setting	Value
Connection	Communication	Type Secol Number	WM3M4C
	🜉 Display	Sehai Number	2.12
	🔯 Security	Software version	2.12
	🚺 Energy	Annual and a second	
Settings		Accuracy class	250
		Calibration Voltage (V)	250
		Calibration Current (A)	40
1		Communication (COMI)	R5485
Measurements		Digital signature algorithm	
		Public Rey	598D5AB6A78CD3BDD3374FBF836ABF59D279ED1AF8447D74
		OCMF format version	1.4
13-704		Software references	
Analysis		Calibration date	7. 06. 2022
		FW upgrade counter	0
_		MID unlock counter	0
(1		MID lock status	Locked
My Devices		Software Checksum	FU3E CO9D
my benees		Calibration Data Check Sum	1ECA
		Phase module L1	Version: 0.40, Checksum: B5E6 / C355
		Phase module L2	Version: 0.40, Checksum: B5E6 / C41E
. T.		Phase module L3	Version: 0.40, Checksum: B5E6 / 7F3C
opgrades		Type Read only information about device type	a.

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 2 : changes should be downloaded to the device by pressing this button when programming is finished.
- SAVE 🛃 : the file settings will be saved.
- EXPORT is 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 (1) : preview of a PDF file.
- GRAPHICAL ANALYSIS I : measurements can be shown in a graphical form (not supported by this meter).
- COMMUNICATION PORT SETTING Ѷ : opens window for communication port settings.
- INTERACTIVE INSTRUMENT I : 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 髿 : for more detailed information how to handle a device.



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

Co	ommunication port	×
	Serial Ethemet USB IR	LPR Flag
	Communication port:	COM3 ~
	Bits per second:	19200 ~
	Parity:	None \sim
	Data bits:	8 ~
	Stop bits:	2 ~
		OK Cancel

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*.

 Image: Stating Studio

 File
 Iools
 View
 Help

 Image: Stating Studio

 Image: Stating Sta

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.







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.

Setting		Value	
Гуре		WM3M4	
Serial Number	nal Number 19390006		
Software versior	1	0.72	
Hardware versio	n	E	
ccuracy class		1	
alibration	ao 00	350	
alibration	Download settings	5	
Communic	Download settings (Only changes)	S485	
Digital sign	Update MiSmart	ecp256r1	
ublic key		EF9BA7531DB575A6D4B36B6CBF6C9AF2D136934B679FF3DE.	
DCMF form	Save	.0	
Software 🗎	Сору		
Calibration date		23. 09. 2019	
W upgrade cou	unter	7	
/ID unlock cou	nter	0	
MID lock status		Unlocked	
Software Check	sum	293F	
Calibration Data	CheckSum	D020	
^p hase module L	1	Version: 0.40, Checksum: B5E6 / A195	
^p hase module L	2	Version: 0.40, Checksum: B5E6 / 9B69	
Phase module L	3	Version: 0.40, Checksum: B5E6 / 0F49	

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:

🕎 MiQen 2.1 - Set	ting Studio		– 🗆 X
File Tools \	/iew Help		
📫 🔒 💕 - 🖆			
Refresh	Address: 33 WM3M4	🔿 Go to: 🔹 Device #33, COM3 - Serial, S	etting: 19200,None,8,2 -
1	G Settings		WM3M4, Serial number: W4124940, Read at 09:02:43
		Setting	Value
Connection	🖃 📸 General	Туре	WM3M4
		Serial Number	W4124940
	Display	Software version	0.49
	Energy	Hardware version	D
Settings	U Ellergy	Accuracy class	1
Settings		Calibration Voltage (V)	250
	Calibration Current (A) 40	40	
		Communication (COM1)	RS485
Measurements		Digital signature algorithm	Signing not supported
		Software references	
	Calibration date 1	11. 03. 2021	
		FW upgrade counter	0
4.27		MID unlock counter	0
Analysis		MID lock status	Locked
		Software Checksum	FDCB AF5A
		Calibration Data CheckSum	831E
		Phase module L1	
My Devices		Phase module L2	
		Phase module L3	Version: 0.40, Checksum: B5E6 / E9D2
Upgrades		🕡 Туре	
		Read only information about device type.	

Figure 17: WM3M4 Identification window

🍓 Refresh	Address: 33 🔄 WM3M4C	r⇒ Go to: - Device #33, CO	DM4 - Serial, Setting: 19200,None,8,1
	Con Settings		WM3M4C, Serial number: W4170617, Read at 12:
		Setting	Value
Connection	General General	Туре	WM3M4C
	Display	Serial Number	W4170617
- 655	Security	Software version	2.12
0	Energy	Hardware version	D
Settings		Accuracy class	1
2		Calibration Voltage (V)	250
		Calibration Current (A)	40
		Communication (COM1)	RS485
Massuramentr		Digital signature algorithm	secp256r1
weasurements	Vieasurements	Public key	598D5AB6A78CD3BDD3374FBF896ABF59D279ED1AF8447D7
		OCMF format version	1.3
11.00		Software references	
1		Calibration date	7. 06. 2022
Analysis		FW upgrade counter	0
		MID unlock counter	0
		MID lock status	Locked
1		Software Checksum	F03E C99D
My Devices		Calibration Data Check Sum	1ECA
		Phase module L1	Version: 0.40, Checksum: B5E6 / C355
		Phase module L2	Version: 0.40, Checksum: B5E6 / C41E
_		Phase module L3	Version: 0.40, Checksum: B5E6 / 7F3C
Upgrades		Type Read only information about device typ	e.

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).

🖥 HiQen 2.1 - Setting Studio					
Ele Iools View Help					
📫 🔒 📂 - 🖆					
Refresh	Address: 33 📃 WM3M4C	Go to: • Device #33, COM5 - Serial, Se	etting: 115200,None,8,1		
	🞲 Settings		WM3M4C, Serial number: W4124943, Read at 14:32:28		
	E WM3M4C	Setting	Value		
Connection	E General	Description			
	Communication	Location			
		Operating mode	Normal mode		
100 A		Date and Time	Do not change		
Settings	100g)	UTC time offset	0		
occurgo		UTC time use			
		Synchronisation timeout	0		
		Digital signature format	HEX 💌		
		Format of complete transaction	Command 'r' "TX":"E" (Transparent SW compatible)		
measurements		Output Message Options	C1-B, C1-E		
		Output Message Config			
100		Cable Loss Energy Config	Not included		
424		Cable Resistance (mOhm)	35		
Analysis					
My Devices					
		Oigital signature format	Password: 2		
5					
Upgrades					
	1				

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.

🖬 MiQen 2.1 - Setting Studio				
Ele <u>I</u> ools <u>Vi</u> ew <u>H</u> elp				
📫 🔒 📂 - 🖆	🛛 🖬 🖾 🔍 🛄 📎 🗖 🤅			
🖏 Refresh	Address: 33 🖾 WM3M4C	→ Go to: - Device #33, C	OM5 - Serial, Setting: 115200,None,8,1	۲
	Settings		WM3M4C. Serial number: W4124943. Read at	t 14:32:28
	E WM3M4C	Setting	Value	
Connection	🖶 🔝 General	Description		
Connection	- Section	Location		
	Display	Operating mode	Normal mode	-
	Security	Date and Time	Normal mode	
	Energy	UTC time offset	Test mode P - Fast	
Setungs		UTC time use	Test mode Q	- 1
		Synchronisation timeout	Test mode Q - Fast Test mode Q - Fast (Counter only)	
	Digital signature format	Digital signature format	HEX	_
		Format of complete transaction	Command 'r' "TX":"E" (Transparent SW compatible)	
Measurements		Output Message Options	C1-B, C1-E	
		Output Message Config		
100		Cable Loss Energy Config	Not included	
-24		Cable Resistance (mOhm)	35	
Analysis			·	
My Devices				
		Operating mode	Pass	word: 0
		The test mode is used for meter testing a	nd is designed to increase resolution of the energy counter and reduce the time r	required
5		for testing.		
Upgrades	1			

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.

🔚 MiQen 2.1 - Sett	ing Studio			_ [] ×
<u>File T</u> ools <u>V</u> i	iew <u>H</u> elp			
📫 🗟 💕 - 🖆	🖬 🕼 🖪 🛕 🛍 🔌 🖬 🛸 🍕			
Refresh	Address: 33 🖾 WM3M4C	🔿 Go to: 👻 Device #33, COM5 - Serial, S	Setting: 115200,None,8,1	
	🞲 Settings		WM3M4C, Serial number: W4124	1943, Read at 14:32:28
	E- WM3M4C	Setting	Value	
Connection	🖻 🔝 General	Description		
		Location	UTC time use	×
	Display	Operating mode		
	Energy	Date and Time		
Settinge	in g Lingy	UTC time offset		
betungs		UTC time use		
		Synchronisation timeout		
		Digital signature format		
		Format of complete transaction		
measurements		Output Message Options		
		Output Message Config		
100		Cable Loss Energy Config		
42**		Cable Resistance (mOhm)		
Analysis				OK
				UK
				Cancel
1				
My Devices				F
		UTC time use		
50				
Upgrades				

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).

l 🗟 📂 - 📫				
Refresh	Address: 33 🔄 WM3M4C	→ Go to: • Device #33, C	OM5 - Serial, Setting: 115200,None,8,1	
_	Ci Settings		WM3M4C, Serial number: V	V4124943, Read at 14:32
	E-E WM3M4C	Setting	Value	
Connection	🖃 🚓 General	Description		
connection	Communication	Location		
	Display	Operating mode	Normal mode	
	Security	Date and Time	Do not change	
	Energy	UTC time offset	0	
Settings		UTC time use	-	
		Synchronisation timeout	0	
		Digital signature format	HEX	-
		Format of complete transaction	HEX	
Measurements		Output Message Options	Base64	
		Output Message Config	-	
277 % .		Cable Loss Energy Config	Not included	
124		Cable Resistance (mOhm)	35	
Analysis				
My Devices				
		(f) Digital signature format		Password:
		~		

Figure 22: Digital signature format window



4.4.1.1 Communication

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

G Settings		WM3M4, Serial number: 19390006, Read at 07:24:58
□-□ WM3M4	Setting	Value
i 😭 General	Communication parameters (COM1)	#32, 19200,None,8,2
Display		
Security		
🚺 Energy		

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.

RiQen 2.1 - Sett	ting Studio			
<u>File T</u> ools <u>V</u>	iew <u>H</u> elp			
📫 🗟 📂 - 🗳	📓 🕼 🖪 🕰 🛍 🔌 🗖 🕪 🕯	3		
Refresh	Address: 33 🔲 WM3M4C	A Go to: - Device #33, CO	M5 - Serial, Setting: 115200,None,8,1	•
	Ci Settings		WM3M4C, Serial number:	W4124943, Read at 14:32:28
	E WM3M4C	Setting	Value	
Connection	🖻 🔚 General	Back light	On	•
	Communication	Displayed params	On	
	Display	Custom text	0	
	Energy	Custom label	Cust	
Settings	U Dielgy	Cycling period (sec)	5	
Securgs		Display MID info screen (sec)	Disabled	
@			· · · · · · · · · · · · · · · · · · ·	
Measurements		😲 Back light		Password: 1

Figure 24: Backlight window

• Display params set the parameters displayed on the LCD.

Displayed params	×
Consumption Duration Signature counter Custom text Date Time Serial number Software version Counter 2 Date	
Consumption 2 (A-) Cable Resistance (mOhm) Cable Loss (A+) Cable Loss 2 (A-) Consumption (A+) - Cable Loss (A+) Consumption 2 (A-) + Cable Loss 2	OK Cancel

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.

署 MiQen 2.1 - Sett	ing Studio		
<u>File Tools V</u>	iew <u>H</u> elp		
📫 🔒 🐸 - 🖺	🔒 🕼 🛃 🛕 🛍 🗞 🗖 🧐 🍪		
Refresh	Address: 33 🖾 WM3M4C	🔿 Go to: 🔻 Device #33, COM5 - Serial, Se	etting: 115200,None,8,1
-	Con Settings		WM3M4C, Serial number: W4124943, Read at 14:32:28
	E- WM3M4C	Setting	Value
Connection	E- Ceneral	Password - Level 1	Not set
	Communication	Password - Level 2	Not set
	Security	Change setting control	0
	Energy	Change Lock control - PERMANENT LOCK	0
Settings	U Diogy		
		I	
		(f) Password - Level 1	Password: 2
Measurements			.::

Figure 26: Security window

PLEASE NOTE

oodc

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.

Eile Tools	View Help		
1 🔒 💕 - 1 🎦	🔒 🕼 🦪 🛕 🕼 🔌 🗖 🥹		
🍓 Refresh	Address: 33 📰 WM3M4C	→ Go to: • Device #33, 0	COM4 - Serial, Setting: 19200,None,8,1
	G Settings		WM3M4C, Serial number: W4170617, Read at 12:48:
		Setting	Value
Connection	🖨 🔚 General	Total Energy Calculation	Evaluation of the sum of phases
	Counter 1		
40	Sotting	Measured Energy	Import Active Energy (Wh)
		Counter 2	
Settings		Measured Energy	Export Active Energy (Wh)
		Counter 3	
1	Measured Energy	Import Squared Current Energy (AAh)	
	Counter 4		
	Measured Energy	Export Squared Current Energy (AAh)	
vieasurements		(i) Total Energy Calculation	

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:

e <u>1</u> 0015	Tienh Tienh				
🚽 📴 📲 🔛		>			
Refresh	Address: 33 🔄 WM3M4C	A Go to: 🔹 Device #33, C	OM4 - Serial, Setting: 1920	0,None,8,1	
	Measurements			WM3M40	, Serial number: W41
	Phase measurements	L1	L2	L3	Total
onnection	Voltage	231,7 V	231,7 V	231,6 V	
	Current	0,097 A	0,000 A	0,000 A	
0.8	Active Power	-1,0 W	0,0 W	0.0 W	-1,0 W
(2)	Reactive Power	22,0 var	0,0 var	0,0 var	22,0 var
Settings	Apparent Power	22,4 VA	0,0 VA	0,0 VA	22,4 VA
	Power Factor	-0,0477 Ind	1,0000 Ind	1,0000 Ind	-0,0477 Ind
_	Power Angle	92,72 °	0.00 °	0.00 *	92,77 °
	THD-Up	2,42 %	2,42 %	2,41 %	
asurements	THD-I	16,88 %	0.00 %	0.00 %	
	Phase to phase measurements	L1 - L2	L2 - L3	L3-L1	Others
	Phase to phase voltage	0,0 V	0.0 V	0.0 V	Inc = 0,097 A
in	Phase Angle	0.02 *	-0.05 °	0.03 *	
Analysis	Energy counters	Counter E1 (Imp)	Counter E2 (Exp)	Counter E3 (Imp)	Counter E4 (Exp)
Analysis	Energy counters	0.000 kWh	0.002 kWh	0.000 kAAh	0.000 k AAh
	Others	Value			
	Frequency	50,01 Hz			
	Temperature	36,9 °C			
My Devices	Status	Value			
	Checksum status	ОК			
	Charge control Massaurante				
20	charge control i Measurements i	_			

Figure 28: Measurements window

🖶 🗁 • 🖺	▋▋₲▎▟▐▖▏▓▎▓▕▋▎▓				
Refresh	Address: 33 🔄 WM3M4C	🔿 Go to: 🔹 Device #33, CC	M4 - Serial, Setting: 192	200,None,8,1	
	Measurements			WM3M40	C, Serial number: W
	Transaction	Status	Duration	Consumption	Power
Connection	Transaction state	Finished	0:00:20	0,000 kWh	-1.0 W
	Transaction events	Time	Value		
0.0	Begin transaction	6.09.2024 14:54:16			
(2)	End transaction	6.09.2024 14:54:36			
Settings	Last Tariff change		-		
	Last Intermediate reading		-		
_	Last Fiscal reading				
	Last Hold measurement command				
	Last Suspend command				
	Transaction statistics	Count			
	Tariff changes	0			
1 mil	Intermediate readings	0			
Analysis	Device statistics	Count			
Analysis	Power up	1.222			
	Signatures	2.699			
	Fiscal readings	2.308			
My Devices	Others	Value			
	Date and Time	6.09.2024 14:56:25	Local time	Synchronised	

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.

Measurements Reco	rder	×		
Recorder Filter				
File name: Path:	18190532.csv C:\\MiQen 2.1\Data	~ 		
File Type: Data Type:	Excel (*.csv) Values & Units	~		
C Start Recording				
Status: Stopped	ng 🚰	Close Recording time: 0:00:00		

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	31
5.2	SELECTION OF AVAILABLE QUANTITIES	32
5.3	CALCULATION AND DISPLAY OF MEASUREMENTS	33


5.1 Online measurements

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

🔒 📂 • 🖺	3 8 G 6 G 6 🗞 🔍 🔲 🕅	» 🗟			
Refresh	Address: 33 🔄 WM3M4C	🔿 Go to: ▾ Device #33,	COM4 - Serial, Setting: 192	00,None,8,1	
-	Measurements			WM3M4	4C, Serial number: W4
	Phase measurements	L1	L2	L3	Total
onnection	Voltage	230,9 V	230,9 V	230,8 V	
	Current	0,097 A	0,000 A	0,000 A	
0.0	Active Power	-0,9 W	0.0 W	0.0 W	-0,9 W
(3)	Reactive Power	22,0 var	0,0 var	0,0 var	22,0 var
Settings	Apparent Power	22,3 VA	0,0 VA	0,0 VA	22,3 VA
-	Power Factor	-0,0437 Ind	1,0000 Ind	1,0000 Ind	-0,0437 Ind
	Power Angle	92,49 °	0.00 *	0.00 °	92,55 °
	THD-Up	2,46 %	2,45 %	2,46 %	
asurements	THD-I	17,28 %	0.00 %	0.00 %	
asarements	Phase to phase measurements	L1 - L2	L2 - L3	L3 - L1	Others
	Phase to phase voltage	0,0 V	0,0 V	0,0 V	Inc = 0,097 A
11-12	Phase Angle	0.02 *	-0,05 °	0.03 °	
Analysis	Energy counters	Counter E1 (Imp)	Counter E2 (Exp)	Counter E3 (Imp)	Counter E4 (Exp)
Analysis	Energy counters	0,000 kWh	0,002 kWh	0,000 kAAh	0,000 kAAh
	Others	Value			
r an	Frequency	49,99 Hz			
	Temperature	36,9 °C			
ly Devices	Status	Value			
	Checksum status	OK			
	Charge control Measurements				

Figure 31: Online measurements window.

1001s					
🖶 🗁 • 🗈					
Refresh	Address: 33 WM3M4C	A Go to: 🔹 Device #33, CC	M4 - Serial, Setting: 192	200,None,8,1	
	Measurements			WM3M4	C, Serial number: W41
	Transaction	Status	Duration	Consumption	Power
Connection	Transaction state	Finished	0:00:20	0,000 kWh	-1,0 W
	Transaction events	Time	Value		
0.0	Begin transaction	6. 09. 2024 14:54:16	-		
0	End transaction	6. 09. 2024 14:54:36	-		
Settings	Last Tariff change				
-	Last Intermediate reading				
	Last Fiscal reading				
	Last Hold measurement command	-	-		
	Last Suspend command	-	-		
	Transaction statistics	Count			
	Tariff changes	0			
Stand	Intermediate readings	0			
Applyric	Device statistics	Count			
Analysis	Power up	1.222			
	Signatures	2.699			
	Fiscal readings	2.308			
My Devices	Others	Value			
	Date and Time	6. 09. 2024 14:56:25	Local time	Synchronised	
	Chame control Measurements				

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	Voltage			
measurements	U ₁₋₃	\checkmark	\checkmark	
	Current			
	I ₁₋₃	\checkmark	$\overline{\mathbf{A}}$	
	I _{NC}			Calculated neutral current
	Power			
	P ₁₋₃	\checkmark	\checkmark	
	P _{TOT}	\checkmark	$\overline{\mathbf{A}}$	
	Q ₁₋₃	\checkmark		
	QTOT	$\overline{\checkmark}$	\checkmark	
	S ₁₋₃	\checkmark	\checkmark	
	S _{TOT}	\checkmark	$\overline{\mathbf{A}}$	
	PF ₁₋₃	\checkmark	$\overline{\mathbf{A}}$	
	PFTOT	\checkmark	\checkmark	
	φ1-3	\checkmark	$\overline{\mathbf{A}}$	
	Фтот	\checkmark	$\overline{\mathbf{A}}$	
	Harmonic analysis			
	THD-U ₁₋₃	\checkmark	\checkmark	
	THD-I ₁₋₃	\checkmark	\checkmark	
Phase to phase	Voltage			
measurements	Upp ₁₋₃		\checkmark	
	ф _{х-у}		\checkmark	Phase-to-phase angle
Metering	Energy		\checkmark	
	Counter E ₁		\checkmark	
Other	Miscellaneous			
measurements	Frequency	\checkmark	\checkmark	
	Temperature	\checkmark		
Status	Checksum status		\checkmark	

Image: 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 (U₁, U₂, U₃) and phase-to-phase voltages (U₁₂, U₂₃, U₃₁).
- Phase and phase-to-phase voltage angles (ϕ_{12} , ϕ_{23} , ϕ_{31}).

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

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:

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

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	36
6.2	DIGITAL SIGNING PROCEDURE	36
6.3	ENERGY METER CRYPTOGRAPHIC FUNCTIONS EXPLANATION	37
6.4	CONSUMPTION MEASURING AND DIGITAL SIGNING PROCEDURE	38
6.5	Crypto Register Definitions	38
6.6	POWER LOSS BEHAVIOUR	54
6.7	UNEXPECTED RESET BEHAVIOUR	54

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: <u>http://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.180-4.pdf</u>. 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.



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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.

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

6.5.2 Communication parameter

Table 10: RS485 communication parameters table

Default settings:

Baud rate: 115200 Parity: None Stop bits: 1

6.5.3 Cryptographic control registers

MODBUS	Size in	Access Type	Description
Address	bytes		
47051	2	R/W	Command Register (see <i>Table 15</i>)
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 2 nd 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 <i>Table 5</i>)
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



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

6.5.4 Signature status register (47052)

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:

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

Figure 35: Cable losses equation

 $I_{\rm x}$ 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	T1	12345	Enable changes for		0	RW
		control			60s			

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:

🖏 MiQen 2.1 - Sett	ing Studio		
Eile <u>T</u> ools ⊻i	iew <u>H</u> elp		
🖬 🗟 📂 - 🔛			
Refresh	Address: 33 🖾 WM3M4C	i Go to: ▼ Device #33, COM5 - Serial, Se	tting: 115200,None,8,1
	() Settings		WM3M4C, Serial number: W4124943, Read at 10:24:38
	E WM3M4C	Setting	Value
Connection	E General	Password - Level 1	Not set
	Communication	Password - Level 2	Not set
	Security	Change setting control	12345
<u> </u>	Energy	Change Lock control - PERMANENT LOCK	0
Settings			
	1	(1) Change setting control	Min: 0 Max: 65535 Password: 2

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": "<mark>T28</mark>"
"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)	End transaction	Active state	
'L' (0x4C)			
'R' (0x52)			
'A' (0x41)			
'P' (0x50)			
'C' (0x43)	Intermediate Reading	Active state	
'X' (0x58)	Exception	Active state	
'T' (0x54)	Tariff Change	Active state	
'S' (0x53)	Suspended command	Active state	
ʻr' (0x72)	End transaction (with begin and end)	Active state	
'f' (0x66)	Fiscal Reading	Any state	
'h' (0x68)	Hold command	Active state	
ʻi' (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 <mark>"RU": "kWh",</mark> //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)	Т6		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)	Т3		
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	Description	
	block		
0	"TX": "r"	The same operation as in version 2.03	
1	"ТХ": "Е"	Improves presentation of data in the Transparenz	
		software	
2	"TX": "E" Command 'E'	Allows compatibility with other devices in case of	
	generates begin and end	different approach to OCMF specification	
	transaction		

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	56
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7.6	Dimensions	60

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:	\pm 1% of I_{ref} from I_{st} to I_{ref}
	\pm 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}
	\pm 1% of measured value from I_{ref} to I_{max}
Reactive, Apparent power:	$\pm 2\%$ of nominal power from I_{st} to I_{ref}
	$\pm 2\%$ 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:	МЗ
	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	Туре:	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	Туре:	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:	11
Installation category	300 Vrms CAT III
Standard:	IEC 62052-31
Mechanical environment:	М1
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



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	
РТВ	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	Data	Ind	Values / Dependencies
		Input Registers		Ì	
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 O	Invalid measurement phase 1
			Bit 1	Invalid measurement phase 2

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				Bit 2	Invalid measurement phase 3
30102	30104	Reserved			
30105	30106	Frequency	Т5		
30107	30108	U1	Т5		
30109	30110	U2	Т5		
30111	30112	U3	Т5		
30113	30114	Uavg (phase to neutral)	Т5		
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	Т5		
30122	30123	U31	Т5		
30124	30125	Uavg (phase to phase)	Т5		
30126	30127	11	Т5		Valid: Reg 30001<7
30128	30129	12	Т5		Valid: Reg 30001<7
30130	30131	13	Т5		Valid: Reg 30001<7
30132	30133	Inc	Т5		
30134	30135	Reserved: Inm	Т5		
30136	30137	lavg	Т5		
30138	30139	SI	Т5		
30140	30141	Active Power Total (Pt)	Т6		
30142	30143	Active Power Phase L1 (P1)	Т6		Valid: Reg 30001<7
30144	30145	Active Power Phase L2 (P2)	Т6		Valid: Reg 30001<7
30146	30147	Active Power Phase L3 (P3)	Т6		Valid: Reg 30001<7
30148	30149	Reactive Power Total (Qt)	Т6		
30150	30151	Reactive Power Phase L1 (Q1)	Т6		Valid: Reg 30001<7
30152	30153	Reactive Power Phase L2 (Q2)	Т6		Valid: Reg 30001<7
30154	30155	Reactive Power Phase L3 (Q3)	Т6		Valid: Reg 30001<7
30156	30157	Apparent Power Total (St)	Т5		
30158	30159	Apparent Power Phase L1 (S1)	Т5		Valid: Reg 30001<7
30160	30161	Apparent Power Phase L2 (S2)	Т5		Valid: Reg 30001<7
30162	30163	Apparent Power Phase L3 (S3)	Т5		Valid: Reg 30001<7
30164	30165	Power Factor Total (PFt)	Т7		
30166	30167	Power Factor Phase 1 (PF1)	Т7		Valid: Reg 30001<7
30168	30169	Power Factor Phase 2 (PF2)	Т7		Valid: Reg 30001<7
30170	30171	Power Factor Phase 3 (PF3)	Т7		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		

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30187		Reserved: U31 THD%	T16		
30188		I1 THD%	T16		
30189		12 THD%	T16		
30190		13 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)	Т2		
30415		Energy Counter 2 Exponent (Non-reset)	Т2		
30416		Energy Counter 3 Exponent (Non-reset)	Т2		
30417		Energy Counter 4 Exponent (Non-reset)	Т2		
30418	30419	Energy Counter 1 (Non-reset)	Т3		
30420	30421	Energy Counter 2 (Non-reset)	Т3		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)	Т3		'= 0 after reset
35505	35506	Frequency	T5		
35507	35508	U1	T5		

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35509	35510	U2	Т5	
35511	35512	U3	Т5	
35513	35514	Uavg (phase to neutral)	Т5	
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	11	T5	
35528	35529	12	T5	
35530	35531	13	T5	
35532	35533	Reserved: Inc	T5	
35534	35535	Reserved: Inm	Т5	
35536	35537	lavg	Т5	
35538	35539	Reserved: S I	T5	
35540	35541	Active Power Total (Pt)	Т6	
35542	35543	Active Power Phase L1 (P1)	Т6	
35544	35545	Active Power Phase L2 (P2)	Т6	
35546	35547	Active Power Phase L3 (P3)	Т6	
35548	35549	Reactive Power Total (Qt)	Т6	
35550	35551	Reactive Power Phase L1 (Q1)	Т6	
35552	35553	Reactive Power Phase L2 (Q2)	Т6	
35554	35555	Reactive Power Phase L3 (Q3)	Т6	
35556	35557	Apparent Power Total (St)	Т5	
35558	35559	Apparent Power Phase L1 (S1)	T5	
35560	35561	Apparent Power Phase L2 (S2)	T5	
35562	35563	Apparent Power Phase L3 (S3)	Т5	
35564	35565	Power Factor Total (PFt)	Т7	
35566	35567	Power Factor Phase 1 (PF1)	Т7	
35568	35569	Power Factor Phase 2 (PF2)	Т7	
35570	35571	Power Factor Phase 3 (PF3)	Т7	
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	

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35591	35599	Reserved		
		MAXIMUM MEASUREMENTS		
35600	35604	Reserved		
35605	35606	Frequency	T5	
35607	35608	U1	T5	
35609	35610	U2	Т5	
35611	35612	U3	Т5	
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	Т5	
35622	35623	U31	Т5	
35624	35625	Uavg (phase to phase)	Т5	
35626	35627	11	Т5	
35628	35629	12	Т5	
35630	35631	13	Т5	
35632	35633	Reserved: Inc	T5	
35634	35635	Reserved: Inm	Т5	
35636	35637	lavg	Т5	
35638	35639	S I	Т5	
35640	35641	Active Power Total (Pt)	Т6	
35642	35643	Active Power Phase L1 (P1)	Т6	
35644	35645	Active Power Phase L2 (P2)	Т6	
35646	35647	Active Power Phase L3 (P3)	Т6	
35648	35649	Reactive Power Total (Qt)	Т6	
35650	35651	Reactive Power Phase L1 (Q1)	Т6	
35652	35653	Reactive Power Phase L2 (Q2)	Т6	
35654	35655	Reactive Power Phase L3 (Q3)	Т6	
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	

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35686Network U3 THD%Ti6Network U3 THD%Ti635687Network U3 THD%Ni6Ni635689Network U3 THD%Ni6Ni635690S THD%Ni6Ni635691S THD%Ni6Ni635692S THD%Ni6Ni635693S SofeRetwordNi6Ni635704S Ni6RetwordNi6Ni635705S TOVacuum (MASUBEMENTS)Ni6Ni635706S Ni6FraquencyTSNi635707S Ni6Vacuum (Masubement)Ni6Ni635708S Ni6Vacuum (Masubement)Ni6Ni635708S Ni6Vacuum (Masubement)Ni6Ni635714S Ni6Vacuum (Masubement)Ni6Ni635714S Ni6Vacuum (Masubement)Ni7Ni635715J Nighe between U and U3Ni7Ni6Ni635716J Nighe between U and U3Ni7Ni6Ni635720J Nighe between U and U3Ni7Ni6Ni635721J Nighe between U and U3Ni7Ni6Ni635722J Nighe between U and U3Ni7Ni6Ni635723J Nighe between U and U3Ni7Ni6Ni635724S Ni7J Nighe between U and U3Ni6Ni635724S Ni7J Ni6Ni6Ni6Ni635734S Ni7Ni6Ni6Ni6Ni635744S Ni7 <th>35685</th> <th></th> <th>Reserved: U12 THD%</th> <th>T16</th> <th></th>	35685		Reserved: U12 THD%	T16	
35687Reserved: U31 THD%T163568811 THD%T163568912 THD%T163569033 THD%T163569135699ReservedT163570035704ReservedT13570535706FrequencyT53570735708U1T535708U1T535710U2T5357113712U335712U32T5357133714Uwg (phase to neutral)T535714Uug (phase to neutral)T73571512 (angle between U3 and U1)T173571612 (angle between U3 and U1)T173571835719U12T535720122T535721U32T535722U32 (phase to phase)T535723313T53572435729I23572512T535726357211335737Reserved: IncT535738Reserved: IncT53573885739S13574Active Power Thase L1 (P1)T635743574Active Power Thase L1 (P1)T635743574Active Power Thase L1 (P1)T635743574Active Power Thase L1 (P1)T635743574Active Power Thase L1 (P1)T635743575Reactive Power Thase L1 (P1)T635743575Reactive Power Thase L1 (P	35686		Reserved: U23 THD%	T16	
356881110%16163569012 110%163569013 110%16356918eeved16MINUM MEAUREMENTS163570035704Reseved163570535706Frequery75357073570811153571335714U21535714U2153571512 (angle between U1 and U2)173571412 (angle between U2 and U3)173571512 (angle between U2 and U3)173571612 (angle between U2 and U3)173571835719U12153572035721U3173572335731U3153574035724U3153572435725U31535725U31516357263572112153572835731131535738Reservet:Inc15357343533Reservet:Inc1535735Reservet:Inc15357343533Reservet:Inc15357343533Reservet:Inc1535744Active Power Phase 11(P1)1635745Active Power Phase 11(P1)163574635737Resctive Power Phase 11(P1)1635740Active Power Phase 11(P1)1635741Active Power Phase 11(P1)1635742Active Power Phase 11(P1)16	35687		Reserved: U31 THD%	T16	
35689 12 THOK T16 I 3690 13 THOK T16 I 3690 Reserved I I 3700 3704 Reserved I I 3707 35708 U1 T5 I 3708 U1 T5 I I 3711 3712 U2 T5 I 3711 3714 Urg (plase to noutral) T5 I 3712 12 (angle between U1 and U2) T17 I 3711 3714 Urg (plase to noutral) T17 I 3717 13 (angle between U3 and U1) T17 I 3718 3719 U12 (angle between U3 and U1) T17 I 3712 14 (angle between U3 and U1) T5 I I 3718 3719 U12 (angle between U3 and U1) T5 I 3724 3723 U31 (D T5 I 3724 3739 V3 Reservet: Inc T5 I 3724 3724 3734 Reservet: Inc T5 I 3738 3739 S374 Reservet: Inc T5 I 3734 3734 Reservet: Inc T5	35688		I1 THD%	T16	
35690is in the image of the imag	35689		12 THD%	T16	
35699 Reserved MINMUM MEASUREMENTS 35700 35704 Reserved Image: Comparison of the co	35690		13 THD%	T16	
MINIMUM MEASUREMENTS Minimum MEASUREMENTS Minimum Measurements 35700 35704 Reserved TS 35707 35708 U1 TS 35709 35700 U2 TS 35710 U2 TS Image: Comparison of the mean	35691	35699	Reserved		
3570035704ReservedIN3570535706FrequencyT53570735706U1T53570835710U2T53571335712U3T535714U32 (phase to neutral)T53571512 (angle between U1 and U2)1173571612 (angle between U2 and U3)T735717j31 (angle between U3 and U1)T73571835719U123571835719U123572035721U335721U3357233572135724U3357253572711T53572635727121235730357313573112357333573135734Reserved: Inm3573535737357363573735737lage power Total (P1)357483574935749Active Power Phase L1 (P1)357403574135747Active Power Phase L1 (P1)357483573735749Reactive Power Phase L1 (P1)357403574135749Reactive Power Phase L1 (P1)357403574135741Active Power Phase L1 (P1)357433574735743Reactive Power Phase L1 (P1)357443574335754Active Power Phase L1 (P1)357643575135755Reactive Power Phase L1 (P1)3576 <td></td> <td></td> <td>MINIMUM MEASUREMENTS</td> <td></td> <td></td>			MINIMUM MEASUREMENTS		
3570535706frequencyT5I3570735708U1T5I35710U2T5I3571135712U3T5I35713J2 (angle between U and U2)T7I35714J2 (angle between U and U3)T7I35715J2 (angle between U and U3)T7I35716J2 (angle between U and U3)T7I35717J3 (angle between U and U3)T7I3572035721U23T5I3572035721U23T5I35723J31T5II35724J23U31T5I35725J3727Uawg (phase to phase)T5I3572635721Uawg (phase to phase)T5I35738S5739Iscenved: IncT5I35739S5731I3T5I35730S5731Iscenved: IncT5I35734S5738Reserved: IncT5I35735Reserved: IncT5I35740S574Active Power Total (Pt)T6I35741Active Power Total (Pt)T6I35743S574Active Power Total (Pt)T6I35744S5749Active Power Total (Pt)T6I35740S575Reactive Power Total (Pt)T6I35743S574Active Power Total (Pt)T6I35744 <t< td=""><td>35700</td><td>35704</td><td>Reserved</td><td></td><td></td></t<>	35700	35704	Reserved		
3570735708U115I3570935710U2T5I3571135712U3T5I3571335714Uay (phase to neutral)T5I35715j12 (angle between U2 and U2)T17I35716j23 (angle between U2 and U3)T17I35717j31 (angle between U3 and U1)T17I3571835719U12T5I35720J35721U23T5I3572335721U23T5I35724U31T5I35725357271T5I35726357271T5I3573835737Reserved: IncT5I3573835737Reserved: IncT5I3574035737Reserved: IncT5I35741Active Power Total (P1)T6I3574235737Active Power Total (P1)T6I3574335747Active Power Phase L3 (P3)T6I3574435745Active Power Phase L3 (P3)T6I3574535751Reactive Power Phase L3 (P3)T6I357443574Active Power Phase L3 (P3)T6I3574535751Reactive Power Phase L3 (P3)T6I357463574Active Power Phase L3 (P3)T6I3575835751Reactive Power Phase L3 (P3)T5I3575835751 </td <td>35705</td> <td>35706</td> <td>Frequency</td> <td>Т5</td> <td></td>	35705	35706	Frequency	Т5	
3570935710U2U2T5I03571135712U3T5I03571335714U3 (phase to neutral)T5I035715J12 (angle between U2 and U3)T17I035716J3 (angle between U2 and U3)T17I035717J13 (angle between U3 and U1)T17I035718S719U12T5I035719J12U23T5I03572035721U3T5I035724U32U3T5I035725Javg (phase to phase)T5I03572635721I2I1T5I035737Reserved: IncT5I035738S5739S1T5I035730S5731Reserved: IncT5I035731S7371lavgT5I035732S5739S1T5I035734S5739S1T5I035740S5741Active Power Total (P1)T6I035741Active Power Total (P1)T6I035743Active Power Total (Q1)T6I035744S5749Reactive Power Total (Q2)T6I035750S5751Reactive Power Total (Q3)T5I035751Reactive Power Total (Q3)T6I035754S5751Reactive Power Total (Q3)T5I035753S5751Reactive Power Total (Q3)T5	35707	35708	U1	Т5	
3571135712U3U315IA35713127(ghase toneutral)T5IA3571512 (angle between U1 and U2)T17IA3571612 (angle between U2 and U3)T17IA35717IAIAIA3571835719U12T5IA3572035720U23T5IA3572035721U23T5IA3572435725Uay (phase to phase)T5IA357253572912T5IA3573035731I3T5IA35733Reserved: incT5IA3574435735Reserved: incT5IA3573435737IavgT5IA3573435737IavgT5IA3574435738Reserved: incT5IA35745Active Power Total (Pt)T6IA3574035741Active Power Phase L1 (P1)T6IA3574435745Active Power Phase L2 (P2)T6IA35745Active Power Phase L3 (P3)T6IA3574635747Active Power Phase L3 (P3)T6IA3574835758Reactive Power Phase L3 (Q3)T6IA3574935751Reactive Power Phase L3 (Q3)T6IA357403574Apparent Power Phase L3 (Q3)T5IA3574035751Reactive Power Phase L3 (Q3)T5IA35740357	35709	35710	U2	Т5	
35713 35714 Uaya (phase to neutral) 15 I 35715 12 (angle between U1 and U2) T17 I 35716 123 (angle between U2 and U3) T17 I 35717 31 (angle between U2 and U3) T17 I 35718 35719 U12 T5 I 35720 35721 U23 T5 I 35723 U31 T5 I I 35724 35725 Uaya (phase to phase) T5 I 35724 35725 Uaya (phase to phase) T5 I 35724 35725 Uaya (phase to phase) T5 I 35726 35721 13 T5 I I 35736 35731 I3 T5 I I 35738 Reservet: Inc T5 I I 35738 Reservet: Inc T5 I I 35738 35737 lavg T5 I I 35740 35731 Active Power Total (Pt) T6 I 35743 3574 Active Power Phase L1 (P1) T6 I 35744 35745 Active Power Phase L3 (P3) T6 I <t< td=""><td>35711</td><td>35712</td><td>U3</td><td>Т5</td><td></td></t<>	35711	35712	U3	Т5	
35715ij 2 (angle between U1 and U2)117I35716j2 2 (angle between U2 and U3)T17I3571731 (angle between U3 and U1)T17I3571885719U12T5I3572035721U23T5I35723U31U23T5I3572435725Uarg (phase to phase)T5I35725Uarg (phase to phase)T5I3572635727III3572835729I2T5I3573035731I3T5I35733Reserved: IncT5I35734Astrope Phase I1 (P1)T5I35735Reserved: IncT5I3574035731avgT5I35743Active Power Total (P1)T6I3574435745Active Power Phase I1 (P3)T6I3574535734Reactive Power Phase I2 (P2)T6I3574635747Active Power Phase I2 (P3)T6I3574835759Reactive Power Phase I2 (P3)T6I35749Reactive Power Phase I2 (P3)T6I357403574Active Power Phase I2 (P3)T6I357433575Reactive Power Phase I2 (P3)T6I357443575Reactive Power Phase I2 (P3)T6I357503573Reactive Power Phase I2 (P3)T6I <trr<tr>357403574</trr<tr>	35713	35714	Uavg (phase to neutral)	Т5	
3571623 (angle between U2 and U3)T17I3571731 (angle between U3 and U1)T17I3571835719U12T5I3572035721U23T5I3572435723U31T5I3572535724Uay (phase to phase)T5I35726357271T5I357283572912T5I357303573113T5I3573435735Reserved: IncT5I3573435737Reserved: IncT5I3573435737Reserved: InmT5I3573435739S1II3574035741Active Power Total (Pt)T6I3574135743Active Power Phase L1 (P1)T6I357443574Active Power Phase L3 (P3)T6I35745Active Power Phase L3 (P2)T6I357463574Active Power Phase L3 (P3)T6I357473575Reactive Power Phase L3 (Q3)T6I357403575Reactive Power Phase L3 (Q3)T6I357453575Reactive Power Phase L3 (Q3)T6I357463575Active Power Phase L3 (Q3)T6I357473575Reactive Power Phase L3 (Q3)T5I357483575Active Power Phase L3 (Q3)T5I357493576Apparent Power Phase L	35715		j12 (angle between U1 and U2)	T17	
3571731 (angle between U3 and U1)T17173571835719U12T5S3572035721U23T5S35723U31T5S3572435725U34 (phase to phase)T5S35726357271T5S357283572912T5S35730357313Reserved: IncT5S357313Reserved: IncT5S3573235737avgT5S3573435737Reserved: InmT5S35735Reserved: InmT5S3573635737avgT5S3574035741Active Power Total (Pt)T6S35741Active Power Total (Pt)T6S3574235743Active Power Total (Q1)T6S3575435751Reactive Power Total (Q2)T6S3575435753Reactive Power Total (Q1)T6S3575435754Apparent Power Phase L3 (Q3)T6S357543575Apparent Power Phase L3 (Q2)T5S35763575Apparent Power Phase L3 (S3)T5S35763576Apparent Power Phase L3 (S3)T5S35763576Apparent Power Phase L3 (S3)T5S35763576Apparent Power Phase L3 (S3)T5S35763576Apparent Power Phase L3 (S3)T5	35716		j23 (angle between U2 and U3)	T17	
35718 35719 U12 T5 I 35720 35721 U23 T5 I 35724 35725 U31 T5 I 35724 35725 Uay (phase to phase) T5 I 35726 35727 I T I 35728 35729 I2 T5 I 35730 35731 I3 T5 I 35734 35735 Reserved: Inc T5 I 35734 35735 Reserved: Inc T5 I 35734 35735 Reserved: Inc T5 I 35738 35737 Iavg T5 I 35740 35741 Active Power Total (Pt) T6 I 35743 35745 Active Power Phase L1 (P1) T6 I 35744 35745 Active Power Phase L2 (P2) T6 I 35744 35747 Reactive Power Phase L3 (P3) T6 I 35744 35758 Reactive Power Phase L3 (Q3) T6 I 35754 35757 Aparent Power Phase L3 (Q3) T6 I 35764 35758 Aparent Power Phase L3 (S3) T5 I 3576	35717		j31 (angle between U3 and U1)	T17	
3372035721U23T5I3572235723U31T5I3572435725Uay (phase to phase)T5I35726357271T5I35728357292T5I357303573113T5I3573435735Reserved: IncT5I3573535737asysReserved: IncT5I3573635737asysReserved: IncT5I3573635737asysSII3573735738Reserved: IncT5I3573835739S1Active Power Total (Pt)T6I3574435745Active Power Total (Pt)T6I357453574Active Power Phase L2 (P2)T6I357463574Active Power Total (Qt)T6I3574735758Reactive Power Total (Qt)T6I3574835759Reactive Power Total (Qt)T6I357543575Apparent Power Phase L3 (Q3)T5I357543575Apparent Power Phase L3 (Q3)T5I357543575Apparent Power Phase L3 (Q3)T5I357543575Apparent Power Phase L3 (Q3)T5I357503576Apparent Power Phase L3 (Q3)T5I35763576Apparent Power Phase L3 (Q3)T5I35763576Apparent Power Phase L3 (Q3	35718	35719	U12	Т5	<u> </u>
3572235723U31T5I3572435725Uavg (phase to phase)T5T5T535726357271T5T5T5357283572922T5T5T5357303573113T5T5T5T53573035731Reserved: IncT5T5T53573435735Reserved: InmT5T5T53573635737lavgT5T5T53573835739Active Power Total (Pt)T6T6T53574035743Active Power Total (Pt)T6T6T635741Active Power Total (Pt)T6T6T6T63574335749Active Power Phase L3 (P3)T6T6T63574435749Reactive Power Phase L3 (P3)T6T6T63575035751Reactive Power Phase L1 (Q1)T6T6T63575435759Reactive Power Phase L3 (Q3)T6T6T63575435759Apparent Power Total (St)T5T6T63576035761Apparent Power Phase L3 (Q3)T5T6T63576435769Apparent Power Phase L3 (Q3)T5T6T63576035761Apparent Power Phase L3 (Q3)T5T6T63576435769Apparent Power Phase L3 (Q3)T5T6T63576435769Apparent Power Phase L3 (Q3)T5 <td>35720</td> <td>35721</td> <td>U23</td> <td>Т5</td> <td></td>	35720	35721	U23	Т5	
3572435725Uavg (phase to phase)151635726357271151635728357291215163573035731331515163573235738Reserved: Inc1516163573385735Reserved: Inm1516163573435735Reserved: Inm1516163573585737avg1516163574035741Active Power Total (Pt)1616163574435743Active Power Phase 11 (P1)1616163574535743Active Power Phase 12 (P2)1616163574435744Active Power Phase 13 (P3)1616163575035751Reactive Power Phase 12 (Q2)1616163575435753Reactive Power Phase 13 (Q3)1616163575435754Apparent Power Phase 13 (Q3)1616163575035751Apparent Power Phase 13 (Q3)1516163575435755Apparent Power Phase 13 (Q3)1516163575435754Apparent Power Phase 13 (Q3)1516163575435754Apparent Power Phase 13 (Q3)1516163576435764Apparent Power Phase 13 (Q3)1516163576435765Power Factor Phase 2 (PF2)1716	35722	35723	U31	Т5	
3572635727111516357283573921515163573035731131515163573235733Reserved: Inc15163573435735Reserved: Inm15163573635737avg15163573835739S 1151635739S 11516163574035741Active Power Total (Pt)16163574135745Active Power Phase L2 (P2)16163574335747Active Power Phase L3 (P3)16163574435747Active Power Phase L3 (P3)16163574835747Active Power Phase L3 (P3)16163575035751Reactive Power Phase L3 (Q3)16163575435755Reactive Power Phase L3 (Q3)16163575435755Reactive Power Phase L3 (Q3)15163575435755Apparent Power Phase L3 (Q3)15163575435754Apparent Power Phase L3 (Q3)15163575435755Apparent Power Phase L3 (Q3)15163575635761Apparent Power Phase L3 (Q3)15163576435765Apparent Power Phase L3 (S3)15163576535767Apparent Power Phase L3 (S3)15163576835769Apparent Power Phase L3 (S3)1516 <td>35724</td> <td>35725</td> <td>Uavg (phase to phase)</td> <td>Т5</td> <td></td>	35724	35725	Uavg (phase to phase)	Т5	
3572835729121215163573035731131315163573235733Resrved: Inc75163573435735Resrved: Inm75163573635737lavg75763573835739S175763574035741Active Power Total (Pt)76635741Active Power Phase 12 (P2)76763574235745Active Power Phase 12 (P2)76763574335747Active Power Phase 12 (P2)76763574435745Reactive Power Phase 12 (P2)76763574535747Active Power Phase 12 (P2)7676357403574Active Power Phase 12 (P2)76763574535748Reactive Power Phase 12 (Q2)76763575435758Reactive Power Phase 12 (Q2)76763575435758Reactive Power Phase 13 (Q3)767635759Apparent Power Phase 13 (Q3)757676357603577Apparent Power Phase 13 (Q3)75763576135763Apparent Power Phase 13 (Q3)7576357643576Apparent Power Phase 13 (Q3)757635763576Apparent Power Phase 13 (Q3)757635763576Apparent Power Phase 13 (Q3)757635763576Apparent Power Phase 13 (Q3)75	35726	35727	11	Т5	
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3573435735Reserved: InmT5I3573635737lavgT5I3573835739S IT5I3574035741Active Power Total (Pt)T6I3574235743Active Power Phase L1 (P1)T6I3574435745Active Power Phase L2 (P2)T6I3574535747Active Power Phase L3 (P3)T6I357463574Active Power Phase L1 (Q1)T6I3575035751Reactive Power Phase L2 (Q2)T6I3575435757Reactive Power Phase L3 (Q3)T6I3575835757Apparent Power Phase L3 (Q3)T6I3575835757Apparent Power Phase L3 (Q3)T5I3575835751Apparent Power Phase L3 (Q3)T5I3575935751Apparent Power Phase L3 (Q3)T5I3575035751Apparent Power Phase L3 (Q3)T5I3575035751Apparent Power Phase L3 (Q3)T5I3575035751Apparent Power Phase L3 (Q3)T5I3576035761Apparent Power Phase L3 (Q3)T5I35763Apparent Power Phase L3 (Q3)T5I3576435763Apparent Power Phase L3 (S3)T5I3576435764Apparent Power Phase L3 (S3)T5I3576535767Power Factor Total (PF1)T7I3577035771Power Fa	35732	35733	Reserved: Inc	T5	
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3574235743Active Power Phase L1 (P1)T6I3574435745Active Power Phase L2 (P2)T6I3574635747Active Power Phase L3 (P3)T6I3574835749Reactive Power Total (Qt)T6I3575035751Reactive Power Phase L1 (Q1)T6I3575235753Reactive Power Phase L2 (Q2)T6I3575435755Reactive Power Phase L3 (Q3)T6I3575435757Apparent Power Total (St)T5I3575835751Apparent Power Phase L1 (S1)T5I3576035761Apparent Power Phase L3 (S3)T5I3576335767Power Factor Total (PF1)T7I3576435767Power Factor Phase L1 (P1)T7I3577835779Power Factor Phase L1 (S3)T5I3576435767Power Factor Total (PF1)T7I3577835767Power Factor Phase L1 (P1)T7I35779Power Factor Phase 3 (PF3)T7I3577035771Power Factor Phase 3 (PF3)T7I35772Power Angle Total (atan2(Pt,Qt))T17I35774j1 (angle between U1 and I1)T17I35774Power Angle Total (atan2(Pt,Qt))T17I	35740	35741	Active Power Total (Pt)	Т6	
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3574635747Active Power Phase L3 (P3)T6163574835749Reactive Power Total (Qt)T6163575035751Reactive Power Phase L1 (Q1)T6163575235753Reactive Power Phase L2 (Q2)T6163575435755Reactive Power Phase L3 (Q3)T6163575635757Apparent Power Phase L3 (Q3)T6163575835759Apparent Power Total (St)T5163576035761Apparent Power Phase L2 (S2)T5163576235733Apparent Power Phase L3 (S3)T5163576435765Power Factor Total (PFt)T7163576435767Power Factor Phase 1 (PF1)T7173576835769Power Factor Phase 3 (PF3)T7173577035771Power Factor Phase 3 (PF3)T1717357731 (angle between U1 and 12)T17173577412 (angle between U2 and 12)T1717	35744	35745	Active Power Phase L2 (P2)	Т6	
3574835749Reactive Power Total (Qt)T6T63575035751Reactive Power Phase L1 (Q1)T613575235753Reactive Power Phase L2 (Q2)T613575435755Reactive Power Phase L3 (Q3)T613575635757Apparent Power Total (St)T513575835759Apparent Power Phase L1 (S1)T513576035761Apparent Power Phase L2 (S2)T513576235763Apparent Power Phase L3 (S3)T513576435757Power Factor Total (PFt)T713576435767Power Factor Total (PFt)T713576835767Power Factor Phase 1 (PF1)T713576835769Power Factor Phase 3 (PF3)T713577035771Power Factor Phase 3 (PF3)T17135773j1 (angle between U1 and I1)T17135774j2 (angle between U2 and I2)T171	35746	35747	Active Power Phase L3 (P3)	Т6	
3575035751Reactive Power Phase L1 (Q1)T63575235753Reactive Power Phase L2 (Q2)T63575435755Reactive Power Phase L3 (Q3)T63575635757Apparent Power Total (St)T53575835759Apparent Power Phase L1 (S1)T53576035761Apparent Power Phase L2 (S2)T53576235763Apparent Power Phase L3 (S3)T53576435765Power Factor Total (PFt)T73576435765Power Factor Total (PFt)T73576635767Power Factor Phase 1 (PF1)T73576835769Power Factor Phase 2 (PF2)T73577035771Power Factor Phase 3 (PF3)T1735772Power Angle Total (atan2(Pt,Qt))T1735774j2 (angle between U2 and I2)T17	35748	35749	Reactive Power Total (Qt)	Т6	
3575235753Reactive Power Phase L2 (Q2)T63575435755Reactive Power Phase L3 (Q3)T63575635757Apparent Power Total (St)T53575835759Apparent Power Phase L1 (S1)T53576035761Apparent Power Phase L2 (S2)T53576235763Apparent Power Phase L3 (S3)T53576435765Power Factor Total (PFt)T73576635767Power Factor Phase 1 (PF1)T73576835769Power Factor Phase 2 (PF2)T73577035771Power Factor Phase 3 (PF3)T735772Power Angle Total (atan2(Pt,Qt))T1735774j2 (angle between U2 and I2)T17	35750	35751	Reactive Power Phase L1 (Q1)	Т6	
35754 3575 Reactive Power Phase L3 (Q3) T6 35756 3575 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 l1) T17 35774 j2 (angle between U2 and l2) T17	35752	35753	Reactive Power Phase L2 (Q2)	Т6	
3575635757Apparent Power Total (St)T5T53575835759Apparent Power Phase L1 (S1)T553576035761Apparent Power Phase L2 (S2)T553576235763Apparent Power Phase L3 (S3)T553576435765Power Factor Total (PFt)T753576635767Power Factor Phase 1 (PF1)T753577035771Power Factor Phase 2 (PF2)T7535772Power Angle Total (atan2(Pt,Qt))T17535774j2 (angle between U1 and I1)T17535774i2 (angle between U2 and I2)T175	35754	35755	Reactive Power Phase L3 (Q3)	Т6	
3575835759Apparent Power Phase L1 (S1)T53576035761Apparent Power Phase L2 (S2)T53576235763Apparent Power Phase L3 (S3)T53576435765Power Factor Total (PFt)T73576635767Power Factor Phase 1 (PF1)T73576835769Power Factor Phase 2 (PF2)T73577035771Power Factor Phase 3 (PF3)T735773j1 (angle between U1 and I1)T1735774j2 (angle between U2 and I2)T17	35756	35757	Apparent Power Total (St)	Т5	
3576035761Apparent Power Phase L2 (S2)T53576235763Apparent Power Phase L3 (S3)T53576435765Power Factor Total (PFt)T73576635767Power Factor Phase 1 (PF1)T73576835769Power Factor Phase 2 (PF2)T73577035771Power Factor Phase 3 (PF3)T735772Power Angle Total (atan2(Pt,Qt))T1735773j1 (angle between U1 and I1)T1735774j2 (angle between U2 and I2)T17	35758	35759	Apparent Power Phase L1 (S1)	Т5	
3576235763Apparent Power Phase L3 (S3)T53576435765Power Factor Total (PFt)T73576635767Power Factor Phase 1 (PF1)T73576835769Power Factor Phase 2 (PF2)T73577035771Power Factor Phase 3 (PF3)T735772Power Angle Total (atan2(Pt,Qt))T1735773j1 (angle between U1 and I1)T1735774j2 (angle between U2 and I2)T17	35760	35761	Apparent Power Phase L2 (S2)	T5	
3576435765Power Factor Total (PFt)T73576635767Power Factor Phase 1 (PF1)T73576835769Power Factor Phase 2 (PF2)T73577035771Power Factor Phase 3 (PF3)T735772Power Angle Total (atan2(Pt,Qt))T1735773j1 (angle between U1 and I1)T1735774j2 (angle between U2 and I2)T17	35762	35763	Apparent Power Phase L3 (S3)	T5	<u> </u>
3576635767Power Factor Phase 1 (PF1)T73576835769Power Factor Phase 2 (PF2)T73577035771Power Factor Phase 3 (PF3)T735772Power Angle Total (atan2(Pt,Qt))T1735773j1 (angle between U1 and I1)T1735774j2 (angle between U2 and I2)T17	35764	35765	Power Factor Total (PFt)	Т7	
3576835769Power Factor Phase 2 (PF2)T73577035771Power Factor Phase 3 (PF3)T735772Power Angle Total (atan2(Pt,Qt))T1735773j1 (angle between U1 and I1)T1735774j2 (angle between U2 and I2)T17	35766	35767	Power Factor Phase 1 (PF1)	Т7	
3577035771Power Factor Phase 3 (PF3)T735772Power Angle Total (atan2(Pt,Qt))T1735773j1 (angle between U1 and I1)T1735774j2 (angle between U2 and I2)T17	35768	35769	Power Factor Phase 2 (PF2)	Т7	
35772Power Angle Total (atan2(Pt,Qt))T1735773j1 (angle between U1 and I1)T1735774j2 (angle between U2 and I2)T1725775i2 (angle between U2 and I2)T17	35770	35771	Power Factor Phase 3 (PF3)	T7	
35773 j1 (angle between U1 and I1) T17 35774 j2 (angle between U2 and I2) T17	35772		Power Angle Total (atan2(Pt,Qt))	T17	
35774 j2 (angle between U2 and I2) T17 25775 i2 (angle between U2 and I2) T17	35773		j1 (angle between U1 and I1)	T17	
	35774		j2 (angle between U2 and I2)	T17	
35/75 3 (angle between U3 and I3) 1/	35775		j3 (angle between U3 and I3)	T17	

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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.

ABBREVIATION/GLOSSARY



Note: Note: <th< th=""><th>Function code</th><th>Address</th><th></th><th>Contents</th><th>Data</th><th>Ind</th><th>Values / Dependencies</th><th>Min</th><th>Max</th><th>P. Level</th><th>RW</th><th>MID</th></th<>	Function code	Address		Contents	Data	Ind	Values / Dependencies	Min	Max	P. Level	RW	MID
Verter Verter Verter Parter Parter<		40000		Holding Registers								
15. 40001 4002 User, Tassword 1. L. 2 PD, Market Market Seebe Mey oppose Market		40000										
18. 4000 4000 Later 1 star passwort T, EN A.Z monomy methods below the star passwort 1 W no. 3.6 4000 Later Acces Level T1 0. VIII passwort 0.	16	40001	40002	User Password (I 1 2 BP)	T Str4	Α 7	Password to attempt user access level up	i arade		0	W	no
16.6 40008	16	40006	40007	Lavel 1 - User password	T Str4	AZ				1	Ŵ	no
5.0 40010 Active Acces Level TI 0 Full protection 0	16	40008	40009	Lavel 2 - User password	T Str4	AZ		<u> </u>		2	W	no
Image Image <th< td=""><td>3,6</td><td>40010</td><td></td><td>Active Acces Level</td><td>T1</td><td>0</td><td>Full protection</td><td>0</td><td>0</td><td>0</td><td>RW</td><td>no</td></th<>	3,6	40010		Active Acces Level	T1	0	Full protection	0	0	0	RW	no
Image Image <th< td=""><td></td><td></td><td></td><td></td><td></td><td>1</td><td>Access up to level 1 user password</td><td></td><td></td><td></td><td></td><td></td></th<>						1	Access up to level 1 user password					
Nome Nome <th< td=""><td></td><td></td><td></td><td></td><td></td><td>2</td><td>Access up to level 2 user password</td><td>ļ</td><td></td><td></td><td></td><td></td></th<>						2	Access up to level 2 user password	ļ				
6. 40011 Menual password activation Ti 1 1 Ackinstrument I I No 0 W no 6 40013 Reset command register 1 1 Starts designs I I W No 7 2 Acort Settings I 2 Acort Settings I I W No 8 Acort Settings I 2 Acort Settings I						3	Access up to level 2 (backup pass.)	ļ				
6 40012 Operator Command Register TI 1 Saw Settings I I W no 6 40013 Rest command register TI Birl Rest counter 2 I I W no 6 40013 Rest counter 3 I I Birl Rest counter 2 I I N no 6 0 Digital Output staw 0 0 Off 0 I 0 N no N no N N no N no N no N no N N no N N no N <	6	40011		Manual password activation	T1	1	Lock instrument	ļ		0	W	no
4.0013 Meast command register 1 TI Back Sector Pack Sector	6	40012		Operator Command Register	T1	1	Save Settings			1	W	no
0 -100/3 Present comminant tragetors 1 Data Present comminant tragetors 1 N	6	40042		Depart command register 1	T1	2	Abort Settings			4	10/	
Interpret in the second of the seco	0	40013		Reset command register 1		Bit-1	Reset counter 2			1	VV	10
a.e. double double and a set and a s						Bit-1	Reset counter 3					
3.6 40016 Digital Curportstate 0 0 0 0 0 1 0 RW no. 3.6. 16 40121 Addition (1) 40120 Decemption T.Str40						Bit-3	Reset counter 4					
No. No. <td>3.6</td> <td>40016</td> <td></td> <td>Digital Output state</td> <td></td> <td>0</td> <td>Off</td> <td>0</td> <td>1</td> <td>0</td> <td>RW</td> <td>no</td>	3.6	40016		Digital Output state		0	Off	0	1	0	RW	no
constrail constrained constrained <thconstrained< th=""> <thconstrained< th=""> <</thconstrained<></thconstrained<>						1	On					
S. 6.1 40101 40120 Description T. SH40 Image: Sh40 <td></td> <td></td> <td></td> <td>GENERAL SETTINGS</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>				GENERAL SETTINGS								
5.6. 4012 40140 Location T.Shr0 Image and the seconds Image and the seconds <thimage and="" seconds<="" th="" the=""></thimage>	3, 6 , 16	40101	40120	Description	T_Str40					2	RW	no
3.6 40174 LCD cycling peried T1 I Seconds 5 60 2 R/W no. 3.6. 4015 Operation mode 0 Normal mode N	3, 6 , 16	40121	40140	Location	T_Str40					2	RW	no
3. 6 40165 Operation mode 0 Normal mode Normal mode </td <td>3,6</td> <td>40174</td> <td></td> <td>LCD cycling period</td> <td>T1</td> <td></td> <td>Seconds</td> <td>5</td> <td>60</td> <td>2</td> <td>RW</td> <td>no</td>	3,6	40174		LCD cycling period	T1		Seconds	5	60	2	RW	no
Image: Section of the sectio	3,6	40185	ļ	Operation mode		0	Normal mode	0	16	0	RW	no
Image: state Image: state <tt>Image: state <tt>Image:</tt></tt>						1	Test mode P - Fast	Onlyw	hen ch	arging not	active	
Image: state Image: state <tt>Image: state <tt>Image: state<</tt></tt>						2	Test mode P - Fast (Counter only)	Only w	hen ch	arging not	active	
Image: second						4	Test mode Q	Onlyw	hen ch	arging not	active	
Image: Section of the sectio						5	Test mode Q - Fast	Onlyw	hen ch	arging not	active	
B Test mode P Fast LED x 1000 Only when charging not carlie COMMUNCATION Fast LED x 1000 Only when charging not carlie S.6 40202 Port 1: Device Artness (Modus) T1 O Baud rate 1200 T1 T Z RW no 3.6 40203 Port 1: Baud Rate T1 O Baud rate 2400 T Z RW no 3.6 40203 Port 1: Baud Rate T1 O Baud rate 4800 T Z RW no 4 Baud rate 19200 T Z RW no Z Z T Z						6	Test mode Q - Fast (Counter only)	Onlyw	hen ch	arging not	active	
Communication Test mode P - Fast LED x 10000 Only when charging not acker with a straight of the stra						8	Test mode P – Fast LED x 1000	Onlyw	hen ch	arging not	active	
COMMUNCATION COMMUNCATION TI Communication Communication <thcommunication< th=""> <thcommunication< th=""></thcommunication<></thcommunication<>						16	Test mode P – Fast LED x 10000	Onlyw	hen ch	arging not	active	
3.6 40203 Port 1: Baud Rate T1 0 Baud rate 1200 1 T 2 RW no 3.6 40203 Port 1: Baud Rate T1 0 Baud rate 1200 1 T 2 RW no 3.6 40203 Port 1: Baud Rate T1 0 Baud rate 1200 1 T RW no 1 T Baud rate 4800 I		40000				ļ			0.47		- D\4/	
3.6 40203 Foll . Baud Rate 11 0 Baud rate 2400 1	3,6	40202		Port 1: Device Adress (Modbus)	11 T1		Bourd roto 1200	1	247	2	RW	no
Image: Control of the system of the system of phases Image: Control of the system of the system of phases Image: Control of the system of the	3,0	40203		For T. Baud Rate		1	Baud rate 2400		1	Z	R VV	10
Image: Control of the second						2	Baud rate 4800					
Image: Control of the second						3	Baud rate 9600	<u> </u>				
Image: Second						4	Baud rate 19200					
Image: Note of the second se					-	5	Baud rate 38400	1				
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$						6	Baud rate 57600	1				
3.6 40204 Port 1: Stop Bit T1 0 1 Stop bit 0 1 2 RW no 3.6 40205 Port 1: Parity T1 0 No parity 0 2 2 RW no 3.6 40205 Port 1: Parity T1 0 No parity 0 2 2 RW no 3.6 40206 Port 1: Data Bits T1 0 8 bits 0 0 2 RW no 3.6 40401 Active Tariff T1 0 8 bits 0 0 2 RW no 3.6 40401 Active Tariff T1 0 Tariff input 0 2 1 R yes 3.6 40401 Active Tariff T1 0 Tariff input 0 2 1 R yes 3.6 40402 Common Energy Counter Exponent T2 Tariff 2 - - - - - - - - - - - - - - - - - <td></td> <td></td> <td> </td> <td></td> <td></td> <td>7</td> <td>Baud rate 115200</td> <td><u> </u></td> <td></td> <td></td> <td></td> <td></td>						7	Baud rate 115200	<u> </u>				
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	3,6	40204		Port 1: Stop Bit	T1	0	1 Stop bit	0	1	2	RW	no
3,6 40205 Port 1: Parity T1 0 No parity 0 2 2 RW no 1 0 Odd parity 1 0 Odd parity 1 0 No parity 1 0 No parity 1 0 Image: Constraint of the second secon						1	2 Stop bits					
Image: Constraint of the second of the sum of phases Image: Constraint of the second of	3,6	40205		Port 1: Parity	T1	0	No parity	0	2	2	RW	no
Addition						1	Odd parity	ļ				
3.6 40200 Port 1: Data Bits 11 0 8 bits 0 0 0 2 RW no 3.6 40401 Active Tariff T1 0 Tariff iput 0 2 1 R yes 40401 Active Tariff T1 0 Tariff iput 0 2 1 R yes 40402 Common Energy Counter Exponent T2 Tariff 2						2	Even parity	ļ				
InstructionInstructi	3,6	40206		Port 1: Data Bits	T1	0	8 bits	0	0	2	RW	no
3,040401Active Family110Family function021Ryes11Tariff 111 <t< td=""><td>2.0</td><td>40404</td><td></td><td>ENEKGY</td><td>T4</td><td></td><td>Toriffingut</td><td></td><td></td><td></td><td>P</td><td>1.00</td></t<>	2.0	40404		ENEKGY	T4		Toriffingut				P	1.00
Image: Control Figure 2 Image: Control	3,0	40401			11		Tanii input	0	2	1	ĸ	yes
3 40402 Common Energy Counter Exponent T2 Image: Common Energy Counter Exponent T1 1 Active Power 0 35 2 R yes 3, 6 40421 Energy Counter 1 Parameter T1 1 Active Power Phase 1 Image: Common Energy Counter Exponent Image: Common Energy Count						2	Tariff 2					
Construction Observed 40403 Other Energy Councer Exponents Tele Construction C	3	40402		Common Energy Counter Exponent	T2	- 4		_2	Л	2	P	Vec
3,640419Total Energy CalculationT10Evaluation of the sum of phases012Ryes3,640421Energy Counter 1 ParameterT11Active Power0352Ryes3,640421Energy Counter 1 ParameterT11Active Power0352Ryes11Active Power0352Ryes11Active Power0352Ryes11Active Power0352Ryes11Active Power0352Ryes11Active Power0352Ryes11Active Power Phase 11111111Active Power Phase 11111111Active Power Phase 11111111Active Power Phase 21111111Apparent Power Phase 211111111Active Power Phase 3111111111Active Power Phase 31111111111111111111111111111 <td></td> <td>40403</td> <td>40418</td> <td>Reserved</td> <td>12</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>yc3</td>		40403	40418	Reserved	12							yc3
Active DiversionActive DiversionActive DowerActive DowerActive Dower3,640421Energy Counter 1 ParameterT11Active Power0352RyesActive Dower3Apparent Power3Apparent Power4444Active Dower Phase 15Active Power Phase 14444Active Dower Phase 16Reactive Power Phase 14444Active Dower Phase 14444444Active Dower Phase 24444444Active Dower Phase 24444444Active Dower Phase 34444444Active Power Phase 344444444Active Power Individual phases44444444Active Power Individual phases44444444Active Power Individual phases444444444 <tr< td=""><td>3.6</td><td>40419</td><td>10110</td><td>Total Energy Calculation</td><td>T1</td><td>0</td><td>Evaluation of the sum of phases</td><td>0</td><td>1</td><td>2</td><td>R</td><td>ves</td></tr<>	3.6	40419	10110	Total Energy Calculation	T1	0	Evaluation of the sum of phases	0	1	2	R	ves
3,640421Energy Counter 1 ParameterT11Active Power0352Ryes11Active Power11Active Power11111111Active Power11 </td <td></td> <td></td> <td></td> <td></td> <td>· · ·</td> <td>1</td> <td>Evaluation of individual phases</td> <td></td> <td>· · ·</td> <td>-</td> <td></td> <td></td>					· · ·	1	Evaluation of individual phases		· · ·	-		
Image: Constraint of the second se	3,6	40421		Energy Counter 1 Parameter	T1	1	Active Power	0	35	2	R	ves
Image: Constraint of the second sec						2	Reactive Power					
Image: constraint of the second sec			1		1	3	Apparent Power	1				
Image: constraint of the second systemImage: constraint of the second systemImage: constraint of the second systemImage: constraint of the systemImage: constraint of the second systemImage: constraint of the second systemImage: constraint of the second systemImage: constraint of the systemImage: constraint of the second systemImage: constraint of the second systemImage: constraint of the second systemImage: constraint of the systemImage: constraint of the second systemImage: constraint of the second systemImage: constraint of the second systemImage: constraint of the systemImage: constraint of the second system <td></td> <td></td> <td></td> <td></td> <td></td> <td>5</td> <td>Active Power Phase 1</td> <td></td> <td></td> <td></td> <td></td> <td></td>						5	Active Power Phase 1					
Image: constraint of the second sec						6	Reactive Power Phase 1					
Image: space of the space of						7	Apparent Power Phase 1			L		
Image: Constraint of the sector of the se						9	Active Power Phase 2	ļ				
Image: Constraint of the second system of						10	Reactive Power Phase 2					
13 Active Power Phase 3 14 14 Reactive Power Phase 3 14 15 Apparent Power Phase 3 14 16 15 Apparent Power Phase 3 14 17 Apparent Power Phase 3 14 18 32 Squared Current (AAh) 14 19 33 Active Power individual phases 14 19 34 Reactive Power individual phases 14						11	Apparent Power Phase 2	ļ				
14 Reactive Power Phase 3 14 15 Apparent Power Phase 3 15 16 32 Squared Current (AAh) 15 16 33 Active Power individual phases 16 16 33 Active Power individual phases 16 17 34 Reactive Power individual phases 16			ļ			13	Active Power Phase 3			ļ		
Apparent Power Phase 3 Image: Comparent Phase 3 Image: Comparent Phase 3						14	Reactive Power Phase 3	ļ		ļ		
32 Squared Current (AAh) 33 Active Power individual phases 34 Reactive Power individual phases						15	Apparent Power Phase 3					
33 Active Power individual phases 34 Reactive Power individual phases 35 Active Power individual phases						32	Squared Current (AAh)			<u> </u>		
34 Reactive Power individual phases						33	Active Power Individual phases					
						34 25	Apparent Power individual phases					

3.6	40422	1	Energy Counter 1 Configuration	T1	Bit-0	Quadrant Enabled	0	63	2	R	ves
0,0			Lineig) obtailer roomigeretteri		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	ves
					1	10					
					2	100					
		1			3	1000					
					4	10000					
3,6	40424		Energy Counter 1 Tarif Selector	T1	Bit-0	Tarif 1 Enabled	0	15	2	R	ves
					Bit-1	Tarif 2 Enabled					
					Bit-2	Tarif 3 Enabled					
					Bit-3	Tarif 4 Enabled					
	40425	40430	Reserved		İ						
3.6	40431		Energy Counter 2 Parameter	T1	1	see Energy Counter 1 Parameter	0	15	2	R	ves
3,6	40432		Energy Counter 2 Configuration	T1	1	see Energy Counter 1 Configuration	0	63	2	R	ves
3	40433		Energy Counter 2 Divider	T1		see Energy Counter 1 Divider	0	4	2	R	ves
3,6	40434		Energy Counter 2 Tarif Selector	T1	1	see Energy Counter 1 Tarif Selector	0	15	2	R	yes
3	40435	40440	Reserved		1						
3,6	40441		Energy Counter 3 Parameter	T1		see Energy Counter 1 Parameter	0	15	2		yes
3,6	40442	1	Energy Counter 3 Configuration	T1	1	see Energy Counter 1 Configuration	0	63	2		yes
3	40443	1	Energy Counter 3 Divider	T1	1	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	ļ	ms	2	1000	2	R	yes
			ENERGY snapshot registers		ļ						
3,6	41901		Auto freeze interval [minutes]	T1			0	65536	0	RW	no
3,6	41902		time to freeze [s]	T1	ļ		0	65536	0	RW	no
3,6	41903	41904	time from freeze [s]	T3u	ļ						
3,6	41905		Freeze status	T1	0	atreset	1	65533	0	RW	no
					65534	at interval					
					65535	at time to freeze					
3	41906		Current Active Tariff	11	ļ					R	no
3	41915	41916	Energy Counter 1 (Non-reset)	T3 T0	ļ					R	no
3	41917	41918	Energy Counter 2 (Non-reset)	13 To						R	no
3	41931	41932	1000x Energy Counter 1 (Non-reset)	13 To			*****			ĸ	00
3	41933	41934	Decement	13			******			ĸ	no
	41939	41989									
2.6	41000			T4		600-60.0 222	0.4	2600		D\//	20
3,0	41990		Time to coloulate internal mass. Is (40)] T4	<u> </u>	ουυ=ου,υ Sec	0,1	3000	0		00
ა, ხ	41991	41000	Posonad	11			0,1	0000	0	R VV 7	110
	41992	41999	Reserved								
L	42000	42149	Reserved		[LL			

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Signature:

Function	Address		Contents	Data	Ind	Values /	Min	Max	Ρ.	RW
code						Dependencies			Level	
			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. 4	7079)	•					
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			0	R
						Current (AAh)				
3	46981	46982	Stop Counter 4 Squared Current (A-)	T3u		Squared			0	R
						Current (AAh)				
3	46983	46984	Consumption 4 Squared Current (A-)	T3u		Squared			0	R
						Current (AAh)				
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			0	R
						Current (AAh)				
3	46991	46992	Stop Counter 3 Squared Current (A+)	T3u		Squared			0	R
						Current (AAh)				
3	46993	46994	Consumption 3 Squared Current (A+)	T3u		Squared			0	R
						Current (AAh)				
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)		ļ		
					3	Active, Error				
						WDR (WD				
	47001	47000	Duration			reset)			0	
3	47001	47002		13u T2		Seconds			0	К
3	47003	47004	Consumption (A+)	13u		wn			U	к
3	47005	47006	Active Power Total (Pt)	16		кед (30140-			U	к
				1	1	30141)		1	1	



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'	Begin	Null	Chr	0	w
					(0x42)	measurement		AZ		
					'E'	End				
					(0x45)	measurement				
					'L'	End				
					(0x4C)	measurement				
					'R'	End				
					(0x52)	measurement				
					'A'	End				
					(0x41)	measurement				
					'P'	End				
					(0x50)	measurement				
					'C'	Intermediate				
					(0x43)	Reading				
					'X'	eXception				
					(0x58)					
					'T'	Tariff Change				
					(0x54)					
					'S'	Suspended				
					(0x53)	command				
					ʻr'	End				
					(0x72)	measurement				
						(with begin and				
				ļ		end)				
					(†′	Fiscal Reading				
					(Ux66)					
					'n'	Hold command				
1	1	1	1	1	(Ux68)	1	I		1	1



					ʻi'	last charge				
					(0x69)	reading (with				
						begin and end)				
3	47052		Signature status	T1	0	Not initialized			0	R
5					1	Idle (Time sync)			•	
					2	Signature in				
					2					
					15	piogress				
					15	Signature /				
					20	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				
					251					
					252	format				
					252	Invalid massage				
					255	nivaliu message				
					254	Size				
					254	Signature error				
2.6.46	47050				255	Undefined error	740	700		D (11)
3,6,16	47053		UTC Time offset	12		Minutes	-/19	720	0	R/W
						relative to GMT				
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			0	R
						supported				
					4	secp256r1				
3,6,16	47061		Backlight	T1	0	Off			0	R/W
					1	On				
3,6,16	47062	1	LCD parameters	T1	Bit-0	Consumption		1	0	R/W*
						(A+)				
					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			1	
						Resistance				
						(mOhm)				
					Bit-11	Cable Loss (A+)			1	
					Bit-12	Cable Loss 2 (A-				
)				
					Bit-13	, Consumption				
						(A+) - Cable Loss				
						(A+)				
					Bit-14	Consumption 2				
					DICI	(A-) + Cable Loss				
						2 (A-)				
3616	47063	47066	ICD Custom string	T Str8		- ()			0	R/W/
3,6,16	47067	47068		T_Str0					0	R/M/
3,0,10	47007	47008		1_504					0	10,00
2	47060		OCME formativarsian	T1		NA2/NA:			0	D
5	47069			11					0	ĸ
2616	47070		Poset command register	T1	Dit O	Transaction value	C (Pog	47000-01	0	D /\\/
3,0,10	47070		Reset command register	11	BIC-0	olso invalid value	es (neg -	47000-0,	0	NY VV
2616	47071		Sunchronication status	T1	0	Lincunchronicod	0	2	0	D /\\/
5,0,10	47071		Synchionisation status	11	0	Unsynchronised	0	5	0	ry vv
					1	IIIIO Currebue size d				
					2	Synchronised				
2.6.16	47070				3	Relative		60000		D /14/
3,6,16	47072		Synchronisation timeout	Τ1		minutes,	0	60000	0	R/W
						0=disabled	_	_		
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	60	0	w
						(0=Disabled)				
3,6,16	47076		TX value in end transaction block	T1	0	"TX": "r" (The	0	2	0	R/W*
						same operation				
						-				
						as v 2.03)				
					1	as v 2.03) "TX": "E"				
					1 2	as v 2.03) "TX": "E" "TX": "E"				
					1 2	as v 2.03) "TX": "E" "TX": "E" Command 'E'				
					1 2	as v 2.03) "TX": "E" "TX": "E" Command 'E' has the function				
					1 2	as v 2.03) "TX": "E" "TX": "E" Command 'E' has the function of command 'r'				
3,6,16	47077		Output Message Options		1 2 Bit-0	as v 2.03) "TX": "E" "TX": "E" Command 'E' has the function of command 'r' Counter 1 begin	1	63	0	R/W*
3,6,16	47077		Output Message Options		1 2 Bit-0 Bit-1	as v 2.03) "TX": "E" "TX": "E" Command 'E' has the function of command 'r' Counter 1 begin Counter 1 end	1	63	0	R/W*
3,6,16	47077		Output Message Options		1 2 Bit-0 Bit-1 Bit-2	as v 2.03) "TX": "E" "TX": "E" Command 'E' has the function of command 'r' Counter 1 begin Counter 1 end Counter 1	1	63	0	R/W*
3,6,16	47077		Output Message Options		1 2 Bit-0 Bit-1 Bit-2	as v 2.03) "TX": "E" "TX": "E" Command 'E' has the function of command 'r' Counter 1 begin Counter 1 end Counter 1 consumption	1	63	0	R/W*



					Bit-3	Counter 1 cable				1
						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	0	1	0	R/W*
						resistance after				
						SW version				
3,6,16	47079		Cable Loss Energy Config	T1	0	not included	0	2	0	R/W*
						((write when				
						Reg 47000=0)				
					1	add to Counter				
						Start value				
					2	subtract from				
						Counter End				
						value				
3,6,16	47080		Cable Resistance	T16		mOhm ((write	0,00	650,00	0	R/W*
						when Reg				
						47000=0)				
2.6.4.6	47081	47095	Reserved		255			255		
3,6,16	47096		OBIS control	11	255	RI extension	0	255	0	R
3,6,16	47097		Change Lock control	11	0	not set (LCD	0	1	0	R/W*
	-				1	Warning)				-
					Ţ	Fermanent				
						can not he				
						changed)				
3.6.16	47098		Change setting control	T1	12345	Enable changes			0	RW
0,0,20					110 10	for 60s			Ŭ	
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					1	0	R
3	48316		Binary Output Message Length	T1					0	R
					+	1			0	Ь
3	48317		Binary Output Message						0	к



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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	11	11	11	*		*	In
11	12	12	12	*		*	In
12	13	13	13	*		*	In
16	Р	Р	Active Power P	*	*	*	Pn
17	P1	P1	Active Power Phase L1 (P1)	*		*	Pn
18	P2	P2	Active Power Phase L2 (P2)	*		*	Pn
19	Р3	Р3	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				
ln =			R30017				
Pn =			Un*In				
Fn =			55				
30015			Calibration voltage				
30017			Calibration current				
55017							



Туре	Value / Bit Mask	Description
T1		Unsigned Value (16 bit)
		Example: 12345 stored as 12345 = 3039(16)
Т2		Signed Value (16 bit)
		Example: -12345 stored as -12345 = CFC7(16)
Т3		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)
Т4		Short Unsigned float (16 bit)
	bits # 1514 bits #	Decade Exponent(Unsigned 2 bit)
	1300	Binary Unsigned Value (14 bit)
		Example: 10000*10 ² stored as A710(16)
Т5		Unsigned Measurement (32 bit)
	bits # 3124 bits #	Decade Exponent(Signed 8 bit)
	2300	Binary Unsigned Value (24 bit)
		Example: 123456*10 ⁻³ stored as FD01 E240(16)
Т6		Signed Measurement (32 bit)
	bits # 3124 bits #	Decade Exponent (Signed 8 bit)
	2300	Binary Signed value (24 bit)
		Example: - 123456*10 ⁻³ stored as FDFE 1DC0(16)
Т7		Power Factor (32 bit)
b	hite # 21 24 hite #	Sign: Import/Export (00/FF)
	23 16 hits # 15 00	Sign: Inductive/Capacitive (00/FF)
	2510 bits # 1500	Unsigned Value (16 bit), 4 decimal places
		Example: 0.9876 CAP stored as 00FF 2694(16)
Т8		Time stamp (32 bit)
	bits # 31.,24 bits #	Minutes 00 - 59 (BCD)
	23 16 bits # 15 08	Hours 00 - 23 (BCD)
	bits # 0700	Day of month 01 - 31 (BCD)
		Month of year 01 - 12 (BCD)
		Example: 15:42, 1. SEP stored as 4215 0109(16)
Т9		Time (32 bit)
	bits # 3124 bits #	1/100s 00 - 99 (BCD)
	2316 bits # 1508	Seconds 00 - 59 (BCD)
	bits # 0700	Minutes 00 - 59 (BCD)
		Hours 00 - 24 (BCD)
T 10		Example: 15:42:03.75 stored as 7503 4215(16)
110		Date (32 bit)
	bits # 3124 bits #	Day of month of - 31 (BCD)
	2316 bits # 1500	Month of year 01 - 12 (BCD)
		Tear (unsigned Integer) 19984095
T. Chal		Example. 10, SEP 2000 Stored as 1009 07D0(10)
1_Str4		The characters
		i wo characters per 10 bit register
I_Strb		lext String 6 characters
(112)		I wo charcters per 16 bit register



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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		Time and Date (64 bit)
		1/100s 00 - 99 (BCD)
	bits # 6356 bits #	Seconds 00 - 59 (BCD)
	5548 bits # 4740	Minutes 00 - 59 (BCD)
	bits # 3932 bits #	Hours 00 - 24 (BCD)
	3124 bits # 2316	Day of month 01 - 31 (BCD)
	bits # 1500	Month of year 01 - 12 (BCD)
		Year (unsigned integer) 19984095
		Example: 15:42:03.75, 10. SEP 2000 stored as 7503 4215 1009 07D0(16)
T_TimeIEC		Time and Date (64 bit) = IEC870-5-4 "Binary Time 2a"
	bits # 6355	Reserved
	bits # 5448 bits #	Years (0 99)
	4744 bits # 4340	Reserved
	bits # 3937 bits #	Months (1 12)
	3632 bit # 31 bits #	Day of Week (17)
	3029 bits # 2824 bit	Day of Month (131)
	# 23 bit # 22 bits #	Summer Time (0 1): Summer time (1), Standard time (0)
	2116 bits # 1500	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		IEEE 754 Elasting-Point Single Precision Value (32 hit)
1_11001		Sign Rit (1 hit)
	bits # 31 bits # 3023	Exponent Field (8 hit)
	bits # 220	Significand (23 hit)
		Example: 123 45 stored as 123 $45000 = 4256 E666(16)$
T0.4		Example: 123.43 Stored as 123.43000 - 4210 E000(10)
ISA	hite # 45 00 hite #	
	UILS # 15U8 DITS #	
	0700	$\frac{1}{10000} = 24 (BCD)$
		Example: 15:42 stored as 4215(16)

ABBREVIATION/GLOSSARY



	Date (16 bit)
oits # 1508 bits #	Day of month 00 - 31 (BCD)
700	Month of year 00 - 12 (BCD)
	Example: 30, SEP stored as 3009(16)
	Signed Value (16 bit), 4 decimal places
	Example: -0.2345 stored as -2345 = F6D7(16)
	HEX value 16 bytes
	Unix time (32 bit)
Bits # 3100	Seconds since January 1, 1970
	Example: 16 May 2012 10:36:46 GMT stored as 4FB3 833E(16)
) }	its # 1508 bits # 700 its # 3100



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