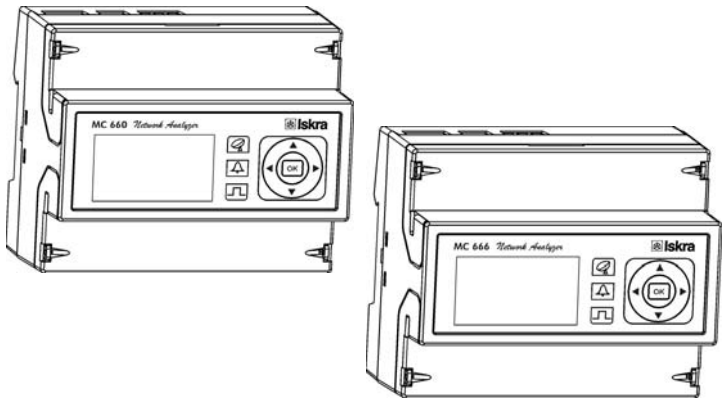
Measuring centres

User's Manual

Network Analyzer	***MC660 / MC666***
Network Recorder	***MC650 / MC656***
Multifunction Meter	***MC640 / MC646***



CE

Table of Contents

Meaning of symbols ○ ◖ ● see page 6!

1. SECURITY ADVICE AND WARNINGS

1.1 Welcome

Please read this chapter carefully before starting work with a Measuring centre.

This chapter deals with important information and warnings that should be considered for safe work with a Measuring centre.

1.2 Introduction

This booklet contains instructions for installation and use of Measuring centres MC660, MC650, MC640, and MC666, MC656, MC646. Installation and use of devices also includes work with dangerous currents and voltages, therefore such work shall be carried out by qualified persons. The ISKRA MIS 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 instrument is used for measuring or supervision, please contact a person who is responsible for installation of such system.

1.3 Health and safety

The purpose of this chapter is to provide a user with information on safe installation and handling with the product in order to assure its correct use and continuous operation.

We expect that everyone using the product will be 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.

1.4 Safety warnings and instructions for use

Check the following before switching on the device:

Nominal voltage,

Supply voltage,

Nominal frequency,

Voltage ratio and phase sequence,

Current transformer ratio and terminals integrity,

Protection fuse (recommended maximal external fuse size is 6 A – a type with a red dot or equivalent),

Integrity of earth terminals (where necessary)

Important: A current transformer secondary should be short circuited before connecting the meter.

Battery replacement

At meters that are provided with built-in batteries, it is necessary to replace them with a corresponding type. A battery shall be replaced by an authorized service. The battery lifetime is approx. 6 years.

Device switch-off Warning!

Auxiliary supply circuits for (external) relays can include capacitors between supply and ground. In order to prevent electrical shock hazard, the capacitors should be discharged via external terminals after having completely disconnected auxiliary supply (both poles of any DC supply).

Waste

It is forbidden to deposit electrical and electronic equipment 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 EZ 2002/96/EG about restriction on the use of certain hazardous substances in electrical and electronic equipment or a corresponding Url 118/04.

1.5 Warnings, information and notes regarding designation of the product

Used symbols:

	See product documentation.
	Double insulation in compliance with the **SIST EN 61010−1**: 2004 standard.
	Functional ground potential. Note: This symbol is also used for marking a terminal for protective ground potential if it is used as a part of connection terminal or auxiliary supply terminals.
	Compliance of the product with directive 2002/96/EC, as first priority, the prevention of waste electrical and electronic equipment (WEEE), and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment.
	Compliance of the product with European CE directives.

Contents of consignment

The consignment includes:

− Measuring centres MC660, MC650, MC640 or MC666, MC656, MC646,

− User's Manual

2. BASIC DESCRIPTION AND OPERATION OF MEASURING CENTRE

2.1 Introduction

Regarding the type of a Measuring centre different chapters should be considered since the types differ in functionality and design. More detailed description of device functions is given in chapter Type differences, pages 10 to 12. Al types of measuring centres are available for direct (65A) or CT connection. Instruments for CT connection are marked as types MC6x0, instruments for direct connection 65A are marked as types MC6x6.

Description of symbols

In different chapters or tables different symbols may appear in User's Manual. According to the position of symbols, they have different meaning.

Chapter

Due to differences among devices, some chapters do not relate to your instrument. Five symbols next to chapter heading are for faster surveying. Type of symbol indicates to which extent the chapter applies for each type of measuring centre. Meaning of each symbol is:

○ − Function not supported
◖ − Function partially supported (see a note)
● − Function completely supported

Each of the five positions, where the symbols are indicates a measuring centre type. Positions follow from left to right:

MC640 and MC646 / MC650 and MC656 / MC660 and MC666

Subchapter

Symbols next to the subchapters indicate accessibility of functions described. Accessibility of functions is indicated with the following symbols:

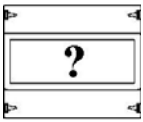
PC − Function accessible via communication (MiQen software)
− Function accessible via navigation keys on the instrument front side

Tables

Supported functions and measurements are listed in tables for all types. Symbols in tables indicate support of enabled functions for each type. Additionally a legend is placed below table of used symbols. Meaning of symbols is:

● − Function is supported
× − Function is not supported
○ − Symbol meaning varies and is described in the legend below the table

User information



For all unknown technical words see chapter Glossary on next page.

2.2 Glossary

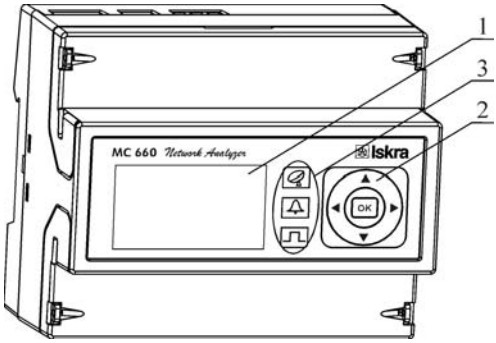
Term	Explanation
RMS	Root Mean Square value
Flash	Type of a memory module that keeps its content in case of power supply failure
MODBUS / DNP3	Industrial protocol for data transmission
MiQen	Software for Iskra MIS instruments
AC	Alternating voltage
PA total	Angle calculated from total active and apparent power
PA1, PA2, PA3	Angle between fundamental phase voltage and phase current
PF	Power factor
THD	Total harmonic distortion
MD	Measurement of average values in time interval
FFT graphs	Graphical display of presence of harmonics
Harmonic voltage − harmonic	Sine voltage with frequency equal to integer multiple of basic frequency
Hand-over place	Connection spot of consumer installation in public network
Flicker	Voltage fluctuation causes changes of luminous intensity of lamps, which causes the so-called flicker
RTC	Real Time Clock
M_v − Sample factor	Defines a number of periods for measuring calculation on the basis of measured frequency
M_p − Average interval	Defines frequency of refreshing displayed measurements on the basis of a Sample factor
Hysteresis expressed as percentage [%]	Percentage specifies increase or decrease of a measurement from a certain limit after exceeding it.
PO	Pulse output module
AO	Alarm output module
TI	Tariff input module
DI	Digital input module

2.3 Description of the product

A measuring centre is used for measuring, analyzing and monitoring three phase electrical power network. Using the latest technologies and numerical methods we have reached high accuracy over a wide measuring range of current and integrated quantities.

Appearance

The meter figure can differ from yours depending on the type.



1 − Graphical LCD

2 − Navigation keyboard

3 − LED indicators

Graphical LCD

A graphical LCD with backlight is used for high resolution of displayed measuring quantities and for a display of selected functions when setting the device.

Navigation keyboard

The "OK" key is used for confirming the settings, selecting and exiting the display. Direction keys are used for shifting between screens and menus.

LED indicators

LED indicators warn of a certain state of the instrument. The top (green) one is blinking when transmitting data via communication. The middle (red) one is blinking when the condition for the alarm is fulfilled. The bottom (red) operates as LED pulse output of selected energy counter.

2.4 Purpose and use of different types of measuring centres

Multifunction meter MC640 / MC646

The instrument is used for monitoring and measuring electric quantities of three-phase electrical power distribution system. The meter is provided with 32 program adjustable alarms, serial communication port, two pulse (alarm) outputs and two tariff (digital) inputs. With the RS485 communication, the meter can be set and measurements can be checked. The meter also functions as an energy counter, with the additional function of cost management by tariffs. A tariff input or a tariff clock can be set. At tariff clock setting, four seasons and four day groups as well as energy cost for each period and a day group (16 different cost periods) are available. Additionally, 20 places are available for setting holidays. As an energy counter it can record energy in all four quadrants in four tariffs.

Network recorder MC650 / MC656

The instrument is used for monitoring, measuring and recording measurements of electric quantities of electrical power distribution system. Up to 32 measurements and up to 32 alarms are recorded in the internal memory. The memory is separated into two sections for measurements (A and B) and one section for recording alarms. The memory division is defined by the user via communication.

Network analyzer MC660 / MC666

The instrument is used for permanent analysis of electricity supply quality in compliance with the SIST EN 50160 standard. A partition in the internal memory is reserved for storing reports for a period of the last seven years. The internal memory capacity enables storing of more than 170,000 variations of the measurements from the standard values, which enables finding eventual reasons for the problems in network. Limits and required quality in a monitored period can be defined for each monitored characteristic. The following characteristics are measured and recorded:

- Frequency variations
- Voltage variations
- Voltage unbalances
- Voltage dips
- Voltage interruptions
- Rapid voltage changes
- Flickers Pst & Plt
- Temporary over voltages
- THD's
- Harmonics

2.5 Type differences

Different types differ on functionality and equipment as shown in the following table.

Differences in hardware

Feature	**MC64X**	**MC65X**	**MC66X**
CT connection (5A)	MC640	MC650	MC660
Direct connection (65A)	MC646	MC656	MC666
Graphical LCD display	●	●	●
LED indicator (Communication/Alarm/Pulse)	●/●/●	●/●/●	●/●/●
Control keys on front panel (5)	●	●	●
Internal flash memory	×	8Mb	8Mb
Real time clock (RTC) with battery	●	●	●
Communication RS485	●	●	●
Two Pulse (Alarm) outputs	○	○	○
Two Tariff (Digital) inputs	○	○	○
Universal power supply	●	●	●

● – serial ○ – option × − not supported

Software functions

	Functions	**MC640 MC646**	**MC650 MC656**	**MC660 MC666**
Basic	Setup wizard	●	●	●
	Wrong connection warning	●	●	●
	Custom screens (3)	●	●	●
	Demonstration screen cycling	●	●	●
	Programmable refresh time	●	●	●
Additional	MODBUS and DNP3 protocols	●	●	●
	Tariff clock	●	●	●
	MD calculation (TF, FW, SW)	●/●/●	●/●/●	●/●/●
	Programmable alarms (32)	●	●	●
	Alarms recording	×	●	●
	Measurements recording	×	●	●
	Measurements graphs (time/FFT)	●/●*	●/●*	●/●
	Evaluation of voltage quality in compliance with SIST EN 50160	×	×	●

● – serial × − not supported

* MC64X and MC65X support harmonic analysis up to 31st harmonic, MC66X up to 63rd

Supported measurements

	Basic measurements	**MC640 MC646**	**MC650 MC656**	**MC660 MC666**
Phase	Voltage U_1, U_2, U_3 and $U^{\sim}$	●	●	●
	Current I_1, I_2, I_3, I_n, I_t and I_a	●	●	●
	Active power P_1, P_2, P_3, and P_t	●	●	●
	Reactive power Q_1, Q_2, Q_3, and Q_t	●	●	●
	Apparent power S_1, S_2, S_3, and S_t	●	●	●
	Power factor PF_1, PF_2, PF_3 and $PF^{\sim}$	●	●	●
	Power angle φ_1, φ_2, φ_3 and $\varphi^{\sim}$	●	●	●
	THD of phase voltage U_{f1}, U_{f2} and U_{f3}	●	●	●
	THD of power angle I_1, I_2 and I_3	●	●	●
Phase-to-phase	Phase-to-phase voltage U_{12}, U_{23}, U_{31}	●	●	●
	Average phase-to-phase voltage U_{ff}	●	●	●
	Phase-to-phase angle φ_{12}, φ_{23}, φ_{31}	●	●	●
	Voltage unbalance U_u	●	●	●
	THD of phase−to−phase voltage	●	●	●
Energy	Counter 1	●	●	●
	Counter 2	●	●	●
	Counter 3	●	●	●
	Counter 4	●	●	●
	Total	●	●	●
	Active tariff	●	●	●
	Cost by counters	●	●	●
	Total cost	●	●	●

● – serial × − not supported

	Other measurements	**MC640 MC646**	**MC650 MC656**	**MC660 MC666**
Min / Max	Voltage U_1, U_2, U_3	●	●	●
	Phase-to-phase voltage U_{12}, U_{23}, U_{31}	●	●	●
	Phase current I_1, I_2, I_3	●	●	●
	Active power P_1, P_2, P_3, P	●	●	●
	Apparent power S_1, S_2, S_3, S	●	●	●
	Frequency f	●	●	●
	Internal temperature	●	●	●
MD values	Phase current I_1, I_2, I_3	●	●	●
	Active power P (Positive)	●	●	●
	Active power P (Negative)	●	●	●
	Reactive power Q − L	●	●	●
	Reactive power Q − C	●	●	●
	Apparent power S	●	●	●

● – serial × − not supported

	Other measurements	**MC640 MC646**	**MC650 MC656**	**MC660 MC666**
Measurement	Frequency	●	●	●
	Internal temperature	●	●	●
	Date & Time	●	●	●
	Time graphs (I_1, I_2, I_3,U_1, U_2, U_3, U_{12}, U_{23} and U_{31})	●	●	●
	FFT graphs (I_1, I_2, I_3,U_1, U_2, U_3, U_{12}, U_{23} and U_{31})	●	●	●
	Phase voltage harmonics	●*	●*	●
	Phase−to−phase voltage harmonics	●*	●*	●
	Current harmonics	●*	●*	●
	Analysis in compliance with SIST EN 50160	×	×	●

● – serial × − not supported

* MC64X and MC65X support harmonic measurements up to 31st harmonic, MC66X up to 63rd

3. CONNECTION

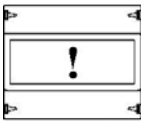
3.1 Introduction

This chapter deals with the instructions for measuring centre connection. Both the use and connection of the device includes handling with dangerous currents and voltages. Connection shall therefore be performed by a qualified person. ISKRA MIS does not take any responsibility regarding the use and connection. If any doubt occurs regarding connection and use in the system which device is intended for, please contact a person who is responsible for such installations.

Before use: Check voltages and phase rotation, supply voltage and nominal frequency.

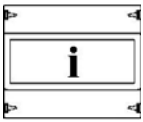
Check protective fuse rating (the recommended maximum rating of the external protective fuse for this equipment is 6A - Red Spot type or equivalent).

Warning!



Wrong or incomplete connection of voltage or other terminals can cause malfunction or damage the device.

Note



After connection, settings have to be performed via communication or instrument keyboard (connection mode, current and voltage transformers ratio …).

3.2 Mounting

Measuring centre is designed for panel mounting. It should be mounted on a 35 mm DIN rail by means of two plastic fasteners. Before installation fasteners should be in open position (pulled). After device is on place, fasteners are locked (pushed) to close position. Remove protection foil from the screen.

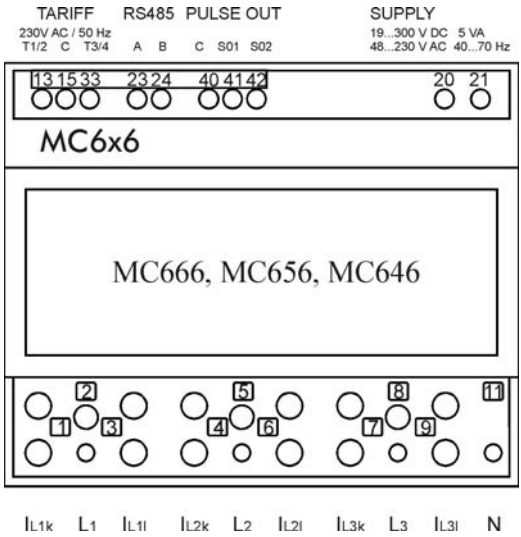
3.3 Electric connection ●●●

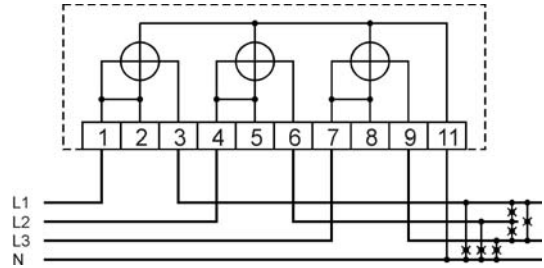
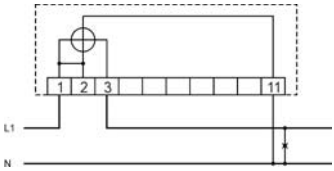
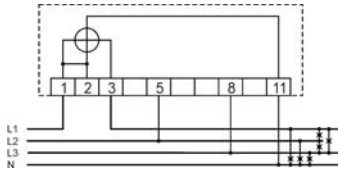
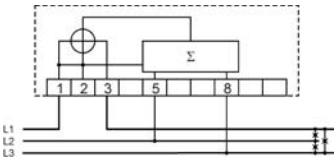
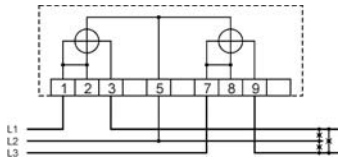
Voltage inputs of measuring centre can be connected directly to low-voltage network or via appropriate voltage measuring transformer to medium or high voltage network.

Current inputs of measuring centre can be connected directly to low-voltage network or via a corresponding current transformer.

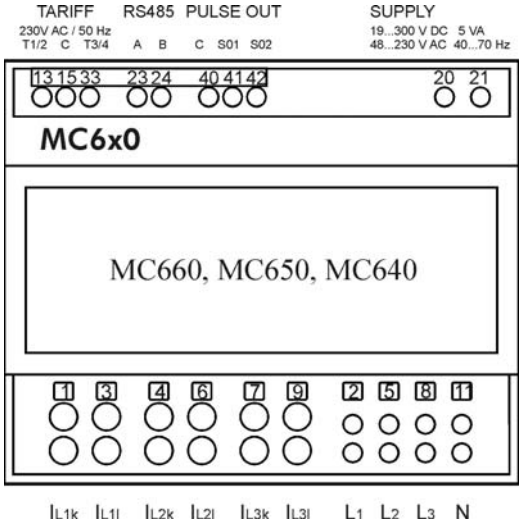
Choose corresponding connection from the figures below and connect corresponding voltages and currents. Information on electrical consumption of current and voltage inputs is given in chapter Inputs on page 67.

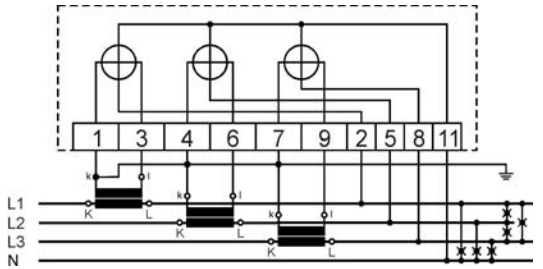
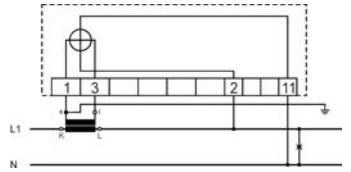
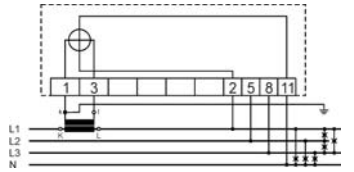
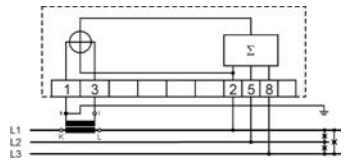
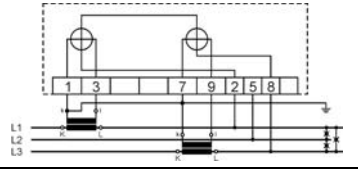
Direct 65A connection (MC6X6)



4u − four-wire, non-uniform load	
	
1b − single wire, uniform load	4b − four-wire, uniform load
	
3b − three-wire, uniform load	3u − three-wire, uniform load
	

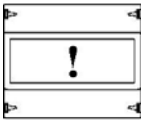
CT 5A connection (MC6X0)



4u − four-wire, non-uniform load	
	
1b − single wire, uniform load	4b − four-wire, uniform load
	
3b − three-wire, uniform load	3u − three-wire, uniform load
	

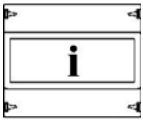
3.4 Connection of input/output modules

Warning!



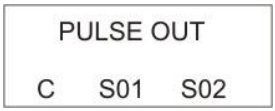
Check the module features that are specified on the label, before connecting module contacts. Wrong connection can cause damage or destruction of module and/or device.

Note



Frequency of the tariff input voltage signal should not essentially deviate from the frequency of the measuring input signal. At no signal on the measuring inputs the tariff triggering is not reliable.

Connect module contacts as specified on the label. Examples of labels are given below and describe modules built in the device. Information on electrical properties of modules is given in chapter Modules on page 68.

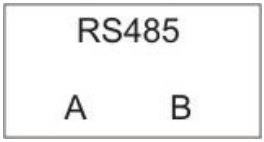
	Tariff input module with two tariff inputs for changeover between up to four tariffs. Terminals 13, 15, 33
	Pulse output (solid state) module with two outputs for energy counters pulses or programmable alarms. Terminals 40, 41, 42

3.5 Communication connection

RS485 communication is intended for connection of devices to network where several instruments with RS485 communication are connected to a common communication interface. We suggest using one of the Iskra MIS communication interfaces!

Connect the communication lines to the corresponding terminals (marked on the label on the instrument). More detailed information on communication is given in chapter Communication on page 68.

Correct connection of individual terminals shall be provided:

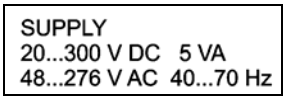
Communication RS485	Position	Data direction	Description
	23	To/From	A
	24	To/From	B

3.6 Connection of power supply

●●●

Measuring centre has universal AC or DC power supply (48-276V AC, 20-300V DC). Information on electric consumption is given in chapter Technical data on page 65.

Regarding power supply voltage specifications on the label choose and connect the power supply voltage:



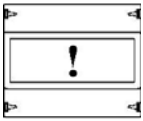
Connection of universal power supply to terminals 20 and 21.

4. FIRST STEPS

4.1 Introduction

Instruction for work with measuring centre is given in the following chapters. Procedure can differ regarding the types and their configuration (functions support). More than one procedure can be used for some types.

Warning!



Measuring centre start-up begins after electrical connection. After proper connection it is assured that the user security is not threatened.
After correct switch-on and respected safety measures the work with device does not represent any danger for a user.

Basic concepts

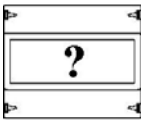
Navigation keys and LCD enable application and basic instrument settings. During the operation some icons can be displayed in upper part of LCD. The significance of icons (from right to left) is explained in the table below.

Icon	Meaning
	Instrument is locked with a password of the second level (L2). The first level (L1) can be unlocked.
	Instrument can be wrongly connected at 4u connection. Energy flow direction is different by phases.
	A built-in battery (for RTC) shall be replaced. A battery test is carried out at power supply connection.
	The device power supply is too low.

Example:

OK Main menu ⇒ Info OK ⇑

User information

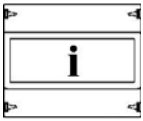


Meaning of icons is displayed on LCD in the Information menu.

Installation wizard

After installation and electrical connection, basic parameters have to be set in order to assure correct operation. The easiest way to achieve that is use the Installation wizard. When entering the Installation menu, settings follow one another when the previous one is confirmed. All required parameters shall be entered and confirmed. Exit from the menu is possible when all required settings are confirmed or with interruption (key ⇐ several times) without changes.

Note



All settings that are performed through the Installation wizard can be subsequently changed by means of the Settings menu or via MiQen by means of communication.

Main menu ⇒ Installation ⇒

The menus follow one after another:

Start menu

Start screen is displayed on LCD.

Language

Set device language.

Date

Set device date.

Time

Set device time.

Connection mode

Choose connection and define load connection.

Primary voltage

Set primary voltage if a voltage transformer is used.

Secondary voltage

Set secondary voltage if a voltage transformer is used; set voltage of low voltage network if connection is direct.

Primary current

Set primary current if a current transformer is used.

Secondary current

Set secondary current.

Common energy exponent

Define common energy exponent as recommended in table below, where counter divider is at default value 10. Values of primary voltage and current determine proper Common energy exponent. For detailed information see chapter Energy on page 37.

Current / Voltage	1 A	5 A	50 A	100 A	1000 A
110 V	−1	0	1	1	2
230 V	0	0	1	2	3
1000 V	0	1	2	3	4
30 kV	2	2	3	4	4*

* − Counter divider should be at least 100

Device address

Set MODBUS address for the device. Default address is 33.

Bits per second

Set communication rate. Default rate is 115200 b/s.

Parity

Set communication parity. Default value is None.

Stop bit

Set communication stop bits. Default value is 2.

4.2 Display of device info

A menu is divided into several submenus with data and information about device:

- Welcome screen
- Information
- Memory
- Time, date, internal temperature and tariff status
- Meaning of icons

◖ − Information display is subordinated to supported functions of an individual MC type.

Welcome screen

When entering the information menu, a welcome screen is displayed on LCD showing type designation and name of measuring centre.

Main men ⇒ Info OK

Information

Data on a meter are collected in the Information menu. They include a serial number, a software version, a hardware version, date of manufacture and a number of operational hours in days, hours and minutes.

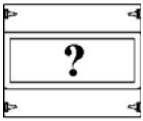
Main menu ⇒ Info OK ⇓

Memory PC

A memory state is displayed in two ways. In a basic display the recording time or a number of records until a scale division is full is displayed, since the last official reading. A graphical display of occupation of individual scale division is used as a help. A more detailed display shows a number of records of a maximal number for each scale division.

Main menu ⇒ Info OK ⇓ ⇓

User information



More data can be stored in the internal memory than displayed, since the display depends upon the official transfer. For transfer of all available data via communication "All data" should be selected when saving data.

Time, date and temperature PC

Data on current date, time, internal temperature and tariff status in submenu are displayed on LCD.

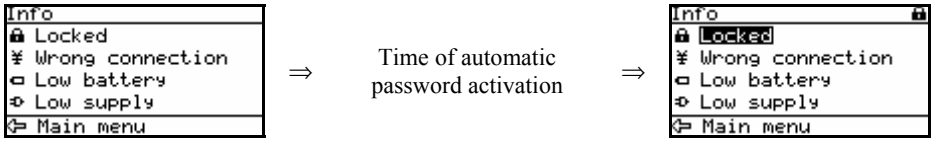
Main menu ⇒ Info OK ⇓ ⇓ ⇓ (⇒)

Meaning of icons

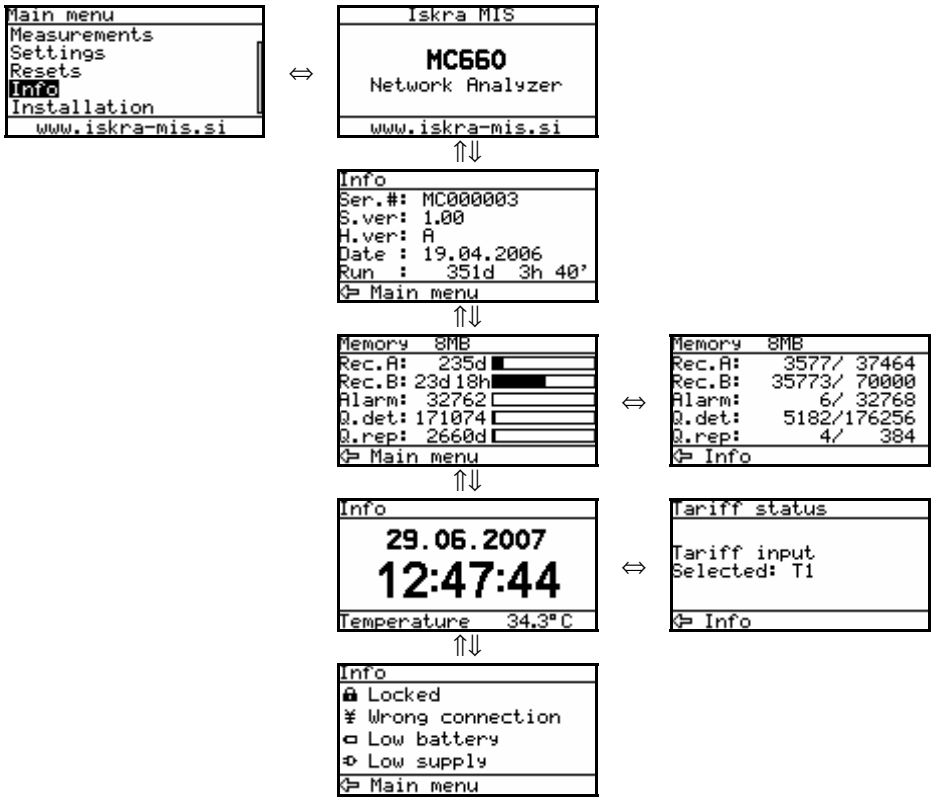
All possible icons with their meaning are displayed.

Main menu ⇒ Info OK ⇓ ⇓ ⇓ ⇓

Example of display of icons with their meaning and when instrument is locked:



Example for MC660 information display:



5. SETTINGS

5.1 Introduction

Instrument settings can be remotely modified with MiQen software, when connected to a PC, or with the use of the navigation keyboard. When using navigation keyboard, modified settings are applied only after confirmation (OK).

5.2 MiQen software

MiQen software is a tool for complete monitoring of the measuring instruments. RS485 communication is used for connection with a PC. A user-friendly interface consists of five segments: devices management, instrument settings, real-time measurements, data analysis and software upgrading.

Two editions of MiQen software are available:

- Professional edition with full functionality and supports all software assemblies. CD-Key is required for the installation.
- Standard edition, freeware edition which supports all software assemblies except data analysis.

Devices management

Easy to do. Just select the instrument in a favourite's line. Use the network explorer to set and explore the devices network. Communication parameters of all devices and their addresses in network can be easily set.

Instrument settings

Multi Register Edit technology assures a simple modification of settings that are organized in a tree structure. Besides transferring settings into the instrument, storing and reading from the setting files are also available.

Real-time measurements

All supported measurements can be seen in real time in a table form. Harmonics and their time-reconstructed signals are displayed also graphically. For further processing of the results of measurements, copying via a clipboard into standard Windows formats is supported.

Data analysis

Analysis can be performed for the instruments with a built-in memory. Recorded quantities can be monitored in a tabular or a graphical form. The events that triggered alarms can be analyzed or a report on supply voltage quality can be made. All data can be exported to an Access data base, Excel worksheets or as a text file.

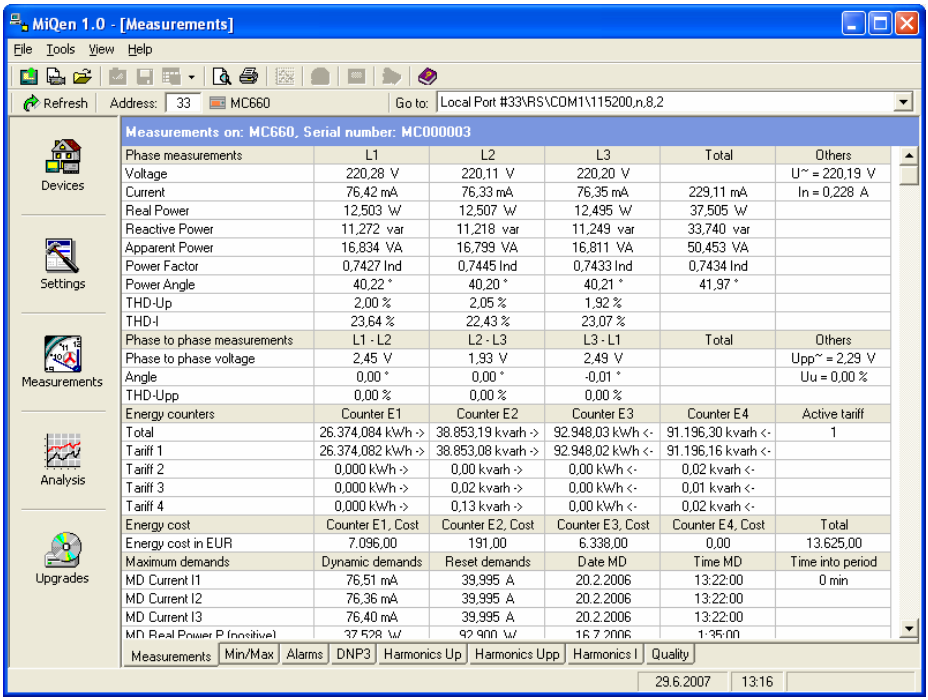
Software upgrading

Always use the latest version of software, both MiQen and software in the instrument. The program automatically informs you on available upgrades that can be transferred from the web site and used for upgrading.

Note

More information about MiQen software can be found in MiQen Help system!

PC MiQen user interface



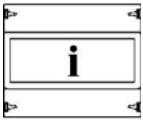
Phase measurements	L1	L2	L3	Total	Others
Voltage	220,28 V	220,11 V	220,20 V		U~ = 220,19 V
Current	76,42 mA	76,33 mA	76,35 mA	229,11 mA	In = 0,228 A
Real Power	12,503 W	12,507 W	12,495 W	37,505 W	
Reactive Power	11,272 var	11,218 var	11,249 var	33,740 var	
Apparent Power	16,834 VA	16,799 VA	16,811 VA	50,453 VA	
Power Factor	0,7427 Ind	0,7445 Ind	0,7433 Ind	0,7434 Ind	
Power Angle	40,22 °	40,20 °	40,21 °	41,97 °	
THD-Up	2,00 %	2,05 %	1,92 %		
THD-I	23,64 %	22,43 %	23,07 %		
Phase to phase measurements	L1 - L2	L2 - L3	L3 - L1	Total	Others
Phase to phase voltage	2,45 V	1,93 V	2,49 V		Upp~ = 2,29 V
Angle	0,00 °	0,00 °	-0,01 °		Uu = 0,00 %
THD-Upp	0,00 %	0,00 %	0,00 %		
Energy counters	Counter E1	Counter E2	Counter E3	Counter E4	Active tariff
Total	26.374,084 kWh ->	38.853,19 kvarh ->	92.948,03 kWh <-	91.196,30 kvarh <-	1
Tariff 1	26.374,082 kWh ->	38.853,08 kvarh ->	92.948,02 kWh <-	91.196,16 kvarh <-	
Tariff 2	0,000 kWh ->	0,00 kvarh ->	0,00 kWh <-	0,02 kvarh <-	
Tariff 3	0,000 kWh ->	0,02 kvarh ->	0,00 kWh <-	0,01 kvarh <-	
Tariff 4	0,000 kWh ->	0,13 kvarh ->	0,00 kWh <-	0,02 kvarh <-	
Energy cost	Counter E1, Cost	Counter E2, Cost	Counter E3, Cost	Counter E4, Cost	Total
Energy cost in EUR	7.096,00	191,00	6.338,00	0,00	13.625,00
Maximum demands	Dynamic demands	Reset demands	Date MD	Time MD	Time into period
MD Current I1	76,51 mA	39,995 A	20.2.2006	13:22:00	0 min
MD Current I2	76,36 mA	39,995 A	20.2.2006	13:22:00	
MD Current I3	76,40 mA	39,995 A	20.2.2006	13:22:00	
MD Real Power P (positive)	37,528 W	92,900 W	16.7.2006	1:35:00	

You can download freeware MiQen (standard edition) from: www.iskra-mis.si

5.3 Setting procedure

In order to modify instrument settings with MiQen, current parameters must be loaded first. Instrument settings can be acquired via a communication link or can be loaded off-line from a file on a local disk. Settings are displayed in the MiQen Setting Window - the left part displays a hierarchical tree structure of settings, the right part displays parameter values of the chosen setting group.

Note



Some settings are probably not available due to unsupported measurements and/or functions that depend on the device type. For a survey of supported measurements and functions see chapter Type differences, pages 10 to 12.

5.4 General settings ●●●

General settings are essential for measuring centre. They are divided into four additional sublevels (Connection, Communication, Display and Security).

Description and Location PC

Two parameters that are intended for easier recognition of a certain unit. They are especially used for identification of the device or location on which measurements are performed.

Average interval PC

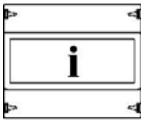
The averaging interval defines a refresh rate of measurements on LCD and communication.

Language PC

Set language on LCD. When language is changed from or to Russian, characters of the password are changed too. For overview of character translation see chapter Password and language on page 37.

Main menu ⇒ Settings ⇒ General ⇒ Language

Note



If a wrong language is set, a menu of languages is displayed by simultaneous pressing up and down keys.

Currency PC

Choose currency for evaluating energy cost (see chapter Energy on page 37). A currency designation consists of up to four letters taken from the English or Russian alphabet and numbers and symbols stated in table below.

English	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
Symbols		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/	0 to 9			:	;	<	=	>	?	@
Russian	А	Б	В	Г	Д	Е	Ж	З	И	Й	К	Л	М	Н	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ
	а	б	в	г	д	е	ж	з	и	й	к	л	м	н	о	п	р	с	т	у	ф	х	ц	ч	ш	Щ

Main menu ⇒ Settings ⇒ General ⇒ Currency

Temperature unit PC

Choose a unit for temperature display.

Main menu ⇒ Settings ⇒ General ⇒ Temperature unit

Date format PC

Set a date format.

Main menu ⇒ Settings ⇒ Date & Time ⇒ Date format

Date and time PC

Set date and time of the meter. Setting is important for correct memory operation, maximal values (MD), etc.

Main menu ⇒ Settings ⇒ Date & Time ⇒ Date / Time

Auto Summer/Winter time PC

If Yes is chosen, time will be automatically shifted to a winter or a summer time, regarding the time that is momentarily set.

Main menu ⇒ Settings ⇒ Date & Time ⇒ Automatic S/W time

Maximum demand calculation (MD mode) PC

The instrument provides maximum demand values from a variety of average demand values:

- Thermal function
- Fixed window
- Sliding windows (up to 15)

Main menu ⇒ Settings ⇒ General ⇒ MD mode / MD time constant

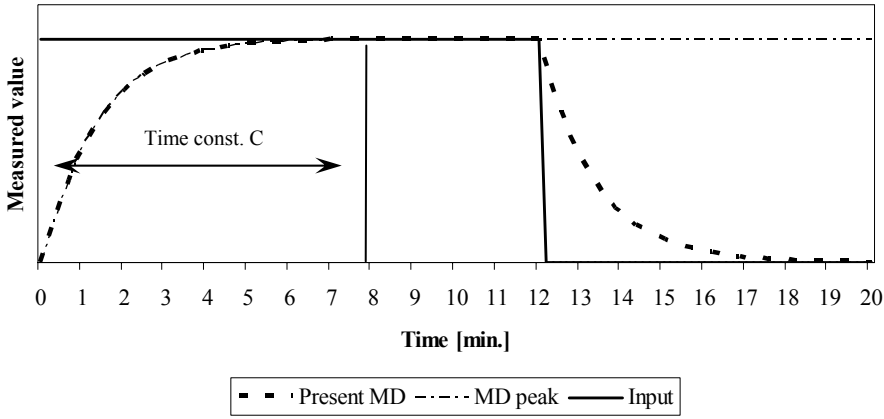
Thermal function

A thermal function assures exponent thermal characteristic based on simulation of bimetal meters. Maximal values and time of their occurrence are stored in device. A time constant (t. c.) can be set from 1 to 255 minutes and is 6 − time thermal time constant (t. c. = 6 * thermal time constant).

Example: Time constant: 8 min.

Current MD and maximal MD: Reset at 0 min.

Thermal function



Fixed window

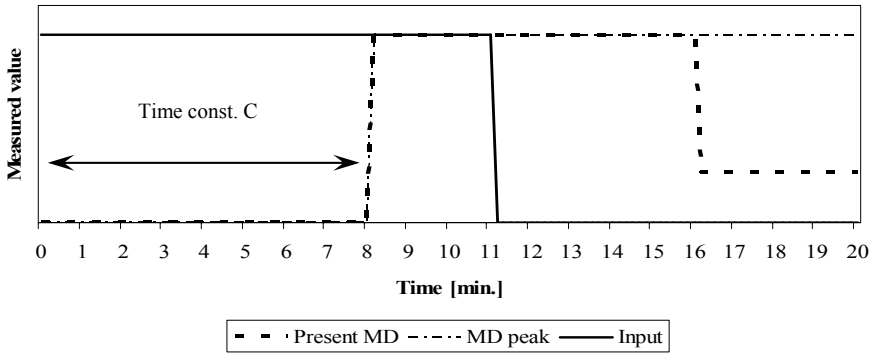
A fixed window is a mode that calculates average value over a fixed time period. This (t. c. – time constant) can be set from 1 to 255 min. »TIME IN A PERIOD« will actively show the remaining time until the end of the period, until a current MD and maximal MD from the last reset are calculated. When displays for Pt(+/−), Qt(L/C), St, I1, I2 and I3 are updated, a new period and measurement of new average values are started. »TIME IN A PERIOD« then shows 0 of X min.

A new period also starts after a longer interruption of power supply (more than 1 s). If time constant is set to one of the values of 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 or 60 minutes, »TIME IN A PERIOD« is set to such value that one of the following intervals will be terminated at a full hour. In other cases of time constants, »TIME IN A PERIOD« is set to 0.

Example: Mode: Fixed window, Time constant: 8 min.

Current MD and maximal MD: Reset at 0 min.

Fixed window



Sliding windows

A mode of sliding windows enables multiple calculation of average in a period and thus more frequent regeneration of measuring results. Average value over a complete period is displayed. A current MD is updated every sub period for average of previous sub periods.

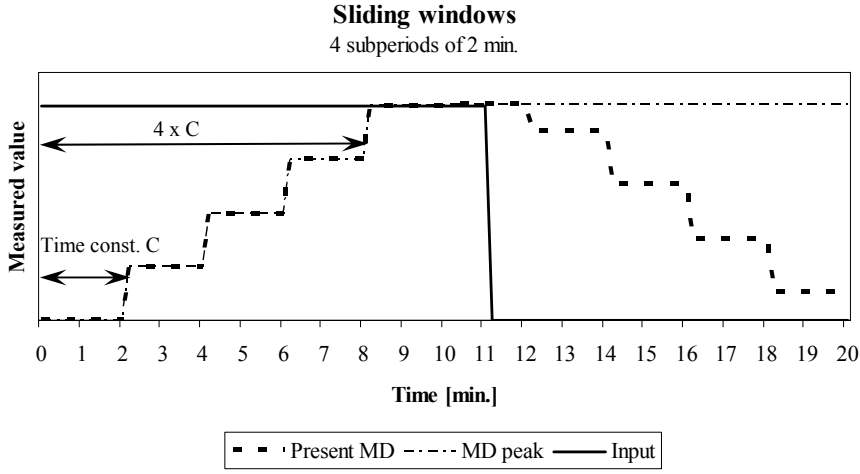
A number of sub periods can be set from 2 to 15.
A time period (t. c.) can be set from 1 to 255 minutes.

A new period also starts after a longer interruption of power supply (more than 1 s). If time constant is set to one of the values of 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 or 60 minutes, »TIME IN A PERIOD« is set to such value that one of the following intervals will be terminated at a full hour. In other cases of time constants, »TIME IN A PERIOD« is set to 0.

Example: Time constant: 2 min., No. of sub periods: 4

Current MD and maximal MD: Reset at 0 min.

A complete period lasts for 8 minutes and consists of 4 sub periods that are 2 minutes long. A current MD and a maximal MD are reset at 0 min. "TIME IN A PERIOD" is data for a sub period so that the values for a current MD and a maximal MD are regenerated every two minutes. After 4 sub periods (1 complete period) the oldest sub period is eliminated when a new one is added, so that average (a window) always covers the last 4 sub periods.



Resetting Min/Max PC

A mode of stored values deletion of Min/Max values is set. It can be set to a manual (see chapter Reset on page 45) or automatic mode (daily, weekly, monthly or yearly reset). Resets are performed at the beginning of a certain term at midnight. Daily – every day, weekly on Monday at 00:00, monthly − the first day in a month at 00:00, and yearly − the first day in a year 1.1. at 00:00.

Main menu ⇒ Settings ⇒ General ⇒ Min/Max reset mode

Starting current for PF and PA (mA) PC

At all measuring inputs noise is usually present. It is constant and its influence on the accuracy is increased by decreasing measuring signals. It is present also when measuring signals are not connected and it occurs at all further calculations as very sporadic measurements. By setting a common starting current, a limit of input signal is defined where measurements and all other calculations are still performed.

Starting current for all powers (mA) PC

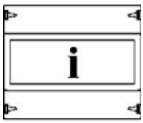
Noise is limited with a starting current also at measurements and calculations of powers.

Calculation of harmonics PC

Selection of reference for calculation is important for calculation of absolute values of harmonics. It is possible to select between a percentage of harmonic of RMS signal value (current, voltage) or relative to the fundamental (first harmonic). At percentage of RMS, a signal rate is calculated for all harmonics. At percentage of 1st harmonic, all other harmonics are calculated relatively to 1st harmonic.

5.5 Connection ●●●

Note



Settings of connections shall reflect actual state otherwise measurements are not valid.

Connection PC OK

When connection is selected, load connection and the supported measurements are defined (see chapter Survey of supported measurements regarding connection mode on page 48).

OK Main menu ⇒ Settings ⇒ Connection ⇒ Connection mode

Setting of current and voltage ratios PC OK

Before setting current and voltage ratios it is necessary to be familiar with the conditions in which device will be used. All other measurements and calculations depend on these settings. Up to five decimal places can be set (up / down). To set decimal point and prefix (up / down) position the cursor (left /right) to last (empty) place or the decimal point.

Settings range	VT primary	VT secondary	CT primary	CT secondary
Maximal value	1638,3 kV	13383 V	1638,3 kA	13383 A
Minimal value	0,1 V	1 mV	0,1 A	1 mA

OK Main menu ⇒ Settings ⇒ Connection ⇒ VT primary / VT secondary / CT primary / CT secondary

Used voltage and current range PC

Setting of the range is connected with all settings of alarms and a display (calculation) of energy and measurements recording, where 100% represents 500 V. In case of subsequent change of the range, alarms settings shall be correspondingly changed, as well.

Nominal frequency PC

A valid frequency measurement is within the range of nominal frequency ±32 Hz. This setting is used for alarms and recorders only.

5.6 Communication ●●●

Communication parameters PC OK

They define parameters that are important for the operation in RS485 network. Factory settings of communication are #33\115200,n,8,2 (address 1 to 247\rate 2400 to 115200 b/s, parity, data bits, stop bit).

OK Main menu ⇒ Settings ⇒ Communication ⇒

5.7 Display ●●●

Display settings PC

A combination of setting of the contrast and back light defines visibility and legibility of a display. Display settings shall be defined in compliance with the conditions in which it will be monitored. Economizing mode switches off back light according to the set time of inactivity.

Main menu ⇒ Settings ⇒ LCD ⇒ Contrast / Back light / Back light time off

Demo cycling period PC

It defines time in seconds for each displayed screen of measurements on LCD.

Main menu ⇒ Settings ⇒ LCD ⇒ Demo cycling period

Settings of customized screens PC

For easier and faster survey of measurements that are important for the user, three settings of customized screens are available. Each customized screen displays three measurements. When setting customized screens the designations are displayed in shorter form, with up to 4 characters. For survey of all designations see chapter Survey of supported measurements regarding connection on page 48.

Example:

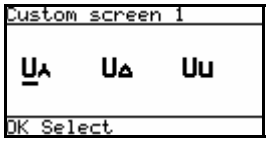
Desired result:

Customized screen 1	Customized screen 2	Customized screen 3
Average phase voltage	Total current	Power angle (U_1–I_1)
Av. Phase to phase volts	Neutral current	Frequency
Voltage unbalance	Average current	THD of power angle I_1

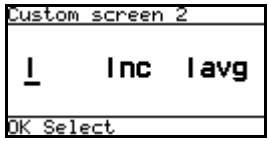
Setting:

Main menu ⇒ Settings ⇒ LCD ⇒ Custom screen 1 / 2 / 3

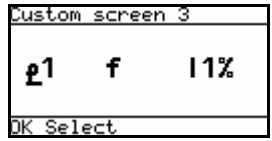
Customized screen 1



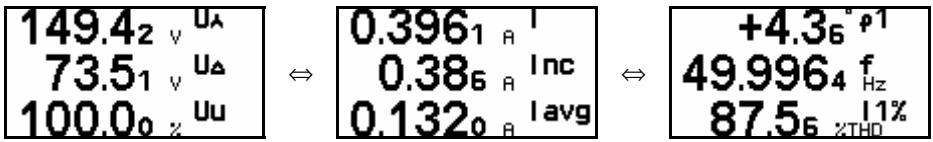
Customized screen 2



Customized screen 3



Main menu ⇒ Measurements ⇒ Present values ⇒ Custom OK



5.8 Security ●●●

Settings parameters are divided into four groups regarding security level:

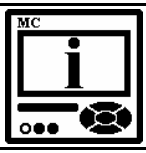
1 At the lowest level (PL0), where a password is not required, parameters of LCD can be set: language, contrast and LCD back light.

2 At the first level (PL1), settings of a real time clock can be changed, energy meters and MD can be reset.

3 At the second level (PL2), the access to all data that are protected with the first level (PL1) and setting of all other parameters in the »SETTINGS« menu are available.

4 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 meter). The BP password is available in the user support department at manufacturer, and is entered instead of the password PL1 or/and PL2. Do not forget to state the meter serial meter when contacting the personnel at manufacturer.

Note

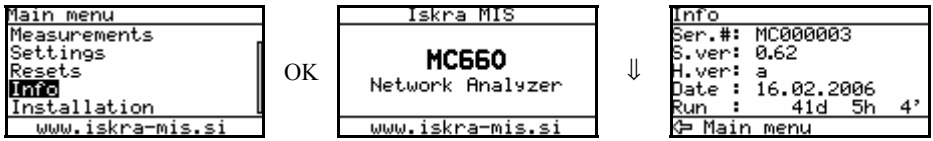


A serial number of device is stated on the label, LCD (see example below) and is also accessible when MiQen software.

The access to the meter serial number via a keyboard

Example:

OK Main menu ⇒ Info OK ⇓



Password setting PC OK

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 *.

A password of the first (L1) and the second (L2) level is entered, and time of automatic activation is set.

OK Main menu ⇒ Settings ⇒ Security ⇒ Password level 1 / Password level 2 / Password lock time

Password modification PC OK

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

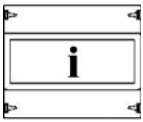
OK Main menu ⇒ Settings ⇒ Security ⇒ Password level 1 / Password level 2

Password disabling PC

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

Main menu ⇒ Settings ⇒ Security ⇒ Password level 1 / Password level 2 ⇒ "AAAA" OK

Note



A factory set password is "AAAA" at both access levels (L1 and L2). This password does not limit access.

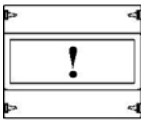
Password and language

Language change is possible without password input. When language is changed from or to Russian, character transformation has to be taken in to account. Character transformation table (English or Russian alphabet) is stated below.

English	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Russian	A	Б	B	Г	Д	E	Ж	З	И	Й	K	Л	M	H	O	П	P	C	T	У	Ф	X	Ц	Ч	Ш	Щ

5.9 Energy

Warning!



After modification of energy parameters, the energy meters must be reset otherwise all further energy measurements could be incorrect.

Active tariff PC

When active tariff is set, one of the tariffs is defined as active; switching between tariffs is done either with a tariff clock or a tariff input. For the operation of the tariff clock other parameters of the tariff clock that are accessible only via communication must be set correctly.

Common energy exponent PC

Common energy exponent defines minimal energy that can be displayed on the energy counter. On the basis of this and a counter divider, a basic calculation prefix for energy is defined (−3 is 10^{-3}Wh = mWh, 4 is 10^{4}Wh = 10 kWh). A common energy exponent also influences in setting a number of impulses for energy of pulse output or alarm output functioning as an energy meter.

Common exponent of energy cost PC

Setting enables resolving the cost display. On the basis of this and a diving constant, a basic calculation prefix for energy cost is defined.

Common exponent of tariff price and energy price in tariffs PC

Exponent and price represent energy price (active, reactive, common) in a tariff. The price exponent is used for recording the price without decimal places.

Counter divider PC

The counter divider additionally defines precision of a certain counter, according to settings of common energy exponent.

An example for 1kW of consumed active energy in the first tariff (price 86.81 EUR/kWh):

Common energy exponent	0	2	2
Counter divider	1	1	100
Common energy cost exponent	−2	−2	−2
Common tariff price exponent	−4	−4	−4
Price for energy in tariff 1	8681	8681	8681
Unit	EUR	EUR	EUR
Example of result, display	2.577 kWh 2,22 EUR	0.2577 MWh 223.74 EUR	25.77 MWh 22375.25 EUR

Tariff clock PC

Basic characteristics of a program tariff clock:

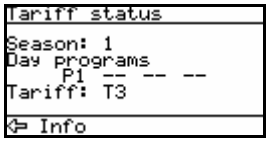
- 4 tariffs (T1 to T4)
- Up to 4 time spots in each Day program for tariff switching
- Whichever combination of valid days in a week or holidays for each program
- Combining of day groups (use of over 4 time spots for certain days in a week)
- Separate settings for 4 seasons a year
- Up to 20 settable dates for holidays

Operation of internal tariff clock

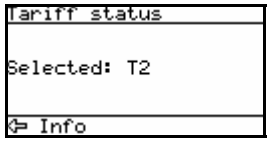
Tariff status is displayed in the Info menu.

Example of display for selected Active tariff:

OK Main menu ⇒ Info OK ⇓ ⇓ ⇓ ⇒



or



or

Day program sets up to 4 time spots (rules) for each day group in a season for tariff switching.

A date of real time clock defines an active period. An individual period is active from the period starting date to the first next date of the beginning of other periods.

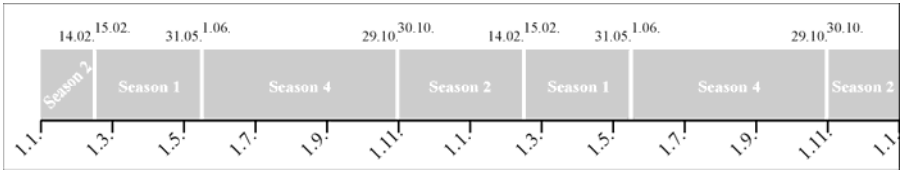
The order of seasons and starting dates is not important, except when two dates are equal. In that case the season with a higher successive number has priority, while the season with a lower number will never be active.

If no starting date of a season is active, the active period is 1.

If the present date is before the first starting date of any period, the period is active with the last starting date.

Example of settings:

Season	**Season start day**
Season 1:	15.02
Season 2:	30.10
Season 3:	−
Season 4:	01.06
Date	**Active season**
01.01. − 14.02.	2 (last in the year)
15.02. − 31.05.	1
01.06. − 29.10.	4
30.10. − 31.12.	2



Days in a week and selected dates for holidays define time spots for each daily group in a period for tariff switching. Dates for holidays have priority over days in a week.

When the real time clock date is equal to one of a date of holidays, tariff is switched to holiday, within a period of active daily group with a selected holiday.

If there is no date of holidays that is equal to the real time clock date, all daily groups with the selected current day in a week are active.

Several daily groups can be active simultaneously, which enables more than 4 time spots in one day (combine of day programs). **If the time spot is not set for a certain day, tariff T1 is chosen**.

Time of a real time clock defines an active tariff regarding currently active day program. A selected tariff T1 to T4 of individual time spot is active from the time of the time spot to the first next time of the remaining time spots.

The order of time spots is not important, except when two times are equal. In that case the time with a higher successive number has priority (if several time spots are active, times of higher time spots have higher successive numbers), while the time spot with a lower number will never be active.

If current time is before the first time of any time spot of active spots, the time spot with the last time is chosen.

If no time spot of active programs is valid, tariff T1 is chosen.

Time selected tariff T1 to T4 or fixed selected tariff (via communication) defines activity of an energy counter.

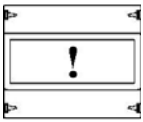
5.10 Inputs and outputs ●●●

Module settings depend on built-in modules. All modules have a double input or output.

Pulse (Alarm) output module PC OK

A corresponding energy counter is defined to a pulse output. A number of pulses per energy unit, pulse length, and a tariff set in which output is active are set.

Warning!



Pulse parameters are defined by SIST EN 62053−31 standard. In chapter Calculation of recommended pulse parameters, below a simplified rule is described to assist you in setting the pulse output parameters.

OK Main menu ⇒ Settings ⇒ Inputs/Outputs ⇒ I/O 1 / 2 / 3 / 4 ⇒ Setting of pulse output

Calculation of recommended pulse parameters

Number of pulses per energy unit should be in certain limits according to expected power. If not so the measurement from pulse output can be incorrect. Settings of current and voltage transformers can help in estimation of expected power.

Principle described below for pulse setting, where e is prefix, satisfies SIST EN 62053−31: 2001 standards pulse specifications:

$$1{,}5\ldots15\ \mathrm{eW} \rightarrow 100\ \mathrm{p/1\ eWh}$$

Examples:

Expected power	→	Pulse output settings
150 − 1500 kW	→	1 p/1kWh
1,5 − 15 MW	→	100 p/1MWh
15 − 150 MW	→	10 p/1MWh
150 − 1500 MW	→	1 p/1MWh

The pulse module can also function as an **alarm output** with limited current load (max. 20 mA). Alarm groups that are connected with an alarm module and a signal shape are defined.

OK Main menu ⇒ Settings ⇒ Inputs/Outputs ⇒ V/I 1 / 2 / 3 / 4 ⇒ Setting of alarm output

Signal shape:

- Normal − A relay is closed until condition for the alarm is fulfilled.
- Normal inverse − A relay is open until condition for the alarm is fulfilled.
- Holds − A relay is closed when condition for the alarm is fulfilled, and remains closed until it is reset via communication.
- Pulse − an impulse of the set length is sent always when condition for the alarm is fulfilled.
- Always switched on / off (permanent) – A relay is permanently switched on or switched off irrespective of the condition for the alarm.

Tariff (Digital) input module

No setting. It operates by setting active tariff at a tariff input (see chapter Tariff clock on page 38). The instrument can have maximal one module with 2 tariff inputs only. With the combination of 2 tariff inputs maximal 4 tariffs can be selected.

5.11 Alarms

Alarms are used for alarming exceeded set values of the measured quantities.

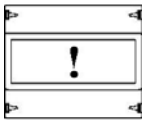
◖ − MC64X no supported alarms recording into memory

Alarms setting PC

Measuring centre supports recording and storing of 32 alarms in 4 groups. For each group of alarms a time constant of maximal values in thermal mode, a delay time and alarm deactivation hysteresis can be defined.

Quantity, value (a current value or a MD – thermal function) and a condition for alarm switch-on are defined for every individual alarm.

Warning!



New values of alarms are calculated in percentage at modification of connection settings.

Types of alarms

Visual alarm

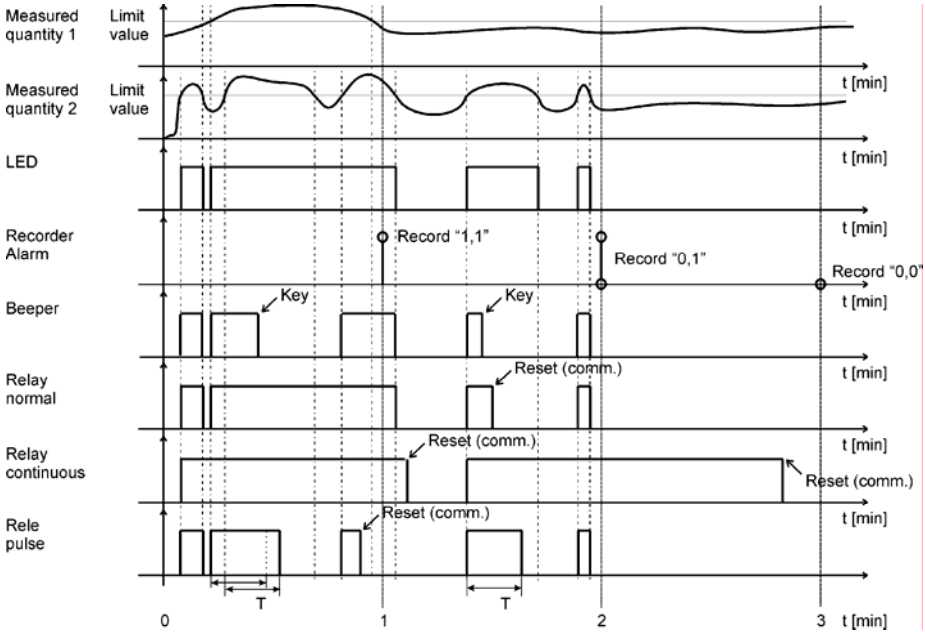
When alarm is switched on, a red LED on the meter front side is blinking (see figure shown on next page).

Audible alarm

When alarm is switched on, an audible alarm is given by the meter (a beep). It can be switched off by pressing any key on the front plate (see figure shown on next page).

Alarm output (pulse module)

According to the alarm signal shape the output will behave as shown on next page.



5.12 Memory

Measurements, alarms, reports and details of supply voltage quality are stored in a built in memory (8MB flash). All records stored in memory are accessible via communication with MiQen software.

○ − MC64X no memory

Memory division PC

Instrument memory is divided into 3 partitions which size is defined by the user. The A and B recorders are intended for recording measurements, while all alarms that occurred are recorded in an alarm partition. MC66X has 2 additional partitions for recording reports and details on the quality of supply voltage (see chapter Quality of supply, next page).

Memory operation

Memory functions in a cyclic mode in compliance with the FIFO method. This means that only the latest records are stored in the memory that will replace the oldest ones. A number of stored data or a storing period depends on selected partition size, a number of recorded quantities and time of division sampling. Occupancy of partitions is shown in the Information menu (see chapter 4.2 Display of device info on page 22).

Memory clearing PC

There is usually no need to clear the memory, because it works in cyclic mode. If you want to clear memory data anyway, the data storing must be stopped first. Read the instrument settings with MiQen and set “Recorder state” in Memory setting group to stopped. Download changes to the device and open Memory info form and then click on Clear memory button. Select memory partitions to be cleared on Memory clearing form and click on OK button. Set “Recorder state” setting back to active.

5.13 Conformity of voltage with SIST EN 50160 standard ○○●

The SIST EN 50160 standard deals with voltage characteristics of electricity supplied by public distribution systems. This specifies the limits or values within which a customer can expect voltage characteristics to lie. Within this definition the Network analyzer is adapted for supervising the compliance of distribution systems with the SIST EN 50160 standard.

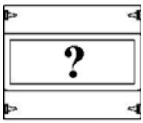
● − MC66X enables supervision of network compliance with the SIST EN 50160 standard

Based on requirements stated in the standard, default parameters are set in the meter according to which supervision of all required parameters is done. Parameters can also be changed in detailed setting of individual characteristic.

Quality of supply PC

Basic parameters are defined that influence other settings.

User information



Un − Nominal supply voltage with which network is marked and to which individual operation parameters refer.
Uc − Agreed supply voltage is usually network voltage (Un). If a client and a supplier agree about voltage that is different from nominal voltage, that voltage is considered as agreed supply voltage.

Monitoring mode

It defines if the instrument performs measurements for network compliance with the standard.

Electric energetic system

Public distribution system and, if necessary, all default settings are selected.

Nominal supply voltage

A value that is usually equal to nominal network voltage is entered.

Nominal power frequency

Nominal frequency of supply voltage is selected.

Monitoring period

For a report of electric voltage quality, a monitoring period is defined. A number of monitored weeks is entered.

Monitoring start day

A starting day in a week is selected. It starts at 00:00 (midnight). The selected day will be the first day in a report.

Voltage hysteresis

Hysteresis for voltage dips, interruptions and overvoltages is set in percentage from nominal voltage.

Frequency variations PC

All frequency measurements are performed in 10−second intervals of averaging. For both required quality variations a range of variation is defined in percentage. Percentage of required measurements within the limits (required quality) in the monitored period is also defined.

Voltage variations PC

All voltage measurements are performed in 10−minute intervals of averaging. For all required variations a range of deviation is defined in percentage. Percentage of required measurements (required quality) within the limits in the monitored period is also defined.

Interruptions and dips PC

A limit for voltage dip and interruption is defined in percentage with regard to nominal voltage. A limit between short-term and long-term interruption is defined in seconds. Other parameters define limits of events in a monitored period.

Rapid voltage changes PC

A change limit in percentage of nominal voltage and permitted number of events in a monitored period are defined.

Temporary overvoltages, flickers PC

There are two types of flickers: short-term flicker intensity (P_{st}) and long-term flicker intensity (P_{lt}). Required quality in a monitored period is defined for flickers. A number of allowed events in the period are defined for temporary overvoltages.

Harmonics and THD PC

Permitted limits for the first 25 harmonic components and required quality in a monitored period are defined.

5.14 Reset operations ●●●

Reset Min / Max values PC

All Min / Max values are reset.

Main menu ⇒ Resets ⇒ Min/Max values ⇒

Reset energy counters (E1, E2, E3, E4) PC

All or individual energy meters are reset.

Main menu ⇒ Resets ⇒ Energy counters ⇒ All energy counters / Energy counter E1 / E2 / E3 / E4 OK

Reset energy counters costs (E1, E2, E3, E4) PC

All or individual energy costs are reset.

Main menu ⇒ Resets ⇒ Energy counters ⇒ All cost counters / Cost counter E1 / E2 / E3 / E4 OK

Reset maximal MD values PC

Thermal mode

Current and stored MDs are reset.

Fixed interval / Sliding windows

The values in the current time interval, in all sub-windows for sliding windows and stored MD are reset. In the same time, synchronization of time interval to the beginning of the first sub-window is also performed.

Main menu ⇒ Resets ⇒ MD values ⇒

Reset the last MD period PC

Thermal mode

Current MD value is reset.

Fixed interval / Sliding windows

Values in the current time interval and in all sub-windows for sliding windows are reset. In the same time, synchronization of the time interval is also performed.

Main menu ⇒ Resets ⇒ Last period MD ⇒

MD synchronization PC

Thermal mode

In this mode, synchronization does not have any influence.

Fixed interval / Sliding windows

Synchronization sets time in a period or a sub-period for sliding windows to 0 (zero). If the interval is set to 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 or 60 minutes, time in a period is set to such value that some intervals will be terminated at completed hour.

Example:

OK Main menu ⇒ Resets ⇒ Synchronize MD ⇒

Time constant (interval)	15 min	10 min	7 min
Synchronization start time	10:42	10:42	10:42
Time in a period	12 min	2 min	0 min
First final interval	10:45	10:50	10:49

Reset alarm output PC

All alarms are reset.

OK Main menu ⇒ Reset ⇒ Reset alarm output ⇒

6. MEASUREMENTS

6.1 Introduction

In the following chapters the meter operation is explained more in detail.

6.2 Supported measurements

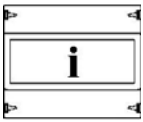
Measurements support regarding the device type is described in chapter Type differences, pages 10 to 12. Selection of supported measurements of individual instrument type is changed with the connection settings.

6.3 Available connections

Different electric connections are described more in detail in chapter Electric connection on page 14. Connections are marked as follows:

−Connection 1b (1W) − Single phase connection
−Connection 3b (1W3) − Three-phase – three-wire connection with balanced load
−Connection 4b (1W4) − Three-phase – four-wire connection with balanced load
−Connection 3u (2W3) − Three-phase – three-wire connection with unbalanced load
−Connection 4u (3W4) − Tree-phase – four-wire connection with unbalanced load

Note



Measurements support depends on connection mode the instrument type. Calculated measurements are only informative.

Survey of supported measurements regarding connection mode

All measurements, with designations can be displayed on customized screens.

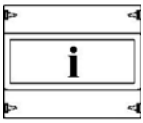
	Basic measurements	Designat.	Unit	1b	3b	3u	4b	4u
Phase	Voltage U_1	U1	V	●	×	×	●	●
	Voltage U_2	U2	V	×	×	×	○	●
	Voltage U_3	U3	V	×	×	×	○	●
	Average voltage U^{-}	U⅄	V	×	×	×	○	●
	Current I_1	I1	A	●	●	●	●	●
	Current I_2	I2	A	×	○	●	○	●
	Current I_3	I3	A	×	○	●	○	●
	Current I_n	Inc	A	×	○	○	○	●
	Total current I_t	I	A	●	○	○	○	●
	Average current I_a	Iavg	A	×	○	○	○	●
	Active power P_1	P1	W	●	×	×	●	●
	Active power P_2	P2	W	×	×	×	○	●
	Active power P_3	P3	W	×	×	×	○	●
	Total active power P_t	P	W	●	●	●	○	●
	Reactive power Q_1	Q1	var	●	×	×	●	●
	Reactive power Q_2	Q2	var	×	×	×	○	●
	Reactive power Q_3	Q3	var	×	×	×	○	●
	Total reactive power Q_t	Q	var	●	●	●	○	●

● – supported ○ − calculated × − not supported

	Basic measurements	Designat.	Unit	1b	3b	3u	4b	4u
Phase	Apparent power S_1	S1	VA	●	×	×	●	●
	Apparent power S_2	S2	VA	×	×	×	○	●
	Apparent power S_3	S3	VA	×	×	×	○	●
	Total apparent power S_t	S	VA	●	●	●	○	●
	Power factor PF_1	PF1/ePF1		●	×	×	●	●
	Power factor PF_2	PF2/ePF2		×	×	×	○	●
	Power factor PF_3	PF3/ePF3		×	×	×	○	●
	Total power factor $PF^{\sim}$	PF/ePF		●	●	●	○	●
	Power angle φ_1	φ1	°	●	×	×	●	●
	Power angle φ_2	φ2	°	×	×	×	○	●
	Power angle φ_3	φ3	°	×	×	×	○	●
	Total power angle $\varphi^{\sim}$	φ	°	●	●	●	○	●
	THD of phase voltage U_{f1}	U1%	%THD	●	×	×	●	●
	THD of phase voltage U_{f2}	U2%	%THD	×	×	×	○	●
	THD of phase voltage U_{f3}	U3%	%THD	×	×	×	○	●
	THD of phase current I_1	I1%	%THD	●	●	●	●	●
	THD of phase current I_2	I2%	%THD	×	○	●	○	●
	THD of phase current I_3	I3%	%THD	×	○	●	○	●
Phase-to-phase	Phase-to-phase voltage U_{12}	U12	V	×	●	●	○	●
	Phase-to-phase voltage U_{23}	U23	V	×	●	●	○	●
	Phase-to-phase voltage U_{31}	U31	V	×	●	●	○	●
	Average phase-to-phase voltage (U_{ff})	U△	V	×	●	●	○	●
	Phase-to-phase angle φ_{12}	φ12	°	×	×	×	○	●
	Phase-to-phase angle φ_{23}	φ23	°	×	×	×	○	●
	Phase-to-phase angle φ_{31}	φ31	°	×	×	×	○	●
	Voltage unbalance U_u	Uu	%	×	●	●	×	●
	THD of phase-to-phase voltage THD_{U12}	U12%	%THD	×	●	●	○	●
	THD of phase-to-phase voltage THD_{U23}	U23%	%THD	×	●	●	○	●
	THD of phase-to-phase voltage THD_{U31}	U31%	%THD	×	●	●	○	●
Energy	Counters 1−4	E1, E2, E3, E4	Wh VAh varh	●	●	●	●	●
	Active tariff	Atar		●	●	●	●	●
	Cost by meters	E1$, E2$, E3$, E4$	XXXX	●	●	●	●	●
	Total cost	E$	XXXX	●	●	●	●	●
Max. values MD	MD current I_1	I1	A	●	●	●	●	●
	MD current I_2	I2	A	×	○	●	○	●
	MD current I_3	I3	A	×	○	●	○	●
	MD active power P (positive)	P+	W	●	●	●	●	●
	MD active power P (negative)	P−	W	●	●	●	●	●
	MD reactive power Q−L	Q⧗	var	●	●	●	●	●
	MD reactive power Q−C	Q⧖	var	●	●	●	●	●
	MD apparent power S	S	VA	●	●	●	●	●

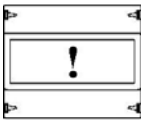
● – supported ○ − calculated × − not supported

Note



Basic and MD measurements have designations for recognition via LCD. In this way they can be selected via LCD for a display on customized screens.

Warning!



When, due to mode of connection, unsupported measurement is selected for customized screen an undefined value is displayed.

	Flicker measurement	**Designat.**	**Unit**	**1b**	**3b**	**3u**	**4b**	**4u**
Flickers Pst / Plt	Short term f. 1. phase voltage	Plt1		●	×	×	●	●
	Short term f. 2. phase voltage	Plt2		×	×	×	○	●
	Short term f. 3. phase voltage	Plt3		×	×	×	○	●
	Short term f. 1. phase-to-phase voltage	Pst1		×	●	●	×	×
	Short term f. 2. phase-to-phase voltage	Pst2		×	●	●	×	×
	Short term f. 3. phase-to-phase voltage	Pst3		×	●	●	×	×
	Long term f. 1. phase voltage	Plt1		●	×	×	●	●
	Long term f. 2. phase voltage	Plt2		×	×	×	○	●
	Long term f. 3. phase voltage	Plt3		×	×	×	○	●
	Long term f. 1. phase-to-phase voltage	Pst1		×	●	●	×	×
	Long term f. 2. phase-to-phase voltage	Pst2		×	●	●	×	×
	Long term f. 3. phase-to-phase voltage	Pst3		×	●	●	×	×

	Min/max measurements	**1b**	**3b**	**3u**	**4b**	**4u**
Instantaneous / Maximal / Minimal values	Voltage U_1	●	×	×	●	●
	Voltage U_2	×	×	×	○	●
	Voltage U_3	×	×	×	○	●
	Phase-to-phase voltage U_{12}	×	●	●	○	●
	Phase-to-phase voltage U_{23}	×	●	●	○	●
	Phase-to-phase voltage U_{31}	×	●	●	○	●
	Phase current I_1	●	●	●	●	●
	Phase current I_2	×	○	●	○	●
	Phase current I_3	×	○	●	○	●
	Active power P_1	●	×	×	●	●
	Active power P_2	×	×	×	○	●
	Active power P_3	×	×	×	○	●
	Total active power P	×	●	●	○	●
	Apparent power S_1	●	×	×	●	●
	Apparent power S_2	×	×	×	○	●
	Apparent power S_3	×	×	×	○	●
	Total apparent power S	×	●	●	○	●
	Frequency f	●	●	●	●	●
	Internal temperature	●	●	●	●	●

● – supported ○ – calculated × – not supported

	Measurements of harmonics	**1b**	**3b**	**3u**	**4b**	**4u**
Harmonics up to 63rd	Phase voltage U_1	●	×	×	●	●
	Phase voltage U_2	×	×	×	○	●
	Phase voltage U_3	×	×	×	○	●
	Phase-to-phase voltage U_{12}	×	●	●	○	●
	Phase-to-phase voltage U_{23}	×	●	●	○	●
	Phase-to-phase voltage U_{31}	×	●	●	○	●
	Phase current I_1	●	●	●	●	●
	Phase current I_2	×	○	●	○	●
	Phase current I_3	×	○	●	○	●

● – supported ○ – calculated × – not supported

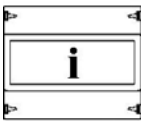
	Graphical display	**1b**	**3b**	**3u**	**4b**	**4u**
Time / FFT	Phase voltage U_1	●	×	×	●	●
	Phase voltage U_2	×	×	×	○	●
	Phase voltage U_3	×	×	×	○	●
	Phase-to-phase voltage U_{12}	×	●	●	○	●
	Phase-to-phase voltage U_{23}	×	●	●	○	●
	Phase-to-phase voltage U_{31}	×	●	●	○	●
	Phase current I_1	●	●	●	●	●
	Phase current I_2	×	○	●	○	●
	Phase current I_3	×	○	●	○	●

● – supported ○ – calculated × – not supported

	Voltage quality measurements	**1b**	**3b**	**3u**	**4b**	**4u**
Quality parameters	Frequency variations 1 / 2	●	●	●	●	●
	Voltage variations 1 / 2	●	●	●	●	●
	Voltage unbalances	×	●	●	×	●
	Voltage dips	●	●	●	○	●
	Voltage interruptions	●	●	●	○	●
	Long interruptions	×	●	●	○	●
	Rapid voltage changes	×	●	●	○	●
	Flickers Pst / Plt	×	●	●	○	●
	Temporary overvoltages	●	●	●	●	●
	THD's	×	○	●	○	●
	Harmonics	×	○	●	○	●

● – supported ○ – calculated × – not supported

Note



For 3b and 3u connection mode, only phase to phase voltages are measured. Because of that factor √3 is applied to calculation of quality considering nominal phase voltage.
For 4u connection mode measurements support is same as for 1b.

6.4 Explanation of basic concepts

Sample factor − M_V

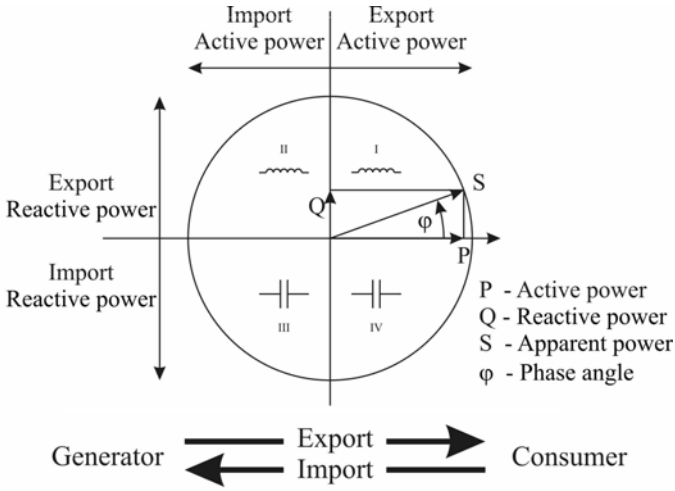
A meter measures all primary quantities with sample frequency which can not exceed a certain number of samples in a time period. Based on these limitations (65Hz·128 samples) a sample factor is calculated. A sample factor (M_V), depending on frequency of a measured signal, defines a number of periods for a measurement calculation and thus a number of harmonics considered in calculations.

Average interval − M_P

Due to readability of measurements from LCD and via communication, an Average interval (M_P) is calculated with regard to the measured signal frequency. The Average interval (see chapter Average interval on page 29) defines refresh rate of displayed measurements based on a sampling factor.

Power and energy flow

Figures below show a flow of active power, reactive power and energy for 4u connection.



6.5 Calculation and display of measurements

●●●

This chapter deals with capture, calculation and display of all supported quantities of measurement. Only the most important equations are described; however, all of them are shown in chapter Equations on page 86 with additional descriptions and explanations.

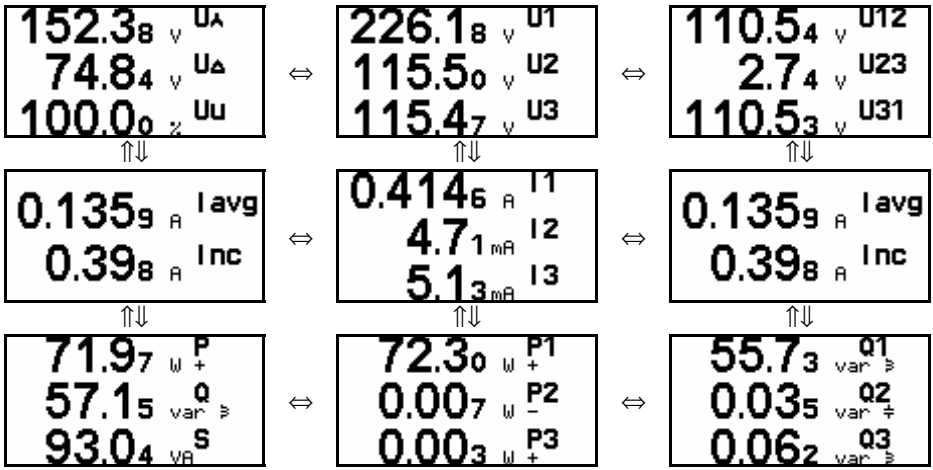
Note

Calculation and display of measurements depend on the device type and connection used. For more detailed information see chapters Survey of supported measurements regarding connection mode on page 48.

For entry and quitting measurement display menu, the OK key is used. Direction keys (left / right / up / down) are used for passing between displays as show in example below.

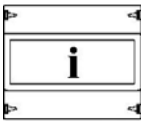
Example for MC640 at 4u connection mode:

OK Main menu ⇒ Measurements ⇒ Present values ⇒ Voltage OK



6.6 Present values ●●●

Note



Since measurement support depends on connection mode some display groups can be combined in to one, within Measurements menu.

Voltage PC

Instrument measures real effective (rms) value of all phase voltages (U_1, U_2, U_3), connected to the meter. Phase-to-phase voltages (U_{12}, U_{23}, U_{31}), average phase voltage (U_f) and average phase-to-phase voltage (U_a) are calculated from measured phase voltages (U_1, U_2, U_3). Voltage unbalance is calculated from phase-to-phase voltages (U_{12}, U_{23}, U_{31}).

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

All voltage measurements are available via communication, serial and customized displays on LCD.

OK Main menu ⇒ Measurements ⇒ Present values ⇒ Voltage OK

Current PC

Instrument measures real effective (rms) value of phase currents, connected to current inputs. Neutral current (I_n), average current (I_a) and a sum of all phase currents (I_t) are calculated from phase currents.

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

All current measurements are available via communication, serial and customized displays on LCD.

OK Main menu ⇒ Measurements ⇒ Present values ⇒ Current OK

Active, reactive and apparent power PC

Active power is calculated from instantaneous phase voltages and currents. All measurements are seen via communication or are displayed on LCD. For more detailed information about calculation see chapter Equations on page 86.

OK Main menu ⇒ Measurements ⇒ Present values ⇒ Power OK

Power factor and power angle PC

Power angle is calculated as quotient of active and apparent power for each phase separately ($\cos\varphi_1$, $\cos\varphi_2$, $\cos\varphi_3$) and total power angle ($\cos\varphi_t$). A symbol for a coil represents inductive load and a symbol for a capacitor represents capacitive load. For correct display of PF via application of the alarm, ePF (extended power factor) is applied. It illustrates power factor with one value as described in the table below. For a display on LCD both of them have equal display function: between −1 and −1 with the icon for inductive or capacitive load.

Load	C	→		←	L
Angle [°]	−180	−90	0	+90	+180 (179.99)
PF	−1	0	1	0	−1
ePF	−1	0	1	2	3

Power angle represents angle between first voltage harmonic and first current harmonic for each individual phase. Total power angle is calculated from total active and reactive power (see equation for Total power angle, chapter Equations on page 86). A positive sign shows inductive load, and a negative sign shows capacitive load.

OK Main menu ⇒ Measurements ⇒ Present values ⇒ PF & Power angle OK

Frequency PC

Network frequency is calculated from time periods of measured voltage. Additionally frequency with 10−second averaging interval is displayed.

OK Main menu ⇒ Measurements ⇒ Present values ⇒ Frequency OK

Energy PC

Three ways of energy display are available: by individual meters, by tariffs for each meter separately and energy cost by meters. At a display of meter energy by tariffs, the sum in the upper line depends on the tariffs set in the meter.

Example:

OK Main menu ⇒ Measurements ⇒ Present values ⇒ Energy OK

MD values PC

Display of MD values and time of recording (time stamp).

OK Main menu ⇒ Measurements ⇒ Present values ⇒ MD values OK

THD − Total harmonic distortion PC

THD is calculated for phase currents, phase and phase−to−phase voltages and is expressed as percent of high harmonic components regarding RMS value or relative to first harmonic (see chapter Calculation of harmonics on page 33).

Instrument uses measuring technique of real effective (rms) value that assures exact measurements with the presence of high harmonics up to 63rd harmonic.

Main menu ⇒ Measurements ⇒ Present values ⇒ THD OK

Flickers

Display of current Short term and Long term flickers for phase or phase-to-phase voltage (depending on mode of connection). Until the flicker value is calculated the symbol − is displayed.

Main menu ⇒ Measurements ⇒ Present values ⇒ Flickers OK

Customized screens

A display of customized screens depends on settings. See chapter Settings of customized screens on page 35.

Overview

It combines several measurements on each display as the following screens are displayed:

Explanation of measurements for MC660 at connection mode 4u:

Screen 1:

	Current phase measurements			Current phase measurements	
U⏢	Average voltage $U^{\sim}$	V	P	Total active power P_t	W
1	Phase voltage U_1	V	P1	Active power P_1	W
2	Phase voltage U_2	V	P2	Active power P_2	W
3	Phase voltage U_3	V	P3	Active power P_3	W
I⏢	Average current $I^{\sim}$	A	Q	Total reactive power Q_t	var
1	Current I_1	A	Q1	Reactive power Q_1	var
2	Current I_2	A	Q2	Reactive power Q_1	var
3	Current I_3	A	Q3	Reactive power Q_1	var

Screen 2:

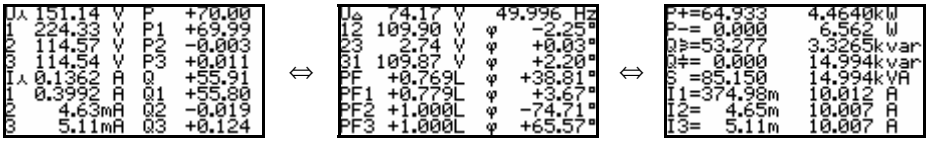
	Current phase-to-phase measurements			Current phase-to-phase measurements	
U△	Average phase-to-phase $U^{\sim}$	V		Frequency f	Hz
12	Phase-to-phase voltage U_{12}	V	φ	Power angle φ_1	°
23	Phase-to-phase voltage U_{23}	V	φ	Power angle φ_2	°
31	Phase-to-phase voltage U_{31}	V	φ	Power angle φ_3	°
PF	Total power factor		φ	Average phase-to-phase angle $\varphi^{\sim}$	°
PF1	Power factor PF_1		φ	Power angle φ_{12}	°
PF2	Power factor PF_2		φ	Power angle φ_{23}	°
PF3	Power factor PF_3		φ	Power angle φ_1	°

Screen 3:

	Dynamic MD values			Maximal MD values	
P+	MD active power P (positive)	W		MD active power P (positive)	W
P−	MD active power P (negative)	W	φ	MD active power P (negative)	W
Q⏢	MD reactive power Q−L	var	φ	MD reactive power Q−L	var
Q⏢	MD reactive power Q−C	var	φ	MD reactive power Q−C	var
S	MD apparent power S	VA	φ	MD apparent power S	VA
I1	MD current I1	A	φ	MD current I1	A
I2	MD current I2	A	φ	MD current I2	A
I3	MD current I3	A	φ	MD current I3	A

Example for MC660 at connection 4u:

Main menu ⇒ Measurements ⇒ Present values ⇒ Overview OK / ⇒



6.7 Min/Max values ●●●

All Min/Max values are displayed in the same way. Current values are displayed large in the middle of the screen, while minimal and maximal values are displayed smaller above and below the current values. Next to the current value is also measurement designation (see chapter Survey of supported measurements regarding connection on page 48)

Phase voltage PC

Display of phase voltages U_1, U_2 and U_3.

Main menu ⇒ Measurements ⇒ Min/Max values ⇒ Phase voltage OK

Phase-to-phase voltage PC

Display of phase-to-phase voltages U_{12}, U_{23} and U_{13}.

Main menu ⇒ Measurements ⇒ Min/Max values ⇒ Phase to Phase voltage OK

Current PC

Display of currents I_1, I_2 and I_3.

Main menu ⇒ Measurements ⇒ Min/Max values ⇒ Current OK

Active power PC

Display of active power P_1, P_2, P_2 and P_t.

Main menu ⇒ Measurements ⇒ Min/Max values ⇒ Active power OK

Apparent power PC

Display of apparent power S_1, S_2, S_2 and S_t.

Main menu ⇒ Measurements ⇒ Min/Max values ⇒ Apparent power OK

Frequency PC

Display of current frequency (f) and frequency with 10−second averaging

Main menu ⇒ Measurements ⇒ Min/Max values ⇒ Frequency OK

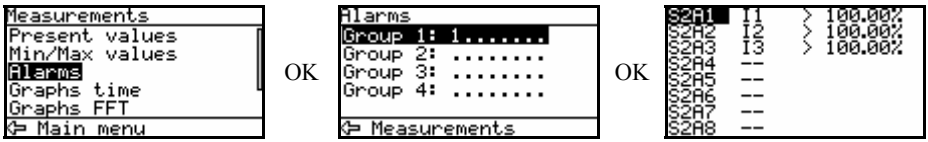
Date and time of reset PC

Display of date and time of the last reset and possibility of resetting Min/Max values.

Main menu ⇒ Measurements ⇒ Min/Max values ⇒ Date and time of reset OK

6.8 Alarms ●●●

An alarm menu enables surveying state of alarms. In the basic alarm menu, groups of alarms with the states of individual alarms and data on alarm outputs are displayed in the bottom line. For each active alarm a number of an alarm is written in a certain group at a certain place: Group 1: 1**.....**. Dot stands for alarm not active.



Survey of alarms PC

In a detailed survey alarms are collected in groups. A number of a group and alarm is stated in the first column, a measurement designation in the second, and a condition for alarm in the third one. Active alarm is marked.

Main menu ⇒ Measurements ⇒ Alarms OK / ⇒

6.9 Power supply quality ○○●

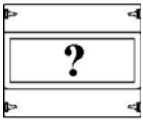
For evaluation of voltage quality, the MC66X network analyzer can store main characteristics in the internal memory. The reports are made on the basis of stored data. Data of the last 7 years and up to 170,000 variations of the measured quantities from the standard values are stored in the report, which enables detection of eventual reasons for troubles on network. The MiQen software offers a complete survey of reports with a detailed survey of individual measured quantities. Via the network analyzer LCD a survey of compliance of individual measured quantities in previous and actual monitored periods is made possible.

● − MC66X enables supervision of voltage compliance with the SIST EN 50160 standard.

Monitoring periods PC

Instrument displays status, compliance and quality of individual parameters without details for actual and previous monitoring period. MiQen supports survey of actual and previous quality reports with all the details for past 7 years that have been registered. Compliance of voltage, status, start and end date, as well as exact monitoring time is register for each report. Displayed status for each report states if whole period was monitored.

User information



To make the complete quality report the aux. power supply for the device should not be interrupted during the whole period for which the report is requested. If firmware is updated or power supply is interrupted within a monitoring period, quality report is incomplete − Status: Not complete.

Actual monitoring period PC

A survey of compliance of voltage quality by measured quantities in previous period.

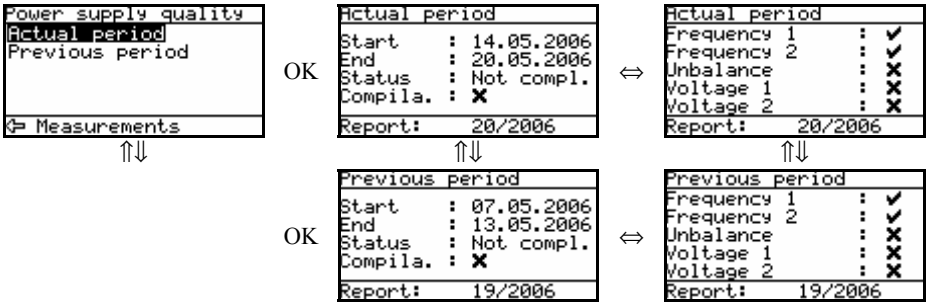
Main menu ⇒ Measurements ⇒ Power supply quality ⇒ Actual period OK / ⇒

Previous monitoring period PC

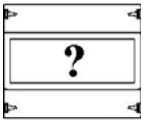
A survey of compliance of voltage quality by measured quantities in previous period.

Main menu ⇒ Measurements ⇒ Power supply quality ⇒ Previous period OK / ⇒

Example:



User information



When surveying quality report via measuring centre, parameters which are not monitored, have no sign (✔, ✘) of quality compliance.

Parameters PC

Frequency variations 1 & 2

Average value is calculated in 10 second intervals and is according to nominal values compared with quality requirements. Frequency measurement is performed from first phase voltage (U_1) and is switched to the next if it is to low. At three−phase connections the phase to phase voltages are calculated to phase voltages. If voltage signals are too low the measurement is performed from current signals. Depending on disturbance signals switch limit is between 1 and 4 V. Measurement performed from current signals requires at leas 30 mA current. Frequency accuracy is better than ± 0.01 Hz.

Voltage variations 1 & 2

Average value of RMS phase voltage is calculated in 10 minute and is compared to allowed range of deviation. Start, stop and average voltage value (absolute and relative) for each phase is recorded in the internal memory. Voltage accuracy is better than ± 0.5 % of nominal value for voltages of over 100 V.

Voltage unbalances

Average value is calculated in 10 minute intervals of periodical calculations via evasion stated in chapter Equations on page 86.

Voltage dips / Temporary overvoltages

Within a period RMS value is monitored and recorded in 1 second periods for both measurements. Phase to phase or phase voltages are monitored when three-wire or four-wire connection is used. Lowest dip and highest overvoltage are monitored for in each second interval respectively for each phase. In case of succession of several second events are detected one longer lasting event is recorded. All events are calculated in respect to fixed (nominal) voltage. In details of quality report start, stop and highest / lowest voltage value (absolute and relative) is recorded for each phase. Measuring uncertainty of monitored voltage is less than 1 % and uncertainty of event duration is 20 ms (1 period).

Voltage interruptions and Long interruptions

According to the upper limit of nominal supply voltage stated relatively interrupts are detected in 1 second periods for each phase. The interruption limit is set between 1 and 25 % of nominal voltage. Each second with at least one interrupt detected is records as an interrupt. Succession of several seconds with interrupts detected is recorded as one longer interrupt. After the interrupt ends, duration is compared to Short interrupt setting and is recorded as long or short interrupt in quality report. 2 % hysteresis is used for interrupts detection with 20 ms (2 periods) duration uncertainty.

Rapid voltage changes

RMS value of two subsequent samples is compared for each phase. For each phase in one second interval in which the limit is exceeded, an event is recorded. Measuring uncertainty of monitored voltage is less than 1 %.

Flickers Pst / Plt

Intensity of a flicker is set by UIE−IEC measuring method and is evaluated as short−term or long−term flicker. Equations for calculating flickers are stated in chapter Equations on page 86. Intensity of a short term flicker is measured in 10 minute intervals and of informative nature. Intensity of a long term flicker is based on 2 hour intervals of short term flicker and is recorded in respect to required quality in quality report.

THD's

Contribution of harmonics to the fundamental component is calculated from THD limit and nominal voltage. Average contribution of harmonic components is calculated in 10 minute intervals and compared to THD limit converted in to voltage value.

Harmonics

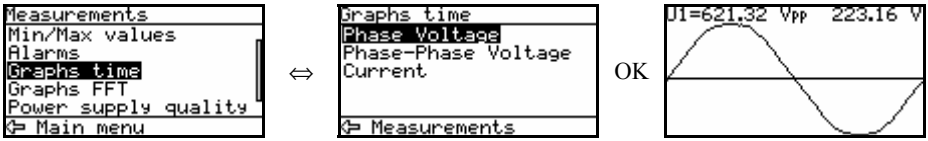
10 minute average is calculated for each harmonic in each phase and is compared to Harmonic limit. All harmonic components should be within the limit, or it will be recorded in quality report in internal memory.

6.10 Time graphical display (Graphs time) ●●●

All time graphs of measured signals are made in the same way. In the upper part of LCD there is a measurement designation that is followed by a pea-to-peak signal value, and on the extreme right there is RMS value. In the central part of LCD a signal shape is drawn. For a better survey of the measured signal a scale is automatically adapted to the peak-to-peak signal value.

Example:

Main menu ⇒ Measurements ⇒ Graphs time ⇒ Phase voltage OK



Phase voltage PC

Display of time flow of voltage signals U_1, U_2 and U_3.

Main menu ⇒ Measurements ⇒ Time graphs ⇒ Phase voltage OK / ⇒

Phase-to-phase voltage PC

Display of time flow of phase-to-phase voltage signals U_{12}, U_{23} and U_{31}.

Main menu ⇒ Measurements ⇒ Time graphs ⇒ Phase–phase voltage OK / ⇒

Current PC

Display of time flow of current signals I_1, I_2 and I_3.

Main menu ⇒ Measurements ⇒ Time graphs ⇒ Current OK / ⇒

6.11 FFT graphical display (Graphs FFT)

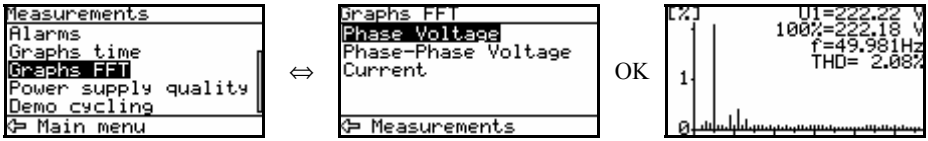
All FFT graphs of the measured signals are made in the same way. In the upper right angle of LCD the following measurements are stated:

- Designation of measurement with current RMS value
- Value of first harmonic
- Current frequency
- THD signal value

The remaining part is used for a (bar) graphic display of relative values of harmonics regarding the first one. For better resolution, first harmonic is not displayed and rating is automatically adapted according to highest harmonic values.

Example:

Main menu ⇒ Measurements ⇒ Graphs FFT ⇒ Phase voltage OK



Phase voltage PC

Display of harmonics of phase voltage signals U_1, U_2 and U_3.

Main menu ⇒ Measurements ⇒ Time FFT ⇒ Phase voltage OK / ⇒

Phase-to-phase voltage PC

Display of harmonics phase-to-phase voltage signals U_{12}, U_{23} and U_{31}.

Main menu ⇒ Measurements ⇒ Time FFT ⇒ Phase−phase voltage OK / ⇒

Current PC

Display of harmonics of current signals I_1, I_2 and I_3.

Main menu ⇒ Measurements ⇒ Time FFT ⇒ Current OK / ⇒

6.12 Demonstration measurements

Demo cycling

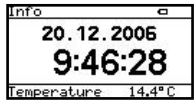
Regarding the period that is defined in settings, measurement screen cycling is started until any key is pressed.

Main menu ⇒ Measurements ⇒ Demo cycling OK

7. BATTERY REPLACEMENT

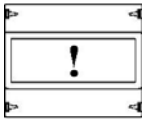
The measuring centre contains a lithium battery. It is used to preserve data (date and time) in the device memory when if the power supply is off. Life time of battery is app.6 years (typical). High temperature and humidity shortens the battery's functionality. When the battery is expired and the power supply was interrupted, flashing battery indicator appears in the up-right corner of the display (before that it is not visible). Battery has no effect on other functionality of the device, except date and time.

Flashing battery indicator:



It is recommended that the instrument is sent back in the factory for battery replacement. Although it is possible that replacement is made by the qualified person, but in this case manufacturer does not take on responsibility for any injuries, dysfunction of the instrument or mechanical damage.

Warning!



You should set device date and time again after replacing the battery.

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8. TECHNICAL DATA

8.1 Accuracy

Measured values	**Range**		**Accuracy class***
Nominal current (I_1, I_2, I_3, Iavg, I_n)	5 A (CT) 10 A (Direct)		0.5 0.5
Maximum current	12.5 A (CT) 65 A (Direct)		0.5** 0.5**
Rms phase voltage (U_1, U_2, U_3, Uavg)	75 V_{L-N} 120 V_{L-N} 250 V_{L-N} 500 V_{L-N}		0.5 0.5 0.5 0.5
Maximum voltage	600 V		0.5**
Rms phase-to-phase voltage (U_{12}, U_{23}, U_{31}, Uavg)	120 V_{L-L} 210 V_{L-L} 400 V_{L-L} 800 V_{L-L}		0.5 0.5 0.5 0.5
Frequency (f) − actual	50 / 60Hz		0.02
Frequency (10 s average)	50 / 60 Hz		0.02
Nominal frequency range	16…400 Hz		0.02
Power angle (φ)	−180…0…180°		0.5
Power factor (PF)	−1…0…+1 U = 50 … 120 % U_n I = 2 % … 20 % I_n I = 20 % … 200 % I_n		 2.0 1.0
Maximal values (MD)	75 120 250 500 [W/var/VA] I_n = 1 A	375 600 1250 2500 [W/var/VA] I_n = 5 A	1.0
THD	5…500 V 0…400 %		0.5
Active power	75 120 250 500 [W/var/VA] I_n = 1 A	375 600 1250 2500 [W/var/VA] I_n = 5 A	0.5
Reactive power			1.0
Apparent power			1.0
Active energy			Class 1
Reactive energy			Class 2
Real time clock (RTC)	–		1 min/month (30 ppm)

Note

* − All measurements are calculated with high harmonic signals. For voltage up to 65 Hz or less, harmonics up to 63th are measured.

** − From range

8.2 Inputs

Voltage input		
	Nominal voltage (Un)	500 V_{L-N}
	Rating	75 V_{L-N} / 250 V_{L-N} / 500 V_{L-N}
	Overload	1.2 x U_n permanently
	Minimal measurement	2 V sinusoidal
	Maximal measurement	600 V_{L-N}
	Consumption	< 0.1 VA per phase
CT current input		
MC6X0	Nominal current (In)	5 A
	Rating	1 A / 5 A
	Overload	3 x I_n permanently, 25 x I_n – 3 s, 40 x I_n – 1 s
	Minimal measurement	Settings from starting current for all powers
	Maximal measurement	12,5 A sinusoidal
	Consumption	< 0.1 VA per phase
Direct current input		
MC6X6	Nominal current (In)	10 A
	Minimal measurement	Settings from starting current for all powers
	Maximal measurement	65 A sinusoidal
	Consumption	< 0.1 VA per phase
Frequency		
	Nominal frequency (f_n)	50, 60 Hz
	Measuring range	16…400 Hz
	Maximum range	10 Hz…1 kHz
Supply		
Universal	AC voltage range	48…276 V
	AC frequency range	40…70 Hz
	DC voltage range	20…300 V
	Consumption	< 5 VA

8.3 Connection

Permitted conductor cross-sections

Terminals	**Max. conductor cross-sections**
Voltage inputs	≤ 2.5 mm^2
Current inputs 65A	≤ 16 mm^2
Current inputs 5A	≤ 6 mm^2
Power supply	≤ 2.5 mm^2
Modules	≤ 2.5 mm^2

8.4 Modules

Pulse (Alarm) output module	No. of outputs	2
	Maximal voltage	40 V AC/DC
	Maximal current	30 mA
	Energy pulse length	Programmable 1…999 ms
Tariff (Digital) input module	No. of inputs	2
	Voltage	230 or 110 V AC ±20%
	Maximal current	< 0.6 mA

8.5 Communication

	RS485
Type of connection	Network
Max. connection length	1000 m
Terminals	Screw terminals
Insulation	In accordance with SIST EN 61010−1: 2002
Transfer mode	Asynchronous
Protocol	MODBUS RTU / DNP3
Transfer rate	2.400 to 115.200 bit/s

8.6 Electronic features

LCD		
Type	Graphic LCD with backlight	
Size	128 x 64 dots	
LCD refreshing	Every 200 ms	
Response time		
LCD Display Communication	All calculations are averaged over an interval of between 8 to 256 periods. Preset interval is 64 periods, which is 1.28 second at 50 Hz.	
Battery		
Manufacturer	Varta	
Type	CR2032 Li-battery	
Battery lifetime	Approx. 6 years (at 23°C − typical)	
Memory	MC65X	MC66X
Capacity	8 Mb	8 Mb
Divisions	Recorder A Recorder B Alarms recorder	Recorder A Recorder B Alarms recorder Q reports Q details
Selection of limit values	Minimal Maximal Average Minimal (thermal function) Maximal (thermal function)	

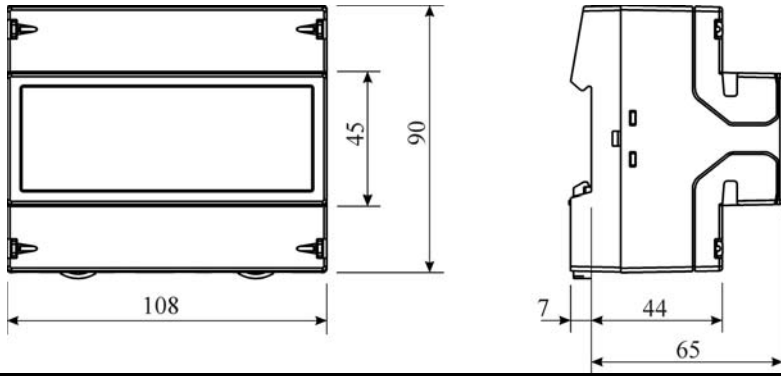
Sampling period	1 to 60 min	
LED's		
Communication	Green	Transmit on the communication
Alarm	Red (blinking)	Fulfilled condition for alarm
Pulse	Red	LED pulse output of selected energy counter

8.7 Safety features

Safety	In compliance with SIST EN 61010−1: 2002 600 V rms, installation category II 300 V rms, installation category III Pollution degree 2
Test voltage	3.7 kV rms
EMC	Directive on electromagnetic compatibility 2004/108/EC In compliance with SIST EN 61326-1: 1998
Protection	In compliance with SIST EN 60529: 1997 Enclosure protection: IP52 Protection for connection terminals: IP20 Protection cover against non authorized access
Ambient conditions	
Temperature range of operation	−20 to +70°C
Storage temperature range	−25 to +70°C
Max. storage and transport humidity	≤ 90% r.h.
Enclosure	
Material	PC, non-flammable, according to UL 94 V0
Weight	up to 600g

8.8 Dimensions

Casing

Construction	Appearance
MC6X0 **MC6X6**	All dimensions are in mm 

9. APENDIX A: MODBUS PROTOCOL

9.1 Modbus communication protocol

Communication protocols:

Modbus and DNP3 protocol are enabled via RS232 and RS485 or Ethernet communication. Both communication protocols are supported on all communication ports of the device. The response is the same type as the request.

Modbus

Modbus protocol enables operation of device on Modbus networks. For device with serial communication the Modbus protocol enables point to point (for example Device to PC) communication via RS232 communication and multi drop communication via RS485 communication. Modbus protocol is a widely supported open interconnect originally designed by Modicon.

The memory reference for input and holding registers is 30000 and 40000 respectively.

Register table for the actual measurements

Parameter	MODBUS		
	Register		Type
	Start	End	
Voltage U_1	30107	30108	T5
Voltage U_2	30109	30110	T5
Voltage U_3	30111	30112	T5
Average phase Voltage $U_{\sim}$	30113	30114	T5
Phase to phase voltage U_{12}	30118	30119	T5
Phase to phase voltage U_{23}	30120	30121	T5
Phase to phase voltage U_{31}	30122	30123	T5
Average phase to phase Voltage $U_{pp\sim}$	30124	30125	T5
Current I_1	30126	30127	T5
Current I_2	30128	30129	T5
Current I_3	30130	30131	T5
Total Current I	30138	30139	T5
Neutral current In	30132	30133	T5
Real Power P_1	30142	30143	T6
Real Power P_2	30144	30145	T6
Real Power P_3	30146	30147	T6
Total Real Power P	30140	30141	T6
Reactive Power Q_1	30150	30151	T6
Reactive Power Q_2	30152	30153	T6
Reactive Power Q_3	30154	30155	T6
Total Reactive Power Q	30148	30149	T6
Apparent Power S_1	30158	30159	T5
Apparent Power S_2	30160	30161	T5
Apparent Power S_3	30162	30163	T5
Total Apparent Power S	30156	30157	T5
Power Factor PF_1	30166	30167	T7
Power Factor PF_2	30168	30169	T7
Power Factor PF_3	30170	30171	T7
Total Power Factor PF	30164	30165	T7

Parameter	MODBUS			
	Register		Type	
	Start	End		
Power Angle U_1–I_1	30173		T2	
Power Angle U_2–I_2	30174		T2	
Power Angle U_3–I_3	30175		T2	
Power Angle atan2(Pt, Qt)	30172		T2	
Angle U_1–U_2	30115		T2	
Angle U_2–U_3	30116		T2	
Angle U_3–U_1	30117		T2	
Frequency f	30105	30106	T5	
Voltage unbalance Uu	30176		T1	
THD I_1	30188		T1	
THD I_2	30189		T1	
THD I_3	30190		T1	
THD U_1	30182		T1	
THD U_2	30183		T1	
THD U_3	30184		T1	
THD U_{12}	30185		T1	
THD U_{23}	30186		T1	
THD U_{31}	30187		T1	
Max Demand Since Last RESET				
MD Real Power P (positive)	30542	30543	T6	
MD Real Power P (negative)	30548	30549	T6	
MD Reactive Power Q − L	30554	30555	T6	
MD Reactive Power Q − C	30560	30561	T6	
MD Apparent Power S	30536	30537	T5	
MD Current I_1	30518	30519	T5	
MD Current I_2	30524	30525	T5	
MD Current I_3	30530	30531	T5	
Dynamic Demand Values				
MD Real Power P (positive)	30510	30511	T6	
MD Real Power P (negative)	30512	30513	T6	
MD Reactive Power Q − L	30514	30515	T6	
MD Reactive Power Q −	30516	30517	T6	
MD Apparent Power S	30508	30509	T5	
MD Current I_1	30502	30503	T5	
MD Current I_2	30504	30505	T5	
MD Current I_3	30506	30507	T5	
Energy				Actual counter value is calculated: Counter * 10^{Exponent}
Energy Counter 1 Exponent	30401		T2	
Energy Counter 2 Exponent	30402		T2	
Energy Counter 3 Exponent	30403		T2	
Energy Counter 4 Exponent	30404		T2	
Counter E1	30406	30407	T3	
Counter E2	30408	30409	T3	
Counter E3	30410	30411	T3	
Counter E4	30412	30413	T3	

Parameter	MODBUS Register		
	Start	End	Type
Counter E1, Cost	30446	30447	T3
Counter E2, Cost	30448	30449	T3
Counter E3, Cost	30450	30451	T3
Counter E4, Cost	30452	30453	T3
Active tariff	30405		T1
Internal Temperature	30181		T2

Actual counter value is calculated: Counter * 10 ^{Exponent}

Register table for the normalized actual measurements

Parameter	MODBUS		100% value
	Register	Type	
Voltage U_1	30801	T16	Un
Voltage U_2	30802	T16	Un
Voltage U_3	30803	T16	Un
Average phase Voltage $U^{\sim}$	30804	T16	Un
Phase to phase voltage U_{12}	30805	T16	Un
Phase to phase voltage U_{23}	30806	T16	Un
Phase to phase voltage U_{31}	30807	T16	Un
Average phase to phase Voltage $U_{pp\sim}$	30808	T16	Un
Current I_1	30809	T16	In
Current I_2	30810	T16	In
Current I_3	30811	T16	In
Total Current I	30812	T16	It
Neutral current In	30813	T16	In
Average Current $I^{\sim}$	30815	T16	In
Real Power P_1	30816	T17	Pn
Real Power P_2	30817	T17	Pn
Real Power P_3	30818	T17	Pn
Total Real Power P	30819	T17	Pt
Reactive Power Q_1	30820	T17	Pn
Reactive Power Q_2	30821	T17	Pn
Reactive Power Q_3	30822	T17	Pn
Total Reactive Power Q	30823	T17	Pt
Apparent Power S_1	30824	T16	Pn
Apparent Power S_2	30825	T16	Pn
Apparent Power S_3	30826	T16	Pn
Total Apparent Power S	30827	T16	Pt
Power Factor PF_1	30828	T17	1
Power Factor PF_2	30829	T17	1
Power Factor PF_3	30830	T17	1
Total Power Factor PF	30831	T17	1
CAP/IND P.F. Phase 1 (PF_1)	30832	T17	1
CAP/IND P.F. Phase 2 (PF_2)	30833	T17	1
CAP/IND P.F. Phase 3 (PF_3)	30834	T17	1
CAP/IND P.F. Total (PFt)	30835	T17	1
Power Angle U_1–I_1	30836	T17	100°
Power Angle U_2–I_2	30837	T17	100°

Parameter	MODBUS		100%
	Register	Type	value
Power Angle U_3–I_3	30838	T17	100°
Power Angle atan2(Pt, Qt)	30839	T17	100°
Angle U_1–U_2	30840	T17	100°
Angle U_2–U_3	30841	T17	100°
Angle U_3–U_1	30842	T17	100°
Frequency	30843	T17	Fn+10Hz
Voltage unbalance Uu	30844	T16	100%
THD I_1	30845	T16	100%
THD I_2	30846	T16	100%
THD I_3	30847	T16	100%
THD U_1	30848	T16	100%
THD U_2	30849	T16	100%
THD U_3	30850	T16	100%
THD U_{12}	30851	T16	100%
THD U_{23}	30852	T16	100%
THD U_{31}	30853	T16	100%
Max Demand Since Last Reset			
MD Real Power P (positive)	30854	T16	Pt
MD Real Power P (negative)	30855	T16	Pt
MD Reactive Power Q − L	30856	T16	Pt
MD Reactive Power Q − C	30857	T16	Pt
MD Apparent Power S	30858	T16	Pt
MD Current I_1	30859	T16	In
MD Current I_2	30860	T16	In
MD Current I_3	30861	T16	In
Dynamic Demand Values			
MD Real Power P (positive)	30862	T16	Pt
MD Real Power P (negative)	30863	T16	Pt
MD Reactive Power Q − L	30864	T16	Pt
MD Reactive Power Q − C	30865	T16	Pt
MD Apparent Power S	30866	T16	Pt
MD Current I_1	30867	T16	In
MD Current I_2	30868	T16	In
MD Current I_3	30869	T16	In
Energy			
Energy Counter 1	30870	T17	Actual counter value MOD 20000 is returned
Energy Counter 2	30871	T17	
Energy Counter 3	30872	T17	
Energy Counter 4	30873	T17	
Energy Counter 1 Cost	30874	T17	
Energy Counter 2 Cost	30875	T17	
Energy Counter 3 Cost	30876	T17	
Energy Counter 4 Cost	30877	T17	
Total Energy Counter Cost	30878	T17	
Active Tariff	30879	T1	
Internal Temperature	30880	T17	100°

100% values calculations for normalized measurements

Un =	(R40147 / R40146) * R30015 * R40149	
In =	(R40145 / R40144) * R30017 * R40148	
Pn =	Un*In	
It =	In	Connection Mode: 1b
It =	3*In	Connection Modes: 3b, 4b, 3u, 4u
Pt =	Pn	Connection Mode: 1b
Pt =	3*Pn	Connection Modes: 3b, 4b, 3u, 4u
Fn =	R40150	

Register	Content
30015	Calibration voltage
30017	Calibration current

Register table for the basic settings

Register	Content	Type	Ind	Values / Dependencies	Min	Max	P. Level
40143	Connection Mode	T1	0	No mode	1	5	2
			1	1b - Single Phase			
			2	3b - 3 phase 3 wire balanced			
			3	4b - 3 phase 4 wire balanced			
			4	3u - 3 phase 3 wire unbalanced			
			5	4u - 3 phase 4 wire unbalanced			
40144	CT Secondary	T4		mA			2
40145	CT Primary	T4		A/10			2
40146	VT Secondary	T4		mV			2
40147	VT Primary	T4		V/10			2
40148	Current input range (%)	T16		10000 for 100%	5,00	200,00	2
40149	Voltage input range (%)	T16		10000 for 100%	2,50	100,00	2
40150	Frequency nominal value	T1		Hz	10	1000	2

Data types decoding

Type	Bit mask	Description
T1		**Unsigned Value (16 bit)** Example: 12345 = 3039(16)
T2		**Signed Value (16 bit)** Example: -12345 = CFC7(16)
T3		**Signed Long Value (32 bit)** Example: 123456789 = 075B CD 15(16)
T4	bits # 15…14 bits # 13…00	**Short Unsigned float (16 bit)** Decade Exponent(Unsigned 2 bit) Binary Unsigned Value (14 bit) Example: 10000*102 = A710(16)
T5	bits # 31…24 bits # 23…00	**Unsigned Measurement (32 bit)** Decade Exponent(Signed 8 bit) Binary Unsigned Value (24 bit) Example: 123456*10-3 = FD01 E240(16)
T6	bits # 31…24 bits # 23…00	**Signed Measurement (32 bit)** Decade Exponent (Signed 8 bit) Binary Signed value (24 bit) Example: - 123456*10-3 = FDFE 1DC0(16)
T7	bits # 31…24 bits # 23…16 bits # 15…00	**Power Factor (32 bit)** Sign: Import/Export (00/FF) Sign: Inductive/Capacitive (00/FF) Unsigned Value (16 bit), 4 decimal places Example: 0.9876 CAP = 00FF 2694(16)
T9	bits # 31…24 bits # 23…16 bits # 15…08 bits # 07…00	**Time (32 bit)** 1/100s 00 - 99 (BCD) Seconds 00 - 59 (BCD) Minutes 00 - 59 (BCD) Hours 00 - 24 (BCD) Example: 15:42:03.75 = 7503 4215(16)
T10	bits # 31…24 bits # 23…16 bits # 15…00	**Date (32 bit)** Day of month 01 - 31 (BCD) Month of year 01 - 12 (BCD) Year (unsigned integer) 1998..4095 Example: 10, SEP 2000 = 1009 07D0(16)
T16		**Unsigned Value (16 bit), 2 decimal places** Example: 123.45 = 3039(16)
T17		**Signed Value (16 bit), 2 decimal places** Example: -123.45 = CFC7(16)
T_Str4		**Text:** 4 characters (2 characters for 16 bit register)
T_Str6		**Text:** 6 characters (2 characters for 16 bit register)
T_Str8		**Text:** 8 characters (2 characters for 16 bit register)
T_Str16		**Text:** 16 characters (2 characters for 16 bit register)
T_Str40		**Text:** 40 characters (2 characters for 16 bit register)

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10. APPENIX B: DNP3 PROTOCOL

10.1 DNP3 communication protocol

Communication protocols:

Modbus and DNP3 protocol are enabled via RS232 and RS485 or Ethernet communication. Both communication protocols are supported on all communication ports of the device. The response is the same type as the request.

DNP3

DNP3 protocol enables operation of MC on DNP3 networks. For device with serial communication the DNP3 protocol enables point to point (for example device to PC) communication via RS232 communication and multi drop communication via RS485.

Object			Request		Response	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
30	2	16-Bit Analogue Input with flag	1	00, 01, 02, 06	129	00, 01, 02, 00
30	4	16-Bit Analogue Input without flag	1	00, 01, 02, 06	129	00, 01, 02, 00

Register table for the actual measurements

DNP3 Point	Parameter	Type	100% value
0	Voltage U1	T16	Un
1	Voltage U2	T16	Un
2	Voltage U3	T16	Un
3	Average phase Voltage U~	T16	Un
4	Phase to phase voltage U12	T16	Un
5	Phase to phase voltage U23	T16	Un
6	Phase to phase voltage U31	T16	Un
7	Average phase to phase Voltage Upp~	T16	Un
8	Current I1	T16	In
9	Current I2	T16	In
10	Current I3	T16	In
11	Total Current I	T16	In
12	Neutral current In	T16	In
13	Reserved	T16	In
14	Average Current I~	T16	In
15	Real Power P1	T17	Pn
16	Real Power P2	T17	Pn

DNP3 Point	Parameter	Type	100% value
17	Real Power P3	T17	Pn
18	Total Real Power P	T17	Pt
19	Reactive Power Q1	T17	Pn
20	Reactive Power Q2	T17	Pn
21	Reactive Power Q3	T17	Pn
22	Total Reactive Power Q	T17	Pt
23	Apparent Power S1	T16	Pn
24	Apparent Power S2	T16	Pn
25	Apparent Power S3	T16	Pn
26	Total Apparent Power S	T16	Pt
27	Power Factor PF1	T17	1
28	Power Factor PF2	T17	1
29	Power Factor PF3	T17	1
30	Total Power Factor PF	T17	1
31	CAP/IND P. F. Phase 1 (PF1)	T17	1
32	CAP/IND P. F. Phase 2 (PF2)	T17	1
33	CAP/IND P. F. Phase 3 (PF3)	T17	1
34	CAP/IND P. F. Total (PFt)	T17	1
35	Power Angle U1−I1	T17	100°
36	Power Angle U2−I2	T17	100°
37	Power Angle U3−I3	T17	100°
38	Power Angle atan2(Pt, Qt)	T17	100°
39	Angle U1−U2	T17	100°
40	Angle U2−U3	T17	100°
41	Angle U3−U1	T17	100°
42	Frequency	T17	Fn+10Hz
43	Voltage unbalance Uu	T16	100%
44	THD I1	T16	100%
45	THD I2	T16	100%
46	THD I3	T16	100%
47	THD U1	T16	100%
48	THD U2	T16	100%

DNP3 Point	Parameter	Type	100% value
49	THD U3	T16	100%
50	THD U12	T16	100%
51	THD U23	T16	100%
52	THD U31	T16	100%
	Max Demand Since Last Reset		
53	MD Real Power P (positive)	T16	Pt
54	MD Real Power P (negative)	T16	Pt
55	MD Reactive Power Q − L	T16	Pt
56	MD Reactive Power Q − C	T16	Pt
57	MD Apparent Power S	T16	Pt
58	MD Current I1	T16	In
59	MD Current I2	T16	In
60	MD Current I3	T16	In
	Dynamic Demand Values		
61	MD Real Power P (positive)	T16	Pt
62	MD Real Power P (negative)	T16	Pt
63	MD Reactive Power Q − L	T16	Pt
64	MD Reactive Power Q − C	T16	Pt
65	MD Apparent Power S	T16	Pt
66	MD Current I1	T16	In
67	MD Current I2	T16	In
68	MD Current I3	T16	In
69	Energy Counter 1	T17	Actual counter value MOD 20000 is returned
70	Energy Counter 2	T17	
71	Energy Counter 3	T17	
72	Energy Counter 4	T17	
73	Energy Counter 1 Cost	T17	
74	Energy Counter 2 Cost	T17	
75	Energy Counter 3 Cost	T17	
76	Energy Counter 4 Cost	T17	
77	Total Energy Counter Cost	T17	
78	Active Tariff	T1	

Data types decoding

See Data types decoding in Appendix A: Modbus protocol on page 77.

100% values calculations

See 100% values calculations for normalized measurements in Appendix A: Modbus protocol on page 76.

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11. APPENDIX C: CALCULATIONS & EQUATIONS

11.1 Calculations

Definitions of symbols

No	Symbol	Definition
1	M_v	Sample factor
2	M_P	Average interval
3	U_f	Phase voltage (U_1, U_2 or U_3)
4	U_{ff}	Phase-to-phase voltage (U_{12}, U_{23} or U_{31})
5	N	Total number of samples in a period
6	n	Sample number ($0 \leq n \leq N$)
7	x, y	Phase number (1, 2 or 3)
8	i_n	Current sample n
9	u_{fn}	Phase voltage sample n
10	u_{ffn}	Phase-to-phase voltage sample n
11	φ_f	Power angle between current and phase voltage f (φ_1, φ_2 or φ_3)
12	U_u	Voltage unbalance
13	U_c	Agreed supply voltage

11.2 Equations

Voltage

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

Phase voltage
N − 128 samples in one period (up to 65 Hz)
N − 128 samples in M_v periods (above 65Hz)
Example: 400 Hz → $M_v = 7$

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

Phase-to-phase voltage
u_x, u_y − phase voltages (U_f)
N − a number of samples in a period

$$U_u = \sqrt{\frac{1-\sqrt{3-6\beta}}{1+\sqrt{3-6\beta}}} \cdot 100\%$$

$$\beta = \frac{U_{12fund}^4 + U_{23fund}^4 + U_{31fund}^4}{\left(U_{12fund}^2 + U_{23fund}^2 + U_{31fund}^2\right)^2}$$

Voltage unbalance
U_{fund} − first harmonic of phase-to-phase voltage

Current

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

Phase current
N − 128 samples in a period (up to 65 Hz)
N − 128 samples in more periods (above 65 Hz)

$$I_n = \sqrt{\frac{\sum_{n=1}^{N} \left(i_{1n} + i_{2n} + i_{3n}\right)^2}{N}}$$

Neutral current
i − n sample of phase current (1, 2 or 3)
N = 128 samples in a period (up to 65 Hz)

Power

$P_f = \frac{1}{N} \cdot \sum_{n=1}^{N} \left(u_{fn} \cdot i_{fn} \right)$	**Active power by phases** n − a sample in a period N − a number of samples in a period f − phase designation
$P_t = P_1 + P_2 + P_3$	**Total active power** t − total power 1, 2, 3 − phase designation
$\mathrm{SignQ}_f(\varphi)$ $\varphi \in [0° - 180°] \Rightarrow \mathrm{SignQ}_f(\varphi) = +1$ $\varphi \in [180° - 360°] \Rightarrow \mathrm{SignQ}_f(\varphi) = -1$	**Reactive power sign** Q_f − reactive power (by phases) φ − power angle
$S_f = U_f \cdot I_f$	**Apparent power by phases** U_f − phase voltage I_f − phase current
$S_t = S_1 + S_2 + S_3$	**Total apparent power** S_f − apparent power by phases
$Q_f = \mathrm{SignQ}_f(\varphi) \cdot \sqrt{S_f^2 - P_f^2}$	**Reactive power by phases** S_f − apparent power by phases P_f − active power by phases
$Q_t = Q_1 + Q_2 + Q_3$	**Total reactive power** Q_f − reactive power by phases
$\varphi_t = \mathrm{a\,tan\,2}(P_t, Q_t)$ $\varphi_t = [-180°, 179{,}99°]$	**Total power angle** P_t − total active power Q_t − total reactive power
$PF_t = \frac{P_t}{S_t}$	**Power factor** P_t − total active power S_t − total apparent power
$PF_f = \frac{P_f}{S_f}$	**Power factor** P_f − phase active power S_f − phase apparent power

THD

$$I_f THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} In^2}}{I_1} \cdot 100$$

Current THD
I_1 − value of first harmonic
n − number of harmonic

$$U_f THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} U_f n^2}}{U_{f1}} \cdot 100$$

Phase voltage THD
U_{f1} − value of first harmonic
n − number of harmonic

$$U_{ff} THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} U_{ff} n^2}}{U_{ff1}} \cdot 100$$

Phase-to-phase voltage THD
U_{ff1} − value of first harmonic
n − number of harmonic

Flickers

$$P_{50S} = (P_{30} + P_{50} + P_{80})/3$$
$$P_{10S} = (P_6 + P_8 + P_{10} + P_{13} + P_{17})/5$$
$$P_{3S} = (P_{2,2} + P_3 + P_4)/3$$
$$P_{1S} = (P_{1,7} + P_1 + P_{1,5})/3$$
$$P_{st} = \sqrt{\begin{matrix} 0{,}0314P_{0,1} + 00525P_{1S} + 0{,}0657P_{3S} \\ + 0{,}28P_{10S} + 0{,}08P_{50S} \end{matrix}}$$

P_{st} − Short-term flicker intensity
Short-term flicker intensity is measured in 10 minute periods.
P_x − flicker levels that are exceeded by x% in a 10-minute period (e.g. $P_{0,1}$ represents a flicker level that is exceeded by 0.1% samples)

$$P_{lt} = \sqrt[3]{\sum_{i=1}^{12} \frac{P_{sti}^3}{12}}$$

P_{lt} − Long-term flicker intensity
Calculated from twelve successive values of short-term flicker intensity in a two-hour period

Energy

$$\text{Price in tariff} = \text{Price} \cdot 10^{\text{Tarif price exponent}}$$

Total exponent of tariff price and energy price in all tariffs

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