GB

User’s Manual

Multifunction Transducer MT440

Iskra MIS

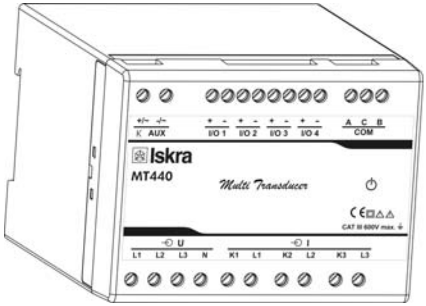
Table of Contents

1. SECURITY ADVICE AND WARNINGS

1.1 Welcome

Please read this chapter carefully before starting work with a measuring transducer.

This chapter deals with important information and warnings that should be considered for safe handling with a measuring transducer.



1.2 Introduction

This booklet contains instructions for installation and use of measuring transducer MT440. Installation and use of a device also includes handling with dangerous currents and voltages and shall be therefore 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 concerning safe installation and handling with the product in order to assure its correct use and continuous operation.

It is essential that everyone using the product is 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,
- Proper connection of auxiliary supply,
- Nominal frequency,
- Voltage ratio and phase sequence,
- Current transformer ratio and terminals integrity,
- Protection fuse - recommended maximal external fuse size is 6 A,
- Proper connection of I/O modules.

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

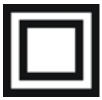
Important: See *Chapter 3.3 Electric connection* for safety warnings regarding connection.

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 2002/96/EC about restriction on the use of certain hazardous substances in electrical and electronic equipment.

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** 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 transducer MT440,

− label for I/O functionality description,

− quick guide.

2. BASIC DESCRIPTION AND OPERATION OF MEASURING TRANSDUCER

2.1 Introduction

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.

<u>Subchapter</u>

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

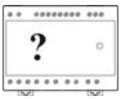
PC − Function accessible via communication (MiQen software)

<u>Tables</u>

Supported functions and measurements are listed in tables. Symbols in tables indicate support of enabled functions. 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 unknown technical terms please refer to Glossary on the next page.

2.2 Glossary

Term	Explanation
RMS	Root Mean Square value
MODBUS	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
Hand-over place	Connection spot of consumer installation in public network
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
AL	Alarm output module
AO	Analog output module
FAO	Fast analog output module
DO	Digital output module

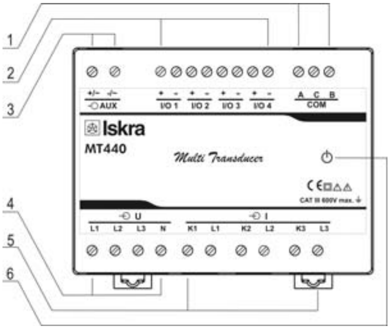
2.3 Description of the product

Measuring transducer is intended for measuring, analyzing and monitoring single-phase or three-phase electrical power network. It measures RMS value by means of fast sampling of voltage and current signals, which makes instrument suitable for acquisition of transient events. A built-in microcontroller calculates measurements (voltage, current, frequency, energy, power, power factor, THD phase angles, etc.) from the measured signals.

Appearance

Measuring transducer can differ from yours depending on the type and functionality.

1 – Communication ports
2 – I/O modules
3 – Auxiliary supply
4 – Voltage inputs
5 – Current inputs
6 – Power ON LED

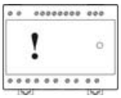


Communication ports and LED indicators

Serial communication can be connected by using screw-in connector (RS232 or RS485). USB can be connected through USB-mini type connector at the bottom of transducer.

LED indicator is intended for POWER ON signaling (red LED).

Warning!



USB communication port is provided with only BASIC insulation and can ONLY be used unconnected to aux. supply AND power inputs!

I/O modules

Four I/O module slots are intended for various I/O modules, which should be chosen at placing the order. Analog outputs, fast analog outputs, relay outputs (alarm, pulse, general-purpose digital outputs) and solid-state relay outputs (alarm, pulse, general-purpose digital outputs).

Universal auxiliary supply

Auxiliary supply is connected by two screw-in connectors. For safety purposes it is important that all wires are firmly fastened. Auxiliary supply is wide range (24 V_{DC} – 300 V_{DC}; 40 V_{AC} – 276 V_{AC}).

Voltage inputs

Each voltage input is connected to measuring circuit through input resistor chain (3.3 MΩ per phase). Maximum value of input voltage is 600 V_{L-N} (1000 V_{L-L}).

Current inputs

Each current input is connected to measuring circuit through current transformer (0.01Ω per phase). Maximum allowed thermal value of input current is 15A (cont.).

2.4 Purpose and use of measuring transducer

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, up to four different modules and communication. With the RS232/RS485 and USB communication, the meter can be set and measurements can be checked. The meter also functions as an energy counter (up to four energy counters), with the additional function of cost management by tariffs.

Supported measurements

	Basic measurements
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}
	THD of phase−to−phase voltage
Energy	Counter 1
	Counter 2
	Counter 3
	Counter 4
	Active tariff
	Other measurements
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
	Other measurements
Measurements	Frequency
	Internal temperature

3. CONNECTION

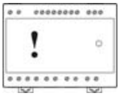
3.1 Introduction

This chapter deals with the instructions for measuring transducer connection. Both the use and connection of the device includes handling with dangerous currents and voltages. Only a qualified person shall therefore perform connection. 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.

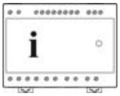
A circuit breaker with current rating of at least 1A shall be included in close proximity with aux. supply installation as a means of disconnection. It shall be properly marked.

Warning!



Wrong or incomplete connection of supply, measurement or other terminals can cause malfunction or damage the device.

Note



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

3.2 Mounting

MT440 measuring transducer is designed for DIN rail 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.

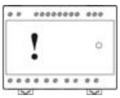
3.3 Electric connection

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

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

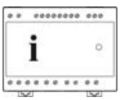
Choose connection from the following figures and connect corresponding voltages and currents. Information on electrical characteristics is given in the chapter *Inputs* on page 35.

Warning!

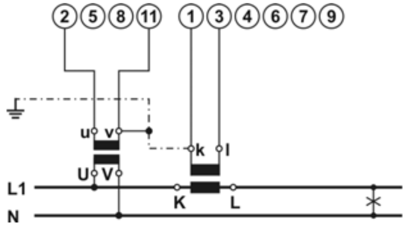
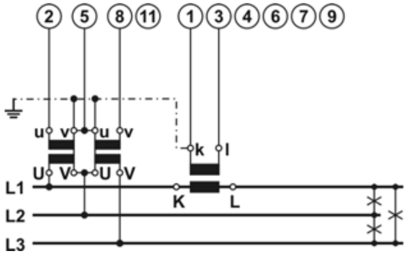
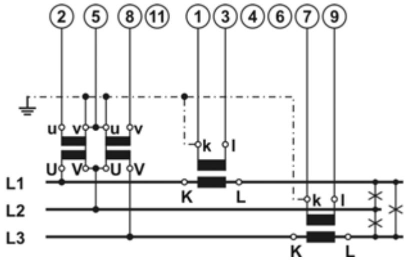
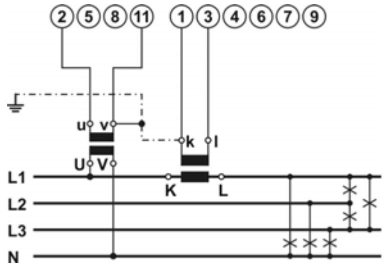
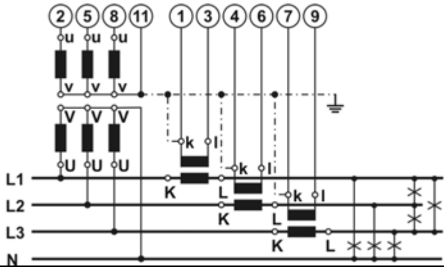


Before using tool for accessing interior or any other part of the transducer which in normal use may be hazardous live (aux. supply and measuring input terminals), transducer MUST BE ISOLATED OR DISCONNECTED from hazardous live voltage.

Note

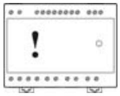


For proper connection wire diameters and other wiring requirements see *Chaper 6.4 Connection*

System/ connection	Terminal assignment
Connection 1b (1W) *Single-phase connection*	
Connection 3b (1W3) *Three-phase – three-wire connection with balanced load*	
Connection 3u (2W3) *Three-phase – three-wire connection with unbalanced load*	
Connection 4b (1W4) *Three-phase – four-wire connection with balanced load*	
Connection 4u (3W4) *Three-phase – four-wire connection with unbalanced 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.

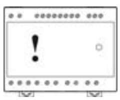
Connect module contacts as specified on the label. Examples of labels are given below and describe modules built in the device. Information on electrical properties of modules is given in chapter *Modules* on page 36.

I/O 1 Relay output 48 V AC/DC +/~ 15 1000 mA −/~ 16	Electromechanical relay output module. (Example of alarm module as I/O module 1)
I/O 1 Solid-state output 40 V AC/DC +/~ 15 30 mA −/~ 16	Solid state relay module output. (Example of pulse module as I/O module 1)
I/O 1 Analog output 0...−/+20 mA + 15 0...−/+10 V − 16	Analog output module with analog output, proportional to measured quantities. The outputs may be either short or open-circuited. They are electrically insulated from each other and from all other circuits. (Example of analog output module as I/O module 1)
I/O 1 Fast analog output 0...−/+20 mA + 15 0...−/+10 V − 16	Fast analog output module with analog output, proportional to measured quantities. The outputs may be either short or open-circuited. They are electrically insulated from each other and from all other circuits. (Example of analog output module as I/O module 1)

3.5 Communication connection

MT440 is equipped with one standard (COM1) serial (RS232 or RS485) communication port and one service communication port (USB).

Warning!

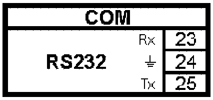
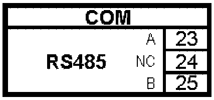
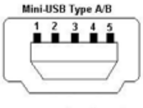


USB communication port is provided with only BASIC insulation and can ONLY be used unconnected to aux. supply AND power inputs!

Connect a communication line by means of corresponding terminals. Connection information is stated on the instrument label. Connector terminals are marked on the label on the upper side of the instrument.

USB connector is positioned on the bottom side of an instrument under removable plastic cover. For driver installation see Note on the next page. Instrument will establish USB connection with PC approx. 3 seconds after physical connection to USB port.

More detailed information about communication is given in chapter *Communication* on page 37.

	COM1 serial communication port (RS232)
	COM1 serial communication port (RS485)
	SERVICE communication port (USB)

RS232

RS232 communication is intended for direct connection of the measuring transducer to the personal computer. It is necessary to provide the corresponding connection of individual terminals of the screw terminal connector (see a table below).

RS485

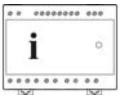
RS485 communication is intended for connection of devices to network where several instruments with RS485 communication are connected to a common communication interface. We recommend the use of Iskra MIS communication interfaces for best compatibility!

It is necessary to provide the corresponding connection of individual terminals of the screw terminal connector (see a table below).

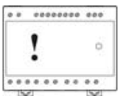
USB

USB communication serves as a fast peer-to-terminal data link. The instrument is detected by host as a USB 2.0 compatible device. The USB connection is provided through a USB standard Type mini B connector.

Note

	When MT440 is connected to a PC through USB communication for the first time, a user is prompted to install a driver. The driver is automatically installed during MiQen software installation. It is also provided on the CD, enclosed in the original shipment package, or can be downloaded from the Iskra MIS web page www.iskra-mis.si. With this driver installed, USB is redirected to a serial port, which should be selected when using MiQen software.

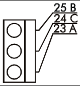
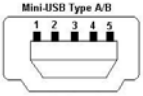
Warning!

	Do not remove USB cover permanently!

The USB port should not remain open. It should be closed immediately after the initial setting through USB port was done and should remain closed during all time of storing & operation. In case the customer has not put the cover on the USB after the initial setting was done, before putting to store, mounting the unit on the DIN rail or the unit operates without USB cover the warranty is void.

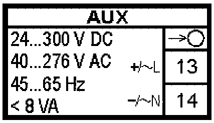
Also unit returned back without USB cover or with clear indications that it was stored or operated without USB cover on the USB port it will be treated as out of the warranty.

Survey of communication connections

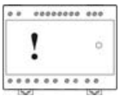
Connector	Terminals	Position	RS232	RS485
SCREW TERMINAL		23	Rx	A
		24	GND	NC
		25	Tx	B
USB-mini B		Standard USB 2.0 compatible cable recommended (Type mini B plug)		

3.6 Connection of auxiliary power supply

Measuring transducer has universal (AC/DC) auxiliary power supply. Information on electric consumption is given in chapter *Technical data* on page 32. Auxiliary supply is connected through screw terminal connector.

	Connection of universal power supply to terminals 13 and 14

Warning!



For safety purposes it is important that both wires (Line and Neutral) are firmly connected.

4. SETTINGS

4.1 Introduction

Instrument settings can be remotely modified with communication (COM1 and/or USB if available) and MiQen software when connected to a PC.

4.2 MiQen software

MiQen is a software tool for complete monitoring of measuring instruments, connected to a PC via serial or USB communication. A user-friendly interface consists of five segments: devices management, instrument settings, real-time measurements and software upgrading.

Two versions of MiQen software are available:

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

For MT440 only standard edition applies since measurement recording and analysis is with MT440 not supported.

Devices management

Select the instrument in a favorite'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.

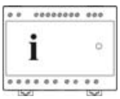
Real-time measurements

All supported measurements can be captured in real time in a table form. For further processing of the results of measurements, copying via a clipboard into standard Windows formats is supported.

Software upgrading

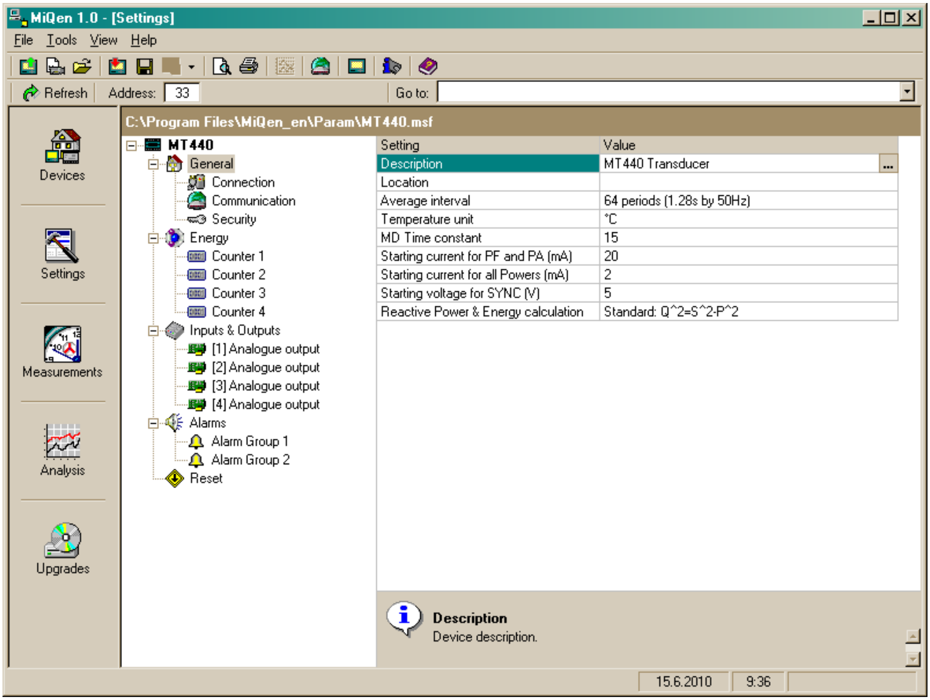
Always use the latest version of software, both MiQen and software in the instrument. The program automatically informs you on available upgrades that can be transferred from the web site and used for upgrading.

Note

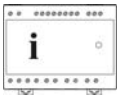


More information about MiQen software can be found in MiQen Help system!

MiQen user interface PC



Note



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

4.3 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 (serial or USB) 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.

4.4 General settings

General settings are essential for measuring transducer. 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

The averaging interval defines the refresh rate of measurements on communication and remote display.

Temperature unit

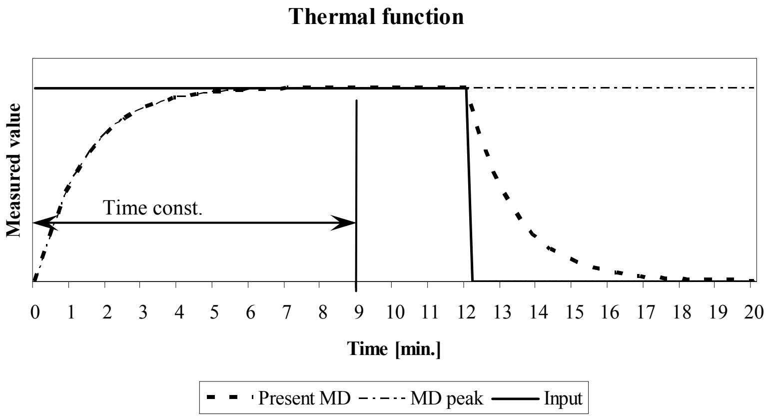
Choose a unit for temperature display.

Maximum demand calculation (MD mode)

The instrument provides maximum demand values using thermal function. A thermal function assures exponent thermal characteristic based on simulation of bimetal meters. Maximal values 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:

Mode: Thermal function
Time constant: 8 min.
Current MD and maximal MD: Reset at 0 min.



Starting current for PF and PA (mA)

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)

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

Minimum synchronization voltage

If all phase voltages are smaller than this (noise limit) setting, instrument uses current inputs for synchronization. If also all phase currents are smaller than *Starting current for PF and PA* setting, synchronization is not possible and frequency displayed is 0.

Reactive power and energy calculation

Two different principles of reactive power and energy calculation are used:

Standard method:

With this method a reactive power and energy are calculated based on assumption that all power (energy) that is not active is reactive.

$Q^2 = S^2 - P^2$

This means also that all higher harmonics will be measured as reactive power (energy).

Delayed current method:

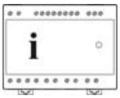
With this method, reactive power (energy) is calculated by multiplication of voltage samples and delayed current samples (see chapter *Equations* on page 53):

$Q = U \times I|_{+90°}$

With this method, reactive power (energy) represents only true reactive component of apparent power (energy).

4.5 Connection

Note



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

Connection

When connection is selected, load connection and the supported measurements are defined (see chapter Survey of supported measurements regarding *Connection* mode on page 27).

Setting of current and voltage ratios

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.

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

Used voltage and current range

Setting of the range is connected with all settings of alarms, analog outputs and a display (calculation) of energy and measurements recording, where 100% represents 500 V 5A. In case of subsequent change of the range, alarms settings shall be correspondingly changed, as well.

Nominal frequency

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

Energy flow direction

This setting allows manual change of energy flow direction (IMPORT to EXPORT or vice versa) in readings tab. It has no influence on readings sent to communication.

CT connection

If this setting is set to REVERSED it has the same influence as if CT's would be reversely connected. All power readings will also change its sign.

4.6 Communication

Serial Communication (COM1)

Define parameters (only for COM1) that are important for the operation in RS485 network or connections with PC via RS232 communication. 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).

Modbus table (MI400 or MT500 compatible): With this setting a MODBUS table for measurements and settings is defined. MODBUS addresses for measurements and settings can be compatible with previous family of transducers (MI400) or with more advanced family of transducers (MT500). See *Modbus table* definitions on page 41.

USB Communication

For description of all settings see *Serial Communication (COM1)*. For driver installation see note on page 13. Instrument will establish USB connection with PC approx. 3 seconds after physical connection to USB port.

4.7 Security

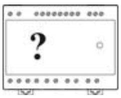
Settings parameters are divided into four groups regarding security level:

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

2 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.

3 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 in ISKRA MIS, and is entered instead of the password PL1 or/and PL2. Do not forget to state the meter serial meter when contacting the personnel in Iskra MIS.

User information



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

Password setting

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 *.
Two passwords (PL1, PL2) and the time of automatic activation could be set.

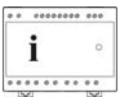
Password modification

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

Password disabling

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

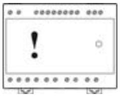
Note



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

4.8 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 (up to four) is defined as active.

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.

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.

Voltage \ Current	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

Counter divider [PC]

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

An example for 12.345kWh of consumed active energy:

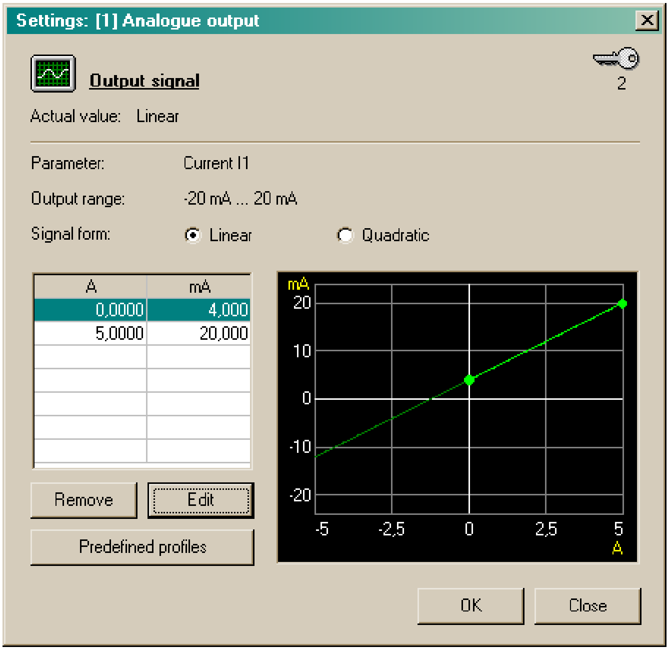
Common energy exponent	0	2	2
Counter divider	1	1	100
Example of result, displayed	12.345 kWh	12.3 kWh	0.01 MWh

4.9 Inputs and outputs

Module settings depend on built-in modules.

Analog output module [PC]

Each of up to four analog outputs is fully programmable and can be set to any of 6 full-scale ranges. Within each of those 6 ranges, other required output ranges can be set. For example, 4 … 20 mA range can be set when ± 20 mA full-scale range is selected:



Output parameter

Set the measured parameter to be transformed onto the analog output.

Output range

Defines analog output full-scale ranges:

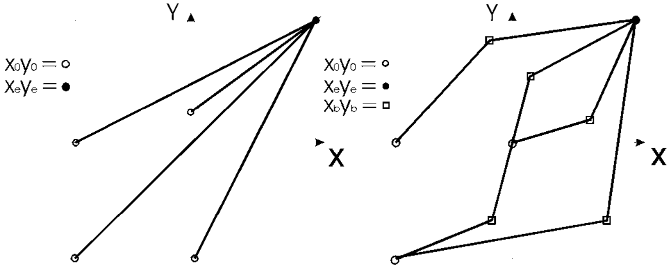
DC current output	DC voltage output
-1 … 0 … 1 mA	-1 … 0 … 1 V
-5 … 0 … 5 mA	
-10 ... 0 ... 10 mA	-10 … 0 … 10 V
-20 ... 0 ... 20 mA	

Output range

Defines the shape and up to 5 break points of an analog output. For intrinsic-error for analog outputs with bent or linear zoom characteristic multiply accuracy class with correction factor (c). Correction factor c (the highest value applies):

Linear characteristic	Bent characteristic
$c = \dfrac{1-\dfrac{y_0}{y_e}}{1-\dfrac{x_0}{x_e}}$ or $c = 1$	$x_{b-1} \le x \le x_b$ b – number of break points (1 to 5) $c = \dfrac{y_b - y_{b-1}}{x_b - x_{b-1}} \cdot \dfrac{x_e}{y_e}$ or $c = 1$

Example of settings with linear and bent characteristic:



Limit of the output range

Average interval for analog output

Defines the average interval for measurements on the analog output. Available settings are from 1 period (0.02 sec by 50 Hz) up to 128 periods (2.56 sec by 50 Hz).

Fast analog output module PC

Functionality of fast analog output module is the same as with standard analog output module.

The only difference is its faster response time (≤ 60 ms), and consequential higher ripple. For a proper behavior of fast analog output module (fast response), average interval shall be set to minimum (1 periode).

Solid state output module PC

See Relay output module.

Relay output module PC

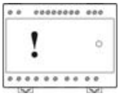
Relay output module as well as Solid state output module can be assigned different functions.

- Alarm notification functionality (alarm output)
- Pulse output for energy measurement (pulse output)
- General purpose digital output (digital output)

Pulse output functionality PC

A corresponding energy counter (up to 4) can be assigned to a pulse output. A number of pulses per energy unit, pulse length, and a tariff in which output is active are set.

Warning!



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

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:

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

Examples:

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

Alarm notification functionality PC

An alarm notification function can also be assigned to output. In case of any alarm occurrence, alarm output will trigger passive electromechanical relay or passive solid-state relay.

Two parameters should be defined for each alarm output:

- The source for assigned alarm (alarm group 1, 2 or both)
- Type of output signal when alarm is detected.

General purpose digital output PC

This functionality allows user to enable / disable output relay (el.mech. or solid-state) by software settings (when appropriate values are set in MODBUS table).

MODULE NUMBER	MODBUS REGISTER	REGISTER VALUE	
Module 1 (if installed)	40722	3 - ON	4 - OFF
Module 2 (if installed)	40725	3 - ON	4 - OFF
Module 3 (if installed)	40728	3 - ON	4 - OFF
Module 4 (if installed)	40731	3 - ON	4 - OFF

4.10 Alarms

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

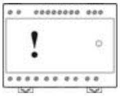
Alarms setting

MT440 supports setting up to 16 alarms in two alarm groups. Alarms can be set for any of measured parameters by setting condition and a limit value.

A time constant of maximum demand values in a thermal mode, a delay time and switch-off hysteresis are defined for each group of alarms.

To each of two alarm groups an alarm output (solid-state or electromechanical relay) can be dedicated.

Warning!



New values of alarms are calculated in percentage at modification of connection settings. If Used voltage, current range is changed, limit values of alarms will change proportionally.

4.11 Reset operations

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

All or individual energy meters are reset.

Reset MD values

Current and stored MDs are reset.

Reset the last MD period

Current MD value is reset.

Reset alarm output

All alarms are reset.

5. MEASUREMENTS

5.1 Introduction

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

5.2 Supported measurements

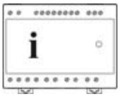
Selection of supported measurements is changed with the connection settings. All supported measurements could be read via communication (MiQen).

5.3 Available connections

Different electric connections are described more in detail in chapter Electric connection on page 10. 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

	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 $U^{\sim}$	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	°	×	×	×	○	●
	THD of phase-to-phase voltage U_{12}	U12%	%THD	×	●	●	○	●
	THD of phase-to-phase voltage U_{23}	U23%	%THD	×	●	●	○	●
	THD of phase-to-phase voltage U_{31}	U31%	%THD	×	●	●	○	●
Energy	Counters 1−4	E1, E2, E3, E4	Wh VAh varh	●	●	●	●	●
	Active tariff	Atar		●	●	●	●	●
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

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.

5.4 Explanation of basic concepts

Sample factor − M_V

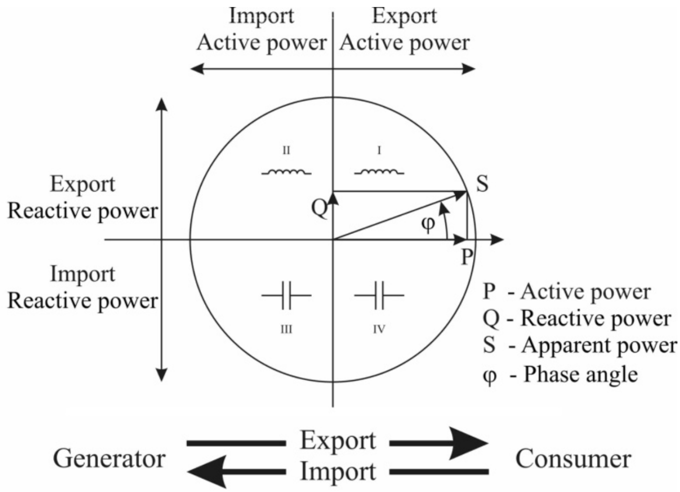
A meter measures all primary quantities with sample frequency which cannot exceed a certain number of samples in a time period. Based on these limitations (65Hz·128 samples) a sample factor is calculated. A sample factor (M_V), depending on frequency of a measured signal, defines a number of periods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

Average interval − M_P

Due to readability of measurements from communication, an Average interval (M_P) is calculated with regard to the measured signal frequency. The Average interval (see chapter *Average interval* on page 18) defines refresh rate of displayed measurements based on a sampling factor.

Power and energy flow

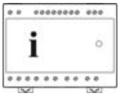
Figures below show a flow of active power, reactive power and energy for 4u connection.



5.5 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 53 with additional descriptions and explanations.

Note



Calculation and display of measurements depend on used connection. For more detailed information see chapters Survey of supported measurements regarding *Connection* mode on page 27.

5.6 Present values

All values are calculated as an average of number of periods set in General settings/average interval.

Voltage PC

Instrument measures true RMS values of all phase voltages (U1, U2, U3), connected to the meter. Phase-to-phase voltages (U12, U23, U31), average phase voltage (Uf) and average phase-to-phase voltage (Ua) are calculated from measured phase voltages (U1, U2, U3).

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

All voltage measurements are available via communication.

Current PC

Instrument measures true RMS values 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.

Active, reactive and apparent power PC

Active power is calculated from instantaneous phase voltages and currents.

Two different principles of reactive power calculation are used:

Standard method:

With this method a reactive power is calculated based on assumption that all power that is not active is reactive.

$Q^2 = S^2 - P^2$

This means also that all higher harmonics will be measured as reactive power.

Delayed current method:

With this method, reactive power (energy) is calculated by multiplication of voltage samples and delayed current samples (see chapter *Equations* on page 53):

$Q = U \times I|_{+90°}$

With this method, reactive power (energy) represents only true reactive component of apparent power (energy).

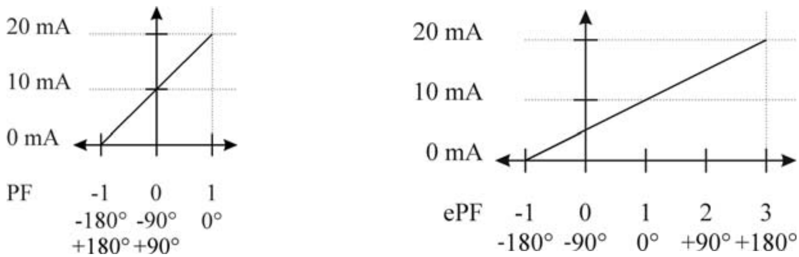
All measurements are seen via communication. For more detailed information about calculation see chapter *Equations* on page 53.

Power factor and power angle [PC]

Power factor 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 ($\cos\varphi_t$). For correct display of PF via analog output and 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 the remote display 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

Example of analog output for PF and ePF:



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 53). A positive sign shows inductive load, and a negative sign shows capacitive load.

Frequency [PC]

Network frequency is calculated from time periods of measured voltage. Frequency is an average of number of periods set in General settings/average interval.

Energy [PC]

Energy of each of four energy counters is available.

MD values [PC]

Measurements of MD values.

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.

Instrument uses measuring technique of true RMS values that assures exact measurements with the presence of high harmonics up to 31st harmonic.

6. TECHNICAL DATA

6.1 Applied standards

EN 61010-1: 2001, Safety requirements for electrical equipment for measurement, control and laboratory use Part 1: General requirements

EN 60688:1992 Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals

EN 60688:1995 / A1: 1999 Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals

EN 60688:1995 / A2: 2001 Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals

EN 61326-1:2006, EMC requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements

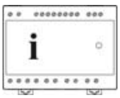
6.2 Accuracy

Total accuracy (measurements and analog output) according to IEC/EN 60 688 is presented as percentage of range except when it is stated as an absolute value.

<table>
<tr><th>Measured values</th><th colspan="2">Range</th><th>Accuracy class</th></tr>
<tr><td>Rms current (I_1, I_2, I_3, Iavg, I_n)</td><td colspan="2">Auto (1, 5, 10 A)</td><td>0.3 (0.2)*</td></tr>
<tr><td>Maximum current</td><td colspan="2">12.5 A</td><td>0.3 (0.2)*</td></tr>
<tr><td>Rms phase voltage
(U_1, U_2, U_3, Uavg)</td><td colspan="2">Auto (62.5, 125, 250, 500 V_{L-N})</td><td>0.3 (0.2)*</td></tr>
<tr><td>Maximum voltage</td><td colspan="2">600 V_{L-N}</td><td>0.3 (0.2)*</td></tr>
<tr><td>Rms phase-to-phase voltage
(U_{12}, U_{23}, U_{31}, Uavg)</td><td colspan="2">800 V_{L-L}</td><td>0.3 (0.2)*</td></tr>
<tr><td>Frequency (f) − actual</td><td colspan="2">50 / 60Hz</td><td>10 mHz (2 mHz)*</td></tr>
<tr><td>Nominal frequency range</td><td colspan="2">16 … 400 Hz</td><td>10 mHz</td></tr>
<tr><td>Power angle (φ)</td><td colspan="2">−180 … 0 … 180°</td><td>0.2°</td></tr>
<tr><td>Power factor (PF)</td><td colspan="2">−1 … 0 … +1
U = 50 … 120 % U_n
I = 2 % … 20 % I_n
I = 20 % … 200 % I_n</td><td>

0.5
0.2</td></tr>
<tr><td>THD</td><td colspan="2">5…500 V
0…400 %</td><td>0.5</td></tr>
<tr><td>Active power</td><td rowspan="3">75
120
250
500
[W/var/VA]
I_n = 1 A</td><td rowspan="3">375
600
1250
2500
[W/var/VA]
I_n = 5 A</td><td>0.5 (0.3)*</td></tr>
<tr><td>Reactive power</td><td>0.5 (0.3)*</td></tr>
<tr><td>Apparent power</td><td>0.5 (0.3)*</td></tr>
<tr><td>Active energy</td><td colspan="2"></td><td>Class 1 (EN 62053-21)</td></tr>
<tr><td>Reactive energy</td><td colspan="2"></td><td>Class 2 (EN 62053-23)</td></tr>
</table>

Note



* − Accuracy on communication

6.3 Inputs

Voltage input		
	Nominal range values	62.5, 125, 250, 500 V_{LN}
	Nominal voltage(U_N)	500 V_{LN}
	Minimal measurement	2 V sinusoidal
	Frequency range	50/60, 400 Hz
	Max. measured value (cont.)	600 V_{LN} ; 1000 V_{LL}
	Max. allowed value (acc. to IEC/EN 60 688)	2 × U_N ; 10 s
	Consumption	< U^2 / 3.3MΩ per phase
	Input impedance	3.3MΩ per phase
Current input		
	Nominal range values	1, 5, 10 A
	Nominal current (I_N)	5 A
	Min. measurement	Settings from starting current for all powers*
	Frequency range	50/60, 400 Hz
	Max. measured value	12.5 A sinusoidal
	Max. allowed value (thermal)	15 A cont.
	(acc. to IEC/EN 60 688)	20 × I_N ; 5 × 1s
	Consumption	< I^2 × 0.01Ω per phase
Frequency		
	Nominal frequency (f_N)	50, 60, 400 Hz
	Measuring range	16 … 400 Hz**
Power supply		
Universal	Nominal voltage AC	40 … 276 V
	Nominal frequency	45 … 65 Hz
	Nominal voltage DC	24 … 300 V
	Consumption	< 8VA
	Power-on transient current	< 20 A; 1 ms

* Starting current is set by setting software MiQen/settings/general

** For frequency measurement only

6.4 Connection

Permitted conductor cross-sections

Terminals	Max. conductor cross-sections
Voltage inputs (4)	2,5 mm^2 with pin terminal 4 mm^2 solid wire
Current inputs (6)	2,5 mm^2 with pin terminal 4 mm^2 solid wire
Supply (2)	2,5 mm^2 with pin terminal 4 mm^2 solid wire
Modules & Com (8 + 3)	2,5 mm^2 with pin terminal 4 mm^2 solid wire

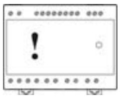
6.5 I/O modules

Electromechanical relay output module	Purpose	alarm, pulse, general purpose digital output
	Type	Electromechanical Relay switch
	Rated voltage	48 V AC/DC (+40% max)
	Max. switching current	1000 mA
	Contact resistance	≤ 100 mΩ (100 mA, 24V)
	Pulse	Max. 4000 imp/hour
	(if used as pulse output)	Min. length 100 ms
	Insulation voltage	
	Between coil and contact	4000 VDC
	Between contacts	1000 VDC
Solid-state relay output module	Purpose	alarm, pulse, general purpose digital output
	Type	Open collecter solid-state switch
	Rated voltage	40 V AC/DC
	Max. switching current	30 mA (R_{ONmax} = 8Ω)
	Pulse length	programmable
	(if used as pulse output)	1 … 999 ms
Analog output		
General	Linearization	Linear, Quadratic
	No. of break points	5
	Output value limits	± 120 % of nominal output
	Response time	< 100 ms (standard analog output) ≤50 ms (FAST analog output)
	Residual ripple	< 1 % p.p. (standard analog output) < 2 % p.p. (FAST analog output)
DC Current output	Output range values	–100 … 0 … 100 %
	-1 … 0 … 1 mA	Range 1
	-5 … 0 … 5 mA	Range 2
	-10 ... 0 ... 10 mA	Range 3
	-20 ... 0 ... 20 mA	Range 4
	Other ranges	possible by MiQen software
	Burden voltage	10 V
	External resistance	RB_{max} = 10 V / I_{outN}
DC Voltage output	Output range values	–100 … 0 … 100 %
	-1 … 0 … 1 V	Range 5
	-10 … 0 … 10 V	Range 6
	Other ranges	possible by MiQen software
	Burden current	20 mA
	External resistance	RB_{min} = U_{outN} / 20 mA

6.6 Communication

Type	RS232	RS485	USB
Type of connection	Direct	Network	Direct
Max. connection length	3 m	1000 m	3 m
Number of bus stations	–	≤ 32	–
Terminals	Screw terminals		USB-mini
Insulation	Protection class I, 3.3 kV_{ACRMS} 1 min		basic isolation only!
Transfer mode	Asynchronous		
Protocol	MODBUS RTU		
Transfer rate	2.400 to 115.200 bit/s		USB 2.0

Warning!



USB communication port is provided with only BASIC insulation and can ONLY be used unconnected to aux. supply AND power inputs!

6.7 Electronic features

Response time Input → 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.	
Status LED's PWR	Red	Instrument power ON

6.8 Safety features

Protection	Protection class II
Pollution degree	2
Installation category	CAT III; 600 V meas. Inputs Acc. to EN 61010-1 CAT III; 300 V aux. supply Acc. to EN 61010-1
Test voltages Acc. to EN 61010-1	UAUX↔I/O, COM: 3320 VACrms UAUX↔U, I inputs: 3320 VACrms U, I in↔I/O,COM: 3320 VACrms U in↔I in: 3320 VACrms
EMC	Directive on electromagnetic compatibility 2004/108/EC Acc. to EN 61326-1
Enclosure material	PC/ABS
Flammability	Acc. to UL 94 V-0
Weight	370 g

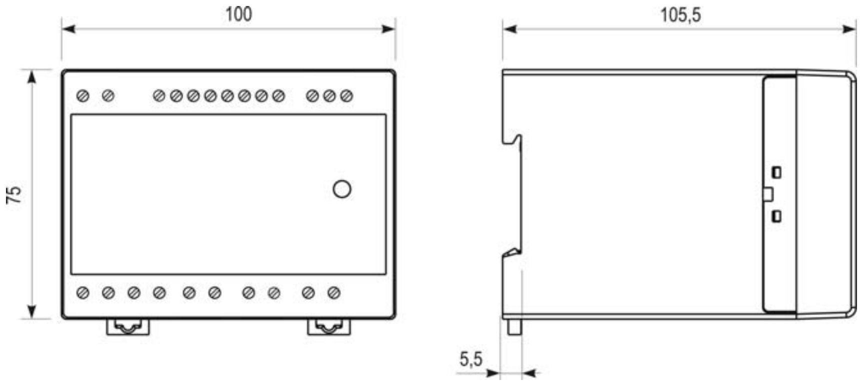
6.9 Mechanical

Dimensions	W100 × H75× D105 mm
Max. conductor cross section for terminals	2,5 mm2 with pin terminal 4 mm2 solid wire
Vibration withstand	7g, 3 … 100 Hz, 1 oct/min
	10 cycles in each of three axes
Shock withstand	300g, 8ms pulse
	6 shocks in each of three axes
Mounting	Rail mounting 35 × 15 mm
	acc. to DIN EN 50 022
Enclosure material	PC/ABS
Flammability	Acc. to UL 94 V-0
Housing protection	IP20
Weight	370 g

6.10 Environmental conditions

Ambient temperature	usage group III
	-10 … 0 … 45 … 55 °C
	Acc. to IEC/EN 60 688
Operating temperature	-30 to +70 °C
Storage temperature	-40 to +70 °C
Average annual humidity	≤ 93% r.h.
Altitude	≤ 2000 m

6.11 Dimensions



Connection table

Function			Connection
Measuring input:	AC current	IL1	1/3
		IL2	4/6
		IL3	7/9
	AC voltage	UL1	2
		UL2	5
		UL3	8
		N	11
		I/O	
Inputs / outputs:	I/O 1	⊖→ +	15
		⊖→ –	16
	I/O 2	⊖→ +	17
		⊖→ –	18
	I/O 3	⊖→ +	19
		⊖→ –	20
	I/O 4	⊖→ +	21
		⊖→ –	22
Auxiliary power supply:		+ / AC (L)	13
		– / AC (N)	14
Communication:	RS232 / RS485	Rx / A	23
		GND / NC	24
		Tx / B	25

7. APPENDIX A: MODBUS PROTOCOL

7.1 Modbus communication protocol

Modbus is enabled via RS232 and RS485 or USB. The response is the same type as the request.

Two versions of MODBUS register tables are available:

- VERSION 1: Compatibility with advanced family of transducers (MT500)
- VERSION 2: Compatibility with previous family of transducers (MI400)

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.

VERSION1:

Register table for the actual measurements

Parameter	MODBUS		
	Register		Type
	Start	End	
Reserved	30101	30104	
Frequency	30105	30106	T5
U1	30107	30108	T5
U2	30109	30110	T5
U3	30111	30112	T5
Uavg (phase to neutral)	30113	30114	T5
φ 12 (angle between U1 and U2)	30115		T17
φ 23 (angle between U2 and U3)	30116		T17
φ 31 (angle between U3 and U1)	30117		T17
U12	30118	30119	T5
U23	30120	30121	T5
U31	30122	30123	T5
Uavg (phase to phase)	30124	30125	T5
I1	30126	30127	T5
I2	30128	30129	T5
I3	30130	30131	T5
INc	30132	30133	T5
INm - reserved	30134	30135	T5
Iavg	30136	30137	T5
Σ I	30138	30139	T5
Active Power Total (Pt)	30140	30141	T6
Active Power Phase L1 (P1)	30142	30143	T6
Active Power Phase L2 (P2)	30144	30145	T6
Active Power Phase L3 (P3)	30146	30147	T6

Parameter	MODBUS Register Start	MODBUS Register End	MODBUS Type	
Reactive Power Total (Qt)	30148	30149	T6	
Reactive Power Phase L1 (Q1)	30150	30151	T6	
Reactive Power Phase L2 (Q2)	30152	30153	T6	
Reactive Power Phase L3 (Q3)	30154	30155	T6	
Apparent Power Total (St)	30156	30157	T5	
Apparent Power Phase L1 (S1)	30158	30159	T5	
Apparent Power Phase L2 (S2)	30160	30161	T5	
Apparent Power Phase L3 (S3)	30162	30163	T5	
Power Factor Total (PFt)	30164	30165	T7	
Power Factor Phase 1 (PF1)	30166	30167	T7	
Power Factor Phase 2 (PF2)	30168	30169	T7	
Power Factor Phase 3 (PF3)	30170	30171	T7	
Power Angle Total (atan2(Pt,Qt))	30172		T17	
φ 1 (angle between U1 and I1)	30173		T17	
φ 2 (angle between U2 and I2)	30174		T17	
φ 3 (angle between U3 and I3)	30175		T17	
Internal Temperature	30181		T17	
THD HARMONIC DATA				
U1 THD%	30182		T16	
U2 THD%	30183		T16	
U3 THD%	30184		T16	
U12 THD%	30185		T16	
U23 THD%	30186		T16	
U31 THD%	30187		T16	
I1 THD%	30188		T16	
I2 THD%	30189		T16	
I3 THD%	30190		T16	
I/O STATUS				
Alarm Status Flags (No. 1 … 16)	30191		T1	
I/O 1 Value	30193		T17	
I/O 2 Value	30194		T17	
I/O 3 Value	30195		T17	
I/O 4 Value	30196		T17	
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	
Current Active Tariff	30405		T1	
Energy Counter 1	30406	30407	T3	
Energy Counter 2	30408	30409	T3	
Energy Counter 3	30410	30411	T3	
Energy Counter 4	30412	30413	T3	

Parameter	MODBUS		
	Register		
	Start	End	Type
DEMAND VALUES			
DYNAMIC DEMAND VALUES			
Time Into Period (minutes)	30501		T1
I1	30502	30503	T5
I2	30504	30505	T5
I3	30506	30507	T5
Apparent Power Total (St)	30508	30509	T5
Active Power Total (Pt) - (positive)	30510	30511	T6
Active Power Total (Pt) - (negative)	30512	30513	T6
Reactive Power Total (Qt) - L	30514	30515	T6
Reactive Power Total (Qt) - C	30516	30517	T6
MAX DEMAND SINCE LAST RESET			
I1	30518	30519	T5
I2	30524	30525	T5
I3	30530	30531	T5
Apparent Power Total (St)	30536	30537	T5
Active Power Total (Pt) - (positive)	30542	30543	T6
Active Power Total (Pt) - (negative)	30548	30549	T6
Reactive Power Total (Qt) - L	30554	30555	T6
Reactive Power Total (Qt) - C	30560	30561	T6

Register table for the normalized actual measurements

Parameter	MODBUS		100% value
	Regist	Type	
U1	30801	T16	Un
U2	30802	T16	Un
U3	30803	T16	Un
Uavg (phase to neutral)	30804	T16	Un
U12	30805	T16	Un
U23	30806	T16	Un
U31	30807	T16	Un
Uavg (phase to phase)	30808	T16	Un
I1	30809	T16	In
I2	30810	T16	In
I3	30811	T16	In
φ I	30812	T16	It
I neutral (calculated)	30813	T16	In
I neutral (measured)	30814	T16	In
Iavg	30815	T16	In
Active Power Phase L1 (P1)	30816	T17	Pn
Active Power Phase L2 (P2)	30817	T17	Pn
Active Power Phase L3 (P3)	30818	T17	Pn
Active Power Total (Pt)	30819	T17	Pt
Reactive Power Phase L1 (Q1)	30820	T17	Pn
Reactive Power Phase L2 (Q2)	30821	T17	Pn

Parameter	MODBUS		100% value
	Register	Type	
Reactive Power Phase L3 (Q3)	30822	T17	Pn
Reactive Power Total (Qt)	30823	T17	Pt
Apparent Power Phase L1 (S1)	30824	T16	Pn
Apparent Power Phase L2 (S2)	30825	T16	Pn
Apparent Power Phase L3 (S3)	30826	T16	Pn
Apparent Power Total (St)	30827	T16	Pt
Power Factor Phase 1 (PF1)	30828	T17	1
Power Factor Phase 2 (PF2)	30829	T17	1
Power Factor Phase 3 (PF3)	30830	T17	1
Power Factor Total (PFt)	30831	T17	1
CAP/IND P. F. Phase 1 (PF1)	30832	T17	1
CAP/IND P. F. Phase 2 (PF2)	30833	T17	1
CAP/IND P. F. Phase 3 (PF3)	30834	T17	1
CAP/IND P. F. Total (PFt)	30835	T17	1
φ1 (angle between U1 and I1)	30836	T17	100°
φ 2 (angle between U2 and I2)	30837	T17	100°
φ 3 (angle between U3 and I3)	30838	T17	100°
Power Angle Total (atan2(Pt,Qt))	30839	T17	100°
φ12 (angle between U1 and U2)	30840	T17	100°
φ 23 (angle between U2 and U3)	30841	T17	100°
φ 31 (angle between U3 and U1)	30842	T17	100°
Frequency	30843	T17	Fn+10Hz
I1 THD%	30845	T16	100%
I2 THD%	30846	T16	100%
I3 THD%	30847	T16	100%
U1 THD%	30848	T16	100%
U2 THD%	30849	T16	100%
U3 THD%	30850	T16	100%
U12 THD%	30851	T16	100%
U23 THD%	30852	T16	100%
U31 THD%	30853	T16	100%
MAX DEMAND SINCE LAST RESET			
Active Power Total (Pt) - (positive)	30854	T16	Pt
Active Power Total (Pt) - (negative)	30855	T16	Pt
Reactive Power Total (Qt) - L	30856	T16	Pt
Reactive Power Total (Qt) - C	30857	T16	Pt
Apparent Power Total (St)	30858	T16	Pt
I1	30859	T16	In
I2	30860	T16	In
I3	30861	T16	In

Parameter	MODBUS		100% value	
	Register	Type		
DYNAMIC DEMAND VALUES				
Active Power Total (Pt) - (positive)	30862	T16	Pt	
Active Power Total (Pt) - (negative)	30863	T16	Pt	
Reactive Power Total (Qt) - L	30864	T16	Pt	
Reactive Power Total (Qt) - C	30865	T16	Pt	
Apparent Power Total (St)	30866	T16	Pt	
I1	30867	T16	In	
I2	30868	T16	In	
I3	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		
Aktiv Tariff	30879	T1		
Internal Temperature	30880	T17	100°	

VERSION2:

Register table for the actual measurements

Parameter	MODBUS		
	Register		Type
	Start	End	
Frequency	30049	30050	T5
U1	30057	30058	T5
U2	30059	30060	T5
U3	30061	30062	T5
Uavg (phase to neutral)	30063	30064	T5
φ 12 (angle between U1 and U2)	30065		T17
φ 23 (angle between U2 and U3)	30066		T17
φ 31 (angle between U3 and U1)	30067		T17
U12	30068	30069	T5
U23	30070	30071	T5
U31	30072	30073	T5
Uavg (phase to phase)	30074	30075	T5
I1	30076	30077	T5
I2	30078	30079	T5
I3	30080	30081	T5
INc	30082	30083	T5
INm - reserved	30084	30085	T5
Iavg	30086	30087	T5
Σ I	30088	30089	T5
Active Power Total (Pt)	30090	30091	T6
Active Power Phase L1 (P1)	30092	30093	T6
Active Power Phase L2 (P2)	30094	30095	T6
Active Power Phase L3 (P3)	30096	30097	T6

Parameter	**MODBUS**			
	Register		**Type**	
	Start	**End**		
Reactive Power Total (Qt)	30098	30099	T6	
Reactive Power Phase L1 (Q1)	30100	30101	T6	
Reactive Power Phase L2 (Q2)	30102	30103	T6	
Reactive Power Phase L3 (Q3)	30104	30105	T6	
Apparent Power Total (St)	30106	30107	T5	
Apparent Power Phase L1 (S1)	30108	30109	T5	
Apparent Power Phase L2 (S2)	30110	30111	T5	
Apparent Power Phase L3 (S3)	30112	30113	T5	
Power Factor Total (PFt)	30114	30115	T7	
Power Factor Phase 1 (PF1)	30116	30117	T7	
Power Factor Phase 2 (PF2)	30118	30119	T7	
Power Factor Phase 3 (PF3)	30120	30121	T7	
Power Angle Total (atan2(Pt,Qt))	30122		T17	
φ 1 (angle between U1 and I1)	30123		T17	
φ 2 (angle between U2 and I2)	30124		T17	
φ 3 (angle between U3 and I3)	30125		T17	
Internal Temperature	30126		T17	
THD HARMONIC DATA				
U1 THD%	30639		T16	
U2 THD%	30640		T16	
U3 THD%	30641		T16	
U12 THD%	30642		T16	
U23 THD%	30643		T16	
U31 THD%	30644		T16	
I1 THD%	30645		T16	
I2 THD%	30646		T16	
I3 THD%	30647		T16	
ENERGY				Actual counter value is calculated: Counter * 10^{Exponent}
Energy Counter 1 Exponent	30037		T2	
Energy Counter 2 Exponent	30038		T2	
Energy Counter 3 Exponent	30039		T2	
Energy Counter 4 Exponent	30040		T2	
Current Active Tariff	30133		T1	
Energy Counter 1	30134	30135	T3	
Energy Counter 2	30136	30137	T3	
Energy Counter 3	30138	30139	T3	
Energy Counter 4	30140	30141	T3	

Parameter	MODBUS		
	Register		
	Start	End	Type
DEMAND VALUES			
DYNAMIC DEMAND VALUES			
Time Into Period (minutes)	30174		T1
I1	30175	30176	T5
I2	30177	30178	T5
I3	30179	30180	T5
Apparent Power Total (St)	30181	30182	T5
Active Power Total (Pt) - (positive)	30183	30184	T6
Active Power Total (Pt) - (negative)	30185	30186	T6
Reactive Power Total (Qt) - L	30187	30188	T6
Reactive Power Total (Qt) - C	30189	30190	T6
MAX DEMAND SINCE LAST RESET			
I1	30207	30208	T5
I2	30213	30214	T5
I3	30219	30220	T5
Apparent Power Total (St)	30225	30226	T5
Active Power Total (Pt) - (positive)	30231	30232	T6
Active Power Total (Pt) - (negative)	30237	30238	T6
Reactive Power Total (Qt) - L	30243	30244	T6
Reactive Power Total (Qt) - C	30249	30250	T6

Register table for the normalized actual measurements

Parameter	MODBUS		100% value
	Register	Type	
U1	30801	T16	Un
U2	30802	T16	Un
U3	30803	T16	Un
Uavg (phase to neutral)	30804	T16	Un
U12	30805	T16	Un
U23	30806	T16	Un
U31	30807	T16	Un
Uavg (phase to phase)	30808	T16	Un
I1	30809	T16	In
I2	30810	T16	In
I3	30811	T16	In
φ I	30812	T16	It
I neutral (calculated)	30813	T16	In
I neutral (measured)	30814	T16	In
Iavg	30815	T16	In
Active Power Phase L1 (P1)	30816	T17	Pn
Active Power Phase L2 (P2)	30817	T17	Pn
Active Power Phase L3 (P3)	30818	T17	Pn
Active Power Total (Pt)	30819	T17	Pt
Reactive Power Phase L1 (Q1)	30820	T17	Pn
Reactive Power Phase L2 (Q2)	30821	T17	Pn

Parameter	MODBUS		100% value
	Register	Type	
Reactive Power Phase L3 (Q3)	30822	T17	Pn
Reactive Power Total (Qt)	30823	T17	Pt
Apparent Power Phase L1 (S1)	30824	T16	Pn
Apparent Power Phase L2 (S2)	30825	T16	Pn
Apparent Power Phase L3 (S3)	30826	T16	Pn
Apparent Power Total (St)	30827	T16	Pt
Power Factor Phase 1 (PF1)	30828	T17	1
Power Factor Phase 2 (PF2)	30829	T17	1
Power Factor Phase 3 (PF3)	30830	T17	1
Power Factor Total (PFt)	30831	T17	1

All other MODBUS registers are a subject to change. For the latest MODBUS register definitions go to ISKRA MIS's web page www.iskra-mis.si

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	

Parameter	MODBUS		Values / Dependencies
	Register	Type	
Calibration voltage	30015	T4	mV
Calibration current	30017	T4	mA

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

EXAMPLE of calculation using MODBUS registers and their data types:

CT Primary = R40145 (<u>Type T4</u>) = 10^2 × 40 = $\mathbf{8028_{(16)}}$ –> **4000 A/10 = 400A**
CT Secondary = R40144 (<u>Type T4</u>) = 10^2 × 50 = $\mathbf{8032_{(16)}}$ –> **5000 mA**
Cal. Current = R30017 (<u>Type T4</u>) = 10^2 × 50 = $\mathbf{8032_{(16)}}$ –> **5000 mA**
Input range = R40148 (<u>Type T16</u>) = 10000 = $\mathbf{2710_{(16)}}$ –> **100,00%**

In = (R40145 / R40144) * R30017 * R40148 = (400 / 5) * 5A * 100% =400A

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)

8. APPENDIX B: CALCULATIONS & EQUATIONS

8.1 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 ($0 \le n \le N$)
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_c	Agreed supply voltage

8.2 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 65 Hz) Example: 400 Hz → N = 7
$$U_{xy} = \sqrt{\frac{\sum_{n=1}^{N} (u_{xn} - u_{yn})^2}{N}}$$	**Phase-to-phase voltage** u_x, u_y − phase voltages (U_f) N − a number of samples in a period

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)
$$I_n = \sqrt{\frac{\sum_{n=1}^{N} (i_{1n} + i_{2n} + i_{3n})^2}{N}}$$	**Neutral current** i − n sample of phase current (1, 2 or 3) N = 128 samples in a period (up to 65 Hz)

Power	
$P_f = \frac{1}{N} \cdot \sum_{n=1}^{N} \left(u_{f\,n} \times i_{f\,n}\right)$	**Active power by phases** N − a number of samples in a period n − sample number ($0 \le n \le N$) f − phase designation
$P_t = P_1 + P_2 + P_3$	**Total active power** t − total power 1, 2, 3 − phase designation
$\mathrm{Sign}Q_f(\varphi)$ $\varphi \in [0° - 180°] \Rightarrow \mathrm{Sign}Q_f(\varphi) = +1$ $\varphi \in [180° - 360°] \Rightarrow \mathrm{Sign}Q_f(\varphi) = -1$	**Reactive power sign** Q_f − reactive power (by phases) φ − power angle
$S_f = U_f \times I_f$	**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
$Q_f = \mathrm{Sign}Q_f(\varphi) \times \sqrt{S_f^2 - P_f^2}$	**Reactive power by phases (standard)** S_f − apparent power by phases P_f − active power by phases
$Q_f = \frac{1}{N} \cdot \sum_{n=1}^{N} \left(u_{f\,n} \times i_{f\,[n+N/4]}\right)$	**Reactive power by phases (delayed current method)** N − a number of samples in a period n − sample number ($0 \le n \le N$) f − phase designation
$Q_t = Q_1 + Q_2 + Q_3$	**Total reactive power** Q_f − reactive power by phases
$\varphi_s = a\tan 2(P_t, Q_t)$ $\varphi_s = [-180°, 179{,}99°]$	**Total power angle** P_t − total active power S_t − total apparent power
$PF = \frac{P}{S}$	**Distortion factor** P − total active power S − total apparent power
$PF_f = \frac{P_f}{S_f}$	**Distortion 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
$$U_f THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} Un^2}}{U_1} \cdot 100$$	**Phase voltage THD** U_1 − value of first harmonic n − number of harmonic
$$U_{ff} THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} Un^2}}{U_1} \cdot 100$$	**Phase-to-phase voltage THD** U_1 − value of first harmonic n − number of harmonic

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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