# User ’s Manual

EN

## Supervision Relay SR100

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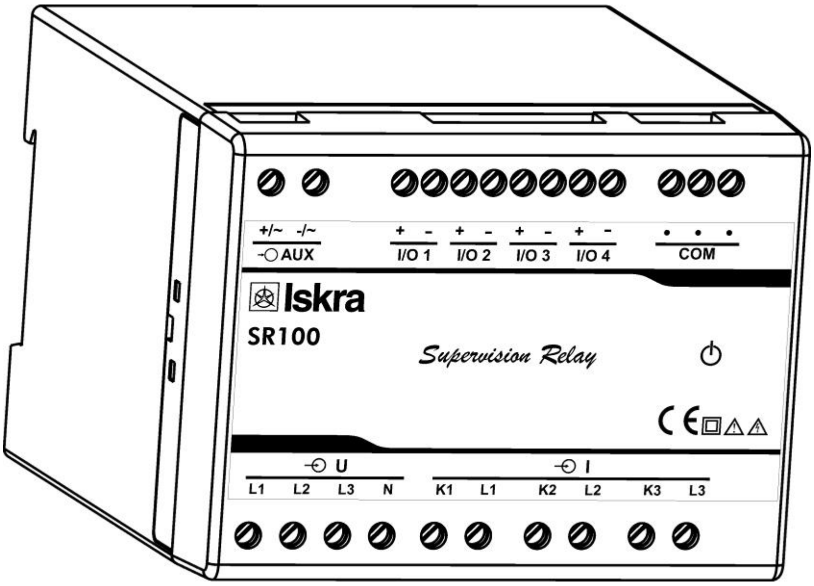
# SUPERVISION RELAY SR100



# SECURITY ADVICE AND WARNINGS

Please read this chapter carefully and examine the equipment carefully for potential damages which might arise during transport and to become familiar with it before continue to install, energize and work with a measuring instrument.

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

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

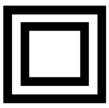
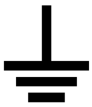
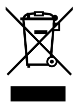
If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

**PLEASE NOTE**

Installation and use of devices includes work with dangerous currents and voltages, therefore such work shall be carried out by qualified persons only. The ISKRA Company assumes no responsibility in connection with installation and use of the product. If there is any doubt, regarding installation and use of the system in which the instrument is used for measuring or protection, please contact a person who is responsible for installation of such system.

# WARNINGS, INFORMATION AND NOTES REGARDING DESIGNATION OF PRODUCT

Used symbols:

| | |
|---|---|
|  | See product documentation. |
|  | Double insulation in compliance with the EN 61010−1 standard. |
|  | Functional ground potential.<br>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. |

# BEFORE SWITCHING THE DEVICE ON

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 for voltage inputs (recommended maximal external fuse size is 6 A),
- external switch or circuit-breaker must be included in the installation for disconnection of the devices' aux. power supply. It must be suitably located and properly marked for reliable disconnection of the device when needed,
- integrity of earth terminal,
- proper connection and voltage level of I/O modules.

**WARNING**

A current transformer secondary should be short circuited before connecting the device.

# 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.

# DISPOSAL

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

# BASIC DESCRIPTION AND OPERATION

This chapter presents all relevant information about the instrument required to understand its purpose, applicability and basic features related to its operation.

Apart from this, it also contains navigational tips, description of used symbols and other useful information for understandable navigation through this manual.

Regarding the options of this instrument, different chapters should be considered since a particular sub variant might vary in functionality. More detailed description of device functions is given in chapters Main Features, Supported options and Functionality.

Supervision Relay SR100 is available in DIN rail mounting enclosure. Specifications of housing are specified in chapter *Connection – Mounting* on page 12.

## Contents

Packaging contains the following items:

- Measuring instrument
- Quick Guide

All related documentation on this product can be found at Iskra web page - https://www.iskra.eu. The instrument desktop based setting software – MiQen2, together with accompanying drivers can be found on Iskra web page - https://www.iskra.eu. Due to environmental reasons, all this information is longer provided on a separate CD.

**CAUTION**

Please examine the equipment carefully for potential damage, which might have occurred during transport.

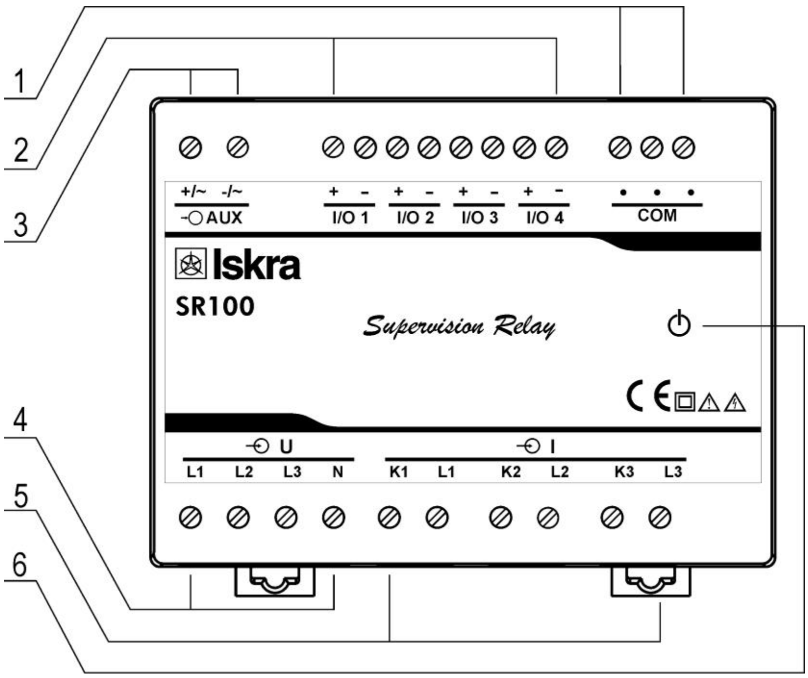
# Description of the Supervision Relay SR100

Supervision Relay SR100 is intended for measuring and monitoring single-phase or three-phase electrical power network. It measures RMS network values and all significant deviations from the nominal values by means of fast sampling of voltage and current signals. There is an option in MiQen Settings Studio software to select also the measurements based only on positive sequence fundamental wave, which does not include harmonics measurements. This option can be found under MiQen Settings menu. With this option included, all corresponding values are replaced by IEC 61400-21 Annex C measurements. This makes Supervision Relay SR100 suitable for acquisition and validation of fast changes in the network. A built-in microcontroller calculates measured values (voltage, current, frequency, energy, power, power factor, THD phase angles and deviations) and sends these data over a reliable CANopen communication interface to the CAN master devices.

Lack of information regarding supplied voltage quality can lead to unexplained production problems and malfunction or can even damage equipment being used during factory production process. Therefore Supervision Relay SR100 can be used to detect predefined faults. With measuring 13 different network deviations, Supervision Relay SR100 could be used as simple but efficient supervision relay. Supervision Relay SR100 is delivered un-configured for customer configuration with user friendly setting software MiQEN. Supervision Relay SR100 supports standard serial communication RS232/RS485 with speed up to 115200 baud and CANopen communication for speeds up to 1 Mbit/s which is perfect for integration into large systems.
Additional USB 2.0 interface can only be used for a fast set-up without the need for auxiliary power supply. This interface is provided with only BASIC insulation and can be used ONLY unconnected to power inputs.

**Appearance**

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). CANopen communication is also connected using screw-in connector. USB can be connected through USB-mini type connector at the bottom of Supervision Relay SR100.
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 electromechanical relay output modules.

**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 (20 … 300 V DC; 48 … 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 (0.01 Ω per phase). Maximum allowed thermal value of input current is 12.5 A (cont.).

# Abbreviation/Glossary

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

| Term | Explanation |
|---|---|
| RMS | Root Mean Square value |
| MODBUS / DNP3 | Industrial protocol for data transmission |
| MiQen | Setting Software for ISKRA instruments |
| AC | Alternating voltage |
| PA total | Power Angle calculated from total active and apparent power |
| $PA_{phase}$ | Angle between fundamental phase voltage and phase current |
| $PF_{phase}$ | Power factor, calculated from apparent and active power (affected by harmonics) |
| THD (U, I) | Total harmonic distortion |
| MD | Max. Demand; 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 |
| 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 |
| Hysteresis [%] | Percentage specifies increase or decrease of a measurement from a certain limit after exceeding it. |
| RO | Relay output module |

*List of common abbreviations and expressions*

# Purpose and use of Supervision Relay SR100

Supervision Relay SR100 is used for measuring and monitoring single-phase or three-phase values and detecting predefined faults. With measuring 13 different network deviations, Supervision Relay SR100 can be used as simple but efficient supervision relay. Supervision Relay SR100 is delivered un-configured for customer configuration with user friendly setting software MiQEN. Supervision Relay SR100 supports standard serial communication RS232/RS485 with speed up to 115200 baud and CANopen communication for speeds up to 1 Mbit/s which is perfect for integration into large systems.

Additional USB 2.0 interface can only be used for a fast set-up without the need for auxiliary power supply. This interface is provided with only BASIC insulation and can be used ONLY unconnected to power inputs.

**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 $\phi_1$, $\phi_2$, $\phi_3$ and $\phi^{\sim}$ |
| | THD of phase voltage $U_{f1}$, $U_{f2}$ and $U_{f3}$ |
| | THD of power angle $I_1$, $I_2$ and $I_3$ |
| | Phase Shift $L_1$\$L_2$\$L_3$ |
| Phase-to-phase | Phase-to-phase voltage $U_{12}$, $U_{23}$, $U_{31}$ |
| | Average phase-to-phase voltage $U_{ff}$ |
| | Phase-to-phase angle $\phi_{12}$, $\phi_{23}$, $\phi_{31}$ |
| | THD of phase–to–phase voltage |
| Energy | Counter 1 |
| | Counter 2 |
| | Counter 3 |
| | Counter 4 |
| | Active tariff |
| Inputs and outputs | Relay output 1 |
| | Relay output 2 |
| | Relay output 3 |
| | Relay output 4 |

| | Other measurements |
|---|---|
| MD values | Phase current I1, I2, I3 |
| | Active Power Total (Pt) - (positive) |
| | Active Power Total (Pt) - (negative) |
| | Reactive Power Total (Qt) - L |
| | Reactive Power Total (Qt) - C |
| | Apparent Power Total (St) |
| Measurements | Voltage Unbalances $U_o$ |
| | Phase imbalance |
| | Frequency |
| | ROCOF df/dt |
| | Internal temperature |

# CONNECTION

This chapter deals with the instructions for measuring instrument connection. Both the use and connection of the device includes handling with dangerous currents and voltages. Only qualified personnel using an appropriate equipment shall therefore perform connections. ISKRA d.d. 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.
A person qualified for installation and connection of a device should be familiar with all necessary precaution measures described in this document prior to its connection.

Before use please check the following:

- Nominal voltage ($U_{P\text{-}Pmax}$ = 1000$V_{ACrms}$; $U_{P\text{-}Nmax}$ = 600$V_{ACrms}$),
- Supply voltage (rated value),
- Nominal frequency,
- Voltage ratio and phase sequence,
- Current transformer ratio and terminals integrity,
- Protection fuse for voltage inputs (recommended maximal external fuse size is 6 A)
- External switch or circuit-breaker must be included in the installation for disconnection of the devices' aux. power supply. It must be suitably located and properly marked for reliable disconnection of the device when needed. See CAUTION below.
- Integrity of earth terminal
- Proper connection and voltage level of I/O modules

WARNING

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

CAUTION

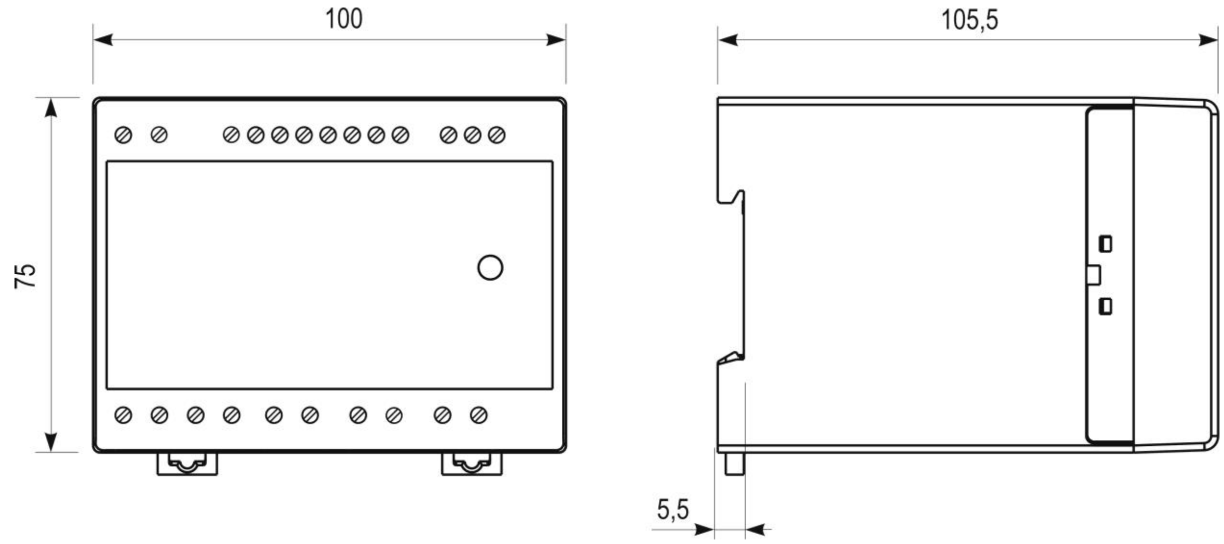
Aux. Supply inrush current can be as high as 20A for short period of time (<1 ms). Please choose an appropriate MCB for disconnection of aux. supply.

**PLEASE NOTE**

After connection, settings have to be performed via communication using MiQen software.

# Mounting

Supervision Relay SR100 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 in place, fasteners are locked (pushed) to close position.




*Dimensional drawing*

# Electrical connection for Supervision Relay SR100

Voltage inputs of a device can be connected directly to low-voltage network or via a voltage measuring transformer to a high-voltage network.

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

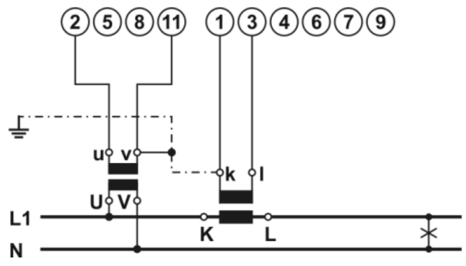
Choose corresponding connection from the figures below and connect corresponding voltages and currents. Information on electrical consumption of current and voltage inputs is given in a chapter *Technical Data – Measuring inputs* on page 64.

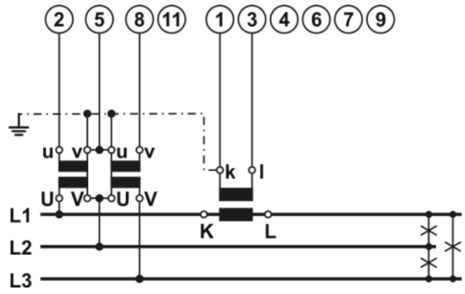
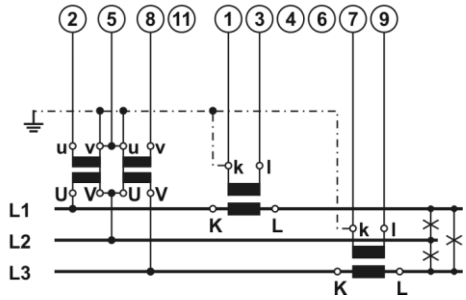
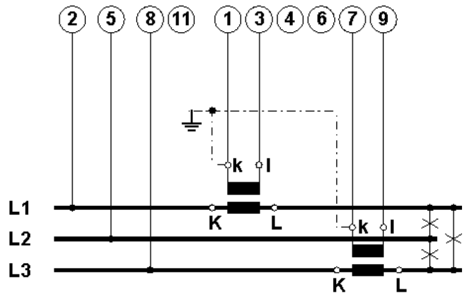
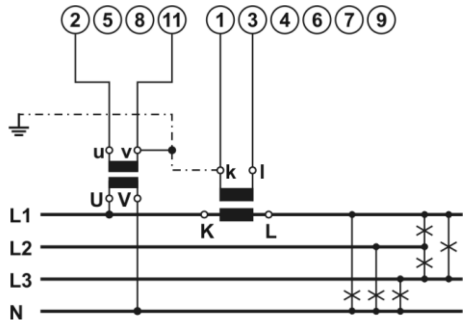
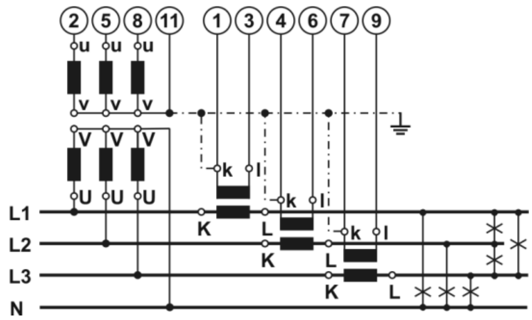
**CAUTION**

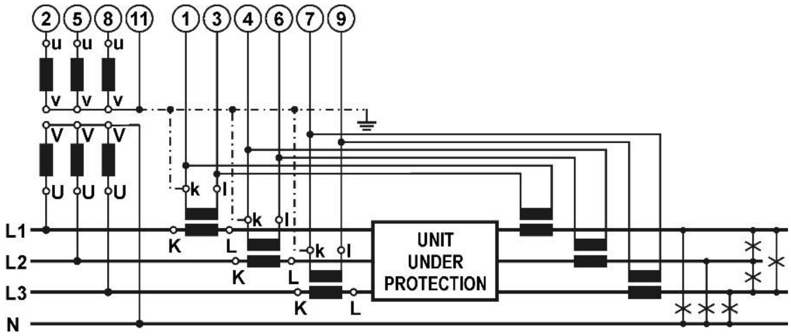
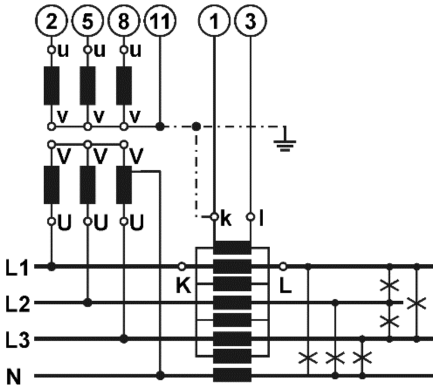
For accurate operation and to avoid measuring signal crosstalk it is important to avoid installation of voltage measuring wires close to current measuring transformers.

**PLEASE NOTE**

For proper connection wire diameters and other wiring requirements see chapter *Technical data – Connection* on page 65.

| System/ connection | Terminal assignment |
|---|---|
| Connection 1b (1W)<br>Single phase connection |  |

| System/ connection | Terminal assignment |
|---|---|
| Connection 3b (1W3)<br>Three phase, three wire connection<br>with balanced load |  |
| Connection 3u (2W3)<br>Three phase, three wire connection<br>with unbalanced load |  |
| Direct connection 3u(2W3)<br>Three phase, three wire direct connection<br>with unbalanced load |  |
| Connection 4b (1W4)<br>Three phase, four wire connection<br>with balanced load |  |
| Connection 4u (3W4)<br>Three phase, four wire connection<br>with unbalanced load |  |

| System/ connection | Terminal assignment |
|---|---|
| Connection Idiff<br>Three phase, four wire connection with unbalanced load |  |
| Connection IE<br>Three phase, four wire connection with unbalanced load |  |

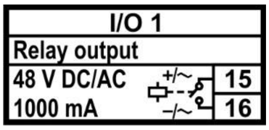
# Connection of input/output modules

**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 a chapter *Technical Data – I/O modules* on page 67.

## I/O module 1

| | |
|---|---|
|  | Electromechanical relay output module. (Example of alarm module as I/O module 1) |

# Communication connection

Supervision Relay SR100 is equipped with one standard (COM1) RS232 / RS485 / CANopen 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. 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 27.

## RS232

RS232 communication is intended for direct connection of the Device to the personal computer. For proper operation it is necessary to assure the corresponding connection of individual terminals (see table: *Survey of communication connection* on page 16).

## RS485

RS485 communication is intended for connection of multiple devices to a network where devices with RS485 communication are connected to a common communication interface. We suggest using one of the *ISKRA, d.d.* communication interfaces! For proper operation it is necessary to assure the corresponding connection of individual terminals. See table: *Survey of communication connection* page 16.

## CAN (CANopen)

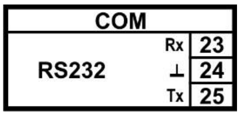
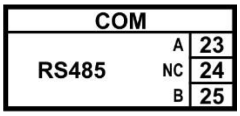
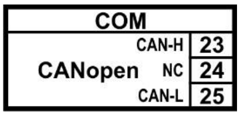
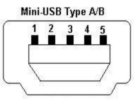
CANopen communication is intended for connection of multiple devices to a fieldbus network systems where Supervision Relay SR100 is connected as slave device to the master device. *ISKRA* has some project examples for different master devices as Beckhoff PLC, Bachmann PLC, … and the User could request for them. Supervision Relay SR100 implements CANopen communication protocol according to CiA 401 specification and implements most of the CANopen NMT standard commands. CAN connector emphasis CAN-L, CAN-H and also CAN-GND signal which is not necessary to be used. See table: Survey of communication connection page 16. For proper operation it is only necessary to assure the corresponding external termination of CAN-L/CAN-H lines with 120 Ohms resistance. Also 120 Ohms termination is highly recommended on the master side of the communication path. More information about the CANopen protocol could be found in the chapter *Settings – General settings – communication – CANopen* on page 28.

## Service USB

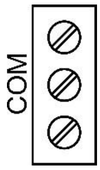
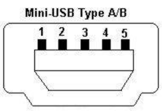
Additionally, Supervision Relay SR100 has a USB communication port, located on the bottom under small circular plastic cover. It is intended for settings ONLY and requires NO auxiliary power supply. When connected to this communication port Supervision Relay SR100 is powered by USB.
The USB port should 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.

**⚠ WARNING**

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

| | |
|---|---|
|  | COM1 serial communication port (RS232) |
|  | COM1 serial communication port (RS485) |
|  | CAN (CANopen) communication port |
|  | SERVICE communication port (USB) |

# Survey of communication connection

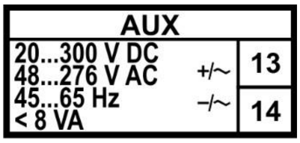
| Connector | Terminals | Position | RS232 | RS485 | CAN (CANopen) |
|---|---|---|---|---|---|
| Screw terminals |  | 23 | Rx | A | CAN-H |
| | | 24 | GND | NC | CAN-GND |
| | | 25 | Tx | B | CAN-L |
| USB-mini B |  | Standard USB 2.0 compatible cable recommended (Type mini B plug) | | | |

# Connection of aux. Power supply

Device can be equipped with either of two types of universal (AC/DC) switching power supply.

| | |
|---|---|
| **Auxiliary Power Supply:** | 20 ... 300 V DC |
| | 48 ... 276 V AC |
| | 45 ... 65 Hz |

Regarding power supply voltage specification on the label, choose and connect the power supply voltage:




Connection of auxiliary power supply type to terminals 13 and 14.

**CAUTION**

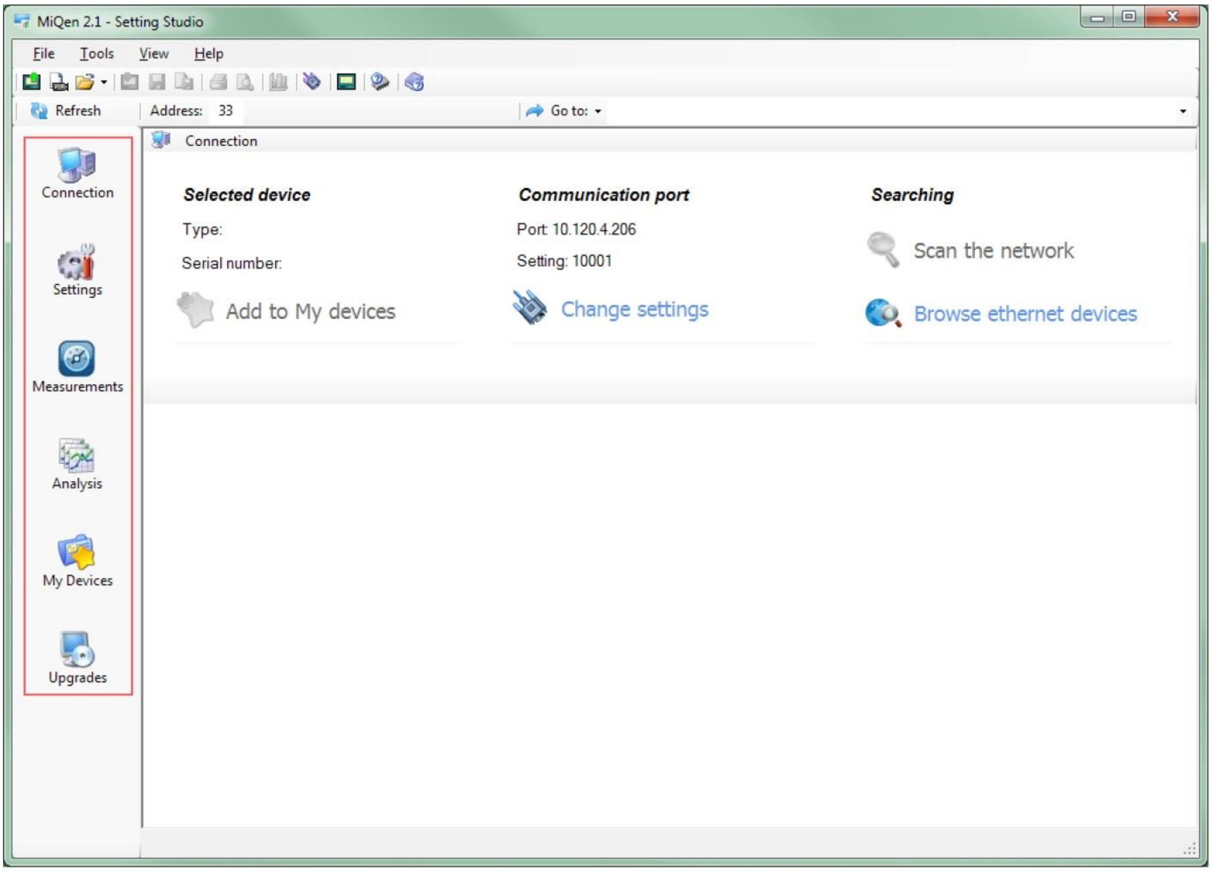
Aux. supply inrush current can be as high as 20A for short period of time (<1 ms). Please choose an appropriate MCB for connection of aux. supply.

# SETTINGS

Settings of the device can be performed via communication with MiQen software. Complete setting of the device can be done using MiQen software.

## MiQen software

MiQen software is a tool for a complete programming and monitoring of ISKRA measuring instruments. Remote operation is possible by means of serial (RS485 / RS232) or USB. A user-friendly interface consists of six segments: connection, settings, measurements, analysis, my devices and upgrades. These segments are easily accessed by means of six icons on the left side:

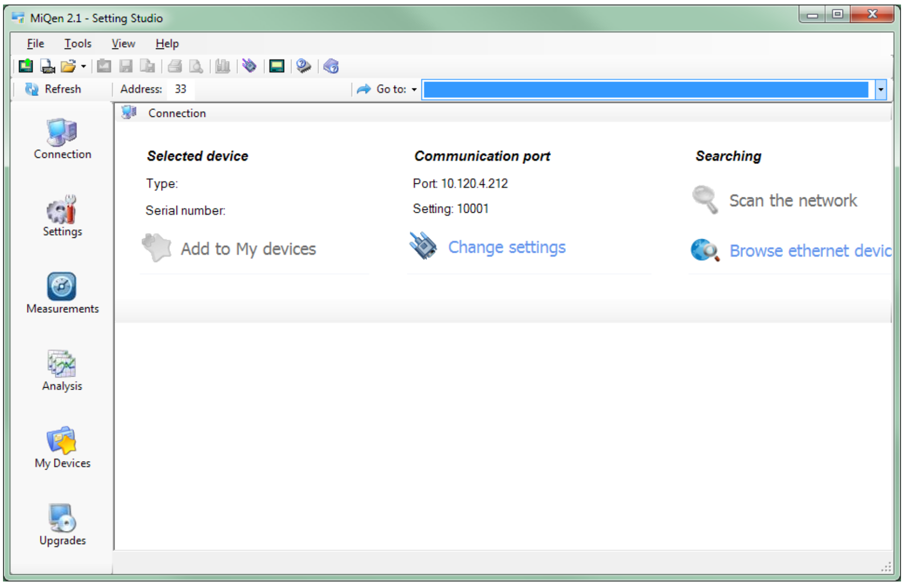



Latest version of MiQen software can be downloaded from ISKRA d.d. website www.iskra.eu.

**PLEASE NOTE**

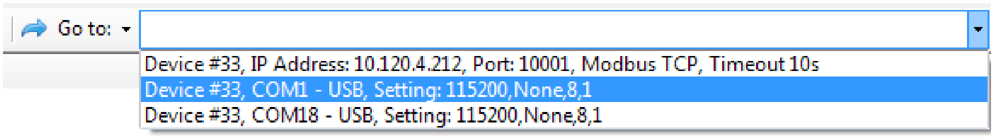
MiQen has very intuitive help system. All functions and settings are described in Info window on the bottom of MiQen window. In MiQen Help file, detailed instructions about software usage, connection and communication with different type of devices, driver installation,… are described.

# Devices management




## MiQen Device Management window

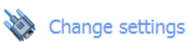
With MiQen it is very easy to manage devices. If dealing with the same device that has been accessed before, it can be easily selected from a favorites' line.



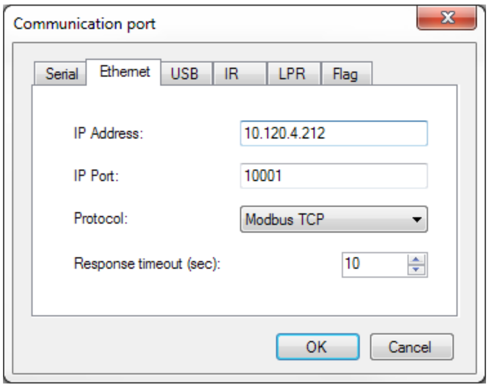

This way is Communication port set automatically as it was during last access.
To communicate with new device follow below instructions:
Connect a device to a communication interface (Depending on type of device):

- Directly to a PC using RS232 cable
- To comm. adapter RS485 / RS232
- Directly to a PC using USB cable

## Set Communication port parameters

Under Communication port, current communication parameters are displayed. To change those parameters click on 

button. A Communication port window opens with settings for different communication interfaces.




To activate desired communication select proper communication tab, set communication parameters and confirm selection with OK button.

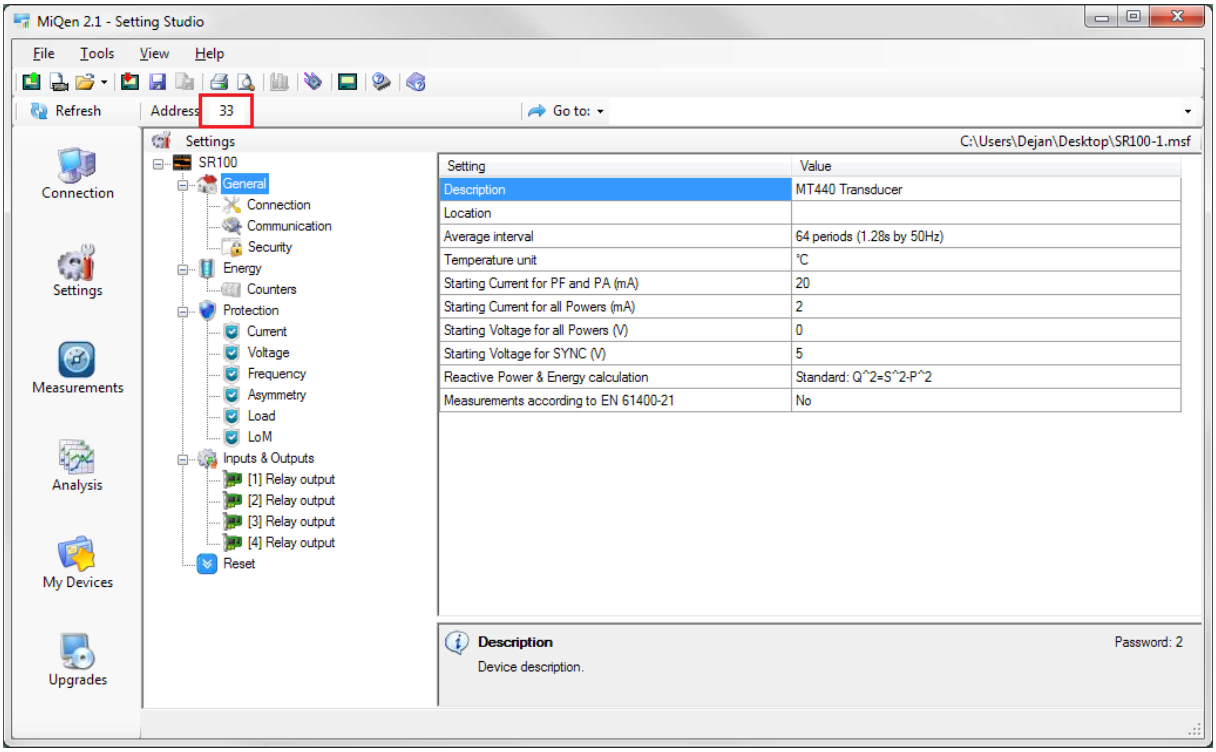
**PLEASE NOTE**

When device with USB communication is connected to a computer for the first time, device driver will be installed automatically. If installation is correct device presents itself in an operating system -> Device manager - Ports (COM and LPT) as a Measuring device. If device is not recognized automatically or wrong driver is installed, valid installation drivers are located in MiQen installation directory, subdirectory Drivers.
With this driver installed, USB is redirected to a serial port, which should be selected when using MiQen software.

For more information regarding communication parameters, please see chapter *Communications* on page 27.

## Set device Modbus address number

Each device connected to a network has its unique Modbus address number. In order communicate with that device an appropriate address number should be set.




Factory default Modbus address for all devices is 33. If devices are connected in to communication network, all should have the same communication parameters, but each of them should have its own unique address.

## Start communicating with a device

Click on Refresh button and devices information will be displayed:

***Selected device***

Type: MC784, Soft. Ver.: 0.48

Serial number: M8000000

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

- **Scan the network** when device is connected to a RS485/RS232 bus
- **Browse Ethernet devices** when device is connected to the Ethernet

***Searching***

Scan the network

Browse ethernet devices

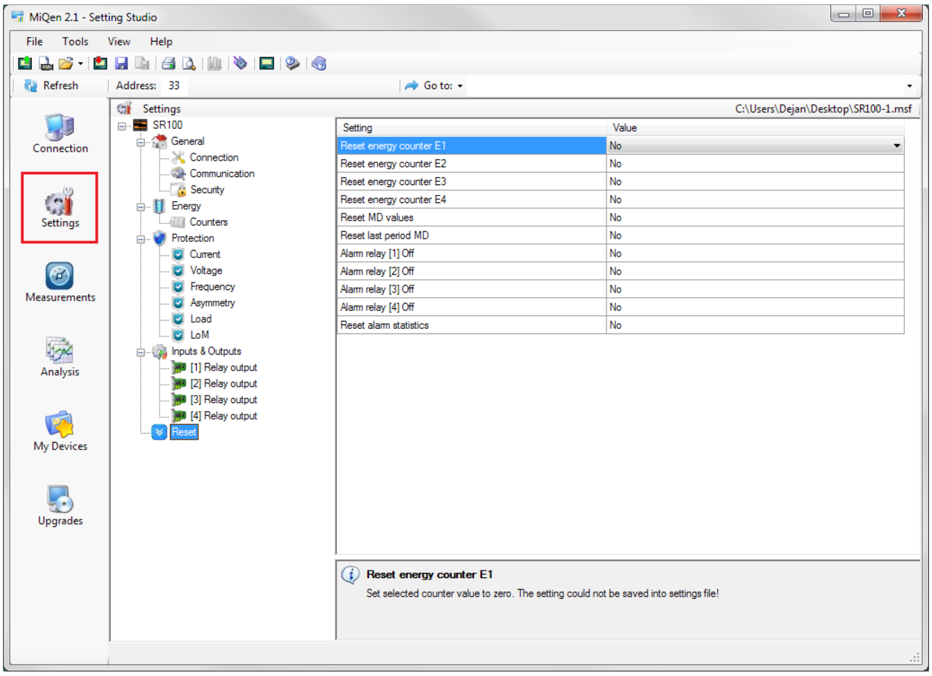
# Settings

Programming devices can be performed ONLINE when device is connected to aux. power supply and is communicating with MiQen. When device is not connected, it is possible to adjust settings OFFLINE.

## Online programming

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

MiQen Device Setting window:




Choose Read settings button to display all devices settings and begin adjusting them according to project requirement.

**PLEASE NOTE**

When finished programming, changes should be confirmed by pressing Download settings button in MiQen menu bar or with a mouse right click menu.

**PLEASE NOTE**

When finished programming, all settings can be saved in a setting file (*.msf file). This way it is possible to archive settings in combination with a date. It is also possible to use saved settings for offline programming or to program other devices with same settings. For more information, see OFFLINE programming.

### Offline programming

When device is not physically present or is unable to communicate, it is still possible to perform OFFLINE programming. From MiQen Device Setting window, choose Open setting file button. From a list of *.msf files choose either previously stored file (a setting file, which has been used for another device and stored) or a file SR100.msf, which holds default settings for this device. When confirmed all device settings are displayed similar as with ONLINE programming.

When finished programming, all settings can be saved in a setting file with a meaningful name (e.g. *SR100_location_date*.msf).

Settings are stored in the directory setting using two recording modes:

- With a type designation and a sequence number from 1 to 9
- With an device serial number

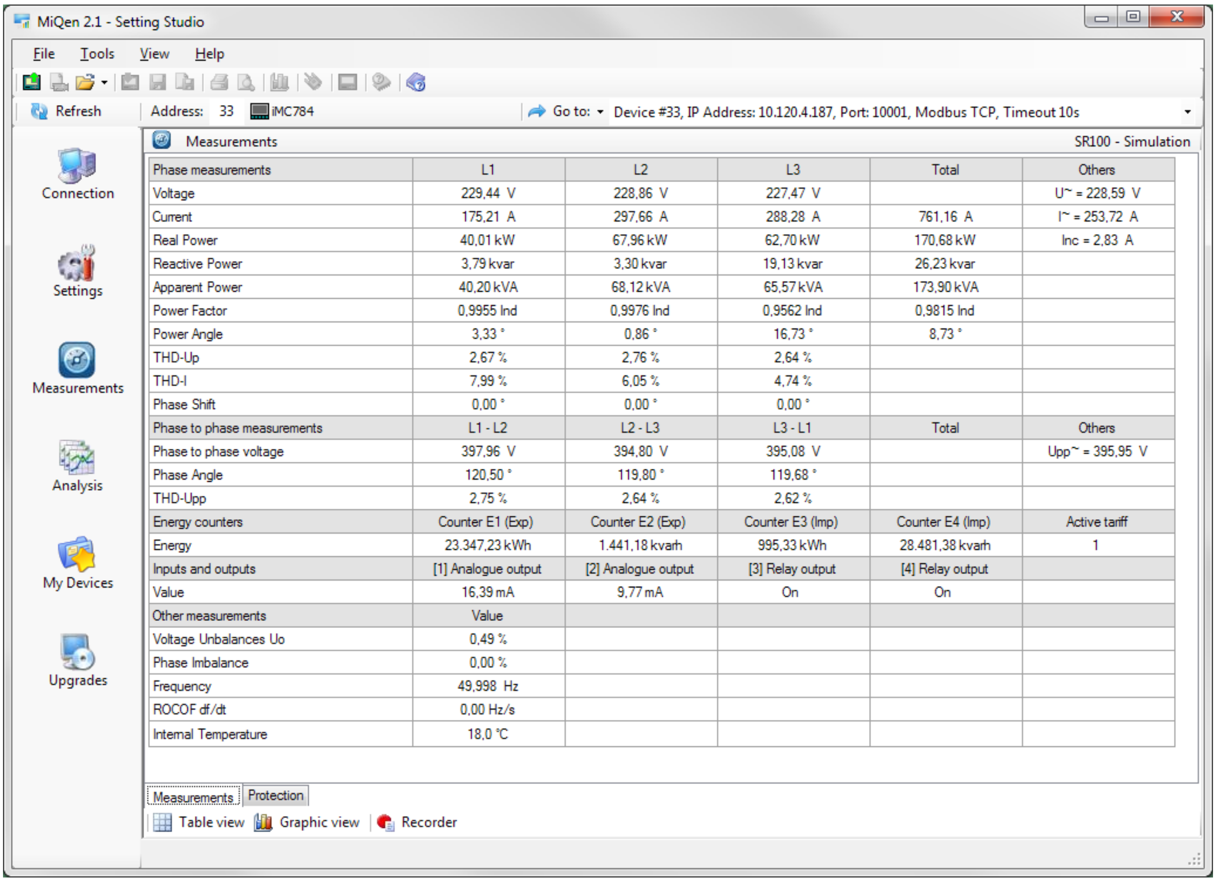
**CAUTION**

SR100.msf file or any other original device setting file should not be modified as it contains device default settings. Please save setting file under another name before adjusting it with your own project requirements.

## Measurements

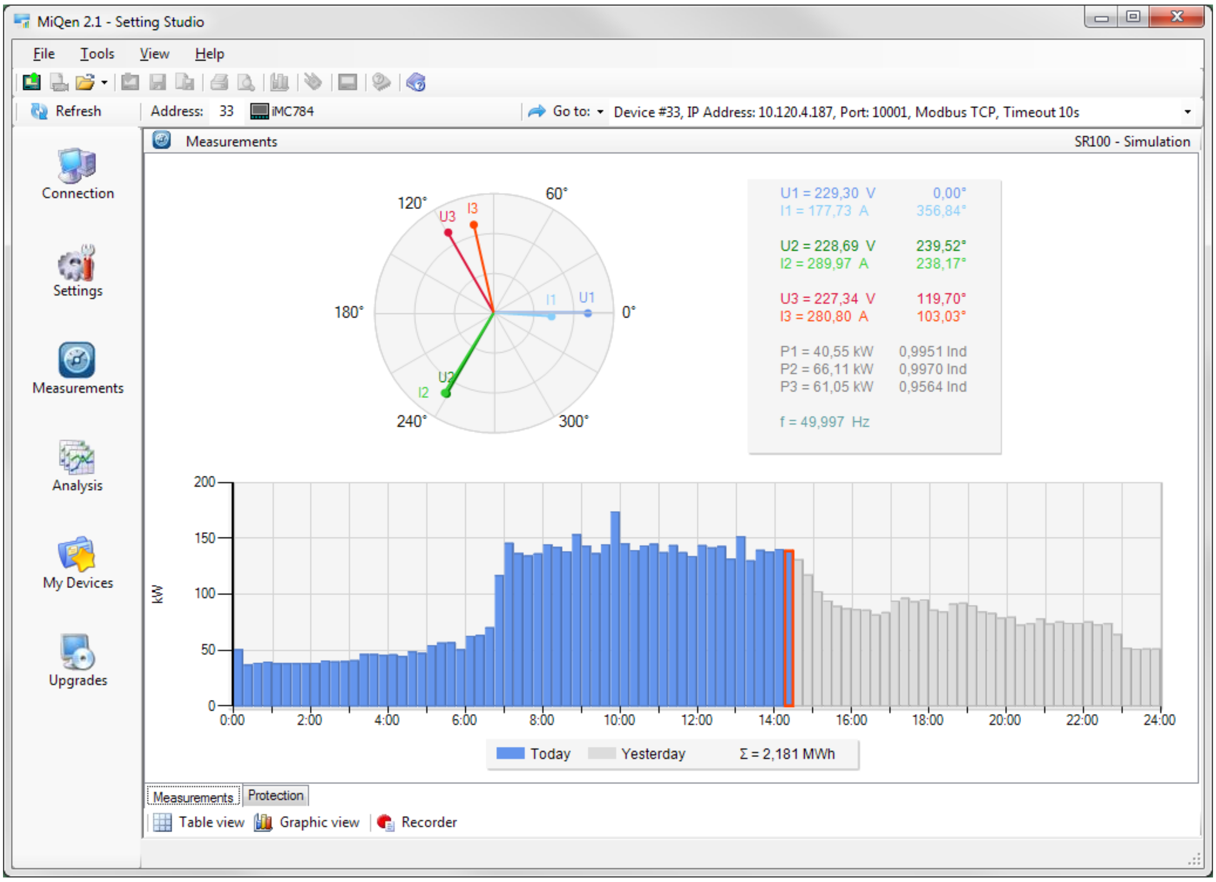
Measurements can be seen ONLINE when device is connected to aux. power supply and is communicating with MiQen. When device is not connected, it is possible to see OFFLINE measurements simulation. The latter is useful for presentations and visualization of measurements without presence of actual device.

In ONLINE mode, all supported measurements and protection functions can be seen in real time in a Table view. Presentation in graphical form is also supported.




| Phase measurements | L1 | L2 | L3 | Total | Others |
|---|---|---|---|---|---|
| Voltage | 229,44 V | 228,86 V | 227,47 V | | U~ = 228,59 V |
| Current | 175,21 A | 297,66 A | 288,28 A | 761,16 A | I~ = 253,72 A |
| Real Power | 40,01 kW | 67,96 kW | 62,70 kW | 170,68 kW | Inc = 2,83 A |
| Reactive Power | 3,79 kvar | 3,30 kvar | 19,13 kvar | 26,23 kvar | |
| Apparent Power | 40,20 kVA | 68,12 kVA | 65,57 kVA | 173,90 kVA | |
| Power Factor | 0,9955 Ind | 0,9976 Ind | 0,9562 Ind | 0,9815 Ind | |
| Power Angle | 3,33 ° | 0,86 ° | 16,73 ° | 8,73 ° | |
| THD-Up | 2,67 % | 2,76 % | 2,64 % | | |
| THD-I | 7,99 % | 6,05 % | 4,74 % | | |
| Phase Shift | 0,00 ° | 0,00 ° | 0,00 ° | | |
| Phase to phase measurements | L1 - L2 | L2 - L3 | L3 - L1 | Total | Others |
| Phase to phase voltage | 397,96 V | 394,80 V | 395,08 V | | Upp~ = 395,95 V |
| Phase Angle | 120,50 ° | 119,80 ° | 119,68 ° | | |
| THD-Upp | 2,75 % | 2,64 % | 2,62 % | | |
| Energy counters | Counter E1 (Exp) | Counter E2 (Exp) | Counter E3 (Imp) | Counter E4 (Imp) | Active tariff |
| Energy | 23.347,23 kWh | 1.441,18 kvarh | 995,33 kWh | 28.481,38 kvarh | 1 |
| Inputs and outputs | [1] Analogue output | [2] Analogue output | [3] Relay output | [4] Relay output | |
| Value | 16,39 mA | 9,77 mA | On | On | |
| Other measurements | Value | | | | |
| Voltage Unbalances Uo | 0,49 % | | | | |
| Phase Imbalance | 0,00 % | | | | |
| Frequency | 49,998 Hz | | | | |
| ROCOF df/dt | 0,00 Hz/s | | | | |
| Internal Temperature | 18,0 °C | | | | |

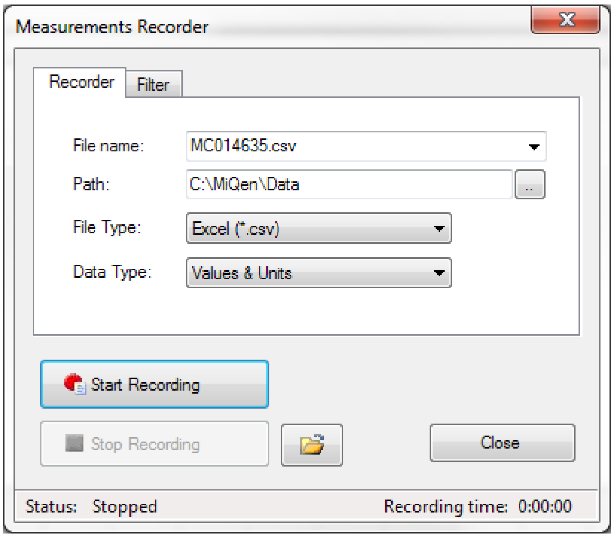
*Online measurements in Table view*




*Online measurements in graphical form – phasor diagram and daily total active power consumption histogram*

Different measuring data can be accessed by means of tabs (Measurements and Protection) in the lower part of MiQen window.

For further processing of real time measuring results, it is possible to set a recorder ( Recorder button) on active device that will record and save selected measurements to MS Excel .csv file format. Data can then be analyzed and processed in any program that supports files in CSV format.




*Window for setting local database recording parameters*

## My Devices

In My Devices user can store connections to devices that are used more often. Each device can be assigned to user defined group and equipped with user defined description and location for easier recognition. By selecting device from the list, access to device settings and downloaded and recorded files is much easier.

## Upgrade

In Upgrades section latest software, both for MiQen and ISKRA measuring devices can be found. The latest version should always be used to assure full functionality. Manual or automatic checking for upgrades is available. Internet connection is required.
List of available updates is divided in to various sections for easier navigation. Each section is named by software or family of devices (MiQen software, Measuring centers', Measuring transducers...). History file with data about corrections and added functionality is also available.

## Software upgrading

**PLEASE NOTE**

MiQen cannot be used for execution of firmware upgrades of devices. It only informs that new version is available and offers link to download it from the server. Software for execution of firmware upgrades is included in downloaded zip file together with upgrade file, upgrade procedure description and revision history.

## Setting procedure

Before configuring device with MiQen software, current settings should be read first. Reading is available either via communication or from a file (stored on a local disk). A setting structure that is similar to a file structure in an explorer is displayed in the left part of the MiQen setting window. Available settings of that segment are displayed in the right part by clicking any of the stated parameters.

**PLEASE NOTE**

Some settings may not be available due to unsupported measurements and/or functions that depend on the device type.

# General Settings

General settings are essential for measuring instruments. They are divided into three additional sublevels (Connection, Communication and Security).

## *Description and Location*

Description is intended for easier recognition of a certain unit in a network. It is especially used for identification of the device on which measurements are performed.

## *Average interval*

The averaging interval defines a refresh rate of measurements on display, communication. It is used also as averaging interval for minimum and maximum values accessible on communication and actual alarm value calculation for alarm triggering.

Average interval for measurements

The averaging interval defines a refresh rate of measurements on display and communication. It also defines response time for alarms set to Normal response (see chapter Alarms).

- Shorter average interval means better resolution in minimum and maximum value in to recorded period detection. Also data presented in display will refresh faster.
- Longer average interval means lower minimum and maximum value in recorded period detection and slower alarm response (alarm response can be delayed also with Compare time delay setting – See chapter Alarms). Also data on display will refresh slower.

Interval can be set from 8 to 256 periods. Default value is 64 periods.

**PLEASE NOTE**

This setting applies only for min. and max. values displayed on LCD and accessible on communication. These values are not used for storing into internal recorder.

## *Temperature unit*

Choose a unit for temperature display. Degrees Celsius or degrees Fahrenheit are available.

## *Starting Current for PF and PA (mA)*

All measuring inputs are influenced by noise of various frequencies. It is more or less constant and its influence to the accuracy is increased by decreasing measuring signals. It is present also when measuring signals are not present or are very low. It causes very sporadic measurements.
This setting defines the lowest current that allows regular calculation of Power Factor (PF) and Power Angle (PA). The value for starting current should be set according to conditions in a system (level of noise, random current fluctuation …)

## *Starting current for all power (mA)*

Noise is limited with a starting current also at measurements and calculations of powers. The value for starting current should be set according to conditions in a system (level of noise, random current fluctuation …)

## *Starting voltage for all powers (V)*

Noise is limited with a starting voltage also at measurements and calculations of powers. Until voltage reaches user defined starting voltage threshold, all powers are set to 0. Using three wire electrical connections, virtual phase voltage is used in calculations.

## *Starting voltage for SYNC (V)*

Device needs to synchronize its sampling with measuring signals period to accurately determine its frequency. For that purpose, input signal has to large enough to be distinguished from a noise.
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. The value for starting voltage should be set according to conditions in a system (level of noise, random voltage fluctuation …)

## *Reactive power & energy calculations*

Harmonic distortion can significantly influence reactive power and energy calculation. In absence of harmonic distortion both described methods will offer the same result. In reality harmonics are always present. Therefore it is up to project requirements, which method is applicable.
User can select between two different principles of reactive power and energy calculation:

### Standard method:

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

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

This means also that all higher harmonics (out of phase with base harmonic) will be measured as reactive power (energy).

### Displacement method:

With this method, reactive power (energy) is calculated by multiplication of voltage samples and by 90° displaced current samples.

$Q = U \times I|_{+90°}$

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

## *Measurements according to EN 61400-21*

Measurements based only on positive sequence fundamental wave, which is the one that produces torque in the rotating machines. Active power, reactive power, active current, reactive current and voltage are calculated according to requirements in EN61400-21. The negative sequence and the harmonics only cause losses.

# Connection

CAUTION

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

## *Connection mode*

When connection is selected, load connection and the supported measurements are defined.

## *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. Aux CT transformer ratios can be set separately from phase CT ratios since Aux CT could differ from phase CTs.
Range of CT and VT ratios:

| Settings range | VT primary | VT secondary | CT, Aux CT primary | CT, Aux CT secondary |
|---|---|---|---|---|
| Max value | 1638,3 kV | 13383 V | 1638,3 kA | 13383 A |
| Min value | 0,1 V | 0,1 V | 0,1 A | 0,1 A |

## *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 or to memory.

## *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.
This setting is useful to correct wrong CT connections.

# Communication

## *Communication parameters (COM1)*

Supervision Relay SR100 has one galvanically separated communication port (COM1), which can be equipped with RS232, RS485, CAN (CANopen) or left open (to be specified with order).

Different configurations are possible (to be specified with order):

| **Configuration** | **COM** |
|---|---|
| Without | Service USB |
| RS232 | RS232 + Service USB |
| RS485 | RS485 + Service USB |
| CANopen | CANopen + Service USB |

| Serial communication: | RS232 | RS485 | CANopen |
|---|---|---|---|
| Connection type | Direct | Network | Network |
| Connection terminals | Screw terminals | | |
| Function | Settings, measurements and FW upgrade | | Measurements |
| Insulation | Protection class II, 3.3 $kV_{ACRMS}$ 1 min | | |
| Max. connection length | 3 m | 2000 m (at CAN depends on baudrate) | |
| Transfer mode | Asynchronous | | Synchronous |
| Protocol | MODBUS RTU | | CAN open |
| Transfer rate | 2.4 kBaud to 115.2 kBaud | | 20 to 1000 kBaud |
| Number of nodes | / | ≤ 32 | ≤ 127 |

## *CANopen*

CANopen is a high-level communication protocol and device profile specification that is based on the CAN (Controller Area Network) protocol. The protocol was developed for embedded networking applications, such as in-vehicle networks. The CANopen umbrella covers a network programming framework, device descriptions, interface definitions and application profiles. CANopen provides a protocol which standardizes communication between devices and applications from different manufacturers. It has been used in a wide range of industries, with highlights in automation and motion applications. *ISKRA* Supervision Relay SR100 implements all standards CANopen features according to the CiA 401 specification. The bottom NMT telegrams are supported:

| Specification of ISKRA CANopen message syntax - COB-Ids (SR100) | | | | |
|---|---|---|---|---|
| Broadcast objects of the CANopen Predefined Master/Slave Connection Set | | | | |
| **Object** | **Function code (ID-bits 10-7)** | **COB-ID** | **Communication parameters at OD index** | **Comments** |
| NMT Module Control | 0000 | 000h | Start/stop node, Enter Pre-operational, Reset node, Reset communication | |
| SYNC | 0001 | 080h | 1005h, 1006h, 1007h | |

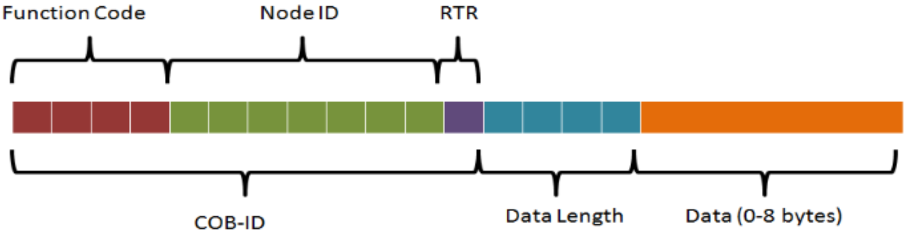
| Peer-to-Peer objects of the CANopen Predefined Master/Slave Connection Set | | | | |
|---|---|---|---|---|
| **Object** | **Function code (ID-bits 10-7)** | **COB-ID *** | **Communication parameters at OD index** | |
| EMERGENCY | 0001 | 081h - 0FFh | 1024h, 1015h | EMCY at generic error |
| PDO 1 (transmit) - TPDO1 | 0011 | 181h - 1FFh | 1800h | Data structure Multiplexed |
| PDO 3 (transmit) - TPDO3 | 0111 | 381h - 3FFh | 1802h | Data structure Multiplexed |
| SDO (transmit/server) | 1011 | 581h - 5FFh | 1200h | Access of settings and data |
| SDO (receive/client) | 1100 | 601h - 67Fh | 1200h | Access of settings and data |
| NMT Heartbeat | 1110 | 700h | (bott-up, stopped, operational, pre-operational) | Sent from SR100 as Producer to Master (Consumer) |

***Object Dictionary***

One of the central themes of CANopen is the object dictionary (OD), which is essentially a table that stores configuration and process data. It is a requirement for all CANopen devices to implement an object dictionary. ISKRA Supervision Relay SR100 Object Dictionary is appended in Table 1 inside the Appendix B on page 79.

***CANopen Message Format***

The message format for a CANopen frame is based on the CAN frame format. In the CAN protocol, the data is transferred in frames consisting of an 11-bit or 29-bit CAN-ID, control bits such as the remote transfer bit (RTR), start bit and 4-bit data length field, and 0 to 8 bytes of data. The COB-ID, commonly referred to in CANopen, consists of the CAN-ID and the control bits. In CANopen, the 11-bit CAN ID is split into two parts: a 4-bit function code and a 7-bit CANopen node ID. The 7-bit size limitation restricts the amount of devices on a CANopen network to 127 nodes.




CANopen Frame Format (bits shown except for data field

***Service Data Objects (SDOs)***

The CANopen protocol also specifies that each node on the network must implement a server that handles read/write requests to its object dictionary. This allows for a CANopen master to act as a client to that server. The mechanism for direct access (read/write) to the server's object dictionary is the Service Data Object (SDO). The node whose object dictionary is accessed is referred to as the SDO server, and the node grabbing the data is referred to as the SDO client. The transfer is always started by the SDO client.

***Process Data Objects (PDOs)***

Process data represents data that can be changing in time, such as the inputs (i.e. sensors) and outputs (i.e. motor drives) of the node controller. *ISKRA* Supervision Relay SR100 uses PDOs as the basic mechanism to transfer measuring data to the Master. Measuring data are also stored in the object dictionary and could be accessed over a SDO requests. There are two types of PDOs: transfer PDOs (TPDOs) and receive PDOs (RPDOs). A TPDO is the data coming from the node (produced) and a RPDO is the data coming to the node (consumed). In addition, there are two types of parameters for a PDO: the configuration parameters and the mapping parameters. The section of the object dictionary reserved for PDO configuration parameters starts at address 1800h and the section reserved for mapping parameters starts at address 1A00h. *ISKRA* Supervision Relay SR100 uses TPDO1 and TPDO3 telegrams which are configured for Synchronous/Cyclic transmission according to received SYNC NMT messages from the Master/Producer. To increase the data efficiency *ISKRA* Supervision Relay SR100 uses multiplexed structure of the data being transmitted inside the TPDO 8-byte data field. The Multiplex data structure is clarified in pictures bellow.

| BYTE 0 | BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 | BYTE 5 | BYTE 6 | BYTE 7 |
|---|---|---|---|---|---|---|---|
| MUX Index | Data byte | Data byte | Data byte | Data byte | Data byte | Data byte | Not used |

Data being transferred inside the TPDO1 are of type 16-bit INTEGER, thus every TPDO1 it's caring 3 measured values/data. The first byte (BYTE 0) inside the data structure of the multiplexed TPDO1/3 is always sequential index of the telegram being transferred, thus the last byte (BYTE 7) could not be used in the data caring process and must be ignored at the Master side. Data which are transferred inside the TPDO3 are of 32-bit FLOAT type and also 16-bit INTEGER type and similar as in TPDO1 utilizes BYTES 1-6, where BYTE 7 must be ignored. TPDO1 messages are sent by default by every SYNC message being received from the Master and the TPDO3 messages are sent by every 10-th SYNC message by default. More information about the detailed TPDO1 and TPDO3 data structure could be found in the Appendix B on page 79.

***Guarding and Heartbeats***

The CANopen specification requires that nodes must use some method to check whether a node is "alive" or not. They are two methods available: node guarding and heartbeats, with the latter being the preferred method. Thus Supervision Relay SR100 prefer Heartbeat method because is more effective for the Master side. In the heartbeat protocol, Supervision Relay SR100 node periodically sends out a heartbeat message which lets the CANopen master or the Heartbeat Consumer, know that the node is still alive. If a heartbeat message does not arrive within a certain period of time, the master can take a specific action. Such an action might be to reset the node or to report an error to an operator. The heartbeat message is identified by a CAN-ID of 0x700 + the node ID. When a Supervision Relay SR100 boots up its first Heartbeat message It's Boot-up message with data byte value 0. After that each Heartbeat message contains the following mode of Supervision Relay SR100 operation:

| Byte 0 value | Meaning |
|---|---|
| 0 | Boot-up |
| 4 | Stopped |
| 5 | Operational |
| 127 | Pre-operational |

## *Serial communication*

Communication parameters (only for main communication port COM1), which are important for the operation in RS485 network or connections with PC via RS232 communication.

Factory settings for serial communication are:

| | | |
|---|---|---|
| MODBUS Address | #33 | address range is 1 to 247 |
| Comm. speed | 115200 | speed range is 2400 to 115200 |
| Parity | none | |
| data bits | 8 | |
| stop bits | 2 | |

## *Service USB Communication*

Has no setting. Device is automatically recognized in Windows environment if device driver has been correctly installed. For more detailed information how to handle device with USB communication use Help section in MiQen software.

**PLEASE NOTE**

USB communication port is provided with only BASIC insulation and can ONLY be used unconnected to aux. supply AND power inputs!
Service USB is intended only for parameterization of the meter and is not galvanic separated. Advantage is that in this case meter does not need a power supply to communicate. Communication via service port is time limited.

# Security

Settings parameters are divided into four groups regarding security level: PL0 >password level 0), PL1 >password level 1) and PL2 >password level 2).

## *Password - Level 0 >PL0)*

Password is not required.
Available settings:

- language
- contrast and
- LCD back light.

## *Password - Level 1 >PL1)*

Password for first level is required.
Available settings:

- RTC settings
- Energy meters reset
- Max. Demand reset
- Active tariff setting

## *Password - Level 2 >PL2)*

Password for second level is required. Available settings:

- All settings are available

## *Password lock time >min)*

Defines the time in minutes for the instrument to activate password protection. Enter value 0 if you want to use manual password activation.

## *Password setting*

A password consists of four letters taken from the British alphabet from A to Z. A password of the first >PL1) and the second >PL2) level is entered, and time of automatic activation is set.

## *Password modification*

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

## *Password disabling*

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

**PLEASE NOTE**

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

# Energy

**WARNING**

Before modification, all energy counters should be read with MiQen software to assure data consistency for the past.

After modification of energy parameters, the energy meters (counters) should be reset. All recorded measurements from this point back might have wrong values so they should not be transferred to any system for data acquisition and analysis. Data stored before modification should be used for this purpose.

### *Active Tariff*

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 Counter Resolution*

Common energy exponent defines minimal energy that can be displayed on the energy counter. A common energy exponent also influences setting of impulses for pulse output or alarm output functioning as an energy meter.

Define common energy exponent as recommended in table below, where *Individual counter Resolution* is at default value 10. Values of primary voltage and current determine proper Common energy exponent.

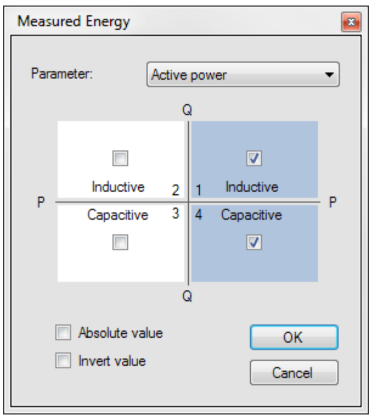
| Current / Voltage | 1 A | 5 A | 50 A | 100 A | 1000 A |
|---|---|---|---|---|---|
| 110 V | 100 mWh | 1 Wh | 10 Wh | 10 Wh | 100 Wh |
| 230 V | 1 Wh | 1 Wh | 10 Wh | 100 Wh | 1 kWh |
| 1000 V | 1 Wh | 10 Wh | 100 Wh | 1 kWh | 10 kWh |
| 30 kV | 100 Wh | 100 Wh | 1 kWh | 10 kWh | 10 kWh * |

** – Individual counter resolution should be at least 100.*

## Counters

### *Measured Energy*

For each of four (4) counters different measured quantities can be selected. User can select from a range of predefined options referring to measured total energy or energy on single phase. Or can even select its own option by selecting appropriate quantity, quadrant, absolute or inverted value.



## *Individual counter Resolution*

The individual counter resolution additionally defines precision of a certain counter, according to settings of common energy counter resolution.
With individual counter resolution is possible to customize counter resolution by multiplying *Common Energy Counter Resolution* by chosen scale factor (x1 … x10000).

Example:
*Common Energy Counter Resolution* is set to 10 Wh
*Individual Counter Resolution* is set to 100

Total resolution for counter is 10 Wh x 100 = 1 kWh

## *Tariff Selector*

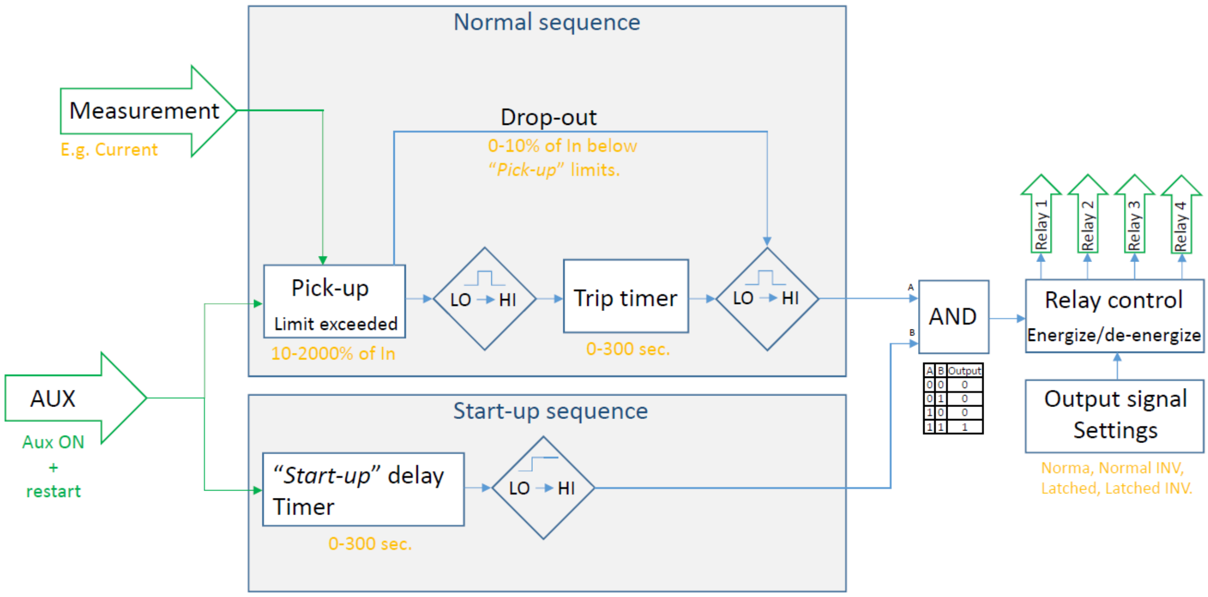
Defines tariffs where counter is active.

# Inputs and outputs

Supervision Relay SR100 can be equipped with four relay output I/O modules. For relay output technical specifications see chapter *Technical data – I/O modules* on page 67.

## Start-up delay for outputs (s)

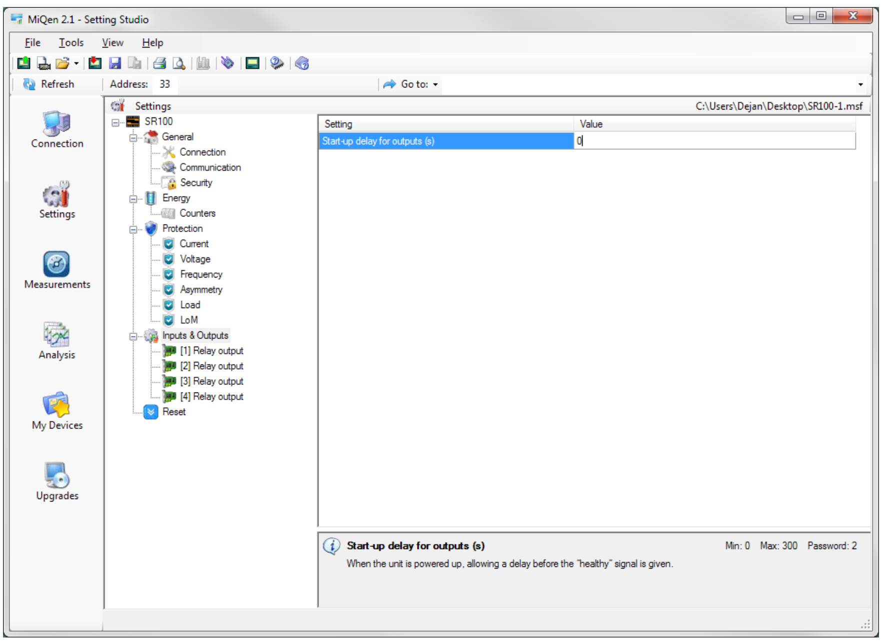
When Supervision Relay SR100 is powered on, relay output modules stay in OFF state until expiration of start-up delay time. After expiration of start-up delay time, modules are set according to present network conditions. Compare time delay starts after expiration of start-up delay time. Please see diagram below for detailed explanation:




⇨ – Input / Output simulations

Yellow – Setting range examples

◇ – "answer"




*MiQen setting – Supervision Relay SR100 > Inputs & Outputs > Start-up delay for outputs*

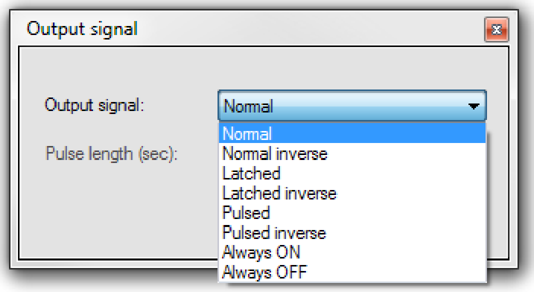
## Enabled protection groups

Selection of logical groups for physical output control.

## Output signal

8 different configurable relay output signal forms:

- normal,
- normal inverse,
- latched,
- latched inversed,
- pulsed (define pulse length in seconds),
- pulsed inversed (define pulse length in seconds),
- always on,
- always off




### *Options for I/O module 1/2/3/4*

***Outputs:***

- Relay output
- Without

### *Relay output module*

Relay output module has an alarm notification function. In case of any alarm occurrence, alarm output will trigger passive electromechanical relay or passive solid-state relay.

For each alarm output type of output signal (normal, normal inverse, latched, latched inverse, pulsed, pulsed inverse, Always ON, always OFF) when alarm is detected should be defined.

# Protection Functions

Supervision Relay SR100 supports 13 different protection functions in 6 different logical categories:

- Current (Overcurrent protection function (Over Current 1 & 2) ANSI# 50 (>I, >>I) / Overcurrent protection function (Over Current IE 1 & 2) ANSI# 50 N/G (>IE) / Overcurrent protection function (Over Current Idiff 1 & 2) ANSI# 87 (>I'))
- Voltage (Overvoltage protection functions (Over Voltage 1 & 2) ANSI# 59 (>U, >>U)/ Undervoltage protection functions (Under Voltage 1 & 2) ANSI# 27 (<U, <<U))
- Frequency (Overfrequency protection functions (Over Frequency 1 & 2) ANSI# 81O (>f, >>f) /Underfrequency protection functions (Under Frequency 1 & 2) ANSI# 81U (<f, <<f))
- Asymmetry (Asymmetry protection functions: Voltage Unbalances ANSI# 47 (>UUn) and Asymmetry protection functions: Phase Imbalance 1&2 ANSI# 46 ($>I_{im}$, $>>I_{im}$))
- Load (Load protection functions: Directional power 1&2 ANSI# 32 (>P, >>P), Load protection functions: Power underrun 1&2 ANSI# 32R/U (<P, <<P))
- LoM (LoM (Loss of Mains) protection functions: Phase Shift ANSI# 78 (> dPhi/dt), LoM (Loss of Mains) protection functions: ROCOF protection ANSI# 81R (> df/dt))

The general parameters represented in the following table can be defined in the Setting and acquisition Software MiQen to define the overall functioning of the protection functions which Supervision Relay SR100 provides:

| ***Settings*** | ***Definition*** |
|---|---|
| Connection mode | Defines the connection mode for the voltage monitoring. |
| Nominal Voltage (V) | Defines the nominal voltage for all voltage related protection functions. |
| Nominal Frequency | Defines the nominal frequency for all frequency related protection functions. |
| Rated Current (A) | Defines the rated current for all current related protection functions. |
| Rated Active Power (W) | Defines the rated active power for all power related protection functions. |
| Phase rotation | Defines the phase rotation direction for correct phase imbalance monitoring. Clockwise (L1-L2-L3); Anticlockwise (L1-L3-L2). |
| Phase Shift monitoring mode | Defines the phase shift monitoring mode. '1- in 3 phase' – tripping occurs if the phase shift exceeds the threshold value (1 phase) in at least one phase or exceeds the threshold value (3 phase) in all three phases: '3 phase' – tripping occurs if the phase shift exceeds the threshold value (3phase) in all three phases. |
| Monitoring** | Defines if monitoring parameter protection function is enabled or not. |
| Parameter limit (%)* | Defines the threshold value for tripping. If the threshold value is reached or fallen below for the period of at least compare delay time, the alarm will be activated. |
| Compare time delay (s)* (In this document will be marked as: $t_{cd}$) | Defines the compare time delay for tripping. If the threshold value is reached or fallen below for the period of at least compare delay time, the alarm will be activated. |
| Hysteresis (%)* | Defines the hysteresis for tripping. The hysteresis is calculated from nominal value and is used when output switch off. |
| Assigned group** | Defines the logical group assigned with the protection function. Use enabled protection groups setting (Relay output) to assign logical groups to physical outputs. |
| Parameter limit – 1 phase ( )*** | Defines the threshold value for tripping. If the threshold value is reached of fallen below for the period of at least compare delay time, the alarm will be activated. |
| Parameter limit – 3 phase ( )*** | Defines the threshold value for tripping. If the threshold value is reached of fallen below for the period of at least compare delay time, the alarm will be activated. |

** Under every particular protection category except Phase Shift*

*** Under every particular protection category*

**** Under category Phase Shift*

See MiQen Settings overview for Supervision Relay SR100 in chapter Protection Functions in MiQEN - Setting and Acquisition Software.

**PLEASE NOTE**

Supervision Relay SR100 response time:
Time from error detection to relay switching on/off is typically below 50ms.

# Overcurrent protection function (Over Current 1 & 2) ANSI# 50 (>I, >>I)

**PLEASE NOTE**

Overcurrent protection function (>I, >>I) has to be used with *Three phase, four wire connection with unbalanced load (4u)* – please refer to chapter *Electrical connection for Supervision Relay SR100* on page 12. Since other current protection functions use different electrical connection mode, it is not possible to use them simultaneously.

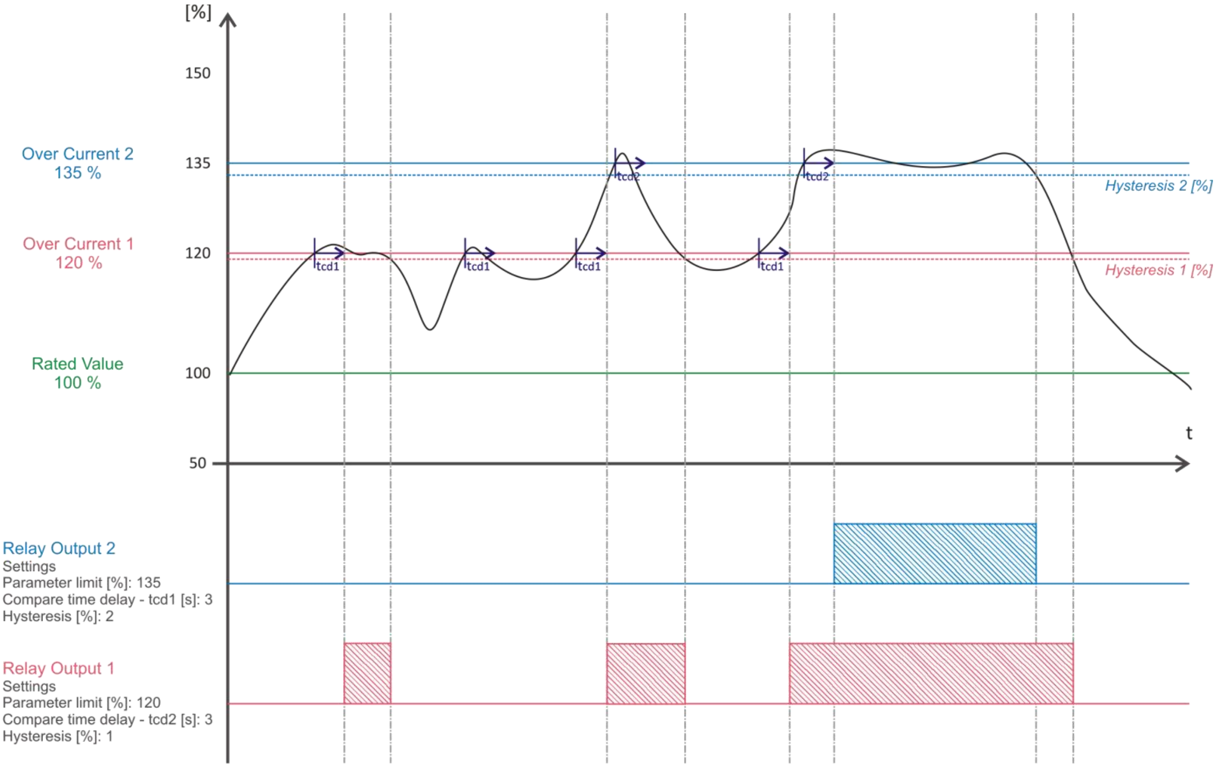
*If >I and >>I are chosen (4u electrical connection), monitoring of >IE and >I´ will not work properly.*

ANSI #50 – Overcurrent protection function detect abnormally high network current on each individual phase. If current exceeds predefined parameter limit, protection function will trigger relay. It is possible to define up to two overcurrent (>I, >>I) relay output limits with up to 2000% of nominal current.

The parameters represented in the table below can be defined within the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Current > Over Current 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Over Current 1** | Monitoring | Yes/No | No |
| | Parameter limit (%) | 10.0 – 2000.0 | 108 |
| | Compare time delay (s) | 0.00 – 60.00 | 0 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection Group 1, Protection Group 2, Protection Group 3, Protection Group 4 | Protection Group 1 |
| **Over Current 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 10.00 – 2000.00 | 112 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.3 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Over Current (>I, >>I)*

# Overcurrent protection function (Over Current IE 1 & 2) ANSI# 50 N/G (>IE)

**PLEASE NOTE**

Overcurrent protection function (>IE) has to be used with *IE electrical connection* – please refer to chapter *Electrical connection for Supervision Relay SR100* on page 12. Since other current protection functions use different electrical connection mode it is not possible to use them simultaneously.

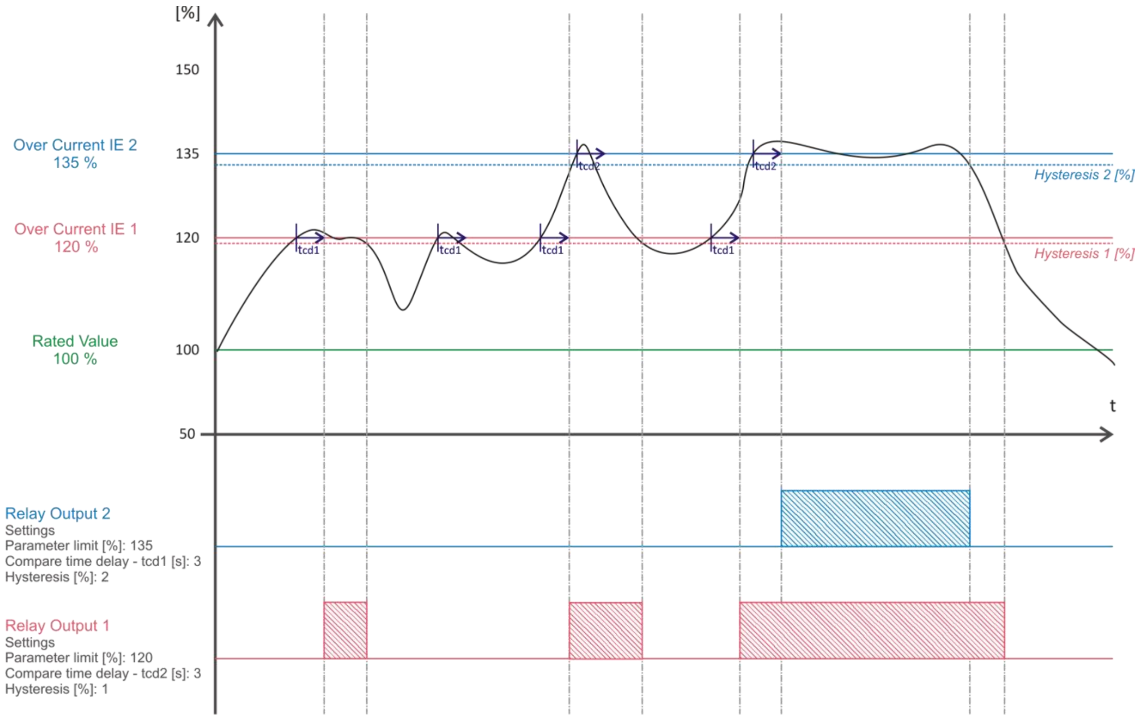
*If >IE is chosen (IE electrical connection), monitoring of >I, >>I and >I´ will not work properly.*

ANSI #50 N/G – Earth fault protection function (>IE) detects earth faults. >IE measurement is performed in a way that external currents are summed. In normal operation summation equals 0. Earth fault on one or more phases will result in abnormally high network current which will trigger Earth fault function. It is possible to define up to two overcurrent (>IE) relay output limits with up to 550% of nominal current.

The parameters represented in the table below can be defined within the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Current > Over Current IE 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Over Current 1** | Monitoring | Yes/No | No |
| | Parameter limit (%) | 0.40 – 550.00 | 108 |
| | Compare time delay (s) | 0.00 – 60.00 | 0 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection Group 1, Protection Group 2, Protection Group 3, Protection Group 4 | Protection Group 1 |
| **Over Current 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 0.40 – 550.00 | 112 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.3 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Over Current (>IE)*

# Overcurrent protection function (Over Current Idiff 1 & 2) ANSI# 87 (>I')

**PLEASE NOTE**

Overcurrent protection function (>I') has to be used with *Idiff electrical connection* – please refer to chapter *Electrical connection for Supervision Relay SR100* on page 12. Since other current protection functions use different electrical connection mode it is not possible to use them simultaneously.

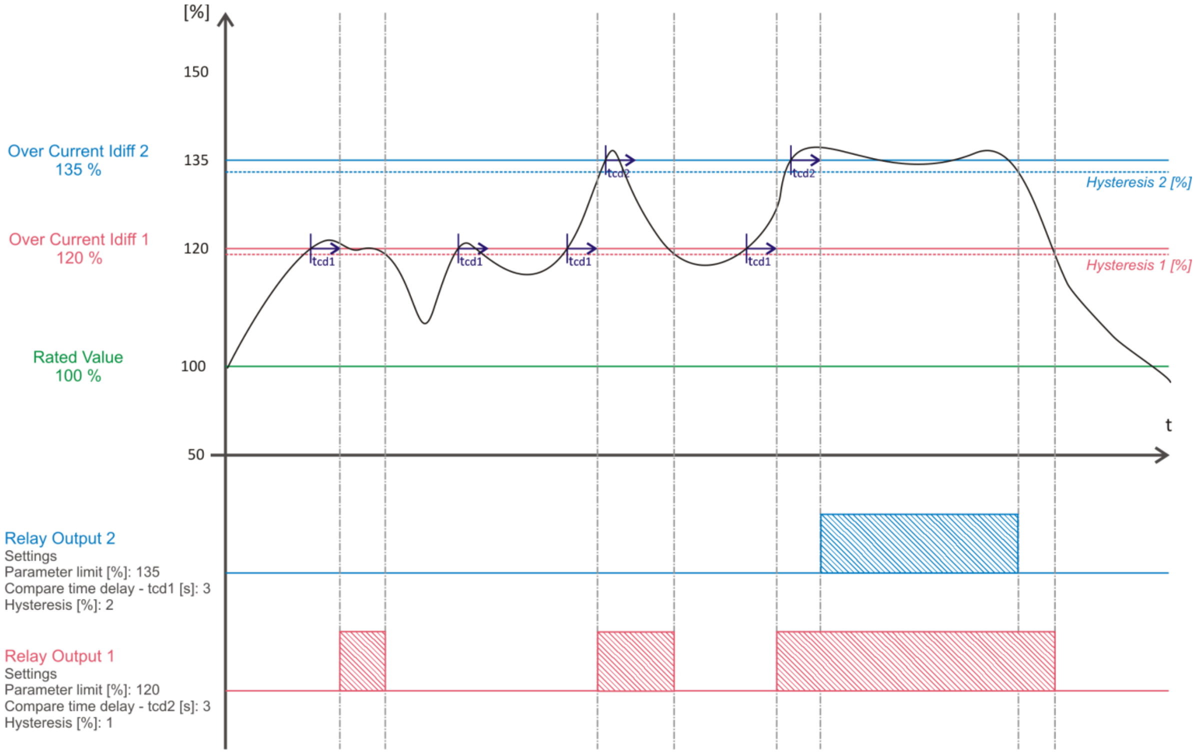
*If >I´ is chosen (Idiff electrical connection), monitoring of >I, >>I and >IE will not work properly.*

ANSI #87 – Over current Idiff protection function compares the differential current of each of the 3 phases, providing an RMS measurement at sinusoidal currents. When measurement exceeds predefined parameter limit, Idiff protection function triggers relay. It is possible to define up to two overcurrent (>I') relay output limits with up to 200% of nominal current.

The parameters represented in the table below can be defined within the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Current > Over Current Idiff 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Over Current 1** | Monitoring | Yes/No | No |
| | Parameter limit (%) | 0.80 – 200.00 | 108 |
| | Compare time delay (s) | 0.00 – 60.00 | 0 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection Group 1, Protection Group 2, Protection Group 3, Protection Group 4 | Protection Group 1 |
| **Over Current 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 0.80 – 200.00 | 112 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.3 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Over Current (>I')*

# Overvoltage protection functions (Over Voltage 1 & 2) ANSI# 59 (>U, >>U)

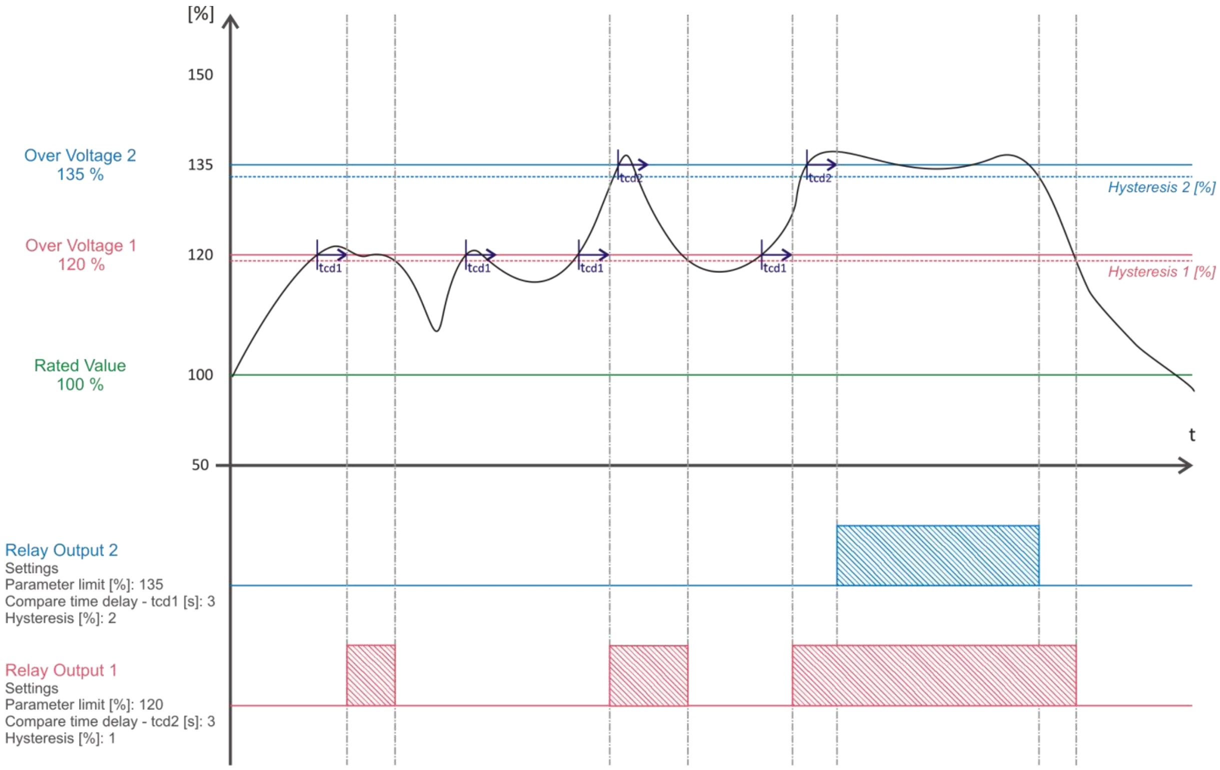
ANSI #59 – Overvoltage protection function detect abnormally high network voltage or checking for sufficient voltage to enable source transfer. This function works with phase-to-phase or phase-to-neutral voltage, each voltage being monitored separately. It is possible to define up to two overvoltage relay output limits with up to 150% of nominal voltage.

The parameters represented in the table below can be defined within the Setting and acquisition Software MiQen(see MiQen: SR100 > Protection > Voltage > Over Voltage ½ protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Over Voltage 1** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 100.00 - 150.00 | 108 |
| | Compare time delay (s) | 0.00 – 60.00 | 5 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |
| **Over Voltage 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 100.00 - 150.00 | 112 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.3 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

*Monitoring – Over Voltage*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Over Voltage*

# Undervoltage protection functions (Under Voltage 1 & 2) ANSI# 27 (<U, <<U)

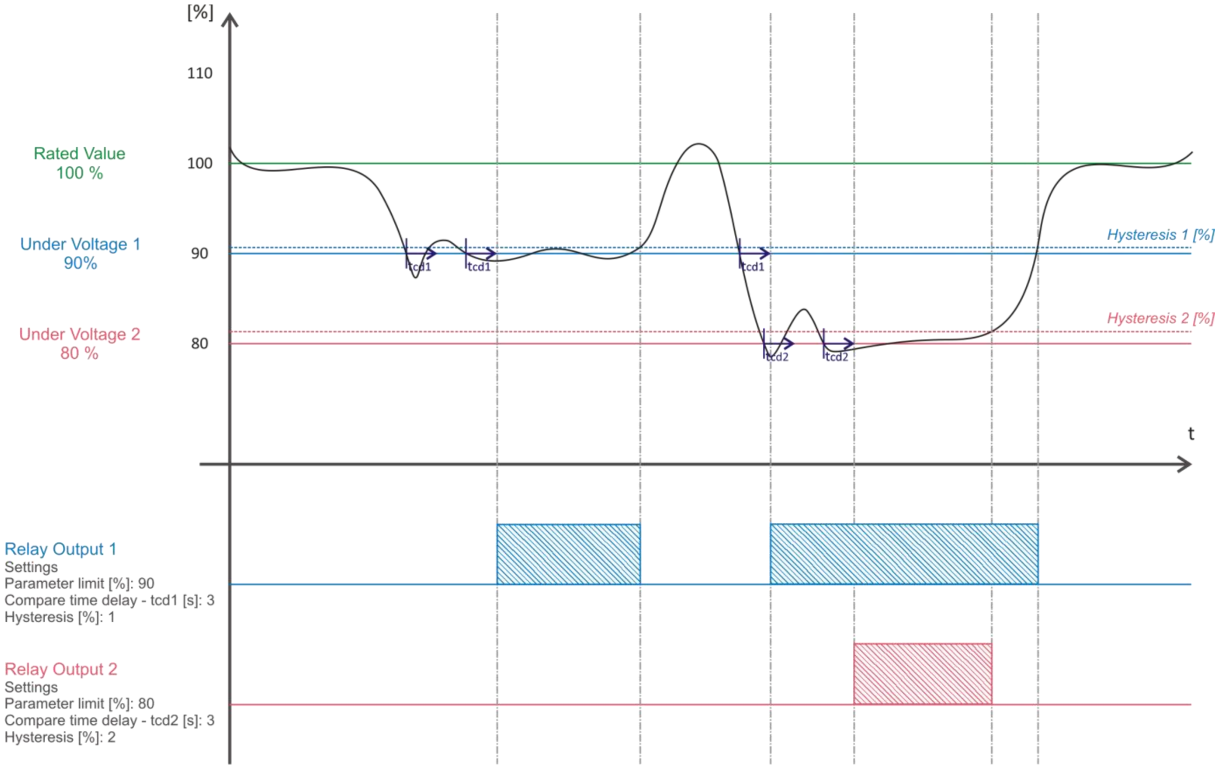
ANSI #27 - Undervoltage is used for protection of motors against voltage sags or detection of abnormally low network voltage to trigger automatic load shedding or source transfer. Works with phase-to-phase or phase-to-neutral voltage, each voltage being monitored separately. It is possible to define up to two undervoltage relay output limits with down to 50% of nominal voltage.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Voltage > Under voltage 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Under Voltage 1** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 50.00 – 100.00 | 92 |
| | Compare time delay (s) | 0.00 – 60.00 | 5 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |
| **Under Voltage 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 50.00 - 100.00 | 88 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.3 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

*Monitoring – Under Voltage*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Under Voltage*

# Overfrequency protection functions (Over Frequency 1 & 2) ANSI# 81O (>f, >>f)

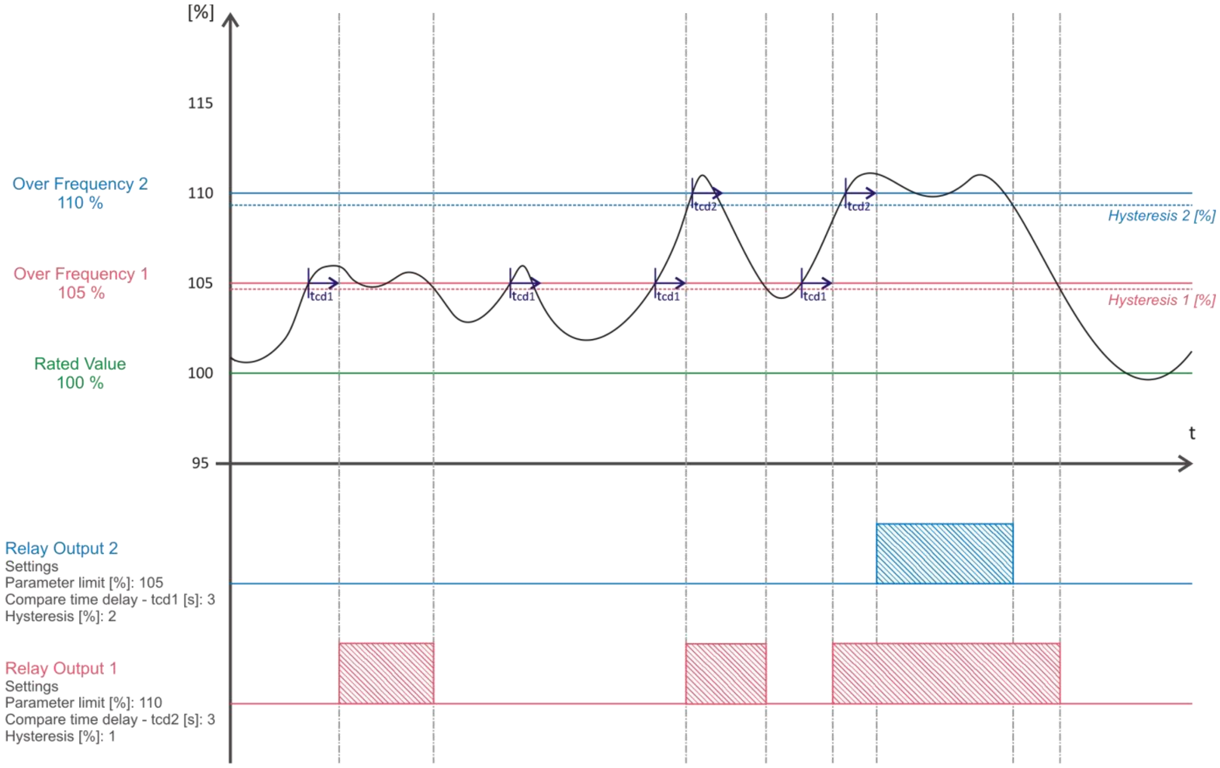
ANSI #81O – Overfrequency represents detection of abnormally high frequency compared to the rated frequency, to monitor power supply quality. Monitoring of the frequency is accomplished in two steps. It is possible to define up to two overfrequency relay output limits with up to 150% of nominal frequency.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Frequency > Over Frequency 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Over Frequency 1** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 100.00 – 150.00 | 110 |
| | Compare time delay (s) | 0.00 – 60.00 | 1.5 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |
| **Over frequency 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 100.00 - 150.00 | 115 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.3 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

*Monitoring – Over Frequency*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Over Frequency*

# Underfrequency protection functions (Under Frequency 1 & 2) ANSI# 81U (<f, <<f)

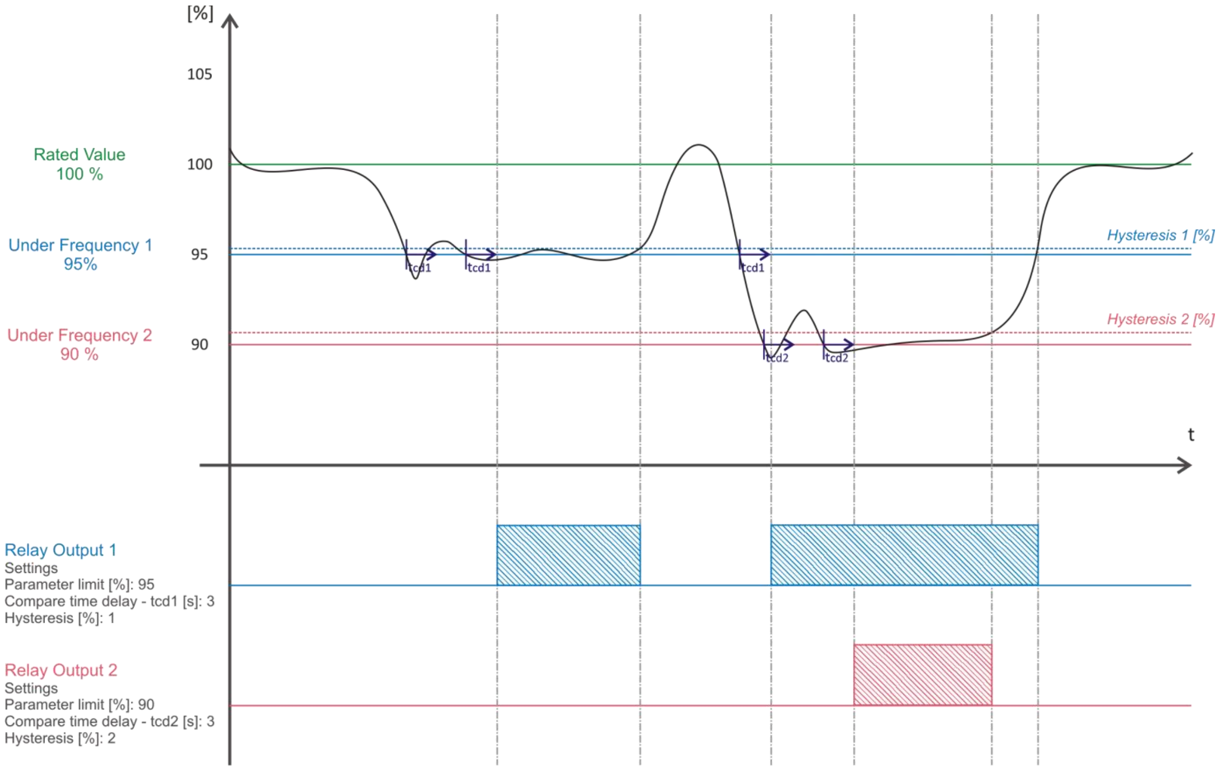
ANSI #81U – Underfrequency is detection of abnormally low frequency compared to the rated frequency, to monitor power supply quality. The protection may be used for overall tripping or load shedding. Protection stability is ensured in the event of the loss of the main source and presence of remnant voltage by a restraint in the event of a continuous decrease of the frequency, which is activated by parameter setting. Monitoring of the frequency is performed in two steps. It is possible to define up to two underfrequency relay output limits with down to 50% of nominal frequency.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Frequency > Under Frequency 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Under Frequency 1** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 50.00 – 100.00 | 90 |
| | Compare time delay (s) | 0.00 – 60.00 | 5 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |
| **Under frequency 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 50.00 – 100.00 | 84 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.3 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

*Monitoring – Under Frequency*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Under Frequency*

# Asymmetry protection functions: Voltage Unbalances ANSI# 47 (>$U_{Un}$)

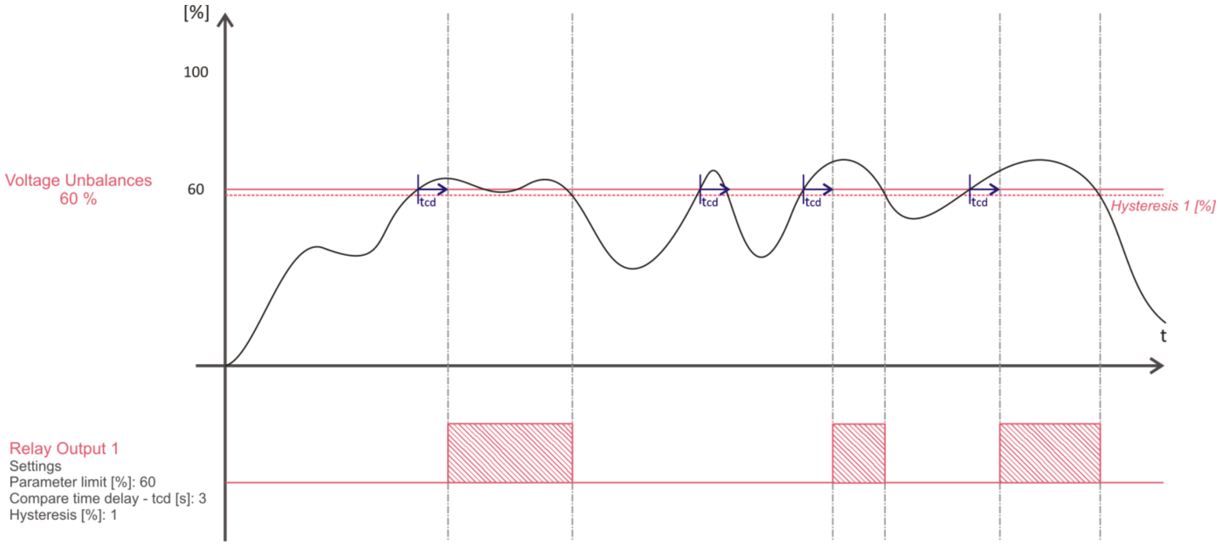
Voltage unbalance is regarded as a power quality problem of significant concern at the electricity distribution level. Although the voltages are quite well balanced at the generator and transmission levels the voltages at the utilization level can become unbalanced due to the unequal system impedances and the unequal distribution of single-phase loads. An excessive level of voltage unbalance can have serious impacts on mains connected induction motors. The level of current unbalance that is present is several times the level of voltage unbalance.
With this protection function Voltage Unbalance is supervised over phase resulting from phase inversion, unbalanced supply or distant fault, detected by the measurement of negative sequence voltage component of a three phase system. This parameter has a range of 0 to 100% of the rated nominal voltage.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Asymmetry > Voltage unbalances protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Voltage Unbalances** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 0.00 – 100.00 | 100 |
| | Compare time delay (s) | 0.00 – 60.00 | 5 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |

*Monitoring – Voltage Unbalances*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Voltage Unbalances*

# Asymmetry protection functions: Phase Imbalance 1&2 ANSI# 46 ($>I_{im}$, $>>I_{im}$)

ANSI #46 represents protection against phase unbalance, detected by the measurement of negative sequence currents. It can be used in the following practical examples:

- Sensitive protection to detect 2-phase faults at the ends of long lines
- Protection of equipment against temperature build-up, caused by an unbalanced power supply, phase inversion or loss of phase, and against phase current unbalance

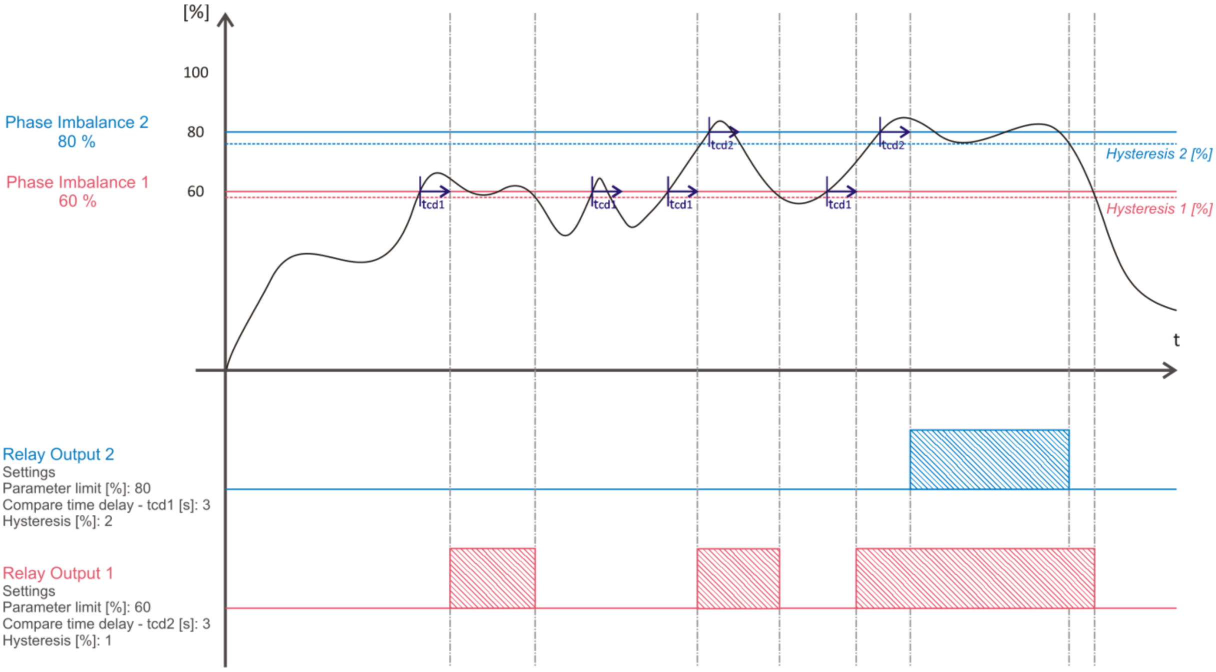
The phase imbalance protection function is used for protection over phase imbalance resulting from phase inversion, unbalanced supply or distant fault, detected by the measurement of negative sequence voltage. This threshold is defined relative to the rated current and has a range between 0 and 100%.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Asymmetry > Phase Imbalance 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Phase Imbalance 1** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 0.00 – 100.00 | 10 |
| | Compare time delay (s) | 0.00 – 60.00 | 10 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |
| **Phase Imbalance 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | 0.00 – 100.00 | 15 |
| | Compare time delay (s) | 0.00 – 60.00 | 1 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

*Monitoring – Phase Imbalance*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Phase Imbalance*

# Load protection functions: Directional power 1&2 ANSI# 32 (>P, >>P)

This protection function is a two-way protection based on calculated active power, for the following applications:

- active overpower protection to detect overloads and allow load shedding
- reverse active power protection:
    - against generators running like motors when the generators consume active power
    - against motors running like generators when the motors supply active power

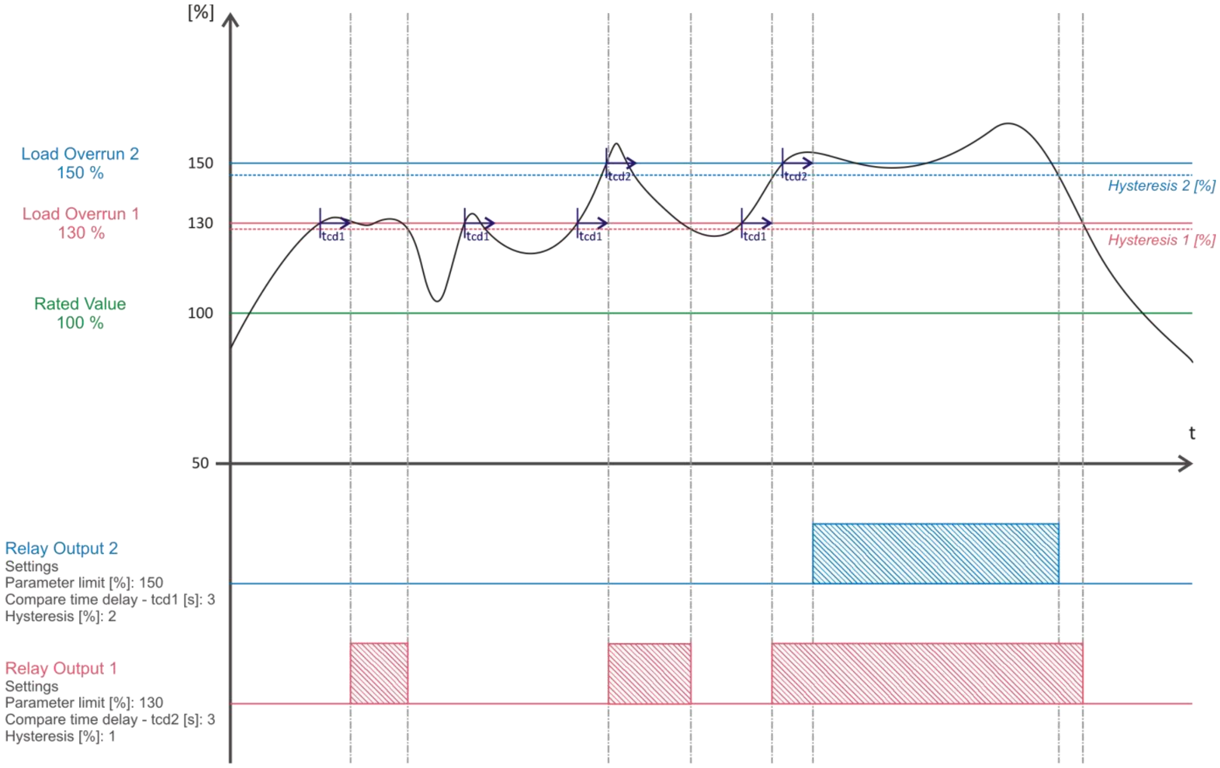
Directional power protection is based on calculated active power. Active overpower monitoring is used to detect overloads and allow load shedding. It is possible to define up to two relay output limits within the range between -300% and 300% of the rated active power.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Load > Directional power 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Directional power 1** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | -300.00 – 300.00 | 110 |
| | Compare time delay (s) | 0.00 – 60.00 | 11 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |
| **Directional power 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | -300.00 – 300.00 | 120 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.1 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 2 |

*Monitoring – Directional power*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Directional power*

# Load protection functions: Power underrun 1&2 ANSI# 32R/U (<P, <<P)

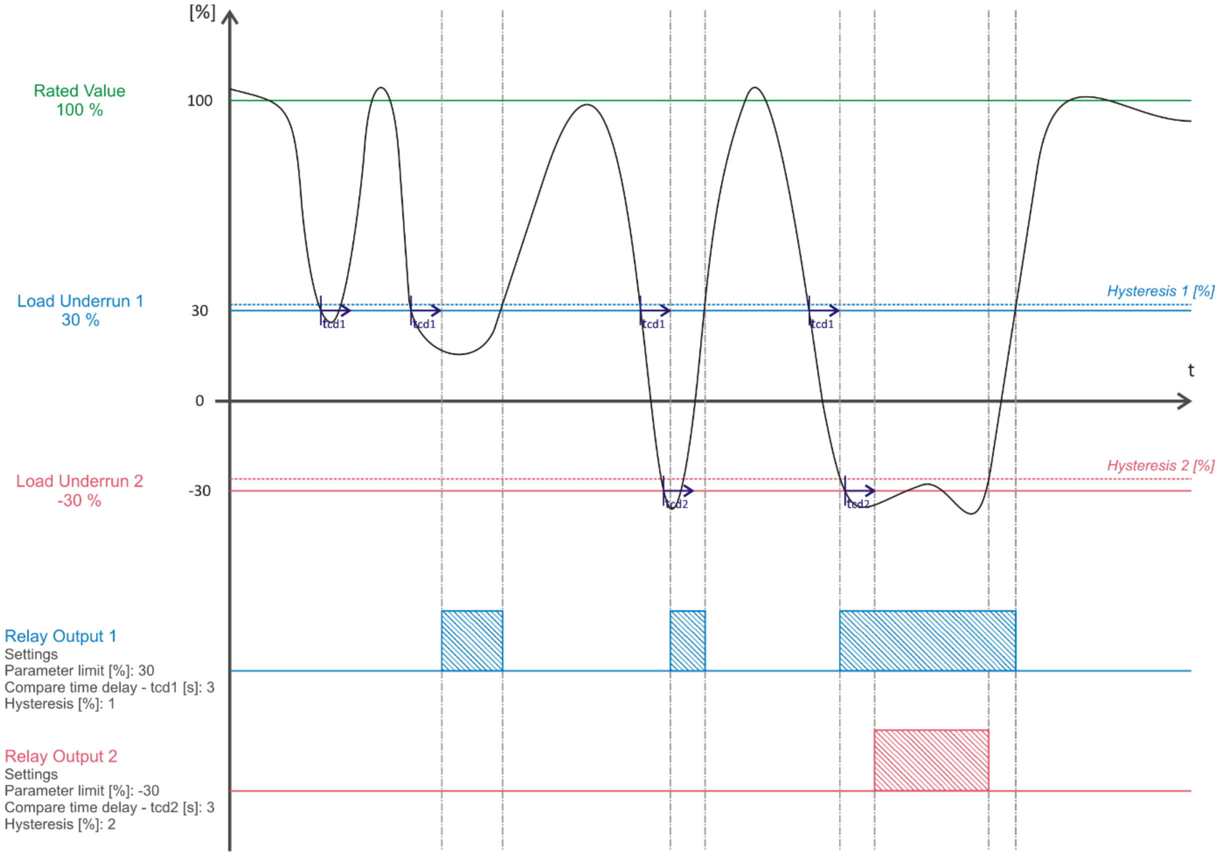
Power underrun Protection is based on calculated active power. This user defined limit defines the permissible deviation of the load from defined thresholds. The function is triggered if the measured value falls below the rated active power limit and can be set between -300% and 300%.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > Load > Power underrun 1/2 protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Power underrun 1** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | -300.00 – 300.00 | -3 |
| | Compare time delay (s) | 0.00 – 60.00 | 5 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2,<br>Protection output 3, Protection output 4 | Protection output 1 |
| **Power underrun 2** | Monitoring | Yes/No | Yes |
| | Parameter limit (%) | -300.00 – 300.00 | -5 |
| | Compare time delay (s) | 0.00 – 60.00 | 3 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Group | Protection output 1, Protection output 2,<br>Protection output 3, Protection output 4 | Protection output 2 |

*Monitoring – Power underrun*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Power underrun*

## LoM (Loss of Mains) protection functions: Phase Shift ANSI# 78(> dPhi/dt)

Loss of Mains occurs when part of the public utility network loses connection with the rest of the system. If LOM is not detected, then the generator could remain connected, causing a safety hazard within the network. Automatic reconnection of the generator to the network may occur causing damage to the generator and the network.

One of LOM detection methods is Voltage Vector Shift/Phase Shift. The Vector Shift protection algorithm is based on voltage angle measurements performed on all three phase voltages. A measurement is taken from each of the 3 phase voltages after every half-cycle and the decision is made after a full cycle. The use of the three phases makes the algorithm less exposed to harmonic distortion, interference and imbalanced faults. This improves protection stability and decreases the probability of spurious tripping during nonsymmetrical faults. This limit for phases 1 and 3 can be set in the range between 0 and 90% respectively.

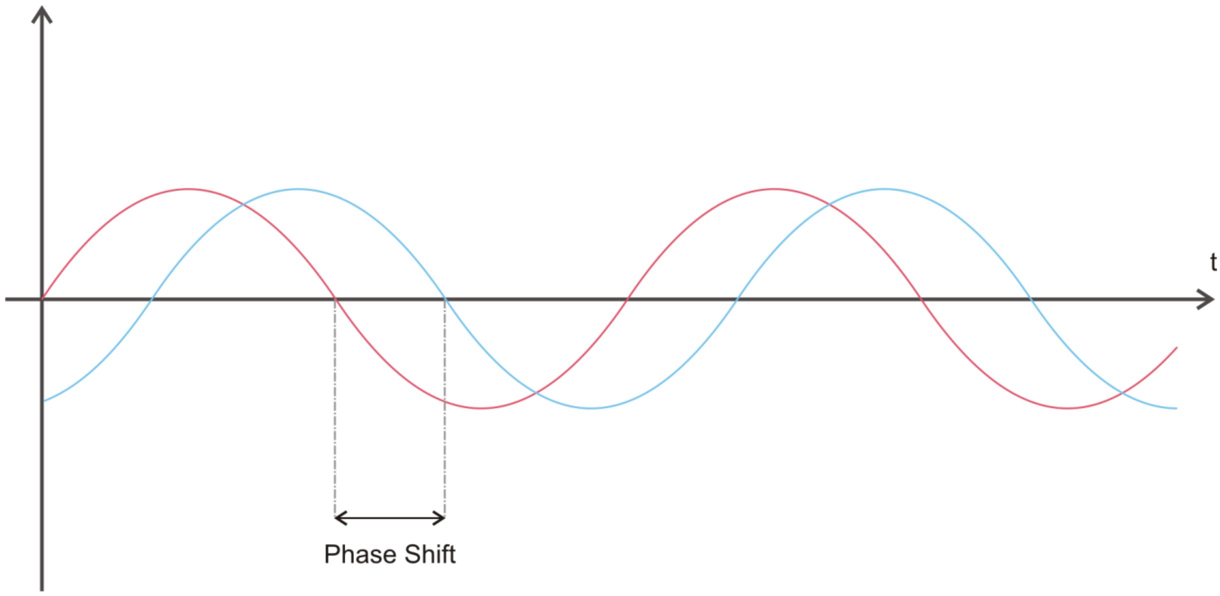
The monitoring may be carried out in three-phase or one-phase mode. The monitoring can be configured in different ways. The vector/phase shift monitor can also be used as an additional method to decouple from the grid. Vector/phase shift monitoring is only enabled after the monitored voltage exceeds 50% of the PT secondary rated voltage.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > LoM > Phase Shift protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **Phase Shift** | Monitoring | Yes/No | Yes |
| | Parameter limit – 1 phase (°) | 0.00 – 90.00 | 20 |
| | Parameter limit – 3 phase (°) | 0.00 – 90.00 | 8 |
| | Assigned Output | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |

*Monitoring – Phase Shift*

The figure below graphically represents the behavior of this particular protection function:




*Monitoring – Phase Shift*

# LoM (Loss of Mains) protection functions: ROCOF protection ANSI# 81R(> df/dt)

Loss of Mains occurs when part of the public utility network loses connection with the rest of the system. If LOM is not detected, then the generator could remain connected, causing a safety hazard within the network. Automatic reconnection of the generator to the network may occur causing damage to the generator and the network. One of LOM detection methods is ROCOF (Rate Of Change Of Frequency). The ROCOF method is based on the local measurement of the generator voltage and estimation of the rate of change of frequency. The rate of change of frequency following an LOM event is directly proportional to the amount of active power imbalance between local load and the generator output. The ROCOF value is calculated in moving 60ms windows and two consecutive calculations are required to assess if this is a permanent change. When both give a result above the set threshold the trip signal is initiated. To provide additional stability against normal load switching events and other small scale system transients, an additional time delay can be applied.
ROCOF parameter has a permissible limit range between 0 and 10 Hz/s. The frequency of a source will vary due to changing loads and other effects. The rate of these frequency changes due to the load variances is relatively high compared to those of a large network. The control unit calculates the unit of measure per unit of time. The df/dt is measured over 4 sine waves to ensure that it is differentiated from a phase shift. This results in a minimum response time of approximately 100ms.

The parameters represented in the following table can be defined in the Setting and acquisition Software MiQen (see MiQen: SR100 > Protection > LoM > ROCOF df/dt protection functions; description is identical for all limits; the limits may only differ in their setting ranges):

| Limit | Text | Setting range | Standard value |
|---|---|---|---|
| **ROCOF df/dt** | Monitoring | Yes/No | Yes |
| | Parameter limit (Hz/s) | 0.00 – 10.00 | 2.6 |
| | Compare time delay (s) | 0.00 – 60.00 | 0.1 |
| | Hysteresis (%) | 0.00 – 10.00 | 0 |
| | Assigned Output | Protection output 1, Protection output 2, Protection output 3, Protection output 4 | Protection output 1 |

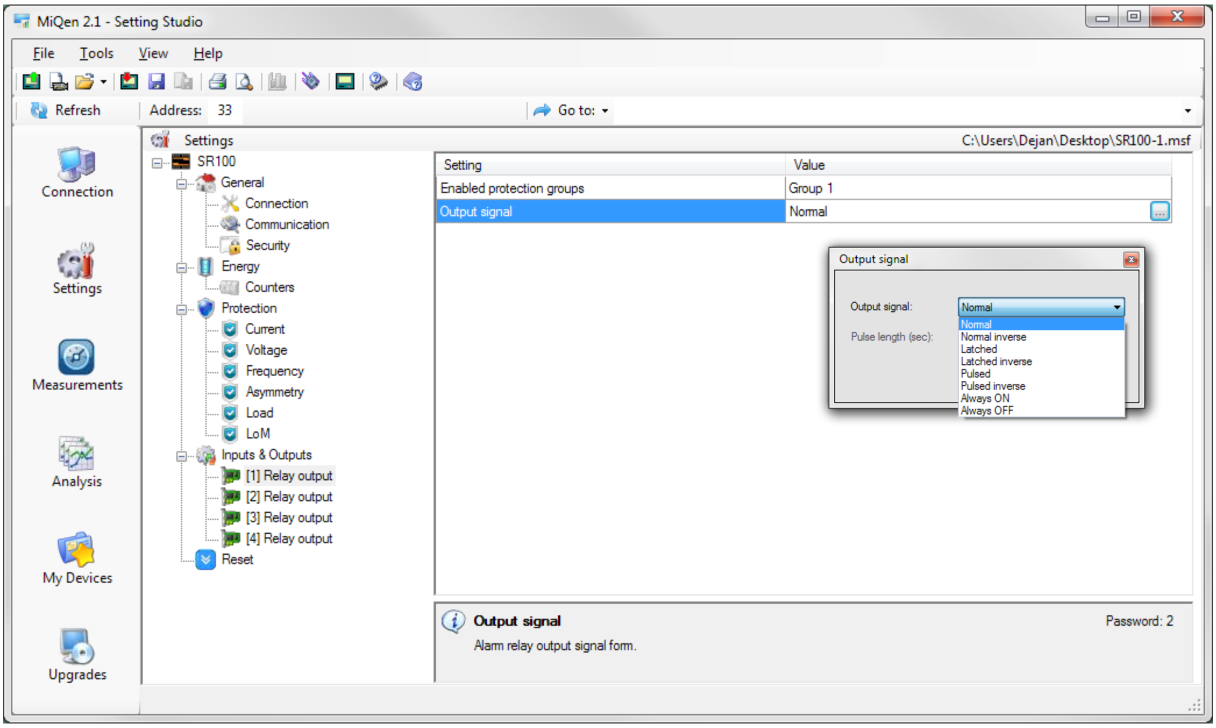
*Monitoring – ROCOF*

# Protection Functions in MiQEN - Setting and Acquisition Software

MiQEN software is intended for setting up the Supervision Relay SR100 and many other instruments through a PC. Network and the transducer setting, display of measured values are possible via the serial communication. The information and measurements can be exported in standard Windows formats. The software runs on Windows XP, Vista, Win7, Win8 and Win10 operating systems.

Main features of MiQEN Setting studio software:

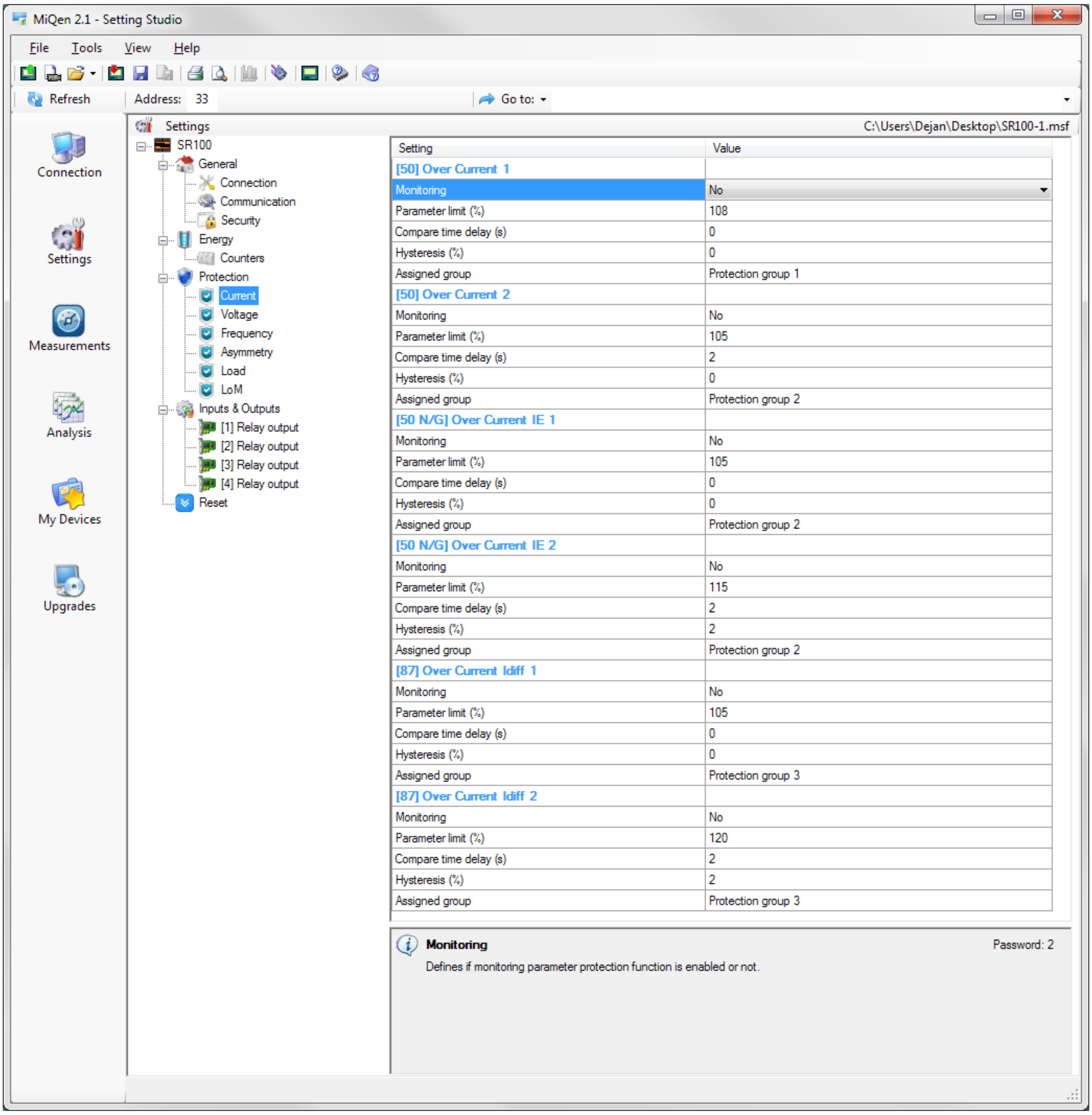
- Setting all of the instruments parameters (online and offline)
- Viewing current measured readings
- Setting and resetting energy counters
- Complete relay Output modules configuration
- Searching the network for devices
- Virtual interactive instrument
- Comprehensive help support




*MiQEN Settings overview for Supervision Relay SR100 (example shows relay output module signal options)*

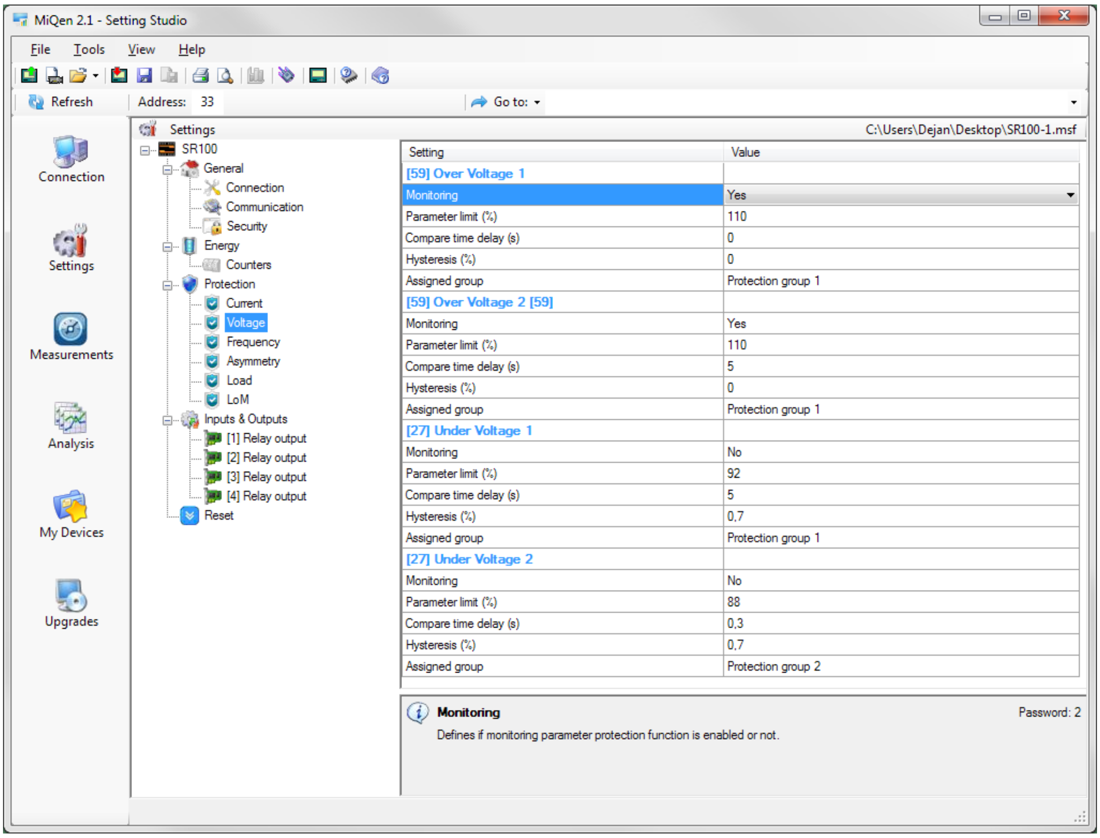
## *Protection Functions*

**Current protection functions:**



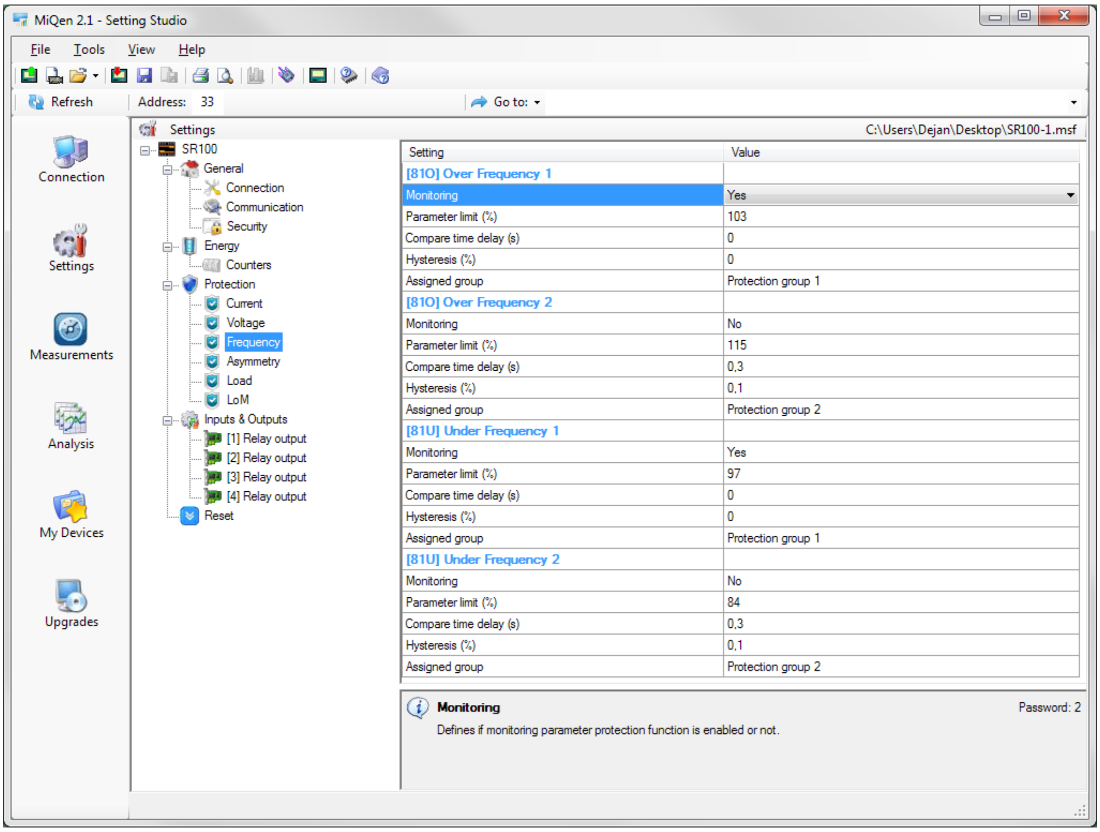

*MiQen: Setting – Current protection functions*

### Voltage protection functions:



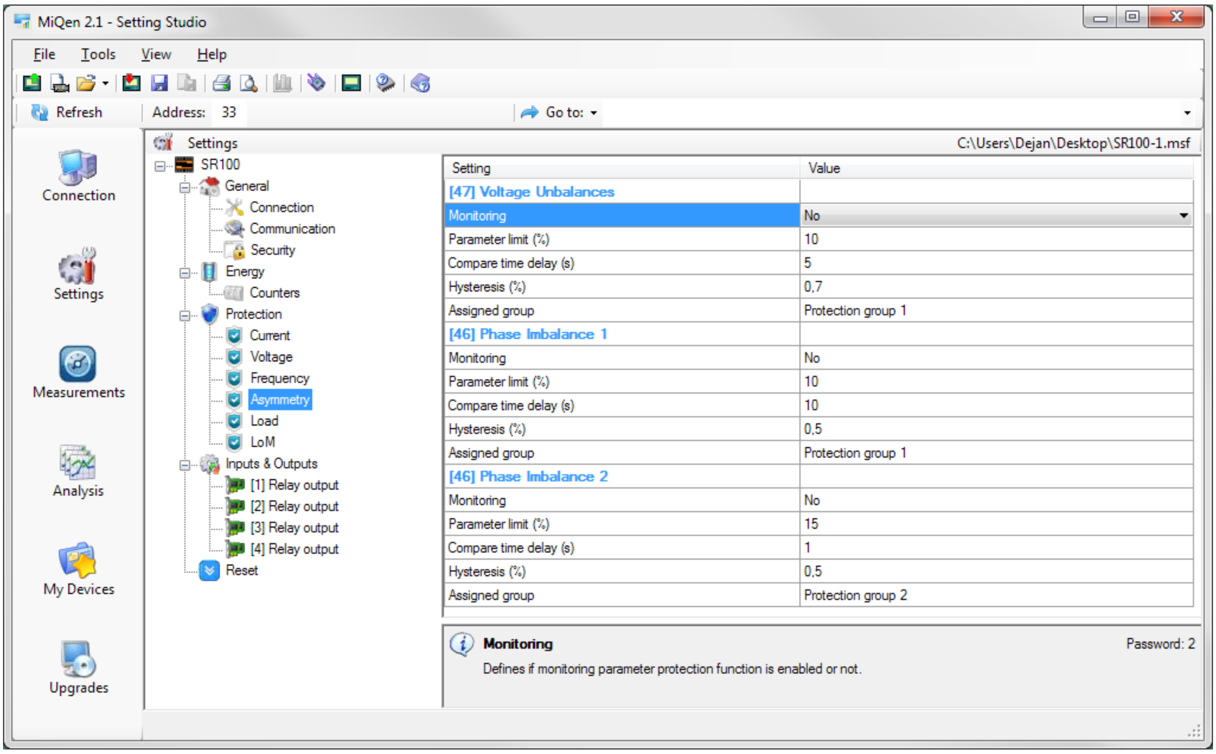

*MiQen: Setting – Voltage protection functions*

### Frequency protection functions:



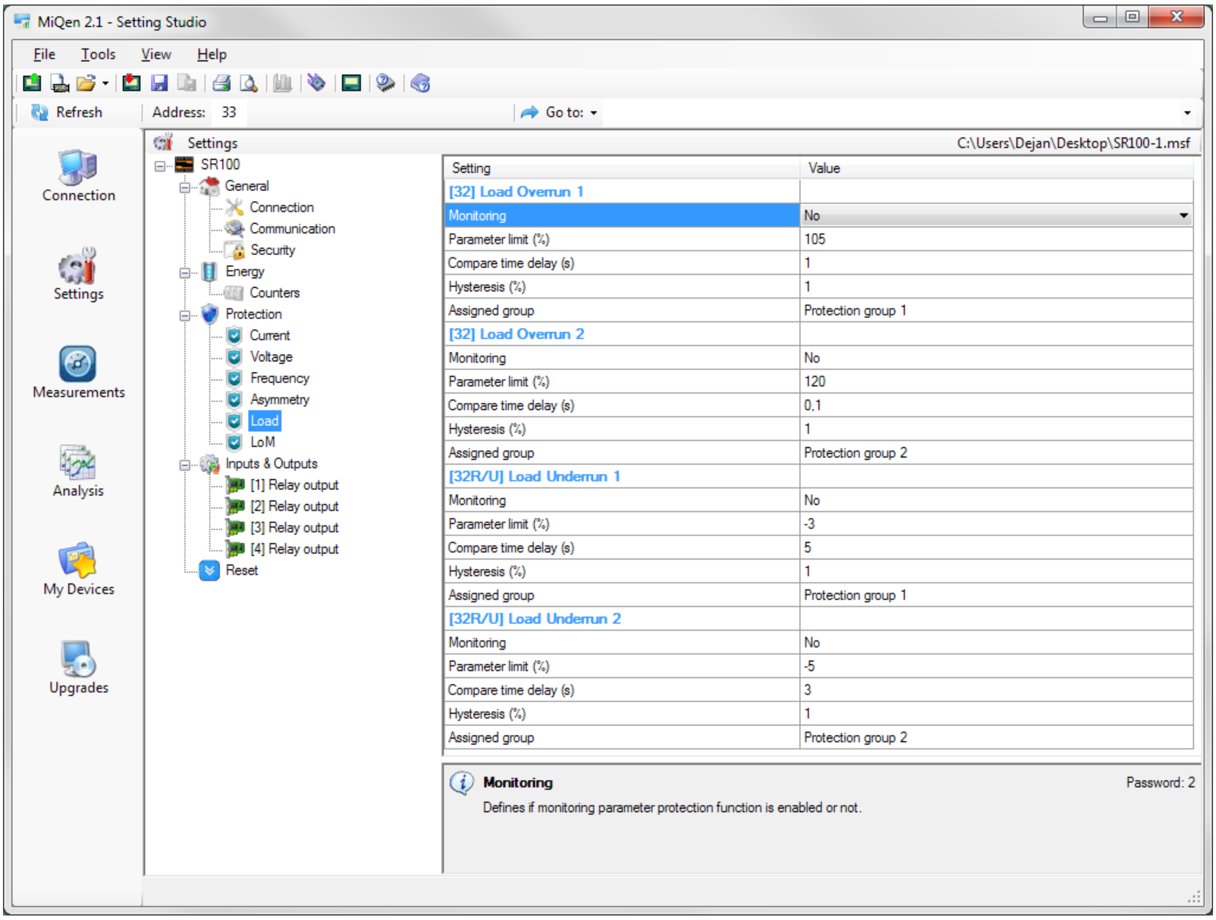

*MiQen: Setting – Frequency protection functions*

### Asymmetry protection functions:



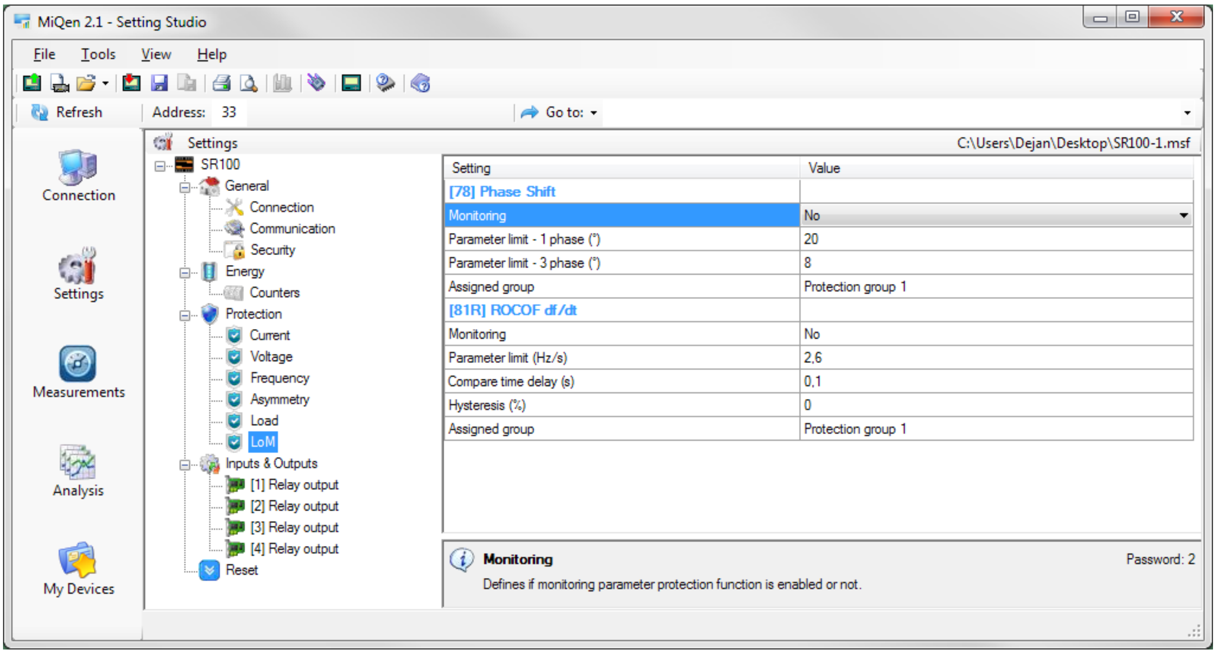

*MiQen: Setting – Asymmetry protection functions*

### Load protection functions:



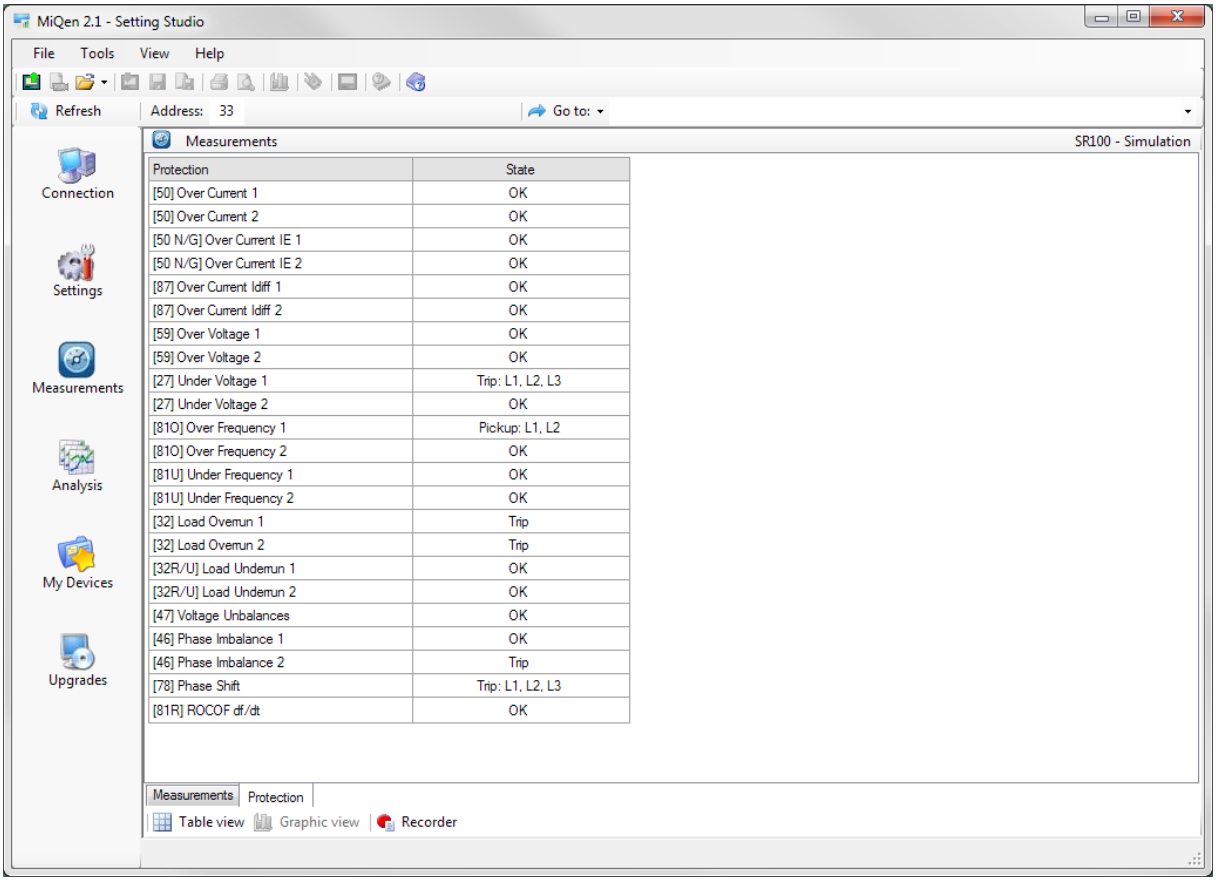

*MiQen: Setting – Load protection functions*

**LoM protection functions:**




*MiQen: Setting – LoM protection functions*

# On-line data monitoring




*On-line data monitoring in Supervision Relay SR100 with MiQEN (example shows actual protection states)*

On-line data monitoring for Supervision Relay SR100 with MiQen provides us with states of protection functions. Three different states are possible over communication (not on relay):

- Ok – normal operation without alarms
- Pickup – parameter limit has been reached
- Trip – alarm

*Pickup state example:*

- Over Voltage parameter limit is set to 110%; Time delay is set to 3s
- When voltage reaches parameter limit of 110%, Pickup state is displayed in MiQen.
- After 3s (time delay), pickup state changes to Trip (presuming that voltage stayed over 110% the entire time)

# Reset

During normal operation of a device different counter values need to be reset from time to time.

## *Reset energy counter [E1/E2/E3/E4]*

All or individual energy meters (counters) are reset.

## Reset MD values

Set maximum demand values to zero. At the same time MD synchronization is performed.

## *Reset Last period MD*

Set maximum demand last period values to zero. At the same time MD synchronization is performed.

## *Alarm relay [1/2/3/4] Off*

When using MiQen, each alarm output can be reset separately.

## *Reset alarm statistic*

Clears alarm statistic. It can be made by MiQen software under Alarm settings. This setting is only for resetting online alarms statistics displayed in MiQen software.

# MEASUREMENTS

## Online measurements

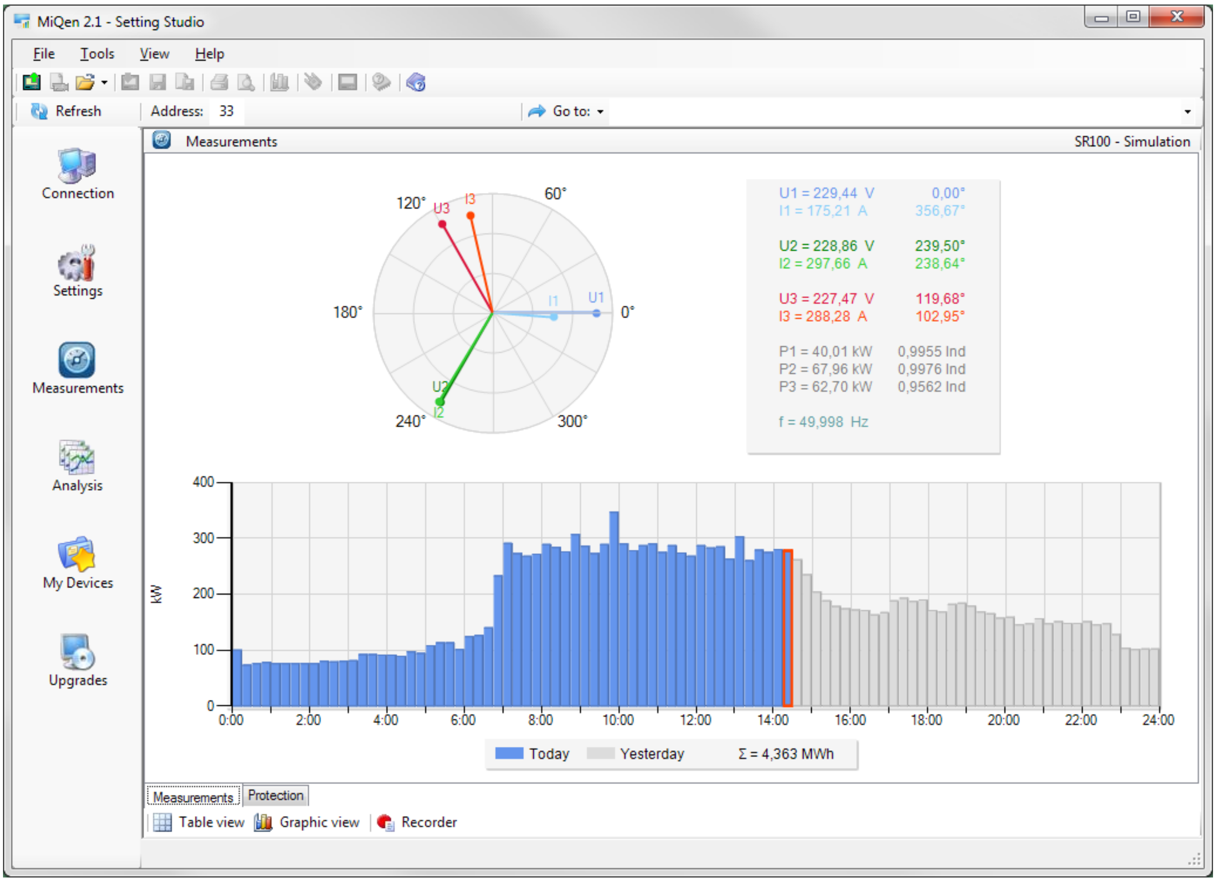
Online measurements can be monitored with setting and monitoring software MiQen.

Refresh rate of readings is fixed to approx. one second in MiQen.

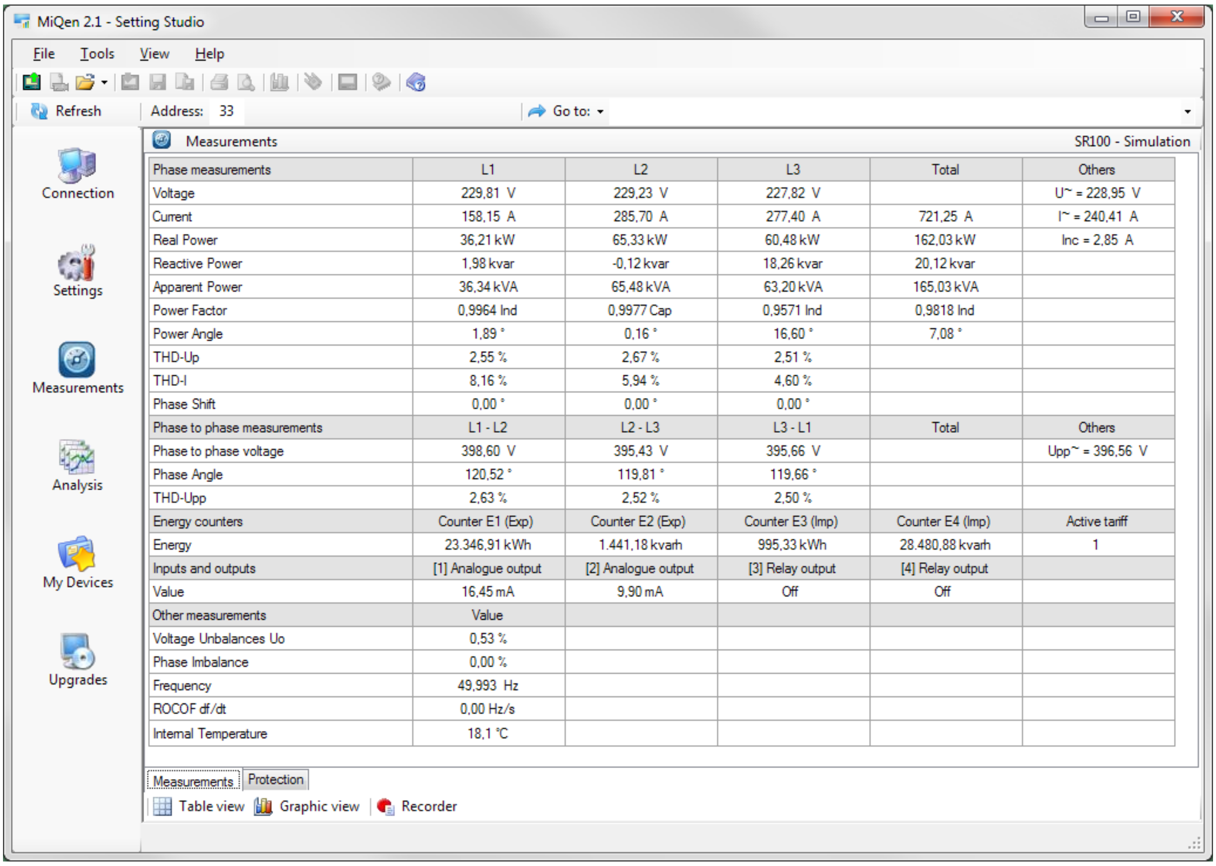
For better overview over numerous readings, they are divided into two groups:

- Measurements
- Protection

Measurements group can represent data in visually favored graphical form or detailed tabelaric form. Latter allows freezing readings and/or copying data into various report generation software tools. Protection group can only present data in tabelaric form.




*Example: Online measurements in graphical form - phasor diagram and daily total active power consumption histogram*




| Phase measurements | L1 | L2 | L3 | Total | Others |
|---|---|---|---|---|---|
| Voltage | 229,81 V | 229,23 V | 227,82 V | | U~ = 228,95 V |
| Current | 158,15 A | 285,70 A | 277,40 A | 721,25 A | I~ = 240,41 A |
| Real Power | 36,21 kW | 65,33 kW | 60,48 kW | 162,03 kW | Inc = 2,85 A |
| Reactive Power | 1,98 kvar | -0,12 kvar | 18,26 kvar | 20,12 kvar | |
| Apparent Power | 36,34 kVA | 65,48 kVA | 63,20 kVA | 165,03 kVA | |
| Power Factor | 0,9964 Ind | 0,9977 Cap | 0,9571 Ind | 0,9818 Ind | |
| Power Angle | 1,89 ° | 0,16 ° | 16,60 ° | 7,08 ° | |
| THD-Up | 2,55 % | 2,67 % | 2,51 % | | |
| THD-I | 8,16 % | 5,94 % | 4,60 % | | |
| Phase Shift | 0,00 ° | 0,00 ° | 0,00 ° | | |
| Phase to phase measurements | L1 - L2 | L2 - L3 | L3 - L1 | Total | Others |
| Phase to phase voltage | 398,60 V | 395,43 V | 395,66 V | | Upp~ = 396,56 V |
| Phase Angle | 120,52 ° | 119,81 ° | 119,66 ° | | |
| THD-Upp | 2,63 % | 2,52 % | 2,50 % | | |
| Energy counters | Counter E1 (Exp) | Counter E2 (Exp) | Counter E3 (Imp) | Counter E4 (Imp) | Active tariff |
| Energy | 23.346,91 kWh | 1.441,18 kvarh | 995,33 kWh | 28.480,88 kvarh | 1 |
| Inputs and outputs | [1] Analogue output | [2] Analogue output | [3] Relay output | [4] Relay output | |
| Value | 16,45 mA | 9,90 mA | Off | Off | |
| Other measurements | Value | | | | |
| Voltage Unbalances Uo | 0,53 % | | | | |
| Phase Imbalance | 0,00 % | | | | |
| Frequency | 49,993 Hz | | | | |
| ROCOF df/dt | 0,00 Hz/s | | | | |
| Internal Temperature | 18,1 °C | | | | |

*Example: Online measurements in tabelaric form*

# Available connections

Different electric connections are described in more detail in chapter Electrical connection.

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
- Connection IE – Tree phase, four wire connection with unbalanced load
- Connection Idiff – Tree phase, four wire connection with unbalanced load

**PLEASE NOTE**

Measurements and protection functions support depends on connection mode. Each current protection function uses different electrical connection mode. When specific current protection function in correlation to its connection mode is used, it is not possible to activate other two current protection functions.

*If >I and >>I are chosen (4u electrical connection), monitoring of >IE and >I´ is not allowed.*
*If >IE is chosen (IE electrical connection), monitoring of >I, >>I and >I´ is not allowed.*
*If >I´ is chosen (Idiff electrical connection), monitoring of >I, >>I and >IE is not allowed.*

Please refer to chapter *Electrical connection for Supervision Relay SR100* on page 12 for more information/details regarding electrical wiring.

## Supported measurements

Selection of supported measurements and protection functions of individual instrument is changed within the connection settings. All supported measurements can be read via communication (through MiQen) or displayed on the device display (not supported no Supervision Relay SR100).

## Selection of available quantities

Available online measuring quantities and their appearance can vary according to the setup type of power network and other settings such as; average interval, maximum demand mode and reactive power calculation method. A complete list of available online measuring quantities is shown in the table below.

**PLEASE NOTE**

Measurements support depends on connection mode as well as the device type (built-in options). Calculated measurements (for example voltages $U_1$ *and* $U_2$ when 3-phase, 4-wire connection with a balanced load is used) are only informative.

**PLEASE NOTE**

For 3b and 3u connection mode, only phase to phase voltages are measured. The factor √3 is then applied to calculate the nominal phase voltage. For 4u connection mode the same measurements are supported as for 1b.

| | *Basic measurements* | *Designat.* | *Unit* | *1b* | *3b* | *3u* | *4b* | *4u* |
|---|---|---|---|---|---|---|---|---|
| **Phase** | Voltage U1 | U1 | V | ● | × | × | ● | ● |
| | Voltage U2 | U2 | V | × | × | × | ○ | ● |
| | Voltage U3 | U3 | V | × | × | × | ○ | ● |
| | Average voltage U~ | U | V | × | × | × | ○ | ● |
| | Current I1 | I1 | A | ● | ● | ● | ● | ● |
| | Current I2 | I2 | A | × | ○ | ● | ○ | ● |
| | Current I3 | I3 | A | × | ○ | ● | ○ | ● |
| | Current In | Inc | A | × | ○ | ○ | ○ | ● |
| | Total current It | I | A | ● | ○ | ○ | ○ | ● |
| | Average current I~ | Iavg | A | × | ○ | ○ | ○ | ● |
| | Frequency | F | Hz | ● | ● | ● | ● | ● |
| | Active power P1 | P1 | W | ● | × | × | ● | ● |
| | Active power P2 | P2 | W | × | × | × | ○ | ● |
| | Active power P3 | P3 | W | × | × | × | ○ | ● |
| | Total active power Pt | P | W | ● | ● | ● | ○ | ● |
| | Reactive power Q1 | Q1 | var | ● | × | × | ● | ● |
| | Reactive power Q2 | Q2 | var | × | × | × | ○ | ● |
| | Reactive power Q3 | Q3 | var | × | × | × | ○ | ● |
| | Total reactive power Qt | Q | var | ● | ● | ● | ○ | ● |
| | Apparent power S1 | S1 | VA | ● | × | × | ● | ● |
| | Apparent power S2 | S2 | VA | × | × | × | ○ | ● |
| | Apparent power S3 | S3 | VA | × | × | × | ○ | ● |
| | Total apparent power St | S | VA | ● | ● | ● | ○ | ● |
| | Power factor PF1 | PF1 | | ● | × | × | ● | ● |
| | Power factor PF2 | PF2 | | × | × | × | ○ | ● |
| | Power factor PF3 | PF3 | | × | × | × | ○ | ● |
| | Total power factor PFt | PF | | ● | ● | ● | ○ | ● |
| | Power angle ϕ1 | ϕ1 | ° | ● | × | × | ● | ● |
| | Power angle ϕ2 | ϕ2 | ° | × | × | × | ○ | ● |
| | Power angle ϕ3 | ϕ3 | ° | × | × | × | ○ | ● |
| | Total power angle ϕt | ϕ | ° | ● | ● | ● | ○ | ● |
| | THD of phase voltage Up1 | U1% | %THD | ● | × | × | ● | ● |
| | THD of phase voltage Up2 | U2% | %THD | × | × | × | ○ | ● |
| | THD of phase voltage Up3 | U3% | %THD | × | × | × | ○ | ● |
| | THD of phase current I1 | I1% | %THD | ● | ● | ● | ● | ● |
| | THD of phase current I2 | I2% | %THD | × | ○ | ● | ○ | ● |
| | THD of phase current I3 | I3% | %THD | × | ○ | ● | ○ | ● |

● – supported ○ – calculated × – not supported

| | *Basic measurements* | *Designat.* | *Unit* | *1b* | *3b* | *3u* | *4b* | *4u* |
|---|---|---|---|---|---|---|---|---|
| **Phase-to-phase** | Phase-to-phase voltage U12 | U12 | V | × | ● | ● | ○ | ● |
| | Phase-to-phase voltage U23 | U23 | V | × | ● | ● | ○ | ● |
| | Phase-to-phase voltage U31 | U31 | V | × | ● | ● | ○ | ● |
| | Average phase-to-phase voltage Upp~ | U | V | × | ● | ● | ○ | ● |
| | Phase-to-phase angle ϕ12 | ϕ12 | ° | × | × | × | ○ | ● |
| | Phase-to-phase angle ϕ23 | ϕ23 | ° | × | × | × | ○ | ● |
| | Phase-to-phase angle ϕ31 | ϕ31 | ° | × | × | × | ○ | ● |
| | THD of phase-to-phase voltage THDU12 | U12% | %THD | × | ● | ● | ○ | ● |
| | THD of phase-to-phase voltage THDU23 | U23% | %THD | × | ● | ● | ○ | ● |
| | THD of phase-to-phase voltage THDU31 | U31% | %THD | × | ● | ● | ○ | ● |
| **Energy** | Counters 1–4 | E1, E2, | Wh VAh | ● | ● | ● | ● | ● |
| | | E3, E4 | varh | | | | | |
| | Active tariff | Atar | | ● | ● | ● | ● | ● |
| **MD Values** | MD current I1 | I1 | A | ● | ● | ● | ● | ● |
| | MD current I2 | I2 | A | × | ○ | ● | ○ | ● |
| | MD current I3 | I3 | A | × | ○ | ● | ○ | ● |
| | Active power total (Pt) - (positive) | Pt | W | ● | ● | ● | ● | ● |
| | Active power total (Pt) - (negative) | Pt | W | ● | ● | ● | ● | ● |
| | Reactive power total (Qt) - L | Qt | var | ● | ● | ● | ● | ● |
| | Reactive power total (Qt) - C | Qt | var | ● | ● | ● | ● | ● |
| | Apparent power total (St) | St | VA | ● | ● | ● | ● | ● |

● – supported ○ – calculated × – not supported

# Explanation of basic concepts

## Sample factor $M_V$

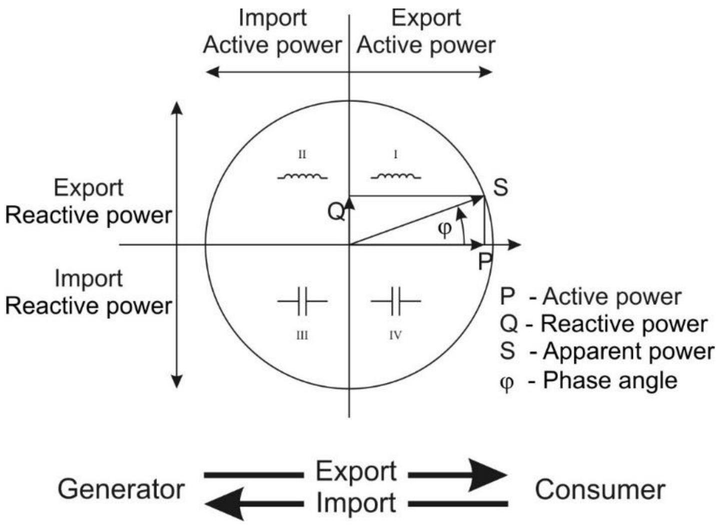
A meter measures all primary quantities with sample frequency which cannot exceed a certain number of samples in a time period. Based on these limitations (128 sample/per at 65Hz) a sample factor is calculated. A sample factor ($M_V$), depending on frequency of a measured signal, defines a number of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

## Average interval MP

Due to readability of measurements from communication or LCD (not supported on Supervision Relay SR100), an Average interval (MP) is calculated with regard to the measured signal frequency. The Average interval (see chapter Average interval) defines refresh rate of displayed measurements based on a sampling factor.

## Power and energy flow

Figures below show the flow of active power, reactive power and energy for 4u connection.
Display of energy flow direction can be adjusted according to connection and operation requirements by changing the Energy flow direction settings.




*Explanation of energy flow direction*

# 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 a chapter *Equations* with additional descriptions and explanations.

**PLEASE NOTE**

Calculation and display of measurements depend on the connection used. For more detailed information see chapter Survey of supported measurements.

# Present values

**PLEASE NOTE**

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

**PLEASE NOTE**

Display of present values depends on connection mode. Therefore display organization slightly differs from one connection mode to another.

All measuring instruments may not support all the measurements. For overview of supportive instruments please see Chapter *Selection of available quantities* on page 61

## Voltage

The device measurements:

- real effective (rms) value of all phase voltages (U1, U2, U3), phase-to-phase voltages (U12, U23, U31) and neutral to earth voltage (Un).
- Average phase voltage (U⅄) and average phase-to-phase voltage (U△)
- Negative and zero sequence unbalance ratio (Uu, U0)
- Phase and phase-to-phase voltage angles (φ1-3, φ12, φ13, φ23)

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

All voltage measurements are available on communication.

## Current

Device measures

- real effective (rms) value of phase currents and neutral measured current (Inm), connected to current inputs
- Neutral calculated current (Inc), Neutral error current (Ie = |Inm – Inc|),
- Phase angle between Neutral voltage and Neutral Current (φIn), Average current (Ia) and a sum of all phase currents (It)

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

All current measurements are available on communication.

## Active, reactive and apparent power

Active power is calculated from instantaneous phase voltages and currents. All measurements are seen on communication. For more detailed information about calculation see chapter *Appendix C - Equations* on page 79.
There are two different methods of calculating reactive power. See chapter *Reactive power and energy calculation* on page 26.

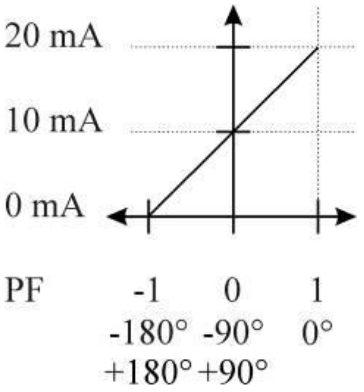
## Power factor and power angle

Power angle (or displacement 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 ($\cos\varphi_T$). It represents angle between first (base) voltage harmonic and first (base) 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*). A symbol for a coil (positive sign) represents inductive load and a symbol for a capacitor (negative sign) represents capacitive load.

Presentation of PF:

| *Load* | *C* | → | | ← | *L* |
|---|---|---|---|---|---|
| Angle [°] | −180 | −90 | 0 | +90 | +180 (179.99) |
| PF | −1 | 0 | 1 | 0 | −1 |

Example of analogue output for PF:




## Frequency

Network frequency is calculated from time periods of measured voltage. Instrument uses synchronization method, which is highly immune to harmonic disturbances.
Device always synchronizes to a phase voltage *U1*. If signal on that phase is too low it (re)synchronizes to next phase. If all phase voltages are low (e.g. short circuit) device synchronizes to phase currents. If there is no signal present on any voltage or current channels, device shows frequency 0 Hz.

## Energy counters

Three ways of Energy - counters display are available:

- by individual counter,
- by tariffs for each counter separately and

At a display of measured counter by tariffs, the sum in the upper line depends on the tariffs set in the instrument.
There are two different methods of calculating reactive energy. See chapter *Reactive power and energy calculation* on page 26.
Additional information, how to set and define a counter quantity is explained in chapter *Energy* on page 32.

## THD – Total harmonic distortion

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 63st harmonic.

## Average interval for min. max. values

Min. and max. values often require special averaging period, which enables or disables detection of short measuring spikes. With this setting is possible to set averaging from 1 period to 256 periods.

# TECHNICAL DATA

In following chapter all technical data regarding operation of device is presented.

## Accuracy

Accuracy is presented as percentage of reading of the measured value except when it is stated as an absolute value.

| Measured values | Accuracy (± % of range) |
|---|---|
| Current Rms | 0.5 |
| Voltage Rms P-N and P-P | 0.5 |
| Power (P, Q, S) | 0.5 |
| Power factor (PF) | 0.5 |
| Frequency (f) | 10 mHz |
| P-N and P-P angle | 0.5° |
| THD (U), THD (I) (0 … 400 %) | 0.5 |
| Active energy | Class 1 |
| Reactive energy | Class 2 |

## Measurement inputs

### Frequency

| | |
|---|---|
| Nominal frequency range | 45 … 65 Hz, 400 Hz |
| Measuring frequency range | 16 … 400 Hz * |

** For frequency measurement only*

### Voltage measurements

| | |
|---|---|
| Measuring range (auto) | 10 … 500 $V_{LN}$ |
| Nominal value ($U_N$) | 500 $V_{LN}$ , 866 $V_{LL}$ |
| Min. voltage for sync. | Settings from starting voltage for all SYNC * |
| Min. measurement | Settings from starting voltage for all powers * |
| Max. measured value (cont.) | 600 $V_{LN}$ ; 1000 $V_{LL}$ |
| Max. allowed value | 1.2 × $U_N$ permanently |
| | 2 × $U_N$ ; 10 s |
| Consumption | < $U^2$ / 3.3 MΩ per phase |
| Input impedance | 3.3 MΩ per phase |

** Starting voltage is set by setting software MiQen>settings>general*

### Current measurements

| | |
|---|---|
| Measuring range (auto) | 0.01 ... 12.5 A |
| Nominal current ($I_N$) | 1 A / 5 A (defined by software setting) |
| Min. measurement | Settings from starting current for all powers * |
| Max. measured value | 20 $I_N$ ($I_N$ = 1 A)<br>4 $I_N$ ($I_N$ = 5 A)<br>sinusoidal |
| Max. allowed value (thermal)<br>(acc. to IEC/EN 60 688) | 12.5 A; continuous<br>20 A; 60 s<br>100A; 1 s |
| Consumption | < $I^2 \times 0.01\ \Omega$ per phase |

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

### Power supply

| | |
|---|---|
| Nominal voltage AC | 48 … 276 V |
| Nominal frequency | 45 … 65 Hz |
| Nominal voltage DC | 20 … 300 V |
| Consumption | < 8 VA |
| Power-on transient current | < 20 A; 1 ms |

### System:

Voltage inputs can be connected either directly to low-voltage network or via a VT to higher voltage network. Current inputs can be connected either directly to low-voltage network or shall be connected to network via a corresponding CT (with standard 1 A or 5 A outputs).

# Connection

Supervision relay SR100 is equipped with screw terminals for measuring voltages/current, auxiliary power supply, communication and I/O modules.

**PLEASE NOTE**

Stranded wire must be used with insulated end sleeve to assure firm connection.

| Terminals | Max. conductor cross-sections | |
|---|---|---|
| Voltage inputs (4) | 2.5 mm2<br>4 mm2 | with pin terminal<br>solid wire |
| Current inputs (6) | 2.5 mm2<br>4 mm2 | with pin terminal<br>solid wire |
| Supply (2) | 2.5 mm2<br>4 mm2 | with pin terminal<br>solid wire |
| Com (3), I/O (8) | 2.5 mm2<br>4 mm2 | with pin terminal<br>solid wire |

## Connection table

<table>
<tr><th colspan="3">Function</th><th>Connection</th><th>Comment</th></tr>
<tr><td rowspan="7">Measuring input</td><td rowspan="3">AC current</td><td>IL1</td><td>1/3</td><td rowspan="3">⚠ CAT III 600V</td></tr>
<tr><td>IL2</td><td>4/6</td></tr>
<tr><td>IL3</td><td>7/9</td></tr>
<tr><td rowspan="4">AC voltage</td><td>UL1</td><td>2</td><td rowspan="4">⚠ CAT III 600V</td></tr>
<tr><td>UL2</td><td>5</td></tr>
<tr><td>UL3</td><td>8</td></tr>
<tr><td>UN</td><td>11</td></tr>
<tr><td rowspan="8">Inputs / outputs</td><td rowspan="2">I/O 1</td><td>+ / ~</td><td>15</td><td rowspan="8">Relay output<br>48V DC/AC<br>1000 mA</td></tr>
<tr><td>– / ~</td><td>16</td></tr>
<tr><td rowspan="2">I/O 2</td><td>+ / ~</td><td>17</td></tr>
<tr><td>– / ~</td><td>18</td></tr>
<tr><td rowspan="2">I/O 3</td><td>+ / ~</td><td>19</td></tr>
<tr><td>– / ~</td><td>20</td></tr>
<tr><td rowspan="2">I/O 4</td><td>+ / ~</td><td>21</td></tr>
<tr><td>– / ~</td><td>22</td></tr>
<tr><td colspan="2" rowspan="2">Auxiliary power supply</td><td>+ / ~ (L)</td><td>13</td><td rowspan="5"></td></tr>
<tr><td>– / ~ (N)</td><td>14</td></tr>
<tr><td rowspan="3">Communication</td><td rowspan="3">RS232/RS485/CANopen</td><td>Rx / A / CAN-H</td><td>23</td></tr>
<tr><td>GND / NC / NC</td><td>24</td></tr>
<tr><td>Tx / B / CAN-L</td><td>25</td></tr>
</table>

# Communication

| *Serial communication:* | *RS232* | *RS485* | *CAN* |
|---|---|---|---|
| Connection type | Direct | Network | Network |
| Connection terminals | screw terminals | | |
| Function | Settings, measurements and FW upgrade | | Measurements |
| Insulation | Protection class II, 3.3 $kV_{ACRMS}$ 1 min | | |
| Max. connection length | 3 m | 2000 m (at CAN depends on baudrate) | |
| Transfer mode | Asynchronous | | Synchronous |
| Protocol | MODBUS RTU | | CAN open |
| Transfer rate | 2.4 kBaud to 115.2 kBaud | | 20 to 1000 kBaud |
| Number of nodes | / | ≤ 32 | ≤ 127 |

Additionally, Supervision Relay SR100 has a USB communication port, located on the bottom under small circular plastic cover. It is intended for settings ONLY and requires NO auxiliary power supply. When connected to this communication port Supervision Relay SR100 is powered by USB.

⚠ 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

**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, 24 V) |
| | 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 |
| | Response time | <= 50ms |

**PLEASE NOTE**

Supervision Relay SR100 response time:
Time from error detection to relay switching on/off is typically below 50ms.

# Safety

| | |
|---|---|
| Protection | protection class II |
| Pollution degree | 2 |
| Installation category | CAT III ; 600 V (meas. inputs)<br>CAT III ; 300 V (aux. supply)<br>Acc. to EN 61010-1 |
| Test voltages | UAUX↔I/O, COM1: 3510 VACrms<br>UAUX↔U, I inputs: 3510 VACrms<br>U, I inputs↔I/O, COM1: 3510 VACrms |
| Enclosure material | PC/ABS<br>Acc. to UL 94 V-0 |

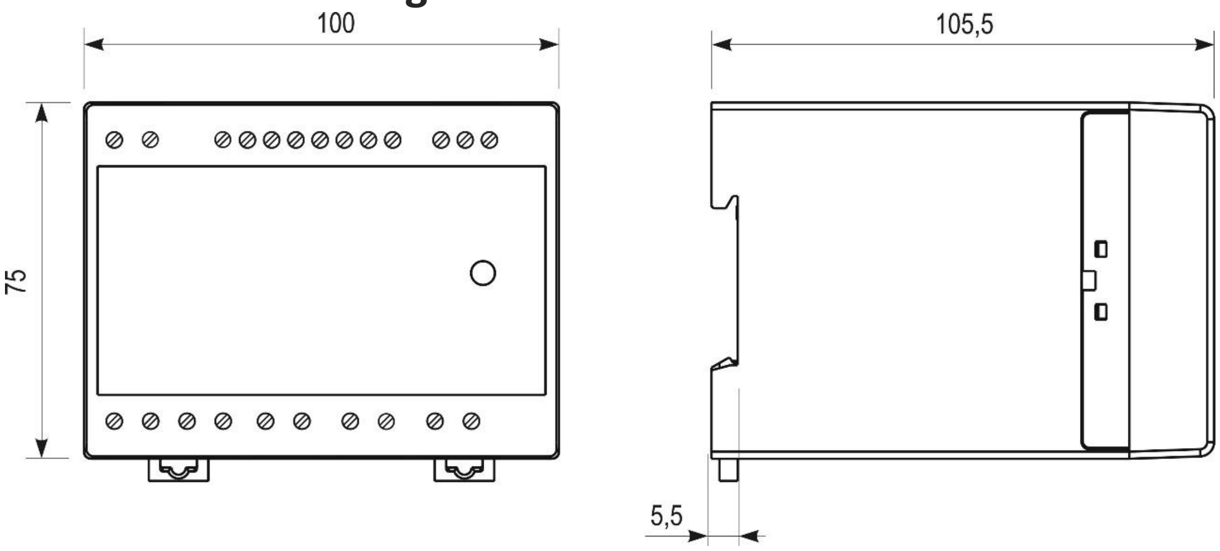
# Mechanical

| | |
|---|---|
| Dimensions | W100 × H75× D105 mm |
| Max. conductor cross section for terminals | 2.5 $mm^2$ with pin terminal<br>4 $mm^2$ solid wire |
| Vibration withstand | 7 g, 3 … 100 Hz, 1 oct/min |
| | 10 cycles in each of three axes |
| Shock withstand | 300 g, 8 ms 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 |

## 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 |

## Dimensional drawing



# APPENDICES

## Appendix A

**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 1.0: Compatibility with advanced family of transducers (MT400)
- VERSION 2.0: Compatibility with previous family of transducers (MI500)

**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.

**VERSION 2.0:**

**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 | | Type | |
| | Start | End | | |
| 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 | |
| Alarm Status Flags (No. 17 … 32) | 30192 | | 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 |
|---|---|---|---|
| | 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 |
| Σ 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 |
| Reactive Power Phase L3 (Q3) | 30822 | T17 | Pn |
| Reactive Power Total (Qt) | 30823 | T17 | Pt |

| Parameter | MODBUS | | 100% value |
|---|---|---|---|
| | Register | Type | |
| 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 |
| φ 1 (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° |
| φ 12 (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 | | |
| Active Tariff | 30879 | T1 | | |
| Internal Temperature | 30880 | T17 | 100° | |
| DIRECTIONAL CURRENTS | | | | |
| Directional Iavg | 30881 | T17 | | |
| Directional I1 | 30882 | T17 | | |
| Directional I2 | 30883 | T17 | | |
| Directional I3 | 30884 | T17 | | |
| Frequency (wide range) 0.00 – 655.35 Hz | 30891 | T16 | | |

**VERSION 1.0:**
**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 | | Type |
| | Start | End | |
| 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 |
| Time Stamp | 30209 | 30212 | T_Time |
| I2 | 30213 | 30214 | T5 |
| Time Stamp | 30215 | 30218 | T_Time |
| I3 | 30219 | 30220 | T5 |
| Time Stamp | 30221 | 30224 | T_Time |
| Apparent Power Total (St) | 30225 | 30226 | T5 |
| Time Stamp | 30227 | 30230 | T_Time |
| Active Power Total (Pt) - (positive) | 30231 | 30232 | T6 |
| Time Stamp | 30233 | 30236 | T_Time |
| Active Power Total (Pt) - (negative) | 30237 | 30238 | T6 |
| Time Stamp | 30239 | 30242 | T_Time |
| Reactive Power Total (Qt) - L | 30243 | 30244 | T6 |
| Time Stamp | 30245 | 30248 | T_Time |
| Reactive Power Total (Qt) - C | 30249 | 30250 | T6 |
| Time Stamp | 30251 | 30254 | T_Time |

**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 |
| Σ 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 |

| Parameter | MODBUS | | 100% value |
|---|---|---|---|
| | Register | Type | |
| Reactive Power Phase L1 (Q1) | 30820 | T17 | Pn |
| Reactive Power Phase L2 (Q2) | 30821 | T17 | Pn |
| 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's web page www.ISKRA.eu.**

**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 (Type T4) = 10^2 × 40 = **8028(16)** | –> | **4000 A/10 = 400 A** |
| CT Secondary | = R40144 (Type T4) = 10^2 × 50 = **8032(16)** | –> | **5000 mA** |
| Cal. Current | = R30017 (Type T4) = 10^2 × 50 = **8032(16)** | –> | **5000 mA** |
| Input range | = R40148 (Type T16) = 10000 = **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)<br>Example: 12345 = 3039(16) |
| T2 | | Signed Value (16 bit)<br>Example: -12345 = CFC7(16) |
| T3 | | Signed Long Value (32 bit)<br>Example: 123456789 = 075B CD 15(16) |
| T4 | bits # 15…14<br>bits # 13…00 | Short Unsigned float (16 bit)<br>Decade Exponent(Unsigned 2 bit)<br>Binary Unsigned Value (14 bit)<br>Example: 10000*102 = A710(16) |
| T5 | bits # 31…24<br>bits # 23…00 | Unsigned Measurement (32 bit)<br>Decade Exponent(Signed 8 bit)<br>Binary Unsigned Value (24 bit)<br>Example: 123456*10-3 = FD01 E240(16) |
| T6 | bits # 31…24<br>bits # 23…00 | Signed Measurement (32 bit)<br>Decade Exponent (Signed 8 bit)<br>Binary Signed value (24 bit)<br>Example: - 123456*10-3 = FDFE 1DC0(16) |
| T7 | bits # 31…24<br>bits # 23…16<br>bits # 15…00 | Power Factor (32 bit)<br>Sign: Import/Export (00/FF)<br>Sign: Inductive/Capacitive (00/FF)<br>Unsigned Value (16 bit), 4 decimal places<br>Example: 0.9876 CAP = 00FF 2694(16) |
| T9 | bits # 31…24<br>bits # 23…16<br>bits # 15…08<br>bits # 07…00 | Time (32 bit)<br>1/100s 00 - 99 (BCD)<br>Seconds 00 - 59 (BCD)<br>Minutes 00 - 59 (BCD)<br>Hours 00 - 24 (BCD)<br>Example: 15:42:03.75 = 7503 4215(16) |
| T10 | bits # 31…24<br>bits # 23…16<br>bits # 15…00 | Date (32 bit)<br>Day of month 01 - 31 (BCD)<br>Month of year 01 - 12 (BCD)<br>Year (unsigned integer) 1998..4095<br>Example: 10, SEP 2000 = 1009 07D0(16) |
| T16 | | Unsigned Value (16 bit), 2 decimal places<br>Example: 123.45 = 3039(16) |
| T17 | | Signed Value (16 bit), 2 decimal places<br>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_Str20 | | Text: 20 characters (2 characters for 16 bit register) |

| Type | Bit mask | Description |
|---|---|---|
| T_Str40 | | Text: 40 characters (2 characters for 16 bit register) |
| T_Time | | Time and Date (64 bit) |
| | bits # 63..56 | 1/100s 00 - 99 (BCD) |
| | bits # 55..48 | Seconds 00 - 59 (BCD) |
| | bits # 47..40 | Minutes 00 - 59 (BCD) |
| | bits # 39..32 | Hours 00 - 24 (BCD) |
| | bits # 31..24 | Day of month 01 - 31 (BCD) |
| | bits # 23..16 | Month of year 01 - 12 (BCD) |
| | bits # 15..00 | Year (unsigned integer) 1998..4095 |
| | | Example: 15:42:03.75, 10. SEP 2000 stored as 7503 4215 1009 07D0(16) |

# APPENDIX B

OBJECT DICTIONARY OF Supervision Relay SR100

| Index (hex) | Sub Index (dec) | Name | Type | Attr | Default | Comment |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1000 | 0 | Device type | U32 | R | 0x400191 | Device with analog outputs (CiA 401) |
| 1001 | 0 | Error register | U8 | R | 0 | Error bits (generic error and heartbeat error supported at EMCY message) |
| 1002 | 0 | Manufacturer Status register | U31 | RW | 0 | |
| 1005 | 0 | COB-ID SYNC | U32 | R | 00000080 | Device doesn't generate SYNC, 11-bit CAN-ID |
| 1008 | 0 | Manufacturer device name | Str | R | "ISKRA SR100" | "ISKRA SR100" |
| 1009 | 0 | Manufacturer hardware version | Str | R | SR100_HW0001" | 126-byte ASCII string |
| 100A | 0 | Manufacturer software version | Str | R | "SR100_SW0001" | 126-byte ASCII string |
| 100B | 0 | NODE ID | U32 | RW | 31 | Defines Node ID of the Device |
| 1014 | 0 | COB-ID emergency message | U32 | RW | 80h + Node ID | COB-ID of the Emergency message |
| 1016 | 0 | Consumer heartbeat time | U32 | RW | 20000 | The value given in multiples of 1 ms (20 s) |
| 1017 | 0 | Producer heartbeat time | U32 | RW | 10000 | The value given in multiples of 1 ms (10 s) |
| | | | | | | |
| 1018 | 0 | Identity object - Highest sub-index supported | U8 | R | 4 | Provides general identification information of the CANopen device |
| | 1 | Vendor-ID | U32 | R | 1234AAAAh | Assigned uniquely to manufacturers by CiA |
| | 2 | Product code | U32 | R | 00000001h | Profile- or manufacturer-specific |
| | 3 | Revision number | U32 | R | 00000001h | Profile- or manufacturer-specific |
| | 4 | Serial number | U32 | R | 00000001h | Profile- or manufacturer-specific |
| | | | | | | |
| 1800 | | TPDO1 communication parameter | | | | Transmit PDO used for short measurements on SR100 |
| | 0 | Highest sub-index supported | U8 | R | 02h | |
| | 1 | COB-ID used by TPDO1 | U32 | W | 0000 01A0 | 0000 0180h + Node ID (32 - 0x20 default) |
| | 2 | Transmission type | U8 | R | 01h | Synchronous (cyclic every sync) |
| | | | | | | |
| 1802 | | TPDO3 communication parameter | | | | Transmit PDO used for long measurements on SR100 |
| | 0 | Highest sub-index supported | U8 | R | 02h | |
| | 1 | COB-ID used by PDO | U32 | W | 0000 03A0 | 0000 0380h + Node ID (32 - 0x20 default) |
| | 2 | Transmission type | U8 | RW | 0Ah | Synchronous (cyclic every 10th sync) |
| | | | | | | |
| 1A00 | | TPDO1 mapping parameters | | | | |
| | 0 | Number of mapped application objects in TPDO1 | U8 | R | 2 | |
| | 1 | 1st application object | U32 | R | 23000140h | Object 0x2300, subindex 0x01, consisting of 64 bits |

| Index (hex) | Sub Index (dec) | Name | Type | Attr | Default | Comment |
|---|---|---|---|---|---|---|
| 1A02 | | TPDO3 mapping parameters | | | | |
| | 0 | Number of mapped application objects in TPDO3 | U8 | R | 2 | |
| | 1 | 1st application object | U32 | R | 24000140h | Object 02400, subindex 0x01, consisting of 64 bits |
| | | | | | | |
| 2300 | | TPDO1 Multiplex data structure | | | | SR100 defined entry which is transferring TPDO1 multiplexed data |
| | 0 | Number of elements | U8 | R | 1 | Number of elements |
| | 1 | TPDO1 Mux | U64 | R | | 8 Bytes Multiplex data for TPDO1 transfer (Byte 0 is Index, Bytes 1-6 contains multiplexed data, Byte 7 not used) |
| | | | | | | |
| 2400 | | TPDO3 Multiplex data structure | | | | SR100 defined entry which is transferring TPDO1 multiplexed data |
| | 0 | Number of elements | U8 | R | 1 | Number of elements |
| | 1 | TPDO1 Mux | U64 | R | | 8 Bytes Multiplex data for TPDO1 transfer (Byte 0 is Index, Bytes 1-6 contains multiplexed data, Byte 7 not used) |
| | | | | | | |
| 2A00 | | Manufacturer specific area | | | | CAN Open device settings area |
| | 0 | Baudrate | U8 | RW | 7 | 0=20kBd, 1=50kBd, 2=100kBd, 3=125kBd, 4=250kBd, 5=500kBd, 6=800kBd, 7=1000kBd |
| | | | | | | |
| 2B00 | | SDO OD Settings entries | | | | |
| | 0 | Number of entries | U16 | R | 5 | SR100 Protection data |
| | 1 | 16 bit value | U16 | R/W | | Nominal Voltage (%) |
| | 2 | 16 bit value | U16 | R/W | | Connection mode |
| | 3 | 16 bit value | U16 | R/W | | Nominal Frequency |
| | 4 | 16 bit value | U16 | R/W | | Assigned Output |
| | 5 | 16 bit value | U16 | R/W | | Reserved |
| | | | | | | |
| 6400 | | 6400h: Read analogue input 8-bit. | | | | SR100 Alarms presented as 8-bit integer analogue input sent over TPDO1 |
| | 0 | Number of entries | U8 | R | | |
| | 1 | analogue input 8-bit | INT8 | R | | Alarm: Over/under voltage 1/2 |
| | 2 | analogue input 8-bit | INT8 | R | | Alarm: Over/under frequency 1/2 |
| | 3 | analogue input 8-bit | INT8 | R | | Alarm: Directional power/Power underrun |
| | 4 | analogue input 8-bit | INT8 | R | | Imbalances |
| | 5 | analogue input 8-bit | INT8 | R | | Other asymmetry |

| Index (hex) | Sub Index (dec) | Name | Type | Attr | Default | Comment |
|---|---|---|---|---|---|---|
| 6401 | | 6401h: Read analogue input 16-bit | | | | SR100 measured (normalized) data are presents as 16-bit integer analogue input sent over TPDO1 and TPDO3 |
| | 0 | Number of entries | U8 | R | 53 | |
| | 1 | analogue input 16-bit | INT16 | R | | U1 |
| | 2 | analogue input 16-bit | INT16 | R | | U2 |
| | 3 | analogue input 16-bit | INT16 | R | | U3 |
| | 4 | analogue input 16-bit | INT16 | R | | U12 |
| | 5 | analogue input 16-bit | INT16 | R | | U23 |
| | 6 | analogue input 16-bit | INT16 | R | | U31 |
| | 7 | analogue input 16-bit | INT16 | R | | I1 |
| | 8 | analogue input 16-bit | INT16 | R | | I2 |
| | 9 | analogue input 16-bit | INT16 | R | | I3 |
| | 10 | analogue input 16-bit | INT16 | R | | Active Power Total (Pt) |
| | 11 | analogue input 16-bit | INT16 | R | | Reactive Power Total (Qt) |
| | 12 | analogue input 16-bit | INT16 | R | | Apparent Power Total (St) |
| | 13 | analogue input 16-bit | INT16 | R | | Power Factor Total (PFt) |
| | 14 | analogue input 16-bit | INT16 | R | | U1 THD% |
| | 15 | analogue input 16-bit | INT16 | R | | U2 THD% |
| | 16 | analogue input 16-bit | INT16 | R | | U3 THD% |
| | 17 | analogue input 16-bit | INT16 | R | | U12 THD% |
| | 18 | analogue input 16-bit | INT16 | R | | U23 THD% |
| | 19 | analogue input 16-bit | INT16 | R | | U31 THD% |
| | 20 | analogue input 16-bit | INT16 | R | | I1 THD% |
| | 21 | analogue input 16-bit | INT16 | R | | I2 THD% |
| | 22 | analogue input 16-bit | INT16 | R | | I3 THD% |
| | 23 | analogue input 16-bit | INT16 | R | | Voltage Unbalances |
| | 24 | analogue input 16-bit | INT16 | R | | Phase Imbalance |
| | 25 | analogue input 16-bit | INT16 | R | | Phase Shift L1 |
| | 26 | analogue input 16-bit | INT16 | R | | Phase Shift L2 |
| | 27 | analogue input 16-bit | INT16 | R | | Phase Shift L3 |
| | 28 | analogue input 16-bit | INT16 | R | | ROCOF df/dt |
| | 29 | analogue input 16-bit | INT16 | R | | I/O 1 Value |
| | 30 | analogue input 16-bit | INT16 | R | | I/O 2 Value |
| | 31 | analogue input 16-bit | INT16 | R | | I/O 3 Value |
| | 32 | analogue input 16-bit | INT16 | R | | I/O 4 Value |
| | 33 | analogue input 16-bit | INT16 | R | | Alarm: Overvoltage 1 |
| | 34 | analogue input 16-bit | INT16 | R | | Alarm: Overvoltage 2 |
| | 35 | analogue input 16-bit | INT16 | R | | Alarm: Under voltage 1 |
| | 36 | analogue input 16-bit | INT16 | R | | Alarm: Under voltage 2 |
| | 37 | analogue input 16-bit | INT16 | R | | Alarm: Over frequency 1 |
| | 38 | analogue input 16-bit | INT16 | R | | Alarm: Over frequency 2 |
| | 39 | analogue input 16-bit | INT16 | R | | Alarm: Under frequency 1 |
| | 40 | analogue input 16-bit | INT16 | R | | Alarm: Under frequency 2 |
| | 41 | analogue input 16-bit | INT16 | R | | Alarm: Directional power 1 |
| | 42 | analogue input 16-bit | INT16 | R | | Alarm: Directional power 2 |
| | 43 | analogue input 16-bit | INT16 | R | | Alarm: Power underrun 1 |
| | 44 | analogue input 16-bit | INT16 | R | | Alarm: Power underrun 2 |
| | 45 | analogue input 16-bit | INT16 | R | | Alarm: Voltage Unbalances |
| | 46 | analogue input 16-bit | INT16 | R | | Alarm: Phase imbalance 1 |
| | 47 | analogue input 16-bit | INT16 | R | | Alarm: Phase imbalance 2 |
| | 48 | analogue input 16-bit | INT16 | R | | Reserved Alarm: Phase shift |
| | 49 | analogue input 16-bit | INT16 | R | | Reserved Alarm: ROCOF df/dt |
| | 50 | analogue input 16-bit | INT16 | R | | Reserved Alarm: Time-dependent under voltage A |
| | 51 | analogue input 16-bit | INT16 | R | | Reserved Alarm: Time-dependent under voltage B |

| Index (hex) | Sub Index (dec) | Name | Type | Attr | Default | Comment |
|---|---|---|---|---|---|---|
| 6404 | | Read manufacturer specific analogue input | | | | SR100 measured (absolute) data are represented as 32-bit float (IEEE754) analogue input sent over TPDO3 |
| | 0 | Number of entries | U8 | R | 0x80 | 0-199 entries |
| | 1 | 32-bit float analog input | float | R | | Frequency |
| | 2 | 32-bit float analog input | float | R | | U1 |
| | 3 | 32-bit float analog input | float | R | | U2 |
| | 4 | 32-bit float analog input | float | R | | U3 |
| | 5 | 32-bit float analog input | float | R | | Uavg (phase to neutral) |
| | 6 | 32-bit float analog input | float | R | | U12 |
| | 7 | 32-bit float analog input | float | R | | U23 |
| | 8 | 32-bit float analog input | float | R | | U31 |
| | 9 | 32-bit float analog input | float | R | | Uavg (phase to phase) |
| | 10 | 32-bit float analog input | float | R | | fi12 (angle between U1 and U2) |
| | 11 | 32-bit float analog input | float | R | | fi23 (angle between U2 and U3) |
| | 12 | 32-bit float analog input | float | R | | fi31 (angle between U3 and U1) |
| | 13 | 32-bit float analog input | float | R | | I1 |
| | 14 | 32-bit float analog input | float | R | | I2 |
| | 15 | 32-bit float analog input | float | R | | I3 |
| | 16 | 32-bit float analog input | float | R | | Active Power Phase L1 (P1) |
| | 17 | 32-bit float analog input | float | R | | Active Power Phase L2 (P2) |
| | 18 | 32-bit float analog input | float | R | | Active Power Phase L3 (P3) |
| | 19 | 32-bit float analog input | float | R | | Active Power Total (Pt) |
| | 20 | 32-bit float analog input | float | R | | Reactive Power Phase L1 (Q1) |
| | 21 | 32-bit float analog input | float | R | | Reactive Power Phase L2 (Q2) |
| | 22 | 32-bit float analog input | float | R | | Reactive Power Phase L3 (Q3) |
| | 23 | 32-bit float analog input | float | R | | Reactive Power Total (Qt) |
| | 24 | 32-bit float analog input | float | R | | Apparent Power Phase L1 (S1) |
| | 25 | 32-bit float analog input | float | R | | Apparent Power Phase L2 (S2) |
| | 26 | 32-bit float analog input | float | R | | Apparent Power Phase L3 (S3) |
| | 27 | 32-bit float analog input | float | R | | Apparent Power Total (St) |
| | 28 | 32-bit float analog input | float | R | | Power Factor Phase 1 (PF1) |
| | 29 | 32-bit float analog input | float | R | | Power Factor Phase 2 (PF2) |
| | 30 | 32-bit float analog input | float | R | | Power Factor Phase 3 (PF3) |
| | 31 | 32-bit float analog input | float | R | | Power Factor Total (PFt) |
| | 32 | 32-bit float analog input | float | R | | fi1 (angle between U1 and I1) |
| | 33 | 32-bit float analog input | float | R | | fi2 (angle between U2 and I2) |
| | 34 | 32-bit float analog input | float | R | | fi3 (angle between U3 and I3) |
| | 35 | 32-bit float analog input | float | R | | Power Angle Total (atan2(Pt,Qt)) |
| | 36 | 32-bit float analog input | float | R | | Energy Counter 1 |
| | 37 | 32-bit float analog input | float | R | | Energy Counter 2 |
| | 38 | 32-bit float analog input | float | R | | Energy Counter 3 |
| | 39 | 32-bit float analog input | float | R | | Energy Counter 4 |

TPDO1 Mapping Structure:

Supervision Relay SR100 uses multiplexed structure for data transferred inside TPDO1 and TPDO3. First byte (Byte 0) inside CAN 8-byte data field designates index of the multiplexed package being sent. TPDO1 contains 5 different packages and TPDO3 contains 50 different multiplexed packages. Bytes 1-6 inside CAN telegram data field are presenting multiplexed data. Byte 7 is never used.

| CAN Byte 0 | CAN Bytes 1-6 | Description | Modbus address | Type (Modbus) | Type (CAN) | Multiplier |
|---|---|---|---|---|---|---|
| **MUX index** | **Data bytes** | | | | | **to multiply the received value** |
| 0 | 1,2 | Protocol ID, always 4600 | | | | |
| 0 | 3,4 | Frequency | 30843 | T17 | int16 | % of nominal Frequency |
| 0 | 5,6 | U1 | 30801 | T16 | int16 | % of nominal Voltage |
| 0 | 1,2 | U2 | 30802 | T16 | int16 | % of nominal Voltage |
| 1 | 3,4 | U3 | 30803 | T16 | int16 | % of nominal Voltage |
| 1 | 5,6 | U12 | 30805 | T16 | int16 | % of nominal Voltage |
| 1 | 1,2 | U23 | 30806 | T16 | int16 | % of nominal Voltage |
| 2 | 3,4 | U31 | 30807 | T16 | int16 | % of nominal Voltage |
| 2 | 5,6 | I1 | 30809 | T16 | int16 | % of nominal Current |
| 2 | 1,2 | I2 | 30810 | T16 | int16 | % of nominal Current |
| 3 | 3,4 | I3 | 30811 | T16 | int16 | % of nominal Current |
| 3 | 5,6 | Active Power Total (Pt) | 30819 | T17 | int16 | % of nominal total Power |
| 3 | 1,2 | Reactive Power Total (Qt) | 30823 | T17 | int16 | % of nominal total Power |
| 4 | 3,4 | Apparent Power Total (St) | 30827 | T16 | int16 | % of nominal total Power |
| 4 | 5,6 | Power Factor Total (PFt) | 30835 | T17 | int16 | |
| 5 | 1 | Alarm: Overvoltage 1 triggered | 37021 | T1 | int8 (bit 0) | Mask: H01 |
| | 1 | Alarm: Overvoltage 2 triggered | 37022 | T1 | int8 (bit 1) | Mask: H02 |
| | 1 | Alarm: Undervoltage 1 triggered | 37023 | T1 | int8 (bit 2) | Mask: H04 |
| | 1 | Alarm: Undervoltage 2 triggered | 37024 | T1 | int8 (bit 3) | Mask: H08 |
| | 1 | Alarm: Overfrequency 1 triggered | 37025 | T1 | int8 (bit 4) | Mask: H10 |
| | 1 | Alarm: Overfrequency 2 triggered | 37026 | T1 | int8 (bit 5) | Mask: H20 |
| | 1 | Alarm: Underfrequency 1 triggered | 37027 | T1 | int8 (bit 6) | Mask: H40 |
| | 1 | Alarm: Underfrequency 2 triggered | 37028 | T1 | int8 (bit 7) | Mask: H80 |
| 5 | 2 | Alarm: Directional power 1 triggered | 37029 | T1 | int8 (bit 0) | Mask: H01 |
| | 2 | Alarm: Directional power 2 triggered | 37030 | T1 | int8 (bit 1) | Mask: H02 |
| | 2 | Alarm: Power underrun 1 triggered | 37031 | T1 | int8 (bit 2) | Mask: H04 |
| | 2 | Alarm: Power underrun 2 triggered | 37032 | T1 | int8 (bit 3) | Mask: H08 |
| | 2 | Alarm: Voltage Unbalances triggered | 37033 | T1 | int8 (bit 4) | Mask: H10 |
| | 2 | Alarm: Phase imbalance 1 triggered | 37034 | T1 | int8 (bit 5) | Mask: H20 |
| | 2 | Alarm: Phase imbalance 2 triggered | 37035 | T1 | int8 (bit 6) | Mask: H40 |
| | 2 | Reserved Alarm: Phase shift triggered | 37036 | T1 | int8 (bit 7) | Mask: H80 |
| 5 | 3 | Reserved Alarm: ROCOF df/dt triggered | 37037 | T1 | int8 (bit 0) | Mask: H01 |

TPDO3 Mapping Structure:

| CAN Byte 0 | CAN Bytes 1-6 | Description | Modbus address | Type (Modbus) | Type (CAN) | Multiplier (to multiply the received value with) | Unit |
|---|---|---|---|---|---|---|---|
| **Mux index** | **Data bytes** | | | | | | |
| 0 | 1,2 | Protocol ID, always 4500 | | | | | |
| 0 | 3,4,5,6 | Frequency | 32498 | T_float | float | | Hz |
| 1 | 1,2,3,4 | U1 | 32500 | T_float | float | | V |
| 2 | 1,2,3,4 | U2 | 32502 | T_float | float | | V |
| 3 | 1,2,3,4 | U3 | 32504 | T_float | float | | V |
| 4 | 1,2,3,4 | Uavg (phase to neutral) | 32506 | T_float | float | | V |
| 5 | 1,2,3,4 | U12 | 32508 | T_float | float | | V |
| 6 | 1,2,3,4 | U23 | 32510 | T_float | float | | V |
| 7 | 1,2,3,4 | U31 | 32512 | T_float | float | | V |
| 8 | 1,2,3,4 | Uavg (phase to phase) | 32514 | T_float | float | | V |
| 9 | 1,2,3,4 | fi12 (angle between U1 and U2) | 32578 | T_float | float | | ° |
| 10 | 1,2,3,4 | fi23 (angle between U2 and U3) | 32580 | T_float | float | | ° |
| 11 | 1,2,3,4 | fi31 (angle between U3 and U1) | 32582 | T_float | float | | ° |
| 12 | 1,2,3,4 | I1 | 32516 | T_float | float | | A |
| 13 | 1,2,3,4 | I2 | 32518 | T_float | float | | A |
| 14 | 1,2,3,4 | I3 | 32520 | T_float | float | | A |
| 15 | 1,2,3,4 | Active Power Phase L1 (P1) | 32530 | T_float | float | | W |
| 16 | 1,2,3,4 | Active Power Phase L2 (P2) | 32532 | T_float | float | | W |
| 17 | 1,2,3,4 | Active Power Phase L3 (P3) | 32534 | T_float | float | | W |
| 18 | 1,2,3,4 | Active Power Total (Pt) | 32536 | T_float | float | | W |
| 19 | 1,2,3,4 | Reactive Power Phase L1 (Q1) | 32538 | T_float | float | | var |
| 20 | 1,2,3,4 | Reactive Power Phase L2 (Q2) | 32540 | T_float | float | | var |
| 21 | 1,2,3,4 | Reactive Power Phase L3 (Q3) | 32542 | T_float | float | | var |
| 22 | 1,2,3,4 | Reactive Power Total (Qt) | 32544 | T_float | float | | var |
| 23 | 1,2,3,4 | Apparent Power Phase L1 (S1) | 32546 | T_float | float | | VA |
| 24 | 1,2,3,4 | Apparent Power Phase L2 (S2) | 32548 | T_float | float | | VA |
| 25 | 1,2,3,4 | Apparent Power Phase L3 (S3) | 32550 | T_float | float | | VA |
| 26 | 1,2,3,4 | Apparent Power Total (St) | 32552 | T_float | float | | VA |
| 27 | 1,2,3,4 | Power Factor Phase 1 (PF1) | 32562 | T_float | float | | |
| 28 | 1,2,3,4 | Power Factor Phase 2 (PF2) | 32564 | T_float | float | | |
| 29 | 1,2,3,4 | Power Factor Phase 3 (PF3) | 32566 | T_float | float | | |
| 30 | 1,2,3,4 | Power Factor Total (PFt) | 32568 | T_float | float | | |
| 31 | 1,2,3,4 | fi1 (angle between U1 and I1) | 32570 | T_float | float | | ° |
| 32 | 1,2,3,4 | fi2 (angle between U2 and I2) | 32572 | T_float | float | | ° |
| 33 | 1,2,3,4 | fi3 (angle between U3 and I3) | 32574 | T_float | float | | ° |
| 34 | 1,2,3,4 | Power Angle Total (atan2(Pt,Qt)) | 32576 | T_float | float | | ° |
| 35 | 1,2,3,4 | Energy Counter 1 | 32638 | T_float | float | | Wah |
| 36 | 1,2,3,4 | Energy Counter 2 | 32640 | T_float | float | | Wah |
| 37 | 1,2,3,4 | Energy Counter 3 | 32642 | T_float | float | | Wah |
| 38 | 1,2,3,4 | Energy Counter 4 | 32644 | T_float | float | | Wah |
| 39 | 1,2 | U1 THD% | 30182 | T16 | int16 | % of nominal value | |
| 39 | 3,4 | U2 THD% | 30183 | T16 | int16 | % of nominal value | |
| 39 | 5,6 | U3 THD% | 30184 | T16 | int16 | % of nominal value | |
| 40 | 1,2 | U12 THD% | 30185 | T16 | int16 | % of nominal value | |
| 40 | 3,4 | U23 THD% | 30186 | T16 | int16 | % of nominal value | |
| 40 | 5,6 | U31 THD% | 30187 | T16 | int16 | % of nominal value | |
| 41 | 1,2 | I1 THD% | 30188 | T16 | int16 | % of nominal value | |
| 41 | 3,4 | I2 THD% | 30189 | T16 | int16 | % of nominal value | |
| 41 | 5,6 | I3 THD% | 30190 | T16 | int16 | % of nominal value | |

| CAN Byte 0 | CAN Bytes 1-6 | Description | Modbus address | Type (Modbus) | Type (CAN) | Multiplier (to multiply the received value with) | Unit |
|---|---|---|---|---|---|---|---|
| **Mux index** | **Data bytes** | | | | | | |
| 42 | 1,2 | Voltage Unbalances | 37001 | T16 | int16 | % of nominal value | |
| 42 | 3,4 | Phase Imbalance | 37002 | T16 | int16 | % of nominal value | |
| 42 | 5,6 | Phase Shift L1 | 37003 | T17 | int16 | % of nominal value | |
| 43 | 1,2 | Phase Shift L2 | 37004 | T17 | int16 | % of nominal value | |
| 43 | 3,4 | Phase Shift L3 | 37005 | T17 | int16 | % of nominal value | |
| 43 | 5,6 | ROCOF df/dt | 37006 | T17 | int16 | % of nominal value | |
| 44 | 1,2 | I/O 1 Value | 30193 | T17 | int16 | 0=Off, 1=On | |
| 44 | 3,4 | I/O 2 Value | 30194 | T17 | int16 | 0=Off, 1=On | |
| 44 | 5,6 | I/O 3 Value | 30195 | T17 | int16 | 0=Off, 1=On | |
| 45 | 1,2 | I/O 4 Value | 30196 | T17 | int16 | 0=Off, 1=On | |
| 45 | 3,4 | Alarm: Overvoltage 1 | 37021 | T1 | int16 | 0=OK, Bit i-1=Alarm Phase i, Bit 4=Alarm Avg | |
| 45 | 5,6 | Alarm: Overvoltage 2 | 37022 | T1 | int16 | 0=OK, Bit i-1=Alarm Phase i, Bit 4=Alarm Avg | |
| 46 | 1,2 | Alarm: Undervoltage 1 | 37023 | T1 | int16 | 0=OK, Bit i-1=Alarm Phase i, Bit 4=Alarm Avg | |
| 46 | 3,4 | Alarm: Undervoltage 2 | 37024 | T1 | int16 | 0=OK, Bit i-1=Alarm Phase i, Bit 4=Alarm Avg | |
| 46 | 5,6 | Alarm: Overfrequency 1 | 37025 | T1 | int16 | 0=OK, 1=Alarm | |
| 47 | 1,2 | Alarm: Overfrequency 2 | 37026 | T1 | int16 | 0=OK, 1=Alarm | |
| 47 | 3,4 | Alarm: Underfrequency 1 | 37027 | T1 | int16 | 0=OK, 1=Alarm | |
| 47 | 5,6 | Alarm: Underfrequency 2 | 37028 | T1 | int16 | 0=OK, 1=Alarm | |
| 48 | 1,2 | Alarm: Directional power 1 | 37029 | T1 | int16 | 0=OK, 1=Alarm | |
| 48 | 3,4 | Alarm: Directional power 2 | 37030 | T1 | int16 | 0=OK, 1=Alarm | |
| 48 | 5,6 | Alarm: Power underrun 1 | 37031 | T1 | int16 | 0=OK, 1=Alarm | |
| 49 | 1,2 | Alarm: Power underrun 2 | 37032 | T1 | int16 | 0=OK, 1=Alarm | |
| 49 | 3,4 | Alarm: Voltage Unbalances | 37033 | T1 | int16 | 0=OK, 1=Alarm | |
| 49 | 5,6 | Alarm: Phase imbalance 1 | 37034 | T1 | int16 | 0=OK, 1=Alarm | |
| 50 | 1,2 | Alarm: Phase imbalance 2 | 37035 | T1 | int16 | 0=OK, 1=Alarm | |
| 50 | 3,4 | Reserved Alarm: Phase shift | 37036 | T1 | int16 | 0=OK, Bit i-1=Alarm Phase i | |
| 50 | 5,6 | Reserved Alarm: ROCOF df/dt | 37037 | T1 | int16 | 0=OK, 1=Alarm | |

# APPENDIX C

## Equations

Definitions of symbols

| No | Symbol | Definition |
|---|---|---|
| 1 | MP | Average interval |
| 2 | Uf | Phase voltage (U1, U2 or U3) |
| 3 | Uff | Phase-to-phase voltage (U12, U23 or U31) |
| 4 | N | Total number of samples in a period |
| 5 | n | Sample number ($0 \le n \le N$) |
| 6 | x, y | Phase number (1, 2 or 3) |
| 7 | in | Current sample n |
| 8 | ufn | Phase voltage sample n |
| 9 | uffn | Phase-to-phase voltage sample n |
| 10 | $\varphi_f$ | Power angle between current and phase voltage f ( $\varphi_1$, $\varphi_2$ or $\varphi_3$) |
| 11 | Uu | Voltage unbalance |
| 12 | Uc | Agreed supply voltage |

## Voltage

| | |
|---|---|
| $U_f = \sqrt{\frac{\sum_{n=1}^{N} u_n^2}{N}}$ | **Phase voltage**<br>N – samples in averaging interval (up to 65 Hz) |
| $U_{xy} = \sqrt{\frac{\sum_{n=1}^{N} (u_{xn} - u_{yn})^2}{N}}$ | **Phase-to-phase voltage**<br>$u_x$, $u_y$ – phase voltages ($U_f$)<br>N – a number of samples in averaging interval |
| $U_u = \sqrt{\frac{1-\sqrt{3-6\beta}}{1+\sqrt{3-6\beta}}} \cdot 100\%$<br>$\beta = \frac{U_{12fund}^4 + U_{23fund}^4 + U_{31fund}^4}{(U_{12fund}^2 + U_{23fund}^2 + U_{31fund}^2)^2}$ | **Voltage unbalance**<br>$U_{fund}$ – first harmonic of phase-to-phase voltage |

## Current

| | |
|---|---|
| $I_{RMS} = \sqrt{\frac{\sum_{n=1}^{N} i_n^2}{N}}$ | **Phase current**<br>N – samples in averaging interval (up to 65 Hz) |
| $I_n = \sqrt{\frac{\sum_{n=1}^{N} (i_{1n} + i_{2n} + i_{3n})^2}{N}}$ | **Neutral current**<br>i – n sample of phase current (1, 2 or 3)<br>N – samples in averaging interval (up to 65 Hz) |

## Power

| | |
|---|---|
| $P_f = \frac{1}{N} \cdot \sum_{n=1}^{N} (u_{fn} \cdot i_{fn})$ | **Active power by phases**<br>N − a number of periods<br>n − index of sample in a period<br>f − phase designation |
| $P_t = P_1 + P_2 + P_3$ | **Total active power**<br>t − total power<br>1, 2, 3 − phase designation |
| $\mathrm{SignQ}_f(\varphi)$<br>$\varphi \in [0° - 180°] \Rightarrow \mathrm{SignQ}_f(\varphi) = +1$<br>$\varphi \in [180° - 360°] \Rightarrow \mathrm{SignQ}_f(\varphi) = -1$ | **Reactive power sign**<br>$Q_f$ – reactive power (by phases)<br>φ – power angle |
| $S_f = U_f \cdot I_f$ | **Apparent power by phases**<br>$U_f$ – phase voltage<br>$I_f$ – phase current |
| $S_t = S_1 + S_2 + S_3$ | **Total apparent power**<br>$S_t$ – apparent power by phases |
| $Q_f = \mathrm{SignQ}_f(\varphi) \cdot \sqrt{S_f^2 - P_f^2}$ | **Reactive power by phases**<br>$S_f$ – apparent power by phases<br>$P_f$ – active power by phases |
| $Q_f = \frac{1}{N} \cdot \sum_{n=1}^{N} \left( u_{fn} \times i_{f[n+N/4]} \right)$ | **Reactive power by phases (displacement method)**<br>N – a number of samples in a period<br>n – sample number (0 ≤ n ≤ N)<br>f – phase designation |
| $Q_t = Q_1 + Q_2 + Q_3$ | **Total reactive power**<br>$Q_t$ – reactive power by phases |
| $\varphi_s = \arctan 2(P_t, Q_t)$<br>$\varphi_s = [-180°, 179{,}99°]$ | **Total power angle**<br>$P_t$ – total active power<br>$Q_t$ – total reactive power |
| $PF = \frac{\lvert P \rvert}{S}$ | **Distortion power factor**<br>P – active power<br>S –apparent power |

## THD, TDD

| | |
|---|---|
| $$I_f THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} I_n^{\,2}}}{I_1} \cdot 100$$ | **Current THD**<br>$I_1$ – value of first harmonic<br>n – number of harmonic |
| $$U_f THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} U_{fn}^{\,2}}}{U_{f1}} \cdot 100$$ | **Phase voltage THD**<br>$U_1$ – value of first harmonic<br>n – number of harmonic |
| $$U_{ff} THD(\%) = \frac{\sqrt{\sum_{n=2}^{63} U_{ffn}^{\,2}}}{U_{ff1}} \cdot 100$$ | **Phase-to-phase voltage THD**<br>$U_1$ – value of first harmonic<br>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 |



**PE Ljubljana**
Stegne 21
SI-1000 , Ljubljana
Phone: + 386 1 513 10 00

**PE Kondenzatorji**
Vajdova ulica 71
SI-8333 , Semič
Phone: +386 7 38 49 200

**PE MIS**
Ljubljanska c. 24a
SI-4000 , Kranj
Phone: +386 4 237 21 12

**PE Baterije in potenciometri**
Šentvid pri Stični 108
SI-1296 , Šentvid pri Stični
Phone: +386 1 780 08 00

**PE Galvanotehnika**
Glinek 5
SI-1291 , Škofljica
Phone: +386 1 366 80 50

**Iskra IP, d.o.o.**
Metliška cesta 8
SI-8333 , Semič
Phone: +386 7 384 94 54

**Iskra Lotrič, d.o.o.**
Otoče 5a
SI-4244 , Podnart
Phone: +386 4 535 91 68

**Iskra ODM, d.o.o.**
Otoče 5a
4244 , Podnart
Phone: +386 4 237 21 96

**Iskra STIK, d.o.o.**
Ljubljanska cesta 24a
SI-4000 , Kranj
Phone: +386 4 237 22 33

**Iskra Tela L, d.o.o.**
Omladinska 66
78250 , Laktaši
Phone: +387 51 535 890

**Iskra Sistemi - M dooel**
Ul, Dame Gruev br. 16/5 kat
1000 , Skopje
Phone: +389 75 444 498

**Iskra Commerce, d.o.o.**
Hadži Nikole Živkoviča br. 2
11000 , Beograd
Phone: +381 11 328 10 41

**Iskra Hong Kong Ltd.**
33 Canton Road, T.S.T.
1705 , China HK City
Phone: +852 273 00 917
+852 273 01 020



Iskra®

**Iskra, d.o.o.**
Stegne 21
SI-1000 Ljubljana, Slovenia

Phone: +386 (0) 1 513 10 00
www.iskra.eu



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