ED2 SERIES

DEVICES

Communication, time synchronization and network redundancy protocols manual

Version 7.1.1.1 and higher

Version EKRASMS-SP 3.0.235.25913 and higher

EKRA.650321.080-01

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CAUTION

Do not turn on the device before reading this document!

The predefined users and default passwords are shown in Table 1.

Table 1 – Default user passwords

Default User	Login	Password
Administrator	admin	0100
Protection and control engineer	engineer	0200
Operator	operator	0300

NOTICE

In order to ensure information security, it is recommended to change the default passwords before operation start.

In case of password loss one shall inform the manufacturing enterprise.

Contents

Designations and abbreviations

ACD	–	activation information of directional protection
ACK	–	acknowledgment
ACSI	–	abstract communication server interface
ACT	–	protection activation information
APCI	–	application control information
APDU	–	application protocol data unit
ASDU	–	application service data unit
BCD	–	binary-coded decimal
BRCB	–	buffered report control block
CDC	–	common data class
COM	–	communications port
COT	–	cause of transmission
CU	–	communication unit
DCO	–	double command
DPC	–	double point controllable
DPS	–	double point status information
DUT	–	device under test
ENC	–	integer status controllable
ENS	–	integer status
FCB	–	frame count bit
FCD	–	functionally constrained data
FCDA	–	functionally constrained data attribute
GAPC	–	generic automatic process control
GGI	–	general group interrogation
GI	–	general interrogation
GIN	–	group identification number
GOOSE	–	generic object-oriented substation event
GSE	–	generic substation event
GSSE	–	generic substation state event
ICD	–	IED capability description
IED	–	intelligent electronic device
INF	–	information field
IPaddress	–	internet protocol-address
KOD	–	type of description
LCB	–	log control block
LEn	–	light edition

LPL	–	logical node name plate
MAC-address	–	media access control-address
MICS	–	model implementation conformance statement
MMS	–	Manufacturing message specification
MSV	–	multicast sampled value
MSVCB	–	multicast sampled value control block
MV	–	measured value
MX	–	measurand analogue value x
OPC	–	open platform communications
ORG	–	object reference setting
PDU	–	protocol data unit
PICS	–	protocol implementation conformance statement
PIXIT	–	protocol implementation conformance extra information for testing
PTP	–	precision time protocol
PTR	–	parallel redundancy protocol
RCB	–	report control block
RTU	–	remote terminal unit
S/E	–	select/execute
SBO	–	select before operate
SCL	–	substation automation system configuration language
SG	–	setting group
SGCB	–	setting group control block
SIQ	–	single-point information with quality descriptor
SNTP	–	simple network time protocol
SPI	–	single point information
SPS	–	single point status
ST	–	status information
SV	–	sampled values
SVC	–	sampled value control
SVCB	–	sampled value control block
TCP/IP	–	transmission control protocol/internet protocol
TICS	–	tissues implementation conformance statement
URCB	–	unbuffered report control block
USB	–	universal serial bus
USV	–	unicast sampled value
USVCB	–	unicast sampled value control block
UTC	–	coordinated universal time
VLAN	–	virtual local area nertwork

XCBR	–	circuit breaker
XSWI	–	switch
DCE	–	data circuit terminating equipment
AR	–	automatic reclosing
SCS	–	stability control system
PCS	–	process control system
SD	–	switching devices
CP	–	communication processor
EKRA RPE Ltd.	–	EKRA Research and Production Enterprise Ltd.
MU	–	merging unit
RAS	–	remedial action scheme
PC	–	personal computer
SW	–	software
RPA	–	relay protection and automation
SI	–	International System of Units
FP	–	functional processor

1 Introduction

1.1 Purpose of this manual

This manual contains a description of the used communication, time synchronization and network redundancy protocols in the ED2 series devices (hereinafter referred to as devices or ED2 series devices).

1.2 Target audience

This manual is intended for relay protection engineers, specialists in commissioning, testing and maintenance of protection, automation and control devices, operating personnel of electrical installations of power plants and substations.

1.3 Functionality and field of application of devices

1.3.1 The ED2 series devices are used at power plants and substations as:

– devices for protection and automation of station and substation equipment, generating units, including metal and oil and gas industry, as well as control and automation purposes;

– automation devices designed for creation of local remedial action scheme (local RAS), as well as emergency control of power generation units and power districts (SCS) of stations and substations;

– recording devices for installation in power stations and substations to register analog and logical signals in case of disturbances accompanying normal modes in the power system;

– control devices of circuit breaker and bay switching devices, interlocking, acquisition and processing of analog and binary information.

1.3.2 Device can be mounted in switchgears, cabinets or on panels and performs a standard set of protection, control and management functions, functions set can be changed in an individual project.

1.4 Related documentation

At different stages of the life cycle of the ED2 series devices, appropriate documentation may be required. The list and title of the documentation covering a certain life cycle (Figure 1):

– certification guide. The certification manual contains the entire list of current certificates and requirements that the ED2 series devices comply with;

– catalog of device types. The catalog of standard versions of devices contains all the necessary information for planning and purchasing. Contains a description of the functions and application of each specific device of the ED2 series;

– operation manual for a series of devices. The operation manual for a series of devices describes the basic principles of operation, actions for the operation and installation of devices of the ED2 series;

– operation manual for a specific device version. The operation manual for a specific version of the device contains basic information about the installation and mounting of the device, technical data, permissible values of inputs and outputs, conditions for preparing the device for operation;

– EKRASMS-SP software package manual. The manual for the software complex “EKRASMS-SP” describes the basic principles of working with the applied software of the ED2 series devices;

– Waves software manual. The manual for working with the Waves software contains complete information on working with disturbance records and their analysis;

– communication, time synchronization and network redundancy protocols manual. The communication, time synchronization and network redundancy protocol manual includes a description of communication protocols, time synchronization protocols and methods for organizing network redundancy in the ED2 series devices;

– Online materials and YouTube video tutorials. Online materials and video tutorials on YouTube, available around the clock on the Internet, describe the basic operations for working with application software, operation and operations with the functionality of devices.

Figure 1 – Use of documents at different stages of the life cycle for the ED2 series devices

1.5 Support

The service support center is available around the clock.

Manufacturer's website	https://ekra.ru/	
E-mail	support@ekra.ru	-
Software support page	http://soft.ekra.ru/smssp/en/downloads/software/	-
Operational documentation	http://soft.ekra.ru/smssp/en/downloads/documents/	
Video tutorials on working with ED2 series devices	https://www.youtube.com/playlist?list=PLSHLRtVG8WJeMyAaGOtNibkO_r2eyJimN	

1.6 Address of manufacturer

Address: STE 541, 3 Yakovlev prospect, Cheboksary, Chuvashia - Chuvash Republic, 428020, Russia.

E-mail: ekra@ekra.ru

ekra3@ekra.ru

1.7 Training

EKRA Training Center implements advanced training programs for products manufactured by EKRA Group and their applications at the facilities. Requests for training courses should be sent to:

Address: 3 Yakovlev Prospect, Cheboksary, Chuvashia – Chuvash Republic, 428020, Russia.

E-mail: training@ekra.ru

1.8 Safety

1.8.1 Warning

Warning signs are used throughout this manual to advise the user to be careful when performing certain operations to avoid personal injury and property damage.

DANGER failure to follow safety precautions will certainly result in death or serious injury

WARNING failure to follow safety precautions may result in death or serious injury

CAUTION failure to follow safety precautions may result in moderate or minor injury

NOTICE failure to follow safety precautions is not dangerous to life and health, but is fraught with other undesirable consequences, for example, losses

1.8.2 Instructions

This documentation contains instructions for setting up and working with the communication protocols, time synchronization protocols and the Ethernet redundancy protocols of this equipment. However, the documentation may not cover all possible situations. In case of questions or problems, you should not take any further action without obtaining the necessary permission from the manufacturer. In this case, in order to obtain the relevant information, it is necessary to send a corresponding request to the technical department of the manufacturer.

This document is not a complete guide to all safety precautions required when using the devices. However, it contains information that you should pay attention to in order to ensure your own safety, as well as in order to avoid material damage.

Personnel associated with this device must know the contents of this document.

Only professionally trained and instructed personnel may be allowed to work with the device. Qualified personnel are individuals who:

– are familiar with the configuration and operation of the communication protocols, time synchronization protocols and the Ethernet redundancy protocols of this equipment and systems with which it is connected;

– who are familiar with the methods of supplying voltage and disconnecting equipment adopted in the power system, and must also be authorized to perform these works;

– prepared for the use of protective equipment applied in accordance with the safety instructions;

– are trained in behavior in an extreme situation (first aid).

Improper handling of the device and non-observance of safety measures can be dangerous for the operating personnel.

Failure to observe the following precautions can result in death, serious injury to personnel and damage to property:

– the equipment must be grounded through the earth terminal before making any connections;

WARNING

Compliance with earthing requirements of the device is mandatory!

– all circuit components connected to the power source may carry hazardous voltages;

WARNING

Hazardous voltages are present on some parts of the device during operation!

– hazardous voltages may be present in the equipment even after the supply voltage has been removed (capacitors may still be charged);

WARNING

Hazardous voltages are present in some parts of the device when disconnecting the device!

– the operation of operating equipment with open secondary circuits of the current transformer is prohibited;

WARNING

The secondary circuits of current transformers on operating equipment must not be allowed to open!

1.8.3 The functional purpose, design and composition of the device's functions are reflected in the order code for the device.

1.8.4 For ordering information, refer to the version manual.

2 Integration of ED2 series devices into PCS

2.1 General

2.1.1 For communication with external devices, ED2 series devices, depending on the version, are provided with RS-485 and Ethernet interfaces.

The list of communication protocols and time synchronization protocols in the ED2 series devices via communication interfaces is given in the Table 2.

Table 2 – The list of communication protocols and time synchronization protocols via communication interfaces

Protocol	Communication interface			Time synchronization
	RS-485 [1)]	Ethernet	Service port Ethernet	
Modbus RTU	Master/Slave	–	–	+
Modbus TCP	–	Client/Server	Server	+
IEC 60870-5-103	Master/Slave	–	–	+
IEC 60870-5-104	–	Server		+
IEC 61850-8-1(MMS)	–	Server	–	–
IEC 61850-8-1 (GOOSE)	–	Publisher/Subscriber	–	–
IEC 61850-9-2LE	–	Subscriber	–	–
PTPv2[2)]	–	Client	–	+
SNTP[2)]	–	Client	–	+

[1)] Assignment of two or more communication protocols per one communication interface RS-485 is not allowed.

[2)] For time synchronization only.

2.1.2 When interacting with the PCS, depending on the version and settings of the device, the following can be provided:

– reading/recording of values in normal and emergency modes;

– transmission of current values of currents, voltages, power and frequency via protocols;

– transfer of disturbance records by protocols;

– data transfer from the internal event recorder to the PCS;

– time synchronization from the PCS common time server (receipt of a time stamp from the PCS);

– operation in a redundant Ethernet network;

– receiving and executing control commands from the PCS.

2.1.3 Devices can optionally have communication interfaces (communication ports) shown in the Table 3.

Table 3 – List of communication interfaces

Interface	Connector type
Ethernet[1)]	Optical: 100Base-FX (LC)
	Electrical: 10/100Base-TX (RJ-45)
RS-485	2 ports RS-485: Electrical
[1)] 2 slots for IEC 61850-9-2LE protocol if available, and up to 3 slots for other protocols.	

2.1.4 Communication interfaces support QoS (IEEE 802.1p) and VLAN (IEEE 802.1Q) mechanisms.

2.1.5 The devices can have at least four communication interfaces providing two parallel redundant PRP communication channels according to IEC 62439-3 for connection to the process bus and station bus.

The location of the communication and time synchronization interfaces of the device is given in Appendices A, B.

2.2 Tools for integration to PCS

The information exchange of devices in the PCS can be carried out in two ways (Figure 2):

– direct connection to devices;

– using an OPC server.

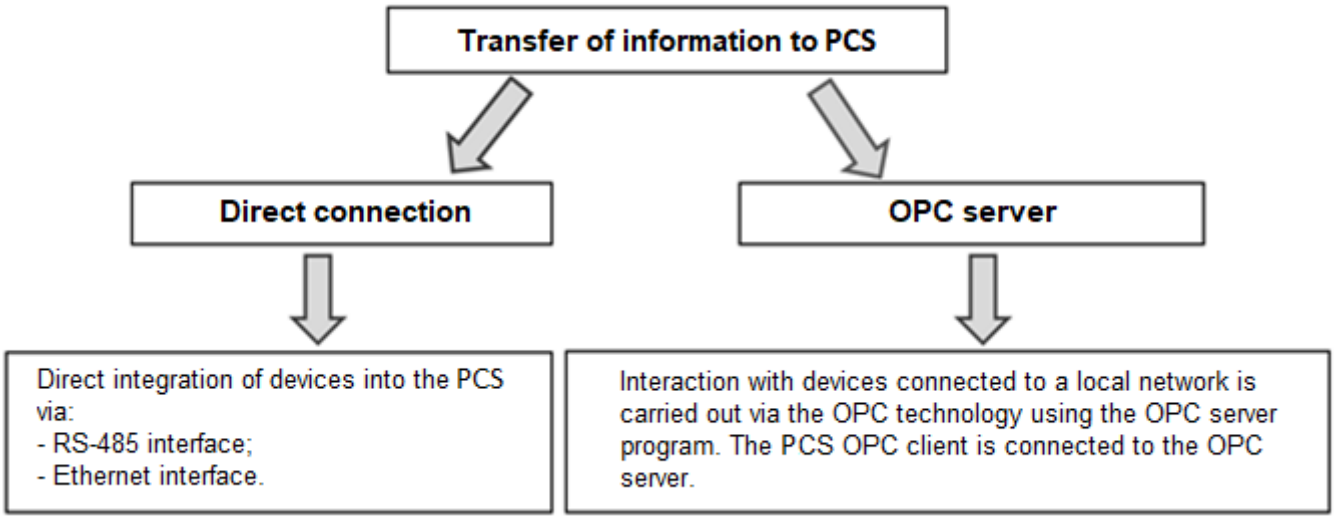


Figure 2 – Tools for integration to PCS

Examples of Smart Monitor connection and integration into PCS of devices are given in Appendix C.

2.2.1 Integration into PCS via RS-485 interface

2.2.1.1 Typical diagrams for integrating devices into the PCS via the RS-485 interface are shown in Figure 3, as well as in Appendix C. For integration, the RS-485-1 or RS-485-2 communication interface configured to operate in the Slave mode can be used. (Terminals for connecting the RS-485 interface of devices are given in Appendix B, Figure B.1).

2.2.1.2 The recommended number of devices in one RS-485 electrical circuit is no more than seven. Using repeaters, for example: MOXA TCC-120I, Advantech ADAM-4510-EE, the number of devices can be increased up to 28.

2.2.1.3 For a stable signal transmission, it is necessary to connect load resistors with a nominal value of 120 Ohm at 0.5 W to the endpoints of the RS-485 electrical network, thereby eliminating signal reflection from the “open” end of the cable. The communication modules also have an internal terminator (a resistor with a resistance equal to the characteristic impedance of the cable, connected to a cable with weakened resonant phenomena), which can be enabled or disabled using jumpers.

It is possible to connect a load resistance directly to the connector (see Figure B.1 of Appendix B).

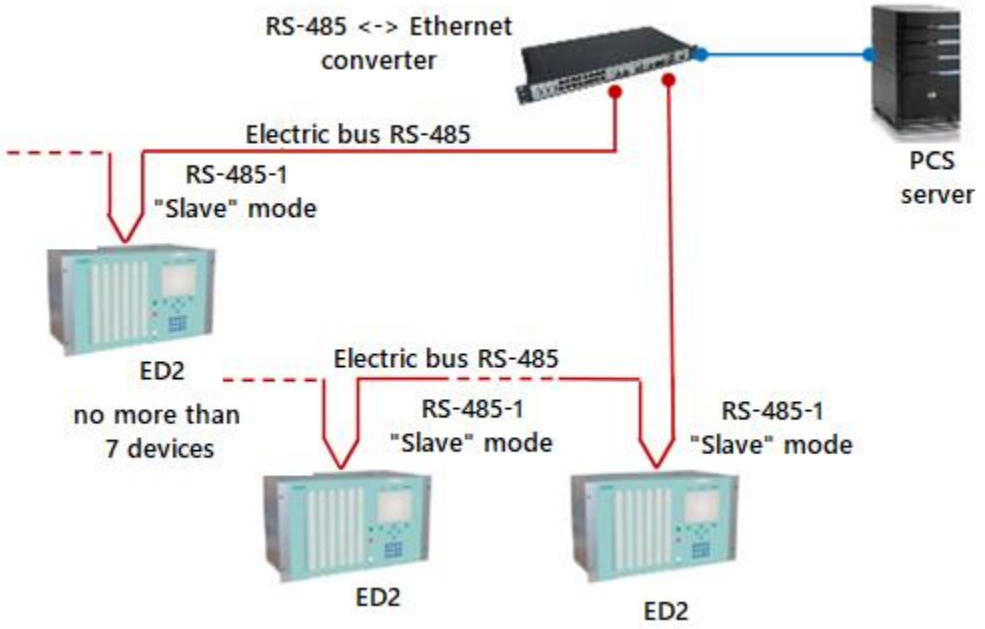


Figure 3 – A typical integration diagram of the device into the process control system via the RS-485 electrical interface. Combined network

2.2.1.4 The devices can be used as a data concentrator in the RS-485 network from devices that support the Modbus RTU protocol in “Slave” mode (see Figure 4). To do this, one of the communication interfaces, for example "RS-485-2", must be configured to work with the Modbus RTU protocol in the "Master" mode. Configuration is performed using the Configurator program included in the EKRASMS-SP software package, the description of which is given in the “EKRASMS-SP software package” manual.

A connection diagram of slave devices to the ED2 series control device is shown in Figure 4.

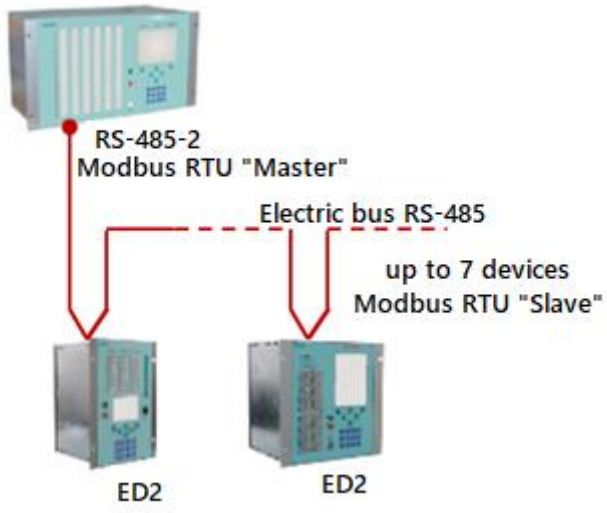


Figure 4 – Using the ED2 series device as a data concentrator in an RS-485 network

2.2.2 Integration into PCS via Ethernet interface

Connection to the network via the Ethernet interface can be performed both with redundancy (LinkBackup, PRP) and without redundancy.

2.2.2.1 A typical integration diagram of ED2 series devices into the process control system via the Ethernet interface is shown in Figure 5. Also, typical integration diagrams are given in Appendix C, Figures C.1, C.2, C.3.

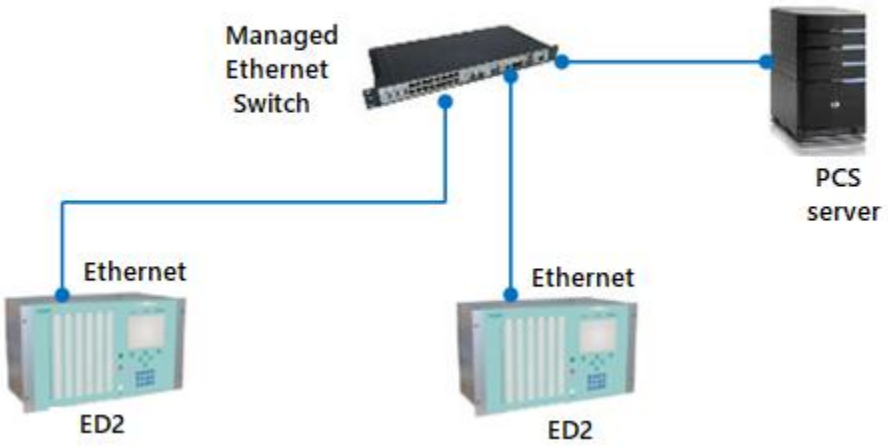


Figure 5 – A typical integration diagram of ED2 series devices into the process control system via the Ethernet interface. Star network

2.2.2.2 The devices can be used as a data concentrator in the Ethernet network from devices that support the Modbus TCP protocol in the "Server" mode. To do this, you must configure the Ethernet communication interface to work with the Modbus TCP protocol in the "Client" mode.

A connection diagram of slave devices to the ED2 series device of control unit is shown in Figure 6.

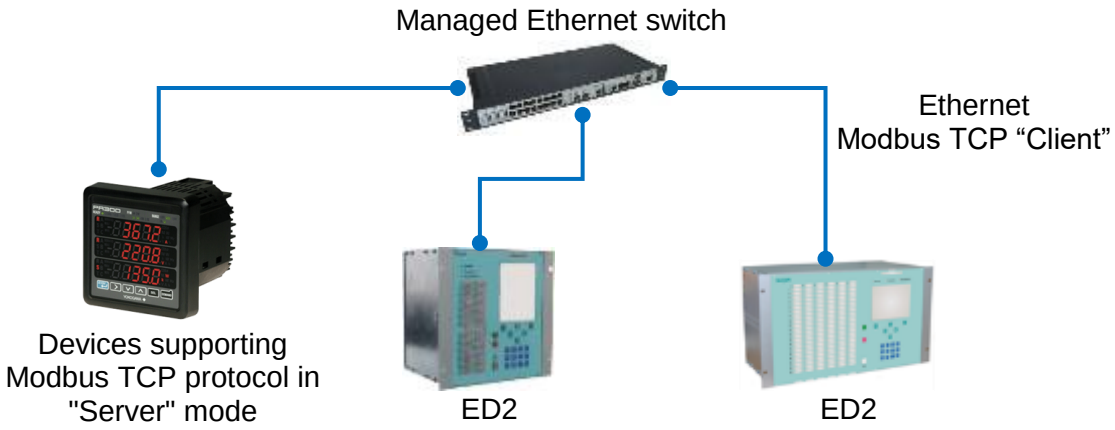


Figure 6 – Using the ED2 series device as a data concentrator in an Ethernet network

2.2.3 Integration via OPC server

The used OPC server is part of the EKRASCADA software package. Setting up the OPC server is described in the manual "EKRASCADA software package". An example of integration into the PCS through the OPC server is shown in Figure 7.

Note – When using an OPC server, a separate RS-485 bus is required to communicate with ED2 series devices.

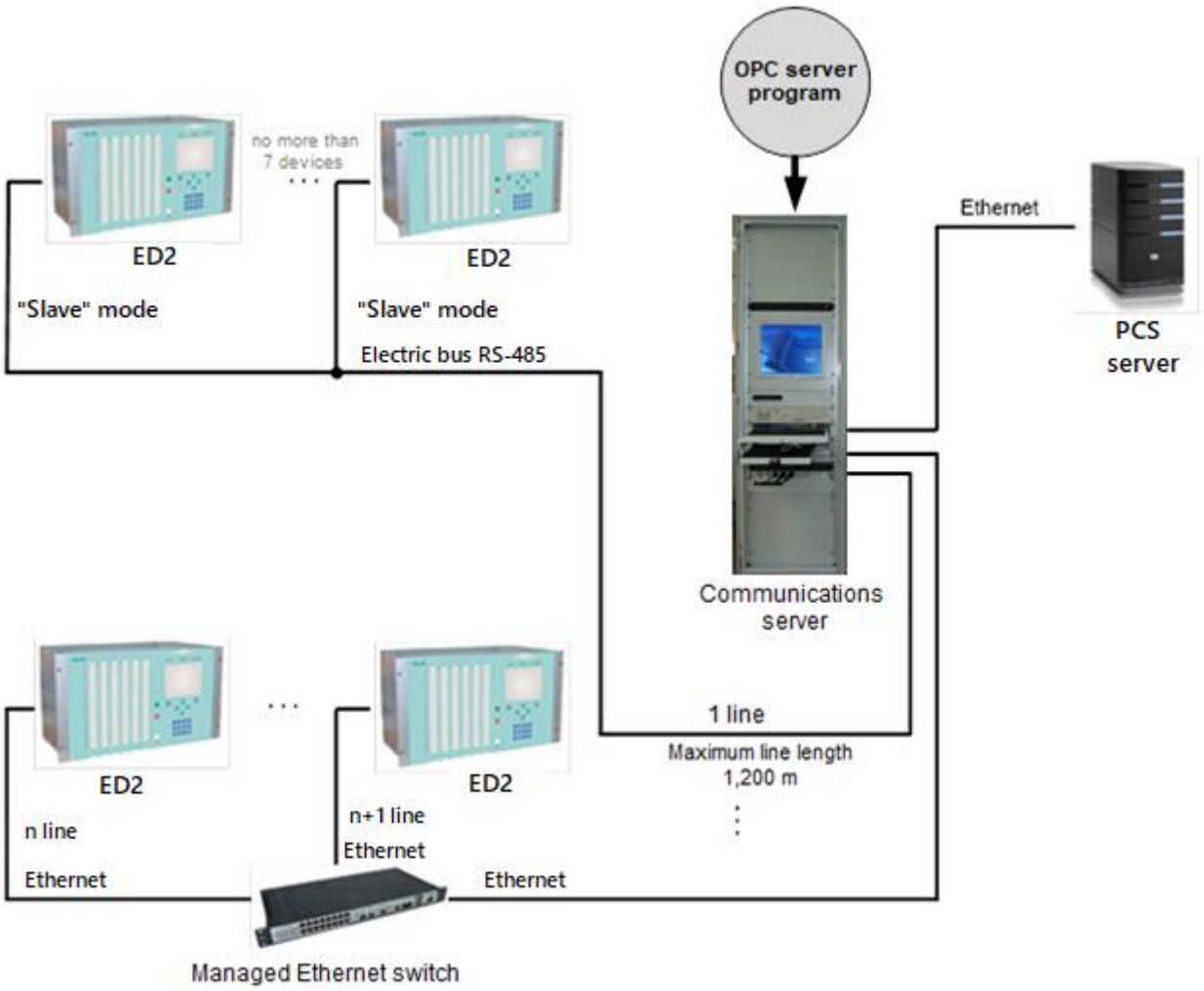


Figure 7 – An example of integration into the PCS using an OPC server

2.3 Communication interface settings

2.3.1 Interface RS-485

2.3.1.1 The list of all configurable parameters of the RS-485 interface, their description and editing tools are given in Table 4, the default parameters are given in Table 5.

Table 4 – Configurable parameters of the RS-485 interface

Parameter name	Editing tool	Description
IED network address	Configurator, Smart Monitor, device menu	Unique device address on one communication line (common parameter for all communication interfaces)
Port speed	Configurator, Smart Monitor, device menu	Data exchange speed. Possible values: 1,200; 2,400; 4,800; 9,600; 19,200; 38,400; 57,600; 115,200 bauds
Delay in symbols (Applicable only for Modbus RTU protocol)	Configurator, Smart Monitor	An integer from 0 to 8. Specifies the transmission delay between packets in symbols. The transmission time of one character is determined by the current baud rate, i.e. the value of the "Port speed" parameter. It is used to interface with slow systems

Parameter name	Editing tool	Description
Protocol	Configurator, Smart Monitor, device menu	Software data transfer protocol. Possible values are "No", Modbus RTU and IEC 60870-5-103. Assignment of two or more communication protocols per one communication interface is not allowed
Data bits	Configurator, Smart Monitor	The number of bits containing data. Possible values: 5 – 8 (Default set according to communication protocol)
Parity	Configurator, Smart Monitor	Parity control. Possible values: No, Odd, Even, Marker, Space[1)] (Default set according to communication protocol)
Stop bits	Configurator, Smart Monitor	The number of stop bits. Possible values: 1, 2 (Default set according to communication protocol)
[1)] A parity bit is added to the data bits to detect errors. Possible values: odd (Odd), even (Even) and additional: No, Marker, Space.		

Table 5 – Default parameters for Modbus RTU and IEC 60870-5-103 protocols

Parameter	Value
Port speed, baud	115,200
Data bits	8
Parity	No
Stop bits	1

2.3.2 Ethernet interface

2.3.2.1 The type of Ethernet interface (electrical or optical) is determined by the type of interface module installed in the device. Each interface module contains one or two Ethernet communication connectors.

2.3.2.2 A device with an electrical Ethernet interface has an RJ-45 connector. Modification of the device with an optical Ethernet interface has an LC-type connector (see Figure B.4, Appendix B). The device may be able to support network redundancy using PRP protocols and LinkBackup technology (depending on the configuration).

The list of all configurable parameters of the Ethernet interface, their description and editing tools are given in Table 6.

Table 6 – Configurable Ethernet interface parameters

Parameter name	Editing tool	Description
Parameters of TCP/IP		
IP-address	Configurator, Smart Monitor, device menu	Unique address of ED2 series device in Ethernet LAN
Mask	Configurator, Smart Monitor, device menu	Subnet mask
Gateway	Configurator, Smart Monitor, device menu	Gateway IP address on the Ethernet LAN
Connection availability check parameters		

Parameter name	Editing tool	Description
Check period, s	Configurator, Smart Monitor	Line downtime, after which connection check starts (in seconds)
Delay between packets,s	Configurator, Smart Monitor	Time between sending service packets in seconds
Packet transmission interval, s	Configurator, Smart Monitor	Service packet send time (in seconds)
Parameters of TCP requests		
Maximum time between TCP request and response, ms	Configurator, Smart Monitor	Maximum time between TCP request and responsein milliseconds
Minimum time between TCP request and response, ms	Configurator, Smart Monitor	Minimum time between TCP request and response in milliseconds
Time of repeated TCP requests, ms	Configurator, Smart Monitor	Time of repeated TCP requests in the absence of TCP responses in milliseconds

2.3.2.3 The Ethernet communication interface can be configured to work with one or more data transfer protocols at the same time (see Table 2).

2.4 Signal testing in PCS

There are manual and automatic modes for signal testing (see 2.4.2 and 2.4.3 respectively).

The manual test mode, unlike the automatic mode, is more reliable, it allows you to check a specific signal independently of others. Before testing, it is recommended to reset the states of all matrix inputs to logical zero in order to avoid errors when comparing signals in the device and in the PCS.

When testing in automatic mode, the sequential output of signals one after another is performed. This test is performed in the case when it is necessary to complete the testing with a minimum amount of time.

Note – In manual mode, the setting of signals and the correct display testing is carried out by the user. In automatic mode, the user's task is only to check the order of appearance, removal of signals in the PCS, as well as skipping signals in the PCS.

2.4.1 Preparing for testing

2.4.1.1 Before starting the Smart Monitor program, you must connect the device to the PC using an RS485 or Ethernet network (the PC and the device must be on the same subnet, respectively), or directly using an Ethernet and connect (in accordance with the "EKRASMS-SP software package" manual)

Without user authentication, the use of the program is limited. The description of the authentication procedure is given in the "EKRASMS-SP software package" manual.

NOTICE

IN ORDER TO AVOID THE DEVICE'S ACTION IN EXTERNAL CIRCUITS, IT IS RECOMMENDED TO SWITCH THE DEVICE TO THE "OFF" STATE!

2.4.1.2 Switching the device to the "OFF" state

The IED installed in the cabinet is taken out of operation by applying voltage to the binary input "OFF". The device of the ED2 series, supplied as a stand-alone device, is disabled by external means of controlling the device's operation mode, connected to the "ON" and "OFF " inputs of the device. If it is not possible to disable the device, take measures to exclude the device excitation of external circuits.

2.4.1.2.1 A sign that the device is in the "Emulation" state is the absence of the green glow of the "READY" LED and the presence of the red glow of the "ERROR" LED in the upper part of the front panel of the device, as well as on the device display in the menu item **Diagnostics** → **IED state** in the line “EMULATION“ is set to “ON”. Entering and escaping this status is implemented only via EKRASMS-SP software.

2.4.1.3 In the "tree" of the Smart Monitor program project, select the menu item **Tests** → **Emulation of matrix inputs** (see Figure 8, designation 1), by clicking once with the left mouse button on the corresponding item in the "tree" of the project, and open the window.

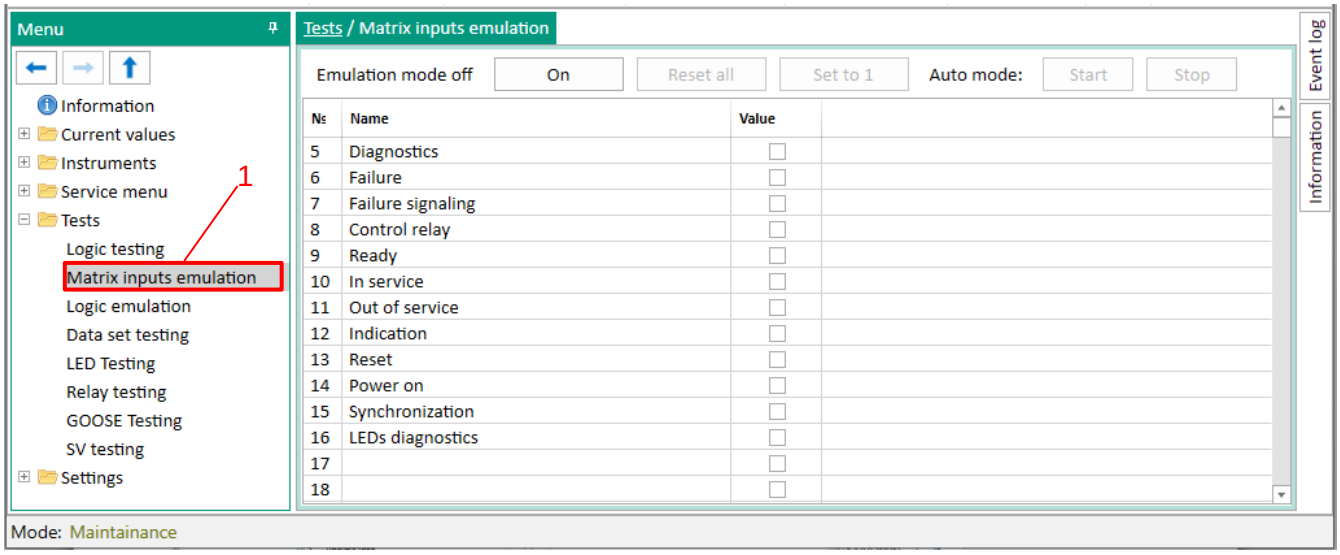


Figure 8 – **Emulation of matrix inputs** window

2.4.2 Manual signal control

2.4.2.1 Turn on the matrix inputs emulation mode by pressing the **On** button (see Figure 9, designation 1).

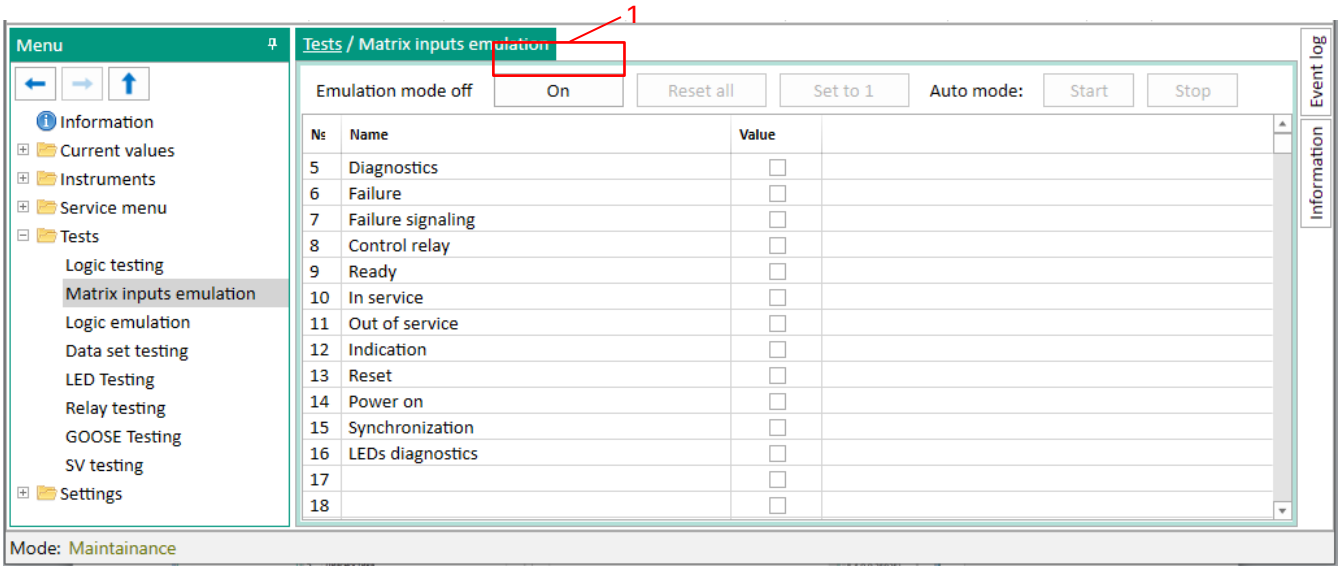


Figure 9 – Enable emulation mode

2.4.2.2 Reset all matrix inputs by pressing the **Reset All** button (see Figure 10, designation 1).

2.4.2.3 Set the signal on the matrix input panel (see Figure 10, designation 2). For example, (No. 5) Diagnostics (see Figure 10, designation 3).

2.4.2.4 Check the read signal in the PCS, that is, check the identity of the signals using means of communication or verbal communication.

2.4.2.5 Pick up a signal in the Smart Monitor

2.4.2.6 Check the picked-up signal, making sure that it has disappeared in the PCS.

2.4.2.7 Do for all signals the actions described in 2.4.2.1 – 2.4.2.6.

2.4.2.8 Disable the matrix input emulation mode by pressing the **Disable** button (see Figure 10, designation 4).

2.4.2.9 Switch the device to “ON” mode.

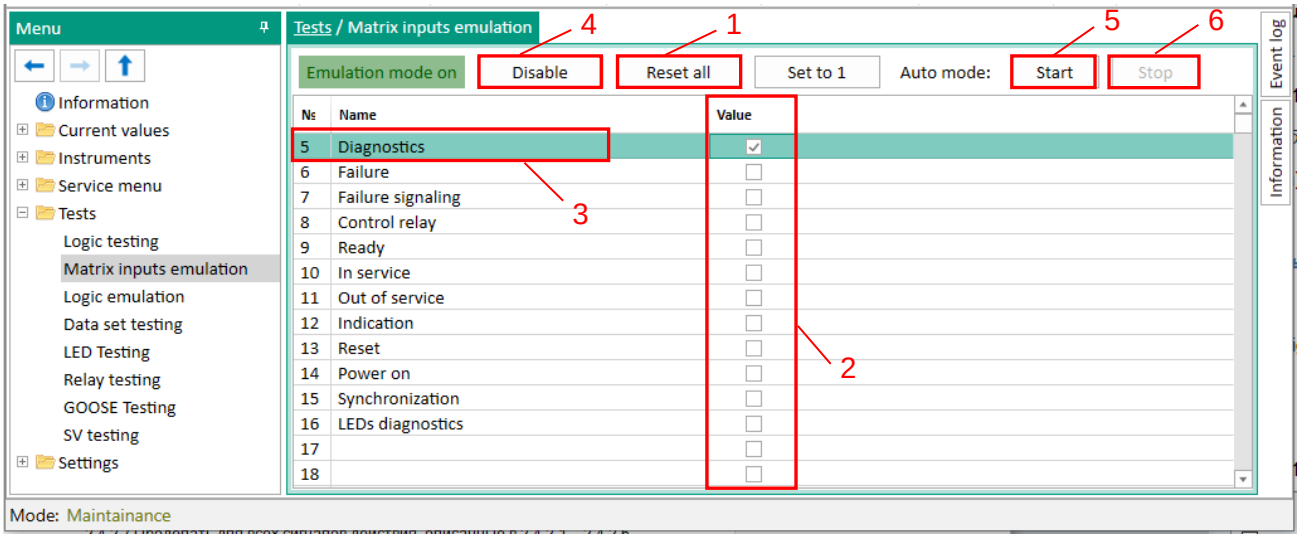


Figure 10 – Emulation of matrix inputs

2.4.3 Automatic signal control mode

Automatic control mode is performed using the buttons on the toolbar:

– **Start** (see Figure 10, designation 5);

– **Stop** (see Figure 10, designation 6).

In this mode, the signals are transmitted sequentially (each signal is set to 1 s, the pause between signals is 1 s).

2.4.3.1 Turn on the matrix inputs emulation mode by pressing the **Enable** button (see Figure 9, designation 1).

2.4.3.2 Enable auto-emulation by pressing the **Start** button (see Figure 10, designation 5).

2.4.3.3 Wait for the check to complete. The check is considered completed if it has passed the entire sequence of read signals.

2.4.3.1 Check the sequence of signals in the PCS with the sequence of changes in the state of the signals recorded in the device event recorder.

2.4.3.1.1 For operating with the event recorder in the Smart Monitor program, move to the menu item **Tools** → **Event recorder** (see Figure 11, designation 1).

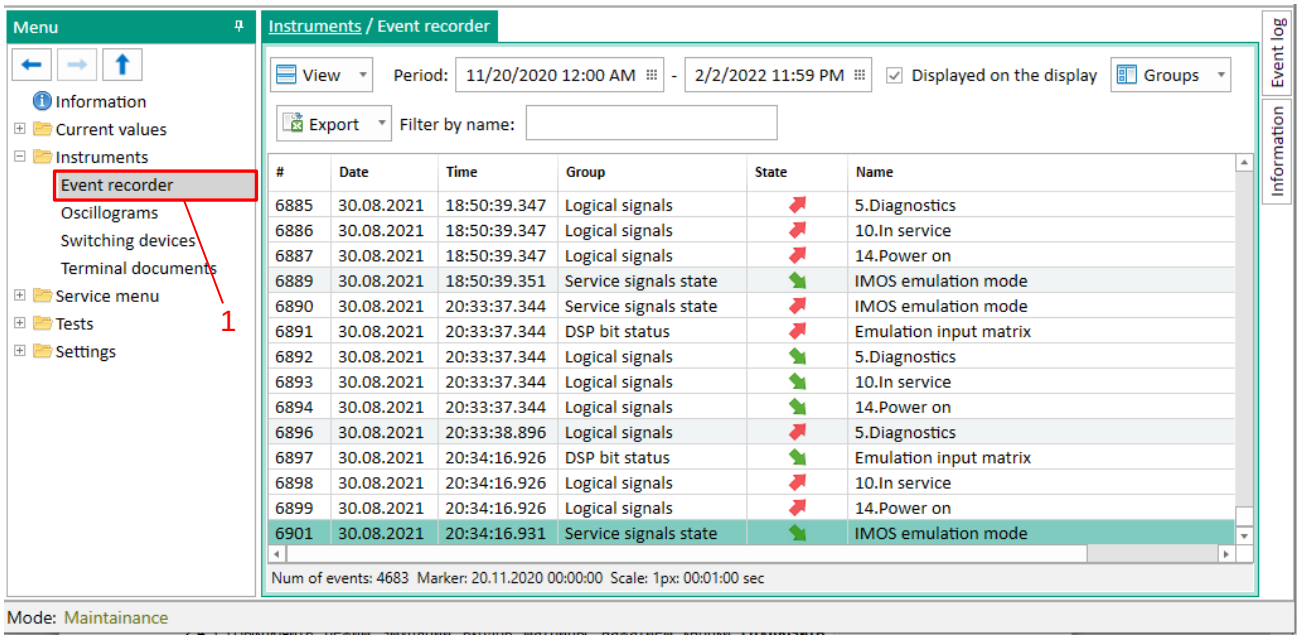


Figure 11 – **Event recorder** window

2.4.3.1.2 The list of signals is updated at a certain time interval corresponding to the time delays in the order of their location in the configuration. Each signal is set to 1 s, the pause between signals is 1 s.

2.4.3.2 Disable auto-emulation by pressing the **Stop** button (see Figure 10, designation 6).

2.4.3.3 Disable the matrix input emulation mode by pressing the **Disable** button (see Figure 10, designation 1).

2.4.3.4 Switch the device to “ON” mode.

2.4.4 Troubleshooting

In case of unsuccessful manual or automatic emulation, the actions listed in Table 7, should be taken.

Table 7 – Cases of unsuccessful manual or automatic emulation

Error	Required actions
Absence of all signals in PCS	1) Check the physical connection between the device and the process control system. 2) Check the settings of the communication protocol in the device or in the PCS (which is used to interact with the PCS).
Absence of some signals or wrong order of signals in PCS	If there are discrepancies, bring them into line with the description of the signals in the PCS

2.5 Formation of a list of signals for integration into PCS

The formation of a list of signals available via communication protocols for their integration into the PCS is carried out using the Smart Monitor or Configurator programs.

2.5.1 Formation of a list of signals using the Smart Monitor program

2.5.1.1 Preparing for setup

Launch the Smart Monitor program in the same way as 2.4.1.1.

2.5.1.2 Formation of signals list

NOTICE

IN CASE OF CHANGING THE PROJECT (ADDING PROTECTIONS, CHANGING THE LOGICAL PART), SIGNAL ADDRESSES MAY CHANGE!

2.5.1.2.1 To form a list of binary and analog device measurements available via communication protocols, you need to create an appropriate report. Microsoft Excel is required to form and view the report.

Note – Forming a list of signals is possible only if the corresponding protocol is available in the device configuration.

2.5.1.2.2 To form a list of signals, select the main menu item **Reports** (see Figure 12, designation 1).

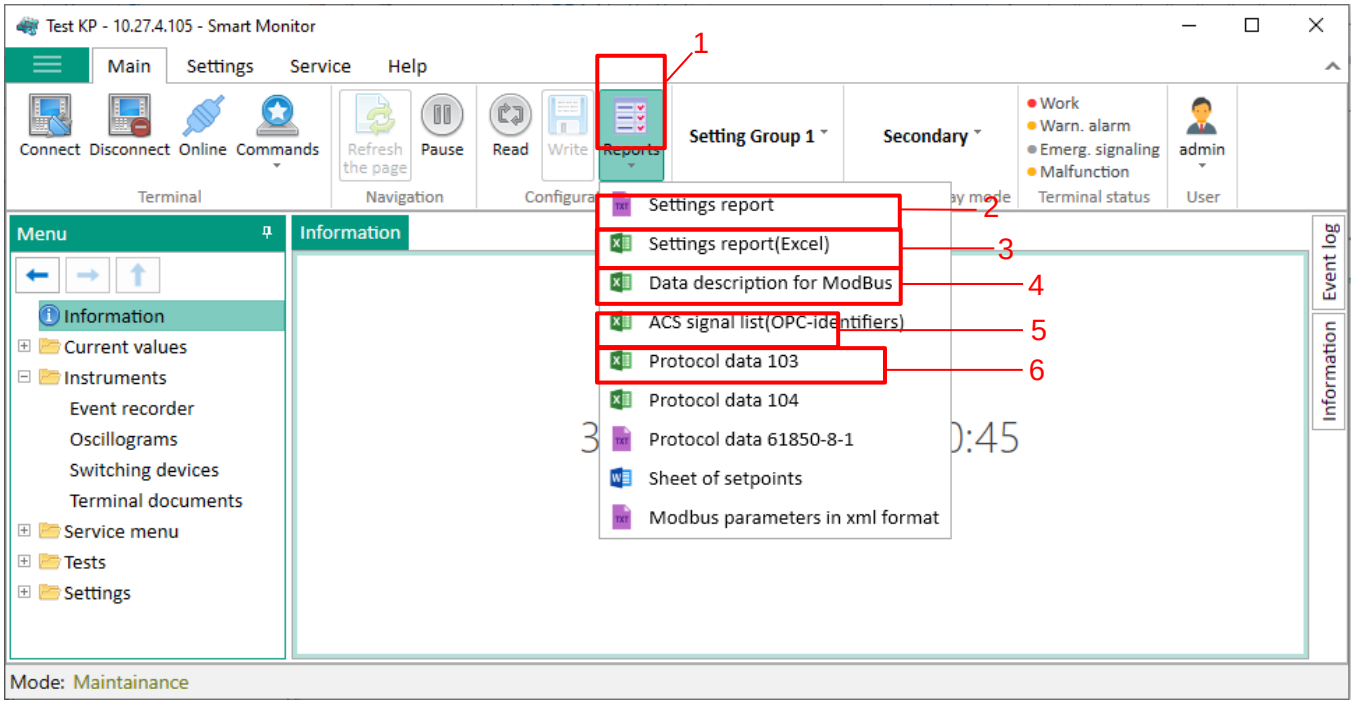


Figure 12 – Menu **Reports**

2.5.1.3 To form a list of signals, you should select a protocol:

– Modbus protocol. In the main menu, select the menu item **Reports** → **Modbus data description** (see Figure 12, designation 2);

– OPC protocol. In the main menu, select the menu item **Reports** → **List of signals in PCS (OPC identifier)** (see Figure 12, designation 3);

– protocol according to IEC 60870-5-103. In the main menu, select the **Reports** → **IEC 60870-5-103 protocol data** (see Figure 12, designation 4);

– protocol according to IEC 60870-5-104. In the main menu, select the **Reports** → **IEC 60870-5-104 protocol data** (see Figure 12, designation 5);

– IEC 61850-8-1 protocol. In the main menu, select the **Reports** → **IEC 61850-8-1 protocol data** (see Figure 12, designation 6).

If you select the IEC 61850-8-1 protocol, the **Save As** dialog box will appear (see Figure 13). Select the folder where you want to save the signal lists file, then click the **Save** button (see Figure 13, designation 1) After that the file in *.xml format will be saved.

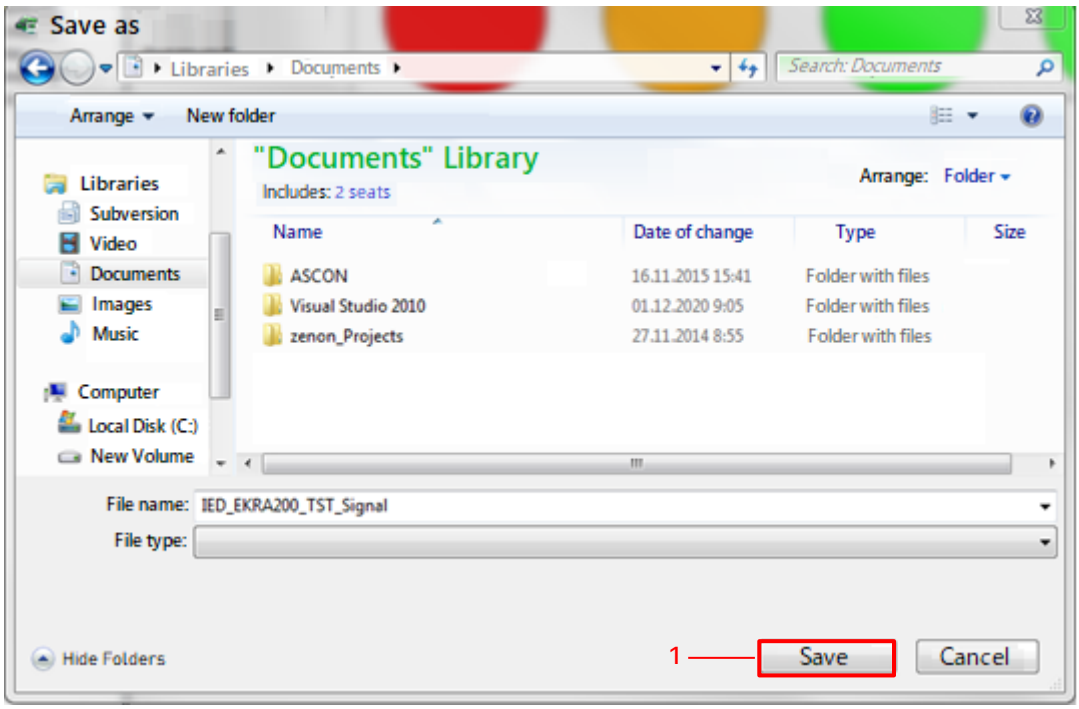


Figure 13 – Saving a file

2.5.1.3.1 It is preferable to familiarize with this file using the Microsoft Excel program, to do so one needs to launch the Excel program, select **File** → **Open** in the main menu (see Figure 14, designation 1) and find the desired *.xml file in the pop-up window, select it and click the **Open** button (see Figure 15, designation 1). After that, the XML-doc will be opened in Excel (see Figure 16).

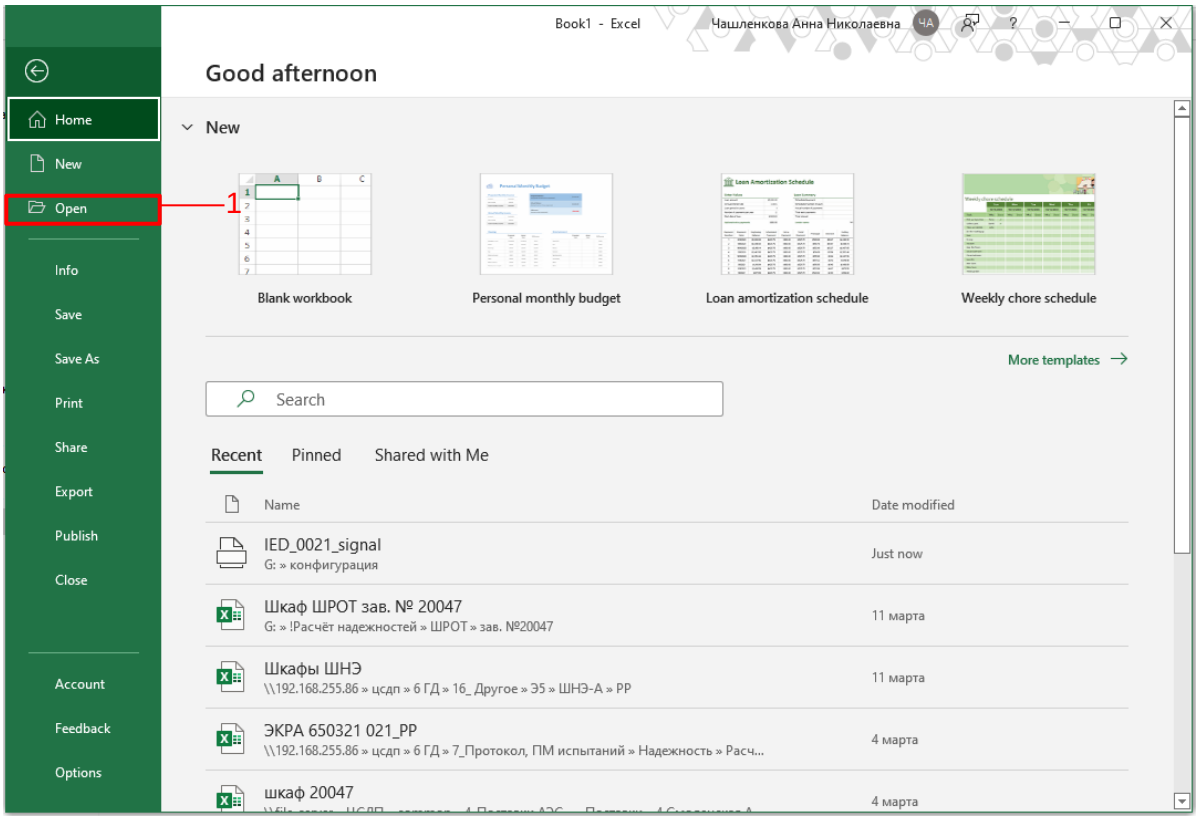


Figure 14 – Opening a file

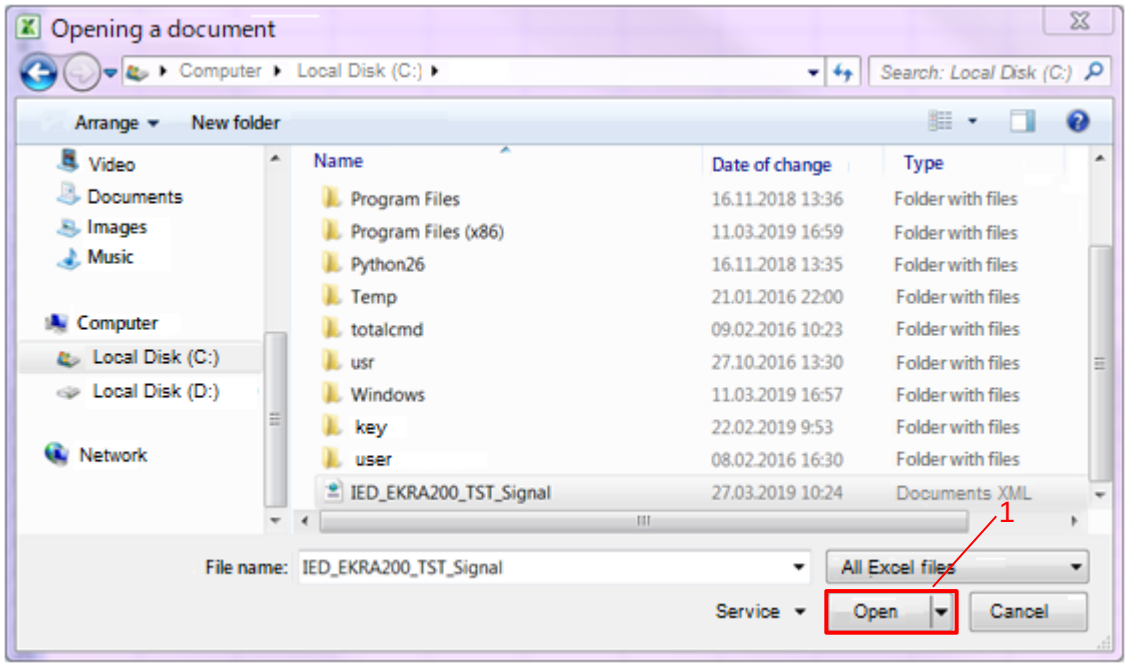


Figure 15 – Opening a document

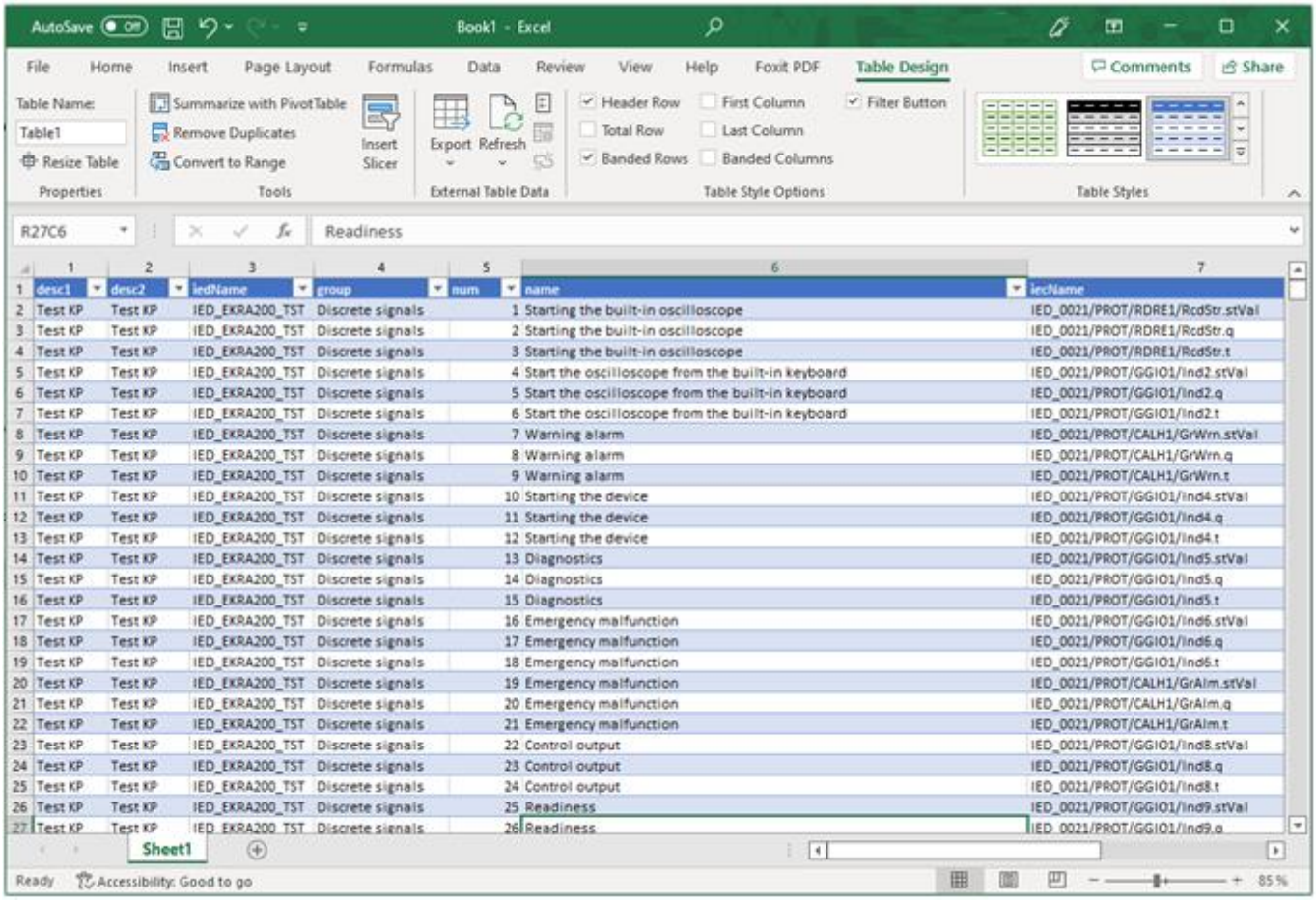


Figure 16 – Excel document

Opening the file is also possible with an internet browser or text editor. To do this, one should right-click on the file, in the pop-up window (see Figure 17, designation 1) select **Open with** and select the desired method for opening the file.

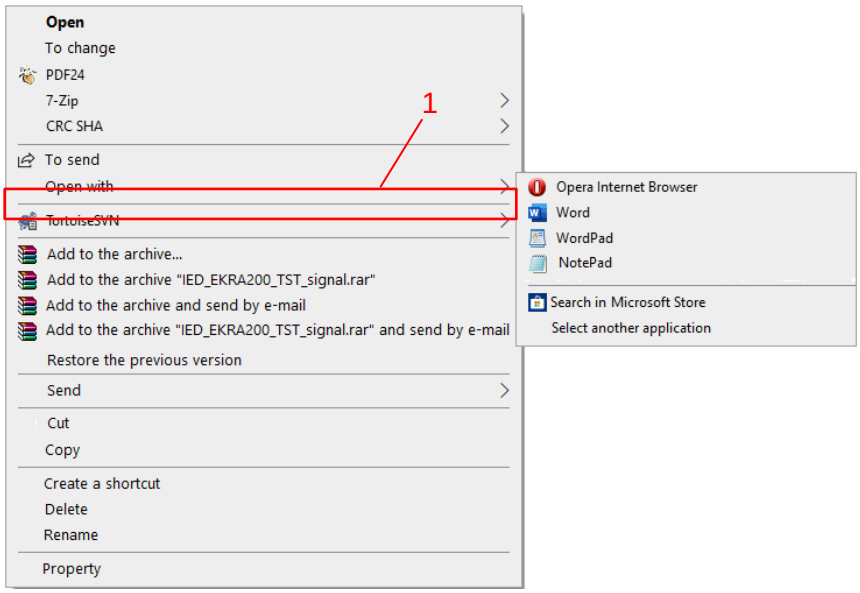
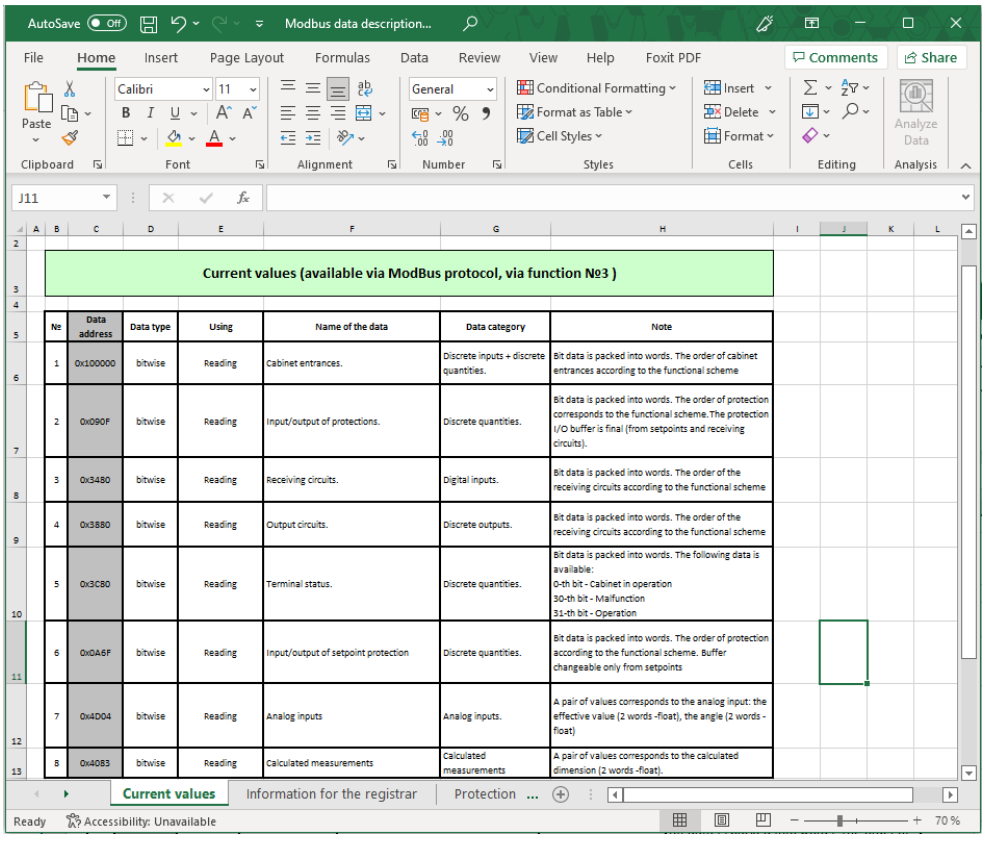


Figure 17 – Opening a document

2.5.1.4 When other protocols are selected, after (10 – 15) seconds, an *.xls file containing a list of signals will be generated and automatically opened in Microsoft Excel (see Figure 18).



№	Data address	Data type	Using	Name of the data	Data category	Note
1	0x100000	bitwise	Reading	Cabinet entrances.	Discrete inputs + discrete quantities.	Bit data is packed into words. The order of cabinet entrances according to the functional scheme
2	0x090F	bitwise	Reading	Input/output of protections.	Discrete quantities.	Bit data is packed into words. The order of protection corresponds to the functional scheme. The protection I/O buffer is final (from setpoints and receiving circuits).
3	0x3480	bitwise	Reading	Receiving circuits.	Digital inputs.	Bit data is packed into words. The order of the receiving circuits according to the functional scheme
4	0x3880	bitwise	Reading	Output circuits.	Discrete outputs.	Bit data is packed into words. The order of the receiving circuits according to the functional scheme
5	0x3C80	bitwise	Reading	Terminal status.	Discrete quantities.	Bit data is packed into words. The following data is available: 0-th bit - Cabinet in operation 30-th bit - Malfunction 31-th bit - Operation
6	0x0A6F	bitwise	Reading	Input/output of setpoint protection	Discrete quantities.	Bit data is packed into words. The order of protection according to the functional scheme. Buffer changeable only from setpoints
7	0x4D04	bitwise	Reading	Analog inputs	Analog inputs.	A pair of values corresponds to the analog input: the effective value (2 words -float), the angle (2 words - float)
8	0x4083	bitwise	Reading	Calculated measurements	Calculated measurements	A pair of values corresponds to the calculated dimension (2 words -float).

Figure 18 – Excel doc

2.5.1.4.1 Save the opened *.xls file.

In the main menu of the Microsoft Excel program, select **File** → **Save As** (see Figure 14, designation 2). You should select the folder where you want to save the file, then click the **Save** button (see Figure 19, designation 1).

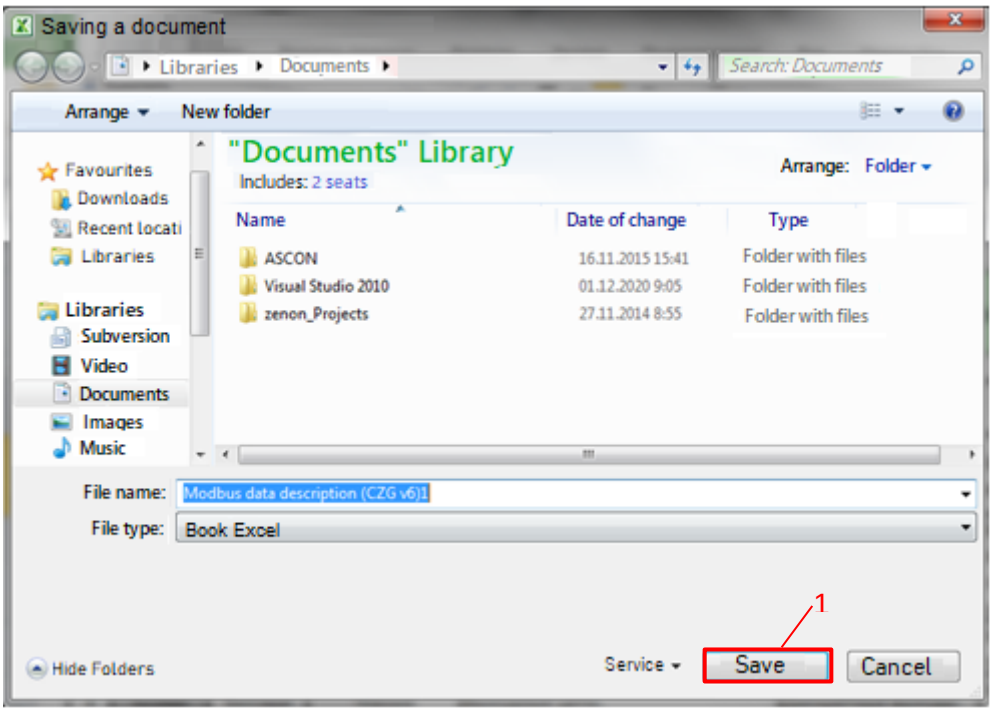


Figure 19 – Saving an Excel document

2.5.1.5 Saving the exported SCL file

The *.cid format SCL file describes the device data structure in terms of the IEC 61850-8-1 standard. This file is used to integrate the device into the PCS.

2.5.1.5.1 In the main menu of the Smart Monitor program, select the item → **Export SCL file** (see Figure 20, designation 1)

Figure 20 – Export SCL file

2.5.1.5.2 In the opened window select a location to save the file and click the **Save** button (see Figure 21, designation 1).

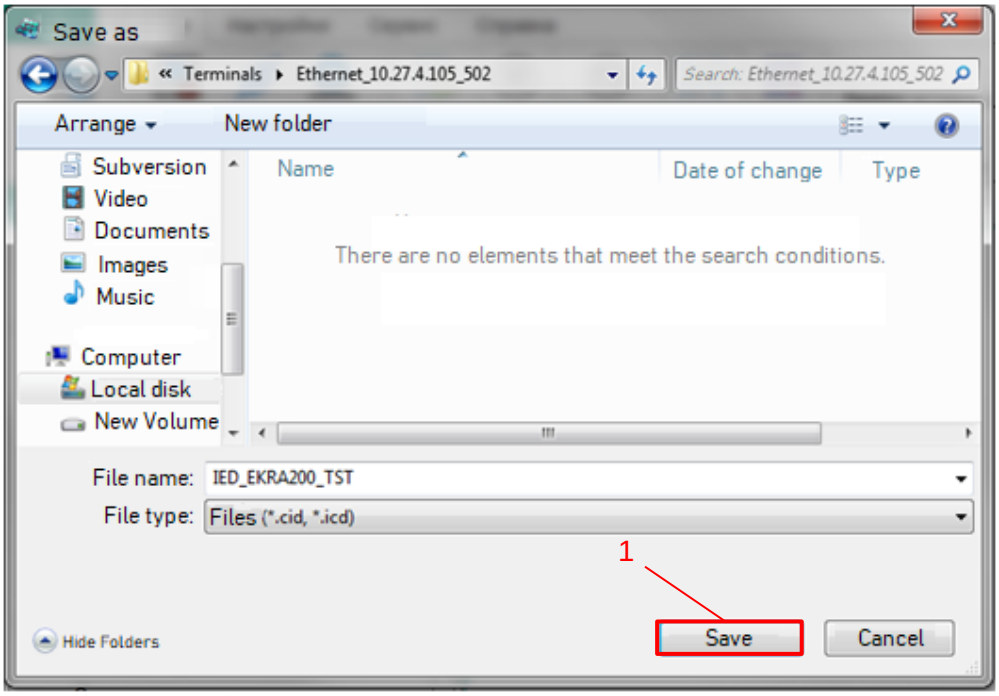


Figure 21 – Saving the exported SCL file

2.5.1.5.3 Saving the SCL file is complete.

2.5.2 Forming a list of signals using the Configurator program

2.5.2.1 Launch the Configurator program

Run the Configurator program and open the device configuration (file *.arh format) (in accordance with the manual "EKRASMS-SP software package").

Note – The procedure for saving the configuration file from the device is described in the manual "EKRASMS-SP software package".

2.5.2.2 Formation of signals list

NOTICE

IN THE CASE OF CHANGING THE PROJECT (ADDING PROTECTIONS, CHANGING THE LOGICAL PART), SIGNAL ADDRESSES MAY CHANGE!

2.5.2.2.1 To form a list of binary signals and analog device measurements available via communication protocols, you must create a corresponding report. In order to form a report Microsoft Excel is required.

Note – Forming a list of signals is possible only if the corresponding protocol is available in the device configuration.

2.5.2.2.2 To form a list of signals, select the main menu item **Service** → **Reports** (see Figure 22).

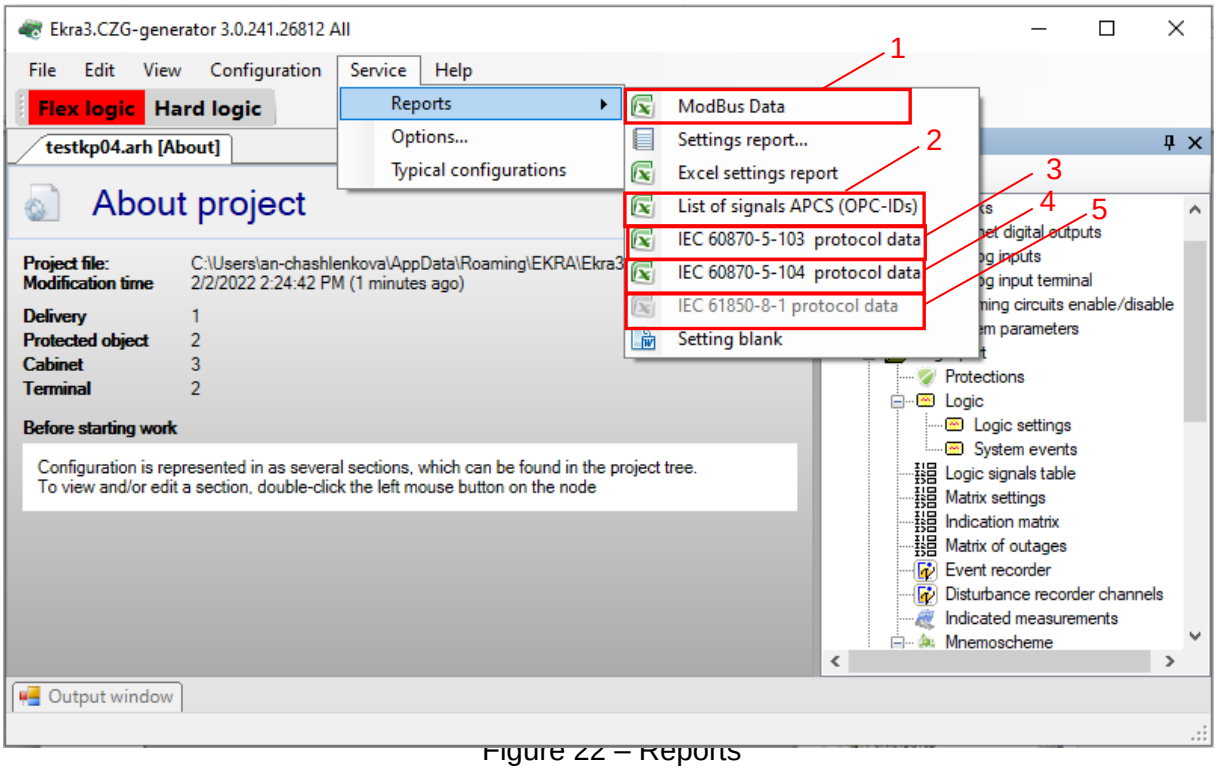


Figure 22 – Reports

2.5.2.3 To form a list of signals, select the required protocol:

– Modbus protocol. In the main menu, select **Service** → **Reports** → **Modbus data description** (see Figure 22, designation 1);

– OPC protocol. In the main menu, select **Service** → **Reports** → **List of signals APCS (OPC-IDs)** (see Figure 22, designation 2);

– protocol according to IEC 60870-5-103. In the main menu, select **Service** → **Reports** → **IEC 60870-5-103 protocol data** (see Figure 22, designation 3);

– protocol according to IEC 60870-5-104. In the main menu, select **Service** → **Reports** → **IEC 60870-5-104 protocol data** (see Figure 22, designation 4);

– IEC 61850-8-1 protocol. In the main menu, select **Service** → **Reports** → **IEC 61850-8-1 protocol data** (see Figure 22, designation 5).

2.5.2.4 The procedure for formating a signal list file when selecting the IEC 61850-8-1 protocol is similar to the procedure given in 0.

One should select a previously saved SCL file and click the **Open** (see Figure 23, designation 1). Then, after (10 – 15) seconds, an *.xls file containing a list of signals will be generated and automatically opened in Microsoft Excel (see Figure 24).

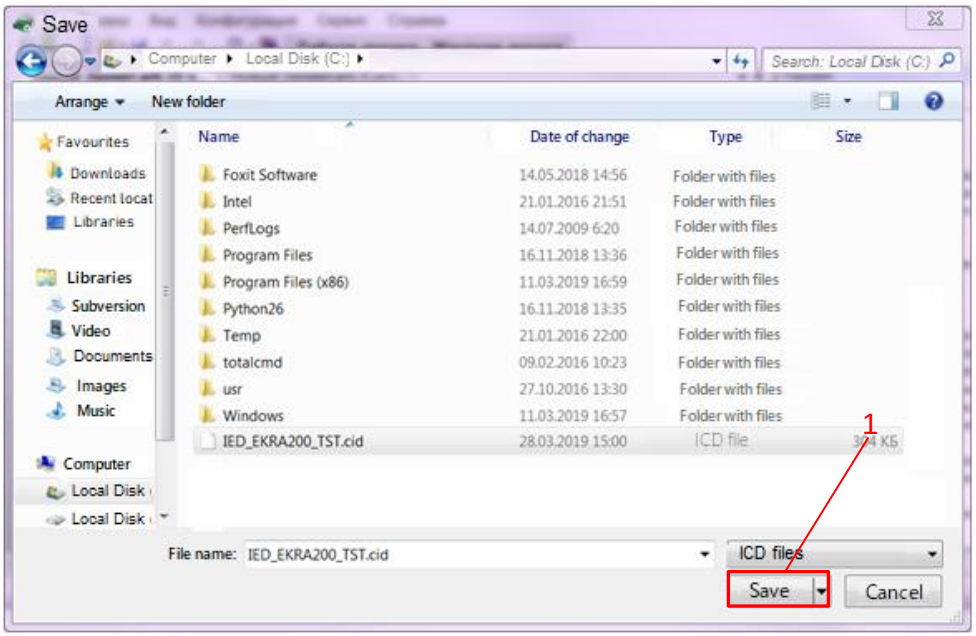


Figure 23 – File saving

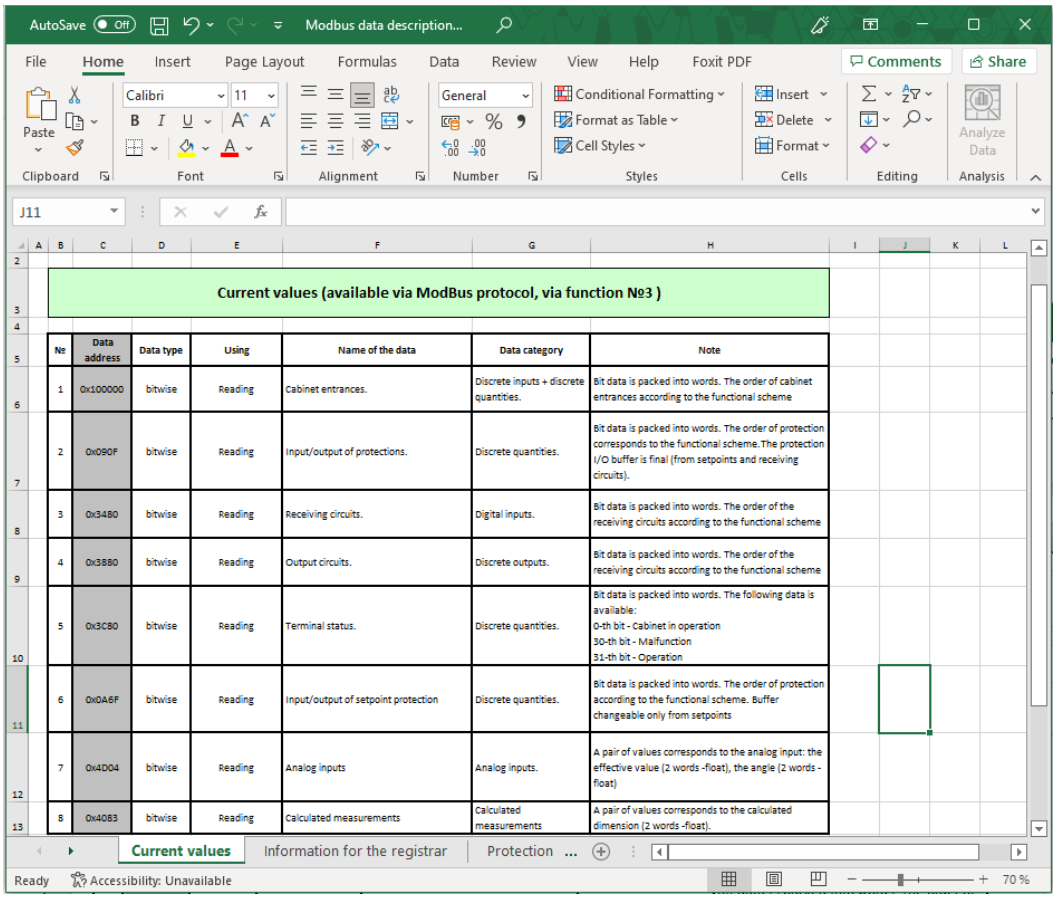


Figure 24 – Excel document

2.5.2.5 When choosing other protocols, the procedure is similar to 2.5.1.4.

2.5.2.6 Save the opened *.xls file (see 2.5.1.4.1).

3 IEC 60870-5-103 protocol

3.1 General

The IEC 60870-5-103 protocol is intended for data transmission between intelligent electronic devices (IED), namely relay protection equipment and control system devices.

3.1.1 Purpose of the protocol

The ED2 series devices use the protocol to receive digital and analog data values, to control switching devices, and to download disturbance records from the device.

The Data Communication Equipment (DCE) of the device can be implemented as either a fiber optic or a wired copper transmission system. The transmission system should comply with the EIA-485 (RS-485) standard. According to the EIA – 485 (RS-485) standard, a maximum of 32 load units can be connected to one physical line.

3.1.2 Connection and communication parameters

Connection to the device according to the IEC 60870-5-103 protocol is performed via the RS-485 interface. Parameters of communication are provided in Table 8.

Table 8 − Communication parameters

Parameter	Value
Baud rate	9,600 bauds or 19,200 bauds[1)]
Data bits	8
Parity	even
Bit stop	1
[1)] The baud rate can be increased up to 115.2 kbaud, provided that all devices on the network support this baud rate. Note – Editing the baud rate can be done through the device menu **Editor -> System parameters -> Communication parameters.**	

3.1.3 Address setting

Each ED2 series device should have a unique identifier on the communication line being used – the device address. This address must be unique within a given network of connected devices. Duplicate address causes a collision. The device address is altered within the range from 1 to 254. The value 255 is reserved as a global address.

The device address can be edited via the device menu item **Parameters -> System parameters -> Communication parameters**.

3.2 Supported functions according to IEC 60870-5-103 protocol

3.2.1 List of protocol application functions

The list of application functions supported by ED2 series devices, operating via IEC 60870-5-103 protocol, is shown in Table 9.

Table 9 – List of protocol application functions

Protocol function		Supported by the ED2 series device	Note
1	Initialization (reset)	Yes	cl. 7.4.1 IEC 60870-5-103
2	Time synchronization	Yes	cl. 7.4.2 IEC 60870-5-103
3	General interrogation	Yes	cl. 7.4.3 IEC 60870-5-103
4	Command transmission	Yes	cl. 7.4.4 IEC 60870-5-103
5	Test mode	No	cl. 7.4.5 IEC 60870-5-103
6	Monitoring direction blocking	No	cl. 7.4.6 IEC 60870-5-103
7	Transmission of data on violations	Yes	cl. 7.4.7 IEC 60870-5-103
8	Group feature	Yes	cl. 7.4.8 IEC 60870-5-103
9	Cyclic data transmission	Yes	cl. 6.3 IEC 870-5-5
10	Sporadic events	Yes	cl. 6.4 IEC 870-5-5

3.2.2 Application layer units in monitoring direction

The range of supported ASDUs (Application Service Data Unit) transmitted by the ED2 series device over the IEC 60870-5-103 protocol in the monitoring direction is shown in Table 10.

Table 10 − Blocks of data, transmitted by the ED2 series device

Type ID	Description	Function number (according to Table 9)
ASDU 1	Timestamp message	10
ASDU 4	Measured timestamp values with relative time	9
ASDU 5	Identification message	1
ASDU 6	Time synchronization	2
ASDU 8	End of the general interrogation	3
ASDU 9	Measured values type 2	9
ASDU 10	Group Information	8
ASDU 23	List of disturbance records	7
ASDU 26	Ready for disturbance record transmission	7
ASDU 27	Ready for channel transmission	7
ASDU 28	Ready for stamp transmission	7
ASDU 29	Stamp transmission	7
ASDU 30	Alarm value transmission	7
ASDU 31	Transmission completion	7

3.2.3 Application service data units in control direction

The range of supported ASDUs (Application Service Data Unit) received by the ED2 series device under the IEC 60870-5-103 protocol is shown in Table 11.

Table 11 − Control system data units

Type ID	Description	Supported by device	Function number (according to Table 9)
ASDU 6	Time synchronization	yes	2
ASDU 7	General poll	yes	3
ASDU 10	Group Information	no	−
ASDU 20	General command	yes	−
ASDU 21	Group command	yes	8
ASDU 24	Order of disturbance record transmission	yes	7
ASDU 25	Confirmation of disturbance record transmission	yes	7

3.2.4 Compatibility form

This section highlights the IEC 60870-5-103 protocol features supported by the ED2 series device.

3.2.4.1 Physical layer

3.2.4.1.1 Electrical interface

☒ EIA – 485 (RS-485)

☒ Number of loads: 32 for one protection device

Note – For the EIA – 485 (RS-485) interface, the allowable total load is 32 units connected to one line.

3.2.4.1.2 Optical interface

☐ Glass fiber

☐ Plastic fiber

☐ F-SMA type connector

☐ BFOC/2.5 type connector

3.2.4.1.3 Baud rate

☒ 9,600 bit/s

☒ 19,200 bit/s

3.2.4.2 Data Link layer

There are no options for the data link layer.

3.2.4.3 Application layer

3.2.4.3.1 Transmission mode for application data

The ED2 series device only uses mode 1 according to IEC 60870-5-4. The low byte is transmitted first.

3.2.4.3.2 ASDU general address

☒ One byte of general ASDU address (same as station address)

☒ More than one shared ASDU address

3.2.4.4 Selection of standard information numbers in the monitoring direction

3.2.4.4.1 System functions in monitoring direction

INFSemantics

☒ <0> End of the general interrogation

☒ <1> Time synchronization

☒ <2> FCB reset

☒ <3> CU reset

☒ <4> Start/Restart

☒ <5> Turn on the supply voltage

3.2.4.4.2 Status signaling in monitoring direction

INFSemantics

☐ <16> AR device active

☐ <17> Teleprotection active

☐ <18> Protection active

☐ <19> LEDs are off

☐ <20> Monitoring direction blocked

☐ <21> Test mode

☐ <22> Local parameter setting

☐ <23> Feature 1

☐ <24> Feature 2

☐ <25> Feature 3

☐ <26> Feature 4

☐ <27> Auxiliary input 1

☐ <28> Auxiliary input 2

☐ <29> Auxiliary input 3

☐ <30> Auxiliary input 4

3.2.4.4.3 Control information in monitoring direction

INFSemantics

☐ <32> Current measurement monitoring

☐ <33> Voltage measurement monitoring

☐ <35> Phase sequence monitoring

☐ <36> Trip circuit supervision

☐ <37> Back-up current protection operation

☐ <38> Damaged voltage transformer fuse

☐ <39> Teleprotection malfunction

☐ <46> Group warning

☐ <47> Group alarm

3.2.4.4.4 Ground fault message in monitoring direction

INFSemantics

☐ <48> Phase A ground fault

☐ <49> Phase B ground fault

☐ <50> Phase C ground fault

☐ <51> Ground fault on line (front)

☐ <52> Ground fault on busbar system (rear)

3.2.4.4.5 Damage information in monitoring direction

INFSemantics

☐ <64> Phase A start

☐ <65> Phase B start

☐ <66> Phase C start

☐ <67> Zero sequence start

☐ <68> General tripping

☐ <69> Phase A tripping

☐ <70> Phase B tripping

☐ <71> Phase C tripping

☐ <72> Trip by backup current protection I>>

☐ <73> Distance to the short circuit point X, Ohm

☐ <74> Damage on the line (front)

☐ <75> Damage on the bus system (rear)

☐ <76> Teleprotection signal transmitted

☐ <77> Teleprotection signal received

☐ <78> Zone 1

☐ <79> Zone 2

☐ <80> Zone 3

☐ <81> Zone 4

☐ <82> Zone 5

☐ <83> Zone 6

☐ <84> General launch

☐ <85> Switch failure

☐ <86> Disabling the phase A measurement system

☐ <87> Disabling the phase B measurement system

☐ <88> Disabling the phase C measurement system

☐ <89> Disabling the zero-sequence measurement system

☐ <90> Tripping I>

☐ <91> Tripping I>>

☐ <92> Tripping I_N>

☐ <93> Tripping I_N>>

3.2.4.4.6 Information about the operation of AR in the monitoring direction

INFSemantics

☐ <128> Circuit breaker closed by AR

☐ <129> Circuit breaker closed by delayed AR

☐ <130> AR disabled

3.2.4.4.7 Measured values in monitoring direction

INFSemantics

☐ <144> Measured value I

☐ <145> Measured value I, V

☐ <146> Measured value I, V, P, Q

☐ <147> Measured value I_N ,V_N

☐ <148> Measured value $I_{A,B,C}$,$V_{A,B,C}$, P, Q,f

3.2.4.4.8 System functions in monitoring direction

INFSemantics

☒ <240> Reading headers of all defined groups

☒ <241> Reading values or attributes of all elements of the same group

☐ <243> Reading a directory of one element

☒ <244> Reading the value or attributes of a single element

☒ <245> General interrogation of group data

☐ <249> Record element with confirmation

☐ <250> Record element with execution

☐ <251> Recorded element aborted

3.2.4.5 Selection of standard information numbers in control direction

3.2.4.5.1 System functions in control direction

INFSemantics

☒ <0> General interrogation initialization

☒ <0> Time synchronization

3.2.4.5.2 General commands in control direction

INFSemantics

☐ <16> AR enable/disable

☐ <17> Teleprotection enable/disable

☐ <18> Protection enable/disable

☐ <19> Turn on LEDs

☐ <23> Activate feature 1

☐ <24> Activate feature 2

☐ <25> Activate feature 3

☐ <26> Activate feature 4

3.2.4.5.3 Group functions in monitoring direction

INFSemantics

☒ <240> Reading headers of all defined groups

☒ <241> Reading values or attributes of all elements of the same group

☐ <243> Reading a directory of one element

☒ <244> Reading the value or attributes of a single element

☒ <245> General interrogation of group data

☐ <248> Record element

☐ <249> Record element with confirmation

☐ <250> Record element with execution

☐ <251> Aborting an element record

3.2.4.5.4 Main application functions

☐ Test mode

☐ Monitoring direction blocking

☒ Violation Data

☒ Group feature

☒ Private data

3.3 Description of the operation of the protocol main functions

3.3.1 Initialization

The reset of the communication functions is initiated by the "Reset" command from the control system. The command is usually sent in case of:

– initialization of the control system;

– no response from the device for a certain period of time t_{wz}.

The reset communications command does not affect the device, but only resets communications. The reset command can be sent as:

– reset the frame count bit (FCB);

– reset the communication units (CU).

In the first case, the FCB bit in the device is set to "0". Messages in the send buffer are not erased. All active objectives that are in the process of being transferred are completed without any messages. If the CU is reset, the messages in the send buffer are also deleted.

The device will respond to a Reset command by sending an ASDU 5 identification message, with either a Reset CU or Reset FCB reason depending on the type of reset command.

The data sector (8 bytes) of this ASDU message will contain the name of the manufacturer: “PREEKRA”. The software identification sector will contain four characters identifying the software version.

In addition to the identification message, if the device has been powered up, an ASDU 5 identification message is also generated with the trassmition reason "Start/Restart".

3.3.2 Time synchronization

The time synchronization (correction) message can be sent to the device as a Send/Acknowledge message or as a broadcast message without an acknowledgment.

If time synchronization has not been carried out for more than 23 hours, then the "Time not valid" bit is set. Immediately after the device is started, this bit is set.

The following data are used as received data for time correction: milliseconds, minutes, bit – time is valid, bit – summer time, day, day of the week, month, year.

To represent time, the day-of-week byte is not used. According to the standard, its value is set to 0.

3.3.3 SD control algorithm

The position control of switching devices is performed in one of two modes:

– direct control;

– mode with SBO confirmation (select before operate).

The current control mode can be changed in the **Switching devices** window in the Smart Monitor program.

Control commands can be blocked via the binary inputs of the device.

For successful execution of the command, permission is required on the binary inputs:

– local control in the value "0", with a given binary input;

– permission to disable in the value "1", with a given binary input;

– permission to enable in the value "1", with a given binary input.

Binary inputs are assigned individually for each SD in the **Switching devices** window.

3.3.3.1 Direct control of SD

To control the SD, it is required to send an ASDU 20 with the transmission reason 20, the function number 8, and the information number corresponding to the given SD. The information number for this SD is generated in the report according to the 103 protocol data on the **Commands** tab in the **Information number** column. The **DCO** (double command) field should contain one of the values specified in Table 12.

Table 12 – Double command of the SD control

Recorded value	Description
1	SD tripping
2	SD closing

Execution of the SD switch command can be blocked in the following cases:

– SD control is not configured for the current interface or communication protocol;

– the current control mode does not correspond to the "direct control" mode;

– SD switching is blocked by a configured binary input.

3.3.3.2 Control with confirmation SBO (select before operate).

SD switching in this mode is performed in two stages:

1) selection of the control command;

2) command execution.

To select the SD, it is required to send an ASDU 20 with the transmission reason 20, a function number of 9, and an information number corresponding to the given SD. The information number for this SD is generated in the report according to the 103 protocol data on the Commands tab in the Information number column.

SD selection can be blocked in the following cases:

– SD control is not configured for the current interface or communication protocol;

– current control mode does not match SBO;

– SD is already selected by another user;

– SD selection is blocked by a configured binary input.

Deselection of the SD occurs in the following cases:

– the command to cancel the selection is recorded;

– higher command waiting timeout – 10 seconds;

– another command is selected.

– a command other than the one previously selected was recorded to the control register.

The selection commands available for recording are shown in Table 13.

Table 13 – Double command of the SD selection

Recorded value	Description
1	deselect SD
2	select SD

The execution of the command is carried out similarly to the mode with direct control of the SD.

Execution of the SD switch command can be blocked in the following cases:

– SD control is not configured for the current interface or communication protocol;

– current control mode does not match SBO;

– SD is already selected by another user or selected to execute another command;

– SD switching is blocked by a configured binary input.

3.3.4 General interrogation

General interrogation is used to read the status of all defined events with the corresponding function numbers and information.

Usually, the general interrogation command is sent by the control system after initialization.

In addition to binary values, at the beginning of the general interrogation, a list of registered violations in ASDU 23 is given.

3.3.5 Analog measurements

Measurement data is transmitted to ASDU 9 and ASDU 4 in groups of eight. Thus, the first group will contain the first eight analog measurements (according to the order in the configuration), the second group the next eight measurements, and so on.

The device provides the results of periodically performed measurements when using ASDU 9, ASDU 4 which can be read using the class 2 data interrogation procedure.

ASDU 9 is used to transmit analog measurements with a period specified in the configuration. The measured values are sent in a ratio of 2:4 in relation to the maximum value.

3.3.6 Transmission of data on violations

Disturbance records stored by the device can be read remotely using the standard mechanism provided by the IEC 60870-5-103 protocol. The disturbance record transmission cycle begins with the issuance of a list of recorded violations via ASDU 23.

ASDU 23 is issued by the device in the following cases:

– when requesting a directory by the control system by sending ASDU 24 with the order type "Request a list of registered violations";

– after the start of the general interrogation;

– when the state of the disturbance record directory changes.

3.3.7 Sporadic events

Events generated by the ED2 series device are sent to the IEC 60870-5-103 control using ASDU 1. Each message contains a function number and information that allows the receiving side to uniquely identify the type of event. The transmitted data also contains the time when the event was registered by the device.

3.3.8 Group feature

Access to group data is provided by the functions presented in Table 14.

Table 14 − Group service functions

Function name	Description
Reading headers of all defined groups	This function sends a request to the device to send a list of group definitions, that is, all elements whose second GIN bytes are zero. For each element, a DESCRIPTION attribute is sent in response, referring to its GIN. If the read fails for one or more groups (for example, a group is defined but temporarily unavailable), the returned ASDUs 10 are marked COT = 43
Reading attributes of all elements of the same group	This function sends a request to the device to send a list of certain attributes of all elements in a certain group, specified by the corresponding GIN and KOD. The transmission starts with the ENTRY 00H attribute. If the requested data does not fit in one packet, then the flag is set. If the reading of the requested attribute fails for one or more GINs, the returned ASDUs 10 are marked COT = 43

Function name	Description
Reading an attribute of a single element	This function sends a request to the device to send one attribute for one element specified by the corresponding GIN and KOD. If the reading of one or more GINs fails, the returned ASDUs 10 are marked COT = 43
General interrogation of group data	The general interrogation of GGI group data is initiated by a GGI command in control direction. This command is transmitted by the control system individually for each device. It is recommended to send a request to GGI at intervals of 15 minutes (or more). In addition, the GGI initialization request is always sent after the initialization procedure. The device keeps a list of all messages - the subjects of the general poll. After a GGI request, information from this list is sequentially processed by sending messages containing COT = GI. When the entire list of GGI message subjects has been sent in response to a GGI command, a GGI end message is sent. A new GGI cycle will only be initiated in the device when a new GGI request is received from the control system. If a GGI request occurs within a GGI general interrogation cycle, then the current GGI cycle will end without a GGI end message. The new cycle will start from the beginning (from the first subject of the GGI message)

3.4 IEC 60870-5-103 protocol configuration

3.4.1 Configuration of protocol using the Smart Monitor software

3.4.1.1 Start the Smart Monitor software similar to 2.4.1.1.

3.4.1.2 In the “tree” of the Smart Monitor software project, select the menu item **Settings** → **Digital communication channels** → **Communication protocols**) (see Figure 25, designation 1), clicking once with the left mouse button the corresponding item in the project “tree”, and open the window.

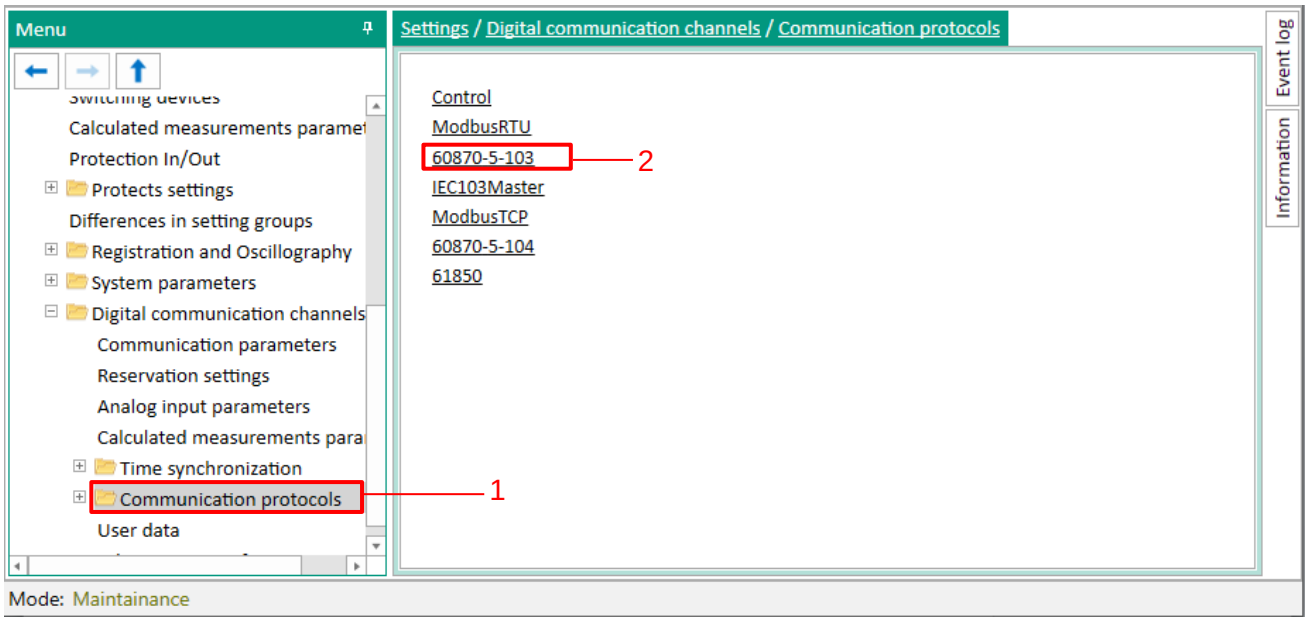


Figure 25 – **Communication protocols** window

3.4.1.3 On the **Communication protocols** tab, select the IEC 60870-5-103 protocol: **60870-5-103** (see Figure 25, designation 2).

3.4.1.4 Set IEC 60870-5-103 protocol parameters according to the project. The default values of the protocol parameters are shown in Figure 26, designation 1. Description of IEC 60870-5-103 protocol parameters is given in Table 15.

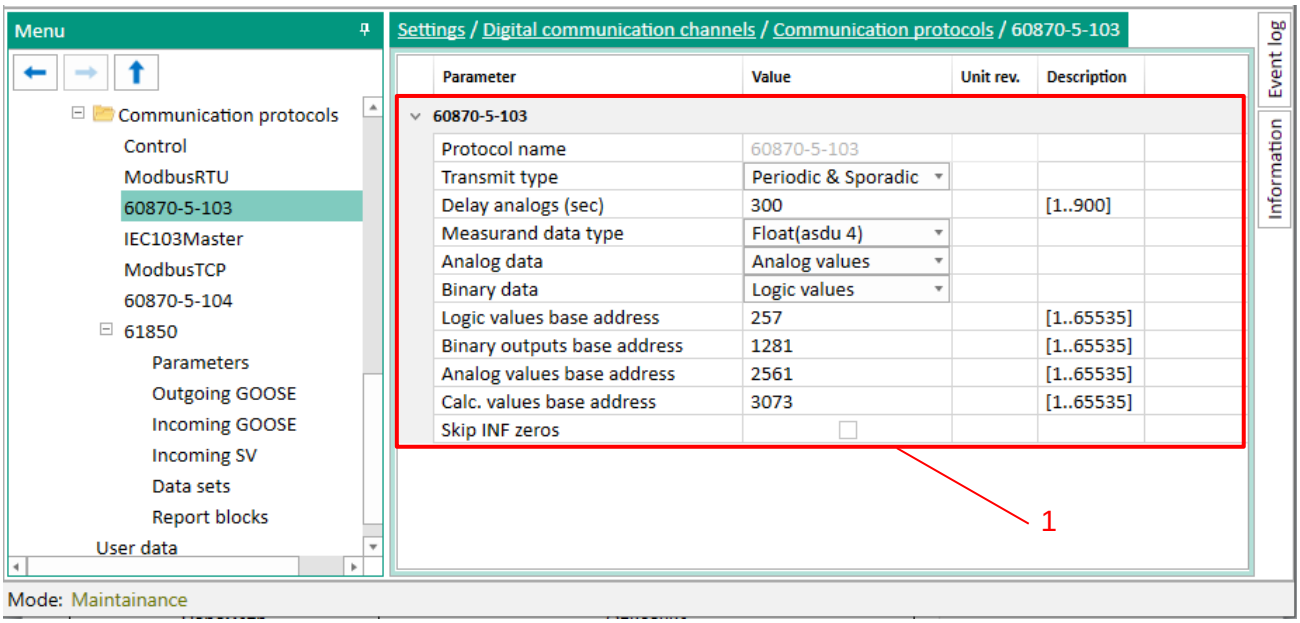


Figure 26 – Setting the IEC 60870-5-103 protocol

Table 15 – Description of IEC 60870-5-103 protocol parameters

Parameter	Description
Measurement transmission type	It sets measurements transmission type: – cyclic transmission (after a specified time interval); – sporadic transmission (when signal is changed); – cyclic and sporadic (after a specified time interval and when the signal changes); – off (transmission of information is not performed)
Measurement transmission period, s	Time interval in seconds (value should be in the range of 1 to 900 s) after which measurements will be transmitted during cyclic transmission
Measurand data type	– floating point (ASDU 4); – fixed point (ASDU 9)
Analog data[1)]	Contents of transmitted analog data: – analog values; – calculated values; – protection phasors
Binary data[1)]	Contents of transmitted binary data: – logical signals; – binary outputs
Logic values base address	Decimal value (value should be between 1 and 65,535) that specifies the IEC 60870-5-103 base address of logic signals. It is not recommended to change the value without the consent of the device developers. Default value 256
Binary outputs base address	Decimal value (value should be between 1 and 65,535) that specifies the IEC 60870-5-103 base address of the binary outputs. It is not recommended to change the value without the consent of the device developers. Default value 1,280

Parameter	Description
Analog values base address	Decimal value (value should be between 1 and 65,535) that specifies the IEC 60870-5-103 base address of the analog values. It is not recommended to change the value without the consent of the device developers. Default value 2,560
Calculated values base address	Decimal value (value should be between 1 and 65,535) that specifies the IEC 60870-5-103 base address of the calculated values. It is not recommended to change the value without the consent of the device developers. Default value 3,072
Skip INF zeroes	When the value of the address parameter for the IEC 60870-5-103 protocol is set, it generates no INF = 0 fields
[1] One can select multiple items.	

3.4.1.5 Saving the changes made

In the main menu of the Smart Monitor program, the operation of saving changes is carried out using the command 

, located on the toolbar (see Figure 27, designation 1).

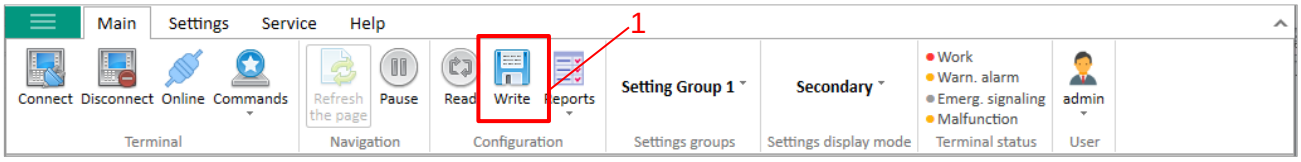


Figure 27 – Toolbar

When saving changes, a password[1] is requested (see Figure 28), using the keyboard, one should enter a character set that is the device password and press **OK**.

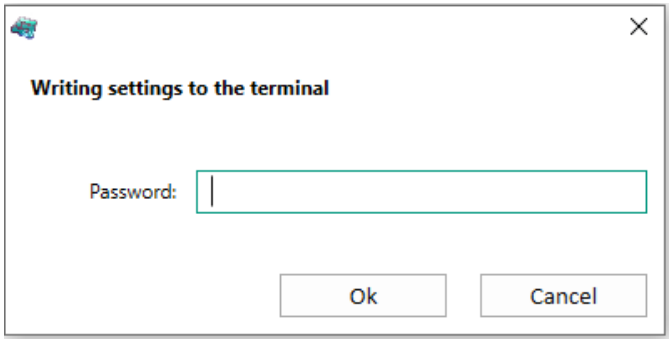


Figure 28 – Password entry window

If the password is correct, the configuration verification process will start (see Figure 29).

[1] Default user passwords are shown in Table 1.

Figure 29 – Configuration Check Information

Wait for the configuration verification process to complete.

Successful configuration update will be indicated by a message in the main window of the Smart Monitor program in the "IED loaded" event log (see Figure 30).

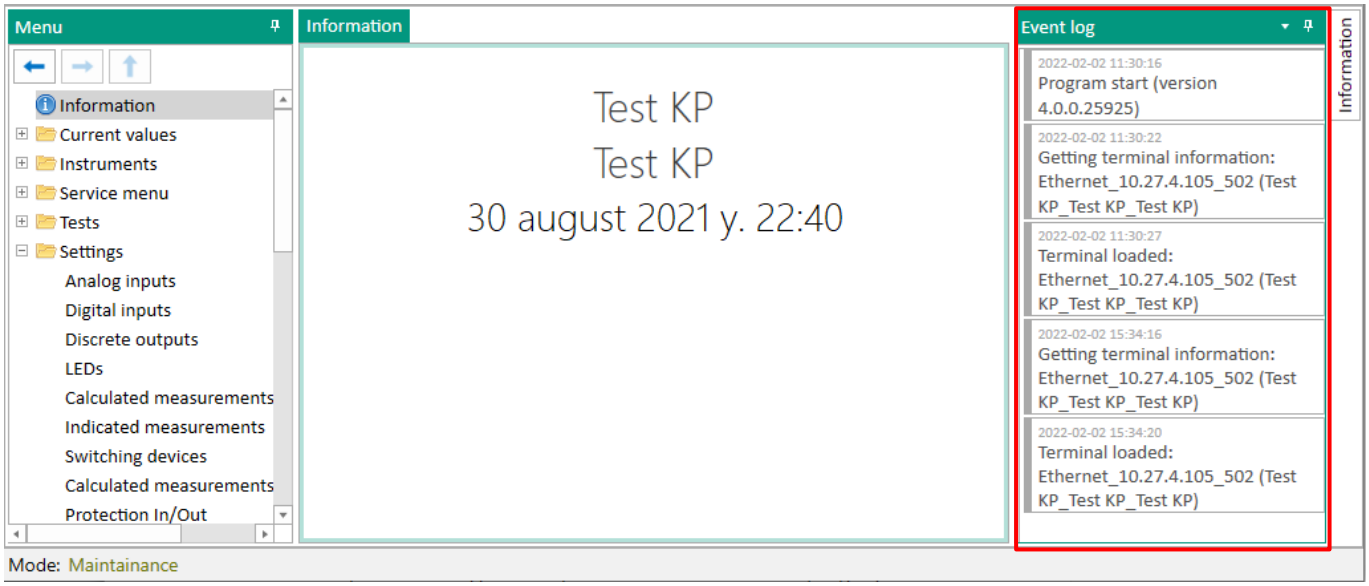


Figure 30 – Information about a successful configuration update

After changes recording current window will be refreshed and new changes will be loaded.

In the event that the password turned out to be incorrect, the informational message “Wrong password” will appear on the screen (see Figure 31).

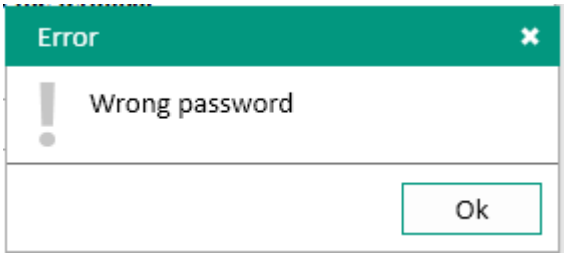


Figure 31 – Information about the wrong password

3.4.2 Configuration of protocol using the Configurator software

3.4.2.1 Run the Configurator program in the same way as 2.5.2.1.

3.4.2.2 In the “tree” of the Configurator software project, select the menu item **System parameters** (see Figure 32, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

3.4.2.3 Select the tab **Serial protocols** (see Figure 32, designation 2).

3.4.2.4 On the field **Protocols**, select the protocol: **60870-5-103** (see Figure 32, designation 3).

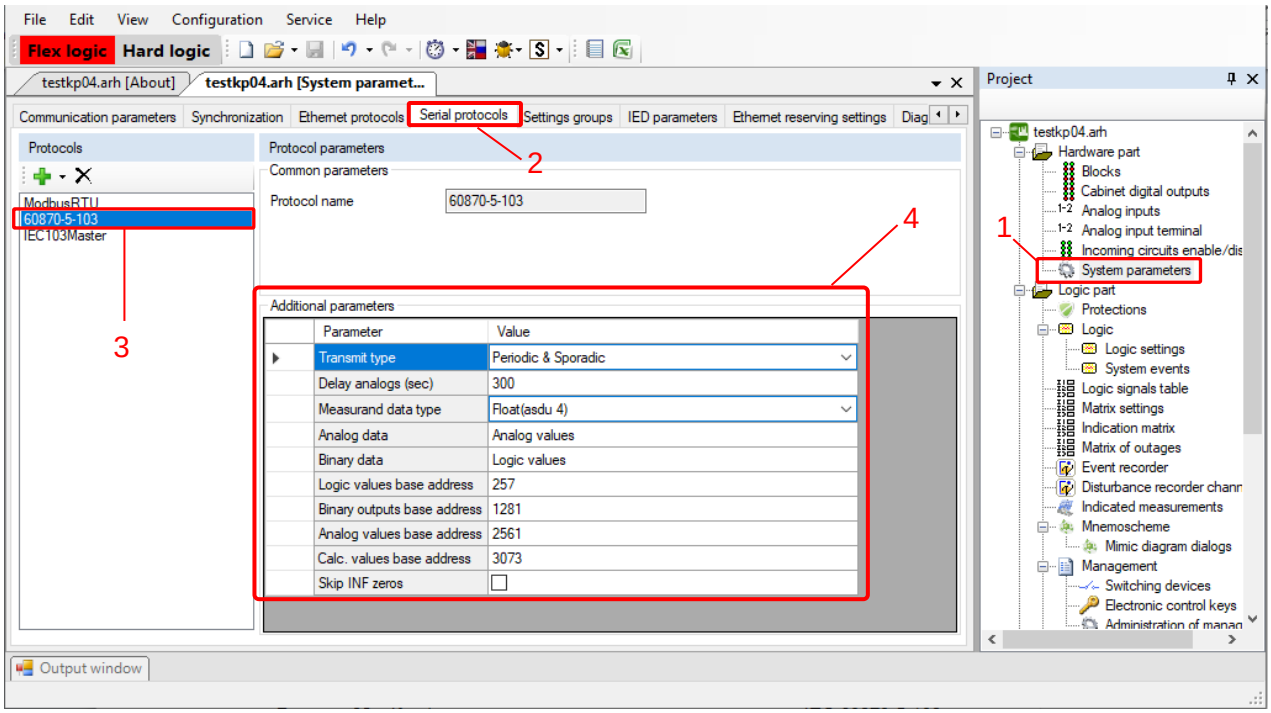


Figure 32 – IEC 60870-5-103 communication protocol configuration

3.4.2.5 Set IEC 60870-5-103 protocol parameters according to the project.

The default IEC 60870-5-103 protocol parameter values are shown in Figure 32, designation 4. Description of IEC 60870-5-103 protocol parameters is given in Table 15.

3.4.2.6 To save the changes made to the device, in the main menu of the program, select the item **File** → **Save Ctrl+S** (see Figure 33, designation 1), or select the item **Save as** (see Figure 33, designation 2), or press the button combination CTRL+S, or by pressing the button “ ” on the toolbar (see Figure 33, designation 3).

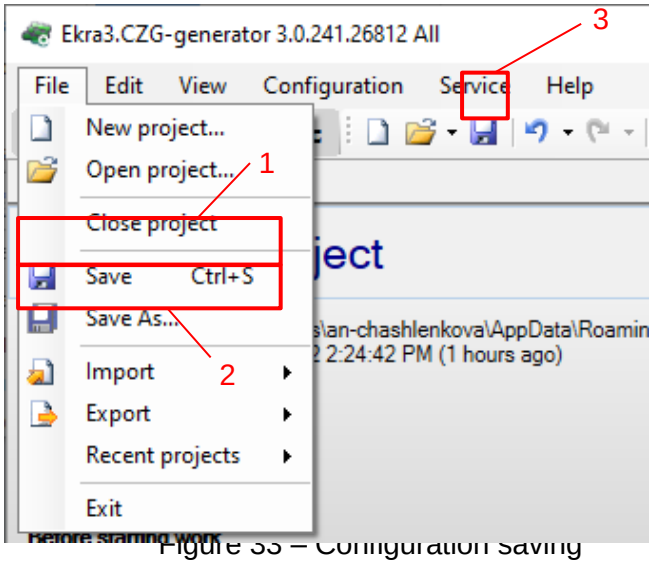


Figure 33 – Configuration saving

3.4.2.7 Configuration of protocol using the device menu

The IEC 60870-5-103 protocol is not configured using the device menu, only using the Smart Monitor program or the Configurator.

3.5 IEC 60870-5-103 (Master) protocol configuration

3.5.1 Configuration of protocol using the Smart Monitor software

3.5.1.1 Start the Smart Monitor software similar to 2.4.1.1.

3.5.1.2 In the "tree" of the Smart Monitor program project, select the menu **Settings** → **Digital communication channels** → **Communication protocols** → **IEC103Master** (see Figure 34, designation 1), clicking once with the left mouse button on the corresponding item of the "tree" of the project, and open the window.

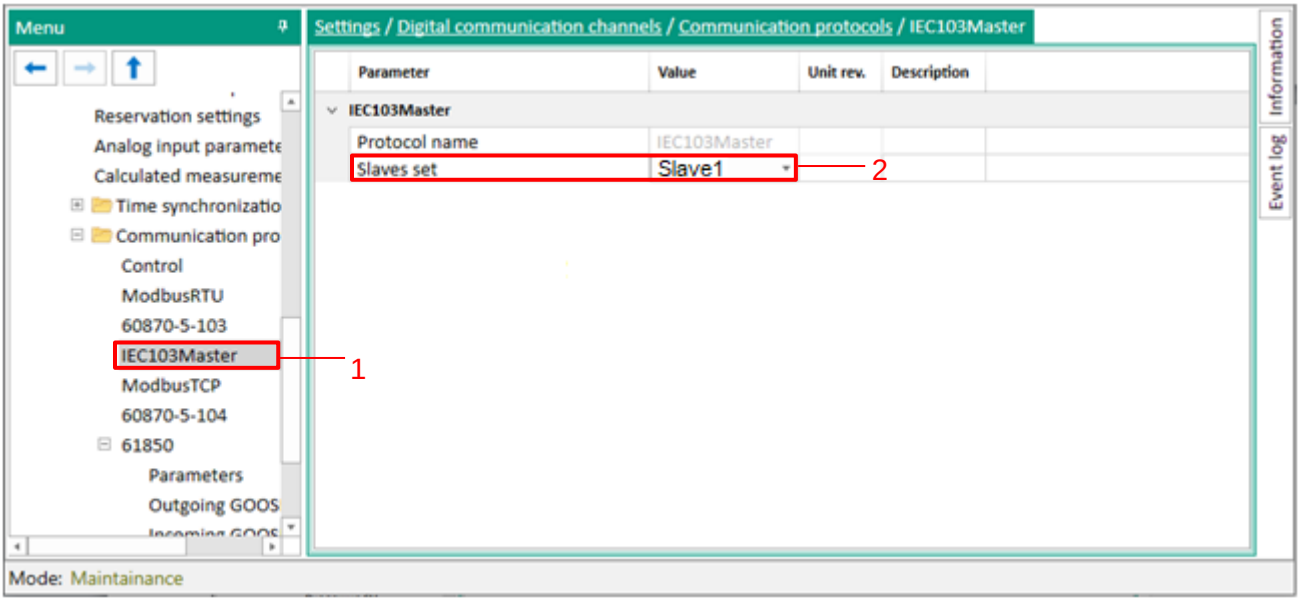


Figure 34 – **IEC103Master** window

3.5.1.3 In the field **Set of slave devices**, select the value "Slave 1" (see Figure 34, designation 1).

3.5.1.4 In the "tree" of the program project, select the menu item **Settings → Digital communication channels → Communication parameters** (see Figure 35, designation 1).

3.5.1.5 Set the baud rate of the serial port (see Figure 35, designation 2). For the selected serial port, set the IEC103Master protocol (see Figure 35, designation 3).

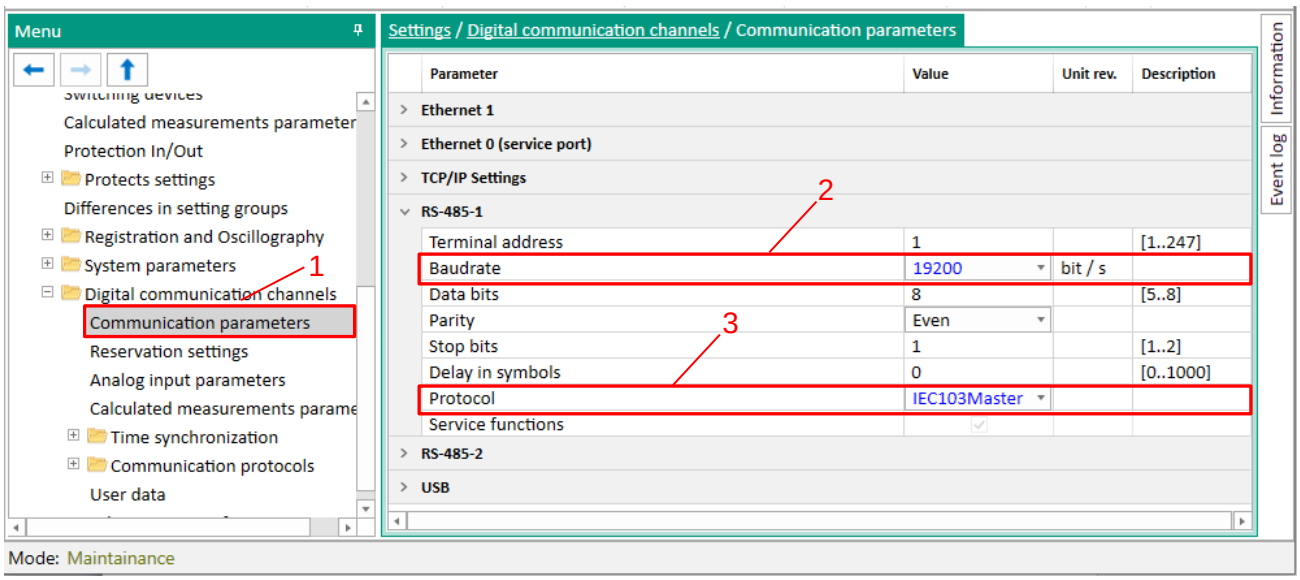


Figure 35 – Communication protocols window

3.5.1.6 Save the changes made to the device similar to 3.4.1.5.

3.5.2 Configuration of protocol using the Configurator software

3.5.2.1 Start the Configurator software similar to 2.5.2.1.

3.5.2.2 In the “tree” of the Configurator software project, select the menu item **System parameters** (see Figure 36, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

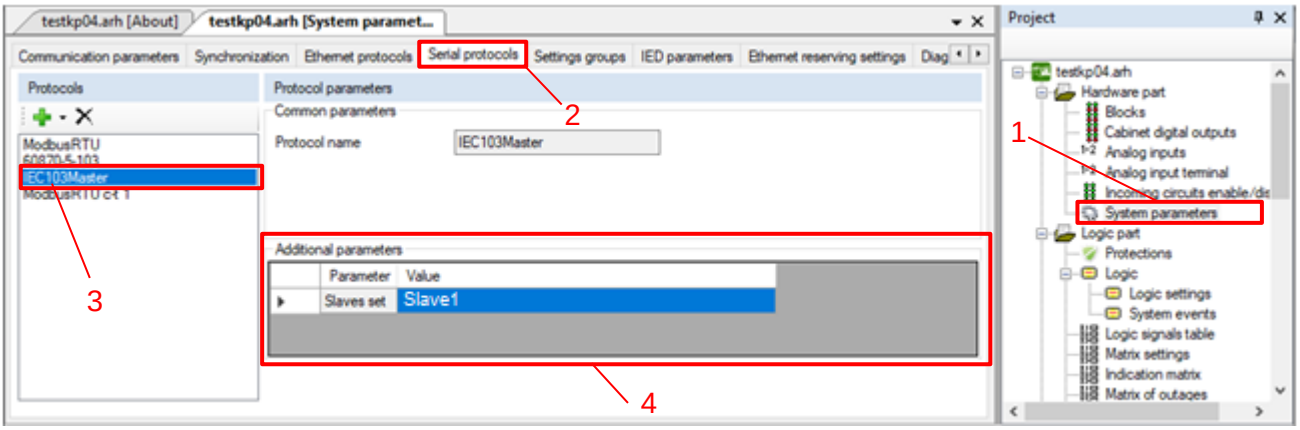


Figure 36 – **Serial protocols** window

3.5.2.3 Select the tab **Serial protocols** (see Figure 36, designation 2).

3.5.2.4 Add the protocol IEC 60870-5-103 Master (in the program the protocol is designated as IEC103Master) by pressing the button " " (see Figure 36, designation 3).

3.5.2.5 Set additional parameters of the IEC103Master protocol according to the project. The default values of the protocol parameters are shown in Figure 36, designation 4. Description of IEC103Master protocol parameters is given in Table 16.

Table 16 – Description of parameters of the IEC103Master protocol

Parameter	Description
Set of slave devices	An interrogated slave device is selected

3.5.2.6 Go to the tab **Communication parameters** (see Figure 37, designation 1). Set the serial port speed. For the selected serial port, set the IEC103Master protocol (see Figure 37, designation 2).

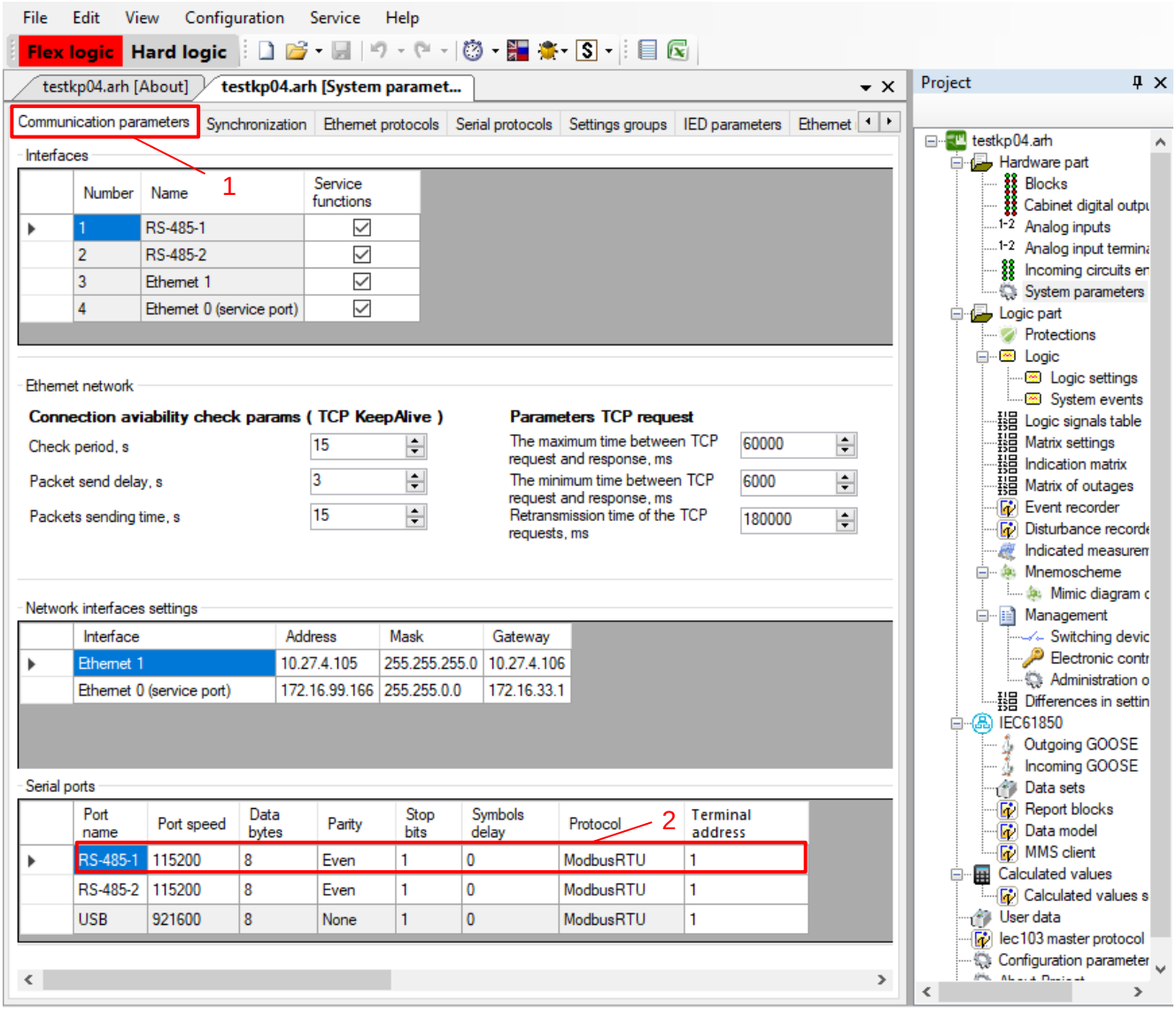


Figure 37 – **System parameters** window

3.5.2.1 In the "tree" of the Configurator program project, select the menu item **IEC 60870-5-103 Master** (see Figure 38, designation 1). Add a slave device (**IEC 60870-5-103 Slave1**) by clicking the button "" (see Figure 38, designation 2).

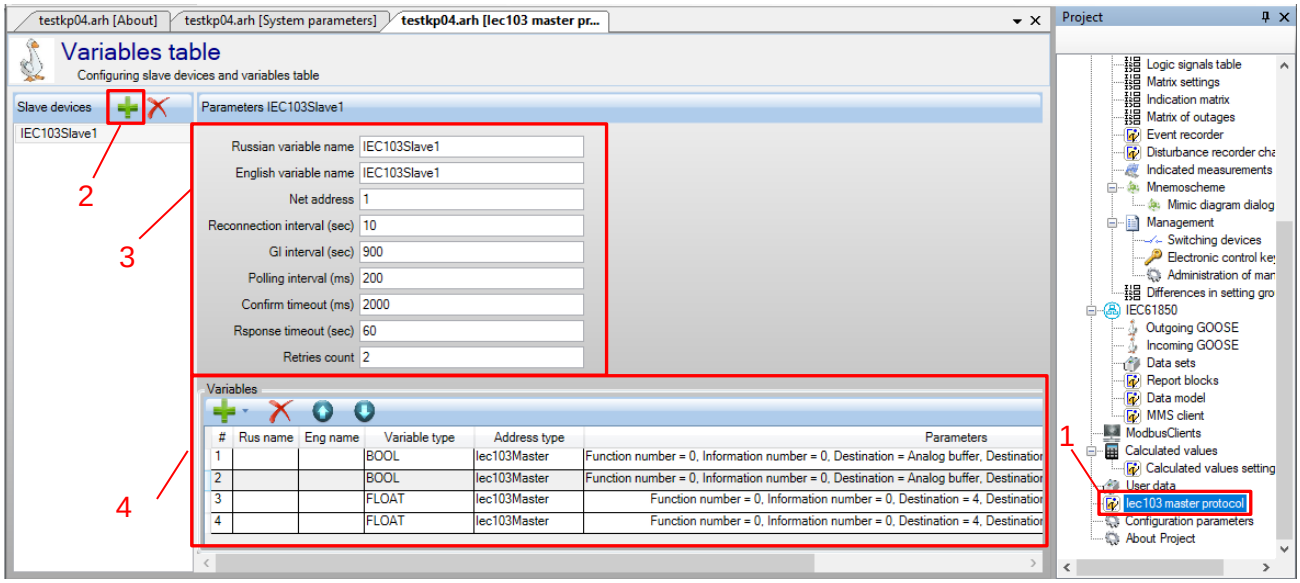


Figure 38 – **103 Protocol Master** window

3.5.2.2 Set parameters of the IEC103Master protocol according to the project. The default values of the protocol parameters are shown in Figure 38, designation 3. Description of IEC103Master protocol parameters is given in Figure 17.

Table 17 – Parameters of the IEC103Master protocol

Parameter	Description
Name in Russian	Slave device in Russian
Name in English	Slave device in English
Network address	Slave device address
Reconnection interval, s	Interval between reconnection commands, in seconds
GI interval, s	Interval between general poll commands, in seconds
Polling interval, ms	Interval between data request, in milliseconds
Time-out of request confirmation, ms	Maximum confirmation time, in milliseconds
Response timeout, s	Maximum response time of a slave device, in seconds
Reties count	Maximum quantity of connectivity attempts

3.5.2.3 In the field **Variables**, add binary signals and analog measurements from the generated report[1)].

3.5.2.4 Specify the signal name in the "Rus name" column.

3.5.2.5 Select the type of "BOOL" variable for binary signals and "FLOAT" for analog measurements (see Figure 38, designation 4).

[1)] Generated IEC 60870-5-103 protocol report (see 2.5.1.3).

3.5.2.6 The default values of the protocol parameters are shown in Figure 38, designation 4. Description of variable parameters are presented in Table 18.

Table 18 – Variable parameters

Parameter	Description
#	Slave device number
Rus name	Russian name of a slave device
Eng name	English name of a slave device
Variable type	Variable type of a slave device
Address type	Address type of a slave device
Parameters	Slave device parameters

3.5.2.7 In the "Parameters" column, click on the "..." button. In the **Variable parameters** window that appears, set the parameters according to the project. The default variable parameter values are shown in Figure 39. The description of the variable parameters is given in Table 19.

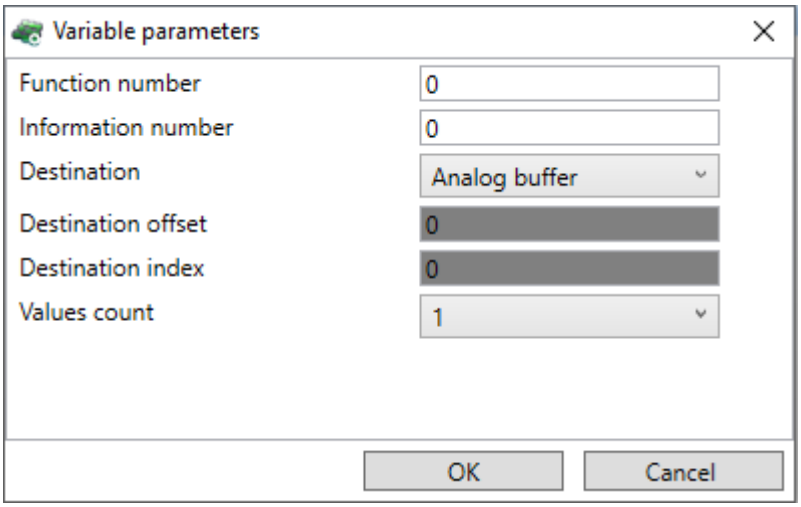


Figure 39 – **Variable parameters** window

Table 19 – Variable parameters

Parameter	Description
Function number	Set according to the parameters of the slave device. Used to form the data read address
Information number	Set according to the parameters of the slave device. Used to form the data read address
Receiver	Selection of the type of signal reception type: none, module (logic signal), binary buffer, analog buffer (used in calculated values)
Receiver offset	Used for the "binary buffer" receiver. It is set automatically, reserves three values for writing to the buffer
Receiver index	Used for receiver "module". Allows you to select the appropriate virtual device input
Quantity of values	Not used

3.5.2.1 An example of using the IEC103Master protocol

3.5.2.1.1 In the "tree" menu of the Configurator program project, select the **Calculated values** item (see Figure 40, designation 1). Add calculated values using the “ ” button (see Figure 40, designation 2).

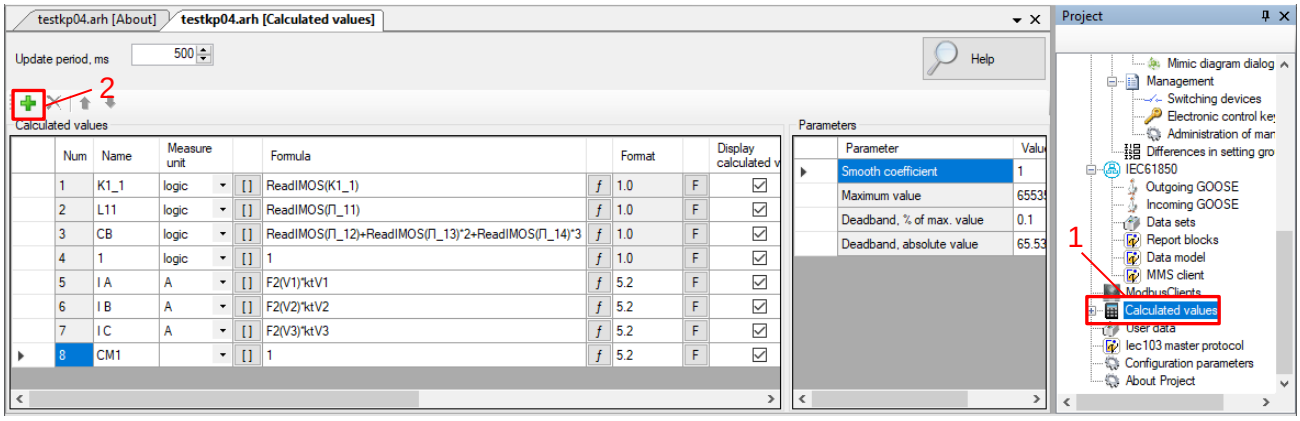


Figure 40 – **Calculated values** window

3.5.2.1.2 Specify the names of the calculated value in the "Name" column.

3.5.2.1.3 In the "Formula" column, click the “ƒ" button. In the **Formula editor** window that appears, open the **Menu** by pressing the CTRL + SPACE button combination (see Figure 41).

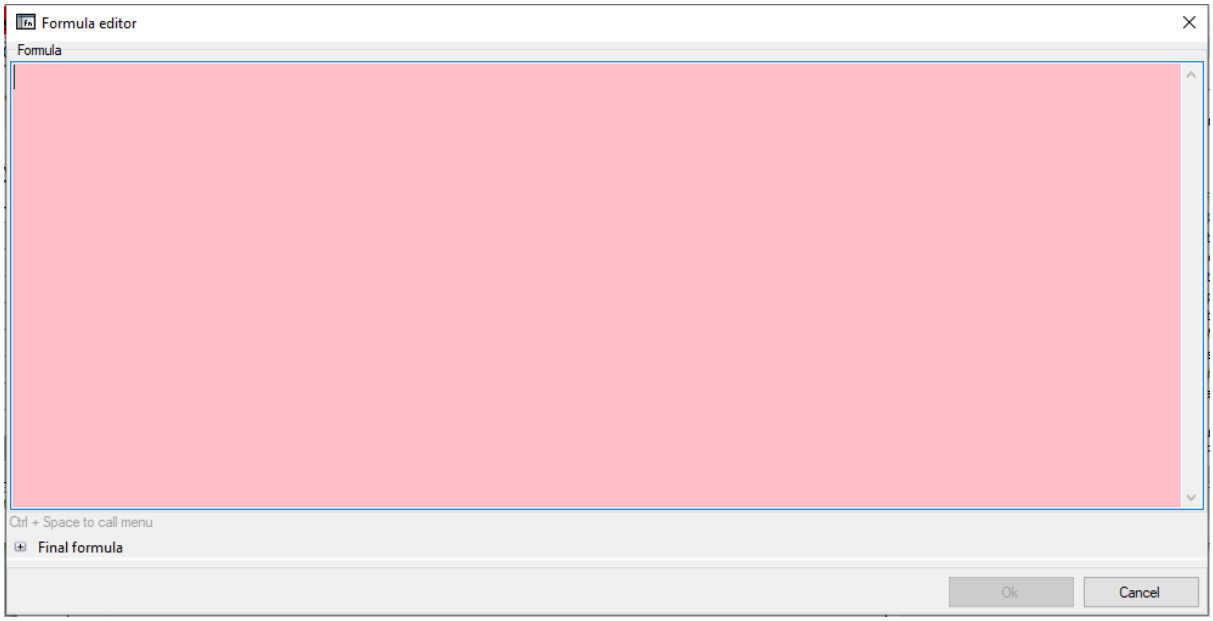


Figure 41 – **Formula Editor** window

3.5.2.1.4 From the drop-down list, select the formula "Getlec103Var: Iec 103 Variable Val” (see Figure 42).

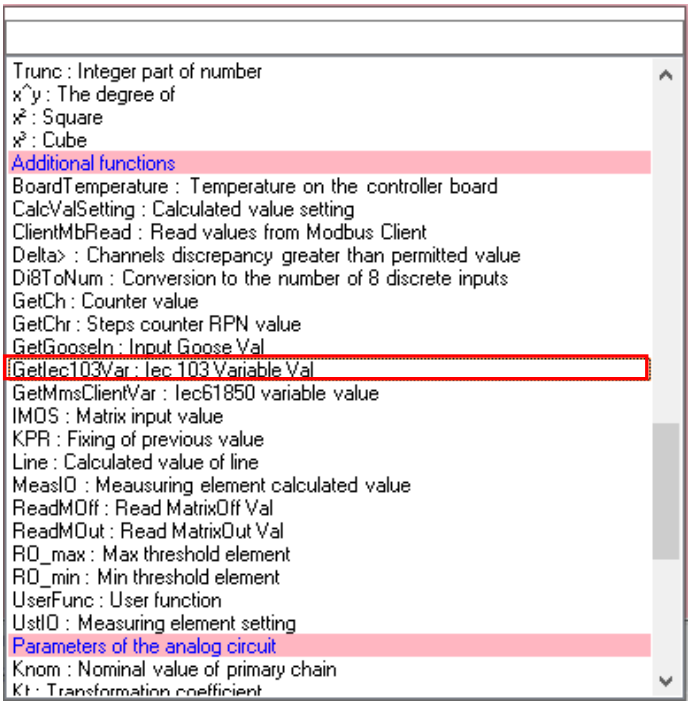


Figure 42 – Formula menu

3.5.2.1.5 Returning to the Formula editor) window, write the name of the setting between the "quotes" (see Figure 43), calling the list of signals using the CTRL + SPACE button combinations (see Figure 44).

Figure 43 – Adding a formula

Figure 44 – List of signals

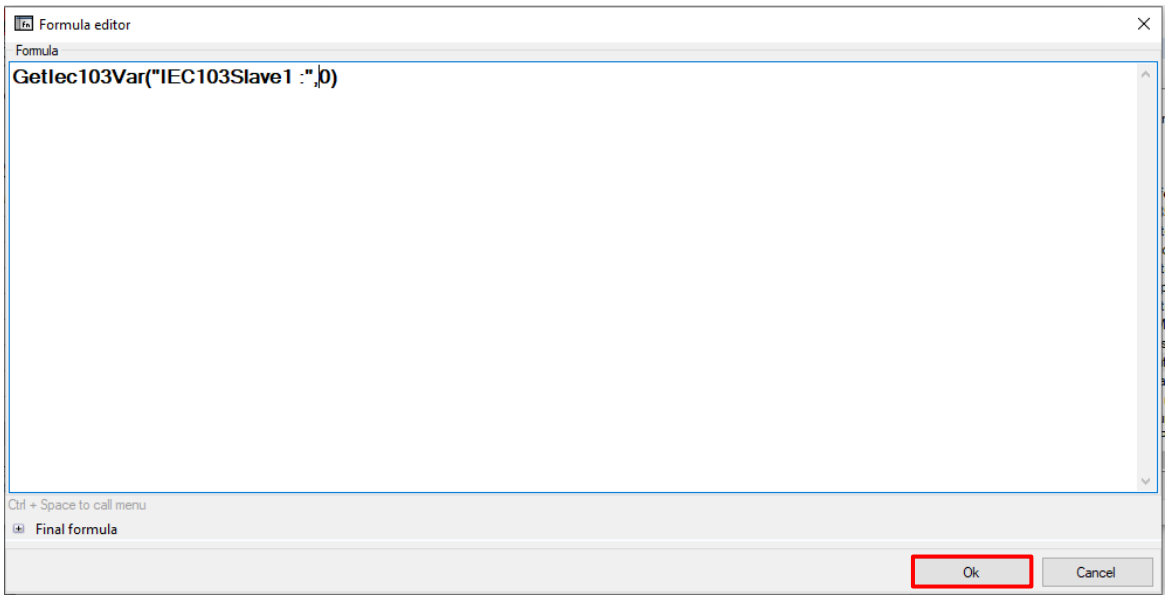


Figure 45 – Final version of the formula

3.5.2.1.6 After writing the formula, click on the **Ok** button (see Figure 45)

3.5.2.1.7 After returning to the **Calculated values** window, it should display the formula “Getlec103Var(“IEC103Slave1 : v1”)” in the "Formula" column (see Figure 46).

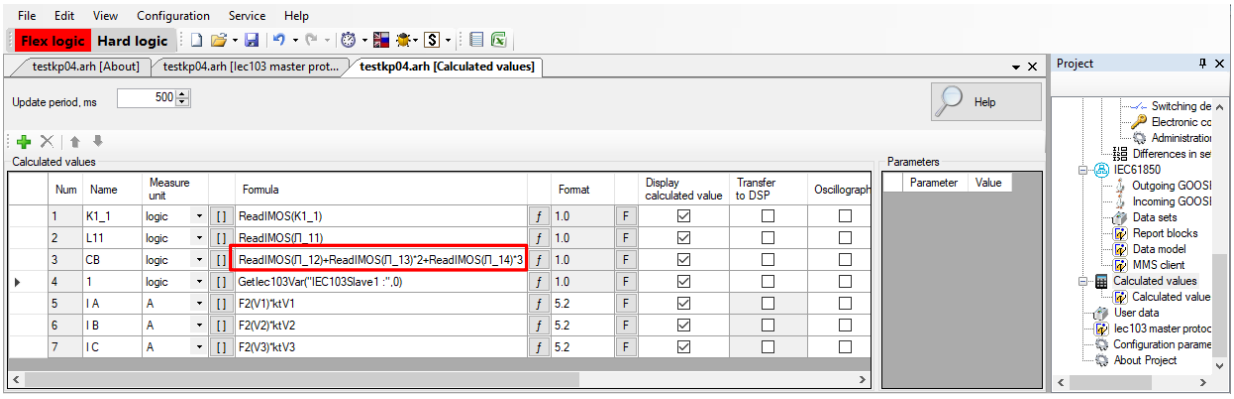


Figure 46 –**Calculated values** window

3.5.2.1.8 Save the changes made to the device similar to 3.4.2.6.

3.6 Setting the parameters of the module for controlling the SD according to the IEC 60870-5-103 protocol

3.6.1 In the “tree” of the Configurator software project, select the **Modules** menu item (see Figure 47, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

3.6.2 Open the **Library** tab (see Figure 47, designation 2) (if there is no **Library** tab, it can be called via the menu item **View** → **Library window** (see Figure 47, designation 3)) and select from the module list – module of software digital inputs (see Figure 47, designation 4).

3.6.3 Specify the name of the module signal (see Figure 47, designation 6).

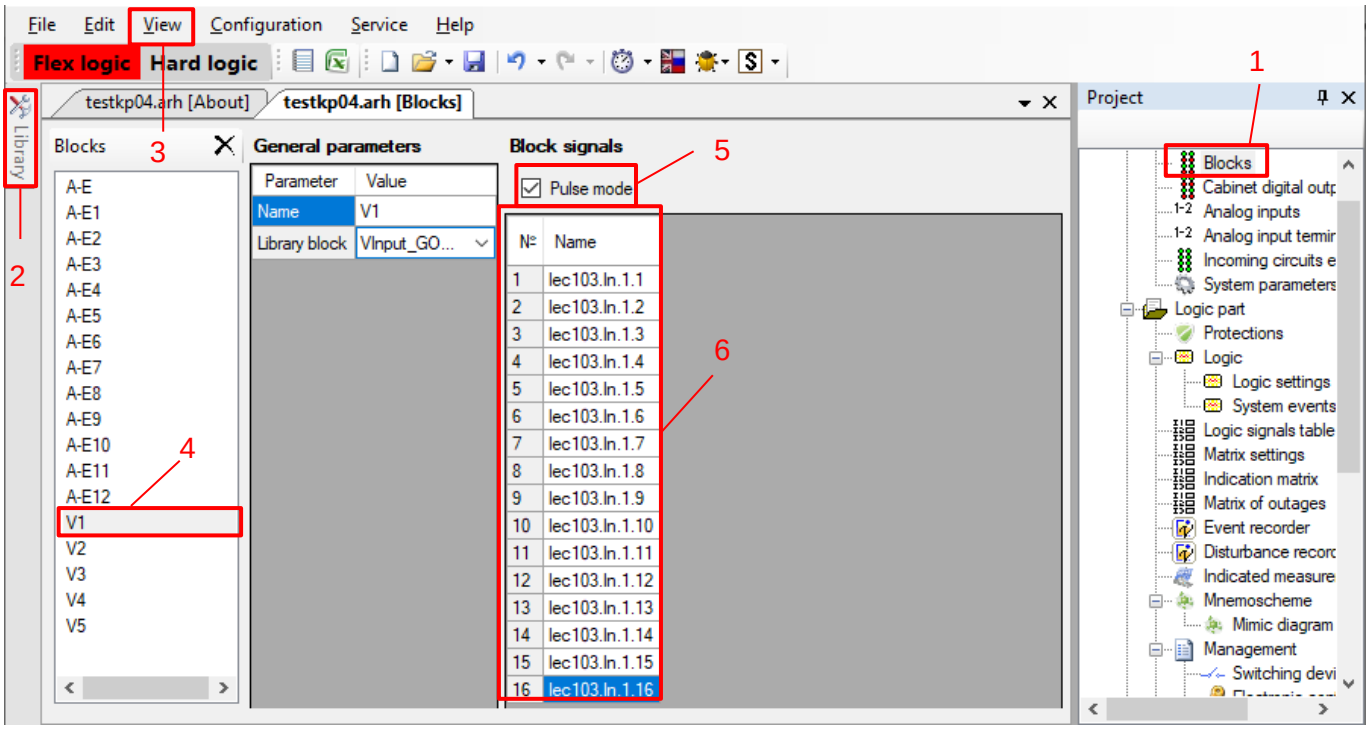


Figure 47 – **Modules** tab

3.6.4 Set the **Pulse mode** checkbox (see Figure 47, designation 5).

Description of signal parameters of software binary inputs module is provided in Table 20.

Table 20 – Description of signal parameters of software binary inputs module

Parameter	Definition	Purpose
Signal	Signal number in module	For all software digital input modules
Signal name	Signal name in the configuration	
Pulse mode	A mode when module signals reset to «0» after processing of received data	Used to receive control commands through the "VInput" module

3.6.5 Open the **Switching devices** tab (see Figure 48, designation 1).

3.6.6 Add switching devices by clicking the button " " (see Figure 48, designation 2).

3.6.7 For each switching device, set the **Type** (Circuit Breacker, Disconnector, other).

3.6.8 Set the **Position signaling** parameter (three-phase or per-phase).

3.6.9 For each switch, set the parameters:

– **Communication interface** (RS-485-1, RS-485-2, Ethernet 1, 2, 0 (service));

– **Program protocol** (Modbus RTU, Modbus TCP, 61850, 60870-5-103, 60870-5-104);

– **Control model** (status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enchanced-security);

– **Remaining life calculation type** (none, mechanical, switching).

Description of the parameters of switching devices (see Figure 48, designation 3) is given in Table 21.

Note – Depending on the required interface, the appropriate protocol is selected.

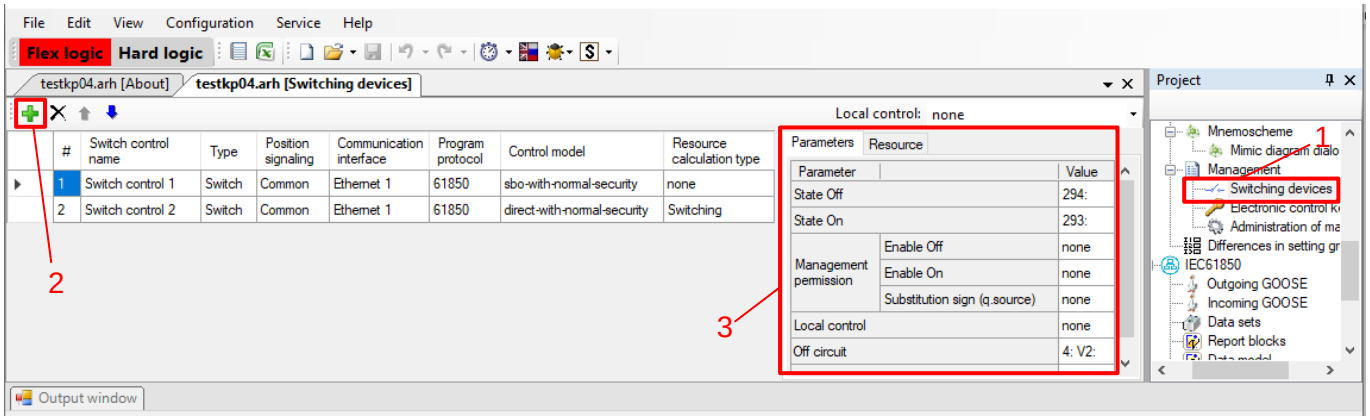


Figure 48 – **Switching devices** window

Table 21 – Description of parameters of switching devices

Parameter		Definition
Opened state		Logical signal indicating the Opened state
Closed state		Logical signal indicating the Closed state
Permission of control	Trip permission	Logical signal enabling opening of the switching device. If the signal is not specified, then opening is enabled, otherwise the state of the signal is analyzed (1 – enabled, 0 – disabled)
	Close permission	Logical signal enabling closing of the switching device. If the signal is not specified, then closing is enabled, otherwise the state of signals is analyzed (1 – enabled, 0 – disabled)
	Substitution sign[1)]	Logic signal indicating that the control enable signals have been replaced by the operator using the IEC 61850 substitution function (1 - signal is replaced, 0 - not)
Local control		Logical signal that determines the control mode of the current switching device
Tripping signal		Output of the virtual module, which transmits to the logic the command to switch the switching device that came via communication protocol
Closing signal		Output of the virtual module, which transmits to the logic the command to switch the switching device that came via communication protocol
[1)] This parameter is available only for the switching device when the program protocol is selected - 61850.		

3.6.10 Save the changes made to the device similar to 3.4.2.6.

3.7 Troubleshooting

Troubleshooting is specified in Table 22.

Table 22 – Troubleshooting

Description of failure	Possible cause of failure	Method of elimination
Lack of communication with the device via RS-485 interface. The device is in good condition	Incorrect communication parameters in the device	Make sure the used address of the device is free in the current network. Set the correct address
		Set a lower port operation rate. When choosing the rate follow the rule: the greater the length of the communication line, the lower the rate
	Installation errors	Check the polarity of interface signals. Set the polarity according to the notation
	Damaged communication cable	Check the communication cable, replace with a non-faulty one that meets the requirements
	When communicating via Smart Monitor software – inconsistency of communication parameters between the device and the Smart Monitor software	Make sure the port operation rate and address of the device in the settings of the device and the Smart Monitor software are compatible
Lack of communication via IEC 60870-5-103 protocol	Failure of RS-485 interface	The RS-485 interface troubleshooting procedure is described above
	Protocol is missing in the configuration	Not a failure. Add the protocol using the Configurator or Smart Monitor software
	Protocol is disabled	Enable the protocol via Smart Monitor software or the menu of the device
	Baud rate inconsistency	Check baud rate

4 IEC 60870-5-104 protocol

4.1 General

The IEC 60870-5-104 standard protocol is designed to exchange information with the operational dispatch control system.

4.1.1 Purpose of the protocol

The ED2 series devices use the protocol to receive binary and analog data values, to control switching devices, and to download disturbance records from the device.

The protocol is designed to transfer data between intelligent electronic devices (IEDs), namely protection relays and control system devices. The protocol defines ASDU that define the format and content of messages, and also describes when and in what order they are transmitted.

The device acts as a slave according to the protocol.

4.1.2 Connection and communication parameters

Connection to the device according to the IEC 60870-5-104 protocol is performed via the Ethernet interface.

To connect via the protocol, the master device needs to know the parameters of the ED2 series device (slave device): IP address, subnet mask, gateway, port number, and device address. The device address acts as the general address of the ASDU. The port number in this protocol is defined as 2404 and is assigned to the entire system (see Table 23).

Table 23 − Communication parameters

Parameter	Description
IP address	Viewing and editing is carried out using the device menu **Parameters** –> **System settings** –> **Communication parameters** –> **Network parameters** –> **IP settings**
Mask	
Gateway	
Port number	2404

4.1.3 Address setting

Each ED2 series device must have a unique identifier – the device address. This address must be unique within a given network of connected devices. Duplicate address causes a collision. The device address is altered within the range from 1 to 254. The value 255 is reserved as a global address.

4.2 Supported functions according to IEC 60870-5-104 protocol

4.2.1 List of protocol application functions

The IEC 60870-5-104 protocol device supports the following application functions:

– initialization;

– time synchronization;

– SD control algorithm;

– general interrogation;

– transmission of data on violations;

– transfer of analog values;

– event data collection.

4.2.2 Application service data units in monitoring direction

4.2.2.1 The list of supported ASDU transmitted by the ED2 series device via the IEC 60870-5-104 protocol in the monitoring direction is shown in Table 24.

Table 24 − Units of data, transmitted by the ED2 series device

Stamp	Type ID	Description	Note
M_SP_NA_1	1	Single-point information without timestamp	Used to transfer binary values
M_SP_TA_1	2	Single-point information with timestamp	Used to transfer binary values
M_ME_NA_1	9	Measured values, normalized value	Used to transfer analog values
M_ME_NB_1	11	Measured value, scaled value	Used to transfer analog values
M_ME_NC_1	13	Measured values, short floating-point value	Used to transfer analog values
M_SP_TB_1	30	Single-point information with timestamp CP56Time2a	Used to transfer binary values
M_ME_TD_1	34	Measured value, normalized value with timestamp CP56Time2a	Used to transfer analog values
M_ME_TE_1	35	Measured value, scaled value with timestamp CP56Time2a	Used to transfer analog values
M_ME_TF_1	36	Measured value, short floating point value with timestamp CP56Time2a	Used to transfer analog values
M_EI_NA_1	70	End of initialization	Used to indicate the end of the slave ED2 series device initialization procedure
C_IC_NA_1[1)]	100	Interrogation command	Used to indicate the start and end of interrogation of binary data
C_CS_NA_1[1)]	103	Time synchronization	Used for positive/negative acknowledgment of the time synchronization procedure
F_FR_NA_1	120	File ready	Used when transmitting disturbance records
F_SR_NA_1	121	Section ready	Used when transmitting disturbance records
F_LS_NA_1	123	Last section, last segment	Used when transmitting disturbance records
F_SG_NA_1	125	Segment	Used when transmitting disturbance records

Stamp	Type ID	Description	Note
F_DR_TA_1	126	Directory	Used when transmitting disturbance records
[1)] ASDUs transmitted in the control direction are acknowledged by the application layer and may be returned in the monitoring direction for various transmission reasons. These reflected ASDUs are used for positive/negative acknowledgment (verification).			

4.2.3 Application service data units in control direction

The range of supported ASDUs received by the ED2 series device over the protocol in the control direction is shown in Table 25.

Table 25 − Client data units

Stamp	Type ID	Description	Note
C_CS_NA_1	45	Single command	Remote alarm reset command
C_IC_NA_1	100	Interrogation command	Starts the procedure for general interrogation of binary data
C_RD_NA_1	102	Read command	Used to get signal values in the background
C_CS_NA_1	103	Time synchronization	Request ED2 series device time synchronization with client
F_SC_NA_1	122	Directory call, file select, file call, section call	Starting the disturbance record transfer procedure
F_AF_NA_1	124	File confirmation, section confirmation	Confirmation of disturbance record transmission

4.2.4 Approval form

The approval form is given in Table 26.

Table 26 – Approval form

Type ID		Reason for transfer															
		1	2	3	4	5	6	7	8	9	10	11	12	13	20-36	37-41	44-47
<1>	M_SP_NA_1																
<2>	M_SP_TA_1			■		■						■	■				
<3>	M_DP_NA_1																
<4>	M_DP_TA_1			■		■						■	■				
<5>	M_ST_NA_1																
<6>	M_ST_TA_1			■		■						■	■				
<7>	M_BO_NA_1																
<8>	M_BO_TA_1			■		■											
<9>	M_ME_NA_1	X															
<10>	M_ME_TA_1			■		■											
<11>	M_ME_NB_1	X															
<12>	M_ME_TB_1																
<13>	M_ME_NC_1	X															
<14>	M_ME_TC_1			■		■											

Type ID		Reason for transfer															
		1	2	3	4	5	6	7	8	9	10	11	12	13	20-36	37-41	44-47
<15>	M_IT_NA_1																
<16>	M_IT_TA_1																
<17>	M_EP_TA_1																
<18>	M_EP_TB_1																
<19>	M_EP_TC_1																
<20>	M_PS_NA_1																
<21>	M_ME_ND_1																
<30>	M_SP_TB_1			X													
<31>	M_DP_TB_1																
<32>	M_ST_TB_1																
<33>	M_BO_TB_1																
<34>	M_ME_TD_1			X													
<35>	M_ME_TE_1			X													
<36>	M_ME_TF_1			X													
<37>	M_IT_TB_1																
<38>	M_EP_TD_1																
<39>	M_EP_TE_1																
<40>	M_EP_TF_1																
<45>	C_SC_NA_1						X										X
<46>	C_DC_NA_1						X										X
<47>	C_RC_NA_1																
<48>	C_SE_NA_1																
<49>	C_SE_NB_1																
<50>	C_SE_NC_1																
<51>	C_BO_NA_1																
<58>	C_SC_TA_1																
<59>	C_DC_TA_1																
<60>	C_RC_TA_1																
<61>	C_SE_TA_1																
<62>	C_SE_TB_1																
<63>	C_SE_TC_1																
<64>	C_BO_TA_1																
<70>	M_EI_NA_1																
<100>	C_IC_NA_1							X			X						
<101>	C_CI_NA_1																
<102>	C_RD_NA_1					X											
<103>	C_CS_NA_1						X	X									
<104>	C_TS_NA_1																
<105>	C_RP_NA_1																
<106>	C_CD_NA_1																
<107>	C_TS_TA_1																
<110>	P_ME_NA_1																
<111>	P_ME_NB_1																
<112>	P_ME_NC_1																

Type ID		Reason for transfer															
		1	2	3	4	5	6	7	8	9	10	11	12	13	20-36	37-41	44-47
<113>	P_AC_NA_1																
<120>	F_FR_NA_1													X			
<121>	F_SR_NA_1													X			
<122>	F_SC_NA_1					X								X			
<123>	F_LS_NA_1													X			
<124>	F_AF_NA_1													X			
<125>	F_CG_NA_1													X			
<126>	F_DR_TA_1			X		X											

	Function or ASDU is not used.
X	The function or ASDU is used as specified in the standard.
	The option is not required.
	An option not allowed in the standard.

4.3 Description of the operation of the protocol main functions

4.3.1 Initialization

A new connection is established by the controlling station issuing an active open call to its TCP after the controlled station has previously issued a passive open call to its TCP.

When a connection is established, the controlled station is in the STOPDT state, and the transfer of user data is not automatically allowed from the controlled station on this connection, except for the unnumbered control and confirmation functions of these functions. The controlling station shall enable forwarding of user data on a connection by sending a STARTDT act via that connection. The controlled station responds to this STARTDT con command. If STARTDT is not acknowledged, the connection is closed by the controlling station. This means that after station initialization, STARTDT must always be sent before any user data transmission is initiated from the controlled station. Any user data at the controlled station ready for transmission is only sent after STARTDT con.

The connection initialization procedure is presented in Table 27.

Table 27 − Connection initialization procedure

Transmission sequence	Customer sending	Device response	Description
1	STARTDT act	–	The client sends a U format APCI device with the STARTDT function's act bit set
2	–	STARTDT con	The device responds to a U format APICI client with the con bit of the STARTDT function set
3	–	M_EI = 70 COT = 4	The device sends an I format APDU to the client containing ASDU 70 (end of initialization)

4.3.2 Time synchronization

The synchronization procedure is initiated by the client by sending APDU C_CS = 103, with COT = 6 (C_CS_ACT).

C_CS_ACT contains the full current time (date and time) with the required time resolution at the time the application layer generates the message. After performing internal time synchronization, the monitored station issues APDU C_CS = 103, with COT = 7 (C_CS_ACT.CON) containing the local time before synchronization occurred.

If time synchronization has not been carried out for more than 23 hours, then the IV "Time not valid" bit is set. Immediately after starting the controlled device, this bit is set. The time synchronization procedure is shown in Table 28.

Table 28 – Time synchronization procedure

Transmission sequence	Client sending	Device response	Description
1	C_CS = 103 COT = 6	–	The client sends an I format APDU to the device containing ASDU 103 with transmission reason 6 (activation)
2	–	C_CS = 103 COT = 7	The device sends an I format APDU to the client containing ASDU 103 with transmission reason 7 (activation confirmation)

4.3.3 SD control algorithm

The position control of switching devices is performed in one of two modes:

– direct control;

– mode with SBO confirmation (select before operate).

The control mode can be changed in the **Switching devices** window in the Smart Monitor program.

For successful execution of the command, permission is required on the binary inputs:

– local control in the value "0", with a given binary input;

– trip permission in the value of "1", with a given binary input;

– close permission in the value "1", with a given binary input.

Control commands can be blocked via the binary inputs of the device.

Binary inputs are assigned individually for each SD in the **Switching devices** window.

4.3.3.1 Direct control

4.3.3.1.1 For direct control of the SD, it is required to send ASDU 45 (single command) or ASDU 46 (double command) with the transmission reason 6 (activation) and the S/E bit cleared. The information object address for this SD is generated in the report according to 104 protocol data on the **Commands** tab in the **Information object address** column. The SD control commands available for recording are shown in Tables 29, 30.

Table 29 – Single command of the SD control

Recorded value	S/E bit	Description
0	0	SD closing
1	0	SD tripping

Table 30 – Double command of the SD control

Recorded value	S/E bit	Description
1	0	SD closing
2	0	SD tripping

Execution of the SD switch command can be blocked in the following cases:

– SD control is not configured for the current interface or communication protocol;

– the current control mode does not correspond to the "direct control" mode;

– SD switching is blocked by a configured binary input.

4.3.3.2 Control with confirmation SBO (select before operate).

SD switching in this mode is performed in two stages:

1) selection of the control command;

2) command execution

To select the SD, it is required to send ASDU 45 or ASDU 46 with the S/E bit of the SCO or DCO field set, respectively.

SD selection can be blocked in the following cases:

– SD control is not configured for the current interface or communication protocol;

– current control mode does not match SBO;

– SD is already selected by another user;

– SD selection is blocked by a configured binary input.

Deselection of the SD occurs in the following cases:

– the command to cancel the selection is recorded;

– higher command waiting timeout - 10 s;

– another command is selected;

– a command other than the one previously selected was recorded to the control register.

The selection commands available for recording are shown in Tables 31, 32.

Table 31 – Single command of the SD selection

Recorded value	S/E bit	Description
0	1	Cancellation of the SD selection
1	1	Selection of a SD

Table 32 – Double command of the SD selection

Recorded value	S/E bit	Description
1	1	Cancellation of the SD selection
2	1	Selection of a SD

The execution of the command is carried out similarly to the mode with direct control of the SD.

Execution of the SD switch command can be blocked in the following cases:

– SD control is not configured for the current interface or communication protocol;

– current control mode does not match SBO;

– SD is already selected by another user or selected to execute another command;

– SD switching is blocked by a configured binary input.

4.3.4 Event data collection

4.3.4.1 General interrogation

General interrogation is used to read the status of all defined binary events with the corresponding information object addresses.

4.3.4.1.1 The general interrogation procedure is initiated by the client by sending the APDU C_IC = 100, COT = 6, QOI = 20. The device confirms the start of the general interrogation with a response C_IC = 100, COT = 7, QOI = 20, followed by M_SP = 1, COT = 20, containing the binary event values recorded at the start of the interrogation. One M_SP_D APDU contains eight binary values. Then analog measurements are transmitted in the format without timestamps M_ME = 9,11,13. After the transmission of the last data unit, C_IC = 100, COT = 10, QOI = 20 are transmitted to the client.

4.3.4.1.2 Table 33 shows an example of a general interrogation procedure.The default base address for binary events is 0x0101.

The size of information object address is 3 bytes. The signal value is represented by the SPI bit of the SIQ field, 1 byte in size.

Table 33 – General interrogation procedure

Transmission sequence	Client sending	Device response	Description
1	C_IC = 100 COT = 6 QOI = 20	–	The client sends an I format APDU to the device containing ASDU 100 with the transmission reason 6 (activation)
2	–	C_IC = 100 COT = 7 QOI = 20	The device sends an I format APDU to the client containing ASDU 100 with the transmission reason 7 (activation confirmation)
3	–	M_SP = 1 COT = 20	Contains the first eight binary values
…	–	…	…
n-3	–	M_ME = 13, COT = 20	Contains the first 16 analog measurements

Transmission sequence	Client sending	Device response	Description
n-2	–	M_ME = 13, COT = 20	Last module with analog measurements
n-1	–	M_SP = 1 COT = 20	Last module with binary values
N	–	C_IC = 100 COT = 10 QOI = 20	Marks the end of the general interrogation

4.3.4.2 Sporadic events

Events generated by the ED2 series device are sent to the control device in the format M_SP = 30. Each message contains the address of the information object that allows the receiving side to uniquely identify the type of event. The transmitted data also contains the time when the event was registered by the device.

4.3.4.3 Background scanning

The values of individual binary signals and analog values can be read using the read command C_RD = 102, COT = 5. Binary signals will be transmitted in the format M_SP = 1, analog values in the format M_ME = 13.

4.3.5 Transmission of data on violations

Disturbance records stored by the device can be read remotely using the standard mechanism provided by the IEC 60870-5-101 protocol. The transmission cycle starts with a request for the F_DR disturbance record directory.

The list of saved disturbance records is given by the device in the following cases:

– when requesting a directory by the control system by sending the data unit F_SC = 122 with the transmission reason COT = 5 (request a list of registered violations);

– occasionally when the state of the disturbance record directory changes.

Table 34 shows an example of a disturbance record transmission procedure.

Table 34 – Starting the disturbance record transmission procedure

Transmission sequence	Client sending	Device response	Description
1	F_SC = 122 COT = 5	–	Directory call. Request a list of disturbance records from the device
2	–	F_DR[1)] = 126 COT = 5	Disturbance record directory. Sending a list of disturbance records to a client (eight file names per data unit)
3	F_SC = 122 SCQ = 1	–	File selection. The data unit contains the number of the file selected by the client for transmission
4	–	F_FR = 120	File ready. Confirmation of the readiness of the file selected by the client for transmission

Transmission sequence	Client sending	Device response	Description
5	F_SC = 122 SCQ = 2	–	File call. Section 1 request
6	–	F_SR = 121	Section ready. Section 1 readiness confirmation
7	F_SC = 122 SCQ = 6	–	Section call. Section 1 transmission request
8	–	F_SG = 125	Segment. Section 1 consisting of one segment and containing the damage parameters is transmitted (ASDU 26 of IEC 60870-5-103 protocol)
9	–	F_LS = 123	Last segment. Section 1 end sign
10	F_AF = 124	–	Section confirmation. Confirmation of section 1 successful transmission
11	–	F_SR = 121	Section ready. Section 2 ready alert
12	F_SC = 122 SCQ = 6	–	Section call. Section 2 transmission request
13	–	F_SG[1)] = 125	Segment. Section 2 segments containing stamps are transmitted (ASDU 29 of IEC 60870-5-103 protocol)
14	–	F_LS = 123	Last segment. Section 2 end sign
15	F_AF = 124	–	Section confirmation. Confirmation of section 2 successful transmission
16	–	F_SR = 121	Section ready. Section 3 ready alert
17	F_SC=122 SCQ = 6	–	Section call. Section 3 transmission request
18	–	F_SG = 125	Segment. Section 3 consisting of one segment, containing the analog channel 1 damage parameters is transmitted (ASDU 27 of the IEC 60870-5-103 protocol)
19	–	F_LS = 123	Last segment. Section 3 end sign
20	F_AF = 124	–	Section confirmation. Confirmation of section 3 successful transmission
21	–	F_SR = 121	Section ready. Section 4 ready alert
22	F_SC = 122 SCQ = 6	–	Section call. Section 4 transmission request
23	–	F_SG[1)] = 125	Segment. Section 4 segments containing analog channel 1 values are transmitted (ASDU 30 of IEC 60870-5-103 protocol)
24	–	F_LS = 123	Last segment. Section 4 end sign

Transmission sequence	Client sending	Device response	Description
25	F_AF = 124	–	Section confirmation
[1)] Data units, the number of which during serial transmission can be greater than or equal to 1. Upon completion, steps 16 to 25 are repeated for sections 5, 6 ... n, n+1, where n depends on the number of analog disturbance record channels. The segment length is 200 characters.			

4.3.6 Analog values

Analog values can be transmitted as a floating point, scalable or normalized values. By default, analog values are transmitted as a floating point. The type of measurement transmission can be periodic and/or sporadic. Sporadic transmission is carried out in formats with a timestamp: M_ME = 34, M_ME = 35, M_ME = 36. Periodic transmission is carried out in formats without timestamps: M_ME = 9, M_ME = 11, M_ME = 13. For a periodic measurement type, the transmission interval is set by the **Transmission period** parameter. The default is 60 s. For the sporadic measurement type, the parameter **Deadband** of analog inputs is used.

Measurements are transmitted in groups of 16 information objects in one package.

The size of information object address is 3 bytes. The measurement value is represented by a short floating-point format of 4 bytes.

4.3.7 Definition of timeouts

The definition of timeouts is carried out according to Table 35.

Table 35 – Time delays

Parameter	Value by default	Note
t0	30	Timeout when establishing a connection
t1	15	Timeout while sending or testing of APDU
t2	10	Timeout for acknowledgment in case of no data message t1 < t2
t3	20	Timeout for sending test units when idle

4.4 IEC 60870-5-104 protocol configuration

4.4.1 Configuration of protocol using the Smart Monitor software

4.4.1.1 Start the Smart Monitor software similar to 2.4.1.1.

4.4.1.2 In the “tree” of the Smart Monitor software project, select the menu item **Settings → Digital communication channels → Communication protocols** (see Figure 49, designation 1), clicking once with the left mouse button the corresponding item in the project “tree”, and open the window.

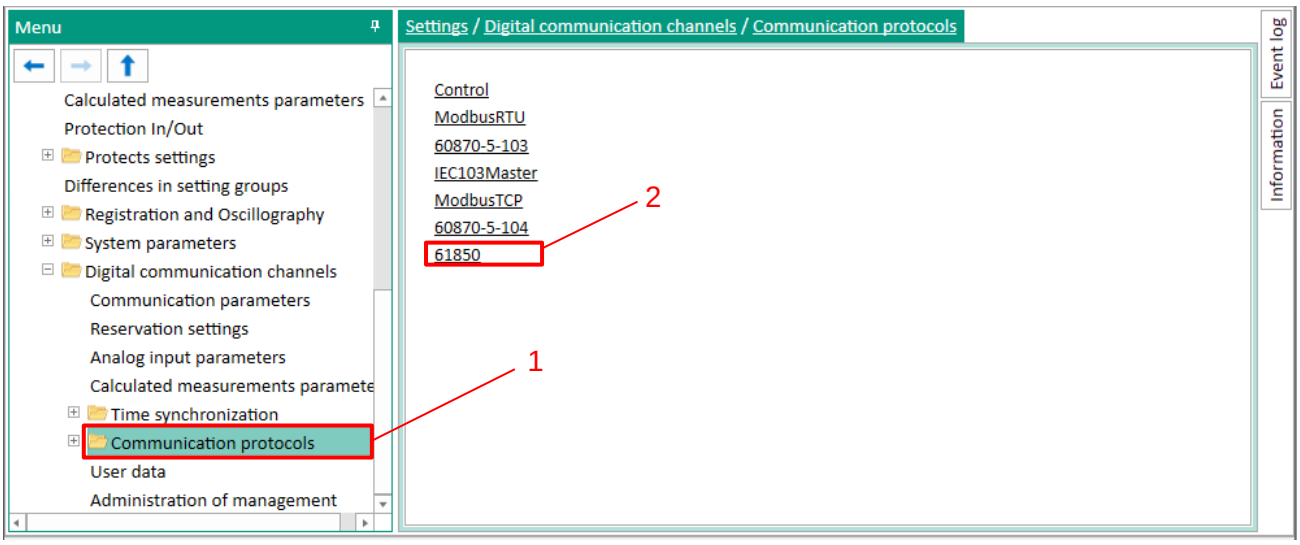


Figure 49 – **Communication protocols** window

4.4.1.3 On the **Communication protocols** tab, select the protocol: **60870-5-104** (see Figure 49, designation 2).

4.4.1.4 Check the **Protocol enabled** box if it has not been checked (see Figure 50, designation 1).

4.4.1.5 Set IEC 60870-5-104 protocol parameters according to the project. The default values of the protocol parameters are shown in Figure 50, designation 2. Description of IEC 60870-5-104 protocol parameters is given in Table 36.

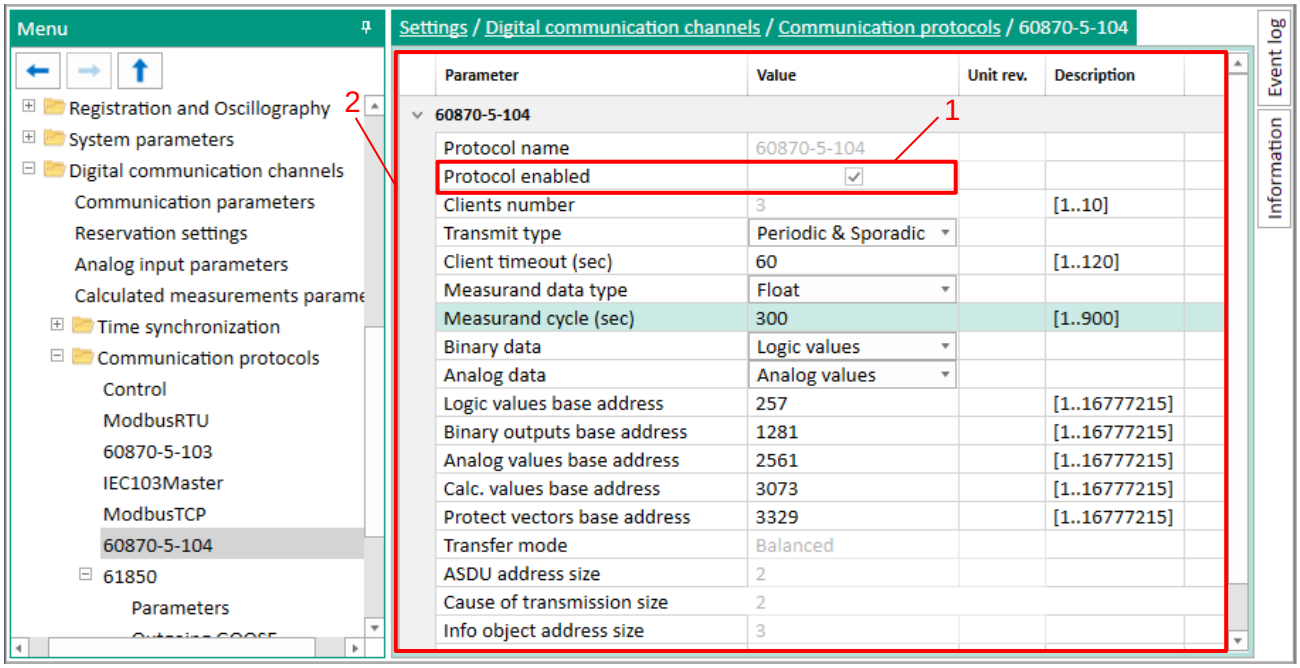


Figure 50 – Setting the IEC 60870-5-104 protocol

Table 36 – Description of IEC 60870-5-104 protocol parameters

Parameter	Description
Protocol enabled	Attribute of protocol using in the configuration

Parameter	Description
Quantity of clients	The maximum possible number of clients (value should be in the range from 1 to 10) connected to the device using the IEC 60870-5-104 protocol
Measurement transmission type	It sets measurements transmission type: – periodic transmission (after a specified time interval); – sporadic transmission (when signal is changed); – periodic and sporadic (after a specified time interval and when the signal changes); – disabled (transmission of information is not performed)
Client timeout, s	Time interval in seconds (the value should be in the range from 1 to 120 s), after which it is considered that there is no connection with the client if no data was received from the client
Measurement data type	It sets measurements transmission type: – normalized; – scaled; – with floating point
Sending period, s	Time interval in seconds (value should be in the range of 1 to 900 s) during which the transmission of cyclic measurements is repeated
Binary data[1)]	Contents of transmitted binary data: – logical signals; – binary outputs; – all signals
Analog data[1)]	Contents of transmitted analog data: – analog values; – calculated values; – protection phasors; – all signals
Logical values base address	Basic address of logical signals (value should be within the range from 1 to 16,777,215), under protocol IEC-61870-5-104. It is not recommended to change the value without the consent of the device developers. Default value 256
Binary outputs base address	Basic address of binary signals (value should be within the range from 1 to 16,777,215) under protocol IEC-61870-5-104. It is not recommended to change the value without the consent of the device developers. Default value 1,280
Analog values base address	Basic address of analog measurements (value should be within the range from 1 to 16,777,215) under protocol IEC-61870-5-104. It is not recommended to change the value without the consent of the device developers. Default value 2,560
Calculated values base address	Basic address of calculated values (value should be within the range from 1 to 16,777,215) under protocol IEC-61870-5-104. It is not recommended to change the value without the consent of the device developers. Default value 3,072
Protection phasors base address	Basic address of protection phasors (value should be within the range from 1 to 16,777,215) under protocol IEC-61870-5-104. It is not recommended to change the value without the consent of the device developers. Default value 3,328
Transmission mode[2)]	Protocol operation mode By default – Balanced
ASDU address size[2)]	By default – 2
Size of transmission reason field[2)]	By default – 2
Size of information object address[2)]	By default – 3

Parameter	Description
k Max. quantity of APDU without acknowledgment	The value of k indicates the maximum number of consecutively numbered I format APDUs that can be transmitted without acknowledgment
W Sending an ACK after receiving w APDU	The W value is the number of APDUs read before an ACK should be sent
[1] One can select multiple items. [2] An unchanged parameter, it is for information purposes.	

4.4.1.6 Save the changes made to the device as to 3.4.1.5.

4.4.2 Configuration of protocol using the Configurator software

4.4.2.1 Start the Configurator software similar to 2.5.2.1.

4.4.2.2 In the “tree” of the project of the Configurator software, select the menu item **System** parameters (see Figure 51, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

4.4.2.3 Open the **Ethernet protocols** tab (see Figure 51, designation 2).

4.4.2.4 On the field **Protocols**, select the protocol: **60870-5-104** (see Figure 51, designation 3).

4.4.2.5 Check the **Protocol enabled** box if it has not been checked (see Figure 51, designation 4).

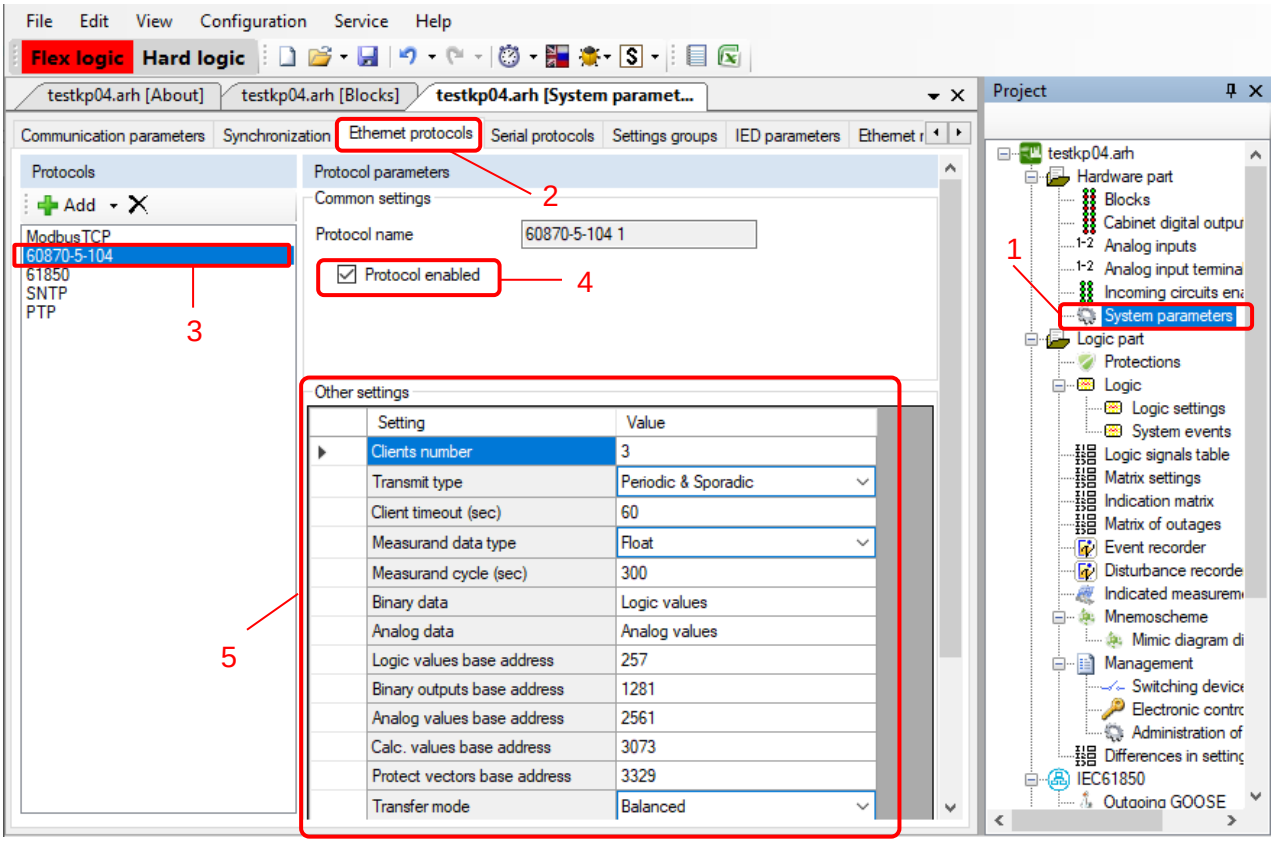


Figure 51 – IEC 60870-5-104 protocol configuration example

4.4.2.6 Set IEC 60870-5-104 protocol parameters according to the project.

The values of the protocol parameters are shown in Figure 51, designation 5. Description of IEC 60870-5-104 protocol parameters is given in Table 36.

4.4.2.7 Save the changes made to the device similar to 3.4.2.6.

4.4.3 Configuration of protocol using the device menu

On the front panel of the device there is a keyboard, through which the service personnel can control the device. The keyboard consists of (0-9) digital buttons, “.” dot, “F” functional button and control buttons: “◄”, “▼”, “►”, “▲”, “I”, “O”, “ESC”, “ ↵ ”.

You can use the "▲" and "▼" buttons to move up and down respectively. The “◄” and “►” buttons are designed to shift horizontally to the left and to the right correspondingly. The “ ↵ " button is used to confirm the selected operation, "ESC" is the button to exit. The “I” and “O” are designed to control a circuit breaker if this function is provided by the project, otherwise, they are blocked.

4.4.3.1 In the device menu, select the item menu **Parameters**[1)] → **System parameters** → **Communication parameters** → **Network parameters** → **Network protocols** (see Figure 52).

4.4.3.2 Select protocol using combination of buttons “F+◄”, “F+►”.

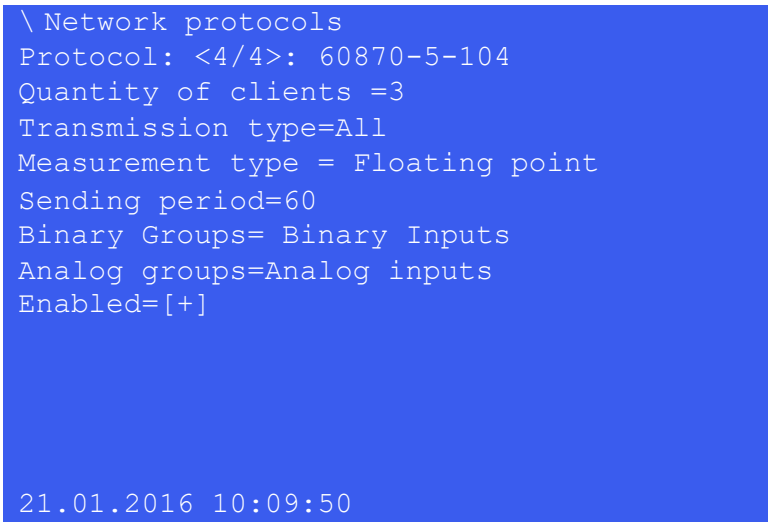


Figure 52 – **Network protocols** item

4.4.3.3 Set the parameters of the IEC 60870-5-104 protocol (in the device, the protocol is designated as 60870-5-104) in accordance with the project.

The IEC 60870-5-104 protocol editing mode is carried out by pressing the button “ ↵ ”. The default protocol parameter values are shown in Figure 52. Description of IEC 60870-5-104 protocol parameters is given in 36.

4.4.3.4 Saving the changes made

All changes made in parameters and settings are temporarily saved in the device RAM and are lost when the device is turned off or restarted.

To apply the settings and save the changes in the non-volatile memory, use the menu **Save settings** (menu **Parameters** –> **Save settings**).

[1)] To change settings, one should enter a password when entering **Parameters**.

When entering the menu **Parameters**, an access password is requested. Enter a combination of symbols[1)], which is a password, and press “ENTER” button. The user enters the menu, the IED switches to the edit mode. Pressing “ESC” button enables entering the menu, but in the viewing mode.

In the menu item **Save settings** (see Figure 53) one should select **Save settings?** (Yes / No) and press “ENTER” button.

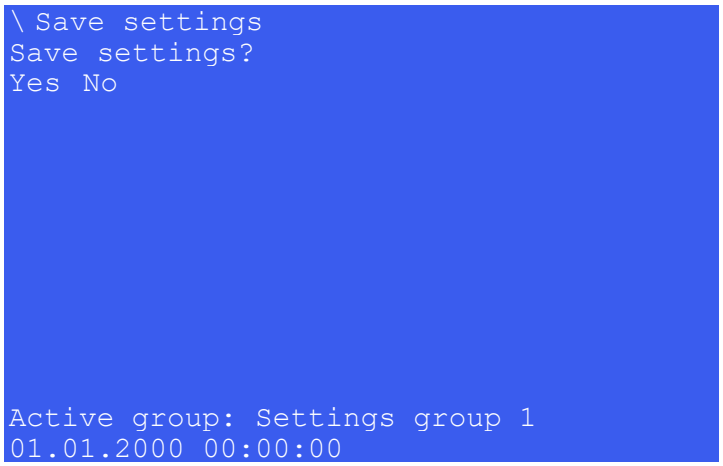


Figure 53 – General view of the menu item **Save settings**

If “Yes” is selected, the screen shows the status of settings saving. There are three possible statuses: “Settings saving”, “Settings saved” and “Settings saving error”. In case of successful saving, the device returns to **Parameters** menu list and starts operating with new values of settings and parameters. If “No” is selected, the device returns to **Parameters** menu list without changing settings and parameters.

Settings are applied in the background mode and the device is not off.

After settings and parameters are saved in the non-volatile memory, it is necessary to make sure whether the new values are correct. If it is impossible to record (for example, in case of failure in the non-volatile memory), “ERORR” LED is on in the upper part of the device front panel.

4.5 Setting the parameters of the module for controlling the SD according to the IEC 60870-5-104 protocol

The procedure for setting the parameters of the module for controlling the SD using the IEC 60870-5-104 protocol is similar to the setting procedure for the IEC 60870-5-103 protocol, presented in 3.5.2.1.8.

4.6 Troubleshooting

Troubleshooting is specified in Table 37.

[1)] Default user passwords are shown in Table 1.

Table 37 – Troubleshooting

Description of failure	Possible cause of failure	Method of elimination
Lack of communication with the device via Ethernet interface (if there is no alarm the device failure)	Incorrect communication parameters in the device	Make sure the used address of the device is free in the current network. Set the correct address
		Make sure the used IP address of the device is free in the current network. Set the correct address
	Damaged communication cable	Check the communication cable, replace with a non-faulty one that meets the requirements
	When communicating via Smart Monitor software – inconsistency of communication parameters between the device and the Smart Monitor software	Make sure the subnet mask specified in the device is compatible with the PC where the Smart Monitor software is installed
		If the device and the PC where the Smart Monitor software is installed are in different subnets, make sure the gateway numbers specified in the device and the PC are compatible
Lack of communication via IEC 60870-5-104 protocol	Failure of Ethernet interface	The Ethernet interface troubleshooting procedure is described above
	Protocol is missing in the configuration	Not a failure. Add the protocol using the Configurator or Smart Monitor software
	Protocol is disabled	Enable the protocol via Smart Monitor software or the menu of the device

5 Modbus protocol

5.1 General

The Modbus protocol for Modbus Server (TCP) and Modbus Slave (RS-485) functions is designed to organize communication between digital devices. The protocol is implemented in two forms: Modbus RTU and Modbus TCP.

5.1.1 Purpose of the protocol

In ED2 series devices the protocol is used to receive binary and analogue data values, as well as to synchronize the time of the device.

The list of functions supported by ED2 series devicesoperating via Modbus protocol is given in Table 38.

Table 38 – List of standard protocol functions

Function number	Function name
03 (0x03)	Reading internal registers
06 (0x06)	Writing register
16 (0x10)	Writing multiple registers (time synchronization) Writing multiple registers (time synchronization in BCD format) Remote reset
17 (0x11)	Receiving information about the addressable device

5.1.1.1 Receiving an up-to-date memory card with signal addresses is given in 2.5.2.2.

5.1.2 Application conditions

The Modbus RTU protocol based on the RS-485 physical interface is multidrop – one master device can communicate with many slave devices on the same communication line. For this reason, each individual slave device must have a unique identifier – the device address. This address must be unique within a given network of connected devices. If the address is duplicated, the data from the master device will go to several slave devices, therefore, several responses will come, the sources of which will be impossible to identify. Thus, a collision (error) occurs. The device address can have a value between 1 and 247. The value 0 is used as the broadcast address without back acknowledgment.

The Modbus TCP protocol based on the Ethernet physical interface uses a point-to-point connection.

The conditions for applying the Modbus RTU and Modbus TCP protocols are given in Table 39.

Table 39 – Protocol application conditions

Parameter	Modbus RTU	Modbus TCP
Interface type	Two-wire RS-485	Fast Ethernet RJ-45
Connector type	MC socket	RJ-45
Rate	(9,600 – 115,200) bps	–
Maximum transmission distance	1,000 m	100 m

Parameter	Modbus RTU	Modbus TCP
Topology	Bus	Star
Address	1 – 247	1 – 247
Data bits	8	–
Parity	No	–
Bit stop	1	–

5.2 Description of main functions of the protocol

This section describes main functions of the Modbus protocol supported by the device.

5.2.1 Reading internal registers. Function 03 (0x03)

5.2.1.1 The function allows the user to get the binary contents of the 16-bit registers of the addressable device. Broadcast mode is not supported. In addition to the device and function address fields, the message requires that the information field contain the number (address) of the first requested register and the number of registers to read.

5.2.1.2 Addressing allows you to get up to 125 registers for each request. Registers are numbered from zero. Permissible values for data request are presented in Table 40.

Table 40 – Permissible request values

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x03
First register address	2	0x0000 – 0xFFFF
Quantity of registers	2	0x0001 – 0x007D

5.2.1.3 The addressable device sends in response its address, the code of performed function and the information field (see Table 41). The information field contains 1 byte describing the quantity of bytes of data returned. The length of each data register is 2 bytes. The first data byte in the message is the high byte of the register, the second is the low byte. If you need to get the value of more than 125 registers, then you need to perform several consecutive requests.

Table 41 – Permissible response values

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x03
Quantity of data bits	1	2 x N[1)]
Register value	N[1)] x 2	0x0000 – 0xFFFF
[1)] Quantity of registers.		

5.2.1.4 The table 42 shows the possible response of the device in case of an error.

Table 42 – Permissible response values in case of an error

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x83
Error code	1	02 or 03
Note – “02” is an invalid address in the data field, “03” is an invalid value in the data field.		

5.2.1.5 An example of a request and response to reading registers with addresses 108 – 110 is shown in Table 43.

Table 43 – Example of a request and response for reading registers with addresses 108 – 110

Request		Response	
Field name	*(HEX)*	*Field name*	*(HEX)*
Function	0x03	Function	0x03
First register address (high)	0x00	Quantity of data bits	0x06
First register address (low)	0x6B	Register value 108 (high)	0x02
Quantity of registers (high)	0x00	Register value 108 (low)	0x2B
Quantity of registers (low)	0x03	Register value 109 (high)	0x00
		Register value 109 (low)	0x00
		Register value 110 (high)	0x00
		Register value 110 (low)	0x64

The contents of register 108 are represented as two-byte values “02 2B” in hexadecimal format or 555 in decimal format. The contents of registers 109 and 110 are “00 00” and “00 64” in hexadecimal, or 0 and 100 in decimal format, respectively.

5.2.2 Writing register. Function 6 (0x06)

5.2.2.1 The function allows the user to modify the contents of one 16-bit register of the addressable device on the memory card. When the request specifies device address 0 (broadcast request), all devices will load the corresponding register with the specified value.

5.2.2.2 Addressing allows you to write one register per request. Registers are numbered from zero. Permissible values for data request and response are given in Tables 44, 45. In case of successful execution of the function, the response message is identical to the request.

Table 44 – Permissible request values

Field name	Field size, byte(s)	Permissible values
Device address	1	0 – 247
Function	1	0x06
Register address	2	0x0000 – 0xFFFF
Register value	2	0x0000 – 0xFFFF

Table 45 – Permissible response values

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x06
Register address	2	0x0000 – 0xFFFF
Register value	2	0x0000 – 0xFFFF

The possible response of the device in case of an error is shown in Table 46.

Table 46 – Permissible response values in case of an error

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x86
Error code	1	02
Notes 1 No response is returned upon a broadcast request. 2 “02” is an invalid address in the data field.		

5.2.2.3 The table 47 shows an example of a request and response for entering the value 0x0003 into the register with address 2.

Table 47 – Example of a request and response for entering the value 0x0003 into the register with address 2

Request		Response	
Field name	*(HEX)*	*Field name*	*(HEX)*
Function	06	Function	06
Register address (high)	00	Register address (high)	00
Register address (low)	01	Register address (low)	01
Register value (high)	00	Register value (high)	00
Register value (low)	03	Register value (low)	03

5.2.3 Writing multiple registers. Function 16 (0x10)

5.2.3.1 Writing multiple registers (time synchronization in BCD format)

5.2.3.2 This message changes the contents of four 16-bit registers of the polled device. The quantity of registers to be written is four. If an address equal to 0 is used as the device address, then the content of the data field is written to all devices (broadcast mode). Permissible values for data request are given in Table 48.

Table 48 – Permissible request values

Field name	Field size, byte(s)	Permissible values
Device address	1	0 – 247
Function	1	0x10
First register address	2	0x0004
Quantity of registers	2	0x0004

Field name	Field size, byte(s)	Permissible values
Quantity of data bits	1	0x08
Data	N[1)] x 2	0x0000 – 0xFFFF
[1)] Quantity of registers.		

5.2.3.3 The addressable device sends in response its address, the code of the performed function and the information field (see Table 49). The information field contains 4 bytes: the address of the first register is always 0x0004 (2 bytes) and the quantity of registers is 0x0004 (2 bytes).

Table 49 – Permissible response values

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x10
First register address	2	0x0004
Quantity of registers	2	0x0004
Note – No response is returned upon a broadcast request.		

5.2.3.4 The possible response of the device in case of an error is given in Table 50.

Table 50 – Permissible response values in case of an error

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x90
Error code[1)]	1	02 or 03
[1)] Possible cause of the error: prohibition of synchronization via interface. Notes 1 No response is returned upon a broadcast request. 2 “02” is an invalid address in the data field, “03” is an invalid value in the data field.		

5.2.3.5 When using hardware time synchronization (pulse synchronization), it is necessary to transmit time via protocol by 1 s more than the current time.

An example of a request and response for writing four registers is given in Table 51.

Table 51 – Example of a request and response for writing four registers

Request		Response	
Field name	*(HEX)*	*Field name*	*(HEX)*
Function	0x10	Function	0x10
First register address (high)	0x00	First register address (high)	0x00
First register address (low)	0x04	First register address (low)	0x00
Quantity of registers (high)	0x00	Quantity of registers (high)	0x00
Quantity of registers (low)	0x04	Quantity of registers (low)	0x04
Quantity of data bits	0x08		
Register value 0 (high)	0x00		
Register value 0 (low)	0x00		

Request		Response	
Field name	*(HEX)*	*Field name*	*(HEX)*
Register value 1 (high)	0x01		
Register value 1 (low)	0x11		
Register value 2 (high)	0x06		
Register value 2 (low)	0x10		
Register value 3 (high)	0x00		
Register value 3 (low)	0x00		
Note – The synchronization request must be sent in the range of 100 to 900 ms.			

5.2.3.6 Upon this request, the device with the given address will set the time and date in accordance with the value of registers.

5.2.3.7 The time and date representation format is given in Table 52.

Table 52 – Time and date representation format

Word	Number format	High byte	Low byte
0	BCD	Minute	Second
1	BCD	Day	Hour
2	BCD	Year	Month
3	HEX	Milliseconds	

The time is counted from January 1, 2000 00:00:00:000.

Value range: second = 0 – 59, minute = 0 – 59, hour = 0 – 23, day = 1 – 31, month = 1 – 12, year = 0 – 99, millisecond = 0 – 999.

Synchronization is allowed when you check the box in the **Synchronization enabled** item in the Smart Monitor software.

Note – A more detailed description of time synchronization is given in section 7.

If the synchronization was successful, the first time you synchronize, one of the following events will appear in the event log:

– Synchronizing via Modbus/RTU;

– Synchronizing via Modbus/TCP.

And at the same time, depending on the communication interface used, – one of the following events:

– Synchronizing via COM1;

– Synchronizing via COM2;

– Synchronizing via Ethernet.

5.2.3.8 Remote reset

This message changes the contents of a 16-bit register. The message allows you to reset the state of the device using the F + 0 key combination of the device. Register address – 0x0A.

Permissible values for data request are given in Table 53.

Table 53 – Permissible request values

Field name	Field size, byte(s)	Permissible values
Device address	1	0 – 247
Function	1	0x10
First register address	2	0x000A
Quantity of registers	2	0x0001
Quantity of data bits	1	0x02
Register value	2	0x0001

The addressable device sends in response its address, the code of the performed function and the information field (see Table 54). The information field contains 2 bytes: the address of the first register is always 0x000A (2 bytes) and the quantity of registers is 0x001 (2 bytes).

Table 54 – Permissible response values

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x10
First register address	2	0x000A
Quantity of registers	2	0x0001

5.2.3.9 The possible response of the device in case of an error is given in Table 55.

Table 55 – Permissible response values in case of an error

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x90
Error code	1	02 or 03
Note – “02” is an invalid address in the data field, “03” is an invalid value in the data field.		

For remote reset using the Smart Monitor software, you must select the main menu item **Commands → Reset alarm**.

If the remote reset was successful, the “Reset” event will appear in the event recorder for group 1, and the “Reset” event will appear for group 2, provided that the signal is set for registration in the configuration.

5.2.4 Receiving information about the addressable device. Function 17 (0x11)

This message requests information about the device. Also, this message is used to determine the presence of the device on the connection. Broadcast request is not supported. The information field of this message is empty.

Permissible values for data request and response are given in Tables 56, 57.

Table 56 – Permissible request values

Field name	Field size, byte(s)	Permissible values
Device address	1	1– 247
Function	1	0x11

Table 57 – Permissible response values

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x11
Quantity of data bits	1	155
Configuration file name	33	string\0
Port number	1	0 – 5
Device functionality code	1	1 – 6
Reserve	3	0x000000
Delivery description	32	string\0
Device name	20	string\0
Serial number	2	0, 1…
Semi-set number	1	0, 1, 2, 3 or 4
Terminal software version	8	string\0
Protected object	32	string\0
Cabinet name	20	string\0
Cabinet serial number	2	0, 1…

The device is connected if the request received a response message that matches the description in Table 57.

An example of a request and response for receiving information about the device is given in Table 58.

Table 58 – Example of a request and response for receiving information about the device

Request		Response	
Field name	*(HEX)*	*Field name*	*(HEX)*
Function	0x11	Function	0x11
		Quantity of data bits	155
		Configuration file name	s113388.czg
		Port number	1
		Device functionality code	1
		Reserve	0x000000
		Delivery description	Zhigulev. HPP
		Device name	ED2-G-011
		Serial number	9
		Semi-set number	1
		Terminal software version	2.8.0.0
		Protected object	G – 15
		Cabinet name	ShE1111.33
		Cabinet serial number	8

5.2.5 Reading analogue input

5.2.5.1 The function allows the user to receive the contents of the effective value of the fundamental harmonic, angle and frequency of the signal, packed into 16-bit registers of the addressable device.

Algorithm for reading analogue inputs:

1) set the amplitude receiving format (16th function);
2) write measurement update command (16th function);
3) read the values of analogue inputs (3rd function).

5.2.5.2 To prepare new values for analogue inputs, use the 16th function to set the value “1” to the register at address 0x008B. After this command, you can read the measurements of analogue inputs. Reading data via Ethernet (ModbusTCP) these two actions (writing using the 16th function and reading using the 3rd function) must be carried out within one TCP connection. That is, it is not allowed to write (to update data) using one TCP connection, and read the values of analogue inputs using another TCP connection.

5.2.5.3 For each analogue input, the buffer stores the effective value of the fundamental harmonic, angle and frequency. These values are packed into six 16-bit registers: two registers per value – **float** storage format (floating-point number) (see Table 59).

Table 59 – Example of the location in the memory of the effective values of the fundamental harmonic, angle and frequency

Register name	Register address	Number byte
Current I Y, phase A, effective value of the fundamental harmonic	0x4D04	1
		0
	0x4D05	3
		2
Current I Y, phase A, angle	0x4D06	1
		0
	0x4D07	3
		2
Current I Y, phase A, frequency	0x4D08	1
		0
	0x4D09	3
		2
Current I Y, phase B, effective value of the fundamental harmonic	0x4D0A	1
		0
	0x4D0B	3
		2
Current I Y, phase B, angle	0x4D0C	1
		0
	0x4D0D	3
		2
Current I Y, phase B, frequency	0x4D0E	1
		0
	0x4D0F	3
		2

Note – Register addresses may vary depending on the project. Actual values can be received by generating the report “Description of data for Modbus” in the Smart Monitor or Configurator software. The report generation method is described in 2.5.2.2.

Broadcast mode is not supported. In addition to the device and function address fields, the message requires that the information field contain the number (address) of the first requested register and the number of 16-bit registers to read.

The **float** format occupies two 16-bit registers. In accordance with the requirements of the protocol, the high byte comes first in the request, and then the low byte.

5.2.5.4 In order to use the angle values, one of the signals should be selected as the base one. The following formula is used to calculate the signal angle relative to the base one:

$$AngleiB = Anglei - AngleB; \quad (1)$$

$$If\ (AngleiB > 180.0°)\ AngleiB = AngleiB - 360.0°; \quad (2)$$

$$else\ if\ (AngleiB < -180.0°)\ AngleiB = AngleiB + 360.0°, \quad (3)$$

where AngleiB – i signal angle relative to the base;

Anglei – read angle value of i-th signal;

AngleB – read angle value of base signal.

Addressing allows you to get up to 125 registers for each request, six registers are required for each analogue input: two for the value of the effective value of the fundamental harmonic, two for the angle value, two for the frequency value (125 / 6 (amplitude (2) + angle (2) + frequency (2)) = 20), i.e. one request allows you to get the parameters of 20 analogue inputs. These parameters occupy 120 registers. The initial address for reading analogue measurements is 0x4D04. The quantity of available addresses depends on the project, but does not exceed the register with address 0x5103. Registers are numbered from zero. Permissible values for data request are given in Table 60.

Table 60 – Permissible request values

Field name	Field size, byte(s)	Permissible values
Device address	1	1 – 247
Function	1	0x03
Device address	2	0x4D04 – 0x5103
Quantity of registers	2	0x0001 – 0x007D

5.2.5.5 The addressable device sends in response its address, the code of performed function and the information field (see Table 61). The **Quantity of data bytes** contains 1 byte describing the quantity of data bytes returned. The length of each data register is 2 bytes. The first data byte in the message is the high byte of the register, the second is the low byte.

The order of words in the **float** type is from low byte to high byte. The low byte is transmitted first, then the high byte. If you need to get the value of more than 125 registers, then you need to perform several consecutive requests.

Table 61 – Permissible response values

Field name	Field size, byte(s)	Permissible values
Device address	1	1– 247
Function	1	0x03
Quantity of data bits	1	2 x N[1)]
Register value	N[1)] x 2	0x0000 – 0xFFFF
[1)] Quantity of registers.		

5.2.5.6 The table 62 shows the possible response of the device in case of an error.

Table 62 – Permissible response values in case of an error

Field name	Field size, byte(s)	Permissible values
Device address	1	1– 247
Function	1	0x83
Error code	1	02 or 03
Note – “02” is an invalid address in the data field, “03” is an invalid value in the data field.		

5.2.5.7 The table 63 shows an example of a request and response for reading registers with the first analogue input.

Table 63 – Example of a request and response for reading registers with the first analogue input

Request		Response	
Field name	*(HEX)*	*Field name*	*(HEX)*
Function	0x03	Function	0x03
First register address (high)	0x4D	Quantity of data bits	0x04
First register address (low)	0x04	Register value1 (high)	0x00
Quantity of registers (high)	0x00	Register value1 (low)	0x0A
Quantity of registers (low)	0x02	Register value2 (high)	0x00
		Register value2 (low)	0x00

The contents of the register are represented as two byte values “00 0A” in hexadecimal format or 10 in decimal format.

5.2.6 Algorithm for reading recorder

5.2.6.1 The recorder allows you to store the change time of bit events. All events are divided into groups for the convenience of working with them. When all events are packed into 16-bit words and added in ascending order of the group number, a slice of the signal state will be obtained. A signal state slice is the state of all signals at a given point in time.

5.2.6.2 The following steps should only be performed on the first reading of the recorder, when there is no history or it is corrupted, and read the recorder from the oldest stored event:

1) reset the oldest event pointer. To do this, use the 16th function to set the value of the 16-bit register at address 0x0008 to 0;

2) read a slice of the state of signals at the time of the oldest stored one in the event recorder. To do this, read the values of **K** 16-bit registers at address 0x0BD5, where **K** is the size of signal slice in words;

3) obtain new events.

5.2.6.3 It is possible to read events without reading the signal slice. Reading the initial slice of signals is necessary in order to know the values of the signals whose changes have been forced out of the recorder. In this case, the values of the preempted signals can be read from the buffer of current values.

5.2.6.4 To receive new events, i.e. update the recorder, follow these steps:

1) request the quantity of new events. To do this, read the value of the 16-bit register at address 0x090C;

2) if the quantity of new events (N) is 0, then the reading of new events is complete, otherwise continue;

3) read recorder events from the buffer. The buffer contains events received after the request described in step 1. The buffer is located at address 0x090D. The buffer is designed for 100 events;

4) confirm that events have been read by writing 0 to the 16-bit register at address 0x00009;

5) go to the first step.

Events in the buffer are located one after another (see Table 64).

Table 64 – Location of events in the buffer

Event 1	Event 2	Event 3	…	Event N

The event format is given in Table 65.

Table 65 – Event format

Word	Number format	High byte	Low byte
0	BCD	Minute	Second
1	BCD	Day	Hour
2	BCD	Year	Month
3	HEX	Millisecond	
4	HEX	Group number	
5	HEX	Event number in group	
6	HEX	–	Bit state

5.2.6.5 Group number from 1 to 6, event number in the group from 0 to the number of events in the group. The total size of all groups packed into 16-bit words depends on the configuration (see Table 66). In the Smart Monitor software, select the main menu item **Reports → Data description for Modbus** (see 12). For more information on generating reports, see 2.5.1.2. In the recorder, only those events are available that are registered in the configuration.

Table 66 – Total size of all groups packed into 16-bit words

Group number	Size of the group packed in 16-bit words	Group name	Comment
1	2	Logical signals of device state and its functions	Bit data packed into words
2	Depends on the project	Device inputs	Bit data packed into words. Order of matrix inputs according to the functional diagram
3	Depends on the project	Input circuits	Bit data packed into words. Order of input circuits according to the functional diagram
4	Depends on the project	Enable/disable protections	Bit data packed into words. Order of protections according to the functional diagram
5	Depends on the project	Output circuits	Bit data packed into words. Order of matrix outputs according to the functional diagram
6	4	Device state	Bit data packed into words. The following data is available: 0th bit – Device in operation; 8th bit – Emergency failure; 9th bit – Emergency alarm

5.2.7 Algorithm for control of switching device

5.2.7.1 The recorder allows you to store the change time of bit events. All events are divided into groups for the convenience of working with them. When all events are packed into 16-bit words and added in ascending order of the group number, a slice of the signal state will be obtained. A signal state slice is the state of all signals at a given point in time.

5.2.7.2 The following steps should only be performed on the first reading of the recorder, when there is no history or it is corrupted, and read the recorder from the oldest stored event:

1) reset the oldest event pointer. To do this, use the 16th function to set the value of the 16-bit register at address 0x0008 to 0;

2) read a slice of the state of signals at the time of the oldest stored one in the event recorder. To do this, read the values of **K** 16-bit registers at address 0x0BD5, where **K** is the size of the signal slice in words;

3) obtain new events.

5.2.7.3 It is possible to read events without reading the signal slice. Reading the initial slice of signals is necessary in order to know the values of the signals whose changes have been forced out of the recorder. In this case, the values of the preempted signals can be read from the buffer of current values.

5.2.7.4 To receive new events, i.e. update the recorder, follow these steps:

1) request the quantity of new events. To do this, read the value of the 16-bit register at address 0x090C;

2) if the quantity of new events (N) is 0, then the reading of new events is complete, otherwise continue;

3) read recorder events from the buffer. The buffer contains events received after the request described in step 1. The buffer is located at address 0x090D. The buffer is designed for 100 events;

4) confirm that events have been read by writing 0 to the 16-bit register at address 0x00009;

5) go to the first step.

Events in the buffer are located one after another (see Table 67).

Table 67 – Location of events in the buffer

Event 1	Event 2	Event 3	…	Event N

The event format is shown in the table 68.

Table 68 – Event format

Word	Number format	High byte	Low byte
0	BCD	Minute	Second
1	BCD	Day	Hour
2	BCD	Year	Month
3	HEX	Millisecond	
4	HEX	Group number	
5	HEX	Event number in group	
6	HEX	–	Bit state

5.2.7.5 Group number from 1 to 6, event number in the group from 0 to the quantity of events in the group. The total size of all groups packed into 16-bit words depends on the configuration (see Table 69). To generate a report in the Smart Monitor software, select the main menu item **Reports → Data description for Modbus** (see 12). For more information on generating reports, see 2.5.1.2. In the recorder, only those events are available that are registered in the configuration.

Note – A more detailed description of configuring registration parameters is given in the manual “EKRASMS-SP software package”.

Table 69 – Total size of all groups packed into 16-bit words

Group number	Size of the group packed in 16-bit words	Group name	Note
1	2	Logical signals of device state and its functions	Bit data packed into words.
2	Depends on the project	Device inputs	Bit data packed into words. Order of matrix inputs according to the functional diagram
3	Depends on the project	Input circuits	Bit data packed into words. Order of input circuits according to the functional diagram
4	Depends on the project	Enable/disable protections	Bit data packed into words. Order of protections according to the functional diagram

Group number	Size of the group packed in 16-bit words	Group name	Note
5	Depends on the project	Output circuits	Bit data packed into words. Order of matrix outputs according to the functional diagram
6	4	Device state	Bit data packed into words. The following data is available: 0th bit – Device in operation; 8th bit – Emergency failure; 9th bit – Emergency alarm

5.3 Configuration of Modbus protocols

The Modbus RTU protocol is configured using the Configurator software.

5.3.1 Configuration of Modbus RTU protocol

5.3.1.1 Start the Configurator software similar to 2.5.2.1.

5.3.1.2 In the “tree” of the project of the Configurator software, select the menu item **System parameters** (see Figure 54, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

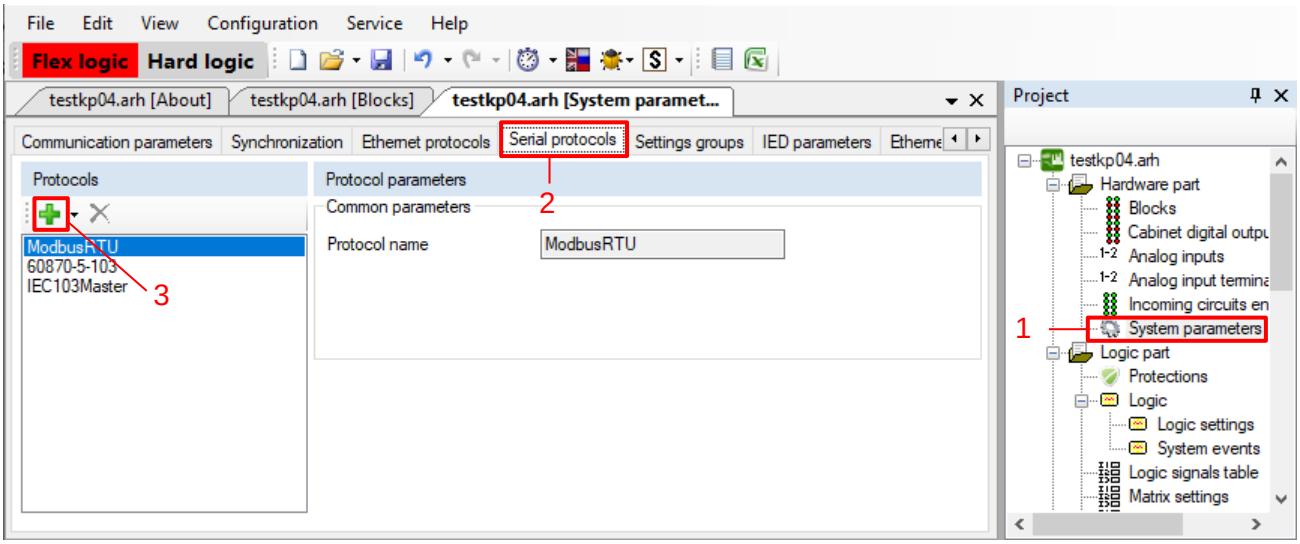


Figure 54 – Adding the Modbus RTU protocol

5.3.1.3 Open the **Serial protocols** tab (see Figure 54, designation 2).

5.3.1.4 In the **Protocols** field, click the “ ” button (see Figure 54, designation 3) and add the Modbus RTU protocol.

5.3.1.5 In the “tree” of the project, select the menu item **System parameters**.

5.3.1.6 Open the **System parameters** tab (see Figure 55, designation 1).

5.3.1.7 Check for the presence of the Service functions flag for the corresponding interface (see Figure 55, designation 2).

Note – Assignment of permission to write to communication ports (see Figure 55, designation 2) is made in accordance with the requirements of the Customer. By default, write access is granted to the Ethernet service port located on the front panel of the device. When opening a record via Ethernet, RS-485-1 and RS-485-2, it is necessary to comply with the requirements for information security of the network, since possible unauthorized access to the device may lead to its incorrect operation, including excessive actuation/non-actuation of protections.

5.3.1.8 Specify the network address of the device in accordance with the project (see Figure 55, designation 3).

5.3.1.9 Set the parameters of communication ports according to the project. For the Modbus RTU protocol, it is necessary to set the port rate, the quantity of data bits, parity, stop bits, delay in symbols and the protocol for serial ports (see Figure 55, designation 4), the default values and permissible values for these parameters are given in Table 70.

Table 70 – Parameters of default serial ports

Name	Permissible value	Default value
Port speed, bps	Fixed values in the range of 50 to 115,200 bps	115,200
Data bits	Value in the range of 5 to 8	8
Parity	Drop-down list contains the following types of parity check: - none; - odd; - even; - mark; - space	no
Stop bits	Value 1 or 2	1
Delay in symbols	Value in the range of 0 to 1,000	0
Protocol	Drop-down list contains the following protocols: - ModbusRTU; - 60870-5-103; - ModbusRTU c-t 1 (ModbusRTU client 1); - ModbusRTU c-t 2 (ModbusRTU client 2); - IEC103Master	ModbusRTU

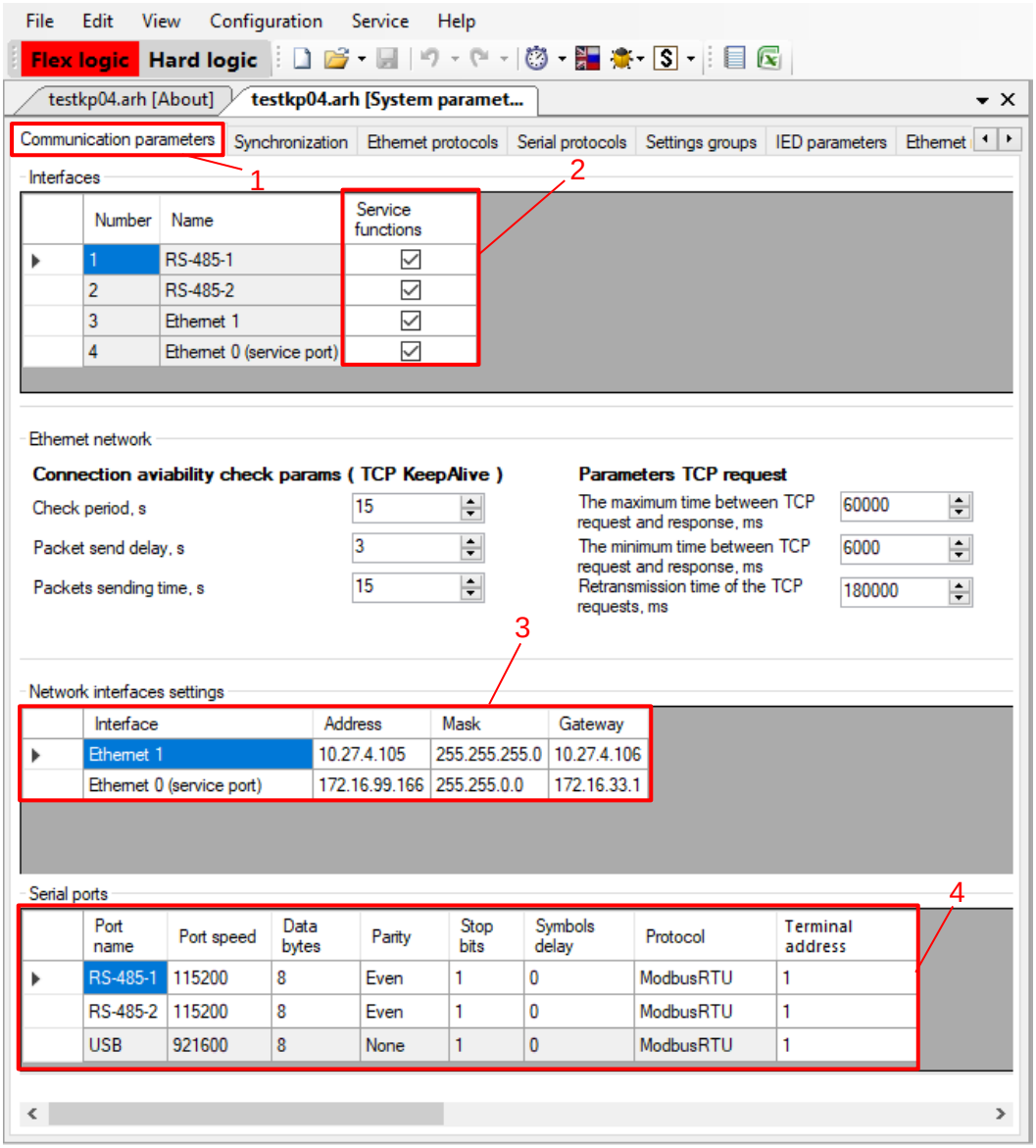


Figure 55 – **Communication parameters** tab

5.3.1.10 Save the changes made to the device similar to 3.4.2.6.

5.3.2 Configuration of Modbus RTU (c-t) protocol)

5.3.2.1 Start the Configurator software similar to 2.5.2.1.

5.3.2.2 In the “tree” of the project of the Configurator software, select the menu item **Modules** (see Figure 56), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

5.3.2.3 Add at least one modules of digital inputs. To add a modules of digital inputs to the configuration, perform the following:

1) Select and add the modules of digital inputs **VAnalog_GOOSE** from the modules library to the list of already used modules (see Figure 56, designation 2);

2) Fill in the **Module name** and **Bit name** fields (see Figure 56, designation 3).

The **Module name** is recommended to be specified according to its functional purpose, the **Bit name** – the name of the received binary signal.

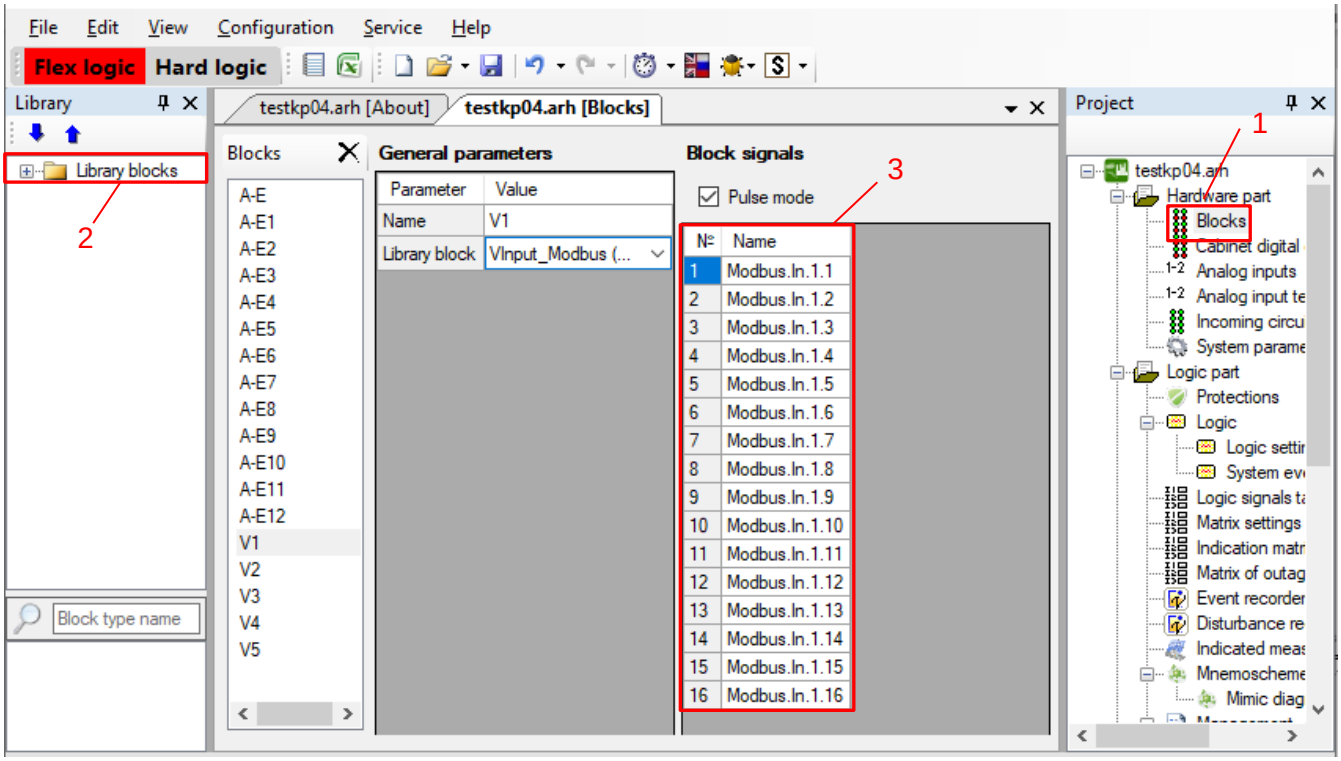


Figure 56 – **Modules** window

5.3.2.1 In the “tree” of the project of the Configurator software, select the menu item **System parameters**, double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

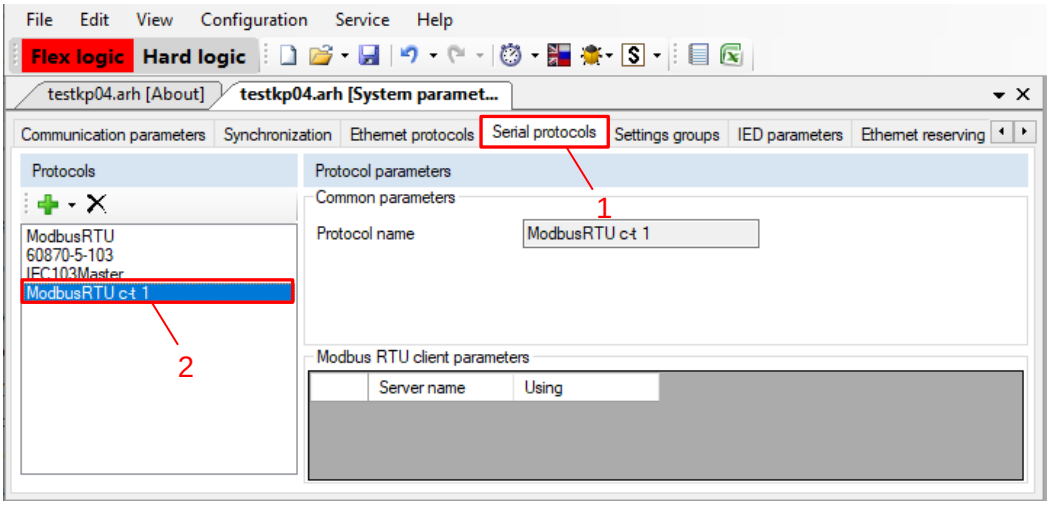


Figure 57 – Adding the ModbusTCP c-t protocol

5.3.2.2 Open the **Serial protocols** tab (see Figure 57, designation 1).

5.3.2.3 In the **Protocols** field, click the “ ” (see Figure 57, designation 2) and add the **ModbusRTU Master** protocol.

Note – Up to two ModbusRTU c-t protocols can be added in the **Protocols** field.

5.3.2.4 **ModbusRTU Master** protocol parameters must be set to default. The description of parameters of the ModbusRTU Master protocol is presented in Table 71.

Table 71 – Parameters of ModbusRTU Master protocol

Parameter	Function	Default value
Server name	Name of selected server	Server 1, Server 2…
Use	Option to select this server	Not selected

5.3.2.5 Save the changes made to the device similar to 3.4.2.6.

5.3.3 Configuration of Modbus TCP protocol

5.3.3.1 Start the Configurator software similar to 2.5.2.1.

5.3.3.2 In the “tree” of the project of the Configurator software, select the menu item **System parameters** (see Figure 58), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

5.3.3.3 Open the **Ethernet protocols** tab (see Figure 58, designation 1).

5.3.3.4 In the **Protocols** field, click the “ Add ” button (see Figure 58, designation 2) and add the Modbus TCP protocol.

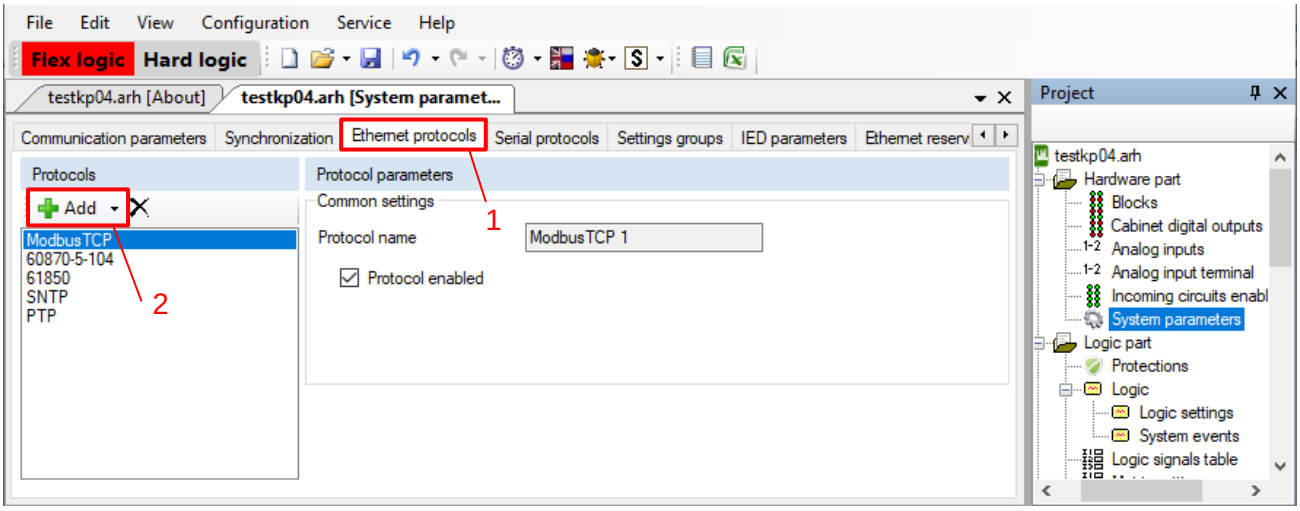


Figure 58 – Adding the Modbus/TCP protocol

5.3.3.5 Further configuration is similar to 5.3.1.5 - 5.3.1.9.

5.3.3.6 Leave the connection check parameters (KeepAlive) (see Figure 58) and TCP request parameters (Table 73) as default (see Figure 55, designation 3).

Table 72 – Parameters of connection check (KeepAlive)

Name	Default value, s
Check period	5
Packet transmission interval	3
Packet transmission time	5

Table 73 – Default parameters of TCP requests

Name	Default value, ms
Maximum time between TCP request and response	60,000
Minimum time between TCP request and response	6,000
Time of repeated TCP requests	180,000

5.3.3.7 Set the parameters of communication ports according to the project. For the Modbus RTU protocol, set the IP address, mask and gateway for the Ethernet network (see Figure 55, designation 4).

5.3.3.8 Save the changes made to the device similar to 3.4.2.6

5.3.4 Configuration of Modbus TCP (Client) protocol

5.3.4.1 Start the Configurator software similar to 2.5.2.1.

5.3.4.2 In the “tree” of the project of the software, select the menu item **System parameters**, double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

5.3.4.3 Open the **Ethernet protocols** tab (see Figure 59, designation 1).

5.3.4.4 In the **Protocols** field, click the “ Add ” button (see Figure 59, designation 2) and select **Modbus TCP Client** from the drop-down list.

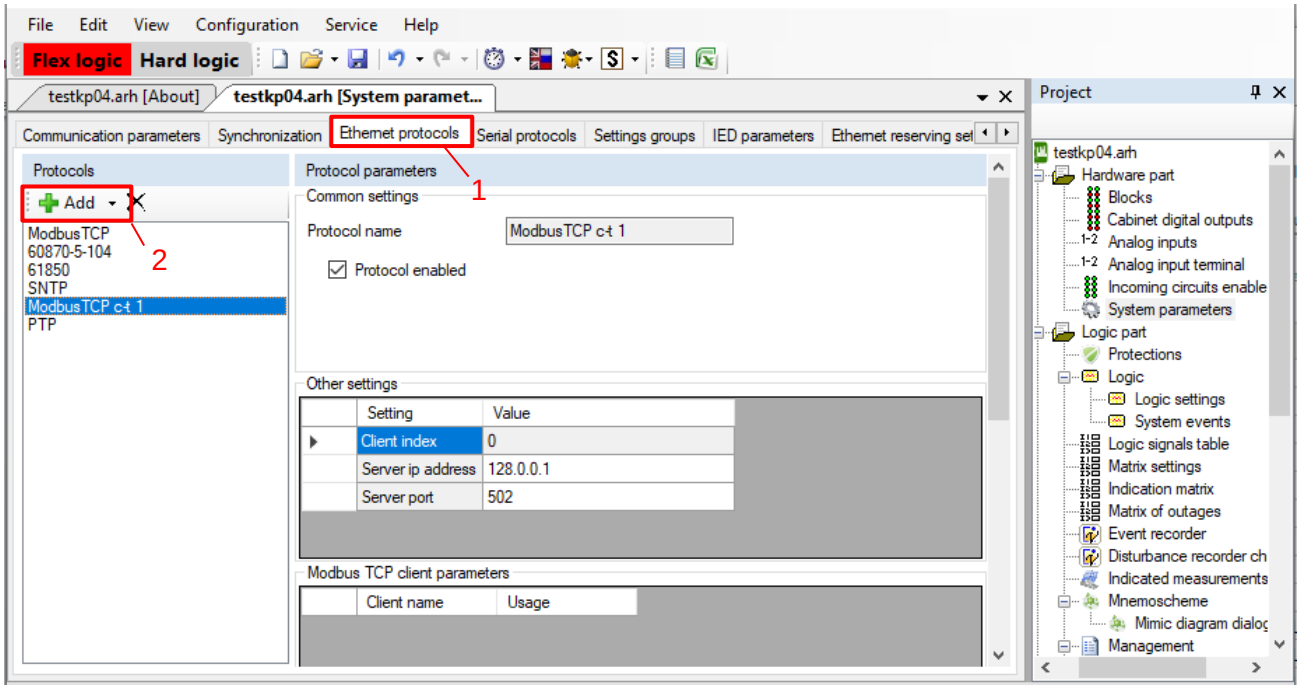


Figure 59 – Adding the Modbus TCP c-t protocol

5.3.4.5 To configure Modbus clients:

1) Open in the project “tree” of the Configurator software the menu item **ModbusClients** (see Figure 60, designation 1);

2) Add a server. To do this, right-click on the **Server** and select **Add server** in the context menu that appears[1)] (see Figure 60, designation 2).

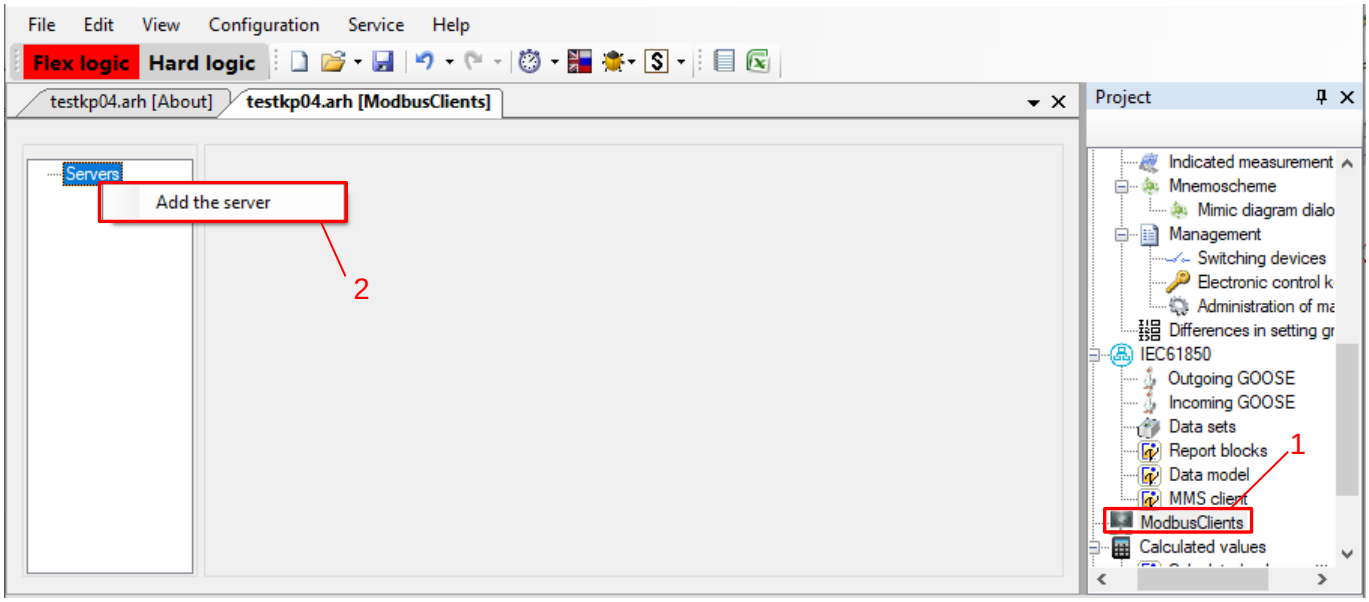


Figure 60 – Adding a server

The window is divided into two areas. One area (see Figure 61, designation 1) displays the hierarchical structure of requests from **Modbus clients**, and the other area (see Figure 61, designation 2) displays parameters of the selected node in the hierarchy. The hierarchical structure is represented as a tree and consists of four levels:

1) **Servers** contains a list of interrogable servers via Modbus TCP c-t protocol;

2) **Server** is an interrogable device. You can add a new server or delete it via the context menu of the tree. Default values of the server are shown in Figure 61. The description of server parameters is given in Table 74.

[1)] Maximum possible quantity of servers – 64.

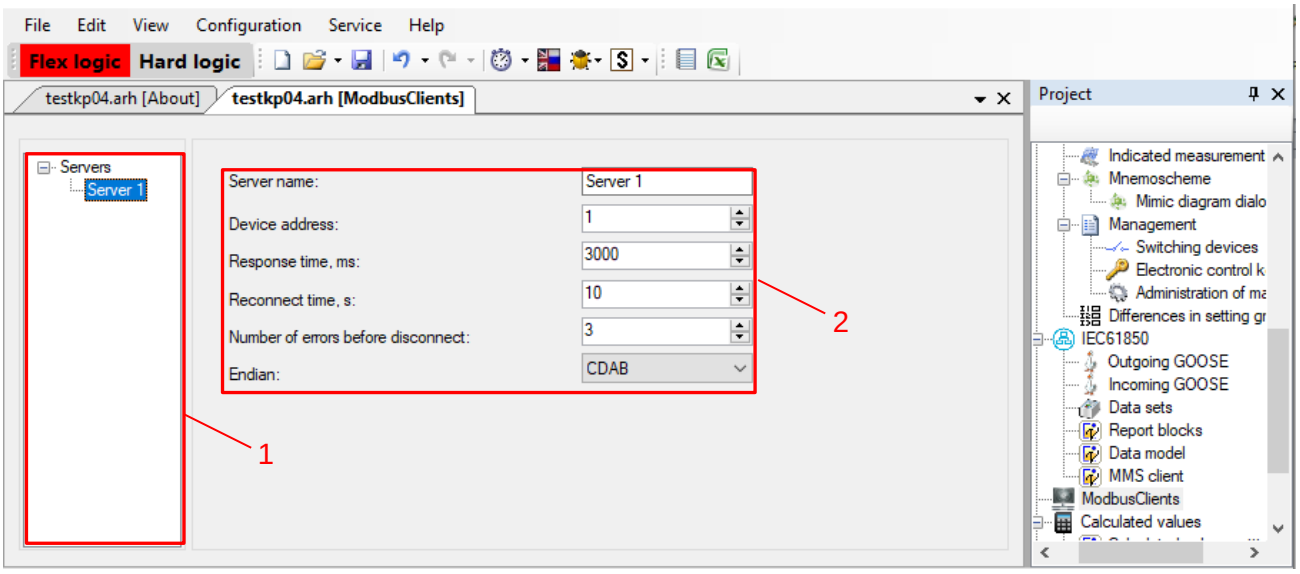


Figure 61 – Server parameters

Table 74 – Server parameters

Parameter name	Description	Range of values	Recommended value
Server name	Name of server	–	–
Device address	Server address	1 – 247	1 – 247
Response wait time, ms	Amount of time (in milliseconds) to wait for a response to a request from the server	1 – 10,000	Less than 1,000 is not recommended
Reconnect period, s	After what period of time (in seconds), it is necessary to reconnect to the server if the connection was not established earlier or there were errors with the communication server	1 – 100	3
Q-ty of errors before disconnect	At what quantity of errors following each other, it will be considered that the connection is lost	1 – 10	2
Endian	Method of organizing the storage of information in the server's memory	0, 1 0 – from lowest to highest; 1 – from highest to lowest	0

3) **Data sets**[1)] (added in the same way as the **Server**) – logically grouped data received when interrogating devices. A dataset can be added or removed via the context menu of the tree. An example of dataset parameter values is shown in Figure 62. The description of data set parameters is given in Table 75;

[1)] You can add one or more datasets to each server.

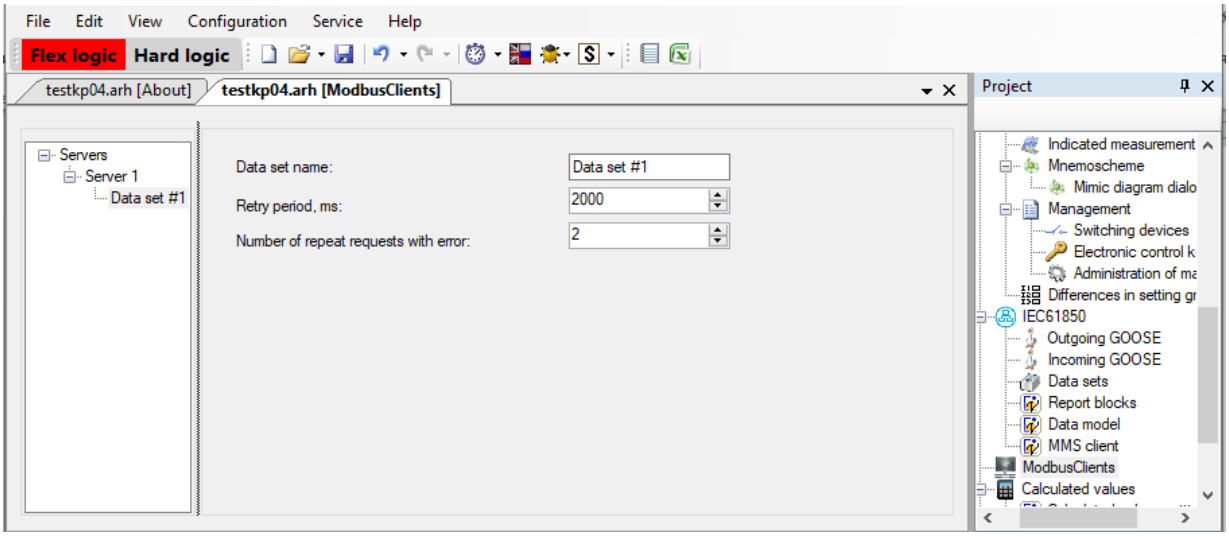


Figure 62 – Adding a dataset

Table 75 – Dataset parameters

Parameter name	Description	Range of values	Recommended value
Data set name	Data set name	–	–
Repeat period, ms	How often (in milliseconds) will the dataset be repeated	1 – 1,000 000	2,000
Q-ty of repeat requests in case of error	How many times will requests be repeated if there was a communication error	1 – 5	2

4) **Requests** (added in the same way as a **Server**) are **Modbus** protocol functions that are performed when interrogating devices. Requests are added and removed via context menu of the tree.

The request consists of functions (see Figure 63):

– function 1 – function of reading logic cells;
– function 2 – function of reading binary inputs;
– function 3 – function of reading internal registers;
– function 4 – function of reading input registers;
– function 5 – function of writing a cell;
– function 6 – function of writing one register;
– function 15 – function of writing several logic cells;
– function 16 – function of writing several registers.

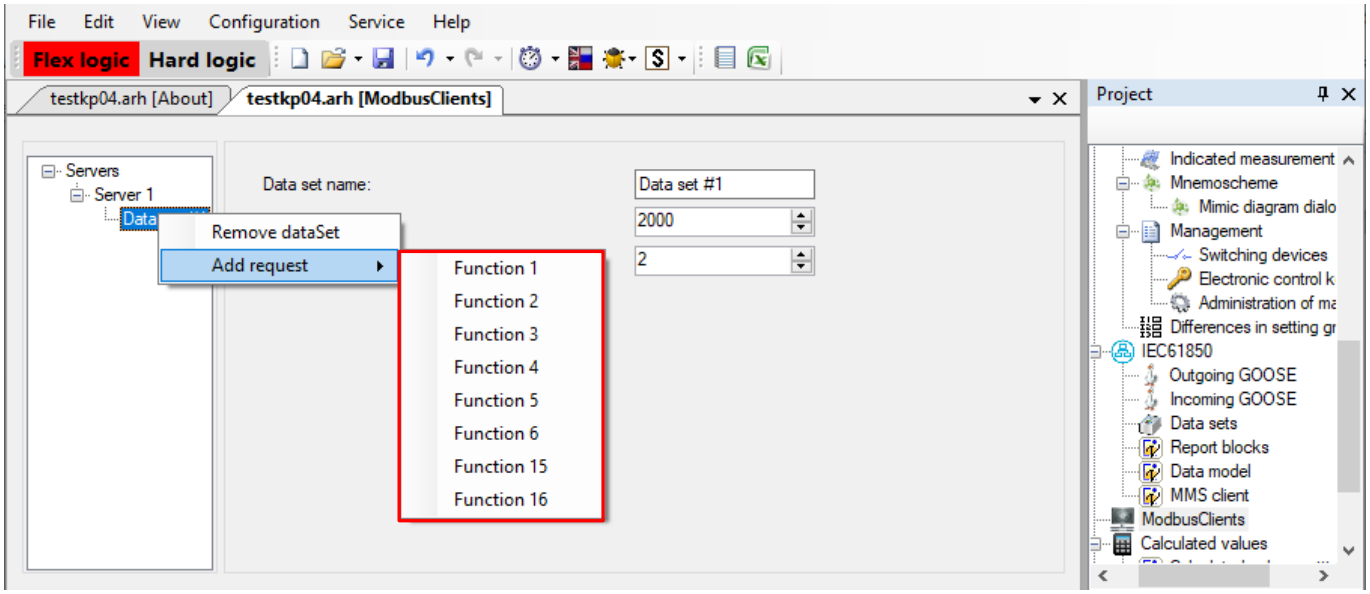


Figure 63 – Adding a request

Each request may consist of several data elements, which are added and deleted with corresponding buttons.

Each request element consists of several parameters. Numbers can be displayed in two formats: **hex** (16th number format) and **dec** (10th number format) (see Figure 64, designation 1).

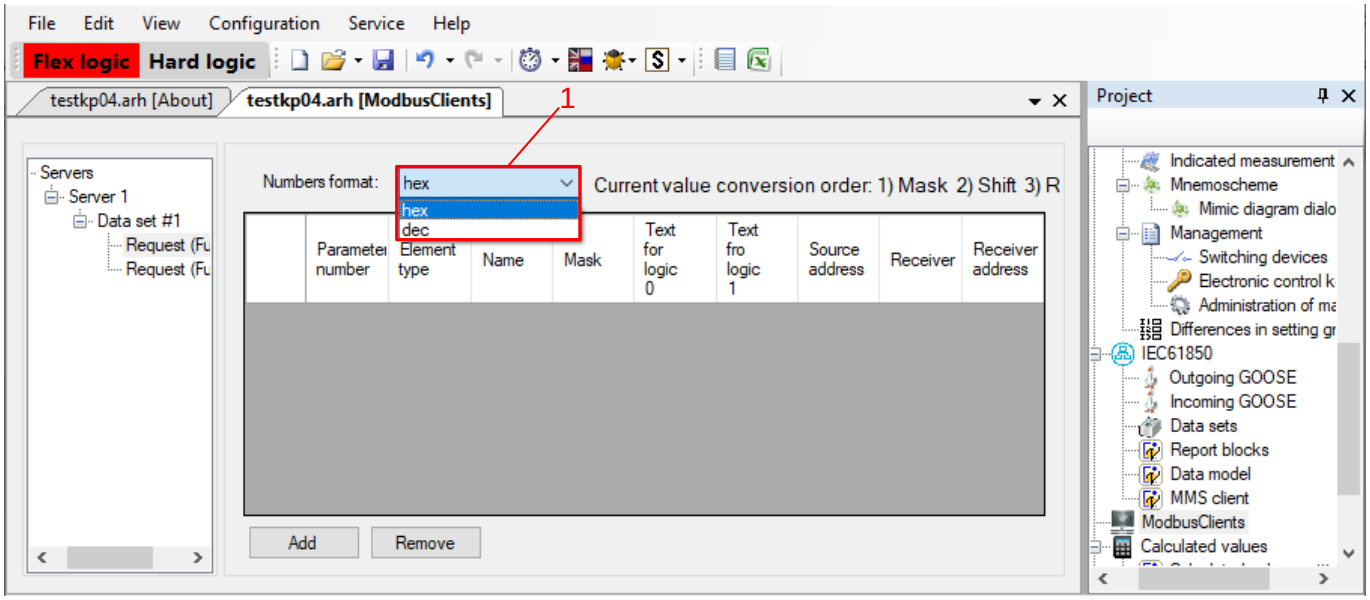


Figure 64 – Request (function 1)

5.3.4.6 Function parameters are presented in Tables 76 – 79.

Table 76 – Parameters of **function 1** and **function 2** (selection of function 1 and function 2 is determined by server configuration)

Parameter	Function	Range of values
Parameter number	Sequence number of binary signals	1…n

Parameter	Function	Range of values
Element type	Type of element: bit, bit in register, DPI, int8, int16, int32, int64, uint8, uint16, uint32, uint64, float32, double64	Bit
Name	Name of binary signals	String value
Mask	Data mask, received from interrogable device	This parameter is not used
Text for logical 0	State string alias (e.g. 0 – off)	String value
Text for logical 1	State string alias (e.g. 1 – on)	String value
Source address	Bit number on the server	0x0000…0xFFFF (hex)
Receiver	Location for storage of received bits	– no; – binary module; – memory card
Receiver address	– if a binary module is selected in the receiver, then the bit number in the module is indicated; – if a memory card is selected in the receiver, then the address of the memory card is indicated	– bit number in module; – address in the memory card (0x6456…0x7455 (hex))

Table 77 – Parameters of **function 3** and **function 4**

Parameters	Function	Range of values
Parameter number	Sequence number of the function parameter	1…n
Element type	Type of element: bit, bit in register, DPI, int8, int16, int32, int64, uint8, uint16, uint32, uint64, float32, double64	Everything but the bit
Name	Name of elements	String value
Mask	Mask of element (for bits in register and DPI)	$1…2^{32}$
Logic shift	Bit shift of the received number	-32…+32
Multiplier	Number by which the result will be multiplied (except for the bit in the register and DPI)	$-2^{32}…+(2^{32}-1)$
Source address	Register address in memory card and server	0x0000…0xFFFF (hex)
Receiver	Place to save received items	– binary module; – memory card
Receiver address	– if a binary module is selected in the receiver, then the bit number in the module is indicated; – if a memory card is selected in the receiver, then the address of the memory card is indicated	– bit number in module; – address in the memory card (0x6456…0x7455 (hex))

Table 78 – Parameters of **function 5**

Parameters	Function	Range of values
Parameter number	Sequence number of the function parameter	1…n
Element type	Type of element: bit, bit in register, DPI, int8, int16, int32, int64, uint8, uint16, uint32, uint64, float32, double64	Bit
Name	Name of cell	String value
Mask	Mask of element	0x0001…0x8000 (hex) or 1…32768 (dec)

Parameters	Function	Range of values
Text for logical 0	These parameters are not used	
Text for logical 1		
Source	Type of data source for recording	– constant; – memory card
Source address	Register address in memory card	– 0 or 1, if a constant is specified in the source; – 0x0000…0xFFFF (hex), if a memory card is specified in the source
Receiver address	Bit number on the server	Depending on server configuration

Table 79 – Parameters of **function 6, function 15 and function 16**

Parameter	Function	Range of values
Parameter number	Sequence number of the function parameter	1…n
Element type	Type of element: bit, bit in register, DPI, int8, int16, int32, int64, uint8, uint16, uint32, uint64, float32, double64	Everything but the bit
Name	Name of element	String value
Mask	Mask of element	0x0001…0x8000 (hex) or 1…32768 (dec)
Logic shift	Bit shift of the received number	-32…+32
Multiplier	Number by which the result will be multiplied (except for the bit in the register and DPI)	-2^{32}…$+(2^{32}-1)$
Source	Type of data source for recording	– constant; – memory card
Source address	Register address in memory card	– 0 or 1, if a constant is specified in the source; – 0x0000…0xFFFF (hex), if a memory card is specified in the source
Receiver address	Bit number on the server	0x0000…0xFFFF (hex)

5.4 Troubleshooting

Troubleshooting is specified in Table 80.

Table 80 – Possible failures

Description of failure	Possible cause of failure	Method of elimination
Lack of communication with the device via RS-485 interface (if there is no alarm the device failure)	Incorrect communication parameters in the device	Make sure the used address of the device is free in the current network. Set the correct address
		Set a lower port operation rate. When choosing the rate follow the rule: the greater the length of the communication line, the lower the rate
	Installation errors	Check the polarity of interface signals. Set the polarity according to the notation
	Damaged communication cable	Check the communication cable, replace with a non-faulty one that meets the requirements

Description of failure	Possible cause of failure	Method of elimination
	When communicating via Smart Monitor software – inconsistency of communication parameters between the device and the Smart Monitor software	Make sure the port operation rate and address of the device in the settings of the device and the Smart Monitor software are compatible
Lack of communication with the device via Ethernet interface (if there is no alarm the device failure)	Incorrect communication parameters in the device	Make sure the used address of the device is free in the current network. Set the correct address
		Make sure the used IP address of the device is free in the current network. Set the correct address
	Damaged communication cable	Check the communication cable, replace with a non-faulty one that meets the requirements
	When communicating via Smart Monitor software – inconsistency of communication parameters between the device and the Smart Monitor software	Make sure the subnet mask specified in the device is compatible with the PC where the Smart Monitor software is installed
		If the device and the PC where the Smart Monitor software is installed are in different subnets, make sure the gateway numbers specified in the device and the PC are compatible
Lack of communication via Modbus RTU protocol	Failure of RS-485 interface	The RS-485 interface troubleshooting procedure is described above
Lack of communication via Modbus TCP protocol	Failure of Ethernet interface	The Ethernet interface troubleshooting procedure is described above
	Protocol is disabled	Enable the protocol via Smart Monitor software or the menu of the device

6 IEC 61850 protocols

6.1 General

6.1.1 Purpose of the protocol

The device supports IEC 61850 protocols.

The main purpose of IEC 61850 is to enable the interoperability of two or more devices (IEDs) from the same or different manufacturers. This means that these devices not only exchange the information defined in IEC 61850, but also interpret it unambiguously, thus making it possible to implement various required functions.

The IEC 61850 communication standard provides a common basis for communication from the process control level to the supervisory level, where signals, data, operating parameters and commands are exchanged.

For a standardized description of all the information that is available in the peripheral device, all functions are simulated. This simulation of data, individually created for each device, serves as the basis for the exchange of information between the device and all control systems interested in this information. To simplify the design at the control system level, a standardized XML-based file describing the device is created using simulation. This file can be imported with the appropriate control system configuration program and further processed. In this way it is possible to automatically create variables for process control, display of electric device and signals.

Communication in Ethernet for the MMS protocol is based on the server-client principle, for the GOOSE and SV protocols it is based on the publisher-subscriber principle based on the “Abstract Communication Service Interface” (ACSI, IEC 61850-7-2). The server is always the device that provides others with the necessary information. After registering with the server, the client can get all the necessary information, such as messages. The server can provide signals and information to a large number of clients on the network.

6.2 Description of implementation of IEC 61850 support

6.2.1 Protocol Implementation Conformance Statement – PICS

The Protocol Implementation Conformance Statement (PICS) contains information on ACSI. The device supports the following statements:

- Basic conformance statement ACSI (Table 81);
- ACSI models conformance statement (Table 82);
- ACSI service conformance statement (Table 83).

The following acronyms are used in Tables 81 – 83:

– Y – supported;

– N – not supported.

Table 81 – Basic conformance statement

Functionality		Server/Publisher	Value/ Comments
Client-Server roles			
B11	Server side (of TWO-PARTY-APPLICATION-ASSOCIATION)	Y	
B12	Client side of (TWO-PARTY-APPLICATION-ASSOCIATION)	N	
SCSMs supported			
B21	SCSM: IEC 61850-8-1 used	Y	
B22	SCSM: IEC 61850-9-1 used	N	Excluded in 2nd edition
B23	SCSM: IEC 61850-9-2 used	Y	
B24	SCSM: other	N	
Generic substation event model (GSE)			
B31	Publisher side	Y	
B32	Subscriber side	Y	
Transmission of sampled value model (SVC)			
B41	Publisher side	N	
B42	Subscriber side	Y	

Table 82 – ACSI models conformance statement

Services		Server/Publisher	Value/Note
Server roles is supported			
M1	Logical device	Y	
M2	Logical node	Y	
M3	Data	Y	
M4	Data set	Y	
M5	Substitution	N	
M6	Setting group control	Y	
Reporting			
M7	Buffered report control	Y	
M7-1	sequence-number	Y	
M7-2	report-time-stamp	Y	
M7-3	reason-for-inclusion	Y	
M7-4	data-set-name	Y	

Services		Server/Publisher	Value/Note
M7-5	data-reference	Y	
M7-6	buffer-overflow	Y	
M7-7	entryID	Y	
M7-8	BufTm	Y	
M7-9	IntgPd	Y	
M7-10	GI	Y	
M7-11	conf-revision	Y	
M8	Unbuffered report control	Y	
M8-1	sequence-number	Y	
M8-2	report-time-stamp	Y	
M8-3	reason-for-inclusion	Y	
M8-4	data-set-name	Y	
M8-5	data-reference	Y	
M8-6	BufTm	Y	
M8-7	IntgPd	Y	
M8-8	GI	Y	
M8-9	conf-revision	Y	
Logging			
M9	Log control	N	
M9-1	IntgPd	N	
M10	Log	N	
M11	Control	Y	
M17	File Transfer	Y	
M18	Application association	Y	
M19	GOOSE Control Block	Y	
M20	Sampled Value Control Block	N	
GSE is supported			
M12	GOOSE	Y	
M13	GSSE	N	Excluded in 2nd edition

Services		Server/Publisher	Value/Note
SVC is supported			
M14	Multicast SVC	Y	
M15	Unicast SVC	N	
For all IEDs			
M16	Time	Y	

The following acronyms are used in Table 83:

– TP – two-party;

– MC – multicast.

Table 83 – ACSI service Conformance statement

	Ed	Services	AA: TP/MC	Server (S)	Note
Server					
S1	1,2	GetServerDirectory (LOGICAL-DEVICE)	TP	Y	
Application Association					
S2	1,2	Associate	–	Y	
S3	1,2	Abort	–	Y	
S4	1,2	Release	–	Y	
Logical Device					
S5	1,2	GetLogicalDeviceDirectory	TP	Y	
Logical Node					
S6	1,2	GetLogicalNodeDirectory	TP	Y	
S7	1,2	GetAllDataValues	TP	Y	
Data					
S8	1,2	GetDataValues	TP	Y	
S9	1,2	SetDataValues	TP	Y	
S10	1,2	GetDataDirectory	TP	Y	
S11	1,2	GetDataDefinition	TP	Y	
Data set					
S12	1,2	GetDataSetValues	TP	Y	
S13	1,2	SetDataSetValues	TP	N	
S14	1,2	CreateDataSet	TP	Y	
S15	1,2	DeleteDataSet	TP	Y	

	Ed	Services	AA: TP/MC	Server (S)	Note
S16	1,2	GetDataSetDirectory	TP	Y	
Substitution					
S17	1	SetDataValues	TP	N	
Setting group control					
S18	1,2	SelectActiveSG	TP	Y	
S19	1,2	SelectEditSG	TP	N	
S20	1,2	SetEditSGValues	TP	N	
S21	1,2	ConfirmEditSGValues	TP	N	
S22	1,2	GetEditSGValues	TP	N	
S23	1,2	GetSGCBValues	TP	Y	
Reporting					
Buffered report control block (BRCB)					
S24	1,2	Report	TP	Y	
S24-1	1,2	data-change (dchg)	–	Y	
S24-2	1,2	quality-change (qchg)	–	Y	
S24-3	1,2	data-update (dupd)	–	N	
S25	1,2	GetBRCBValues	TP	Y	
S26	1,2	SetBRCBValues	TP	Y	
Unbuffered report control block (URCB)					
S27	1,2	Report	TP	Y	
S27-1	1,2	data-change (dchg)	–	Y	
S27-2	1,2	quality-change (qchg)	–	Y	
S27-3	1,2	data-update (dupd)	–	N	
S28	1,2	GetURCBValues	TP	Y	
S29	1,2	SetURCBValues	TP	Y	
Logging					
Log control block					
S30	1,2	GetLCBValues	TP	N	
S31	1,2	SetLCBValues	TP	N	
Log					

	Ed	Services	AA: TP/MC	Server (S)	Note
S32	1,2	QueryLogByTime	TP	N	
S33	1,2	QueryLogAfter	TP	N	
S34	1,2	GetLogStatusValues	TP	N	
Generic substation event model (GSE)					
GOOSE					
S35	1,2	SendGOOSEMessage	MC	Y	
GOOSE-CONTROL-BLOCK					
S36	1,2	GetGoReference	TP	Y	
S37	1,2	GetGOOSEElementNumber	TP	N	
S38	1,2	GetGoCBValues	TP	Y	
S39	1,2	SetGoCBValues	TP	N	
GSSE					
S40	1	SendGSSEMessage	MC	N	Excluded in 2nd edition
GSSE-CONTROL-BLOCK					
S41	1	GetGsReference	TP	N	Excluded in 2nd edition
S42	1	GetGSSEElementNumber	TP	N	Excluded in 2nd edition
S43	1	GetGsCBValues	TP	N	Excluded in 2nd edition
S44	1	SetGsCBValues	TP	N	Excluded in 2nd edition
Transmission of sampled value model (SVC)					
Multicast SV					
S45	1,2	SendMSVMessage	MC	Y	
Multicast Sampled Value Control Block					
S46	1,2	GetMSVCBValues	TP	N	
S47	1,2	SetMSVCBValues	TP	N	
Unicast SV					
S48	1,2	SendUSVMessage	TP	Y	
Unicast Sampled Value Control Block					
S49	1,2	GetUSVCBValues	TP	N	
S50	1,2	SetUSVCBValues	TP	N	
Control					
S51	1,2	Select	–	Y	

	Ed	Services	AA: TP/MC	Server (S)	Note
S52	1,2	SelectWithValue	TP	Y	
S53	1,2	Cancel	TP	Y	
S54	1,2	Operate	TP	Y	
S55	1,2	Command Termination	TP	Y	
S56	1,2	TimeActivatedOperate	TP	N	
File Transfer					
S57	1,2	GetFile	TP	Y	
S58	1,2	SetFile	TP	N	
S59	1,2	DeleteFile	TP	N	
S60	1,2	GetFileAttributeValues	TP	Y	
S61	1,2	GetServerDirectory (FILE-SYSTEM)	TP	Y	
Time					
T1	1,2	Time resolution of internal clock	–	20	Nearest negative power of 2^{-n} in seconds (number 0 – 24)
T2	1,2	Time accuracy of internal clock	–	T1	TL (ms) (low accuracy), T3 < 7 (only Ed2); T0 (ms) (<= 10 ms), 7 <= T3 < 10; T1 (µs) (<= 1 ms), 10 <= T3 < 13; T2 (µs) (<= 100 µs), 13 <= T3 < 15; T3 (µs) (<= 25 µs), 15 <= T3 < 18; T4 (µs) (<= 25 µs), 15 <= T3 < 18; T5 (µs) (<= 1 µs), T3 >= 20
T3	1,2	Supported TimeStamp resolution	–	10	

6.2.2 Model Implementation Conformance Statement – MICS

MICS reflects the composition of the object model implemented in the device, the details of the information model implementation, the list of logical nodes (Table 84), contains a description of the new common data classes (CDC) (see Table 85 – 90) and enumerated types (Enum Types) (see Table 91, 92), created in accordance with the requirements of the IEC 61850 standard.

Table 84 – Logical Nodes List

A: Logical node for automatic control
ANCR (Neutral current regulator)
ATOC (Measuring element of current overflow considering the ambient temperature)
ATCC (Automatic tap changer controller)
C: Logical Nodes for control
CALH (Alarm handling)
CILO (Interlocking)
CSYN (Synchronizer controller)
G: Logical Nodes for generic references
GAPC (Generic automatic process control)
GGIO (Generic process I/O)
L: Logical node classes
LPHD (Physical device information)
LCCH (Physical communication channel supervision)
LLN0 (Logical node zero)
LSVS (Sampled value subscription)
M: Logical Nodes for metering and measurement
MMTR (Metering 3 Phase)
MMXN (Non-phase-related measurement)
MMXU (Measurement)
P: Logical Nodes for protection functions
PDIF (Differential)
PDIS (Distance)
PDOP (Directional overpower)
PDUP (Directional underpower)
PFRC (Rate of change of frequency)
PHIZ (Ground detector)
PIOC (Instantaneous overcurrent)
PPAM (Phase angle measuring)
PSDE (Sensitive directional earthfault)
PCRC (Current change rate)
PTOC (Time overcurrent)
PTOF (Overfrequency)
PTOV (Overvoltage)
PTTR (Thermal overload)
PTCF (Change of frequency protection)

PTUC (Undercurrent)
PTUF (Underfrequency)
PTUV (Undervoltage)
PVOC (Voltage controlled time overcurrent)
PVRC (Voltage change rate)
PVPH (Volts per Hz)
R: Logical Nodes for protection related functions
RBRF (Breaker failure)
RDRE (Disturbance recorder function)
RFLO (Fault locator)
RFUF (Voltage circuit integrity control)
RPSB (Power swing detection/blocking)
RSYN (Synchronism-check)
S: Logical nodes for supervision and monitoring
SCBR (Circuit breaker supervision)
X: Logical Nodes for switchgear
XCBR (Circuit breaker)
XSWI (Circuit switch)

6.2.2.1 New logical nodes

The following acronyms are used in Tables 85 – 90:

- M – mandatory attribute;
- O – optional attribute.

Table 85 – LN: Measuring element of current overflow considering the ambient temperature Name: ATOC

ATOC class				
Data object name	Common data class	Explanation	M/O	Note
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, clause 22		
Data objects				
Common Logical Node Information				
Mod	ENC	Mode	M	Status-only
Beh	ENS	Behaviour	M	
Health	ENS	Health	M	
NamPlt	LPL	Name plate	M	
Status Information				
Str	ACD	Start	O	

ATOC class				
Data object name	Common data class	Explanation	M/O	Note
Op	ACT	Operate	O	
Op1	ACT	Operate «TS1 fail»	O	
Op2	ACT	Operate «TS2 fail»	O	
Op3	ACT	Operate «Adapt T saved»	O	
Op4	ACT	Operate «Adapt T actual»	O	
Op5	ACT	Operate «Nonadapt»	O	

Table 86 – LN: Voltage circuit integrity control Name: RFUF

RFUF class				
Data object name	Common data class	Explanation	M/O	Note
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, clause 22		
Data objects				
Common Logical Node Information				
Mod	ENC	Mode	M	Status-only
Beh	ENS	Behaviour	M	
Health	ENS	Health	M	
NamPlt	LPL	Name plate	M	
Status Information				
Str	ACD	Start	O	
Op	ACT	Operate	O	

Table 87 – LN: Voltage change rate element Name: PVRC

PVRC class				
Data object name	Common data class	Explanation	M/O	Remarks
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, clause 22		
Data objects				
Common Logical Node Information				
Mod	ENC	Mode	M	Status-only
Beh	ENS	Behaviour	M	

PVRC class				
Data object name	Common data class	Explanation	M/O	Remarks
Health	ENS	Health	M	
NamPlt	LPL	Name plate	M	
Status Information				
Str	ACD	Start	M	
Op	ACT	Operate	M	

Table 88 – LN: Current change rate element Name: PCRC

PCRC class				
Data object name	Common data class	Explanation	M/O	Remarks
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, clause 22		
Data objects				
Common Logical Node Information				
Mod	ENC	Mode	M	Status-only
Beh	ENS	Behaviour	M	
Health	ENS	Health	M	
NamPlt	LPL	Name plate	M	
Status Information				
Str	ACD	Start	M	
Op	ACT	Operate	M	

Table 89 – LN: Change of frequency protection Name: PTCF

PTCF class				
Data object name	Common data class	Explanation	M/O	Note
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, clause 22		
Data objects				
Common Logical Node Information				
Mod	ENC	Mode	M	Status-only
Beh	ENS	Behaviour	M	
Health	ENS	Health	M	
NamPlt	LPL	Name plate	M	

PTCF class				
Data object name	Common data class	Explanation	M/O	Note
Status Information				
Str	ACD	Start	O	
Op	ACT	Operate	O	

Table 90 – Logical node: Subscription to sample value. Designation: LSVS

LSVS class				
Data object name	Common data class	Explanation	M/O	Note
Data objects				
Description				
NamPlt	LPL	Name plate	M	
Status data				
Beh	ENS	Behaviour	M	
Health	ENS	Health	M	
Control				
Mod	ENC	Mode	M	
Settings				
SvCBRef	ORG	Link to subscribed SV control module	O	

6.2.2.2 New types of enumerations

Table 91 – Check

Value	Description	Note
0	no-check	
1	synchrocheck	
2	interlocking-check	
3	both check	

Table 92 – Dbpos

Value	Description	Note
0	intermediate	
1	off	
2	on	
3	bad	

6.2.3 Additional information on the implementation of the protocol – PIXIT

PIXIT contains system-specific information about the capabilities of devices that are additional to the Protocol Implementation Conformance Statement (PICS), as well as information about the physical structure that is not included in ACSI (see Tables 93 – 105). PIXIT contains information that is not available in a PICS, MICS, TICS, or SCL file.

The following acronyms are used in Tables 93, 94, 97, 98, Table 100, 101, 103 – 106:

– Y – supported;

– N – not supported.

Table 93 – Association model

ID	Ed	Description	Value/Clarification
As1	1	Maximum number of clients that can set up an association simultaneously	10
As2	1.2	TCP_KEEPALIVE value. The recommended range is 1...20 s	15 s (setting, variable in the range from 1 to 86,400 s)
As3	1.2	Lost connection detection time	30 s (determined by two settings in the range from 2 to 95,400 s)
As4	–	Authentication is not supported yet	
As5	1.2	What association parameters are necessary for successful association?	Transport selector N Session selector Y Presentation selector N AP Title (ANY) N AE Qualifier (ANY) N
As6	1.2	If association parameters are necessary for association, describe the correct values e.g	Transport selector Session selector Presentation selector 0001 AP Title (ANY) AE Qualifier (ANY)
As7	1.2	What is the maximum and minimum MMS PDU size?	Max. MMS PDU size: 65,000 bytes; Min. MMS PDU size: 16,384 bytes
As8	1.2	What is the maximum start up time after a power supply interrupt?	120 s
As9	1.2	Does this device function only as test equipment? (test equipment need not have a non-volatile configuration; but it cannot be part of the substation automation system)	N

Table 94 – Server model

ID	Ed	Description	Value/Clarification
Sr1	1.2	Which analog value (MX) quality bits are supported (can be set by server)?	Validity: Y Good Y Invalid Y Reserved Y Questionable N Overflow Y OutofRange N BadReference N Oscillatory Y Failure N OldData N Inconsistent N Inaccurate Source: N Process N Substituted Y Test N OperatorBlocked
Sr2	1.2	Which status value (ST) quality bits are supported (can be set by server)?	Validity: Y Good Y Invalid Y Reserved Y Questionable N BadReference Y Oscillatory Y Failure N OldData N Inconsistent N Inaccurate Source: N Process N Substituted Y Test N OperatorBlocked
Sr3	–	What is the maximum number of data values in one GetDataValues request?	Excluded
Sr4	–	What is the maximum number of data values in one SetDataValues request?	Excluded
Sr5	1	Which Mode values are supported?[1)]	On Y On/Blocked N Test N Test/Blocked Y Off[2)] Y

[1)] Section 9 of IEC 61850-6-2009 specifies that if only a subrange of an enumeration value set is supported, it must be specified in the ICD file by an enumeration type that does not have any unsupported values.

[2)] Value Off is supported. But it is installed only in case of a serious error in software or hardware. And cannot be verified.

Table 95 – Data set model

ID	Ed	Description	Value/Clarification
Ds1	1	What is the maximum number of data elements in one data set (compare ICD setting)?	128
Ds2	1	How many persistent data sets can be created by one or more clients (this number includes predefined datasets)?	98
Ds3	1	How many non-persistent data sets can be created by one or more clients?	3 for each client

Table 96 – Substitution model

ID	Ed	Description	Value/Clarification
Sb1	1	Are substituted values stored in volatile memory?	N/A

Table 97 – Setting group control model

ID	Ed	Description	Value/Clarification
Sg1	1	What is the number of supported setting groups for each logical device?	8
Sg2	1.2	What is the effect of when and how the non-volatile storage is updated?(compare IEC 61850-8-1 $16.2.4)	N/A
Sg3	1	Can multiple clients edit the same setting group?	N/A
Sg4	1	What happens if the association is lost while editing a setting group?	N/A
Sg5	1	Is EditSG value 0 allowed?	Y
Sg6	2	When ResvTms is not present how long is an edit setting group locked?	N/A

Table 98 – Reporting model

ID	Ed	Description	Value/Clarification
Rp1	1	The supported trigger conditions are (compare PICS)?	integrity Y data change Y quality change Y data update[1)] N general interrogation Y
Rp2	1	The supported optional fields are	sequence-number Y report-time-stamp Y reason-for-inclusion Y data-set-name Y data-reference Y buffer-overflow Y entryID Y conf-rev Y segmentation N
Rp3	1.2	Can the server send segmented reports (when not supported it is allowed to refuse an association with a smaller than minimum PDU size)?	N

ID	Ed	Description	Value/Clarification
Rp4	1.2	Mechanism on second internal data change notification of the same analogue data value within buffer period (Compare IEC 61850-7-2 $14.2.2.9)?	Send report immediately
Rp5	1	Multi client URCB approach (compare IEC 61850-7-2 $14.2.1)?	URCB is available to all clients
Rp6	–	What is the format of EntryID?	Excluded
Rp7	1.2	What is the buffer size for each BRCB or how many reports can be buffered?	Depending on the configuration up to 16,384 data set elements
Rp8	–	Pre-configured RCB attributes that are online changeable, compare SCL report settings?	Excluded
Rp9	1	May the reported data set contain: – structured data objects? – data attributes?	 Y Y
Rp10	1.2	What is the scan cycle for binary events? Is this fixed, configurable?	0.833; 1; 2; 4; 5; 10 ms depending on dsp frequency (dsp frequency is configurable)
Rp11	1	Does the device support pre-assignment of RCB to a specific client in SCL?	N
Rp12	2	After restart of the server is the value of ConfRev restored from the original configuration or retained prior to restart?	Restored from original configuration
Rp13	1.2	Does the server accept any client to configure/enable BRCB with ResvTms=-1? What fields are used to do the identification?	N
[1)] Data update can be installed but it is not used.			

Table 99 – Logging model

ID	Ed	Description	Value/Clarification
Lg1	1.2	What is the default value of LogEna (Compare IEC 61850-8-1 $17.3.3.2.1, the default value should be FALSE)?	N/A
Lg2	–	What is the format of EntryID?	Excluded
Lg3	1.2	Are there multiple Log Control Blocks that specify the Journaling of the same MMS NamedVariable and TrgOps and the Event Condition (Compare IEC 61850-8-1 $17.3.3.3.2)?	N/A
Lg4	1	Pre-configured LCB attributes that cannot be changed online	N/A

Table 100 – GOOSE publish model

ID	Ed	Description	Value/Clarification
Gp1	1.2	Can the test (Ed1)/simulation (Ed2) flag in the published GOOSE be set?	Yes
Gp2	1	What is the behaviour when the GOOSE publish configuration is incorrect?	Device under test (hereinafter – DUT) saves GoEna=F NdsCom=T
Gp3	1.2	Published FCD supported common data classes are	SPS, DPS, MV
Gp4	1.2	What is the slow retransmission time? Is it fixed or configurable?	2,000 ms, configurable
Gp5	1.2	What is the fastest retransmission time? Is it fixed or configurable?	4 ms, not configurable
Gp6	–	Can the GOOSE publish be turned on/off using SetGoCBValues(GoEna)?	Excluded
Gp7	1.2	What is the initial GOOSE sqNum after restart?	0
Gp8	1	May the GOOSE data set contain: – structured data objects (FCD); – timestamp data attributes	 Y Y

Table 101 – GOOSE subscribe model

ID	Ed	Description	Value/Clarification
Gs1	1.2	What elements of a subscribed GOOSE message are checked to decide the message is valid and the allData values are accepted? If yes, describe the conditions. Notes: – VLAN tag may be removed by an Ethernet switch and shall not be checked; – simulation flag shall always be checked (Ed2)	Y destination MAC address Y APPID (application ID) Y gocbRef (GOOSE control block reference) N timeAllowedtoLive (maximum time to wait for the next retransmission) N datSet (data set) Y goID (GOOSE control block reference) N t (timestamp) Y stNum (status number) Y sqNum (sequence number) Y test/simulation (testing/simulation) confRev (configuration revision) Y ndsCom (needs commissioning) Y numDatSetEntries (enumeration of Y dataset entries) Y out-of-order dataset members (unordered dataset elements)
Gs2	1.2	When is a subscribed GOOSE marked as lost? (TAL = time allowed to live value from the last received GOOSE message)	Message did not arrive until expiration of TAL
Gs3	1.2	What is the behaviour when one or more subscribed GOOSE messages isn't received or syntactically incorrect (missing GOOSE)?	Message is ignored, error counters are incremented
Gs4	1.2	What is the behaviour when a subscribed GOOSE message is out-of-order?	Message is received. The counter of missed packets is incremented by 1
Gs5	1.2	What is the behaviour when a subscribed GOOSE message is duplicated?	Message is received

ID	Ed	Description	Value/Clarification
Gs6	1	Does the device subscribe to GOOSE messages with/without the VLAN tag?	Y, with the VLAN tag Y, without the VLAN tag
Gs7	1	May the GOOSE data set contain: – structured data objects (FCD)? – timestamp data attributes?	 Y Y
Gs8	1.2	Subscribed FCD supported common data classes are	SPS, DPS, MV
Gs9	1.2	Are subscribed GOOSE with test=T (Ed1) / simulation=T (Ed2) accepted in test/simulation mode?	Y
Gs10	1.2	Max. number of dataset members	64

Table 102 – GOOSE performance

ID	Ed	Description	Value/Clarification
Gf1	1.2	Performance class	P1
Gf2	1.2	GOOSE ping-pong processing method	Event based
Gf3	1.2	Application logic scan cycle (ms)	0.833; 1; 2; 4; 5; 10 ms depending on dsp frequency (dsp frequency is configurable)
Gf4	1	Maximum number of data attributes in GOOSE dataset (value and quality has to be counted as separate attributes)	64

Table 103 – Control model

ID	Ed	Description	Value/Clarification
Ct1	1	What control models are supported?	Status-only Y Direct-with-normal-security Y Sbo-with-normal-security Y Direct-with-enhanced-security Y Sbo-with-enhanced-security Y
Ct2	1.2	Is the control model fixed, configurable and/or online changeable?	Configurable
Ct3	–	Is TimeActivatedOperate supported (compare PICS or SCL)?	Excluded
Ct4	–	Is“operate-many” supported (compare sboClass)?	Excluded
Ct5	1	Will the DUT activate the control output when the test attribute is set in the SelectWithValue and/or Operate request (when N test procedure Ctl2 is applicable)?	N
Ct6	–	What are the conditions for the time (T) attribute in the SelectWithValue and/or Operate request?	Excluded
Ct7	–	Is pulse configuration supported (compare pulseConfig)?	Excluded

ID	Ed	Description	Value/Clarification
Ct8	1	What is the behaviour of the DUT when the check conditions are set. Is this behaviour fixed, configurable, online changeable?	N synchrocheck Y interlock-check DUT uses the check value to perform the check. Fixed
Ct9	1.2	Which additional cause diagnostics is supported?	Y Unknown Y Not-supported Y Blocked-by-switching-hierarchy N Select-failed Y Invalid-position N Position-reached N Step-limit Y Blocked-by-Mode Y Blocked-by-process Y Blocked-by-interlocking N Blocked-by-synchrocheck Y Command-already-in-execution N Blocked-by-health N 1-of-n-control N Abortion-by-cancel Y Time-limit-over N Abortion-by-trip Y Object-not-selected **Edition 1 specific values:** N Parameter-change-in-execution **Edition 2 specific values:** Y Object-already-selected N No-access-authority N Ended-with-overshoot N Abortion-due-to-deviation N Abortion-by-communication-loss N Blocked-by-command N None Y Inconsistent-parameters Y Locked-by-other-client N Parameter-change-in-execution
Ct10	1.2	How to force a «test-not-ok» respond with SelectWithValue request?	invalid orCat value
Ct11	1.2	How to force a «test-not-ok» respond with Select request?	invalid orCat value
Ct12	1.2	How to force a «test-not-ok» respond with Operate request?	invalid orCat value
Ct13	1.2	Which origin categories are supported/accepted?	Y Bay-control Y Station-control Y Remote-control Y Automatic-bay Y Automatic-station Y Automatic-remote Y Maintenance Y Process
Ct14	1.2	What happens if the orCat value is not supported or invalid?	DUT sends a negative response with an additional “not supported” cause.

ID	Ed	Description	Value/Clarification
Ct15	1.2	Does the IED accept a SelectWithValue/Operate with the same control value as the current status value? Is this behaviour configurable?	DOns: Y SBOns: Y DOes: Y SBOes: Y Configurable N
Ct16	1	Does the IED accept a Select/Operate on the same control object from 2 different clients at the same time?	DOns Y SBOns N DOes Y SBOes N
Ct17	1	Does the IED accept a Select/SelectWithValue from the same client when the control object is already selected (Tissue #334)?	SBOns N SBOes N
Ct18	1.2	Is for SBOes the internal validation performed during the SelectWithValue and/or Operate step?	SelectWithValue and Operate
Ct19	–	Can a control operation be blocked by Mod=Off or [On-]Blocked (Compare PIXIT-Sr5)?	Excluded
Ct20	1.2	Does the IED support local/remote operation?	Y
Ct21	1.2	Does the IED send an InformationReport with LastApplError as part of the Operate response for control with normal security?	SBOns: N DOns: N
Ct22	2	How to force a “parameter-change-in-execution”?	SBOns: N SBOes: N
Ct23	1.2	How many SBOns/SBOes control objects can be selected at the same time?	SBOns: multiple SBOes: multiple
Ct24	1.2	Can a controllable object be forced to keep its old state e.g. Internal Controllable Objects may not be accessible to force this, whereas a switch like Circuit Breaker outside the DUT can?	N
Ct25	1.2	When CDC=DPC is supported, is it possible to have DPC (Controllable Double Point) go to the intermediate state? (00)	N/A
Ct26	1.2	Name a DOes point (if any) with a finite operate timeout and specify the timeout (in milliseconds)	All DOes and SBOes 10,000 ms
Ct27	2	Does the IED support control objects with external signals?	DOns N SBOns: N DOes: N SBOes: N
Ct28	2	Does the IED support DPC control objects with external signals?	DOns N SBOns: N DOes: N SBOes: N

Table 104 – Time synchronisation model

ID	Ed	Description	Value/Clarification
Tm1	1	What time quality bits are supported (may be set by the IED)?	Y LeapSecondsKnown Y ClockFailure Y ClockNotSynchronized
Tm2	1.2	Describe the behaviour when the time server(s) ceases to respond. What is the time server lost detection time?	Internal time of the device is used. Set to ClockNotSynchronized. Detection time is not configurable (67 s by default)

ID	Ed	Description	Value/Clarification
Tm3	1.2	How long does it take to take over the new time from time server?	Configurable (64 s by default)
Tm4	1.2	When is the time quality bit “ClockFailure” set?	Set upon dsp failure. Not checked
Tm5	1.2	When is the time quality bit “Clock not Synchronized” set?	When communication with all time servers is lost
Tm6	–	Is the timestamp of a binary event adjusted to the configured scan cycle?	Excluded
Tm7	1	Does the device support time zone and daylight saving?	Time zones – yes. Switching to summer time, only according to the rules that were previously valid in Russia
Tm8	1.2	Which attributes of the SNTP response packet are validated?	Y Leap indicator not equal to 3 Y Mode is equal to SERVER N OriginateTimestamp is equal to value sent by the SNTP client as Transmit Timestamp N RX/TX timestamp fields are checked for reasonableness Y SNTP version 3 and/or 4
Tm9	1.2	Do the COMTRADE files have local time or UTC time and is it configurable?	UTC, not configurable

Table 105 – File transfer model

ID	Ed	Description	Value/Clarification
Ft1	1	What is structure of files and directories? Where are the COMTRADE files stored? Are comtrade files zipped and what files are included in each zip file?	File system with folders Directory name for COMTRADE: /COMTRADE/ Not zipped
Ft2	1.2	Directory names are separated from the file name by	/
Ft3	1	Maximum file name size including path (recommended 64 chars)	254
Ft4	1.2	Are directory/file name case sensitive?	Y
Ft5	1.2	Maximum file size for SetFile	N
Ft6	1	Is the requested file path included in the file name of the MMS fileDirectory respond?	Y
Ft7	1	Is the wild char supported upon MMS fileDirectory request?	Y, * – special character
Ft8	1.2	Is it allowed that 2 clients get a file at the same time?	Y the same file Y different files
Ft9	1.2	Which files can be deleted?	N

Table 106 – Service tracking model

ID	Ed	Description	Value/Clarification
Tr1	2	Which ACSI services are tracked by LTRK.GenTrk?	N

Table 107 – IEC 61850-9-2LE Subscriber

Description	Value/Clarification
Supported rated frequencies	50 Hz Yes 60 Hz No
Supported sample rates	80 samples per cycle Yes 256 samples per cycle No
Connector type 9-2	LC or RJ45
Input voltage and current signals	0 – 4 phase voltages 0 – 4 phase voltages
Maximum quantity of SV streams	12 SV streams B and A combined 12 SV streams B and A in a separate stream
Maximum length for SvID	Maximum SvID length = 34
What is the maximum permissible (rated) delay time between taking samples and receiving the corresponding SV message?	Configurable (1 – 10) ms
What quality codes are supported?	Derived Yes Test Yes Validity Yes
DUT supports the following methods for indicating subscription failure: – LED indication on the front panel; – IEC 61850 data point; – add an event to the internal log; – output contact; – other	1: Yes 2: Yes, available via GOOSE or report 3: Yes 4: Yes <describe, to be agreed by test lab> (note: one method is mandatory)
Does the subscriber support test mode?	Yes
What is the behaviour of DUT when receiving the required data with quality=test?	DUT in normal mode – SV stream is not received. DUT in test mode – SV stream is received
What is the behaviour of DUT when receiving the required data with quality=invalid?	SV stream is received. Action determined by configuration
What is the behaviour of DUT with SV smpSynch: – no; – local; – global?	SV stream is received. Behaviour is determined by configuration 1: SV stream marked as “false” 2 and 3: SV stream marked as “true”
What is the action of DUT when only the number (1-10-100) of the required SV samples is missing?	1 consecutive SV stream sample can be restored. If more samples are missing than the SV stream is not received
What is the behaviour of DUT when getting double SVs?	SV stream is received by the first SV. The second SV is not received. SV stream is marked as replacement stream
What is the behaviour of DUT when the quantity of required SV samples is delayed beyond the maximum permissible delay time?	SV stream is not received
If the timesynch signal is lost, how long will it take to be detected by DUT?	30 s
When restoring the timesynch signal, how long will it take to be detected by DUT?	10 s
What is the behaviour of DUT when the timesynch signal is lost: – in one of the merging units (MU)? – in all signed merging units? – in DUT? – in all MU and DUT?	1, 2, 3 and 4: SV stream is received. Action is determined by configuration

Description	Value/Clarification
What values are checked for subscription to an SV stream? What is the behaviour of DUT when the check fails?	Destination MAC address, svID. SV stream is not received
What is the typical start time after a power interruption?	60 seconds
<additional items>	

6.2.4 Tissues implementation conformance statement – TICS

TICS provides a list of approved issues of the IEC 61850 standard and reflects the fact that they are taken into account in the IED (Table 108).

The following acronyms are used in Table 108:

– Y – supported;

– na – not supported.

Table 108 – List of main approved issues

Tissue	Description	Implemented Y/na
Part 6		
658	Tracking related features	na
663	FCDA element cannot be a “functionally constrained logical node”	Y
668	Autotransformer modelling	na
687	SGCB ResvTms	na
719	ConfDataSet – maxAttributes definition is confusing	Y
721	Log element name	na
768	bType VisString65 is missing	Y
779	object references	Y
788	SICS S56 from optional to mandatory	na
789	ConfLdName as services applies to both server and client	na
804	valKind and IED versus System configuration	na
806	Max length of log name inconsistent between -6 and -7-2	na
807	Need a way to indicate if “Owner” present in RCB	na
822	Short addresses on structured data attributes	na
823	ValKind for structured data attributes	na
824	Short addresses on structured data attributes	na
825	Floating point value	Y
845	SGCB ResvTms	na
853	SBO and ProtNs	na
855	Recursive SubFunction (yes for 401 with merging unit)	na
856	VoltageLevel frequency and phases	na
857	Function/SubFunction for ConductingEquipment	na
886	Missing 8-1 P-types	na

Tissue	Description	Implemented Y/na
901	tServices as AP or as IED element	Y
936	SupSubscription parameter usage is difficult	na
1168	doName and daName of ExtRef; doName may have one dot (DO.SDO)	na
1175	IPv6 address lowercase only	na
Part 7-1		
828	Data model namespace revision IEC 61850-7-4:2007[A]	na
1151	simulated GOOSE disappears after 1st appearance when LPHD.Sim = TRUE	na
1196	Extensions to standardized LN classes made by third parties	na
Part 7-2		
778	AddCause values – add value not-supported	Y
780	What is an unsupported trigger option at a control block?	Y
783	TimOper Resp-; add Authorization check	Y
786	AddCause values 26 and 27 are switched	Y
820	Mandatory ACSI services (use for PICS template)	Y
858	typo in enumeration ServiceType	na
861	dchg of ConfRev attribute	Y
876	GenLogiclNodeClass and SGCB, GoCB, MsvCB, UsvCB	Y
1038	Loss of Info Detection After Resynch	Y
1050	GTS Phycomaddr definition in SCL	na
1062	Entrytime not used in CDC	na
1071	Length of DO name	Y
1091	The sentence “The initial value of EditSG shall be 0”, has to be stated in part 7.2 not in 8.1	Y
1127	Missing owner attribute in BTS and UTS	na
1163	Old report in URCB	Y
1202	GI not optional	Y
Part 7-3		
697	persistent command / PulseConfig	na
698	Wrong case is BAC.dB attribute	na
722	Units for “h” and “min” not in UnitKind enumeration	na
919	Presence Condition for sVC	na
925	Presence of i or f attribute – Problem with writing	na
926	Presence Conditions within RangeConfig	Y
Part 7-4[1)]		
671	mistake in definition of Mod & Beh	Y
674	CDC of ZRRC.LocSta is wrong	na
675	SIML LN	na
676	Same data object name used with different CDC	na
677	MotStr is used with different CDC in PMMS and SOPM LN classes	na

Tissue	Description	Implemented Y/na
679	Remove CycTrMod Enum	na
680	SI unit for MHYD.Cndct	na
681	Enum PIDAlg	na
682	ANCR.ParColMod	na
683	Enum QVVR.IntrDetMth	na
685	Enum ParTraMod	na
686	New annex H – enums types in XML	Y
694	Data object CmdBlk	na
696	LSVS.St (Status of subscription)	na
712	interpretation of quality operatorBlocked	na
713	DO Naming of time constants in FFIL	na
724	ANCR.Auto	na
725	Loc in LN A-group	na
734	LLN0.OpTmh vs. LPHD.OpTmh	na
735	ISAF.Alm and ISAF.AlmReset	na
736	PFSign	na
742	GAPC.Str, GAPC.Op and GAPC.StrVal	na
743	CCGR.PmpCtl and CCGR.FanCtl	na
744	LN STMP, EEHealth and EEName	na
772	LPHD.PwrUp/PwrDn should be transient	na
773	Loc, LocKey and LocSta YPSH and YLTC	na
774	ITCI.LocKey	na
775	KVLV.ClsLim and OpnLim	na
776	LPHD.OutOv/InOv and LCCH.OutOv/InOv	na
800	Misspelling in CSYN	na
802	CCGR and Harmonized control authority	na
808	Presence condition of ZMoT.DExt and new DOs	na
831	Setting of ConfRevNum in LGOS	na
838	Testing in Beh=Blocked	na
844	MFLK.PhPiMax, MFLK.PhPiLoFil, MFLK.PhPiRoot DEL->WYE	na
849	Presence conditions re-assessing in case of derived statistical calculation	na
877	QVUB-settings should be optional	na
909	Remove ANCR.ColOpR and ColOpL	na
920	Resetable Counter is NOT resetable	na
932	Rename AVCO.SptVol to AVCO.VolSpt	na
939	Change CDC for ANCR.FixCol	na
991	LGOS: GoCBRef (as well as LSVS.SvCBRef) should be mandatory	Y
1007	PTRC as fault indicator – Update of description required	na
1044	TapChg in AVCO	na

Tissue	Description	Implemented Y/na
1077	Rename DOnames within LTIM	na
Part 8-1		
784	Tracking of control (CTS)	na
817	Fixed-length GOOSE float encoding	na
834	File dir name length 64	Y
951	Encoding of Owner attribute	na
1040	More associate error codes	na
1178	Select Response+ is non-null value	na
Part 9-2 (2004)		
124	Syntax – incorrect “pattern”	na
125	Is SmpRate optional?	na
126	Is SV APPID unique?	na
127	Safety in GOOSE	na
139	Destination address must be in SVCB	na
178	Non-conformance in ASN encoding between 9-1 and 9-2	na
423	Default VLAN ID 0	na
431	Safety	na
579	“Data” encoding in Table 13	na
Part 9-2 (IEC 61850-9-2LE)		
863	Application beyond CT/VT	na
944	SV message encoding table	na
965	Sample value control block attribute must be encoded in APDU, not in each ASDU	na
1055	Input time was never used in 9-2	na
1272	Bit mappings for parameters in OptFlds	na
1349	Incorrect type of MSVCB DstAddress parameter	na
[1)] Issues 675, 735, 772, 775, 776 are not suitable for testing.		

6.3 Description of implementation of IEC 61850-9-2 support

6.3.1 Protocol Implementation Conformance Statement – PICS

The Protocol Implementation Conformance Statement (PICS) contains information on ACSI. The device supports the following statements:

– Basic conformance statement ACSI (Table 109);

– ACSI models conformance statement (Table 110);

– ACSI service conformance statement (Table 111).

The following acronyms are used in Tables 109 – 111 :

– Y – supported;

– N – not supported.

Table 109 – Main conformance statement ACSI

Functionality		Service availability/support in device	Value/Note
Client – Server roles			
B11	Server side (of TWO-PARTY-APPLICATION-ASSOCIATION)	Y	
B12	Client side (of TWO-PARTY-APPLICATION-ASSOCIATION)	N	
SCSM support			
B21	SCSM: IEC 61850-8-1 used	Y	
B22	SCSM: IEC 61850-9-1 used	N	Excluded in 2nd edition
B23	SCSM: IEC 61850-9-2 used	Y	
B24	SCSM: other	N	
Model of generic substation events (GSE)			
B31	Publisher side	Y	
B32	Subscriber side	Y	
Model of transmission of sample values (SVC)			
B41	Publisher side	N	
B42	Subscriber side	Y	

Table 110 – ACSI models conformance statement

Services		Service availability/support in device	Value/Note
Supported server roles			
M1	Logical device	Y	
M2	Logical node	Y	
M3	Data	Y	
M4	Data set	Y	
M5	Substitution	N	
M6	Setting group control	Y	
Reporting			
M7	Buffered report control	Y	
M7-1	sequence-number	Y	
M7-2	report-time-stamp	Y	
M7-3	reason-for-inclusion	Y	
M7-4	data-set-name	Y	
M7-5	data-reference	Y	
M7-6	buffer-overflow	Y	
M7-7	entryID	Y	

Services		Service availability/support in device	Value/Note
M7-8	BufTm	Y	
M7-9	IntgPd	Y	
M7-10	GI (general interrogation)	Y	
M7-11	conf-revision	Y	
M8	Unbuffered report control	Y	
M8-1	sequence-number	Y	
M8-2	report-time-stamp	Y	
M8-3	reason-for-inclusion	Y	
M8-4	data-set-name	Y	
M8-5	data-reference	Y	
M8-6	BufTm	Y	
M8-7	IntgPd	Y	
M8-8	GI (general interrogation)	Y	
M8-9	conf-revision	Y	
Registration			
M9	Log control	N	
M9-1	IntgPd	N	
M10	Log	N	
M11	Control	Y	
M17	File Transfer	Y	
M18	Application association	Y	
M19	GOOSE Control Block	Y	
M20	Sampled Value Control Block	N	
GSE support			
M12	GOOSE	Y	
M13	GSSE (generic substation state event)	N	Excluded in 2nd edition
SVC support			
M14	Multicast SVC (multicast control of sampled values)	Y	
M15	Unicast SVC (unicast control of sampled values)	N	
For all devices of ED2 series			
M16	Time	Y	

The following acronyms are used in Table 111:

– TP – two-party;

– MC – multicast.

Table 111 – ACSI Service Conformance Statement

	Ed	Services	TP/MC	Service (S) availability in device	Note
Server					
S1	1.2	GetServerDirectory (LOGICAL-DEVICE)	TP	Y	
Application association					
S2	1.2	Associate		Y	
S3	1.2	Abort		Y	
S4	1.2	Release		Y	
Logical device					
S5	1.2	GetLogicalDeviceDirectory	TP	Y	
Logical Node					
S6	1.2	GetLogicalNodeDirectory	TP	Y	
S7	1.2	GetAllDataValues	TP	Y	
Data					
S8	1.2	GetDataValues	TP	Y	
S9	1.2	SetDataValues	TP	Y	
S10	1.2	GetDataDirectory	TP	Y	
S11	1.2	GetDataDefinition	TP	Y	
Data set					
S12	1.2	GetDataSetValues	TP	Y	
S13	1.2	SetDataSetValues	TP	N	
S14	1.2	CreateDataSet	TP	Y	
S15	1.2	DeleteDataSet	TP	Y	
S16	1.2	GetDataSetDirectory	TP	Y	
Replacement					
S17	1	SetDataValues	TP	N	
Setting group control					
S18	1.2	SelectActiveSG	TP	Y	
S19	1.2	SelectEditSG	TP	N	
S20	1.2	SetEditSGValues	TP	N	
S21	1.2	ConfirmEditSGValues	TP	N	
S22	1.2	GetEditSGValues	TP	N	
S23	1.2	GetSGCBValues	TP	Y	
Reporting					
Buffered report control block					
S24	1.2	Report	TP	Y	
S24-1	1.2	data-change (dchg)		Y	

	Ed	Services	TP/MC	Service (S) availability in device	Note
S24-2	1.2	quality-change (qchg)		Y	
S24-3	1.2	data-update (dupd)		N	
S25	1.2	GetBRCBValues	TP	Y	
S26	1.2	SetBRCBValues	TP	Y	
Unbuffered report control block					
S27	1.2	Report	TP	Y	
S27-1	1.2	data-change (dchg)		Y	
S27-2	1.2	quality-change (qchg)		Y	
S27-3	1.2	data-update (dupd)		N	
S28	1.2	GetURCBValues	TP	Y	
S29	1.2	SetURCBValues	TP	Y	
Logging					
Log control block					
S30	1.2	GetLCBValues	TP	N	
S31	1.2	SetLCBValues	TP	N	
Log					
S32	1.2	QueryLogByTime	TP	N	
S33	1.2	QueryLogAfter	TP	N	
S34	1.2	GetLogStatusValues	TP	N	
Model of generic substation events					
Generic object-oriented substation event (GOOSE)					
S35	1.2	SendGOOSEMessage	MC	Y	
GOOSE control block					
S36	1.2	GetGoReference	TP	Y	
S37	1.2	GetGOOSEElementNumber	TP	N	
S38	1.2	GetGoCBValues	TP	Y	
S39	1.2	SetGoCBValues	TP	N	
Generic substation state event					
S40	1	SendGSSEMessage	MC	N	Excluded in 2nd edition
GSSE control block					
S41	1	GetGsReference	TP	N	Excluded in 2nd edition
S42	1	GetGSSEElementNumber	TP	N	Excluded in 2nd edition
S43	1	GetGsCBValues	TP	N	Excluded in 2nd edition
S44	1	SetGsCBValues	TP	N	Excluded in 2nd edition

	Ed	Services	TP/MC	Service (S) availability in device	Note
Model of transmission of sample values (SVC)					
Multicast sample value					
S45	1.2	SendMSVMessage	MC	N	
Multicast SVC block					
S46	1.2	GetMSVCBValues	TP	N	
S47	1.2	SetMSVCBValues	TP	N	
Unicast sample value					
S48	1.2	SendUSVMessage	TP	N	
Unicast SVC block					
S49	1.2	GetUSVCBValues	TP	N	
S50	1.2	SetUSVCBValues	TP	N	
Control					
S51	1.2	Select		Y	
S52	1.2	SelectWithValue	TP	Y	
S53	1.2	Cancel	TP	Y	
S54	1.2	Operate	TP	Y	
S55	1.2	Command Termination	TP	Y	
S56	1.2	TimeActivatedOperate	TP	N	
File transfer					
S57	1.2	GetFile	TP	Y	
S58	1.2	SetFile	TP	N	
S59	1.2	DeleteFile	TP	N	
S60	1.2	GetFileAttributeValues	TP	Y	
S61	1.2	GetServerDirectory (FILE-SYSTEM)	TP	Y	
Time					
T1	1.2	Time resolution of internal clock		20	Nearest negative power of 2^{-n} in seconds (a number in the range from 0 to 24)

	Ed	Services	TP/MC	Service (S) availability in device	Note
T2	1.2	Time accuracy of internal clock		T1	TL (ms) (low accuracy), T3 < 7 (only Ed2); T0 (ms) (≤ 10 ms), 7 ≤ T3 < 10; T1 (μs) (≤ 1 ms), 10 ≤ T3 < 13; T2 (μs) (≤ 100 μs), 13 ≤ T3 < 15; T3 (μs) (≤ 25 μs), 15 ≤ T3 < 18; T4 (μs) (≤ 25 μs), 15 ≤ T3 < 18; T5 (μs) (≤ 100 μs), T3 ≥ 20
T3	1.2	Supported TimeStamp resolution		10	

6.3.2 Model Implementation Conformance Statement – MICS

This MICS reflects information regarding the reception of SV streams:

– composition of the object model implemented in the devices of the ED2 series;

– implementation details of the information model;

– list of logical nodes (Table 112), participating in the reception of SV streams, and their description (Tables 113 – 115);

– description of common data classes (CDC) (Tables 116 – 126);

– description of data attributes (Tables 127 – 131) and enumerated types (Enum Types) (Tables 132 – 137).

Table 112 – List of logical nodes

L: Classes of logical nodes
LSVS (Sampled value subscription)
M: Logical nodes for recordkeeping and measurement
MMXN (Non-phase-related measurement)
MMXU (Analogue measurements)

6.3.2.1 Logical nodes

The following acronyms are used in Tables 113 – 131:

– M – mandatory attribute;

– O – optional attribute;

– GC_1 – this DATA copy must have at least one attribute.

Table 113 – Logical node: Sampled value subscription. Designation: LSVS_1

LSVS class				
Data object name	Common data class	Explanation	M/O	Note
Data objects				
Description				
NamPlt	LPL_1	Name plate	M	
Status data				
Beh	ENS_2	Operation mode	M	
Health	ENS_1	Operating state	M	
St	SPS_1	Subscription status (True = active, False = not active)	O	
Control				
Mod	ENC_1	Mode	M	
Settings				
SvCBRef	ORG_1	Reference to signed SV control block	O	

Table 114 – Logical node: Non-phase-related measurement. Designation: MMXN_1

MMXN class				
Data object name	Common data class	Explanation	M/O	Note
Data objects				
Description				
NamPlt	LPL_1	Name plate	M	
Status data				
Beh	ENS_2	Operation mode	M	
Health	ENS_1	Operating state	M	
Control				
Mod	ENC_1	Mode	M	
Measured and dosed values				
Amp	MV_1	Current I is not distributed in phase	O	
Vol	MV_1	Voltage V is not distributed in phase	O	
Hz	MV_1	Frequency	O	
Ang	MV_2	Angle	O	

Table 115 – Logical node: Measurement name. Designation: MMXU_1

MMXU class				
Data object name	Common data class	Explanation	M/O	Note
Data objects				
Description				
NamPlt	LPL_1	Name plate	M	
Status data				
Beh	ENS_2	Operation mode	M	
Health	ENS_1	Operating state	M	
Control				
Mod	ENC_1	Mode	M	
Measured and dosed values				
Hz	MV_1	Frequency	O	
PPV	DEL_1	Voltage from phase to phase	O	
PhV	WYE_1	Voltage phase – ground	O	
A	WYE_1	Phase currents	O	

6.3.2.2 Common data classes

Table 116 – Common data class: Nameplate of logical node. Designation: LPL_1

LPL class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Configuration, description and extension					
Vendor	VISIBLE STRING255	DC			M
SwRev	VISIBLE STRING255	DC			M
Du	UNICODE STRING255	DC			O

Table 117 – Common data class: Integer status. Designation: ENS_2

INS class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Status					
stVal	LISTED	ST	dchg, dupd	Operation mode	M
Q	Quality	ST	qchg		M
T	Time stamp	ST			M

Table 118 – Common data class: Integer status. Designation: INS_1

INS class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Status					
StVal	LISTED	ST	dchg, dupd	Operating state	M
Q	Quality	ST	qchg		M
T	Time stamp	ST			M

Table 119 – Common data class: Controllable integer status. Designation: INC_1

INC class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Status and control mirror					
stVal	LISTED	ST	dchg	Mode	M
q	Quality	ST	qchg		M
t	Time stamp	ST			M
Configuration, description and extension					
ctlModel	LISTED	CF	dchg	Ctl models	M

Table 120 – Common data class: Configuration of reference to object. Designation: ORG_1

ORG class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Parameter					
setSrcRef	ObjectReference	SP	dchg	Object Reference	M

Table 121 – Common data class: Single-point status. Designation: SPS_1

SPS class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Parameter					
stVal	LOGICAL	ST	dchg	TRUE | FALSE	M
Q	Quality	ST	qchg		M
t	Time stamp	ST			M

Table 122 – Common data class: Measured value. Designation: MV_1

MV class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Measured attributes					
instMag	Analogue value	MX			O
mag	Analogue value	MX	dchg, dupd		M
q	Quality	MX	qchg		M
t	Time stamp	MX			M
Configuration, description and extension					
units	Unit	CF	dchg		O
db	INT32U	CF	dchg	0– 100,000	O
dU	UNICODE STRING255	CF			O

Table 123 – Common data class: Measured value. Designation: MV_2

MV class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Measured attributes					
instMag	Analogue value	MX			O
mag	Analogue value	MX	dchg, dupd		M
q	Quality	MX	qchg		M
t	Time stamp	MX			M
Configuration, description and extension					
units	Unit	CF	dchg		O
db	INT32U	CF	dchg	0 – 100,000	O
dU	UNICODE STRING255	CF			O
dataNs	VISIBLE STRING255	EX			O

Table 124 – Common data class: Complex measured value. Designation: CMV_1

CMV class					
Data attribute name	Type	Functional connection	Start options	Value / Range of values	M/O
Data attribute					
Measured attributes					
instCVal	Vector	MX			O
cVal	Complex value	MX	dchg, dupd		M
q	Quality	MX	qchg		M
t	Time stamp	MX			M
Configuration, description and extension					
units	Unit	CF	dchg		O
db	INT32U	CF	dchg	0 – 100,000	O
dU	UNICODE STRING255	CF			O

Table 125 – Common data class: Measured values related to phase of three-phase system. Designation: DEL_1

DEL class		
Data attribute name	Type	M/O/GC_1
Data subobject		
phsAB	CMV_1	GC_1
phsBC	CMV_1	GC_1
phsCA	CMV_1	GC_1

Table 126 – Common data class: Measured values between phase and ground/neutral in three-phase system. Designation: WYE_1

WYE class		
Data attribute name	Type	M/O/GC_1
Data subobject		
phsA	CMV_1	GC_1
phsB	CMV_1	GC_1
phsC	CMV_1	GC_1

6.3.2.3 Constructed attribute classes

Table 127 – Quality

Determination of quality type			
Attribute name	Attribute type	Value / Range of values	M/O
	PACKED LIST	–	
validity	CODED ENUM	good | invalid | reserved | questionable	M
detailQual	PACKED LIST	–	M
overflow	BOOLEAN	–	M
outOfRange	BOOLEAN	–	M
badReference	BOOLEAN	–	M
oscillatory	BOOLEAN	–	M
failure	BOOLEAN	–	M
oldData	BOOLEAN	–	M
inconsistent	BOOLEAN	–	M

Determination of quality type			
Attribute name	Attribute type	Value / Range of values	M/O
inaccurate	BOOLEAN	–	M
source	CODED ENUM	process | substituted DEFAULT process	M
test	BOOLEAN	DEFAULT FALSE	M
operatorBlocked	BOOLEAN	DEFAULT FALSE	M

Table 128 – Analogue value

Determination of analogue value type			
Attribute name	Attribute type	Value / Range of values	M/O/GC_1
f	FLOAT32	floating point value	GC_1

Table 129 – Reference to object

Determination of type of reference to object			
Attribute name	Attribute type	Value / Range of values	M/O/GC_1
ObjectReference	VISIBLE STRING129	ObjectReference comprises the whole path-name of an instance of a class that identifies the instance uniquely. The ObjectReference shall be composed of two parts: up to 64 characters for the LD name followed by one separator “/” followed by up to 64 characters for the path below the LD name. The NULL ObjectReference is an empty ObjectReference (i.e. empty VISIBLE STRING129)	GC_1

Table 130 – Module

Determination of module type			
Attribute name	Attribute type	Value / Range of values	M/O
SIUnit	ENUMERATED	ITSIUnit	M
Multiplier	ENUMERATED	Multiplier	O

Table 131 – Vector

Determination of vector type			
Attribute name	Attribute type	Value / Range of values	M/O
Mag	AnalogueValue		M

6.3.2.4 Enumeration types

Table 132 – Operation mode

Value	Description	Note
1	On	
2	Blocked	
3	Test	
4	test/blocked	
5	Off	

Table 133 – Operating state

Value	Description	Note
1	Ok	
2	Warning	
3	Alarm	

Table 134 – Operation mode

Value	Description	Note
1	On	
2	Blocked	
3	Test	
4	test/blocked	
5	Off	

Table 135 – Ctl models

Value	Description	Note
0	status-only	
1	direct-with-normal-security	
2	sbo-with-normal-security	
3	direct-with-enhanced-security	
4	sbo-with-enhanced-security	

Table 136 – ITSI unit

Value	Description	Note
1		
2	m	
3	kg	
4	s	
5	A	
6	K	
7	mol	
8	cd	
9	deg	
10	rad	
11	sr	
21	Gy	
22	q	
23	°C	
24	Sv	
25	F	
26	C	
27	S	
28	H	
29	V	

Value	Description	Note
30	Ohm	
31	J	
32	N	
33	Hz	
34	Lx	
35	Lm	
36	Wb	
37	T	
38	W	
39	Pa	
41	m^2	
42	m^3	
43	m/s	
44	m/s^2	
45	m^3/s	
46	m/m^3	
47	M	
48	kg/m^3	
49	m^2/s	
50	W/m K	
51	J/K	
52	ppm	
53	1/s	
54	rad/s	
61	VA	
62	Watts	
63	VAr	
64	phi	
65	cos(phi)	

Value	Description	Note
66	Vs	
67	V^2	
68	As	
69	A^2	
70	A^2t	
71	VAh	
72	Wh	
73	VArh	
74	V/Hz	
75	Hz	
76	char	
77	char/s	
78	kgm	
79	dB	
80	J/Wh	
81	W/s	
82	l/s	
83	dBm	
84	h	
85	min	

Table 137 – Factor

Value	Description	Note
-24	y	
-21	z	
-18	a	
-15	f	
-12	p	
-9	n	

Value	Description	Note
-6	μ	
-3	m	
-2	c	
-1	d	
0		
1	da	
2	h	
3	k	
6	M	
9	G	
12	T	
15	P	
18	E	
21	Z	
24	Y	

6.3.3 Additional information on the implementation of protocol – PIXIT

PIXIT contains system-specific device capability information in addition to the Protocol Implementation Conformance Statement (PICS), as well as information on physical structure not included in ACSI (see Table 138). PIXIT contains information that is not available in PICS, MICS, TICS or SCL file. PIXIT is formed in accordance with Test procedures for Sampled Values Subscribers according to the “Implementation Guideline for Digital Interface to Instrument Transformers using IEC 61850-9-2” (9-2LE) v 0.1.

The following acronyms are used in Table 138:

– Y – supported;

– N – not supported.

Table 138 – PIXIT for 9-2LE subscriber

Description	Value/Clarification	
Supported SV specification?	9-2LE	
Supported nominal frequencies?	50 Hz 60 Hz	Y N

Description	Value/Clarification
Supported sampling rates?	80 samples per cycle Y 256 samples per cycle N
9-2 connector type?	LC or RJ-45
Input voltage and currents signals	0, 3 or 4 phase voltages 0, 3 or 4 phase currents
Maximum number of SV streams?	12 SV streams (V and A combined) 12 SV streams (V or A in separate stream)
Max length for SvID?	Max length of SvID = 30
What is the maximum acceptable (rated) delay time between taking the sample and receiving the corresponding SV message?	Configurable (1 – 10) ms
Which quality codes are supported?	Validity – good Y – invalid Y – reserved Y – questionable N detailQual Y Source N Test N OperatorBlocked Y Derived N
DUT supports the following methods to indicate a subscribe failure: – LED indication on front panel; – IEC 61850 data point; – add event to internal log; – output contact; – other	Y Y, available by GOOSE or report Y Y <describe, to be agreed by test lab> (note: one method is mandatory)
Does the subscriber support test mode?	Y
What is the behaviour of the DUT when SV required data is received with quality.test = true?	DUT in normal mode – SV stream is not accepted. DUT in test mode – SV stream is accepted. DUT in test mode – SV stream is accepted if any voltages or currents are in good quality. Test = true. DUT is switched from normal mode into test mode after (3 – 12) ms (determined by configuration)
What is the behaviour of the DUT when SV required data is received with quality.validity ≠ good?	Protection functions of DUT working from this SV stream's phases will be blocked (the behaviour may change due to configuration)
What is the behaviour of the DUT when SV required data is received with smpSynch: – none – local – global	SV stream is accepted. The behaviour is determined by configuration. 0: SV stream marked as noSmpSynch
What is the behaviour of the DUT when the main SV stream is lost:	DUT is switched from the main SV stream into the reserved SV stream (the behaviour may change due to configuration). The SV stream is switched after 1 ms
What is the behaviour of the DUT when only a number (1-10-100) of required SV samples is missing?	1-2 consecutive sample of the SV stream can be restored. If more samples are missing, than SV stream is not accepted. SV stream marked as noValue

Description	Value/Clarification
What is the behaviour of the DUT when double SV messages received (with the same smpCnt)?	DUT accepted the first SV. Second SV is not accepted. SV stream marked as replace stream
What is the behaviour of the DUT when a number of required SV samples are delayed beyond the maximum acceptable delay time?	1 or 2 consecutive samples of the SV stream can be restored. If more samples are delayed, SV stream is not accepted. SV stream marked as oldValue
At losing the timesync signal after how much time this is detected by the DUT?	Not more than 30 s
When restoring the timesync signal how long does it take for it to be detected by the DUT?	Not more than 10 s
What is the behaviour of the DUT when the timesync signal is lost: – in one of the merging units? – in all subscribed merging units? – in the DUT? – in all merging units and DUT?	1 and 2 and 3 and 4: SV stream is accepted. The behaviour is determined by configuration. 1: SV stream marked as noSmpSynch 2: SV streams marked as noSmpSynch 3: DUT marked as hhNoSyncPTP 4: SV streams marked as noSmpSynch. DUT marked as hhNoSyncPTP
Which values are verified to subscribe to an SV stream? And what is the behaviour of the DUT when the verification fails?	svID, confRev are verified. smpRate, dataSet are not verified.[1)] If the verification fails, SV stream is not accepted
What is the typical start time for SV processing after a power interruption?	Not more than 90 s
What is the behaviour of the DUT when the smpCnt sequence order of incoming SV frames is wrong?	DUT correctly accepts data if out of order frames are in consistency with the configuration parameter of the delayed 0-sample processing (1 – 10) ms
<additional items>	
[1)] According to 9-2LE their values are fixed.	

6.3.4 Tissues Implementation Conformance Statement – TICS

TICS lists the approved IEC 61850 issues and reflects the fact that they are taken into account in the devices of the ED2 series (Table 139).

The following acronyms are used in Table 139:

– N/A (not applicable) – not supported.

Table 139 – List of main approved issues

Issue	Description	Implementation N/A
Part 9-2 (2004)		
124	Syntax – «sample» incorrect	N/A
125	SmpRate optional?	N/A
126	SV APPID unique?	N/A
127	Security in GOOSE	N/A
139	Destination Address needs to be in SVCB	N/A
178	Inconsistency in ASN encoding between 9-1 and 9-2	N/A
423	Default VLAN ID 0	N/A
431	Security	N/A

Issue	Description	Implementation N/A
579	Encoding of «Data» in Table 13	N/A
Part 9-2 (IEC 61850-9-2LE)		
863	Application beyond CT/VT	N/A
944	Table of Encoding of SV message	N/A
965	sample value control block attribute should be encoded in the APDU rather than encoded in each ASDU	N/A
1055	EntryTime never used in 9-2	N/A
1272	Bit mappings for options in OptFlds	N/A
1349	The type of the MSVCB parameter DstAddress is incorrect	N/A

6.4 Description of device (ICD file) capability

The IEC 61850 standard determines the ICD file type to describe the capabilities, communication parameters of an IED.

In the ICD file all logical devices, logical nodes, elements and data attributes are described. In addition, preconfigured data sets (Dataset), blocks for control of sending GOOSE messages (GOOSE Control Block), reports (Report Control Block), instantaneous values (SV Control Block) are described; configuration in the device is performed using the EKRASMS-SP software package.

An ICD file describes the capabilities of the device and consists of four main parts:

– Title;

– Communication;

– Device;

– Templates of data type.

The internal software of ED2 IED generates a file with *.cid extension based on the configuration written in it (a file containing the information model of an already configured device with all information about access points, data sets, functions etc.). Accordingly, * .cid is stored on the device's memory card.

6.5 Configuration of GOOSE and MMS protocols (IEC 61850-8-1)

6.5.1 Configuration of protocol using the Smart Monitor software

6.5.1.1 Start the Smart Monitor software according to 2.4.1.1.

6.5.1.2 In the “tree” of the project of the Smart Monitor software, select the menu item **Settings → Digital communication channels → Communication protocols → 61850 → Parameters** (see Figure 65, designation 1), clicking once with the left mouse button the corresponding item in the project “tree”, and open the window.

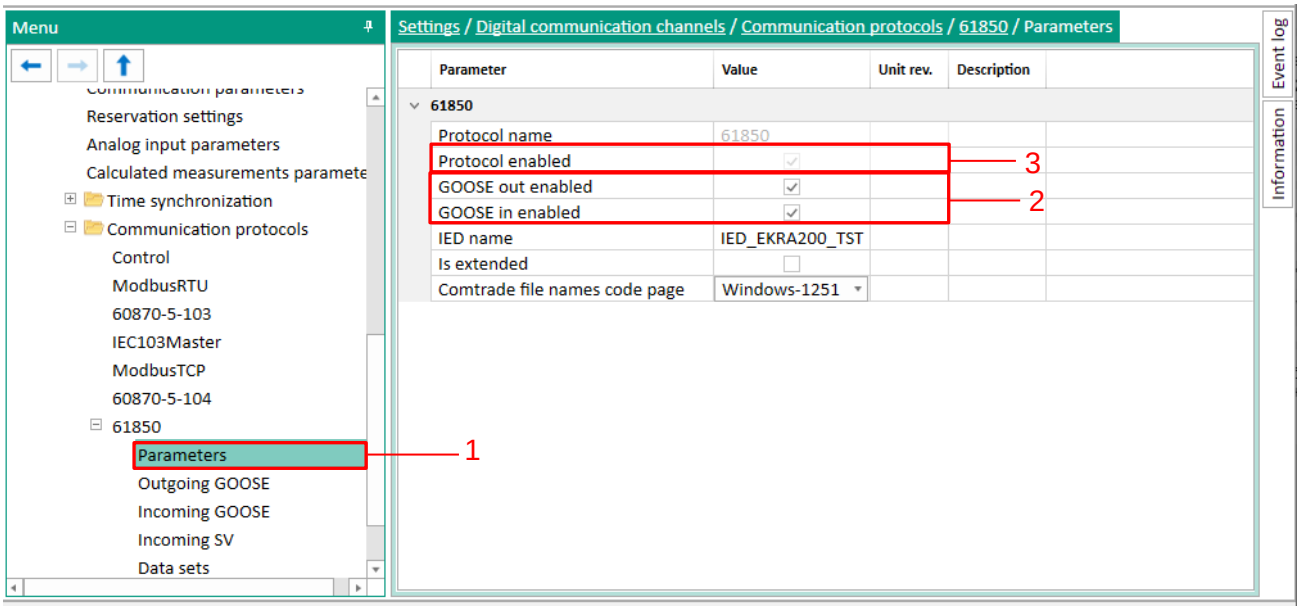


Figure 65 – Parameters of IEC 61850 protocol

6.5.1.3 Specify parameters of IEC 61850 protocol:

1) Check the box in front of the **Enable outgoing GOOSE** field (see Figure 65, designation 2) to enable the transmission of binary and analogue data via GOOSE messages;

2) Check the box in front of the **Enable incoming GOOSE** field (see Figure 65, designation 2) to enable the reception of binary and analogue signals via GOOSE messages.

The purpose of the IEC 61850 protocol parameters is given in 140.

Table 140 – Parameters of IEC 61850 protocols

Parameter	Description	Recommended value
Protocol name	Name of the protocol	61850
Protocol enabled	Sign of using the protocol in configuration	Box checked
Enable outgoing GOOSE	Sign of enabling publishing of GOOSE messages	Box checked
Enable incoming GOOSE	Sign of enabling subscription to GOOSE messages	Box checked
IED name	Name (ID) of the device	IED_<Text>
Sign of using an extended protocol	Sign of enabling addition of custom data types and attributes to the data model	No checkbox
Encoding of COMTRADE file names	Encoding used for COMTRADE file names (Windows-1251 or UTF-8)	Windows-1251
Note – In the Smart Monitor software, it is not possible to check/uncheck the box in front of the **Protocol enabled** field (see 65, designation 3) if you are not logged in with administrator rights.		

6.5.1.4 Configuration of data sets

6.5.1.4.1 In the “tree” of the project of the Smart Monitor software, select the menu item **Settings → Digital communication channels → Communication protocols → 61850 → Data sets** (see Figure 66, designation 1), clicking once with the left mouse button the corresponding item in the project “tree”, and open the window.

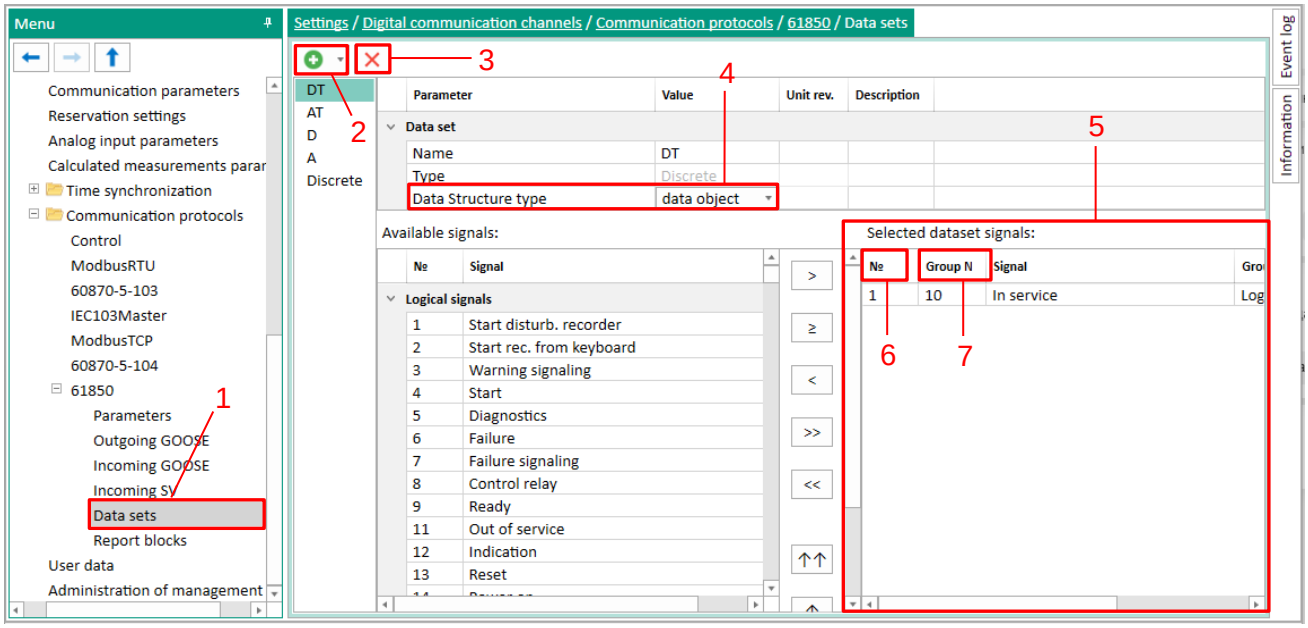


Figure 66 – **Data sets** window

6.5.1.4.2 Click the button “ ” (see Figure 66, designation 2) and from the drop-down list (binary set, analogue set, service set, mixed set) select one of the listed data sets. Data sets can be deleted using the “ ” button (see 66, designation 3).

A binary set can be created from various groups of signals: binary inputs of the signal table of the ED2 series device, calculated values with a logical type of data, CP status flags, FP status flags, LED status, module serviceability signals, status of subscription to incoming GOOSE messages, switching devices (two-bit data type). Service set – authorization, firmware update, configuration update and reset. Analogue set – analogue inputs and calculated values with the data type other than logical. Mixed set – signals of analogue and binary sets.

When creating the **Data set**, keep in mind:

– it is forbidden to use spaces, underscores in the name of the **Data set**;

– in the name of the **Data set,** the first character must not be a digit;

– **Data set** names must be unique;

– **Data sets** must not be empty.

Select the **Structure type** data set parameter (see Figure 66, designation 4):

– value (only values will be sent);

– value, quality (value, quality will be sent in reports);

– value, quality, timestamp (will be sent as separate attributes in reports);

– data object (value, quality, timestamp in reports will be sent combined into a common structure).

Add the required signals from the source list to the **Selected signals of data set** field (see Figure 66, designation 5) by dragging one or more selected signals to the list on the right (drag&drop technology). The selected signals for transmission are assigned a sequence number in the data set

(see Figure 66, designation 6), in addition, the field indicates the sequence number of the signal from the list of binary signals of the ED2 series device (see Figure 66, designation 7). When adding signals to the existing data set list, the new signals will be added to the end of the list. It is possible to move signals in the list.

6.5.1.5 Configuration of GOOSE protocol

6.5.1.5.1 Configuration of outgoing GOOSE messages

6.5.1.5.2 Before configuring outgoing GOOSE messages, make sure that in the menu item **Settings → Digital communication channels → Communication protocols → 61850 → Parameters** (see Figure 65, designation 1) the **Outgoing GOOSE enabled** box is checked (see Figure 65, designation 2).

6.5.1.5.3 In the “tree” of the project, select the menu item **Settings → Digital communication channels → Communication protocols → 61850 → Outgoing GOOSE** (see Figure 67, designation 1), clicking once with the left mouse button on the corresponding item in the project “tree” and open the window. If necessary, you can add outgoing GOOSE messages using the “ ” button (see Figure 67, designation 2), you can delete outgoing GOOSE messages using the “ ” button (see Figure 67, designation 3).

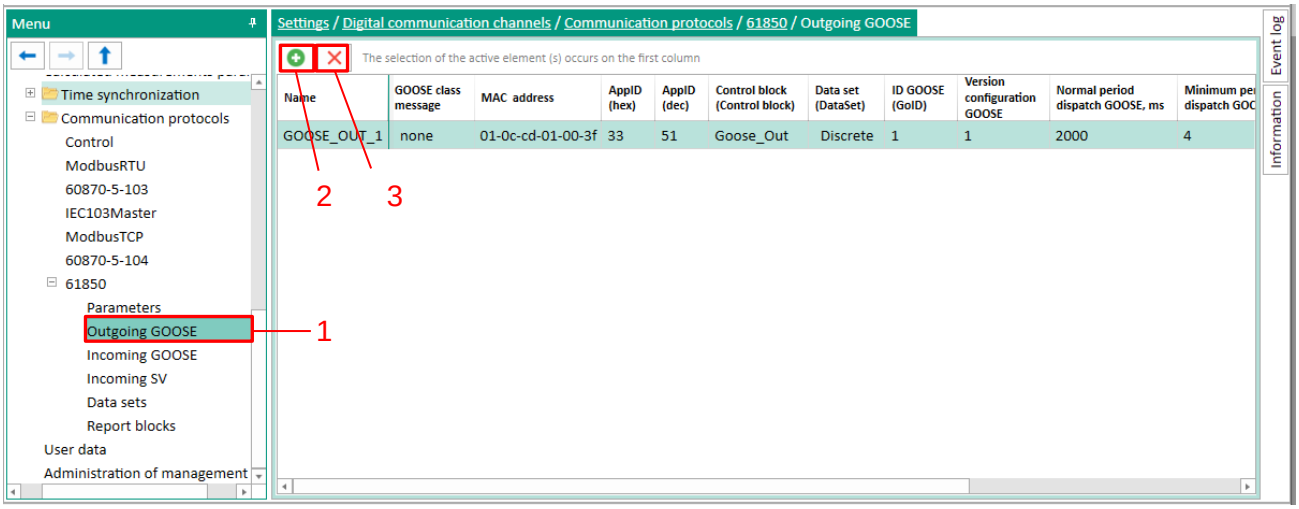


Figure 67 – **Outgoing GOOSE** window

Specify the parameters (see Table 141) of outgoing GOOSE messages in accordance with the project.

Table 141 – Default parameters of outgoing GOOSE

Parameter	Function	Default value
Name	Name of outgoing GOOSE message	GOOSE_OUT_N[1)]
GOOSE message class	Type of GOOSE message according to IEC 61850 classification. Selecting a GOOSE message class for the rest of the parameters listed below will automatically change the	None

Parameter	Function	Default value
	default values and ranges of possible values	
Multicast MAC-address	Broadcast MAC address to which GOOSE packets will be sent	01-0c-cd-01-00-00[2)]
AppID (hex)	Identifier of the application using a multicast: - hex – hexadecimal representation of the field; - dec – decimal representation of the field (integer). Must be unique for all GOOSE messages at the substation for proper operation of the device	3FFE
AppID (dec)		16382
Control block	Name of control block, responsible for GOOSE multicast	Goose_Out_N[1)]
DataSet	Name of GOOSE data set	None
ID GOOSE (GoID)	Unique sign of an object that distinguishes it from other objects	goID
GOOSE configuration version	Version of GOOSE configuration is necessary to keep track of the number of changes to the GOOSE configuration	1
Standard period for GOOSE transmission, ms	Period of cyclic transmission when there are no signal changes. Periodic transmission is used to control connectivity	2,000
Minimal period for GOOSE transmission, ms	Period of cyclic transmission when at least one signal in the message changes is specified in milliseconds. Adjustable in the range from 4 to 10,000 ms	4
Enable VLAN	Enabling the use of VLAN in outgoing GOOSE messages	Box not checked
ID VLAN	Integer value, which is used in VLAN for identification	0
VLAN priority	Integer value of priority of outgoing GOOSE messages using VLAN	4
Network interface	Ethernet interface, through which GOOSE message is sent	Ethernet 1
Fixed coding checkbox	Sign of transmitting GOOSE message with fixed length of fields	Box not checked
[1)] N is the sequence number of the GOOSE message. [2)] For broadcast MAC addresses, a certain range of addresses 01-0c-cd 01-(00...01)-(00...FF) is reserved by the GOOSE standard.		

Note – In order to select a string (strings) for deletion, as well as to work with the context menu items, it is necessary to click with the left mouse button on the first string.

6.5.1.5.4 Configuration of incoming GOOSE messages

6.5.1.5.5 Before configuring incoming GOOSE messages, make sure that in the menu item **Settings → Digital communication channels → Communication protocols → 61850 → Parameters** (see Figure 65, designation 1) the **Outgoing GOOSE enabled** box is checked (see Figure 65, designation 2).

6.5.1.5.6 There are two ways to configure incoming GOOSE messages:

– by importing cid or icd file (see 6.5.1.5.7 and 6.5.1.5.8);

– manually (see 6.5.1.5.9).

6.5.1.5.7 Importing data from cid file

It is not possible to directly open the cid file in the Smart Monitor software, for this you need to:

1) Click the “  ” button (see Figure 68, designation 1).

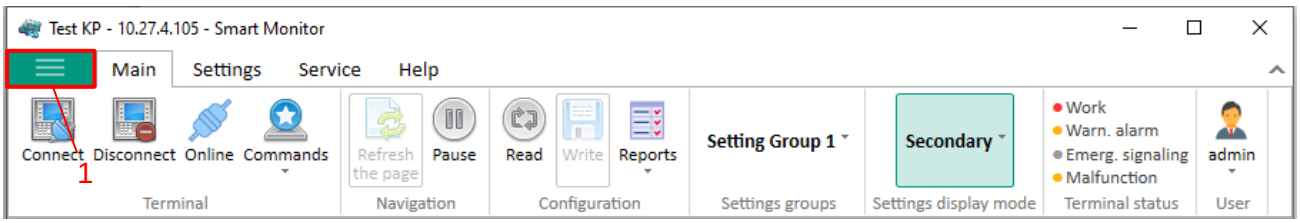


Figure 68 – Workspace of the main menu of the Smart Monitor software

In the drop-down list of commands of the main menu you must select the item **Export SCL file** (see Figure 69, designation 1).

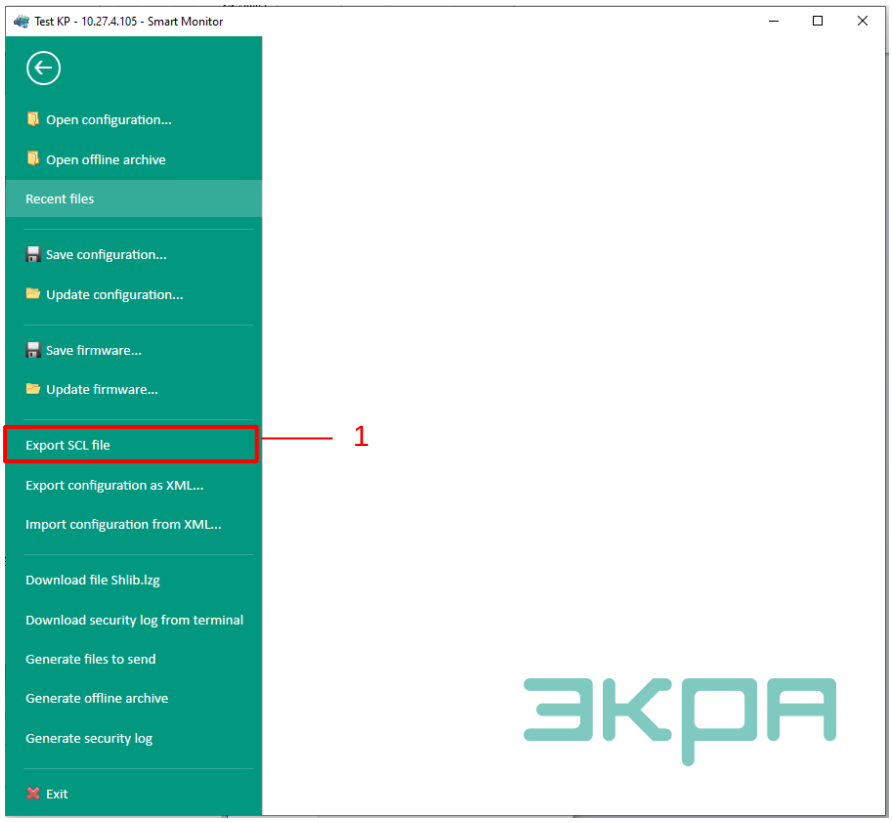


Figure 69 – Window for Export SCL file

Then select a location to save the file and click the **Save** button (see Figure 70, designation 1).

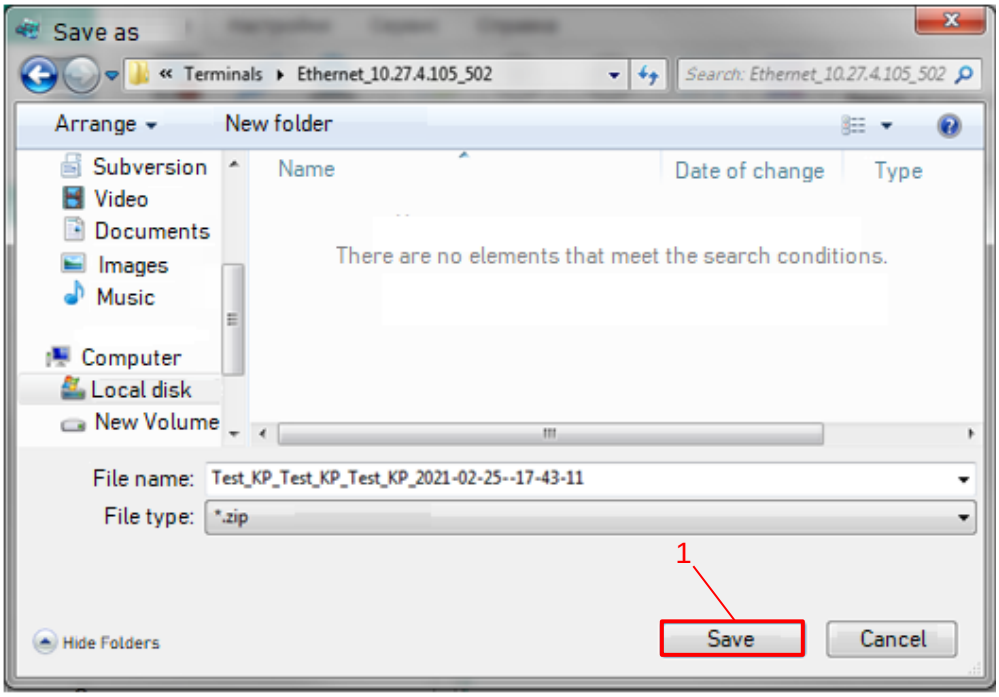


Figure 70 – Saving file

3) Go to the "Incoming GOOSE» tab. Click the "  " button (see Figure 71, designation 4).

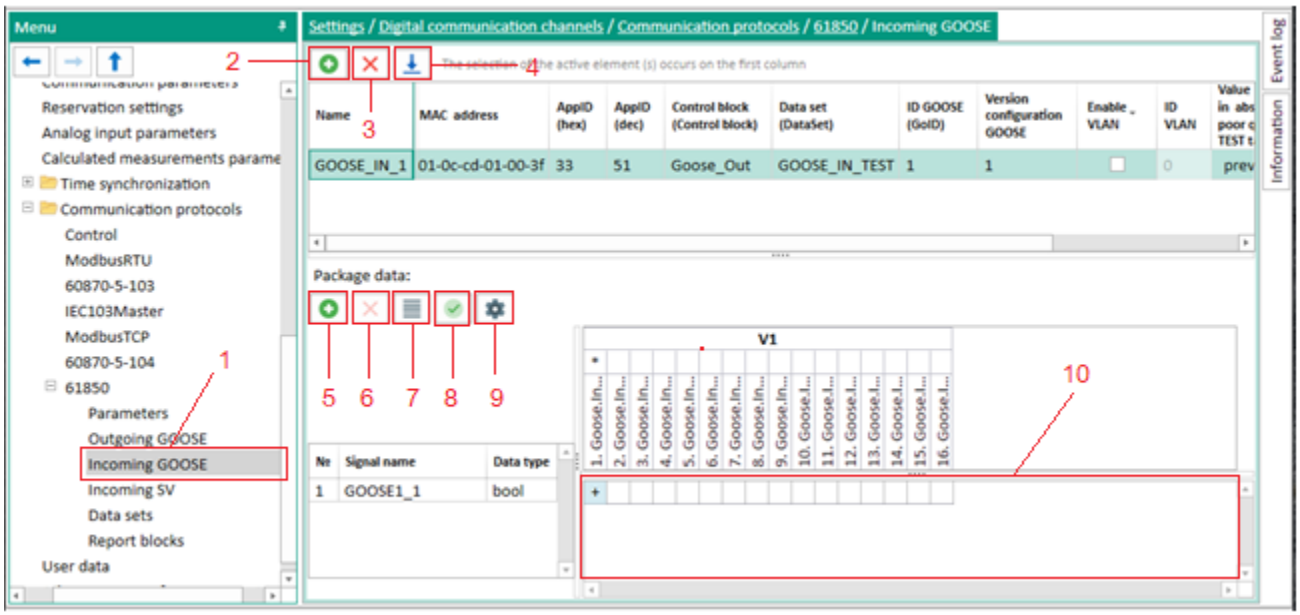


Figure 71 – **Incoming GOOSE** window

Select the cid file and click the **Open** button (see Figure 72, designation 1).

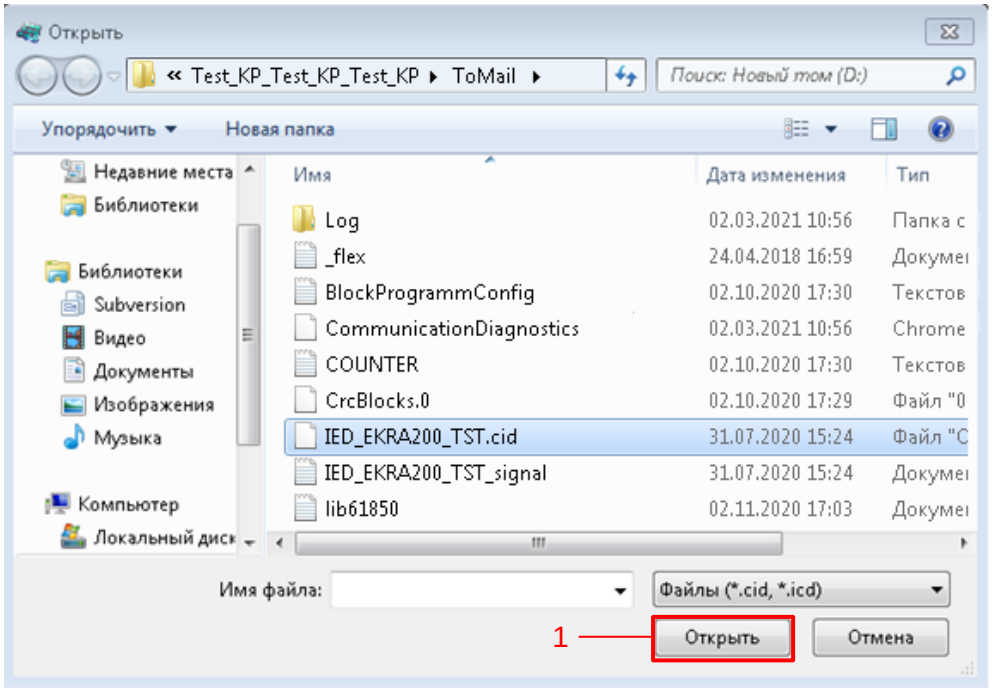


Figure 72 – Opening of a cid file

After pressing the **Open** button, the **Import incoming GOOSE** window will appear, where you are supposed to select which messages from the entire list you want to import. After selecting the desired items, click the **Import** button (see Figure 73, designation 1).

Figure 73 – **Import incoming GOOSE** window

Then, the data from the cid file will be generated. When importing, the settings for outgoing GOOSE messages from the cid file are used to configure the incoming GOOSE messages of the device being configured. Paragraph 6.5.1.5.10 describes the field for assigning GOOSE message signals to logical signals of the device.

6.5.1.5.8 Importing data from an icd file

Click the “ ” button (see Figure 71, designation 4). Select the icd file and click the **Open** button (see Figure 74, designation 1).

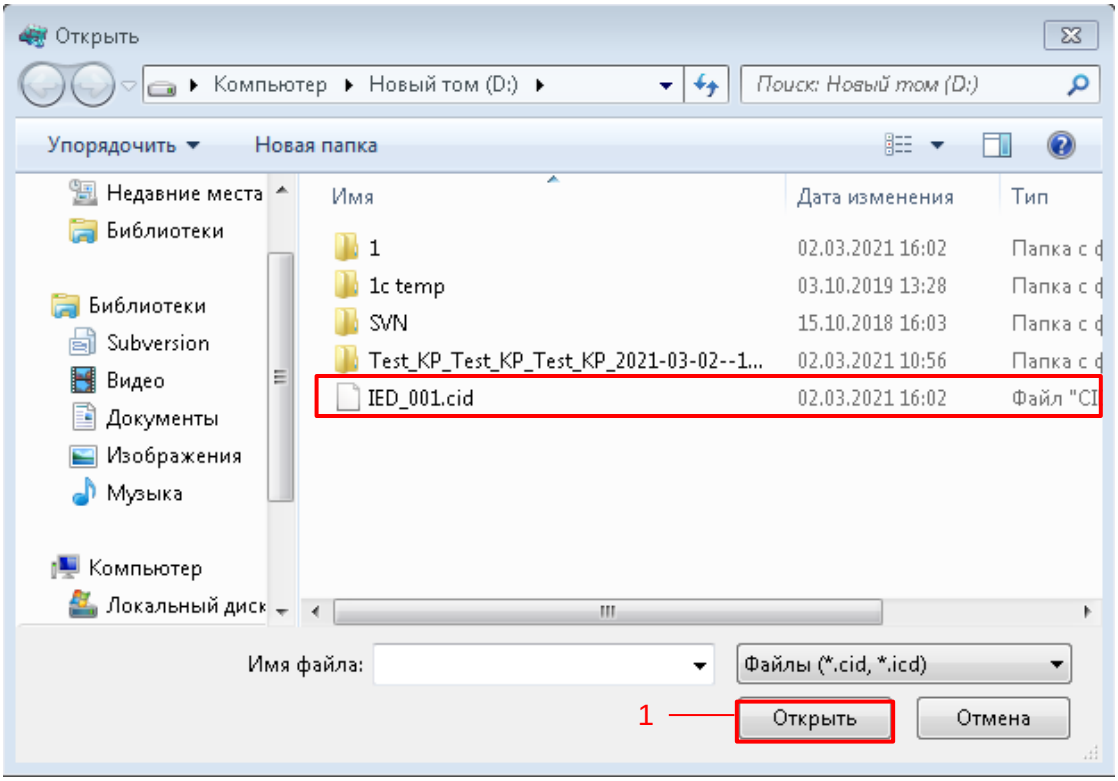


Figure 74 – Opening of an icd file

After clicking the **Open** button, the **Import incoming GOOSE** window will appear, where you are supposed to select which messages from the entire list you want to import. Having selected the desired elements, click the **Import** button (see Figure 75, designation 1).

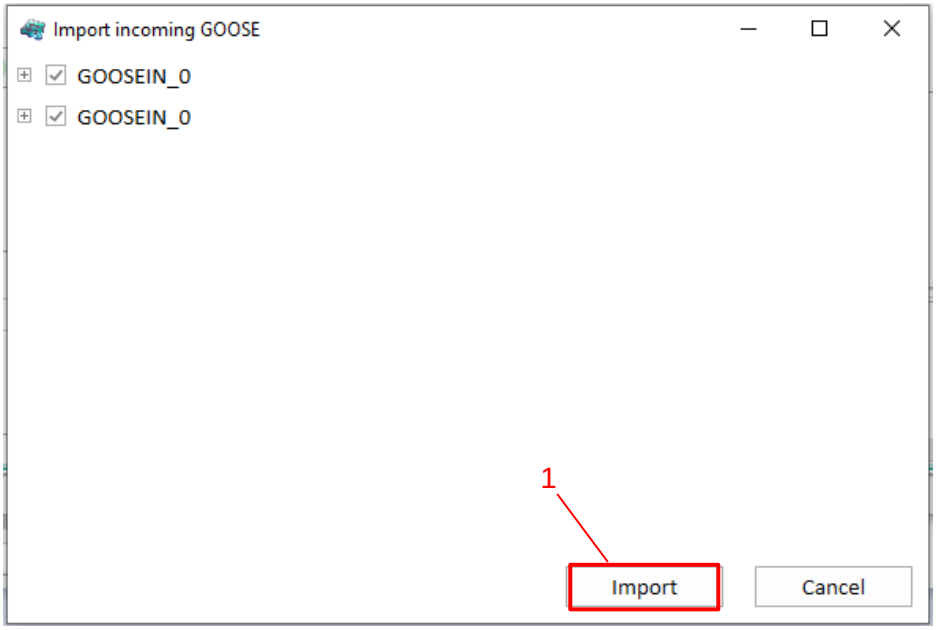


Figure 75 – **Import incoming GOOSE** window

Then the data from the icd file will be generated. When importing, the outgoing GOOSE message settings from the icd file are used to configure the incoming GOOSE messages of the device being configured. Paragraph 6.5.1.5.10 describes the field for assigning GOOSE signals to the logical signals of the device.

6.5.1.5.9 When configuring incoming GOOSE messages manually, you need to add incoming GOOSE messages using the "" button (see Figure 71, designation 2). One incoming message (one packet containing several signals) – one click on the button. You can delete an incoming GOOSE message using the "" button (see Figure 71, designation 3). Signals can be added using the "" button (see Figure 71, designation 5), deleted using the "" button (see Figure 71, designation 6).

6.5.1.5.10 Field for assigning GOOSE messages to device signals (see Figure 71, designation 10) allows you to specify the values of GOOSE message signals to the logical signals of the device.

A tick in the table cell means that when signals of GOOSE messages appear (rows in the table), it will be transmitted to the logical signals of the device (columns in the table).

The cell filled with a light blue color "+" means that the setting value in the device differs from that shown on the screen. After writing the settings, the color scheme of the cell will change.

By clicking the "" button (see Figure 71, designation 7), it is possible to edit the names of signals (see Figure 76). To save the changes made, click the **OK** button (see Figure 76, designation 1).

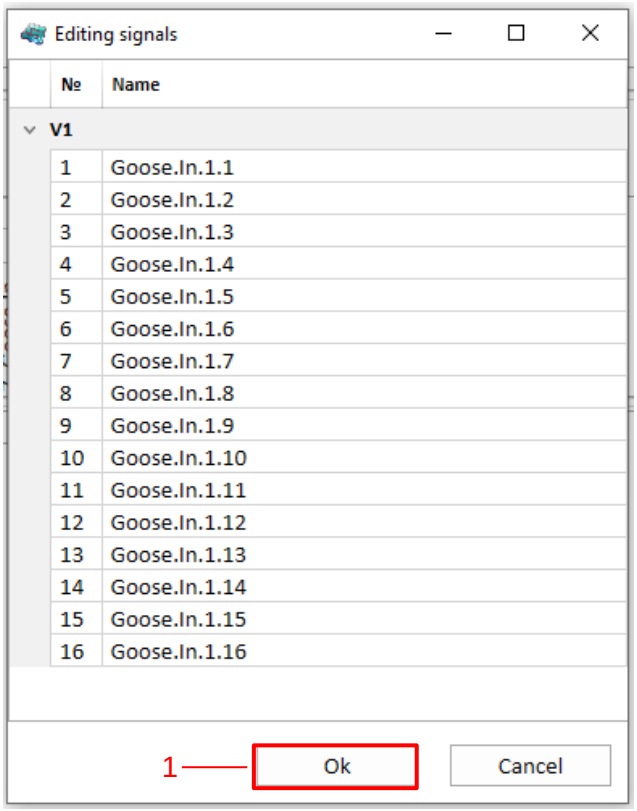


Figure 76 – **Editing signals** window

The “ ” button (“Active inputs”) allows you to display on the screen only used inputs of virtual modules (unused ones are hidden) (see Figure 71, designation 8). It is for the convenience of the user and does not affect the configuration.

The “ ” button (Default value) allows you to specify the default value for signals in the absence / bad quality of incoming GOOSE (see Figure 71, designation 9). The default values will only be used if the incoming GOOSE has its Value for no connection / Bad Quality / TEST label in the ON mode set to the default value.

6.5.1.5.11 Specify the parameters (see Table 142) and data (see Table 143) of incoming GOOSE messages in accordance with the project.

Table 142 – Parameters of incoming GOOSE messages

Parameter	Function	Default value
Name	Name of incoming GOOSE message	GOOSE_IN_N[1)]
MAC-address	Broadcast MAC address from which GOOSE packets will be received	01-0c-cd-01-00-01[2)]
AppID (hex)	Identifier of the application using a multicast: - hex – hexadecimal representation of the field; - dec – decimal representation of the field (integer).	3FFE
AppID (dec)		16382
Control block	Name of control block, responsible for GOOSE multicast	Goose_Out_N[1)]
DataSet	Name of the GOOSE data set. Analogue signals with a time stamp and service ones are not implemented	Goose_DataSet
ID GOOSE (GoID)	Unique sign of an object, that distinguishes it from other objects	goID
GOOSE configuration version	Version of GOOSE configuration is necessary to keep track of the number of changes to the GOOSE configuration	1
Enable VLAN	Enabling the use of VLAN in incoming GOOSE messages	Box not checked
ID VLAN	Integer value, which is used in VLAN for identification	0
Value for no connection / Bad quality / TEST label in ON mode	Value for no connection / Bad quality / TEST label in ON mode	Previous value
Fixed coding checkbox	Sign of transmitting GOOSE message with fixed length of fields	Box not checked
[1)] N is the sequence number of the GOOSE message. [2)] For broadcast MAC addresses, a certain range of addresses 01-0c-cd 01-(00...01)-(00...FF) is reserved by the GOOSE standard.		

Table 143 – Data of incoming GOOSE messages

Parameter	Description
No.	Number of input signal
Signal name	Name of input signal
Data type	Data type of an input signal: – none (no data); – bool (logical type, assigned to virtual inputs via data index);

Parameter	Description
	– bitstring2 (two-bit value); – float (floating point data type, assigned to virtual analogue inputs via data index); – quality (data quality); – timestamp; – sps (structure, which contains a logical type, data quality and a time stamp); – dps (this type is similar to sps, only the value is bistring. Also assigned to blocks similar to the bitstring2 type)

Note – In order to select a string (strings) for deletion, as well as to work with the context menu items, click with the left mouse button on the first line.

6.5.1.6 Configuration of MMS protocol

6.5.1.6.1 Configuration of report blocks

6.5.1.6.2 In the “tree” of the project of the Smart Monitor software, select the menu item **Settings → Digital communication channels → Communication protocols → 61850 → Report blocks** (see Figure 77, designation 1), clicking once with the left mouse button the corresponding item in the project “tree”, and open the window.

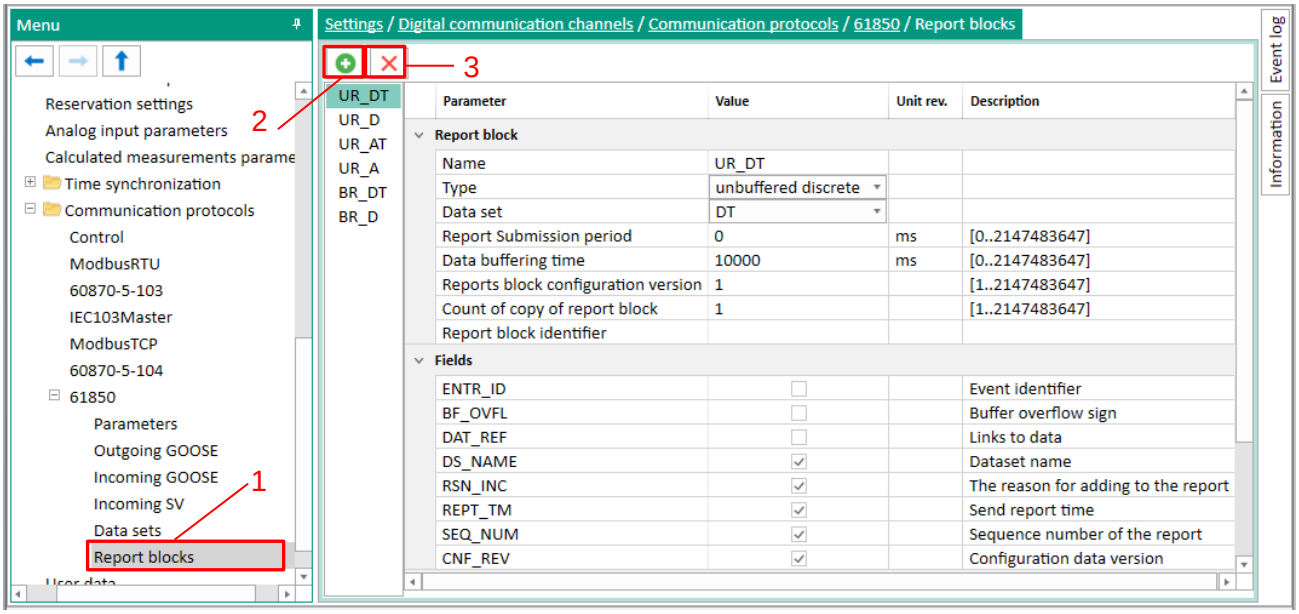


Figure 77 – **Report blocks** window

Create report blocks using the “ ” button (see Figure 77, designation 2), so that MMS protocol clients can receive reports included in **Data sets**. Report blocks can be deleted using the “ ” button (see Figure 77, designation 3).

6.5.1.6.3 Specify parameters of report blocks (see Figure 144) and their transmission modes (see Figure 145) in accordance with the project.

Table 144 – Default parameters of report blocks

Parameter	Function	Default value
Name	Report block ID: – urcbSTn – unbuffered block; – brcbSTn – buffered block, where n = 00, 01, 02…	urcbSTNN[1)]
Type: – unbuffered binary; – buffered binary; – unbuffered analog – buffered analog; – unbuffered service; – buffered service; – unbuffered mixed; – buffered mixed	Unbuffered – in the absence of a connection, the transmitted data are not stored; Buffered – for the period of absence of a connection the data are stored in the volatile memory of the device and transmitted to the client when the connection is restored	Unbuffered, binary
Data set	Name of the data set transmitted by the report	not specified[2)]
Report send period, ms	Time of periodic sending of current values in milliseconds	10,000
Data buffering time, ms	Data accumulation time before reporting on signal changes in the data set in milliseconds	250
Report block configuration version	Version of configuration of report blocks, integer in the range of 1 to 1,999 999 999	1
Quantity of copies of report block	Quantity of identical report blocks, integer in the range of 1 to 13	1
Report block identifier	Report block identifier. Optional parameter (the value may contain an empty string)	not specified
[1)] NN – sequence number when created. [2)] First matching data set that exists in the configuration.		

Table 145 – Modes of transmission of report blocks

Parameter	Function	Default value
Transmitted fields	List of fields (optional) transmitted in the report: – ENTRYID (entry ID); – BFOVFL (buffer overflow sign); – DATREF (data reference); – DSNAME (data set name); – RSNINC (reason for including to report); – REPTTM (report transmission time); – SEQNUM (sequence number); – CNFREV (configuration revision)	RSNINC; REPTTM; SEQNUM; CNFREV
Transmission modes	List of transmission modes: – GI (general interrgation); – INTEGRT (periodic); – DATUPD is not supported; – QLTCNG is not supported; – DATCNG (by data changes)	GI INTEGRT; DATCNG

6.5.1.6.4 Configuration of logical nodes XCBR, XSWI and GAPC

6.5.1.6.5 In the “tree” of the project, open the menu item **Settings → Switching devices** (see Figure 78, designation 1), clicking once with the left mouse button the corresponding item of the menu “tree”, and open the window. The **Switching devices** menu item is intended for viewing the settings of switching devices of the IED.

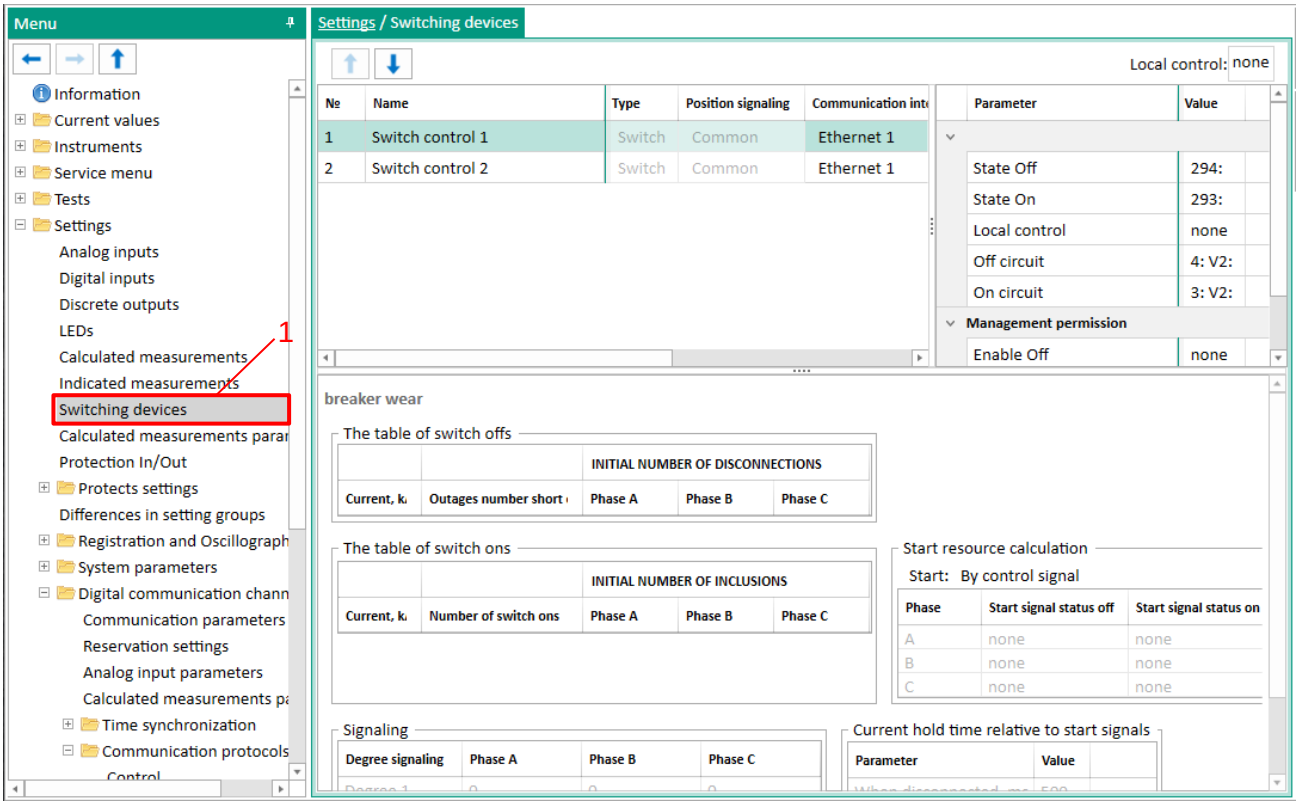


Figure 78 – **Switching devices** window

6.5.1.6.6 The settings for switching devices are given in Table 146.

Table 146 – Parameters of **Switching devices** window

Parameter	Description
No.	Number of switching device
Name	Name of switching device
Type	Circuit-breaker (XCBR), disconnector (XSWI) and others (GAPC)
Position signaling	Type of position signaling is selected depending on the type of switching device
Communication interface	Communication interface is selected for each switching device, through which control will be enabled
Software protocol	Used software protocol of data transmission
Control model	Type of model for control of switching device according to IEC 61850
Type of remaining life calculation	Link to the switching device in the **Type of service life calculation** section, which is used to obtain data on service life of the switching device
Opened state	Logical signal indicating the Tripped state
Closed state	Logical signal indicating the Closed state

Parameter	Description
Trip permission	Logical signal enabling tripping of the switching device. If the signal is not specified, then tripping is enabled, otherwise the state of the signal is analyzed (1 – enabled, 0 – disabled)
Close permission	Logical signal enabling closing of the switching device. If the signal is not specified, then closing is enabled, otherwise the state of signals is analyzed (1 – enabled, 0 – disabled)
Local control	Logical signal that determines the mode of local control of the current switching device
Tripping signal	Output of the virtual module, which transmits to the logic the command to switch the switching device that came via communication protocol
Closing signal	Output of the virtual module, which transmits to the logic the command to switch the switching device that came via communication protocol

6.5.1.7 Save the changes made to the device similar to 3.4.1.5

6.5.2 Configuration of protocol using the Configurator software

6.5.2.1 Start the Configurator software similar to 2.5.2.1.

Please note that the Ethernet parameters must be configured according to 8.3. The parameter values are determined by the user based on the network settings.

6.5.2.1.1 In the “tree” of the project of the Configurator software, select the menu item **Hardware part → System parameters** (see Figure 79, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

6.5.2.1.2 Open **Ethernet protocols** tab (see Figure 79, designation 2).

6.5.2.1.3 In the **Protocols** field, select the IEC 61850 protocol (see Figure 79, designation 3).

6.5.2.1.4 Specify additional parameters:

1) Check the box in front of the **Outgoing GOOSE enabled** field (see Figure 79, designation 4) to enable the transmission of binary and analogue data via GOOSE messages;

2) Check the box in front of the **Incoming GOOSE enabled** field (see Figure 79, designation 4) to enable the reception of binary and analogue signals via GOOSE messages;

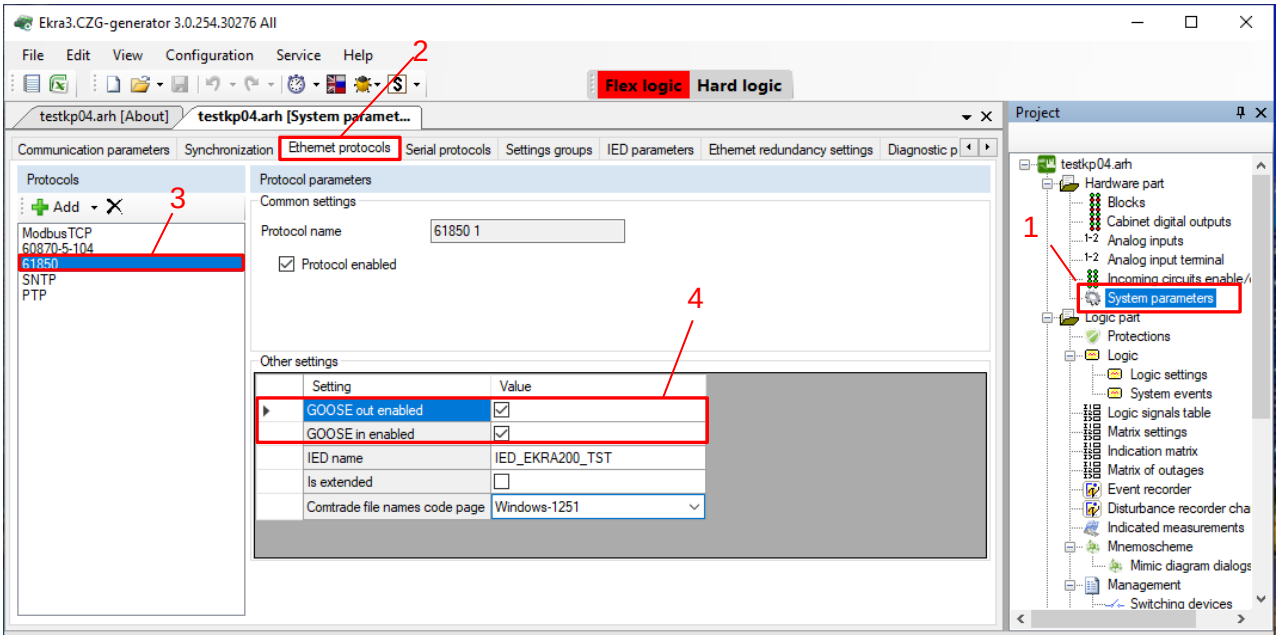


Figure 79 – Addition of IEC 61850 protocols

The purpose of IEC 61850 protocol parameters is given in Table 147.

Table 147 – Additional parameters of IEC 61850 protocols

Parameter	Function	Recommended value
Outgoing GOOSE enabled	Enabling/disabling transmission of binary data via GOOSE messages	Box checked
Incoming GOOSE enabled	Enabling/disabling reception of data via GOOSE messages	Box checked
IED name	Name (identifier) of the physical device, accessible only via IEC 61850 protocols	IED_<Text1>
Sign of using extended protocol	Enabling/disabling extension of protocol. Enable extension of protocol – the protocol allows you to create your own nodes and data attributes. Disable use for extending protocol – standard general purpose nodes will be used	No checkbox
Encoding of COMTRADE names	Encoding used for COMTRADE file names (Windows-1251 or UTF-8)	Windows-1251

6.5.2.2 Configuration of data sets

6.5.2.2.1 In the “tree” of the project of the Configurator software (see Figure 80, designation 1) select the menu item **Iec61850** → **Data sets** (see Figure 80, designation 2), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

The data set (named list of signals) is determined by the project of integration into PCS.

The purpose of **Data set** is to control and analyze the state of signals for transmission to the upper level of PCS or the organization of horizontal connections between devices via IEC 61850 protocols.

Data sets are used in the generation of outgoing GOOSE messages and report blocks via MMS protocol.

6.5.2.2.2 Click the “  ” button (see Figure 80, designation 3) and from the drop-down list (binary set, analogue set, service set, mixed set) select one of the listed data sets. The data set can be deleted using the “  ” button (see Figure 80, designation 4).

A binary set can be created from various groups of signals: binary inputs of the table of device signals, calculated values with a logical type of data, CP status flags, FP status flags, LED status, module serviceability signals, status of subscription to incoming GOOSE messages, switching devices (two-bit type of data). Service set – authorization, firmware update, configuration update and reset. Analogue set – analog inputs and calculated values with data type other than logical. Mixed set – analogue and binary signals.

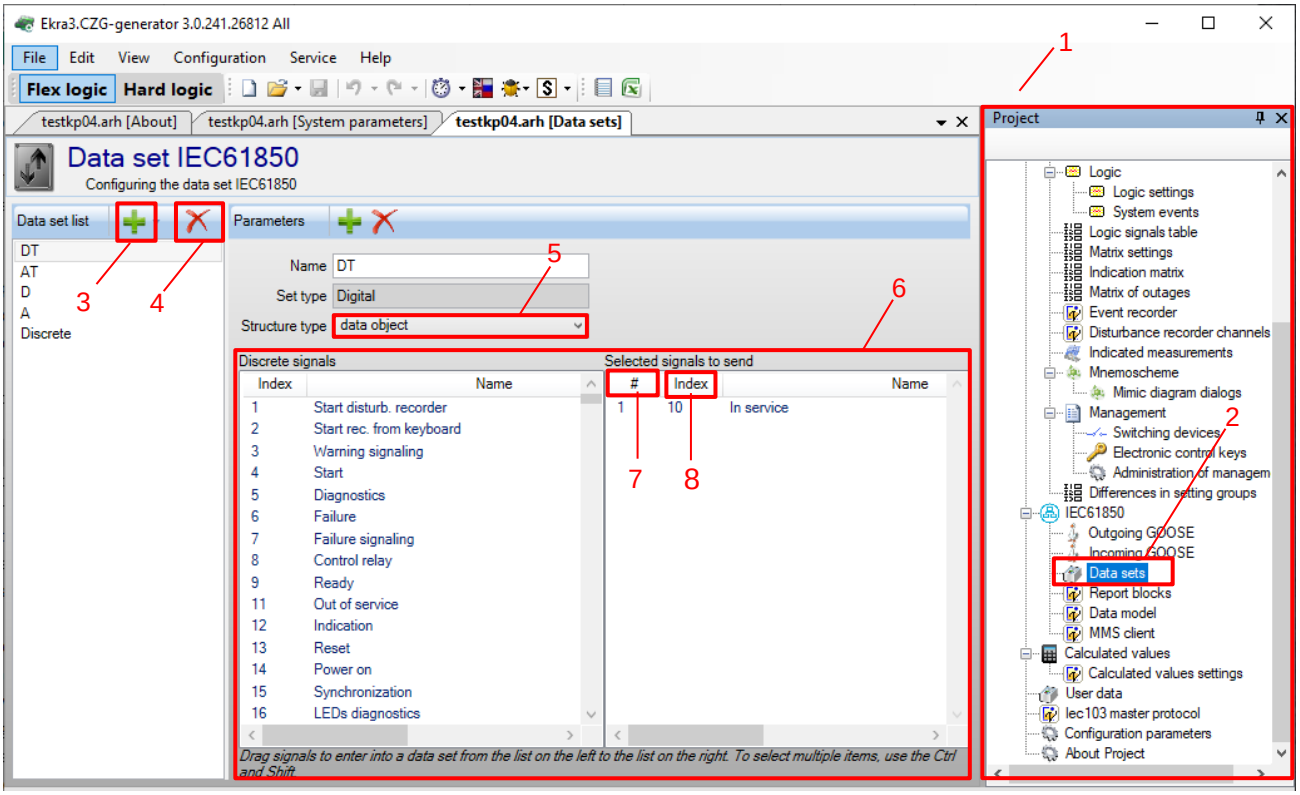


Figure 80 – Configuration of IEC 61850 data set

When creating the **Data set**, keep in mind:

– it is not recommended to use Russian characters, spaces, underscores in the name of the **Data set**;

– in the name of the **Data set,** the first character must not be a digit;

– **Data set** names must be unique;

– **Data sets** must not be empty.

Select data set parameter **Structure type** (see Figure 80, designation 5):

– value (only values will be sent);

– value, quality (value, quality will be sent in reports);

– value, quality, timestamp (will be sent as separate attributes in reports);

– data object (value, quality, timestamp in reports will be sent combined into a common structure).

Add the required signals from the source list to the **Selected signals for transmission** field (see Figure 80, designation 6) by dragging one or more selected signals to the list on the right (drag&drop technology). The selected signals for transmission are assigned a sequence number in the data set (see Figure 80, designation 7), in addition, the field indicates the sequence number of the signal from the list of binary signals of the device (see Figure 80, designation 8). When adding signals to the existing data set list, new signals will be added to the end of the list. It is possible to move signals in the list.

6.5.2.3 Configuration of GOOSE protocol

6.5.2.3.1 Configuration of outgoing GOOSE messages

6.5.2.3.2 Before configuring outgoing GOOSE messages, make sure that in the menu item **System parameters** → **Ethernet protocols** → **61850** (see Figure 81, designation 1) the **Outgoing GOOSE enabled** box (see Figure 81, designation 2) is checked.

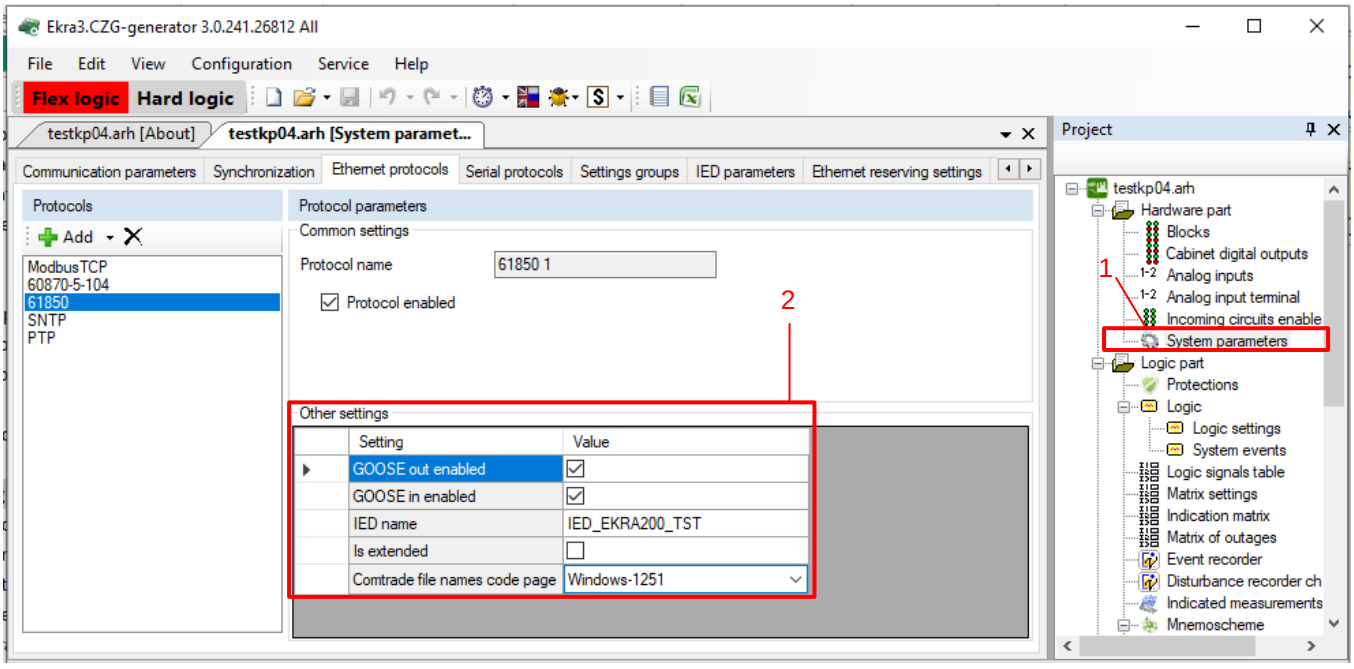


Figure 81 – **System parameters** window

6.5.2.3.3 In the “tree” of the project, select the menu item **IEC61850** → **Outgoing GOOSE** (see Figure 82, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window. If necessary, you can add outgoing GOOSE messages using the “” button (see Figure 82, designation 2), you can delete outgoing GOOSE messages using the “” button (see Figure 82, designation 3).

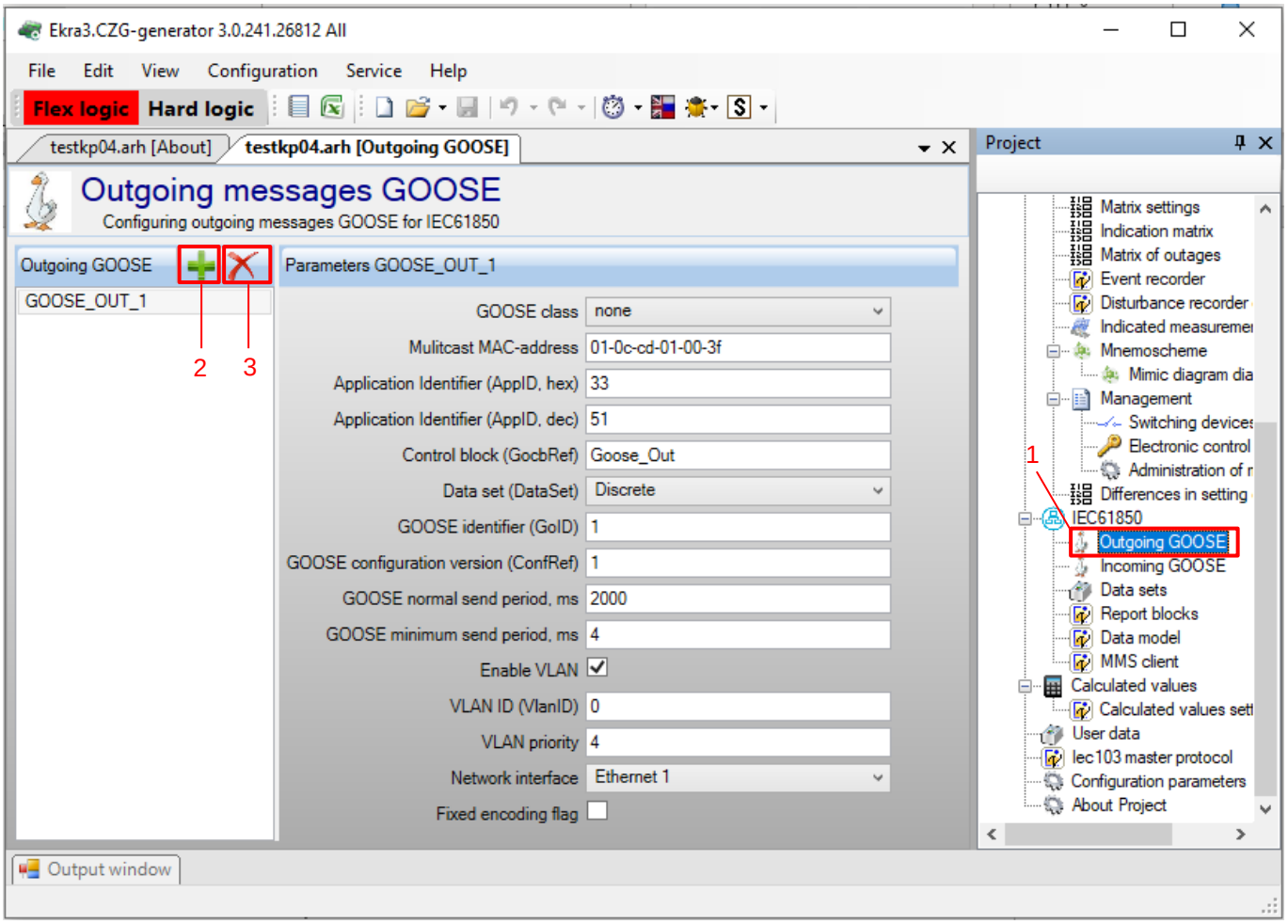


Figure 82 – **Outgoing GOOSE messages** window

Specify the parameters (see Table 141) of outgoing GOOSE messages in accordance with the project.

6.5.2.3.4 Virtual modules of incoming GOOSE

6.5.2.3.5 In the “tree” of the project, select the menu item **Hardware part → Modules** (see Figure 83, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open it.

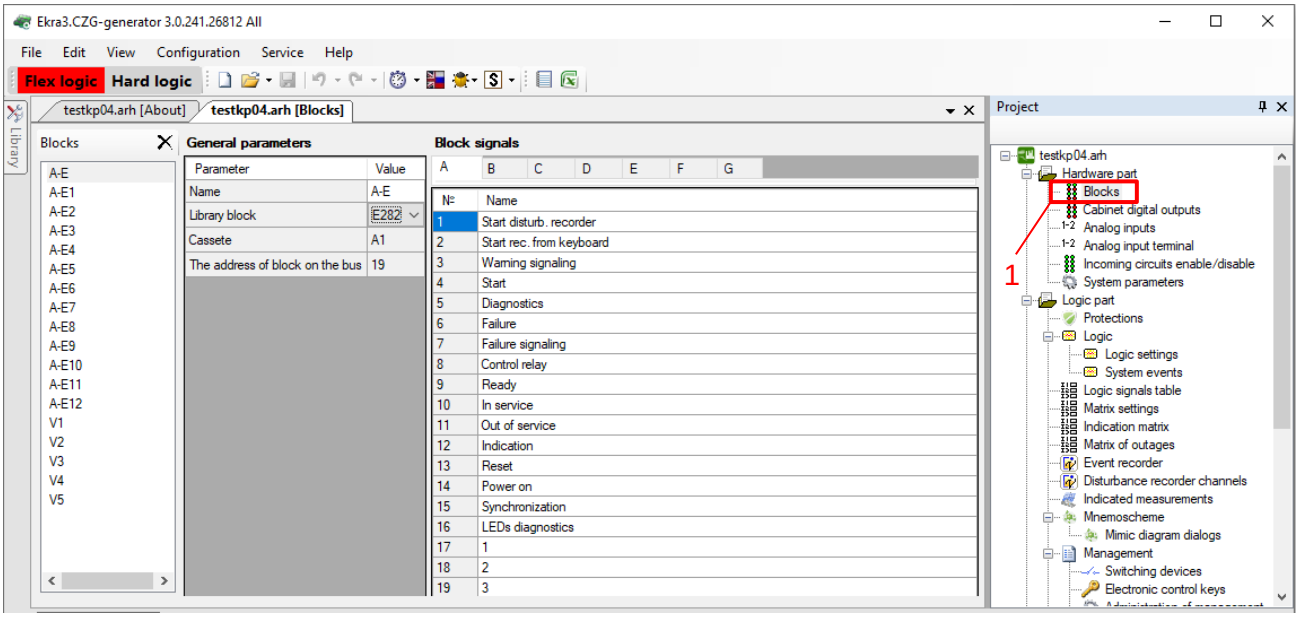


Figure 83 – **Modules** window

6.5.2.3.6 Modules of virtual inputs VInput_GOOSE are used to receive and process data sets of logical type received via GOOSE messages from various devices, and the modules of virtual analogue inputs VAnalog_GOOSE are used to receive GOOSE messages with analogue data.

6.5.2.3.7 Each modules of virtual inputs VInput_GOOSE consists of 16 bits to which binary signals can be assigned. The signals received through virtual inputs can be used in the logical part of the ED2 series device on a par with the real physically installed modules of binary inputs of the ED2 series device.

6.5.2.3.8 To configure data sets for receiving GOOSE messages, at least one module of virtual inputs VInput_GOOSE must be present in the configuration.

6.5.2.3.9 Using the Configurator software with a Protection Int or Bay Controller Int license, it is possible to add modules of virtual inputs to the configuration.

To add a module of virtual inputs VInput_GOOSE, do the following:

1) select and add from the library of modules the module of virtual inputs VInput_GOOSE to the list of already used modules (see Figure 84, designation 1);

2) fill in the **Module name** and **Bit name** fields (see Figure 84, designation 2).

The Module name is recommended to be specified according to its functional purpose, the Bit name – the name of the received binary signal.

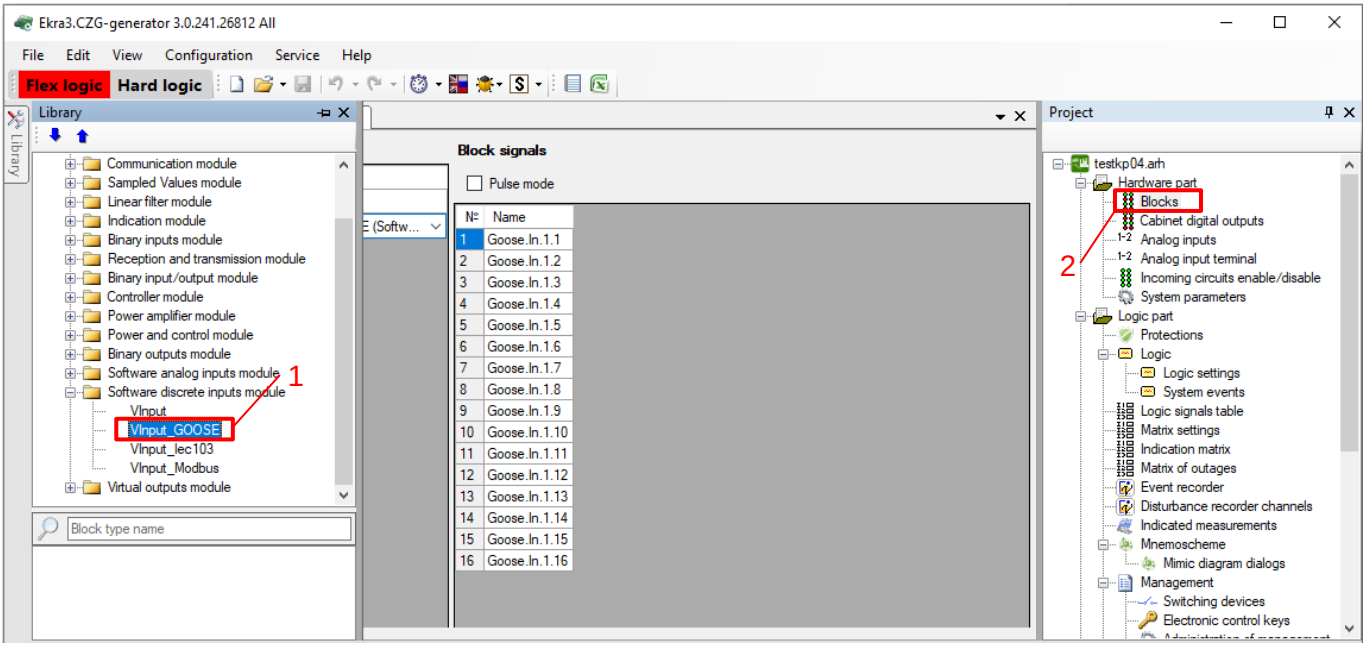


Figure 84 – Addition of the VInput_GOOSE virtual module

6.5.2.3.10 To add the module of virtual inputs VAnalog_GOOSE to the configuration, do the following:

1) select and add the module of virtual analogue inputs VAnalog_GOOSE from the module library to the list of already used modules (see Figure 85, designation 1);

2) add input values using the "  " button (see Figure 85, designation 2).

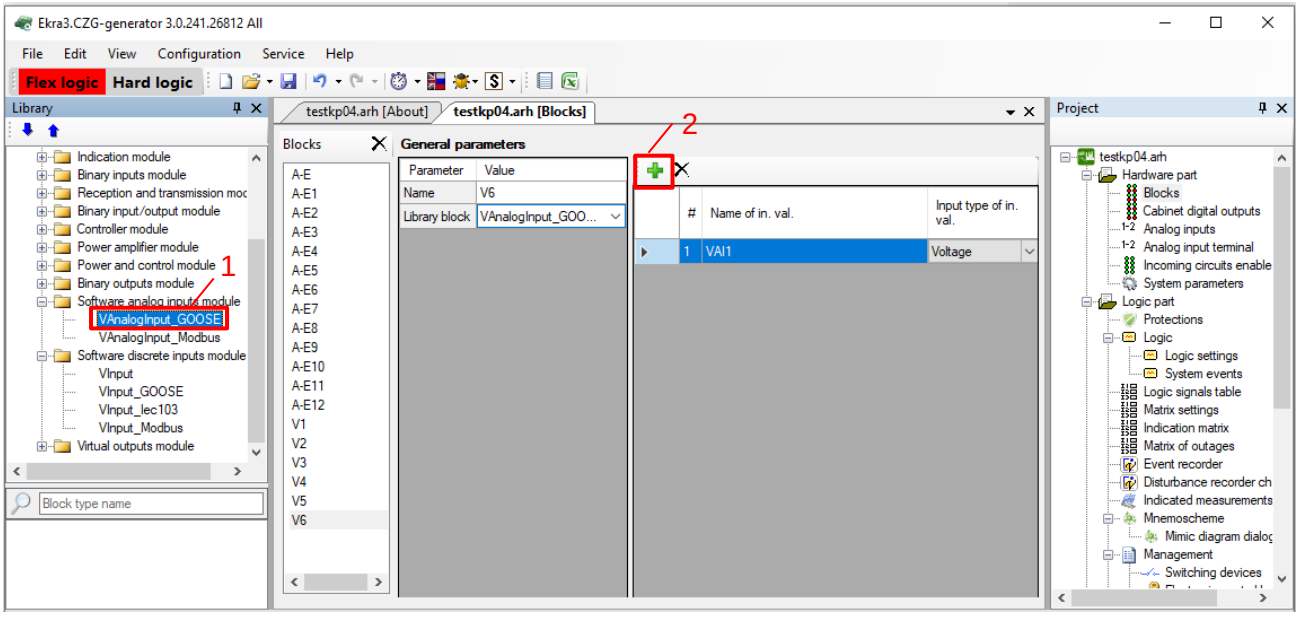


Figure 85 – Addition of the VAnalog_GOOSE virtual module

Description of parameters of virtual analogue inputs is given in Table 148.

Table 148 – Description of parameters of virtual analogue inputs

Parameter	Description
Name of input value	Name of input value
Type of input value	Type of input value: – voltage; – current
Max. input value	Maximum input value
Reduc. factor in SI system	Factor of reduction to SI system (B, A). Default value 1

6.5.2.4 Configuration of MMS protocol

6.5.2.5 Configuration of report blocks

Report blocks are messages sent by the server and designed to organize the transmission of reports of binary and analogue signals to PCS.

6.5.2.5.1 In the “tree” of the project of the Configurator software, select the menu item **IEC61850 → Report blocks** (see Figure 86, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

6.5.2.5.2 Create report blocks using the “  ” button, so that clients of MMS protocol can receive reports included in **Data sets** (see Figure 86, designation 2). Report blocks can be deleted using the “  “ button (see Figure 86, designation 3).

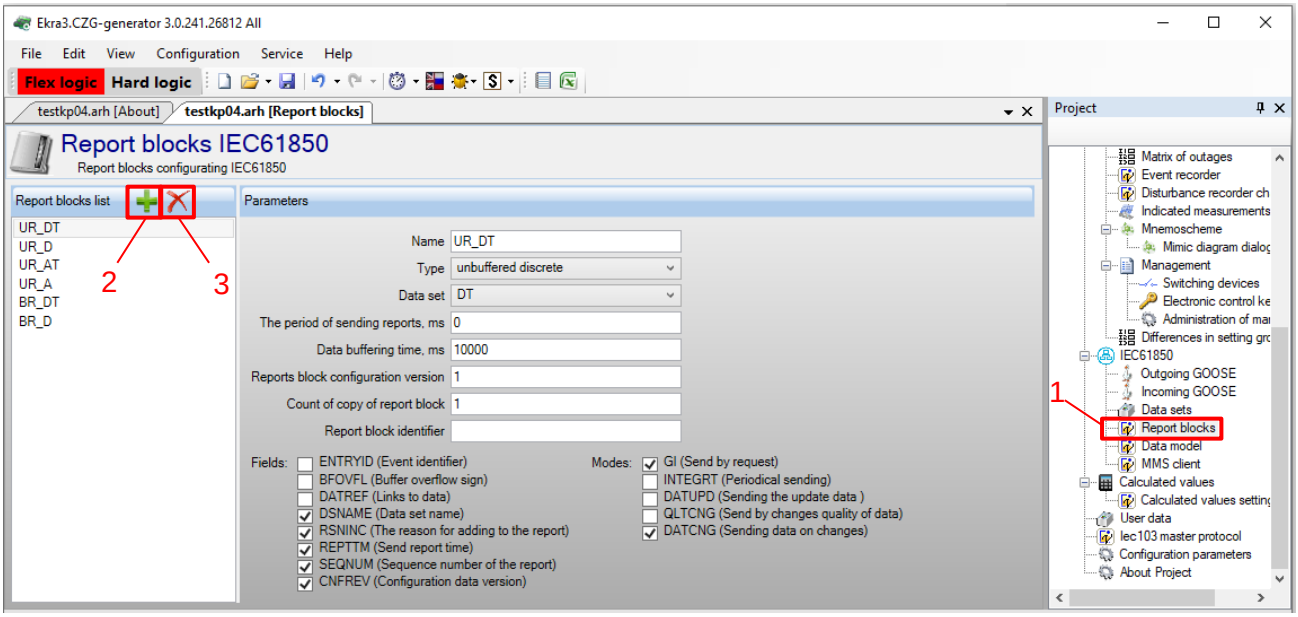


Figure 86 – Configuration of IEC 61850 report blocks

6.5.2.5.3 Specify parameters of report blocks (see Table 144) and modes of their transmission (see Table 145) in accordance with the project.

6.5.2.6 Configuration of logical nodes XCBR, XSWI and GAPC

6.5.2.6.1 In the “tree” of the project, open the menu item **Logical part** → **Menagement** → **Switching devices** (see Figure 87, designation 1), double-clicking with the left mouse button the corresponding item of the project “tree”, and open the window. The **Switching devices** menu item is intended for viewing and editing the settings configuration of switching devices of the equipment.

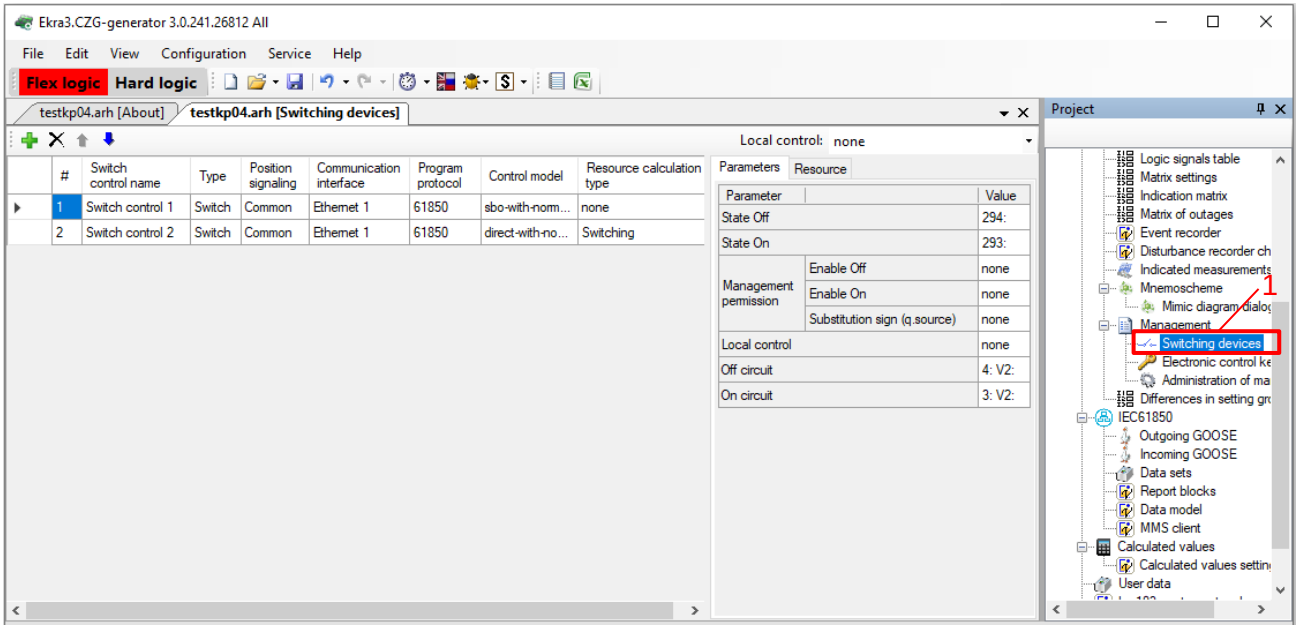


Figure 87 – **Switching devices** window

6.5.2.6.2 Description of parameters of the Switching devices window is given in Table 146.

6.5.2.7 Save the changes made to the device similar to 3.4.2.6.

6.6 Configuration of SV protocols (IEC 61850-9-2)

The reception of SV according to IEC 61850-9-2 specification LE (Light Edition) is configured using the Configurator and Smart Monitor software.

6.6.1 Configuration of parameters of the SV reception module using the Configurator software

6.6.1.1 To configure the parameters of the SV reception module using the Configurator software, you must:

1) start the Configurator software and create the configuration for editing (according to the manual “EKRASMS-SP software package”) (see Figure 88, designation 1);

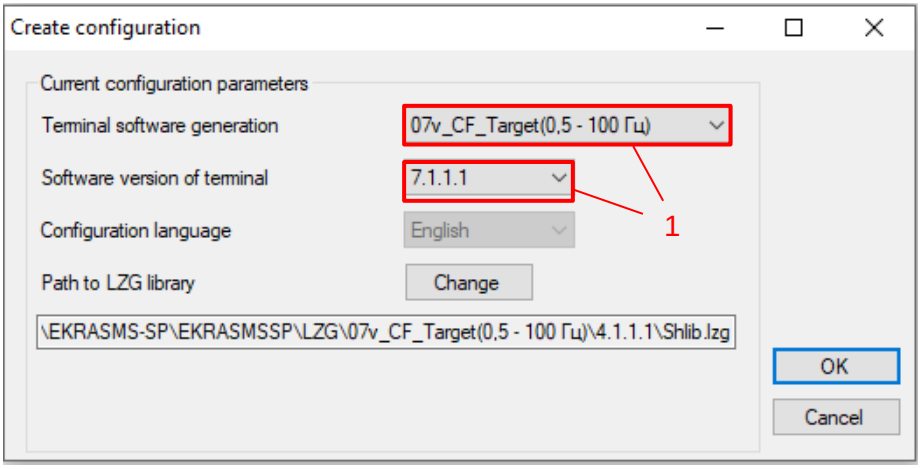


Figure 88 – **Creation of configuration** window

2) in the “tree” of the project, select the menu item **Modules** (see Figure 89, designation 1);

Configure the SV reception module.

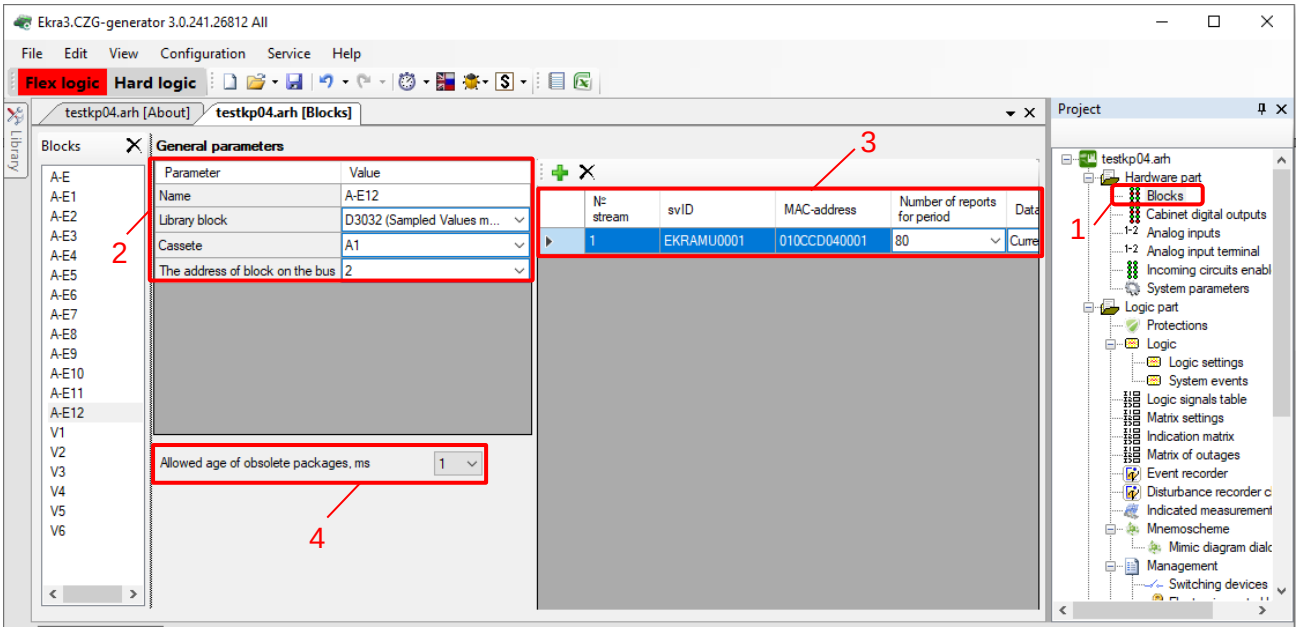


Figure 89 – **Modules** window

The “General parameters” form of the SV module is shown in Figure 89 (see designation 2).

The form of the Application service data unit (ASDU) is shown in Figure 89 (see designation 3), where

– svID – string ID of the SV stream;

– MAC-address – destination MAC address;

– Data sets – ASDU current and/or voltage data.

Specify the setting “Permissible age of obsolete packets, ms” (from 1 to 10 ms). “Permissible age of obsolete packets, ms” is the time delay between receiving and processing SV packets (see Figure 89, designation 4);

3) go to the **System parameters** menu item (see Figure 90, designation 1);

4) open the **Ethernet protocols** tab (see Figure 90, designation 2).

Add the PTP protocol by clicking the **Add** button (see Figure 90, designation 3) and select the desired protocol in the drop-down list. In the **Protocols** field, select the PTP protocol (see Figure 90, designation 4) and check the **Protocol enabled** box if it has not been checked (see Figure 90, designation 5).

Specify parameters of the PTP protocol according to the settings of the source of PTP packets. The default values of protocol parameters are shown in Figure 90, designation 6. The description of parameters of the PTP protocol is given in Table 149.

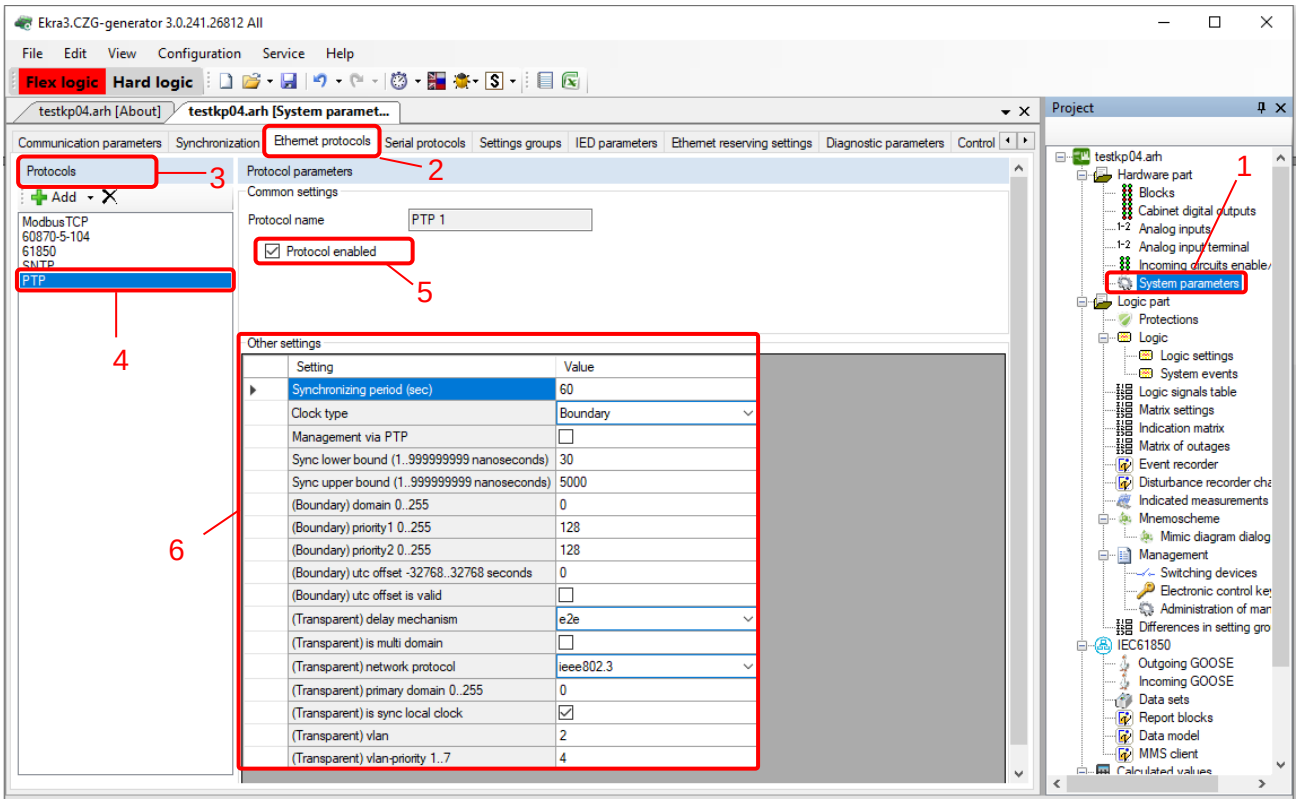


Figure 90 – **System parameters** window (**Ethernet protocols** tab)

Table 149 – Description of parameters of the PTP protocol

Parameter	Description
Synchronization period (s)	Time interval in seconds (value should be in the range of 2 to 3,600 s) by the expiration of which synchronization is repeated
Clock type	Specifies the synchronization algorithm: – boundary; – transparent
Management via PTP	Enable/disable PTP management
Sync lower bound	Minimum time difference between local clock and source of reference time in nanoseconds (value must be in the range of 1 to 999,999 999 ns)
Sync upper bound	Maximum time difference between local clock and source of reference time in nanoseconds (value must be in the range of 1 to 999,999 999 ns)
(Boundary) domain	Assignment of the device to a specific PTP domain (value must be in the range of 0 to 255)

Parameter	Description
(Boundary) priority1	Determines priority for port 1 (value must be in the range of 0 to 255)
(Boundary) priority2	Determines priority for port 2 (value must be in the range of 0 to 255)
(Boundary) utc offset	Difference in seconds between PTP and UTC timelines (value must be in the range of minus 32,768 to plus 32,767 s)
(Boundary) utc offset is valid	Offset from timeline: – box checked – timeline offset; – box not checked – no timeline offset
(Transparent) delay mechanism	Measurement algorithm of delay in the device transmitted in PTP messages: – e2e; – p2p; – e2e-optimized; – none
(Transparent) is multi domain	Operation of PTP synchronization independent from the domain: – box checked – operation of PTP synchronization is on; – box not checked – operation of PTP synchronization is off
(Transparent) network protocol	Network protocol, through which synchronization messages are transmitted: – ieee802.3; – udp-ipv4
(Transparent) primary domain	Assignment of the device to PTP domain (value must be in the range of 0 to 255)
(Transparent) is sync local clock	Synchronization of local clock: – box checked – local clock is synchronized; – box not checked – local clock is not synchronized
(Transparent) vlan	Operation of PTP in a specified virtual network (VLAN ID), virtual network No.: – none; – 0; – 1
(Transparent) vlan-priority	Priority with which the device transmits messages of PTP synchronization related to this VLAN ID (value must be in the range of 1 to 7)

5) open the **Time synchronization** tab (see Figure 91, designation 1).

Select interface for software time synchronization **Ethernet 1** and **PTP** time synchronization protocol (see Figure 91, designation 2).

6.6.1.2 Adjustment of time synchronization

Specify the value for adjusting the device's internal clock in hours relative to Coordinated Universal Time (UTC). The adjustment is used to specify the local time when synchronizing the device in the UTC system (see Figure 91, designation 2).

Permissible range of values from minus 24 to plus 24 h in 1 h increments[1)].

If you need the function of automatic seasonal time adjustment, you should check the box **Adjust for daylight saving time automatically** (see Figure 91, designation 3).

[1)] The parameter value depends on the project.

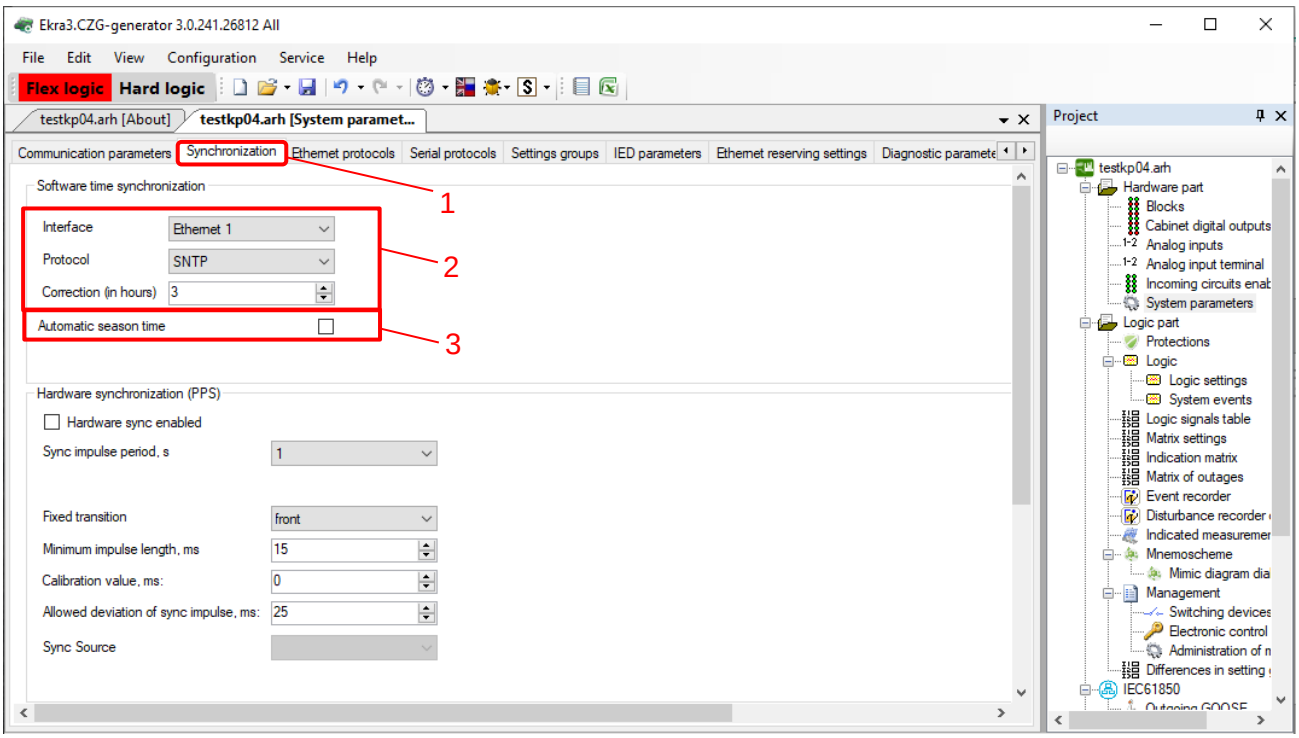


Figure 91 – **System parameters** window (**Time synchronization** tab)

6.6.1.3 Save the changes made to the device similar to 3.4.2.6

6.6.2 Configuration of parameters of the SV reception module using the Smart Monitor software

6.6.2.1 Start the Smart Monitor software similar to 2.4.1.1.

6.6.2.2 In the “tree” of the project of the Smart Monitor software, select the menu item **Settings → Digital communication channels → Communication protocols → 61850 → Incoming SV** (see Figure 92, designation 1), clicking once with the left mouse button the corresponding item in the project “tree”, and open the window.

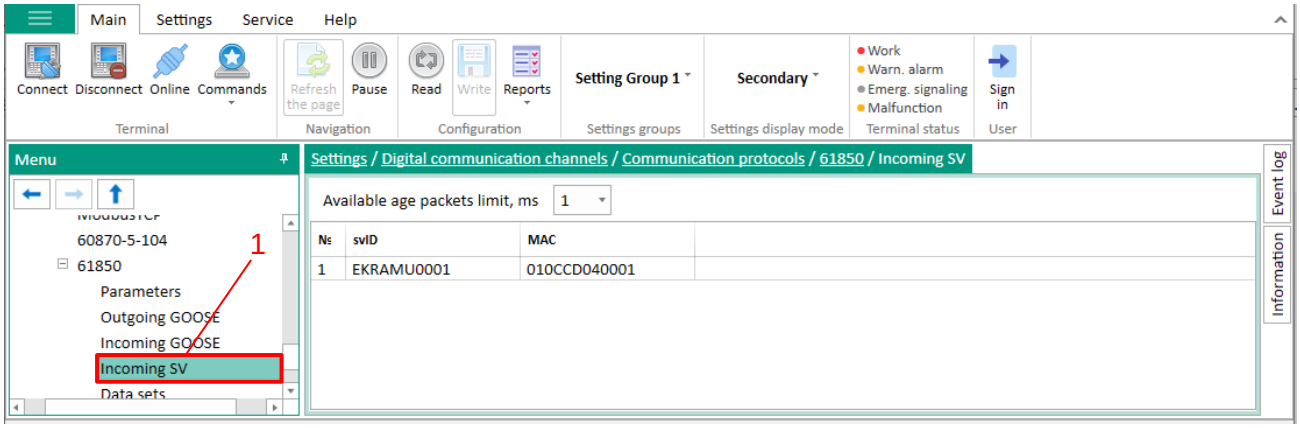


Figure 92 – **Incoming SV** window

6.6.2.3 Specify parameters of the SV ID and broadcast MAC address, which are specified in accordance with the operational documentation or SV streams existing in the network. SV streams existing

in the network can be viewed in any available network analyzer. The description of parameters of incoming SV is given in Table 150.

Table 150 – Description of parameters of incoming SV

Parameter	Description
Permissible age of obsolete packets, ms	Permissible age of obsolete packets in milliseconds
No.	Packet number
svID	SV stream ID
MAC	MAC address

6.6.2.4 In case of long network delays, it is recommended to change the parameter “Permissible age of obsolete packets” by selecting the required value from 1 ms to 10 ms in the drop-down list.

6.6.3 Diagnostics of reception of SV streams

The reception of SV streams is diagnosed using the Smart Monitor software.

6.6.3.1 To diagnose the reception of SV streams, do the following:

1) Start the Smart Monitor software similar to 2.4.1.1;

2) In the Smart Monitor software, select the menu item **Current values** → **Logic** (see Figure 93, item 1), clicking once with the left mouse button the corresponding item in the project “tree”, and open the window.

Locate the SV diagnostic signals and evaluate their condition. An example of SV diagnostic signals is shown in the figure (see Figure 93, designation 2). The description of signals is given in Table 151.

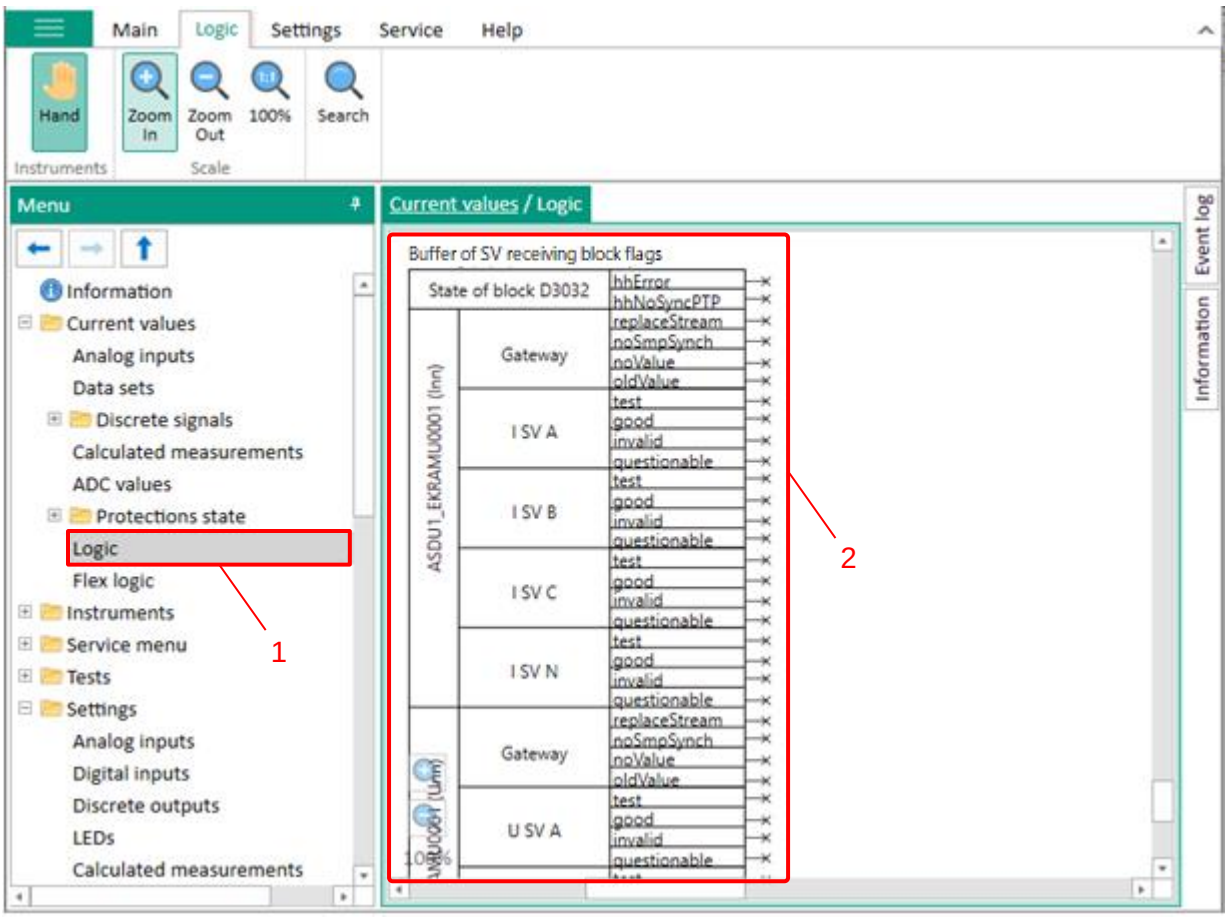


Figure 93 – **Logic** window

6.6.3.2 It is also possible to evaluate the state of the SV diagnostic signals in the menu item **Current values → Binary signals → Diagnostic signals** (see Figure 94, designation 1), clicking once with the left mouse button the corresponding item in the project “tree”, and open the window. An example of SV diagnostic signals is shown in Figure (see Figure 94, designation 2). The description of signals is given in Table 151.

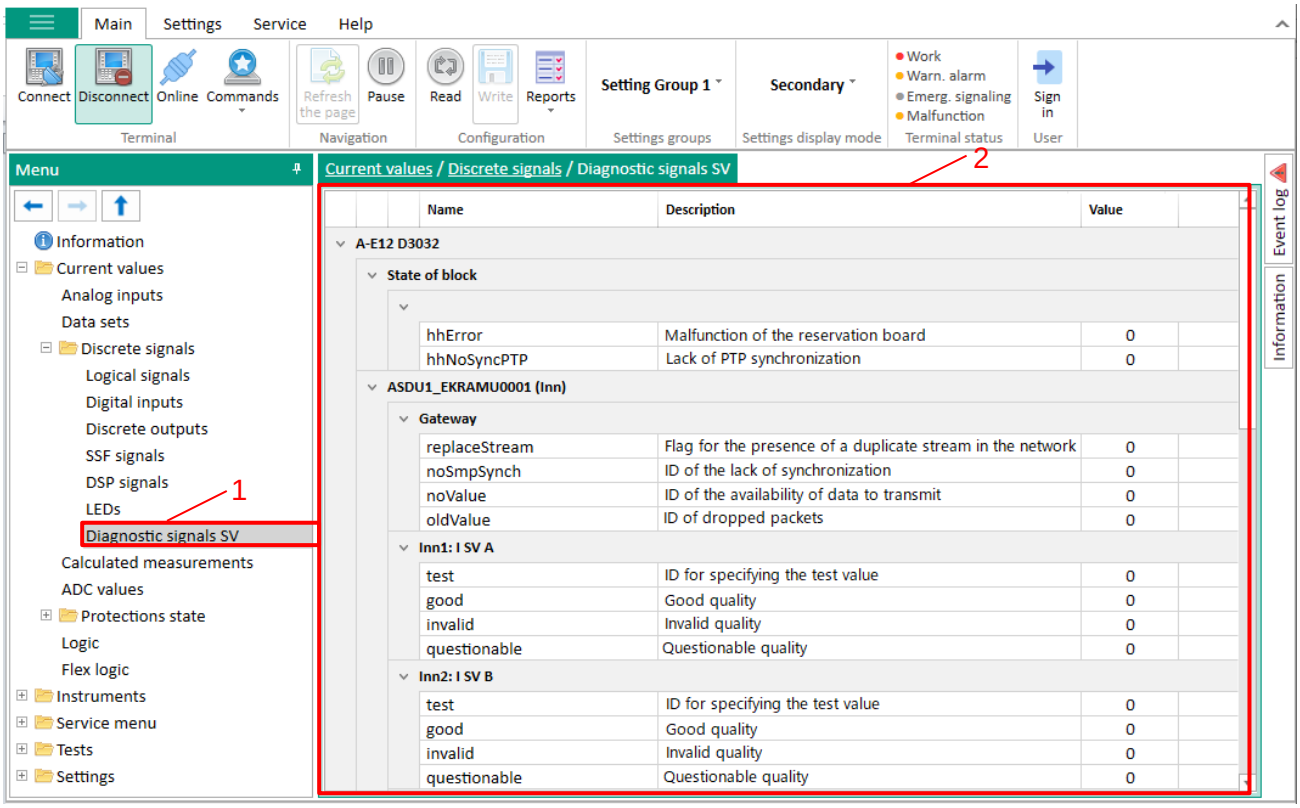


Figure 94 – **SV diagnostic signals** window

Table 151 – Description of signals

Signal	Description
hhErorr	Failure of redundancy board (0 – no failure of redundancy board, 1 – failure of redundancy board)
hhNoSyncPTP	No PTP synchronization (0 – PTP synchronization, 1 – no PTP synchronization)
replaceStream	Checkbox of presence of a duplicate stream in the network (0 – duplicate stream not detected, 1 – duplicate stream detected)
noSmpSynch	Checkbox of absence of synchronization (0 – smpSynch is “0”, 1 – smpSync is “1”)
noValue	Checkbox of presence of data to be transmitted to the functional processor (0 – data in the reception buffer of all three data sets, 1 – no data in the reception buffer of at least one data set)
oldValue	Checkbox of dropped packets (0 – no data packets were dropped, data of all ASDUs are received and determined to be up-to-date, 1 – at least one data packet is dropped; data of at least one ASDU data set is received, but determined to be outdated and dropped)
Test	Checkbox for specifying the test value (0 – measured value, 1 – test value)
Good	Checkbox of good stream quality (0 – signal quality is not good, 1 – signal quality is good)
Invalid	Checkbox of invalid stream quality (0 – signal quality is not invalid, 1 – signal quality is invalid)
Questionable	Checkbox of questionable stream quality (0 – signal quality is not questionable, 1 – signal quality is questionable)

6.7 Troubleshooting

If a failure is detected during diagnostics, contact the technical support of manufacturer.

7 Configuration of time synchronization

7.1 General

The ED2 series device supports time synchronization via communication and service interfaces.

Time synchronization of the internal clock of the device can be performed using:

– protocols: Modbus RTU, Modbus TCP, SNTP, PTPv2, IEC 60870-5-103, IEC 60870-5-104;

– IRIG-B synchronization signal;

– signal of pulsed synchronization of PPS.

7.2 Selection of time synchronization method

7.2.1 The synchronization method can be selected using the device menu. To do this, select the menu item **Parameters**[1)] –> **System parameters** –> **Time synchronization** –> **SW synchronization**.

7.2.2 Select the interface through which time synchronization will be carried out (see Figure 95). Possible values: Ethernet 1, RS-485-1, RS-485-2, None.

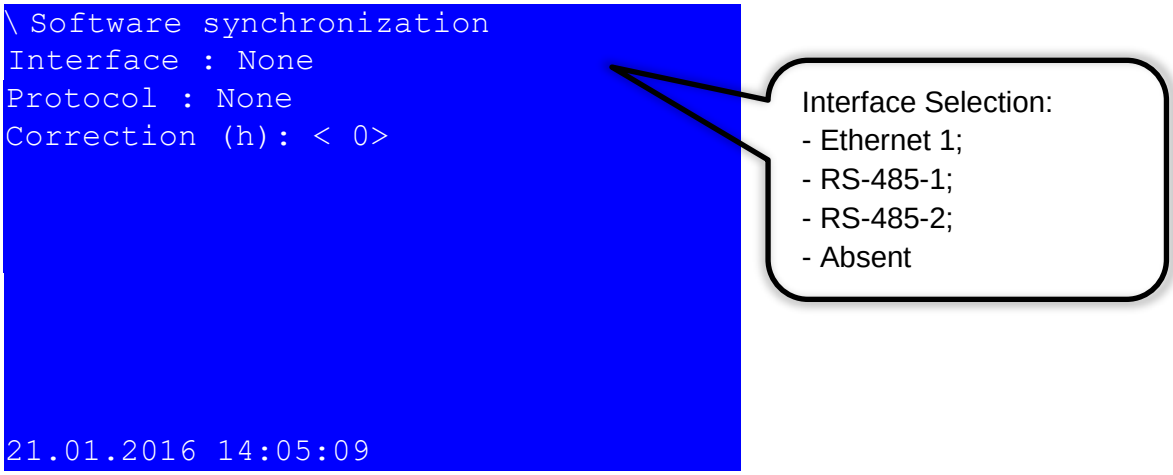


Figure 95 – **SW synchronization** item

7.2.3 Select the protocol for time synchronization depending on the selected interface. Protocols applicable for Ethernet 1 interface: SNTP, PTPv2, IEC 60870-5-104, Modbus TCP (see Figure 96), for RS-485-1, RS-485-2 interface – IEC 60870-5-103, Modbus RTU (see Figure 97).

[1)] To change settings, you must enter a password when entering **Parameters**. Default user passwords are shown in Table 1.

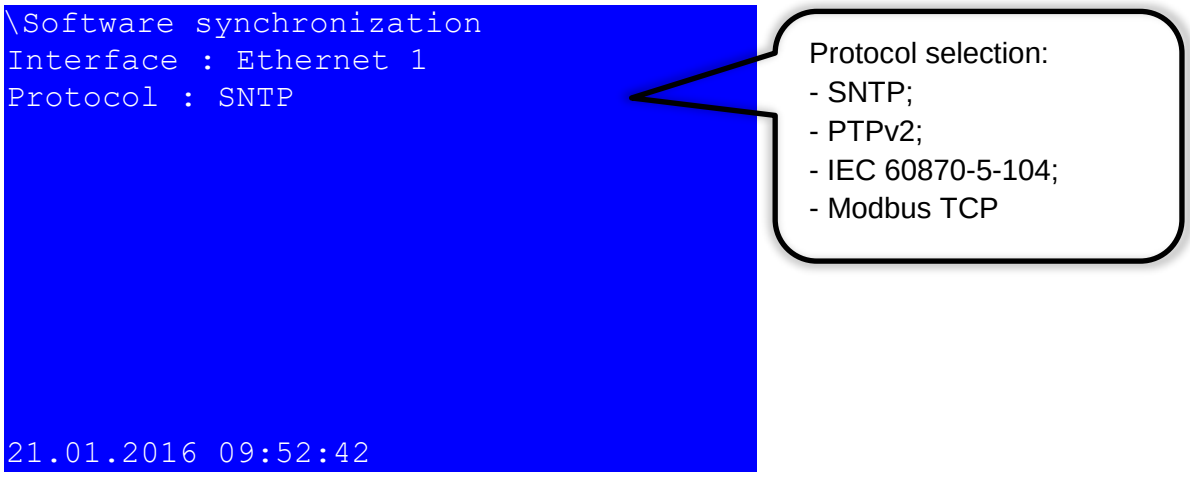


Figure 96 – Selection of protocol for Ethernet 1 interface

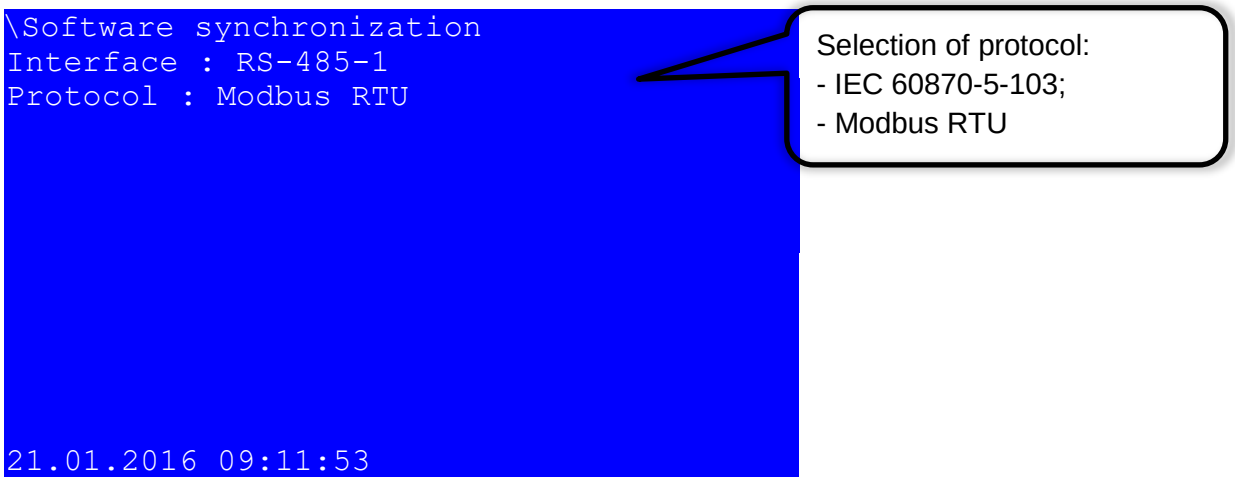


Figure 97 – Selection of protocol for RS-485-1 interface

7.2.4 Save the changes made to the device similar to 4.4.3.4

7.3 Software time synchronization

You can configure parameters of software time synchronization (for example, assign a communication protocol to a specific port or set a time zone) using the Smart Monitor software or using the device menu.

7.3.1 Configuration of time synchronization via SNTP protocol

Time synchronization via SNTP protocol is configured using the Smart Monitor software or the device menu.

7.3.1.1 Configuration using the Smart Monitor software

7.3.1.1.1 Start the Smart Monitor software similar to 2.4.1.1.

7.3.1.1.2 In the “tree” of the project of the Smart Monitor software, select **Settings** –> **Digital communication channels** (see Figure 98, designation 1), clicking once with the left mouse button the corresponding item of the project “tree”, and open the window.

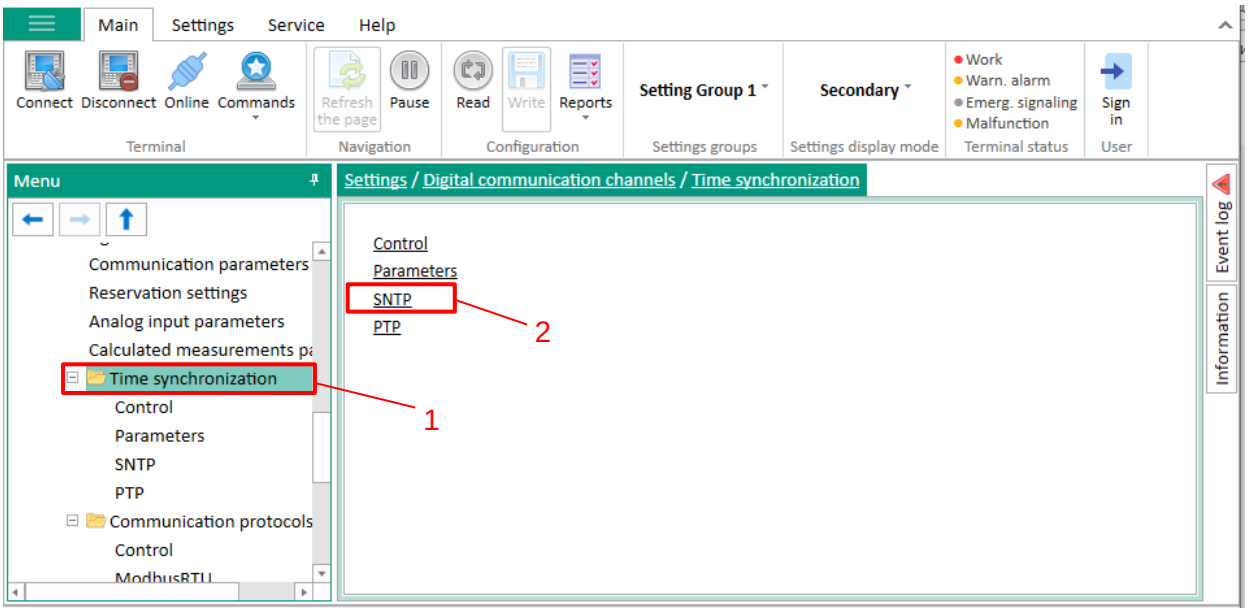


Figure 98 – **Time synchronization** window

7.3.1.1.3 Select **SNTP** protocol (see Figure 98, designation 2).

7.3.1.1.4 Check the **Protocol enabled** box if it has not been checked (see Figure 99, designation 1).

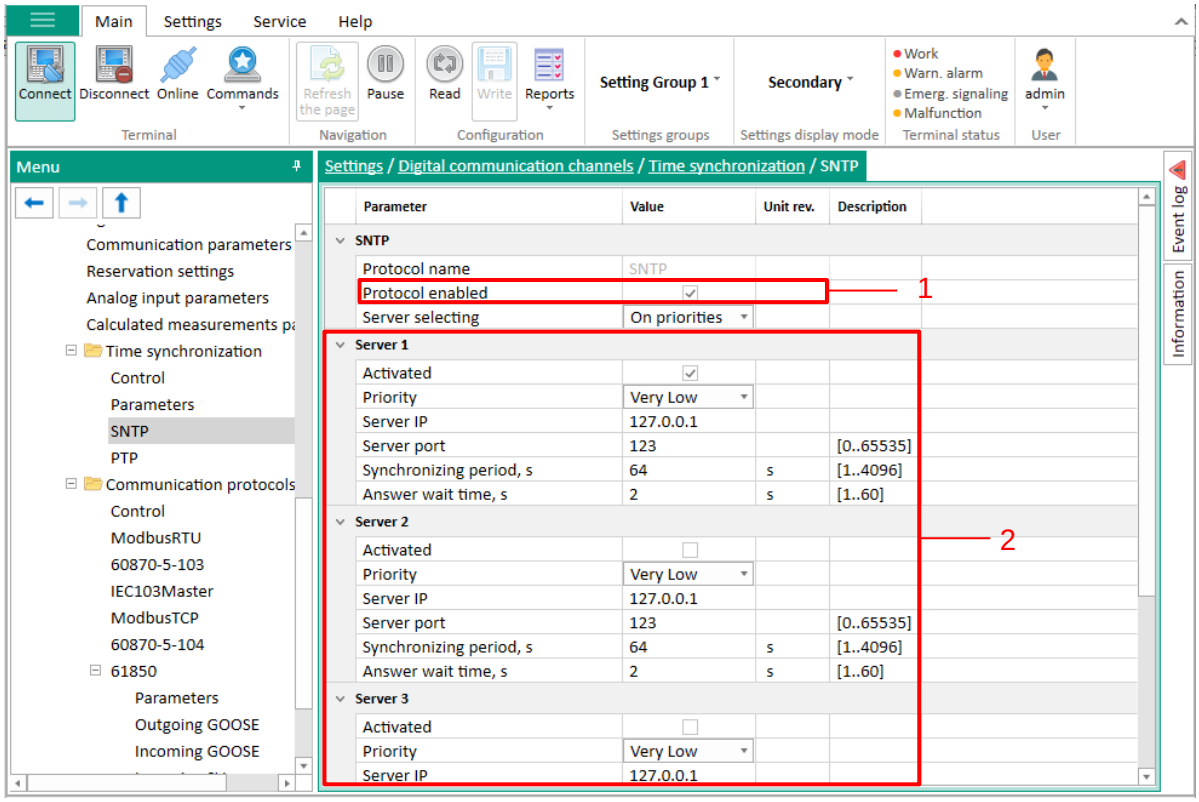


Figure 99 – Configuration of time synchronization via SNTP protocol

7.3.1.1.5 Specify parameters of the SNTP protocol in accordance with the project. Default values of protocol parameters are shown in Figure 99, designation 2. Description of parameters of the SNTP protocol is given in Table 152.

Table 152 – Description of parameters of the SNTP protocol

Parameter	Description
Server selection:	– by priority (the user additionally specifies the priority value for each server. If the specified priorities are the same, the first one declared in the device configuration is considered the main one); – automatically (server selection is made by position in the server hierarchy. The most accurate server is at the top level of the hierarchy. When located at the same level of the hierarchy, the first one declared in the device configuration is considered the main one)
Server No.1 (No.2, No.3, No.4)	
Activated	Box checked – server No.1 (No.2, No.3, No.4) is enabled for time synchronization
Priority	Priority of server selection during time synchronization, if the server isselected by priority: – very low; – low; – high; – very high
Server IP address	Address of the server with which the time is synchronized
Server port	Server port through which time is synchronized (123 standard port for SNTP)
Synchronization period	Time interval (value must be in the range of 1 to 4,096 s) after which synchronization is repeated
Response wait time	Time to wait for a response from the server (value must be in the range of 1 to 60 s)

7.3.1.1.6 On the **Parameters** tab (see Figure 100, designation 1) in the **Interface** drop-down list select the interface to which the **SNTP** protocol is assigned (see Figure 100, designation 2).

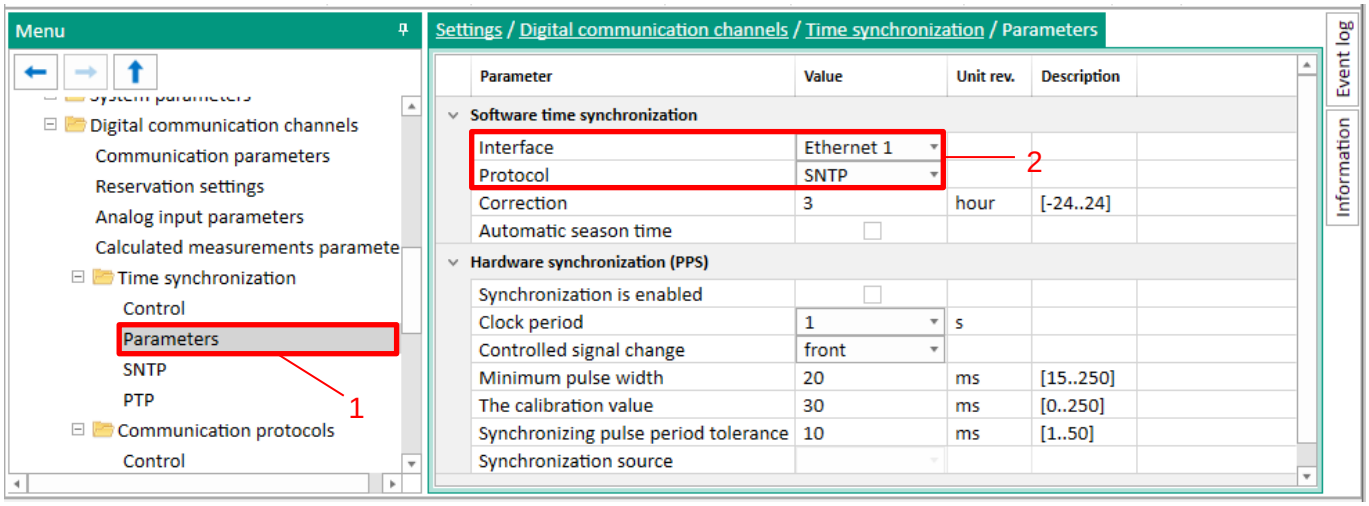


Figure 100 – Configuration of time synchronization via SNTP protocol

7.3.1.1.7 Adjustment of time synchronization similar to 6.6.1.2.

NOTICE

NEW PARAMETERS OF SYNCHRONIZATION WILL BE APPLIED ONLY AFTER SAVING THE SETTINGS!

7.3.1.1.8 Savethe changes made to the device similar to 4.4.3.4.

7.3.1.2 Configuration using the device menu

7.3.1.2.1 In the device menu, select the item **Parameters**[1)] –> **System parameters** –> **Communication parameters** –> **Network parameters** –> **Network protocols** (see Figure 101).

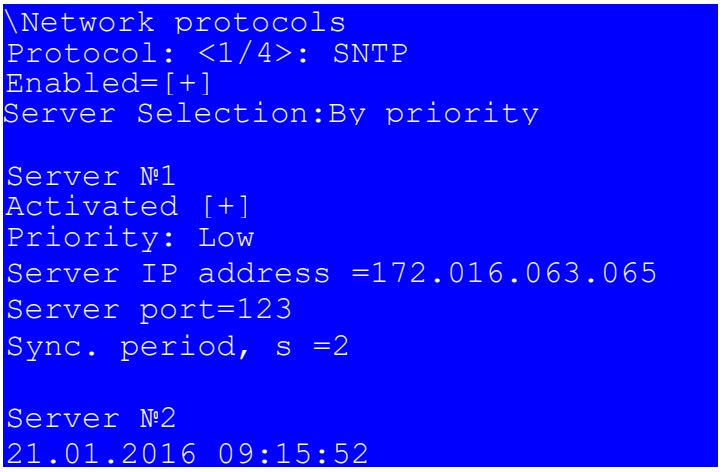


Figure 101 – **Network protocols** item

7.3.1.2.2 Specify parameters of the SNTP protocol in accordance with the project or leave the default values (see Figure 101). The SNTP protocol is edited by pressing the “ ” button. Description of parameters of the SNTP protocol is given in Table 152.

NOTICE

NEW PARAMETERS OF SYNCHRONIZATION WILL BE APPLIED ONLY AFTER SAVING THE SETTINGS!

7.3.1.2.3 Savethe changes made to the device similar to 4.4.3.4.

7.3.1.2.4 Viewing the state of time synchronization

To view the state of time synchronization do the following:

1) Select the menu item **Diagnostics** –> **State of communication**
2) Select the SNTP protocol using control buttons “◄”, “►” (see Figure 102).

[1)] To change settings, you must enter a password when entering **Parameters**. Default passwords are shown in Table 1.

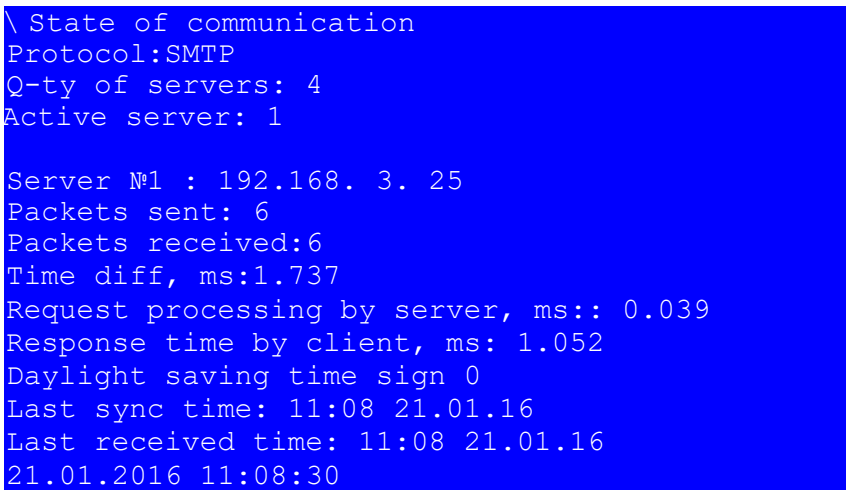


Figure 102 – **State of communication** item

Specify parameters of the SNTP protocol in accordance with the project or leave the default values (see Figure 102). The SNTP protocol is edited by pressing the “ ” button. Description of parameters of the SNTP protocol is given in Table 152.

After a certain amount of time, according to the time of the synchronization period, the data change.

7.3.1.2.5 Troubleshooting

Possible failures of time synchronization via SNTP protocol are shown in Table 153.

Table 153 – Possible failures of time synchronization via SNTP protocol

Description of failure	Possible cause of failure	Method of elimination
No time synchronization via SNTP protocol	Incorrect parameters of server IP address and server port in the configuration	Specify appropriate server IP address and server port in the configuration
	No physical connection to the server	Establish a connection with the server

7.3.2 Configuration of time synchronization via PTPv2 protocol

Time synchronization via PTPv2 protocol is configured using the Smart Monitor software.

7.3.2.1 In the “tree” of the project of the Smart Monitor software, select **Settings** –> **Digital communication channels** –> **Time synchronization** (see Figure 103, designation 1), clicking once with the left mouse button the corresponding item of the project “tree”, and open the window.

7.3.2.2 Open **PTP** tab (see Figure 103, designation 2).

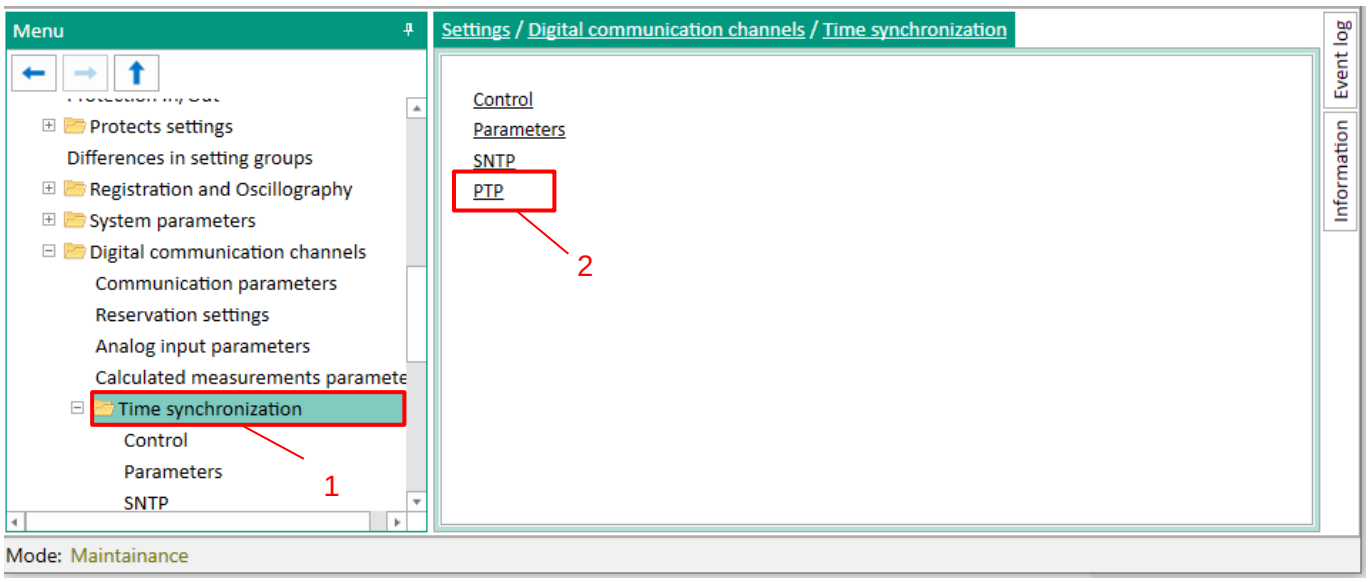


Figure 103 – **Time synchronization** window

7.3.2.1 Check the **Protocol enabled** box if it has not been checked (see Figure 104, designation 1).

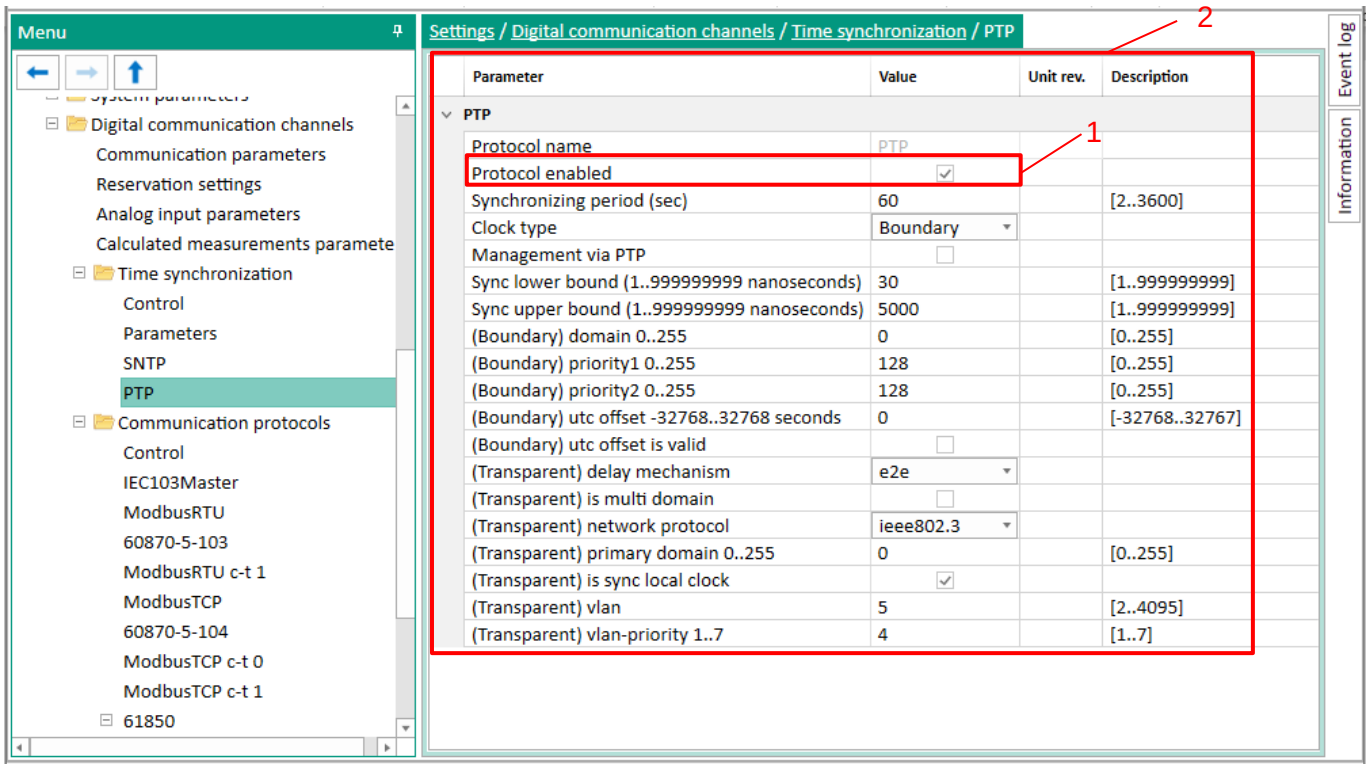


Figure 104 – Configuration of time synchronization via PTP protocol

7.3.2.2 Specify parameters of the PTPv2 protocol in accordance with the project or leave the default values (see Figure 103, designation 2). Description of parameters of the PTPv2 protocol is given in Table 154.

Table 154 – Description of parameters of the PTPv2 protocol

Parameter	Description
Synchronization period	Time interval (value must be in the range of 2 to 3,600 s) after which synchronization is repeated
Clock type	Specifies the synchronization algorithm: – boundary; – transparent
Management via PTPv2	Enabling/disabling PTPv2 management
Sync lower bound	Minimum time difference between local clock and source of reference time (value must be in the range of 1 to 999,999 999 ns)
Sync upper bound	Maximum time difference between local clock and source of reference time (value must be in the range of 1 to 999,999 999 ns)
(Boundary) domain	Assignment of the device to a specific PTPv2 domain (value must be in the range of 0 to 255)
(Boundary) priority1	Determines the first priority for port (value must be in the range of 0 to 255)
(Boundary) priority2	Determines the second priority for port (value must be in the range of 0 to 255)
(Boundary) utc offset	Difference between PTPv2 and UTC time scale (value must be in the range of minus 32,768 to plus 32,768 s)
(Boundary) utc offset is valid	Offset from time scale: – box checked – time scale offset; – box not checked – no time scale offset
(Transparent) delay mechanism	Algorithm for measurement of delay in the device transmitted in PTPv2 messages: – e2e; – p2p; – e2e-optimized; – none
(Transparent) is multi domain	Operation of the PTPv2 synchronization independent from the domain: – box checked – synchronization does not depend on the domain; – box not checked – synchronization depends on the domain
(Transparent) network protocol	Network protocol, through which synchronization messages are transmitted: – ieee802.3; – udp-ipv4
(Transparent) primary domain	Assignment of the device to the PTPv2 domain (value must be in the range of 0 to 255)
(Transparent) is sync local clock	Synchronization of local clock: – box checked – local clock is synchronized; – box not checked – local clock is not synchronized
(Transparent) vlan	Operation of PTPv2 in the specified virtual network (VLAN ID), virtual network No.: – none; – 0; – 1
(Transparent) vlan-priority	Priority with which the device transmits messages of the PTPv2 synchronization related to this VLAN ID (value must be in the range of 1 to 7)

7.3.2.3 On the **Parameters** tab (see Figure 105, designation 1) in the **Interface** drop-down list select the interface to which the **PTPv2** protocol is assigned (see Figure 105, designation 2).

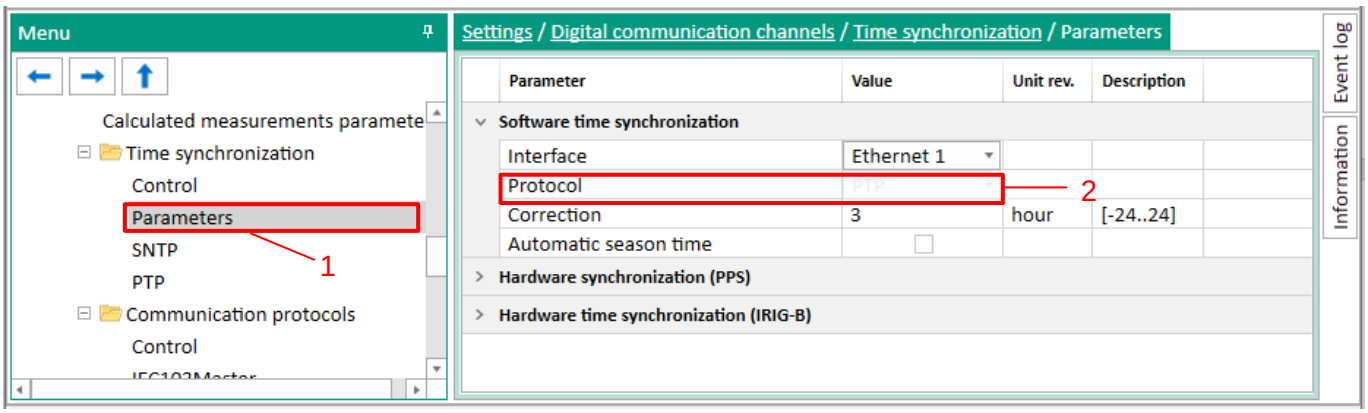


Figure 105 – Configuration of time synchronization via PTPv2 protocol

Note – If you select the PTPv2 time synchronization protocol, an information window will appear (see Figure 106).

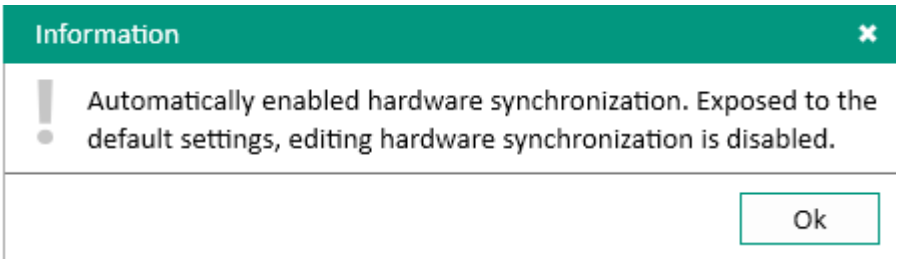


Figure 106 – Information window

7.3.2.3.1 Adjustment of time synchronization similar to 6.6.1.2.

7.3.2.4 After configuration, in order to apply the settings and save the changes made, it is necessary to write the settings to the device similar to 4.4.3.4.

7.3.2.5 Possible failures of time synchronization via PTPv2 protocol

Possible failures of time synchronization via PTPv2 protocol are shown in Table 155.

Table 155 – Possible failures of time synchronization via PTPv2 protocol

Description of failure	Possible cause of failure	Method of elimination
No time synchronization via PTPv2 protocol	No physical connection to the time server	Establish a connection with the server

7.3.3 Configuration of time synchronization via IEC protocol 60870-5-103

Time synchronization via IEC 60870-5-103 protocol is configured using the Smart Monitor software.

7.3.3.1 In the “tree” of the project of the Smart Monitor software, select **Settings** –> **Digital communication channels** –> **Time synchronization** –> **Parameters** (see Figure 107, designation 1), clicking once with the left mouse button the corresponding item of the project “tree”, and open the window.

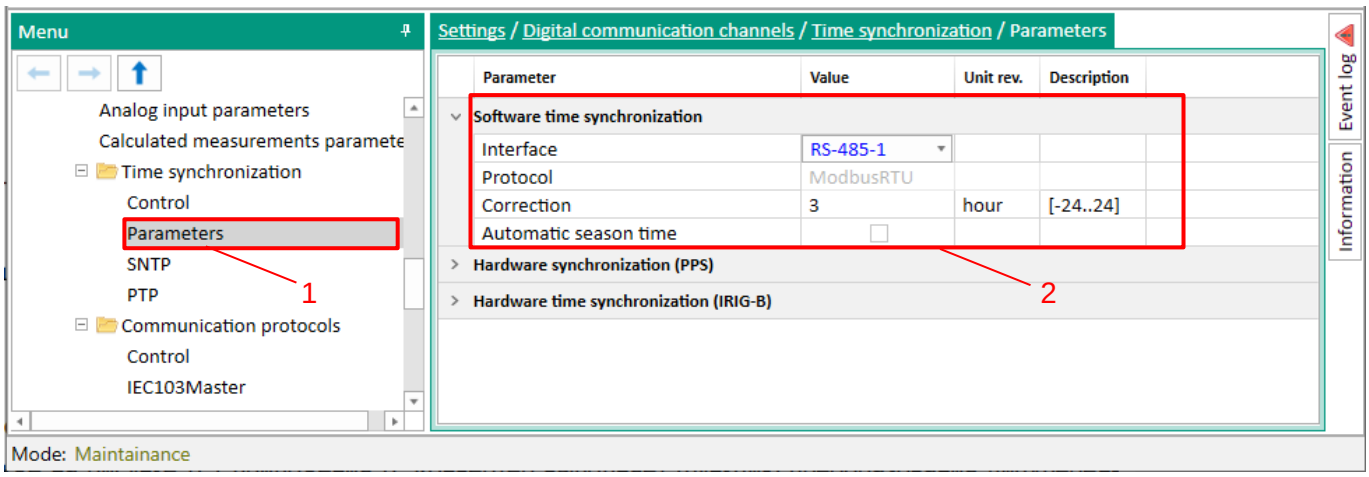


Figure 107 – Configuration of time synchronization via IEC 60870-5-103 protocol

7.3.3.2 In the **Software time synchronization** field (see Figure 107, designation 2) in the **Interface** drop-down list select the interface to which the IEC 60870-5-103 protocol: **60870-5-103** is assigned.

7.3.3.2.1 If it is necessary to specify the adjustment value of the internal clock of the device relative to the time stamp transmitted via IEC 60870-5-103 protocol, in the **Correction** field (see Figure 107, designation 2) the required difference should be set in accordance with the project.

7.3.3.2.2 If you need the function of automatic seasonal time adjustment, you should check the box **Adjust for daylight saving time automatically** (see Figure 107, designation 2).

7.3.3.2.3 Save the changes made to the device similar to 3.4.1.5

7.3.3.3 Possible failures of time synchronization via IEC 60870-5-103 protocol

Possible failures of time synchronization via IEC 60870-5-103 protocol are shown in Table 156.

Table 156 – Possible failures of time synchronization via IEC 60870-5-103 protocol

Description of failure	Possible cause of failure	Method of elimination
No time synchronization via IEC 60870-5-103 protocol	No physical connection to the server	Establish a connection with the server

7.3.4 Configuration of time synchronization via IEC protocol 60870-5-104

Time synchronization via IEC 60870-5-104 protocol is configured using the Smart Monitor software.

7.3.4.1 In the “tree” of the project of the Smart Monitor software, select **Settings** –> **Digital communication channels** –> **Time synchronization** –> **Parameters** (see Figure 108, designation 1), clicking once with the left mouse button the corresponding item of the project “tree”, and open the window.

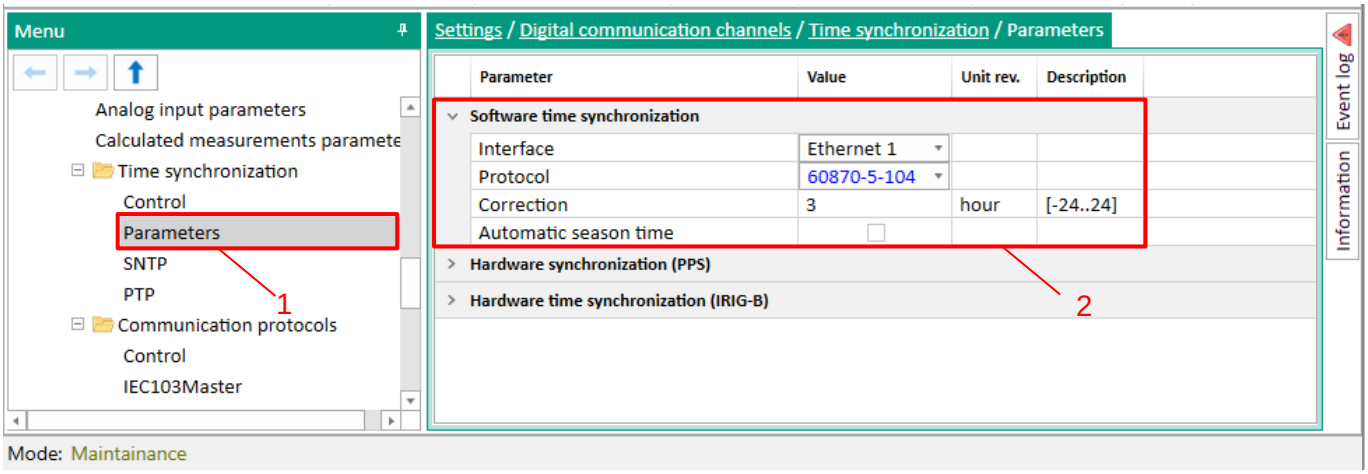


Figure 108 – Configuration of time synchronization via IEC 60870-5-104 protocol

7.3.4.2 In the **Software time synchronization** field (see Figure 108, designation 2), in the **Interface** drop-down list, select the interface to which the protocol: **60870-5-104** is assigned

7.3.4.3 If it is necessary to specify the adjustment value of the internal clock of the device relative to the time stamp transmitted via IEC 60870-5-104 protocol, in the **Correction** field (see Figure 108, designation 2) the required difference should be set in accordance with the project.

7.3.4.4 If you need the function of automatic seasonal time adjustment, you should check the box **Adjust for daylight saving time automatically** (see Figure 108, designation 2).

7.3.4.4.1 Save the changes made to the device similar to 3.4.1.5.

7.3.4.5 Possible failures of time synchronization via IEC 60870-5-104 protocol

Possible failures of time synchronization via IEC 60870-5-104 protocol are shown in Table 157.

Table 157 – Possible failures of time synchronization via IEC 60870-5-104 protocol

Description of failure	Possible cause of failure	Method of elimination
No time synchronization via IEC 60870-5-104 protocol	No physical connection to the server	Establish a connection with the server

7.3.5 Configuration of time synchronization via Modbus TCP protocol

Time synchronization via Modbus TCP protocol is configured using the Smart Monitor software.

7.3.5.1 In the “tree” of the project of the Smart Monitor software, select **Settings** –> **Digital communication channels** –> **Time synchronization** –> **Parameters** (see Figure 109, designation 1), clicking once with the left mouse button the corresponding item of the project “tree”, and open the window.

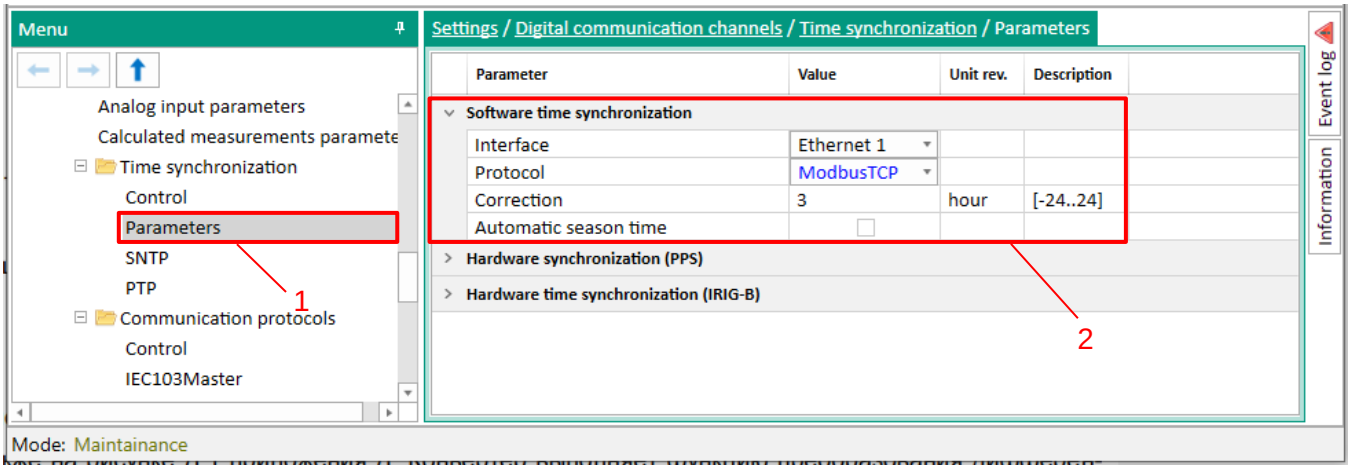


Figure 109 – Configuration of time synchronization via Modbus TCP protocol

7.3.5.2 In the **Software time synchronization** field (see Figure 109, designation 2) in the **Interface** drop-down list select the interface to which the Modbus TCP protocol is assigned.

7.3.5.3 If it is necessary to specify the adjustment value of the internal clock of the device relative to the time stamp transmitted via Modbus TCP protocol, in the **Correction** field (see Figure 109, designation 2) the required difference should be set in accordance with the project.

7.3.5.4 If you need the function of automatic seasonal time adjustment, you should check the box **Adjust for daylight saving time automatically** (see Figure 109, designation 2).

7.3.5.5 Save the changes made to the device similar to 3.4.1.5

7.3.5.6 Possible failures of time synchronization via Modbus TCP protocol

Possible failures of time synchronization via Modbus TCP protocol are shown in Table 158.

Table 158 – Possible failures of time synchronization via Modbus TCP protocol

Description of failure	Possible cause of failure	Method of elimination
No time synchronization via Modbus TCP protocol	Incorrect parameters of server IP address and server port in the configuration	Specify appropriate server IP address and server port in the configuration
	No physical connection to the server	Establish a connection with the server

7.3.6 Configuration of time synchronization via Modbus RTU protocol

Time synchronization via Modbus RTU protocol is configured using the Smart Monitor software.

7.3.6.1 Time synchronization via Modbus RTU protocol is configured using the Smart Monitor software.

7.3.6.1.1 In the “tree” of the project of the Smart Monitor software, select **Settings** –> **Digital communication channels** –> **Time synchronization** –> **Parameters** (see Figure 110, designation 1), clicking once with the left mouse button the corresponding item of the project “tree”, and open the window.

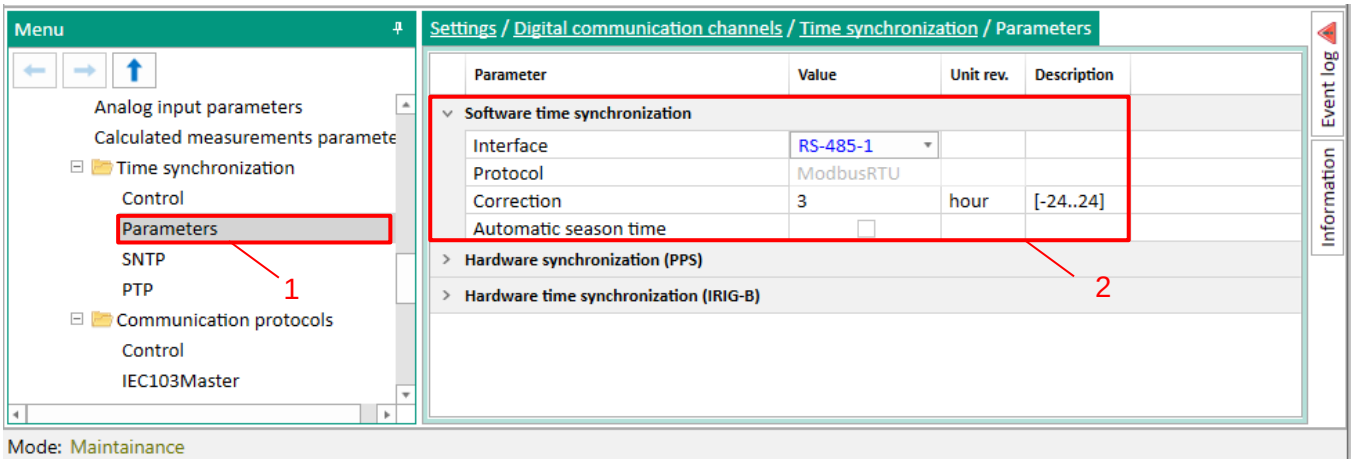


Figure 110 – Configuration of time synchronization via Modbus RTU protocol

7.3.6.1.2 In the **Parameters** tab select the Ethernet 1 interface and the Modbus TCP protocol (see Figure 110, designation 2).

7.3.6.1.3 If it is necessary to specify the time difference between the device and the time source in the **Correction** field (see Figure 110, designation 2) the required difference should be set in accordance with the project.

7.3.6.1.4 If you need the function of automatic seasonal time adjustment, you should check the box **Adjust for daylight saving time automatically** (see Figure 110, designation 2)

7.3.6.1.5 Save the changes made to the device similar to 3.4.1.5

7.3.6.1.6 Possible failures of time synchronization via Modbus RTU protocol

Possible failures of time synchronization via Modbus RTU protocol are shown in Table 159.

Table 159 – Possible failures of time synchronization via Modbus RTU protocol

Description of failure	Possible cause of failure	Method of elimination
No time synchronization via Modbus RTU protocol	Incorrect parameters of device address and server port in the configuration	Specify appropriate device address and server port in the configuration
	No physical connection to the server	Establish a connection with the server

7.4 Hardware-software synchronization

7.4.1 General

Hardware-software time synchronization consists of software (see 7.3) and hardware time synchronization.

There are two ways of hardware time synchronization – pulse time synchronization (see 7.4.1.1) or time synchronization via IRIG-B protocol (see 7.4.3).

7.4.1.1 Pulse synchronization

The diagram for connecting the ED2 series device to the time server of PCS via bus of differential signal RS-422 PPS using the converter is shown in 111, as well as in Figure E.1 of Appendix E. The converter performs the function of converting differential signals of twisted pair into PPS second pulses of

a given amplitude and polarity (default 24 V). The quantity of devices connected to one PPS bus is determined by the specifications of the server. The connection port of PPS pulse synchronization signal is located on the back panel of the device (see Figure C.3 of Appendix C). The PPS port has terminal connectors for screws.

The recommended converter of differential signal of the RS-422 (PPS) bus is TCS-02 manufactured by EKRA Research and Production Enterprise Ltd, or any other converter with similar specifications.

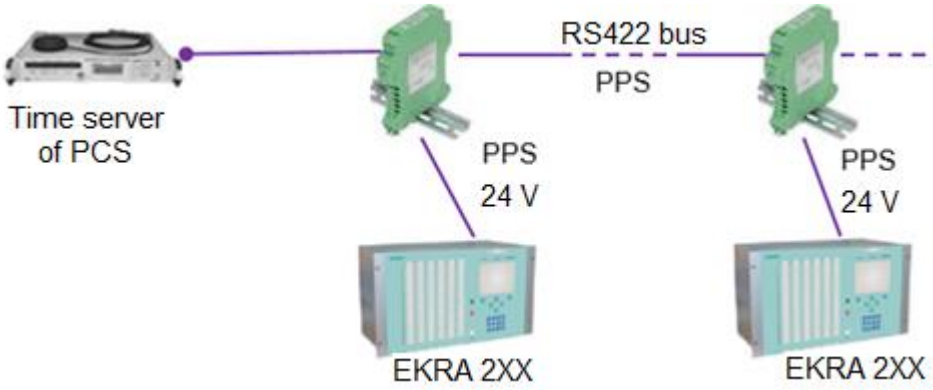


Figure 111 – Standard diagram for connecting the ED2 series device to the time server of PCS via RS422 PPS bus

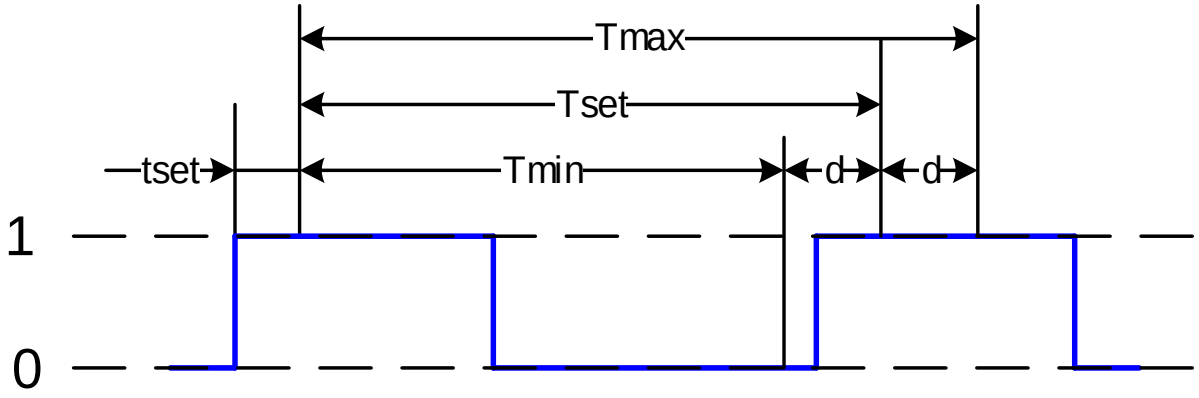
7.4.1.1.1 Parameters of PPS pulse time synchronization

The list of parameters for configuring pulse time synchronization, their description and editing tools are given in Table 160. Graphical representation of the parameters is shown in Table 112.

Table 160 – Parameters of PPS pulse synchronization

Description of setting	Editing tool	Range of values	Default value	Function
Synchronization enabled	Configurator, Smart Monitor, device menu	0; 1	0	Enabling/Disabling pulse time synchronization
Registered transition	Configurator, Smart Monitor, device menu	1 (0 → 1, front), 0 (1 → 0, fall)	1	Start of synchronization can be detected by a change in the signal level from low to high (front), and a change from high to low (fall)
Minimum pulse duration, ms	Configurator, Smart Monitor	from 15 to 250 in increments of 1	15	Minimum pulse width at which a pulse is recognized as a timestamp signal
Calibration value, ms	Configurator, Smart Monitor, device menu	from -250 to +250 in increments of 1	0	Takes into account the time spent on the passage of data over the network from the source (for example, PCS) to the receiver (device)

Description of setting	Editing tool	Range of values	Default value	Function
Synchropulse period, s	Configurator, Smart Monitor, device menu	1; 10; 20; 30; 40; 50; 60	1	Synchropulse period is the expected time between two adjacent events of determining synchropulse If this time differs from the period setting by more than the permissible trip, then it is not rounded up to an integer number of seconds (synchropulse is ignored) and a warning failure is set
Permissible deviation of synchropulse period, ms	Configurator, Smart Monitor	from 0 to 50 in increments of 1	25	



where t_{set} is the minimum pulse duration (setting);

T_{set} – synchropulse period (setting);

d – permissible deviation of the period (setting);

$T_{max} = T_{set} + d$ – maximum pulse duration, taking into account the permissible deviation;

$T_{min} = T_{set} – d$ – minimum pulse duration, taking into account the permissible deviation

Figure 112 – Graphical representation of parameters

7.4.1.2 IRIG-B synchronization

The ED2 series device supports IRIG-B standards: B007 and B003. The B007 standard includes full astronomical time (year, month, day, hours, minutes, seconds, milliseconds), while the B003 standard does not have a year. The exact time signals come strictly once a second. The B003 standard requires additional time synchronization sources of the SNTP type, while B007 does not.

To use the IRIG-B synchronization protocol, you must specify it in the order card.

The connector for connection to the IRIG-B time synchronization module is located on the back panel of the device (see Figure B.1 of Appendix B). The connector is implemented as a terminal connector for screws.

The diagram for connecting the device to the time server of PCS via bus of differential signal RS-422 IRIG-B using the converter of differential signal is shown in Figure 113, as well as in Figure E.1 and E.2 of Appendix E. The quantity of devices connected to one IRIG-B bus is determined by the specifications of the server. The recommended converter of differential signal of the RS-422 (IRIG-B) bus

is TCS-02 manufactured by EKRA Research and Production Enterprise Ltd, or any other converter with similar specifications.

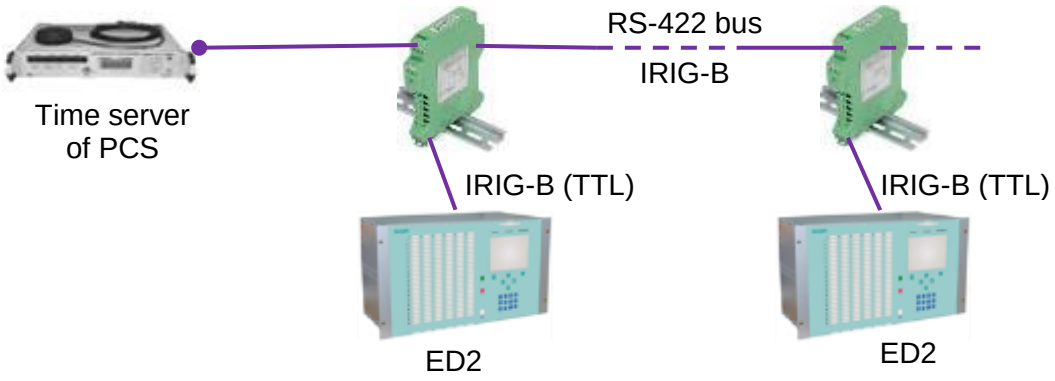


Figure 113 – Standard diagram for connecting the ED2 series device to the time server

The list of parameters for configuring IRIG-B time synchronization, their description and editing tools are given in Table 161.

Table 161 – Configurable parameters of time synchronization

Configurable parameter	Editing tool	Range of values	Function
Synchronization enabled	Configurator, Smart Monitor, device menu	–	Enabling/Disabling time synchronization via IRIG-B protocol
Modification	Configurator, Smart Monitor, device menu	B003; B007	Version of the IRIG-B protocol

7.4.2 Configuration of time synchronization via PPS pulses

Time synchronization via PPS pulses is configured using the Smart Monitor software or the device menu.

7.4.2.1 Configuration of time synchronization via PPS pulses using the Smart Monitor software

7.4.2.1.1 In the “tree” of the project of the Smart Monitor software, select **Settings** –> **Digital communication channels** –> **Time synchronization** –> **Parameters** (see Figure 114, designation 1), clicking once with the left mouse button the corresponding item of the project “tree”, and open the window.

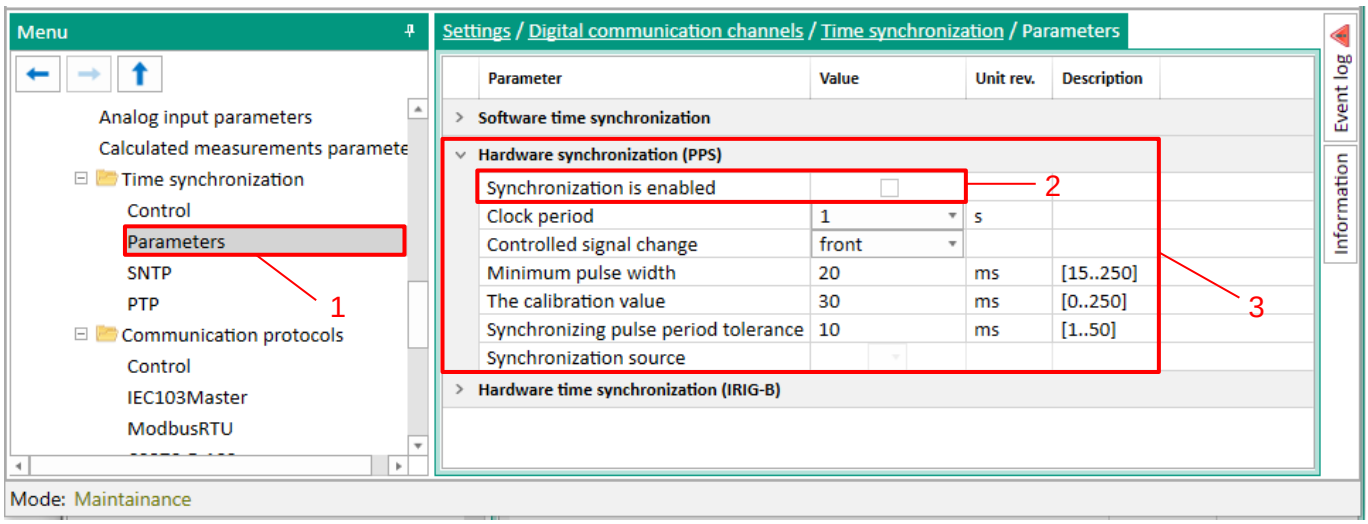


Figure 114 – Configuration of time synchronization via PPS pulses

7.4.2.1.2 To enable time synchronization using PPS pulses, check the box **Synchronization enabled** (see Figure 114, designation 2).

Note – If the PTP protocol is selected, the configuration of synchronization via PPS will not be available.

7.4.2.1.3 In the **Hardware synchronization (PPS)** field (see Figure 114, designation 3) in the **Synchropulse period** drop-down list, select the synchronization pulse repetition period in seconds (see Figure 115).

Possible values of the sync pulse period: 1 s (1PPS); 10; 20; 30; 40; 50; 60 s (1PPM)1).

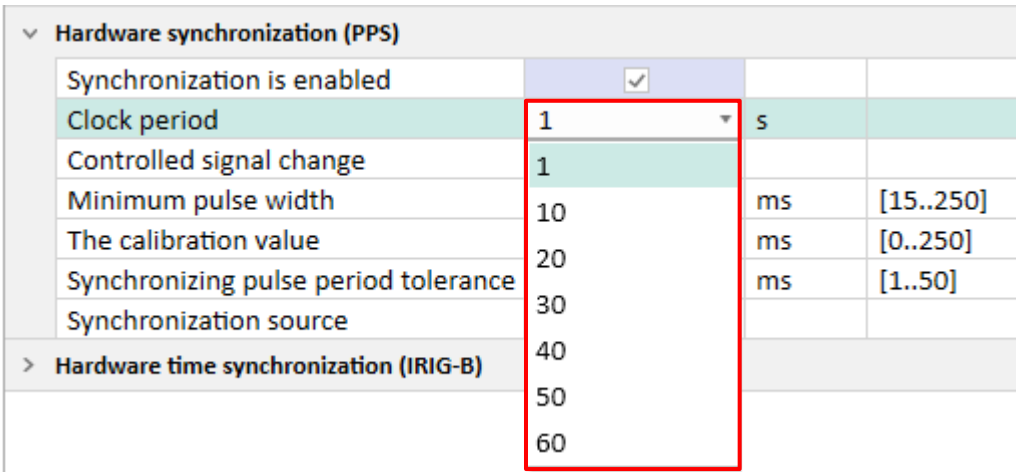


Figure 115 – Configuration of sync pulse period

7.4.2.1.4 In the **Registered transition** drop-down list, select the start of synchronization (see Figure 116). The start of synchronization can be detected by a change in the signal level from low to high (front) or a change from high to low (fall)[1)].

[1)] The parameter value depends on the project.

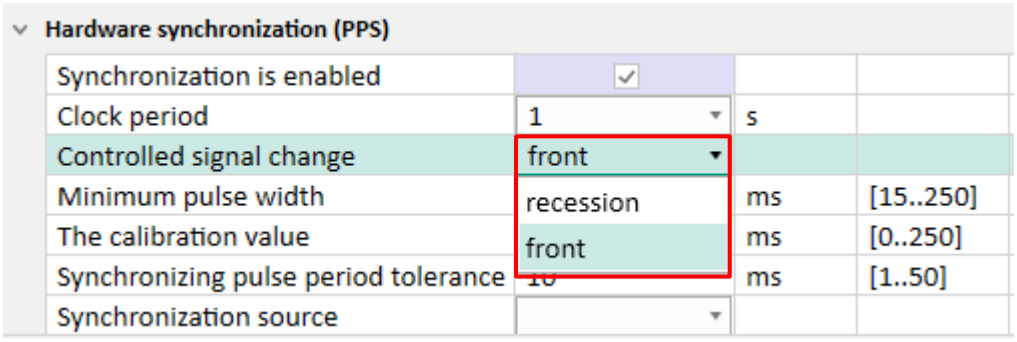


Figure 116 – Configuration of signal change

7.4.2.1.5 Set a value from the permissible range of the minimum duration of synchronization signal pulse in milliseconds – the time to determine the appearance of a sync pulse and at the same time the time to determine its disappearance (see Figure 117, designation 1).

The permissible range of values is 15 to 250 ms in 1 ms increments[1)].

Note – When entering a value, a check is automatically made to ensure that the specified value is within the permissible range. If it is impossible to accept the specified value, it is set to the nearest value from the permissible range.

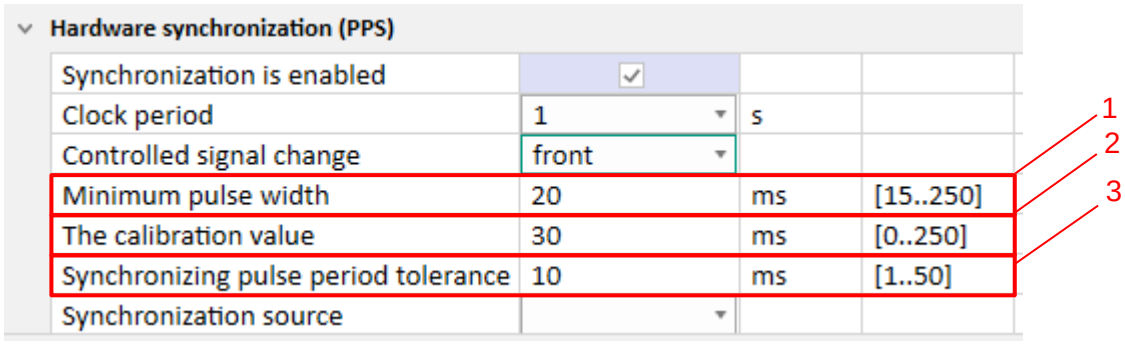


Figure 117 – Configuration of minimum duration of pulse

7.4.2.1.6 Set the calibration value of the synchronization signal in milliseconds from the permissible range (see Figure 117, designation 2). The calibration time takes into account the time spent on the passage of data (hardware pulse) through the network from the source (for example, PCS) to the receiver (device).

The permissible range of values is 0 to 250 ms in 1 ms increments[1)] (default 0).

Note – When entering a value, a check is automatically made to ensure that the specified value is within the permissible range. If it is impossible to accept the specified value, it is set to the nearest value from the permissible range.

7.4.2.1.7 Specify the permissible deviation of the sync pulse period in milliseconds from the permissible range (see Figure 117, designation 3).

The permissible range of values is 0 to 50 ms in 1 ms increments[1)] (default 25 ms).

[1)] The parameter value depends on the project.

Note – When entering a value, a check is automatically made to ensure that the specified value is within the permissible range. If it is impossible to accept the specified value, it is set to the nearest value from the permissible range.

7.4.2.1.8 Specify the synchronization source (see Figure 118). There are the following types of synchronization via PPS:

– External PPS (from the power supply);

– Internal PPS (from the redundancy board).

Note – In the case of the ED2 device in the 1/3 19'' design, synchronization via PPS can only be electrical PPS.

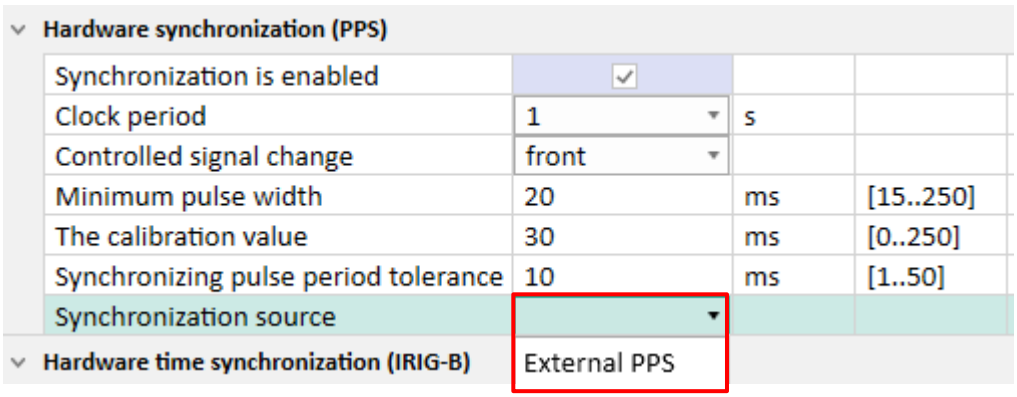


Figure 118 – Configuration of synchronization source

7.4.2.1.9 If the sync pulse does not meet the specified requirements (sync pulse period, permissible deviation), after saving the new parameters (see 4.4.3.4) a warning failure will be set, and synchronization via PPS pulses will not be performed (the device will switch to software time synchronization).

7.4.2.2 Configuration of time synchronization via PPS pulses using the device menu

7.4.2.2.1 Select the menu item **Parameters**[1)] –> **System parameters** –> **Time synchronization** –> **HW synchronization**. In the window that opens, select the type of pulse synchronization (or disable hardware synchronization of the device) by pressing the " ↵ " button in a cyclic manner (see Figure 119).

[1)] To change settings, you must enter a password when entering **Parameters**. Default user passwords are shown in Table 1.

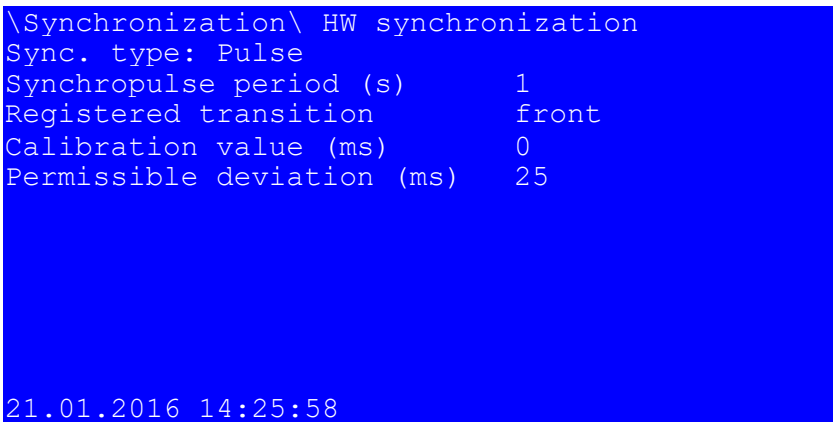


Figure 119 – Configuration of pulse synchronization

7.4.2.2.2 Select the synchropulse period – the period of repetition of synchronization pulses in seconds.

Possible values of the sync pulse period: 1 s (1PPS); 10; 20; 30; 40; 50; 60 s (1PPM).

7.4.2.2.3 Select registered transition – start of synchronization. The start of synchronization can be detected by a change in the signal level from low to high (front) or a change from high to low (fall)[1)].

7.4.2.2.4 Specify the calibration value in milliseconds from the permissible range. The calibration time takes into account the time spent on the passage of data (hardware pulse) through the network from the source (for example, PCS) to the receiver (device).

The permissible range of values is 0 to 250 ms in 1 ms increments[1)] (default 0).

Note – When entering a value, a check is automatically made to ensure that the specified value is within the allowable range. If it is impossible to accept the set value, it is set to its previous state.

7.4.2.2.5 Specify the permissible deviation in milliseconds from the permissible range.

The permissible range of values is 0 to 50 ms in 1 ms increments[1)] (default 25 ms).

Note – When entering a value, a check is automatically made to ensure that the specified value is within the permissible range. If it is impossible to accept the specified value, it is set to its previous state.

7.4.2.2.6 If the synchropulse does not meet the specified requirements (synchropulse period, tolerance) after saving the new parameters (see 4.4.3.4), a warning failure will be set, and synchronization via PPS pulses will not be performed (the device will switch to software time synchronization).

7.4.2.3 Troubleshooting

7.4.2.3.1 Possible options for pulse synchronization failure are shown in Table 162. If there are no synchronization errors, but the “SYNCHRONIZATION” LED is off, it is necessary to check whether the output is assigned to this LED in the indication matrix. The periodicity of glow of the “SYNCHRONIZATION” LED completely coincides with the period of the incoming sync pulse.

Table 162 – Possible failures of pulse synchronization

Description of failure	Possible cause of failure	Method of elimination
After three expected sync pulse periods, a warning failure is set: the “DIAGNOSTICS” LED lights up and	No pulses / Pulses do not match	Supply a pulse

Description of failure	Possible cause of failure	Method of elimination
the **Diagnostics** menu displays the “W Pulse sync failure” message. In the event recorder: – “Synchronization available” signal – Off (Group 1); – “Synchronization” signal – Off (immediately after recording the failure) (Group 1); – “Synchronization failure (warning)” signal – On (Group 1). “SYNCHRONIZATION” LED is off	settings	corresponding to the specified settings, or disable time synchronization via PPS pulses

7.4.3 Configuration of time synchronization via IRIG-B protocol

The configuration of time synchronization via IRIG-B protocol is carried out using the Smart Monitor software or using the device menu.

7.4.3.1 Configuration of time synchronization via IRIG-B protocol using the Smart Monitor software

7.4.3.1.1 In the “tree” of the project of the Smart Monitor software, select the menu item **Settings** –> **Digital communication channels** –> **Time synchronization** –> **Parameters** (see Figure 120, designation 1), clicking once with the left mouse button on the corresponding item in the project “tree”, and open the window.

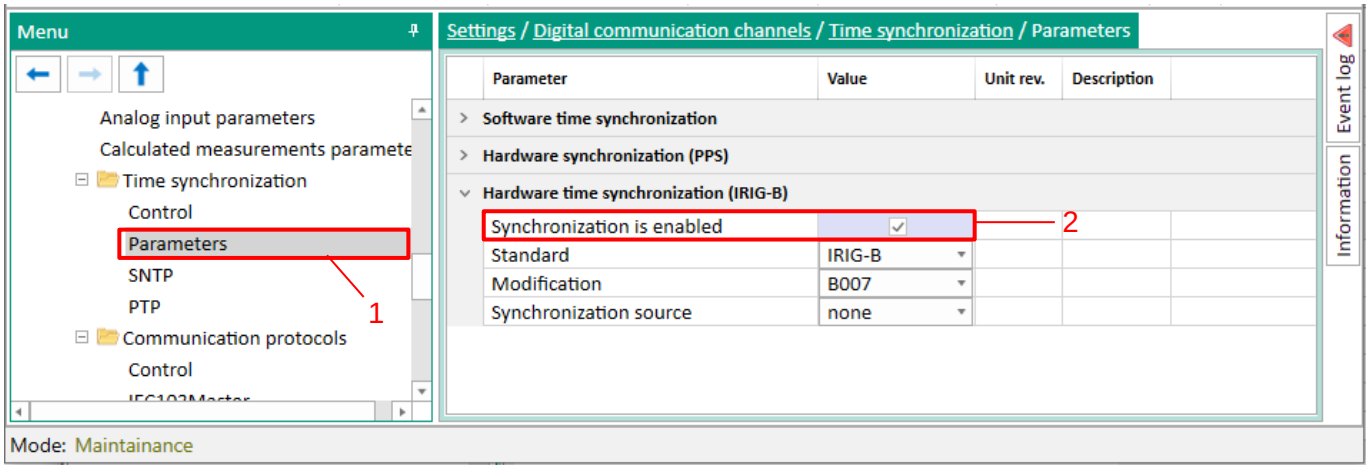


Figure 120 – Configuration of time synchronization via IRIG-B protocol

Note – To synchronize the internal clock of the device via IRIG-B protocol, a specialized module must be installed in the device.

7.4.3.1.2 To enable synchronization, check the box **Synchronization enabled** (see Figure 120, designation 2).

7.4.3.1.3 Select the type of modification of the IRIG-B standard (see Figure 121).

Possible values: B003; B007.

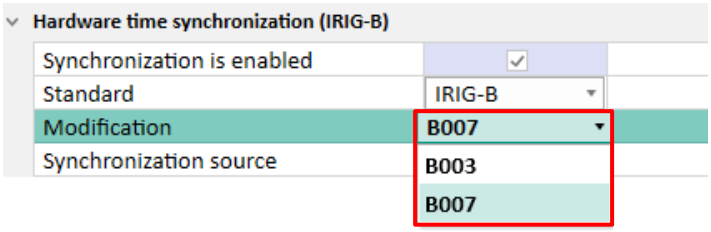


Figure 121 – Selection of the type of version of the IRIG-B standard

7.4.3.1.4 After configuration, in order to apply the settings and save the changes made, it is necessary to write the settings to the device similar to 3.4.1.5.

7.4.3.2 Configuration of time synchronization via IRIG-B protocol using the device menu

7.4.3.2.1 Select the menu item **Parameters**[1)] –> **System parameters** –> **Synchronization** –> **HW synchronization**. In the window that opens, select the type of IRIG-B synchronization (or disable hardware synchronization of the device) by pressing the “ ” button in a cyclic manner (see Figure 122).

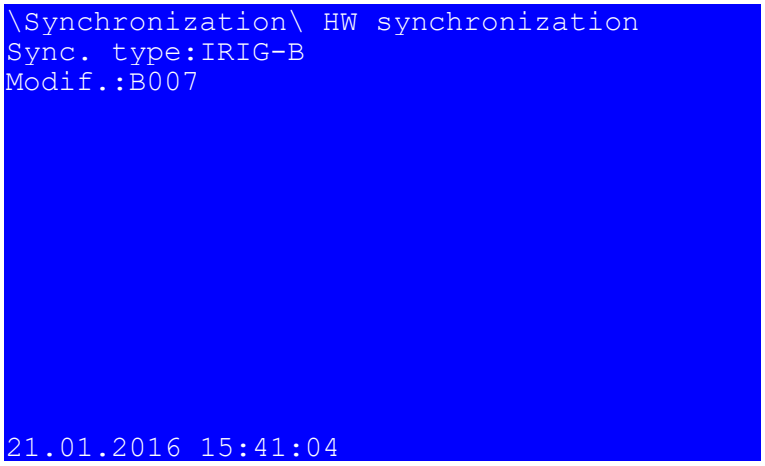


Figure 122 – Configuration of IRIG-B time synchronization

7.4.3.2.2 Select a modification of the IRIG-B synchronization standard: B003 or B007. Save the changes made to the device similar to 4.4.3.4

7.4.3.3 Troubleshooting

7.4.3.4 Possible failures of time synchronization via IRIG-B protocol are shown in Table 163. If there are no synchronization errors, but the “SYNCHRONIZATION” LED is off, it is necessary to check whether the service signal “SYNCHRONIZATION” is assigned to the corresponding LED in the indication matrix.

7.4.3.4.1 The timestamp of registration of the logical signal “SYNCHRONIZATION” for the IRIG-B protocol has a value of 999 in milliseconds. This feature does not affect the accuracy of time synchronization.

[1)] To change settings, you must enter a password when entering **Parameters**. Default user passwords are shown in Table 1.

Table 163 – Possible failures of time synchronization via IRIG-B protocol

Description of failure	Possible cause of failure	Method of elimination
After 3 s after the last recording of the exact time flag, a warning failure is set (the “DIAGNOSTICS” LED lights up). In the event recorder: – “Synchronization available” signal – Off (immediately after recording the failure) (Group 1); – “Synchronization” signal – Off (immediately after recording the failure) (Group 1); – “Synchronization failure (warning)” signal – On (Group 1); – “Synchronization module failure (warning)” signal – On in case of an error of communication with the module (Group 1). “SYNCHRONIZATION” LED is off	No IRIG-B signal on the line	Supply IRIG-B signal

8 Ethernet redundancy

8.1 General

The ED2 series devices have two options for redundant Ethernet network: hardware and software. Both Ethernet redundancy options provide LinkBackup[1)], PRP redundancy methods.

8.1.1 When making a redundancy using LinkBackup technology, the device and each subsequent switch checks for the presence of an Ethernet “carrier frequency” in one of the two ports, if one of the ports loses connection at this level, it switches to the port in which the “carrier frequency” is present. Figure 123 shows the integration into a redundant Ethernet network.

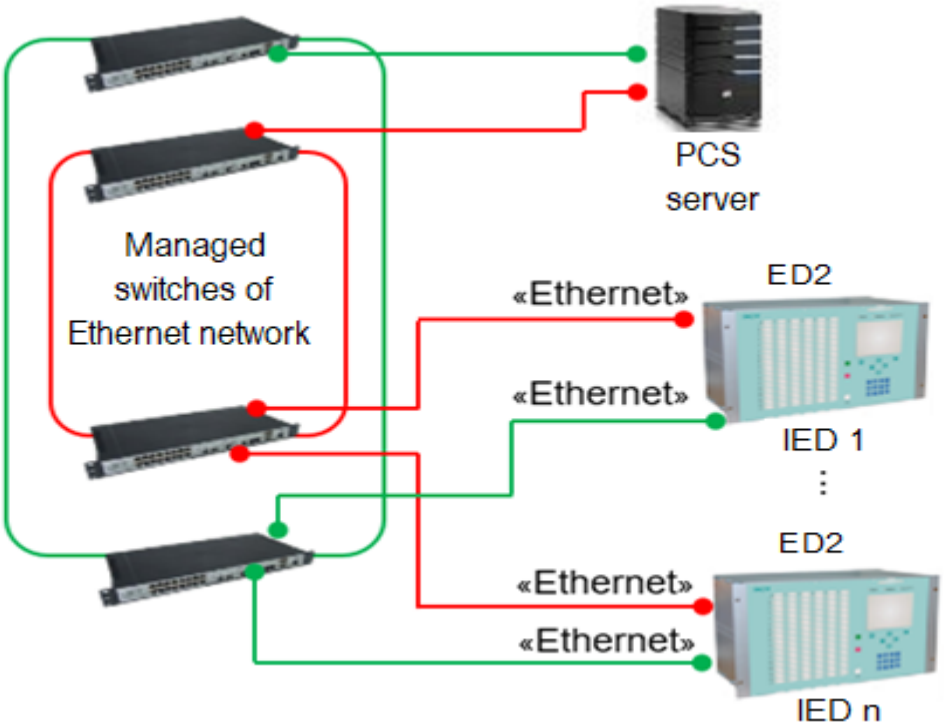


Figure 123 – Standard diagram for integrating the ED2 series device into the redundant Ethernet using the LinkBackup technology

8.1.2 Redundancy using the PRP protocol according to IEC 62439-3

The approach to network redundancy is based on the presence of two independent active paths between two devices. The ED2 series device uses two independent network interfaces that transmit/receive the same data at the same time. The redundancy monitoring protocol makes sure that the receiver uses only the first data packet and discards the second one. If only one packet is received, the receiver knows that the other path has failed. Figure 124 shows the integration into a redundant Ethernet network via PRP protocol. To use the PRP protocol, you must specify it in order sheets.

[1)] This redundancy method is standard and is used in cases where a specific type of protocol is not selected in order sheets.

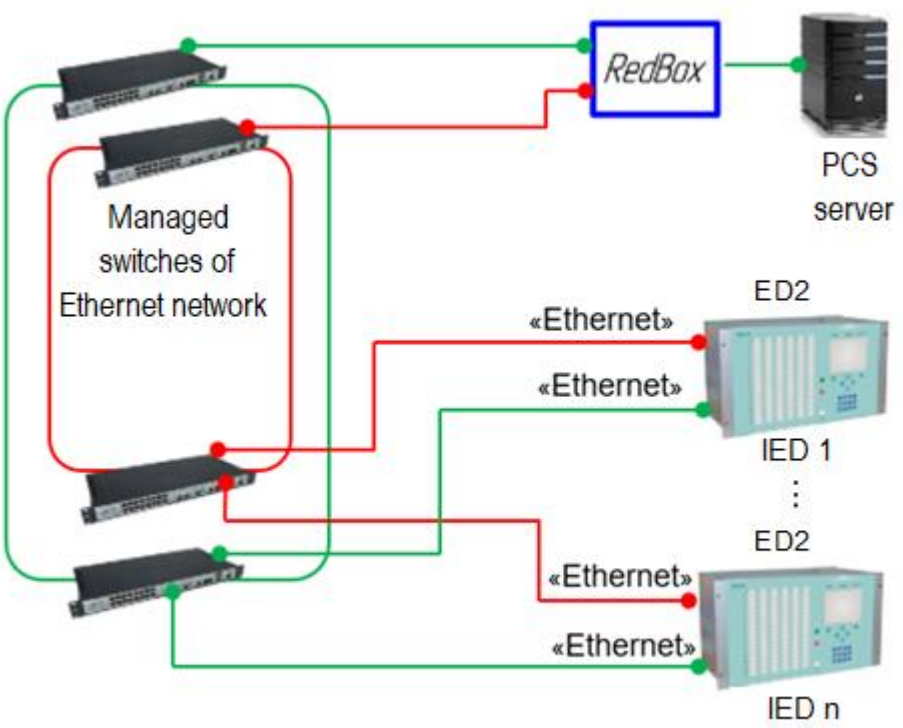


Figure 124 – Standard diagram for integrating the ED2 series device into the redundant Ethernet via PRP protocol

8.2 Configuration of Ethernet redundancy using the Smart Monitor software

8.2.1 Start the Smart Monitor software similar to 2.4.1.1.

8.2.2 In the “tree” of the project of the Smart Monitor software, select **Settings** –> **Digital communication channels** → **Redundancy parameters** (see Figure 125, designation 1), clicking once with the left mouse button the corresponding item of the project “tree”, and open the window.

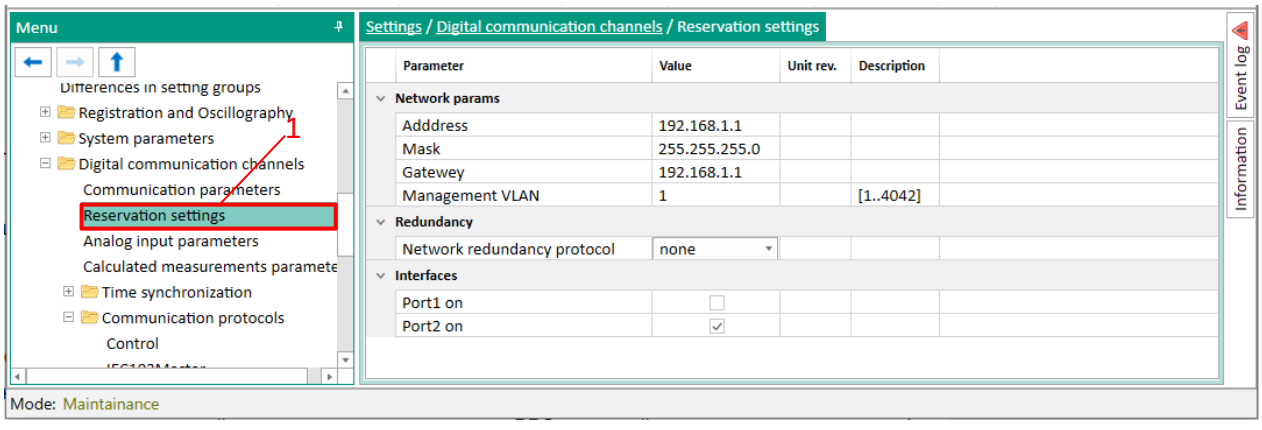
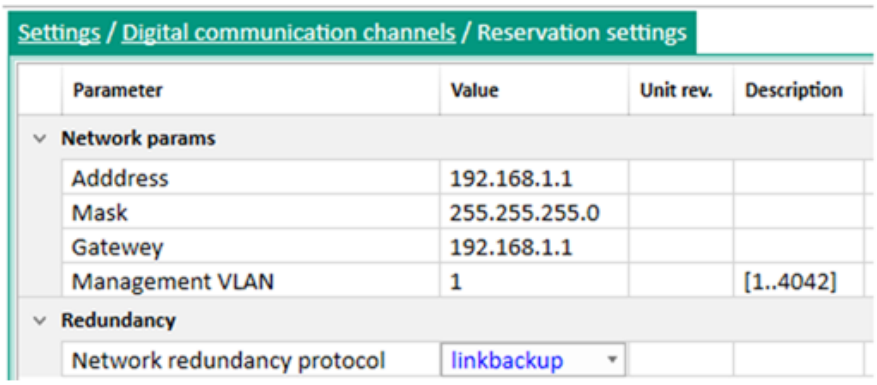
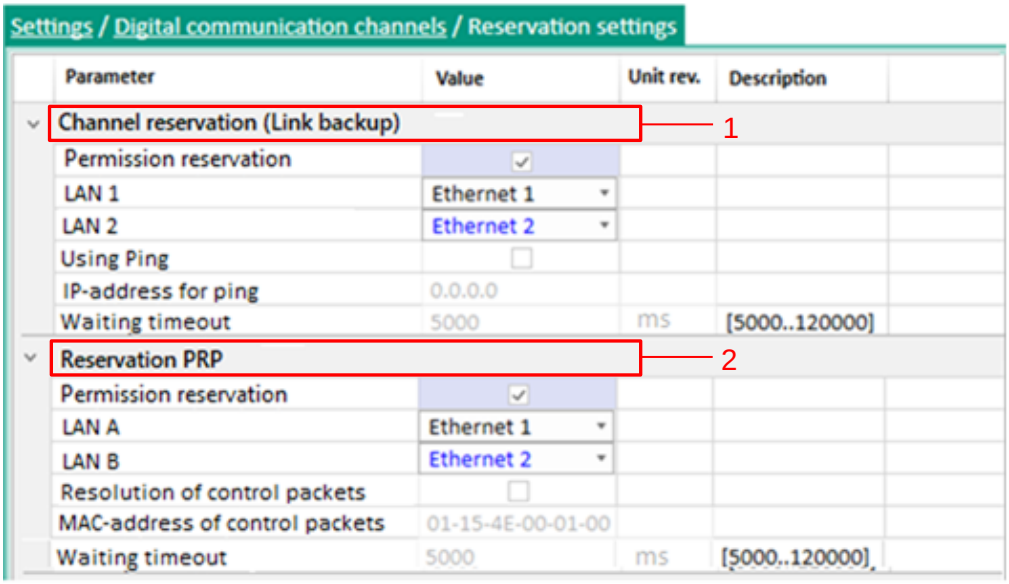


Figure 125 – **Redundancy parameters** window

8.2.3 Options for displaying the **Redundancy parameters** tab, depending on the type of logic unit used in the device, are shown in Figure 126.



a – Hardware



b – Software

Figure 126 – Options for displaying the **Redundancy parameters** tab in the Smart Monitor software, depending on the redundancy implementation

8.2.4 Configuration of the Ethernet redundancy for hardware

8.2.4.1 General parameters

The description of general parameters (see Figure 126, a) for all redundancy methods for hardware is given in Table 164.

Table 164 – Description of general parameters for all redundancy methods

Group	Parameter	Description	Note
Network parameters	Address	IP address of the redundancy module[1)]	These parameters refer to the redundancy module. Parameters of the device for operation in the Ethernet network are specified in the menu item **Settings** -> **System parameters** in the **Communication parameters** tab
	Mask	Subnet mask of redundancy module	
	Gateway	Subnet gateway of redundancy module	
	Control VLAN	Virtual network, which provides access to the settings of the redundancy module. Affects all protocols for remote access to the redundancy module	

Group	Parameter	Description	Note
Redundancy	Network redundancy protocol	Selection of a redundancy method: – none; – prp; – linkbackup	

[1)] Located in the logic module. The IP address of the redundancy module can be determined using specialized software such as HiDiscovery. The IP address of the redundancy module only needs to be changed if it matches the IP address of a device in the same network.

From the factory, the ED2 series device is supplied with a redundancy method according to the order sheet. The default redundancy method is LinkBackUp. If the wrong method is specified in the device, then it can be changed (see Figure 127).

8.2.4.2 Procedure for configuring redundancy using LinkBackUp redundancy technology

Install the LinkBackUp network redundancy protocol (see Figure 127).

If you select the LinkBackUp redundancy technology, no additional settings need to be configured.

Figure 127 shows the form when you select the LinkBackUp redundancy technology.

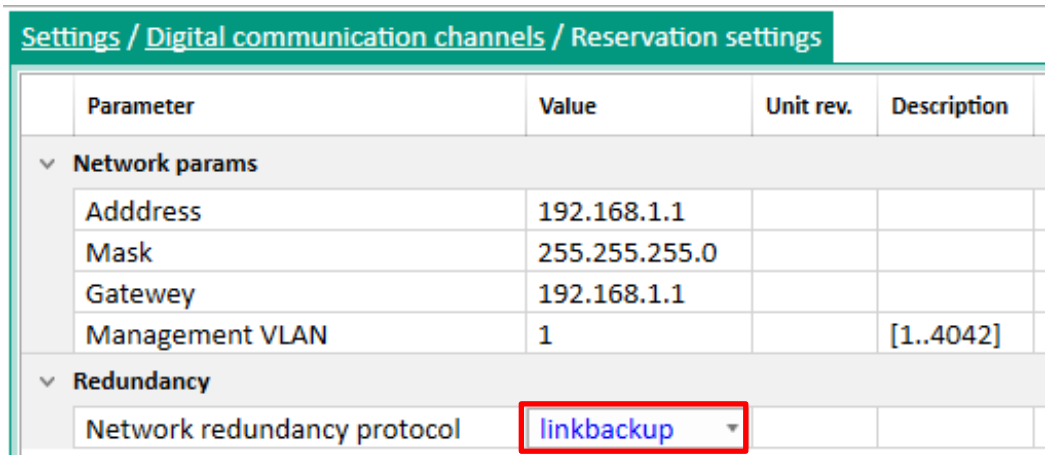


Figure 127 – Configuration of redundancy using LinkBackUp redundancy technology

NOTICE

AFTER SETTING THE REDUNDANCY PARAMETERS,

IT IS NECESSARY TO SAVE THE CHANGES MADE IN ACCORDANCE WITH 4.4.3.4!

Appendix D provides general information on the LinkBackUp redundancy technology.

8.2.4.3 Procedure for configuring redundancy via PRP protocol

Install the PRP network redundancy protocol.

When selecting the PRP redundancy protocol, it is recommended to specify the parameters shown in Figure 128.

NOTICE

AFTER SETTING THE REDUNDANCY PARAMETERS,

IT IS NECESSARY TO SAVE THE CHANGES MADE IN ACCORDANCE WITH 4.4.3.4!

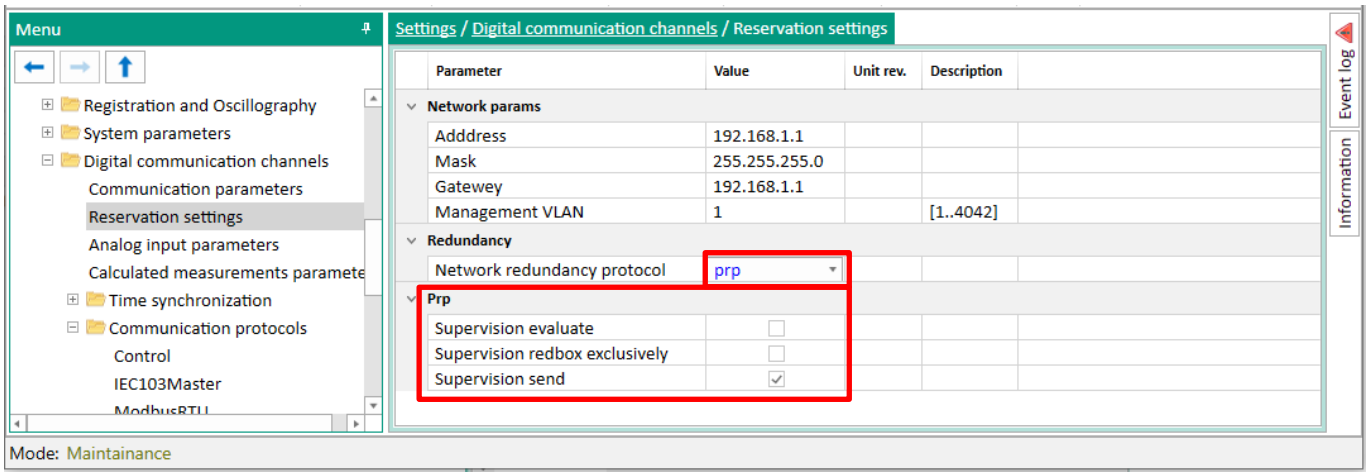


Figure 128 – Configuration of redundancy via PRP protocol

The description of parameters for configuring redundancy via PRP protocol is given in Table 165.

Table 165 – Description of parameters for configuring redundancy via PRP protocol

Group	Parameter	Description
Prp	Reception of supervision packets	Enabling tracking of supervision packets. Reception of packets is required to collect statistics and diagnose the PRP network
	Transmission of supervision packets	Enabling the generation of supervision packets from this redundancy module[1)]. Transmission of packets is required to collect statistics and diagnose the PRP network
	Transmission of VDAN packets	Enabling transmission of supervision VDAN packets. These packets contain additional diagnostic information on network devices connected to the PRP network via redundancy module of the device. Transmission of supervision VDAN packets is carried out only when the parameter **Transmission of supervision packets** is enabled
[1)] Located in the logic module		

Appendix F provides general information on the PRP protocol.

8.2.5 Configuration of Ethernet redundancy for software

8.2.5.1 Procedure for configuring redundancy using LinkBackUp redundancy technology

Select the LinkBackUp network redundancy method (see Figure 126 b, designation 1, 2).

Figure 129 shows the form when you select the LinkBackUp redundancy technology. The description of parameters of the LinkBackUp redundancy technology is given in Table 166.

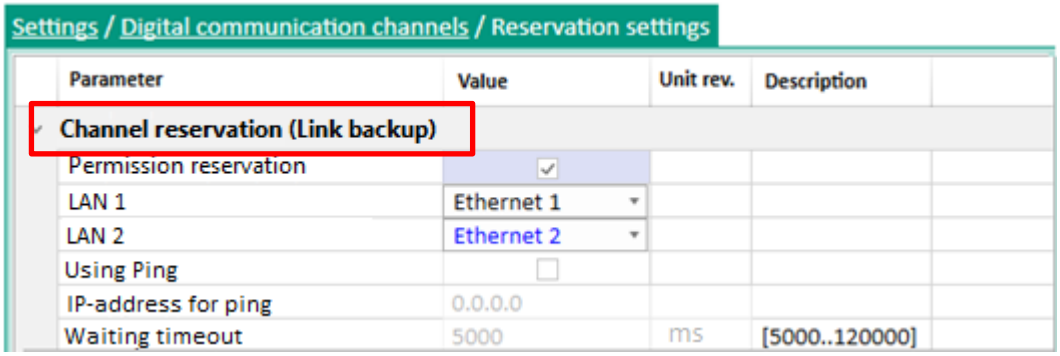


Figure 129 – Configuration of redundancy using LinkBackUp redundancy technology

Table 166 – Description of parameters of the LinkBackUp redundancy technology

Name	Default value	Description
Enable redundancy	Sign specified	Selection of the LinkBackUp redundancy technology
LAN 1	Ethernet 1	Network interface
LAN 2	Ethernet 2	Network interface
Use ping	Sign not specified	Using a link test to the device with a specified IP address
IP address for ping	0.0.0.0	Address of interrogated device
Wait timeout (ms)	5,000	Timeout waiting for response to ICMP request

After selecting the LinkBackUp redundancy technology, the communication parameters (IP address and gateway) of the Ethernet 1 and Ethernet 2 interfaces will become the same. In this case, editing communication parameters is allowed only for the LAN 1 network interface.

NOTICE

AFTER SETTING THE REDUNDANCY PARAMETERS,

IT IS NECESSARY TO SAVE THE CHANGES MADE IN ACCORDANCE WITH 4.4.3.4!

8.2.6 Save the changes made to the device similar to 3.4.1.5.

8.3 Configuration of Ethernet redundancy using the Configurator software

8.3.1 Preparation for configuration

8.3.1.1 Start the Configurator software and open the device configuration to configure the redundancy method.

8.3.1.2 In the “tree” of the project of the Configurator software, select the menu item **System parameters** (see 130, designation 1), double-clicking with the left mouse button the corresponding item in the project “tree”, and open the window.

8.3.1.3 Open the **Ethernet redundancy settings** tab (see 130, designations 2 and 3). Options for displaying the **Ethernet redundancy settings** tab, depending on the type of logic module used in the device, are shown in 130.

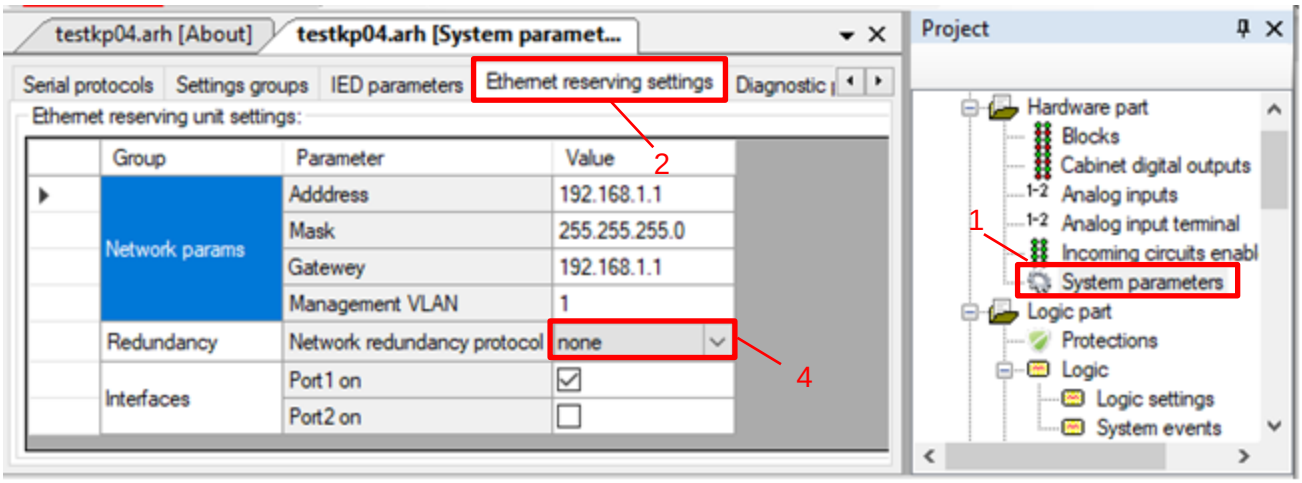


Figure 130 – Options for displaying the **Ethernet redundancy settings** tab of the Configurator software depending on the redundancy implementation

8.3.2 Configuration of Ethernet redundancy for hardware

The description of general parameters for all redundancy methods for hardware implementation is given in Table 167.

Table 167 – Description of general parameters for all redundancy methods

Group	Parameter	Description	Note
Network parameters	Address	IP address of the redundancy module[1)]	These parameters refer to the redundancy module. Parameters of the device for operation in the Ethernet network are specified in the menu item **Settings** -> **System parameters** in the **Communication parameters** tab
	Mask	Subnet mask of redundancy module	
	Gateway	Subnet gateway of redundancy module	
	Control VLAN	Virtual network, which provides access to the settings of the redundancy module. Affects all protocols for remote access to the redundancy module	
Redundancy	Network redundancy protocol	Selection of a redundancy method: – none; – prp; – linkbackup	

[1)] Located in the logic module. The IP address of the redundancy module can be determined using specialized software such as HiDiscovery. The IP address of the redundancy module only needs to be changed if it matches the IP address of a device in the same network.

NOTICE

AFTER SETTING THE REDUNDANCY PARAMETERS,

IT IS NECESSARY TO SAVE THE CHANGES MADE IN ACCORDANCE WITH 4.4.3.4!

The procedure for configuring redundancy using LinkBackUp redundancy technology is described in 8.2.4.2.

The procedure for configuring redundancy via PRP protocol is described in 8.2.4.3

8.4 Troubleshooting

Troubleshooting is specified in Table 168.

Table 168 – Troubleshooting

Description of failure	Possible cause of failure	Method of elimination
Connecting both ports resulted in loss of communication with network nodes	Appearance of a closed path of packet transmission	You need to disconnect one of the patch cables from the device and check the redundancy protocol settings. It is also possible that the external Ethernet switches are configured incorrectly or the network does not support the selected type of redundancy.

8.5 Methodology for testing the operability of networks of various topologies and corresponding redundancy algorithms

8.5.1 It is advisable to break the tests into two stages:

– checking the static network configuration;

– checking the network's capability to perform its functions when the network topology changes dynamically.

8.5.1.1 Checking static network configuration

It is necessary to check that the network is configured correctly and performs its basic data transfer functions. Evaluate the reliability of data delivery between nodes, quantify the detected data losses.

а) Link layer test with the ping[1)] utility, which relies on the ICMP service message protocol. The test runs a continuous stream of requests for the state of the remote host. For the purity of tests, you should select several topologically spaced nodes and simultaneously observe the timeliness of responses from these nodes.

б) The payload test is carried out:

– by generating cyclic GOOSE messages from one device to another;

– by creating an additional load on the network by supplying analogue signals to the devices that change stepwise in time.

To analyze network operability, criteria should be specified, such as: maximum permissible number of lost ICMP packets, maximum GOOSE message delay time, maximum number of GOOSE messages not received for a long-time interval.

8.5.1.2 Checking the network's capability to perform its functions when the network topology changes dynamically

At this stage, upon successful completion of the tests of the first stage, the same criteria should be monitored, but including the impact on the redundancy communication lines in the test conditions. Breaking

[1)] Auxiliary computer software as part of general software for checking the integrity and quality of connections in networks based on TCP/IP.

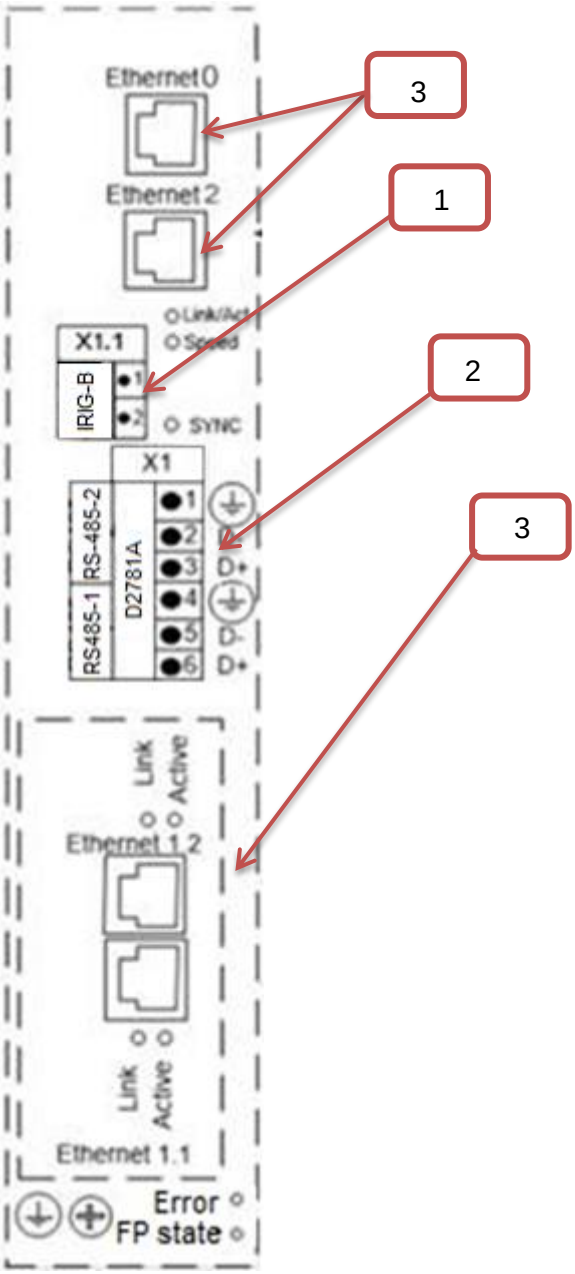
in turn various backup sections of the network, it is necessary to record the changes in the previously specified criteria.

8.5.2 Based on the test results, a conclusion is made about the suitability of the redundancy scheme for use at power facilities.

The applied redundancy topologies are given in Appendix G.

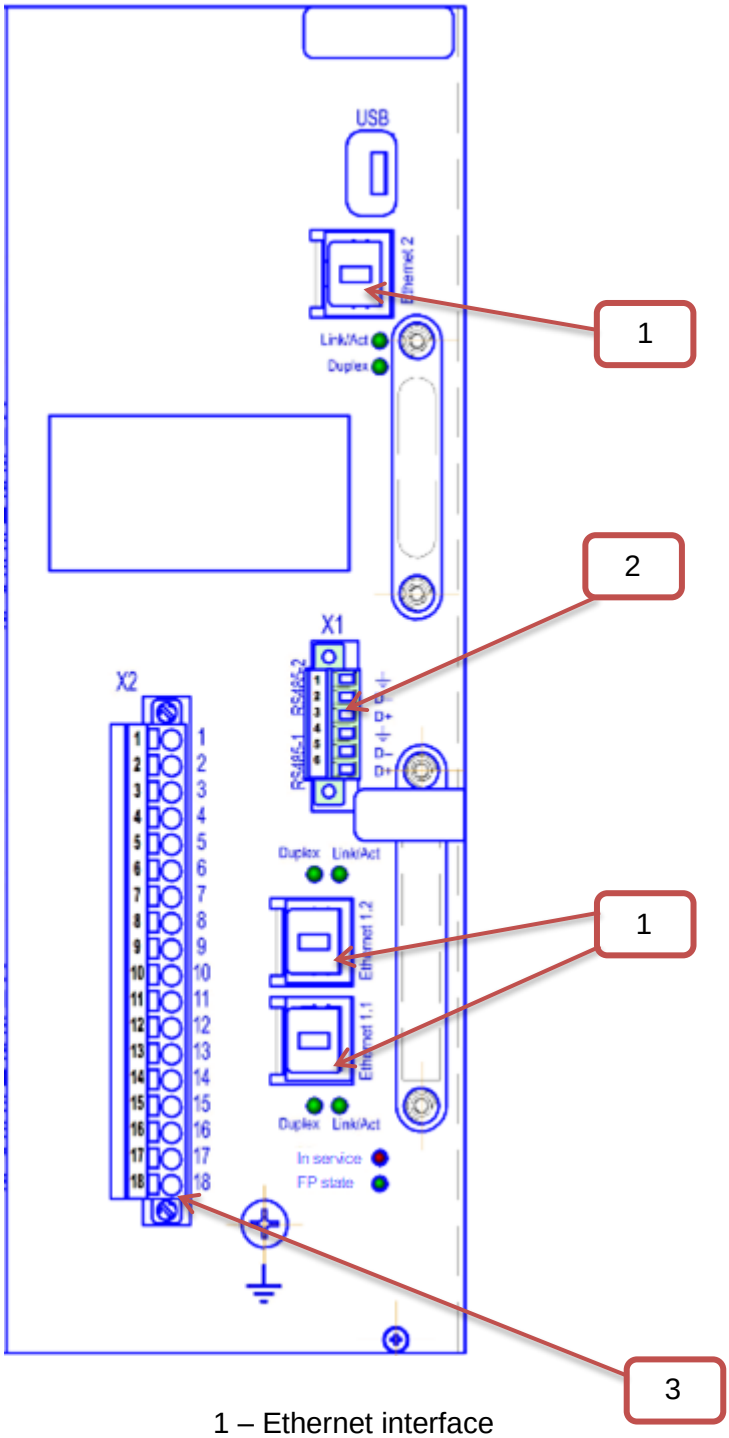
Appendix A
(reference)
Examples of location of terminal blocks and connectors of communication interfaces on the back panel of the device

Figures A.1, A.2 show examples of the location of terminal blocks and connectors for communication interfaces on the back panel of the ED2 series device.



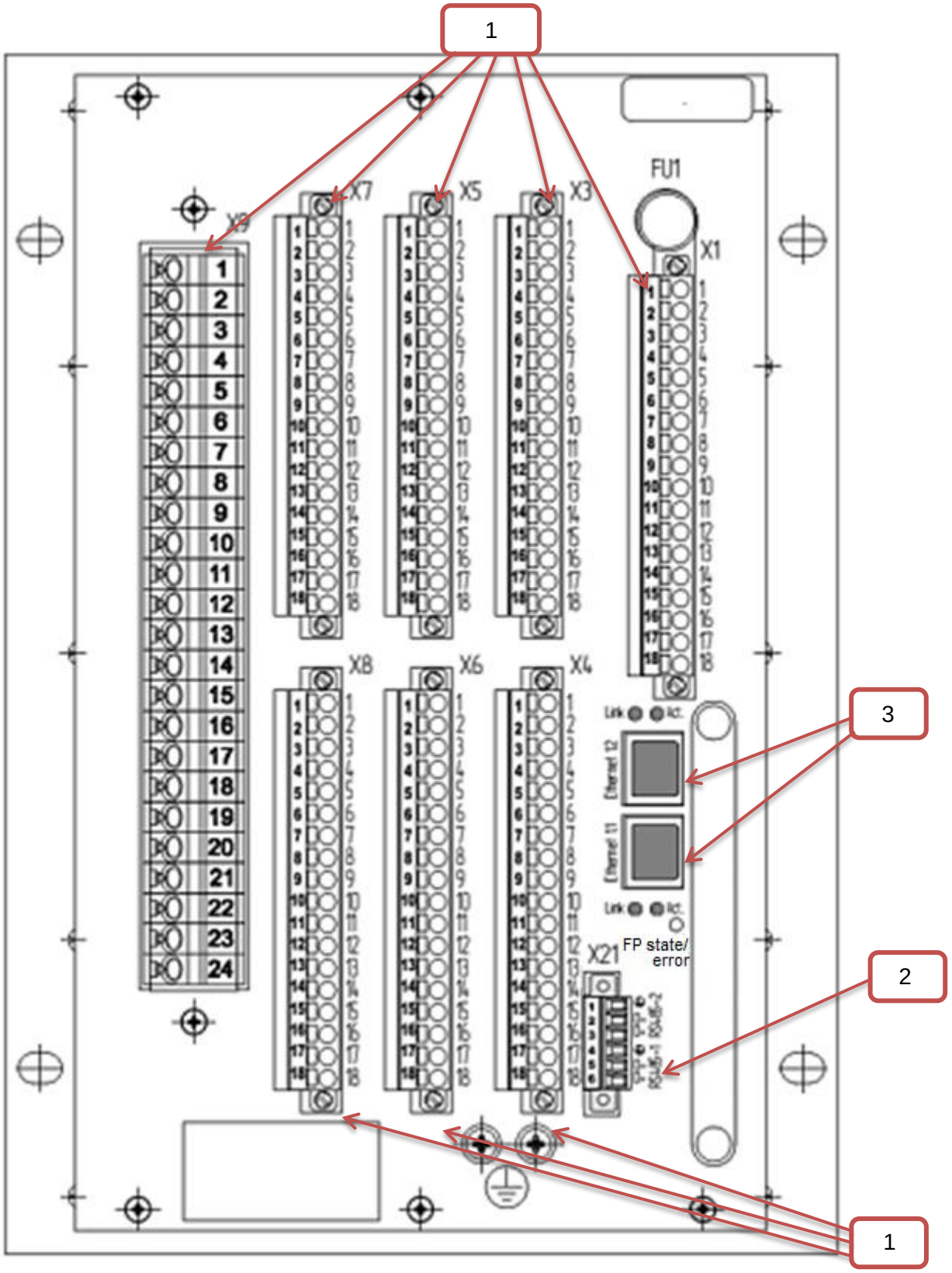
1 – IRIG-B time synchronization interface
2 – RS-485 interface
3 – Ethernet interface

Figure A.1 (Sheet 1 of 2)



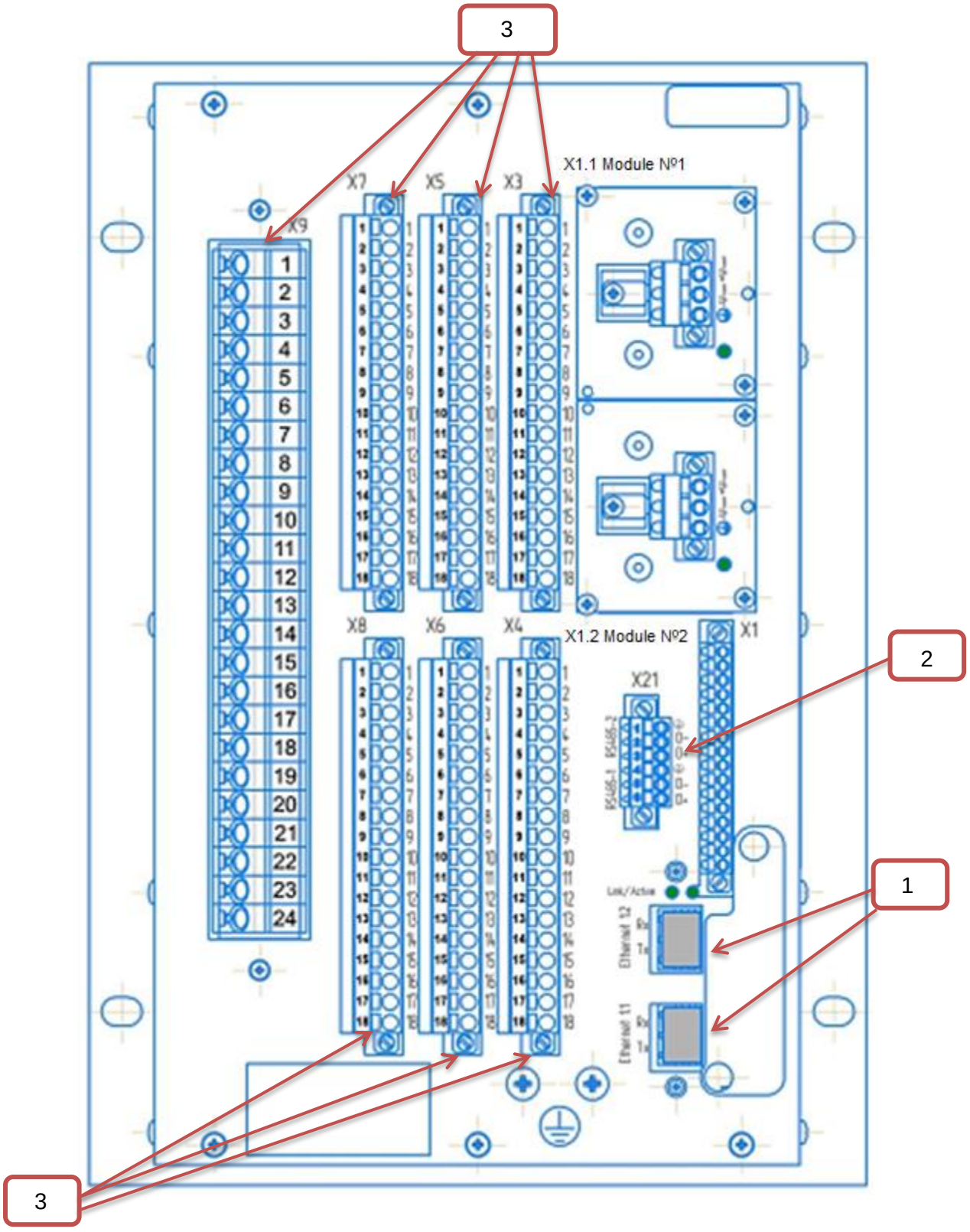
1 – Ethernet interface
2 – RS-485 interface
3 – terminal connectors

Figure A.1 (Sheet 2 of 2)



1 – terminal connectors;
2 – RS-485 interface;
3 – Ethernet interface

Figure A.2 (Sheet 1 of 2)



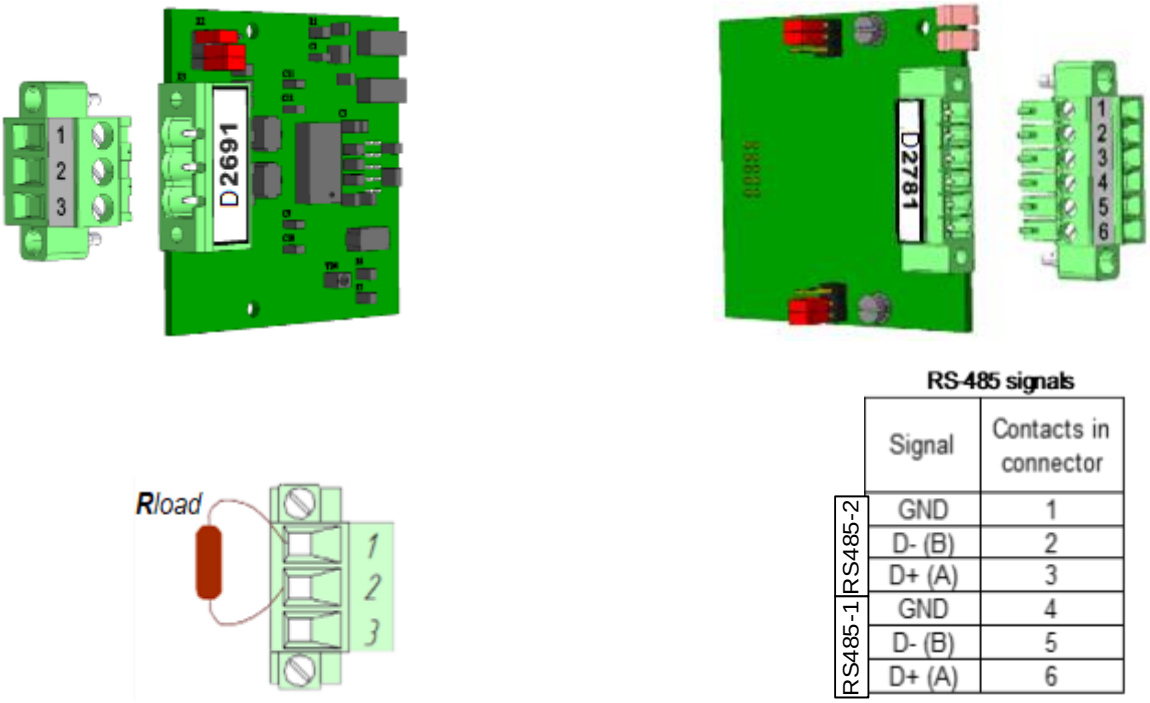
1 – Ethernet interface;
2 – RS-485 interface;
3 – terminal blocks

Figure A.2 (Sheet 2 of 2)

Appendix B

(reference)

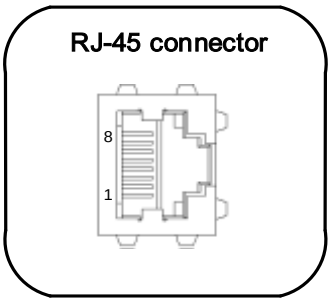
Location of contacts in interface modules



RS-485 signals

	Signal	Contacts in connector
RS485-2	GND	1
	D- (B)	2
	D+ (A)	3
RS485-1	GND	4
	D- (B)	5
	D+ (A)	6

Figure B.1 – RS-485 interface and RS-485 connection terminals for ED2 series devices



Ethernet (EIA/TIA-568) signals

Signal	Contacts in connector
Tx+	1
Tx-	2
Rx+	3
Rx+	6

Figure B.2 – Ethernet (electrical)

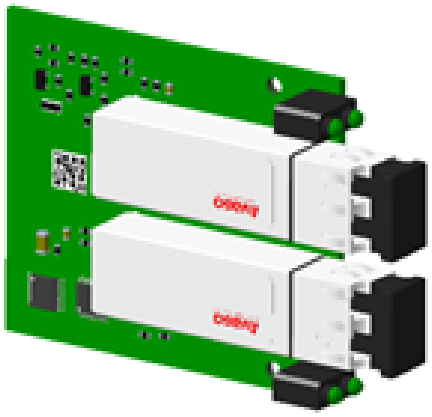
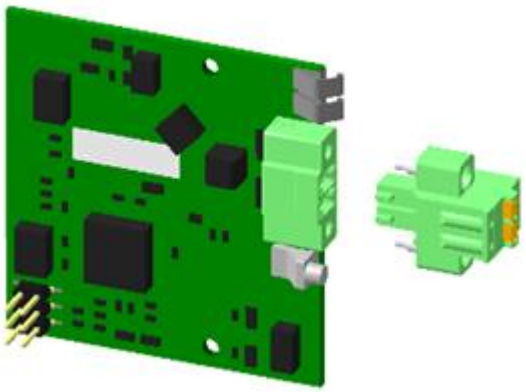


Figure B.3 – LC connector of the Ethernet interface (optical)



IRIG-B signals

Signal	Contacts in connector
Synchro+	11
Synchro-	12

PPS signals

Signal	Contacts in connector
IRIG-B+	1
IRIB-B-	2

Figure B.4 – Location of terminals for connecting time synchronization IRIG-B and PPS

Appendix C

(reference)

Examples of integration into PCS and connecting the Smart Monitor software

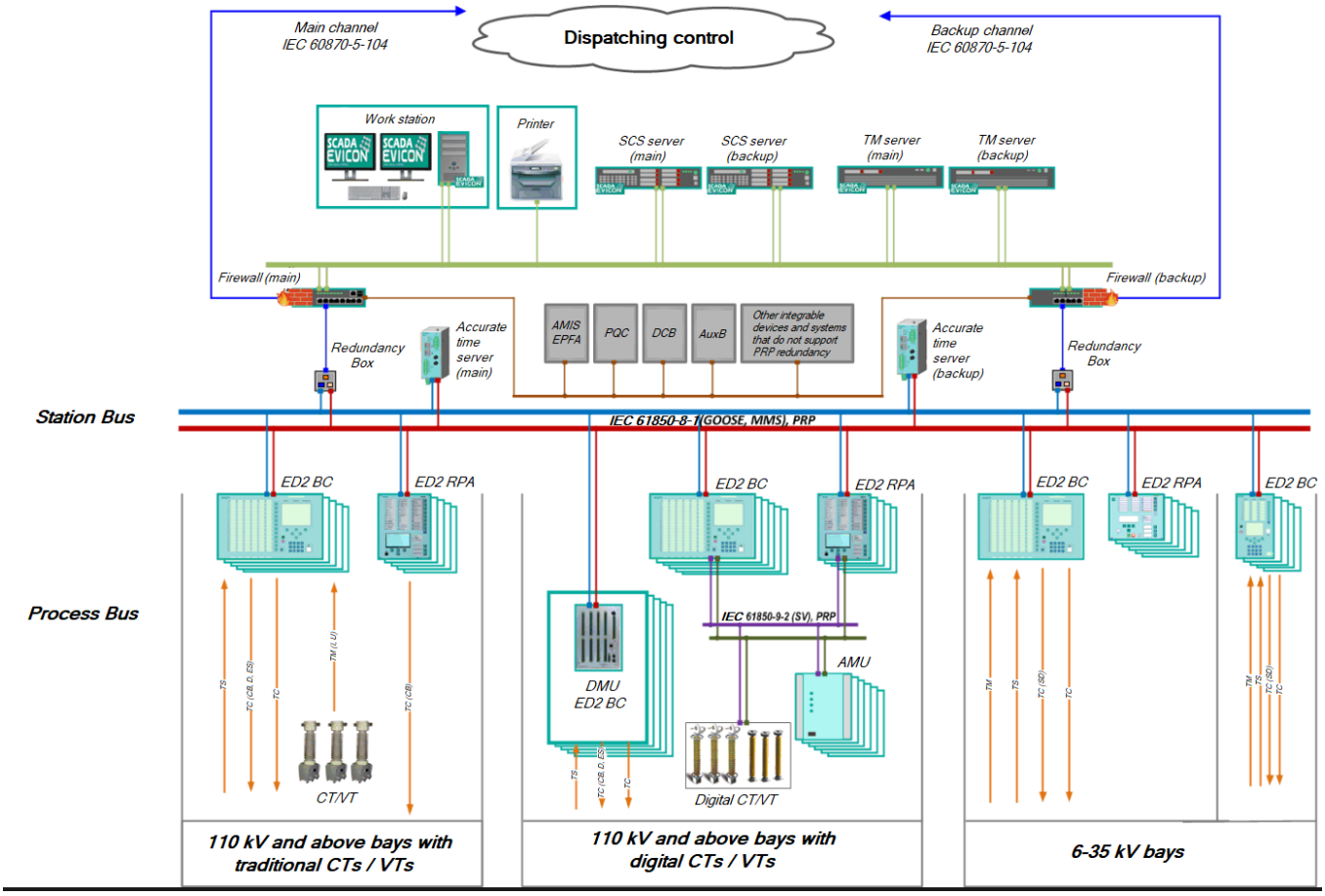
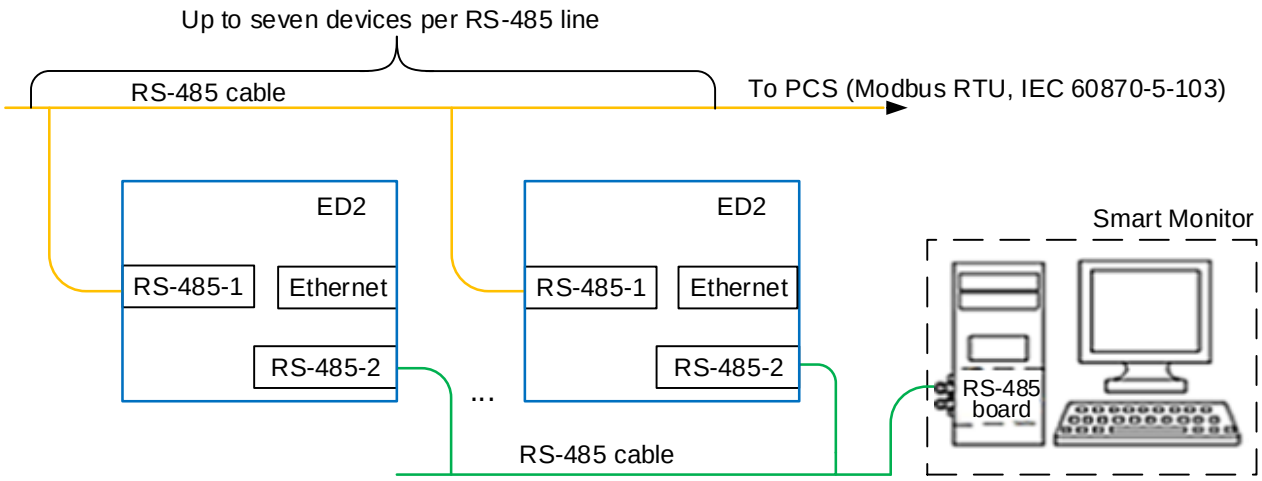


Figure C.1 – Examples of integration into PCS

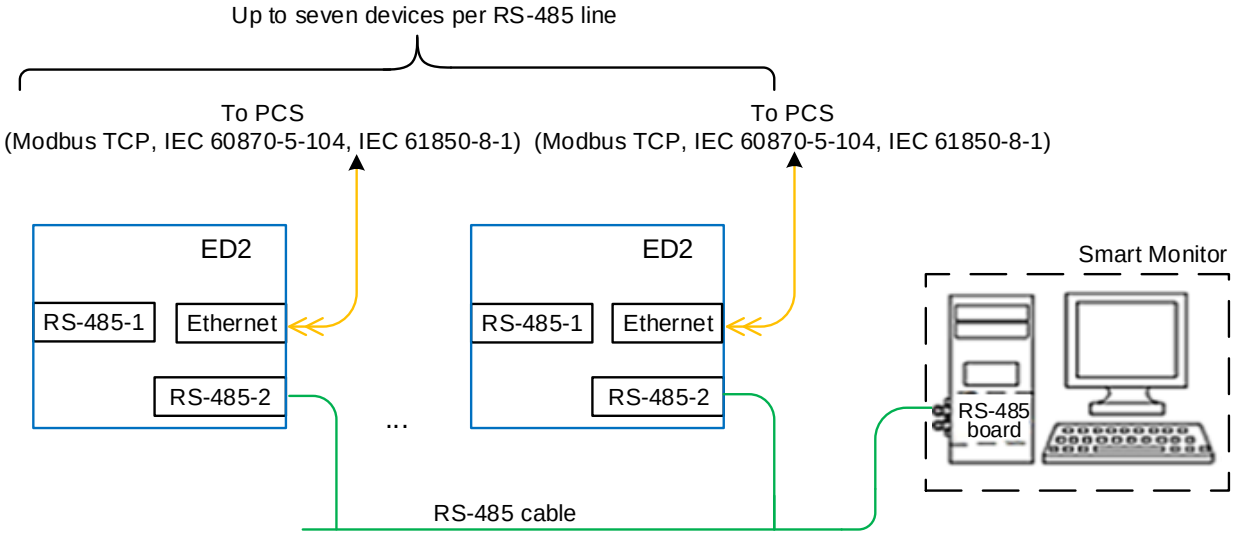
Scheme No.1

Integration into the Smart Monitor software and PCS via RS-485 interface



Scheme No.2

Integration into the Smart Monitor software via RS-485 interface and into PCS via Ethernet



Scheme No.3

Integration into PCS and the Smart Monitor software via Ethernet

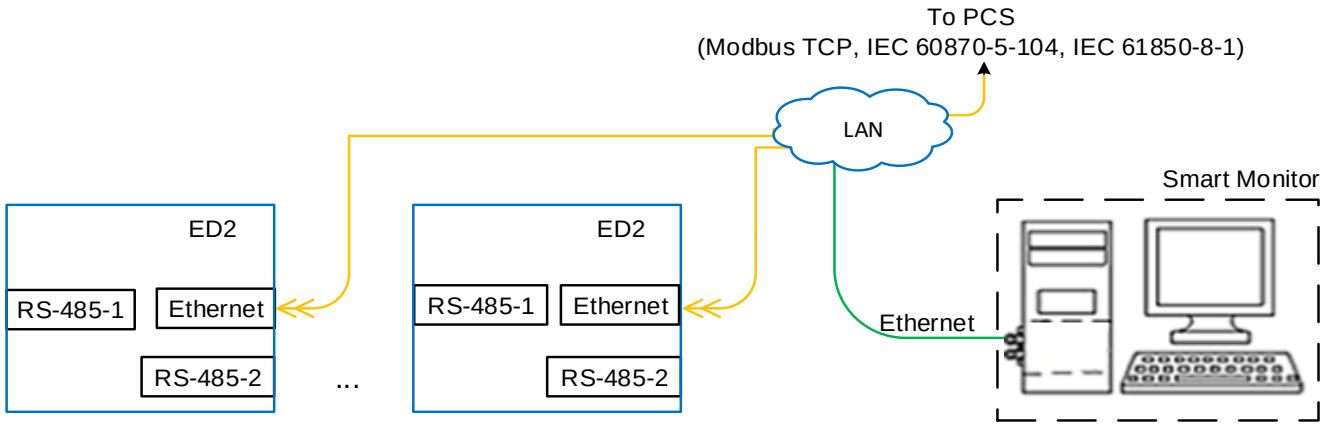
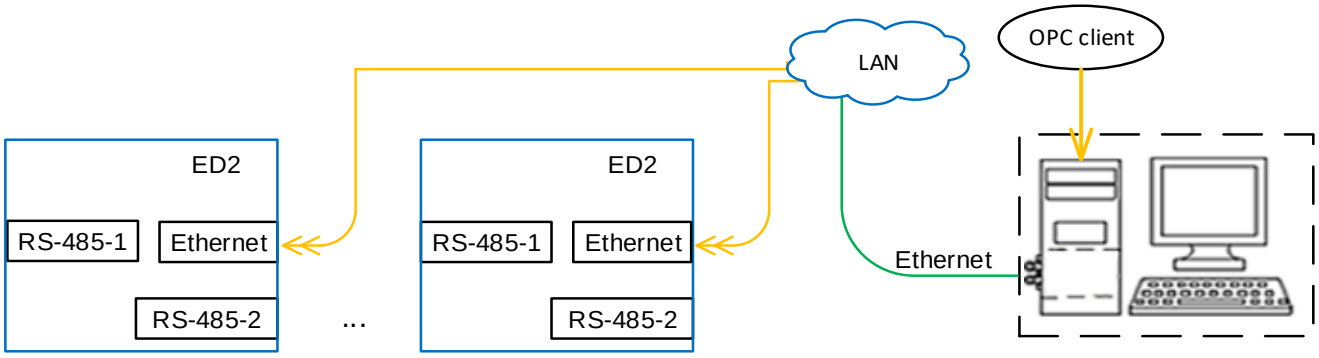


Figure C.2

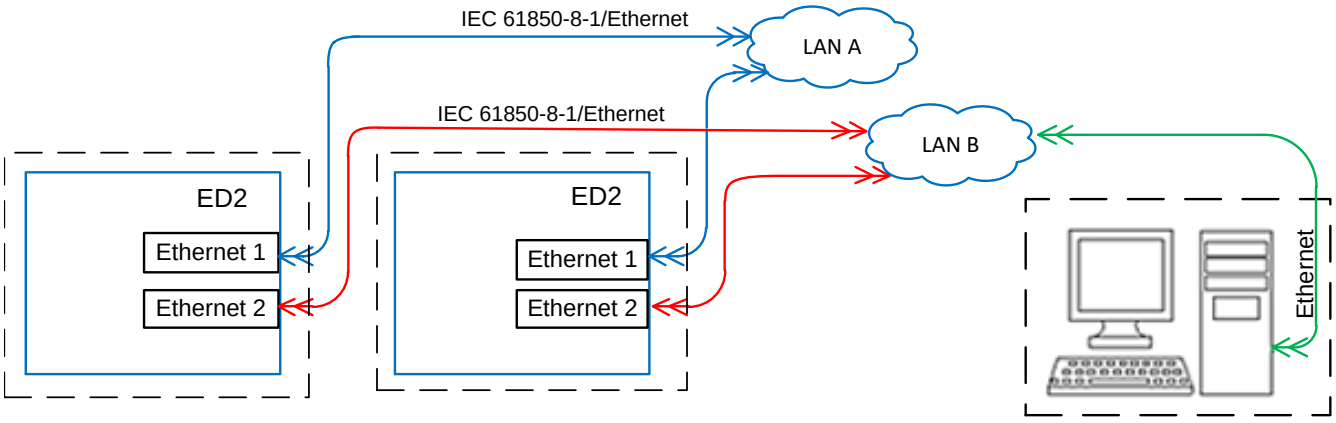
Scheme No.4

Integration into the Smart Monitor software via Ethernet. Into PCS using OPC technology



Scheme No.5

Integration into the Smart Monitor software according to IEC 61850-8-1 with a duplicated Ethernet communication channel. Into the Smart Monitor software via Ethernet



Scheme No.6

Integration into the Smart Monitor software according to IEC 61850-8-1 with a duplicated Ethernet communication channel. Into the Smart Monitor software via Ethernet

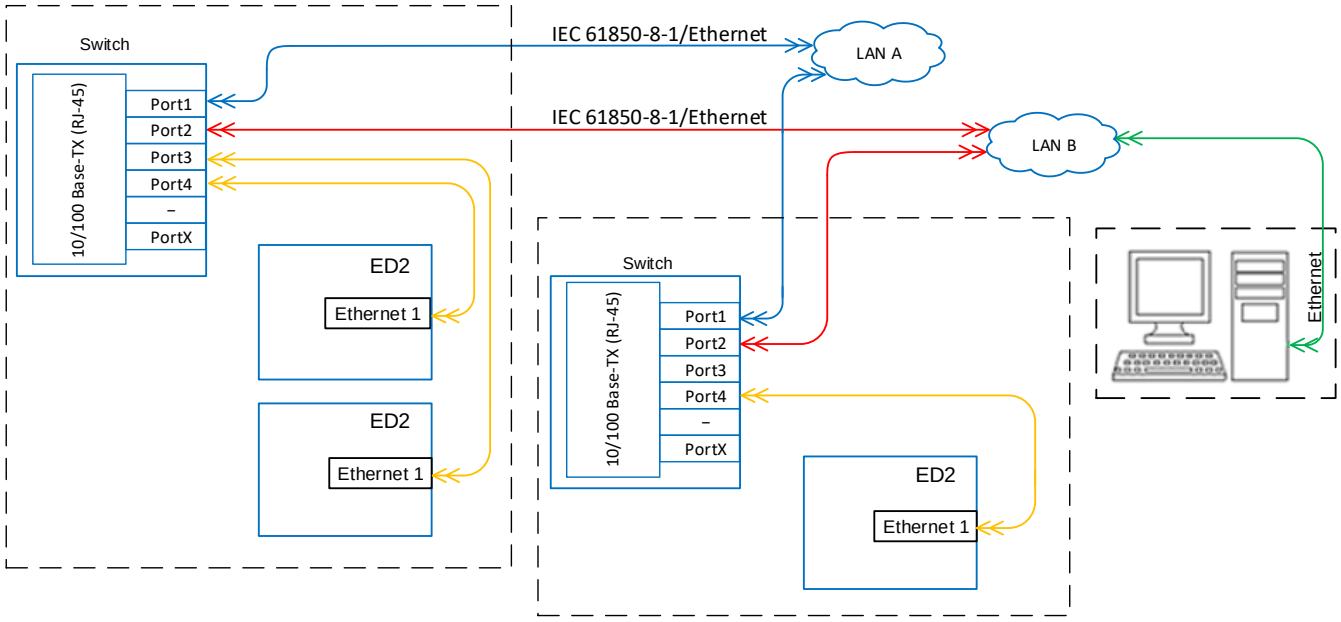


Figure C.3

Scheme No.7

Integration of the Smart Monitor software via RS-485 interface and into PCS using OPC technology

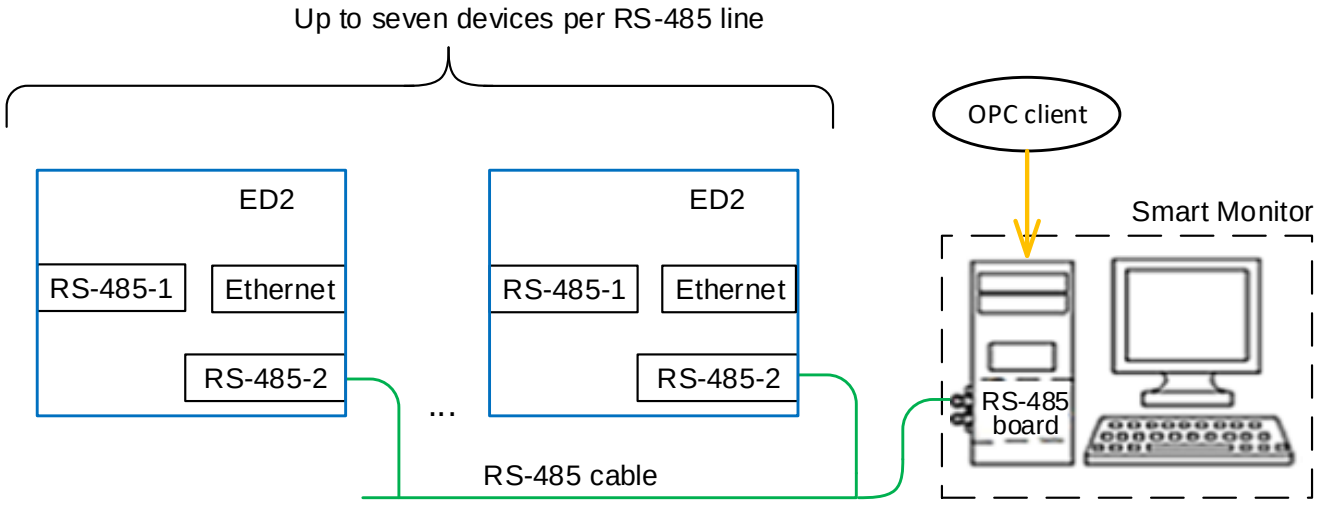


Figure C.4

Appendix D

(mandatory)

General information about network connection redundancy technology (LinkBackUp)

D.1 LinkBackUp network connection redundancy algorithm

D 1.1 Without using echo requests (ICMP type 8 – Echo-Request)

LinkBackup backs up to the nearest switch, the link status of the Ethernet cable is used to check the link operability

If the link status on the main link shows no connection, it switches to the backup port, where the link status shows the presence of a link. If then on the main channel the link status shows a connection, then the return to the main channel will occur. The connection status check period is 1 s.

D.1.2 Using echo requests (ICMP type 8 – Echo-Request)

Using echo requests allows you to back up the entire route to the end device. If there are no responses to echo requests, after the waiting timeout expires, a switch to the backup link occurs.

If, after switching to the backup channel, the connection of the main link is restored, then the return to the main link will not occur.

D.2 Application

By default, logic modules with software implementation of Ethernet network redundancy with LinkBackUp redundancy technology are used. Logic modules providing redundancy of the Ethernet network with hardware implementation are used by special order.

Appendix E

(reference)

Diagrams of hardware time synchronization

Diagram No.1 Hardware time synchronization PPS with 24 V sync pulse amplitude

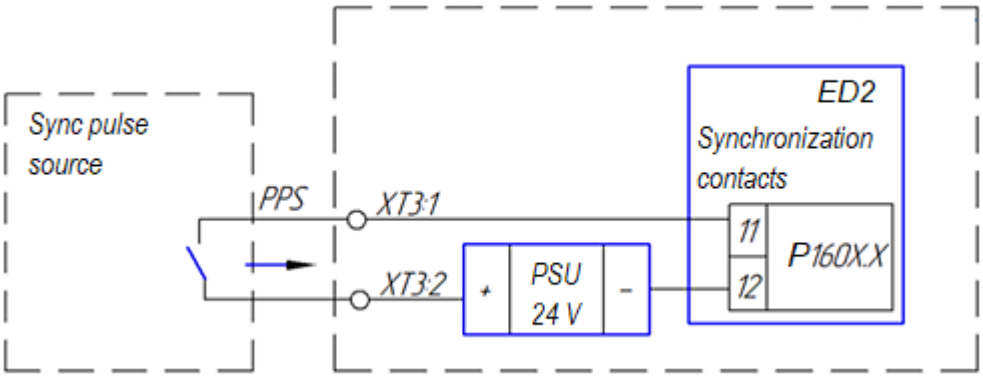


Diagram No.2 Hardware time synchronization with differential sync pulse PPS and 24 V binary input, ED2 devices

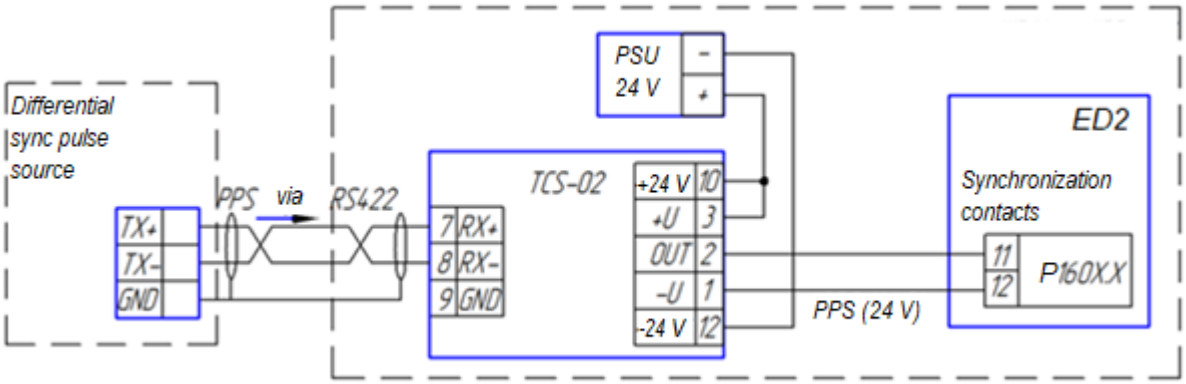


Diagram No.3 Hardware time synchronization with differential sync pulse PPS and 220 V binary input, ED2 devices

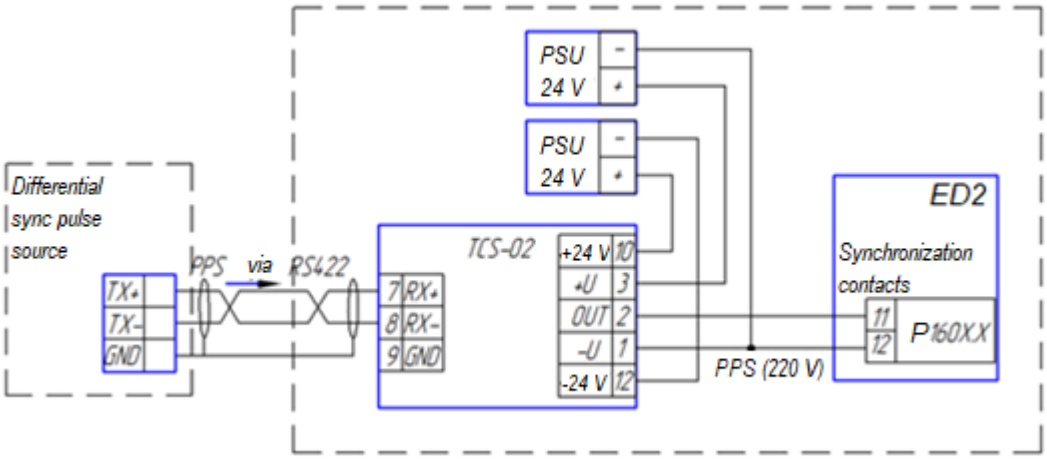


Figure E.1

Diagram No.4 Hardware time synchronization with differential sync pulse IRIG-B and synchronization contacts of TTL IRIG-B level, ED2 devices

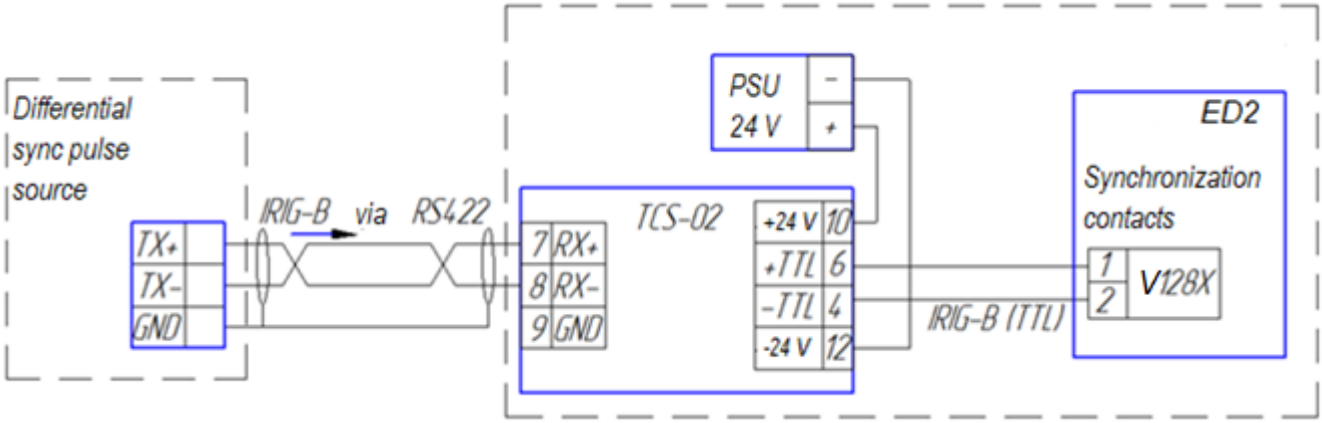


Diagram No.5 Hardware time synchronization with optical sync pulse PPS and 24 V binary input, ED2 devices

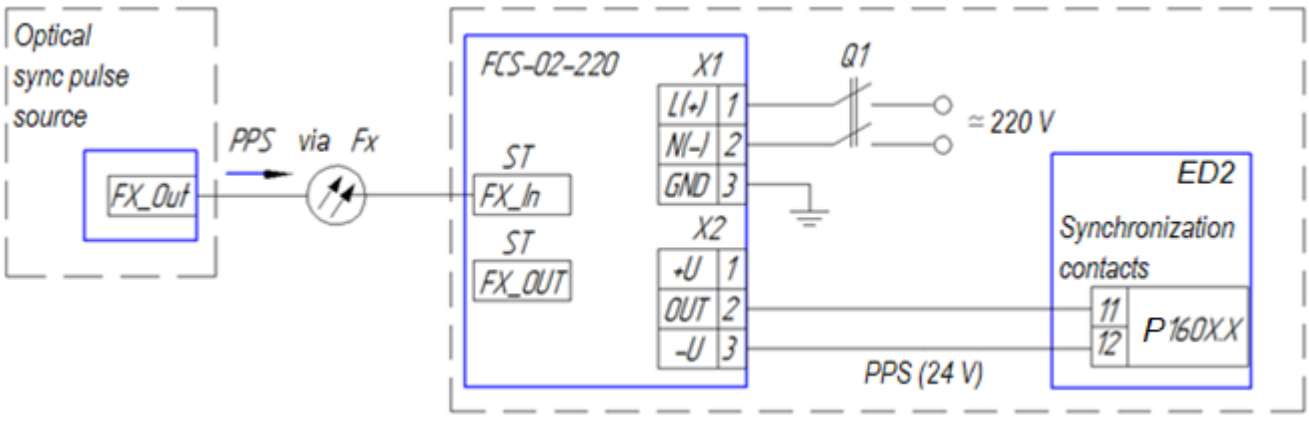


Diagram No.6 Hardware time synchronization with optical sync pulse PPS and 220 V binary input, ED2 devices

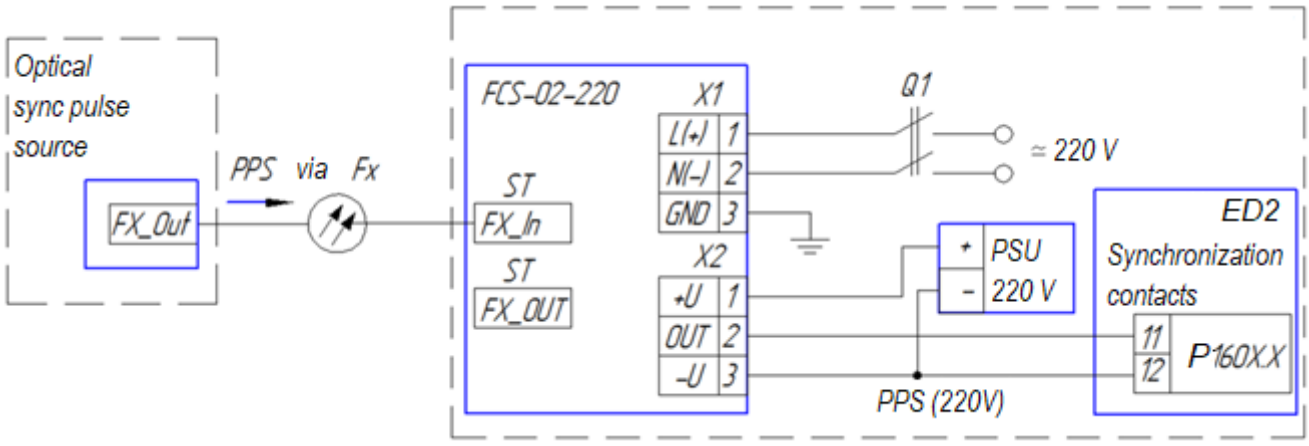


Figure E.2

Diagram No.7

Hardware time synchronization with optical sync pulse IRIG-B and synchronization contacts of TTL IRIG-B level, ED2 devices

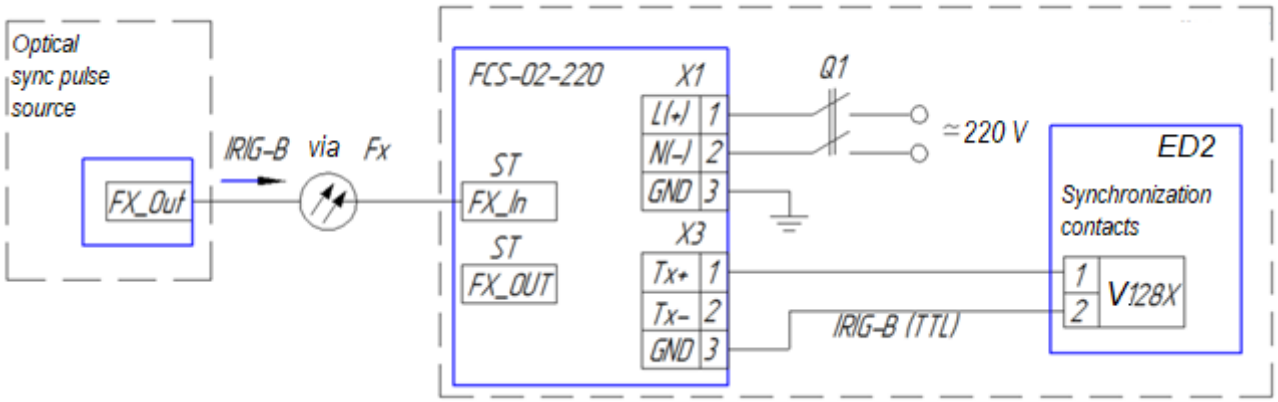


Figure E.3

Appendix F
(mandatory)
General information on the PRP protocol

F.1 Protocol description

The PRP (Parallel Redundancy Protocol) redundancy mechanism described in the IEC 62439-3 standard is based on the use of at least two simultaneously active connections between two network nodes in such a way that the sender of information sends data frames synchronously over two Ethernet channels. The receiver, in accordance with the redundancy protocol, accepts the first data frame and rejects the second one. If the second data frame is not received, the receiver concludes that the connection on the corresponding channel is lost.

F.2 Field of application

There are applications where even the minimum network recovery time (GOOSE, SV) is unacceptable. These applications require a completely new approach to high availability of network. The PRP protocol allows to “seamlessly” (without breaks) back up a connection with instant switching from the main to the redundant communication channel, using two parallel data transmission networks with an arbitrary topology, not limited by rings or other structures.

Duplicate frames in each channel in the data area contain a special marker – RCT, which distinguishes one frame from another in DAN nodes (DAN (Double Attached Node for PRP) – PRP-enabled end devices that have two network interfaces and connect to two independent networks).

On the other hand, for SAN nodes (see below), the token looks like user data, which requires standard Ethernet equipment to only support longer ethernet frames, such as jumbo frames.

SANs are ordinary end devices with a single network interface (SAN – Single Attached Node), which can also be connected to PRP without support for “seamless” redundancy.

Annex G

(mandatory)

Applied redundancy topologies

G.1 An example of a network topology with “zero frame loss” when using the PRP protocol in the device is shown in Figure G.1;

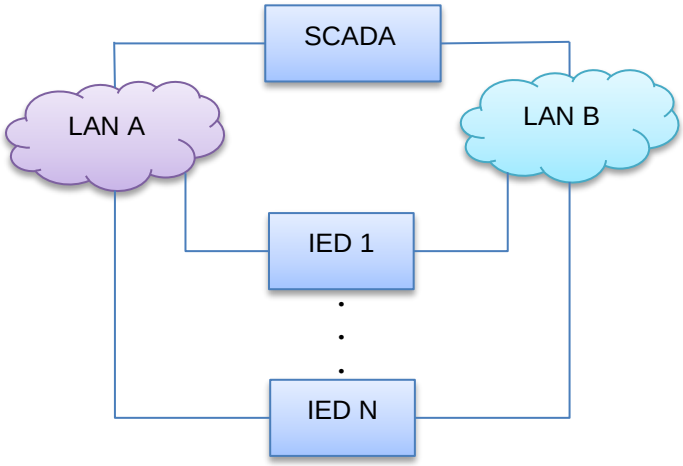


Figure G.1

A PRP driver or a network card with PRP support is installed on ports 1 and 2.

G.2 An example of a network topology with “frame loss” when using network connection redundancy (LinkBackup) in the device is shown in Figure G.2;

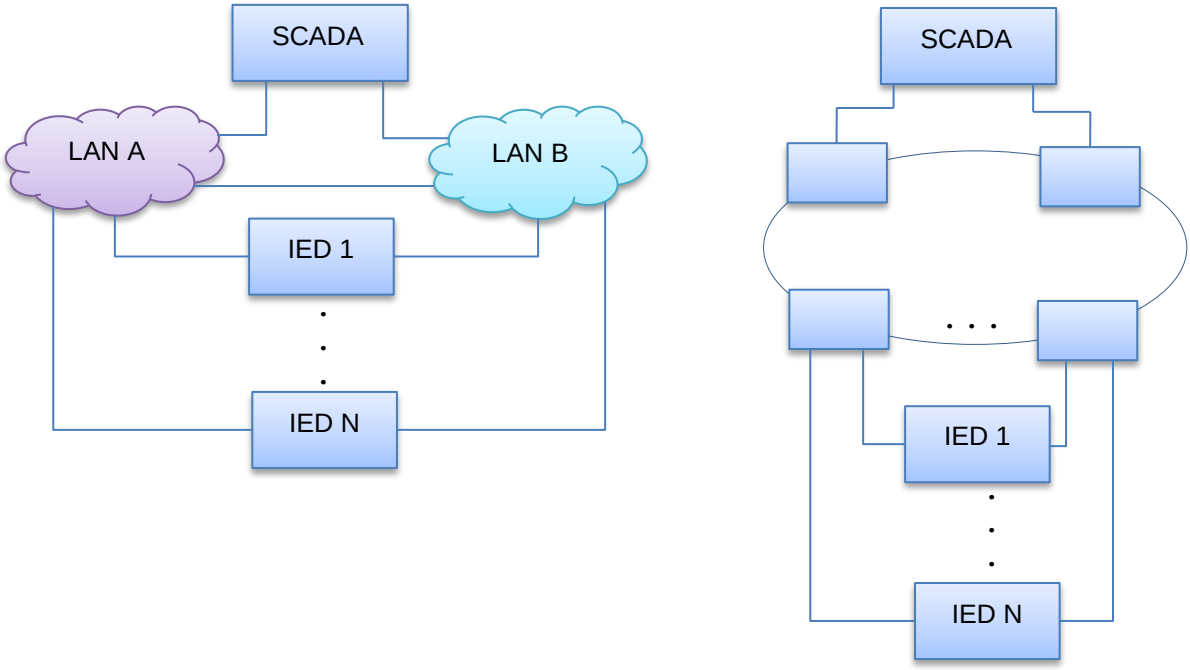


Figure G.2