
Multifunctional measuring device ESM

Manual

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Introduction

The Manual contains information on functionality, recommendations for usage, maintenance, packing, transportation, storage, getting technical support as well as connection of the ESM device to the measurement circuits, power circuits and digital interfaces.

Read this manual carefully before using the device.

Typical users

The document is intended for the personnel involved in the design, installation, commissioning and operation of the device.

Support

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ATTENTION:

- Use ESM as described in this manual only;
- ESM should be installed, operated and maintained by qualified personnel only;
- Do not use any cleanser except recommended;
- Save ESM from impact;
- Before connecting ESM, ensure that the local power supply conditions agree with the specifications on the label of the ESM.



NOTICE:

- The information contained in this document is a subject to change without notice;
- New features may be added to the devices without notice.
- The most up-to-date documentation and software are available for download from www.enip2.com

If the device is used not as specified in the manual, safety, functionality and accuracy of the device may be impaired.

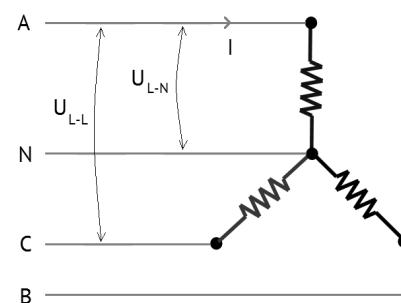
Glossary

- AC – Alternating current;
- ADC – Analog-to-digital converter;
- CT – Current Transformer;
- DC – Direct current;
- DI – Digital (binary) input;
- DIO – Digital (binary) signal;
- DO – Digital (binary) output;
- DSP – Digital Signal Processor;
- EMC – Electromagnetic compatibility;
- FTP – File Transfer Protocol;
- LPCT – Low Power Current Transformer;
- MCU – Microcontroller unit;
- PE – Protective earth;
- PC – personal computer;
- PQ – Power Quality monitoring;
- PRP – Parallel Redundancy Protocol;
- RSTP – Rapid Spanning Tree Protocol;
- RTU – Remote Terminal Unit;
- SCADA – Supervisory Control and Data Acquisition;
- SSR – Solid-state relay;
- SV – Sampled Values (IEC 61850-9-2);
- VT – Voltage Transformer;

$U_{L-L}(U_{AB}, U_{BC}, U_{CA})$ – line-to-line voltage

$U_{L-N}(U_A, U_B, U_C)$ – line-to-neutral voltage

$I (I_A, I_B, I_C)$ – phase current



1 General information

1.1 Overview

1.1.1 ESM devices are designed for:

- measuring of voltage, current, frequency, phase, electric power in 3-wire or 4-wire 3-phase AC electrical grids;
- measuring and interpreting of results for power quality parameters in 3-phase electrical grids (in accordance with IEC 61000-4-30:2008, IEC 61000-4-7:2009, IEC 61000-4-15:2010);
- electricity metering (both active and reactive) in 3-phase power system (in accordance with IEC 62052-11:2003, IEC 62053-22:2003, IEC 62053-23:2003);
- transmitting measured parameters via RS-485 and Ethernet.

1.1.2 ESM devices can be operated as a part of various automated systems, e.g., industrial control systems, electricity accounting systems, power quality monitoring systems etc.

1.1.3 ESM devices can be used as:

- revenue meters in accordance with IEC 62052-11:2003, IEC 62053-22:2003 and IEC 62053-23:2003 standards: active energy class 0.2S or 0.5S, reactive energy class 0.5 or 1;
- power quality meters in accordance with IEC 61000-4-30:2008 (A or S classes) and IEC 61000-4-7:2009 (I class);
- panel meters (when combined with ENMI display panel);
- digital measuring transducers for measuring (and calculating) phase current, phase and line-to-line voltage, frequency, phase differences for phase currents, phase voltages, phase voltage and phase current, power factor (for each phase and average value), active, reactive and apparent power (each phase and total);

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1.2 ESM modifications

1.2.1 Three modifications of ESM are available:

- ESM-HV with analog inputs to connect to conventional current and voltage instrument transformers;
- ESM-ET with low-voltage inputs to connect to electronic instrument transformers;
- ESM-SV processing IEC 61850-9-2 sampled values.

1.2.2 ESM-HV



Figure 1.1. ESM-HV modification

- current inputs for connection to the electromagnetic CT with the nominal secondary current up to 5 A;
- voltage inputs for connection to the electromagnetic VT with the secondary voltage rated at 57.7 L-N V or for connection straight to the grid (230 L-N (400 L-L) V or 400 L-N (690 L-L) V).

1.2.3 ESM-ET



Figure 1.2. ESM-ET modification

ESM-ET modification is intended for connection to the electronic instrument transformers (IEC 60044-8, IEC 60044-7, IEC 61869-6, LPCT, Rogowski coil etc.) via ET1, ET2, ET3, ET4 interfaces.

1.2.4 ESM-SV



Figure 1.3. ESM-SV modification

ESM-SV modification is for connection to the process bus (IEC 61850-9-2 SV256, SV288). Connection ports are “LAN5”, “LAN6” and “LAN7” – (SV input).

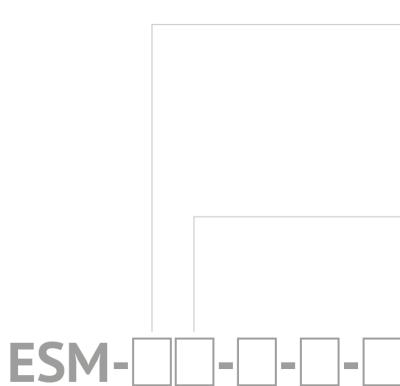
1.2.5 ESM combined with display module



Figure 1.4. ESM and display module

ENMI-5 display module can complement ESM devices. It displays measuring data as well as further information. ESM, combined with display module, is used in the panel meters.

1.3 Naming convention



Connection type

HV – conventional CT and VT
ET – electronic CT and VT
SV – according IEC 61850-9-2

Rated input values

ESM-HV

100 – 57.7 (100) V phase (line-to-line)
400 – 230 (400) V phase (line-to-line)
690 – 400 (690) V phase (line-to-line)

ESM-ET

– current, V: **1** – 0.15, **2** – 0.2, **3** – 0.225,
4 – 0.333, **5** – 1.0, **6** – 1.625, **7** – 2, **9** – 4
– voltage, V: **2** – 0.2, **4** – 0.333, **5** – 1.0,
6 – 1.625, **7** – 2.0, **8** – 3.25, **9** – 4

TOU revenue metering and PQM

ESM-HV

02A – energy class (active/reactive) 0.2S/0.5; PQM class A
02S – energy class (active/reactive) 0.2S/0.5; PQM class S
05A – energy class (active/reactive) 0.5S/1.0; PQM class A
05S – energy class (active/reactive) 0.5S/1.0; PQM class S

ESM-ET

05S – energy class (active/reactive) 0.5S/1.0; PQM class S
ESM-SV

02A – energy class (active/reactive) 0.2S/0.5; PQM class A

Interfaces

A2E2 – 2 × RS-485, 2 × 100Base-TX
A2E4 – 2 × RS-485, 4 × 100Base-TX

Power supply voltage

220 – 100–265 V AC (45–55 Hz) or 120–370 V DC
110 – 40–160 V DC
24 – 18–36 V DC

Options:

SD8G.esm – additional storage for power quality reports and logs.

1.4 Design and dimensions

1.4.1 ESM devices are produced in molded plastic enclosure for din-rail (35 mm) mounting. It can be paired with display module to display measured and calculated information. There are optical and impulse outputs for the purpose of device verification.

1.4.2 Dimensions, weight, installation method and IP code are shown in Table 1.1.

Table 1.1

Parameter	ESM device + sealing cover	ESM and display module
Weight, kg	0.6	0.9
Dimensions HWD, mm	75x100x125	120x120x152
Installation	DIN-rail 35 mm	dimensions of hole (in the panel) are 111x111 mm, panel's width is not more than 6 mm
IP code (IEC 60529-89)	IP40	IP51 on the front panel

1.4.3 Technical drawings of ESM devices are in the fig. 1.5, 1.6.

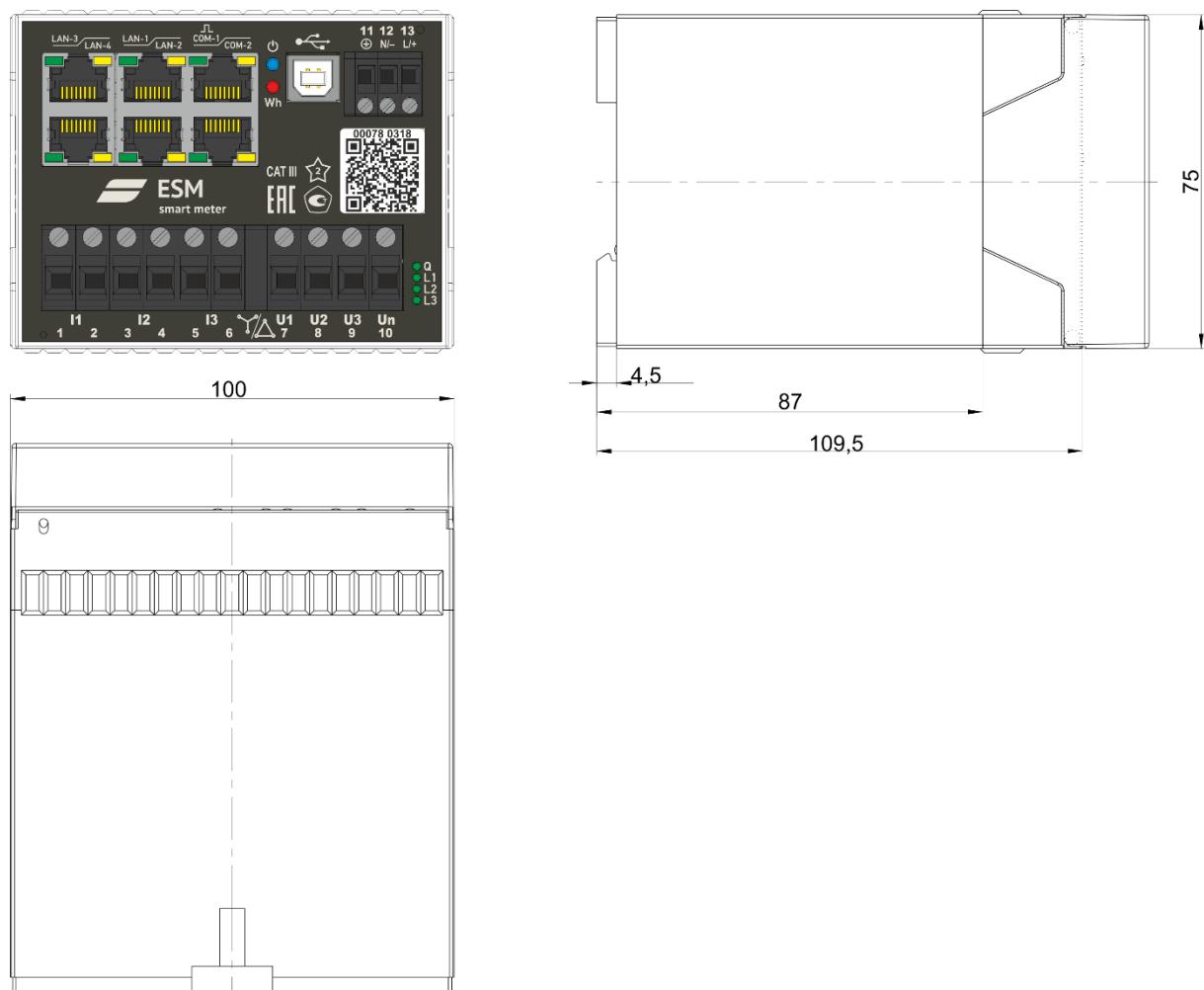


Figure 1.5. ESM dimensions

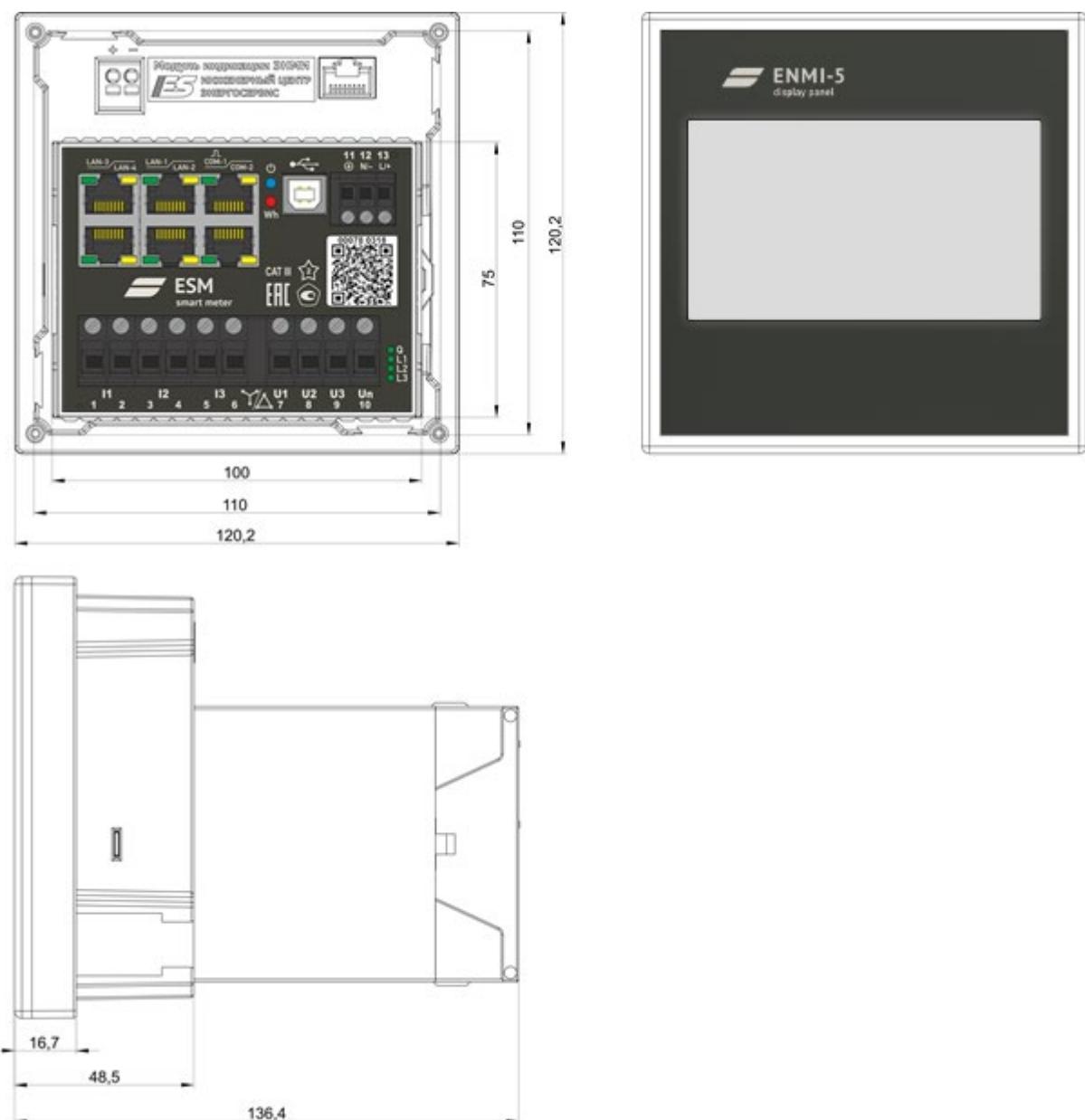


Figure 1.6. Dimensions of ESM paired with display module

2 Feature

2.1 Measurements

2.1.1 All ESM modifications measure and calculate the parameters listed at the table 2.1.

Table 2.1

No.	Parameter	Symbol	3/4 – wire connection for ESM-HV modification
Voltage and current parameters			
1	RMS phase voltage, V	U_A, U_B, U_C, U_{av}	4
2	RMS line-to-line voltage, V	$U_{AB}, U_{BC}, U_{CA}, U_{LLav}$	3,4
3	RMS phase voltage of fundamental harmonic, V	$U_{A(1)}, U_{B(1)}, U_{C(1)}$	4
4	RMS line-to-line voltage of fundamental harmonic, V	$U_{AB(1)}, U_{BC(1)}, U_{CA(1)}$	3,4
5	Phase voltage over deviation, %	$\delta U_{A(+)}, \delta U_{B(+)}, \delta U_{C(+)}$	4
6	Line-to-line voltage over deviation, %	$\delta U_{AB(+)}, \delta U_{BC(+)}, \delta U_{CA(+)}$	3,4
7	Phase voltage under deviation, %	$\delta U_{A(-)}, \delta U_{B(-)}, \delta U_{C(-)}$	4
8	Line-to-line voltage under deviation, %	$\delta U_{AB(-)}, \delta U_{BC(-)}, \delta U_{CA(-)}$	3,4
9	Steady-state voltage deviation, %	$\delta U_{steady-state}$	3,4
10	RMS positive sequence voltage, V	U_1	4
11	RMS negative sequence voltage, V	U_2	4
12	RMS zero sequence voltage, V	U_0	4
13	Phase voltage harmonics ($n = 1 \dots 50$), V	$U_{A(n)}, U_{B(n)}, U_{C(n)}$	4
14	Line-to-line voltage harmonics ($n = 1 \dots 50$), V	$U_{AB(n)}, U_{BC(n)}, U_{CA(n)}$	3
15	Phase voltage harmonics, %	$K_{UA(n)}, K_{UB(n)}, K_{UC(n)}$	4
16	Line-to-line voltage harmonics, %	$K_{UAB(n)}, K_{UBC(n)}, K_{UCA(n)}$	3
17	Phase voltage THD, %	K_{UA}, K_{UB}, K_{UC}	4
18	Line-to-line voltage THD, %	$K_{UAB}, K_{UBC}, K_{UCA}$	3
19	Negative sequence voltage unbalance, %	K_{2U}	4
20	Zero sequence voltage unbalance, %	K_{0U}	4
21	Phase voltage interharmonics, V	$U_{Aisg(m)}, U_{Bisg(m)}, U_{Cisg(m)}$	4
22	Line-to-line voltage interharmonic, V	$U_{ABisg(m)}, U_{BCisg(m)}, U_{CAisg(m)}$	3
23	Phase angle of fundamental harmonic line-to-line voltages, °	$\varphi_{UAB(1)}, \varphi_{UBC(1)}, \varphi_{UCA(1)}$	4
24	Frequency, Hz	f	3,4
25	Frequency deviation, Hz	Δf	3,4
26	RMS phase current, A	I_A, I_B, I_C, I_{cp}	3,4
27	RMS phase current of fundamental harmonic, A	$I_{A(1)}, I_{B(1)}, I_{C(1)}$	3 ¹⁾ ,4
28	RMS positive sequence current, A	I_1	3,4
29	RMS negative sequence current, A	I_2	3,4
30	RMS zero sequence current, A	I_0	3,4
31	Phase current harmonics, A	$I_{A(n)}, I_{B(n)}, I_{C(n)}$	3,4
32	Current harmonics, %	$K_{IA(n)}, K_{IB(n)}, K_{IC(n)}$	3,4
33	Phase current THD, %	K_{IA}, K_{IB}, K_{IC}	3,4
34	Negative sequence current unbalance, %	K_{2I}	3,4
35	Zero sequence current unbalance, %	K_{0I}	3,4
36	Phase current interharmonics, A	$I_{Aisg(m)}, I_{Bisg(m)}, I_{Cisg(m)}$	3,4
37	Phase angle of current fundamental harmonic, °	$\varphi_{IA(1)}, \varphi_{IB(1)}, \varphi_{IC(1)}$	3,4
38	Voltage and current phase difference, °	$\varphi_{UIA(1)}, \varphi_{UIB(1)}, \varphi_{UIC(1)}$	4

No.	Parameter	Symbol	3/4 - wire connection for ESM-HV modification
39	Voltage and current phase difference (positive, negative and zero sequence), °	$\varphi_{U1I1}, \varphi_{U2I2}, \varphi_{U0I0}$	4
40	Voltage and current harmonics phase difference, °	$\varphi_{UIA(n)}, \varphi_{UIA(n)}, \varphi_{UIA(n)}$	4
Voltage sags and swells			
41	Voltage sag duration (Δt_d), s	Δt_d	3,4
42	Voltage sag magnitude (δU_d), %	δU_d	3,4
43	Voltage interruption duration (Δt_{int}), s	Δt_{int}	3,4
44	Voltage swell duration (Δt_s), s	Δt_s	3,4
45	Voltage swell coefficient (K_s)	K_s	3,4
46	Short term flicker	P_{St}	3,4
47	Long term flicker	P_{Lt}	3,4
Electric power parameters			
48	Power factor (A, B, C and average) ($K_p = P/S$)	$K_{PA}, K_{PB}, K_{PC}, K_{Pcp}$	4
49	Active power (A, B, C), W	P_A, P_B, P_C	4
50	Total active power, W	P	3,4
51	Active power (A, B, C) of fundamental harmonic, W	$P_{A(1)}, P_{B(1)}, P_{C(1)}$	4
52	Total active power of fundamental harmonic, W	$P_{(1)}$	3,4
53	Active power (A, B, C and total) of n th harmonic, W	$P_{A(n)}, P_{B(n)}, P_{C(n)}, P_{(n)}$	4
54	Positive, negative and zero sequence active power, W	$P_{1(1)}, P_{0(1)}, P_{2(1)}$	4
55	Reactive power (A, B, C), var	Q_A, Q_B, Q_C	4
56	Total reactive power, var	Q	3,4
57	Reactive power (A, B, C) of fundamental harmonic, var	$Q_{A(1)}, Q_{B(1)}, Q_{C(1)}$	4
58	Total reactive power of fundamental harmonic, var	$Q_{(1)}$	3,4
59	Reactive power (A, B, C and total) of n th harmonic, var	$Q_{A(n)}, Q_{B(n)}, Q_{C(n)}, Q_{(n)}$	4
60	Positive, negative and zero sequence reactive power, var	$Q_{1(1)}, Q_{0(1)}, Q_{2(1)}$	4
61	Apparent power (A, B, C), VA	S_A, S_B, S_C	4
62	Total apparent power, VA	S	3,4
63	Apparent power (A, B, C) of fundamental harmonic, VA	$S_{A(1)}, S_{B(1)}, S_{C(1)}$	4
64	Total apparent power of fundamental harmonic, VA	$S_{(1)}$	3,4
65	Apparent power (A, B, C and total) of n th harmonic, VA	$S_{A(n)}, S_{B(n)}, S_{C(n)}, S_{(n)}$	4
66	Positive, negative and zero sequence apparent power, VA	$S_{1(1)}, S_{2(1)}, S_{0(1)}$	4
Electric energy parameters			
67	Active energy, Wh	W_p	3,4
68	Fundamental harmonic active energy, kWh	$W_{P(1)}$	3,4
69	Positive sequence active energy, kWh	W_{P1}	4
70	Reactive energy, kvarh	W_Q	3,4
71	Fundamental harmonic reactive energy, kvarh	$W_{Q(1)}$	3,4
72	Positive sequence reactive energy, kvarh	W_{Q1}	4

2.2 Communication protocols

For data transmit ESM support following protocols:

- Modbus RTU;
- Modbus TCP;
- IEC 60870-5-101;

- IEC 60870-5-104;
- IEC 61850-8-1 (optional);

Additional protocols:

- PRP (parallel redundancy protocol) – Ethernet protocol for working at two separated networks that provides seamless failover;
- RSTP (rapid spanning tree protocol) – Ethernet protocol for loop network topology;
- SNTP v4 – time synchronization protocol;
- SNMP – protocol for diagnostic information;
- RS-TCP – pass-through mode.

2.3 Event logs

2.3.1 ESM keeps record of the following logs:

Table 2.2

Nº	Log name	Max. num.	Available events
1	discrete signals	1000	on/off DO on/off DI on/off Set point on/off Logic on/off GOOSE on/off Diagnostic
2	authorization	100	Access level 1(2/3) Access level 1(2/3). Error
3	authorization errors	100	Authorization blocked
4	energy resets	10	Reset energy counters
5	profile resets	10	Reset power profile
6	power on/off	100	Reboot, On, Off
7	calibration coefficients changes	10	Calibration coefficients written
8	overvoltage and undervoltage	100	Overvoltage event end of overvoltage event Undervoltage End of undervoltage
9	time synchronization	100	Коррекция времени Синхронизация времени
10	firmware updates, settings/password changes	10	Firmware updated Settings changed Password changed Passwords reset
11	correct coefficients changes	10	Correction coefficients written
12	memory test	31	Result of non-volatile memory testing
13	logs reset	10	Reset logs

2.3.2 Every event in the logs has timestamp with 1 ms accuracy.

2.4 Revenue metering

- 2.4.1 ESM devices can segregate energy consumption by tariff zones (8), day type (255) and time of day (255) and provide time-of-use data.
- 2.4.2 ESM devices can measure electric energy when power quality standards are not met.
- 2.4.3 Active and reactive energy (data) retention time:
- 30-min intervals – 123 days;
 - 60-min intervals – 180 days;
 - 24 hours – 366 days;
 - 1 month – 10 years.
- 2.4.4 ESM can generate power quality report based on power quality statistical analysis.

2.5 ESM-HV analog inputs

- 2.5.1 Rated values for ESM-HV voltage and current inputs are in the table 2.3.

Table 2.3

Parameter	Value
Rated phase (line-to-line) voltage AC U_n , V ¹⁾	57.7 (100); 230 (400); 400 (690)
Rated current (max values), A	5 (10)
Rated frequency, Hz	50
Meter constant, imp/(kW·h) (imp/(kvar·h))	1000 - 100000
Starting current, A,	0.001

¹⁾ Depends on device modification;

2.6 ESM-ET low level inputs

- 2.6.1 Electronic current and voltage transformers must be connected to ET1, ET2, ET3, ET4 interfaces (these are shielded RJ45 ports).



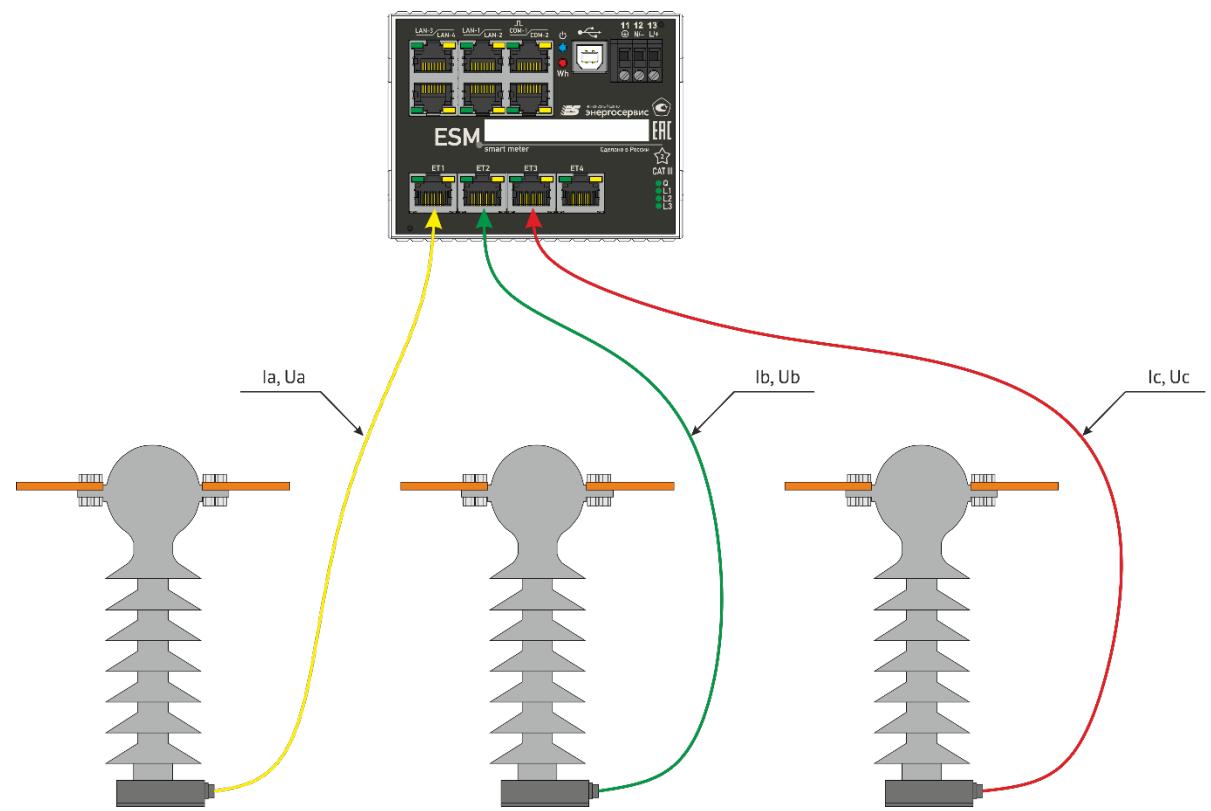


Figure 2.1. Using of ESM-ET with low level inputs.

2.6.2 The pinout of the RJ45 connectors for connecting measuring sensors to the ESM hw 3.2 in accordance with IEC 61869-6. The connection to current sensors of the LPCT type is shown in table 2.4. The connection diagram to the Rogowski coil current sensors (modifications ESM-ET9X and ESM-ETX9) is shown in table 2.6.

Table 2.4. Pinout of ESM-ET inputs (besides ESM-ET9X and ESM-ETX9) hw. 3.2

Port	Pin	Signal	Description
ET1 ET2 ET3	1	AGND	Sensor ground (cable shield)
	2	-	-
	3	V+	Sensor power supply +12 V
	4	TV-	
	5	TV+	Voltage inputs
	6	V-	Sensor power supply -12 V
	7	TA+	
	8	TA-	Current inputs

Table 2.5. Pinout of ESM-ET9X and ESM-ETX9 inputs hw. 3.2

Port	Pin	Signal	Description
ET1 ET2 ET3	1	AGND	Sensor ground (cable shield)
	2	-	-
	3	-	-
	4	TA-	
	5	TA+	Current inputs
	6	-	-
	7	TV+	
	8	TV-	Voltage inputs

Table 2.6 Pinout of ESM-ET of older hardware versions.

Port	Pin	Description	
		hw 1.2 – hw 2.1	hw 3.0 – hw 3.1
ET1	1	TA-	AGND
	2	TA+	AGND
ET2	3	-	TA-
ET3	4	-	TA+
	5	TV-	TV-
	6	TV+	TV+
	7	V+	V+
	8	V-	V-

2.6.3 Possible nominal voltages for voltage channels:

- 200 mV;
- 333 mV;
- 1.0 V;
- 1.625 V;
- 2.0 V;
- 3.25 V;
- 4.0 V;

or these divided by $\sqrt{3}$.

Possible nominal voltages for current channels:

- 150 mV;
- 200 mV;
- 225 mV;
- 333 mV;
- 1.0 V;
- 1.625 V;
- 2.0 V;
- 4.0 V.

These nominal values must be specified in the ordering information.

2.6.4 The maximum operating voltage of 12 V; maximum input capacitance - 10 pF.

- 2.6.5 Combined current and voltage transformer (CVS by Altea B.V., Netherlands; TECV.P1 by Optimetrik, Russia) can be connected to ESM-ET75 modification (see characteristics in table 2.7).

Table 2.7

Characteristics	Value	Description
Current channel (measurements)		
Nominal voltage	2 V	Differential signal
Voltage range	0.02 – 3.25 V	
Nominal input resistance	10 MΩ ±5%	
Voltage channel (measurements/protection)		
Nominal voltage	1V	Differential signal
Voltage range	0.02 – 2 V	
Nominal input resistance	10 MΩ ±5%	
Power supply channel		
Voltage	±12 V ±10%	
Current (power) consumption / phase	15 mA (180 mBA)	
Plug type	shielded RJ45	Shield of cable needs to be grounded

- 2.6.6 ESM-ET calculates current and voltage of primary circuit based on these low-level input signals and scale coefficients (settings for scale coefficients can be changed by «ES Configurator» software).

Table 2.8 shows what the device will display if scale coefficients are equal to 1.

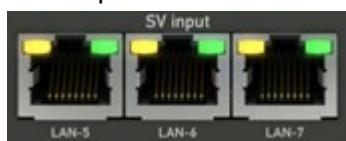
Table 2.8

Channel	Low-level signal value	Scale coefficient	Primary current and voltage
Current channel (ET1, ET2, ET3)	2 V	1	5 A
Voltage channel (ET1, ET2, ET3)	1 V	1	57.7 V

- 2.6.7 Wiring diagrams for ESM-ET and electronic transformers are in the appendix A.3.

2.7 ESM-SV IEC 61850 9-2 streams

- 2.7.1 ESM-SV has LAN-5, LAN-6, LAN-7 (shielded RJ45 ports) interfaces to connect the device to the process bus.



- 2.7.2 ESM-SV modification is able to receive up to 3 IEC 61850-9-2LE streams for up to 4 current (I_a , I_b , I_c , I_n) and 4 voltage (U_a , U_b , U_c , U_n) channels at a rate of 256 samples per second. It is possible to use the first data stream for phase current, the second data stream for the phase voltage and the third data stream for the current and for the voltage in neutral wire.

3 Specification

3.1 Interfaces

The following interfaces are available at ESM devices:

	ESM-...-A2E2	ESM-...-A2E4
USB	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
RS-485-1, RS-485-2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2xEthernet 100Base-T	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2xEthernet 100Base-T (additional)		<input checked="" type="checkbox"/>

See pin diagrams in the table 2.6.

3.1.1 Available protocols for clock synchronization: IEC 60870-5-101, IEC 60870-5-104, SNTP.

3.1.2 Normal and working conditions for ESM operation are in the table

3.1.

Table 3.1

Parameter	Normal conditions	Working conditions
Temperature, °C	+15...+25	-40...+70*
Relative humidity, %	up to 98 (+25 °C)	
Atmospheric pressure, kPa (mmHg)	80-106,7 (600-800)	65-106,7 (487,5-800)

* If ESM device is combined with display module, the range is from -10 to +70 °C

3.1.4 Power supply requirements are in table 3.2.

Table 3.2

Parameter	Value
For ESM-...-220-... modifications	
Input AC voltage range	~100...265 V, 45...55 Hz
Input DC voltage range	=120...370 V
Power consumption	max 10 VA
For ESM-...-110-... modifications	
Input DC voltage range	=42...176 V
Power consumption	max 10 W
For ESM-...-24-... modifications	
Input DC voltage range	=18...36 V
Power consumption	max 10 W
For ESM device + display module	
Power consumption	max 19 VA

3.1.5 Apparent power consumption by individual series circuit of ESM-HV device (if the current and the frequency have their nominal value) is up to 0.1 VA. Apparent power consumption

by individual parallel circuit of ESM-HV device (if the voltage and the frequency have their nominal value) is up to 0.1 VA.

- 3.1.6 Insulation between each separated circuit and housing is more than $100\text{ M}\Omega$ (500 V DC).
- 3.1.7 ESM insulation coordination is according to IEC 60255-5-2000:
 - for insulation between power input and housing: 2.0 kV voltage, 50 Hz frequency, 1 min duration;
 - for insulation between interface circuits (RS-485, Ethernet) and all other circuits and housing: 0.5 kV voltage, 50 Hz frequency, 1 min duration;
 - for insulation between measuring circuits and all other circuits and housing:
 - 2.0 kV voltage, 50 Hz frequency, 1 min duration (for ESM-HV modification);
 - 0.5 kV voltage, 50 Hz frequency, 1 min duration (for ESM-ET modification).
- 3.1.8 ESM devices can pass short-term overcurrent from the table 3.3.

Table 3.3

No.	Current value	Voltage value	Number of overloads	Duration, s	Interval, s
1	$7 \cdot I_n$	U_n	2	15	60
2	$10 \cdot I_n$	U_n	1	15	-
3	$40 \cdot I_n$	U_n	1	1	-
4	I_n	$2 \cdot U_n$	1	60	-

- 3.1.9 ESM works in continuous mode. The duration of continuous work is not limited.
- 3.1.10 Warm-up time is not more than 5 min.
- 3.1.11 Mean time between failures is not less than 170 000 hours for ESM-HV and for ESM-ET modifications, 220 000 for ESM-SV modification in service conditions.
- 3.1.12 ESM devices are repairable. Mean time to recovery is not more than 1 hour.
- 3.1.13 Mean lifetime is not less than 25 years.
- 3.1.14 Calibration interval is 12 years for ESM-HV, ESM-ET modifications and 16 years for ESM-SV modification.
- 3.1.15 ESM devices are class I electrical protection products according to IEC 61010-1-2001.
- 3.1.16 ESM devices comply with EMC standards (IEC 61326-1-2014, IEC 61000-6-5-2001).

3.2 Power supply

Symbols for power supply terminals are in the table 3.4.

Table 3.4

Symbol	Designation	
	AC Power	DC Power
	Protective Earth	Protective Earth
	Neutral	+
	Line	-

Connection diagrams for power supply (for AC or DC and voltage) is in the fig.3.1.

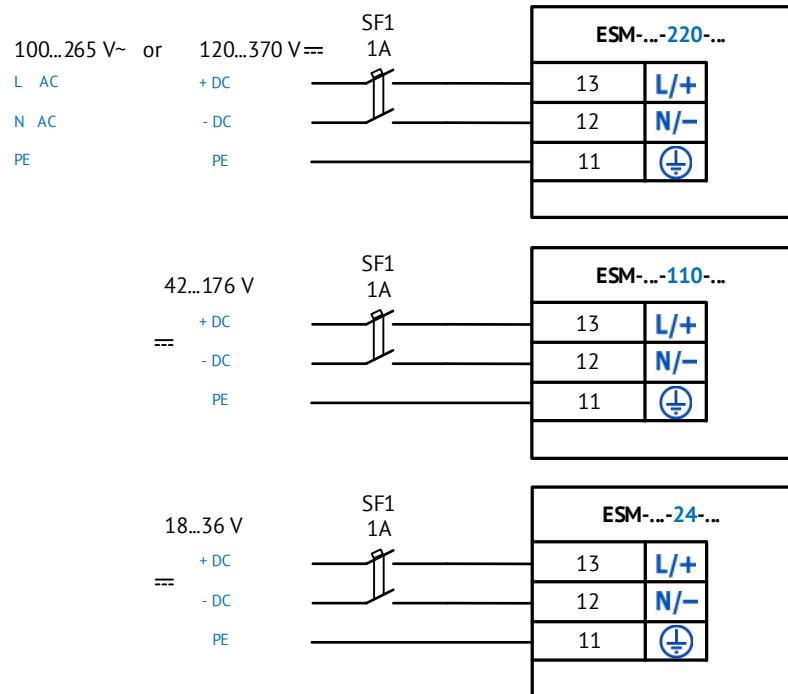


Figure 3.1. Connection diagrams for power supply

4 Display

Display module has a sensor screen to display measuring and calculating data, archives and supplementary information.

Main menu can be divided into 2 groups (fig. 4.1.):

- menu setting;
- menu parameters.

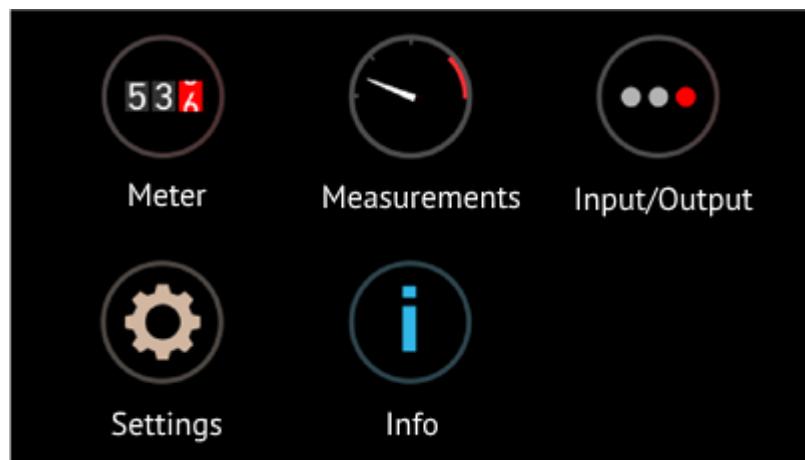


Figure 4.1. Main menu

Menu parameters consist of:

- Menu «Meter» (displays measuring data in two possible formats: as induction meter and in tables);
- Menu «Measurements» (measured values in digital form);
- Menu «Input/output» (displays received discrete signals or allows to provide discrete signals);
- Menu «Info» (information about display module and measuring device).

4.1.1 Menu «Meter»

- Two possible formats are in the fig. 4.2., 4.3..

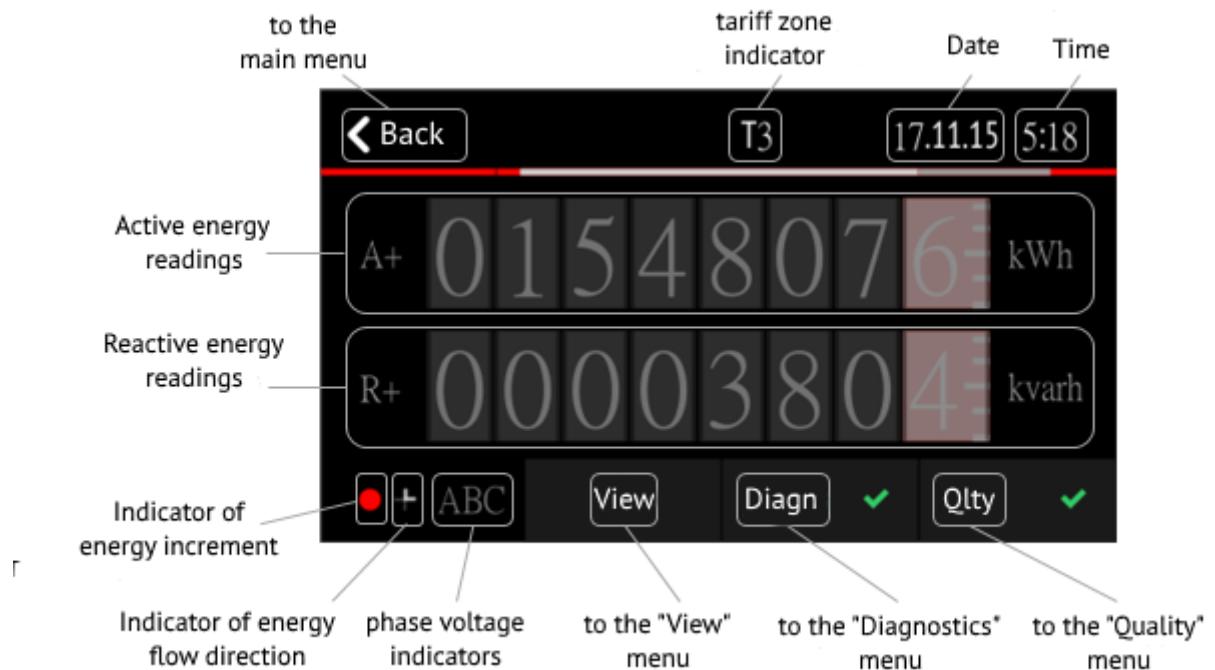


Figure 4.2. Menu «Meter», view counter

Active and reactive energy readings are displayed in quadrants (current readings, fixed readings (by periods or events), differentiated by tariff zone).

T1, T2, T3...T8 or Total indicate specific tariff zone.

Indicator of energy flow direction (symbols):

- right (↗, ↛) – «A+» – active energy is consumed;
- left (↖, ↙) – «A-» – active energy is generated (reverse direction);
- up (↑, ↗) – «R+» – reactive energy is consumed;
- down (↓, ↙) – «R-» – active energy is generated (reverse direction).

Indicator of energy increment is in the lower left corner of the screen. Default value is 1/100 000 kWh.

ABC are phase voltage indicators in A, B and C phases. When some phase voltage is zero, this indicator starts to blink.

The «Back» button returns to the main menu.

The «View» button changes the view (possible options are counter and table)

tariff partition indicator

A+	5679478,1 kWh	P	15,4 kW
A-	89632,3 kWh	Q	3,4 kvar
R+	35412,2 kvarh	f	50,002 Hz
R-	34243,6 kvarh	cos	0,976

displayed parameters (for certain tariff)

displayed parameters

	Total	1.11.15	00:00
A+	5679478,1 kWh	R1	28596,9 kvarh
A-	89632,3 kWh	R2	6815,3 kvarh
R+	35412,2 kvarh	R3	12559,8 kvarh
R-	34243,6 kvarh	R4	21683,8 kvarh

units of measurement

Figure 4.3. Menu «Meter», view table

4.1.2 Menu «Measurements»

The screen displays measured parameters in the table format.

«Diagnostics» section:

- time synchronization;
- ADC;
- battery.

«Quality» section:

- frequency variation (10 s);
- voltage variation;
- THD;
- asymmetry coefficient;
- harmonics.

4.1.3 Menu «Input/Output»

This menu displays received discrete signals or allows to provide discrete signals.

4.1.4 Menu «Info»

It displays the following information:

- type;
- serial number;
- hardware version;
- firmware version;
- rated voltage;
- rated current;
- supply voltage.

5 Package contents

Package contents include:

- | | |
|---|-----|
| - ESM multifunctional measuring device | -1; |
| - ESM.422160.001 PC | -1; |
| - CD (with ESM.422160.001 Manual, verification methodology
ESM.422160.001 VM, software and additional information) | -1; |

It can also include:

- | | |
|--|----|
| - Power converter (for ESM-ET calibration) | -1 |
| - ENMI display module | -1 |

For all necessary documentation and software updates, please, visit our website:

www.enip2.ru

6 Operation

ESM can be installed in protection compartments of enclosed switchgear, in panels and cabinets. Due to wide operating temperature range, ESM can be applied in unattended and non-heated facilities.



Make sure that selective main circuit breaker for power supply circuit is set near the ESM.



Attention! Before connecting/disconnecting ESM to power supply grid, make sure that all sources of power supply are disconnected.

6.1 Before installation

After receiving ESM from distributor, make sure that the package has no defects.

After Unpacking ESM, check the package contents.

Compare characteristics in passport with label on the front side of the device.

Before connecting or disconnecting ESM to digital interface or measuring inputs, make sure that all sources of power supply are disconnected.

ESM is connected only to the current and to the voltage transformers with suitable characteristics.

When connecting ESM to RTU (or SCADA), follow the manual of RTU (SCADA).

Do not use ESM in explosive or corrosive environment.

Save ESM from heating above 70 °C, large temperature variations and strong electromagnetic fields.

6.2 Mounting

For safety, read the instructions in this manual before mounting and operation. Only qualified personnel shall perform installation.

ESM meter is intended to be mounted inside the cabinet at the panel (combined with ENMI) or onto DIN rail according to DIN EN 60715 TH 35).

ESM could be sealed with cover (see Appendix B).

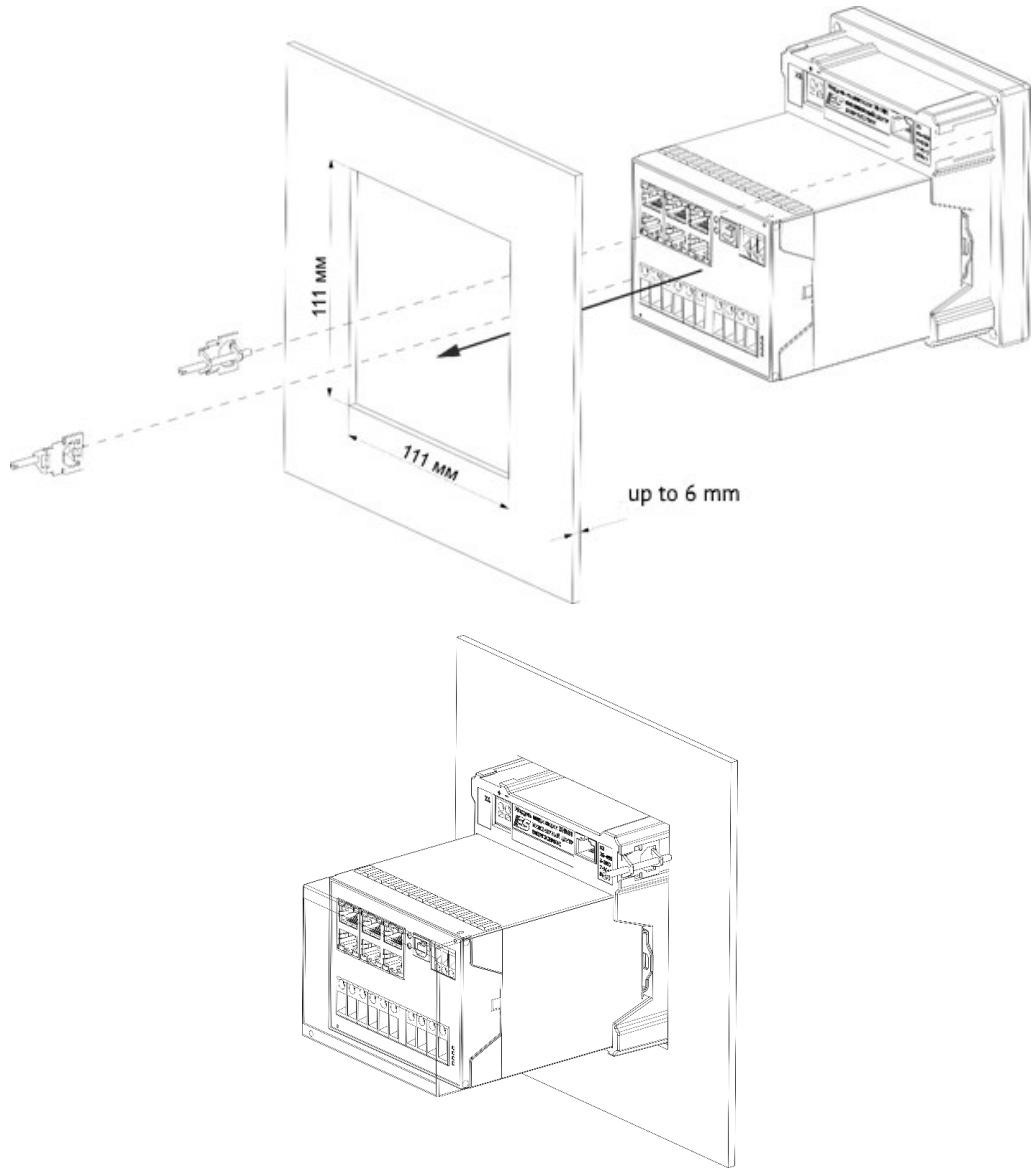


Figure 6.1. Installation of ESM device paired with display module

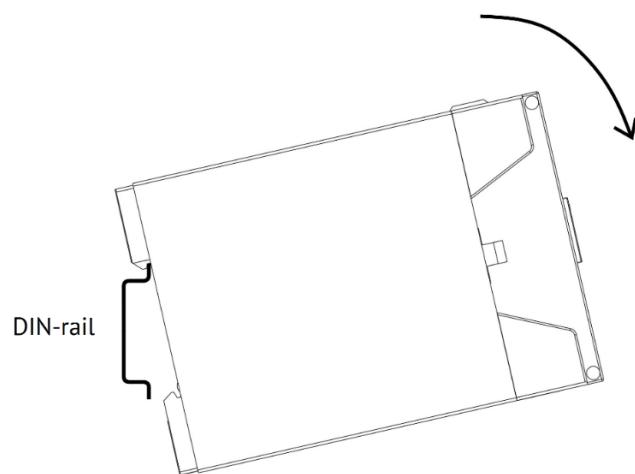


Figure 6.2. ESM installation to 35 mm DIN-rail.

Pull down the clip in bottom to release ESM from DIN-rail.

6.3 Terminal connection

6.3.1 Connection terminals for measuring circuits and power supply are listed in the table below.

terminal	ESM	
	symbol	description
1	IL1	I1 input
2		I1 output
3	IL2	I2 input
4		I2 output
5	IL3	I3 input
6		I3 output
7	L1	U1 input
8	L2	U2 input
9	L3	U3 input
10	N	UN input
11	-	Power supply PE conductor
12	N/-	Power supply N/-
13	L/+	Power supply L/+

6.3.2 All wires must have cord end terminals.

Inputs	Wire type	Cord end terminals length
Power supply	2.5 mm ² wires (AWG 14)	8 mm
Current input		
Voltage input	4 mm ² wires (AWG 12)	10 mm
ENMI display	shielded patch cord Cat5 cables using 8P8C (RJ45)	
Digital interface	shielded patch cord Cat5 cables using 8P8C (RJ45)	

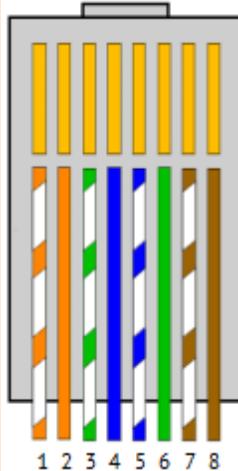
Connections' diagrams are in appendix A.



Terminals tightening torque is 0.5 to 0.6 N·m.

6.3.3 Digital interfaces pinout:

Interface	8P8C pinout
COM-1	5 – GND 7 – A (data+) 8 – B (data-)
COM-2 (with 24VDC power*)	1,2 – power supply for ENMI (+24 V DC) 3,4 – power supply for ENMI (0 V) 5 – GND 7 – A (data+) 8 – B (data-)
Ethernet	1 – TX+ (Transmit Data+) 2 – TX- (Transmit Data-) 3 – RX+ (Receive Data+) 6 – RX- (Receive Data-)



*COM-2 is recommended for connecting ESM with ENMI display. COM-2 RJ45 socket has RS-485 lines and 24VDC power lines together.

There are two COM-2 use cases: one ESM plus one ENMI, one ESM plus several ENMI.

Please note that ESM internal 24VDC power supply shall be used only for redundant power supply for one ENMI display panel.

If there are one ESM and several ENMI then only one ENMI could be powered from ESM and others ENMI shall be powered from external power supply. To simplify connections between ESM and several ENMI please use EX5RX splitter and patch cord RJ45. Please read EX.273313.091 Operating Manuals about EX5RJX using.

7 Configuring

7.1 Access levels

Table 7.1

Level	Default password	Description
User	111111	reading measurements, reading logs, reading configuration, time correction
Administrator	222222	+ configuration record, firmware update, time setting, clear logs, USB-COM mode

Change default passwords to avoid unauthorized access to device settings!

7.2 Software «ES Configurator»

To configure ESM device means to assign connection addresses, IP addresses, baud rates for data exchange via RS-485, protocols, synchronization methods etc.

Software: ES Configurator. Interfaces: RS-485, Ethernet or USB. Description of ES Configurator is in ENIP. 411187.02 ([download](#)) manual.

You can also use ESM test to monitor measured and calculated parameters, read the logs, display discrete signals, change the password, set time and even update the firmware.

8 Disposal

At the end of its useful life, the device must be disposed of in accordance with the rules, regulations and methods in force at the disposal site. Do not dispose of the device with household waste. At the end of the life of the device, take it to the collection point for disposal, if it is provided by local regulations.

Appendix A1. Wiring diagrams of ESM-HV

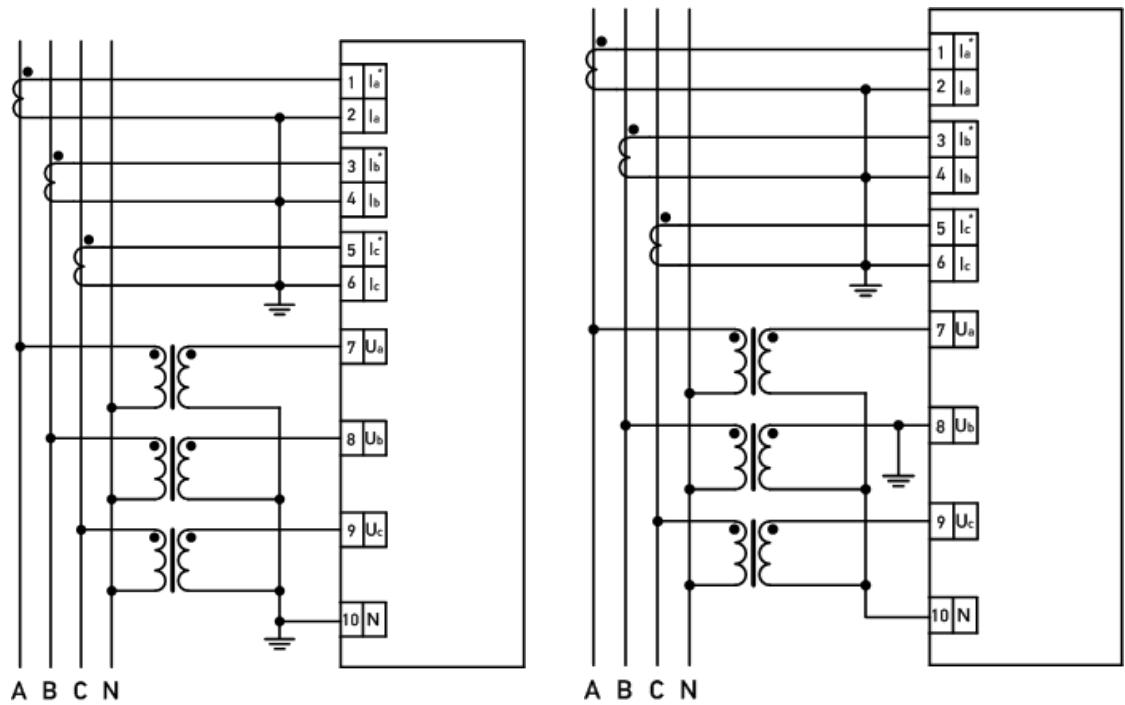


Figure A1.1. Wiring diagrams of ESM-HV for 4-wire three-phase grid
("4-wire" measurement mode must be activated).

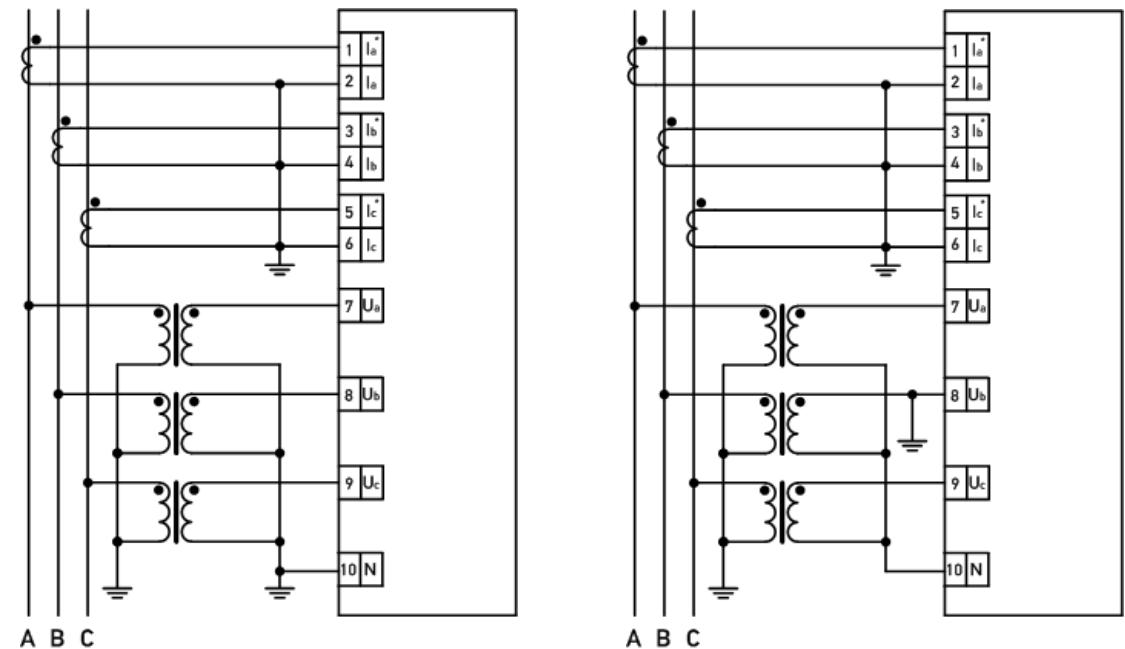


Figure A1.2. Wiring diagrams of ESM-HV for 3-wire three-phase grid
("3-wire" measurement mode must be activated).

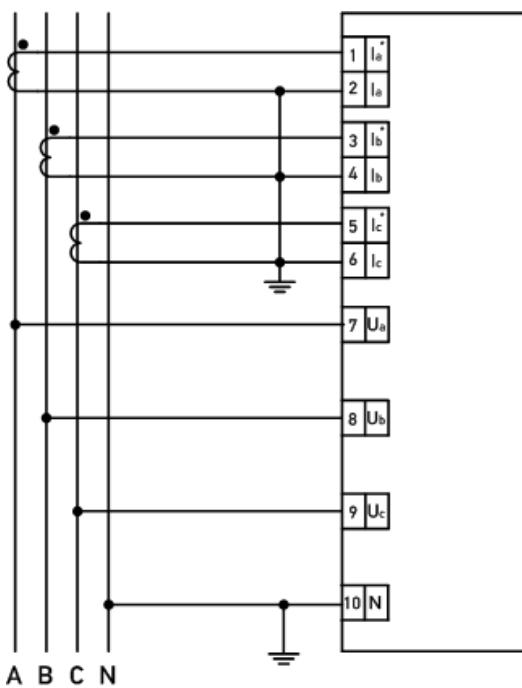


Figure A1.3. Wiring diagrams of ESM-HV for 4-wire three-phase grid 230 (400) V или 400 (690) V. (“4-wire measurement mode must be activated”).

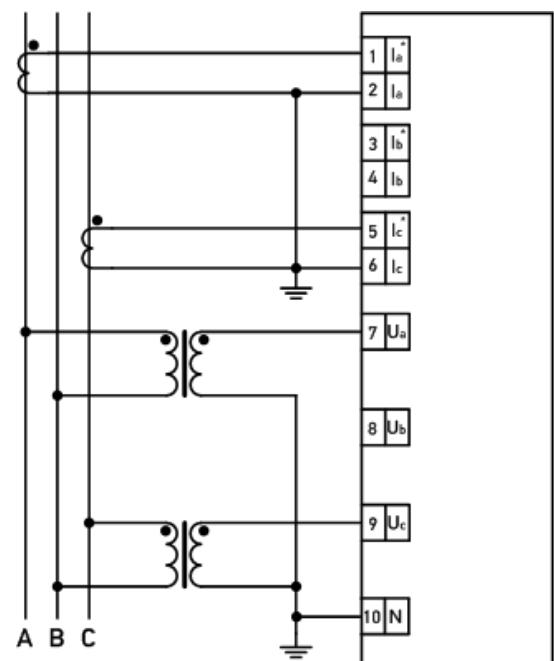
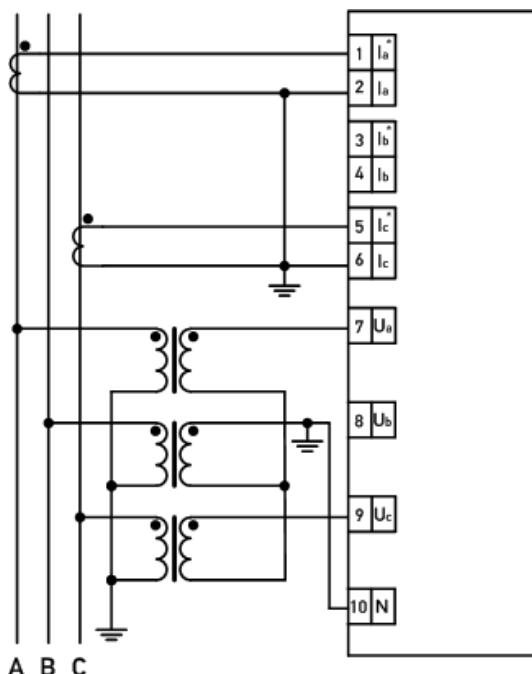
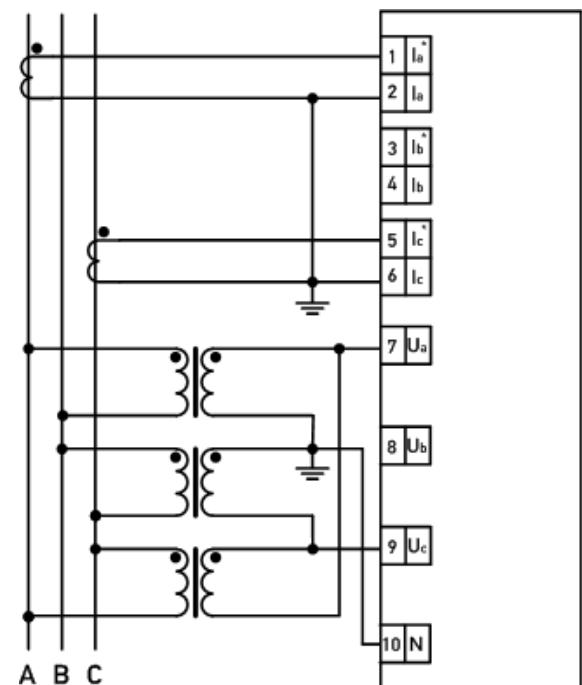


Figure A1.4. Wiring diagrams of ESM-HV for 3-wire three-phase grid and 2 voltage transformers (“3-wire” measurement mode must be activated).



Star-connected voltage transformers



Delta-connected voltage transformers

Figure A1.5. Wiring diagrams of ESM-HV for 3-wire three-phase grid and 3 voltage transformers (“3-wire” measurement mode must be activated).

Appendix A2. Connection diagrams of ESM-SV

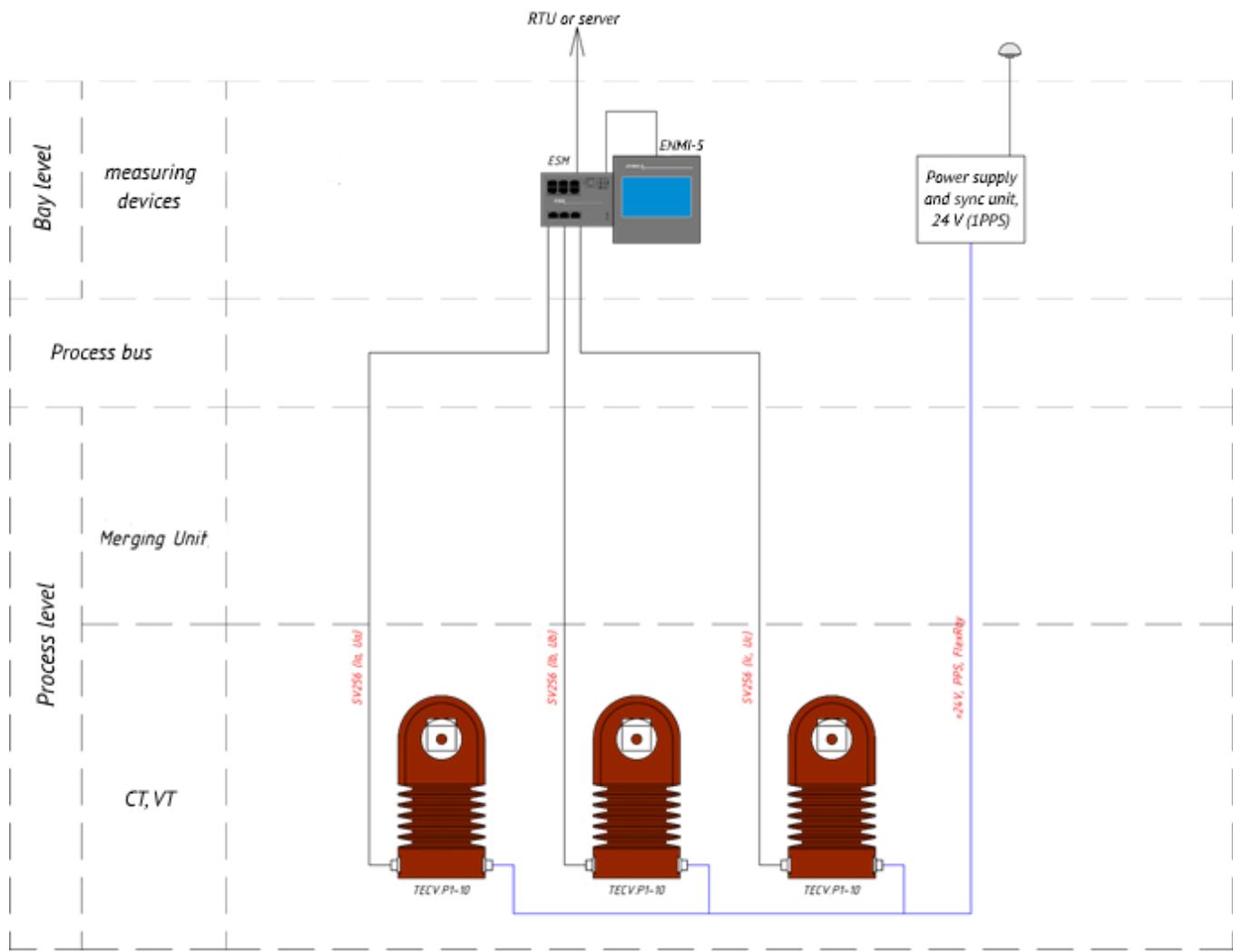


Figure A2.1. Connection diagram of ESM-SV and combined current and voltage transformers (TECV.P1 6-20 kV with digital interfaces, made by Optimetrik, Russia).

Note that:

1. It is necessary to synchronize TECV.P1 transformers for the SV stream to be correct. Use series of 1PPS impulses from synchronization unit and separate power supply cable to synchronize TECV.P1.
2. ESM can be synchronized from RTU or directly from ENCS-2 time sync device via SNTP protocol.

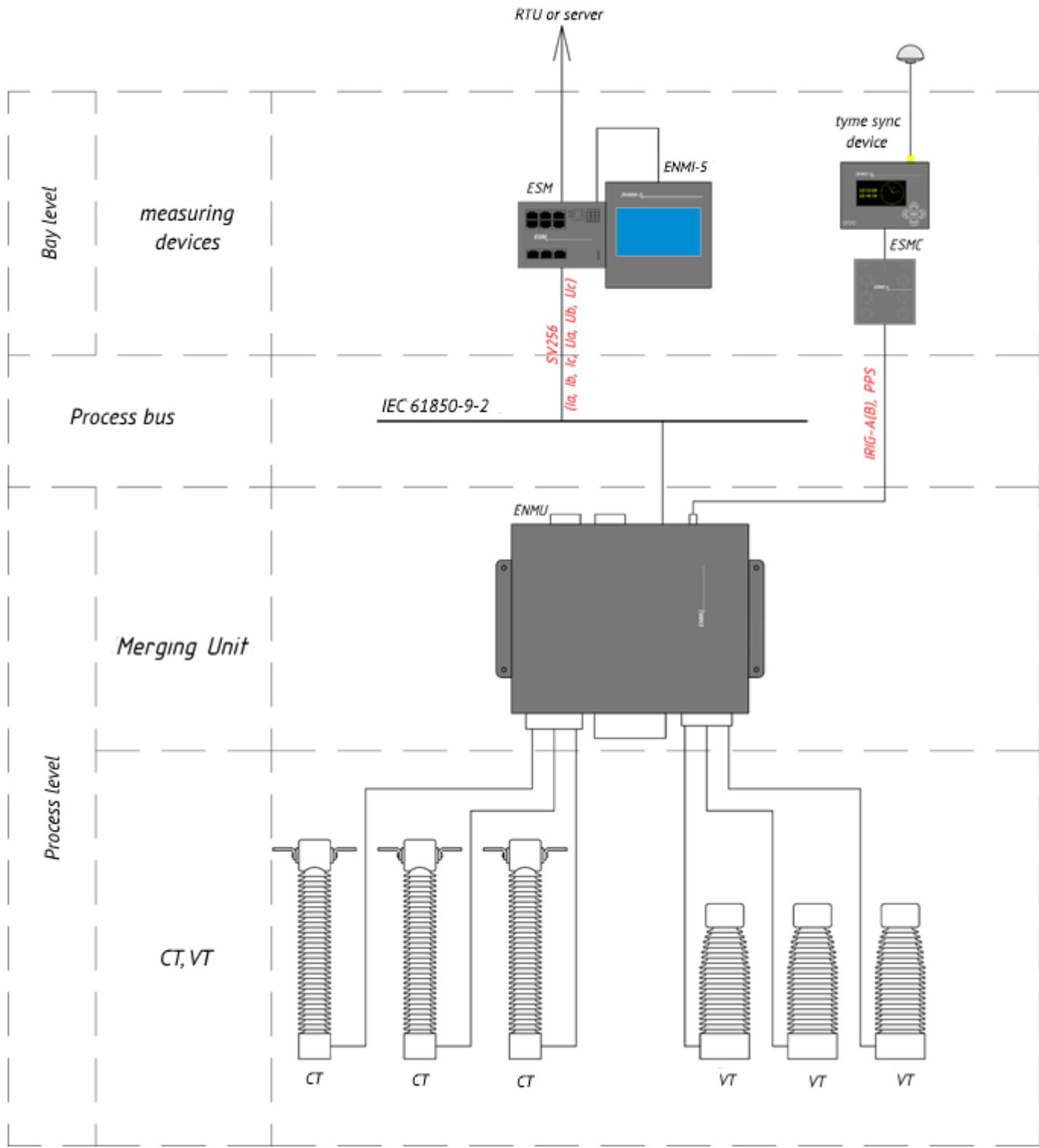


Figure A2.2. Connection diagram of ESM-SV and electromagnetic current and voltage transformers 35-750 kV through the ENMU merging unit (made by Engineering Center “Energoservice”).

Note that:

1. It is necessary to synchronize ENMU merging unit for the SV stream to be correct. Use series of 1PPS impulses or ENCS-2 time sync device (via IRIG-A, IRIG-B protocols).
2. ESM can be synchronized from RTU or directly from ENCS-2 time sync device via SNTP protocol.

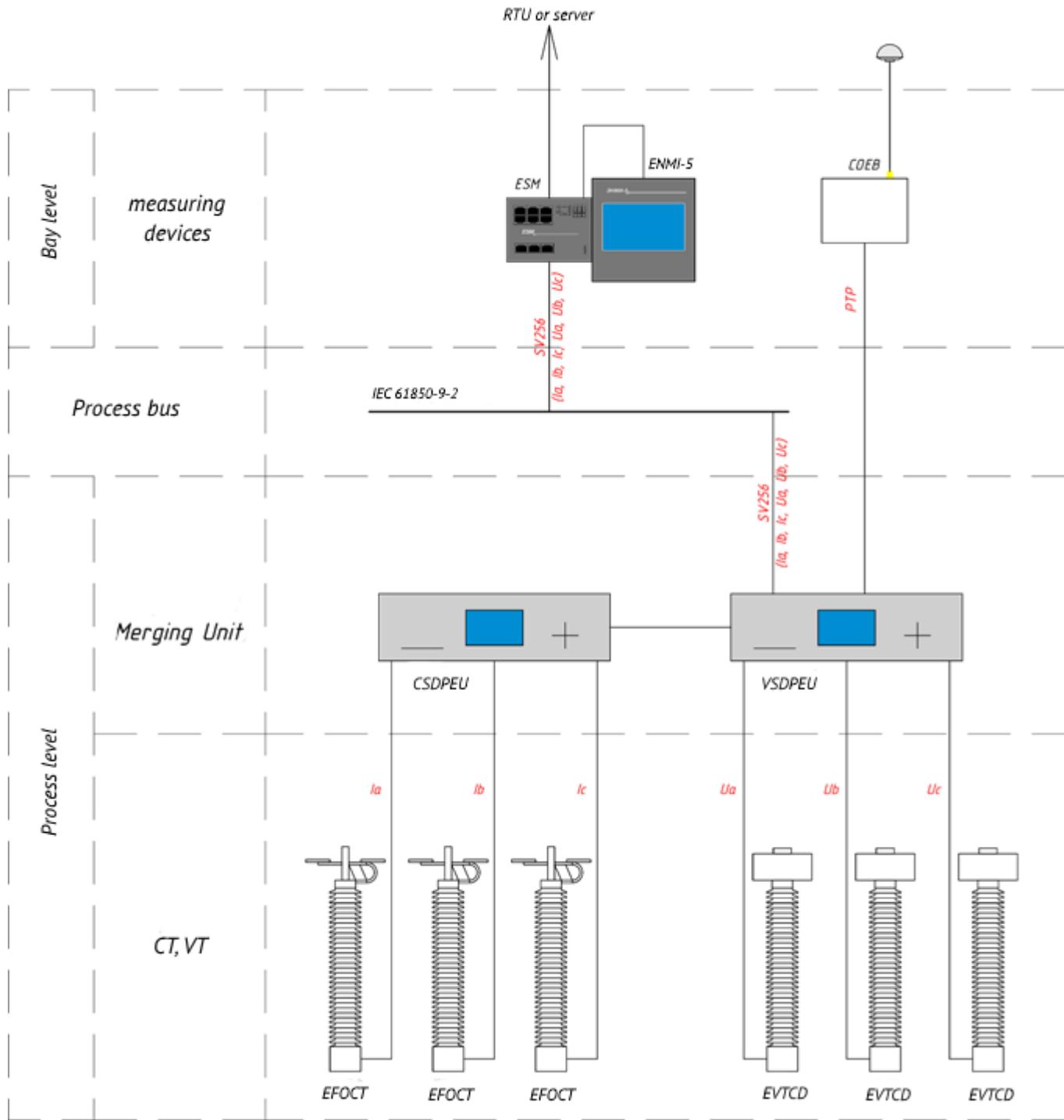


Figure A2.3. Connection diagram of ESM-SV and optical current and voltage transformers 110-220 kV (made by Profotech, Russia).

Note that:

1. EFOCT – electronic fiber-optical current transformers, EVTCD – electronic voltage transformers with capacitive divider, CSDPEU (VSDPEU) – current (voltage) sensor data processing electronic unit.
2. It is necessary to synchronize data processing electronic unit (DPEU) for the SV stream to be correct. It can be synchronized from time sync server via PTPv2 protocol.
3. ESM can be synchronized from RTU or directly from time sync server via SNTP protocol.

Appendix A3. Connection diagrams of ESM-ET

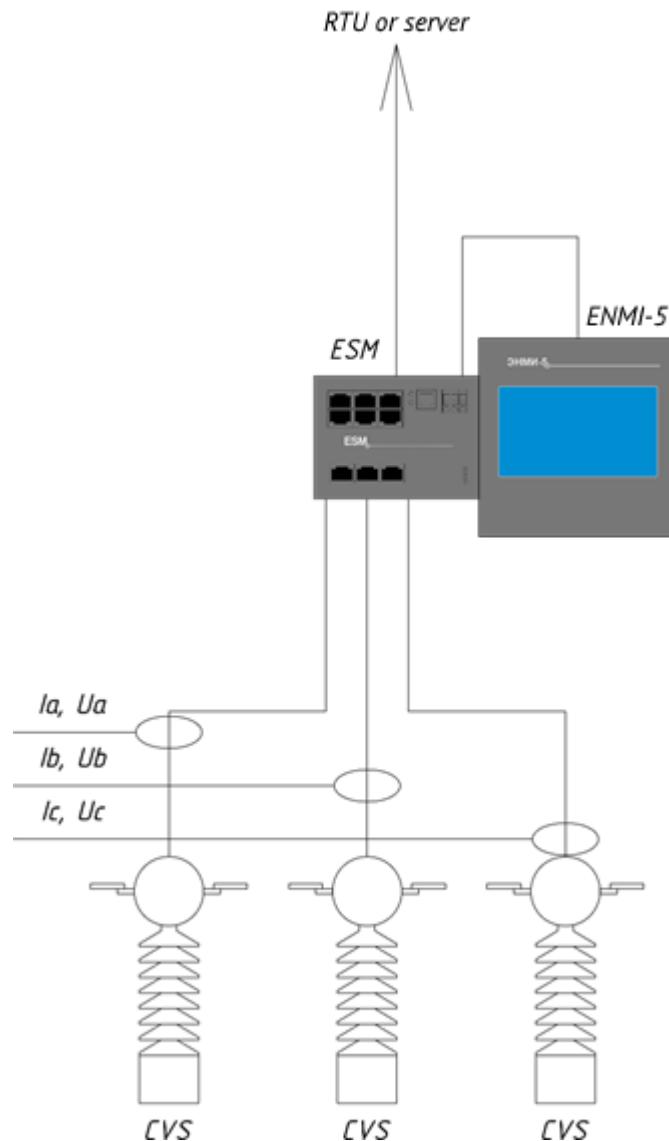


Figure A3.1. Connection diagram of ESM-ET and electronic current and voltage transformers.

Note that:

1. Examples of electronic transformers: combined current and voltage transformers CVS (made by Altea B.V., Netherlands) and TECV.P1 (made by Optimetrik, Russia);
2. ESM-ET can also be included in the pole-mounted metering facilities (for power lines 6, 10, 20, 35, 110 kV).

Appendix B. Sealing of the ESM devices

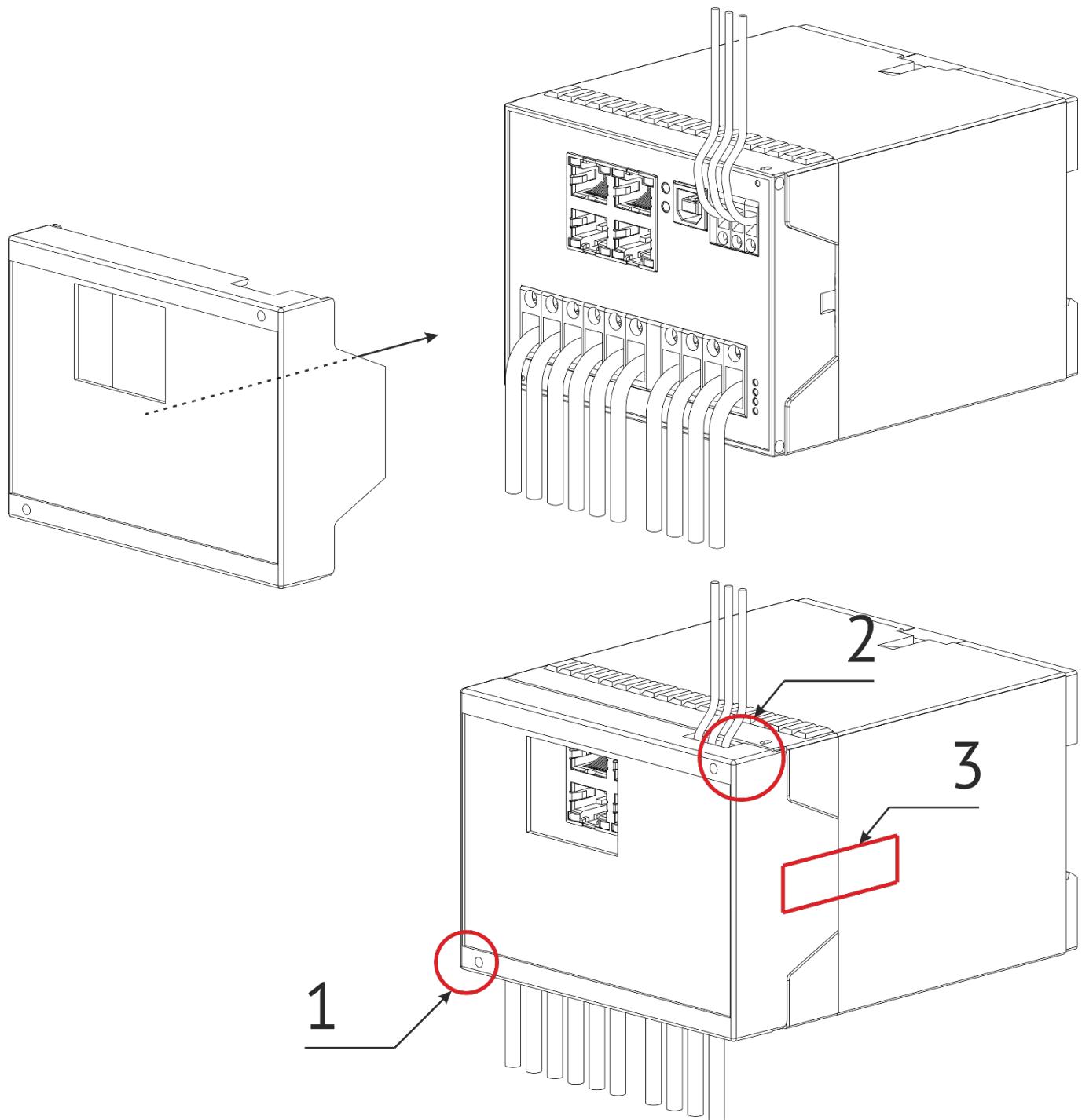


Figure B1. Sealing of the ESM-HV device
(1 and 2 – wire seal; 3 – indicative seal).

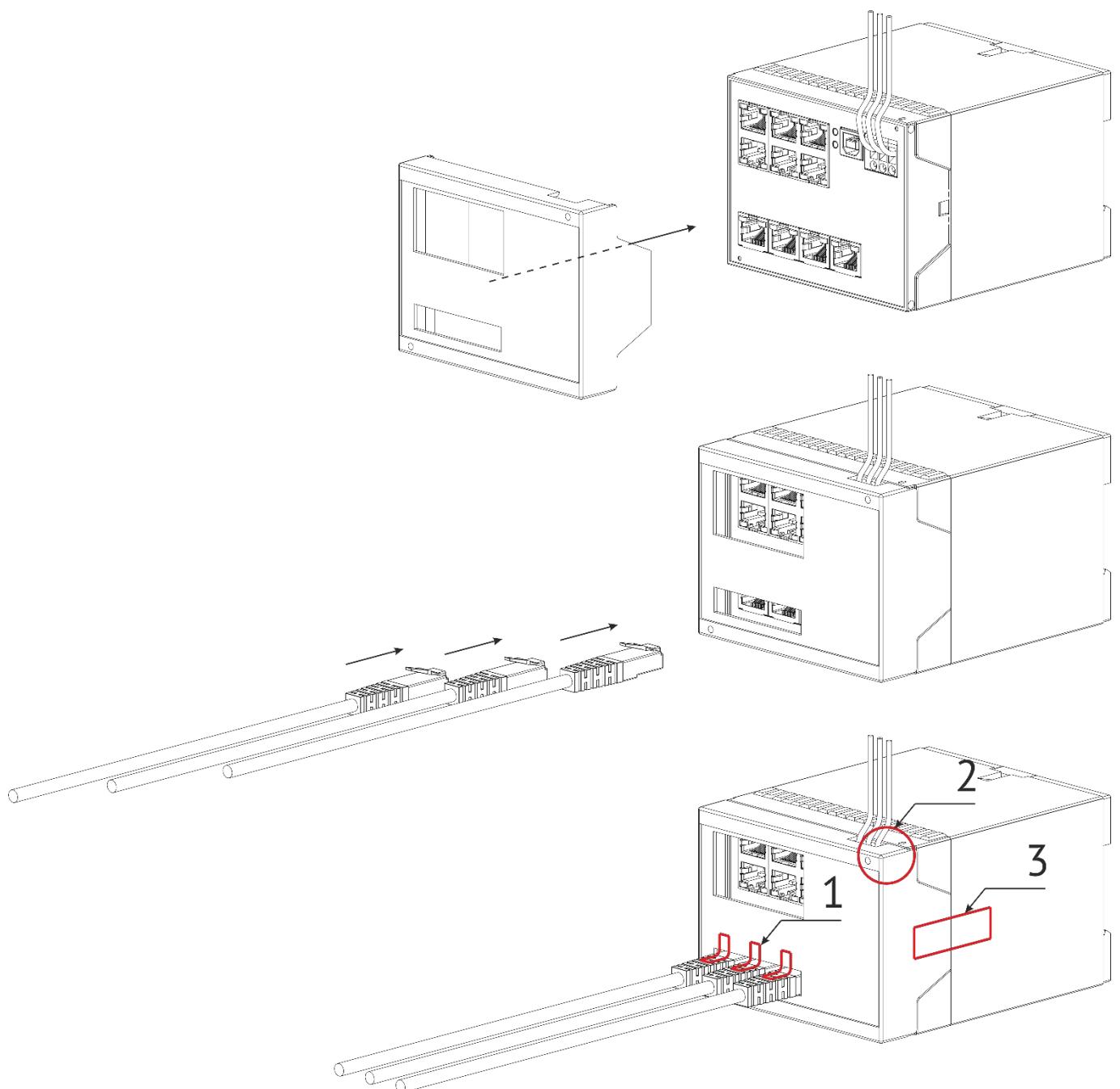


Figure B2. Sealing of the ESM-ET and ESM-SV devices
(1 и 3 – indicative seals; 2 – wire seal).

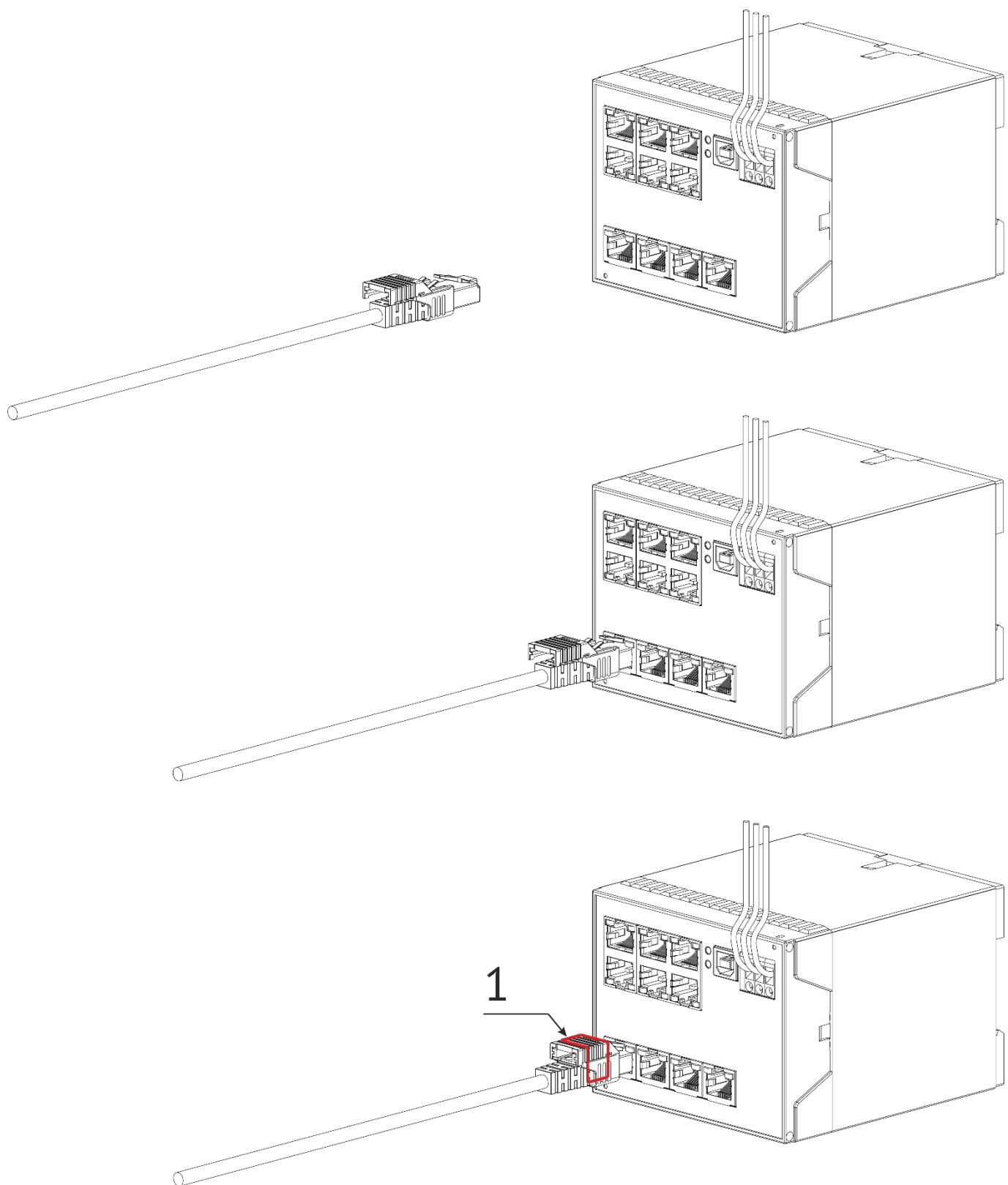


Figure B3. Sealing of the ESM-ET and ESM-SV devices using protective cover for RJ45
(1 – indicative seal).

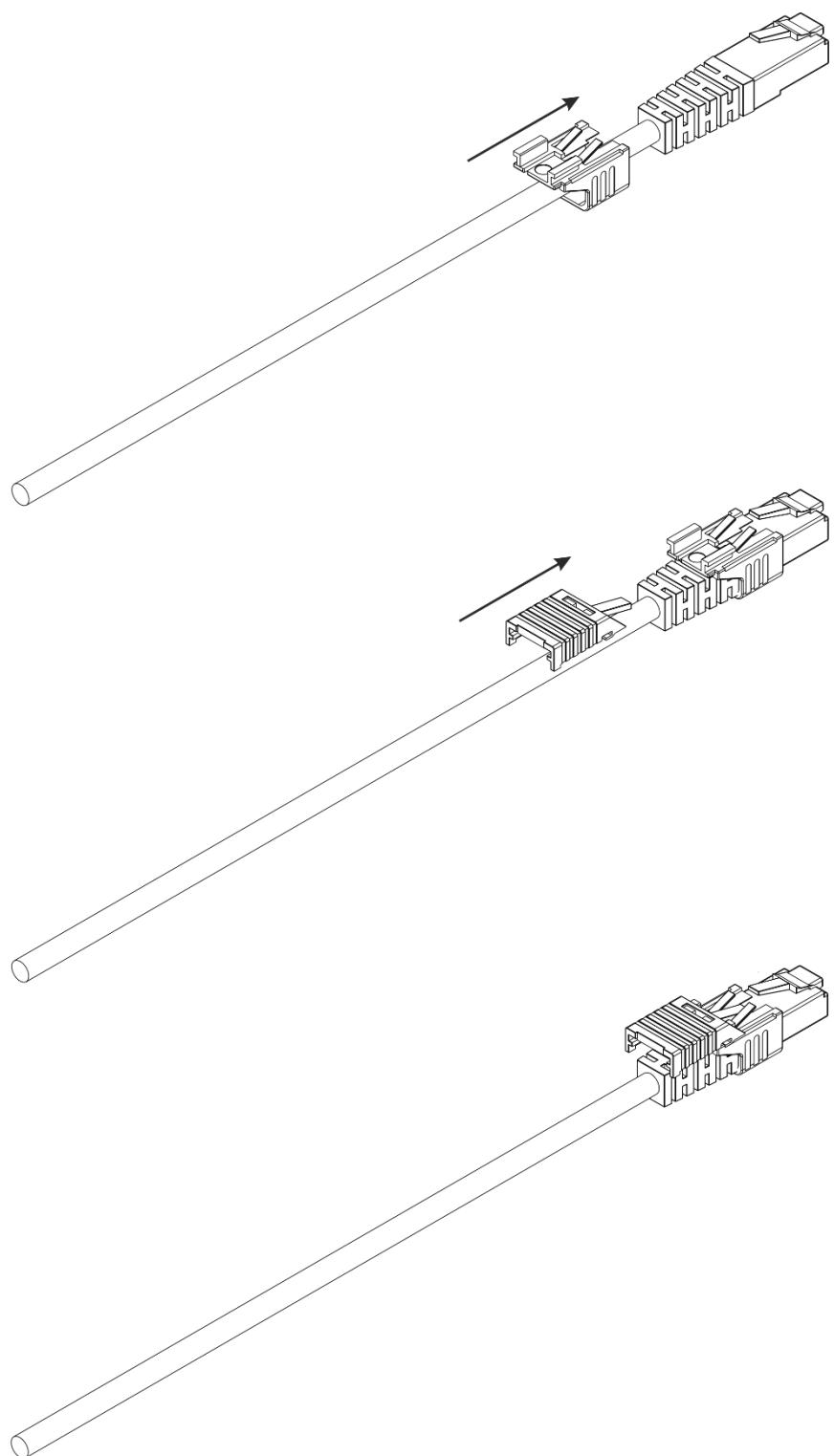


Figure B4. Installation of protective cover for RJ45 on a patch cord

Appendix C. Accuracy

General information

ESM devices error limits (accuracy class is 0.5) of reactive energy measurement (normal conditions, symmetric three-phase load) are shown in the table C.1.

Table C.1

Current value	$\sin \varphi$	Relative error limits, %, for 0.5 accuracy class
$0,02 \cdot I_n \leq I < 0,05 \cdot I_n$	1	$\pm 0,8$
$0,05 \cdot I_n \leq I \leq I_{max}$		$\pm 0,5$
$0,05 \cdot I_n \leq I < 0,10 \cdot I_n$	0,5	$\pm 0,8$
$0,10 \cdot I_n \leq I \leq I_{max}$		$\pm 0,5$
$0,10 \cdot I_n \leq I \leq I_{max}$	0,25	$\pm 0,8$

Relative error limits of the ESM devices (accuracy class is 0.5) of reactive energy measurement (normal conditions, one-phase load, multi-phase voltage system is symmetric) are in the table C.2.

Table C.2

Current value	$\sin \varphi$	Relative error limits, %, for 0.5 accuracy class
$0,05 \cdot I_n \leq I \leq I_{max}$	1	$\pm 0,5$
$0,10 \cdot I_n \leq I \leq I_{max}$	0,5	$\pm 0,8$

The average temperature coefficient in reactive energy measurement (accuracy class is 0.5, temperature range is from minus 40 to plus 70 °C) is in the table C.3.

Table C.3

Current value	$\sin \varphi$	Average temperature coefficient in reactive power and energy measurement, %/°C for 0.5 accuracy class
$0,05 \cdot I_n \leq I \leq I_{max}$	1	$\pm 0,03$
$0,10 \cdot I_n \leq I \leq I_{max}$	0,5	$\pm 0,05$

ESM-HV

ESM-HV modification is connected to the measuring inputs by 3- or 4-wire schemes (is set by the program).

Metrological characteristics of ESM-HV devices are in the table C.4.

Table C.4

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; γ ¹⁾ conventional, %)	Modification
Electric energy parameters				
1	Active energy W_p , kWh	IEC 62053-22:2003	Accuracy class: 0,2S	...-02...
			Accuracy class: 0,5S	...-05...

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)	Modification
2	Active energy (total) of fundamental frequency $W_{P(1)}$, active energy of positive sequence W_{P1} , kWh	$0,01 \cdot I_n - 2,0 \cdot I_n$ $0,2 \cdot U_n - 2,0 \cdot U_n^{(8)}$	$\pm 0,4 (\delta)$ for $0,01 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < K_P \leq 1$; where $K_P = P/S$	
			$\pm 0,2 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < K_P \leq 1$	
			$\pm 0,5 (\delta)$ for $0,02 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq K_P \leq 0,8$...-02...
			$\pm 0,3 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq K_P \leq 0,8$	
			$\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq K_P < 0,5$	
			$\pm 1,0 (\delta)$ for $0,01 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < K_P \leq 1$	
			$\pm 0,5 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < K_P \leq 1$	
			$\pm 1,0 (\delta)$ for $0,02 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq K_P \leq 0,8$...-05...
3	Reactive energy W_Q , kvarh	IEC 62053-23:2003	Accuracy class: $0,5^2)$...-02...
			Accuracy class: $1,0$...-05...

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)	Modification
4	Reactive energy of fundamental harmonic $W_{Q(1)}$, reactive energy of positive sequence W_Q , kvarh	$0,02 \cdot I_n - 2,0 \cdot I_n$ $0,2 \cdot U_n - 2,0 \cdot U_n^{(8)}$	$\pm 0,8 (\delta)$ for $0,02 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < \sin \varphi \leq 1$	
			$\pm 0,5 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < \sin \varphi \leq 1$	
			$\pm 0,8 (\delta)$ for $0,05 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$...-02...
			$\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$	
			$\pm 0,8 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq \sin \varphi < 0,5$	
			$\pm 1,5 (\delta)$ for $0,02 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < \sin \varphi \leq 1$	
			$\pm 1,0 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < \sin \varphi \leq 1$	
			$\pm 1,5 (\delta)$ for $0,05 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$...-05...
			$\pm 1,0 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$	
			$\pm 1,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq \sin \varphi < 0,5$	
AC voltage and current parameters				
5	RMS phase (line-to-line) voltage U_n , V ³⁾	$0,1 \cdot U_n - 2 \cdot U_n^{(8)}$	$\pm (0,1 + 0,01 \cdot U_n/U - 1) (\delta)$	-...A
			$\pm (0,2 + 0,01 \cdot U_n/U - 1) (\delta)$	-...S
6	RMS voltage of positive sequence U_1 , V	$0,1 \cdot U_n - 2 \cdot U_n^{(8)}$	$\pm (0,1 + 0,01 \cdot U_n/U - 1) (\delta)$	-...A
			$\pm (0,2 + 0,01 \cdot U_n/U - 1) (\delta)$	-...S
7	RMS voltage of negative sequence U_2 , zero sequence U_0 , V	$0 - 2 \cdot U_n^{(8)}$	$\pm 0,1 (\gamma)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$; $K_{2U} < 15\% ; K_{0U} < 15\%$	-...A
			$\pm 0,2 (\gamma)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$; $K_{2U} < 15\% ; K_{0U} < 15\%$	-...S
8		0-100	$\pm 0,1 (\Delta)$	-...A

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)	Modification
	Phase (line-to-line) overdeviation $\delta U_{(+)}$, %		$\pm 0,2 (\Delta)$	-...S
9	Phase (line-to-line) underdeviation $\delta U_{(-)}$, %	0-90	$\pm 0,1 (\Delta)$	-...A
			$\pm 0,2 (\Delta)$	-...S
10	Steady-state phase (line-to-line) voltage deviation $\delta U_{\text{steady-state}}$, %	От -90 до 100	$\pm 0,1 (\Delta)$	-...A
			$\pm 0,2 (\Delta)$	-...S
11	RMS phase (line-to-line) voltage of n^{th} harmonic $U_{(n)}$ ⁴⁾ ($n=2 \dots 50$), V	0-0,5· U_n	$\pm 0,0005 \cdot U_n (\Delta)$ for $U_{(n)} < 0,01 \cdot U_n$ $\pm 5 (\delta)$ for $U_{(n)} \geq 0,01 \cdot U_n$	-...A -...S
12	Phase (line-to-line) voltage harmonic spectrum (n^{th} harmonic) $K_{U(n)}$ ($n=2 \dots 50$), %	0-50	$\pm 0,05 (\Delta)$ for $K_{U(n)} < 1 \%$ $\pm 5 (\delta)$ for $K_{U(n)} \geq 1 \%$	-...A -...S
13	Voltage THD K_U , %	0-50	$\pm 0,05 (\Delta)$ for $K_U < 1 \%$ $\pm 5 (\delta)$ for $K_U \geq 1 \%$	-...A -...S
14	Voltage unbalance of negative sequence K_{2U} , %	0-20	$\pm 0,15 (\Delta)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$	-...A
			$\pm 0,3 (\Delta)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$	-...S
15	Voltage unbalance of zero sequence K_{0U} , %	0-20	$\pm 0,15 (\Delta)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$	-...A
			$\pm 0,3 (\Delta)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$	-...S
16	RMS phase (line-to-line) voltage of m^{th} interharmonic $U_{\text{isg}(m)}$ ($m=0,5 \dots 49,5$), V	0-0,15· U_n	$\pm 0,005 \cdot U_n (\Delta)$ for $U_{(n)} < 0,01 \cdot U_n$ $\pm 5 (\delta)$ for $U_{\text{isg}(m)} \geq 0,01 \cdot U_n$	-...A -...S
17	Phase angle for phase voltage of fundamental harmonic φ_U , °	From -180 to 180	$\pm 0,1 (\Delta)$	-...A -...S
18	Frequency f , Hz	From 42,5 to 57,5	$\pm 0,01 (\Delta)$ ⁷⁾	-...A -...S
19	Frequency deviation Δf , Hz	From minus 7,5 to plus 7,5	$\pm 0,01 (\Delta)$ ⁷⁾	-...A -...S
20	RMS current, A ⁵⁾	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$	$\pm (0,1 + 0,005 \cdot I_n / I - 1) (\delta)$	-...A
			$\pm (0,2 + 0,005 \cdot I_n / I - 1) (\delta)$	-...S
21	RMS positive sequence current of fundamental harmonic I_1 , A	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$	$\pm (0,1 + 0,005 \cdot I_n / I - 1) (\delta)$	-...A
			$\pm (0,2 + 0,005 \cdot I_n / I - 1) (\delta)$	-...S
22	RMS negative I_2 and zero I_0 sequence current of fundamental harmonic, A	From 0 to $2,0 \cdot I_n$	$\pm 0,1 (\gamma)$	-...A
			$\pm 0,2 (\gamma)$	-...S

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; γ ¹⁾ conventional, %)	Modification
23	RMS current of n th harmonic $I_{(n)}$, A	From 0 to $0,5 \cdot I_n$	± 0,0005 · I_n (Δ) for $I_{(n)} < 0,01 \cdot I_n$ ± 5 (δ) for $I_{(n)} \geq 0,01 \cdot I_n$	-...A -...S
24	Current harmonic spectrum (n th harmonic), $K_{I(n)}$ %	From 0 to 50	± 0,05 (Δ) for $K_{I(n)} < 1$ % ± 5 (δ) for $K_{I(n)} \geq 1$ %	-...A -...S
25	Current THD K_I , %	From 0 to 50	± 0,05 (Δ) for $K_I < 1$ % ± 5 (δ) for $K_I \geq 1$ %	-...A -...S
26	Current unbalance of negative sequence K_{2l} , %	From 0 to 20	± 0,15 (Δ) ± 0,3 (Δ)	-...A -...S
27	Current unbalance of zero sequence K_{0l} , %	From 0 to 20	± 0,15 (Δ) ± 0,3 (Δ)	-...A -...S
28	RMS phase voltage of m th interharmonic $I_{isg(m)}$ (m=0,5...49,5), A	From 0 to $0,15 \cdot I_n$	± 0,005 · I_n (Δ) for $I_{isg(m)} < 0,01 \cdot I_n$ ± 5 (δ) for $I_{isg(m)} \geq 0,01 \cdot I_n$	-...A -...S
29	Phase angle of fundamental harmonic phase currents φ_l , °	From -180 to 180	± 0,1 (Δ) for $0,1 \cdot I_n \leq l \leq 2 \cdot I_n$ ± 0,5 (Δ) for $0,01 \cdot I_n \leq l < 0,1 \cdot I_n$	-...A -...S
30	Phase difference between phase voltage and current of fundamental harmonic $\varphi_{U(l)}$, °	From -180 to 180	± 0,1 (Δ) for $0,1 \cdot I_n \leq l \leq 2 \cdot I_n$ ± 1 (Δ) for $0,01 \cdot I_n \leq l < 0,1 \cdot I_n$	-...A -...S
31	Phase difference between phase voltage and positive φ_{U1l1} , negative φ_{U2l2} and zero φ_{U0l0} sequence current, °	From -180 to 180	± 1,5 (Δ) for $0,1 \cdot I_n \leq l \leq 2 \cdot I_n$ ± 5 (Δ) for $0,01 \cdot I_n \leq l < 0,1 \cdot I_n$	-...A -...S
32	Phase difference between n th harmonic phase voltage and current $\varphi_{U(l)}$, °	From -180 to 180	± 5 (Δ)	-...A -...S
Voltage dips and swells				
33	Voltage dip duration Δt_d , s	From 0,01 to 60	± 0,01 (Δ)	-...A -...S
34	Voltage dip magnitude δU_d , %	From 0 to 100	± 0,2 (Δ) ± 1,0 (Δ)	-...A -...S
35	Voltage interruption duration Δt_{inter} , s	From 0,02 to 60	± 0,1 (Δ)	-...A -...S
36	Voltage swell duration Δt_{sw} , s	From 0,01 to 60	± 0,01 (Δ)	-...A -...S
37	Voltage swell coefficient K_{sw} , отн. ед.	From 1,0 to 2,0 From 1,0 to 1,4	± 0,002 (Δ) ± 0,01 (Δ)	-...A -...S
Electric power parameters				

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)	Modification
38	Power factor (A, B, C phase and average) K_P ($K_P = P/S$) ⁶⁾	From -1 to -0,1 From 0,1 to 1	$\pm 0,01 (\Delta)$	-...A -...S
39	Active power (A, B, C phases and total) P , active power (A, B, C phases and total) of fundamental harmonic $P_{(1)}$, W	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n^{(8)}$ $0,25 \leq K_P \leq 1$	$\pm 0,4 (\delta)$ for $0,01 \cdot I_n \leq I \leq 0,05 \cdot I_n;$ $0,8 < K_P \leq 1$ $\pm 0,2 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,8 < K_P \leq 1$ $\pm 0,5 (\delta)$ for $0,02 \cdot I_n \leq I \leq 0,1 \cdot I_n;$ $0,5 \leq K_P \leq 0,8$ $\pm 0,3 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,5 \leq K_P \leq 0,8$ $\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,25 \leq K_P < 0,5$	-...A -...S
40	Active power of positive $P_{1(1)}$, negative $P_{2(1)}$ and zero $P_{0(1)}$ sequence, W	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n^{(8)}$	$\pm 0,5 (\delta)$	-...A -...S
41	Active power (A, B, C phase and total) of n^{th} harmonic $P_{(n)}$, W	From $0,01 \cdot I_n$ to $0,5 \cdot I_n$ From $0,1 \cdot U_n$ to $0,5 \cdot U_n$ $0,5 \leq K_P \leq 1$	$\pm 5,0 (\delta)$	-...A -...S
42	Reactive power (A, B, C phase and total) Q , reactive power (A, B, C phase and total) of fundamental harmonic $Q_{(1)}$, var	From $0,02 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n^{(8)}$ $0,25 \leq \sin \varphi \leq 1$	$\pm 0,8 (\delta)$ for $0,02 \cdot I_n \leq I \leq 0,05 \cdot I_n;$ $0,8 < \sin \varphi \leq 1$ $\pm 0,5 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,8 < \sin \varphi \leq 1$ $\pm 0,8 (\delta)$ for $0,05 \cdot I_n \leq I \leq 0,1 \cdot I_n;$ $0,5 \leq \sin \varphi \leq 0,8$ $\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,5 \leq \sin \varphi \leq 0,8$ $\pm 0,8 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,25 \leq \sin \varphi < 0,5$	-...A -...S
43	Reactive power of positive $Q_{1(1)}$, negative $Q_{2(1)}$ and zero $Q_{0(1)}$ sequence, var	From $0,02 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n^{(8)}$	$\pm 0,8 (\delta)$	-...A -...S

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)	Modification
44	Reactive power (A, B, C phase and total) of n^{th} harmonic $Q_{(n)}$, var	From $0,01 \cdot I_n$ to $0,5 \cdot I_n$ From $0,1 \cdot U_n$ to $0,5 \cdot U_n$ $0,5 \leq \sin \varphi \leq 1$	$\pm 5,0 (\delta)$	-...A -...S
45	Apparent power (A, B, C phase and total) S , apparent power (A, B, C phase and total) of fundamental harmonic $S_{(1)}$, VA	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n^3)$	$\pm 0,5 (\delta)$	-...A -...S
46	Apparent power of positive $S_{1(1)}$, negative $S_{2(1)}$ and zero $S_{0(1)}$ sequence, VA	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n^3)$	$\pm 0,5 (\delta)$	-...A -...S
47	Apparent power (A, B, C phase and total) of n^{th} harmonic $S_{(n)}$, VA	From $0,01 \cdot I_n$ to $0,5 \cdot I_n$ From $0,1 \cdot U_n$ to $0,5 \cdot U_n$	$\pm 5,0 (\delta)$	-...A -...S

¹⁾ Normalized value for conventional error calculation is the nominal value.

²⁾ Measurement range and error limits for 0,5 accuracy class are in tables C0.1 - C.0.3.

³⁾ Voltage RMS includes voltage RMS of fundamental harmonic $U_{(1)}$, overall voltage RMS for the spectrum U and average voltage RMS U_{av} .

⁴⁾ In addition, it measures maximum value of the characteristics over some period.

⁵⁾ Current RMS includes current RMS of fundamental harmonic $I_{(1)}$, overall current RMS for the spectrum I and average current RMS I_{av} .

⁶⁾ $K_P = \cos \varphi$ for sine wave.

⁷⁾ For ESM-HV690 modification $U \leq 1,15 \cdot U_n$.

Every $\pm 10^{\circ}\text{C}$ temperature change causes additional measurement error increase on 0.5 of the main error limits.

Additional error limits, caused by permanent or alternating magnetic field (0.5 Tl induction) are 0.5 of the main error limits.

ESM-SV

For ESM-SV modification nominal values of the current and voltage input signals are defined by SV data streams according to IEC 61850-9-2, as well as by an additional programmable scale coefficient for nominal current and voltage values in range: from 0,01 to 10^6 . ESM-SV modification has up to three Ethernet ports to receive SV messages. Three SV data streams imply that these three sources are synchronized from the same device and the data streams have the same sample rate (SV80/256 are available).

Metrological characteristics of ESM-SV devices are in the table C.5.

Table C.5

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)	Modification
Electric energy parameters				
1	Active energy W_P , active energy (total) of fundamental frequency $W_{P(1)}$, active energy of positive sequence W_{P1} , kWh	$0,01 \cdot I_n - 2,0 \cdot I_n$ $0,2 \cdot U_n - 2,0 \cdot U_n^{(8)}$	$\pm 0,4 (\delta)$ for $0,01 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < K_P \leq 1$; where $K_P = P/S$ $\pm 0,2 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < K_P \leq 1$ $\pm 0,5 (\delta)$ for $0,02 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq K_P \leq 0,8$ $\pm 0,3 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq K_P \leq 0,8$ $\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq K_P < 0,5$...-02...
2	Reactive energy W_Q , reactive energy of fundamental harmonic $W_{Q(1)}$, reactive energy of positive sequence W_{Q1} , kvarh	$0,02 \cdot I_n - 2,0 \cdot I_n$ $0,2 \cdot U_n - 2,0 \cdot U_n^{(8)}$	$\pm 0,8 (\delta)$ for $0,02 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < \sin \varphi \leq 1$ $\pm 0,5 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < \sin \varphi \leq 1$ $\pm 0,8 (\delta)$ for $0,05 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$ $\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$ $\pm 0,8 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq \sin \varphi < 0,5$...-02...
AC voltage and current parameters				
3	RMS phase (line-to-line) voltage U_n , V ³⁾	$0,1 \cdot U_n - 2 \cdot U_n^{(8)}$	$\pm (0,1 + 0,01 \cdot U_n/U - 1) (\delta)$	-...A
			$\pm (0,2 + 0,01 \cdot U_n/U - 1) (\delta)$	-...S
4	RMS voltage of positive sequence U_1 , V	$0,1 \cdot U_n - 2 \cdot U_n^{(8)}$	$\pm (0,1 + 0,01 \cdot U_n/U - 1) (\delta)$	-...A
			$\pm (0,2 + 0,01 \cdot U_n/U - 1) (\delta)$	-...S
5	RMS voltage of negative sequence U_2 , zero sequence U_0 , V	$0 - 2 \cdot U_n^{(8)}$	$\pm 0,1 (\gamma)$	-...A
			$\pm 0,2 (\gamma)$	-...S
6	Phase (line-to-line) overdeviation $\delta U_{(+)}$, %	0 - 100	$\pm 0,1 (\Delta)$	-...A
			$\pm 0,2 (\Delta)$	-...S

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; γ ¹⁾ conventional, %)	Modification
7	Phase (line-to-line) underdeviation $\delta U_{(i)}$, %	0 - 90	± 0,1 (Δ)	-...A
			± 0,2 (Δ)	-...S
8	Steady-state phase (line-to-line) voltage deviation $\delta U_{\text{steady-state}}$, %	From -90 to 100	± 0,1 (Δ)	-...A
			± 0,2 (Δ)	-...S
9	RMS phase (line-to-line) voltage of n th harmonic $U_{(n)}$ ⁴⁾ (n=2...50), V	0-0,5· U_n	± 0,0005· U_n (Δ) for $U_{(n)} < 0,01 \cdot U_n$	-...A
			± 5 (δ) for $U_{(n)} \geq 0,01 \cdot U_n$	-...S
10	Phase (line-to-line) voltage harmonic spectrum (n th harmonic) $K_{U(n)}$ (n=2...50), %	0-100	± 0,05 (Δ) for $K_{U(n)} < 1 \%$ ± 5 (δ) for $K_{U(n)} \geq 1 \%$	-...A -...S
			± 0,05 (Δ) for $K_U < 1 \%$ ± 5 (δ) for $K_U \geq 1 \%$	-...A -...S
12	Voltage unbalance of negative sequence K_{2U} , %	0-20	± 0,15 (Δ)	-...A
			± 0,3 (Δ)	-...S
13	Voltage unbalance of zero sequence K_{0U} , %	0-20	± 0,15 (Δ)	-...A
			± 0,3 (Δ)	-...S
14	RMS phase (line-to-line) voltage of m th interharmonic $U_{\text{isg}(m)}$ (m=0,5...49,5), V	0-0,15· U_n	± 0,005· U_n (Δ) for $U_{(n)} < 0,01 \cdot U_n$	-...A
			± 5 (δ) for $U_{\text{isg}(m)} \geq 0,01 \cdot U_n$	-...S
15	Phase angle for phase voltage of fundamental harmonic φ_U , °	From -180 to 180	± 0,1 (Δ)	-...A -...S
16	Frequency f , Hz	From 42,5 to 57,5	± 0,01 (Δ) ⁶⁾	-...A -...S
17	Frequency deviation Δf , Hz	From minus 7,5 to plus 7,5	± 0,01 (Δ) ⁶⁾	-...A -...S
18	RMS current, A ⁵⁾	From 0,01· I_n to 2,0· I_n	± (0,1+0,005· $I_n/I - 1$) (δ)	-...A
			± (0,2+0,005· $I_n/I - 1$) (δ)	-...S
19	RMS positive sequence current of fundamental harmonic I_1 , A	From 0,01· I_n to 2,0· I_n	± (0,1+0,005· $I_n/I - 1$) (δ)	-...A
			± (0,2+0,005· $I_n/I - 1$) (δ)	-...S
20	RMS negative I_2 and zero I_0 sequence current of fundamental harmonic, A	From 0 to 2,0· I_n	± 0,1 (γ)	-...A
			± 0,2 (γ)	-...S
21	RMS current of n th harmonic $I_{(n)}$, A	From 0 to I_n	± 0,0005· I_n (Δ) for $I_{(n)} < 0,01 \cdot I_n$	-...A
			± 5 (δ) for $I_{(n)} \geq 0,01 \cdot I_n$	-...S

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; γ^1 conventional, %)	Modification
22	Current harmonic spectrum (n^{th} harmonic), $K_{I(n)}$, %	From 0 to 100	$\pm 0,05 (\Delta)$ for $K_{I(n)} < 1 \%$ $\pm 5 (\delta)$ for $K_{I(n)} \geq 1 \%$	-...A -...S
23	Current THD K_I , %	From 0 to 100	$\pm 0,05 (\Delta)$ for $K_I < 1 \%$ $\pm 5 (\delta)$ for $K_I \geq 1 \%$	-...A -...S
24	Current unbalance of negative sequence K_{2l} , %	From 0 to 20	$\pm 0,15 (\Delta)$	-...A
			$\pm 0,3 (\Delta)$	-...S
25	Current unbalance of zero sequence K_{0l} , %	From 0 to 20	$\pm 0,15 (\Delta)$	-...A
			$\pm 0,3 (\Delta)$	-...S
26	RMS phase voltage of m^{th} interharmonic $I_{\text{isg}(m)}$ ($m=0,5 \dots 49,5$), A	From 0 to $0,15 \cdot I_n$	$\pm 0,005 \cdot I_n (\Delta)$ for $I_{\text{isg}(m)} < 0,01 \cdot I_n$ $\pm 5 (\delta)$ for $I_{\text{isg}(m)} \geq 0,01 \cdot I_n$	-...A -...S
27	Phase angle of fundamental harmonic phase currents φ_i , °	From -180 to 180	$\pm 0,1 (\Delta)$ for $0,1 \cdot I_n \leq I \leq 2 \cdot I_n$ $\pm 0,5 (\Delta)$ for $0,01 \cdot I_n \leq I < 0,1 \cdot I_n$	-...A -...S
28	Phase difference between phase voltage and current of fundamental harmonic $\varphi_{UI(1)}$, °	From -180 to 180	$\pm 0,1 (\Delta)$ for $0,1 \cdot I_n \leq I \leq 2 \cdot I_n$ $\pm 1 (\Delta)$ for $0,01 \cdot I_n \leq I < 0,1 \cdot I_n$	-...A -...S
29	Phase difference between phase voltage and positive φ_{U1I1} , negative φ_{U2I2} and zero φ_{U0I0} sequence current, °	From -180 to 180	$\pm 1,5 (\Delta)$ for $0,1 \cdot I_n \leq I \leq 2 \cdot I_n$ $\pm 5 (\Delta)$ for $0,01 \cdot I_n \leq I < 0,1 \cdot I_n$	-...A -...S
30	Phase difference between n^{th} harmonic phase voltage and current $\varphi_{UI(n)}$, °	From -180 to 180	$\pm 5 (\Delta)$	-...A -...S
Voltage dips and swells				
31	Voltage dip duration Δt_d , s	From 0,01 to 60	$\pm 0,01 (\Delta)$	-...A -...S
32	Voltage dip magnitude δU_d , %	From 0 to 100	$\pm 0,2 (\Delta)$ $\pm 1,0 (\Delta)$	-...A -...S
33	Voltage interruption duration Δt_{inter} , s	From 0,02 to 60	$\pm 0,1 (\Delta)$	-...A -...S
34	Voltage swell duration Δt_{sw} , s	From 0,01 to 60	$\pm 0,01 (\Delta)$	-...A -...S
35	Voltage swell coefficient K_{sw} , отн. ед.	From 1,0 to 2,0	$\pm 0,002 (\Delta)$	-...A
		From 1,0 to 1,4	$\pm 0,01 (\Delta)$	-...S
Electric power parameters				
36	Power factor (A, B, C phase and average) K_P ($K_P = P/S$) ⁶	From minus 1 to 1	$\pm 0,01 (\Delta)$	-...A -...S
37	Active power (A, B, C phases and total) P , active power (A, B, C phases and total) of	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$	$\pm 0,4 (\delta)$ for $0,01 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < K_P \leq 1$	-...A -...S

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; γ^1) conventional, %)	Modification
	fundamental harmonic $P_{(1)}$, W	From $0,2 \cdot U_n$ to $2,0 \cdot U_n$ $0,25 \leq K_P \leq 1$	$\pm 0,2 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,8 < K_P \leq 1$ $\pm 0,5 (\delta)$ for $0,02 \cdot I_n \leq I < 0,1 \cdot I_n;$ $0,5 \leq K_P \leq 0,8$ $\pm 0,3 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,5 \leq K_P \leq 0,8$ $\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,25 \leq K_P < 0,5$	
38	Active power of positive $P_{1(1)}$, negative $P_{2(1)}$ and zero $P_{0(1)}$ sequence, W	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$	$\pm 0,5 (\delta)$	-...A -...S
39	Active power (A, B, C phase and total) of n^{th} harmonic $P_{(n)}$, W	From $0,01 \cdot I_n$ to $0,5 \cdot I_n$ From $0,1 \cdot U_n$ to $0,5 \cdot U_n$ $0,5 \leq K_P \leq 1$	$\pm 5,0 (\delta)$	-...A -...S
40	Reactive power (A, B, C phase and total) Q , reactive power (A, B, C phase and total) of fundamental harmonic $Q_{(1)}$, var	From $0,02 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$ $0,25 \leq \sin \varphi \leq 1$	$\pm 0,8 (\delta)$ for $0,02 \cdot I_n \leq I < 0,05 \cdot I_n;$ $0,8 < \sin \varphi \leq 1$ $\pm 0,5 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,8 < \sin \varphi \leq 1$ $\pm 0,8 (\delta)$ for $0,05 \cdot I_n \leq I < 0,1 \cdot I_n;$ $0,5 \leq \sin \varphi \leq 0,8$ $\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,5 \leq \sin \varphi \leq 0,8$ $\pm 0,8 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n;$ $0,25 \leq \sin \varphi < 0,5$	-...A -...S
41	Reactive power of positive $Q_{1(1)}$, negative $Q_{2(1)}$ and zero $Q_{0(1)}$ sequence, var	From $0,02 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$	$\pm 0,8 (\delta)$	-...A -...S
42	Reactive power (A, B, C phase and total) of n^{th} harmonic $Q_{(n)}$, var	From $0,01 \cdot I_n$ to I_n From $0,1 \cdot U_n$ to U_n $0,5 \leq \sin \varphi \leq 1$	$\pm 5,0 (\delta)$	-...A -...S
43	Apparent power (A, B, C phase and total) S , apparent power	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$	$\pm 0,5 (\delta)$	-...A -...S

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)	Modification
	(A, B, C phase and total) of fundamental harmonic $S_{(1)}$, VA			
44	Apparent power of positive $S_{1(1)}$, negative $S_{2(1)}$ and zero $S_{0(1)}$ sequence, VA	From $0,2 \cdot U_n$ to $2,0 \cdot U_n^8$	$\pm 0,5 (\delta)$	-...A -...S
45	Apparent power (A, B, C phase and total) of n^{th} harmonic $S_{(n)}$, VA	From $0,01 \cdot I_n$ to I_n From $0,1 \cdot U_n$ to U_n	$\pm 5,0 (\delta)$	-...A -...S

Note that:

- 1) Normalized value for conventional error calculation is the nominal value.
- 2) Voltage RMS includes voltage RMS of fundamental harmonic $U_{(1)}$, overall voltage RMS for the spectrum U and average voltage RMS U_{av} .
- 3) In addition, it measures maximum value of the characteristics over some period.
- 4) Current RMS includes current RMS of fundamental harmonic $I_{(1)}$, overall current RMS for the spectrum I and average current RMS I_{av} .
- 5) $K_p = \cos \varphi$ for sine wave.

ESM-ET

ESM-ET modification has:

- up to four voltage inputs, they must be connected to the electronic voltage transformers. Nominal voltage values are: 200 mV; 333 mV; 1 V; 1,625 V; 2 V; 3,25 V; 4 V; or divided by $\sqrt{3}$.
- up to four current inputs, they must be connected to the electronic current transformers. Nominal voltage values: 150 mV; 200 mV; 225 mV; 333 mV; 1 V; 1,625 V; 2 V; 4 V.

Metrological characteristics of ESM-ET devices are in the table C.6.

Table C.6

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)
Electric energy parameters			
1	Active energy W_P , active energy (total) of fundamental frequency $W_{P(1)}$, active energy of positive sequence W_{P1} , kWh	0,01· I_n -2,0· I_n 0,2· U_n -2,0· U_n	$\pm 1,0 (\delta)$ for $0,01 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < K_P \leq 1$;
			$\pm 0,5 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < K_P \leq 1$
			$\pm 1,0 (\delta)$ for $0,02 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq K_P \leq 0,8$
			$\pm 0,6 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq K_P \leq 0,8$
			$\pm 1,0 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq K_P < 0,5$
2	Reactive energy W_Q , reactive energy of fundamental harmonic $W_{Q(1)}$, reactive energy of positive sequence W_{Q1} , kvarh	0,02· I_n -2,0· I_n 0,2· U_n -2,0· U_n	$\pm 1,5 (\delta)$ for $0,02 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < \sin \varphi \leq 1$
			$\pm 1,0 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < \sin \varphi \leq 1$
			$\pm 1,5 (\delta)$ for $0,05 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$
			$\pm 1,0 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$
			$\pm 1,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq \sin \varphi < 0,5$
AC voltage and current parameters			
3	RMS phase (line-to-line) voltage U_n , V ²⁾	0,1· U_n -2· U_n	$\pm (0,2+0,01 \cdot U_n/U - 1) (\delta)$
4	RMS voltage of positive sequence U_1 , V	0,1· U_n -2· U_n	$\pm (0,2+0,01 \cdot U_n/U - 1) (\delta)$
5	RMS voltage of negative sequence U_2 , zero sequence U_0 , V	0-2· U_n	$\pm 0,2 (\gamma)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$; $K_{2U} < 15\%$; $K_{0U} < 15\%$
6	Phase (line-to-line) overdeviation $\delta U_{(+)}$, %	From 0 to 100	$\pm 0,2 (\Delta)$
7	Phase (line-to-line) underdeviation $\delta U_{(-)}$, %	From 0 to 90	$\pm 0,2 (\Delta)$

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, γ - relative, %; $\gamma^{(1)}$ conventional, %)
8	Steady-state phase (line-to-line) voltage deviation $\delta U_{\text{steady-state}}$, %	From -90 to 100	$\pm 0,2 (\Delta)$
9	RMS phase (line-to-line) voltage of n^{th} harmonic $U_{(n)}$ ⁴⁾ ($n=2 \dots 50$), V	From 0 to $0,5 \cdot U_n$	$\pm 0,0005 \cdot U_n (\Delta)$ for $U_{(n)} < 0,01 \cdot U_n$ $\pm 5 (\delta)$ for $U_{(n)} \geq 0,01 \cdot U_n$
10	Phase (line-to-line) voltage harmonic spectrum (n^{th} harmonic) $K_{U(n)}$ ($n=2 \dots 50$), %	From 0 to 50	$\pm 0,05 (\Delta)$ for $K_{U(n)} < 1 \%$ $\pm 5 (\delta)$ for $K_{U(n)} \geq 1 \%$
11	Voltage THD K_U , %	From 0 to 50	$\pm 0,05 (\Delta)$ for $K_U < 1 \%$ $\pm 5 (\delta)$ for $K_U \geq 1 \%$
12	Voltage unbalance of negative sequence K_{2U} , %	From 0 to 20	$\pm 0,3 (\Delta)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$
13	Voltage unbalance of zero sequence K_{0U} , %	From 0 to 20	$\pm 0,3 (\Delta)$ for $0,5 \cdot U_n \leq U \leq 2,0 \cdot U_n$
14	RMS phase (line-to-line) voltage of m^{th} interharmonic $U_{\text{isg}(m)}$ ($m=0,5 \dots 49,5$), V	From 0 to $0,15 \cdot U_n$	$\pm 0,005 \cdot U_n (\Delta)$ for $U_{(n)} < 0,01 \cdot U_n$ $\pm 5 (\delta)$ for $U_{\text{isg}(m)} \geq 0,01 \cdot U_n$
15	Phase angle for phase voltage of fundamental harmonic φ_U , °	From -180 to 180	$\pm 0,1 (\Delta)$
16	Frequency f , Hz	From 42,5 to 57,5	$\pm 0,01 (\Delta)$
17	Frequency deviation Δf , Hz	From minus 7,5 to plus 7,5	$\pm 0,01 (\Delta)$
18	RMS current, A ⁵⁾	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$	$\pm (0,2 + 0,005 \cdot I_n / I - 1) (\delta)$
19	RMS positive sequence current of fundamental harmonic I_1 , A	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$	$\pm (0,2 + 0,005 \cdot I_n / I - 1) (\delta)$
20	RMS negative I_2 and zero I_0 sequence current of fundamental harmonic, A	From 0 to $2,0 \cdot I_n$	$\pm 0,2 (\gamma)$
21	RMS current of n^{th} harmonic $I_{(n)}$, A	From 0 to $0,5 \cdot I_n$	$\pm 0,0005 \cdot I_n (\Delta)$ for $I_{(n)} < 0,01 \cdot I_n$ $\pm 5 (\delta)$ for $I_{(n)} \geq 0,01 \cdot I_n$
22	Current harmonic spectrum (n^{th} harmonic), $K_{I(n)}$ %	From 0 to 50	$\pm 0,05 (\Delta)$ for $K_{I(n)} < 1 \%$ $\pm 5 (\delta)$ for $K_{I(n)} \geq 1 \%$
23	Current THD K_I , %	From 0 to 50	$\pm 0,05 (\Delta)$ for $K_I < 1 \%$ $\pm 5 (\delta)$ for $K_I \geq 1 \%$
24	Current unbalance of negative sequence K_{2I} , %	From 0 to 20	$\pm 0,3 (\Delta)$
25	Current unbalance of zero sequence K_{0I} , %	From 0 to 20	$\pm 0,3 (\Delta)$
26	RMS phase voltage of m^{th} interharmonic $I_{\text{isg}(m)}$ ($m=0,5 \dots 49,5$), A	From 0 to $0,15 \cdot I_n$	$\pm 0,005 \cdot I_n (\Delta)$ for $I_{\text{isg}(m)} < 0,01 \cdot I_n$ $\pm 5 (\delta)$ for $I_{\text{isg}(m)} \geq 0,01 \cdot I_n$

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; $\gamma^1)$ conventional, %)
27	Phase angle of fundamental harmonic phase currents φ_I , °	From -180 to 180	$\pm 0,1 (\Delta)$ for $0,1 \cdot I_n \leq I \leq 2 \cdot I_n$ $\pm 0,5 (\Delta)$ for $0,01 \cdot I_n \leq I < 0,1 \cdot I_n$
28	Phase difference between phase voltage and current of fundamental harmonic $\varphi_{U(I)}$, °	From -180 to 180	$\pm 0,1 (\Delta)$ for $0,1 \cdot I_n \leq I \leq 2 \cdot I_n$ $\pm 1 (\Delta)$ for $0,01 \cdot I_n \leq I < 0,1 \cdot I_n$
29	Phase difference between phase voltage and positive φ_{U1I1} , negative φ_{U2I2} and zero φ_{U0I0} sequence current, °	From -180 to 180	$\pm 1,5 (\Delta)$ for $0,1 \cdot I_n \leq I \leq 2 \cdot I_n$ $\pm 5 (\Delta)$ for $0,01 \cdot I_n \leq I < 0,1 \cdot I_n$
30	Phase difference between n^{th} harmonic phase voltage and current $\varphi_{U(I)}$, °	From -180 to 180	$\pm 5 (\Delta)$
Voltage dips and swells			
31	Voltage dip duration Δt_d , s	From 0,01 to 60	$\pm 0,01 (\Delta)$
32	Voltage dip magnitude δU_d , %	From 0 to 100	$\pm 1,0 (\Delta)$
33	Voltage interruption duration Δt_{inter} , s	From 0,02 to 60	$\pm 0,1 (\Delta)$
34	Voltage swell duration Δt_{sw} , s	From 0,01 to 60	$\pm 0,01 (\Delta)$
35	Voltage swell coefficient K_{sw} ,	From 1,0 to 1,4	$\pm 0,01 (\Delta)$
Electric power parameters			
36	Power factor (A, B, C phase and average) K_p ($K_p = P/S$) ⁶⁾	from -1 to -0,1 from 0,1 to 1	$\pm 0,01 (\Delta)$
37	Active power (A, B, C phases and total) P , active power (A, B, C phases and total) of fundamental harmonic $P_{(1)}$, W	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$ $0,25 \leq K_p \leq 1$	$\pm 0,4 (\delta)$ for $0,01 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < K_p \leq 1$ $\pm 0,2 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < K_p \leq 1$ $\pm 0,5 (\delta)$ for $0,02 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq K_p \leq 0,8$ $\pm 0,3 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq K_p \leq 0,8$ $\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq K_p < 0,5$
38	Active power of positive $P_{1(1)}$, negative $P_{2(1)}$ and zero $P_{0(1)}$ sequence, W	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$	$\pm 0,5 (\delta)$
39	Active power (A, B, C phase and total) of n^{th} harmonic $P_{(n)}$, W	From $0,01 \cdot I_n$ to $0,5 \cdot I_n$	$\pm 5,0 (\delta)$

No.	Measured parameter	Measurement range	Measurement error limits (Δ - static, Δ - relative, %; γ ¹⁾ conventional, %)
		From $0,1 \cdot U_n$ to $0,5 \cdot U_n$ $0,5 \leq K_P \leq 1$	
40	Reactive power (A, B, C phase and total) Q , reactive power (A, B, C phase and total) of fundamental harmonic $Q_{(1)}$, var	From $0,02 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$ $0,25 \leq \sin \varphi \leq 1$	$\pm 0,8 (\delta)$ for $0,02 \cdot I_n \leq I < 0,05 \cdot I_n$; $0,8 < \sin \varphi \leq 1$ $\pm 0,5 (\delta)$ for $0,05 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,8 < \sin \varphi \leq 1$ $\pm 0,8 (\delta)$ for $0,05 \cdot I_n \leq I < 0,1 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$ $\pm 0,5 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,5 \leq \sin \varphi \leq 0,8$ $\pm 0,8 (\delta)$ for $0,1 \cdot I_n \leq I \leq 2,0 \cdot I_n$; $0,25 \leq \sin \varphi < 0,5$
41	Reactive power of positive $Q_{1(1)}$, negative $Q_{2(1)}$ and zero $Q_{0(1)}$ sequence, var	From $0,02 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$	$\pm 0,8 (\delta)$
42	Reactive power (A, B, C phase and total) of n^{th} harmonic $Q_{(n)}$, var	From $0,01 \cdot I_n$ to $0,5 \cdot I_n$ From $0,1 \cdot U_n$ to $0,5 \cdot U_n$ $0,5 \leq \sin \varphi \leq 1$	$\pm 5,0 (\delta)$
43	Apparent power (A, B, C phase and total) S , apparent power (A, B, C phase and total) of fundamental harmonic $S_{(1)}$, VA	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$	$\pm 0,5 (\delta)$
44	Apparent power of positive $S_{1(1)}$, negative $S_{2(1)}$ and zero $S_{0(1)}$ sequence, VA	From $0,01 \cdot I_n$ to $2,0 \cdot I_n$ From $0,2 \cdot U_n$ to $2,0 \cdot U_n$	$\pm 0,5 (\delta)$
45	Apparent power (A, B, C phase and total) of n^{th} harmonic $S_{(n)}$, VA	From $0,01 \cdot I_n$ to $0,5 \cdot I_n$ From $0,1 \cdot U_n$ to $0,5 \cdot U_n$	$\pm 5,0 (\delta)$

Note that:

¹⁾ Normalized value for conventional error calculation is the nominal value.

²⁾ Voltage RMS includes voltage RMS of fundamental harmonic $U_{(1)}$, overall voltage RMS for the spectrum U and average voltage RMS U_{av} .

³⁾ In addition, it measures maximum value of the characteristics over some period.

⁴⁾ Current RMS includes current RMS of fundamental harmonic $I_{(1)}$, overall current RMS for the spectrum I and average current RMS I_{av} .

⁵⁾ $K_P = \cos \varphi$ for sine wave.

Every ± 10 °C temperature change causes additional measurement error increase on 0.5 of the main error limits

Limits of an additional error caused by permanent or alternating magnetic field (0.5 mTl induction) are 0,5 of the main error limits.

Appendix D. EMC

The EMC characteristics for the ESM devices are presented in the table D.1.

Table D.1

No.	Standard	Level
1	IEC 61000-4-2	±4kV contact ±8kV air discharge
2	IEC 61000-4-3	3 V/m, 80 MHz-1000 MHz ¹⁾ 10 V/m, 80 MHz-1000 MHz ^{2) 3)} 3 V/m, 1.4-2GHz 1 V/m, 2-2.7GHz
3	IEC 61000-4-4	± 2 kV (Port: AC) ⁴⁾ ± 1 kV (Port: Ethernet) ⁴⁾
4	IEC 61000-4-5	± 1 kV L-N; ± 2 kV L-PE; N-PE
5	IEC 61000-4-6	3 V, 0.15 MHz-80 MHz 10 V, 0.15 MHz-80 MHz
6	IEC 61000-4-8	30 A/m
7	IEC 61000-4-11	0 % 20ms 40 % 200ms 70 % 500ms 0 % 5s
8	CISPR 11	Class A

Note that:

¹⁾ During the test, the measured analog value may differ at the following test frequencies: 670-640 MHz (V), 100-110 MHz (H), 860-890 MHz (H).

²⁾ During the test, the measured analog value may differ at the following test frequencies: 110-130 MHz (V), 170-180 MHz (V), 330-405 MHz (V), 405 MHz-1 GHz (V), 100-130 MHz (H), 160-180 MHz (H), 340-480 MHz (H), 480 MHz – 1 GHz (H).

³⁾ During the test, software «ESMTest» may display notification «connection setup / установка соединения» at the following test frequencies: 83-110 MHz (V), 90-100 MHz (H).

⁴⁾ During the test, software «ESMTest» may display notification «connection setup / установка соединения».



ATTENTION:

- High-level external radio frequency interference may affect measurement. Analog values can be incorrect temporarily. Software «ESMTest» may display notification «connection setup / установка соединения».
- Conducted disturbances induced by radio-frequency fields may cause changes of analog measurement data. Software «ESMTest» may display notification «connection setup / установка соединения».

Appendix E. Modbus

About Modbus

Modbus (Schneider Electric trademark) is a serial communication protocol. Full description see on www.modbus.org. This protocol is used for data communication via RS-485 or Ethernet interfaces.

Address

Available slave addresses of ESM are from 01 to 254 (01-hFE). h00 and hFF are multicast addresses. Any device in network responds to the request if it's address is h00. Any device in network executes a command if the request address is hFF.

Available function codes

- h01 read coil;
- h02 read discrete inputs;
- h03 read holding registers;
- h04 read input registers;
- h05 write single coil;
- h06 write single register (reset, fixing data, delete event log);
- h14 read file record;
- h2B read ID.

Service function codes

h64 service read;

h65 service write.

Exception codes

01 – illegal function

02 – illegal data address

03 – illegal data value

04 – slave device failure

Analog registers

Register addresses range is 0 to 59999. You can change the addresses of values using «ES Configurator». Values in registers are saved in integer and float formats.

Available data type:

- Short
- Float

ESM integer is little-endian order.

For the data conversion obtained use the following formulas (register's value/coefficient):

Integer conversion coefficients:	
Parameter	Coefficient
Other	1
Voltage	100
Current	1000
Power	100
Frequency	1000
Power factor	1000
Harmonics	1000
Assymetry	1000
Angle	100

- Float

ESM float corresponds to [IEEE 754](#).

Default addresses

Address		Quantity of registers	Value	Type
Dec	hex			
Integer RMS				
0	0x00	1	Ua	unsigned short
1	0x01	1	Ub	unsigned short
2	0x02	1	Uc	unsigned short
3	0x03	1	Average U	unsigned short
4	0x04	1	Uab	unsigned short
5	0x05	1	Ubc	unsigned short
6	0x06	1	Uca	unsigned short
7	0x07	1	Average line-to-line U	unsigned short
8	0x08	1	Ia	unsigned short
9	0x09	1	Ib	unsigned short
10	0x0A	1	Ic	unsigned short
11	0x0B	1	Average I	unsigned short
12	0x0C	1	Pa	short
13	0x0D	1	Pb	short
14	0x0E	1	Pc	short
15	0x0F	1	Total P	short
16	0x10	1	Qa	short
17	0x11	1	Qb	short
18	0x12	1	Qc	short
19	0x13	1	Total Q	short
20	0x14	1	Sa	short
21	0x15	1	Sb	short
22	0x16	1	Sc	short
23	0x17	1	Total S	short

Address		Quantity of registers	Value	Type
Dec	hex			
Integer first harmonic				
24	0x18	1	Fa	unsigned short
25	0x19	1	Fb	unsigned short
26	0x1A	1	Fc	unsigned short
27	0x1B	1	Average F	unsigned short
28	0x1C	1	WPb	long
32	0x1D	1	WPm	long
36	0x1E	1	WQp	long
40	0x1F	1	WQm	long

Here is an example of request with function code 01 if ESM has slave address 01, DIO requested from 2 to 13:

Slave address	Function code	Data address of the first coil		Number of coils	CRC	
01	01	00	02	00	0C	9D CF

And this is the response to previous request:

Slave address	Function code	Byte counter	Answered states	CRC	
01	01	02	02 00	B8	9C

Second and third byte describe DIO status:

byte	02								00							
bit	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
DIO	9	8	7	6	5	4	3	2					13	12	11	10

Appendix F. IEC 61850

Additional conformance statement of ESM IEC 61850 available at links:

- [MICS – Model Implementation Conformance Statement](#);
- [PICS – Protocol Implementation Conformance Statement](#);
- [PIXIT – Protocol Implementation Extra Information for Testing](#);
- [TICS – TISSUES Implementation Conformance Statement](#).

*.icd file download [here](#).

ACSI conformance statement according to IEC61850-7-2 first edition 2003-05

- – available services

Table E.1.1 – Basic conformance statement

		Client/ subscriber	Server/ publisher	Value/ comments
Client-server roles				
B11	Server side (of TWO-PARTY APPLICATION-ASSOCIATION)		•	
B12	Client side of (TWO-PARTY APPLICATION-ASSOCIATION)			
SCSMs supported				
B21	SCSM: IEC 61850-8-1 used		•	
B22	SCSM: IEC 61850-9-1 used			
B23	SCSM: IEC 61850-9-2 used			
B24	SCSM: other			
Generic substation event model (GSE)				
B31	Publisher side		•	
B32	Subscriber side	•		
Transmission of sampled value model (SVC)				
B41	Publisher side			
B42	Subscriber side			

Table E.1.2 – ACSI models conformance statement

		Client/ subscriber	Server/ publisher	Value/ comments
If Server side (B11) supported				
M1	Logical device		•	
M2	Logical node		•	

		Client/ subscriber	Server/ publisher	Value/ comments
M3	Data		•	
M4	Data set		•	
M5	Substitution			
M6	Setting group control			
	Reporting			
M7	Buffered report control		•	
M7-1	sequence-number		•	
M7-2	report-time-stamp		•	
M7-3	reason-for-inclusion		•	
M7-4	data-set-name		•	
M7-5	data-reference		•	
M7-6	buffer-overflow		•	
M7-7	entryID		•	
	conf_revision		•	
M7-8	BuTm		•	BuTm = 0
M7-9	IntgPd		•	
M7-10	GI		•	
M8	Unbuffered report control		•	
M8-1	sequence-number		•	
M8-2	report-time-stamp		•	
M8-3	reason-for-inclusion		•	
M8-4	data-set-name		•	
M8-5	data-reference		•	
	conf_revision		•	
M8-6	BuTm		•	BuTm = 0
M8-7	IntgPd		•	
M8-8	GI		•	
	Logging			
M9	Log control			
M9-1	IntgPd			
M10	Log			
M11	Control			
If GSE (B31/B32) is supported				
	GOOSE			
M12-1	entryID			
M12-2	DataRefInc			
M13	GSSE			
If SVC (B41/B42) is supported				
M14	Multicast SVC			
M15	Unicast SVC			
M16	Time			
M17	File Transfer			

Table E.1.3 – ACSI service conformance statement

Services		AA: TP/MC	Client/ subscriber	Server/ publisher	Comments
Server (Clause 6)					
S1	Server Directory	TP		•	
Application association (Clause 7)					
S2	Associate			•	
S3	Abort			•	
S4	Release			•	
Logical device (Clause 8)					
S5	LogicalDeviceDirectory	TP		•	
Logical node (Clause 9)					
S6	LogicalNodeDirectory	TP		•	
S7	GetAllDataValues	TP		•	
Data (Clause 10)					
S8	GetDataValues	TP		•	
S9	SetDataValues	TP		•	
S10	GetDataDirectory	TP		•	
S11	GetDataDefinition	TP		•	
Data set (Clause 11)					
S12	GetDataSetValues	TP		•	
S13	SetDataSetValues	TP		•	
S14	CreateDataSet	TP		•	
S15	DeleteDataSet	TP		•	
S16	GetDataSetDirectory	TP		•	
Substitution (Clause 12)					
S17	SetDataValues	TP			
Setting group control (Clause 13)					
S18	SelectActiveSG	TP			
S19	SelectEditSG	TP			
S20	SetSGValues	TP			
S21	ConfirmEditSGValues	TP			
S22	GetSGValues	TP			
S23	GetSGCBValues	TP			
Reporting (Clause 14)					
Buffered report control block (BRCB)					
S24	Report	TP		•	
S24-1	data-change (dchg)			•	
S24-2	qchg-change (qchg)			•	
S24-3	data-update (dupd)			•	
S25	GetBRCBValues	TP		•	

Services		AA: TP/MC	Client/ subscriber	Server/ publisher	Comments
S26	SetBRCBValues	TP		•	
Unbuffered report control block (URCB)					
S27	Report	TP		•	
S27-1	data-change (dchg)			•	
S27-2	qchg-change (qchg)			•	
S27-3	data-update (dupd)			•	
S28	GetURCBValues	TP		•	
S29	SetURCBValues	TP		•	

Logging (Clause 14)					
Log control block					
S30	GetLCBValues	TP			
S31	SetLCBValues	TP			
Log					
S32	QueryLogByTime	TP			
S33	QueryLogAfter	TP			
S34	GetLogStatusValues	TP			

Generic substation event model (GSE) (14.3.5.3.4)					
GOOSE-CONTROL-BLOCK					
S35	SendGOOSEMessage	MC		•	
S36	GetGoReference	TP			
S37	GetGOOSEElementNumber	TP			
S38	GetGoCBValues	TP		•	
S39	SetGoCBValues	TP		•	
GSSE-CONTROL-BLOCK					
S40	SendGSSEMessage	MC			
S41	GetGsReference	TP			
S42	GetGSSEEElementNumber	TP			
S43	GetGsCBValues	TP			
S44	SetGsCBValues	TP			

Transmission of sampled value model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC			
S46	GetMSVCBValues	TP			
S47	SetMSVCBValues	TP			
Unicast SVC					
S48	SendUSVMessage	TP			
S49	GetUSVCBValues	TP			
S50	SetUSVCBValues	TP			

Control (17.5.1)					
S51	Select	TP			
S52	SelectWithValue	TP		•	

Services		AA: TP/MC	Client/ subscriber	Server/ publisher	Comments
S53	Cancel	TP		•	
S54	Operate	TP		•	
S55	CommandTermination	TP		•	
S56	TimeActivated-Operate	TP			

File transfer (Clause 20)					
S57	GetFile	TP			
S58	SetFile	TP			
S59	DeleteFile	TP			
S60	GetFileAttributeValue	TP			

Time (Clause 18)					
T1	Time resolution of internal clock	TP		1 ms	
T2	Time accuracy of internal clock	TP		1 ms	
T3	Supported TimeStamp resolution	TP		1 ms	

Mandatory tissues

Table D.1.4

Part	Tissue #	Technical Issue Subject	Applied/Yes/ Not applied
8-1	116	GetNamesList with empty response?	Yes
	165	Improper Error Response for GetDataSetValues	Yes
	183	GetNamesList error handling	Yes
	246	Control negative response	Not applied
	545	File directories	Not applied
7-4			
7-3	28	Definition of APC	Not applied
	54	Point def xVal, not cVal	Not applied
	55	Ineut = Ires ?	Not applied
	63	mag in CDC CMV	Yes
	219	operTm in ACT	Not applied
	270	WYE and DEL rms values	Yes
7-2	30	control parameter T	Yes
	31	Typo	Not applied
	32	Typo in syntax	Not applied
	35	Typo Syntax Control time	Not applied
	36	Syntax parameter DSet-Ref missing	Not applied
	37	Syntax GOOSE "T" type	Yes
	39	Add DstAddr to GoCB	Yes
	40	GOOSE Message "AppID" to "GoID"	Yes
	41	GsCB "AppID" to "GsID"	Not applied
	42	SV timestamp: "EntryTime" to "TimeStamp"	Not applied
	43	Control "T" semantic	Not applied
	44	AddCause - Object not sel	Yes
	45	Missing AddCauses	Yes
	46	Synchro check cancel	Yes
	47	".." in LD Name?	Yes
	49	BRCB TimeOfEntry? (part of #453)	-
	50	LNNName start with number?	Yes
	51	ARRAY [0..num] missing	Yes
	52	Ambiguity GOOSE SqNum	Yes
	53	Add DstAddr to GsCB, SV	Not applied
	151	Name constraint for control blocks etc.	Yes
	166	DataRef attribute in Log	Not applied
	185	Logging - Integrity periode	Not applied
	189	SV Format	Not applied
	190	BRCB: EntryId and TimeOfEntry	-
	191	BRCB: Integrity and buffering reports (part of #453)	-
	275	Confusing statement on GI usage (part of #453)	-
	278	EntryId not valid for a server (part of #453)	-
	297	Sequence number (part of #453)	-
	298	Type of SqNum	Yes
	305	Reporting with BufTm=0 (part of #453)	Yes

	322	Write Configuration attribute of BRCBs (part of #453)	-
	329	Reporting and BufOvl (part of #453)	-
	333	Enabling of an incomplet GoCB	Yes
	335	Clearing of Bufovfl (part of #453)	-
	348	URCB class and report (part of #453)	-
	349	BRCB TimeOfEntry has two definitions (part of #453)	-
	453	Reporting & Logging model revision	Yes
6	1	Syntax	Yes
	5	tExtensionAttributeNameEnum is restricted	Yes
	8	SIUnit enumeration for W	Not applied
	10	Base type for bitstring usage	Yes
	17	DAI/SDI elements syntax	Yes
	169	Ordering of enum differs from 7-3	Not applied
	249	Mapping of CODED ENUM	Yes
	529	sev	Yes

Notice: Tissue 49, 190, 191, 275, 278, 297, 305, 322, 329, 333, 335, 348 and 349 are parts of optional tissue # 453.

Other tissues completed

Table D.1.5

Part	Tissue #	Описание
7-2	333	Enabling of an incomplet GoCB
7-2	322	Write Configuration attribute of BRCBs
8-1	177	Ignoring OptFlds bits for URCB

Appendix G. IEC 60870-5-101 and IEC 60870-5-104

Available ASDU

Value	ASDU		Description
Digital signals	1	M_SP_NA_1	Single-point information
	30	M_SP_TB_1	Single-point information with time tag CP56
Measured value	11	M_ME_NB_1	Measured value, scaled value
	13	M_ME_NC_1	Measured value, short floating point value
	35	M_ME_TE_1	Measured value, scaled value with time tag CP56
	36	M_ME_TF_1	Measured value, short floating point value with time tag CP56
Integrated totals	15	M_IT_NA_1	Integrated totals
	37	M_IT_TB_1	Integrated totals with time tag CP56

Default register's addresses of ESM:

Адрес по умолчанию	Наименование параметра	Тип ASDU
65	Ua	11/13/35/36
66	Ub	11/13/35/36
67	Uc	11/13/35/36
68	Average U	11/13/35/36
69	Uab	11/13/35/36
70	Ubc	11/13/35/36
71	Uca	11/13/35/36
72	Average line-to-line U	11/13/35/36
73	Ia	11/13/35/36
74	Ib	11/13/35/36
75	Ic	11/13/35/36
76	Average I	11/13/35/36
77	Pa	11/13/35/36
78	Pb	11/13/35/36
79	Pc	11/13/35/36
80	Total P	11/13/35/36
81	Qa	11/13/35/36
82	Qb	11/13/35/36
83	Qc	11/13/35/36
84	Total Q	11/13/35/36
85	Sa	11/13/35/36
86	Sb	11/13/35/36
87	Sc	11/13/35/36
88	Total S	11/13/35/36
89	Fa	11/13/35/36
90	Fb	11/13/35/36
91	Fc	11/13/35/36
92	Average F	11/13/35/36
93	Wpp	15/37
94	Wpm	15/37
95	WQp	15/37
96	WQm	15/37

IEC 60870-5-101/104 Protocol Implementation Conformance Statement

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This Clause summarizes the parameters of the previous Clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers, it is necessary that all partners agree on the selected parameters.

Designation:

- Function or ASDU is not used;
- Function or ASDU is used as standardized (default);
- R - Function or ASDU is used in reverse mode;
- B - Function or ASDU is used in standard and reverse mode/

The possible selection (blank, X, R, or B) is specified for each specific Clause or parameter.

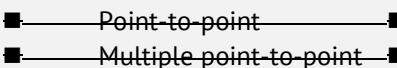
1. System or device

(system-specific parameter, indicate the definition of a system or a device by marking one of the following with an «X»)

IEC 60870-5-101	IEC 60870-5-104
<input type="checkbox"/> System definition <input type="checkbox"/> Controlling station definition (master) <input checked="" type="checkbox"/> Controlled station definition (slave)	<input type="checkbox"/> System definition <input type="checkbox"/> Controlling station definition (master) <input type="checkbox"/> Controlled station definition (slave)

2. Network configuration

IEC 60870-5-101
<input checked="" type="checkbox"/> Point-to-point <input type="checkbox"/> Multipoint-partyline <input checked="" type="checkbox"/> Multiple point-to-point <input type="checkbox"/> Multipoint-star

IEC 60870-5-104
 

3. Physical layer

(network-specific parameter, all interfaces and data rates that are used are to be marked with an «X»)

Transmission speed (control direction)

IEC 60870-5-101		
Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 recommended if >1200 bit/s	Balanced interchange circuit X.24/X.27
<input type="checkbox"/> 100bit/s	<input checked="" type="checkbox"/> 2400bit/s	<input type="checkbox"/> 2400bit/s
<input type="checkbox"/> 200bit/s	<input checked="" type="checkbox"/> 4800bit/s	<input type="checkbox"/> 4800bit/s
<input type="checkbox"/> 300bit/s	<input checked="" type="checkbox"/> 9600bit/s	<input type="checkbox"/> 9600bit/s
<input checked="" type="checkbox"/> 600bit/s	<input checked="" type="checkbox"/> 19200bit/s	<input type="checkbox"/> 19200bit/s
<input checked="" type="checkbox"/> 1200bit/s	<input checked="" type="checkbox"/> 38400 bit/s	<input type="checkbox"/> 38400bit/s
	<input checked="" type="checkbox"/> 57600 bit/s	<input type="checkbox"/> 56000bit/s
	<input checked="" type="checkbox"/> 115200 bit/s	<input type="checkbox"/> 64000bit/s

IEC 60870-5-104			
Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 recommended if >1200 bit/s	Balanced interchange circuit X.24/X.27	
<input type="checkbox"/> 100bit/s	<input checked="" type="checkbox"/> 2400bit/s	<input checked="" type="checkbox"/> 2400bit/s	<input checked="" type="checkbox"/> 38400bit/s
<input type="checkbox"/> 200bit/s	<input checked="" type="checkbox"/> 4800bit/s	<input checked="" type="checkbox"/> 4800bit/s	<input checked="" type="checkbox"/> 56000bit/s
<input type="checkbox"/> 300bit/s	<input checked="" type="checkbox"/> 9600bit/s	<input checked="" type="checkbox"/> 9600bit/s	<input checked="" type="checkbox"/> 64000bit/s
<input checked="" type="checkbox"/> 600bit/s	<input checked="" type="checkbox"/> 19200bit/s	<input checked="" type="checkbox"/> 19200bit/s	
<input checked="" type="checkbox"/> 1200bit/s			

Transmission speed (monitor direction)

IEC 60870-5-101		
Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 recommended if >1200 bit/s	Balanced interchange circuit X.24/X.27
<input type="checkbox"/> 100bit/s	<input checked="" type="checkbox"/> 2400bit/s	<input type="checkbox"/> 2400bit/s
<input type="checkbox"/> 200bit/s	<input checked="" type="checkbox"/> 4800bit/s	<input type="checkbox"/> 4800bit/s
<input type="checkbox"/> 300bit/s	<input checked="" type="checkbox"/> 9600bit/s	<input type="checkbox"/> 9600bit/s
<input checked="" type="checkbox"/> 600bit/s	<input checked="" type="checkbox"/> 19200bit/s	<input type="checkbox"/> 19200bit/s
<input checked="" type="checkbox"/> 1200bit/s	<input checked="" type="checkbox"/> 38400 bit/s	<input type="checkbox"/> 38400bit/s
	<input checked="" type="checkbox"/> 57600 bit/s	<input type="checkbox"/> 56000bit/s
	<input checked="" type="checkbox"/> 115200 bit/s	<input type="checkbox"/> 64000bit/s

IEC 60870-5-104			
Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 recommended if >1200 bit/s	Balanced interchange circuit X.24/X.27	
<input type="checkbox"/> 100bit/s	<input checked="" type="checkbox"/> 2400bit/s	<input checked="" type="checkbox"/> 2400bit/s	<input checked="" type="checkbox"/> 38400bit/s
<input type="checkbox"/> 200bit/s	<input checked="" type="checkbox"/> 4800bit/s	<input checked="" type="checkbox"/> 4800bit/s	<input checked="" type="checkbox"/> 56000bit/s
<input type="checkbox"/> 300bit/s	<input checked="" type="checkbox"/> 9600bit/s	<input checked="" type="checkbox"/> 9600bit/s	<input checked="" type="checkbox"/> 64000bit/s
<input checked="" type="checkbox"/> 600bit/s	<input checked="" type="checkbox"/> 19200bit/s	<input checked="" type="checkbox"/> 19200bit/s	
<input checked="" type="checkbox"/> 1200bit/s			

4. Link layer

Network-specific parameter, all options that are used are to be marked with an “x”. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.

IEC 60870-5-101

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure	Address field of the link
<input type="checkbox"/> Balanced transmission <input checked="" type="checkbox"/> Unbalanced transmission	<input type="checkbox"/> Not present (balanced transmission only) <input checked="" type="checkbox"/> One octet <input type="checkbox"/> Two octets <input type="checkbox"/> Structured <input checked="" type="checkbox"/> Unstructured
Frame length 255 Maximum length L (control direction) 255 Maximum length L (monitor direction)	
5 - repetitions Time during which repetitions are permitted (Trp) or number of repetitions	

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

- The standard assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission

- A special assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission
1, 3, 11, 13, 15, 30, 31, 35, 36, 37	<3>

~~NOTE: In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.~~

IEC 60870-5-104

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure	Address field of the link
<input checked="" type="checkbox"/> Balanced transmission <input type="checkbox"/> Unbalanced transmission	<input checked="" type="checkbox"/> Not present (balanced transmission only) <input checked="" type="checkbox"/> One octet <input checked="" type="checkbox"/> Two octets <input checked="" type="checkbox"/> Structured <input checked="" type="checkbox"/> Unstructured
Frame length <input checked="" type="checkbox"/> Maximum length L	

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

■ ~~The standard assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission

■ ~~A special assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission

5. Application layer

Transmission mode for application data Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked with an X).

IEC 60870-5-101	IEC 60870-5-104
<input checked="" type="checkbox"/> One octet	<input type="checkbox"/> One octet
<input checked="" type="checkbox"/> Two octets	<input type="checkbox"/> Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked with an X).

IEC 60870-5-101	
<input type="checkbox"/> One octet	<input checked="" type="checkbox"/> Structured
<input checked="" type="checkbox"/> Two octets	<input checked="" type="checkbox"/> Unstructured
<input checked="" type="checkbox"/> Three octets	

IEC 60870-5-104	
<input type="checkbox"/> One octet	<input type="checkbox"/> Structured
<input type="checkbox"/> Two octets	<input checked="" type="checkbox"/> Unstructured
<input checked="" type="checkbox"/> Three octets	

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked with an X).

IEC 60870-5-101	
<input checked="" type="checkbox"/> One octet	<input checked="" type="checkbox"/> Two octets (with originator address)

IEC 60870-5-104	
<input type="checkbox"/> One octet	<input checked="" type="checkbox"/> Two octets (with originator address)

Originator address is set to zero if not used

Selection of standard ASDUs

Process information in monitor direction

Type identification and cause of transmission assignments

((station-specific parameters).

IEC 60870-5-104																	
Type identification		Cause of transmission															
		1	2	3	4	5	6	7	8	9	10	11	12	13	20-36	37-41	44-47
<1>	M_SP_NA_1		X	X											X		
<2>	M_SP_TA_1																
<3>	M_DP_NA_1		X	X											X		
<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																
<10>	M_ME_TA_1																
<11>	M_ME_NB_1	X	X	X											X		
<12>	M_ME_TB_1																
<13>	M_ME_NC_1	X	X	X											X		
<14>	M_ME_TC_1																
<15>	M_IT_NA_1						X									X	
<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					X											
<32>	M_ST_TB_1																
<33>	M_BO_TB_1																
<34>	M_ME_TD_1																
<35>	M_ME_TE_1					X											
<36>	M_ME_TF_1					X											
<37>	M_IT_TB_1					X										X	
<38>	M_EP_TD_1																
<39>	M_IT_TB_1																
<40>	M_EP_TD_1																
<45>	C_SC_NA_1							R	R	R	R	R					R
<46>	C_DC_NA_1							R	R	R	R	R					R
<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																
<70>	M_EI_NA_1																
<100>	C_IC_NA_1							R	R	R	R	R					
<101>	C_CI_NA_1							R	R			R					
<102>	C_RD_NA_1						R									R	
<103>	C_CS_NA_1							R	R								R
<104>	C_TS_NA_1																

<105>	C_RP_NA_1																									
<106>	C_CD_NA_1			X																						X
<110>	P_ME_NA_1				X																					
<111>	P_ME_NB_1					X																				
<112>	P_ME_NC_1						X																			
<113>	P_AC_NA_1							X																		
<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															X	
<124>	F_AF_NA_1										X														X	
<125>	F(CG)_NA_1											X														
<126>	F_DR_TA_1					X							X													

IEC 60870-5-101		Cause of transmission																								
Type identification		1	1	1	1	1	1	1	1	1	1	1	1													
<1>	M_SP_NA_1		X	X																			X			
<2>	M_SP_TA_1																									
<3>	M_DP_NA_1		X	X																			X			
<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	X	X																				X		
<12>	M_ME_TB_1																									
<13>	M_ME_NC_1	X	X	X																				X		
<14>	M_ME_TC_1																									
<15>	M_IT_NA_1					X																				X
<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								X																	
<21>	M_ME_TD_1																									
<30>	M_SP_TB_1				X																					
<31>	M_DP_TB_1				X																					
<32>	M_ST_TB_1																									
<33>	M_BO_TB_1																									
<34>	M_ME_TE_1						X																			
<35>	M_ME_TF_1					X																				
<36>	M_IT_TB_1					X																				
<37>	M_EP_TD_1						X																			X
<38>	M_IT_TB_1																									
<39>	M_EP_TD_1																									
<45>	C_SC_NA_1									R	R	R	R	R											R	
<46>	C_DC_NA_1								R	R	R	R	R												R	
<47>	C_RC_NA_1								R	R	R	R	R												R	
<48>	C_SE_NA_1																									
<49>	C_SE_NB_1																									
<50>	C_SE_NC_1																									

<51>	C_BO_NA_1																				
<70>	M_EI_NA_1																				
<100>	C_IC_NA_1						R	R	R	R	R										
<101>	C_CI_NA_1						R	R					R								
<102>	C_RD_NA_1					R															R
<103>	C_CS_NA_1						R	R													R
<104>	C_TS_NA_1																				
<105>	C_RP_NA_1																				
<106>	C_CD_NA_1																				
<110>	P_ME_NA_1																				
<111>	P_ME_NB_1																				
<112>	P_ME_NC_1																				
<113>	P_AC_NA_1																				
<120>	F_FR_NA_1																	X			
<121>	F_SR_NA_1																	X			
<122>	F_SC_NA_1																	X			
<123>	F_LS_NA_1																	X			
<124>	F_AF_NA_1																	X			
<125>	F(CG)_NA_1																	X			
<126>	F_DR_TA_1																				

6. Basic application functions

Station initialization

Remote initialization

Cyclic data transmission

Cyclic data transmission

Read procedure

Read procedure

Spontaneous transmission

Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type with an “X” where both a type ID without time and corresponding type ID with time are issued in response to a single spontaneous change of a monitored object) The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1,

M_PS_NA_1

- Double-point information M_DP_NA_1, M_DP_TA_1, M_DP_TB_1
- Step position information M_ST_NA_1, M_ST_TA_1, M_ST_TB_1
- Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1, M_BO_TB_1 (if defined for a specific project, see 7.2.1.1)
- Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1, M_ME_TD_1
- Measured value, scaled value M_ME_NB_1, M_ME_TB_1, M_ME_TE_1
- Measured value, short floating point number M_ME_NC_1, M_ME_TC_1, M_ME_TF_1

Station interrogation

- Global
- | | | |
|---|-------------------------------------|---|
| <input checked="" type="checkbox"/> – Group 1 | <input type="checkbox"/> – Group 7 | <input type="checkbox"/> – Group 13 |
| <input type="checkbox"/> – Group 2 | <input type="checkbox"/> – Group 8 | <input type="checkbox"/> – Group 14 |
| <input type="checkbox"/> – Group 3 | <input type="checkbox"/> – Group 9 | <input type="checkbox"/> – Group 15 |
| <input type="checkbox"/> – Group 4 | <input type="checkbox"/> – Group 10 | <input type="checkbox"/> – Group 16 |
| <input type="checkbox"/> – Group 5 | <input type="checkbox"/> – Group 11 | <input type="checkbox"/> – Information object addresses assigned to each group are configurable |
| <input type="checkbox"/> – Group 6 | <input type="checkbox"/> – Group 12 | |

Clock synchronization

- Clock synchronization

Command transmission

- Direct command transmission
- Direct set point command transmission
- Select and execute command
- Select and execute set point command
- C_SE ACTTERM used
- No additional definition
- Short-pulse duration (1 sec.)
- Long-pulse duration (1 sec.)
- Persistent output (255 sec.)

Transmission of integrated totals

- Mode A: local freeze with spontaneous transmission
- Mode B: local freeze with counter interrogation
- Mode C: freeze and transmit by counter interrogation commands
- Mode D: freeze by counter-interrogation command, frozen values reported spontaneously
- Counter read
- Counter freeze without reset
- Counter freeze with reset
- Counter reset
- Clock synchronization
- Request counter group 1
- Request counter group 2
- Request counter group 3
- Request counter group 4

Parameter loading

- Threshold value
- Smoothing factor
- Low limit for transmission of measured value
- High limit for transmission of measured

Parameter activation

- Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

- Test procedure

File transfer

File transfer in monitor direction

- Transparent file
- Transmission of disturbance data of protection equipment
- Transmission of sequences of events

- Transmission of sequences of recorded analogue values

File transfer in control direction

- Transparent file

Background scan

- Background scan

For IEC 60870-5-104 only:

Definition of time outs

Parameter	Default value	Remarks	Selected value
t_0	30 s	Time-out of connection establishment	
t_1	15 s	Time-out of send or test APDUs	15
t_2	10 s	Time-out for acknowledges in case of no data messages $t_2 < t_1$	10
t_3	20 s	Time-out for sending test frames in case of a long idle state	20

Maximum range for timeouts t_0 to t_2 : 1 s to 255 s, accuracy 1 s.

Maximum number of outstanding I format APDUs k and latest acknowledge APDUs (w):

Parameter	Default value	Remarks
K	1 APDU	Maximum difference receive sequence number to send state variable
W	1 APDU	Latest acknowledge after receiving w I format APDUs

K and W are not change.

Port number

Parameter	Value	Remarks
Port number	2404	In all cases

IP settings

	IP address	ASDU address
ESM default	192.168.0.10	
Socket №1	-	1
Socket №2	-	1
Socket №3	-	1
Socket №4	-	1