



**TOR 200 SERIES
PROTECTION AND AUTOMATION
INTELLIGENT ELECTRONIC DEVICES**

Operation Manual. General technical requirements

AIPB.656122.025 OM1

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IMPORTANT PREFACE

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Purpose of this manual

The manual describes the technical data, functionality, operation, installation and commissioning procedure for TOR 200 Intelligent Electronic Devices.

Targeted audience

Protection engineers, mechatronic engineers, commissioning engineers, personnel concerned with setting, monitoring and service of protection equipment, industrial automatic and control facilities within the electrical power systems.

Applicability

This manual is valid for TOR 200 multifunctional Intelligent Electronic Devices; software version 2.16.

Liability statement

All responsible specialists have checked the contents of this document to ensure the description of both, hardware and software are as accurate as possible. However, deviations from the description cannot be completely ruled out, so that no liability can be accepted for any errors or failures contained in the given document, which content is reviewed regularly. Corrections will be included in following editions. Any suggested improvements are highly appreciated. Relematika, LLC reserves the right to make technical improvements without notice.

Safety symbols and messages

The warnings and notes contained in this manual serve for your own safety as well as safety of people and property around you. Please observe them!

The following indicators and standard definitions are used:

DANGER



Indicates an imminently hazardous situation which, if not avoided, will result in death, serious injury or property damage.

CAUTION



Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury or property damage.

WARNING



Indicates a potentially hazardous situation which, if not avoided, could result in death, serious injury or property damage.

NOTE



Indicates information about the device or respective part of instruction manual which is essential to highlight.

Warning

Only qualified personnel can work on this device. Certain parts of the device inevitably have dangerous voltage. Thorough familiarity with all warnings and safety notices of this manual along with applicable safety regulations is required. Failure to observe these precautions can result in fatality, personal injury or extensive material damage. The successful and safe operation of this device is dependent on proper handling, installation, operation, and maintenance by qualified personnel.

QUALIFIED PERSONNEL



For the purpose of this manual and product, a qualified person is one who is familiar with the installation, construction and operation of the equipment and hazards involved. The following qualifications are needed:

- knowledge of how to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety standards.
- knowledge of proper care and use of protective equipment in accordance with established safety standards.
- proficiency in rendering first aid.

TABLE OF CONTENTS

1 Application	9
1.1 General technical specifications and characteristics	9
1.1.1 Auxiliary power supply	9
1.1.2 AC input circuits.....	10
1.1.3 Binary inputs.....	11
1.1.4 Binary outputs	11
1.1.5 Electromagnetic compatibility.....	12
1.1.6 Insulation resistance.....	13
1.1.7 Required environmental conditions	13
1.1.8 Reliability parameters	14
1.1.9 Data communication interfaces	14
1.2 TOR 200 hardware design and operating characteristics	15
1.2.1 Power supply module	16
1.2.2 Binary input/output (IO) module	17
1.2.3 Input transformer module.....	18
1.2.4 Central Processing Module.....	18
1.2.5 Local Human Machine Interface (HMI)	18
1.2.6 Data communication ports.....	18
1.3 Basic parameters of protection and measuring elements	21
1.3.1 Measuring elements reset factor	21
1.3.2 Measuring elements tripping and reset time	21
1.3.3 Accuracy of measuring elements	22
1.4 TOR 200 functionality.....	23
1.4.1 Processing of analog input values	23
1.4.2 Protection functions	23
1.4.3 Binary inputs.....	23
1.4.4 Binary outputs	23
1.4.5 LED indication	24
1.4.6 Device control via local HMI	24
1.4.7 Disturbance recording	25
1.4.8 Event recording	26
1.4.9 Integration into Substation Control System (SCS)	27
1.4.10 Device Synchronization	27
1.4.11 Digital substation applications using IEC 61850	27
1.4.12 RelayTool software for monitoring and basic configuration	28
1.4.13 PCAP software for flexible logic programming	29
1.4.14 BSCOPE software for disturbance record analysis	29
1.5 Measuring instruments, tools and accessories	29
1.6 Labelling and sealing	29
1.7 Packaging	30
2 Operational guidelines	31
2.1 Operating limitations	31
2.2 Getting started and commissioning	31

2.2.1	Safety information	31
2.2.2	Visual inspection	31
2.2.3	Installation and connection.....	31
2.2.4	Commissioning	31
2.3	Information security	31
2.3.1	General.....	31
2.3.2	Access privileges setup.....	31
2.3.3	Prohibit configuration changes via Ethernet port.....	33
2.3.4	Accounts.....	34
2.3.5	Physical identification (Physical ID).....	35
2.3.6	Connecting and configuring the smart card reader	36
2.3.7	List of allowed MAC and IP addresses.....	36
2.3.8	Audit log.....	36
2.4	Parameter setting	37
2.5	User interface (local HMI) structure	38
2.5.1	Local HMI structure.....	38
2.5.2	Push buttons	38
2.5.3	Functional buttons assignment.....	39
2.5.4	Standby mode	39
2.5.5	User interface menu	39
2.5.6	Measurements	39
2.5.7	Events.....	41
2.5.8	Disturbance recorder	41
2.5.9	Settings.....	42
2.5.10	Testing.....	42
2.5.11	Diagnostics	43
2.5.12	Parameters.....	43
2.5.13	Information	45
2.5.14	IEC 61850	45
2.6	Test mode	46
2.6.1	Test mode for protection functions	46
2.6.2	Test mode setup.....	46
2.6.3	Hardware test mode	46
3	Maintenance.....	51
3.1	General	51
3.1.1	Maintenance cycle	51
3.2	Safety precautions	51
3.3	Maintenance order and operability checks	51
3.3.1	Insulation resistance and strength test.....	52
3.3.2	Checking the applied setting parameters and configuration	53
3.3.3	Testing the validity of displayed analog values.....	53
3.3.4	Protection parameters (settings, protection functions, measuring elements) check.....	53
3.3.5	Test of IEDs functionality when applying and removing auxiliary supply voltage	53
3.3.6	Test of operation towards the central signalling system and interaction with external devices	54

3.3.7 Test of IED interaction with other low voltage equipment	54
3.3.8 Testing the IEDs under load (current and voltage) conditions	54
3.4 Failure list and troubleshooting	54
3.4.1 Introduction.....	54
3.4.2 Self-diagnostic	54
3.4.3 Error codes	55
3.4.4 Troubleshooting	57
3.5 Disposal	58
4 Transportation and storage	59
5 Manufacturer WARRANTY	60
APPENDIX A (obligatory) Ordering structure	61
APPENDIX B (obligatory) Layout, overall and mounting dimensions	62
APPENDIX C (obligatory) Binary inputs and outputs of different modules	74
APPENDIX D (obligatory) Layout of transformer modules	75
APPENDIX E (obligatory) Communication port contacts designation	76
APPENDIX F (obligatory) List of equipment and measuring instruments	77
ABBREVIATIONS	78

PLEASE READ THIS MANUAL BEFORE ENERGIZING TOR 200 IED!

This operation manual applies to microprocessor-based protection, automation, and control Intelligent Electronic Devices (IEDs) of **TOR 200** series (hereinafter referred to as “IED”, “Device” or “Relay”) and contains all the necessary information about their technical characteristics as well as it determines the operation, maintenance, storage and transportation requirements.

This operation manual is extended to TOR 200 IEDs with basic software version not lower than 2.16.

The operation manual is divided into the following documents: AIPB.656122.025 OM1 and AIPB.656122.025-XXX OM2. The first one – OM1 – contains information relating to all the device functional versions: technical data, existing IED design descriptions, structure and functioning of IED modules, operation, and maintenance guidelines. The second document – OM2 – contains description of functional and corresponding logical schemes (interaction of the logic blocks and protection), applied for a specific release.

TOR 200 is a microprocessor-based IED composed by different standardized modules. The corresponding application software is downloaded to each device depending on the power system element to be protected, providing the performance of all required functionality. Free programmable logic of TOR 200 allows adjusting the typical functional and logic schemes to specific requirements for a particular application.

Implementation of various communication protocols, such as IEC 61850-8-1 (MMS, GOOSE), ensures integration of the IEDs into digital substation protection, automation and control systems (hereinafter SCS).

Reliability and lifetime of TOR 200 IEDs are ensured by both the product quality and the compliance with operation conditions, transportation, storage, and installation requirements. Therefore, meeting of all the requirements specified herein is obligatory.

Considering that Relematika, LLC (hereinafter Relematika) is continuously developing the functionality and design of the IEDs, this operation manual cannot cover all the changes, improving parameters and quality of the product. The company reserves the right to make changes and IED improvements without prior notice to the customer.

1 APPLICATION

TOR 200 series IEDs are microprocessor-based devices intended for protection, control, automation, and monitoring purposes in MV (6-35) kV power networks. The devices also provide continuously the effective values of AC voltages and currents, their power, (active, reactive and apparent), corresponding power factor, and frequency. They can register and store information about disturbances and emergency deviations in electrical networks. They can be used as well to provide support to power system information and measuring systems.

The units are intended for installation in indoor and outdoor switchgears, on the relay protection and control cubicles or panels, on control boards of power plants and substations. The IEDs can be applied in installations with AC, rectified AC or DC auxiliary voltage.

The IEDs are freely programmable. Functional logical diagrams are developed by the graphical programming tool, which enables the user to configure the binary inputs and outputs, analog inputs, control buttons, LEDs, disturbance recorder, event recorder, user interface, etc. Freely programmable logic allows modifying and additionally developing typical functional logical diagrams, considering the special needs of the protected object.

The main application functionality of the IED is represented in the ordering code structure shown in Appendix A.

An example of ordering code for **TOR 200 L 22 3232-16 P C**, is presented below:

- **TOR 200** (IED type);
- **L 22** (directional protection of the 6-35 kV line with measuring function);
- **3** (three I/O modules);
- **23** (data port performance: fiber optic communication line (port 1), RS-485 (port 2), two ports of Ethernet 100 Base-T);
- **2** (rated auxiliary voltage of 220 V DC or AC);
- **P** (communication protocol according to IEC 61850 option);
- **C** (calibration protocol option for measuring function if applicable).

Several optional functions not covered by the present manual can be implemented on special request. All deviations (concerning design and algorithm) from the standard version are described in the project specific documentation.

1.1 General technical specifications and characteristics

1.1.1 Auxiliary power supply

Table 1.1: Auxiliary power supply – basic data

Parameter	Value		
U _{aux} nominal auxiliary power supply voltage (U _n)	Standard	On request	
	110 or 220 V DC / AC / rectified AC	(24 – 48) V DC	
U _{aux} variation	(80 – 110) % of specified nominal voltage		
Current pulse at power up ¹⁾	10 A for 1 ms		
Maximum load at DC/AC supply circuits	Number of binary IO modules (housing)	Normal operation	25 % of energized relays
	4 modules (1/2 x 19")	6 W(DC)/11 W(AC)	9 W(DC)/16 W(AC)
Power consumption of single binary input	max. 0.6 W continuously at 220 V DC/AC max. 0.3 W continuously at 110 V DC / 100 V AC		
Start-up time	max. 10 s at first power-up after the configuration has been changed max. 0.2 s at the following power-ups		
Interruption time (at U _n , normal operation)	max. 500 ms without restarting the IED		
U _{aux} connection	No damage occurs to IED when power supply connected with reverse polarity		
¹⁾ It is recommended to protect auxiliary power supply circuit with 15 A rated current automatic fuse.			

Table 1.2: Auxiliary power supply – immunity tests

Immunity tests	Value	Standard
Harmonics and interharmonics including mains signalling at AC power supply voltage	Up to 15 %	IEC 61000-4-13:2015
Voltage fluctuation for equipment with input current not exceeding 16 A per phase	Within ± 20 % of U_n	IEC 61000-4-14:2009 Severity – special Performance criteria– A
Ripple on DC input power port	± 15 % of U_n (100 Hz)	IEC 61000-4-17:2008, SL=3, PC=A
Variations of power frequency	± 15 % of f_n	IEC 61000-4-28:2009, SL=3, PC=A
Voltage dips, short interruptions and voltage variations on DC input power port	$\leq 0,3 U_{aux}$ ($t_{pf} = 1000$ ms) $\leq 0,6 U_{aux}$ ($t_{pf} = 100$ ms) max $t_{inter} = 500$ ms	IEC 61000-4-29:2000



Abbreviations: SL = Severity Level and PC = Performance Criteria.

1.1.2 AC input circuits

Table 1.3: AC current inputs

Description	Value	
Type designation	CT1	CT2
Rated AC current I_r	$(1/5) A^{1)}$	$1/0.2 A^{2)}$
Burden at I_r (per phase)	max. 0.1 VA at $I_r=1$ A max. 0.5 VA at $I_r=5$ A	max. 0.1 VA at $I_r=1$ A max. 0.1 VA at $I_r=0.2$ A
Thermal withstand capability		
$I_r = 1/5$ A or 0.2 A	$4 \cdot I_r$ continuously	$80 \cdot I_r$ for 1 s
Current operating range		
$I_r = 1/5$ A or 0.2 A	$(0.01 - 50) \cdot I_r$	
Measuring accuracy		
At measured current range	Amplitude (relative error)	Angle (absolute error)
Additional relative error at:		
$U_{aux} = (80 - 110)$ % of U_r	max. ± 1 % of value measured at U_r	
Ambient temperature between $(-40 - 55) ^\circ C$	± 5 % of mean value measured at $(20 \pm 5) ^\circ C$	
Frequency range $(0.9 - 1.1) \cdot f_r$	± 5 % of mean value measured at f_r	
¹⁾ Phase or residual currents.		
²⁾ Residual current circuits.		

Table 1.4: AC voltage energizing inputs

Description	Value	
Type designation	VT	
Rated AC voltage U_r	100 V (110 V)	
Burden at U_r (per phase)	max. 0.5 VA	
Thermal withstand capability	$2 \cdot U_r$ continuously	$2.5 \cdot U_r$ for 10 s
Voltage operating range	$(0.01 - 2.0) \cdot U_r$	
Measuring accuracy:		

Description	Value	
At measured voltage range:	Amplitude (relative error)	Angle (absolute error)
Additional relative error at:		
$U_{aux}=(80 - 110) \% \text{ of } U_r$	max. $\pm 1 \%$ of value measured at U_r	
Ambient temperature between $(-40..+55) ^\circ\text{C}$	$\pm 5 \%$ of mean value measured at $(20 \pm 5) ^\circ\text{C}$	
Frequency range $(0.9 - 1.1) \cdot f_r$	$\pm 3 \%$ of mean value measured at f_r	

1.1.3 Binary inputs

Table 1.5: Binary inputs

Description	Value	
Type designation	BI_DC	BI_AC
Rated input voltage U_{rBI}	$(110 \text{ or } 220) \text{ V DC } ^{1)}$	$(110 \text{ or } 220) \text{ V AC } ^{1)}$
Contact oxide burning current (Start-up)	min. 30 mA , min 10 ms	
Continuous binary input current	max. 4 mA	
Continuous permitted voltage	max. 300 V	max. 250 V
Reliable trip voltage	max. $0.75 \cdot U_{rBI}$	max. $0.6 \cdot U_{rBI}$
Reliable failure to operating voltage	min. $0.65 \cdot U_{rBI}$	min $0.55 \cdot U_{rBI}$
Setting ranges of trip/reset time	$(0 - 60) \text{ s, step } 1 \text{ ms } ^{2)}$	$(0 - 60) \text{ s, step } 1 \text{ ms } ^{2)}$
¹⁾ Rating value and DC/AC type specified at ordering.		
²⁾ Default settings on each binary input are: trip time - 20 ms, reset time - 5 ms.		

1.1.4 Binary outputs

Table 1.6: Output relays with increased inter-contact gap on Power supply module P2101

Description	Value
Type designation	REL_IG
Rated contact DC voltage U_{rCON}	220 V DC
Maximum commutated DC voltage	300 V
Maximum commutated AC voltage	400 V
Maximum continuous current	10 A
Commutation ability (220 V DC, inductive load, time constant 50 ms)	2000 cycles
Breaking capacity	0.25 A (220 V DC, inductive load, time constant 50 ms) 1 A (230 V DC, resistive load, 1 min interval, max. 10 times)
Making capacity	40 A for 0.03 s 30 A for 0.2 s 15 A for 0.3 s 10 A for 1 s
Trip / Reset time	max. 10 ms
Commutation wear resistance	min. 10000 cycles at resistive load

Table 1.8: Output relays with increased inter-contact gap on Power supply module P2101

Description	Value
Type designation	REL_IG
Rated contact DC voltage U_{rCON}	220 V DC
Maximum commutated DC voltage	300 V
Maximum continuous current	12 A

Description	Value
Commutation ability (220 V DC, resistive load)	10000 cycles
Breaking capacity	5 A (220 V DC, resistive load) 10 A (250 V DC, resistive load, 1 min interval, max. 50 times)
Making capacity	150 A
Trip / Reset time	max. 15ms
Commutation wear resistance	min. 10000 cycles at resistive load

Table 1.9: Bistable output relays on Power supply module P2101

Description	Value
Type designation	REL_BS
Rated contact DC voltage U_{rCON}	220 V DC
Maximum commutated DC voltage	250 V
Maximum continuous current	2 A
Maximum making current	3 A
Breaking capacity	0.2 A (220 V DC, inductive load, time constant 7 ms)
Trip / Reset time	max. 20 ms
Commutation wear resistance	min. 50000 cycles at resistive load

Table 1.10: Double contact output relays on Power supply module P2101

Description	Value
Type designation	REL_S2
Rated contact DC voltage U_{rCON}	220 V DC
Maximum commutated DC voltage	250 V
Maximum continuous current	8 A
Maximum making current	10 A
Breaking capacity	min. 30 W (250 V, inductive load, time constant 20 ms)
Trip / Reset time	max. 10 ms/5 ms
Commutation wear resistance	min. 10000 cycles

1.1.5 Electromagnetic compatibility

TOR 200 remains operative and functional without performance derating under the influence of the following factors, presented in Table 1.7. Abbreviations: SL corresponds to "Severity Level" and PC corresponds to "Performance Criteria".

Table 1.7: Electromagnetic compatibility

Type of test	Type test values	Related reference standards
Electrostatic discharge immunity test: - contact discharge - air discharge	6 kV, 150 pF 8 kV, 150 pF	IEC 61000-4-2:2008, SL=3, PC=A
Radio frequency electromagnetic field immunity test	10 V/m	IEC 61000-4-3:2010, SL=3, PC=A
Power frequency (50 Hz) magnetic field immunity test: - continuous - transient (for 3 s)	100 A/m 1000 A/m	IEC 61000-4-8:2009, SL=5, PC=A
Pulse magnetic field immunity test	1000 A/m	IEC 61000-4-9:2016, SL=5, PC=A
Damped oscillatory magnetic field immunity test	100 A/m	IEC 61000-4-10:2016, SL=5, PC=A

Type of test	Type test values	Related reference standards
Electrical fast transient/burst immunity test: communication ports other ports	4 kV pulse (5/50 ns) 4 kV pulse (5/50 ns)	IEC 61000-4-4:2012, SL=4, PC=A
Surge immunity test with 1/50µs and 6.4/16µs pulses: power supply communication other ports	4 kV line-to-earth, 2 kV line-to-line 4 kV line-to-earth 4 kV line-to-earth, 2 kV line-to-line	IEC 61000-4-5:2014 SL=4, PC=A SL=3, PC=A SL=1, PC=A
Immunity to conducted disturbances, induced by radio-frequency fields	10 V, f = (0.15 – 80) MHz	IEC 61000-4-6:2013, SL=3, PC=A
Voltage dips, short interruptions and voltage variations:	min 0,2 U _{aux} (t _{pf} = 5000 ms); min 0,3 U _{aux} (t _{pf} = 500 ms); min 0,6 U _{aux} (t _{pf} = 200 ms); min U _{aux} (t _{pf} = 20 ms); min t _{inter} = 500 ms	IEC 61000-4-11:2004, PC=A
Ring wave immunity test: single oscillations repeating oscillations	4 kV line-to-earth; 2 kV line-to-line 2,5 kV line-to-earth; 1 kV line-to-line	IEC 61000-4-12:2006, SL=4, PC=A SL=3, PC=A
Conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz: continuously for 1 s	30 V 100 V	IEC 61000-4-16:2015, SL=4, PC=A
Radio-frequency disturbance characteristics	Class A	CISPR 11:2016, CISPR 22:2008

1.1.6 Insulation resistance

Unless otherwise specified, all the below values refer to following: ambient temperature within (20±5) °C, relative humidity within (45 – 80) %, rated AC voltage frequency of 50 Hz.

Table 1.8: Insulation tests

Type of test	Type test values	Related reference standards
Insulation resistance of not connected IED: - between independent circuits - between circuits and earth	> 100 MΩ, 500 V DC > 100 MΩ, 500 V DC	IEC 60255-5:2000
Dielectric test ¹⁾ : - communication ports - other circuits	0.5 kV, 50 Hz, 1 min 2 kV, 50 Hz, 1 min	IEC 60255-5:2000
Impulse voltage withstand test: Between independent circuits and between circuits and the case: - communication ports - other circuits	Three positive and three negative pulses (1.2±0.36)/(50±10) µs 1 kV, source energy 0.5 J 5 kV, source energy 0.5 J	IEC 60255-5:2000
¹⁾ At repeated tests, test voltage should not exceed 85 % of the specified value.		

1.1.7 Required environmental conditions

TOR 300 IEDs are designed for operation in the environmental conditions according to Table 1.9 and Table 1.10. Place of installation should be protected against water, oil, emulsion splashes and direct solar radiation.

Table 1.9: Required environmental conditions

Parameter description	Value (range)
Maximum altitude above the sea level	up to 2000 m

Parameter description	Value (range)
Maximum permitted ambient temperature	+55 °C
Minimum permitted ambient temperature	- 40 °C, (no frost and condensed moisture)
Maximum permitted relative humidity	98 % at 25 °C, non-condensing
Required environmental conditions	non-explosive, free from current-conducting dust, corrosive gases and fumes in concentrations, which could be disruptive for insulation and metals
Pollution degree	degree 1, i.e. no pollution, only dry, non-conductive pollution may occur

Table 1.10: Vibration, shock, bump and seismic tests

Type of test	Type test values	Related reference standards
Vibration response (sinusoidal)	Class 1	IEC 60255-21-1:1988
Vibration endurance	Class 1	IEC 60255-21-1:1988
Shocks response	Class 1	IEC 60255-21-2:1988
Shocks withstand	Class 1	IEC 60255-21-2:1988
Bump	Class 1	IEC 60255-21-2:1988
Seismic	Class 1	IEC 60255-21-3:1993
IP code (ingress protection)		IEC 60529:2013
- front part	IP54	
- other parts	IP20	

1.1.8 Reliability parameters

Specially implemented software and hardware back-up methods secure correct performance of implemented functionality. Self-supervision system continuously monitors software and hardware with available parameter checkout. In case a persistent failure is detected the IED generates a failure signal indicating the cause of a failure.

Table 1.11: Reliability parameters

Parameter description	Value (range)	Note
Mean time between failures (MTBF)	≥ 125.000 hours	-
Average unit repair time	0.5 h	Considering that all spare parts are available
Average service lifetime	At least 25 years	Considering that all operating conditions and maintenance procedures are followed
Average module service time	At least 10 years	-
Probability of failure to operate	$< 10^{-6}$ /year	-
Probability of false operation	$< 10^{-6}$ hour	-

1.1.9 Data communication interfaces

Table 1.12: Ethernet 100Base-TX port technical data

Parameter description	Value (range)
Connector type	RJ45
Maximum transmission segment distance	Up to 100 m

Table 1.13: Ethernet 100Base-FX connector technical data

Parameter description	Value
Connector type	LC type, for glass optic fiber
Optic fiber type	Multimode
Optic fiber diameter	62,5/125 μm at NA = 0,275 50/125 μm at NA = 0,2

Parameter description	Value
Wavelength	(1270 – 1380) nm
Transmitter power	–20 dBm
Receiver sensitivity	–31 dBm
Communication range	max. 2000 m

Table 1.14: RS-485 port technical data

Parameter description	Value
Connector type	Plug MSTB 2,5/4 (PHOENIX)
Insulation strength	1500 V RMS (1 min)
The number of IEDs in the line	max. 32
Total length of a communication line	max. 1200 m

Typical connection scheme is based on parallel connection of devices with the limitations specified in Table 1.14, technical data are specified in Table 1.14.

Table 1.15: Technical data for built-in fiber optical port

Parameter description	Value
Connector type	Type ST, for a glass optical fiber
Optic fiber type	Multimode
Diameter of an optical fiber	62.5/125 μ m
Radiation wavelength	(792 – 865) nm
Transmitter power	–16 dBm
Receiver sensitivity	–24 dBm
Communication range	max. 1500 m with an attenuation coefficient in an optical fiber no more than 3 dB/km

1.2 TOR 200 hardware design and operating characteristics

The TOR 200 IED is designed as a programmable logic controller having a central processing unit as a core, which provides interaction between all units included into the device. The structural diagram is shown in Figure 1.1.

The TOR 200 IED is designed within a standard euro rack unit with different modules installed. Two versions for two different mounting methods are available depending on the intended installation site: flush mounting monobloc with rear connections and surface mounting unit with front connections and removable, front connected HMI.

Flush mounting is used when IED is placed on the door of the switchgear relay compartment or on the panel of the protection cabinet with rear mounting of secondary circuits.

Surface mounting requires IED and a removable, front connected HMI. The IED is placed on the rear panel of the relay compartment of a switchgear or protection cabinet. Cables of the secondary circuits are connected to the front panel. The front connected HMI (remote control) is placed on the door of the relay compartment, cabinet panel or any other appropriate place and is connected to the IED by the cable included in the delivery.

Overall, mounting dimensions, weight, layout and arrangement of the control elements of the front panel are shown in Appendix B. Designation of connection contacts to the I/O modules is given in Appendix C. Designation of communication ports and their contacts is presented in Appendix E.

TOR 200 contains the following HW modules:

- power supply module;
- input transformer module(s);
- binary input/output module(s);
- central processing module with communication elements;
- front panel local human-machine interface (HMI) module;
- combined backplane modules.

Each TOR 200 unit includes different number of specified modules, depending on project specific requirements. Their number and type are determined by the corresponding HW and SW version. Modules are electrically connected by a backplane board.

The front panel (local HMI) contains:

- LED indicators;
- alphanumeric display;
- push-buttons;
- USB port connector.

Quantity of installed LED indicators and push-buttons depends on indication unit version.

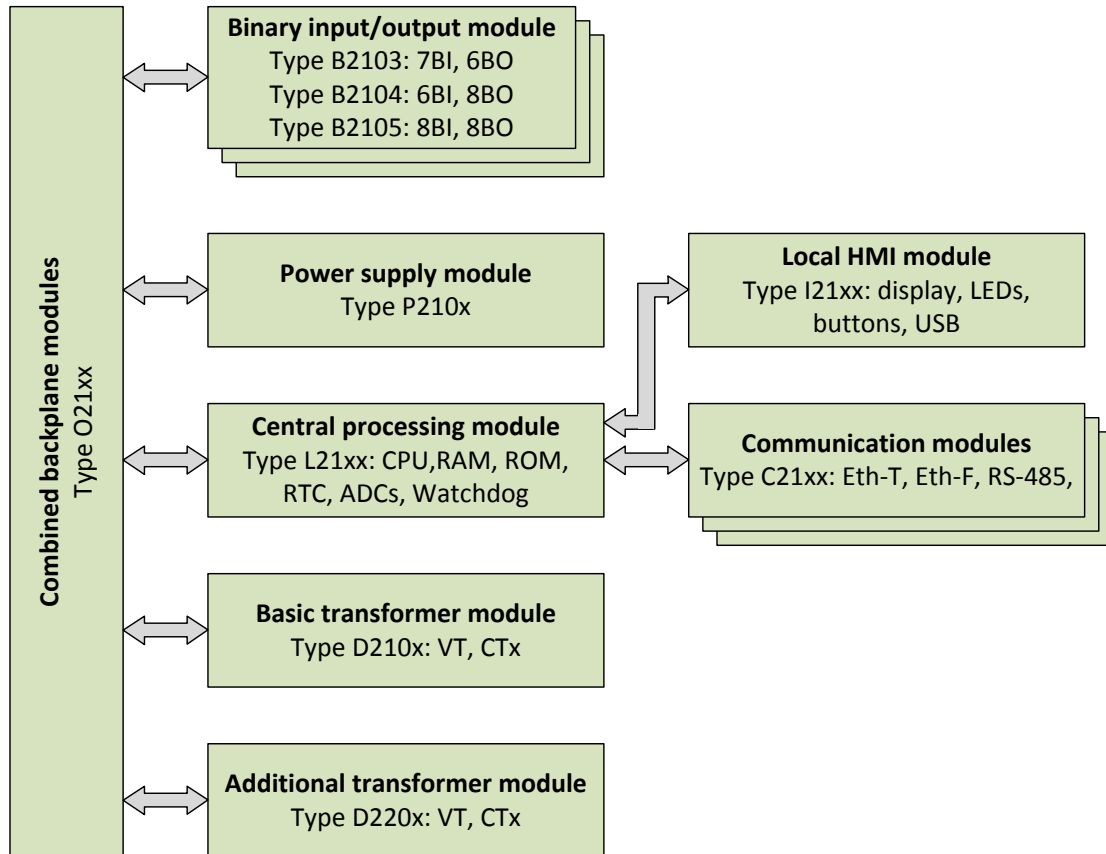


Figure 1.1: Structural diagram of TOR 200 hardware design

The rear panel accommodates terminal blocks for connection to measuring, power supply, and signalling circuits together with communication ports for connection to different communication systems and a grounding connection screw.

Terminal blocks enable connection of one or two cable conductors of the same type:

- for screw connection of measuring current and voltage circuits: with minimum cross sectional area of 0,5 mm². Maximum summary cross section of conductors is 3 mm²;
- plug-in connectors provide screw connection for one rigid (flexible) cable with maximum 2.5 mm² cross section, or two identical cables with maximum cross section area 1 mm² (rigid) or 1,5 mm² (flexible), each with a cross section not less than 0.5 mm².

IED design provides air gaps and insulation distance between the contact pins and the housing not less than 3 mm over the air and 4 mm over the surface.

Protective earth connection continuity is ensured in compliance with the IEC 60439-1 standard. Electrical resistance measured between the ground screw and any grounded metal part does not exceed 0.1 Ω.

1.2.1 Power supply module

Power supply module with voltage range from 88 to 242 V operates with either AC or DC source voltage. Operational power supply of the IED is provided via the connection terminals X2:1 and X2:3.

Power supply module is separated from the sensitive electronic elements by individual slot, shielded against electromagnetic interference.

Power supply module P210x incorporates 6 output relays:

- two relays with increased contact gap (relay 1.1, relay 1.2);
- two bistable relays (relay 1.3, relay 1.4 – command latched relay, which fixes the latest control command sent to the circuit breaker (breaker position) and stores the information in the absence of control and/or power supply);
- one signalling relay (relay 1.5, relay “Failure”). Relay “Failure” is controlled by an internal signal from the logic module. Under normal operation conditions the relay is energized, and the contact is closed (in a tripped state). The relay releases when persistent fault is detected by the self-supervision system or auxiliary power supply of IED is lost;
- one signalling relay «Test output» (relay 1.6) for connecting of tripping signals of protection fault detectors and time delay settings during commissioning and routine maintenance.

1.2.2 Binary input/output (IO) module

Binary input/output modules are used for receiving and transmitting binary signals. See block-diagram in Appendix C (Figure C.1)

IO modules are available in two versions:

- B2103 module has 7 binary inputs and 6 outputs (Figure C.1a), time synchronization input (1PPS) is implemented on input pins 1 and 2;
- B2104 module has 6 binary inputs and 8 outputs (Figure C.1b);
- B2105 module has 8 binary inputs and 8 outputs (Figure C.1c).

Binary inputs and outputs are connected via X15-X22 connectors.

Number of binary input/output modules in the IED is determined by its version and a type of protected power system element. An IED can contain from one to four binary input/output modules (four modules are used if only one module of input transformers is installed).

General technical data and characteristics of binary inputs are given in section 1.1.3 and for binary outputs - in section 1.1.4.



For commutation of the currents exceeding the output relay switching capacity it is necessary to use intermediate relays. The same applies also in cases when several independent circuits should be simultaneously commutated, i.e. for contact multiplication. Relays should be selected on the basis of resulting operating time. When intermediate relays are used, it is recommended to apply quenching circuit with an intermediate relay coil shunted by a resistor and a diode (see Figure 1.2 below).

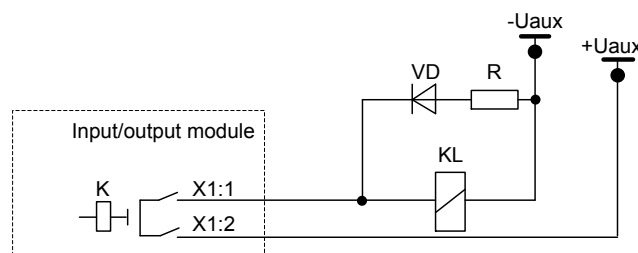


Figure 1.2: Connection of an external auxiliary relay to TOR 200 output contacts, when required

The resistor in a quenching circuit is selected according to the following condition

$$R=0.1 R_{KL},$$

where R_{KL} [Ω] is intermediate relay coil resistance.

The power is selected according to expected short-term current flow (at least 2 W).

The diode should have a setting with triple margin for current and reverse voltage

$$I_{VD}=3 U_{aux}/R; U_{VD}=3 U_{aux},$$

where I_{VD} [A] is direct current flowing through the diode in forward direction; and U_{VD} [V] is a DC voltage applied to the diode in reverse direction.

1.2.3 Input transformer module

TOR 200 generally contains one basic input transformer module of D21xx type. The device can also contain one more additional input transformer module of D21xx type. Number of transformer modules in TOR 200 depends on its version. If two transformer modules are set in the terminal, then there cannot be more than three input/output modules.

Basic transformer module can contain various combinations of up to 8 input current and/or voltage transformers in. Corresponding input cables are in general case connected to X0.1, X0.2 terminal blocks.

Current transformer inputs of CT1 type are used for measuring phase and residual currents and have separate taps for connection to primary CTs with rated secondary current (I_r) of both 1 A and 5 A. Current transformer inputs of CT2 type have rated secondary current (I_r) of 0.2 A correspondingly and typically used for measuring of residual current. Voltage transformer inputs of VT type are used for measuring both phase-to-ground and phase-to-phase voltages and have rated secondary voltage (U_r) of 100 V.

The layout of D21xx modules is shown in Appendix D.

1.2.4 Central Processing Module

Central Processing (CP) module is a central module within TOR 200 IED, incorporating the following components:

- central microprocessor;
- random-access memory (RAM);
- non-volatile memory (ROM);
- real-time clock;
- analog-digital converter (maximum 16 analog signals can be processed);
- communication modules of C21xx type, see 1.2.6

CP module serves to acquisition and final processing of analog and digital signals, delivery of control commands to output relays and other IEDs via digital communication channels. The module can also perform the following functions:

- real-time clock;
- GPS/GLONASS time synchronization;
- disturbance and event recording and storage;
- human-machine interface;
- device self-supervision;
- communication with substation control system.

Protection algorithms, functional settings and IED configuration are stored in a non-volatile flash memory.

Events are registered with a real time tag. Real-time clock accuracy without time synchronisation is better than 1 s per day at the permitted temperature range. A redundant power supply is used for real-time clock supply at de-energizing of CP module.

1.2.5 Local Human Machine Interface (HMI)

HMI module, located on the front of TOR 200 IED, incorporates LEDs, display (OLED or TFT) and pushbuttons.

OLED alphanumeric display has six rows with 21 characters in each, or a graphical display with 800x480 resolution.

Number of LEDs and control buttons depends on the IED version and is given in AIPB.656122.025-XXX OM2 and AIPB.656122.026-XXX OM2. Control buttons assignment is presented in 2.5.2.

USB-port is described in 1.2.6.

1.2.6 Data communication ports

General on communication ports

Communication to the substation control system (SCS) and substation monitoring system (SMS) is provided in accordance with the following standards:

- IEC 60870-5-103:1997 “Telecontrol equipment and systems. Part 5-103. Transmission protocols – Companion standard for the informative interface of protection equipment”;
- IEC 60870-5-104:2006 “Telecontrol equipment and systems. Part 5-104. Transmission protocols – Network access for IEC 60870-5-101:2015 using standard transport profiles”;
- MODBUS – set of standards: “Modbus Application Protocol” containing specification of an application layer and “Modbus over serial line” specifying channel and physical layers;
- IEC 61850 is a set of standards including peer-to-peer and client-server communication standard, standard for the design and configuration of electrical substation automation, standard for test procedure, environmental and engineering standard. The standard defines object-oriented programming (approach to analysis) of data and services.

The standard enables interoperation of IEDs from different vendors bypassing SCS and simplifies its design. The performance GOOSE is provided not worse than the class P2 in IEC 61850-5 (13.6.1) and IEC 61850-10.

Synchronization of real-time clocks of the IEDs is performed by means of one-per-second pulses PPS (from GPS or substation synchronization system) sent according to IEC 60870-5-103:1997, NTP/SNTP, PTP.

USB-port installed on the front HMI panel is intended for connection of a PC via USB 2.0 A-B cable. The port is used for local configuration and parameterization of a device as well as for software update.¹

Communication ports on the rear panel (RS-485 or Ethernet, copper, or fiber-optic) are available for connection of TOR 200 to the SCS and/or SMS. Configuration and parameterization of IED is also possible via these ports. Physical interfaces of communication ports, quantity and their type are specified in the order sheet for a specific project.

Protection relay integration to SCS (also to station bus) and SMS are provided:

- according to IEC 60870-5-103:1997 or Modbus-RTU, Modbus-ASCII using two serial ports (RS-485 or fibre-optic communication line) via **XT1** and **XT2** connectors;
- according to IEC 61850-8-1 (MMS, GOOSE), IEC 60870-5-104:2006 via Ethernet ports (100 Base-T or 100 Base-F) from **XT5** and **XT6** connectors. Data structure complies with IEC 61850-7.²

On the rear panel two serial ports can be placed connected to **XT3** and **XT4** terminal blocks, which are intended for remote data communication via an optical communication channel according to IEEE C37.94 standard (for example, for line current differential protection).

Assignment of communication ports are given in Table 1.16.

Table 1.16: Back panel connectors designation

Connector designation	Type of interface
XT1	RS-485/ FO (SCADA)
XT2	RS-485/ FO (SCADA)
XT5	Ethernet 100 Base-T/ Ethernet 100 Base-F
XT6	Ethernet 100 Base-T/ Ethernet 100 Base-F

Baud rate of port interface:

- 100Base-TX and 100Base-FX Ethernet – up to 100 Mbit/s;
- RS-485 (fiber-optic communication line) – up to 0.2 Mbit/s.

Communication port connectors' designation is presented in Appendix E.

Access to TOR 200 file system is provided by means of FTP protocol via Ethernet and USB-ports. Both, active and passive operating modes are supported. Anonymous access is ensured, i.e. read-only access to disturbance recording files only. Simultaneously only one FTP connection is supported. When the current connection is not active within three minutes, it is forced to disconnect.

If the client connection of any protocol is inactive for more than two minutes, automatic disconnection is performed by timeout.

Assignment and technical data of communication ports

1.2.6.1.1 Port with Ethernet 100Base-TX interface

Ethernet 100Base-TX port is used for connection of IED to a local area network via communication line based on the twisted pair cable. Technical data of the port is given in the Table 1.12, connector pins assignment is shown in Table 1.17.

Table 1.17: Ethernet 100Base-TX port. Connector pins assignment

Pin	Signal	Assignment
1	Transmission + (TX+)	Transmission of a positive signal by the IED
2	Transmission – (TX–)	Transmission of a negative signal by the IED
3	Reception + (RX+)	Reception of a positive signal by the IED
6	Reception – (RX–)	Reception of a negative signal by the IED

¹ Driver CP210x VCP version 6.7.6 is required for front port connection.

² Communication ports for operation with standard IEC 100 Base-F should be implemented at special request.

Recommendations:

- Connect an intermediate protection device (RG5 or RG6 type) to protect against electromagnetic interference via the Ethernet communication ports (twisted pair).
- Install ZCAT 2035-0930 filter on RG5 or RG6 cable directly in front of the port for additional protection against electromagnetic interference.
- Lay communication cables in cable trays or shielding sheaths.
- Use shielded twisted pair cable with a shielded RJ45 connector.

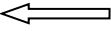
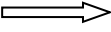
Note: Devices RG5, RG6 and filter ZCAT 2035-0930 are not included in the IED delivery but can be purchased under a separate order.

Attention! When connecting a PC to TOR 200 via Ethernet port, it is necessary to set all parameters of the subnet including "Default gateway" to enable correct adjustment of communication settings.

1.2.6.1.2 Port with Ethernet 100Base-FX interface

Ethernet 100Base-FX port connected to fiber optic cable is recommended for SCS communication under harsh electromagnetic environment. Such port implementation provides galvanic isolation and the highest interference immunity of communication channel. Port version includes two connectors for fiber optic cable, with connector assignment as shown in Table 1.18. Port technical data is presented in Table 1.13.

Table 1.18: Ethernet 100Base-FX connector assignment

Connector symbol	Assignment
	Rx – reception of signals by the device
	Tx – transmission of signals by the device

Attention! When connecting a PC to TOR 200 via Ethernet port, it is necessary to set all parameters of the subnet including "Default gateway" to enable correct adjustment of communication settings.

1.2.6.1.3 Port with RS-485 interface

RS-485 communication port provides a half-duplex communication via twisted pair cable with the devices on the two-wire link. This method of communication is recommended in case of rather small amount of devices at simple objects, when use of fiber-optic cable is economically unjustified. Pin assignment of RS-485 interface connector is given in Table 1.19 and relevant technical data are presented in Table 1.14.

A typical connection scheme provides for parallel connection of IEDs to a communication line of an arbitrary topology, taking into account the restrictions indicated in Table 1.14.

Table 1.19: RS-485 port pin assignment

Contact	Signal	Value
1, 6	Common	Signal grounding
2, 7	DATA B (D+)	The positive data input/output
3, 8	DATA A (D-)	The negative data input/output
4, 9	R	Terminating resistor pin

Port operation is ensured by two-wire circuit connection of the homonymous contacts, however for long communication links it is recommended to use the cable shield as the third conductor for signal potential equalization. Besides, to reduce signal reflections in a long communication line and to increase noise immunity, the termination resistors should be installed at the ends of the communication link. Nominal value of terminating resistor must be equal to the cable characteristic impedance. Typical value for the twisted pair cable is 120 Ohm.

The RS-485 port of the IED has a terminating resistor (120 Ohm). To connect it to the communication line, a jumper must be installed in accordance with Figure E.2 in Appendix E. The cable shield must be grounded on both sides in accordance with **STO 56947007-29.240 .044-2010** from the IED side through a ground screw located on the rear panel next to the RS-485 port.

1.2.6.1.4 Built-in fiber optical port (for SCADA and line differential protection)

Fiber optic technology is recommended for the purposes of SCS communication due to complex electromagnetic environment. Fiber optic communication is used also for the communication between line differential protection IEDs.

This version contains two fiber optic connectors with the assignment given in Table 1.20 and technical data according to Table 1.15.

Table 1.20: Connector assignment for built-in fiber optical port

Connector	Assignment
Dark	RX – signal reception by IED
Light	TX – signal transmission by IED

1.3 Basic parameters of protection and measuring elements

1.3.1 Measuring elements reset factor

The values of the basic reset factors of the measuring elements are given in Table 1.26.

Table 1.26 - Measuring elements return coefficients

Parameter	Value
Resetting ratio of overcurrent or overvoltage measuring element, min	0.9
Resetting ratio of undercurrent or undervoltage measuring element, max	1.1
Resetting ratio of impedance measuring element, max	1.1
Resetting ratio of differential unit with restraint and maximum voltage measuring element of the third harmonic, min	0.8

1.3.2 Measuring elements tripping and reset time

The tripping time of power measuring elements during the simultaneous supply of a sinusoidal voltage of $3 U_{trip}$ and a current of $3 I_{trip}$ is maximum 35 ms, the reset time does not exceed 40 ms with simultaneous reset of the input voltage $3 U_{trip}$ and current $3 I_{trip}$ to zero.

The tripping time of the impedance measuring element when operating at the maximum sensitivity angle, short-circuit currents of minimum $3 I_{trip}$ and an abrupt decrease in voltage at the measuring element input from the value corresponding to the impedance at the measuring element terminals of at least $1.2 Z_{trip}$, to a voltage corresponding to $0.6 Z_{trip}$, does not exceed 25 ms.

The reset time of the impedance measuring element when operating at the maximum sensitivity angle, short-circuit currents of at least $3 I_{trip}$ and an abrupt increase in voltage at the measuring element input from the value corresponding to the impedance at the measuring element terminals of $0.1 Z_{trip}$, to a voltage corresponding to $1.2 Z_{trip}$ (but not more than 100 V for the phase-to-phase channel and 57 V for the phase-to-earth channel), does not exceed 50 ms.

Tripping (reset) time of over(under) current and voltage measuring elements does not exceed 30 ms during the supply of corresponding $3 I_{trip}$ or $3 U_{trip}$ and does not exceed 40 ms during the supply of $1,2 I_{trip}$.

Reset (tripping) time of over(under) current and voltage measuring elements does not exceed 35 ms during the input current reset from $10 I_{trip}$ to zero, or voltage reset from $3 U_{trip}$ to zero.

Tripping time of the CBFP measuring elements does not exceed 30 ms during the supply of $2 I_{trip}$; reset time during the input current dropping from $25 I_{nom}$ to zero is 25 ms.

Tripping time of the restrained differential element, during the supply of differential current exceeding the tripping level twice or more, does not exceed 50 ms.

Reset time of the restrained differential element, when resetting the ten-fold current to zero, does not exceed 50 ms.

Tripping time of the restrained differential element, during the supply of a two-time trip current, does not exceed 30 ms, including the operating time of the IED output relays.

Tripping (reset) time of over(under) frequency measuring elements reacting to the change in frequency does not exceed 120 ms.

Reset (tripping) time of all measuring elements reacting to the rate of frequency change does not exceed 150 ms.

Reference mean relative error at the exposure time of the protection does not exceed:

- ± 30 ms with a time delay of less than 5 s;
- $\pm 1\%$ of the setting with a time delay of more than 5 s.

Important! The time delays are pure times that do not include the operating times of the measuring element, the start of protection, the operation of the logic circuit and the operation of the output relay.

1.3.3 Accuracy of measuring elements

Directional power relay (directional power element)

Reference mean error of the directional power element for current and voltage tripping does not exceed $\pm 10\%$ of the setting.

Reference mean absolute error of the directional power relay does not exceed $\pm 5^\circ$ for the relay characteristic angle

Additional error of the directional power relay for current and voltage tripping at temperature difference in operation range does not exceed $\pm 5\%$ of mean value, measured at temperature of $(20 \pm 5)^\circ\text{C}$.

Additional error of directional power relay for current and voltage tripping at frequency difference in the range from 0.9 to 1.1 f_{nom} does not exceed $\pm 10\%$ of mean value, determined at nominal frequency.

Impedance based protection

Reference mean error of the impedance measuring element by the tripping impedance value **Ztrip** at a current equal to I_{nom} (or, depending on the setting, a lower current based on the maximum voltage at the PC terminals equal to 100 V) does not exceed $\pm 3\%$ of the setting.

Reference mean absolute error of the impedance measuring element for the tripping characteristic angles **Achar**, **Aload** at fault current equal to I_n (or, depending on the setting, a lower current, based on the maximum voltage at the PC terminals, equal to 100 V), does not exceed $\pm 5^\circ$.

Additional absolute error of the impedance measuring element for the tripping characteristic angles **Achar**, **Aload** at fault current changing in the range from $2 I_{\text{pwc}}$ to $30 I_n$ does not exceed $\pm 7^\circ$ relative to the values measured at I_n .

Additional mean error of the impedance measuring element in terms of the tripping impedance value **Ztrip**, within the ambient temperature operating range, does not exceed $\pm 5\%$ of the average value determined at a temperature of $(20 \pm 5)^\circ\text{C}$.

Additional mean error of the impedance measuring element in terms of the tripping impedance value **Ztrip**, at frequency change range from 0.9 to 1.1 f_{nom} does not exceed $\pm 5\%$ of the average value measured at nominal frequency.

Current and voltage measuring elements

Reference mean error of trip current (voltage) of current (voltage) measuring elements (voltage, except for the third harmonic voltage) does not exceed $\pm 3\%$.

Reference mean error of the third harmonic voltage measuring elements does not exceed $\pm 5\%$.

Additional error of trip current (voltage) of current (voltage) measuring elements at temperature difference in operation range does not exceed $\pm 5\%$ of mean value, defined at temperature of $(20 \pm 5)^\circ\text{C}$.

Additional error of trip current (voltage) of current (voltage) measuring elements at frequency difference in the range from 0.9 to 1.1 f_{nom} does not exceed $\pm 5\%$ of the limits of the permissible basic error.

Frequency measuring elements

Reference mean error of tripping threshold of frequency measuring element does not exceed $\pm 0.02\text{ Hz}$.

Additional error of tripping threshold of the frequency measuring element at temperature difference in operation range does not exceed $\pm 0.02\text{ Hz}$ of mean value, defined at temperature of $(20 \pm 5)^\circ\text{C}$.

Rate of frequency change measuring elements (ROCOF)

Reference mean error of ROCOF tripping threshold measuring elements does not exceed $\pm 0.15\text{ Hz}$.

Additional error of tripping threshold of all ROCOF measuring elements at temperature difference in operation range does not exceed $\pm 0.15\text{ Hz/s}$ of mean value defined at temperature of $(20 \pm 5)^\circ\text{C}$.

Differential current unit

Reference mean error of the initial differential tripping current does not exceed $\pm 10\%$.

Reference mean error of the initial braking currents and braking coefficient does not exceed $\pm 5\%$.

Additional error of the initial differential tripping current, the initial restraining currents and bias ratio at temperature difference in operation range does not exceed $\pm 5\%$ of mean value, defined at temperature of $(20 \pm 5)^\circ\text{C}$.

Reference mean error of the level of blocking for the second (fifth) harmonic does not exceed $\pm 10\%$.

Current circuit supervision elements

Reference mean error of trip current of differential CCS measuring elements does not exceed $\pm 10\%$.

Additional error of trip current of differential CCS measuring elements at temperature difference in operation range does not exceed $\pm 5\%$ of mean value defined at temperature of $(20 \pm 5)^\circ\text{C}$.

Additional error of trip current of CCS differential current measuring elements at frequency difference in the range from 0.9 to 1.1 f_n does not exceed $\pm 5\%$ of mean value, defined at nominal frequency.

1.4 TOR 200 functionality

TOR 200 IEDs perform all the required functionality for relay protection, automation, and control of the power system, as well as measurement, signalling, event recording, disturbance recording and communication functionality in accordance with provided software and hardware. Basic software (SW) ensures with the help of available library functions communication between application software and the device hardware platform. Application SW together with the library modules of basic SW provides the execution of a complete protection schemes, which are designed with the help of a PCAP graphical programming tool. The complete PAC scheme is usually divided into analog signal processing part, logical scheme part and configuration part, which enables to implement all basic and additional functions.

PCAP software allows creating initial logical scheme on the manufacturing plant and then to adjust it in accordance with the certain project requirements during engineering and commissioning works.

Instead of PCAP graphical programming tool a separate RelayTool software is provided for monitoring the IEDs, viewing and changing settings in setting groups, downloading disturbance records and event list, performing basic configuration of inputs, outputs, LEDs, communication protocols, etc.

Disturbance recordings can be viewed and analysed by means of BSCOPE software.

1.4.1 Processing of analog input values

Analog signal processing algorithm ensures communication with analog-to-digital (A/D) converter, calibration, filtering, calculation, and delivery of various measured analog values. During calibration process it is possible to adjust input CT and VT signal values by their amplitude and phase angle. In general, TOR 200 enables measurement and calculation of current, voltage, impedance, power, energy, network frequency values as well as corresponding amplitude and RMS values, phase angles, symmetrical and transient signal components with possibility to display and transfer them via communication channels. A PCAP graphical programming tool comprises a sufficient set of mathematical elements for calculation of all the required parameters, while the hardware platform makes it possible to connect current, AC and DC voltage power sources, depending on a TOR 200 version and functionality.

Basic technical data and characteristics of measurement channels are shown in Table 1.3

1.4.2 Protection functions

Various protection functions can be implemented in different versions of TOR 200 relays. Protection functions of the certain version of TOR 200 are described in the corresponding document (AIPB.656122.025-XXX OM2 or AIPB.656122.026-XXX OM2).

TOR 200 IEDs include a list of basic and additional protection and automation, monitoring and control functions for different power system elements such as power transmission lines, transformers, autotransformers, reactors, generators, busbars, stubs, capacitor banks, circuit breakers, disconnectors and other power system elements within the voltage range from 6 to 35 kV on the basis of the following basic functions:

- line current differential protection of distributed objects with optical communication channel;
- distance protection including teleprotection schemes;
- current differential protection for transformers, generators, etc.;
- over/under current protection;
- protection and automation with voltage, frequency and power control;
- circuit breaker control functionality.

1.4.3 Binary inputs

Binary inputs are used to receive and process external binary signals from external operational circuits. General technical data and characteristics of binary inputs are given in par. 1.1.3.

Binary inputs are assigned to certain internal functions by the help of PC based RelayTool or PCAP software, i.e. definite internal variables can get their logical values according to the state of assigned binary inputs.

1.4.4 Binary outputs

Output relays are used for sending binary (control) signals to the external circuits. Basic technical data and characteristics of output relays are given in par. 1.1.4.

Internal binary signals are assigned with the help of RelayTool or PCAP software to specified output relays and transferred through their “dry” contacts to external auxiliary circuits. Output relay “Failure” is not configurable and is driven by the central processor.

1.4.5 LED indication

In order to display the current state of IED the following LEDs are available on local HMI panel (Appendix B):

- three LEDs with fixed functionality: **READY**, **TEST**, **ERROR**;
- 16 or 32 general purpose configurable LEDs (48 for TOR 200 (CAS) central signalling version);
- two LEDs on control buttons with fixed control function: **I**, **O**;
- 6 or 13 LEDs on control buttons **K1**, **K2**, ... **K6 (K13)**;
- two LEDs on **L/R** button with a fixed assignment (availability depends on the version).

LEDs operating modes are described in Table 1.21.

Table 1.21: Local HMI LEDs operating modes

LED name	Light mode	Operating mode
READY	green	Power is On
TEST	yellow	Device is in a test mode, see sec. 2.6
ERROR	red	Permanent internal failure detected by self-supervision system
O	green	Controlled switching device (e.g. circuit breaker) is turned off
I	red	Controlled switching device (e.g. circuit breaker) is turned on
L / R	green	Switching devices control mode using I, O buttons: L – local (operator) control, R – remote control
K1...K13	red green	LED operating mode is specified by configuration
General	red green	LED operating mode is specified by configuration

By using PC based RelayTool and PCAP software it is possible to configure LEDs operating modes, representing the switch position of the corresponding controlled IEDs.

It is also possible to configure each of general LEDs in two indication modes. Each LED corresponds to one logical signal.

LED starts blinking periodically with changing colour in the following cases:

- at presence of a signal assigned to two different indication modes of one LED at a time;
- at presence of two different signals assigned to different indication modes of one LED.

There is a possibility to invert LED signals and to latch LED state in a non-volatile memory. When the IED is energized, latched LEDs revert to the state recorded before the power-off.

Recorded LED states can be reset by **RESET** button on a front panel, by issuing a signal to the corresponding binary input or by a command from a SCS via communication channels.

Functionality of programmable LEDs in an indication module is configurable. The purpose of the programmable LEDs of the display unit is presented in AIPB.656122.025-XXX OM2.

1.4.6 Device control via local HMI

A local HMI (Appendix B) provides the following items:

- four navigation pushbuttons: **MENU**, **SET**, **METER**, **MNEMO**;
- four menu navigation pushbuttons: **Left** (◀), **Right** (▶), **Up** (▲), **Down** (▼);
- one “command acknowledge” (**E**) and one “command cancel” (**C**) buttons;
- two functional pushbuttons: **F1** and **F2**;
- one button for resetting of local LEDs: **RESET**;

- programmable control buttons: **K1...K13** (**K1...K6** for compact version);
- one power button for commutating device **I** or audible alarm reset pushbutton **AUDIO** (availability depends on version);
- one shutdown button for commutating device **O** or alarm channel (group alarm) reset pushbutton **GROUP** (availability depends on version);
- one pushbutton **L / R** to choose local (operator) or remote control mode (availability depends on the version).

For detailed information on user interface buttons refer to item 2.5.2.

1.4.7 Disturbance recording

TOR 200 unit includes disturbance recording functionality designed for recording of disturbances with a possibility for their further analysis. Recordings are stored in COMTRADE® format (IEC 60255-24:2013). PC based RelayTool software enables selection of disturbance recorder parameters as given in Table 1.22. Up to 29 starting conditions can be set by proper selection of starting signals. Four types of starting modes for each of the starting signals are provided, see Table 1.23. The start-up delay from the emergency process beginning does not exceed 10 ms. Starting conditions for each separate disturbance recording can be viewed both via local HMI and RelayTool software.

Disturbance recorder capacity depends on the amount of recorded signals. Available duration and sampling rate of each disturbance recording is shown in Table 1.22. The number of stored disturbance recordings is at least 30 with a duration of at least 10 seconds. Maximum buffer capacity is 200 saved recordings. Recordings are stored according to the FIFO principle; when the buffer is overflowed, the oldest recording is overwritten with the new one. When starting conditions are fulfilled, all binary input and output signals, as well as start-up reasons are recorded. All measured and selected calculated values as well as up to 256 additional logical signals are recorded; the recorded content is defined during the IED configuration procedure. Binary input signals are registered after the defined trip and reset time delays are expired in accordance with par. 1.1.3. Registered binary output signals are the command signals, initiating operation of the output relays.

Table 1.22: Disturbance recorder setting parameters

Parameter (HMI notation)	Range	Description
Pre-fault recording time (Prefault)	(100 – 1000) ms step 100 ms	Pre-fault recording time (before the first starting condition occurred)
Post-fault recording time (Postfault)	(100 – 5000) ms step 100 ms	Post-fault recording time (after starting conditions disappeared)
Maximum allowed recording time (Max.duration)	(1000 – 10000) ms	Maximum disturbance recording time, should be more than a sum of parameters Prefault and Postfault
Sampling frequency	1000 Hz	Signal sampling frequency



Sampling frequency must be 1000 Hz or 2000 Hz. Value of 4000 Hz is available in special cases.

Table 1.23: Disturbance recorder start-up modes

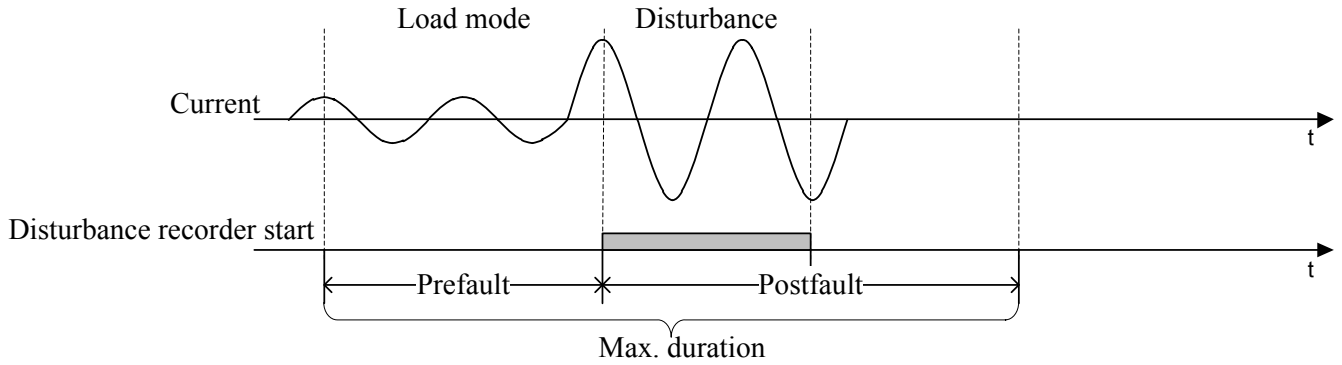
Start signal type	Description
DR start at signal change	Disturbance record duration is set by recording parameter values Prefault and Postfault (Figure 1.3a)
DR start at signal appearance	
DR start at signal loss	
Continuous DR starting	Maximum duration is limited by the value of parameter Max.duration . If starting conditions duration exceeds Max.duration , then disturbance recording terminates. When starting conditions disappear, an additional disturbance recording is made, the duration of which is determined by the value of recording parameters Prefault and Postfault (Figure 1.3b)

Figure 1.3 below presents a disturbance recorder operating principle under various starting conditions.

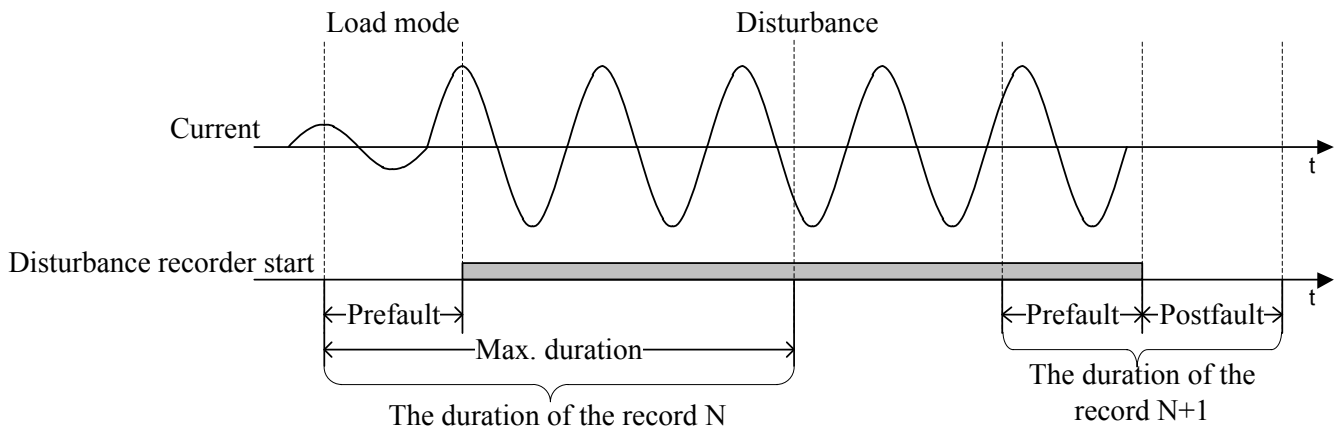
When a start signal occurs upon its change, appearance or reset, a pre-fault information, duration of which is determined by the parameter **Prefault**, is stored in the memory. When triggering is finished the disturbance recording is

prolonged for the time defined by the parameter **Postfault**. Recording duration of one disturbance recording is determined by the sum of recording parameters **Prefault** and **Postfault**.

When a start signal of continuous starting type appears, a disturbance recording can have a variable duration, equal to the sum of continuous start duration (e.g. protection trip signal) with **Prefault** and **Postfault** durations but not exceeding the value of **Max.duration**. When the starting signal lasts longer, than the value set by the parameter **Max.duration**, an additional disturbance recording is created at starting signal reset with duration equal to the sum of the parameters **Prefault** and **Postfault** (Figure 1.3b).



a) Recorder start upon signal change, rise, reset



b) Continuous start of the disturbance recorder

Figure 1.3: Definitions of disturbance recorder operating times

To prevent the overflow of the non-volatile internal memory when a bounce occurs for any start reason, an additional blocking is provided. If in total for more than 1 hour any start reason was in the triggered state for more than 20% of the time, then blocking is performed. The blocking is returned with a subsequent reduction in the total duration to 10%.



Bounce blocking of the disturbance recorder start has been implemented since the IED firmware version 2.16.

The recordings download is performed via SMS or SCS or by the help of RelayTool software as well as IEC 61850-8-1 MMS (1.4.6.2RU). Disturbance recordings can be also imported via FTP protocol. For preliminary and additional disturbance analysis, fast report function can be used via the **Fast view** window in RelayTool software, which contains a summary of the start time, disturbance duration, reasons of start, available settings, etc.

1.4.8 Event recording

TOR 200 IEDs include an event recorder, intended for time tagging of binary signals triggering from 0 to 1 and vice versa, which are used for further analysis of protection, measuring elements, logic, etc. during different system events. Time tagging accuracy is 1 ms.

Maximum event recorder capacity is 1500 events, which are stored in ROM. Event storage is performed according to the FIFO principle. Up to 256 different logical signals can be recorded; the event list is defined by RelayTool or PCAP software.

All events with their time-tags can be viewed via local HMI, all events can be sent to SCS or SMS system. Specified software is used to download the Event log.

1.4.9 Integration into Substation Control System (SCS)

Integration of protection devices into APCS is provided according to Table 1.24.

Table 1.24: Protection devices integration into SCS

Standard	Port type	Connector designation
IEC 60870-5-101:2003	RS-485 or FOCL	XT1 and XT2
IEC 60870-5-103:1997	RS-485 or FOCL	XT1 and XT2
ModBus-RTU, ModBus-ASCII	RS-485 or FOCL	XT1 and XT2
SPA-Bus	RS-485 or FOCL	XT1 and XT2
ModBus-TCP	Ethernet	XT5 and XT6
IEC 60870-5-104-2000	Ethernet	XT5 and XT6
IEC 61850-8-1 MMS	Ethernet	XT5 and XT6
IEC 61850-8-1 GOOSE	Ethernet	XT5 and XT6

Supported communication interfaces for TOR 200 are specified in par. 1.2.6. Configuration of TOR 200 IED functionality for communication with SCS is done via RelayTool software. The procedure of managing the IED via communication interfaces is given in RelayTool User Manual.

Remote control commands are configured with the help of RelayTool or PCAP software. Maximum number of control commands is 32.

List of parameters and events for data transmission to SCS depends on a specific project scheme (functional logic diagram) and installed functional modules. The standard list of parameters for typical functional logic scheme is formed at the manufacturer place in correspondence with the set of protection, automation and other functions used in a certain project. Such a list is attached as an Appendix to the corresponding operation manual AIPB.656122.025-XXX OM2. Parameters and settings to be sent to SCS should be selected according to SCS requirements at the stage of project design process and implemented during the commissioning stage.³

1.4.10 Device Synchronization

Synchronization of real time clocks of the IEDs is carried out by means of IEC 60870-5-103-1997, IEC 60870-5-104-2000, IEC 60870-5-101-2003, ModBus, SPA-Bus, NTP / SNTP, NMEA0183, PPS.



The IED has the ability to adjust the time through the HMI, to synchronize from the internal real-time clock and through the BDUBus technology protocol.

Synchronization parameters are configured in the IED menu **Time sync.methods** (2.5.12.3).

The IED can receive one-second sync pulses (1PPS). The 1PPS pulses are supplied by feeding a pulse with the auxiliary voltage level of the operative circuits (110 V or 220 V DC) to the binary input of the IED. The synchronization input implementation is presented in item 1.2.2. To convert the 1PPS optical signal into a signal of the required level, a solid-state pulse relay is used.

Synchronization via NTP/SNTP is carried out by means of Ethernet ports **XT5** and **XT6**, while precise GPS or GLONAS synchronization via NMEA0183 is processed by means of serial ports **XT1** and **XT2**.

1.4.11 Digital substation applications using IEC 61850

Integration of devices into digital substations is ensured using the IEC 61850 series standards.

Communication interfaces to ensure IEC 61850 support

If you require the IED to support the IEC 61850 standard as well as the availability of process bus ports, indicate these requirements in the order sheet. Ethernet ports characteristics are presented in 1.2.6.2.1 and 1.2.6.2.2.

The substation bus ports are configured via the menu item **Ethernet 1**

The substation bus ports support the IEC 62439-3 PRP redundancy protocol to ensure reliable data transmission and reception. The PRP mode is selected via the **Mode** menu.

Additionally, the substation bus ports support virtual network (VLAN) mode to control traffic in the digital substation. Up to sixteen VLAN numbers are allowed. Enabling and disabling VLANs, as well as configuring ports to belong to VLANs is carried out in the corresponding Ethernet menu item.

³ List of parameters sent to the process control system is provided on request.

Supporting IEC 61850-8-1 MMS protocol

The IEC 61850-8-1 MMS protocol is supported over the substation bus ports. Up to six clients can simultaneously receive information from the IED using the IEC 61850-8-1 MMS protocol.

The IED supports services in accordance with the IEC 61850 standard using the following main functions:

- device structure retrieving and data reading;
- working with datasets;
- working with reports;
- control;
- disturbance records reading.

The IED processes the quality attributes of each signal using internal diagnostics.

1.4.11.1.1 Device structure retrieving and data reading

The device supports services for obtaining the structure of logical devices and logical nodes, objects and data attributes, types and classes of logical nodes and data, parameters of control blocks, implemented in the terminal.

1.4.11.1.2 Working with datasets

The device supports services for working with datasets. Within the framework of the standard, static and dynamic data sets are implemented that are created in the process. The data set can include any elements of the device structure.

1.4.11.1.3 Working with reports

The device supports reporting services. Buffered and unbuffered report types are implemented.

Report parameters can be configured via the service software or directly by the client application.

1.4.11.1.4 Control functions

The device supports all control models provided by the standard:

- status-only (status only);
- direct-with-normal-security (direct control with normal security);
- sbo-with-normal-security (SBO control with normal security);
- direct-with-enhanced-security (direct control with enhanced security);
- sbo-with-enhanced-security (SBO control with enhanced security).

The control model can be changed using the service software in the **IEC 61850 configuration** of the IED. By default, all controllable items are set to the "direct-with-normal-security" control model.

1.4.11.1.5 Disturbance records reading

The device supports a service for working with files. Reading oscillograms from the device via the MMS protocol is implemented within this service. File deletion and writing operations are not provided by the device software.

Disturbance records files, depending on the archiving setting, can be transferred either as separate files in COMTRADE format, or in the form of a zip archive.

Supporting IEC 61850-8-1 GOOSE protocol

The IED provides support for the IEC 61850-8-1 GOOSE protocol over station bus ports.

The device provides reception and sending of up to 16 GOOSE messages with up to 100 signals each via the substation bus ports.

Using GOOSE messages, the IED can receive and send logical signals (one-point and two-point states) in an arbitrary data structure (determined by the configuration).

Receiving signals using GOOSE messages is performed with quality control of the very signals and control of the test flag.

The time between receiving a signal and sending it in a GOOSE message via the substation bus is no more than 10 ms.



GOOSE messages contain a mandatory VLAN number, which is set in the service software. When VLAN is enabled on the substation bus ports, it is necessary to configure the supported VLAN numbers on the Ethernet ports, otherwise GOOSE messages with a VLAN number that is not in the port settings will not be transmitted or received.

1.4.12 RelayTool software for monitoring and basic configuration

RelayTool software is a PC based software tool, which has been designed to:

- monitor on site Intelligent Electronic Devices;

- view and edit settings, fix their changes and compare different setting files;
- download and analyse disturbance recordings via BSCOPE software, manual trigger disturbance recording, change disturbance recorder parameters;
- monitor signals (view their current values), diagnose communication channels with IEDs;
- download and view event logs;
- configure different signals towards binary inputs, outputs, LEDs, disturbance recorder, event recorder, SCS communication protocols etc.;
- authorize users.

For details, refer to RelayTool User manual.

1.4.13 PCAP software for flexible logic programming

PCAP software is a PC based software tool, which is designed to:

- create functional logic diagrams using graphical elements;
- parse, validate and translate schemes to IED files;
- create new measuring modules and functional blocks;
- program analog processing of measured values;
- configure analog inputs, binary inputs and outputs, LED indications for disturbance and event recorders, signals for SCS communication etc.;
- determine the appearance of user-defined HMI;
- edit parameter structure;
- upload/download diagrams to/from IED;
- authorize users.

For details, refer to PCAP User manual.

1.4.14 BSCOPE software for disturbance record analysis

BSCOPE software is a PC based software tool, which has been designed to:

- read recordings stored in COMTRADE[®] format (IEC 60255-24:2013);
- display recorded waveforms of analog and binary signals;
- calculate and display analog signals phases and modules;
- calculate and display power frequency, symmetrical components;
- calculate and display user defined signals;
- plot phasor diagrams and hodographs;
- print recordings.

For details, refer to BSCOPE User manual.

1.5 Measuring instruments, tools and accessories

The list of equipment and measuring instruments required for carrying out operational checks of the terminal is given in Appendix F.

1.6 Labelling and sealing

TOR 200 has labelling in accordance with design documentation and IEC 60255-27:2005, which is done in a way providing its clarity and preservation during its life time.

Each IED has a label on the rear panel, which shows:

- manufacturer trademark;
- name and notation of the device;
- rated auxiliary supply voltage;
- binary inputs rated voltage;
- manufacturing date (month, year);
- serial number of the device;
- connection type and remote control type (if applicable);
- "Made in Russia" mark;
- sign of product conformity.

Shipping container is labelled with handling signs “Fragile”, “Keep dry”, “This way up”.

Labelling of shipping container, when the IED is shipped separately (not within the relay cubicle), contains also:

- recipient name;
- shipping address;
- device notation;
- device serial number;
- additional information, specified by the ordering documentation.

Device design provides sealing.

1.7 Packaging

TOR 200 packaging is done in accordance with Relematika design documentation for storage and transportation conditions. Allowed storage time is presented in section 4.

2 OPERATIONAL GUIDELINES

2.1 Operating limitations

Device operation and maintenance should be performed according to these instructions. Operating conditions concerning the influence of climatic and mechanical factors shall comply with the requirements specified under item 1.1.7.

IED possibility to operate under the conditions, which differ from the specified ones should be coordinated with Relematika company.

2.2 Getting started and commissioning

2.2.1 Safety information



When getting started and commissioning one should be guided by all applicable instructions and directives as well as present operation manual instructions.

Only specially trained personnel should be admitted for installation, maintenance and operation of devices.

Removing/inserting of modules from/to the IED and working on its connectors should be performed only on a de-energized device.

Before power-on and during operation, the IED should be reliably grounded by the ground screw, placed on the IEDs rear panel, to the earthing loop (bay, cubicle case) with the shortest earthing path by a copper wire of at least 4 mm² section area.

2.2.2 Visual inspection

A packed device TOR 200 should be put on a horizontal surface according to the manipulation sign "This way up". Remove the transport package and assure that its content corresponds to the packaging list.

Examine the delivered IED to ensure that it has no mechanical, package damages, occurred during transportation. Check that marking is available and not damaged.

In a case of any deviations or damages of the device, Relematika or its official representative should be informed immediately.

2.2.3 Installation and connection

Overall and installation dimensions are specified in Appendix B. Install the IED accordingly to its location.

Connect an earthing wire as to 2.2.1.

Connect the device according to approved project and present operating instructions. Connection should be carried out with the wires as it is described in 1.2.

2.2.4 Commissioning

At delivery, each TOR 200 IED has default factory settings. During its commissioning all the settings should be checked and, if required, changed according to 2.4.

In order to put the unit into commissioning, all the required operations, specified in Table 3.2 for testing at initial power-on should be performed.

When shipping the IED as a part of relay protection cubicle, all the required tests for the cubicle at initial power-on should be performed in accordance with the attached operating documentation.

2.3 Information security

2.3.1 General

In order that the protection relay could operate as part of an automated process control system at significant facilities of critical information infrastructure, it is equipped with a number of functional capabilities that implement the requirements for certified means of protecting confidential information.

2.3.2 Access privileges setup

2.3.2.1 TOR 200 software implements a role-based policy for controlling access to IED functions and data. Role nomenclature and permissions are built into the software by the developer and cannot be changed by the user. The following roles (groups) of users are supported: "Relematika", "Admin", "Relay specialists", "Operating personnel", "Guests".

Authorized access to IED functions is implemented via user groups with different access rights, as presented in Table 2.1.

Table 2.1: User groups

Role (group) name	Group description	Group user by default	Default password
Relematika	Group intended for manufacturer's specialists during service works etc. Contains only one user	Relematika	*
Admin	Group used for adding and deleting users in groups Relay specialists, Operating personnel, Guests	Admin	admin
Relay specialists	Group, allowing functions for relay protection operating and commissioning staff	Specialist	1
Operating personnel	Group, allowing functions for operating staff. Contains at least one user	Operator	1
Guests	Group, allowing basic (reading) functions. Contains only one user	Guest	–
* Accessible only to Relematika specialists.			

2.3.2.2 The role of **Relematika** can only be used by the developer specialists when performing maintenance of the IED (2.3.4). The group performing this role has a single built-in account **Relematika**, which has full access to all functions and data of the IED. The user cannot add new accounts to this group and use or delete the built-in **Relematika** account. However, the user has the option to disable this role, making it impossible to perform any actions on behalf of the **Relematika** user. This limitation is available to users of the Administrator group.

2.3.2.3 The **Admin** role allows configuring security functions and obtaining information about their operation. Only users of this group can manage other accounts. If it is impossible to get access to a user of the **Admin** group (for example, if the corresponding password has been lost), you should contact the technical support service of the developer. To prevent the described situation, it is recommended to use a set of organizational and technical measures, including, for example, the following:

- appointment of employees responsible for using the **Admin** role;
- appropriate training and knowledge testing of designated employees;
- adding additional (backup) accounts of the **Admin** group;
- reservation of account passwords in sealed envelopes and keeping records of the use / opening of these envelopes in a special register;
- ensuring the storage of reserved passwords in a separate lockable storage and securing responsibility for access to it.

2.3.2.4 The **Relay specialists** role provides access to all functions of the IED, their parameters and corresponding data, excluding the capabilities of the **Admin** role.

2.3.2.5 The role **Operating personnel** is designed to provide access to the main functions of the IED, excluding the capabilities of the **Admin** role.

2.3.2.6 The **Guest** role is intended to obtain the data about the IED operation and performing functions not related to information security capabilities. The built-in **Guest** account does not have a password as the functions and data available for this account are publicly available.

Basic access rights to IED functionality via local HMI are presented in Table 2.2.

Table 2.2: Access rights to IED functionality

HMI function	RM	A	R	O	G
LED indication reset via RESET button (2.5.2)	+	+	+	+	+
I, O, AUDIO, GROUP, L/R and K1...K13 buttons usage (2.5.2)	+	-	+	+	-
Event list clearing (2.5.7)	+	-	-	-	-
Disturbance records clearing (2.5.8)	+	-	-	-	-
Disturbance recorder manual start (2.5.8)	+	-	+	+	-
Settings group editing/activation/creation/deleting (2.5.9)	+	-	+	-	-
Disabling configuration changes via Ethernet port (2.3.3) ¹⁾	-	+	-	-	-
Test output signal selection (2.5.10)	+	-	+	-	-
Test/Operation mode selection, test mode parameters changing (2.5.10)	+	-	+	-	-
LED test (2.5.11)	+	-	+	-	-
Hardware test (2.5.11)	+	-	+	-	-
Communication port adjustment (2.5.12.1.1)	+	-	+	-	-
Date/Time adjustment (2.5.12.1.2)	+	+	+	+	+
Synchronization methods adjustment (2.5.12.1.2)	+	-	+	-	-
Entering, editing, deleting accounts (2.3.4) ²⁾	-	+	-	-	-
Password parameters editing (2.3.4.5 – 2.3.4.9) ³⁾	-	+	-	-	-
Entering, editing, deleting MAC and IP addresses (2.3.7) ²⁾	-	+	-	-	-
Enabling / disabling the service mode (2.3.4.4) ³⁾	+	-	-	-	-
Read access to audit log data (2.3.8) ³⁾	-	+	-	-	-
Enabling / disabling physical identification (2.3.5) ³⁾	-	+	-	-	-
Configuring smart card reader (2.3.6) ³⁾	-	-	+	-	-
Associating a smart card with a user account (2.3.6.4) ²⁾	-	+	-	-	-
¹⁾ The function can only be controlled via the HMI display menu. ²⁾ The function can only be controlled using the RelayTool service software. ³⁾ The function can be controlled using the HMI display menu and the RelayTool service software.					
 In Table 2.2 the following abbreviations of groups are used: RM – “Releamatika”, A – “Admin”, R – “Relay specialists”, O – “Operating personnel”, G – “Guests”.					

When IED is started the user **Guest** is activated. User group selection can be done via menu **Settings/Access** (2.5.12.1.2) or via the dialog box that appears in a case of function control without proper right access. Adding and deleting of the users in groups and passwords changing can be done only via the RelayTool software (1.4.12). Current user session is terminated, if the user is changed via local HMI, after inactivity timeout expiration or at restart and power loss.

The functions are controlled using the RelayTool service software after connecting to the IED using a virtual COM port or Ethernet port.

2.3.3 Prohibit configuration changes via Ethernet port

2.3.3.1 This function allows you to enable or disable remote update of settings. The function is controlled only from the HMI menu.

2.3.3.2 The mode of changing the settings over the network is controlled through the **Parameters/Security** menu items by setting the parameter Config over net (On - enable, Off - disable). After exiting the menu, a confirmation message is displayed on the screen, allowing you to save the changes.

2.3.4 Accounts

2.3.4.1 Account Management

2.3.4.1.1 During the initial configuration of the TOP 200 protection relay, each of the roles contains one built-in namesake account. For the groups **Admin**, **Relay specialists** and **Operating personnel**, the user can add up to 15 accounts in total, as well as edit or delete existing accounts. Built-in accounts have passwords shown in Table 2.1, it is recommended to replace them with those that meet the security requirements at this protected site during the initial configuration of the IED.



In order to ensure the confidentiality of authentication data, when entering passwords, the entered characters are not displayed and are replaced by the * character.

2.3.4.1.2 Account management is possible only with the RelayTool service software. To manage accounts, it is necessary to sequentially select items **Security/User editor** in the left part of the window, then click the **Download** button in the right part of the window.

2.3.4.1.3 To add a new account, it is necessary to select the group to which the new account will be added by clicking the left mouse button, and click on the **Add user** button, then in the window that appears, enter the name of the new user and the password, and click on the **Apply** button. If the entered data is correct, the account is added to the selected group, if it is incorrect, an error message is displayed.

2.3.4.1.4 It is allowed to change the password and the user name of accounts. When changing the username, you must also change the password. To edit data of accounts, left-click the mouse to select the group that contains the edited account and double-click the left mouse button on the user name and/or password value field, then enter a new value and press the **Enter** button. If the entered data is correct, the account is added to the selected group, if it is incorrect, an error message is displayed.

2.3.4.1.5 Any account, including built-in one, can be deleted. To do this, click the left mouse button to select the group that contains the account to be deleted, and then select the line with data of the deleted account and click the **Delete user** button. In this case, a window for confirming the deletion is displayed, in which you must click **Yes** to delete the account or **No** to refuse deletion. It is impossible to transfer an account from one group to another (change the role). If you still need this, you must first delete an account in one group and then create the same account in another group.

2.3.4.2 Username

Username may consist of a combination of uppercase and/or lowercase letters of the Russian and/or English alphabets and numbers. Other characters are not allowed when entering usernames. The username cannot be longer than 15 characters. If you try to add a user with a longer name, only the first 15 characters will be saved.

2.3.4.3 Managing security settings (2.3.4.4 - 2.3.4.9)

The control of safety parameters using the HMI is carried out via **the Parameters/Security** menu items by setting the appropriate parameter. After exiting the menu, a confirmation message is displayed on the screen, allowing you to save the changes.

To manage security parameters by means of the RelayTool service software, select the item **Parameters** in the menu tree and then click on the **Download** button. In the appearing list of parameters, go sequentially to the items **Settings/Security**, double-click the left mouse button, and enter the value in the cell of the corresponding parameter. The changes made are saved by clicking the **Upload** button. If the entered parameter value is incorrect, the changes will not be loaded, and the screen will display an error of IED properties change.

Parameter setting (items 2.3.4.5, 2.3.4.6, 2.3.4.7, 2.3.4.8, 2.3.4.9) can also be performed using the RelayTool software by going to the **Security / User editor** items in the menu tree and clicking the **Settings** button. In the appeared window, select the field of the corresponding parameter and enter the required value and click the **Apply** button.

2.3.4.4 Service mode

Service mode refers to the functions and data available to the **Relematika** role, which are used only for service maintenance, updating the IED software or when providing assistance to users by the developer employees. If there is no need for the services of the developer employees, **Service mode** should always be disabled.

Service mode management is carried out by setting the parameter **Service mode** (On - enable, Off - disable).

2.3.4.5 Password length

In order to increase brute-force attack resistance, it is recommended to introduce user passwords of maximum length consisting of upper- and lower-case English letters and numbers (the maximum possible number of characters is eight).



The parameter is controlled only when the **Complexity** parameter is enabled (2.3.4.7).

The minimum password length is specified by the value of the **Min. length** parameter.

2.3.4.6 Validity limit

Limiting the password expiration date increases its resistance to brute-force attack due to forced rotation. The password expiration value ranges from 1 to 999 days. It is recommended to set the value of this parameter in accordance with the requirements for this protected object. The set value will be valid for all accounts.



Attention! Password aging can occur after the protection relay is synchronized.
The password expiration counter is reset when the protection relay is restarted.

When attempting to access IED via the HMI after the password expired, the user is automatically prompted to enter a new password twice. The new password is saved only if the new values entered twice match. Otherwise, an error message is displayed, and access is not granted. Using the service software RelayTool, you can enter a new password by going to the items **Security / User Editor** in the menu tree, then selecting a group, user and double-clicking the left mouse button in the **Password** field.

Setting the password expiration date by defining the value of the **Validity limit** parameter.

2.3.4.7 Password Complexity

The password complexity requirement specifies the minimum acceptable list of characters that the password must consist of. It is recommended to enable this requirement to increase the strength of user passwords against password guessing attempts. The set value will be valid only for created accounts and when changing passwords of existing accounts.



When enabling this requirement, it is necessary to set the minimum password length according to 2.3.4.5.

Setting the password complexity requirement is carried out by defining the **Complexity** parameter value (**Yes** - enabled, **No** - disabled).

2.3.4.8 Number of attempts to enter an invalid password (Max. tries)

To limit the number of password guessing attempts, it is recommended to set the counter value for the maximum allowed number of incorrect password entry in the range from 1 to 999. The set value will be valid for all accounts and will be monitored for each user session. When the counter reaches the set maximum value, the account is locked. It is recommended to set the value of this parameter in accordance with the requirements for each particular protected site.



- 1) The number of attempts to enter an incorrect password is controlled for each type of user connection.
- 2) Counting the number of attempts to enter an incorrect password using the RelayTool software and through the HMI is carried out separately.
- 3) The counter of the invalid attempts to enter password is reset when the protection relay is restarted.
- 4) If the number of attempts to enter an incorrect password for one account is exceeded, all accounts of this connection are blocked.

Setting the maximum number of attempts to enter an incorrect password is carried out by setting the value of the parameter **Max.tries**.

2.3.4.9 Password block time (Block time)

This parameter allows you to set the time (from 1 to 999 minutes) for which the user account will be temporarily blocked when it reaches the maximum number of password entering attempts within one session. The set value will be valid for all accounts. It is recommended to set the value of this parameter in accordance with the requirements of the protected site.

The blocking time is set by defining the **Block time** parameter.

2.3.5 Physical identification (Physical ID)

The possibility of identification by means of physical devices is realized by connecting additional smart card readers to the IED and a PC with the RelayTool service software installed, configuring them and performing smart cards control.

After enabling this function and restarting the protection relay, any action using the HMI or the RelayTool software will be accompanied by the requirement to present the user's smart card. Access becomes impossible without presenting a smart card. To gain access, one must attach a smart card associated with this user to the reader. It is necessary to associate smart cards during the initial setup of the protection relay and immediately after creating new accounts.



If no smart card has been associated with this user, any smart card can be temporarily used.

Physical identification is controlled by setting the **Physical ID** parameter (On - enable, Off - disable).

2.3.6 Connecting and configuring the smart card reader

2.3.6.1 Readers are connected to the RS-485 port of the IED and the USB port of the PC, respectively. The reader connected to the IED is used for local user identification. The reader connected to the PC is used for remote identification of users by means of the RelayTool service software and for assigning smart cards to user accounts.

After connecting the reader to the protection relay, you need to configure it using the HMI menu or the RelayTool service software. This function is available only to users of the “**Relay specialists**” role.

2.3.6.2 The reader is configured:

- by means of the HMI via menu items **Configuration/Communication ports/RS-485/FOCL** and items Port 1 or Port 2 (depending on which port the reader is connected to);
- by means of the service software RelayTool through the menu items **Parameters/RS485_1** or **RS485_2** (depending on which port the reader is connected to).

It is necessary to select the RFID protocol in the cell of the **Protocol** parameter value, Speed - 9600, Parity - No, Stop bits - 1.

2.3.6.3 Configuring Physical ID on PC

The reader is connected to one of the standard USB ports of the PC. For the reader to work correctly, you need to install the **ftdi32_certified.msi** and **ftdi64_certified.msi** drivers for 32-bit and 64-bit Microsoft Windows, respectively. The installation files are located on the optical disc supplied with the device. Driver installation is performed using the authority of the local OS administrator. Additional configuration of the driver or the RelayTool service software is not required.

2.3.6.4 Associating a smart card with a user account

This function is performed only by using the RelayTool service software and is available only to users with the **Admin** role. One smart card can be associated with multiple accounts. In order to ensure control over the use of smart cards, it is recommended to organize accounting of issued identifiers, their correspondence to their accounts, and use smart card labelling. In case of loss of a smart card, to prevent unauthorized access, it is necessary to associate another smart card with this account as soon as possible. When you delete an account, the previously associated smart card can be used for another account without additional steps.

To associate a smart card with a user account, go to the **Security/User Editor** menu items, select a group and a user account and click on the **Snap card** button. When the window appears with the message **'Attach the key to be bound to the reader'**, you must attach the associated smart card to the reader. The smart card has a 60 second time-out and when it expires, the error message **'Error. Reader timeout has expired'** appears.

2.3.7 List of allowed MAC and IP addresses

2.3.7.1 To ensure the ability to restrict remote control of the IED, as well as to identify the IED by the control system servers, the ability to filter traffic by maintaining a list of allowed MAC and IP addresses is implemented.

2.3.7.2 In case of adding incorrect or erroneous entries to the list of allowed MAC and IP addresses, remote access to the IED may be impossible. In this situation, it is necessary to connect to the protection relay via a virtual COM port and correct the erroneous entries in the list.

2.3.7.3 To get a list of allowed MAC and IP addresses, go to items **Security/ List allowed IP and MAC** in the menu and click on the **Download** button. During the initial setup of the protection relay, the list is empty. It is recommended to include here only the MAC and IP addresses of the PCs with the RelayTool service software installed, as well as the process control servers.

2.3.7.4 To add an entry to the list, click on the **Add** button, and the address 127.0.0.1 is automatically added to the IP field, which must be replaced with the required address and the corresponding MAC address. In addition, you can add the addresses of the PCs with the RelayTool service software installed by clicking the **Add my IP + MAC button**. In this case, a window with a list of local addresses is displayed, from which you can select the required address and click the **Select** button, and the MAC address value is added automatically. To delete an entry from the list, just select it with the mouse and click on the **Delete** button.

2.3.7.5 To apply the list of allowed MAC and IP addresses, click on the **Upload** button, and the window for confirming changes is displayed with a message asking to restart the protection relay. The IED must be rebooted manually.

2.3.8 Audit log

2.3.8.1 During the IED operation, the events generated during the execution of security functions are stored in the security audit log. This log is implemented in the form of a table displaying the following data:

- date and time of the event;
- the name of the user from whose session the event was registered;

- the source of the event (for example, the IP address of the PC and the communication protocol);
- event message;
- event status (for example, 'Success' or 'No access').

2.3.8.2 The audit log does not have any parameters and settings and cannot be modified, deleted or disabled. The audit log is designed to accumulate information about events, the data about which can be used in the investigation of info-security incidents.

2.3.8.3 To view the audit log, go to the items **Security/Audit log** in the RelayTool menu and click on the **Download** button. Audit log data is presented in the form of a table, the rows of which can be coloured: green for a successful event, red for an error event, and no colour for access denied.

2.3.8.4 The entire audit log is displayed automatically. The user can specify filtering options to display only the required data. To do this, you must specify the values of the fields at the top of the log table, by which the data will be selected.

2.3.8.5 If the audit log becomes full, new data is automatically recorded while the old data is erased. To ensure the continuity of saving data on security events, it is recommended to save the audit log to files at a sufficient frequency for the given protected site. To save the audit log, you must click the **Export** button, select one of the saving formats (PDF, DOCX, XSLX) and specify the file name.

2.4 Parameter setting

The IED is freely configurable and has adjustable parameters. Table 2.3 shows IED settings, which can be entered via the device HMI.

Table 2.3: IED parameters configurable via HMI

Setting	Editable parameters
Bay connection parameters (2.5.13)	Rated values of currents, voltages, other measurable values; measuring transformer parameters
Protection function settings (2.5.9)	Activation/deactivation and operating mode (setting position selection), entering setting values
Communication parameters (0)	Selection of a communication protocol and its parameters
Time and date parameters, synchronization method (0, 0)	Date, time and UTC
Disturbance recording (0)	Archiving
Test (2.5.10)	Disturbance recorder enabling, check signal definition

The RelayTool software should be used for configuration of the parameters given in Table 2.4.

Table 2.4: Configurable parameters

Object	Editable parameters
Protection function settings	Activation/deactivation and operating mode (setting position selection), entering setting values
Analog inputs	Selection of CT and VT ratings
Binary inputs	Quantity, assignment, connection to hardware input, Operating delay, reset delay
Binary outputs	Quantity, assignment, connection to hardware output, Test mode permission
LEDs	Quantity, assignment, glow mode
Functional keys	Quantity, assignment
Disturbance recording	Disturbance recorder parameters, definition of starting and operating conditions, setting of analog and binary signals
Event recording	Logical signals configuration
Test	Selection of logic signal effecting on Relay K1.6 'Test output' in a test mode

2.5 User interface (local HMI) structure

2.5.1 Local HMI structure

Local human-machine interface is divided into two functional parts: the user interface module and the LED module.

The user interface module provides two-way communication. This means that:

- if an event occurs, it is displayed in the HMI menu in order to inform the operator and to require from him some action;
- if necessary, the operator can display certain information himself.

The user interface module consists of a display and push-buttons. The display represents the current status of the controlled object and the IED itself. The IED interface is based on a tree-coded menu with navigation by means of push buttons. The pushbuttons can perform various functions, depending on the position in a menu structure.

The LED indication module has several LEDs, their quantity depends on the IED version. Each LED has a name on the front panel according to the appointed function. LED indication modes are specified in par. 1.4.5.

2.5.2 Push buttons



The functionality of the push buttons presented below is described for single pressing of each particular button.

The **C** button (Cancel) has two main functions:

- **cancel** any operation presented in a dialog window;
- **exit** the present level or move one step higher in the menu tree.

The **E** button (Enter) executes the following functions:

- **enter** down to the lower-level menu marked with cursor;
- **execute** - confirm the displayed action;
- **confirm** presented numeric values and select an item from the list;
- **move** to the parameter fast editing menu.

The **Left** (◀) and **Right** (▶) arrow buttons have the following functions:

- fast cursor move (over four items or up to the page beginning/end) between menu items on the same level;
- move the cursor in a horizontal direction in parameter editing mode in order to change the active character location.

The **Up** (▲) and **Down** (▼) arrow buttons have four functions:

- move up and down between the current menu items on the same level;
- move between the confirmation alternatives in a command window;
- change parameter values in the edit mode;
- switch between information windows in standby mode.

The **F1** button is designed to view different reference information:

- settings description in **Settings** menu;
- reference phasor for analog signals in **Measurements** menu.

The **F2** button is used to fast move from standby screen to corresponding menu item and enhanced editing mode.

The **RESET** button is used to reset the IED alarm signalling.

Button **I (AUDIO)** is intended for opening (tripping) of the switching device, button **O (GROUP)** is used for closing (resetting) of the switching device.



The buttons AUDIO and GROUP are installed instead of I / O buttons on the TOR 200 device with central signalling function.

The buttons **MENU**, **SET**, **METER**, **MNEMO** are intended for ease of navigation and provide a transition to the corresponding section of the HMI.

The **L/R** button provides a choice of local or remote control mode. The signal from the button is added according to the OR scheme with a similar input signal for selecting the control mode from a discrete input. The button LEDs provide control of the current control mode.

2.5.3 Functional buttons assignment

The buttons **K1...K13** (**K1...K6** for compact version) are intended for operational control. At single pressing on such a button, the acknowledgment request menu appears: press **E** to confirm or press **C** to cancel the action. These buttons can be used as operational buttons and as switches on control panels and cubicles. In the first case, a short pulse signal is sent to the IED logic diagram from the button. In the second case, when using the button as a switch (with two fixed positions), every pressing changes the state of the program key, and the value of the state is sent to the IED logic. The state of the program key is stored in the non-volatile memory.

The buttons are configured via the RelayTool software.

When the value 'Lock action from buttons' is set, the button action is blocked, while the button signal is controlled by the signals 'Set button state' and 'Reset button state'.

The interface of the RelayTool software also provides the possibility of inverting the LEDs of the buttons and picking up the LEDs of the buttons; in the latter case, the LEDs are reset by pressing the RESET button.

2.5.4 Standby mode

As soon as the IED is turned on, the local HMI enters the standby mode. In this mode the IED screens switch sequentially, displaying the following information:

- information on disturbance recordings: number, date and time of the latest recording, cause of triggering;
- information on the latest events: signal abbreviation, status (0 or 1), date and time of the event;
- information on failures detected by built-in self-supervision: 'WARNING!!! ERROR!', description of the failure;
- information on the current measured values.

The screens are displayed only when records, events, failures or selected values are available. The screen displaying a failure has the highest priority: when a failure is detected, only this screen is displayed.

Every screen displays date, time and active setting group number 'Active group' at the top.

The display turns off when inactive for 2.5 minutes. Pressing any button will activate the display.

The HMI display switches to standby mode screen after 60 minutes if there is no pressing on any button. In this case the system moves to the mode with 'Guest' rights access.

2.5.5 User interface menu

The user interface menu is the main tool for controlling IED operation and receiving information about its state.

Pressing the **E** button will switch the device from standby mode to the main menu.

The main menu (depending on the IED version) includes the following items:

- Measurements (2.5.6);
- Events (2.5.7);
- Disturbance recorder (2.5.8);
- Settings (2.5.9);
- Testing (2.5.10);
- Diagnostics (2.5.11);
- Parameters (2.5.12);
- Information (2.5.13);
- IEC 61850 (2.5.14).

The lower-level menu content depends on the device current state and therefore some of the items can be unavailable. An active state is indicated at the top screen line (for example, 'Settings').

There are several screen types of the menu:

- **selection list** (most of the menu): current selection is underlined with a cursor in the left part of the screen; jumping to the sub-menu is possible;

- **list without selection** (indication of read-only parameters): no cursor on the screen;

- **dialog window** (request for an action execution): no cursor, functions of the buttons are shown on the screen.

If the number of menu items exceeds the number of the screen rows, symbols \uparrow , \updownarrow or \downarrow are shown on the left top of the scrollbar.

2.5.6 Measurements

The menu **Measurements** represents the current values of analog and logical signals. **This is a configurable menu.** The factory setting of menu content depends on the IED version and generally can include the following items:

Input signals

The **Input signals** menu shows the states of binary input signals, grouped on HW modules basis. Each signal is defined by its number, name and value (logical 1 or 0).

Output signals

The **Output signals** menu shows binary output signals, grouped on HW modules basis. Each signal is defined by its number, name and value (logical 1 or 0).



Input and output signal numbers correspond to the address designation of each signal in the functional logic diagram.

Analog signals

The displayed information about analog values is determined by the firmware and is not common for all IEDs. This menu can also include calculated analog values.

The menu names correspond to the measured analog values and contain:

- primary and secondary measured values of phase currents and voltages (fundamental harmonic), their symmetrical components;
- primary values of active and reactive power (phase and total) in the line (transformer), and corresponding power factor;
- primary and secondary values of phase-to-ground and phase-to-phase impedances as well as symmetrical component impedances;
- frequency.

AC current and voltage values are displayed in a polar form (RMS value and voltage phase-angle value for phase A). Impedances are shown in polar form (absolute value in Ohm, argument value in degrees).

Reference signal data is displayed by pressing **F1** in **Analog signals** menu.

Motor startup limitation counters

The menu **Motor startup limitation counters** determines the following:

- Cold starts – the number of cold startups of the engine;
- Hot starts – the number of hot startups of the engine;
- Total starts – the total number consequent startups.

Circuit breaker diagnostics

The **Breaker diagnostics** menu is used to display information about the controlled circuit breaker (CB).

The menu **Trip time** contains information about the date and time of the last circuit breaker operation and corresponding tripping time (in ms) for each phase separately.

The **Tripping currents** menu contains information on the last circuit breaker currents at breaking for each phase (kA) separately.

Breaker (CB) state contains the following information:

- **Mech. life, %** – the remaining mechanical resource of the CB (percentage);
- **Mech. life** – the remaining number of mechanical durability cycles;
- **N trips** – the number of breaks;
- **Com. life A** – the remaining breaker phase A switching lifetime (percentage);
- **Com. life B** – the remaining breaker phase B switching lifetime (percentage);
- **Com. life C** – the remaining breaker phase C switching lifetime (percentage);
- **Reset conditions** item sets the state of the CB to the initial (default) values - recovers values to the maximum residual resource;
- **Reset maint. counter** resets trip counter after maintenance.

The user can correct the remaining switching resource for each phase separately, as well as set the residual mechanical resource. Selecting a value with the **E** button enables the user to set the value of the function parameter. Further on, the user will be offered to enter a new value of this parameter. Entry confirmation is made by pressing the **E** button.

The menu **Closing time** contains information about the date and time of the last circuit breaker closing.

2.5.7 Events

The **Events** menu is used to display information about the events, recorded by the IED. All recorded events are stored in the internal non-volatile memory.

The Event menu contains the following items:

- **Event list** – event info representation;
- **Clear all** – removal of all events from the memory.

View events

The menu **Event List** allows the user to choose the event for viewing. Consecutive pressing of the **E** button opens the screens on which the date, time and event list are displayed. For selected event the data, time and setting group number are represented.



The date and time are shown in the following format: ***DD.MM.YYYY*>HH:MM:ss.ms.**

DD = date, MM = month, YYYY = year, HH = hours, MM = minutes, ss = seconds, ms = milliseconds

Clear all events

The menu **Clear all** (with acknowledgement) allows the user to erase event recorder internal memory, for example, after commissioning or configuring the device, when the previous information is not actual.

Clear all function should be used with caution since it leads to permanent loss of event data.



This menu can be used only by Relematika specialists.

2.5.8 Disturbance recorder

The **Disturbance records** menu is used to display information recorded by the device during the latest disturbance situation. All disturbance recordings are stored in an internal non-volatile memory. They can be accessed via a process control system or the RelayTool software.

The menu **Disturbance records** contains the following items:

- **Records list** – contains information about saved disturbance recordings and their quantity;
- **Clear all** – clears all disturbance recordings from the memory;
- **Manual trigger** – manual start of disturbance recorder (requires confirmation);
- **Parameters** – viewing of disturbance recorder parameters.

View

The User is offered to select a disturbance recording to be viewed. In the **Record list** menu the current, previous and next disturbance recording are displayed with the time stamp (in the format: HH:MM:ss:ms, where HH is hours, MM is minutes, ss is seconds, ms is milliseconds), date (DD.MM.YYYY, where DD is date, MM is month, YYYY is year), disturbance duration, short name of a signal, which has initiated triggering of the current disturbance recording. Scrolling through the list of recordings is made by means of **Left** and **Right** control buttons.

After selecting of the desired disturbance recording with the **E** button, the user jumps to the next menu level containing the following information about the recording:

Triggers – List of signals which initiated disturbance recording;

Events – List of events recorded by the IED;

Clear – Erasing the current recording from the internal memory (requires confirmation).

Clearing the disturbance recorder memory

The **Clear all** menu (with confirmation) allows clearing the internal memory, for example, during device commissioning or configuration, when the previous information is not actual.

The **Clear all** function should be used with care as it leads to permanent loss of data about all the previous disturbance conditions recorded by the IED.



This menu can be used only by Relematika specialists.

Manual triggering

The **Manual trigger** menu is used for manual triggering of disturbance recorder. Use this function to get a snapshot of the controlled object status.

Parameters

The **Parameters** menu contains information about the parameters of disturbance recorder function:

- **Max.duration** – Maximum disturbance recording length, in ms;
- **Postfault** – postfault disturbance recording length (after triggering conditions disappear), in ms;
- **Prefault** – prefault disturbance recording length (before triggering conditions appear), in ms;
- **Sample rate** – sampling frequency;
- **Archiving** – permission for automatic compression of the recordings in a separate *.zip archive;
- **Signal names** – choosing a signal name to be displayed with the recording: Eng – internal tag, Ru1251 – user short name.

Disturbance recorder parameters can be edited by means of the RelayTool or PCAP software.

2.5.9 Settings

Use the **Settings** menu to view and edit different parameters of protection functions included in the IED and to set IED operating modes. The IED can have up to eight setting groups, one of which is set as active. An active group number is displayed in a standby mode and in the main menu. Reference information is displayed by pressing **F1** in the setting menu row.

View

Use the **View** menu to view the current setting values, timers' characteristics, state (positions) of programming switches.

Edit

In order to edit parameters, enter the **Edit** menu, select an active group, enter a password and select a setting. By pressing **E** button, the user will get the possibility to change the parameter. Confirm entry by **E** button. In order to enter the settings extended editing mode press **F2**.

After the setting is changed, exit the menu, then you will be offered to save the changes.

Parameters can be also edited with the RelayTool software.

Activate

Enter the **Activate** menu in order to select (change) an active setting group from the list. The user will be offered to enter a required password so that the changes would come into effect.



A setting group can also be activated via a binary input.

Create

Use the menu **Create** to create a setting group with default values.

Delete

Use the menu **Delete** to delete selected setting group(s).

2.5.10 Testing

There are functions, which are impossible to test without participation of qualified maintenance personnel. In order to test functionality of measuring elements, the device is set into the test mode. For detailed description of the test mode refer to par. 2.6.

Use the **Testing** menu to verify the IED operation capability:

- **Test output** – setting the operating test output relay. The submenu includes the **Reset** function which, if selected, de-energizes the relay which then cannot be controlled until the next signal assignment;
- **Test mode** – test mode enabling/disabling;
- **Enable recording** – enabling/disabling disturbance and event recording during the active test mode;
- **Number of trig.** – number of disturbance recorder triggering in a test mode (resets on test mode exit).

- **SCADA test** – displayed in a test mode, used for automatic testing of communication protocols (IEC 103, IEC 104/101, IEC 61850, Modbus).

2.5.11 Diagnostics

TOR 200 has built-in internal self supervision functions which enable detecting and alarming (output signal, LED indication) the internal faults in operating mode. Use the **Diagnostics** menu to check the IED status according to self-supervision tests:

- **Status** – shows general and current status of the hardware (the central and signal processors, peripheral units). When a failure is detected, it contains error codes, see 3.4.3;
- **LEDs** – contains three LED tests for the LEDs on the front panel of the IED. The first test is used for testing the red lightening mode of general double-coloured LEDs, the LEDs of CB status and the yellow lightening of the Test LED. The second test is used for testing the green lightening mode of general double-coloured LEDs, the LEDs of CB status, the status of the switching device, control mode. In the third test all general double-coloured LEDs change cyclically from red to green and single-coloured LEDs blink. The user controls the status of LEDs visually when choosing the 'LEDs' function;
- **Hardware** – switching to an expanded testing mode. In this mode all external circuits are to be disconnected, protection functions are taken out of operation. The detailed description of a testing mode is presented in 2.6.3;
- **Information** – contains information about the number of the device starts, the last start (date, time in the format HH:MM:ss.ms, where HH is hours, MM is minutes, ss is seconds, ms is milliseconds), reset function (resets information about all the starts), software version.

2.5.12 Parameters

Use the **Parameters** menu to edit the displayed data and time, to set communication parameters for connection with a process control system, entering and editing the access rights to IED functions.



The internal clock accuracy is important for joint (simultaneous) analysis of disturbances from several IEDs.

Communication ports

The **Comm. ports** menu contains the following elements: **RS-485 / FO** (connectors XT1, XT2), **Ethernet** (connectors XT5, XT6), with editable settings for joint work of several IEDs within the same network and for remote access to the device.

2.5.12.1.1 RS-485 / FO (Port 1, Port2)

The menu item **RS-485 / FO** (Port 1, Port 2) is used to view and set (selection and adjustment) the following communication port parameters:

- **Protocol** – selection of a communication protocol IEC 103, Modbus, NMEA0183, SPA-Bus, RFID, IEC 101, BDUBus (dedicated internal protocol for communication with graphic programming environment);
- **Comm. parameters** used for setting the following parameters:
 - **Baudrate** – baud rate for each port. Baud rate options in bit/s are: 2400; 9600; 19200; 38400; 57600; 115200; 230400;
 - **Data bits** – number of data bits;
 - **Parity** – check bit, it is usually set to zero or one so that the total number of digits in a byte is always either even or odd. It is used for data transfer check;
 - **Stop-bits** – bits denoting the end of the byte transferred;
 - **Prot. params** – specific parameters of the protocol used for certain communication port (not specified for NMEA0183, SPA-Bus, RFID).

For IEC 103, IEC 101 protocol:

- **Address** – IED network address according to IEC 60870-5-103:1997 and IEC 60870-5-101:2003, respectively;
- **Timeout** – maximum permissible time to generate response, ms;
- **Latency** – delay in a communication channel, ms;
- **Disturbance records** – determines the order of processing the disturbances according to IEC 60870-5-103:1997 and IEC 60870-5-101:2003, and contains:
 - **List** – defines a number of disturbances transmitted by the device (latest 8 (by default), latest 16, 24 or all);
 - **Clear** – defines if disturbances should be deleted after download;
 - **Notify** – defines if a spontaneous message should be generated to list the new disturbance recordings.

For Modbus protocol:

- **Address** – device address in a Modbus network;
- **Timeout** – maximum permissible time to generate the response, ms;
- **Mode** – ASCII or RTU mode selection.

For BDUBus protocol:

- **Address** – device address in a BDUBus network.

2.5.12.1.2 Ethernet menu

The **Ethernet 1** (connectors XT5, XT6) menu is used to view and set communication port parameters and contains the following:

- **MAC** – unique MAC-address of the device. This number is used to identify a sender and a receiver of a frame;
- **IP** – unique network address in computer network, created according to IP protocol;
- **Mask** – IP network mask;
- **Gate** – IP gateway address; it should be defined taking into account the device IP and the network mask.



The settings in the **Gate** item and the mode selection in the **Mode** item of the **Ethernet 1** menu are applied only after the IED is restarted.

- **Protocol** – it is used when connecting according to the IEC 60870-5-104:2000 standard; the volume of data output from the event log by the IED (in days) is set in the menu;
- **Mode** – selection of communication ports operation mode:
 - **PRP** – it is used when applying PRP network topology. The mode should be enabled only after confirmation of the presence of PRP by the ACS service engineers. **If the network does not support PRP, then this mode must be disabled**, otherwise communication problems may occur;
 - **Witch** – it is used when there is no PRP at the site;
 - **Hot standby** – it is used when there is no PRP at the site, but it is required to provide redundancy. The mode provides simultaneous connection of the IED to the facility network via two ports: one port is always used for receiving and transmitting data, the other port is in reserve. If communication is lost on the active port, the backup port is activated;
- **VLAN** – in PRP mode, the VLAN parameter of incoming GOOSE messages can have values from 0 to 16. **With other VLAN values, the IED will not receive and send GOOSE messages;**
- **PRP parameters** – parameter setting:
 - **SVF period** – period for sending packages, s;
 - **MAC** – despatch address.

Menu Date/Time

The **Date/Time** menu is used for editing of date, time and UTC (Universal Time Coordinate) parameters. Non-volatile clock indication is presented in the following format: DD.MM.YY, hh:mm, UTC indication.

Menu Time sync. methods

The **Time sync. methods** menu contains:

- **Methods** – synchronization method selection: **HMI** (possibility of time correction via HMI), **BDUBus** (technological interface of BDUBus), **RTC** (real-time clock), **PPS** (synchronization input), **IEC103**, **NTP/SNTP**, **IEC104/101**, **MODBUS**, **NMEA0183**, **SPA-Bus**. Additional synchronization parameters: for SNTP (IP - addresses of the primary and secondary SNTP servers; Period - server polling period); for PPS: mode and type – they are set in accordance with the operating mode of the PPS pulse source;
- **Parameters** – threshold (the minimum difference between the IED and server time, above which the server time will be applied), ms.



- 1) PPS mode settings are applied only after the IED reboot.
- 2) One precise (Internal RTC, PPS) and one non-precise method can be selected at the same time.

Menu Access

The **Access** menu is intended for user selection and password entry.

Menu Permissions

The **Permissions** menu is intended to select operation with or without a password for the functional keys **K1, K2...K12** (Kx Ctrl) and control buttons for switching devices M, I, O (SD Ctrl).

Menu Security

The **Security** menu is intended to enter parameters for accessing the IED functions and contains the following:

- **Min.length** – the minimum number of password characters required to set it (2.3.4.5). It is recommended to use user passwords of maximum length (eight characters), consisting of upper and lower case letters and numbers. The set value will be valid only for created accounts and when changing passwords of existing accounts;
- **Validity limit** – the password validity limit (2.3.4.6);
- **Complexity** – selection of the minimum acceptable character set (2.3.4.7). When the requirement is enabled, simultaneous presence of uppercase and lowercase letters of the English alphabet and numbers are obligatory, with the requirement disabled - any letters of the English alphabet or numbers can be used;
- **Max.tries** – the number of incorrect input attempts in each user session, upon reaching which the account is blocked (2.3.4.8);
- **Block time** – the time for blocking the account (2.3.4.9);
- **Service mode** – enabling / disabling the Service mode (2.3.4.4);
- **Eth config ban** – selection of the setting change mode (2.3.4);
- **Physical ID** – identification by means of smart cards (2.3.5).

Changing the settings in the **Security** menu is available only to users of the Admin role.

2.5.13 Information

The **Information** menu displays information about the controlled power system object and IED parameters:

- **ID** – device functional diagram version;
- **Bay** – protected bay name;
- **S/S** – substation/station name;
- **Ser.N** – IED serial number.

2.5.14 IEC 61850

The **IEC 61850** menu is used to display the status and to check the operability of the IEC 61850 server, located within the device (substation bus, where MMS and GOOSE protocols are used (**Station bus** menu item)). It is also possible to enable the simulation mode (menu item **Simulation**).

In the lines of **Station bus** menu item, the following status is displayed:

- **OK** – all IEC 61850 protocols used in the selected bus are properly configured and operate correctly;
- **Err** – wrong configuration has been found for at least one of the protocols used on the bus.

Menu **Station bus** contains the following items:

- **Inc. GOOSE** – status of incoming GOOSE-messages;
- **Outg. GOOSE** – status of outgoing GOOSE messages;
- **MMS server** – status of MMS server operability.

Incoming GOOSE-messages adjusted in the IED are displayed as a list in the **Inc. GOOSE** menu. Each message representation has the following parameters:

- **MAC** – MAC-address of the incoming GOOSE-message, to which the device is subscribed;
- **ID** – GOOSE-message identifier;
- **ConfRev** – GOOSE-message configuration revision number;
- **StNum** – number of state change of signals in GOOSE-message;
- **SqNum** – number of message retransmissions.

Outgoing GOOSE-messages configured in the IED are displayed as a list in **Outg. GOOSE** menu. Each message is represented by the following parameters, which can be used for verification:

- **MAC** – MAC-address of the outgoing GOOSE-message;
- **StNum** – number of state change of signals in GOOSE-message;
- **SqNum** – number of message retransmissions.

The menu **MMS server** contains the following information:

- **Analog** – number of configured analog signals;

- **Binary** – number of configured binary signals;
- **Control** – number of configured control signals;
- **Settings** – number of configured settings;
- **Clients** – number of clients connected to server.

2.6 Test mode

In the IED units two test modes are implemented for built-in protection functions and hardware.

2.6.1 Test mode for protection functions

Application and operation

The **Test mode** for protection functions is intended for testing of measuring elements and generation of logical signals. Test mode allows the user to perform protection tests in disabled state for a specific functionality as well as under the operation.

Signal transmission to the control system in a test mode is subject to communication protocols specified in par. 1.2.6.

Disturbance and event recording are automatically switched off when the **Test mode** is activated. At the same time, protection functions, various background tasks, configuration functions, operation with settings and system event recording are still active.

The Test mode is initiated by issuing a **Test IED** signal to the binary input or via menu **Testing (Test mode submenu)**. It is also possible to enter the test mode using RelayTool software. During the test mode the output relays are blocked and **Test** (green) LED is lit.

2.6.2 Test mode setup

The item **Test output** in the **Testing** menu assigns logic signals to the output relay **Test output**. The submenu contains a complete list of logical signals in the form of a numerical notation corresponding to one on the functional logical diagram and a short signal name. The menu title displays designation of a logical block containing functional element under the test.

The RelayTool software is used to select output relays to be blocked in a test mode in order to avoid unnecessary operation of output relays.

Disturbance and event recording can be enabled from the **Testing** menu:

- from menu item **Enable recording**; in this case disturbance and event recorders are enabled. Disturbance recording is performed according to standard triggering conditions; triggering on test output should be configured separately;
- from menu item **Number of trig.**; in this case disturbance recorder is triggered by test output, all other triggering conditions are disabled.



The menu items **Enable recording / Number of trig** are active only in the test mode.

After the 'Test IED' signal is reset, the IED exits the test mode and returns to normal operation.

2.6.3 Hardware test mode

Function and operation

The hardware test mode is used for checking the operation of the hardware nodes during periodic tests or before commissioning in order to determine failures in the hardware components.

Protection functions, disturbance and event recording as well as self-diagnostic functionality stop automatically when entering the testing mode.

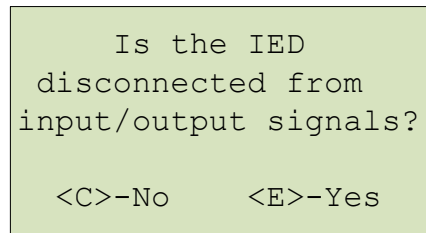
When the test detects an error (mismatch), it should be reported in a failure protocol, so the possibility of fixing the test result is provided, whether the test result is successful or not.

Preparation for testing

Before testing it is necessary to disconnect from the TOR 200 IED the following circuits:

- binary input signals,
- analog input signals,
- binary output signals,

When entering the test mode via **Diagnostics / Hardware** menu the following requirement must be confirmed (Figure 2.1).



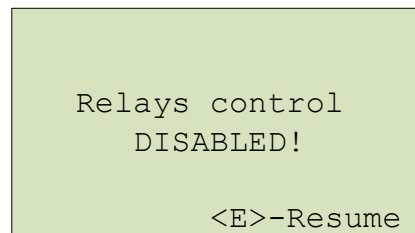
Is the IED
disconnected from
input/output signals?

<C>-No <E>-Yes

Figure 2.1: Confirmation of circuit disconnection

If disconnection of all input and output circuits is confirmed by **Yes**, the option test mode is activated and the output relay operation is allowed.

When **No** option is chosen the output relays are automatically blocked and corresponding message is displayed (Figure 2.2) on the LCD. In the test mode binary outputs are not checked (items **IO-boards test**).



Relays control
DISABLED!

<E>-Resume

Figure 2.2: Confirmation of binary outputs disabling

Running the tests

Test mode started and a list of tests is displayed in the **Diagnostics** menu:

- Test display;
- Test pushbuttons;
- Test LED;
- Test CP module;
- 'Fault' Test;
- Test IO modules.

Each particular test runs after the appropriate menu choice in HMI has been confirmed. All tests, except the keyboard test, can be cancelled by pressing **C** button.

After finishing of each test, it is necessary to confirm its result (message: **Is test passed? <C>-No <E> -Yes** appears on the LCD and the appropriate button should be pressed).

Test result is displayed on the screen in front of the corresponding menu item as **ok** or **er**.

Testing the LCD (by selecting **Test display** item)

The test checks the functionality of LCD display.

During the test:

- all segments of the display are lit simultaneously, then the screen is cleared;
- all segments are lit and dimmed sequentially.

Pushbuttons test (by selecting **Test pushbuttons** item)

By this test functionality of control and functional buttons of local HMI is checked.

2.6.3.5.1 Control buttons

The test is carried out by short-time pressing of each separate button and checking that the corresponding symbol of the pressed button is activated in **Test buttons** line. By this test, the operation of all buttons of the device can be checked (Figure 2.3).

```

Buttons: E
MENU SET MEAS MNEMO Rst
F1    <  ^  >
F2    C   v   E
M/#   SwOn SwOff
      <C>+<E>-Exit

```

Figure 2.3: Control buttons test

The exit is done by briefly pressing of both, **E** and **C** buttons or by receiving the corresponding command via diagnostic port.

2.6.3.5.2 Functional buttons

The test is carried out by short-time pressing of each separate button and checking that the button number should be displayed in reverse order in the **Gr.1** line.

LED test (by selecting LEDs test item)

All signalling LEDs are checked after activating the LED test.

During testing the verification of the following states is provided:

- all LEDs are turned off;
- LEDs are turned on in the 'red' and 'yellow' colour mode;
- LEDs are turned on in the 'green' colour mode;
- turning on and off of each double-colour LED twice (in 'red' light mode, and then in 'green' light mode), and each single-color LED once.

Microprocessor module test (by selecting MB Test item)

For verifying the correct operation of the real-time clock chip, installed in the logic module, the device displays a message about date and time data (Figure 2.4). It is necessary to acknowledge the displayed information.

```

*      MB test      *
Date      30.03.2020
Time      HH.MM.SS
Displayed correctly?
  <C>-No   <E>-Yes

```

Figure 2.4: Check of real-time clock

For checking the validity of the file system, the information about all devices and system parts is displayed (Figure 2.5):

- device name (ram, boot, log, oscil);
- total/free memory in kB;
- validation status of file operations.

If all operations are correctly executed a message 'passed' is displayed. To continue the tests of the logic module press **E**.

```

*      MB test      *
Device:    ram
Memory:   26096/6544kB
File ops:  passed
          <C>-Exit <E>-Next

```

Figure 2.5: Check of file system correctness

On error of file operations, the line **File ops** indicates one of the following messages (Figure 2.6):

- error creating the file – **er crt f**;
- error writing to the file – **er wr f**;
- error closing the file – **er cls f**;
- error opening the file – **er opn f**;
- error reading the file – **er rd f**;
- error deleting the file – **er del f**.

```
*      MB test      *
Device:   log
Memory:   0/   0kB
File ops: er del f

<C>-Exit <E>-Next
```

Figure 2.6: Example of error during File ops test

It is necessary to make sure that all data is correctly displayed and then press **E** to continue CP module test.

Messages with the names of missing files are displayed, when checking for presence of obligatory protection files.

When detecting the absence of obligatory protection files the test is considered to be passed **unsuccessfully** and it is required to copy the information displayed on the screen and report it to Relematika.

'Fault' relay test (by selecting "Fault" relay test item)

The test is intended for checking the operability of '**Fault**' relay and **ERROR** LED. The command for changing the relay state is entered by pressing **E** button. The relay closes or opens when triggering its state with the help of **Up** and **Down** buttons. Together with closing/opening of the relay the **ERROR** LED must be accordingly turned on/off.

When the test procedure is over, the '**Fault**' relay opens and **ERROR** LED, respectively, turns off.

Test of power supply and/or binary input/output modules (by selecting IO-boards test item)

This test checks modules containing binary inputs and outputs. Depending on the configuration of TOR 200, this menu contains the appropriate number of items, equal to the number of modules.

When entering the **IO-boards test** submenu, the screen displays the following information line by line, depending on TOR 200 version, (Figure 2.7):

- type of the tested module;
- number of binary inputs and outputs of the module;
- information about status of binary input channels;
- information about status of binary output channels;
- number of the checked output during the outputs test.



Symbol '-' in lines **Ins** and **Outs** of Figure 2.7 means the absence of input signal or opened contacts of output signal, a **digit** means the existence of input signal or closed contacts of the relay. The digit corresponds to the least significant digit of binary input/output number (exp., for input 4.9, digit '9' is displayed, for output 4.10 – digit '0' is displayed).

```
*Test Slot01-P2103*
7in/7out
Ins:   |12-----
>Outs: |--3----
N of out: 03
```

Figure 2.7: Check of binary inputs/outputs

Check of binary inputs is carried out by applying auxiliary voltage to the IED binary inputs.

Check of binary outputs (relay outputs) of tested module is carried out by changing of their status using the **E** button. The button **C** is used to exit the output relays status changing mode. Output relay state is changed by pressing **Up** or **Down** buttons correspondingly.

Out of the relay state changing mode, it is possible to choose the next or the previous module from the list by means of **Right** or **Left** buttons respectively.

When another module is selected for testing or testing of the module is terminated, the status of the output relays is reset.

3 MAINTENANCE

3.1 General

3.1.1 Maintenance cycle

TOR 200 IEDs maintenance cycle, while in operation, is eight years. A maintenance cycle means TOR 200 operating period between two nearest preventive maintenance tests, during which several maintenances of different types are executed in a certain time order:

- check at commissioning phase;
- first preventive maintenance check;
- preventive supervision;
- preventive restoration.

The tests are carried out within the appropriate time limits and to the extent as agreed with the customer. The test scope can be reduced during the operation and test procedures can be changed according to the Customer’s internal maintenance rules for microprocessor based (protection) equipment.

Maintenance and repair of IEDs should be carried out by specially trained, certified personnel, Relematika representatives.

Relematika recommendations related to TOR 200 maintenance intervals are specified in Table 3.1.

Table 3.1: Suggested TOR 200 maintenance periods

Name	MC, years	Maintenance period																								
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
TOR 200 relay	8	C	S1	-	S	-	-	-	R	-	-	-	S	-	-	-	R	-	-	-	S	-	-	-	R	-



Notation conventions: C – check at commissioning, S1 – first preventive inspection, S – preventive supervision; R – preventive restoration.

3.2 Safety precautions

The IEDs are designed as fire-proof and safe in accordance with IEC 60255-27:2005.

When operating and maintaining the IED one should be guided by the appropriate standards and rules applied for microprocessor relay protection devices.

Personnel requirements and instructions for the device operation and maintenance are specified in par. 2.2.1 of this Operation manual.

The IED causes no environmental hazard when operated and stored according to the requirements.

3.3 Maintenance order and operability checks



Only specially trained personnel should be admitted to maintenance of the above mentioned equipment.



Relematika should be immediately informed in case of any defects being detected within tested TOR 200 IED or PC communication device.



Devices can contain circuits effecting the tripping of operative or reserve feeder CB (Line protection, CBFP circuits etc.), so before starting the maintenance or checking device protection functions it is necessary to carry out the activities excluding disconnection of the equipment which is not withdrawn from operation for repair (it is necessary to disable automated devices or switches and operative control switches). The works are to be performed when primary equipment is derived.

Table 3.2 presents required activities during corresponding maintenance works.

Table 3.2: Types of activities during TOR 200 maintenance

Check type	Checking activities
C, S1, S, R	a) visual inspection: check for marks of shocks, leakage including dried-up spots, oxidized spots on metal surfaces, dust content, visual inspection of input and output signal terminals, contact surface condition of communication interface terminals
C, S1, S, R	b) insulation resistance test of independent circuits (except for communication interface circuits) towards the rack and between each other
C, R	c) dielectric strength test of independent circuits (except for communication interface circuits) towards the rack and between each other
C	d) operability check of binary inputs, output relays and LEDs
C, S1, R	e) setting (or check) of required IED configuration according to accepted design solutions and technical characteristics (functions)
C, S1, R	f) setting (or check) of relay settings according to the defined configuration
C, S1, R	g) checking the validity of displayed quantities and phase angles of currents (voltages) from an external source
C, S1, R	h) testing of operating parameters (settings) and reset ratios of each measuring element when applying current (voltage) from an external source; monitoring of LED status during operation
C	i) test of IED operation with the set values and measurement of the operating value change at auxiliary supply voltage equal to 0.8 and 1.1 U_{rated}
R	j) testing of protection operating time for compliance with set time delays
C	k) test for absence of maloperation during connection and disconnection of auxiliary supply voltage with repeated energizing after 0.5 s at the minimum value of the setting range with current (voltage) set for 0.8 of the operating current (voltage)
C, R	l) test of measuring elements and logic circuit interaction with supervision of all the output relay contacts status and visual inspection of LEDs and signalling lamps status. The test is performed with auxiliary supply voltage equal to 0.8 U_{rated} and provided that corresponding operation of each measuring element and presence of required signals to binary protection inputs is ensured
C, S1, S, R	m) test of protection and control functions with output relay contact action towards the circuit breaker or other switching devices control circuits
C, R	n) test of event recording, disturbance recording, protection parameter displaying functions
C, S1, S, R	o) test of bay breaker or other switching devices control (close/open)
C, S1, R	p) test of common control and signalling operation with other devices, with required actions to the breaker or other switching devices
C, S1, S, R	q) test under load conditions



Notation conventions: C – check at commissioning, S1 – first preventive inspection, S – preventive supervision; R – preventive restoration.

3.3.1 Insulation resistance and strength test

Insulation test is performed in a cold state according to IEC 60255-27:2005 requirements.

Before the tests

Before starting the test, the following actions should be obligatory taken:

- de-energize the relay and disconnect all external AC (be sure to short-circuit the incoming current circuits before their disconnection) and DC circuits;
- connect circuits inside the independent groups by temporary jumpers. Depending on a version of TOR 200 (cubicle) the following independent groups of circuits can be differentiated:
 - a) AC current;

- b) AC voltage;
- c) power supply;
- d) alarm (signalling) circuits;
- e) trip coil 1 and close coil auxiliary circuits;
- f) trip coil 2 auxiliary circuits;
- g) output relays.

Insulation resistance measurement

Insulation resistance measurement between the circuits connected to each other and the housing, also between each circuit and the rest of circuits connected to each other is performed by mega-ohmmeter with 1000 V for the circuits with rated voltage of more than 60 V according to the rules of technical maintenance. Measured insulation resistance should be at least 100 MOhm for all specified cases.

Insulation strength test

Insulation strength between the mentioned circuits towards the housing and between themselves should be tested with the test voltage of 1000 V and frequency of 50 Hz for 1 min. After the test, the IED insulation resistance should be measured once again. Insulation resistance test is considered to be successful if the insulation resistance value remains within at least 100 MΩ.

3.3.2 Checking the applied setting parameters and configuration

Checking of the applied setting parameters and configuration is performed according to the detailed project design documentation. A local HMI is used for an active setting group selection and settings adjustment (2.5.9).

TOR 200 is shipped with default factory configuration. Using the PCAP or RelayTool software the customer can change the default configuration.

The list of parameters to be configured is given in 2.4.

3.3.3 Testing the validity of displayed analog values

External output circuits should be disconnected from the IED's output terminals.

The test is carried out by applying current and voltage from an external source to the corresponding TOR 200 connectors. Current and voltage values and phase angles are monitored on local HMI display and/or by the RelayTool software. Additionally, current and voltage values can be viewed via web-interface.



Here and further, a specialized protection testing device is used as an external source.

3.3.4 Protection parameters (settings, protection functions, measuring elements) check

External output circuits should be disconnected from the IED's output terminals. Test procedure for the protection functions is performed according to their description and applicable standards.

During the tests as per paragraphs 0 and 0 the corresponding LEDs are also supervised.

Testing of protection functions measuring elements

Testing of measuring elements is carried out by supplying currents and/or voltages from an external source, corresponding to the setting values of the tested functions (simulation of fault conditions). Measuring element operation is supervised by the operation of the corresponding check output relay with operation and reset parameters being recorded.

Testing of complete protection functions

Testing of complete protection functions (measuring elements and related logic circuits interaction) is carried out by simultaneous activating of the logical signals and currents and/or voltages corresponding to the tripping state. Supervision is performed by detecting the operation of the check output relay.

3.3.5 Test of IEDs functionality when applying and removing auxiliary supply voltage

External output circuits should be disconnected from the IED's output terminals. When operating currents and voltages of 90 % of operating values are applied to the IED, the auxiliary supply voltage is removed and applied once again. During the test no protection operation should occur.

3.3.6 Test of operation towards the central signalling system and interaction with external devices

Test of IED operation towards the central signalling system and interaction with external devices is carried out by commissioning personnel according to the established procedures.

3.3.7 Test of IED interaction with other low voltage equipment

Possibility of operation on primary equipment control circuits should be eliminated. Test of interoperability with other low-voltage electrical equipment available on the site is carried out by simulating corresponding conditions and supervision of output signalling.

3.3.8 Testing the IEDs under load (current and voltage) conditions

Depending on IED version, operating current and voltage test includes the following:

- test of current circuits by measuring secondary load currents in phases;
- test of serviceability and connection correctness of voltage circuits;
- current circuit connection check for each current transformer group using vector diagram and checking it against the actual power direction in primary circuits;
- test for correct operation of fuse failure blocking and power swing blocking;
- test for correct operation of directional overcurrent (also power and impedance) relays;
- test for correct assembly of differential protection current circuits by measuring the differential and bias currents.

3.4 Failure list and troubleshooting

3.4.1 Introduction

Failures can occur due to improper transportation, storage and maintenance, component wear. Self-supervision (diagnostic) system tests for failures at power-on and during operation of the IED.

3.4.2 Self-diagnostic

Self-diagnostic is divided to the following two stages: initial (at power on/restart of IED) and continuous (during IED operation).

Self-diagnostic comprises supervision of the following important IED components: CP module, power supply module, binary input/output modules and HMI module. Binary input/output units include current-based supervision of output relays coils. Self-diagnostic information is collected from all controllers within the device and is analysed in central and signal processors.



IED self-diagnostic does not supervise output relay contacts (for example, 'stuck' state), binary input operability and winding integrity of input current and voltage transformers.

When a persistent failure is detected within any of the supervised elements, and **ERROR** LED is lit on the IED front panel, and the control of output relays is blocked.

When a failure is detected **during the operation**, two error code sets are generated: current and general ones. The current error code represents the self-diagnostic state at the present moment, the general error code displays all detected failures, including fleeting and then disappeared faults.

Information about detected failures is available under the **Diagnostics/Status** menu item.

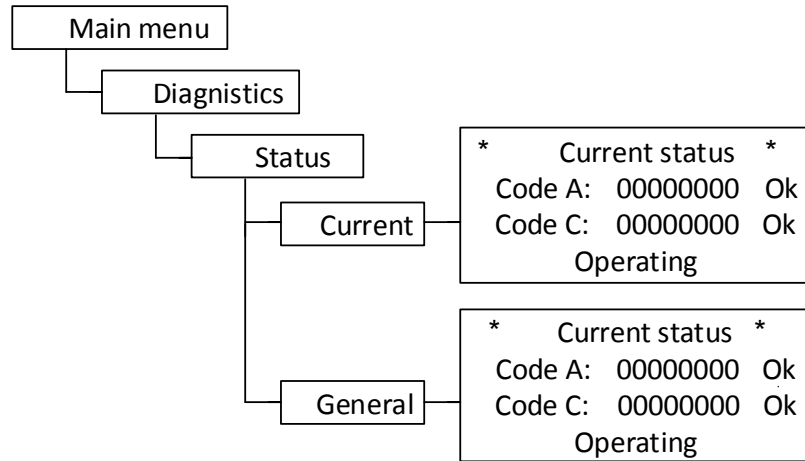


Figure 3.1: Example of Diagnostic / Status menu

The following two code types are displayed in menu items **Current** and **General**:

- **Code A** means failures detected by central processor (CP);
- **Code C** (auxiliary) means total amount of failures detected in peripheral units (power supply, binary input/output).

Entering the menu item and pressing **E** button, one can initiate failure codes per each module; the second right digit indicates the number of the module starting from the power supply unit.

The displayed codes make possible identification of every detected failure. The list of codes is given in Table 3.3. Text descriptions of failures are available by entering the menu item (except for C codes).

3.4.3 Error codes

Failures detected during continuous self-diagnostics are presented in a hexadecimal format according to the rules stated below.

Error code consists of eight digits and comprises information about the type of failure. Every digit is a hexadecimal number of four binary-code bits (Table 3.4). Every bit corresponds to a certain event (failure), the list of which is given in Table 3.3. Zero self-diagnostic codes mean no faults detected. A failure code provides information about one or several faults detected simultaneously. For example, code A is 00000001 means 'CP module error F' (serial bit number is 1, digit is 1); 00000200 denotes 'CP module error 6' (serial bit number is 2, digit is 3); 00000800 stands for 'Scheme error 1' (serial bit number is 4, digit is 3), 00000A01=00000800+00000200+00000001 indicates 'CP module error 1', 'CP module error 6', 'Scheme error 1'. Other codes are generated in the same way.

Table 3.3: Error code A

HMI message		Description
Error code	Text	
0x00000001	CP module fail F	Central processor board failure
0x00000002	CP module fail E	Central processor board failure
0x00000004	SW failure 1	Software failure
0x00000008	HMI failure 1	HMI board failure
0x00000010	CP module fail 3	Central processor board failure
0x00000020	Parameters reset	Central processor board failure
0x00000040	CP module fail 4	Central processor board failure
0x00000080	Dist. rec. fail	Central processor board failure
0x00000100	CP module fail 5	Central processor board failure
0x00000200	CP module fail 6	Central processor board failure
0x00000400	Clock reset	Central processor board failure
0x00000800	Scheme error1	Central processor board failure
0x00001000	Reserved	
0x00002000	ASW error	Failure raised by functional diagram logic

HMI message		Description
Error code	Text	
0x00004000	ASW block error	Failure raised by functional diagram logic with device disabling
0x00008000	ADC failure	
0x00010000	BIO config error	Binary input / output configuration failure
0x00020000	BIO config error	Binary input / output configuration failure
0x00040000	Reserved	
0x00080000	Reserved	
0x00100000	CP module fail 1	Central processor board failure
0x00200000	Reserved	
0x00400000	ADC1 cfg error	Analog input configuration failure
0x00800000	ADC2 cfg error	Analog input configuration failure
0x01000000	No setting group	Setting group is absent
0x02000000	No calibration	The IED is not calibrated
0x04000000	Button pressed	Button pressed
0x08000000	HMI exch. error	HMI exchange error
0x10000000	SW failure 5	Software failure
0x20000000	ASW scheme error	
0x40000000	SW failure 6	Software failure
0x80000000	CPU overload	

Table 3.4 Hexadecimal number of four binary-code bits

Error code digit value (hexadecimal code)	Active bit numbers (binary code)
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

3.4.4 Troubleshooting

In case a **persistent** failure is detected, which can cause a possible maloperation or failure to operate, the output circuits of the IED are set out of operation; in this case **ERROR** LED is lit. Signalling is provided by a normally-closed contact. Possible failures and troubleshooting are given in Table 3.5.



If a failure is detected, please report registered error codes, text description of the failure, information about the latest device restart and configuration to Relematika or its representative.

Only specially trained personnel with dedicated equipment and tools is admitted to perform troubleshooting service.

After the failure is repaired and before the IED is put again into operation, the corresponding parameters (settings, disturbance recorder parameters, etc.) should be checked. Be sure that the IED operates properly.



Upon detection of the failure, it is necessary **first** to write down the error codes, which are displayed on the HMI and described in 3.4.3 and in Table 3.5, then report it to Relematika or its representative. In some cases (for short-term failures) it can be sufficient to interrupt power supply to remove the failure.

Table 3.5: Troubleshooting

Symptoms	Possible cause	Error code	Troubleshooting
The device does not start at power on, READY LED is off	Failure in power supply module	–	Power supply module repair/replacement
The device does not start at power on, but READY LED is on. Text ' Relematika ' is displayed on the HMI	Failure in central processor module	–	Central processor module repair/replacement
SW error message	Single SW failure. Possible central processor module failure	A:0x00000002 A:0x00000004	At repeated error appearance, update a protection circuit with service SW and restart the device by short-time (for 3 s) power reset. If the problem remains, repair/replace central processor module
Parameters reset message	Single failure of non-volatile memory of recorders and settings	A:0x00000020	Configuration parameters should be checked and set. If the problem remains, repair/replace central processor module
Disturbance record memory error message. Previous disturbance records could be lost.	Single failure of disturbance recorder non-volatile memory	A:0x00000080	If the problem remains, repair/replace central processor module. Emergent device disabling is not required
Clock error message	Single time reset	A:0x00000400	Device time parameters shall be checked and set, if necessary. If the problem remains, repair/replace central processor module. Emergent device disabling is not required
Messages about error caused by configuration or protection scheme	Device operates with false or improper protection scheme	A:0x00000800 A:0x00010000 A:0x00020000 A:0x00400000 A:0x00800000 A:0x20000000	Check the compliance between the diagram and protection scheme, update the diagram with service SW
Other errors			Perform troubleshooting and repair/replace faulty module
TOR 200 does not detect output relay contact failure (for example, contact sealing), also binary input operability, input CT and VT winding integrity.			

3.5 Disposal

On expiry of specified service life the IED should be dismantled and disposed. No special safety measures should be taken while dismantling and disposing of a device, and no special tools and accessories are required.

4 TRANSPORTATION AND STORAGE

Transportation and storage conditions correspond to 1.1.7. Permissible shelf life period before commissioning is two years.

Transportation of a packed IED should be carried out by means of any closed-type transport. Transport packaging must be rigidly fixed.

Loading, fixing and transportation of the device should be carried out according to valid regulations for carriage of goods by corresponding means of transportation.

5 MANUFACTURER WARRANTY

Relematika ensures compliance of the IEDs with the standard specifications subject to operating, transportation and storage conditions by the customer.

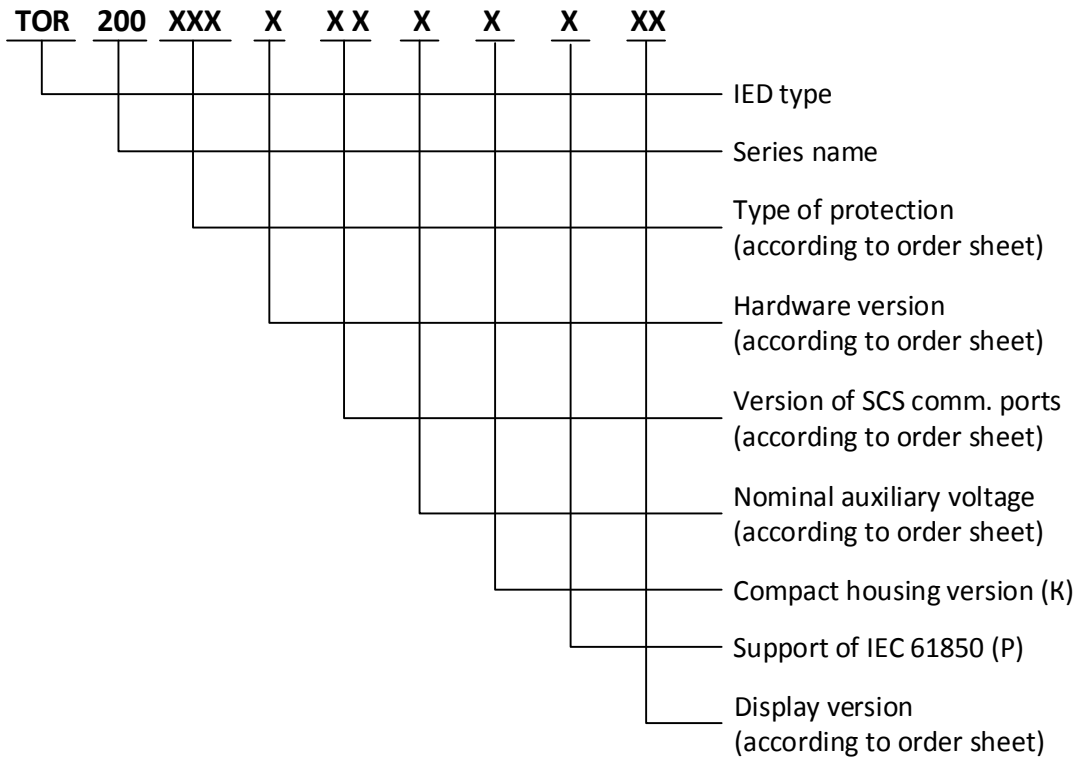
The warranty period is ten years from the date of putting into operation, but not more than 10 years from the date of shipping from Relematika or from the moment when the product is crossing the border of state-manufacturer when exporting.

Manufacturer warranty does not cover the IEDs with mechanical damages and are not valid in the case of breach of operating conditions (effecting of increased values of voltage, current, disturbance level, ingress of moisture and foreign current-conductive materials or objects inside the rack, etc.).

If the device is supposed to be returned to Relematika, it should be packed ensuring safety during storage and transportation.

The Manufacturer should guarantee repair or replacement of the device during its lifetime. Shipment term of spare parts from Relematika warehouse should not exceed three months from the moment of signing the contract for purchasing of these spare parts.

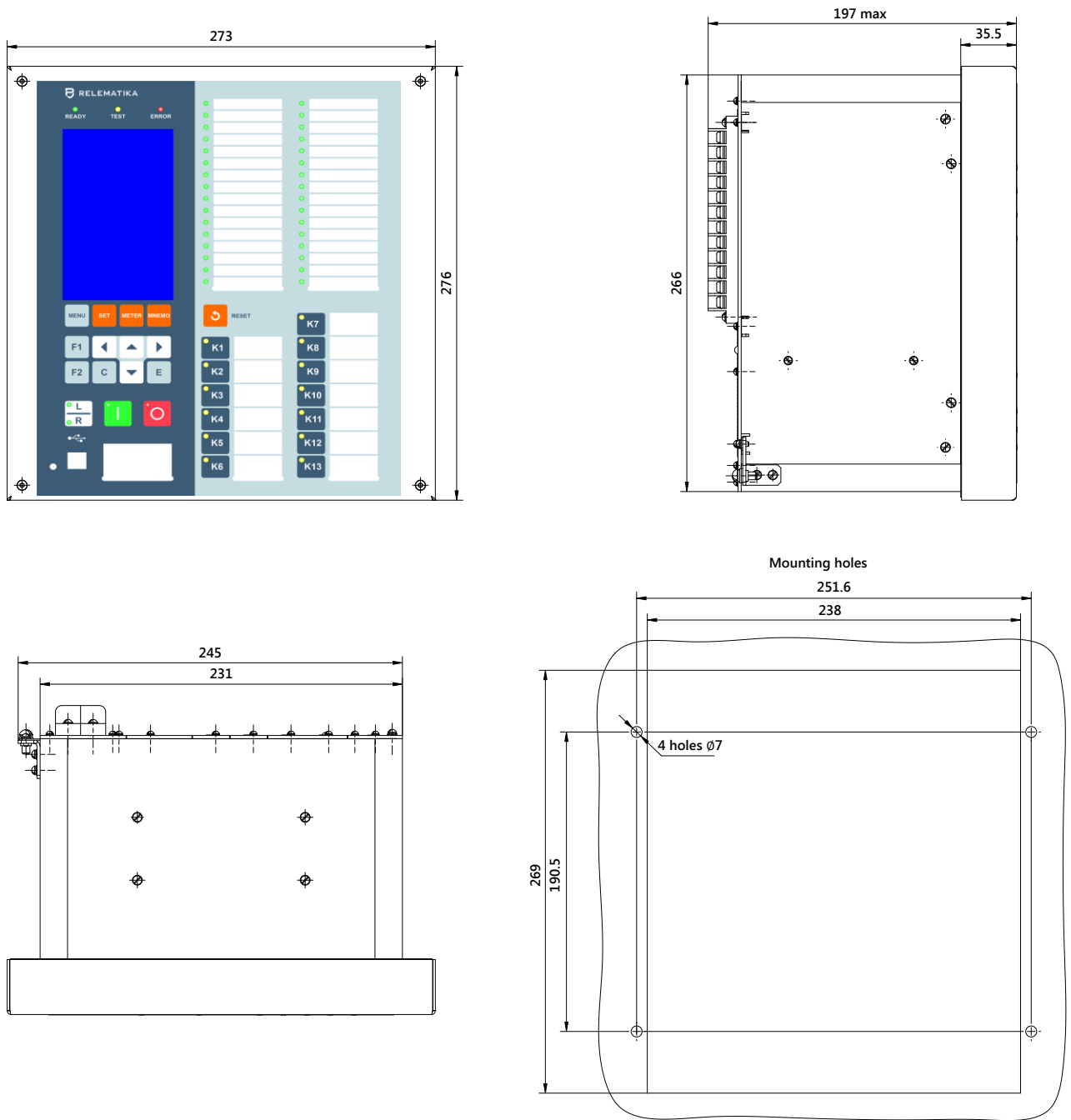
**APPENDIX A
(obligatory)
Ordering structure**



The hardware version is defined by Relematika according to application version, quantity and type of analog and binary inputs as well as outputs specified in order form.

Figure A.1 – Ordering structure

APPENDIX B (obligatory) Layout, overall and mounting dimensions



TOR 200 unit weight is max. 8 kg

Figure B.1: TOR 200 housing layout, overall and mounting dimensions for flush mounting (for mounting on the door of the switchgear or relay cabinet panel), example with graphic display

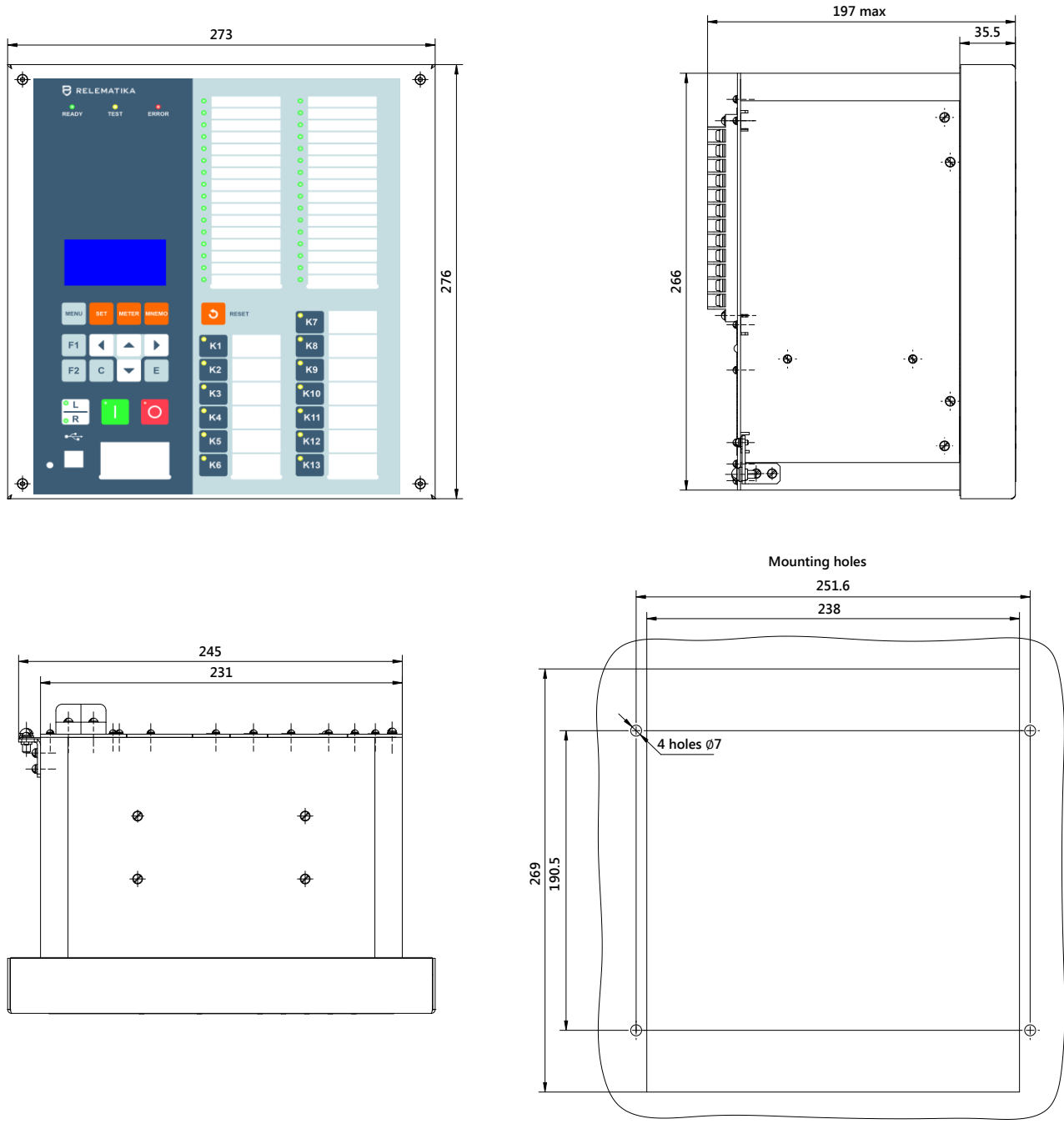
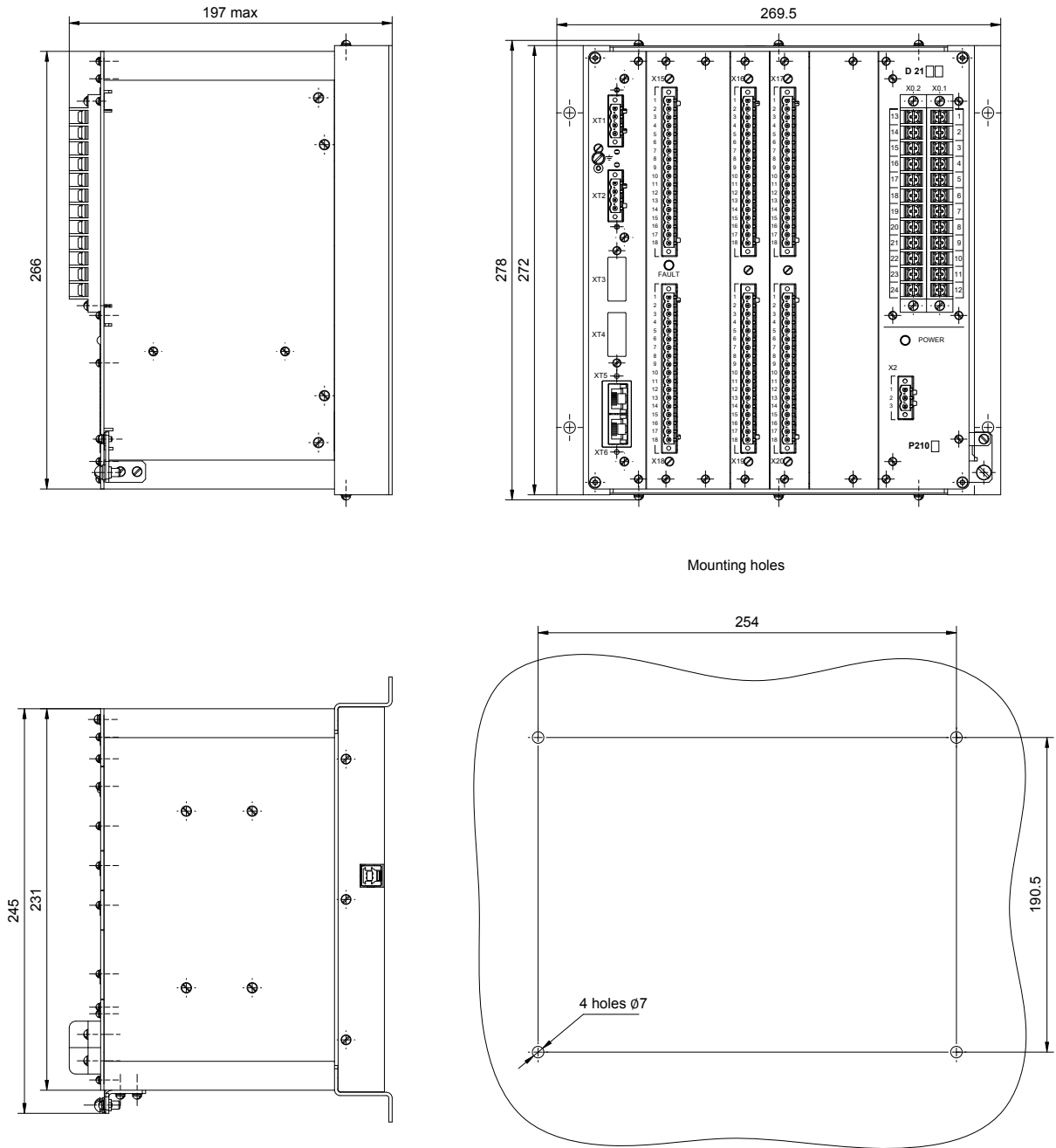
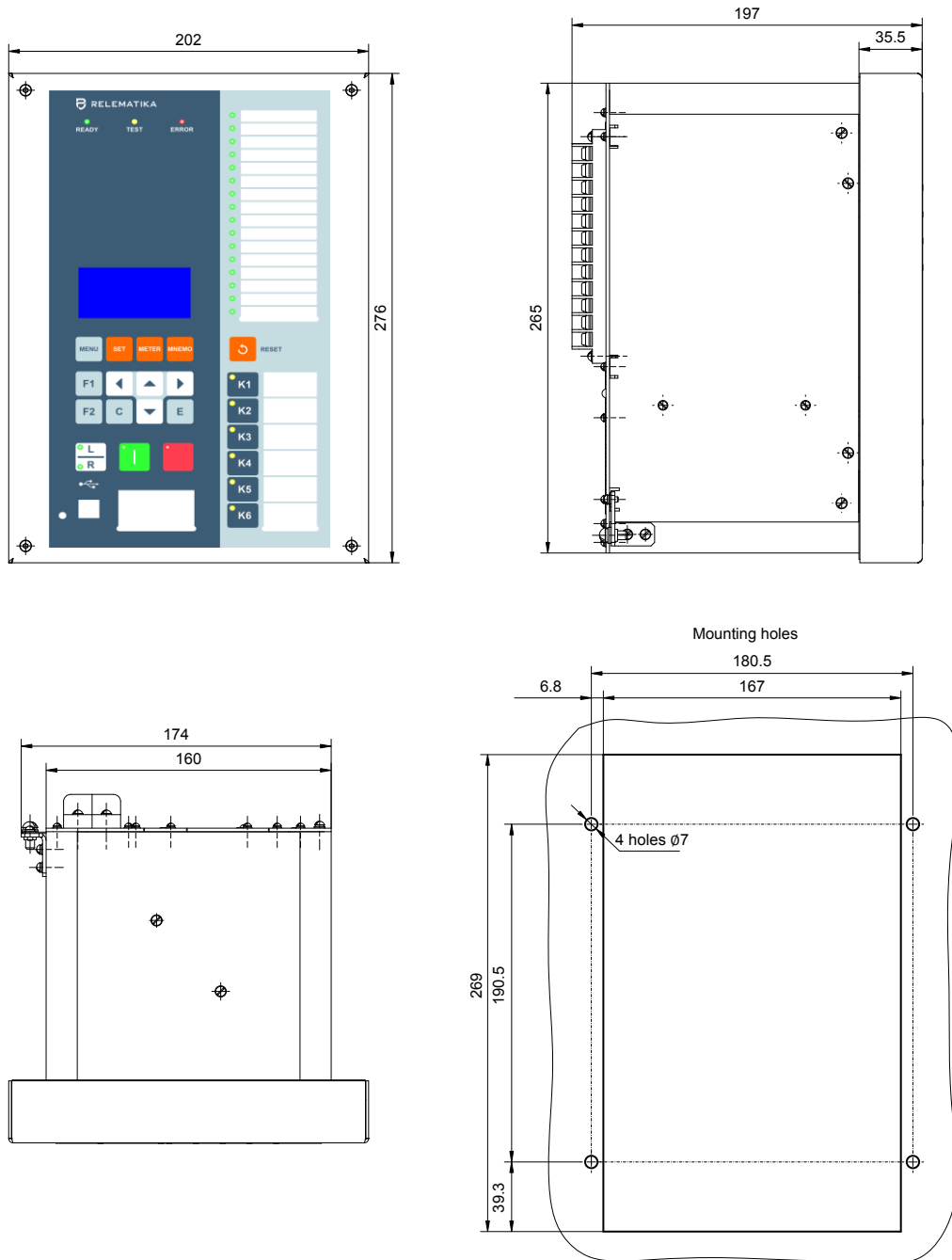


Figure B.2: TOR 200 housing layout, overall and mounting dimensions for flush mounting (for mounting on the door of the switchgear or relay cabinet panel), example with alphanumeric display



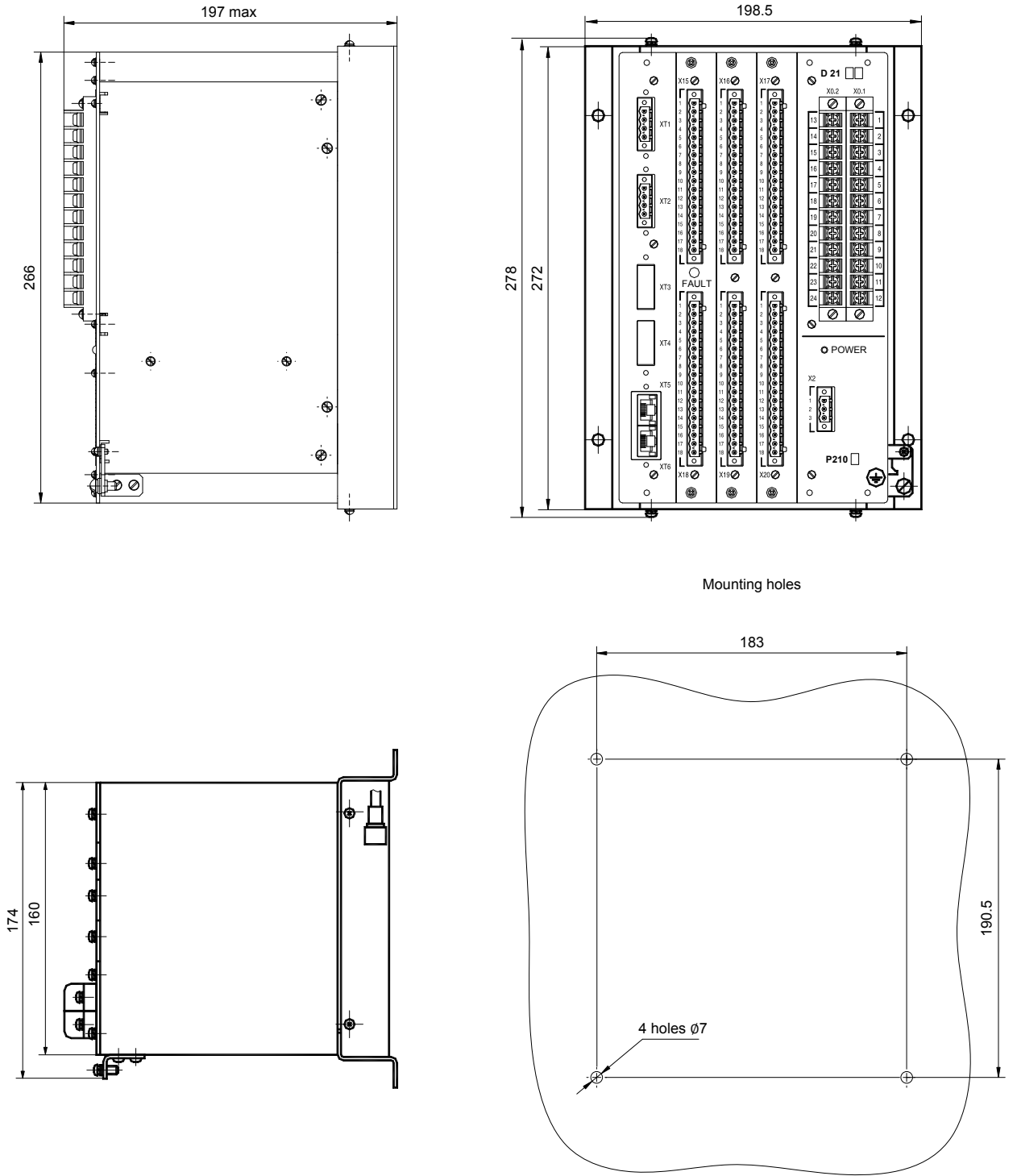
TOR 200 unit weight is max. 8 kg

Figure B.3: TOR 200 housing layout, overall and mounting dimensions for the point-to-point-wiring (for mounting on the back wall of the switchgear or relay cabinet)



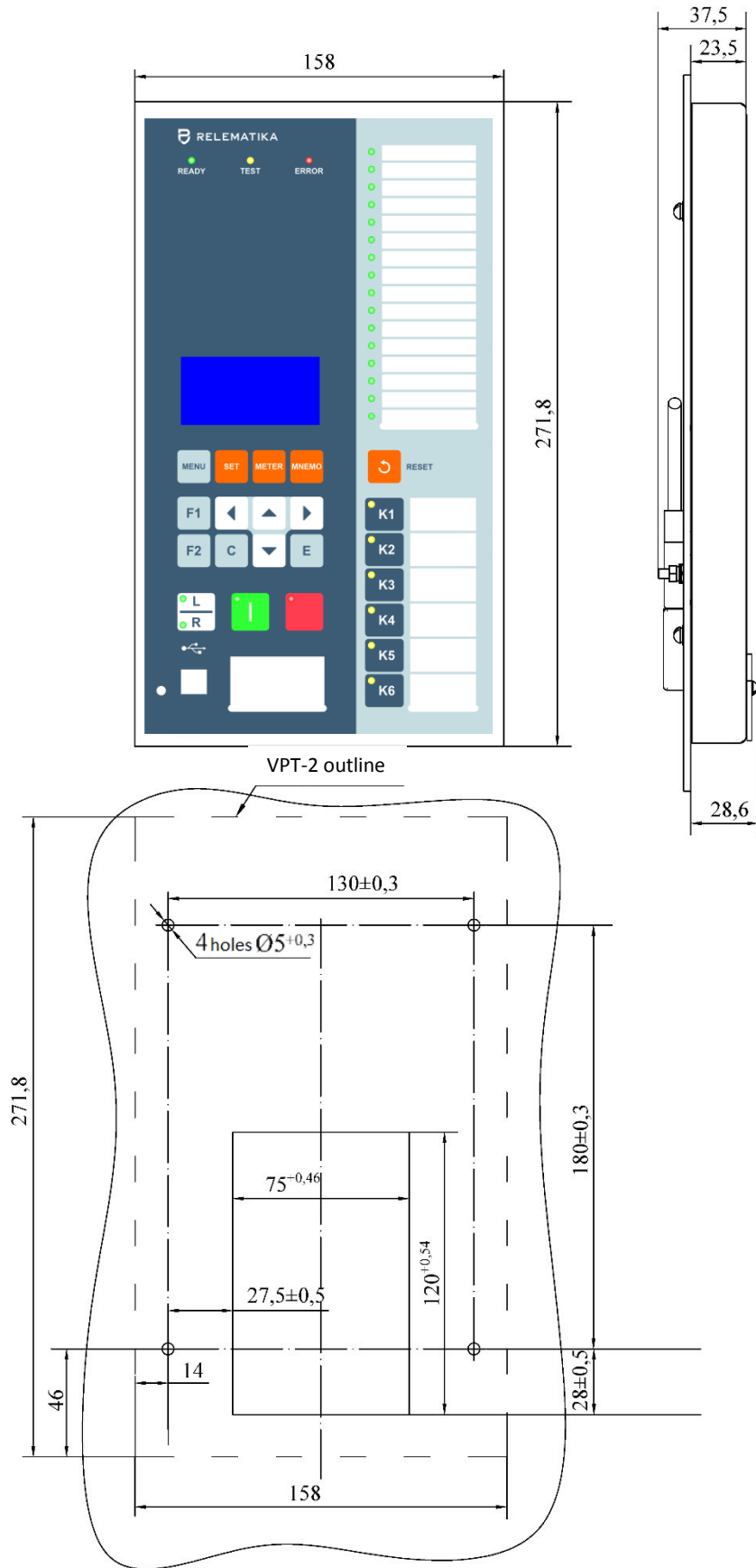
Compact TOR 200 unit weight is max. 7 kg

Figure B.4: Compact TOR 200 housing layout, overall and mounting dimensions for flush mounting (for mounting on the door of the switchgear or relay cabinet panel), example with alphanumeric display



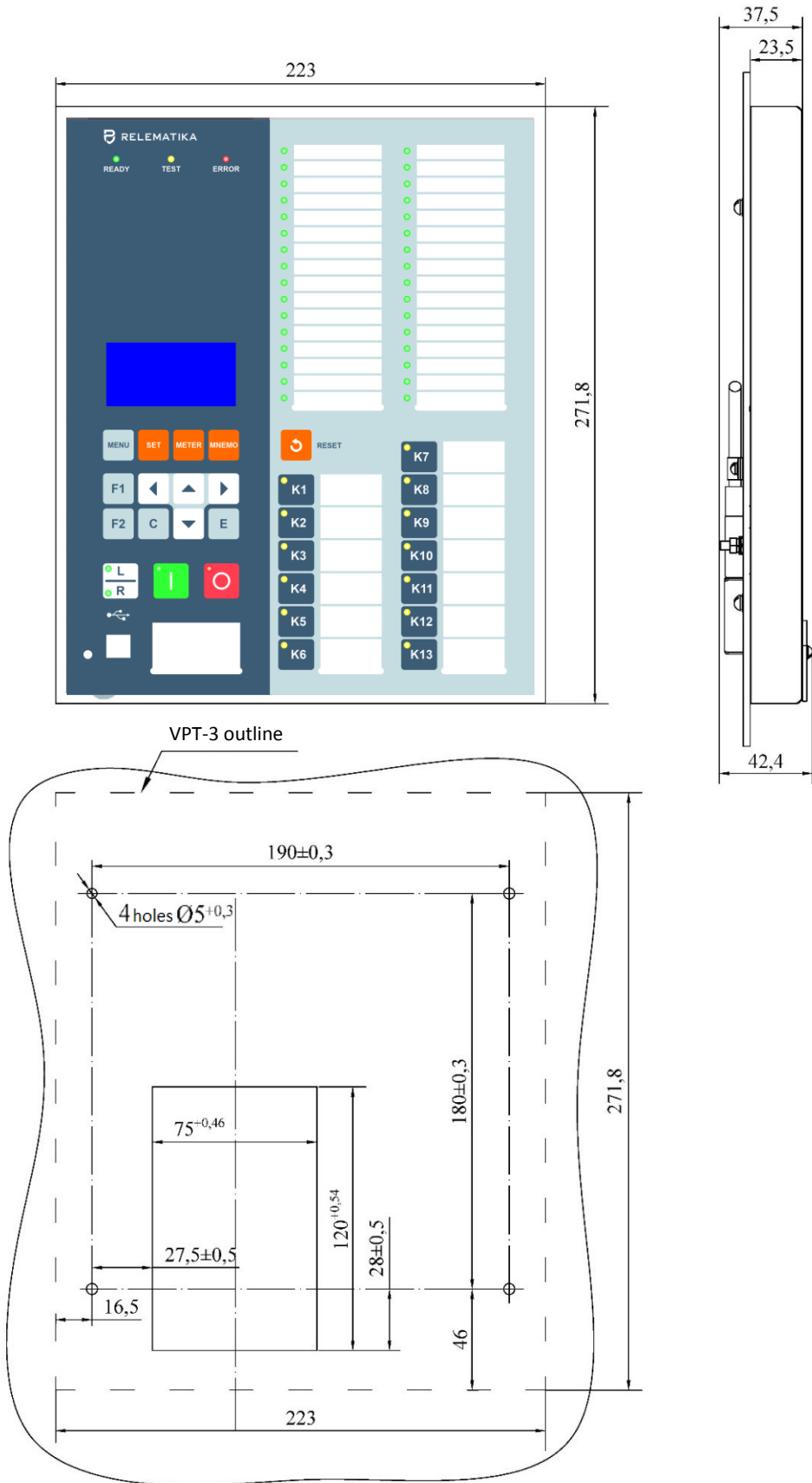
Compact TOR 200 unit weight is max. 7 kg

Figure B.5: Compact TOR 200 housing layout, overall and mounting dimensions for the surface mounting with front connections and removable, front connected HMI (for mounting on the back wall of the switchgear or relay cabinet)



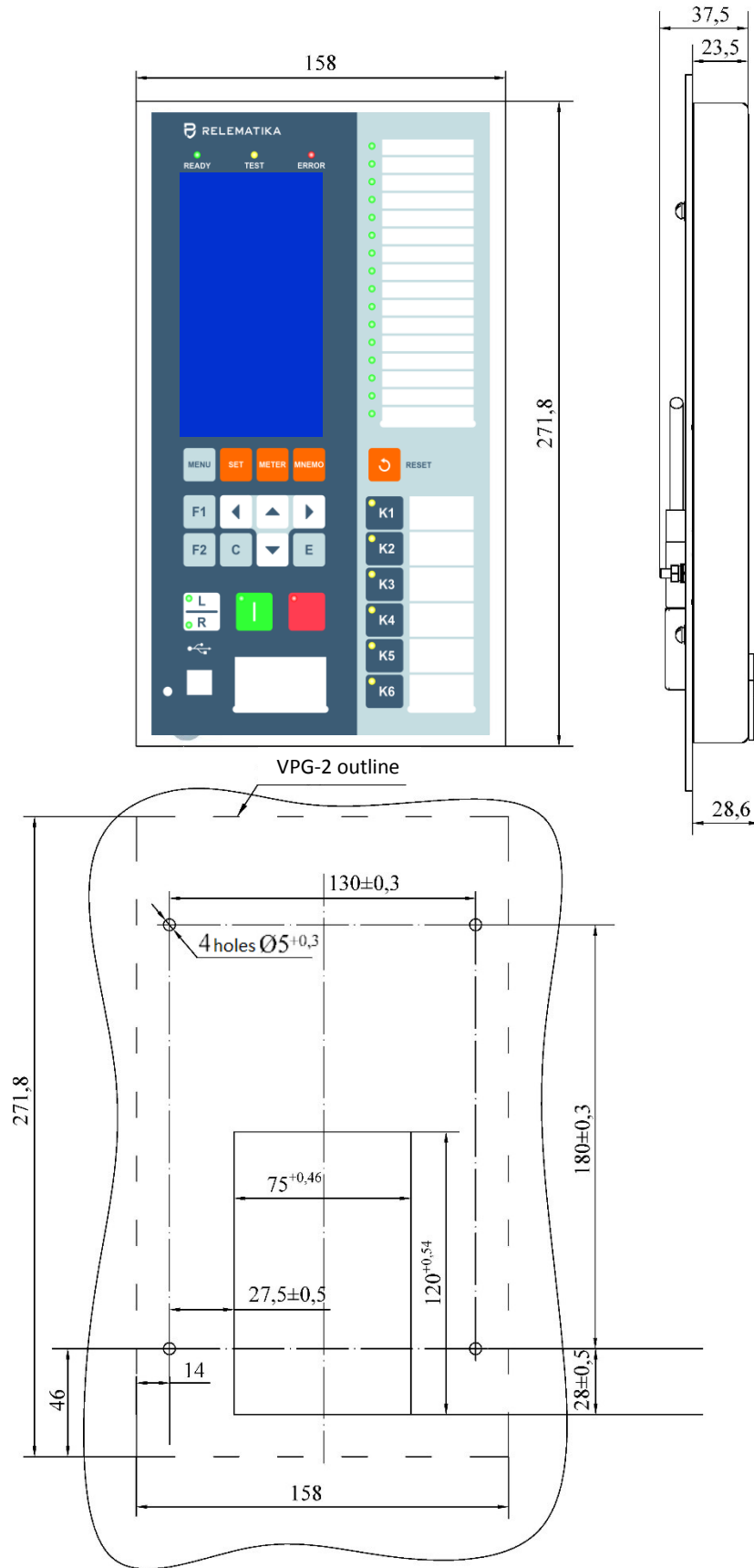
The remote control weight is max. 0,65 kg

Figure B.6: Layout, overall and mounting dimensions for the remote control VPT-02



The remote control weight is max. 0,85 kg

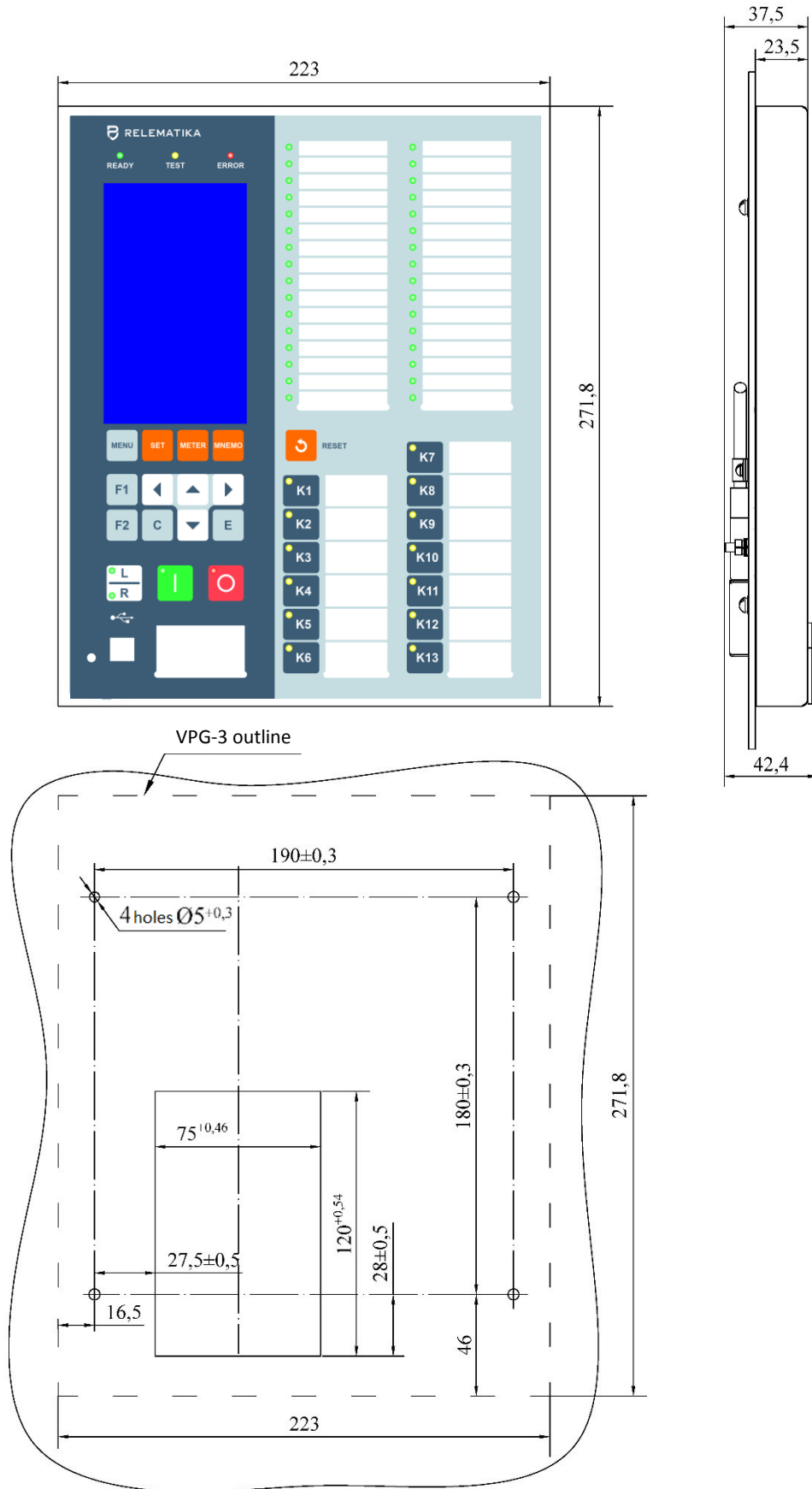
Figure B.7: Layout, overall and mounting dimensions for the remote control VPT-03



VPG-2 outline

The remote control weight is max. 0,65 kg

Figure B.8: Layout, overall and mounting dimensions for the remote control VPG-02



The remote control weight is max. 0,85 kg

Figure B.9: Layout, overall and mounting dimensions for the remote control VPG-03

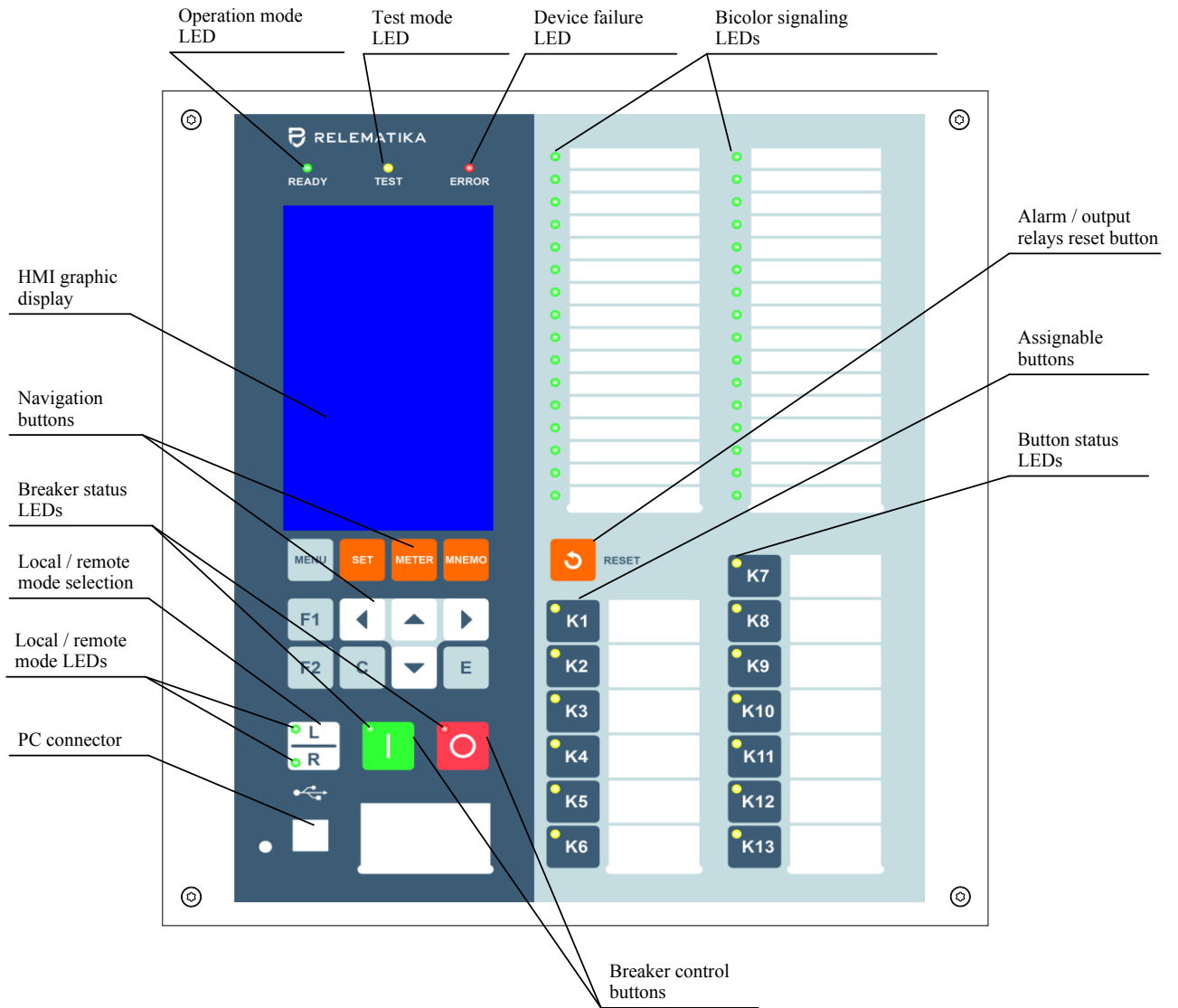


Figure B.10: The location of control and display elements for TOR 200, example with graphic display

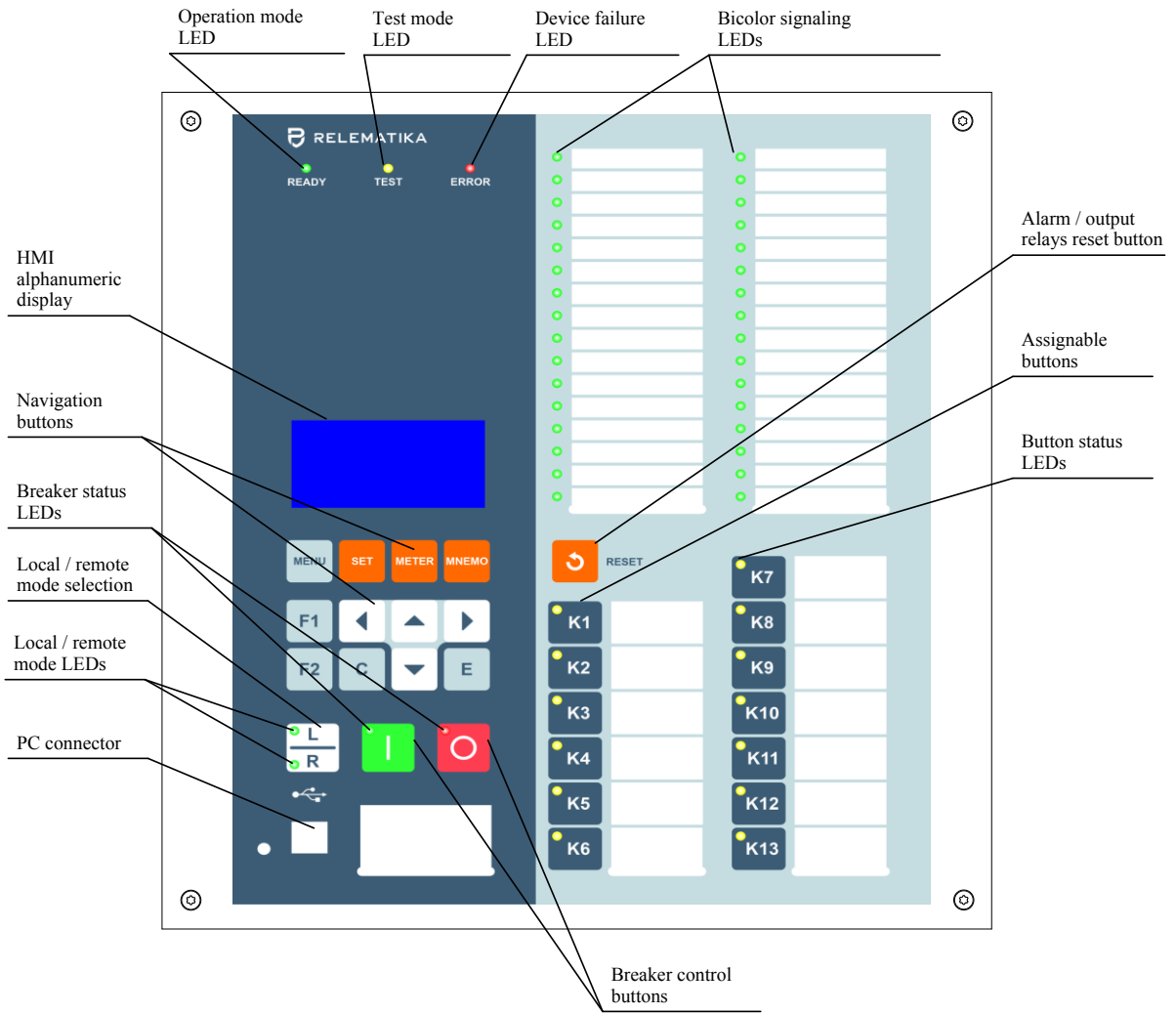


Figure B.11: The location of control and display elements for TOR 200, example with alphanumeric display

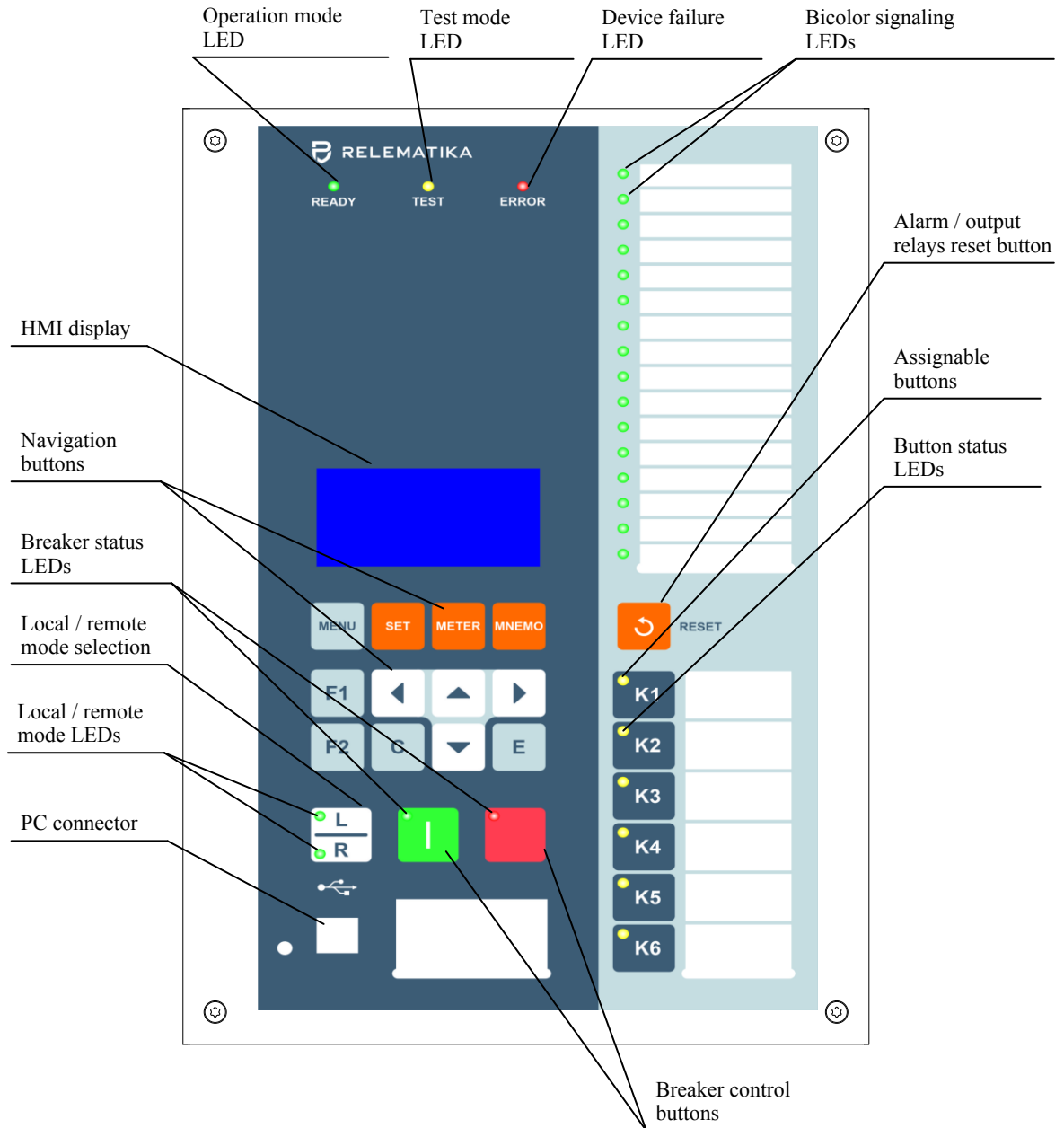
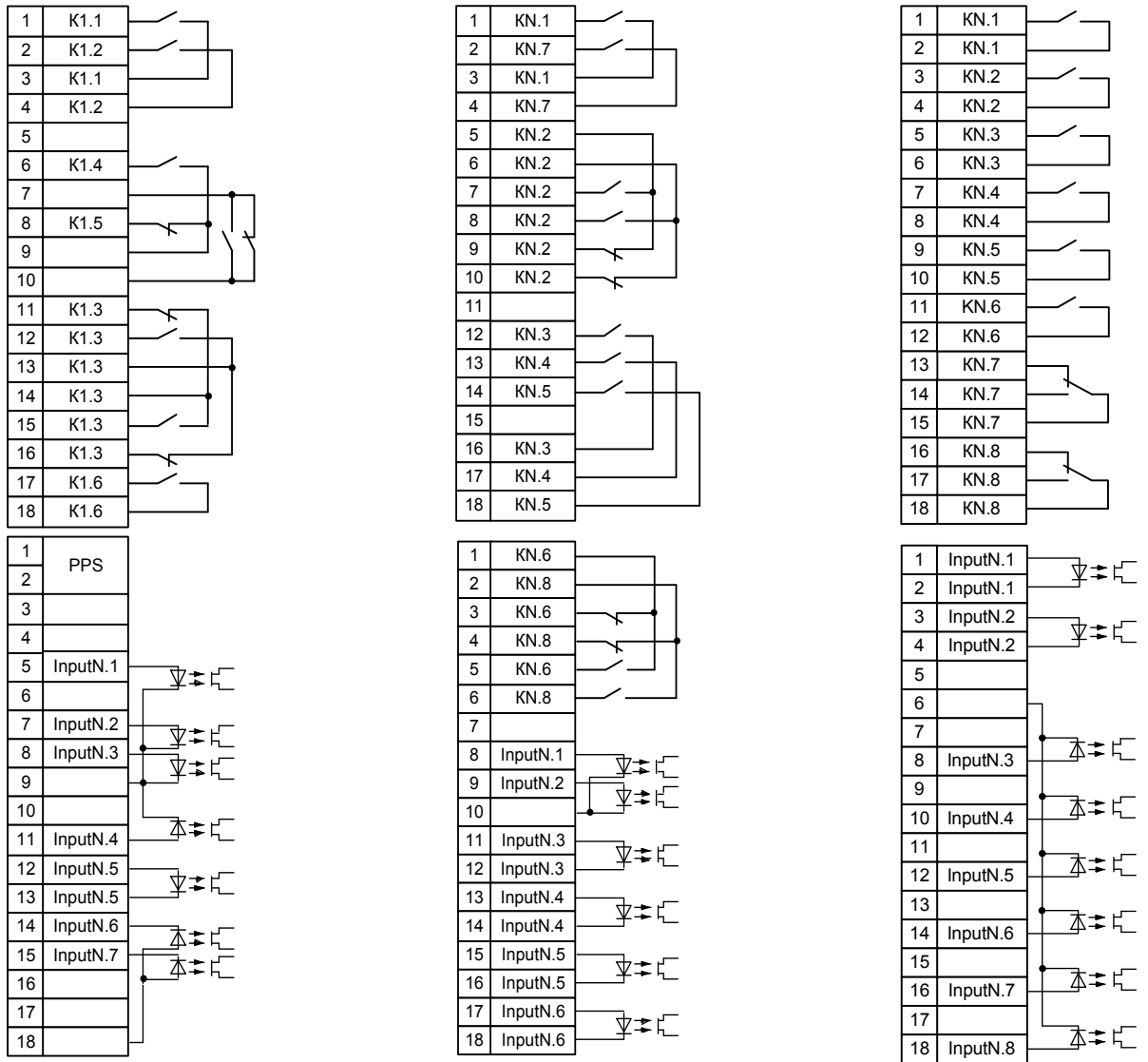


Figure B.12: The location of control and display elements for compact TOR 200, example with alphanumeric display

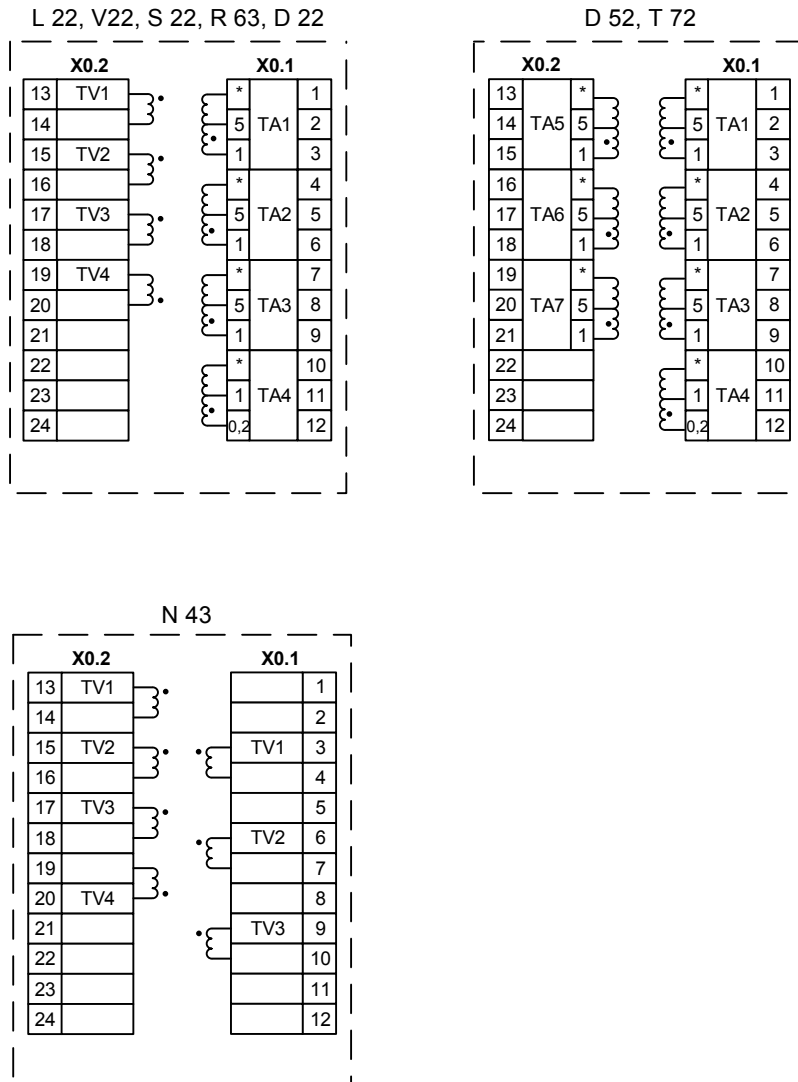
APPENDIX C (obligatory) Binary inputs and outputs of different modules



N is the serial number of module (1 – the first module),

Figure C.1: Connectors designation of binary IO modules

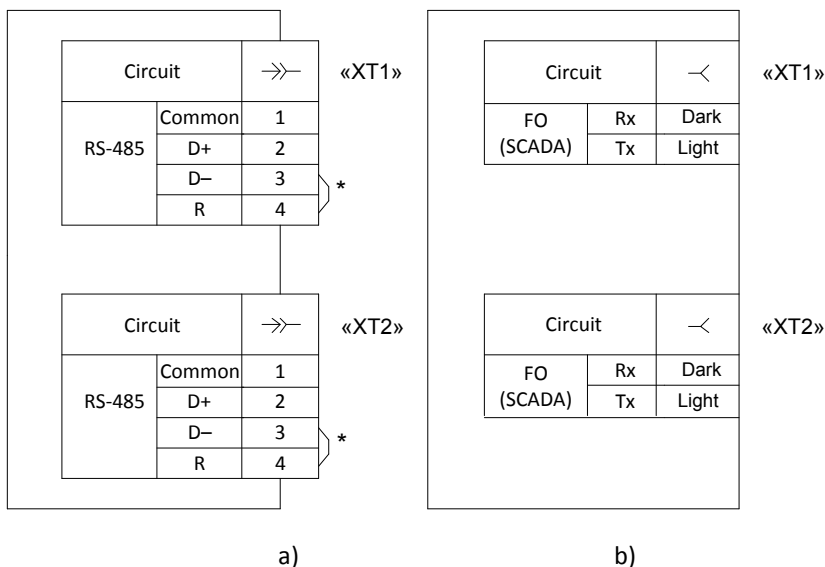
APPENDIX D (obligatory) Layout of transformer modules



TV – input voltage transformers (VT type),
 TA – input current transformers (CT1 type – 1 A or 5 A, CT2 type – 0.2 A)

Figure D.1: Basic transformer modules layout

APPENDIX E (obligatory) Communication port contacts designation



The jumpers are used if device is installed at the end of communication line. Resistor quantity should not exceed two.

Figure E.1: Communication ports for RS-485 and fiber-optic interface (SCADA)

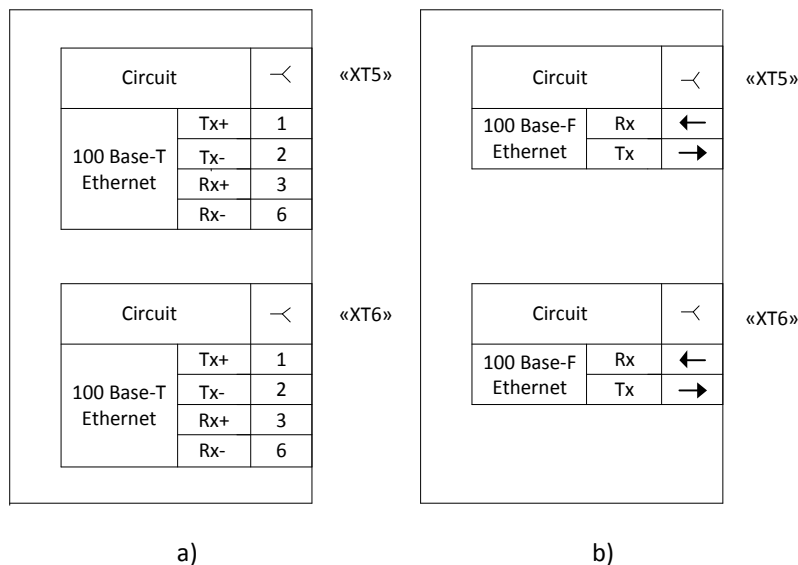


Figure E.2: Ethernet communication ports

Communication ports parameters are described in table E1.1.

Table E1.1: Communication port description

Connector designation on the backplane	Figure	Communication port
«XT1» («XT2»)	E.1 a)	RS-485/ Fiber-optic communication line (SCADA)
	E.1 b)	RS-485/ Fiber -optic communication line (SCADA)
«XT5» («XT6»)	E.2 a)	Ethernet 100 Base-T/ Ethernet 100 Base-F
	E.2 b)	Ethernet 100 Base-T/ Ethernet 100 Base-F

APPENDIX F
(obligatory)
List of equipment and measuring instruments

Table 1 - List of equipment and measuring instruments

Name	Range of measured (controlled) values	Accuracy class or measurement error	Recommended equipment or normative document
Voltmeter universal digital	(0-1000) V	±0,1 %	GDM-8246 GDM-8245
Multimeter digital	(0-750) V, (0-10) V	±0,1 %	APPA-107N, APPA-109N
AC ammeter	(0,5-1) A, (5-10) A	0,5	E537, E539
DC power supply	(0-6) A, (0-30) V	±0,5 %	GPS-2303, GPS-3303, GPS-4303
DC power supply	(8-300) V, (1-30) A	±(0,005U _{set} +0,2V) ±(0,005I _{set} +0,02A)	GPR
Milliohmmeter	from 10 μOhm to 1 kOhm	±(0,1 % + 0,5 μOhm)	MIKO-7
Megohmmeter	(0-1000) MOhm 500 V	± 15 %	ES0202/1-Γ
Electronic oscilloscope	(0-300) V, (5-400) Hz	± 10 %. ± 1 %	TDS2012, GDS-820S
Relay timing meter	(0-100) s	0,005/0,004	TU25-04-08.003-83
Calipers	(0-400) mm	±0,05 mm	ShC-II-400-0,05 GOST 166-89
Meter of resistance, humidity and degree of aging of electrical insulation	(50-2500) V, 50 Hz	± 10 %	MIC-2500
Installation for testing electrical safety	(100-5000) V	± (0,03U+30 V)	GPT-815
Note – When carrying out tests and checks, it is allowed to use other equipment that ensures the measurement of controlled parameters with an accuracy not lower than required.			

ABBREVIATIONS

A_{char}	Relay characteristic angle
A_{load}	Load angle
ADC	Analog-Digital Converter
ASW	Application Software
CP	Central Processing
CT	Current Transformer
CTCS	Current Transformer Circuit Supervision
DR	Disturbance Recorder
HW	Hardware
IED	Intelligent Electronic Devices
I_{pwc}	Precision work current
HMI	Human Machine Interface
MC	Maintenance cycle
OM	Operation Manual
PC	Performance Criterion
PLC	Power Line Carrier
RAM	Random-Access Memory
ROM	Non-volatile Memory
SCS	Substation Control System
SL	Severity Level
SMS	Substation Monitoring System
SW	Software
VT	Voltage Transformer