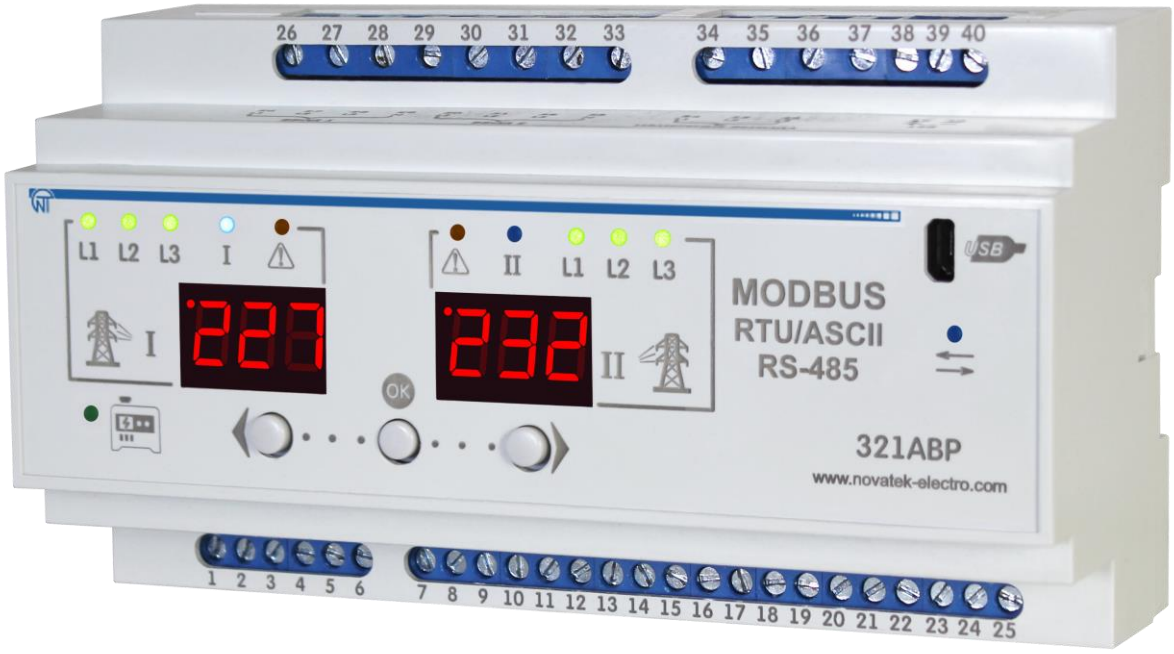
CONTROL UNIT FOR THREE-PHASE AUTOMATIC TRANSFER SWITCH

PEF-321ABP



OPERATING MANUAL

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Quality control system on the development and production complies with requirements ISO 9001:2015

Dear customer,
Company NOVATEK-ELECTRO LTD thanks you for purchasing our products.
You will be able to use properly the product after carefully studying the Operating Manual.
Keep the Operating Manual throughout the service life of the product.

ATTENTION! ALL REQUIREMENTS OF THIS OPERATING MANUAL ARE COMPULSORY TO BE MET!

WARNING! – PRODUCT TERMINALS AND INTERNAL COMPONENTS ARE UNDER POTENTIALLY LETHAL VOLTAGE.

TO ENSURE THE PRODUCT SAFE OPERATION **IT IS STRICTLY FORBIDDEN THE FOLLOWING:**

- **TO CARRY OUT MOUNTING WORKS AND MAINTENANCE <u>WITHOUT DISCONNECTING THE PRODUCT FROM THE MAINS;</u>**
- TO OPEN AND REPAIR THE PRODUCT INDEPENDENTLY;
- TO OPERATE THE PRODUCT WITH MECHANICAL DAMAGES OF THE CASE.

IT IS NOT ALLOWED WATER PENETRATION ON TERMINALS AND INTERNAL ELEMENTS OF THE PRODUCT.

During operation and maintenance the regulatory document requirements must be met, namely:

- Regulations for Operation of Consumer Electrical Installations;
- Safety Rules for Operation of Consumer Electrical Installations;
- Occupational Safety when in Operation of Electrical Installations.

Installation, adjustment and maintenance of the product must be performed by qualified personnel having studied this Operating Manual.

In compliance with the requirements of this Operating Manual and regulations the product is safe for use.

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Terms and abbreviations:

AR – automatic re-closure.

ABP – automatic transfer switch.

The term "**Normal voltage**" means that the voltage value does not go beyond the thresholds set by the User.

This Operation Manual is intended to let you know about the device, safety requirements, operation and maintenance procedures for the Control unit for automatic transfer switch PEF-321ABP ((hereinafter in the text 321ABP; device).

1 DESIGNATION

The device is designed to operate as a part of control cabinets for automatically turning on backup power in uninterruptible power supply systems.

321ABP controls automatic transfer from the main three-phase power source to the backup one and vice versa in case of unacceptable voltage deviations in phases, asymmetry or phase imbalance, changing the phase sequence, breaking one or more phases in the "main" or "standby" networks.

The device can be used in power supply networks as a part of devices:

- automatic switching on a standby source (ABP);
- automatic start of a three-phase electric generator.

Device 321ABP controls voltage at two inputs of three-phase four-wire networks 230 / 400V with a grounded or insulated neutral wire.

2 TECHNICAL SPECIFICATIONS

The general data of 321ABP are shown in Table 1. The main technical characteristics of 321ABP are shown in Table 2. Output contact specifications are shown in Table 3.

Table 1 - General

Description	Value
Designation of the device	Control and distribution equipment
Rated operating mode	Long lasting
Product protection	IP20
Electrical shock protection class	II
Climatic version	NF 3.1
Permissible pollution	II
Overvoltage category	III
Rated insulation voltage, V	450
Rated impulse withstand voltage, kV	4.0
Wire cross section for connecting to terminals, mm^2	0.5 – 2
Tightening torque of terminal screws, N * m	0.4

Table 2 – Main technical specifications

Description	Value
Rated AC three-phase supply voltage, V	380 – 400
Type of lines controlled	Two three-phase four-wire inputs
Mains frequency, Hz	48 – 62
Voltage hysteresis, V	5
Number of three-phase controlled inputs	2
Voltage at which operability is maintained: - phase voltage with supply from one phase and connected neutral wire, V, not less - linear voltage with supply from three phases, V, not more	 100 450
Cutoff thresholds for **Input 1**, **Input 2**, acc. to Umax, V	Table 5
Cutoff thresholds for **Input 1**, **Input 2**, acc. to Umin, V	
Contactor sticking control	yes
Switching wear resistance, thousand times	30
Inputs: - analog inputs for measuring three-phase voltage at the inputs, pcs. - analog inputs for measuring three-phase voltage at the load, pcs. - analog input for connecting 12 V DC, pcs.	 6 3 1
Outputs: - discrete output for connecting the control winding of a three-phase load contactor, pcs. - discrete output of voltage state at the inputs, pcs. - discrete output of voltage presence at least at one phase of any input, pcs. - discrete output for connecting indication of generator work, pcs. - discrete output of generator control, pcs. - digital input/output for connecting via RS-485 protocol, pcs. - digital input/output for connecting via USB, pcs.	 2 2 1 1 1 1 1
Time delay for voltage distortion, s	Table 5
Time delay of response to phase sequence failure, s	Table 5
Time delay of response to phase failure alarm, s	Table 5

Time delay of response to phase-slip, s	Table 5
Time delay of response to contactor sticking, s	Table 5
Power consumption (under the load), W, not more	4
Mass, not more, kg	0.4
Overall dimensions (HxBxL), mm	90.6x156.5x56
Mounting (assembling) on a standard 35 mm DIN rail	
The device meets the requirements of: EN 60947-1; EN 60947-6-2; EN 55011; EN 61000-4-2.	
The device maintains its serviceability in any position in the space	
Material of the body frame - self-extinguishing plastic	
No harmful substances in amount that exceeds permissible exposure limits	

Table 3 – Characteristics of output contacts

	Used terminals	**Max. current at U ~250 V, A**	**Number of responses x1000**	**Max. switched power, VA**	**Max sustained AC/DC voltage, V**	**Max. current at U_{DC} = 30 V, A**
Repay cos φ = 1.0	1 - 6, 20 - 22	5	100	1100	250 AC	5
Triacoutput photocoupler	12 - 15	0.06	-	-	400 AC	-
Optotransistor	16 - 19	0.14	-	-	280 AC / 400 DC	-

3 CONTROLS AND OVERALL DIMENSIONS

The overall dimensions of 321ABP are shown in Figure 1. The controls are shown in Figure 2. The connection diagram is shown in Figure 3.

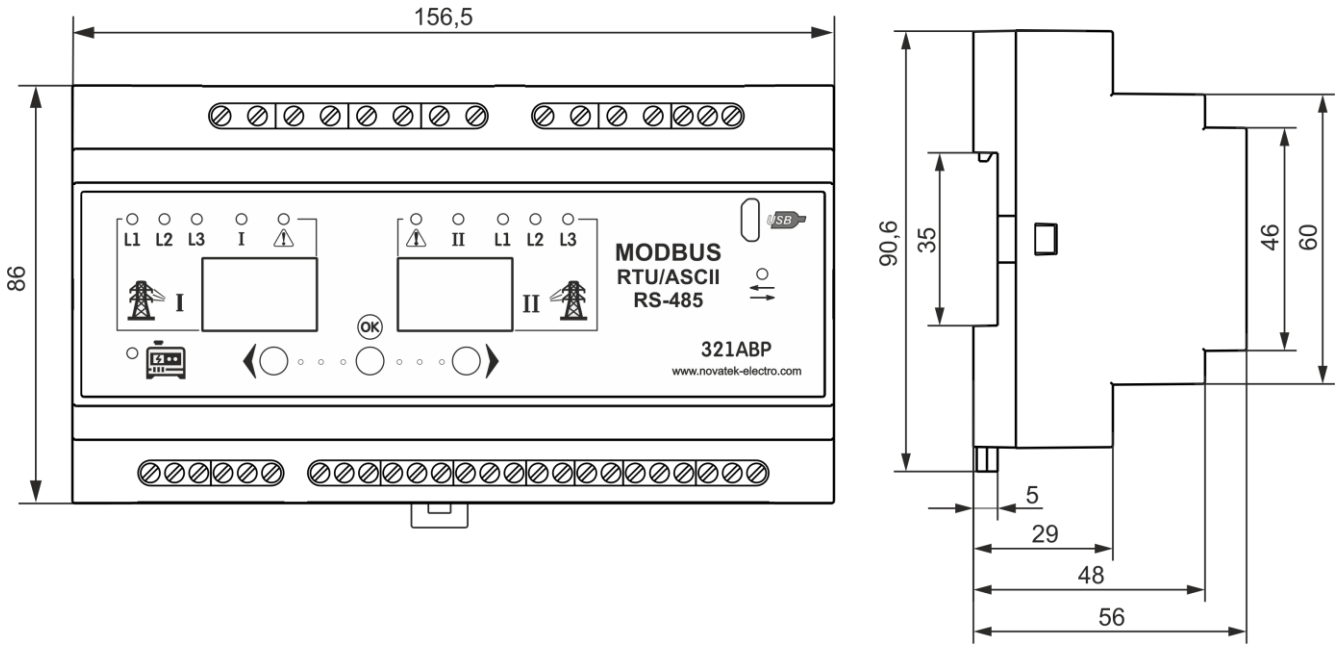


Fig. 1 – Overall dimensions of 321ABP

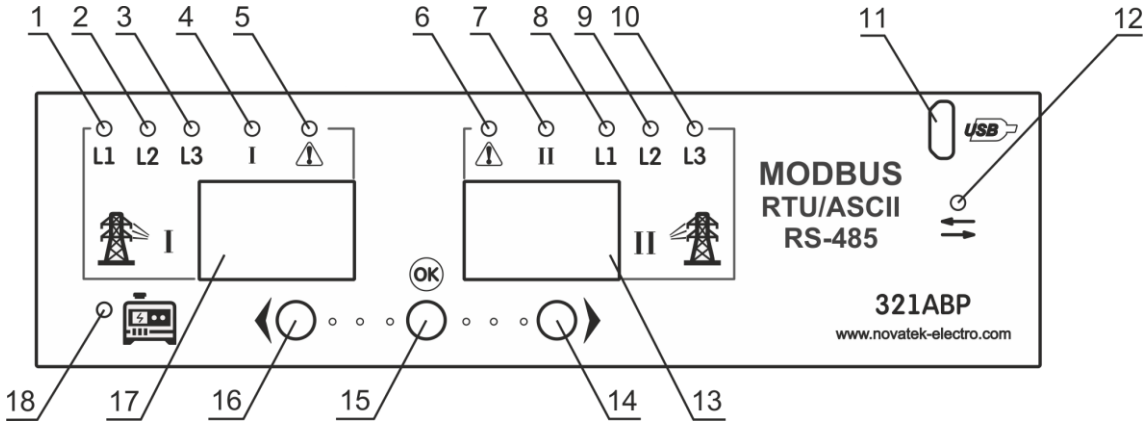


Fig. 2 – Controls and indication of 321ABP

The controls and indication:

1 – green LED «**L1**» lights if normal voltage is in phase 1 at **input 1**;
2 – green LED «**L2**» lights if normal voltage is in phase 2 at **input 1**;
3 – green LED «**L3**» lights if normal voltage is in phase 3 at **input 1**;
4 – blue LED «**I**» lights if the load has power supply from **input 1**;
5 – red LED «⚠» lights if there is at least one failure at **input 1**;
6 – red LED «⚠» lights if there is at least one failure at **input 2**;
7 – blue LED «**II**» lights if the load has power supply from **input 2**;
8 – green LED «**L1**» lights if normal voltage is in phase 1 at **input 2**;
9 – green LED «**L2**» lights if normal voltage is in phase 2 at **input 2**;
10 – green LED «**L3**» lights if the normal voltage is in phase 3 at **input 2**;
11 – connector for USB communication;
12 – blue LED « ⇄ » blinks when transmitting data via USB or RS-485, it does not light up if data transfer is not used;
13 – **input 2** displays phase and line voltage values, **input 2** network frequency and menu values;
14 – button «⟩»;
15 – button «OK»;
16 – button «⟨»;
17 – display of **input 1** displays phase and line voltage values, **input 1** network frequency and menu.
18 – green LED «  » lights if the generator is connected to the load; blinks if time is running. It is off when operating from the mains.

Functions of 321ABP terminals:

1 – **input 1** control (normally open contact);
2 – **input 1** control (common contact);
3 – **input** 1 control 1 (normally closed contact);
4 – **input 2** control (normally open contact);
5 – **input 2** control (common contact);
6 – **input 2** control (normally closed contact);
7,8,9,10,11 – not involved;
12,13 – the state of voltage at input 1;
14,15 – the state of voltage at input 2;
16,17 – the state of voltage on both inputs;
18,19 – the state of generator operation;
20 – generator control (normally open contact);
21 – generator control (common contact);
22 – generator control (normally closed contact);
23 – RS-485-A;
24 – RS-485-B;
25 – RS-485-G;
26 – the first phase of **input 1** to power the device;
27 – the second phase of **input 1** to power the device;
28 – the third phase of **input 1** to power the device;
29 – neutral wire of **input 1** to power the product;
30 – the first phase of **input 2** to power the device or connect the generator;
31 – the second phase of **input 2** to power the device or connect the generator;
32 – the third phase of **input 2** to power the device or connect the generator;
33 – neutral wire of **input 2** to power the device or connect the generator;
34 – the first phase of voltage measurement at the load;
35 – the second phase of voltage measurement at the load;
36 – the third phase of voltage measurement at the load;
37 – not involved;
38 – external button to turn on the device from the battery;
39 – "+" of power supply from the 12-V battery;
40 – "-" of power supply from the 12-V battery.

4 OPERATION CONDITIONS

The product is designed for operation in the following conditions:

- Ambient temperature: from minus 35 to +55°C;
- Atmospheric pressure: from 84 to 106.7 kPa;
- Relative air humidity (at temperature of +25°C): 30 … 80%.

If the temperature of the device after transportation or storage differs from the ambient temperature at which it is supposed to be operated, then before connecting to the mains keep the device under the operating conditions within two hours (because of condensation may be on the device elements).

ATTENTION! The product is not intended for operation in the following conditions*:*

- Significant vibration and shocks;
- High humidity;
- Aggressive environment with content in the air of acids, alkalis, etc., as well as severe contaminations (grease, oil, dust, etc.).

5 CONTENTS OF DELIVERY

The contents of delivery is shown in Table 4.

Table 4 - The contents of product delivery

Description	Quantity, pcs
321ABP	1
Coupling cable to connect a PC via USB	1
Operation Manual	1
Packing	1

6 USE AS INTENDED

6.1 Preparation for use

6.1.1 Preparation for connection::

- unpack the device and check the product for damage after transportation; in case of their detection, contact the supplier or manufacturer;
- carefully study the Operation Manual (pay a special attention to the power supply circuits of the device);
- If you have any questions about the installation of the device, please contact the manufacturer over the telephone number indicated at the end of the Operation Manual.

6.1.2 Connection of the device

ATTENTION! THE DEVICE IS NOT INTENDED FOR LOAD SWITCHIN OVER AT SHORT CASES. THEREFORE, THE CIRCUIT OF INPUTS 1 AND 2 CONTROL CONTACTS MUST INCLUDE A CIRCUIT BREAKER WITH A RATED CURRENT OF MORE THAN 5 A, CLASS "B".

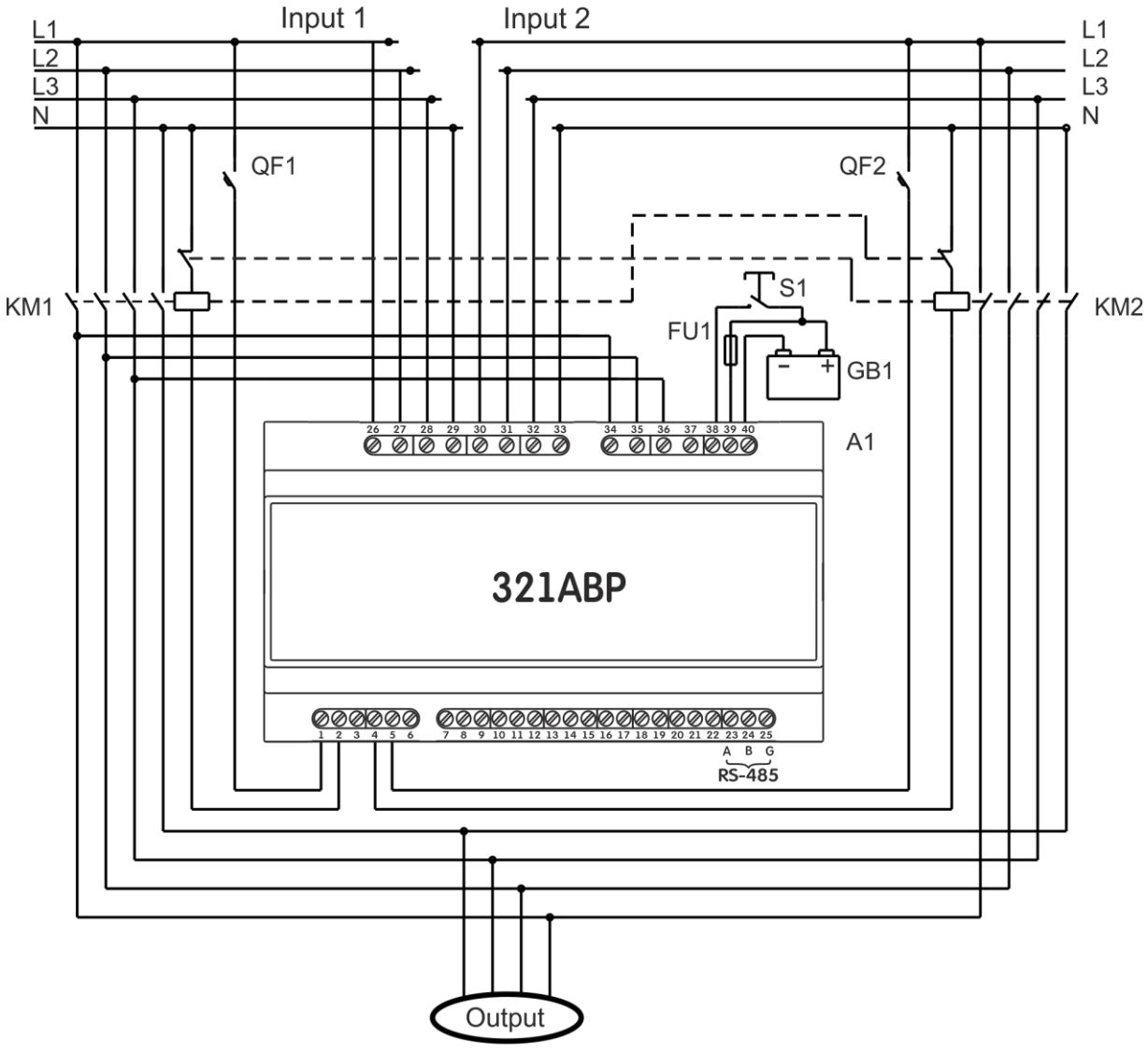
ALL CONNECTIONS MUST BE PERFORMED WITH THE DEVICE BEING DEENERGIZED.

An error in installation work may result in damage of the device and instruments connected to it.

To ensure reliability of electrical connections, flexible (multi-wire) conductors should be used with insulation for voltage of at least 450 V, the ends of which must be stripped of insulation by 5 ± 0.5 mm and crimped with bushings. It is recommended to use a wire with a cross-section of at least 1 mm^2. The fastening of the wires should exclude mechanical damage, twisting and abrasion of wire insulation.

DO NOT LEAVE BARE SPOTS OF WIRE EXTENDING OUTSIDE THE TERMINAL.

For reliable contact, it is necessary to tighten the terminal block screws with the force specified in Table 1.



A1 – 321ABP;
FU1 – 0.5 A fuse;
GB1 – battery 12 V, 2 A·h;
KM1, KM2 – three-phase magnetic starters;
QF1, QF2 – circuit breakers;
S1 – normally open button without locking. Current of 0.5 A at 12 V in the closed position.

Fig. 3 - Connection diagram of 321ABP

If the tightening torque decreases the connection site heats up, the terminal board may melt and the wire may flame up. With an increase in the tightening torque, there may be breakage in the thread of the terminal block screws or pinching in the connected wire.

To improve the operational properties of the product, it is recommended to install circuit breakers in the 321ABP power supply circuit rated for current of 0.5 A.

The option of the 321ABP connection is shown in Figure 3.

If the neutral wires of various inputs are isolated, then contactors with four contact groups must be used. The measuring circuits of various inputs inside the device are galvanically isolated from each other.

It is recommended for additional protection against simultaneous connection of two inputs, to switch on additional groups of contacts on the contactors (normally closed) in the power supply circuit of the opposite inputs (as shown in Fig, 3).

To ensure MODBUS communication in the absence of voltage at two inputs, it is recommended to connect a 12 V 2 A h battery to terminals **39 - 40**.

Attention! When working with the generator, terminals 39 - 40 must get supply from an external battery.

6.2 Operation of the device

6.2.1 Modes of operation

321ABP supports 6 operating modes:

– two equivalent three-phase inputs;
– two three-phase inputs with priority **input 1**;
– two three-phase inputs with priority **input 2**;
– three-phase **input 1** and a three-phase generator at **input 2**;
– work only with **input 1**;
– work only with **input 2.**

6.2.1.1 With equivalent inputs and with normal voltages at the both inputs, the device connects the load to **input 1** by contactor **K1**.

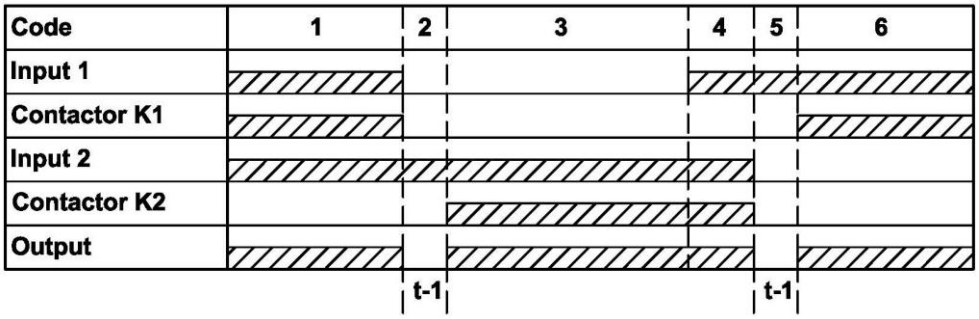


Fig. 4 – Diagram of work with equivalent entries

Figure 4 shows the diagrams of work with equivalent inputs. Detailed description of Figure 4:

1 – Normal voltages are present at **inputs 1 and 2**. The 321ABP connects the load to **input 1** by contactor **K1**.
2 – At input 1, the voltage went beyond the limits set by the user (a failure occurred). The device disconnects the load from **input 1** by contactor **K1** and counts the transition time to another input («t- 1», table 5).
3 – After completion of the countdown «t- 1», the device connects the load to **input 2** by the contactor **K2**.
4 – Some voltage appeared at **input 1**.
5 – At input 2, the voltage went beyond the limits set by the user (a failure occurred). The device disconnects the load from **input 2** by the contactor **K2** and counts the transition time to another input («t- 1», table 5).
6 – After completion of the «t- 1» countdown, the device connects the load to **input 1** by the contactor **K1**.

6.2.1.2 Figure 5 shows the diagrams of work with priority input 1 (Work with priority input 2 is similar).

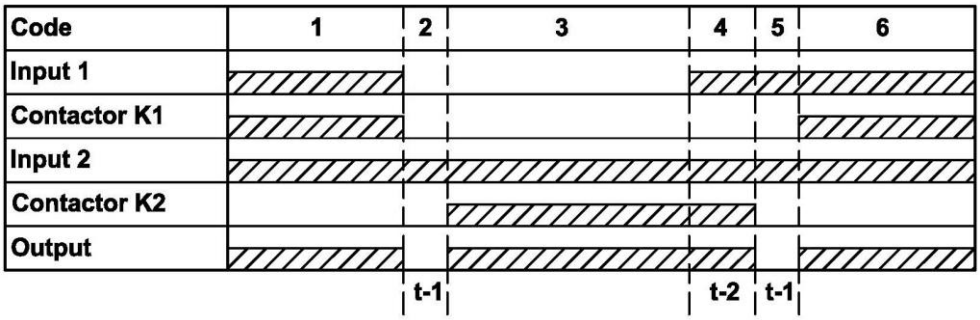


Fig. 5 – Diagrams of work with priority **input 1**

Detailed description of Figure 5:

1 – normal voltages are present at inputs 1, 2. Device 321ABP connected the load to **input 1** by contactor **K1**.

2 – at **input 1**, the voltage went beyond the limits set by the user (a failure occurred). The device disconnects the load from **input** 1 by contactor **K1** and counts the transition time to **input 2** («t- 1», table 5).

3 – after the completion of the «t- 1», countdown, the device connects the load to **input 2** by contactor **K2**.

4 – Some voltage appeared at **input 1**. Device 321ABP counts the time of return to the priority input («t-2», table 5).

5 – the device disconnects the load from **input 2** by contactor K2 and counts the transition time to another input («t- 1», table 5).

6 – the device connects the load to **input 1** by contactor **K1**.

6.2.1.3 To work with a three-phase generator, it must be connected to **input 2** (terminals **30**–**33**) and select the appropriate mode of operation with a three-phase generator – «3» («rEr», table 5). The trigger signal for the generator is generated by the device in the event that a failure occurs at **input 1**. The start and stop signal of the generator is shaped by the internal relay of the device, the contacts of which go to terminals **20, 21, 22 (20 - 21** - normally open contact, **21 - 22** normally closed contact).

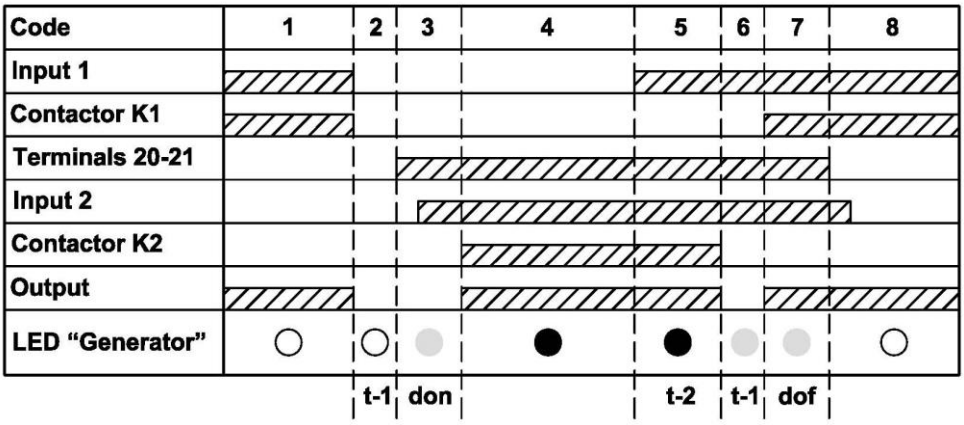


Fig. 6 – Diagrams of works with a generator at **input 2**

A detailed description of work with a generator, in accordance with Fig. 6:

1 – **Input 1** has a normal voltage. Device 321 ABP connected the load to **input 1** by Contactor K1. The LED « » does not light.

2 – At input 1, voltage went beyond the limits set by the user (a failure occurred). The device disconnects the load from **input 1** by contactor **K1** and counts the transition time to the secondary input («t- 1», table 5).

3 – After completion of the «t- 1», 321ABP time countdown, device 321ABP closes terminals **20 - 21** (sends a signal to start the generator). The time for starting and warming up of the generator is counted («don», table 5). A test check is made for absence of voltage at the load (terminals **34 - 36**) and for absence of failures at **input 2**. The LED « » flashes.

4 – The device connects the load to **input 2** by contactor **K2**. The LED « » lights up.

5 – Some voltage appeared at **input 1**. The device counts the time of return to the priority input («t-2», table 5).

6 – After completion of the «t-2» countdown, the device disconnects the load from **input 2** by the contactor **K2**. A test check is made for absence of voltage at the load (terminals **34 36**) and absence of failures at **input 1**. The device will count the time «t- 1» and «doF» (table 5). The LED « » flashes.

7 – After completion of time «t- 1» countdown, the device will connect the load to **input 1** by contactor **K1**.

8 – After completion of the «doF» countdown, the device will open terminals **20 - 21** (it sends a signal to turn off the generator). The LED « » goes off.

6.2.1.4 Battery connection

The battery is connected to terminals 39 and 40, as shown in Figure 3.

The battery is charged in the buffer mode with current of not more than 60 mA. It is not recommended to use a battery with a capacity of more than 2 Ah because of the low charge current.

Attention! Devices connected in parallel to the battery affect its charge.

If there is voltage of 100 V, at least at one of the phases of any input, the device is powered by this voltage. Otherwise, 321 ABP is powered by a battery with current of not more than 100 mA. If the battery is discharged to 11.5 V, then 321ABP will disconnect the battery from the circuit and it will stop working. The next time the device

will be energized when voltage appears at one of the inputs or after replacing the battery with a charged one, followed by a short pressing of an external button connected to the terminals (38 - 39).

If voltage appeared at any input when supply is from the battery, then after 12 s device 321 ABP will be switched over to the mains supply, and the battery will be charging.

The measured battery voltage is available for reading at MODBUS and is converted to an integer value (multiplied by 100), address 25. Also, the flag of battery connection to the terminals (38 - 39) is transmitted to address 43, bit 4.

6.2.2 *Menu setting and viewing*

6.2.2.1 Menu settings

To enter the menu, press and hold the «**OK**» button for 3 s. Display at **input 1** will show «PAS», and at display of **input 2** there will be «000». Enter the password in accordance with clause 6.2.2.2. The factory default password is « 123». If the «PAS» value (table 5) is set to «000» (password is not set), then after holding the «**OK**» button for 3 seconds, you will immediately enter the menu.

To view and change menu values it is necessary:

- after entering the menu to select the desired menu item by using «❮» or «❯» buttons, it will be displayed on the **input 1** display, and its value - on the input 2 display;
- to change the value, press the «**OK**» button, thereby the value on the input 2 display will flash;
- change the flashing value with the buttons «❮» and «❯»;
- to save the data, briefly press the «**OK**». The value on the input 2 display stops flashing, you can proceed to view and configure other menu items.

In order to exit the menu, press and hold the «**OK**» button for 3 s. If no button is pressed within 30 s, the menu will exit automatically.

Table 5 - Menu

Menu	Value	Name	Description	Address
Basic items				
rEr	0	Mode of operation	«0» – equivalent inputs; « 1» – priority input 1; «2» – priority input 2; «3» – work with a 3-phase generator; «4» – work only with input 1; «5» – work only with input 2.	100
PAS	123	Setting of the password	Described in clause 6.2.2.2	101
UUU	0	Voltage output	«0» – permanent display of one of the voltages; « 1» – voltage display in turn, with interval of 5 s	102
bLo	2	Ratio of the minimum time of work after load activation	Within 0 to 5 activations. If «0» is selected, this parameter is disabled	103
PFo	0	Full phase shutdown	«0» – full phase shutdown – a norm; « 1» – full phase shutdown – a failure	104
PPP	---	Reset to factory settings	If «1» is written, there will be resetting of all parameters of the menu	105
Voltages				
r-U	0	Type of voltage measurement	«0» – phase voltages; « 1» – line voltages	106
u_1	185	Minimum phase voltage at input 1	From 140 to 230 V with interval of 5 V	107
u_2	185	Minimum phase voltage at input 2		108
u¯1	250	Maximum phase voltage at **input 1**	From 235 to 260 V with interval of 5 V	109
u¯2	250	Maximum phase voltage at **input 2**		110
U_1	310	Minimum line voltage at **input 1**	From 240 to 395 V with interval of 5 V	111
U_2	310	Minimum line voltage at **input 2**		112
U¯1	425	Maximum line voltage at **input 1**	From 405 to 450 V with interval of 5 V	113
U¯2	425	Maximum line voltage at **input 2**		114
P-1	25	Voltage imbalance at **input 1**	From 15 to 140 V with interval of 5 V	115
P-2	25	Voltage imbalance at **input 2**	From 15 to 140 V with interval of 5 V	116
Response time in case of failure				
tU_	7.0	Minimum voltage	From 0.0 to 10.0 seconds with interval of 0.5 s. If «0.0» value is set, this item of the check is not used	117

Table 5 (continued)

tU‾	0.5	Maximum voltage	From 0.0 to 3.0 seconds with interval of 5 s. If «0.0» value is set, this item of the check is not used.	118
tPF	0.5	Voltage imbalance		119
tPP	0.5	Phase sequence		120
toF	0.5	Phase breakage		121
tSF	0.5	Phase sticking		122
tcr	0.5	Contactor sticking	From 0.5 to 3.0 seconds with interval of 0.5 s	123
tbL	60	Minimum time of operation after load connection	From 5 to 600 s	124
Time of switching over				
t-1	2.0	Switching over to another input	From 0.5 to 900.0 s	125
t-2	10.0	Reset to the priority input		126
Work with a generator				
don	180	Time of idle work of the generator before its start	From 5 to 900 s	129
doF	180	Time of idle work of the generator before its switching off		130
dEr	0	Generator de-energizing in case of failure	«0» – enabled; «1» – forbidden	131
Parameters of the series connected interface (RS-485/ USB)				
rPc	0	Enabling to change data throughout the network	«0» – enabled; «1» – forbidden	132
rPP	1	Data transfer interface	«2» – communication via RS-485; «1» – communication via USB; «0» – communication is forbidden	133
bUS	1	Type of communication protocol	0 – «ASCII»; 1 – «RTU» – MODBUS modes	134
PAr	0	Parity check	«0» – parity check is off; «1» – even parity check; «2» – odd parity check	135
bit	2	Number of stop bits	«1» or «2».	136
rSS	2	Transfer rate	«0» – transfer rate – 2400 baud; «1» – transfer rate – 4800 baud; «2» – transfer rate – 9600 baud; «3» – transfer rate – 14,400 baud; «4» – transfer rate – 19,200 baud	137
nPP	1	Number of the device in the network	From 1 to 247 with interval 1	138
Frequency				
Pch	1	Frequency protection	«0» – no frequency protection; «1» – protection on both inputs; «2» – protection of **input 1**; «3» – protection of **input 2**	139
cch	10	Response time for frequency control	From 5 to 20 seconds with interval of 5 s	140
F‾1	51.00	Upper limit of frequency at **input 1**	From 50.10 to 65.00 Hz with interval of 0.10 Hz	141
F_1	49.00	Lower limit of frequency at **input 1**	From 45.00 to 49.90 Hz with interval of 0.10 Hz	142
F=1	0.50	Upper hysteresis of frequency at **input 1**	From 0.10 to 2.00 Hz with interval of 0.10 Hz	143
F=1	0.50	Lower hysteresis of frequency at **input 1**		144
F‾2	51.00	Upper limit of frequency at **input 2**	From 50.10 to 65.00 Hz with interval of 0.10 Hz	145
F_2	49.00	Lower limit of frequency at **input 2**	From 45.00 to 49.90 Hz with interval of 0.10 Hz	146
F=2	0.50	Upper hysteresis of frequency at **input 2**	From 0.10 to 2.00 Hz with interval of 0.10 Hz	147
F=2	0.50	Lower hysteresis of frequency at **input 2**		148

6.2.2.2 Password setting

Input 1 will display «PAS» and **input 2** will display – «000», with the most significant digit flashing. Use the «❮»and «❯»buttons to alternately a flashing value of the high, middle and low order bits, while preserving the value of each bit by briefly pressing the «**OK**» button. If you set the password value to «000», then it will not be requested.

6.2.2.3 Displaying of network voltage and frequency values

Depending on the «UUU» setting (Table 5), the values can be displayed in two modes:

1) If «UUU» = «0», then during 321ABP operation, both displays will read values of phase or linear voltages, the network frequency value at inputs 1 and 2.

In this mode, using the «❮»and «❯»you can switch the display of voltage values and network frequency in accordance with Table 6.

2) If «UUU» = « 1», then during 321ABP operation, both displays will alternately read with an interval of 5 s values of phase or linear voltages at inputs 1 and 2 depending on the parameter «r-U». If «r-U» = «0», then phase voltages will be output alternately, and if «r-U» = «1», then linear voltages will be output. However, the frequency value is not displayed.

Using the «❮»and «❯»buttons, you can switch the display of network voltage and frequency in accordance with Table 6, but 15 seconds after the last pressing of the «❮» and «❯» buttons, only phase or only linear voltages will be displayed again, as described above.

Table 6 - Indication of phase and linear voltage values

Type of voltage	Designation of the type of voltage	Address of input 1	Address of input 2
Phase voltage of phase 1	220. High order dot is lighting	11	12
Phase voltage of phase 2	2.20 Mid-order dot is lighting	13	14
Phase voltage of phase 3	22.0 Low-order dot is lighting	15	16
Linear voltage of phases 1, 2	380. High-order dot is flashing	17	18
Linear voltage of phases 2, 3	3.80 Mid-order dot is flashing	19	20
Linear voltage of phases 1,3	38.0 Low-order dot is flashing	21	22
Frequency	50.2 Dots in the high and mid-order are flashing and a dot in the low order if lighting	23	24

Flags of voltage presence at the load are transmitted via MODBUS with addresses 44.1 (phase 1), 44.2 (phase 2), 44.3 (phase 3). If the corresponding bit is «**1**» there is voltage in the phase, if «**0**» - there is no voltage in the phase.

6.2.2.4 Indication of failures

Failures are indicated on the display by three characters. The first two are «Er»,and the third one is different for each failure (according to Table 7). If one of the indicated failures occurs, the **input 1** or **2** display (depending on the input at which the failure occurred) will periodically display a code for this failure. The EEPROM failure (ErE) is displayed on two displays at once and the device will be blocked.

In case of a failure as contactor sticking (Erc), the failure can be displayed both on one of the displays and on the both of them at once (the device is blocked until the power is reset). In the first case (indication Erc on one of the displays), device 321ABP determined that sticking occurred on the corresponding input (input 1 - the left display, input 2 –the right display) when the contactor opens. In the second case (indication Erc on the both displays), it was not possible to determine on which contactor sticking had occurred.

Table 7 – Types of failures

Code of failure	Explanation	Address of the register Bit №	
		Input 1	Input 2
ErC	Contactor sticking when switching on	41:0	41:1
Erc	Contactor sticking when switching off	41:2	41:3
ErP	Voltage imbalance	41:4	41:5

Table 7 (continued)

ErH	Failure in phase sequence	41:6	41:7
Ero	Phase breakage	41:8	41:9
ErS	Phase sticking	41:10	41:11
Er 1	Failure of generator start	---	41:13
Er2	Failure in generator stoppage	---	41:15
		42:0	
Erb	Failure in automatic re-closure ratio	42:1	42:2
ErF	Failure in frequency	42:3	42:4
Eru	Voltage goes beyond the lower limit set by the User	42:5	42:6
ErU	Voltage goes beyond the higher limit set by the User	42:7	42:8

If a failure occurs at **input 1**, then the LED «⚠» of input 1 will light up**,** if at **input 2**, then the LED «⚠» of input 2 will light up.

6.2.2.5 External indication

The 321ABP has 4 outputs to the terminal for connecting an external indication. Table 8 shows the connections for external displays.

Table 8 - External Indication

Terminals	Type of thermocouple	Name	Explanation of operation of the indicator connected to respective terminals in series with the source of power supply	Max. duration of allowable AC/DC voltage, V
12 – 13	Triacoutput photocoupler	The state of voltage at input 1	**Lighting up** – voltage is within the norm; **Is flashing** – voltage is beyond the limits set by the User; **Is not lighting** – no voltage	400 AC
14 – 15	Triacoutput photocoupler	The state of voltage at input 2	**Lighting up** – voltage is within the norm; **Is flashing** – voltage is beyond the limits set by the User; **Is not lighting** – no voltage	400 AC
16 – 17	Optotransistor	Availability of the battery	**Is not lighting** – the battery is disconnected; **Is lighting** – the battery is connected	280 AC / 400 DC
18 – 19	Optotransistor	The state of generator operation	Duplicates LED 	

6.2.3 MODBUS parameters

The parameters available for reading upon the MODBUS protocol are shown in Table 9. The parameter sets available upon the MODBUS protocol are shown in Table 10.

Table 9 - Parameters accessible for reading upon MODBUS protocol

Parameter		Address
Type of the device	Code, defining the device of MODBUS for a manufacturer (25 321ABP)	0
Firmware version	Firmware version for the built-in software (firmware version, for example «2.3», is transmitted upon MODBUS as «0x0203»)	1
Time account for switching over to another input		26
Time account for return to the foreground input		27
Time account for waiting for generator start		29
Time account for generator idle work before switching off		30
The state of input 1 relay	1 – normally-open contacts are closed; 0 – normally-open contacts are open	43:0
The state of input 2 relay		43:1
The state of the generator relay		43:2
The state of the battery relay		43:3
Availability of voltage at the load, phase 1	1 – voltage is present at the load; 0 – no voltage at the load	44:1
Availability of voltage at the load, phase 2		44:2
Availability of voltage at the load, phase 3		44:3

Table 10 – Parameters available upon the MODBUS protocol

Access	Addresses
Reading and writing	100 – 250
Only reading	0 – 99

6.3 Work with interface RS (EIA/TIA)-485 upon the MODBUS protocol

6.3.1 General

321ABP allows to perform data exchange with external devices via the serial RS (EIA/TIA)-485 interface using the MODBUS protocol with a limited set of commands (the list of supported functions is shown in Table 12.

Table 12 - List of supported functions

Function (hex)	Purpose	Note
0x03	Reading of one or several registers	Maximum 50
0x06	Writing of one value to the register	----

When designing a network, the principle of the master-slave arrangement is used, where device 321ABP acts as a slave. A network can have only one master unit and several slave units. The master unit is a personal computer or a programmable logic controller. With this setting up, the initiator of the exchange cycles can only be the master unit.

Requests of the master unit are individual (addressed to a specific device). The 321ABP device performs transmission, responding to individual requests of the master unit.

If errors are detected in receiving requests, or if it is impossible to execute the received command, 321ABP generates an error message as a response (Table 13).

In 321ABP, all values with a dot are converted to integers. Therefore, when processing data, it is necessary to apply additional mathematical operations.

When reading a value with a dot (for example, **1.000**) 321ABP will return an integer value of **1000,** in order to convert the read value to the correct format, it is necessary to divide by.

Before writing a value with a dot (for example, **1.000**) you must reduce it to an integer value by multiplying the value by 1000, then write the value to 321ABP.

The coefficient of reduction to an integer value is determined by a number of decimal places (1,0 – 10; 1,00 – 100; 1,000 - 1000).

Table 13 - Error codes for the MODBUS protocol

Error code	Name	Error description
01	ILLEGAL FUNCTION	The accepted function code cannot be processed
02	ILLEGAL DATA ADDRESS	The data address specified in the request is not available
03	ILLEGAL DATA VALUE	The value contained in the query data field is not a valid value
04	SERBER DEVICE FAILURE	An unrecoverable error occurred while the slave device was attempting to perform the requested action
05	ACKNOWLEDGE	The slave device has accepted the request and is processing it, but this is time consuming
06	SERBER DEVICE BUCY	The slave device is busy processing the command. The master unit should retry the message later when the slave is free
07	NEGATIVE_ACKNOWLEDGE	The slave device cannot execute the software function specified in the request
08	MEMORY PARITY ERROR	When reading the extended memory, the slave device detected a parity error

6.3.2 Message Formats

The exchange protocol has clearly defined message formats. Compliance with the formats ensures the correctness and stability of the network.

The data in the message is transmitted in high byte forward.

6.3.2.1 Byte format

321ABP is configured to work with one of two data byte formats: with parity control (Figure 7) and without parity control (Figure 8). In the mode of operation with parity control, the type of control is also indicated: parity (Even) or oddness (Odd). The transmission of data bits is performed by the least significant bits forward.

By default (during manufacture), the device is configured to operate without parity and with two stop bits.

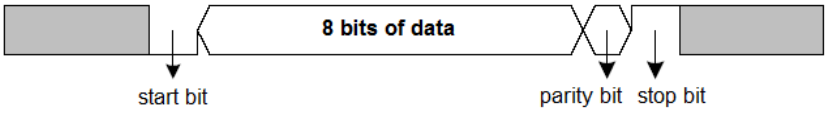


Fig. 7 – Byte format with a parity control

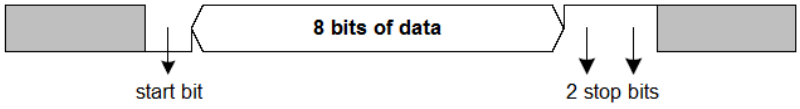


Fig. 8 - Byte format without parity control (2 stop bits)

Bytes are transmitted at speed of 2400, 4800, 9600, 14400 and 19200 bps. By default, during manufacture, the device is configured to operate at a speed of 9600 bps.

Note *- for* ***MODBUS RTU*** *mode, 8 data bits are transmitted, and for* ***MODBUS ASCII*** *mode, - 7 data bits are transmitted.*

6.3.2.2 Frame format

In the **MODBUS RTU** mode, the start and end of the frame are controlled using silence intervals of at least 3.5 bytes transmission time. The frame should be transmitted as a continuous stream of bytes. The correctness of the frame acceptance is further controlled by checking the CRC checksum.

The address field takes up one byte. Addresses of the slave devices are in the range from 1 to 247.

Figure 9 shows the RTU frame format.

Silence interval >3.5 bytes	Address	Function code	Data	CRC checksum	Silence interval >3.5 bytes
	1 byte	1 byte	Up to 50 bytes	2 bytes	

Fig. 9 - RTU frame format

In the **MODBUS ASCII** mode, the start and end of the frame are controlled using special characters (symbol (':' 0x3A) – to start the frame; characters ('CRLF' 0x0D0x0A) – to end the frame). The frame should be transmitted as a continuous stream of bytes. The correctness of the frame acceptance is further controlled by checking the LRC checksum.

The address field takes up two bytes. Addresses of the slave devices are in the range from 1 to 247.

Figure 10 shows the ASCII frame format.

: 1 byte	Address	Function code	Data	CRC checksum	CRLF 2 bytes
	2 bytes	2 bytes	Up to 504 bytes	2 bytes	

Fig. 10 - ASCII frame format

Note - *in the* ***MODBUS ASCII*** *mode, each byte of data is encoded with two bytes of ASCII code (for example: 1 byte of data 0x25 is encoded with two bytes of ASCII code 0x32 and 0x35).*

6.3.3 Generation and verification of a checksum

The transmitting device generates a checksum for all bytes of the transmitted message. 321ABP similarly generates a checksum for all bytes of the received message and compares it with the checksum received from the transmitting device. If the generated checksum does not match the accepted one, an error message is generated.

6.3.3.1 CRC checksum generation

The checksum in the message is transmitted in the lower byte forward; it is a cyclic check code based on the irreducible polynomial 0xA001.

The subroutine for generating CRC checksum is in C language:

```
1:  uint16_t GenerateCRC(uint8_t *pCendRecvBuf, uint16_t uCount)
2:  {
3:      conc uint16_t Polynom = 0xA001;
4:      uint16_t crc = 0xFFFF;
5:      uint16_t i;
6:      uint8_t byte;
7:      for(i=0; i<(uCount-2); i++){
8:          crc = crc ^ pCendRecvBuf[i];
9:          for(byte=0; byte<8; byte++){
10:             if((crc& 0x0001) == 0){
11:                 crc = crc>> 1;
12:             }elce{
13:                 crc = crc>> 1;
14:                 crc = crc ^ Polynom;
15:             }
16:         }
17:     }
18:     returncrc;
19: }
```

6.3.3.2 LRC checksum generation

The checksum in the message is transmitted in high byte forward, which is a longitudinal redundancy check.

The subroutine for generating LRC checksum is in C language:

```
1:  uint8_t GenerateLRC(uint8_t *pCendRecvBuf, uint16_t uCount)
2:  {
3:      uint8_t lrc = 0x00;
4:      uint16_t i;
5:      for(i=0; i<(uCount-1); i++){
6:          lrc = (lrc + pCendRecvbuf[i]) & 0xFF;
7:      }
8:     lrc = ((lrc ^ 0xFF) + 2) & 0xFF;
9:    returnlrc;
10: }
```

6.3.4 Set of instructions

6.3.4.1 Function 0x03 - read operation of a group of registers

The 0x03 function reads the contents of 321ABP registers. The master's request contains the address of the initial register, as well as the number of words to read.

Answerback of 321ABP contains the number of bytes returned and the requested data. The number of registers returned is limited to 50. If the number of registers in the request exceeds 50, the response is not split into frames.

An example of a request and response in the **MODBUS RTU** is shown in Figure 11.

Request

Address	Function	In. address HB	In. address LB	Number of words HB	Number of words LB	CRC LB	CTC HB
01h	03h	00h	A0h	00h	02h	C4h	29h

Answerback

Address	Function	Number of bytes	HW HB data	HW LB data	LW HB data	LW LB data	CRC LB	CTC HB
01h	03h	04h	44h	7Ah	00h	00h	CFh	1Ah

Fig. 11 - Example of request and response of function 0x03 - reading a group of registers

6.3.4.2 Function 0x06 - register entry

Function 0x06 provides writing to one 321ABP register. The master's request contains the address of the register and data for entering.

The answer of the device coincides with the request of the master unit and contains the address of the register and the established data. An example of a request and answer in the **MODBUS RTU** mode is shown in Figure 12.

Request – register 00A0h = 1000 (INT)

Address	Function	In. address HB	In. address LB	HB data	LB data	CRC LB	CTC HB
01h	06h	00h	A0h	03h	E8h	89h	56h

Answerback

Address	Function	In. address HB	In. address LB	HB data	LB data	CRC LB	CTC HB
01h	06h	00h	A0h	03h	E8h	89h	56h

Fig. 12 - Example of request and answer of function 0x06 - register setting

7 MAINTENANCE

7.1 *Safety precautions*

THE TERMINALS AND THE DEVICE INTERNAL ELEMENTS CONTAINS POTENTIALLY LETHAL VOLTAGE.
DURING MAINTENANCE IT IS NECESSARY TO DISABLE THE DEVICE AND CONNECTED DEVICES FROM THE MAINS.

7.2 *Maintenance of the device must be performed by the skilled professionals***.**

7.3 *Recommended frequency of maintenance is* ***every six months*****.**

7.4 ***Maintenance Procedure*****:**

1) Check the connection reliability of the wires, if necessary, clamp with the force specified in Table 1;

2) Visually check the integrity of the housing, in case of detection of cracks and damages take the device out of service and send for repair;

3) If necessary, wipe the front panel and the housing of the device with cloth.

Do not use abrasives and solvents for cleaning.

8 SERVICE LIFE AND MANUFACTURER WARRANTY

8.1 The lifetime of the device is 10 years. Upon expiration of the service life, contact the manufacturer.

8.2 Shelf life is 3 years.

8.3 Warranty period of the device operation is 5 years from the date of sale.

During the warranty period of operation (in the case of failure of the device) the manufacturer is responsible for free repair of the device.

ATTENTION! IF THE DEVICE HAS BEEN OPERATED IN VIOLATION OF THE REQUIREMENTS OF THIS OPERATION MANUAL, BUYER WILL FORFEIT THE RIGHT TO WARRANTY SERVICE.

8.4 Warranty service is performed at the place of purchase or by the manufacturer of the device.

8.5 Post-warranty service of the device is performed by the manufacturer at current rates.

8.6 Before sending for repair, the device should be packed in the original or other packing excluding mechanical damage.

You are kindly requested, in case of the device return and transfer it to the warranty (post-warranty) service please indicate detailed reason for the return in the field of the claims data.

9 TRANSPORTATION AND STORAGE

The device in the original package is permitted to be transported and stored at the temperature from minus 45 to +60 °C and relative humidity of no more than 80 %.

10 ACCEPTANCE CERTIFICATE

PEF-321ABP has been manufactured and accepted in accordance with the requirements of valid technical documentation and classified as fit for operation.

Head of QCD _____

Date of manufacture _____

Seal

11 CLAIMS DATA

_____

_____

_____

_____

_____

_____

_____

_____

The Company is grateful to you for the information about the quality of the device and suggestions for its operation.

♦♦♦♦♦

For all questions, please contact the manufacturer:

NOVATEK-ELECTRO Ltd,
59 Admiral Lazarev Str.;
Odessa 65007, Ukraine.
Tel.: (048)738-00-28;
Tel./fax: (0482) 34-36-73;
http://novatek-electro.com

Date of sale: _____ **VN190618**