MPPT SEC
Solar Energy
Controller

WEC
Wind Energy
Controller

USER'S MANUAL

www.microart.pro
www.invertor.ru

"MicroART" LLC

sale@microart.ru
energo@microart.ru

CONTENT

INTRODUCTION

The present manual sets out safety standards, installation process and settings of the device and related system components. This manual is for use by any qualified personnel who plan to install the device and related system components. Some connection and setting work should be carried out by qualified personnel only in cooperation with local energy supplier or authorized dealer. We strongly recommend the installation, commissioning, maintenance and repair carried out by well qualified personnel only.

GENERAL DESCRIPTION AND FEATURES

The solar controller SEC is a MPPT controller (hereinafter referred to as the "controller") of the Accumulator battery charge (hereinafter referred to as "AB") from the solar panels array (hereinafter referred to as "SP"), with the tracking of the maximum power point (MPPT). This product has many important advantages, namely:

- Efficiency up to 98% allows not only to collect all solar energy practically without losses, but also makes it possible to avoid using cooling fans: it significantly increases the reliability of device.
- High performance, and therefore up to 10% higher efficiency (compared to some 3rd party MPRT controllers) and up to 40% compared to PWM controllers.
- The allowable input voltage limit of the controller is 200 V (or 250 V - depending on the modification), therefore the array of solar panels may consist of up to 3 (or 4) solar panels with 24 V rate, connected in series (open circuit voltage of each one - without load - can reach 45 V at temperature + 25C°, which is in total 3 * 45 = 135 V, or 4 * 45 = 180 V).
- Two current Hall Effect sensors (which is much better than a shunt) for monitoring of charging/discharging by other device (for example, by a wind turbine and/or from an inverter) - are optional.
- The current sensors make possible to cooperate with a hybrid inverter onto the AC grid of 220 V: it allows to add current instantly in AB bypass. It may be even greater than AB allowed charge current; anyway, the use of AB with a minimum capacity is necessary. It concerns any ordinary inverter: power addition to the load by use of SP without AB charge wasting. This option is very important as the energy can go "in transit". AB are not wasted, and therefore, they serve much longer.
- Own transformer-based power supply from the SP allows to feed the controller regardless the battery state. Operation is possible even with fully discharged battery, at a minimum voltage.
- Counter of incoming A*h / W*h.
- Ability to update the firmware in the flash-memory.
- The controller allows to set manually any non-standard voltage for working with AB (besides 12/24/48/96V). It is useful for non-standard alkaline batteries, or batteries with a non-standard number of cells.
- Peak current (up to 100A or 60A depending on the modification) and the ability to operate in 96V systems, allows to obtain the peak power from one controller: up to 11kW (current 100A is multiplied by the AB buffer voltage 110V).

- The possibility to connect lithium-iron-phosphate ($LiFePO_4$) batteries with BMS. The controller manages BMS or, if necessary, automatically transfers the control to the MAC inverter (the controller is connected by additional cable to MAC, and MAC can control the BMS).
- Three programmable powerful relays for external devices control: for example, in complete autonomy, it is possible to turn off the refrigerator automatically for the night by keeping more ice or cold accumulator in the freezer for energy saving. Unlike competitors, SEC DOMINATOR and PRO have the powerful relay of 3.5kW - 240V 16A (i.e. it is possible to connect, for example, a refrigerator, directly through the controller, without any supplementary relays). Temperature compensation and charging mode correction extend the battery life.
- Three stage buffer charge.
- Tropicalized construction: the controller board is protected by a waterproof coating (varnish), which minimizes the harmful effect of a high humidity and insects.
- Possibility of remote monitoring with “MALINA” Appliance.

The controller also can be used to charge battery from wind turbine.

ATTENTION! The use of additional equipment is necessary for the cooperation of the controller and wind turbine! More information about operating with wind turbine can be found in Appendix №4.

TECHNICAL SPECIFICATIONS

Battery voltage	12 / 24 / 36 / 48 / 96V Automatic selection (you can manually set any voltage in the range 12 – 96V)
Maximal charging current	100A @ 40°C / 60A @ 40°C (depending on model)
Maximal power of PV array	12V: 1350W / 24V: 2750W / 48V: 5500W / 96V: 11KW (for the model 200/100) 12V: 810W / 24V: 1650W / 48V: 3300W / 96V: 6.6KW (for the model 200/60 and the model 250/60)
Maximum voltage of the open PV array	200V (for models 200/60 and 200/100) 250V (for the model 250/60)
Minimum voltage of PV array	Battery voltage plus 5V for start, Battery voltage plus 1V for operation
Maximum operating voltage of PV array	185V (for the models 200/60 and 200/100) 233V (for the model 250/60)
Power consumption in standby mode	Not more than 1.9 W
Full load efficiency	12V: 95% / 24V: 96,5% / 36V: 97% / 48V: 98% / 96V: 99%

AB type	GEL, AGM, sealed, flooded, alkaline, $LiFePO_4$(BMS is required)
Temperature sensor	Internal
Temperature compensation (default)	-3mV / °C for 2V battery cell
Programmable relay	3 pcs DPST AC: 240V / 16A
Ability to work onto AC network in pair with the hybrid inverter (current addition by request, including greater than allowed by AB)	Yes (with MAC or with current sensor (optional), in the case of an outdated MAC model, or an external third-party inverter)
The ability to monitor currents from third-party devices (inverter, wind turbine)	Yes (optional, with current sensor)
Communication port	RS-232, USB
Protection	Protection from overheating (power is reduced with temperature rising), short circuit PV and reverse polarity protection. Protection against battery reverse polarity
Operating temperature	From -40°C to 60°C with decreasing output current at temperature inside the body is above 65°C
Cooling	Passive
Humidity (without condensation)	95%
Terminals size	35 mm^2/ AWG2
Body material, color	Aluminum / steel
Protection class	IP20
Installation	Vertical wall mount

Weight, kg	3.7 (for the model 200/60) 5 (for the models 200/100 and 250/60)
Dimensions, mm	240 x 125 x 190 (for the model 200/60) 360 x 125 x 210 (for the models 200/100 and 250/60)

The controller allows you to update its flash-memory firmware. Details are given in Appendix № 3.

ATTENTION! This manual is valid for firmware version 6.0 and higher. If you are using a device with an earlier firmware version, we recommend you update it to the latest or use earlier versions of the user manual.

The main difference between version 6.0 and previous versions is the modification in the control interface and indication algorithms.

SAFETY PRECAUTIONS

**IMPORTANT SAFETY INSTRUCTIONS.
STUDY, SAVE AND STRICTLY FOLLOW!**

This manual contains important safety instructions that must be followed when installing and operating the device. Read this manual and save it for the further use. Before starting the installation, operation or maintenance, please read the rules and become familiar with the device. In this manual and on the product body, the special signs and notices are used. They warn of potential danger or draw attention to information that clarifies or simplifies the operation.

This sign is used together with a warning notice "Danger" or "Warning", or instead of it and means that violation of the requirements may cause an electric shock.

This is a sign of warning. It is used to draw an attention to the potential danger of personal injury or essential property damage. Follow all the requirements listed after this sign. Violation of the requirements may cause a damage to equipment and injury or death.

SAFETY REQUIREMENTS:

1. Before using the controller please study all the instructions and warning labels on your device and batteries, as well as all the relevant chapters of this manual.

2. The use of accessories which are not recommended or not supplied by the manufacturer may cause a risk of fire, electric shock or injury.

3. Make sure that existing wiring is in a good condition and has a proper sectional area to avoid the risk of fire and electric shock. Do not connect the controller to a damaged or defective wiring, as well as defective electrical equipment.

4. In the case of any failure of the inverter please don't use it.

5. This device contains no user serviceable parts. Do not disassemble the inverter, except when it is directly mentioned for wire and/or cables connection. Inside repair may cause a risk of electric shock or fire. Internal capacitors remain charged after power is switched off completely.

6. Before maintenance, cleaning or working with any components connected to the controller please disconnect the inverter from AC and DC sources to reduce the risk of electrical shock. Standby mode of the device does not reduce the risk.

7. The device must be protected from rain, snow or any liquids. Operating in a humid environment shorten the product lifetime. The warranty does not cover the corrosion caused by high humidity.

8. To avoid the risk of short-circuit use always the tools with insulated handles while installing or working with this equipment.

9. When working with electrical equipment please take off metal items, such as rings, bracelets, necklaces, watches, etc.

10. It is necessary to observe polarity of the AB strictly when attaching to the controller. Incorrect connection leads to controller damage. In this case the repairing will not be covered by warranty.

11. It is necessary to observe the temperature conditions and humidity during operating.

12. Do not place the controller in dusty environments.

13. It is not allowed to use the converter for other purposes, the same as to exceed the recommended operating parameters.

14. If AB are not sealed, they should be placed in a ventilated room.

15. It is necessary to prevent the access of children, animals and unskilled personnel to the controller and battery.

ATTENTION! Dangerous voltages are possible in the system!
The installation and all connections should be done by well qualified personnel only.

ATTENTION! If the controller is connected to both the solar panels (SP) and AB (especially when the charge with SP is going on) it is forbidden to disconnect the controller from the AB. This can lead to the controller damage, which is not covered by warranty. For the same reason, it is forbidden to install a circuit breaker between the controller and the battery or, if necessary, it must have a large current reserve relative to the controller current (at least 150% of the controller's maximum current).

CONTROLLER PLACEMENT AND INSTALLATION

When choosing a controller placement, it is necessary to follow the fire safety regulations and electrical equipment and accumulator batteries operating rules.

The controller must be installed in a dry and well-ventilated place. The controller should be placed as close to AB as possible and connected by conductors of the required sectional area. The conductors must withstand the expected charging current of your system. It is not recommended to make AB connection conductors more than 3 m long to avoid a large voltage loss. When longer cables are required it is necessary to increase their sectional area by 2-3 times.

It is necessary to install the temperature sensor on one of the AB sides and fix it securely.

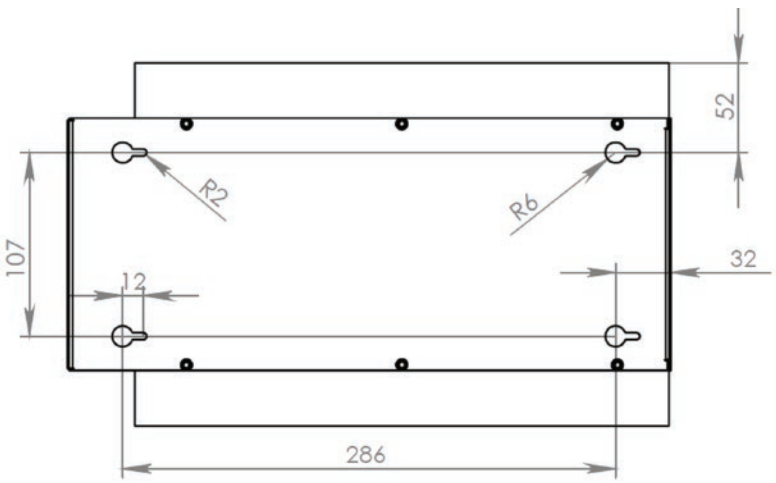
ATTENTION! The input voltage of the controller connected to the solar panels array should never exceed 220V/250V (depends on model). The controller can be damaged by input voltage surplus which is not covered by warranty.

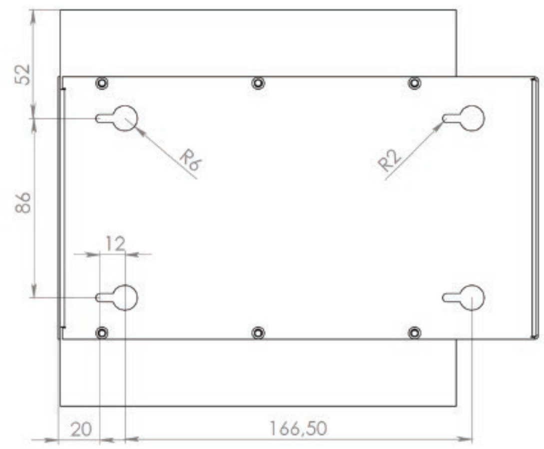
Watch this restriction especially when installing the system in places where high solar radiation and low temperatures may occur. Approximately, the voltage of the open SP circuit increases by 20-25% at -30°C, i.e. the solar panel with 45 V open circuit voltage at + 25°C, will generate 55V at -30°C.

The required sectional area of SP conductors depends on the array capacity and its voltage. The best efficiency is achieved when the input voltage of the controller is twice the battery voltage.

The controller is wall-mounted. Installation should be done on a vertical surface (wall) with free space of at least 15 cm from the sides and at least 25 cm from the top. Otherwise, the controller may become overheated, what reduces the generated power.

To mount the product please fix 4 screws of proper size in the wall according to the drawings and fix the product on them.



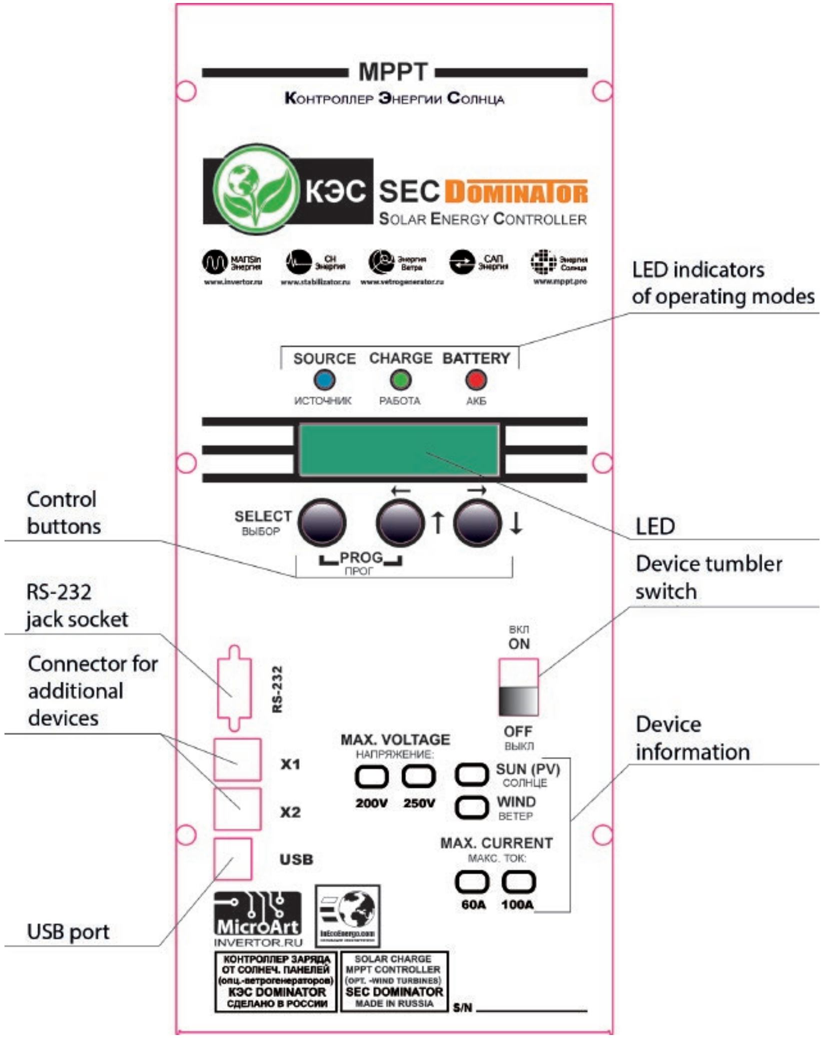


ATTENTION! The height of each screwed screw from the wall surface should be no more than 5-6 mm, otherwise the controller internal components may be damaged.

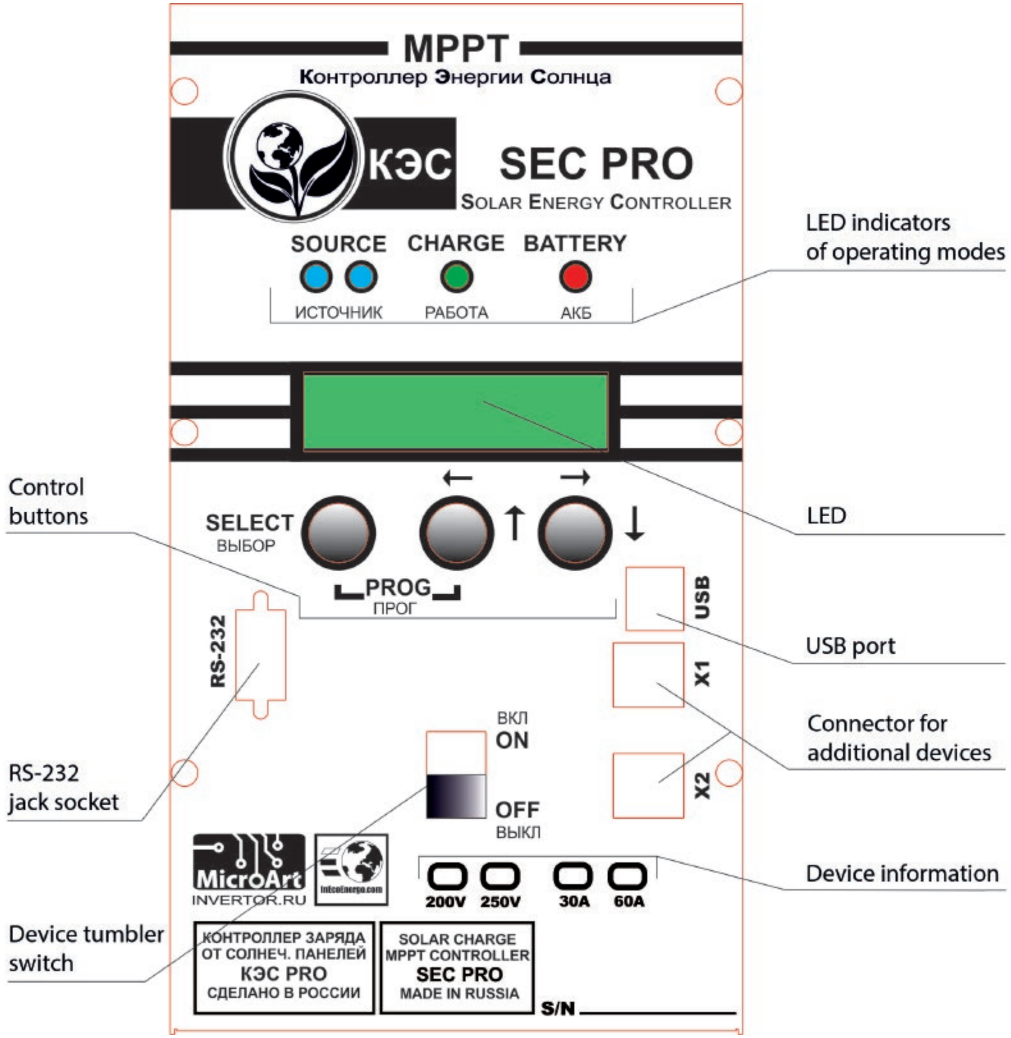
For the cables connecting please remove the bottom cover by unscrewing the 4 screws at the bottom of the body, cut the required size holes through the rubber gaskets, pass the cables through them and put the cover back. The description of the connectors and the recommended wiring diagrams are given below in the description.

CONTROLS AND INDICATION

The appearance and location of the control devices of DOMINATOR model line are shown in Picture 1, of PRO model – in Picture 2.



Picture 1. Exterior view of SEC DOMINATOR controller.



Picture 2. Exterior view of SEC PRO controller.

Modes and operational parameters are displayed by the LCD and 3 LEDs:

"SOURCE" (Blue LED) – indicates the input voltage level (the state of SP). If the SP voltage exceeds AB voltage for more than 5V then the LED is constantly on. When the difference is more than 1-5V - then the LED is blinking. But when SP voltage is below AB voltage plus 1V then the LED is OFF.

"CHARGE" ((Green LED) – indicates AB charge mode. For cyclic charge (charge by maximum current) the LED is constantly ON.
In absorption charging mode the LED blinks evenly.
In the modes of equalization and charge maintaining the LED blinks seldom.

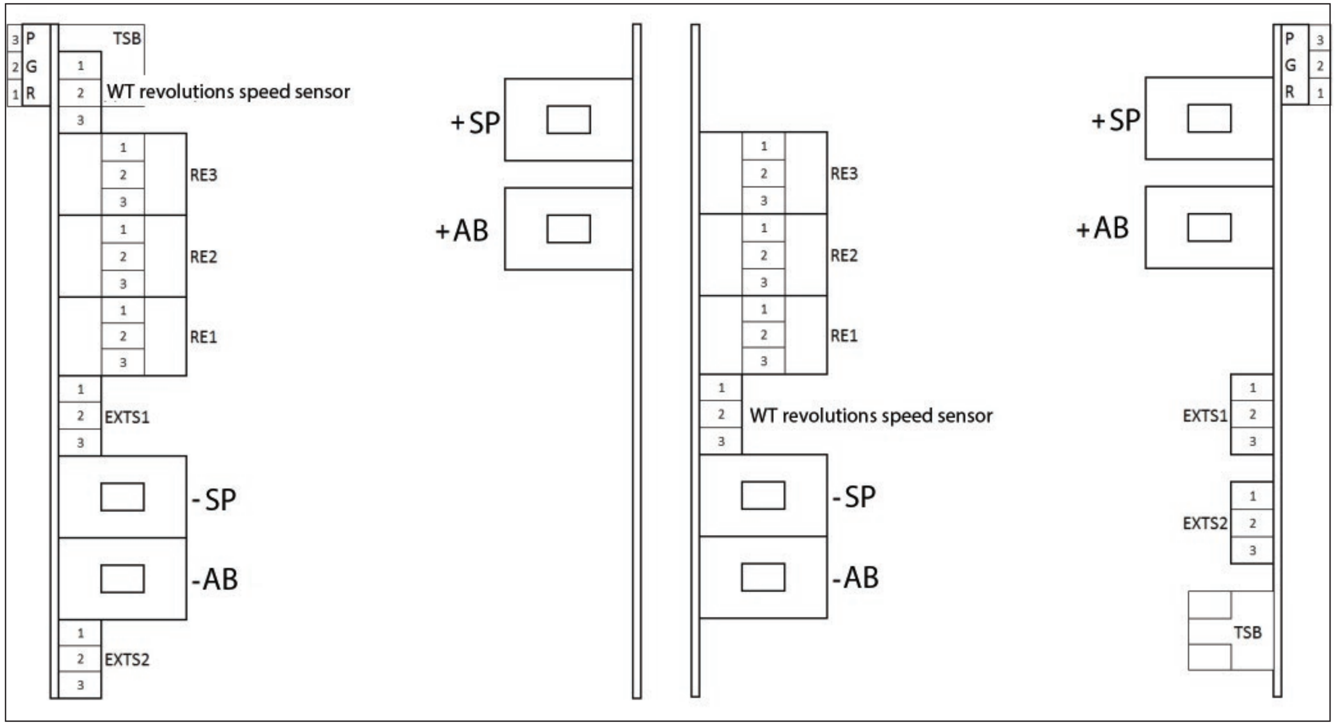
"Battery" (Red/Green LED) – indicates AB charge level.
The LED changes its color in 2-second period. The higher AB charge is the longer the LED is green and the remainder of period (the rest from 2s) it is red. Thus, when AB is fully charged the LED is constantly green; if AB is half charged then the light is green/red changing one after another; for discharged AB the light is constantly red.

LCD display has 2 rows of 16 characters each and is served for displaying the current parameters and user settings input.

CONNECTION PORTS

Location and purpose of controller connecting ports are shown in Pic. 3 (The bottom view is shown with the bottom cover is removed):

View of the connectors for DOMINATOR model *View of the connectors for PRO model*



Picture 3.

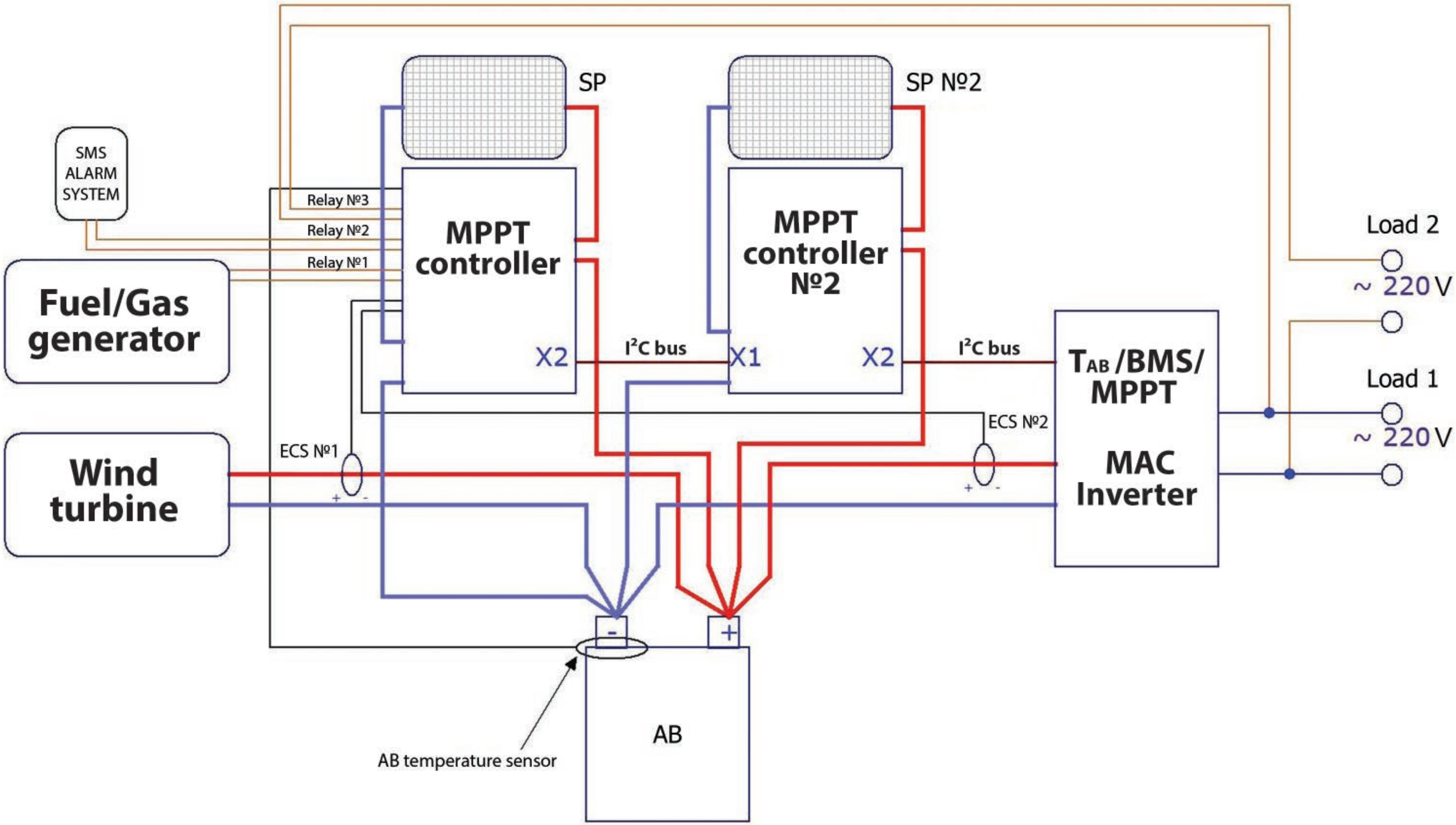
"–SP" – SP minus wire terminal;
"+SP" – SP plus wire terminal;
"–AB" – AB minus wire terminal;
"+AB" – AB plus wire terminal;

TSB – AB temperature sensor connector (a wired temperature sensor is connected to this receptacle. It can be found inside the box)
RE1...RE3 – auxiliary relays for additional control of external devices;
For all relays:
Pin 1– normally closed (NC);
Pin 2 – common (COM);
Pin 3 – normally open (NO);

EXTS1 –External current sensor №1 (hereinafter referred to as ECS №1);
EXTS2– External current sensor №2 (hereinafter referred to as ECS №2);
"P G R" — Mini DIP switch for some setting of connection between several controllers and MAC.

The recommended wire diagram of the controller connection is shown in Picture 4 (the use of current sensors and control relays is not necessary):

WIRE DIAGRAM OF THE CONTROLLER CONNECTION



Picture 4

The use of external current sensors ECS1 and ECS2 allows the controller to count the additional external charging/discharging currents coming from the inverter and/or the wind turbine. This gives an opportunity to reduce charging current automatically when AB is being charged by both wind turbine and solar panels and charging current exceeds the maximum allowed AB current. Also, the use of ECS2 for the control of charging/discharging inverter currents allows if needed to add instantly the charging current from the solar panels to the inverter (for the load) even when AB are fully charged and the controller is in trickle charge mode (high current is not allowed for AB at the end of charge).
You should consider that communication via I^2C bus is available ONLY with "MicroART" equipment and connecting cable supplied with the controller set! At the same time, there is no need in ECS2 sensor (MAC inverter transmits its data on currents via I^2C bus). If the sensor duplicates the I^2C data from the MAC, the controller will produce incorrect charge currents.

ATTENTION! When I^2C connection is used between MAC and controller then the ESC2 sensor should be disconnected!

FIRST START, PRESTARTING PROCEDURES

1. Follow the polarity to connect the controller to AB (firstly without SP) and switch on the device by a tumbler switch.
2. Choose the interface language: Russian or English.
3. Set the battery voltage.

ATTENTION! If the controller has AB factory settings 12V as an example, and the user connects 24V or 48V AB then the device will beep and display: "Battery overvoltage".

In this case, you must go to the controller menu and enter your own settings. To go to the setup menu, you must press long two buttons: “SELECT” and “←↑” ("LEFT/UP").

Note. The first press on a button activates LCD backlit if it is off and only then the chosen function is activated.

Enter the controller menu and scroll it by arrow buttons then select the submenu “AB settings” enter it and the controller will set working voltage automatically.

Voltage		AB
12V?	Yes	No

To confirm, press "Left / Up" (i.e. the button that is located under the text "Yes"), to cancel the proposed option, press "Right / Down" (the button located under the sign "No"). In case of failure, the user must set all voltages manually.

To confirm the offered option, it is enough to set AB type, capacity and charging current - charging voltages will be set automatically. But in this case, the user has an opportunity to edit voltages (by selecting the corresponded submenu item).

Check up the parameters (by scrolling the controller menu), which are set automatically. Compare them with the AB and solar panels passport data and if necessary, adjust. Check up the voltage thresholds in the menu.

4| Switch the controller off.

5| Connect the SP array.

6| Connect the AB temperature sensor and place it on your battery.

7| If necessary, calibrate (see the relevant chapter of the manual) and connect ECS1 and ECS2.

8| Connect the loads and/or the alarm system to the external devices control relay if necessary.

9| In case you have an additional equipment like MAC inverter and/or BMS from "MicroART" or additional controllers, please connect the devices via I^2C bus using the connecting cable supplied with controller and make the necessary settings.

10| Turn the controller on.

11| Make your system parameters settings using control buttons.

12| Controller is ready for operating.

ATTENTION! If you made a mistake during the setup, the controller starts to beep continuously, which means that you need to adjust the settings or the connection. You can also reset the controller to the factory default settings (use the proper menu section) and repeat the setup.

USER SETTINGS EDITING

All settings (including ECS calibrations) are stored in a non-volatile memory (NVRAM) and they don't depend on the power switch position. When you change the parameter values, after confirming it takes effect immediately.

Control and indication algorithms are extremely close to the MAC inverter ones.

The controller has two modes:

- “Indication” - the main operating mode, the information about all device operating parameters are displayed on the screen on several pages.
- “Settings” - the mode where all device parameters are set up and all calibrations can be done.

Enter/Exit “Settings” mode can be done by long pressing two buttons:
"SELECT" and "←↑" ("Left/Up").
By LONG pressing (from 0,5 to 2 sec) the button “SELECT” you can enter submenu, start editing and confirm the action.
The menu navigation, sections browsing and settings selection can be done by a short pressing (less than 0.5 seconds) the buttons "Left / Up" and "Right / Down".

The parameter values can be changed as follows:
Right button "↑←" selects the desired digit, and the central button "←↑" the desired value (values are cycled from 0 to 9).
To exit the settings submenu scroll it to the "Exit" then confirm the action by a LONG pressing the "Select" button.

“INDICATION” MODE

The "Indication" mode is the main operating mode. The screen on several pages displays the information about all the basic parameters of the device. Below is a detailed description of the parameters displayed in the "Indication" mode:

Page 1 contains the following information:

1| PAGE 1

1	2	3	4		5
i	+	Sol	0.00 A	/	0.00 V
R		AB	0.00 A	/	0.00 V
6		7	8		9

1 – AB charge indicator:
"i" – cyclic charge mode;
"v" – absorption charging mode;
"B" – initial buffer charge mode (balancing);
"b" – secondary buffer charge mode (charge level maintenance);
"S" – scan mode (search for the maximum power point).

2 – Indicator of Excess/Shortage of power generated by the SP to maintain the necessary charge/load current:
"+" – Lack of input power (requires to "add" the power);
"—" – excess of input power (requires to "reduce" the power);
"=" – the load power is equal to the input power.
3 – "Sol" – the parameters of SP;
4 – SP current in amperes;

5 – SP voltage in volts;
6 – indicator of the operating point position (OP) relative to the maximum power point (MPP):
"R" – PT on the right of MPP;
"L" – PT on the left of MPP;
"O" – PT is in MPP.
7 – "AB" – parameters of AB / load;
8 – total AB and load current in amperes;
9 – AB voltage in volts.

Page 2 contains information on the currents measured by external current sensors:

2| PAGE 2

		1		2	
S 1		0.00 A	/	0	W
S 2		0.00 A	/	0	W
		3		4	

Where:
1 – current measured by an external current sensor №1;
2 – power measured by an external current sensor №1 (Is defined as the multiplication of voltage by AB current measured by the external current sensor №1);
3 – current measured by an external current sensor №2;
4 – power measured by an external current sensor №2 (Is defined as the multiplication of voltage by AB current measured by the external current sensor №2).

Page 3 contains information on power:

3| PAGE 3

			1
P out			0 W
P in	0 W	/	0 W
	2		3

Where:
1 – output power of the controller: W;
2 – power generated by the SP: W;
3 – Power generated by an alternative energy source (Wind turbine). The alternative source is connected through external current sensor №1 (Optional).

Page 4 contains information on temperature:

4| PAGE 4

Temperature, °C	
Intrn, +25	AB, +25
1	2

Where:
1 – internal controller temperature;
2 – AB temperature.

When the battery temperature sensor is disconnected, the temperature is set equal to 25 deg. In this case, the absence of a temperature sensor is indicated by a flashing "+25".

Page 5 contains the information on the energy drawn during the last 24 hours:

Note: in 4 hours of the dark period these values will be reset to zero. (They are reset also by “Malina” appliance at 23:59, to avoid them to be counted on next day).

5| PAGE 5

Day energy			
xxx	,	xxx	kW*h
1		2	

Where:
1 – drawn energy kW*h;
2 – drawn energy kW*h (thousands).

The total energy in kWh is calculated as: (number 1) + (number 2) / 1000.

"SETTINGS" MODE

"Settings" mode – is a mode where all device operating parameters are set and all needed calibrations can be done. By selecting that mode, you enter the setting menu which consists of the following submenus:

1. AB settings
2. MAC/BMS/ MPPT connection
3. Factory settings
4. Calibration
5. Display settings
6. Indication
7. Operation modes
8. Source settings
9. Threshold voltages
10. Relay settings

To exit the submenu, you should scroll it to the "Exit" (each submenu has it) and a LONG pressing the button "Select" will confirm the action.
When you change a parameter value, the new value takes effect immediately.
Below you can find the detailed description of each menu section.

1 | "AB SETTINGS"

All data on used AB are in that section.

1.1"Type" – type of used AB, there are 6 options available:
1. "Acid" – Lead-Acid battery with liquid electrolyte;
2. "Gel/AGM" – Gel or standard AGM AB;
3. "AGM-Shoto" – AGM AB produced by "Trojan Shoto";
4. "AcidTrojan" – acid AB produced by "Trojan";
5. "Li-Ion 3.9" – Lithium-ion battery with a voltage of 3.9V per cell;
6. "Li-Ion 3.7" – Lithium-ion battery with a voltage of 3.7V per cell;
Type of input – "Option selection".

1.2. "Capacity" - overall capacity of AB connected in parallel – ampere-hours.

1.3. «The cyclic charge voltage» – maximum AB voltage (V) to be switched over to maintaining AB voltage mode. Type of input – "Numeric".
1.4. "The buffer charge voltage" – voltage (V) of primary charge equalization. Type of input – "Numeric".
1.5. "The charge initial voltage" – voltage (V) below which the controller starts AB charging. Type of input – "Numeric".
1.6. "Maximum charge current" – maximum allowed AB charge current (A). Type of input – "Numeric".
1.7. "Temperature coefficient" – AB voltage temperature coefficient, in mV per cell. Type of input – "Numeric".

ATTENTION! For Li-Ion AB charge at subzero temperatures is prohibited!!!

To charge alkaline batteries by means of MPPT Pro controller you must do the following:

1. Select the required AB voltage (12, 24, 48, 96) V.
2. 2. Calculate the required number of cells in series connection (Nc) to achieve the required AB voltage.
For example, for KGL cell type the charge voltage is 1,44 V at 25C (degrees Celsius). In that case the number of cells in series connection (Nc) will be equal to 10, and cycle charge voltage will be 14,44 V.
3. Set in the controller AB type – “Acid”.
4. Set the cyclic charge voltage manually.
5. Set the real AB system capacity.
6. Set the cyclic charging rate manually equal to 0,2C. For systems of more than 500 Ah capacity the value of the cycle charge current is limited by 99A.
7. Calculate the temperature coefficient by multiplying the temperature coefficient from alkaline batteries passport by Nc and divide it by K, where K is:

 6 – for 12V system;
 12 – for 24V system;
 24 – for 48V system;
 48 – for 96V system;

8. You should set in the controller the nearest integer value of the temperature coefficient.

2| “MAC/BMS/MPPT CONNECTION“

This submenu contains all necessary settings for other devices connection for a complex system.
7 choices for complex system are available:

1. Controller+MAC;
2. Multiple controllers+MAC;
3. Controller+MAC+BMS;
4. Multiple controllers+MAC+BMS;
5. Controller+BMS;
6. Multiple controllers;
7. Multiple controllers+BMS.

When you have a MAC in the system (options 1 and 2), the Controller (or all controllers - if there is a number of them) should be set in “Slave/MAC” mode.
For the system without MAC but with BMS (option 5) the Controller should be set as “Master MPPT+BMS”.
For the system without MAC and with a number of controllers (option 4) – one of the Controllers should be set as “Master MPPT”, the others – as “Slave/MAC”.
For the system without MAC and with a number of controllers plus BMS (option 3) – one of the Controllers should be set as “Master MPPT+BMS”, the others – as “Slave/MAC”.

To interconnect the devices, you need to use 6-core flat cables both sides terminated by RJ12 jack plugs according to the scheme of direct connection Pin-to-Pin.

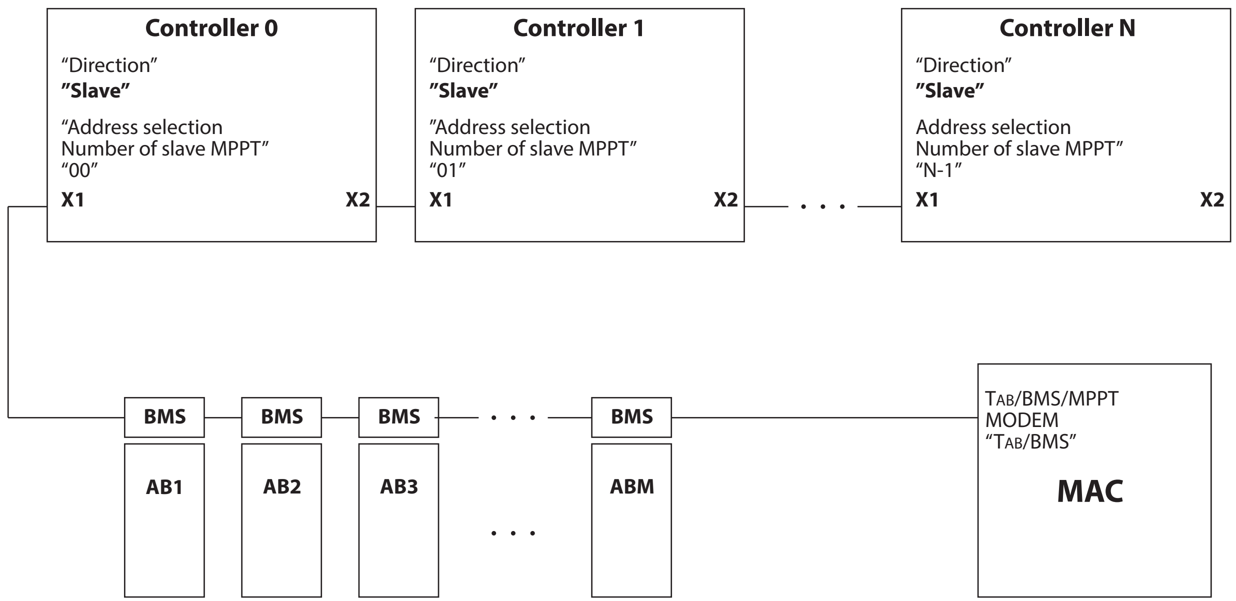
2.1. **"DIRECTION"** – a selection of MAC, BMS and other MPPT connection:

1. **"Slave"** – connection to MAC in "Slave" mode.
This connection mode can be used either for Controller working with MAC or without MAC but in the group of controllers operating in parallel for one AB pack. In this mode, all three switches "P G R" should be in OFF position.
2. **"Master MPPT"** – connection to the other controllers in "Master" mode.
This connection mode serves for the Controller operating without MAC in a group of several Controllers connected in parallel to one AB pack. This mode must be set only for one Controller.
In this mode, all three switches "P G R" should be in ON position.
3. **"Master MPPT+BMS"** – the connection with other Controllers and BMS in "Master" mode.
This connection mode serves for either Controller operating without MAC or its operating in a group of several Controllers in parallel connection without MAC to one AB pack with a BMS system. Only one controller can be set in this mode. For this mode, all three switches "P G R" should be in ON position.

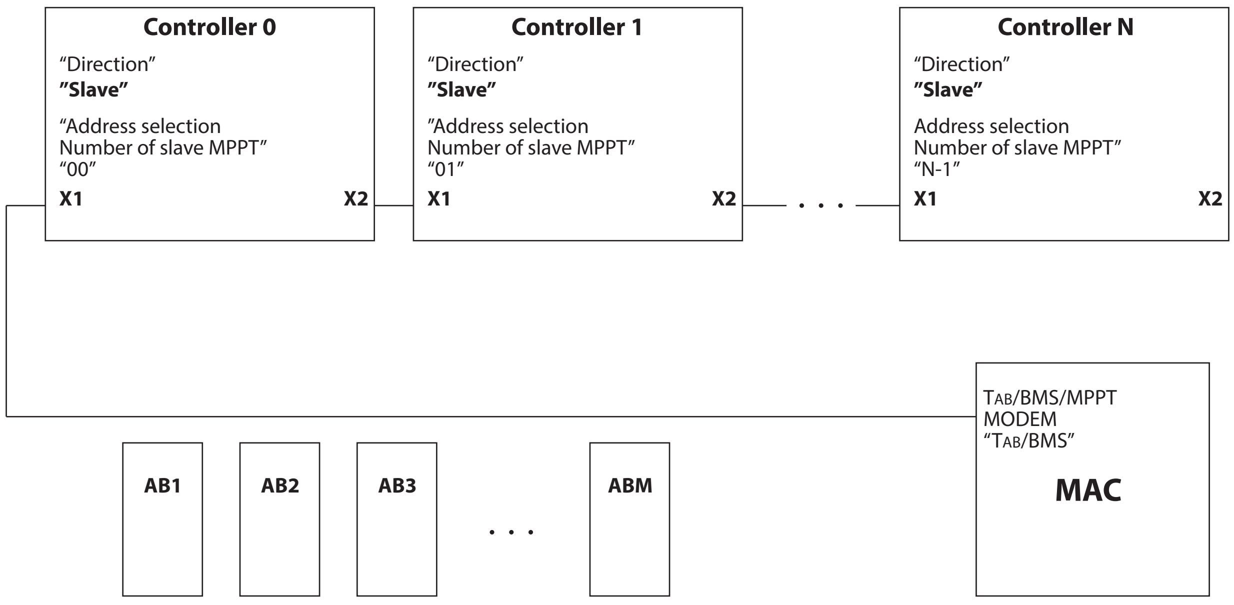
2. 2. **"ADDRESS SELECTION/NUMBER OF SLAVE MPPT"** – number of controllers operating in parallel for one AB pack.

For the slave device, the number which is set here represents its address.
For master device – the total number of controllers in the system minus one. Therefore, the combination of "Master MPPT" with zeroed "Address selection/Number of slave MPPT" is incorrect. Type of input - "Numeric".

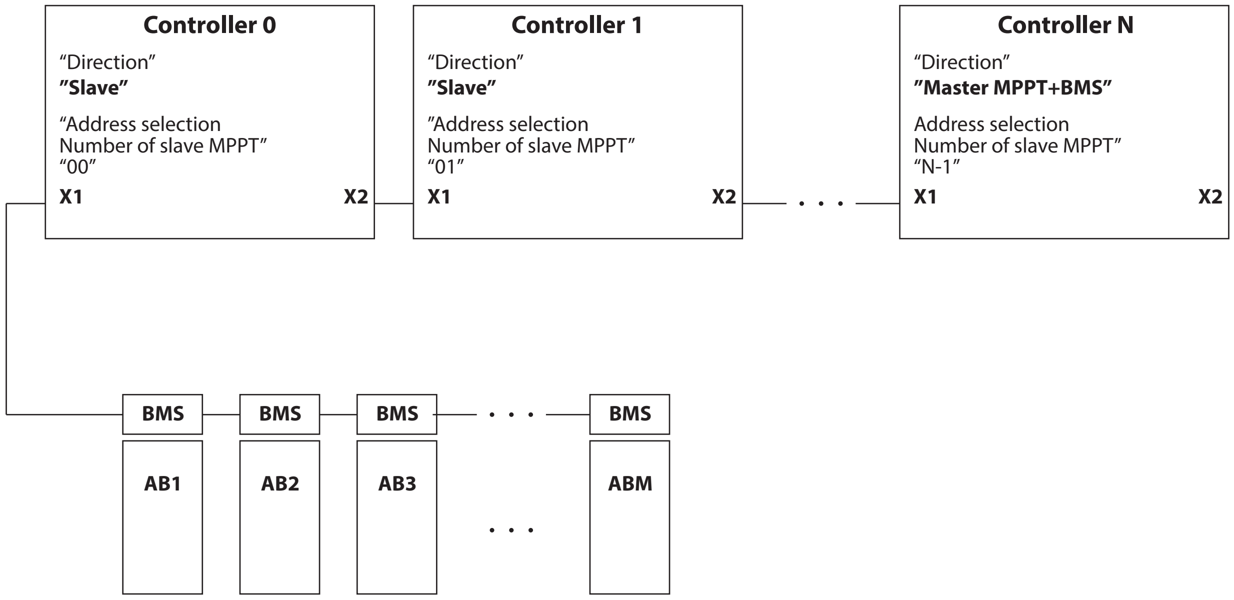
The order of connections and required settings are shown in the pictures 1-5.



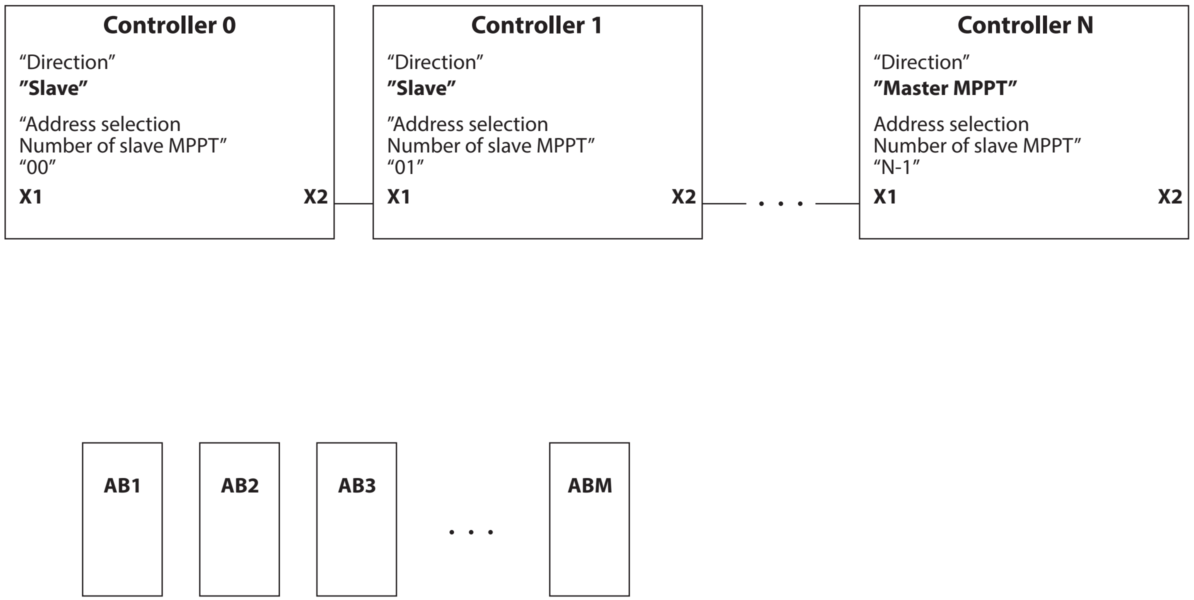
Pic.1. Scheme of the system "Multiple Controllers + MAC+ BMS".



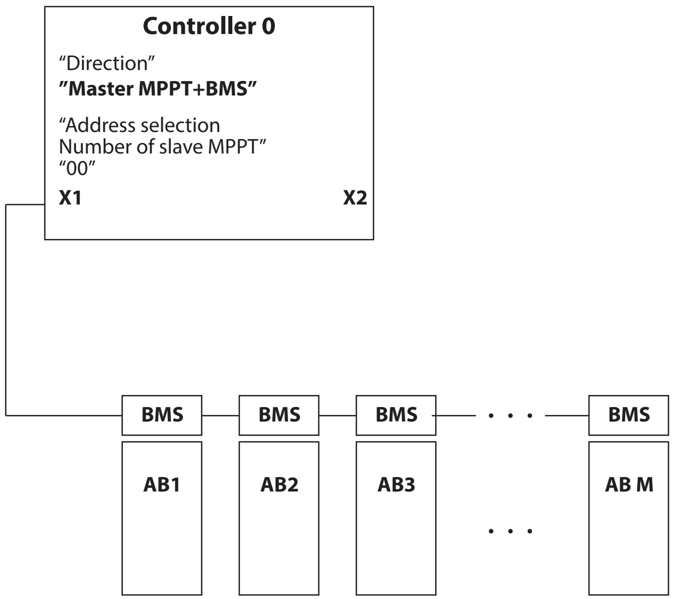
Pic. 2 . Scheme of the system "Multiple Controllers + MAC".



Pic. 3. Scheme of the system "Multiple Controllers + BMS".



Pic. 4. Scheme of the system "Multiple Controllers".



Pic. 5. Scheme of the system "Controller + BMS".

ATTENTION!
1. For the system with multiple Controllers all the AB settings should be the same for all Controllers!
2. Each controller must be connected to its own AB temperature sensor!
3. Each controller must be connected to its own, independent array of Solar Panels!
4. The connection of Controllers inputs in parallel (with one SP array) is not allowed!

For the correct operation of the Controller with MAC please make the following MAC settings:
1. "FuelGenerator/BMS MPPT" -> "BMS / MPPT" item "MPPT (C)mART " (or "BMS+MPPT (C)mART", in case there is also BMS (C)mART in the system).
2. "FuelGenerator/BMS MPPT" -> "NumberConnected MPPT" – set the number of connected in parallel MPPT.

ATTENTION! The firmware version of MAC should be at least 21.0! We strongly recommend to update the firmware to the latest version before commissioning.

3 | "FACTORY DEFAULTS"

This subsection contains the following items:

3.1. **"Settings reset".** Reset the device to the factory defaults.
3.2. **"Firmware version".** The version of controller firmware.

4 | "CALIBRATION"

This section is described in detail in Appendix №2.

5 | "DISPLAY SETTINGS"

5.1. **"Creeping line speed"**. Selection of creeping line speed. Type of input – "Scale".
5.2. **"Backlit brightness"**. Selection of required brightness of the backlit. Type of input – "Scale".
5.3. **"Backlit delay"**. Selection of delay time in seconds when the backlit is active from the moment of its activation by any button. Can be set from 1 to 98 seconds. If you set "99" the backlit will be active permanently. Type of input – "Numeric".
5.4. **"Display time"**. Selection of the delay time for one of four pages displaying the running parameters in automatic mode (see the section "Display"). Possible range is from 0 to 99 seconds.

6| "INDICATION"

In this section, the user can set the most convenient indication mode of the controller current operational data. All displayed parameters are divided into 5 pages. Each page can be set in one of three conditions:

"**Auto"** – The page is changing automatically to another which was also set as ("Auto") in a period set via section 5.4 "Display time";
"Manual" – The page is scrolled manually by pressing the " →↓" ("Down") / "←↑" ("Up") button;
"Off" – the page is not displayed;
Type of input – "Option selection".

7| "OPERATING MODES"

7.1. **"MPP search"**. A choice between two Maximum power point searching modes – manual and automatic. The main mode is "Automatic". 'Manual" mode is used for diagnostics and troubleshooting in the system "SP-Controller-AB", and it is intended for experienced users and service center engineers. Operation in the "Manual" mode is described in Appendix № 1.
Type of input – "Option selection".
7.2. **"Type of stabilization"**. This point is reserved for the future applications.
7.3. **"Scanning period"**. The time interval in minutes between two scannings of SP condition which is set to avoid of been stuck at the local maximum power point. The recommended range is from 2 to 10 minutes.
Type of input – "Numeric".
7.4. **"Parallel connection"**. The number of controllers that are connected in parallel to one AB array.
Type of input – "Numeric".
7.5. **"Source type".** Energy source type selection: "SUN" - solar panels, "WIND" - the source is a wind turbine output (needs Block 2 additionally installed for wind turbine control).

8| "SOURCE SETTINGS"

This section contains all necessary data on used SP and its configurations (Panels array).

8.1. **"Number of panels in series"**. The number of panels connected in series. Type of input – "Numeric".
8.2. **"Number of panels in parallel"**. The number of panels connected in parallel. Type of input – "Numeric".
8.3. **"Short-circuit current "**. Short-circuit current of one SP (mentioned in SP technical specifications). Type of input – "Numeric".
8.4. **"OC Voltage"**. Open circuit voltage of one SP (mentioned in SP technical specifications). Type of input – "Numeric".
8.5. **"MPP voltage"**. Voltage at the Maximum power point of one SP (mentioned in SP specifications). Type of input – "Numeric".
8.6. **"MPP current"**. Current of one SP at the Maximum power point (mentioned in SP specification). Type of input – "Numeric".

9 "THRESHOLD VOLTAGES"

In this subsection, the user can set SP power thresholds or AB voltage at which the built-in relays are switched ON/OFF. Each relay is rated at 16A/220 V, i.e. For the load below 3.5 kW.

Details of the relay operating at SP power excess.

The power excess means that SP can produce more power than is being drawn now. For example, if you have panels of 800W power in total (like an array of 2x2 and of 200W each) and only 200W are taken by the AB (by the load) during the maximum solar activity this means that power excess is 800-200=600W. Controller calculates the available instant SP power depending on insolation and position of the Sun. This available power may not be used if AB are full or the load is not enough. In this case relays help to use this energy.

Important: in case of work according to SP power the relays by default operate according to their number. It means, that at the beginning, the first relay #1 will draw all the SP power excess according to menu presets. If more additional SP power is available the second relay will start operating within its preset power limits. If we still have a power excess – 3rd relay will switch on.

As well any of the relays can be used not only for the load connection but in case of equipment failure ("Error"). In this case, the relay pins can be connected to the security alarm systems to notify remotely about the problems occurred: for more details, see "Relay Settings".
It should also be considered that relay can be programmed for both direct and inverse starting.
It means the following:
a) When the turn-on voltage is set to be higher than the turn-off voltage, the relay trips (starts consuming a current) at the current voltage higher than the turn-on voltage, but switches off (stops consuming a current) when the current voltage is lower than the turn-off voltage.
b) When the turn-on voltage is set to be lower than the turn-off voltage, the relay trips (starts consuming a current) at the current voltage lower than the turn-on voltage, but switches off (stops consuming a current) when the current voltage is higher than the turn-off voltage.
The choice of the relay switching mode (direct / inverse) allows to configure the system optimally in terms of reducing the controller current consumption during the absence of energy coming from SP.

9.1. **"AB voltage ON"**. The AB Voltage for the relay switching on.
Type of input – "Numeric".
9.2. **"AB voltage OFF".** The AB Voltage for the relay switching off.
Type of input – "Numeric".
9.3. **"SP1 power ON"**. The SP power excess for relay # 1 is switching on.
Type of input – "Numeric".
9.4. **"SP2 power ON "**. The SP power excess for relay # 2 is switching on.
Type of input – "Numeric".
9.5. **"SP3 power ON"**. The SP power excess for relay # 3 is switching on.
Type of input – "Numeric".
9.6. **"Eco mode".** This mode is used when the relay is programmed to be switched on at power excess and for the cooperation of controller and MAC. While operating without MAC, a relay is switched ON/OFF only at SP power excess/shortage.

In case of Controller and MAC are connected via special cable and all required settings have been done then the Relay state will also be depended on MAC operating mode.

In MAC modes "Charge" and "Network transmitting" the relays are switched on when the "Eco mode" is activated, and Off if "Eco mode" is disabled. In other words, the relays connect the load if AC grid is available and disconnect when there is no grid. In this case there is no sense in savings as an excess/shortage of SP power doesn't affect a grid power consumption.

For the MAC "Hybrid" models in "Charge" and "Network transmitting" modes and with Eco mode activated ("power addition" mode):
– For enabled **"Eco mode"** a relay operation depends only on excess/shortage of SP power.
– For disabled **"Eco mode"** the relays are switched on. In this case savings are done by the reduction of power consumption from the grid due the power addition to the load at SP power excess.
In MAC "Generation" mode a relay switching On/Off depends only on excess/shortage of the SP power.
Type of input – "Option selection".

10| "RELAY SETTINGS"

In this subsection, the User can set the conditions when each of 3 relays is triggered:

10.1. **"Off".** The relay is always off;
10.2. **"Error".** The relay is triggered when an emergency occurs:

— SP voltage is higher than the permissible;
— AB voltage is higher than the permissible (recharge);
— AB voltage is lower than the permissible (full discharge);
— AB array short circuit;
— AB overheating; (T> 60°C).

10.3. **"AB voltage".** Relay is triggered according to AB voltage preset is in the section 10.4. "Threshold voltages".
10.4. **"Threshold voltages".** The firmware of the version 6.1 and higher allows to control the delay of relay triggering at power excess.
The address EEPROM 0x0083 stores the values when the triggering delay is activated, and the address EEPROM 0x0087 stores values of switching off delay. Each delay unity is equal to 30 seconds. For example, if the address 0x0083 contains the value '3' and address 0x0087 the value '8' then the switching on delay will be 3*30=90 seconds and off - 8*30=240 seconds (4 minutes).
You can read and change the values of above mentioned cells using the "Loader" software (see Appendix № 3).
10.5. **"External Cooler".** The relay is triggered at temperature excess above 50°C inside the body. Return of the relay to the initial state occurs when the temperature inside the body drops to 40 ° C. This option allows to use an external cooler for operating in high-temperature environments. This option is available only for firmware version 6.1. and higher.

1 APPENDIX №1. MANUAL OPERATING MODE.

When the Manual mode (hereinafter MM) is activated, the additional (sixth) page appears in the "Indication" subsection:

1	2		3
P W	M m	/	I p A
U p B		/	P W
4			5

1 – Manual Mode indicator;
2 – (pulse-width modulation) PWM depth (see below);
3 – SP current, A;
4 – SP voltage, V;
5 – power generated by the SP.

You can change the indication from the additional sixth to the main five pages mode and back as follows: while holding the "SELECT" button, press the "Right / Down" button for a long time (0.5 to 2 seconds).

There is an additional parameter in the Manual mode: PWM depth.
This parameter can be changed from 1 to 999.
The value 1 corresponds to the complete SP disconnection from AB (open SP loop).
The value 999 is equal to complete SP connection to AB (SP voltage is equal to AB voltage). When changing the PWM parameter, it should be considered that the controller's internal protection also operates in Manual mode. This means when SP voltage is less than AB voltage plus 1V the controller switches off and resets a PWM value.
The PWM parameter can only be changed in the fifth additional page in "Display" mode.

It can be done as follows:

Increasing the PWM-value by units – short pressing (less than 0.5 seconds) "Right / Down" button;
Reducing the PWM-value by units – short pressing (less than 0.5 sec) "Left / Up" button;
Increasing the PWM-value by tens – long pressing (0.5 ... 2 seconds) "Right / Down" button;
Reducing the PWM-value by tens – long pressing (0.5 ... 2 seconds) "Left / Up" button;
Increasing the PWM-value by hundreds – pressing and holding the "Left / Up" button, short (less than 0.5 seconds) pressing the "Right / Down" button;
Reducing the PWM-value by hundreds – pressing and holding the "Right / Down" button short (less than 0.5 sec) pressing the "Left /Up" button.

2 APPENDIX №2. EXTERNAL CURRENT SENSORS. CONNECTION AND CALIBRATION.

ATTENTION! Strictly follow the polarity of an external sensor connection: charging current should have "+" sign and discharging current a "-" sign! Violation of this requirement can lead to the AB failure or even to its destruction!

ATTENTION! Calibration of external current sensors is possible only if the battery is connected and SP current is at least 5A!

Calibration procedure:

1. Please connect one ECS to the controller as shown in Pic. 4, by inserting the ECS connector into the corresponding seat of the controller.

2. Without turning off the controller, carefully disconnect one of two cables coming from the SP array ("+ SP" or "- SP") and thread the wire through the ECS hole. For high-current ECS (from 100A and over), to improve the accuracy of current measurement, it is desirable to make several turns (from 2 to 4). Reconnect the cable back to the Controller. The larger number of turns is, the higher is a measurement accuracy.

ATTENTION! Voltage on the panels can be dangerous for life!
Be careful: arc discharge and spark are possible!

3. Enter the "Calibration" subsection. The following message appears on the LCD screen:

Calibration	
CS	WT

By a short pressing the right button (in this case it is the one which is located under the text you want to select) select the calibration target:

CS – Current sensor;
WT – wind turbine revolutions speed sensor.

The current sensor calibration algorithm is given here and below. The calibration algorithm of wind turbine revolutions speed sensor is given in Appendix № 4

Select sensor	
1	2

By a short pressing the appropriate button (in this case the one which is located under the number you want to select) chose the sensor.

4. Put the number of turns:

Number Turns
> 1

Type of input – "Numeric".

5. Calibration (consists of 2 stages) will start and the following message appears on the LCD:

CS xx.xx A
Wait*

The calibration process is accompanied by intermittent sound signal.
In case the SP current doesn't reach 5 A, the message appears:

Calibration
Impossible!

In this case, you need to exit the subsection and repeat the steps from step 3.

6. At the end of the 1st stage, the beep stops and the message should appear on the LCD:

Cange
Polarity!

7. Disconnect the ECS cable and change ECS polarity (make the turns in the opposite direction). Reconnect the SP to the Controller with the cable once again.

8. When the calibration is complete, the following message appears on the LCD:

Done
1 0 1 0 0 F F A 6 3 0 4 6 F 0 4

The bottom row of the message shows the coefficients for calculation ECS real current in hexadecimal format.

9. Disconnect the ECS from the SP array (then reconnect the SP cable back to the controller) and connect it to the required conductor following the polarity:
«–» ECS №1 to "+" battery – this sensor is connected to "+" of a wind turbine;
«+» ECS №2 to "+" battery – this sensor is connected to "+" of an inverter.

10. Exit the menu to the “Display” mode. Select page 2 for information on the currents measured with external current sensors, make sure that a displayed information is correct and a polarity is set in a right way. Calibration is complete.

ATTENTION! For multiple controllers in parallel connection all ECS should be put on the one cable running from AB to the Inverter.

3 APPENDIX №3. FIRMWARE UPDATE

The user may update the controller firmware (hereinafter referred to as FW). For that on the website http://www.invertor.ru in the section of technical support-> firmware and manuals you can find and download required FW (a loader and FW for the controller – "Firmware"). As well you can find there a description of the necessary equipment and all necessary steps.

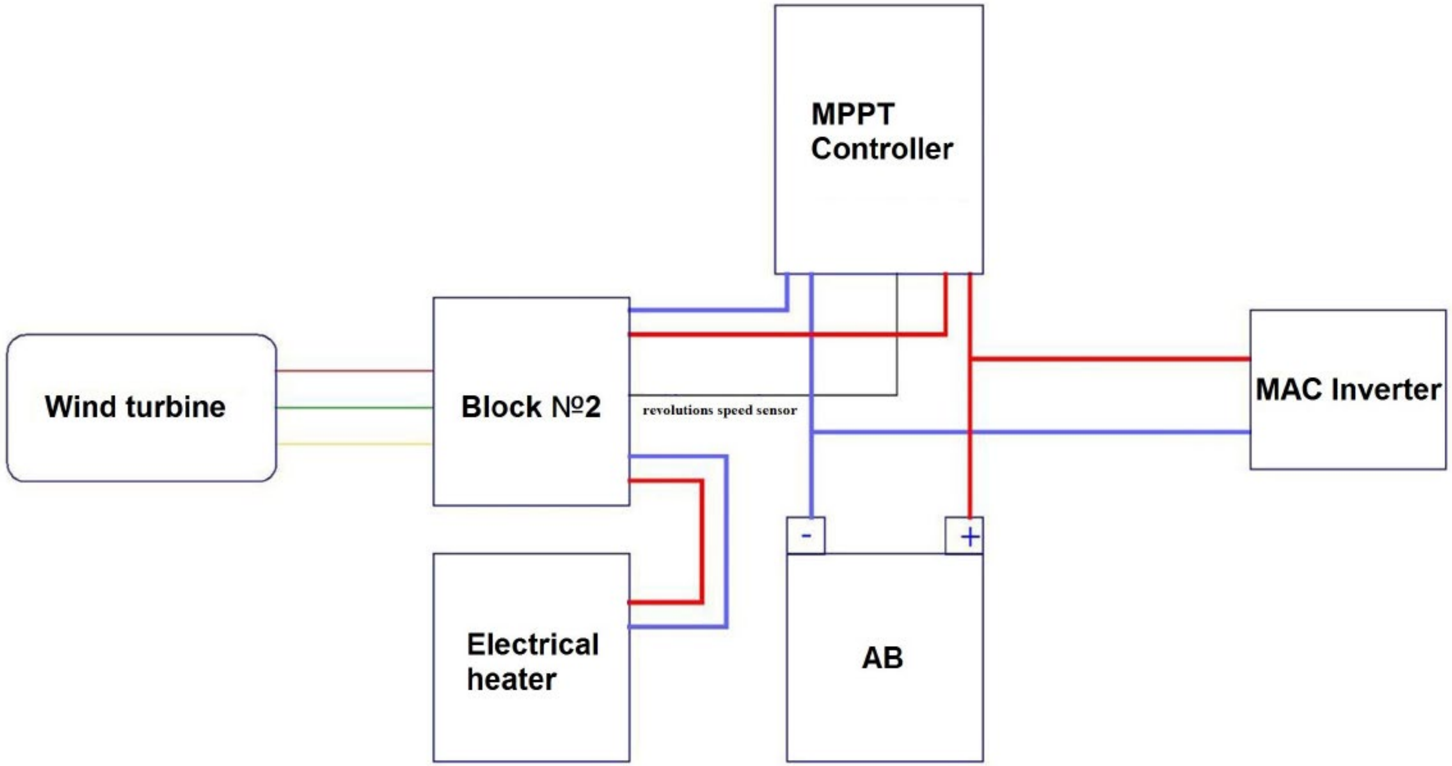
ATTENTION! Before upgrading the firmware, you should disconnect the Controller from everything but the AB and computer. The battery should be at least 80% charged!

4 APPENDIX №4. CONTROLLER OPERATING WITH WIND TURBINE

ATTENTION! Operation of the Controller with Wind Turbine is possible only with the use of additional block №2!

The main difference between the wind turbine (hereinafter referred to as WT) and the SP as the energy source is that during a strong wind and absence of the load the output voltage increases significantly same as WT rotor speed. The voltage increase can cause the controller damage and the increase of rotor speed leads to damage of the WT. To avoid undesirable consequences, you should install the additional Block No. 2 between the WT and the Controller. The purpose of this unit is to control the voltage and WT speed – in case the output voltage (revolutions) achieve(s) the dangerous values, the Block No. 2 connects an additional load in the form of heating elements (electrical heater), which decreases both the output voltage and Wind Turbine revolutions speed (WT deceleration).

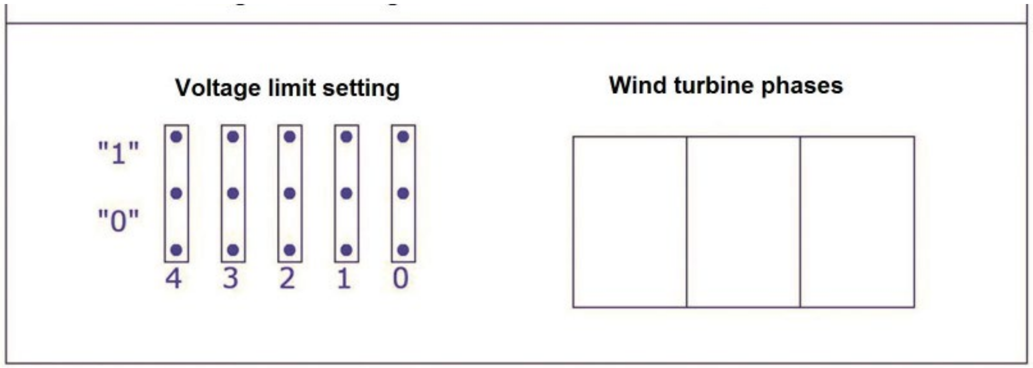
The wire diagram of Wind turbine and Controller connection is shown in picture:



1. FEATURES OF CONTROLLER OPERATING WITH WIND TURBINE

Before WT mounting on the tower please assemble the circuit according to the picture above. Besides power connections it is required to connect "Revolutions speed sensor" connectors of the controller to the Block No 2 via the signal cable.

Please set the voltage limit in the Block No 2 required by your WT. The voltage limit has a range 85...180V. To set the required voltage use the jumpers on the top of the Block No2.



Jumper4	Jumper3	Jumper2	Jumper1	Jumper0	K	The Voltage limit
0	0	0	0	0	0	85 V
0	0	0	0	1	1	88 V
0	0	0	1	0	2	91 V
0	0	0	1	1	3	94 V
0	0	1	0	0	4	97 V
0	0	1	0	1	5	100 V
0	0	1	1	0	6	103 V
0	0	1	1	1	7	106 V
0	1	0	0	0	8	109 V
0	1	0	0	1	9	112 V
0	1	0	1	0	10	116 V
0	1	0	1	1	11	119 V
0	1	1	0	0	12	122 V
0	1	1	0	1	13	125 V
0	1	1	1	0	14	128 V
0	1	1	1	1	15	131 V
1	0	0	0	0	16	134 V
1	0	0	0	1	17	137 V
1	0	0	1	0	18	140 V
1	0	0	1	1	19	143 V
1	0	1	0	0	20	146 V
1	0	1	0	1	21	149 V
1	0	1	1	0	22	152 V
1	0	1	1	1	23	155 V
1	1	0	0	0	24	158 V
1	1	0	0	1	25	161 V
1	1	0	1	0	26	164 V
1	1	0	1	1	27	168 V
1	1	1	0	0	28	171 V
1	1	1	0	1	29	174 V
1	1	1	1	0	30	177 V
1	1	1	1	1	31	180 V

Voltage Limit is calculated as:

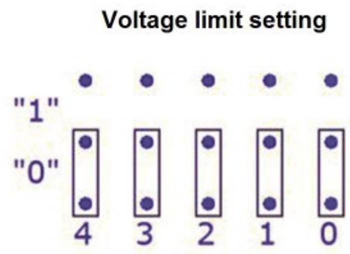
Ulim= 85 + 3 * K;
Where K is the number from 0 to 31, set by jumper 0 ... 4 in binary format.

The table of correspondence for jumpers position, K value and preset voltage limit is given on the left.

The Voltage limit is specified approximately with inaccuracy +/- 1V.

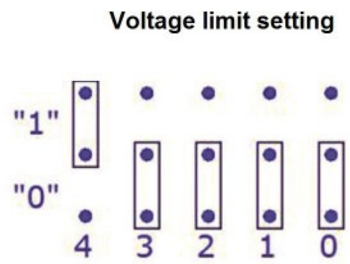
As for an example, below you can see the picture of three options of jumpers position.

A



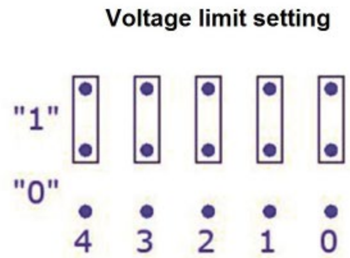
Option A.
Voltage limit is 85 V;

B



Option B.
Voltage limit is 134 V;

C



Option C.
Voltage limit is 180 V.

2. USER SETTINGS OF THE CONTROLLER FOR OPERATING WITH WIND TURBINE

Select "Wind" in the menu "Operating Modes" submenu "Type of Source". After that go to the menu "Settings" submenu "Source Settings" where WT parameters will be available for editing:

"RPM to start"- WT rpm when the power takeoff starts.
"RPM to stop" - WT rpm when the power takeoff stops.

The WT speed and its generated voltage are closely connected: the higher revolution rate is, the higher voltage is. The “RPM to start” as well as the “RPM to stop” should be set in accordance with the appropriate voltage. On the one hand, the “RPM to stop” should be set so that the WT voltage would be not lower than the AB voltage. On the other hand, the “RPM to start” should be set so that the WT voltage doesn't exceed the voltage limit. It is possible to set these values experimentally.

Before setting the RPM to start/stop please make the revolutions speed sensor calibration. For that, proceed as follows:

Enter the "Calibration" submenu. The following message appears on the LCD:

Calibration	
CS	WT

Select the calibration target by a short pressing the corresponded button (in this case it is the one that is located under the text you want to select).
(CS - Current sensor; WT – wind turbine revolutions speed sensor).

The following message appears:

Multiplier Hz/rev
> 0

Make 4 turns of the WT rotor. The revolutions should be done with enough accuracy for that it is desirable to use a lever and some mark of the beginning/end of a turn. The value in the second row should change.

Multiplier Hz/rev
> 8

The number in the second row must be even! If an odd number appears during the calibration, wait more than 5 seconds and repeat the rotation.
Please make sure the multiplier is correct and write it into the memory of the controller by pressing the "Select" button.

After all the mentioned above steps are done you can mount WT on the tower, set all required parameters of the AB and other parameters (see the main part of the Manual). After that the system is ready for operating.

The indication of the current WT speed appears on page 3 in the upper left corner:

w 0000	Pout	0 W
Pin	0 W	/ 0 W

In other respects, it makes not differ from the operating with the Solar Panels.

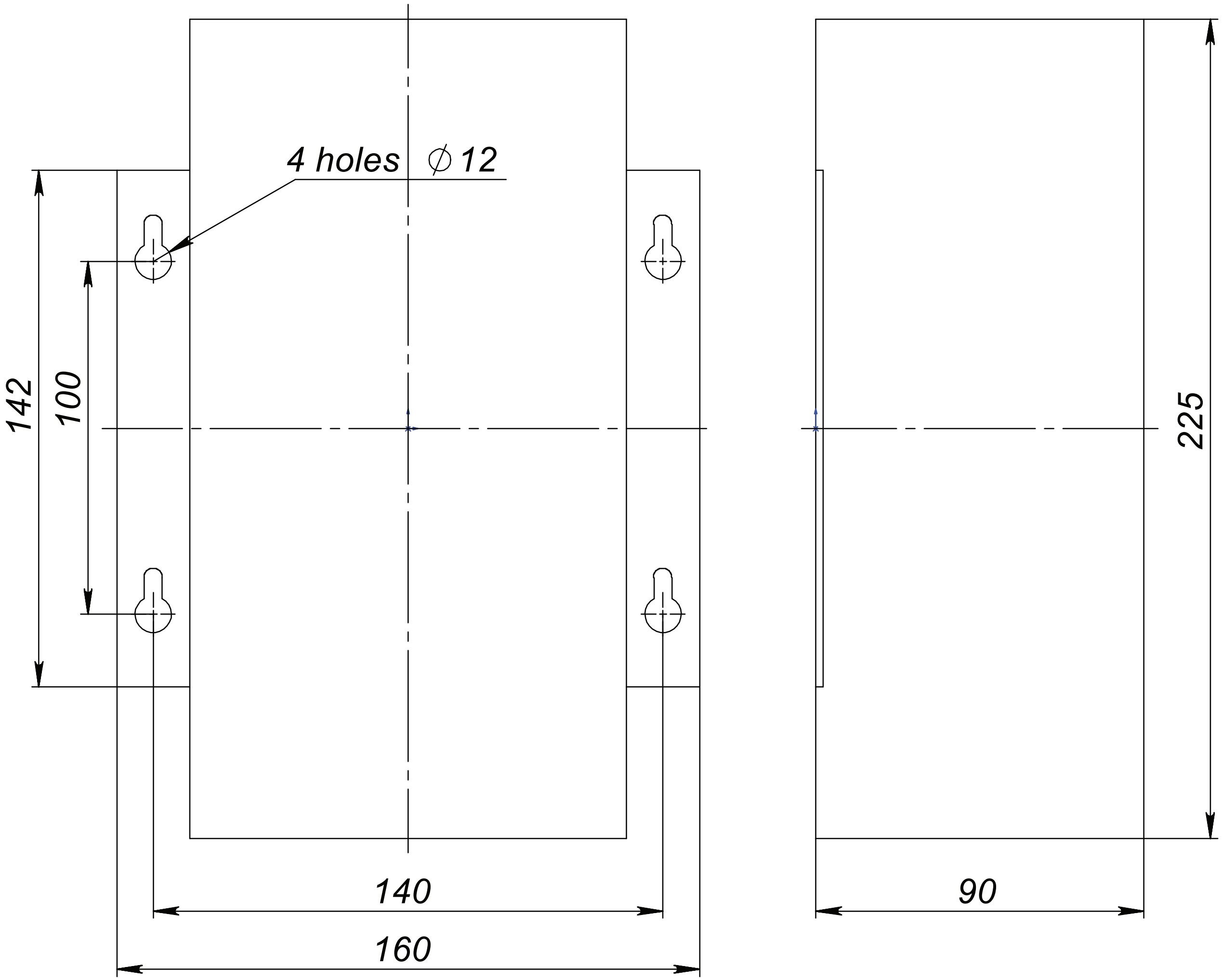
3. TECHNICAL SPECIFICATIONS

Max power, kW	1,5; 3; 4; 5
Max voltage, V	200
Efficiency	98%
Dimensions (HxDxW) except Block 2 and electrical heater, cm	35x12x21
Block 2 dimensions (HxDxW) , cm	23x10x15.5
Electrical heater dimensions (HxDxW) , cm	52x10.5x13
Weight (except block 2 and electrical heater), kg	5.00
Block 2 weight, kg	3.00
Electrical heater weight	1-1,5: 1,5kg / 2-3: 2kg/ 3-4: 2,5kg / 5: 3,5 kg
Cooling	Natural
Humidity (without condensate)	95%
Terminals size	$35mm^2$ / AWG2
Box material, color	Aluminum/ steel
Protection class	IP20
Installation	Vertical wall mounting

4. OVERALL AND MOUNTING DIMENSIONS OF THE CONTROLLER COMPONENTS

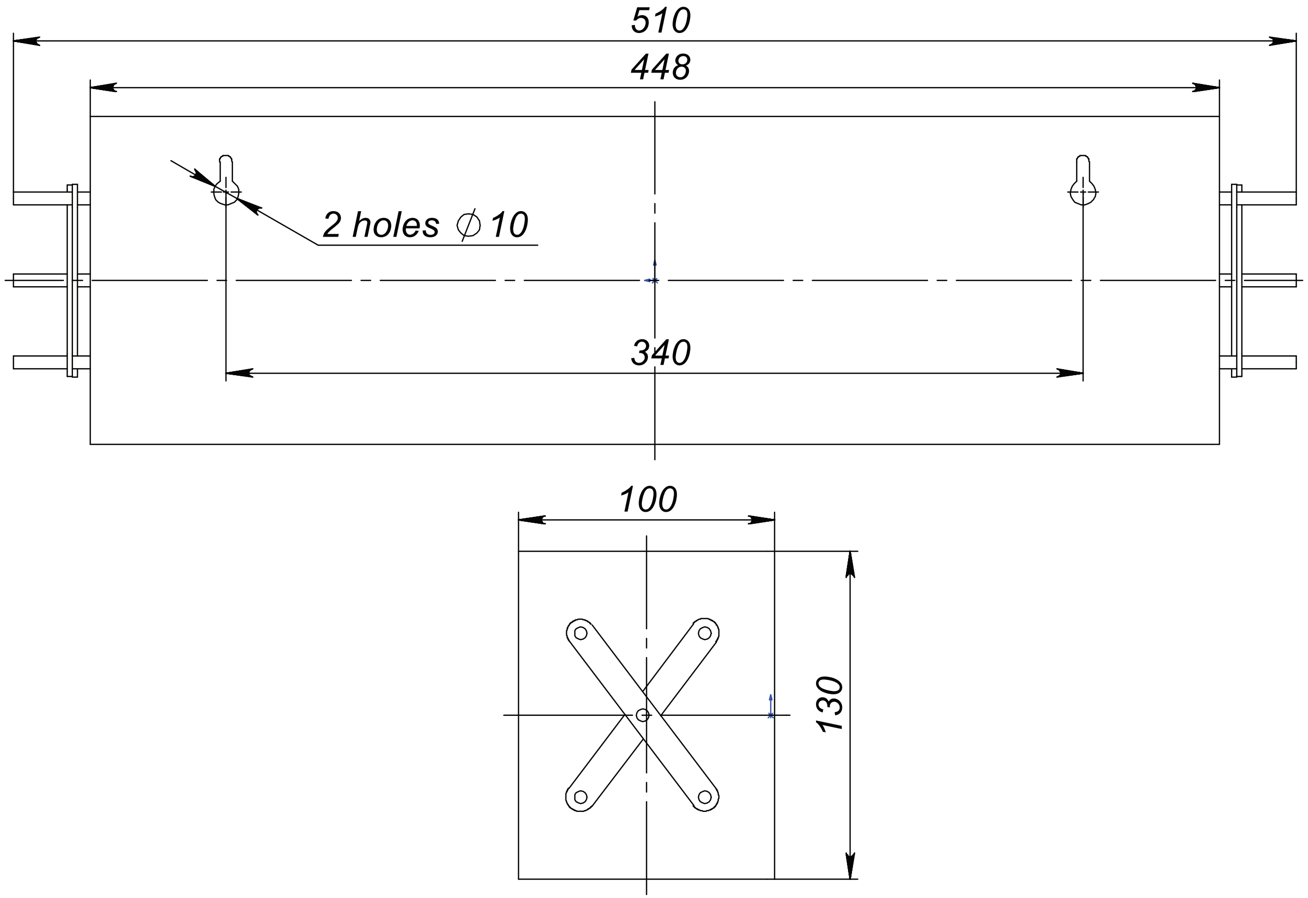
The controller is wall-mounted. Installation should be done on a vertical surface (wall) with a free space of at least 15 cm from the sides and at least 25 cm from the top. Otherwise, it is possible to increase the heating of the controller and therefore reduce the generated power.

To mount the product please fix 4 screws of proper size in the wall, in accordance with the drawings and fix the product on them.



Block No2.

ATTENTION! The height of each screwed screw from the wall surface should be no more than 5-6 mm, otherwise the controller internal components may be damaged.



Electrical heater block.

5 APPENDIX №5. GENERAL RECOMMENDATIONS FOR OPERATION AND CONNECTION OF THE CONTROLLER, SP AND OTHER EQUIPMENT

1. For a minimum comfort in a country house on the latitude of central Russia region, SP total capacity should not be less than 600 W, for example: 3 solar panels of 24V 200W. And it is better to install SP from 1000 to 2000W for seasonal use. But for the whole of autumn/winter period the SP power should start from 2000W, but better from 4000W.

2. It is necessary to create the conditions when the solar panels work partially on the cloudy weather. To make it possible please connect SP in the way when their total voltage is high enough. For example: 3 panels (24V each) in series connection, or, better, 4 panels in series connection. The controller MPPT SEC DOMINATOR 200\100 allows to make it (in this case it is possible without a load as the controller operates at input voltages up to 200V). The controller MPPT SEC DOMINATOR 250\60 can withstand even greater voltage, - it allows to connect in series up to 5 solar panels with the nominal voltage of 24V each.

But it should be noted that the maximum SP idling voltage at the controller input should not exceed 200V/250V (open circuit voltage without load) in any weather conditions. Watch this restriction especially when placing the system in the environments of high solar activity and low temperatures. Approximately, the open-circuit voltage increases at -30°C by 20-25%, i.e. the solar panel with 45 V open circuit voltage at + 25°C, will generate 55V at -30°C.

As a result, even when SP are in a cloud shadow they will give enough voltage for AB charge. For sure the controller can operate with any AB at its output (12V, 24V, 48V, 96V) – the optimal one is 48 V, especially when the most efficient wind turbines are usually designed for this voltage.

Also, the solar controller power depends on the current that it can provide. It means that when the controller is designed for 100A is connected to the 24V battery, then it can produce power up to 100A * 24V = 2.4kW. If the same controller model on 100A is used in a 48V system, then it gives 4.8kW. The further SP array voltage increase (300V and more) is usually impractical, because it leads to a significant efficiency reduction, as well the installation of SP is becoming more dangerous. Even 150V DC voltage is life-threatening and requires the fulfilling safety precautions carefully when installing panels and connecting them to the controller.

If even more power is required the SP chains should be connected in parallel.

3. In the central part of Russia and norther for the year-round use it is reasonable to mount the SP vertically (or almost vertically, for example at an angle 70°) and preferably with a partial orientation along the cardinal directions (for example, half of the panels should be turned 30° to the south-east, and another half 30° to the south-west). It is possible to place them on the sides of the house, on the facade if you can (it is unnecessary to strictly observe the mentioned angles).

Vertical orientation is good for snowy winters (and in general it is good for SP lifetime which becomes almost endless, as well as it helps to keep SP clean and therefore gives more efficiency). The orientation of the panels along the cardinal directions is desirable for the full autonomy. This allows to prolong the duration of energy intake during daylight hours (it gives an opportunity to use more energy without AB discharge as well AB are charged more carefully as long trickle charge is required). If SP are oriented differently in the mentioned above way then they must be connected through 2 solar controllers or to one solar controller, but each of the differently directed groups should be connected through its own blocking diode of the relevant nominal.

The overall energy production by vertical panels oriented along the cardinal directions will be slightly less than from the ones with southern orientation with the optimal angle for particular time of year in a particular latitude. However, this energy surplus exists only for 2-3 hours a day, i.e. when there is enough energy and when there is nowhere to use it (in case of non-use of the additional relays).

The monocrystalline SP are the best in terms of efficiency and durability. But they are slightly more expensive than polycrystalline ones. Black mono-panels are even more expensive (inter-cell gaps filling is black; the aluminum frame is also anodized in black). It would seem that this beauty leads to SP overheating and therefore to a certain drop in its efficiency (a part in total efficiency percent). Nevertheless, there is usually an energy surplus in a bright sun, however in the autumn-winter period black panels are much better at self-cleaning from snow and icing.

An air gap of 5 to 10 cm should be left to provide a natural ventilation between the panels and the base (the panels, for example, can be fixed by the aluminum corners, which are screwed to the base through struts with aluminum tubes 5 to 10 cm long).

4. Perhaps, you have already solved how to "prolong" the daylight hours (by placing SP differently along the cardinal directions), you have provided the energy arrival even in cloudy weather (by connecting the SP in series in high voltage strings). And after that you have to think how to make the main energy consumers operate during the day and leave a small amount of electrical equipment (LED lamps, TV, computer, etc.) for evening and night to avoid AB discharge, which makes batteries serve for years (of course, much depends on the AB design). It is clear that is better to start washing from 12 o'clock in the afternoon and vacuum around the same time. But some things can be automated, which is extremely important.

For example, it is necessary to connect such energy-consuming devices as a boiler to the autonomous 220V electrical power supply during the daytime with solar activity (or when the battery voltage is still high, i.e., they are not very low). As its tank has an inside thick layer of thermo-insulation and therefore can keep the heat for a very long time (until late at night, at least). It is also convenient for the air conditioner to be turned on during the day.

The automatic connection/disconnection of the refrigerator to the autonomous electrical power supply system is even more important. At first sight, it seems that the refrigerator consumes just a little of energy – 150W only (but on start can be up to 1.5kW). However, the refrigerator is running almost the whole day round and as a result it becomes one of the biggest energy consumers. Besides, it works during the night what leads to AB discharge and as a result very fast loss of its capacity. What measures can be taken to avoid all that?

It is necessary to use three built-in powerful programmable relays (rated on 220V 3.5kW). You can connect the refrigerator through one of such relays and program the solar controller to switch on the relay only when the solar energy is available (or when the battery voltage is not lower than 12.3 V per 1 battery, which is equal to its discharge by 20 to 30%).

It is better to connect the boiler (for water heating) through another powerful relay, as one relay can't cope with both start powers of the boiler and refrigerator, also you can set the higher priority for the refrigerator. When it is cloudy and the energy is not enough for all consumers then the controller leaves the only refrigerator connected.

If necessary, one of these relays can be programmed to start the generator automatically or to activate the alarm as shown in the wire diagram.

5. A little about refrigerators.

As the refrigerators are the most energy-consuming devices let's consider in more detail the principles of its selection in case it is a solar powered refrigerator. In autonomy conditions and low-energy consumption, the refrigerator should be A+ + + (at least A+ +) energy saving class and placed in a cool environment (the radiator behind the refrigerator should be free ventilated).

Suitable volume and ability to maintain the required subzero temperature are the main criteria for the freezer. At different temperatures food can be stored for a long time, the temperature -6°C is required to store products for a week. If the freezer maintains the temperature -12°C, then it is guaranteed food preservation for up to one month. If the temperature regime is -18°C - foodstuffs can be stored in the refrigerator for about three months.

But if the temperature level can be maintained at -24°C, then it is possible to store products for 6-12 months.

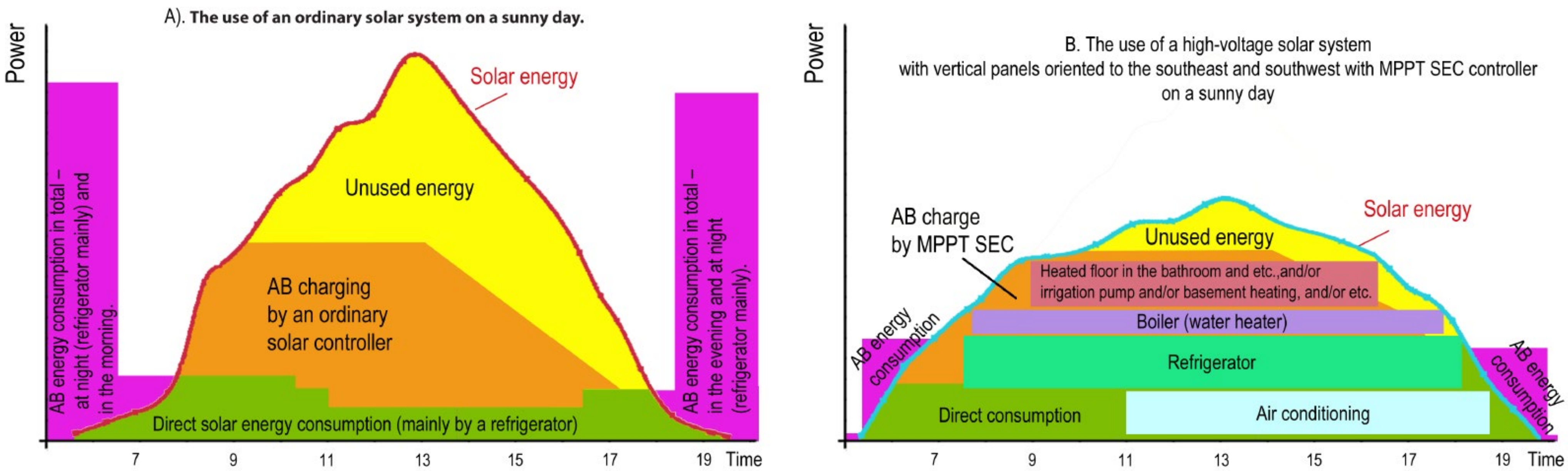
The last option of the refrigerator is the best. Due to a high-quality thermo-insulation, many refrigerators can maintain a low enough temperature inside, even after the power is cut off. Cold saving time is the most important parameter of refrigerators. Good refrigerators have this parameter equal to 20 hours, or even 40 hours. Of course, it is necessary to set the lowest possible temperatures in the freezer and in the refrigerator.

In case the solar activity is not enough for some days or weeks and there is a huge lack of energy – it is very useful to use cold accumulators (in fact, they must always be kept in a small part of the freezer).

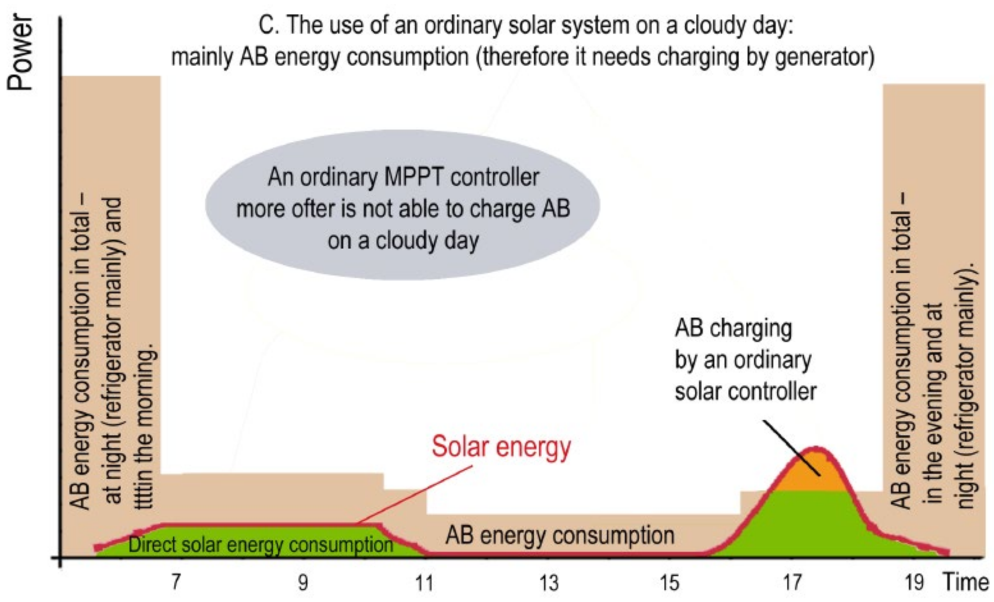
There are several types of modern cold accumulators (they are sold in plastic containers or in sealed bags, the period of their lifetime is not limited):
- gel: maintains the temperature from -70°C to + 80°C, is a gel solution sealed in a hermetic strong polymer bag (up to -20°C), or a solid container (up to -70°C);
- water-salt: the most common. Standard feature - plastic briquettes with saline solution, which are to place in the freezer before the use and can maintain temperature from -20°C to + 8°C;
- silicone - maintains temperature from 0°C to -2°C, but within 7 days. The main advantage of silicone accumulators before water-salt and gel is the ability to maintain the constant temperature near zero for a long period (up to 7 days).

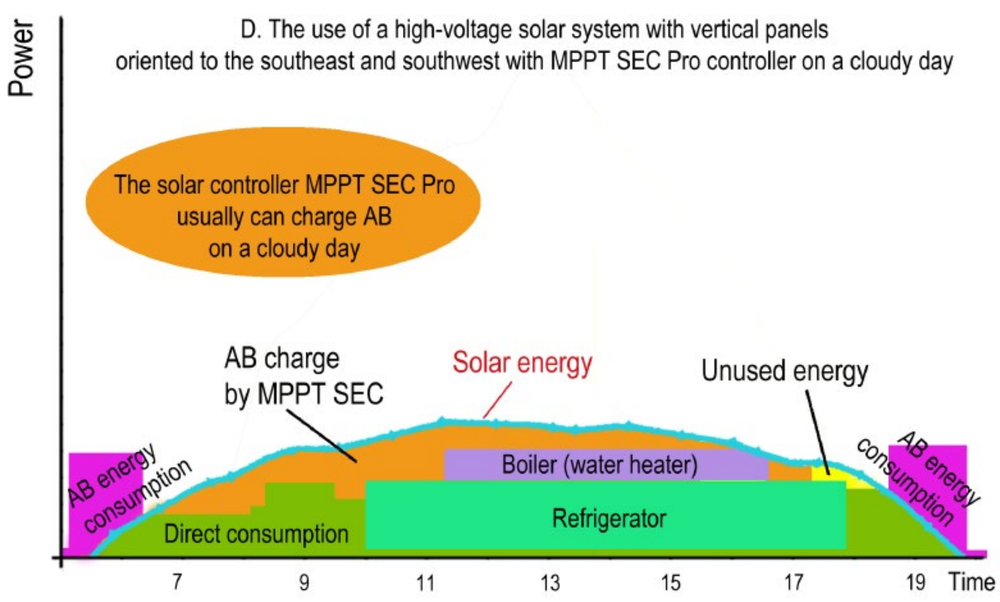
6. Comparative graphs showing the different SP locations and the use of built-in switching loads relays:

The graph of the ordinary solar system and the "correct" solar system operating with installed SP of 1500-2000W capacity on a hot sunny June day.



The graph of the ordinary solar system and the "correct" solar system operating with installed SP of 1500-2000W capacity on a cloudy June day.





For a detailed description of the graphs (and about the features of using batteries, etc.), see http://www.invertor.ru/vibor.html
In conclusion, we note that for energy saving (which is especially important for the autonomy) it is better to use autonomous sewage system (for example, “Osina” reinforced concrete septic tanks).

WARRANTY LIABILITIES

1. The seller guarantees that the purchased product does not contain the mechanical damages and corresponds to the passport characteristics.

2. The warranty period is 1 year from the date of sale, but not more than 1 year and 4 months from the date of manufacture.

Warranty does not apply to:

- Damage caused by lightning;
- Damage caused by incorrect installation (incorrect connection);
- Damage caused by high humidity in the room and/or liquids on / inside the device.

3. Warranty obligations of the Seller don't cover the cases of the product damage by foreign objects, insects and liquids inside the device as well as mishandling and violation of the security measures provided by the Present manual.

4. The manufacturer and seller of the product are not responsible for a direct or indirect damage related to the operation of the product, including damage coursed to the third parties.

CERTIFICATE OF CONFORMITY №____
for solar controller
MPPT SEC of PRO and DOMINATOR models LLC «MicroART»

S/N ______________________________

Model

	PRO	DOMINATOR
Model	☐	☐

Voltage (V)	☐ 200	☐ 250
Peak current (A)	☐ 60	☐ 100
WEC power	☐	

WEC SUPPLEMENTARY EQUIPMENT:

Block №2 S/N ______________________________

Electrical heater ______________________________

Cable ______________________________

MicroArt

www.invertor.ru

WARRANTY CARD (ON THE MODEL OF MAC INVERTER PASSPORT)

Date of sale __________ _____ 20 ____ г.

"МикроАРТ" МОСКВА

Price

Sellers signature ______________________________

Price ______________________________

Date of production _____ _____ 20 ____ г.

Warranty period – 1year from the date of sale, but no more than 1 year and 4 months from the date of production.

The operation life of the device – 6 years.

Warranty repair (date) _____ _____ 20 ____

Warranty repair (date) _____ _____ 20 ____

Warranty repair (date) _____ _____ 20 ____

The procedure of the operable goods return in case of on-line shopping: seven days after receiving the goods by the customer.

Note:
The warranty repair is carried out only if the warranty card is stamped and signed by the seller and has the date of sale. The warranty doesn't cover the violations of the present manual and inviolability sticker or any other construction alterations.
The procedure of operable goods returns in case of on-line shopping: seven days after receiving the goods by the customer.