



**MACSINE**

Multifunctional  
Autonomous Converter

# USER'S MANUAL



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## 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.

### BRIEF INTRODUCTION OF MAC INVERTERS (MODELS PRO, HYBRID, DOMINATOR)

MAC — multifunctional autonomous converter (hereinafter MAC, inverter or device ).

The MAC multifunctionality implies the ability to use the device either as UPS (Uninterruptible Power Supply) or as a multi-purpose battery charger or as power network inverter, optimizing the use of alternative energy sources.

Full description of the entire range of inverters, accumulator batteries (AB), mini power stations, wind turbines, solar panels, charge controllers and other equipment can be found on the website [www.invertor.ru](http://www.invertor.ru).

The inverter is used to supply equipment with uninterruptable and/or autonomous power of alternating voltage (AC) from 220 / 230V (or 380 / 400V for three-phase systems). The inverter converts stored in AB energy into AC of 220 / 230V (or 380 / 400V for three-phase systems of 3 inverters such as HYBRID MAC or MAC DOMINATOR). To charge the AB you may use power supply network of general purpose 220/230V (hereinafter network), generating complexes, mini power stations, solar batteries (panels, modules), wind turbines or share different power sources.

The AB pack is an expensive equipment that can be damaged by the incorrect use. Undercharging or overcharging the AB reduces its lifetime significantly and essentially decreases its characteristics. Besides, AB are produced per different technologies and require complicated charging algorithms. MAC can charge different types of AB by different charging methods according to parameters required by the world's top producers.

MAC monitors AB condition to use stored energy as a power supply for connected equipment while the external power source is switched off. Special controllers should be used for connection of solar panels and wind turbines to provide charging functions and AB protection. Solar and wind controllers created by MICROART can interact with MAC directly what gives an opportunity for maximal use and storage of energy from the alternative sources.

Hybrid and Dominator inverters are able to self-synchronize with a central network and optimize all energy sources cooperation with the lowest effect on AB to prolong its lifetime.

When MAC is used with traditional gas, gasoline or diesel generators (hereinafter – “fuel generator”) it provides a fair increasing of system efficiency as well as fuel economy because generator runs in optimal mode charging AB and supplying power through the inverter. Idle running of generator will be reduced what will highly increase its durability.

MAC circuit technology is based on the use of both high-quality expensive toroidal power transformers (exactly toroidal, not just low frequency transformers) and components base from the world's top producers. Before selling every inverter is tested and adjusted, selectively inspected with infrared scanner and as a final stage checked by quality control department.

All testing data on every inverter are recorded into the database and the inverter gets its unique serial number. According to this serial number, it is always possible to check all stress testing parameters of every produced item.

In some cases, it is in need to purchase a circuit protection device to save your equipment and prevent MAC breakdown. Under the conditions of an interruptible or poor-quality waveform of central power network or life-expired and overloaded classical generators – it is proposed to install a set of MAC protection devices: network suppression filters EMI, surge protectors, phase-shift controllers, etc.

Nº	Features	MAC PRO	MAC HYBRID	MAC DOMINATOR
1	Maximal power range	1,3-20 kW	1,3-20 kW	3-20 kW
2	Rated AB voltage	12V/24V/48V	12V/24V/48V	12V/24V/48V
3	Battery inverter option	✓	✓	✓
4	AC voltage inverter option (network power addition, ECO mode)	—	✓	✓
5	Operating in 3-phase network	—	Optional	✓
6	Two 220/230V network inputs (one may be used as input for standby generator)	—	—	✓
7	Synchronized (parallel) work of up to 10 devices in one-phase power network and up to 27 in 3-phase network	—	—	✓
8	Two voltage-free output relay contacts (to control generator or other demands)	—	—	✓
9	Built in AB display (based on internal minicomputer)	—	—	✓
10	Embedded minicomputer with Web-server for remote monitoring and control (including SMS control over GSM)	—	—	✓

In cases of permanent deviations of 220/230V characteristic in the power grid (voltage often drops below 190V or exceeds 250V), it is necessary to purchase the stabilizer SN “Energy”.

## SAFETY. PRECAUTIONS

### **BIMPORTANT 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 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, 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 inverter 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. The inverter is designed for permanent connection to the alternating current (AC) and direct current (DC) electrical systems. The manufacturer recommends you to make all wiring connections by certified specialists to ensure that connections meet all the actual rules and regulations. Otherwise, you need to study and then follow the safety procedures when working with electrical equipment, carefully study and observe fire safety measures;
4. 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 inverter to a damaged or defective wiring, as well as defective electrical equipment;
5. In the case of any failure of the inverter please don't use it;
6. 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;

7. Before maintenance, cleaning or working with any components connected to the inverter 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;
8. The inverter grounding wire must be connected to the ground circuit of AC input;
9. The device must be protected from rain, snow or any liquids. Operating in a humid environment reduces the product lifetime. The warranty does not cover the corrosion caused by high humidity;
10. To avoid the risk of short-circuit use always the tools with insulated handles while installing or working with this equipment;
11. When working with electrical equipment please take off metal items, such as rings, bracelets, necklaces, watches, etc.;
12. It is not allowed to switch on the inverter without the AB;
13. It is not allowed to connect the inverter output to AC grid;
14. It is necessary to observe polarity of the AB strictly when attaching to the inverter. Incorrect connection leads to inverter damage. In this case the repairing will not be covered by warranty;
15. It is not allowed to connect inverter output to its input;
16. It is necessary to protect the inverter with lightning protection device, especially for full autonomy;
17. Please follow the temperature and humidity requirements while operating;
18. Do not place the inverter in dusty environments. Cooling system failure, as well as damage of the device in such case will not be covered by warranty;
19. It is not allowed to use the inverter for other purposes, the same as to exceed the recommended operating parameters;
20. If AB are not sealed, they should be placed in ventilated non-residential room;
21. It is necessary to prevent the access of children, animals and unskilled personnel to the inverter and battery.

## RESTRICTIONS OF USE



### RISK OF ELECTRIC SHOCK, EXPLOSION OR ARC DISCHARGE!

- Strictly follow electric safety precautions. Use personal protective equipment while working.
  - When operating at high voltage do not operate the device with covers removed.
  - The device is powered from several sources. Before removing the covers please locate all the sources, turn them off, block them, and hang a warning board up then make a two-minute pause until electrical circuits are discharged.
  - After power is switched off use suitable voltmeter or tester to make sure there is no voltage.
  - Take off watches, rings and other metal things.
  - Do not allow sparks and open fire near batteries.
  - Use isolated tools.
  - Use safety glasses, gloves and shoes.
  - Do not put tools or other metal things on battery.
- Violation of these requirements may cause serious injuries or death.



## INFLAMMABILITY DANGER!

- Precautions related to the explosive gas environment.

This equipment is not protected against inflammation. To avoid fire or explosion do not install the device in places where protected equipment shall be used. Do not install the device in any closed unventilated spaces containing vented batteries or inflammables such as natural gas, liquefied petroleum gas, benzol/petrol vapor, etc.

Violation of these requirements may cause serious injuries, death or fire.



## RESTRICTIONS OF USE

- The inverter is not approved for use in the life-support systems or with other medical equipment or devices.

The inverter is equipped with internal electromagnetic interference suppression devices, but if installation and operating requirements are not fulfilled then radio frequencies of this equipment can cause electromagnetic interferences with radio communications. Nevertheless, in each case it is impossible to guarantee the absence of interference. If this equipment interferes with radio or television signal that fact could be found out by turning on and off the device, we recommend the user to remove the interferences by the following measures:

- reorient or relocate the receiving antenna;
- to move the device and the receiver for a longer distance from each other;
- connect the device to a different power source separated from the receiver;
- ask for a help the supplier or an experienced radio or television technician.

## INVERTER PLACEMENT

When choosing an inverter placement, it is necessary to follow the fire safety regulations and electrical equipment operating rules.

The inverter should be placed close to the AB and connected by factory-installed conductors of a large sectional area. If you need longer cables, it is possible to replace them with longer ones (the wire sectional area should be as many times larger as longer it is), but not longer than 3 meters. See the details in "Connection procedure". The cable path should be as short as possible. It is recommended to place the positive and negative AB cables next to each other. Avoid cable loops. Place the device as close to the battery room or battery box as possible: it will help to avoid additional voltage loss.

Please consider when choosing a place to install that the inverters, especially high-power models, that they have a significant weight (up to 60 kg).



**It is necessary at least 2 people to carry high-power models (from 6 kW) to prevent device falling or peoples' injury.**

It is possible to place the inverter MAC with AB on the racks, which withstand the weight of all the equipment. In private houses inverters and batteries are often located in basements or boiler rooms. Sometimes people build some constructions for mini power stations where generators, MAC and AB pack can be placed. In the apartments and small cottages inverters and sealed batteries are located even in residential areas, often under the stairs on the handmade racks.



**When choosing the inverter placement please follow the rules:**

1. The inverter must be installed on a solid, non-flammable, horizontal surface withstanding the weight of the device without deformation;
2. Avoid contact with water or other liquids;
3. Ambient humidity should not exceed 95% (no condensation);
4. The recommended temperature range is from -25°C to + 35°C (at the same time we must remember that the battery temporarily loses its capacity in low temperature environment);
5. Do not cover the inverter's ventilation openings. The distance from the vents to a wall must be at least 10 cm from all sides of the inverter;
6. Do not use the inverter in areas with dust-loaded air;
7. Do not allow foreign objects or particles in the inverter, as well as insects;
8. Do not place the device on flammable surfaces, such as carpets. If the MAC must be placed on a wooden rack, it is necessary to use a nonflammable base sheet like a thin metal plate.

## INVERTER TRANSPORTATION

For the transportation it is important to follow the device transportation positioning (top / bottom), as well as to protect it from falling (the product is fragile!). Do not spill liquids on the packaging, etc. All necessary transportation signs are marked on the package.



**ATTENTION!** If the inverter is transported in low ambient temperature and then gets into a warm room – don't switch on it earlier than in 5 hours (that time is required for condensate elimination).

## CHOOSING THE RIGHT MAC POWER RATING AND AB CAPACITY

The selection of a right MAC power rating depends on time of autonomous off grid mode, load type and power.

Depending on AB pack capacity the inverter will keep the uninterrupted operation of your system without grid for a certain time. The operating time of MAC for different loads and AB capacities is mentioned in the table **"Approximate battery operating time" (see technical parameters of MAC).**

To avoid AB voltage slumps and to prolong its lifetime the discharge rate shouldn't exceed at least 0.4C for lead-acid batteries and 1C for LiFePO<sub>4</sub>. For example, for the often-used load of 5kW and 48V pack the discharge rate will be equal to  $5000W / 48V \approx 100A$ . It means AB capacity should be less than  $100A / 0.4C = 250Ah \times 48V$  (means 4 serial jars of 250Ah x 12V) for lead-acid AB and  $100 / 1C = 100Ah \times 48V$  for LiFePO<sub>4</sub> AB.

The load type also influences the choice of power rating. For a regular loads the power should not exceed the inverter rated one. MAC power reserve is required for the equipment with large starting currents as pumps\*, microwave, laser printer, etc. Compressors normally require 5 times higher power reserve, for more difficult loads (like a refrigerator) the reserve should be even more (for example for a fridge of 150W you need the inverter with 1.3 kW power).

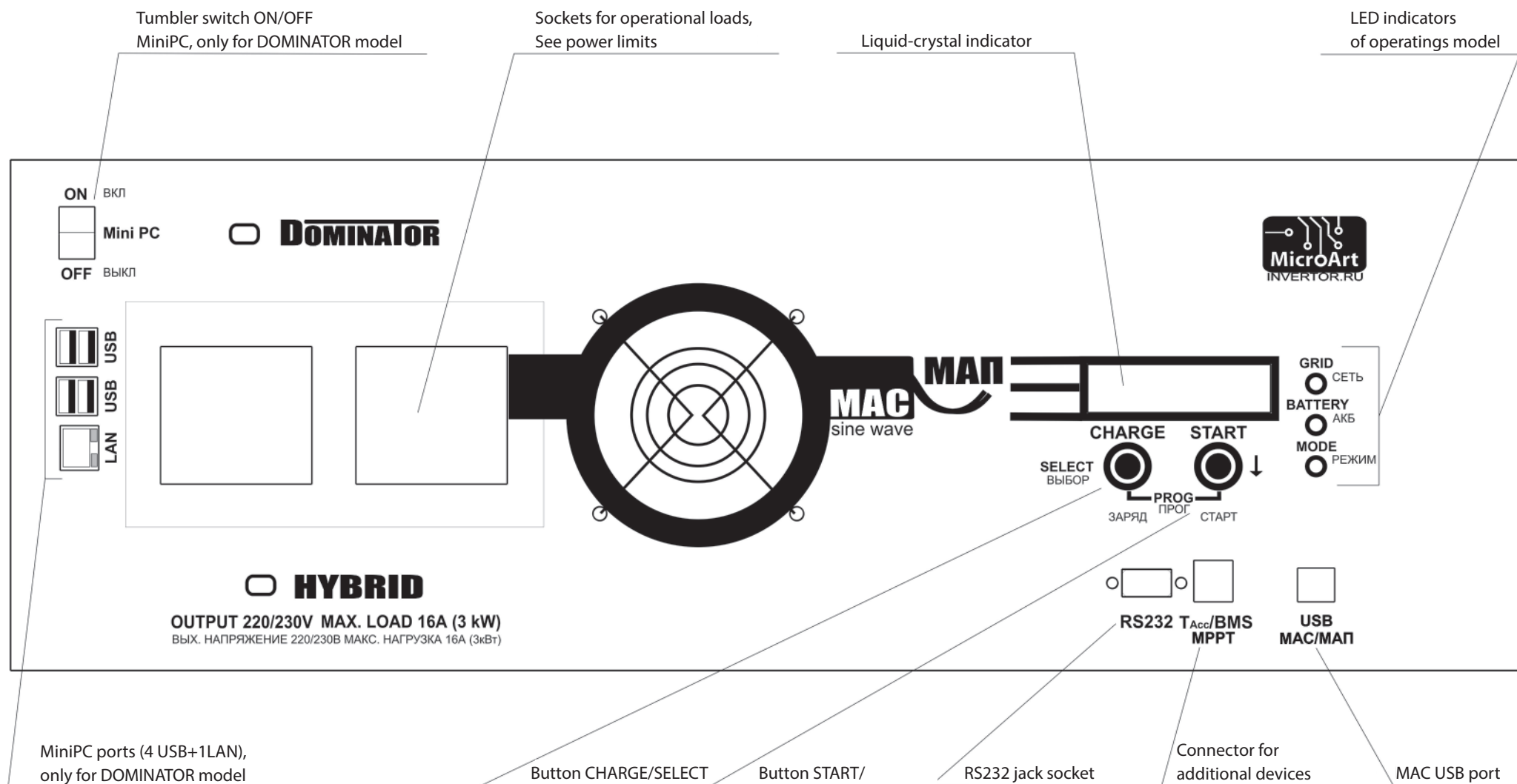
MAC is capable to withstand peak power 2 - 2.5 times higher than rated one for a few seconds that allows the load to get its operating mode.

*\* Note: The deeper a well pump is (without a soft-start system), the higher starting power it has. Multiplication factor varies from 3 to 7 (for depth more than 50 m).*

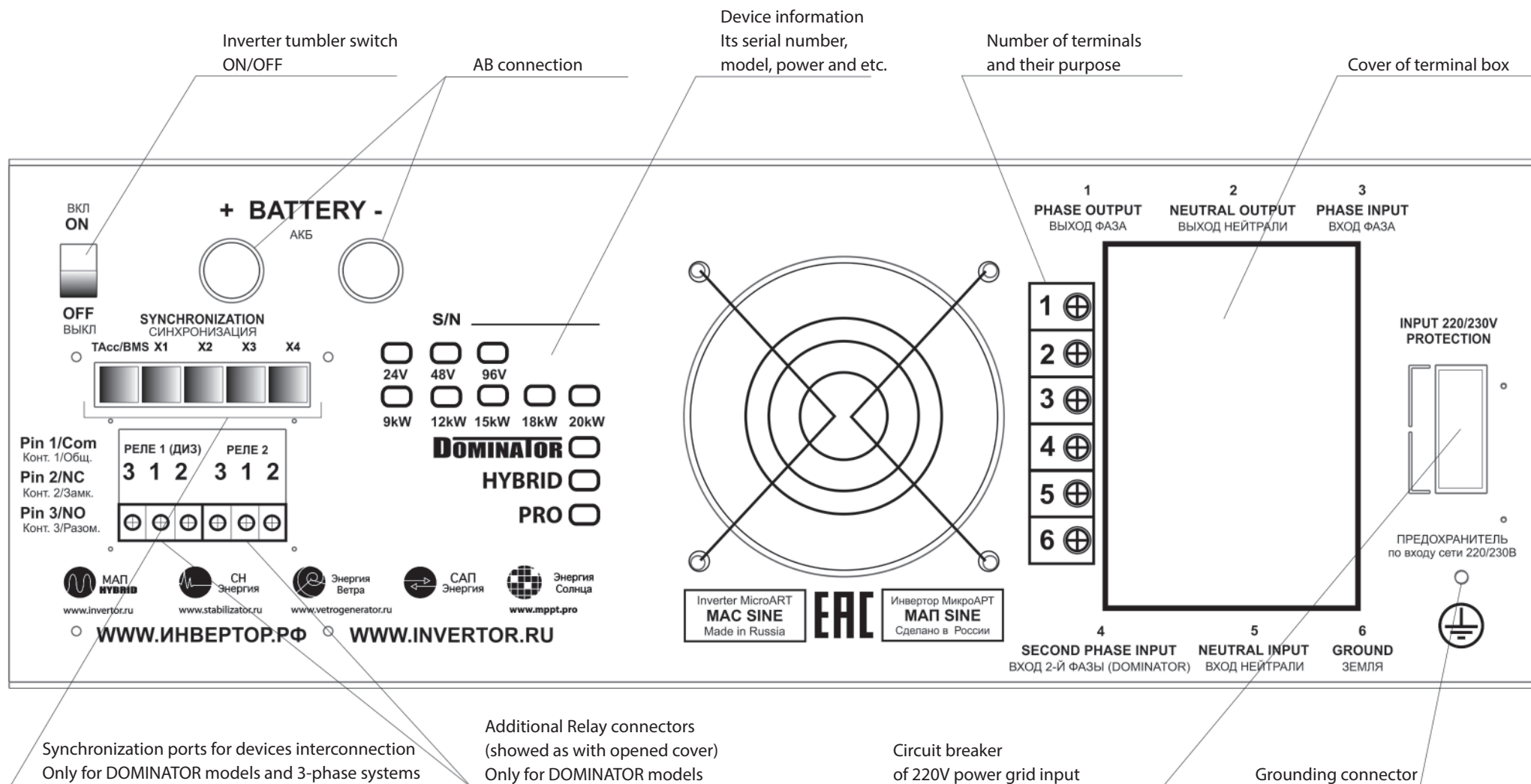


## GENERAL VIEW. LOCATION OF THE CONTROL ELEMENTS AND THEIR FUNCTIONS

In the pictures below you may see the front and rear views of devices with rated power 9 kW and higher. The control elements for lower power models are similar with similar signs and notes.



Pic.1. The front view.



Pic.2. The rear view.

### 1 | INVERTER (GENERATION MODE)

At the beginning let's consider the MAC operating without external power network of 220/230V connection. The main purpose of the device is to convert stored in the AB energy into AC of 220/230V (or 380/400V for three-phase systems of 3 inverters such as MAC HYBRID or MAC DOMINATOR) and supply this energy to the consumers.

Press "Start" button shortly to switch on MAC for AC generation of 220/230V. The green LED "MODE" lights up. Alternating voltage of 220/230V will appear on the output terminals and sockets "output 220/230V". Same short pressing the button stops the generation mode.

If total power of all connected devices exceeds the maximum output power for 5 seconds - MAC automatically turns off for 8 seconds (internal buzzer will sound). Then MAC will continue switching on for 5 seconds 6 times and after that will shut off completely. If overload (excess of maximum power rate) lasts less than 5 seconds, then MAC will not turn off. This feature provides the ability of starting the devices with huge starting currents (these currents may exceed the maximum MAC current). Short-circuit protection responds and immediately stops the generation at the load power which is much higher than allowed peak rate, by analogy with overload the device repeats 6 starting attempts. If overloads do not occur within next 10 minutes, then MAC starts counting 6 attempts from the beginning after overload appears again.

Internal cooling fans start up at the load of 50% of the rated one or when the temperature on elements is over 40°C.

It should be mentioned that if the load of maximum allowed power is connected then output voltage may drop below 200V (in some cases even lower, depends on the level of battery discharge and presetting of "SineWaveAccuracy" mode).

In case the battery is discharged below 11V/22V/44V (these settings are preset but You're allowed to set other voltage thresholds for battery release) then the yellow LED "AB" starts blinking and the buzzer turns on, finally in 1 minute MAC shuts down. Then MAC stays in standby mode until AB voltage is restored to 12.5V/25V/50V (from an external source of charging like a solar or wind generator), or when the MAC input voltage of 220/230V appears (from the grid or generator). This is to protect the battery from full discharge, as AB can regain approximately 1 volt, or even more after release (depending on the ratio of load power to the battery capacity).

If battery voltage drops below 11V/22V/44V for a short time (less than one minute) – then MAC will not shut off; that allows to use devices with high starting currents. Short-time battery voltage drop (below 11V/22V/44V) is acceptable and doesn't cause any damage, as it is during such a short period a sulphatation of plates is impossible. For example, when you start the car in wintertime then battery voltage drop can be up to 7V (within few seconds).

## 2 | CHARGER MODE

MAC is a powerful multi-stage battery charger. The maximal charging current (charging rate), which MAC can provide (grid is normal, the AB capacity is enough and the charging current meets settings) is calculated as follows:

---

$$\begin{aligned} &P_{\max} \cdot 0,4 / V_{ABnom} \\ &\text{or} \\ &P_{\max} \cdot 0,3 / V_{ABnom}, \text{ for the model 48V from 15kW inclusive.} \\ &\text{For example, MAC 3kW (} P_{\max} = 3 \text{ kW),} \\ &V_{ABnom} = 3000W \cdot 0,4 / 24V = 50A. \end{aligned}$$

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To force MAC charge mode press and hold "Charge" button for about 2 seconds (long pressing). If grid is available and wait time has expired, then MAC will activate the charge mode. While the wait time is not expired, then notice "to the full charge \_\_\_\_ (time) left" will appear on the display. If grid doesn't meet state standards the long pressing the button "Charge" will cause the warning "!" and in the errors and warnings menu "No 220 for charging" can be seen. After the normal mains voltage recovers again, wait time to charge will be 20 sec. Activation of forced charge mode is possible from network transmitting mode only when LED "GRID" is ON.

If battery voltage is below 12.5V/25V/50V (these settings are preset but You're allowed to set other voltage thresholds) MAC will start charge mode automatically (of course if the network is available and charge mode is allowed).

It must be born in mind that if trickle charge mode – so called buffer charge or float stage (not active by default) – is set up, then the charge will not be stopped on reaching values 14.5V/29V/58V, it will change over to a low current and will keep this mode until the network is available. To deactivate the trickle charge mode as well as charge mode you can by long pressing again the button "Charge". If the buffer charge mode is not set, then the charge will be stopped on reaching 14.5V/29V/58V.

While the batteries are being charged the blue LED of GRID is blinking (1 time every 2 seconds). When the buffer charge mode is activated then the symbol \* (asterisk) will appear on LCD.

Stop charging or buffer charging threshold voltage is available to change in settings, which correspond to values for temperature +20°C. The real voltage values of charging and buffer charging depend on the AB temperature. AB temperature is measured by a temperature sensor. In case of the sensor absence default temperature is set to +20°C. The temperature value could be received by MAC from additional devices such as MPPT or BMS (produced by MiCROART).

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*Note. The real voltage values of stop charging and buffer charging with temperature correction can be seen on the display as one of the menu pages (press shortly "Charge" button to change the page).*

### 3 | UNINTERRUPTIBLE POWER SUPPLY MODE (UPS MODE)

This is the main mode. It is described here only as it is a combination of previous ones and as it automatically switches GRID or GENERATION mode and charges the battery, if necessary.

At short "Start" button press MAC starts to transmit network from the input to the output. If grid is available and AB voltage is below 12.5V/25V/50V (these values are preset but it is possible to set other voltage thresholds) MAC starts to charge the AB. When charging is over and AB voltage is more than 4.5V/29V/58V (default settings, may be changed) MAC will start either network transmitting or trickle charge - buffer charge (if the latter one was set).

If grid is unavailable or more than 265V (programmable) or less than 120V (programmable), as well as the frequency is out of 40 - 63 Hz range (possible short-term frequency 35 - 75Hz if input from generator is selected in menu) MAC stops charging and starts generation of 220 / 230V from the AB.

*Note. There is no delay in switching from generation to transmitting mode (after the input has been stabilized) the generation signal is replaced by the mains voltage at zero-crossing value. The reverse change takes about 2-4ms and is associated with the "network is lost." event. The identification process is rather complicated and depends on the load, for example, on idle mode the algorithm will be fundamentally different.*

Besides, if the input voltage is not sine-wave or moreover it has the form of superimposed pulsations then MAC can identify it as "network is lost" event. Such a case occurs when fuel generator is used as industrial network, especially if the generator is low-powered and has an unknown origin. In that case "Input 220V" -> "FuelGenerator" may be set in the menu. This algorithm will be configured for working with a poor sine wave accuracy. As well as due to "desensitization" of response to voltage drops at generator power supply failure the switching to generation can take up to 8ms under the load and 20 ms for idle running. For a high-power high-quality Fuel generator, you can leave default setting: "Input 220V" -> "Power grid" to ensure fast and qualitative switching (2-4ms) from Generator to generation.

It should be noted that even if MAC is off (i.e. the operation mode, but not AB terminals disconnected) and mode "AB Preserving" is set, at AB voltage is below 12.5V/25V/50V MAC will automatically start AB charging simultaneously transmitting input voltage of 220/230V (if power grid is connected) to the output. MAC autonomous operating time from AB can be found in table «**Approximate battery operating time**». Here should be mentioned that it is not recommended to discharge AB by currents higher than 0.4C (1C for Li-Ion) for long-continued load - no more than 0.2C (0.5C for Li-Ion). For example, if average load is 1kW the current for 24V system comes to  $1000W/24V \approx 40A$ . It means AB capacity should be not less than  $\sim 40A/0.2C = 200Ah \times 24V$  (for two batteries in series 200Ah x 12V). At that if for example a 2kW pump starts often then peak current comes to  $3000W/24V \approx 120A$ , in this case it is recommended to increase AB capacity to  $\sim 120A/0.4C = 300Ah \times 24V$ .

The power that MAC can transmit is limited by the capacity of its power components and the automatic circuit breaker. Therefore, MAC loading must not exceed its maximum power even if MAC powered by external AC source.



**WARNING!** Due a SC (short circuit) at high currents, inner contacts of switching relay can get stuck. This will cause MAC damage. Please try to avoid short-circuit at the output, especially if the network is connected.



**WARNING!** Keep in mind that MAC only transmits the network, partially filtering it from the "impurity", but not leveling the voltage. If your network does not meet the standards or it is constantly undervalued / overvalued, we recommend to install the voltage stabilizer between the network and MAC (for ex. SN "Energy").

The synchronization with the external source (phase tuning) is implemented in MAC. It allows to switch to the grid with the same phase for any load type. For the switching from the network to the generation the phase is also synchronized. It provides easy and fast switching between grid and MAC.

The additional modes such as ECO, power addition (mixing) Pmax, forced generation, grid power consumption limits etc., are described in the next chapters of the manual.

## CONNECTION ORDER

### 1 | Grounding of all electrical equipment.

The Inverter MAC (for permanent installation) as well as all devices must be grounded in accordance with the Rules of Electrical Installation. Grounding must be unified (including cabinets and shelves, which devices may contact to) this means that potentials and bad contacts should not arise in different connection points. Shelves and metal structures which are in contact with the device must be also grounded.

For example: the grounding is as minimum (as a protection against inducing) – a metal rod (galvanized pipe with wall thickness no less than 3.5 mm) vertically driven 1.5-3.0 meters into the ground with a conductor connected to it (usually yellow with a green stripe insulation).



**WARNING!** MAC has 2 ground connectors (both on the body and the terminal block). For your safety, it is strongly recommended to connect the ground to the both.

### 2 | Preparing AB pack. It is prohibited to switch on MAC without AB!



**WARNING!** It is necessary to strictly observe the polarity of AB connection to the inverter. Even a short-time incorrect AB connection may cause a failure of the inverter. This damage is not covered by warranty.

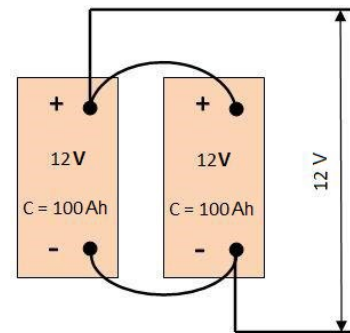
The connection of AB arrays (Pic. 3):

- a) parallel connection of 2x Battery: 12V 200 Ah
- b) in series connection 2x Battery: 24V 100Ah
- c) mixed in series - parallel connection 4 Battery: 24V 200 Ah
- d) in series connection 4 Battery: 48V x 100 Ah

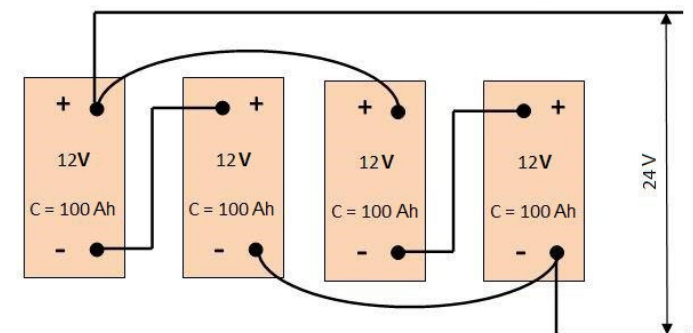
For parallel connection AB capacities are summed up, but the voltage stays the same (options a, b).

For in series connection AB capacity stays the same, and voltages are summed up (options: c, d).

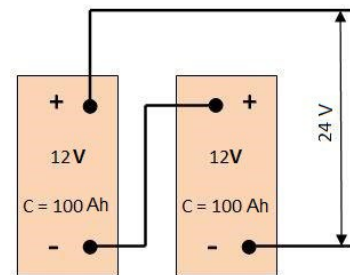
Details can be found in annex "Selection and operation of AB".



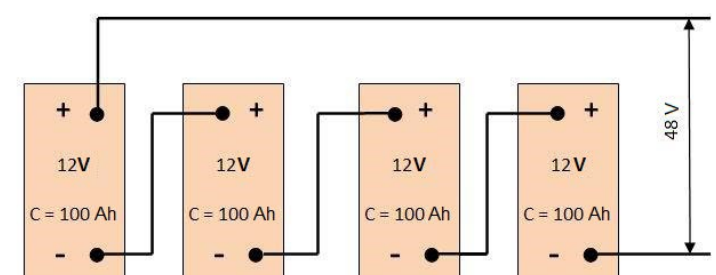
a)



b)

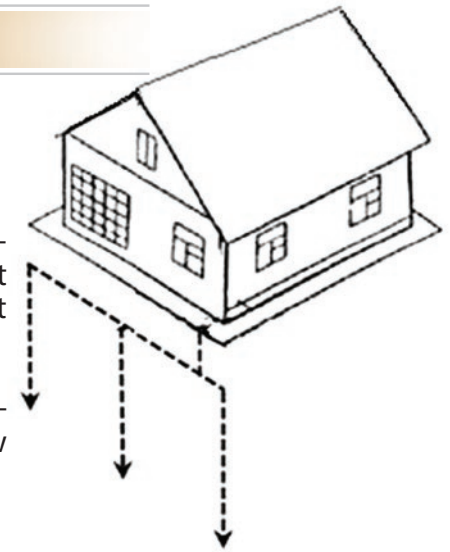


c)



d)

(Pic. 3)







**WARNING!** MAC can be damaged if you disconnect the battery while the inverter is operating! Therefore, it is not recommended to connect the battery terminals by "alligator" clips except for low-powered 12V inverters with rated power less than 2 kW for outdoor use with a car battery.



**WARNING!** MAC cables should be fixed very thoroughly on AB terminals. We recommend using a special electrically conductive paste. Poor connection to the AB terminals can lead to failure of the device! The poor contact will heat up connections and wires, that cause their melting and short circuit, and a large power loss.



**WARNING!** Jumper-cables between AB must be fixed carefully! We recommend using electrically conductive paste.

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For jumper-cables we recommend to choose wire sectional area no less than inverter wires.

If you need longer wires to contact AB it is allowed to cut off the supplied ones at a length about 10-15 cm from the body and then solder with new long wires or crimp them with a sleeve. For two times longer wires (2m length) you need 2 times larger sectional area comparing with MAC regular wires. If 3 times longer - then sectional area is 3 times larger.

Depending on the current MAC analyzes the voltage drop across the AB wires and corrects the voltage level. The correction is based on the calculation of the current, wire sectional area for each MAC model and wire standard length. These values are "factory preset" and cannot be changed by the user.

We recommend to connect AB pack diagonally: to the positive terminal of the first AB in the pack to the negative terminal of the last one.

Please tape the temperature sensor to the middle of any AB and insert its wire into the port of additional devices "Tab/BMS/MPPT" (in old models "MODEM"). DOMINATOR model has the same port from the backside.



**WARNING!** It is forbidden to assemble different AB in one pack! Batteries must be originated from the same manufacturer, must be of the same type, same series, same marked: as ideal from the same batch: means identical, all purchased at the same time.



**WARNING!** It is forbidden to connect AB negative to the ground (PE – protective earthing). By doing that you are creating a return circuit which cause battery discharge and sometimes the inverter damage.



**ATTENTION!** Before installation please take off the metal jewelry (especially chains and bracelets) and remove all the metal tools while installing AB pack. If such items get between the AB terminals it will cause a high current there, the metal will be melted, and you can get very serious burns.



**ATTENTION!** Check the voltage of AB pack with a voltmeter. Do not connect MAC to the AB pack if its voltage does not meet the inverter rated one.

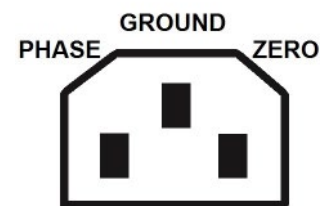
### 3 | Power grid connection.



**ATTENTION!** There is a risk of electric shock when working with high voltages so please cut off all input circuits before starting the work. The voltage absence in the conductors needs to be proved by special probes before starting the work.

Models up to 3 kW have no distribution box therefore the load output is available only on the sockets. The input of 220/230V in such devices is implemented by means of a standard computer power cable (which is included in the delivery set of devices up to 3 kW, with a copper strand sectional area is no less than 0.75 mm), see picture 4 below:

220V network input



Pic.4



**ATTENTION!** It is necessary to follow the device phasing strictly. Violation of the right phase, zero and ground connections may cause the incorrect work of the device or its damage.

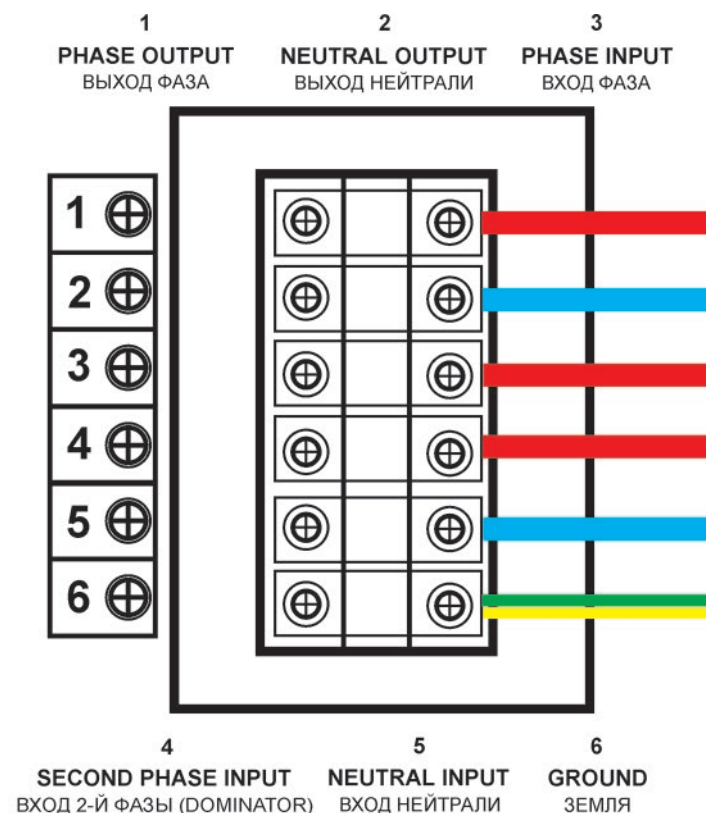
For the stationary installed devices (this is usually all devices from 3 kW) you must remove the cover from the terminal (junction) box on the device back panel, see Picture 5.

The connection wires should be carried out through rubber gaskets, after their perforation for the required cable size. It is important to tighten thoroughly the conductors in the terminal blocks, and after installation to put the cover back on its place. Below you may see an example of MAC connection to the input / output of the network 220/230V:

It should be mentioned that the 4th connection is used in DOMINATOR models only for generator or a spare phase of 220/230V connection, for details please see the appropriate paragraph. It is not used in the other models.

Power, kW	Recommended sectional area, mm <sup>2</sup>
3	2,5
4,5	2,5
6	4
9	6
12	10
15	10
18	16
20	16

Pic.5



**ATTENTION!** Strictly follow the terminals marking in the terminal box on the MAC back panel. The ground, zero, input phases are connected to the terminals with the corresponding signs on the inverter body. Any incorrect connection can lead to very serious consequences: damage of MAC, loads (consumers), as well as fire, because of a short circuit.



## 4| Starting MAC in idle mode and basic parameters settings in MAC menu.

MAC tumbler switch should be turned "ON". Circuit-breaker of network input 220/230V is switched off.

Use the buttons "Charge" and "Start" together to enter the type and capacity of your AB pack, see paragraph "parameters selection". Then connect a small load to test generation mode (for ex. desk lamp).

## 5| System settings specific to your situation. (See "Parameters selection").

AB operating parameters for main modes, different ECO modes, power boost modes, selection of nonstandard voltage levels for network, or specific parameters of AB charging rate can be set through MAC menu or monitoring software and parameter settings (see "**parameters selection**").

## 6| Load connection.

MAC models up to 3kW are connected to the load of 220/230V via sockets located on the front panel. It is important to follow phasing when connecting (phase and zero "from the socket" must match the phase and zero on the device which are marked on its body). High-power devices from 3 kW are connected to the load 220/230 via the terminal box, which is located on the back panel. See Picture 5. For high-power devices, the load with total capacity of up to 3.5 kW can also be connected via socket on the front panel.

## 7| Starting supply MAC with 220/230V .

Turn the circuit breaker ON (I).

MAC tumbler switch and/or the circuit breaker may locate either on the front or back panel depending on the body revision.



**ATTENTION!** For MAC complete shutdown, please switch off the circuit breaker (fuse), disconnect the grid (if any), press the button "Start" (it stops MAC generation of 220/230V from the AB), and then turn off the MAC tumbler switch. Then you may disconnect MAC from the network (before disconnecting MAC from the network switch off the circuit breaker in the electrical distribution box) and then from the AB terminals.

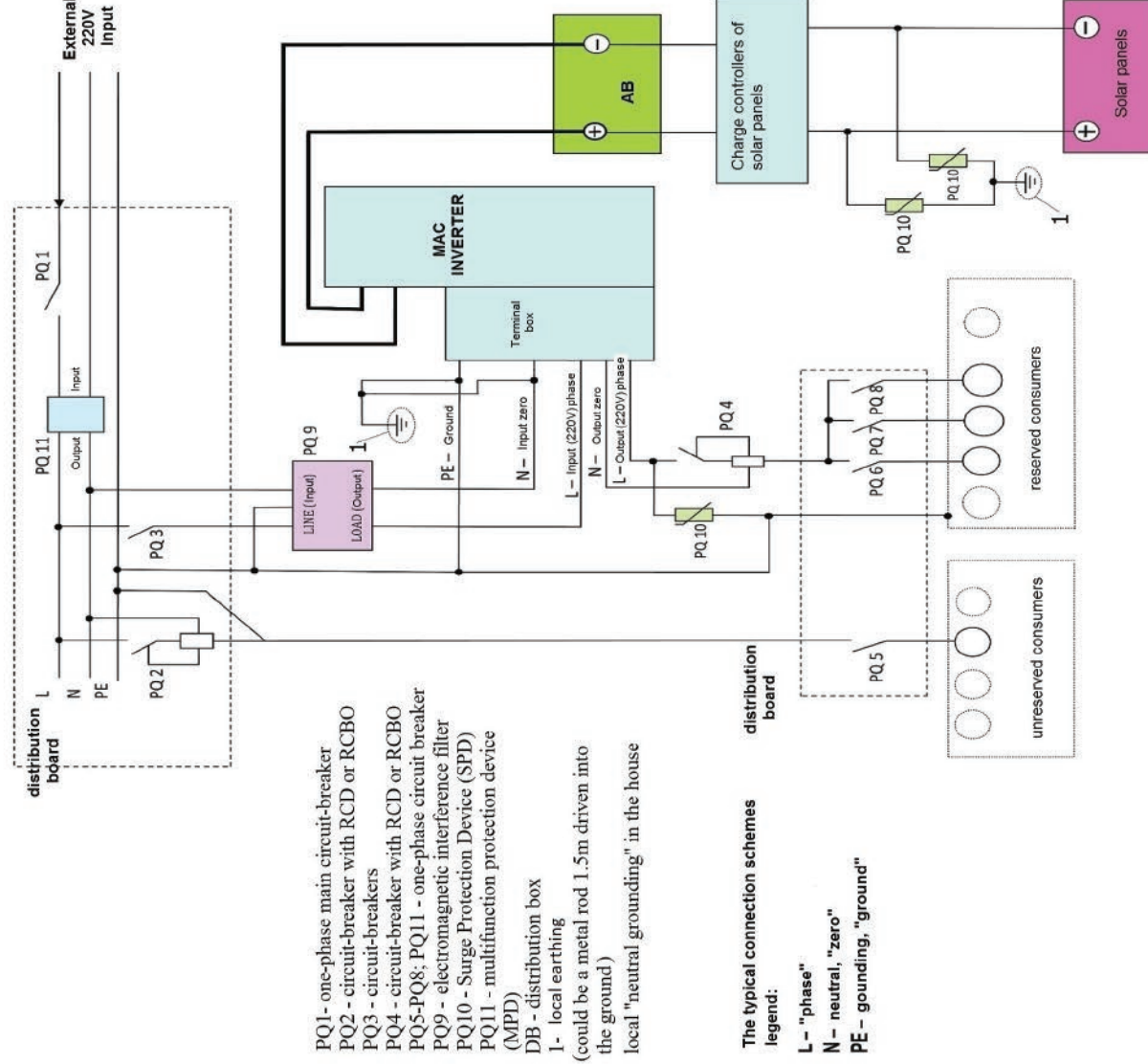


**ATTENTION!** MAC starting should be done in reverse order. In any case, don't connect 220/230V network cables to MAC during generation. Be careful with connections: attach phase and zero in accordance with the marking on the body.

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Detailed MAC connection scheme. It is important to connect MAC correctly. We offer the most secure connection scheme with an additional protection, required when full power is off, especially, when a charge from a mini electrical power stations is possible.

Typical connection for private house



Surge Protection Device (SPD) should be installed as the protection of electric installations from lightning and switching surges in the 220 / 230V AC networks of 50Hz frequency there - PQ10 in the scheme. This is especially important for a complete autonomy. It is installed at the MAC output, between the phase and local grounding (as a minimum it could be a metal rod or a number of rods (for example galvanized pipe with a diameter 3/4", length 2m), which is driven vertically 1.5-1.8 meters into the ground).

**THE LOCAL GROUNDING SHOULD BE DONE AS WELL, MEANS INPUT ZERO OF GRID SHOULD BE BOUNDED TO THE GROUND, FOR THAT WE RECOMMEND TO USE WIRES OF LARGER SECTIONAL AREA.**

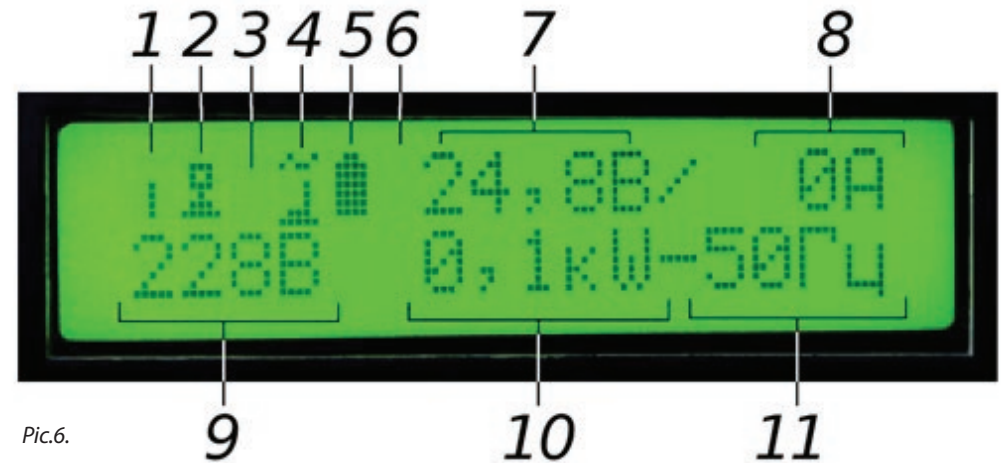
If the conductors between the solar panels and the controller are rather long, both of them (plus and minus) should be equipped with SPD according to the scheme. EMI suppression filters are used to protect the device against electromagnetic impulses (this is especially true in terms of autonomous life, without any power grid, and when the energy is supplied by fuel or gas generators) - in the scheme «PQ9». The filter must always be installed when using generators, as well as we highly recommend to put the filter before MAC in any case, even if a generator is not used. For the protection of consumers from overvoltage surges, phase distortions, break of zero, we recommend to install a voltage-check relay MPD (multifunction protection device) at the electrical distribution box input (in the scheme «PQ11»).

*Note: if you have in the house an equipment with internal grounding (usually boilers and pumps) and it is not connected in accordance with phases, the problems may occur. For example, the well pump may have the capacitors connected to the housing, and until its housing remains in the water, it will be grounded. Please note – if you don't observe the phases order for the 220V network connection, the inverter can fail while operating even though the pump is not running. To solve such a problem swap pump 220V AC Network conductor ends.*

## CONTROL PANEL AND LCD MENU OVERVIEW








MAC modes control and indication are realized over LCD (liquid crystal display). LCD has 2 rows of 16 characters each. There are two LCD operating modes: indication mode and setting mode via the menu.

In indication mode, the top row shows 8 parameters, the bottom row – 3 ones. LCD top row shows modes: errors (the sign “!” appears) and AB condition; the bottom rows: MAC output voltage, load power, generation frequency, errors and warnings and additional parameters (for ex. for operating in ECO or Hybrid modes, etc.) In the table below you can find all the possible symbols which can appear while device is operating:



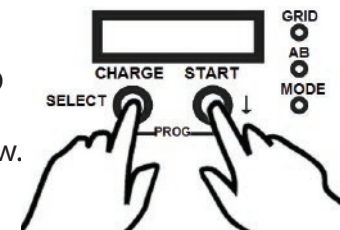
Pic.6.

Position on the LCD	Symbol	Description and parameters: top row of LCD
1	⏻	The inverter is switched off, no generation, no network transmitting
		The inverter is switched on – a vertical column of 4 cells is blinking in rotation with the letter of related generation mode (SineWaveAccuracy) *
	P	Precision (true) sine
	O	Optimal sine
	* In details these modes are described in paragraph “parameters selection”	
2	—	No connection (empty symbol)
	🖨	Computer is connected
	S	AGCS connected
3	—	Errors: no errors or warnings (empty symbol)
	!	Blinking: errors or warnings occurred (latest errors review is possible in the menu of current errors and warnings)
	1	Blinking: with the number of errors or warnings (latest errors review is possible in the menu of current errors and warnings)

4		Grid state: no output (empty symbol)
		Generation of 220/230V from AB
		Transmitting the power grid (or voltage from generator) to the output
		Blinking (1 time per second): there is AC network on the input but it is not transmitted to the output (for ex. switched off mode) Changing the picture for generation and back: network power addition ECO (ECO-Mixing) mode
	1 or 2	If the second input is switched on it shows the number of active input
5		AB Condition: normally charged AB pack
		Filled rectangle means the battery output voltage is above the maximum
		Animation: filling – AB charge goes on, if the filling starts from the empty battery sign – charging current rate is initial, if from the middle-charging current rate is final, the last discharge symbol is blinking – means trickle charging
		The number of filled cells corresponds to AB voltage
6	*	Blinking - trickle charge mode is near V_FloatCharge (maintaining charge – the floating stage of charge) (13.2V/26.4V/52.8V default settings)– buffer charge mode
	* ↓	Changing from asterisk to down arrow: during 24 hours of buffer charge the voltage V_FloatCharge has decreased by 1V/2V/ 4V
	3/4	Blinking – absorption charging mode
7	numbers, V	AB voltage. If the symbol appears on the right side, then it shows voltage drop relatively to average value (appears when the voltage is close to deep discharge)
8	numbers, A	The value of AB current (with symbol “+” if charge is going on)
9	numbers, A	The value of MAC output voltage for generation mode or mains voltage for network transmitting mode (if MAC is switched off then the network output voltage is blinking)
10	numbers, kW	Load power (including load consumed by MAC for AB charge) kW
11	numbers, Hz	Generation frequency or frequency of the transmitted network
9, 10, 11	For Hybrid and DOMINATOR models the bottom row displays network consumption. Symbol "+" means the power addition from AB. The bottom row also shows information about overloads and problems. (see “errors, failures and warnings”)	
* New symbols may appear after MAC firmware upgrade		

## PARAMETERS SETTINGS

MAC inverter parameters can be entered by means of two buttons (CHARGE and START) located under the LCD. The buttons have two pressing modes: short press about 0.5 sec (SHORTLY) and long press for more than 1 sec (LONG). If LCD backlit is disabled, the first pressing on any button turns on the LCD backlit only and does not perform its function. There are signs CHARGE and START above the buttons. The options of control buttons pressing are described in the table below.



<b>START SHORTLY</b>	The button START SHORTLY switches on and off the generation of 220/230V from the inverter to a load at no input AC voltage or switches on and off network transmitting if grid is available.	
<b>CHARGE LONG</b>	In transmitting mode/charge mode the button CHARGE LONG starts/stops the forced AB charge.	
<b>CHARGE SHORTLY</b>	In Indication mode, you may enter:	
	The list of current errors and warnings (in case if they have occurred and the symbol “!” will blink in the main menu) or statistics of network/AB consumption in kWh.	<b>START SHORTLY</b> –warnings scroll <b>CHARGE SHORTLY</b> – go to temperatures chart <b>START LONG</b> - reset statistics
	In the temperatures chart for AB - AB_T, heat sink – HeatST, transformer – TrT (not for all models) and voltage values for stop charging - Vmax and buffer charge – Vbuf with AB temperature compensation.	<b>CHARGE SHORTLY</b> – exit to indication mode <b>ЗАРЯД КОРОТКО</b> - выход в режим индикации
<b>CHARGE LONG + START LONG</b>	Enter the MAC menu and programming mode, where you should select a submenu and then the parameter to change, which can be changed and saved then (it could be used also to exit the programming mode):	
	<b>START SHORTLY</b>	Programming menu navigation: step-right in the numeric field or selecting parameter options.
	<b>CHARGE SHORT</b>	Parameter increasing or programming menu navigation (the numbers change in the order from 0 to 9, to decrease the parameter is possibly through the full cycle scroll.
	<b>CHARGE LONG</b>	Enter the editing, exit the editing with the saving of parameter into the MAC memory.
	<b>START LONG</b>	Return to the factory default value (in editing mode).

MAC menu navigation: the logic of menu access is uniform across all the interface and intuitively clear.

**WARNING!** Remember that new setting should be saved in MAC memory at the end by pressing **CHARGE LONG**.

## SUBDIRECTORIES OF THE LCD MENU

- **MAC Generation**
- **FuelGenerator/BMS MPPT**
- **AC / Eco Energy AB**
- **BAT Charge Param**
- **External Relay (DOMINATOR)**
- **Other options**

The MAC inverter operates in standard mode by default. For the correct operation, you need to set the capacity of AB for its proper charge. Additionally, many specialized modes and settings in MAC, which can be changed through MAC menu, or by use of configuration and monitoring software, are implemented.

*Note. Some menu items are available (become unblocked) only after an item or mode has been selected. Some menu items are available only for certain MAC models. New menu items can be added after MAC firmware upgrade. All the options described below are valid for MAC software ver. 24.1 and above only.*

### - MAC GENERATION

*Navigation: **CHARGE LONG** + **START LONG**, scroll the menu with button **START SHORTLY** to MAC Generation, enter the submenu with button **CHARGE LONG**  
 Submenu navigation MAC Generation: scroll the menu with button **START SHORTLY** to SineWaveAccuracy, start editing the parameter **CHARGE LONG**, scroll parameter values **START SHORTLY**, save in MAC memory **CHARGE LONG**, scroll the menu **START SHORTLY** to EXIT - back to the main menu, **CHARGE LONG** to enter the main menu*

*The other submenu navigation is similar to the example mentioned above*

#### SineWaveAccuracy

*Optimal sine (by default)*

*Optimal sine* - provides no more than 5% of a sine deviation until the voltage drops to 200V. Then if the sine deviation goes to 20% MAC will maintain the voltage level at 200V, allowing the connection of maximal loads when the voltage drops (if AB charged) below 200V. Recommended to use.

*In modern models the output voltage may drop below 200V only when AB are completely discharged and load is maximal.*

*True sine*

*True sine* – the sine deviation is not more than 1%. Suitable for the appliances (instruments for ex.), where the input sine quality is critical. The output voltage can considerably slump under the maximum load; therefore, we don't recommend to use it if the planned load goes beyond the MAC rated power.






<b>- MAC GENERATION</b>	
<b>MAC synchronization (Hybrid/DOMINATOR)</b> Master Master/Phase1 Phase2 Phase3 Slave	For <b>DOMINATOR</b> models (other MAC modifications equipped with optional synchronization modules). Master – the first device (master device) in the chain of parallel MAC DOMINATOR devices, see the appropriate paragraph of the description. Master/Phase1- the first device (Master device) in the chain of parallel MAC DOMINATOR devices and phase1 for 3-phase connection, see the appropriate paragraph of the description. Phase2, Phase3 – the device configured as the second and third phase for 3-phase connection, see the appropriate paragraph of the description. Slave – the second and consecutive devices in the chain of parallel MAC DOMINATOR, see the appropriate paragraph of the description.
<b>MAC voltage</b> <b>V=220V</b>	MAC output voltage at generation from AB (AB operation). For some types of load (power tools, pumps, compressors) it is possible sometimes to choose a higher output voltage to increase their power. Reduced voltage is useful for AB energy saving and increasing its operation time with no power grid, but only in case if your equipment can operate at reduced voltage. Keep in mind that if a big load occurs and battery is discharged, then the output voltage may be less than this setting.
<b>ModePmaxGrid (Hybrid/DOMINATOR)</b> ForcedGeneration PowerAddition	For Hybrid and DOMINATOR models. When you select "Power addition" (mixing) mode MAC will add power to its output in a way to limit the power which is drawn from the input of 220/230V (from power grid or generator). For the forced generation mode as well as for the PRO models, in case of exceeding "MaxGridPower" (see. below the input power of 220/230V), MAC will switch to forced generation mode from AB. The function is especially useful for holiday villages, where is often set a maximum permitted power to draw from the grid (for example for your house you have only 5 kW allocated, and sometimes, you need more power). See the details in appropriate paragraph of the description.
<b>PowAdd.ECO(ECO-mixing)</b> <b>(Hybrid/DOMINATOR)</b> ForcedECOGener PowAdd.ECO/ECO-mixing " Sell to the grid"  * Mode is activated through the special .operating system	For Hybrid and DOMINATOR models. Eco modes. Settings for ECO mode operation principle of MAC. The menu is available when you select the network management mode: "AC / Eco Energy" -> "AC Network control" -> "ECO mode" or "AC / Eco Energy" -> "AC Network control" -> "Grid.Tariff + ECO". With an appropriate choice MAC will start power addition or forced generation from AB to its output. This mode is useful if there are alternative energy sources (solar panels or wind turbine), to minimize the energy consumption from the grid as well as cycles of AB charge-discharge. See more details, including "Sell to the grid" in appropriate paragraph of the description.

<b>Switch off generation</b> $V_{ABmin}$	$V_{ABmin}=11V/22V/44V$ (basic settings) –When battery voltage is below this setting MAC is operating for 60 seconds only. Battery LED blinks in yellow and the buzzer sounds, then the inverter switches off. Then MAC stays in standby mode until the battery voltage is restored to 12.5 V / 25V / 50V by means of external charging source or solar/wind generator or until the charge from the grid/generator starts (AC voltage - 220/230V - appears on the MAC input).
<b>Load Detection</b> <b>0 OFF</b> xx W —Power limits setting for generation start	MAC Automatic start occurs when an output load power is higher than set one. This option allows to set the load power value at which the generation starts. In this mode MAC activates generation for 0.2 seconds every 5 seconds. When the load exceeds the set value the generation goes into continuous mode and runs until the load disappears. The mode is OFF by default. To exclude MAC self-consumption power, we recommend you to set this parameter at idle generation (IG), means with no load. The threshold of sensitivity of this parameter ~ 10W (for high-power models ~ 50W). In this mode MAC may save AB energy, as its own consumption during idling and 220/230V generating, varies from 10W to 20W depending on model.  <i>Note:</i> a) This mode may work incorrectly with equipment that automatically controls the network. b) High-power MAC models have poor sensitivity to loads less than 50W. c) The option is valid for low-power models with minimum of consumers, where every watt is important.
<b>- FUELGENERATOR/BMS/MPPT</b>	
<b>Input 220V (Input voltage)</b> Power Grid FuelGenerator	The source of MAC input power. It is possible to select "Power Grid" or "FuelGenerator". If you select "FuelGener" you have to enter generator rated power value in the menu "AC / Eco Energy" -> "PowerMax": the operation will be optimized for a "poor" network.
<b>Input2 220V FuelGener (DOMINATOR)</b> OFF Grid FuelGenerator	Additional input of 220/230V for DOMINATOR model. Disabled by default. This input can be used to connect a standby power supply, such as fuel generators. As in the previous paragraph when "FuelGenerator" is selected, it allows also to optimize operating for a "poor" network. For more details see the appropriate paragraph of the description.
<b>MaxPowerInp2 (DOMINATOR)</b> $P_{max}=12.0kW$ ⌘ ⌘- shown as an example you should enter your values	Maximum power settings for the second input. The paragraph is similar to "AC / Eco Energy" -> "PowerMax" for the primary input of 220 / 230V, see below.
<b>VABStartFuelGener</b> $V_{AB\_FG} = 23.0V$ ⌘ ⌘- shown as an example, you should enter your own values	AB voltage threshold value the generator starts at. Menu becomes active if you select one of the relays as the StartFuelGener or if AGCS is selected, the menu Other Options -> AGCS – charge.



<b>Number of slave MACs (<i>DOMINATOR</i>)</b> <i>N=0</i>	For DOMINATOR models. It defines the number of devices in the parallel connection which are operating synchronously.
<b>BMS / MPPT</b> OFF BMS (C)mART MPPT (C)mART BMS+MPPTmART	Connection of external BMS and/or MPPT (for third-party BMS the selection is made through the program “ <b>Monitor</b> ” ( <b>MapGui_.exe</b> ). OFF – no external devices BMS (C)mART– BMS produced MICROART MPPT (C)mART– MPPT produced MICROART BMS+MPPTmART– joint connection of BMS and MPPT by MicroART, the number of parallel MPPT is in the next row.
<b>Number of connected MPPT</b> <i>N=1⌘</i> ⌘ - shown as an example you should enter your values	Number of connected MPPTs mART(C), in parallel, if N=1 – one MPPT is connected. For more details, see the appropriate paragraph of the description.
<b>- AC / ECO ENERGY</b>	
<b>MaxGridPower</b> (including generator if it is connected to network input) <i>Pmax = XX kW</i>	Maximal Power on MAC input. The option is useful when it is required to limit MAC consumption from the Grid/-Generator (if Generator is connected to MAC input – enter its (generator) rated power).
<b>AC highest threshold - AC top limit</b> <i>V=265V of Grid</i>	Top limit of MAC generation mode. MAC starts the generation from AB if the input voltage (grid/generator) is higher than this value (by default 265V).
<b>AC lowest threshold – AC bottom limit</b> <i>V=120V of Grid</i>	Bottom limit of MAC generation mode. MAC starts generation from AB if the input voltage (network/generator) is lower than this value (by default 120V, for 3-phase network – 170V).
<i>Note: For the use of mini electrical power stations (gasoline generator, etc.) these network limits must be expanded as much as possible, otherwise, MAC may activate generation mode due to the possible voltage drop caused by the low power generator.</i>	
<b>AC Network control</b>  Transmitting+Charge Transmitting Only ECO modes GridTariff+ECO	Transmitting+Charge- a standard operating mode of the MAC inverter. The device transmits incoming network to the output and if needed charges the AB (if AB voltage dropped below VABStartCharge level from subdirectory AB parameters).  Transmitting Only – MAC transmits the network to the loads on the output. In this mode MAC doesn't switch AB charge ON. It is useful if you have an external charger.  ECO modes — One of two ECO modes is activated: either forced generation or power addition from the alternative energy sources.  GridTariff+ECO– similar to previous “ECO modes” but it takes into account time of minimal electricity rates. <i>For more details, see the appropriate paragraph of the description.</i>

<b>VminECO</b> V <sub>ABECO</sub>	AB voltage (by default 13V/26V/52V), which power addition algorithm or switch over to the forced generation depend on; should be set no lower than V <sub>AB_BUF</sub> ; see below.
<b>Min tariff</b> Start 00:00  <b>Min tariff</b> End 00:00	<p>Minimal rate time settings. Start and end time of minimal kilowatt-hour rate. This time value should be set if the option "GridTariff+ECO" is selected. The time can be set with 10 min step. You must also set the current time (in subdirectory "Other Options"). It is used for two-rated grids.</p> <p>In this period MAC will charge AB and supply your equipment with energy in priority for external grid then during the expensive rate it will increase the use of alternative energy sources.</p> <p><i>For more details, see the appropriate paragraph of the description.</i></p>
<b>Proc.PowerAddECO (ProcECO-mixing)</b> (Hybrid/DOMINATOR) P_MinGenECO = 10%	Power addition in % from maximal power of the device. More details see in appropriate paragraph of the description.
<b>- AB parameters for charge</b>	
<b>AB type</b> lead-acid Gel / AGM AGM Shoto Trojan105RE LiLYP4*x3,9v (only with external BMS) Li LT 4*x3,7v (only with external BMS)  <i>*It automatically sets the number of cells depending on rated voltage</i>	<p><b>AB TYPE SETTINGS.</b></p> <p> Extremely important parameter for MAC operating. You must correctly identify and set the type of your batteries. MAC will set the best charging algorithm, considering many factors that are programmed in the inverter memory, as well as many other factors, including temperature, the time of day, current load, etc. MAC uses an internal database for the most efficient use and accumulation of AB energy.</p> <p>A useful resource on <a href="http://invertor.ru">http://invertor.ru</a> site in the section "Batteries" - can be read for the correct settings. New types of batteries as well as the algorithms may appear after MAC hardware upgrade.</p>
<b>AB capacity</b> Ёмкость АКБ  0100 Ah for 24V⌘  ⌘ - shown as an example you should enter your values	<p><b>AB PACK CAPACITY SETTING.</b></p> <p> It is necessary to calculate and set up the capacity of the AB properly. AB capacity for all the modern MAC is calculated according to connection type and AB pack voltage. Example: for a pack of two cascade-connected (in series) 12V batteries of 100 Ah each one you must enter 100Ah 24V (C = 100). If the pack consists of two parallel-connected 12V batteries 100 Ah each one, then the parameter "AB capacity" will be equal to 200 Ah at 12V (C = 200).</p> <p>In the section "Preparing AB pack" the examples of the AB connections for 12V, 24V, and 48V are given. Basing on parameter "AB Capacity" MAC charges and maintain AB charged correctly what ensure its longer lifetime.</p>
	<p><b>ADDITIONAL AB PARAMETERS. CAUTION!</b> MAC sets these parameters by itself basing on the selected AB type. By changing the settings, you can reduce a battery lifetime! Do not change the advanced settings of AB subdirectory if you are not sure, and certainly do not understand what you are changing! Before changing these settings, refer to the battery specifications and recommendations from the paragraph "Batteries" on <a href="http://invertor.ru">http://invertor.ru</a> site. After you change the type of battery, these values will be restored to the factory default.</p>

<p><b>Initial charging current</b></p> <p>0.10C I= 20A ⌘</p>	<p>Initial rate. The first stage of charge – initial current of charge. This current of charge will be maintained until the AB voltage is 0.5V/1V/2V lower than the voltage of stop charging (V<sub>AB_MAX</sub>) then charge goes to the second stage (see next paragraph). The current value is calculated from the Capacity C. 1/10 (0.1) of the capacity is set by default, (except Li).</p>
<p><b>Final charging current</b></p> <p>0.05C I= 10A ⌘ ⌘- an example</p>	<p>Final rate (the second stage). Changeover to this current occurs when the voltage is 0.5V/1V/2V lower than the voltage of stop charging (V<sub>AB_MAX</sub>) and will be maintained until these values (V<sub>AB_MAX</sub>) are reached. The current value is calculated from the Capacity C. 1/20 (0.5) of the capacity is set by default (except Li). It is acceptable to equate this current with the initial one in case of charge algorithm “with Absorption charge” is selected.</p> <p>Default values are optimal. For faster AB charging you may select 0.2 C for the first stage and 0.1 C for the second one. It will reduce the time of charge approximately of one and a half times.</p> <p>This is convenient for work with generators. However, the charge takes about 5-6 hours for only 80% of AB capacity. For the charge from only the generator we recommend once in two weeks/month to switch on Absorption charge (see further information), reduce currents and charge AB for 12 hours until 100% charge level is reached.</p>
<p><b>Charge algorithm</b></p> <p>2stage 2-currents 3stageAbsorption 3stageBuffer 4stageAbsorption/Buffer</p>	<p>2stage 2-currents – MAC will charge AB in two steps: at first, with “initial rate” till AB voltage is almost full and then with “final rate” till AB voltage reaches the maximum (V<sub>AB_MAX</sub>). When two-stage algorithm of charge is over the charge switches off.</p> <p>3stageAbsorption = 2 stages + absorption stage of charge – default algorithm. After MAC has charged AB with charging current of the rates according to the first two stages (is acceptable in this case to put the same current for the first and the second stages, for faster charge) it will charge the AB by such current which maintains the maximum charge voltage (for lead-acid – 14.5V / 29B / 58B, for a GEL battery – a bit lower (see the battery data sheet).</p> <p>The charge will be continued until the current is reduced to 2% of AB capacity (means 0.02C, for example, 2 A for 100Ah AB), but no longer than 4.5h. In Absorption stage the display will show ¾ sign near the sign of battery (means the 3rd from 4 stages) also the LED “AB” will light up in red from time to time, as the voltage will be near the full charge. We recommend to use this mode as the main one. Also, this mode provides faster charge by increasing the first stage charge currents; in this case the 3rd stage will charge AB to the end. It is necessary to specify (from the producer) the maximum charge current for your AB and check the charge level at the end of each stage.</p> <p>3stageBuffer - after two-stage charge is over, MAC switches over to trickle charge mode (buffer charge). In this mode, the display will show the blinking sign *. The charge will not end: the AB voltage will be maintained near V<sub>AB_BUF</sub> (may be changed through settings). When AB voltage exceeds V<sub>AB_BUF</sub> charging current stops and starts again when the voltage drops by a few percent.</p> <p>Buffer charge level is maintained for 24 hours, whereupon it will be decreased by 0.5V/1V/2V for 12/24/48V models accordingly. If nothing is changed then in a week MAC will start a basic charge mode, then the buffer mode with V<sub>AB_BUF</sub> voltage and so on. Such an algorithm protects AB plates from crumbling.</p>

<p><b>Charge algorithm</b></p> <p>2stage 2-currents 3stageAbsorption 3stageBuffer 4stageAbsorption/Buffer</p>	<p>This mode provides an activation of two-stage charge occasionally because when the network is available, a low current maintains AB charged, which allows to prolong working time without the network. In ECO modes, the forced exit from buffer charge may occur. See the details in annex “Addition. ECO modes”.</p> <p>4stageAbsorption/Buffer is similar to 3stageBuffer but with trickle charge (buffer), means when Absorption charge is finished system will switch over to buffer mode.</p> <p><i>Note. Mostly, 3stageBuffer mode or its extension to 4stageAbsorption/Buffer mode are used by default. The other modes are used in special cases such as work with alkaline batteries or for occasional use with a generator for a quick charge.</i></p> <p><b>ATTENTION!</b> Voltage VAB_BUF and VAB_MAX are automatically set when you select battery type: "lead-acid", "Gel/AGM", etc. and it depends on AB temperature.</p>
<p><b>V<sub>AB</sub> Start Charge</b> V<sub>AB</sub>_Start=12,5V/25V/50V</p>	<p>When AB voltage is below this value MAC activates charge mode. This value can be changed in accordance with the recommendations of the batteries producer.</p>
<p><b>V<sub>AB</sub> FloatCharge (VAB BufCharge)</b> V<sub>AB</sub>_BUF=13,6V/27,2V/54,4V</p>	<p>Buffer or float voltage value. MAC will maintain the AB voltage about this value. It is automatically set upon “AB type” selection. This value can be changed in accordance with the recommendations of the batteries producer. Automatically will be changed every time you change the “AB type”. It works with algorithms that provide a “Buffer charge”.</p>
<p><b>V<sub>AB</sub> EndCharge</b> V<sub>AB</sub>_MAX=14,5V/29V/58V</p>	<p>AB voltage for stop charging at. It is automatically set upon “AB type” selection. This parameter can be changed in accordance with the recommendations of your batteries producer. Automatically will be changed every time you change the “AB type”.</p>
<p><b>- EXTERNAL RELAY (<i>DOMINATOR</i>)</b></p>	
<p><b>Function Relay1 and 2</b> OFF StartFuelGenerator On AB voltage On time On AB temp. OFFgrid NetworkTransmit ChargeMode ExternalControl</p>	<p>Condition or threshold for Relay 1 or 2 activation. For more details, see the appropriate paragraph of the description.</p>

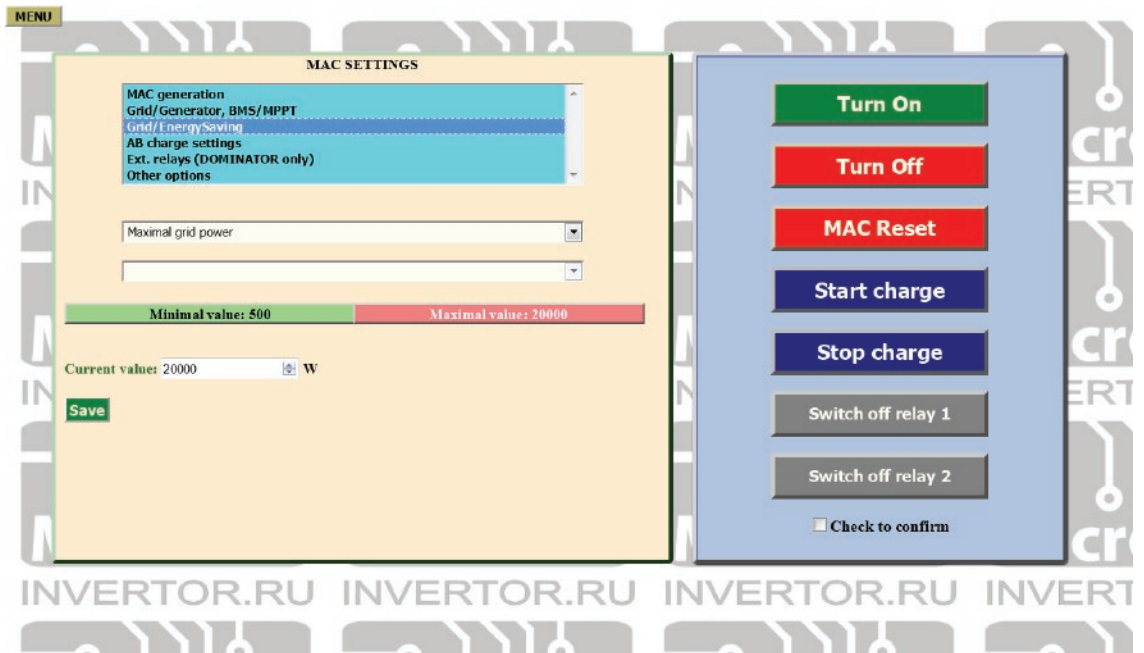
<b>- OTHER OPTIONS</b>	
According to xx.x uu V/y,y kW # P7+v12L/10/10L	The parameter is not editable. LCD shows information: xx.x – version of firmware; vv V – MAC rated voltage; y,y kW – MAC rated power. A text like: P7+v12L/10/10L – circuit boards versions. It is necessary to specify the version for correct MAC firmware upgrade.
<b>Current time</b> 00:00	Current time of the internal MAC clock. It should be set if you use "GridTariff" mode. Time is set accurate to minute; seconds are set to zero. This time will be displayed in the bottom line of LCD together with the frequency (if "Grid-Tariff" is selected).
<b>MAX Time of charge</b> T=24h	Maximum charging time. It is intended to stop charging if mains voltage is low. Also for work with alkaline AB.
<b>LCD backlit</b>  Eventual OFF Always ON	LCD backlit mode. Eventual – backlit is activated at mode change (generation, network transmitting, AB charge), with button pressing and when error or warning occurs. OFF – LCD backlit is turned off always. Always ON - LCD backlit is always active; convenient when you are getting familiar with the device.
<b>Sounds (Alerts)</b>  Allowed Problems only None	Allowed – enabled alerts only. By default, it is the most of errors, warnings or state change (generation, grid, charge, stop charging, maintaining charge). Problems only – only (permitted) errors and warnings alerts except for modes change. None – the sound will appear as a button pressing confirmation only.
<b>OFFGrid alert</b> OFF Every minute Every 10 minutes	OFF - the alert is off. Otherwise the buzzer produces 3 signals every minute or every 10 minutes on grid failure (at MAC input).
<b>Speed RS /AGCS/VddWiFi</b>  2400 bit/s - 115200 bit/s AGCS - Charge VddWiFi	RS232 serial port bit rate (speed). The longer wires are and the older you PC is, the lower speed should be chosen. For cable length up to 5m it can work on 19 200 bps (by default).  AGCS – Charge – is set to start and stop the generator, when MAC needs to start or to stop the charge. In DOMINATOR models, it is possible to switch on the AGCS through Relay 2. Power ON / OFF for external Wi-Fi adapter.  For more details, see the appropriate paragraph of the description.
<b>AB Preserving</b>  OFF ON	This mode allows switched off MAC to charge the AB. It is convenient to use for AB preserving, for example, in the winter, but of course, only if the network is connected. Keep in mind that the network will be automatically transmitted to the output during charging, therefore please disconnect all the loads from the inverter output.

## REMOTE MONITORING AND CONFIGURING

The "Malina" (MALINA Appliance) is developed for remote monitoring and control of MicroART products. MALINA Appliance is made on the minicomputer platform, and is developed for power grids monitoring and the control of MAC inverters, the MPPT solar controller, SEC for wind turbines and batteries (including BMS).

It has the ability of AB monitoring with the option of generation disabling according to AB charge (discharge) level.

MALINA is an autonomous Web-server, based on a minicomputer with Linux operating system. Minicomputer collects necessary data from MAC and MPPT SEC controller (just either MAC or solar controller will be enough) and outputs them in a format supported by any Web-browser on any platform. With LAN connection, the user can monitor or make setting through any device such as PC, phone or tablet with any operating system. With the appropriate Internet connection, control and monitoring can be done via any other device connected to the Internet.



MALINA Appliance has a Battery Monitor option for measurement of real actual AB capacity, and the additional option of 220/230B MAC generation disabling if AB charge level drops to the preset one.

MALINA Appliance is connected to the MAC and MPPT controller via USB interface. The connection to the minicomputer network is implemented through 10/100 Ethernet port. MALINA also gives an opportunity for USB modem connection that let you control your MAC via SMS.

MALINA Appliance collects all data received during its operating and creates databases of all the parameters, which can be viewed as convenient diagrams in real time or later by selection of required time interval. As well as the statistics of main parameters are collected for the whole system analysis.



The device is powered from the mains voltage of 220/230V usually it is a MAC socket. If MAC is disconnected then MALINA also will be OFF and therefore MAC monitoring and control will be lost, for such things don't occur we recommend to connect MALINA through any portable AB power box (which are used for charging portable electronics).

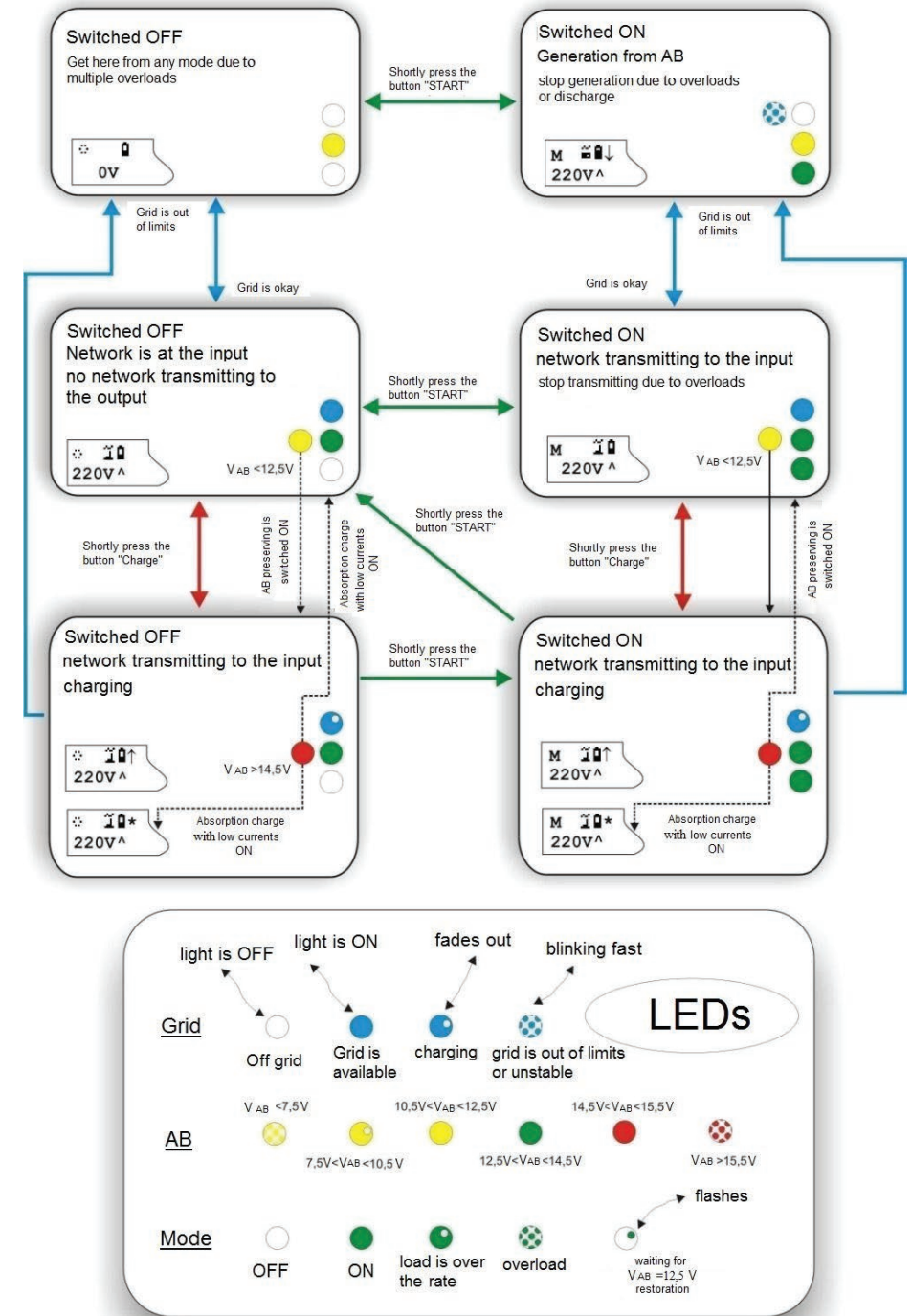
The functionality of MALINA Appliance completely repeats remote monitoring functionality of MAC DOMINATOR model (MALINA comes as an embedded appliance for this MAC model) except for power supply of the minicomputer: this point is reviewed in the appropriate paragraphs.



### LED INDICATION

### The main modes and switching between them

	
Light is OFF	OFF grid
Blue Light	Grid is available
Blue Light, fades out slowly	Charge is in progress
Fast blinking in blue	Grid is unstable. Voltage is out of range. Exceeds $V_{min}$ (120V factory defaults) $< V_{grid} < V_{nmax}$ (265V factory defaults), or grid is overloaded, or load power exceeds the generator rated one
Light is OFF, flashes blue rarely	Grid is available but forced generation in ECO mode is activated
Double rare flashes	Shows that MAC has switched to the additional (second) Input of 220/230V
	
Fast blinking in yellow	$V_{AB} < V_{low}$ The voltage is very low $< V_{low}$ (7.5V/15V/30V factory defaults), generation will be stopped after a few trials.
Yellow light is ON, fades out rarely	$V_{low} < V_{AB} < V_{min}$ . The voltage is in range $V_{low} - V_{min}$ (10.5V/21V/42V factory defaults). MAC continues working for 1 minute in generation mode and switches OFF. Then, it stands by and does not activate the generation mode until the voltage reaches $V_{restor}$ (12.5V/25V/50V factory defaults).
Yellow light is ON	$V_{min} < V_{AB} < V_{norm}$ . The voltage is in range $V_{min} - V_{norm}$ (12.5V/25V/50V factory defaults). For voltage $V_{AB} < V_{norm}$ charge will start if grid is available.
Green light is ON	$V_{norm} < V_{AB} < V_{max}$ The voltage is in range $V_{norm} - V_{max}$ (14.5V/29V/58V factory defaults).
Red light is ON	$V_{max} < V_{AB} < V_{top}$ . The voltage is in range $V_{max} - V_{top}$ (15.5V/31V/62V factory defaults).
Fast blinking in red	$V_{AB} > V_{top}$ . The voltage exceeds the maximum allowed - $V_{top}$ (15.5V/31V/62V factory defaults). Generation of 220/230V will be stopped.





Light is OFF	<p>MAC is OFF partially: like a standby mode (LCD works).          In this mode MAC doesn't transmit the network to the output, but, shows its value by blinking, MAC doesn't generate 220/230V from AB.          If "AB preserving" has been chosen and voltage <math>V_{AB} &lt; V_{charge}</math> (12.5V/25V/50V factory default), the inverter starts charge mode (if the network is available) and transmitting the network to its output. After the charge is done the inverter stops network transmitting.</p> <p>*If voltage <math>V_{AB} &lt; V_{min}</math>, the Relay will switch to network transmitting to lower the power consumption.</p>
Light is ON	<p>MAC is ON          The main MAC working mode when it either transmits the network or generates 220/230V from AB.</p>
Fast blinking	<p>Overload. The overload caused by AB or grid currents has occurred.</p>
Blinking, fades out rarely	<p>The load is above the rated one during generation.          This mode occurs while generating of 220/230V from AB in case the consumption power is above the rated one (2/3 of the maximum). In such case MAC generates 220/230V for 30 minutes and after turns off for 30 minutes (for cooling), after that starts work again. The more accurate algorithm works as follows: if load power is higher than the rated one, the time counter starts. If load power drops below the rated one, the counter switches to countdown. So, if the load is floating, but in average higher than the rated one, the shutoff may occur in one hour, two, etc., but in any case, MAC self-cooling time is 30 minutes. Make sure that the load does not exceed the rated power too often to avoid shutoffs.</p>
Blinking, lights rarely	<p>No generation, waiting for AB full charge.          This mode occurs when AB are fully discharged. Generation stops and resumes when the voltage exceeds the indicated one on the display.          Similarly, if the battery overheats (temperature is higher than the preset one), the generation stops and resumes when the temperature returns within the set limits.</p>

## PMAX MODE – POWER ADDITION AND INTERCEPTION

When the external 220/230V power grid is used, it is possible to set Pmax (maximum power) which will be drawn from the grid. For that, you should go to programming through the menu "AC/Eco Energy" -> "MaxGridPower". Default setting is 150% of the MAC peak power. That parameter (hereinafter Pmax) is referred to maximal power that MAC can transmit. However, for operating from fuel generator you should set up its rated power in case this power is below this default value.



*Note. Some producers often overestimate the rated power of generators and the real value can be lower (in such a case you should set up the real nominal power (load-carrying ability))*

*Note. The second network input has a similar parameter "MaxPowerInput2". Available only in DOMINATOR models.*

The power limit feature is especially useful for holiday villages, where often is a power takeoff limit (for example for your house you have only 5 kW allocated, and sometimes, you need more power).

The operating principle is as follows: when the load power exceeds the limit, there are two working algorithms for MAC.

**The first algorithm: "Power Interception"** is always enabled by default and available for any MAC model.

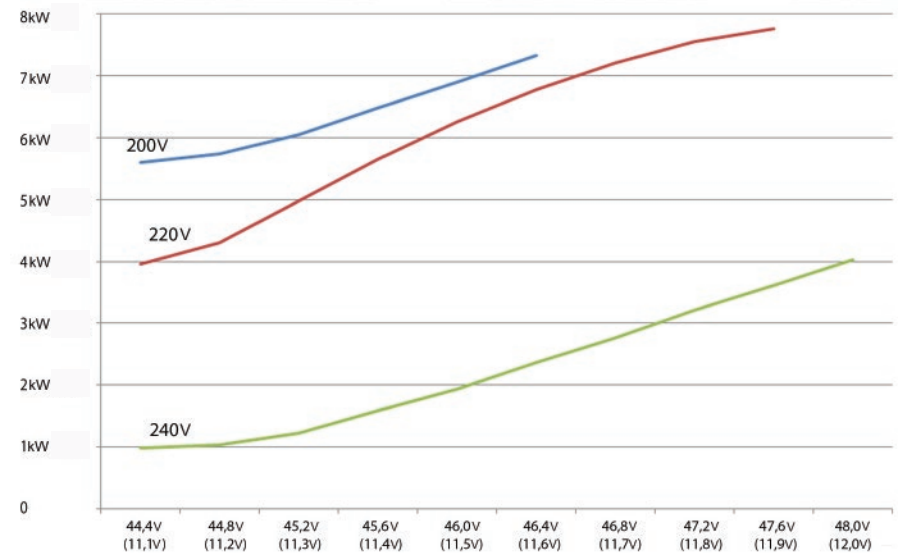
If total load power is above  $P_{max}$ , MAC disconnects all the loads from the input (stops network transmitting) and switches on the generation mode of 220/230V from AB. As soon as the load becomes below  $P_{max}$ , MAC switches on network transmitting mode and resumes the charge mode if it had been interrupted or in need on discharge.

Obviously, in this algorithm, the maximal load power should not exceed the maximal MAC power.

**The second algorithm:** Power Addition  $P_{max}$  (PA  $P_{max}$ ) is available only for Hybrid and DOMINATOR models. Disabled by default.

If "power addition" option is enabled and  $P_{max}$  is exceeded, the transmitting continues and the power generated from AB is added to the power consumed from the external grid in such a way as to grid consumption does not exceed  $P_{max}$ . The maximal power which can be added is equal to the rated power of MAC and strongly depends on AB charge level and mains voltage (the higher mains voltage is, the less power can be added). For example, MAC Hybrid device of 9kW can add up to 6kW, for network limited by 8 kW it is possible to work shortly (till AB discharge) under the loads up to 14kW (if the load is getting lower than 8kW MAC may start to charge AB). By comparison, to intercept 14kW load with 8kW network limit you have to choose MAC PRO of 15kW power. On the other hand, AB capacity requirements for power addition are almost 3 times less for Hybrid model.

In picture 7 you may see a typical dependence of maximum possible power addition on AB voltage for the network of 200V and 240V. In the case mentioned below the device of maximum power 6kW for 48V was tested (rated power 4kW). On the graph the power is shown in kW and as proportion of the device rated power; on the power scale this value is reduced to 12V (quoted in parentheses). The parameter is approximate and may differ from the MAC model and rated power.



Pic. 7 Maximum possible power addition dependence on AB voltage

Pmax displayed in the bottom row of LCD.

Both algorithms allow operating with "high-quality" generators. If the load and charging rate exceed Pmax, MAC firstly begins to reduce the charging rate to reduce network power consumption, and only then the power addition or forced generation will start.

For the system with MPPT mART©:

In Pmax mode together with ECO mode, when the load power exceeds the threshold, and MPPT current is enough, the power addition will supply more power, the system will go beyond Pmax, taking the maximal (available) power from the solar panels and offloading the 220/230V network. See "ECO mode".



**ATTENTION!** During forced generation or power addition according to Pmax when AB are deeply discharged the switching over to the grid will occur in spite of the maximum grid power limits.

PA Pmax will be reactivated when the voltage returns to the threshold of deep discharge ( $\sim 12.5/25/50V$ ). It means if, under high load, AB voltage drops below the limit of stop generating ( $V_{ABmin}$ ), MAC will stop generation or power addition and switch over to the grid. In case the load is not released, a tripping of the circuit-breaker, which limits the consumption, may occur. This is to protect AB from full discharge.

*Note. The similar situation may occur when MAC is not able to provide required power addition. Usually, it happens when AB are discharged and/or mains voltage is too high and at the same time too high current of power addition is requested. In this case MAC will generate maximal possible power addition, but will not be able to provide a defined Pmax limit. Then the consumption from the network will be increased and it may cause a tripping of the incoming circuit-breaker.*

To avoid such difficulties, AB capacity should be chosen in such a way as to guaranty a stable work without voltage drops below  $V_{ABmin}$ . As well as the batteries voltage should not slump under power addition. For example, you want to assure a 10kW load with network limited to 5kW, so the needed power addition is 5kW. For 48V unit the current of power addition comes to  $5000\text{ W}/48V = \sim 100A$ . The battery (except for Lit-Ion) current must not exceed at least 0.4C, lest to slump too much. Therefore, battery capacity should be no less than  $100A / 0.4C = 250Ah \times 48V =$  means 4 in series-connected battery cells of 250Ah x 12V. As the best option the capacity should be twice bigger as if the network fails all 10kW load will be drawn from AB and the currents over 0.4C will extremely decrease the number of AB charge cycles and as result its lifetime.

## ECO MODES AND NETWORK TARIFFS

If you have multiple-tariff meter or ordinary AC mains together with alternative energy sources like solar batteries or wind turbine MAC has special modes to reduce power grid consumption.

If MAC is connected to the grid it always transmits the grid to a load. If you have additional AB chargers which are working from alternative energy sources, then after AB full charge they will be idling. In that moment, it is possible to disconnect the grid but it is not always convenient and possible.

As in the case of power addition on Pmax there are two operating algorithms. The first one - "forced generation ECO" - is available for any MAC, the second one - "Power addition ECO" - is available only for Hybrid and DOMINATOR models.

To enable ECO mode, you need to:

- set "AC/Eco Energy" -> "ACNetworkControl" in "ECO modes";
- set required voltage  $V_{ABECO}$  in menu "AC/Eco Energy" -> "VminECO";

*Note. This is enough for PRO models, because these models have the only one operating algorithm "Forced ECO generation" available. It is activated automatically.*

- set the parameter MAC Generation -> PercentPowAddECO (ECO-mixing) (P\_MinGen ECO by default 10%).
- set the operating mode in the menu MAC Generation -> PowerAddECO (ECO-mixing) mode -> ForcedECOGener or Power Addition ECO;

Let's review both modes.

## FORCED ECO GENERATION MODE (FORCED ECO GENER)

In this mode network is not transmitted, MAC switches over to the generation ("Forced ECO Generation"), when AB voltage is over  $V_{ABECO}$ . But as soon as the voltage drops below  $V_{ABECO}$ , 2-minutes countdown will start: this gap is needed to ignore short-time drops if high power devices are connected (like, pump, kettle, etc.). If high load persists ( $V_{AB} < V_{ABECO}$ ), in 2 minutes MAC will start transmitting.

Then MAC will continue transmitting until AB are fully charged (from alternative energy sources) the text will be displayed: "WaitingExtCharge", after that MAC will switch over to generation mode and the cycle will be repeated.

You should remember that after a switch over to network transmitting when the voltage drops below  $V_{ABECO}$ , MAC can activate charge mode, if AB voltage is below  $V_{ABCharge}$  (available to set in "AB Parameters/During Charge" -> " $V_{AB}$  Start Charge"). If you want to use alternative energy sources for AB charging as much as possible after network transmitting is enabled, it is necessary that  $V_{ABCharge}$  should be less than  $V_{ABECO}$ : the lower  $V_{ABECO}$  value is, the more energy from AB will be drawn and therefore alternative sources of energy will be used more effectively but at the same time AB resource will be spent more intensively. In "ForcedEcoGeneration" mode the trickle charge (i.e. float or buffer stage) is unavailable even if you set it up.

The disadvantage of that mode is rather frequent changeovers from the network to the generation and in the reverse order and as a result it reduces the life-time of the switching relay especially at high loads.

## POWER ADDITION (MIXING) ECO MODE

This mode is available for Hybrid and DOMINATOR models only. The operating in this mode is similar to "forced generation". But instead of switching over from transmitting to the "generating from AB", a certain power will be added ("power addition or power mixing") to the consumer's network. At that MAC doesn't disconnect the grid. The purpose of power addition is to reduce grid consumption by adding some power to the MAC output, if there is a load. But to avoid energy cross-flow to the grid the power of addition should never exceed the load power.

There are some more differences between "Power addition ECO" and "Forced ECO generation". If AB voltage is  $< V_{ABECO}$  the power addition stops otherwise it continues. Moreover, for operating with MPPT mART© even if AB voltage  $< V_{ABECO}$  but the power generated by alternative sources is more than the charge requires, the power addition continues. For details, see below.

**For both modes if AB voltage hasn't reached the full charge level for past 3 days – MAC starts to wait a full-charge from an external charge controller.**

If in a week the AB voltage does not reach the full-charge value, the charging from AC network will start.  
The maximum added power for MPPT mART© (in contrast with other producers' MPPT) will depend on the energy that solar panels can produce.

Besides, as for the "Power addition Pmax" mode the maximum power of "Power addition ECO" mode, as a rule, doesn't exceed MAC rated power and depends on the network and AB voltage.

In the power addition mode in the bottom row of LCD you can see the information about power consumption from the network and how much of power is added. When the power addition finished (see above the conditions of power addition stop), the waiting for AB full charge from the external source will start with appropriate text in the bottom row of LCD.

## GRID TARIFF+ECO MODE

This mode can be used in two cases.

**First one:** if you have a multiple-rate meter and you want to save energy from the grid by enabling the forced generation mode during the day. The term "to save" is to be disputed because with energy saving you waste AB resource at the same time. But the use of alternative energy sources changes the situation: it allows to maintain the AB. Moreover, besides the forced generation, you may enable the power addition. It allows you to consume cheaper energy within low tariff time. It may be solar panels in daytime, or a wind turbine at the nighttime. Usually, this mode is not recommended for solar panels.

**Second one:** even if multiple tariffs are not available, this mode can be useful for work with such sources as solar panels. To avoid obtaining the energy from AB at nighttime you may set the time of sunrise and sunset. It is also possible to disable the obligatory charge during the minimal rate (see below). For that you should uncheck the option "obligatory charge for tariff mode" in the program of MAC firmware upgrade (MAP2Gui\_.exe, "Monitor" pane), which can be downloaded from the web <http://www.invertor.ru> in the section of technical support->firmware and manuals.

This is to set in the menu: "AC/Eco Energy" -> "ACNetworkControl" - operates in the same manner as "ECO modes", but, moreover, during the minimum grid rates MAC will switch over from the ECO modes to the network transmitting. (even if AB voltage is above  $V_{AB\_ECO}$ ).

As switching to the minimum rate occurs MAC activates the charge mode in spite of AB voltage setting; the trickle (buffer) mode will also operate if set.

If the minimum tariff time is over but MAC hasn't finished the forced generation will be deferred to the end of the charge.

The minimum rate time is set in:

"AC/Eco Energy"->"MinTariffStart"

"AC/Eco Energy"->"MinTariffStop"

The time of start and stop of "minimum tariff time" – are usually nighttime. During this time the price for electricity is lower (if you have a multiple tariff meter and appropriate contract). The minimum tariff time is set up with 10 min step. For the correct work, it is needed to set up current time in the menu "Other options"-> "Current time". Current time will be displayed in the bottom row of LCD with the AC frequency (if set "GridTariff+ECO").

*Note. Please note that operation in all mentioned above modes (Pmax and ECO) wastes the AB life. The deeper AB discharge is, the shorter AB lifetime will be. We recommend not to allow deep discharges: more than 70%-80% of rated capacity.*

The parameter which controls that discharge is  $V_{AB\_ECO}$ . For AB with a small resource of charge-discharge cycles – that voltage should be set about (but no less than)  $V_{AB\_BUF}$ , for increased resource that parameter should be set far from  $V_{AB\_BUF}$ .

To control that you may use external AB monitor (for example on the base of MALINA) or analogue embedded in DOMINATOR.

## OPERATING IN POWER ADDITION ECO (ECO-MIXING ) MODE WITH THIRD-PARTY CHARGE CONTROLLERS

For third-party MPPT the power addition is calculated from the formula, which essence is that the higher AB voltage is, the more power is added. Linear subjection of  $kx + b$ , starting from  $V_{AB\_ECO}$  (the power addition stops when the voltage is below it) and to  $V_{AB\_MAX}$  (voltage of stop charging). Term “b” is the value set in “Percentage of power addition”.

I.e. if percentage of power addition is 0 then starting from  $V_{AB\_ECO}$  the added power is increasing linearly from 0 to the maximum value.

If power addition percentage is set to 10%, for example, the initial added power for 3kW device is 300W, starting from  $V_{AB\_ECO}$  and then it will be growing linearly. This parameter can control the efficiency of power addition in the range from  $V_{AB\_ECO}$  to  $V_{AB\_MAX}$ .

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*Note. If there is a lot of sun and a load starts occasionally then the percentage of power addition can be set to a higher value for providing maximum energy for the load when it works. Of course, it works at the expense of AB discharging which will be recharged from the abundant sun as soon as the load is turned off. If there is not enough of sun and the load starts often then the higher percentage of power addition leads to increase of charge-discharge cycles number which affects AB lifetime.*

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**ATTENTION!** For the correct system work  $V_{AB\_ECO}$  voltage should be less than buffer charge  $V_{AB\_BUF}$  voltage. Therefore, for third-party MPPT user should set  $V_{AB\_ECO}$  value below MPPT buffer voltage (as MAC doesn't “know” the current voltage of MPPT float charge)

*Note. If third-party solar controller is used, we are not able to track which mode it operates in now (cyclic charge or buffer). In case of MAC has entered the mode of external charge waiting, besides the standard switching to the power addition or forced generation after a full charge ( $V_{AB} > V_{AB\_Max}$ ) this will happen also in two hours after AB voltage reaches  $V_{AB\_BUF}$ .*

## OPERATING IN POWER ADDITION ECO MODE WITH MPPT MART©

For MPPT mART© (which MAC has full-featured interconnection with) the algorithm of power addition will be as follows:

$V_{AB}$  – current AB voltage

$V_{AB\_BUF}$  – buffer or float AB voltage. It is recommended to keep this voltage ( $V_{AB\_FloatCharge}$ ) about this value. Is to be taken from the AB service manual or specifications.

$V_{AB\_ECO}$  – limit of ECO mode:

A) If  $V_{AB} > V_{AB\_BUF}$  the power addition is set to the maximum. It means the maximum power that MAC can provide during network transmitting.

B) If  $V_{AB\_ECO} < V_{AB} < V_{AB\_BUF}$  – the adding power will be equal to the power from solar controller plus the power is set in “PercentPowerAddECO” (means % from the maximum MAC power)

There is an exception for both conditions (A and B). If within 3 days the controller has not charged AB completely then AB charge from the solar controller will start. In this case the power addition is limited by the current from solar controller minus the actual AB charging current.

C) If  $V_{AB} < V_{AB\_ECO}$  – power addition is equal to the current from solar controller minus the AB charging current.

The “Percentage of power addition” setting is the same as for third-party MPPT. See above.

From the operating algorithm of the MPPT mART© it is obvious that the use of solar energy is about the maximal in contrast to third-party MPPT in tandem with MAC where the analysis of adding power is based on extremely nonlinear correlation with AB voltage.

**In addition, the use of MPPT mART© allows to prolong AB lifetime noticeably or reduce the capacity requirements, because power addition will occur mainly while solar energy is coming.**

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*Note. For MPPT mART© controllers the buffer voltage is adjusted by MAC while operating. After full charge is complete, MPPT switches to Buffer mode “B” – initial buffer charge mode (balancing). In this mode MPPT stabilizes AB voltage at the level of  $V_{AB\_BUF}$  which has been set in MAC menu. In 24 hours MPPT will switch over to buffer mode “b”- secondary buffer charge mode (charge level maintenance) with the voltage 0.5/1/2V below the set one. Besides, you have to remember that the buffer voltage depends on temperature. Thus, if  $V_{AB\_ECO}$  is set near the buffer voltage then in 24 hours or depending on the temperature  $V_{AB\_BUF}$  may become lower than  $V_{AB\_ECO}$  and power addition would not be so efficient. Therefore if  $V_{AB\_BUF}$  becomes lower than  $V_{AB\_ECO}$ , MAC will automatically adjust  $V_{AB\_ECO}$  as  $V_{AB\_ECO} = V_{AB\_BUF} - 0.2/0.4/0.8V$*



**ATTENTION!** We strongly recommend you to use the same operating algorithm for both ECO and Pmax modes. It should be either “power addition” or “forced generation” for both modes.

## OPERATING IN “SELL TO THE GRID (I.E. SURPLUS TO THE GRID)” MODE

This mode is available for Hybrid and DOMINATOR models only. It almost similar to “Power addition ECO” mode therefore all algorithms described above for MPPT mART© or third-party MPPT are observed. The only difference is that MAC sends (sells) all the energy surplus to the grid. In ordinary “Power addition” mode the power is limited by the load despite MAC can add more.

Therefore, in factory presets this option is blocked. To unblock it you should check the option “Unblock the Sale to network” in the program of MAC firmware upgrade (MAP2Gui\_.exe “Monitor” pan), which can be downloaded from the web <http://www.invertor.ru> in the section technical support-> firmware and manuals. Then in the MAC menu “PowerAdditionECO” the option “Sale to the grid” will be unblocked and available to select.

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*Note. Please draw your attention that operation in all the modes (Pmax and ECO) mentioned above wastes the AB resource. The deeper AB discharge is, the shorter AB lifetime will be. We recommend not to allow deep discharges: no deeper than 70%-80% DOD (depth of discharge) drawn from the rated or reduced capacity. For its control, you can use an external AB monitor (for example based on MALINA) or DOMINATOR model with embedded micro-PC.*

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## SUMMARY AND FAQ

### **Which mode (if the model gives a choice) and parameters for operating with alternative energy sources are better to choose.**

First of all, it should be mentioned that, as the last note says, ECO modes use energy from batteries. It is good when alternative energy is enough but sometimes it is cloudy, no wind or the connected load power is higher than alternative energy source can produce. In this case, it is not good sometimes to limit this energy for the load. Of course, AB energy can be spent in expectation of some sun for AB charging. Otherwise AB are staying constantly charged and when the sun comes out this energy will be lost if you have not enough load.

The parameter, which adjusts the depth of such discharge, is  $V_{AB\_ECO}$ . For AB with a small resource of charge-discharge cycles – this voltage should be set about (but no less than)  $V_{AB\_BUF}$ , with bigger resource this parameter could be set farther from  $V_{AB\_BUF}$ .

There is one more rule to choose  $V_{AB\_ECO}$ , but the value should be found out experimentally. The more alternative energy (on average) exceeds the consumption (on average), the lower  $V_{AB\_ECO}$  may be set, and in the power addition mode a higher percentage of power addition correspondingly. If alternative energy is below the consumption,  $V_{AB\_ECO}$  should be set closer to  $V_{AB\_BUF}$  and use only power addition mode with a small percentage of power addition.

Besides, you should keep in mind that if only solar energy is used then at nighttime energy won't be produced. In this case to avoid nightly discharge (for example by fridge, heating etc.) especially for the low  $V_{AB\_ECO}$  with a high percent of power addition set it is preferable to use tariff mode. (See above).

### **Forced generation.**

Forced generation, for example, can be useful when a grid-tie inverter is used, see the appropriate paragraph. Besides, it is apparently better to use with third-party MPPT controllers which don't have full-featured interconnection with MAC. In any case a weak point of this mode is the switching to external charge waiting, at the voltage is below  $V_{AB\_ECO}$ . Thus, alternative energy is spent for the charge only and limited by charging rate. Therefore, the use of that mode will be effective only if the alternative energy is enough to maintain AB voltage above  $V_{AB\_ECO}$  during all day for the tariff mode, or otherwise - during 24 hours (i.e. the voltage decrease below  $V_{AB\_ECO}$  occurs rarely) .

So, you may see from aforesaid the advantage of setting  $V_{AB\_ECO}$  as low as possible for the forced generation mode. But in that case, you should buy expensive AB with a higher number of charge-discharge cycles or change them often. For example, if you use  $\text{LiFePO}_4$  batteries, then forced generation mode would be a good choice.

The disadvantage of this mode is rather frequent transfers from the network to the generation and backward and as a result the reduction of the switching relays life-time especially at high loads.

### **Network power addition (power mixing).**

"Power addition" in cooperation with our solar controller MPPT SEC© mART® is perhaps the most effective mode, because the alternative energy always used to the maximum. The selection of  $V_{AB\_ECO}$  is not so critical and depends only on the resource of used AB. It means that in contrast to forced generation you may use AB with a smaller resource. Of course, in this case efficiency of alternative energy will decrease but you have a choice.

The power addition for third-party MPPT will be beneficial if it is impossible to provide the conditions described above for the forced generation. For example, you use ordinary lead-acid batteries and/or alternative energy sources produce less than the load consumes.

Unlike the forced generation, the power addition works only when alternative energy is available. Therefore, to give the maximum power to the load there is one more parameter: "percentage of power addition". Even though there is no alternative energy, some extra power will come to the load from AB. This parameter depends mostly on the load. If it is constant or frequently repetitive then you should not set a high percentage of power addition otherwise AB voltage will be about  $V_{AB\_ECO}$  all the time. On the contrary, for rare load if alternative energy is not enough it all should be drawn from AB therefore a higher percentage of the power addition should be preset.

The disadvantage of this mode is that the power addition works with accuracy of 20-100W (depends on MAC model), i.e. such power is always drawn from the network for the load.

## CONNECTION TO A FUEL GENERATOR AND AGCS

When using MAC with fuel (gasoline, diesel, or gas) generator its output of 220/230V is connected through a cable to the MAC input connector for 220/230V network. For DOMINATOR model the connection to the individual input 2 is possible. See in appropriate paragraph.

By analogy with the mains voltage, if generator is running, MAC transmits its 220/230V voltage to the output socket and charges the batteries, if necessary. When the generator stops (for example it runs out of fuel after 3-4 hours of running), MAC automatically starts converting AB voltage to 220/230V. Interoperating of MAC and generator allows to save fuel, provides the silence and reduces harmful exhausts. Also, it prolongs generator lifetime, as its total working time reduces.

In operating mode generator burns the fuel in a small dependence on current load. It means if you connect TV, fridge and lighting, for example, of 300W total power to a 2.2 kW generator it will consume only a bit less fuel than if all its power were used. Therefore, the competent use (saving operation while only MAC is working and maximal load while the generator is running) may lead to considerable fuel saving. Approximately 5-6 hours of generator work are usually enough to charge at least 80% of the AB capacity.

Also, it will be necessary to program the inverter parameters "Max Power" to the appropriate output rated power of the generator and activate one of Pmax algorithms. In this case, if MAC switches on charging with connected load and both load and charging power in total exceed the power of generator then charging rate will be limited to avoid generator overload. As soon as the load is reduced (for example a pump has switched off or a kettle has stopped boiling), the charging rate will be restored in accordance with charging program.

*Note. If MAC AC input is connected to 220/230V generator, it is strongly recommended to install a surge protector of 220/230V (of corresponding power) after generator. For the operation with generator, it is necessary to set the extended input voltage range from 120V to 265V. The generator power is recommended to choose no less than the rated power of MAC. Otherwise during abrupt changes of load power the generator will produce high-voltage harmonics which can damage the equipment. We recommend to purchase an inverter generator with starter. This type of generators produces ideal true sine of 220/230V and significantly reduce the fuel consumption on low loads. This ensures the long and high-quality AB charging with small fuel consumption. For high-powered generators you should set "Input 220V"->"FuelGenerator".*

Not to start a Generator manually on AC network failure and AB discharge it is comfortable to use the Automatic Generator Control System - AGCS. AGCS supports many generator models and have a connection to MAC through the RS232 port located on the front panel. In order to MAC can operate with AGCS you should set in the menu "RS Speed/AGCS/VddWiFi-> "AGCS-Charge", and also set the start voltage for generator: " $V_{AB\_FGStart}$ "->" $V_{AB\_FG}$ ". The algorithm is as follows: when the voltage is below  $V_{AB\_FG}$ , MAC will change the polarity of AGCS control signal. AGCS in its turn starts the generator, warms it up, in case it is required, adjusts generator controls, and then connects a generator output voltage to the MAC AC input of 220/230V. After that MAC will switch over to transmitting with charge. Then as soon as the battery is fully charged, MAC will restore the polarity of AGCS control signal, which will turn off the generator (preliminarily disconnecting it from the MAC input)

Full details of the AGCS operation, connection and features see in description in the AGCS on web [www.invertor.ru](http://www.invertor.ru). DOMINATOR model can also work with a generator, equipped with ATS (Automatic Transfer Switch). See below.

For the use of generator with starting device in full autonomy and especially if MICROART AGCS is installed, the built-in charger is not such a powerful for a full charge of small generator battery as the generator starts seldom (working with MAC and AB). Gradually the pre-installed generator battery may exhaust and auto start will work no longer.

To avoid such a problem, it is in need to integrate a small cheap charger on 12V with the option of float AB charge at the level of 13.6V. This device is connected to the inverter output, and its terminal posts are to be connected to the generator battery.

If you have a generator with starter, and AGCS is installed, when AC power grid of 220/230V is used you don't need an additional charging device as AGCS will charge the generator inside battery from AC when needed.

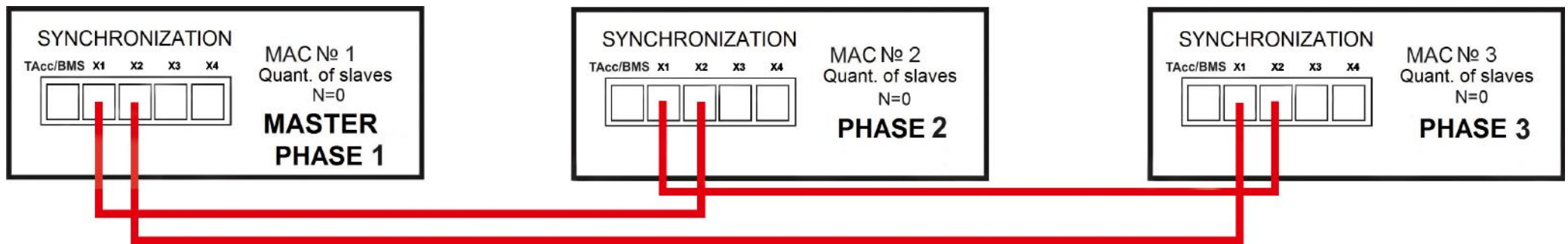


## THREE-PHASE MAC COMPLEX

Three-phase complex includes three MAC DOMINATOR devices (or MAC HYBRID equipped with optional synchronization modules) of identical power. The complex is connected to the common AB pack. A way of connection to AB and AB capacity setting are the same as for standalone device: the whole AB pack capacity should be set for each device.

To configure the system, you should enter the menu “MAC generation” then go to subdirectory “MAC synchronization” and set “master/phase1” on one of the devices, for the others set “phase2” and “phase3” correspondingly, they will be as “Slave phases”: don’t mix it up with SLAVE in parallel connection of MAC.

After the necessary parameters are set and the devices are divided into phases you need to interconnect the devices for their synchronization. For that purpose, they have dedicated RJ-12 ports on the back panel marked as “X1” and “X2”. Then you link by appropriate wires the output X1 of one MAC to the input X2 of the other MAC and so on. The connection scheme is shown below:



After AB and wires for devices synchronization are connected the first start should be done without a load. At first, you should turn on the power tumbler switch of a low-voltage board on each device sequentially. After the power tumbler switch is turned on the sound signal may appear and disappear in a few seconds if all three devices are synchronized, otherwise your MACs have an improper connection or settings are incorrect. If you have no errors, you may press shortly “Start” button on the “Master Phase1” device; the other devices will switch on automatically. “Start” button on the devices “Phase2” and “Phase3” will be inactive for switch them on/off. Check the devices operating in generation mode, switch them off (press “Start” button shortly, then turn off the power tumbler switch of a low-voltage board).

## 380/400V POWER GRID CONNECTION



**ATTENTION!** Before connecting the device to the 380/400V network make sure that all power tumbler switches are turned OFF, make sure there is no voltage in the connected network wires (the main circuit-breaker in the distribution box should be switched OFF)

For 380/400V network connection we recommend to use a terminal block of appropriate power, so each device would be connected through its separate three-core cable. The possible terminal block connection is shown in the picture below; the terminal block can be hidden in a terminal box or mounted in a distribution cabinet.

Please turn ON the power tumbler switch (do NOT press the button “Start” now). Then turn on the circuit-breaker of 220/230V network supply for each device. At first, switch ON the circuit-breaker of the MAC is indicated as “Master Phase1”, then “Phase2” and “Phase3”.

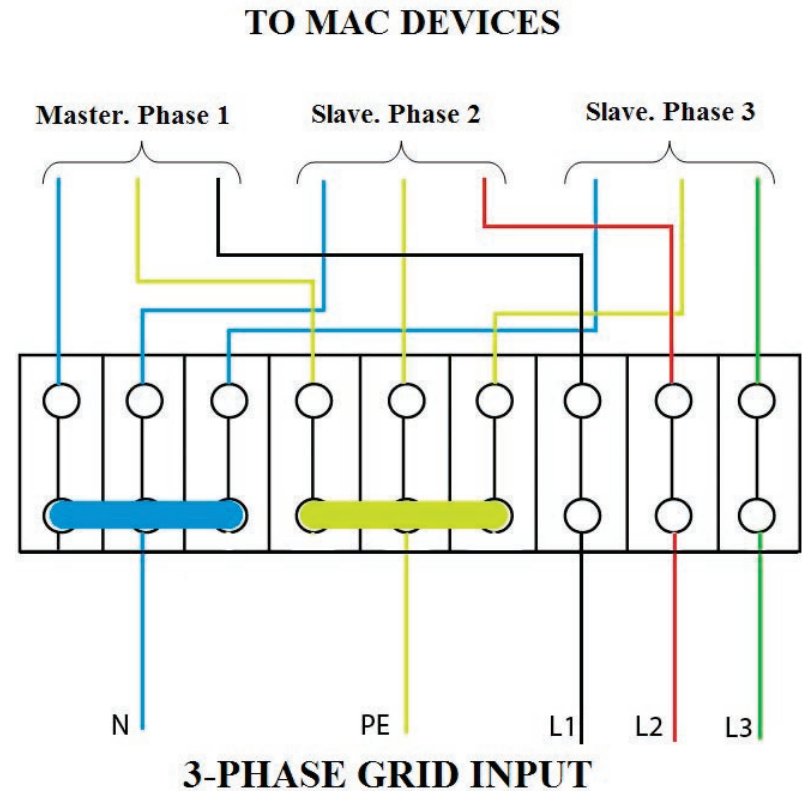


**ATTENTION!** If after switching ON the circuit-breaker of “Phase2” device you can hear short beeps please switch OFF the devices, switch OFF the main circuit-breaker of 380/400V. Then swap the input grid phases of 380/400V «L2» and «L3» on the terminal block, then repeat the procedure of switching ON: the sound signals should stop. In this case input grid phases are arranged in the right order for their further synchronization.

The second way is to change phases numeration in the menu: it means to swap “Phase2” and “Phase3” in settings of slave MAC.

After the input phases order is corresponded to phases numeration of MAC the generation can be switched ON by a short press on the “Start” button if the grid 380/400V is available.

It is preferable as well to make a “neutral grounding” if the structure of the power grid allows it (connection of an input zero to its own ground of the building) - see “Detailed scheme of MAC connection”.



### THREE-PHASE MAC COMPLEX FUNCTIONALITY

Due to synchronization of three devices, the complex can provide uninterruptible work on three phases and at the same time allows to connect three-phase loads. As it was mentioned above the devices are connected to the same AB pack and its charge is effectuated and controlled by all devices depending on the preset capacity and charge algorithm.

If AC grid has failed at one of the phases, the device where it has occurred will switch over to generation from AB, two other devices will continue transmitting the network. The system will not switch over to generation from AB even if two phases have failed, it means the device(s) with non-fault phase(s) will transmit them and charge AB pack at the same time. Foreign analogues start the generation from AB on all the devices if power failure occurred on Master device only. In our MAC complex if one of devices has a grid failure, even though it is a Master-device, the others will continue network transmitting and AB charging if needed, and only the devices, where grid is unavailable, will switch over to generation. Such a way of operating prolongs to the maximum the working time in generation mode from AB, as AB pack charge will be continued even by one of the devices.

It should be mentioned that charging rate is divided evenly on 3 phases, means  $1/3$  for each MAC, if they all are working from the grid. If one phase is absent, each of two others MAC supplies  $\frac{1}{2}$  of needed current. Finally, if the only one device with available grid remains it provides the full charging rate. At the same time if MACs on failed phases have the load then the charging current of the other increases to equilibrate this load (of course if charging current may is enough). For example, for AB capacity of 400Ah x 24V, charging current is 40A, if one phase fails the others two should provide 20A each. If maximal charging current of a device is 75A then two remaining MACs have  $(75-20)*2=110A$ . It allows to compensate the load up to  $110A*24V=2.64kW$  and only the load over this value will reduce the charging current, and the load more than  $75A*2*24V=3.6kW$  will start to discharge AB despite charging from available phases.

As for the last case when AB voltage drops below  $V_{min}$  the MACs on failed phases will stop the generation, the remained one will continue charging and on Vrated level the generation will be restarted.

Also, it should be mentioned that each device (on each phase) has a charging rate limit, and if full capacity is set, LCD may show a charge limit. Since AB pack is common, total current from all three phases can provide the required charging current. For example, AB pack capacity of 1500Ah requires charging current of 150A.

One device of 4.5 kW rated power and 24V has a 75A charging limit and surely will not provide a needed charging current, but in three-phase connection each device will provide the charge of 50A. If one of the phases is disconnected two remained devices will also give needed charging current  $2*75A$ . Finally, if only one working phase left then the charge will last twice longer (of course with no loads on other MACs).

Charge mode is controlled by Master device and only if it has no AC voltage this duty is delegated to MAC on next phase. As well as Master MAC controls the activation/deactivation of ECO modes (if they are preset).

The system operability remains even when all three phases fail: in this case all three devices will start the generation.



**ATTENTION!** For the three-phase network so called three-phase loads are to be connected separately (i.e. in bypass), mainly there are AC motors. For such a load, not only the phase sequence is very important but also none of them disappears. To protect such an equipment there is a special device as phase-sequence relay, which disconnects all the phases on failure of any. It is required to install such a protection device on all three-phase loads to avoid their damage. It may occur for example if one of phase protection device has activated or a MAC is switched off on AB discharge.

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External devices such as BMS and MPPT should be connected to the Master MAC, which in its turn intercommunicates with other devices.

## SYNCHRONOUS (PARALLEL) WORK OF MAC DOMINATOR

### ONE-PHASE PARALLEL WORK

MAC DOMINATOR can synchronize not only with AC grid of 220/230V (or electric generator), but to work in parallel with other MAC DOMINATOR inverters (up to 10 units in parallel). It may be useful for a step-by-step increasing of power and improvement of system reliability. The system with a number of parallel MAC DOMINATOR can be built from devices with equal rated power. It is possible as well to enlarge the capacity of three-phase systems. To use the system, you should interconnect the devices with special synchronization cables (purchased separately): there are special SYNCHRONIZATION ports for connection on the back panel of device marked as X1-X4. Connection logic is as follows:

MASTER->1-st SLAVE X3->X2;

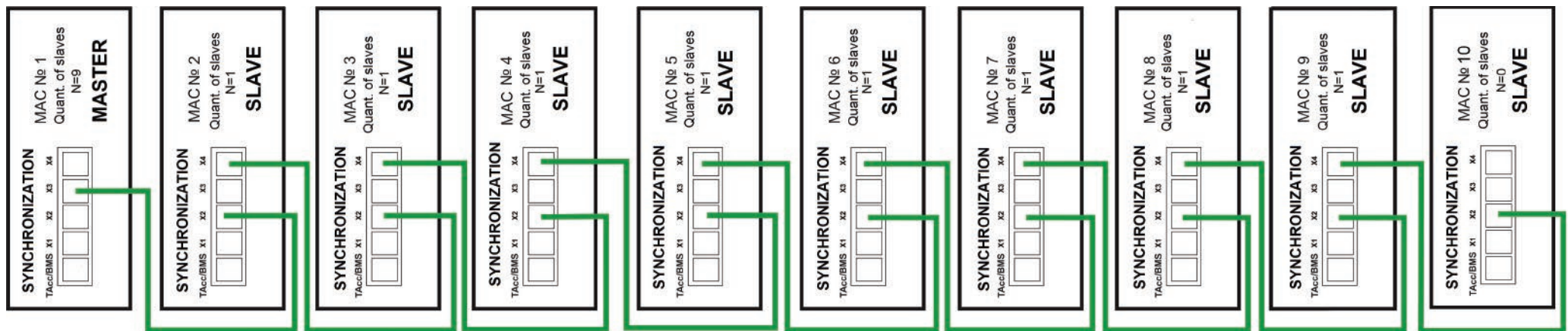
1-st SLAVE->2nd and following SLAVES X4 ->X2.

You must define the master device by setting it as MASTER through its menu as well as the number of SLAVES. For each SLAVE MAC you should set that it is SLAVE device and for each except the last one enter a number of SLAVES more than one. For the last device enter the number of SLAVES 0, for that:

1. Enter MAC menu
2. Select item "MAC generation"
3. Select submenu "MAC synchronization"
4. Accordingly set a feature of device: MASTER or SLAVE
5. To set the number (quantity) of slaves enter the menu "FuelGenerator/BMS MPPT"-> "Number of MAC Slaves" (sets as total amount for the Master, 1 - for the slaves, 0 - for the last one in chain)

Then it is possible to parallel 220/230V network inputs for all devices (observing phase and zero). All devices are connected to the one AB pack. All MAC AC inputs of 220/230V should be connected to one source of an input AC voltage (observing phase and zero as well).

In picture 8 you may see the scheme of MAC parallel connection for a one-phase network.



*Note: if one of the SLAVE MAC fails the whole system most likely will keep operating, as the control goes through the slaves at the hardware level. The weak point is a MASTER MAC which provides the control.*

Even though MASTER device fails the system may remain in operation if its processor is not damaged and electric part is not overloaded or a short-circuit has not occurred.

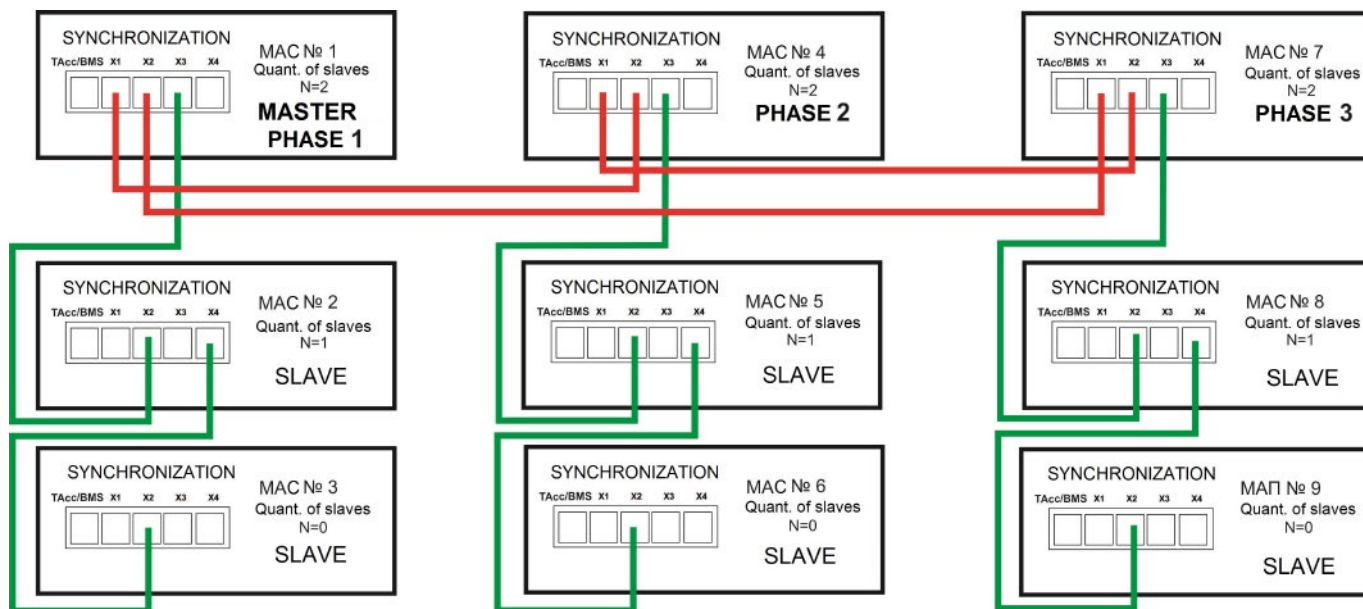
However, the actual MAC version controls SLAVES sequentially: disconnection of physical link of i-th MAC control will cause the disconnection of all consecutive devices.

### THREE-PHASE PARALLEL OPERATION

For connection order and description of a three-phase system see **THREE-PHASE MAC COMPLEX**.

To enlarge the power of three-phase system you need to connect devices according to scheme in picture 9. As an example, a scheme of 9 devices is shown (3 for each phase), but for 27 devices connection you should add SLAVE to each phase in accordance with the picture 8.

Then the phases of MASTER devices should be set correctly (in the picture they are on the top and connected by a red line) in accordance with the paragraph THREE-PHASE MAC COMPLEX. Then you should set in the menu the number of SLAVES and for each SLAVE set it as slave, for that:



Pic. 9



1. Enter MAC menu
2. Select "MAC generation" item
3. Select submenu "MAC synchronization"
4. Accordingly set the role of device: MASTER/Phase1 (correspondingly for the other phases: Phase 2 and Phase 3) or SLAVE
5. To set the number of slaves enter menu "FuelGenerator/BMS MPPT"-> "Number of MAC Slaves" (sets as total amount for the Master, 1 - for the slaves, 0 - for the last one in chain)

It is recommended firstly to set the right order of phases for MASTER devices (no errors or sounds after the phase inputs have been energized) and then connect SLAVE chains to the MASTERS. All work should be carried out in accordance with the appropriate paragraph "three-phase MAC complex" without any load. All devices should be connected to one AB pack.



**ATTENTION!** Switch off all the MACs and disconnect 220/230V grid/network while manipulating with input/output voltage of 220/230V.  
**EVERYTHING SHOULD BE CURRENTLESS!**

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### ADDITIONAL RELAYS IN DOMINATOR MODEL

On the backside of DOMINATOR model (see picture 1), there are contacts from 2 relays. These contacts are accessible after four screws are unscrewed and the cover with rubber seal (for wires connection) is removed. The connectors are marked with text "SYNCHRONIZATION". Inside it you will see two screw terminals of three posts for load wires connection (or generator control). These are so called "dry contacts"; they are connected nowhere inside the device. Interpretation of the numbers is printed nearby, on the body, namely:

"Pin1 /Com" - Number 1 – this is a shared (common) contact of Relay 1 and Relay 2 accordingly.

"Pin 2/NC" - Number 2 – this is a normally closed contact of a relay, Relay 1 and Relay 2 accordingly.

"Pin 3/NO" - Number 3 – this is a normally open contact of Relay 1 and Relay 2 accordingly.

When a relay is switched OFF its "Pin 1/Com" and "Pin 2/NC" contacts are closed. When a relay switches ON then the contacts "Pin 1/Com" and "Pin 3/NO" are closed.

These relays can be programmed for Fuel Generator start, obviously, the generator should have a system of automatic start. As well it is possible to switch ON the relay conditionally. Usually, it is required for switching ON/OFF the load or indication.

If a relay has been programmed for Fuel Generator start, then as soon as one of conditions appears: the grid fails or a threshold of generator start is reached – the relay will switch ON via "F-Gen StartDelay". The relay will be switched OFF after a full charge cycle or the grid is recovered.



A threshold of Generator start VAB\_FG (in volts) is set in the menu FuelGenerator/BMS MPPT. The menu becomes active if one of the relays is set as Start Fuel-Generator or if AGCS is selected in the menu of Other Options ->AGCS-Charge.

The DOMINATOR model can be connected to Generator directly via any control Relay if Generator has ATS (Automatic Transfer Switch). See below.

It should be mentioned that the output of AGCS is the same as for Relay 2, and for work with AGCS, you may just program Relay 2 for Generator start. On the contrary, if the "Other Options ->AGCS-Charge" is set, Relay 2 will switch while working with AGCS and it will be impossible to use it for other needs. For other MAC models, it is possible to start fuel generator via AGCS system (MicroART) by connecting it to RS232 port, see paragraph "CONNECTION TO FUEL GENERATOR AND AGCS"

In the menu **"Additional Relay"**, submenu **"Relay X.Function"**, where X – the number of Relay 1 or 2, each relay can be programmed for any of the following switching conditions (some of conditions have additional parameters):

**"OFF"** – Relay is not active

**"StartFuelGener"** - Relay is configured to start Fuel Generator

When the condition of generator start occurs the relay will switch ON through "F-Gen StartDelay"

**"On AB voltage"** - Relay switches ON according to AB voltage

**"On AB temp"** - Relay switches ON according to AB temperature

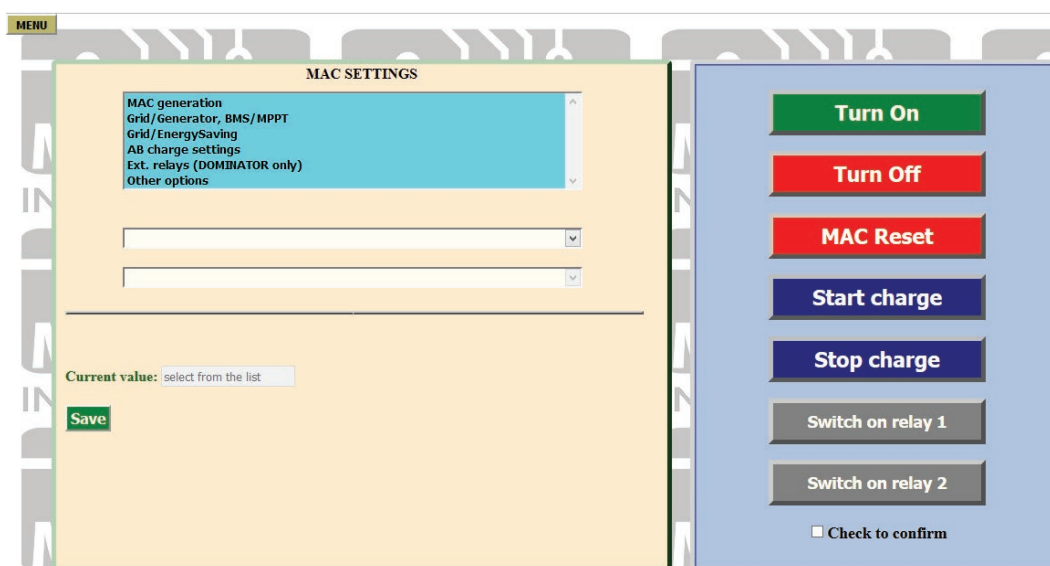
**"On theTime"** - Relay switches ON according to time

**"Power failure"** - Relay switches ON at grid failure

**"AC Transmit"** - Relay switches ON at network transmitting start including charge mode. Keep in mind that even if 220/230V AC network is at the input the transmitting may not run (for example the network voltage exceeds the limits or MAC operates in forced generation mode)

**"In Charge mode"** - Relay switches ON on AB charge start

**"External ctrl"** - Relay is controlled via Web-interface in the MAC control pan or via special software, see picture 10



Pic. 10

Both Relays are rated for maximum switching current of 16A, means that the load connected to them should be below  $16A \times 220V \sim 3 \text{ kW}$ . For maximal load the wire sectional area should be more than  $1.5 \text{ mm}^2$ .

To switch ON the load conditionally use contacts "Pin 1/Com" and "Pin 3/NO". If you need to switch the load OFF when one of the conditions is fulfilled then use contacts "Pin 1/Com." and "Pin 2/NC". When the condition is selected in the other two menu items you should set additional parameters (depends on the selection of "RelayX.Function")

For "RelayFunction"-> **"StartFuelGenerator"**:

"F-Gen StartDelay" - value in seconds. Defines a delay before relay switches ON for start, to avoid an activation due to short AB voltage drops.

For "RelayFunction"-> **"On AB voltage"**, then the following parameters are available:

**"Voltage ON"** - value in volts. The voltage above which the Relay will switch ON.

**"Voltage OFF"** - value in volts. The voltage above which the Relay will switch OFF.

**"Hysteresis"** - value in volts. A small voltage difference (delta) near the threshold values. It is required for slowly changing parameter to avoid multiple switches when the value is near a border.

For "RelayFunction"-> **"On AB temp"**, then the following parameters are available:

**"Temperature ON"** - value in degrees.

**"Temperature OFF"** - value in degrees.

The Relay is switched ON in range from t1 (lower value) to t2 (higher value). Otherwise it is switched off.

**"Hysteresis"** -value in degrees.

For "RelayFunction"-> **"OnTime"**:

**"Time ON"** - value in hours and minutes (10 min step). Time when Relay switches ON. In 24-hours the cycle will be repeated.

**"Time OFF"** - value in hours and minutes (10 min step). Time when Relay switches OFF. In 24-hours the cycle will be repeated.

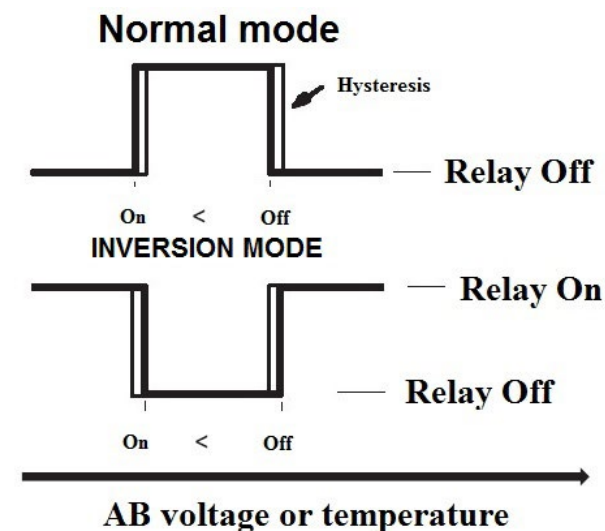
If one of the limits is not required, then set it to the minimum value (for "ON" threshold) or accordingly to the maximum value (for "OFF" threshold).

For all Relay functions (except **"External control"**) the parameter of switching-on in direct or inverse mode is available.

For the functions without a direct option as "Relay Inversion" is possible to set it by changing the ON parameter to be as OFF: it means the value ON will be greater than OFF. Picture 11 explains the principle of operation in normal and inverse modes.

It may seem that the inversion mode is excessive because Relay has normally open and closed contacts and the selection of one of them will give an inversion. But the fact is that energized Relay coil consumes about 60mA, which may be critical when AB is fully discharged. But the main thing is that Relay will be OFF if AB is fully discharged or MAC is damaged. In this case it is convenient to connect an emergency load (connected to 220/230V network through the relay) to "Pin 1/Com." and "Pin 2/NC", and thus the load switches OFF when Relay is ON, and continue working when Relay is OFF.

As an example you need to start air conditioner if AB temperature is from  $+30^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ , see picture 12.



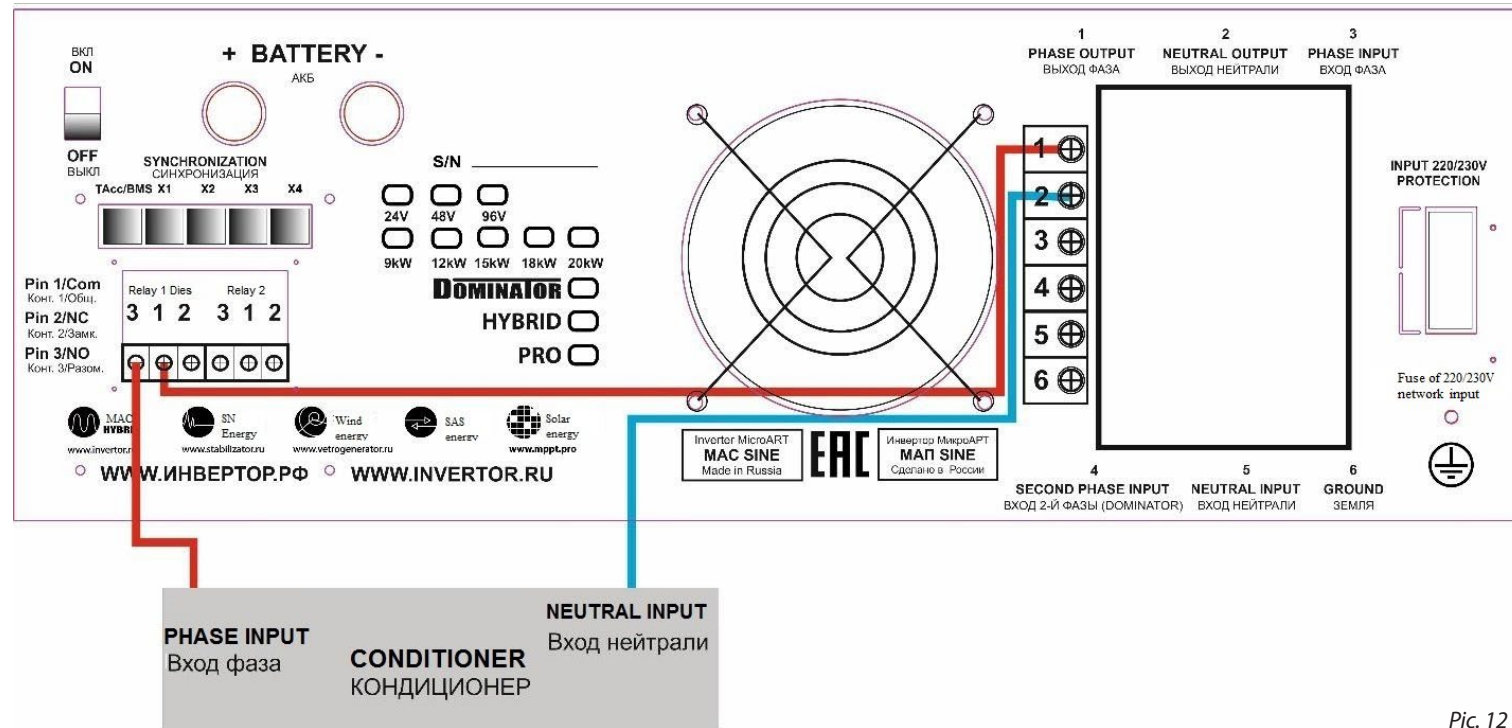
Pic. 11

For example, we use Relay 1 for that and make settings "Add. Relay"->"Function Relay1"-> "On AB Temp" and "Add. Relay"->"condition ON Relay1"->"Temperature ON" - values +30°C and "Temperature OFF" - value +40°C.

Then one of the air conditioner AC wires (phase wire is shown in the picture) should be connected via Relay contacts - "Pin 1/Com." and "Pin 3/NO". The air conditioner may be powered either from the MAC output or from its input, depending on whether you want the air conditioner to work on grid failure or not (in the picture the load is powered from the MAC output).

If you don't want the load to switch ON between + 30°C and + 40°C (and accordingly switch ON beyond the limits), then you should reconnect the load from Relay contact "Pin 3/NO" to "Pin 2/NC".

Without changing the contacts, it will be enough to set: "Temperature ON" - value +40°C and "Temperature OFF" - value +30°C.



Pic. 12

## ADDITIONAL GRID INPUT 2 ON MAC DOMINATOR

MAC DOMINATOR has the second input for AC 220/230V. It is located on the back panel in the terminal box (on the old body was marked as "INPUT GEN" as the most likely use). A back panel view is shown in picture 2.

**⚠ ATTENTION!** For the connection of the 2nd grid input please make sure that the phase (hot) and neutral wires are not muddled up, if swapped wires are connected it will damage your equipment (MAC, Generator and other equipment) and this is not covered by warranty.

The second input is disabled by default and even if there is a voltage MAC will not use it.

The second input is used as a spare one, if there is no grid on the 1st (main) input MAC will switch over to the 2-nd one. Input 1 (MAIN) has a priority over the 2-nd one: as the voltage restores, MAC synchronizes and reverts to the 1-st one.

The device indicates the second input (without voltage at the 1st one) by double intermittent blinking of "GRID" LED. Some models have an additional white LED to indicate the second grid input.

This input can be programmed via the menu FuelGenerator/BMS MPPT-> Input2 220Vfuel, and there are 3 options: "OFF", "GRID", "FuelGenerator".

The 2-nd input can be used for the second and third phase (if you have three-phase network). In this case, you should select "Grid". When the first phase is lost on the main input, after synchronization MAC will switch over to the network transmitting from input 2.

---

*Note. Any three-phase equipment should be connected before the MAC (in bypass). This is connected not only with possible transmitting another phase to the MAC output, but with a common feature of a single MAC device while operating in the three-phase system. At grid failure MAC starts the AC generation, which is not synchronized with the other phases, and three-phase equipment will stop working or can be damaged (of course if it is not a simple three-phase heater like a sauna). The similar situation may occur if another phase switches to the 1-st input.*

---

By analogy with the main input it is possible to set for the second one a limit of the maximum power consumption, the menu FuelGener/BMS MPPT-> MaxPowerInp2. Sell to the grid from the 2-nd input is unavailable unlike from the 1-st one.

In the remote monitoring bookmark "DEVICES" the voltage of the 1-st and the 2-nd inputs are displayed on the input voltage voltmeter, green color indicates an active input, gray-blue -voltage presence, orange – voltage absence, see picture 13. If there is no voltage at both inputs the voltmeter color will change for red and the voltage value will be zero.

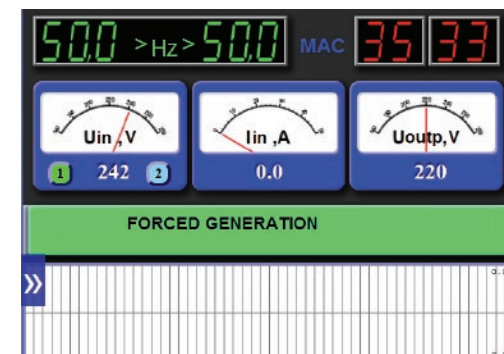
The 2-nd input can be used also for connecting a FuelGenerator. In this case its START/STOP can be controlled by an additional relay.

For generator without ATS (Automatic Transfer Switch) it is possible to use AGCS as described in appropriate paragraphs. But DOMINATOR model has an advantage. Regular AGCS connection (controlled through RS232) gives an opportunity to commute to the MAC output both grid from the first grid input and AGCS output from the second grid input.

Then AGCS can commute both Generator and, for example, another phase (in three-phase network, see notes above). Three power sources of 220/230V can be connected to a MAC DOMINATOR and AGCS in total: two phases from the grid and generator.

If generator is equipped with ATS (Automatic Transfer Switch), there are two options depending on ATS model. It should be mentioned that generators are equipped mainly with ordinary ATS, which have the following work algorithm. An available 220/230V network at the ATS input is transmitted to its output, when the network has failed it is substituted by generator AC and its power is transmitted to the output.

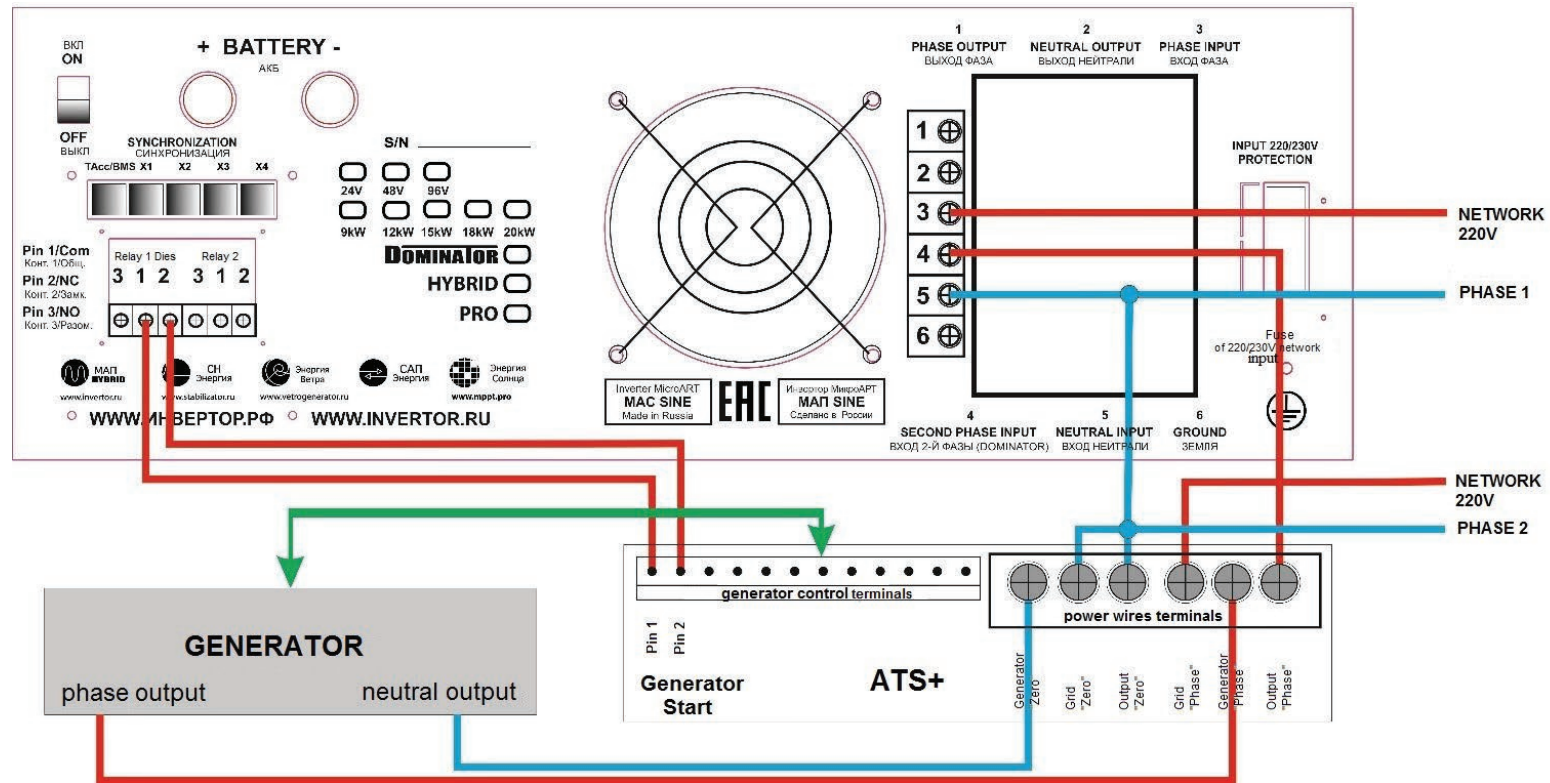
Advanced ATS systems (as a rule, expensive high-power generators have such a systems), let's call it ATS+, have an additional input (usually programmable one) in the form of "dry contacts", which allows to control generator start on grid failure. This is very useful control input for fuel economy as you can start generator when AB are discharged to a certain level.



Pic. 13



For ATS+ the commutation to the generator is as simple as a conventional AGCS connection. The ATS+ output should be connected to the second MAC input; by analogy another phase can be used (in 3-phase network) via ATS+ network input. At the same time ATS+ control input should be connected to a MAC additional Relay, programmed to control a generator. The connection example is shown in picture 14. A detailed way of connection should be specified in generator manual.



Pic.14

In case you have a conventional ATS with a help of MAC additional Relay it is possible to “mislead” the ATS and start a generator on MAC request, i.e. when AB are discharged. However, that is achieved by use of ATS AC input which makes the use it for an additional phase impossible (that's not a problem as three-phase networks are pretty rare). A background of such a connection is that an additional Relay is configured for a diesel generator, commutates 220/230V voltage from MAC output to the ATS network input, disallowing a generator start. As soon as the condition of generator start has been fulfilled, MAC switches off the additional relay: 220/230V AC voltage disappears from the ATS network input, thus generator starts and begins AC transmitting to the ATS output.

By analogy, especially if it is a one-phase network, it is possible to connect the AGCS through a Relay avoiding RS232 control link. Such a connection has an advantage because it is free from any interference induction influence. Since if MAC is located far from a generator, many errors in RS232 links may occur.

A commutation is not so complicated but there are 3 points to be noticed.

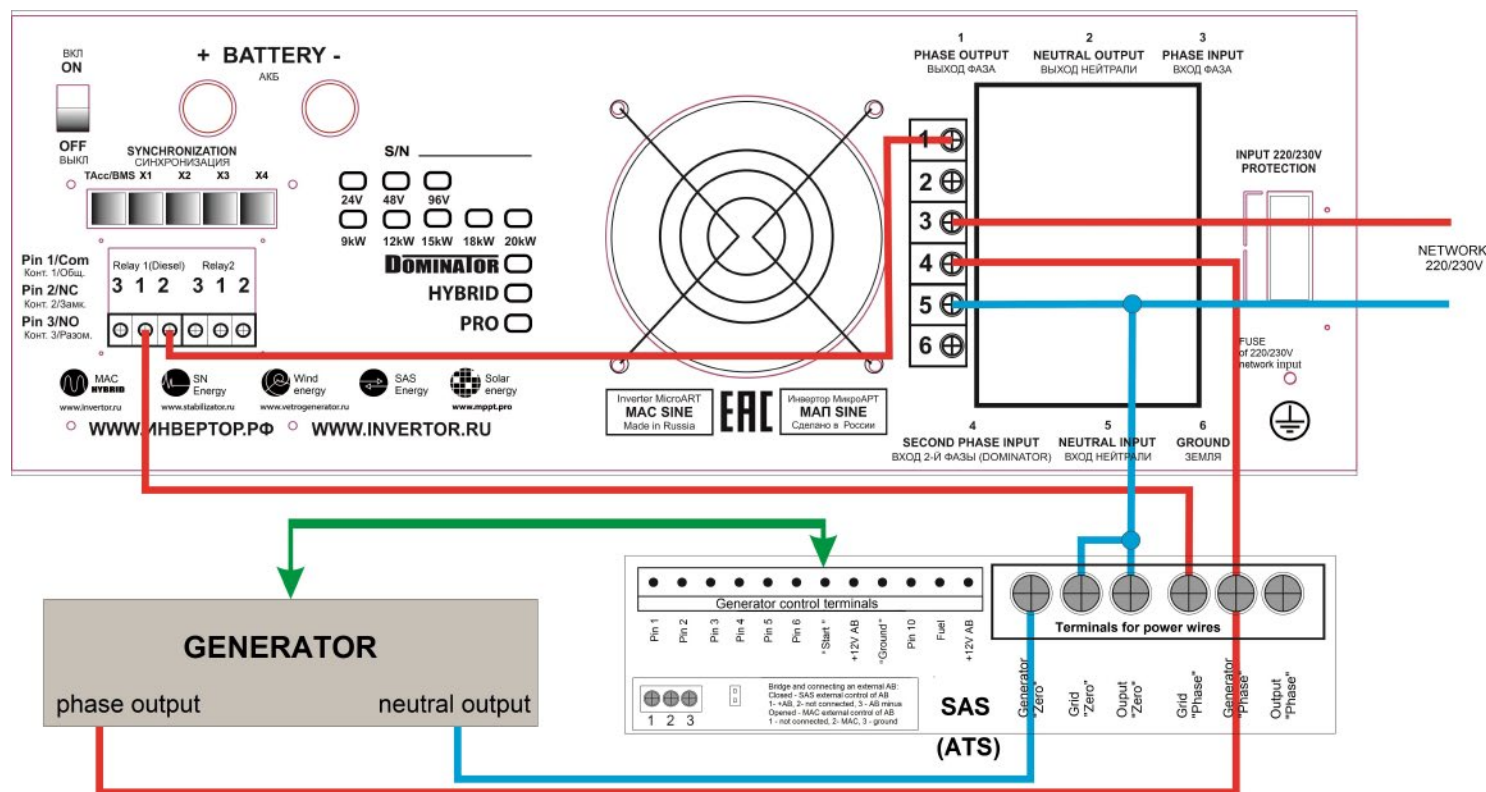
At first, the cable, which connects MAC output to AGCS network input (ATS) (through an additional Relay) has a signal function, it has no current, therefore can be used a wire with minimum sectional area. But same time it is under tension and you need to follow all safety regulations!

At second, the 2nd network input of MAC is NOT connected TO AGCS OUTPUT or ATS, but to generator INPUT. If it is connected to the OUTPUT, you will make a looped circuit scheme (connecting output with input).

At third, if there is no MAC input voltage (MAC is switched off, non-operating mode), AGCS (ATS) will start a generator even if the network is available, therefore if you switch off MAC don't forget to switch OFF AGCS (ATS) as well.

As an example, the connection between the FUEL generator and MAC Dominator is shown in picture 15.

*Note. By analogy with the main input you should set in the menu "Input 220V" -> "FuelGenerator". In this case the algorithm will be configured for working with a poor waveform. But it should be mentioned that on grid failure a transfer from generator to MAC generation takes from 8 ms under load up to 20 ms for idle mode. Therefore if you have a high-power high-quality generator for quick switching (2-4 ms) from generator to MAC generation, it would be better to leave a default option: "Input 220V" -> "Power grid".*



Pic.15



## GENERAL DESCRIPTION OF REMOTE MONITORING OF MAC DOMINATOR MODEL

MAC DOMINATOR model has an embedded minicomputer based on RaspberryPi 3 Model B platform: system-on-chip with four cores ARMv8 CPU frequency of 1200 MHz. Minicomputer is equipped with four USB ports, one HDMI etc.

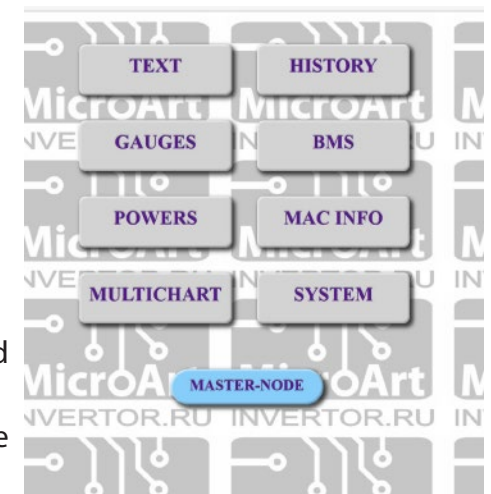
Specially developed software for MAC is based on Linux operating system and already preinstalled on the minicomputer. It is a small web server that can be accessed by your request from any device in the world, which has an Internet connection and uses any web browser. You can monitor all devices work in real time and manage them both within home and remotely, for example, from a Smartphone. Some pages are created especially in a very simple form for viewing them from any simple device.

### IDEOLOGY, ARCHITECTURE AND BASIC FUNCTIONALITY OF THE SOFTWARE:

- 1| There are services in the system of data reading/saving from/to MAC, controller MPPT data reading, battery monitoring, SMS. The principle of construction - modular. The architecture is three-level. Data collecting, saving, displaying.
- 2| The system provides a connection via COM-port (either build in MAC/MPPT controller adapter, or separate USB-RS232 adapter) of a MAC (the first USB slot of mini PC), or a controller (the second USB slot of mini PC) or both devices same time. As well it is possible to use external GSM modem to preset SMS notification and control (the third USB slot of mini PC). The fourth USB slot of mini PC is busy with a USB-drive, on which the whole system installed and where all data with system parameters are kept.

### FUNCTIONS:

- 1| MAC monitoring and control.
- 2| MPPT monitoring. MPPT must be connected with another data cable!
- 3| User-defined SMS notifications or MAC SMS control from trusted phone numbers.
- 4| Modular adaptive web-interface. You see the connected devices only.
- 5| The interface is adapted for visual perception and has a bubble floating help.
- 6| LiFePO<sub>4</sub> with BMS (MICROART) battery system are supported.
- 7| Real-time & history diagrams. RT graphs replay.
- 8| MAC and MPPT errors history.
- 9| Battery statistics (with battery monitor daemon started).
- 10| A simple html table with most MAC settings and info allows you to send it to the support through copy-paste.
- 11| Two user modes. Restricted and Full. In restricted mode you cannot change some sensitive MAC settings or send some commands.
- 12| All the settings are in password-protected web zone. Moreover, you may add IP access list to nginx config file. All the interface can be password-protected.



- 13| Battery monitor. See full manual in battery\_monitor\_en.rtf.
  - a. Counts and register ampere-hours to/from the battery (pack).
  - b. Calculates battery discharge % depending on discharge currents.
  - c. Allows customer to perform a control-training cycle for a battery for evaluating its real capacity Cn.
  - d. Measures battery capacity by the OCV (open circuit voltage) algorithm.
  - e. Can register battery currents from all MPPTs connected to MAC via I<sup>2</sup>C.
  - f. Can register battery currents from/to all MACs connected to I<sup>2</sup>C.
- 14| Database web management. Backup, restore, reset.
- 15| Remote \*nix servers or workstations control (RSA-protected) based on battery monitor or MAC/MPPT data. You can shut down them, for example, at %DOD threshold. See full guide in servers\_off\_en.rtf file.
- 16| Web-control of main services: MAC and MPPT daemons, mysql, sms, battery monitor. As well as PC reboot and shutdown (i.e. halt: shutdown -h now).
- 17| Port reader daemons are fault-tolerant to communication errors.
- 18| Web interface has almost no bitmapped graphics, except for master-node. All forms and patterns are css and java-based. It allows to use very thin communication channels.
- 19| Linux-based design. many functions are delegated to bash scripts. it allows the user to customize them very easy.
- 20| Standard mysql database. So, you can enjoy all the benefits: to have distributed or replicated DB and many others.
- 21| Email notifications.
- 22| MASTER-NODE section. It's a very powerful feature. Allows you to combine in one system many PCs with this soft and have one centralized battery monitor for each battery pack. So it means you're able to monitor all the nodes (MACs & MPPTs) on one screen at once.
- 23| In raspberry pi appliance webmin web panel is integrated and accessible through port 10 000. [http://your\\_IP:10000](http://your_IP:10000).



RaspberryPi 3 is used as any other computer and it should be switched OFF/ restarted softly. Via the menu **SYSTEM->SERVICES**.

RaspberryPi 3 while operating uses a minimum of resources. Average CPU load - no more than 3%.

## PRESTARTING PROCEDURES AND MONITORING START

Unlike the other MAC models, DOMINATOR has in its delivery set additionally:

- Interface cable USB 2.0 AM / BM - 1 pc.
- USB-stick (flash drive) 16Gb (with pre-installed software and manuals) - 1 pc.

In picture 1 you can see the schematic layout of 9kW MAC DOMINATOR controls (3-6kW models have a similar front panel). All monitoring ports and controls are located on the right-hand side of the device after the sockets block, and it includes "Mini PC power switch", 4 USB ports and local network LAN port (RJ45).

To start work you should do the following steps:

1. Switch ON and configure MAC according to the manual and your needs. It is also recommended not to turn ON "MiniPC" if you are not going to monitor/-control the system remotely it is recommended to leave MiniPC OFF.
2. Insert the USB-drive (stick), from the delivery set, to any slot of miniPC (if not inserted yet).
3. Connect LAN port of MiniPC to the computer or router with DHCP server using standard network patch-cord of appropriated length (not included into the delivery set).
4. **Connect MAC USB port to any MiniPC USB port via the USB cable from the delivery set.**
5. Connect MPPT USB port (if you have a MPPT) to any miniPC USB port.
6. Turn the «Mini PC» ON. Wait about 1 minute for device boot. The device will indicate its work with glow/ blinking of GRID LED.
7. Using a Web-browser, go to your local network router settings and look which IP-address it has given to MAC.
8. Enter in the address line of the Web browser the given IP address and you will reach the device interface. For example, if MAC IP address is 192.168.0.22 then you should enter into the browser address line: `http://192.168.0.22`.
9. Enter the menu SYSTEM submenu SERVICES and start step by step service MAC, then if needed MPPT service, AB monitor service, etc. Note: The Battery Monitor must be configured properly before the first start. Otherwise, you will see in logs "localhost Battery monitor daemon[6455]: Entering Daemon" repeatedly.

**Login the submenu SYSTEM. By default, Login/Password: admin/microart**

10. It is necessary to go back to the Devices menu and check whether you are getting the correct data. The first-time setup is complete.



**ATTENTION!** MAC has only one RS232 port, MAC USB port is connected to the same port inside the device through the interface converter RS-USB, therefore the connection to the PC (to firmware upgrade or monitoring) or to the miniPC (for monitoring) can be the only one either via RS232 or USB-MAC.

*Note. For a direct MAC ("Malina" appliance) connection to PC or to the network without DHCP-server, you need to edit the file monitor.ini beforehand for IP address source and MAC settings/commands working mode (restricted or full). This file is on USB-drive FAT partition, it is accessible, viewable and editable under any OS.*

## ADDITIONAL INFORMATION REQUIRED FOR MONITORING

A lite administrator interface WEBMIN is available on port 10000, means [http://your\\_IP:10000](http://your_IP:10000). Through it you can set a desired IP-address and the correct time (and time zone). By default, **Login/Password: admin/microart.**

You may install also a GSM (3G USB) modem and configure notification and control via SMS commands. The modem must be switched to "modem only" mode in advance. Pay attention to 3G modem dimensions: probably you may need an USB 2.0 compatible extension cable. GSM modem can be connected to any vacant USB port of miniPC. The cable of poor quality may cause the problems and failures. Because many modern 4G dongles have no option such as "Only modem" mode, we recommend to make sure the device has such an ability before purchase.

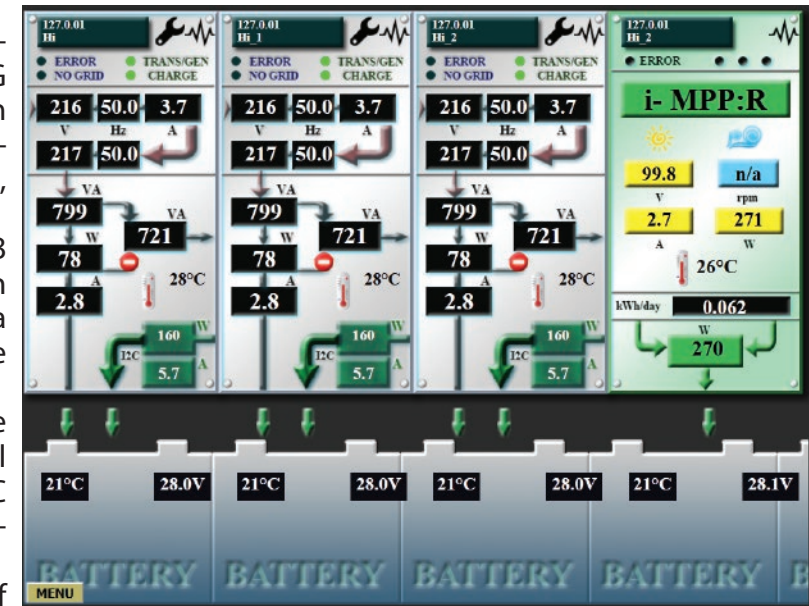
For both connected devices (MAC and MPPT) database size growing is about 4-5 Gb per year. DB partition size on USB-drive - about 10Gb. Current database size can be viewed in the section "SYSTEM" - "WORK WITH DB". When DB reaches a big size, you can either save DB to another media or clear the DB tables with the button "clear the tables" and start with empty BD, or simply create the system image on a new media and the old database can be put on the shelf for keeping.

For three-phase system or for a number of parallel MAC DOMINATOR, we recommend to use the option "**MASTER NODE**", where you can set the displaying of all collected information from several devices on one screen. You may set up the system, disconnect it from the local area network or PC and it will keep saving all the data from the devices to the USB drive. Then later on you can reconnect the system to the LAN or PC again and review all needed data via menu "**HISTORY**".

With an appropriate Internet connection monitoring/control can be done from any device. Brief guide to connection the "MALINA" Appliance to the Internet you can see on website: <http://inverter.ru/monitoring.html>.

Default system settings don't allow to Switch OFF MAC remotely and edit sensitive or important items. If you need it, you should edit the file monitor.ini with a PC before its installation into MAC. By editing parameters in the file monitor.ini you can also set an interface language, a way of obtaining IP-address, the password protection zone etc.

The system has an intuitive and logical user interface with necessary tips and does not cause any difficulties in use, the detailed description of all features and some useful programs you can find on the USB-drive in device description files.



## MAC GENERAL TECHNICAL SPECIFICATION

Devices modifications, recommended and minimal AB capacity										
Parameters	MAC									
<b>Modifications of MAC devices, kW</b>	1,3	2,0	3,0	4,5	6,0	9,0	12,0	15,0	18,0	20,0
<b>Maximal power (active load mode) (kW)</b>	1,3	2,0	3,0	4,5	6,0	9,0	12,0	15,0	18,0	20,0
<b>Peak power, sec (kW)</b>	2,5	3,5	5	7	9	13	17	19	22	25
<b>Rated power (kW)</b>	0,8	1,4	2,0	3,0	4,0	6,0	8,0	10,0	12,0	13,5
<b>Circuit protection (automatic)</b>	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto
<b>Recommended total AB capacity (Ah):</b> <i>(Total capacity of 12V-s AB)</i>	200	300	400	600	800	900	1000	1100	1400	2000
<b>Minimal total AB capacity (Ah):</b> <i>(Total capacity of 12V-s AB)</i>	50	50	100	150	200	300	400	600	800	800
<i>Maximal charging current (A)</i>	40% of the maximum power divided by the AB pack voltage (for 12V model and the models starting from 15 kW - 30%). The charge is carried out with the power correction									



Autonomous work (generation from AB)	
Output waveform	True sine
Output voltage/ Sine distortion - Meets State Standard (GOST) 13109-97 “Electric energy. Electromagnetic compatibility of technical equipment. Power quality limits in public electrical systems”	Optimal sine <sup>1</sup> (recommended) – 220/230V (+2% -9%) distortion under the rated load is no more than 5% for models Pro, HYBRID, DOMINATOR
	True sine – 220/230V - operating up to rated load, a distortion is no more than 1%, models Pro, HYBRID, DOMINATOR (if the load is larger than rated one the voltage may drop below 200V).
Frequency of the output voltage	50 Hz (±0.1%)
AB current in “OFF” state/ if grid is available <sup>2</sup>	80 – 170 mA on AB / 0 mA on AB with grid available
Idle current on AB <sup>3</sup>	200 – 700 mA Pro, Hybrid, DOMINATOR
Efficiency of the models 12/24/48 V	91 / 94 / 96 %
Electronic protection against	Overloads, short-circuit, deep AB discharge or overcharge, voltage surges in 220/230V network, overheat, etc.
Temperature Range <sup>4</sup>	-25°C...+35°C

Work with external grid	
Switch to autonomous work <sup>5</sup>	Set up by the User
Electronic protection against	Overloads

Typical switching time	
inverter → network <sup>5</sup>	0 ms
network → inverter <sup>6</sup>	~2-4 ms (in “FuelGenerator mode” under load ~8 ms, for idle mode no more than 20 ms)

*1 In autonomous mode with power above the rated one MAC will be operating no more than 20 min.*

*2 Depends on AB voltage and LCD backlit state. For the full shutdown, MAC must be switched OFF by the circuit-breaker, tumbler switch, the «+» terminal should be disconnected from the AB then.*

*3 Depends on model.*

*4 All the elements except LCD to -40°C. For temperature >35°C, the power of device is getting lower as a thermal protection starts to work at lower powers.*

*5 Switching to the network will be done in 5 seconds after the voltage 220/230V restores, but the switching takes <1ms.*

*6 In case the work from the generator was set in the menu, switching time will be increased to 4-8ms but not more than 20 ms if there is no load.*



### Dimensions and weight of the devices

	12 V				24 V				48 V			
	length (cm)	depth (cm)	height (cm)	weight (kg)	length (cm)	depth (cm)	height (cm)	weight (kg)	length (cm)	depth (cm)	height (cm)	weight (kg)
1,3 kW	33	28	13	12								
2,0 kW	33	28	13	15	33	28	13	15				
3,0 kW	51	37	18	21	51	37	18	19	51	37	18	19
4,5 kW					51	37	18	23	51	37	18	23
6,0 kW					51	37	18	28,5	51	37	18	28,5
9,0 kW					56	41	21	48	56	46	21	46
12,0 kW									56	46	21	48
15,0 kW									56	46	21	51
18,0 kW									56	46	21	56
20,0 kW									56	46	21	60

Dimensions of the device in a 19-inch package (power up to 9 kW)	length (cm)	depth (cm)	height (cm)
	49	41	18
Dimensions of the device in a 19-inch package (power over 9 kW)	length (cm)	depth (cm)	height (cm)
	49	59	21

Approximate battery operating time						
AB pack	100 W	300 W	500 W	1 kW	2 kW	4 kW
8 pcs. x 200 Ah	174h	52h	34h	17h	8h	4h
6 pcs. x 200 Ah	130h	39h	25h 30m	12h 30m	6h	2h 50m
4 pcs. x 200 Ah	86h	26h	17h	8h 20m	4h	1h 50m
2 pcs. x 200 Ah	42h	13h	7h 20m	3h 50m	1h 40m	50m
1 pcs. x 200 Ah	21h	6h	3h 50m	1h 40m	45m	13m
1 pcs. x 100 Ah	9h 30m	3h	1h 40m	45m	12m	3m
1 pcs. x 70 Ah	5h 40m	1h 45m	50m	13m	3m	----

## SUPPLEMENTS

### AB SELECTION AND MAINTENANCE. BATTERIES (LEAD-ACID, GEL, AGM, LIFEPO<sub>4</sub>)

**1** | On grid failure the inverter starts the generation and during a long-time grid absence will consume all AB energy and switch OFF the generation then. AB will stay discharged if the grid is not restored. It will reduce AB lifetime. You should notice that MAC consumes ~100mA from AB even in OFF mode. It means if there is no grid for a long time (~ a week), even such a small current may cause AB voltage drop below 9V (what leads to an abrupt parameters degradation of lead-acid AB and shorts its lifetime. In such a case, it would be better to disconnect the device from the grid, and then press the button from its back (or disconnect MAC terminal from the AB) to avoid its self-discharge. It will be almost full MAC switching OFF (tumbler switch de-energize MAC boards).

If MAC is not switched OFF by tumbler switch when voltage drops below 7V/14V/28V MAC switches off completely. When grid restores, MAC will start operating and switch on charge mode. But due to a deep battery discharge (less 3V/6V/12V) and network undervoltage even if it is available the inverter might not be able to start (the scheme is designed to prevent it, but there is no 100% guaranty), then you have to charge batteries to the operating level voltage by an external charger after disconnecting MAC from the grid.

**2** | Ordinary lead-acid AB have a limited number of charge-discharge cycles (~ 200 – 400 cycles) and this number sharply decreases after deep discharges. Therefore, lead-acid AB can be used for rare grid failures, otherwise, battery resource runs out earlier than it was predefined by the producer. For a 220/230V network with occasional failures, we recommend to use AGM or Gel batteries. For a frequent network disconnections or a full autonomy, we recommend to use maintainable batteries, which have more than ~ 1000 charge-discharge cycles, they are more tolerant to deep discharges. This is, for example, lead-acid type traction AB with tubular plates (1500 cycles) or lithium-iron-phosphate batteries (3000 cycles).

**3** | All AB should be of one type, capacity, of one batch and from one producer.

**4** | For 24V or 48V packs of 12V batteries the maintenance of each AB should be carried out once a year. For that you should charge each battery separately by 12V charger (a car charger). Because during the operating one of the batteries in series may be undercharged. Another way is the use of BMS.

**5** | If batteries lost their capacity you may try to recover and recondition them. For that 5-10 charge-discharge cycles should be done. Moreover, the charge should be done by very low current (0.01C for both stages), and discharge by high current (0.2-0.5C). Such a charge is continuous (no less than 24 hours), therefore the grid should be available. The discharge can be done by MAC disconnecting from the grid, and connecting the appropriate load to the inverter output. For example, for AB 100Ah, charging rate should be  $100 \text{ Ah} \cdot 0.01\text{C} = 1\text{A}$ , discharging rate  $100 \text{ Ah} \cdot 0.3\text{C} = 30\text{A}$ , it means discharging load for MAC of 12V approximately -  $12\text{V} \cdot 30\text{A} = 360\text{W}$ .

To prolong AB lifetime, we recommend not to discharge them below 20% - 30% of remained capacity (70-80% DOD). For that you should set in the MAC menu:

- 1) Open circuit voltage of discharged AB 11.5 V (23V or 46V);
- 2) For the charge from the grid we recommend you to set the current of the first and the second stages below 0.1C and 0.5C respectively with charge algorithm 4StAbsorption/Buffer or 3StageAbsorption. For the charge from fuel generator the currents of the first and the second stages could be higher but at least once a month you should set charging rates no higher than 0.1C and 0.5C with top up for full battery charge;
- 3) Don't leave AB discharged for more than 20 hours;
- 4) For winter storage please charge AB and disconnect terminals from them. Lead-acid AB needs to be charged once in three months to compensate its self-discharge, Gel batteries - every 6 months;
- 5) Use an external temperature sensor (stick on the battery) and set in the menu your AB type "lead-acid" or "Gel and AGM", or enter the voltage of stop charging and buffer charging for your AB type.



**ATTENTION!** In living or poorly ventilated rooms it is necessary to use "fully maintenance-free" batteries – the main thing is their hermeticity. In all other respects, the best choice is low-maintenance batteries.

## MAC WITH ALKALINE AB PACK

The operation with alkaline batteries is individual for each AB type. Therefore, you need to read carefully the charge requirements for specific AB and set its parameters.

Particularly for AB 5HK-125Π-III operation (according to its technical manual) you need to set as follows:

### **1. Putting AB 5HK-125Π-III into operating (as alkaline AB delivered in non-charged state).**

Fill AB with liquid electrolyte and wait a while in accordance with its technical manual.

Then in program mode of MAC select:

"AB parameters"

"Charge Input "

"AB type ";"#acid"

"TotalAB Capacity";"0125A.h = C"

"InitialRate";"0.25C I=31A"

"FinalRate";"0.25C I = 31A"

"VABStopCharge";"V<sub>AB</sub>\_MAX=17,0V"

"ChargeAlgoruthm";"#2Stages 2-currents"

"Other options "

"Input "

"MAX Charging time";"14h"

(i.e. set AB capacity, charging rate 0.25C, maximal time of charging 14 hours and stop charging voltage is 17V).

After charging is finished AB are ready for work, but:

We recommend to do several charge cycles, by discharging AB with current  $0.1C=12A$ , i.e. switch ON MAC in generation mode for the load of 100-150W (a filament bulb), you should set in advance:

"MAC Generation"

"Input"

"V<sub>AB</sub>GenerOFF"

"V<sub>AB</sub>\_MIN=10,0V"

When voltage reaches 10V, MAC switches OFF the generation. If AB discharges in more than 10-11h, then you should charge it one more time and stop cycling: AB are ready for operating.

## **2. Batteries which are prepared for operating you should connect to MAC and make the following settings:**

Set up:

"MAC Generation"

"Input"

"V<sub>AB</sub>GenerOFF"

"V<sub>AB</sub>\_MIN=10,0V"

For charge:

"AB parameters"

"Charge Input "

"AB type ";#acid"

"TotalAB Capacity";"0125A.h = C"

"Initial rate";"0.25C I=30A"

"Final rate";"0.25C I=30A"

"V<sub>AB</sub>StopCharge";"VAB\_MAX=15,0V"

"ChargeAlgorithm";"#3StagesBuffer"

"V<sub>AB</sub>FloatCharge";"VAB\_BUF=14,3V"

"Other options"

"Input"

"MAX Charging time";"07h".

---

*Note. "Float Charge" mode is optional; in AB 5HK-125Π-III manual it is recommended to use. For high-voltage network of 240V and above stop charging voltage should be decreased in settings to 15.3-15.5V to prolong charging time. The key point is that the AB charge takes 6-7 hours from the full discharge (10V).*

## BMS, MAC WITH LI-ION AB, LIFEPO<sub>4</sub> (LITHIUM IRONPHOSPHATE )

For operating with Li-ion AB pack, every battery cell (voltage 3.2V) should be connected to a special control and charge equalization device — BMS (Battery Management System).

There are different algorithms of the operation with BMS. As a rule, if during the charge the voltage of one cell from AB pack becomes higher than tolerable level – charging current reduces (or charging is stopped) and BMS starts to equalize the voltage of this cell. BMS also monitors the cell voltage and raises a signal of a full charge or overcharge.

It is desirable to connect BMS to any AB type, including lead-acid ones, either to every AB jar (when AB are divided into jars) or to the each 12V AB in case their connection in series on 24V, 48V etc.

For Li-ion AB the use of BMS is obligatory. As the cells capacities of Li-ion AB can differ considerably then at the end of charge or at deep discharge their voltages will also differ a lot. At that if cell voltage exceeds the maximum after a while AB will swell and get out of order, and some types of Li-ion AB can even explode. Conversely, when the voltage is below the minimum value the cell gets out of order (loses its capacity totally). It is impossible to discover which one is out-of-range by measuring the whole AB pack voltage (which is controlled by MAC).

BMS mART© has been designed for MAC. It intercommunicates with MAC via I2C bus and interacts with it in optimal way. The algorithms for third-party BMS (BMSI, BMSII, BMSII inverse., BMS RS232) are supported by MAC and described below.

## BMS, MART© OPERATING ALGORITHM

First of all, you should connect BMS to the MAC. Any MAC model has a jack socket (for the phone jack) RJ-12 in the front marked with text “T<sub>AB</sub>/BMS/MPPT” (for the old models it is marked as “MODEM”), DOMINATOR model has a similar jack socket on the backside with the text “T<sub>AB</sub>/BMS”. MPPT connects to the same jack socket (see below).

It is better to connect BMS to the jack socket on the backside of DOMINATOR device, as it has a buffered digital output with galvanic isolation. As it was mentioned above the AB temperature sensor can be connected also to this port. If BMS is used, then the port is occupied but in DOMINATOR model the temperature sensor can be connected to the jack socket on front panel. But as BMS has its own temperature sensor the complete MAC sensor can be kept disconnected. However, MAC collects information from all the temperature sensors, such as BMS, MPPT, or MAC complete sensor and select the maximum temperature. BMS mART© consists of separate enumerated blocks, connected to each cell and interconnected via data cable.

BMS has two identical RJ-12 sockets. Any of them may be used as an input and another one as an output accordingly. All the BMS are connected to each other and to MAC in cascade. We recommend to connect MAC to the first BMS which is connected to the AB pack “minus” terminal. For connection and configuration details, see BMS manual.

To enable operating MAC with BMS you should make settings in the menu:

“FuelGenerator/BMS MPPT” -> “BMS / MPPT” item “BMS (C)mART ” (or “BMS+MPPT (C)mART”, if there is also MPPT (C)mART in the system).

Then MAC automatically discovers the number of BMS assuming that 12V system has 4 devices, it means 8 devices for 24V system, for 48V – 16 pcs., etc.

The algorithm of interaction MAC and BMS mART© is similar to a third-party BMS algorithm (see below), but it has an advantage as the MAC has information on every cell and optimizes the charging algorithm, as a result the battery is charged in a shorter time. The essence of the algorithm is that during Generation if the voltage of any cell goes below the lowest critical level, MAC will consider it as a deep discharge and will switch OFF the generation in a minute in analogy as if the whole AB pack was discharged. During the charge, as soon as cell voltage approaches the top level, the equalizing resistors will be activated. The bigger voltage difference between cells with minimal and maximal voltage is, the higher current will go through the resistors. As one of the cells reaches the top limit MAC will start to reduce the charging rate. So, as all cells voltage level is reached the top limit, but no longer than 4 hours, the charge will be finished.



*Note. MAC also supports control actions from a third-party BMS through one of dry contacts or RS232 with open protocol (see the description of third-party BMS support).*



**ATTENTION!** A joint work of MAC, BMS © MicroART (**if LiFePO<sub>4</sub> batteries are used**) and third-party solar controllers is prohibited, as it is impossible to limit the battery charging rate. The only exception is third-party solar manageable controllers or if there is an ability to cut the controller current off by additional device, but in this case, such a controller can be managed only by MAC DOMINATOR model.

## SOLAR CONTROLLERS MPPT SEC

MPPT (Maximum Power Point Tracker) - solar controller which can search the maximum power point. Nowadays the ordinary (PWM) solar controllers have become a thing of the past as MPPT controller efficiency is much higher.

By analogy with BMS, MAC supports two algorithms: for a third-party MPPT controllers (and in general for any solar controller) and for the MPPT mART© controller – SEC® trademark - which is connected to MAC via I<sup>2</sup>C bus and they are interacting in optimal way. Some SEC models can operate with wind turbines (new firmware should be uploaded and block No.2 with electrical heaters should be added).

## OPERATING ALGORITHM OF MPPT SEC CONTROLLER

We produce 3 SEC controller modifications:

1. SEC DOMINATOR 200 V 100 A or 250 V 60 A
2. SEC PRO 200 V 60 A
3. SEC 100 V 20 A (this entry-level model cannot communicate with MAC).

At first, you should connect your SEC to the MAC. Any MAC model has on the front side a jack socket for an additional device (phone jack) RJ-12 marked with the sign "TAB/BMS/MPPT" (for the older models "MODEM"). DOMINATOR model has the same port from the backside of the body with the text "TAB/BMS". BMS is connected to the same port.

It is better to connect SEC to the jack socket on the backside of DOMINATOR device, as it has a buffered digital output with galvanic isolation. As it was mentioned above this port can be connected also to an AB temperature sensor. If SEC is used then this socket is occupied, but in DOMINATOR model the temperature sensor can be connected to the front panel socket. But as SEC has its own temperature sensor the complete MAC sensor can be left disconnected. However, MAC collects information from all the temperature sensors, such as BMS, MPPT, or MAC complete sensor and select the maximum temperature.





Similar to BMS, SEC has two identical jack sockets RJ-12 – “X1” and “X2”. All the SECs connected to MAC should be set as SLAVES: for that go to the SEC menu and set there an appropriate mode of communication with MAC, also set correctly SEC dip-switches. If you have more than one SEC then enter the devices addresses in the menu; for details see SEC manual.

You may use any of SEC RJ-12 ports for MAC connection (“X1” or “X2”) and “TAB/BMS” jack socket of MAC. To connect a number of SEC to MAC similarly to BMS you should connect one SEC RJ-12 jack to MAC, the second one to another SEC and so on.

If BMS is also used then SEC should be connected to the last vacant BMS jack socket or in the reverse order, BMS is connected to the last vacant SEC port.

To enable MAC operation with MPPT SEC you have to select in the menu:

“FuelGenerator/BMS MPPT” -> “BMS / MPPT” item “MPPT (C)mART” or “BMS+MPPT (C)mART”, if BMS (C) mART is also used in the system), then set “FuelGenerator/BMS MPPT” -> “NumbMPPTConnect” – the number of connected in parallel MPPT.

Every parallel MPPT should be connected to its own PV panels array and all together they should be connected to one (common) AB pack.

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*NOTE! Beginning from MPPT SEC firmware version 4.1 every controller monitors only its temperature sensor therefore the temperature sensor should be connected to AB from each of parallel MPPT SEC.*

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### **When MAC and SEC are working together (they are connected via I<sup>2</sup>C cable):**

1. MAC as the MASTER manages MPPT operation modes and overlays some MPPT settings, such as stop charging voltage, buffer voltages and currents, with the values are set in MAC.
2. MAC collects all MPPT currents values and if there is charging currents from SEC, it limits (or even zeroes) its own charging rate in charging mode.
3. In ECO modes MAC sends a command for SEC current alteration depending on the MAC load. Besides it assures the appropriate mode of SEC operating in accordance with ECO modes.



**ATTENTION!** When SEC is a SLAVE, some parameters are overlaid by the MASTER MAC (or MASTER SEC). But in a case of communication failure or in some other conditions the SLAVE one restores its own parameters, therefore all SEC settings (AB type, AB voltage, charging rates etc.) of all SECs in parallel connection should be the same: you should not rely on the MASTER settings.

## LIGHTNING PROTECTION

During thunderstorms, if lightning strikes nearby (for example, 100 m from the wiring), and MAC output is connected with long wires, for example, to the whole house wiring, then a high-voltage induced surge and spikes may arise in there. It can cause the damage of all devices, even if the inverter is switched OFF (if long wires are connected to its output).

Of course, a lightning strikes so close very rarely, for example once in 2-4 years (it depends on region). To exclude such a situation, we can offer to purchase special lightning protectors (SPD -Surge Protection Device – surge arrestors) – visit the on-line shop on [www.invertor.ru](http://www.invertor.ru), which are mounted in the electrical cabinet.

If there is no electricity provided on the site and no grounding made according to the rules, you can make your proper local grounding. You should calculate the necessary number of grounding elements according to your local standards and requirements, or you should turn to qualified specialists. As an example: it could be a metal rod or a number of rods (for example galvanized pipe with a diameter 3/4", length 2m), which could be driven 1.5-1.8 meters into the ground and screw on it two wires with sectional area no less than 1.5mm<sup>2</sup> (depends on other wires sectional area), the other ends should be connected to MAC (with pin "Ground" and zero input (neutral input), means MAC grounding and a neutral grounding should be done).

The protection from high-voltage lightning surges and spikes will work only with properly made grounding and a neutral grounding. It wouldn't go amiss if you get a MPD (multifunction protection device) installed after SPD.

The grounding and neutral grounding significantly reduce the risk of damage caused by lightning.

If you are leaving the system out of work for a long time (for example seasonal work on the village) then after AB is charged it is better to disconnect MAC terminal from AB + (plus), as well as from the house wiring (to avoid induced lightning surges on 220/230V wires in the house, which may cause the damage of MAC, even though it is switched OFF but is connected to the wires).



## FILTERS



A cable extender with surge protection (surge protector), for example, SvenPlatinumPro (index Pro usually means that it includes an inductor) is recommended to install after MAC, if you use such loads as pumps, refrigerators, electric tools (grinders, trimmers) etc. We recommend to mount such a filter at the inverter input as well, if a fuel generator is used as an external power source or the power quality from the regional AC grid is poor.

Such a domestic surge protectors are designed for the load less than 2kW. If a load exceeds this value, then it is possible to divide the load into several protectors or you can purchase in specialized shops the protector called EMI suppression filter (electromagnetic interference filter). For example, DL-50D3 EMI filter. (visit on-line shop [www.invertor.ru](http://www.invertor.ru)).

## UNINTERRUPTED POWER SUPPLY FOR HEATING BOILERS

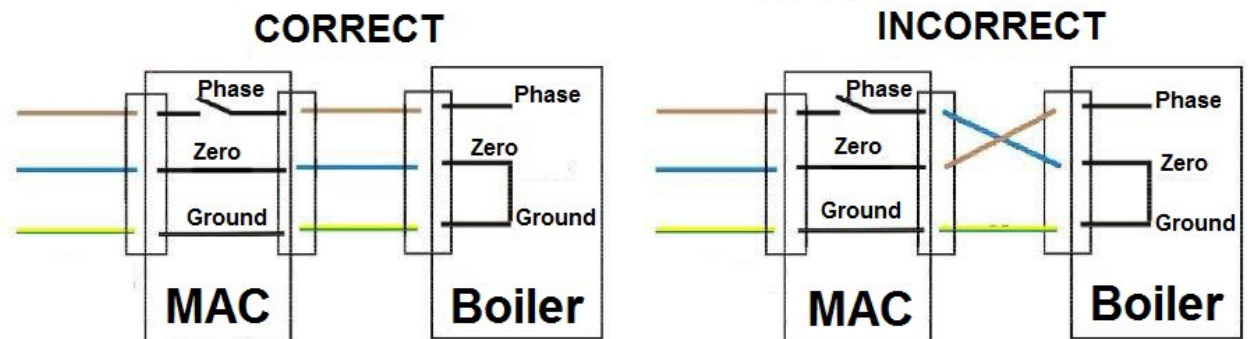
There are different natural gas boiler designs. Some of them, for example, equipped with atmospheric burner. Besides the correct connection of boiler phase to the network phase and its “zero” to the network “zero” (pic. 4 and 5), boiler requires the permanent connection to the grid “zero” or neutral for its operating and for autonomous work from MAC. It is PROHIBITED to organize such a connection in MAC bypass. A low-power MAC (up to 2 kW inclusive) model doesn't have a distribution box. So, if it is used as a source of uninterrupted power, to provide the uninterrupted boiler work it may be necessary to invert a plug in the power socket (AC socket) (i.e. the cable from MAC to 220/230V network) and/or the boiler plug as well. The point is that the AC relay inside MAC breaks only one network wire of two. And you need to connect the input cable plug in a way to break a phase circuit. Then the “zero” wire connection will remain even if 220/230V grid has failed. Therefore, it would be incorrect to check an uninterrupted power supply operability for such boilers by habitual unplugging.

For such a checking, it is enough just to disconnect a phase (hot) wire, by switching OFF the corresponding circuit-breaker. You can use a tester to find a “zero” wire (continuous neutral), checking the continuity between the plug and output socket (MAC should be disconnected from the grid and AB) or connect them using some marks, if there are available (see illustrations below). This one pin should be connected to the network zero. The grounding cable also must be continuous (the third, open socket pin). It is connected to nowhere inside MAC. If you have no Protective Earthing on the site, its connecting is not necessary - it depends on the boiler and your local network. MAC body has also the appropriate contacts for PE connection.

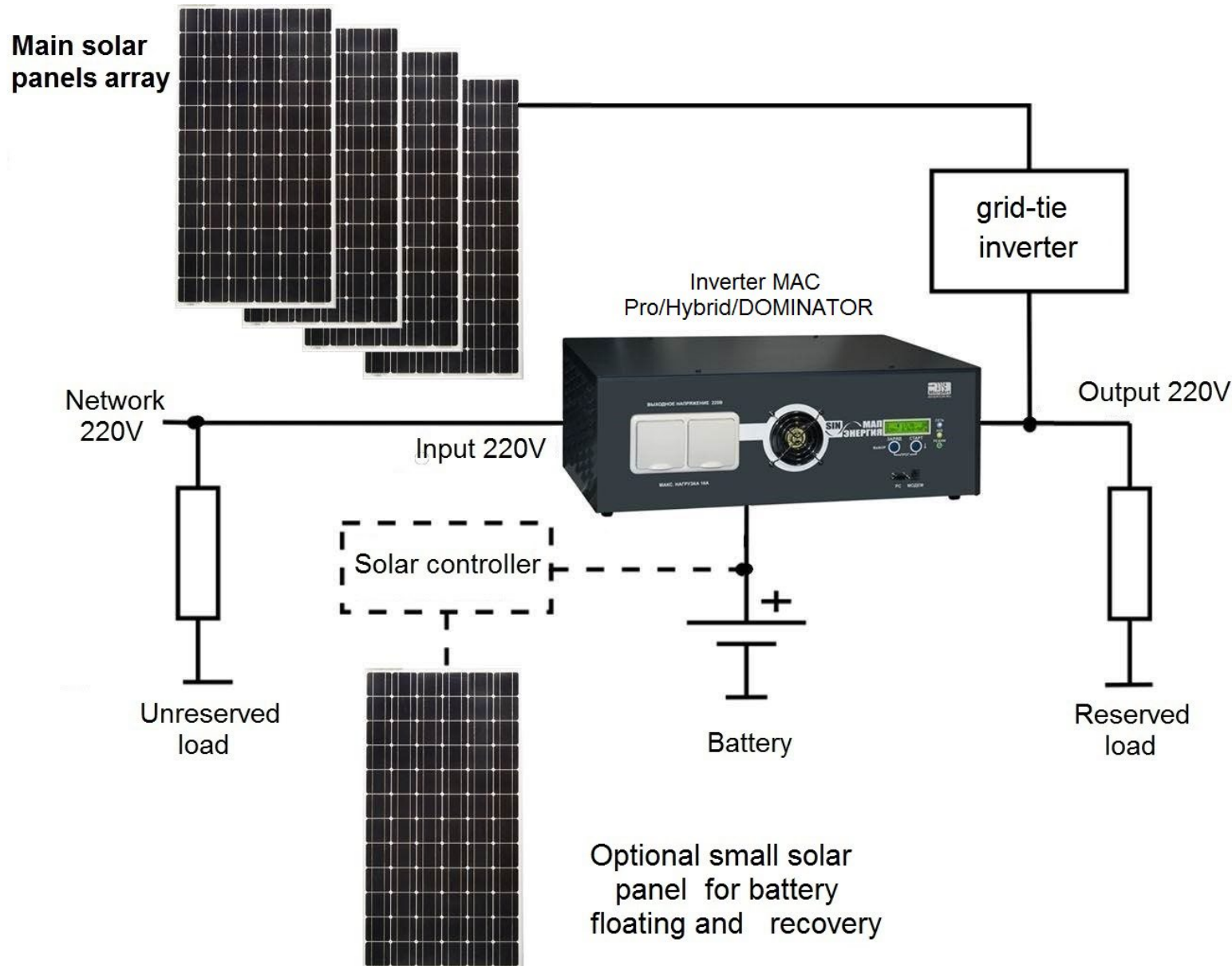
Sometimes for some boiler models the spark ignition system requires the voltage to be no less than 230V. For such cases for regular boiler work it is possible to raise MAC output voltage during battery operation (generation) to 230-240V.

**For the correct MAC operating with boiler you should check:**

- 1 | Accurate bonding – neutral to neutral, phase to phase.
- 2 | Many boilers require constant network zero connection even on MAC battery operation. It means you can't check its operability by just unplugging the inverter from the grid during MAC battery operation. You should check it ONLY by breaking the PHASE wire (for example a circuit-breaker in electrical cabinet), saving the neutral continuous.
- 3 | Some boilers need grounding.
- 4 | Try also to raise the output voltage up to 230-240V, or reduce it to 210-200V.



## MAC OPERATING WITH GRID-TIE INVERTERS



If a grid-tie inverter is on the MAC output, MAC will operate as a reference voltage source for the grid-tie inverter (including the cases of grid failure – i.e. battery operation).

Energy from solar panels will be supplied by grid-tie inverter to the MAC output and to the loads, and MAC will redirect it to the batteries. However, if there is no load and the batteries are charged for stop charging you should suspend a grid-tie inverter operation, i.e. AC generation.

In accordance with grid-tie inverter abilities it can be done by changing MAC output AC frequency to 52Hz (and revert to 50 Hz on AB voltage drops). For the process automation, you should configure your MAC by checking the option "Grid-tie controller 52 Hz manage" in the MAC firmware upgrade program menu (MAP2Gui.exe section Monitor"), which can be downloaded from the web <http://www.invertor.ru> in the section technical support->firmware and manuals.

The total power of all grid-tie inverters connected to MAC should be less or equal to the MAC charger rated power (MAC charging power is no more than its  $P_{max} \cdot 0.4$ , it means for example maximal charging power of 9kW MAC =  $9 \cdot 0.4 = 3.6$  kW). This is required for total energy utilization from solar panels when the grid is not available or the batteries are discharged.

If grid-tie inverter has no option such as gradual reducing of energy generation depending on gradual changing of AC frequency (most of the inverters are like that), then to avoid AB charge by high currents you must follow the rule: the power of installed solar panels should not exceed the maximum charging power of installed AB capacity.

For example, for AB pack of 200Ah\*48V (4 pcs AB each of 200Ah\*12V, connected in series), the maximal allowed charging rate is 0.1C means  $0.1 \cdot 200 = 20$ A. Then, charging power is  $20 \cdot 48 = 960$ W. Therefore, the allowable total power of connected solar panels is below 1kW for mentioned AB capacity and grid-tie inverter on the MAC output. To connect 3kW solar panels in such scheme you should triple AB capacity.

**All the aforesaid concerns the battery operation (AC generation) mode. If you plan to use power grid of 220/230V, then after switching to it the grid-tie inverter will send the energy surplus to the industrial network (grid).**

However, MAC DOMINATOR model has 2 programmable internal Relays, which can react to "Network transmitting mode" for example. One of them, for example, can control a generator start (if it is used) and another one can disconnect an AC circuit of grid-tie inverter with solar panels from MAC output during transmitting (to avoid selling to grid from the grid-tie inverter). But in this case the grid-tie inverter will be useless as it will be staying always disconnected when 220V AC is at the input. For its full use, you should enable ECO mode, or even better Grid tariff+ECO mode with forced generation. At the same time the start charging voltage should be set to equal to or higher a bit than Veco. In this case after AB are fully charged from the grid or after a tariff (night) time is over, MAC will switch over to the forced generation, and both load and AB will be powered from the grid-tie controller. When there is a lack of sun and/or the load is high, MAC will switch over to the network transmitting and external charge (when the voltage drops below Veco), so to MAC does not freeze in this mode (as in this mode the grid-tie controller is disconnected) the start charging voltage is required to be above Veco, to make MAC start the charge. As it is finished the cycle will be continued. The tariff system here is like a switching off the inverter for the night time when there is no sun. This mode will be effective only if MAC occasionally switches over to transmitting and charge, it means when the sun energy is enough for the inverter to cover the load power.

## FIRMWARE (EEPROM) UPGRADE

We recommend to check regularly the latest versions of MAC firmware availability on the website <http://www.invertor.ru> in the section of technical support-> firmware and manuals. If new version is available, we recommend to install it. The instruction for firmware upgrade is in the archive file with firmware binary one.

For direct connection of entry-level MAC models (as they may have no USB port) to a computer with no RS232 port we recommend to use an USB-RS232 adapter. High-power models of MAC as well as any MAC DOMINATOR have built in USB port with galvanic isolation.

For high-speed work enter the waiting time 1 ms instead of 16 ms in the settings of USB driver: "device manager" -> "ports (USB and LPT)" -> "port parameters" -> "additionally..." in the section "waiting time (ms)".

 **ATTENTION!** Before the firmware upgrade you should disconnect the MAC inverter from everything but the AB and computer.



## ADDITIONAL DEVICES

- If AC voltage in your region is often out of normal range (220/230V+/- 10%) - for the stable work of the equipment it is preferable to use AC voltage stabilizer. The MICROART company produces such a high speed and accuracy AC voltage regulator of 220/230V called SN "ENERGY" (from 3.0 to 12 kW). The range of input voltage is 140-260V with +4% accuracy. The range of input voltage is 130-275V with +10% accuracy. The input voltage limits, out of which the stabilizer automatically switches off, are 120-280V. See details on the website [www.stabilizator.ru](http://www.stabilizator.ru).

- [www.vetrogenerator.ru](http://www.vetrogenerator.ru)  
[www.stabilizator.ru](http://www.stabilizator.ru)  
[www.invertor.ru](http://www.invertor.ru)





## ERRORS, FAILURES AND WARNINGS

If overloads or problems occur the following messages may appear in the bottom row of LCD:

AboveNom	In the beginning the load power value is blinking and a direct time count starts. In 30 minutes of operating under the load higher than rated one, the device will be automatically switched OFF for 30 minutes for cooling. If during the time of rated power excess, it becomes below the rated power the reverse countdown starts, if it exceeds over again – the direct count begins and so on.
FullDischarge	AB voltage dropped below 11V/22V/44V (factory defaults). It is blinking for 60 sec and then displays the count-down, after that it switches OFF the generation and switches over to the waiting mode.
Discharge, WaitVV	The device is waiting for the battery voltage equal to VV, then it starts operating again. AB voltage can raise due to external charge (like a solar panel or wind turbine etc); if AC on the input has restored (a fuel generator is connected), then the charge mode will switch ON.
Overload AC Overload	It appears when the load current exceeds the limit in generation mode, when the power consumption is over 110% and for the transmitting mode over - 130% of Pmax. When an overload is continuing for 9 seconds the countdown starts, then the generation or transmitting stops. If the power consumption is much higher than MAC Pmax – over 150%, or over 160% for generation mode then the generation or transmitting will be stopped immediately. After that, the countdown for a pause between overloads will start – for 7 sec. There will be 6 attempts, this number will be displayed by blinking of 3rd symbol. If the overloads have ceased then in 10 minutes the number of attempts will be reset, otherwise see the next paragraph.
ABoverloadOFF	After 6 successive times an overload occurred during the generation, it will be switched OFF. When the input grid restores MAC transmits it to the output, as well as a charge may be started. It is possible to return to regular mode by pressing shortly the “Start” button, but in advance, the problems with the load should be eliminated.
Fan	Fan(s) failure. Also, its number and/or quantity are displayed. Write it down: this information is required by the service department.
Time to charge	Time countdown to charge start.
PowGridToOuput	Possibly the inside MAC Relay got stuck or the grid AC voltage appeared on the MAC output socket or on the pin “phase output” in the terminal box. In this case the error could not be displayed due to device failure.
>PmaxFuelGener >Pmax 220Network	The load exceeds the rated power of a fuel generator or AC grid, but is below MAC rated power. The inverter activated the generation mode and disconnected the load from a generator. When the load goes down and becomes lower than the rated power of generator, MAC will reconnect the load to the generator again.

Overheat-Cools	Temperature sensor(s) alert: generation is paused until the temperature returns to normal. It may occur during abnormal operations, for example, if the fans do not work, or at high charging rates.
ChargeModeOFF	An attempt to start the charge mode (for ex. by CHARGE button) with activated option “Transmitting Only” in the menu.
ForcedECOGener	Despite the grid availability the generation from AB continues as one of the ECO Network control modes was set in the MAC menu.
Preserving	Preserving mode was activated.
WaitExtFullCharge	In ECO mode when the AB voltage drops below $V_{minECO}$ , then “Forced generation” or “Power addition ECO” is stopped. If at that VAB Start Charge is lower than current AB voltage then AB charge from the network will not be carried out, and MAC will stay waiting for a full charge from the alternative energy sources. (See attachment “Addition. ECO modes”).
Reverse polarity	Internal error, MAC will stop working and start to sound a signal. You have to send the device to the service center.
No input AC	Warning. There is no AC grid at the input (if the option “Alert on grid failure” is active).
Power addition +x,x kW	Shows how many Watt are being added to the network from AB.
>Pmax	The network limiting has been activated on maximum power settings.
BMS Full Discharge	One of the AB cells is fully discharged (if BMS is installed).
BMS Full Charge	One of the AB cells is fully charged (if BMS is installed).
Temperature! AB	AB temperature is beyond the limits.
Min tariff zone	Time zone of the minimal tariffs is active (settings of “tariff grid” option).
$T < 0^{\circ}C$ Charge OFF	AB temperature is below $0^{\circ}C$ (if Lilon AB are selected). In this case AB charge is disabling.
Charge Limited	For some reason (for ex. Heat sink high temperature, ultralow AB voltage) AB charging rate is limited.

## ERRORS WITH EXCLAMATION MARK (!)

Besides, there are errors and warnings, which appear on display of “current warnings and errors” (if they occur in the main menu the sign “!” will blink).

System errors: MAC will stop working and start to sound an alarm signal. It is required to send the device to the service center (exception - the temperature sensor failure and error of bridges: work will be continued).

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Write to EEPROM	- Microcontroller or programming error.
Interrupt	- Microcontroller error.
NoTemperSensor	- Temperature sensor failure.
System error	- Microcontroller error.
Jumpers error	- Internal, possibly caused by incorrect actions of an unqualified person during MAC repair (the initial state after firmware upgrade).
Reverse polarity	- Internal, MAC will stop working and start to sound a signal.

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### Other errors and warnings:

AB are exhausted!!	- a huge AB voltage slump has occurred.
V <sub>AB</sub> overvoltage	- AB voltage out of limit.
SC while charging	- AB Short-circuit current during charge.
SC Current on AB	- AB short-circuit current during generation.
Safety Relay Sticking	- Relay sticking (sealing) or the mains voltage is on the input. Critical error: You should either to correct a wrong connection, or contact the service center.
SC Current on AC	- Short-circuit current at the MAC output.
ExtAC_onOut	- External voltage is on the output – possibly the grid was connected to the output or contact the service center.
Reset has occurred	- Occurs when power is turned ON (or after AB connection). Otherwise contact the service center.

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AB discharged	- AB voltage is lower than minimum allowed threshold.
Overload	- Load power is higher than allowed one.
Load AboveRate	- Load power is higher than rated one.
High temperature	- Temperature at one of the internal temperature sensors is higher than allowed one.
Fan failure	- Fan doesn't operate or no signal from it Operating mode failure - Please contact the service center.
MultipleScOnCharge	- Short-circuit occurred more than 10 times during the charge. The charge will be restarted in 24 hours.

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No func for the button - An incorrect combination of button has pressed.

Grid beyond limits (ACVoltOutOfRange) - The grid AC voltage was out of present limits of voltage or frequency.

Surges on the load - May occur due to "dirty" loads. As a rule, high power electric tools are powered from a low-power (relative to load) MAC.

Surges on AC - May occur due to "dirty" loads. As a rule, high power electric tools are powered from a low-power (relative to load) fuel (diesel) Generator.

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Button sticking - Possible a button got stuck or was damaged.

No AC for charging - You were trying to start forced charge at there was no 220/230V grid at the input.

Load>Pmax AC - The network limit is set lower than the current load power. Switching over to transmitting is impossible.

ACVoltIsUnstable - mains voltage "jumps", usually it occurs when a low-power fuel generator operating with high "dirty" loads.

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No Synchro Phase - For the operation in 3-phase network: there is no signal from the other two phases.

Phase shift - Abnormal phase shift: out of tolerance (it can appear at abrupt load power alteration at one of the phases).

Error I<sup>2</sup>C BMS - BMS communication error.

Error I<sup>2</sup>C MPPT - MPPT communication error.

Diff. MPPT software - It is necessary to update either MAC or MPPT firmware, or both.

Error Slave MAC - Problems with parallel-connected MAC.

SLAVE off-grid - The circuit-breaker triggered or poor input AC voltage connection at one of the parallel-connected MAC.

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## REPAIR

For any service issue please contact your local distributor:

Company name \_\_\_\_\_

Address \_\_\_\_\_

Phone number \_\_\_\_\_

Or contact the producer for being redirected to the nearest service center:

LLC "MICROART PRO"

Moscow, Iovaya st. 2, room № 43 (ground floor),

Monday to Friday from 11.00 a.m. to 06.00 p.m..

+7 (926) 887-3617, +7 (499) 180-8598 (or multi-line phone: +7 (495) 504-2025)

## ADVICES. RESOURCES

1| Copy down and save the serial number of your device, board number and the software version from the LC menu "Other options"

2| Write down MAC voltage, AB type and capacity

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Advices and news about MAC you can find on the web <http://microart.pro> and <http://invertor.ru>.

Software news can be found in the "Technical" support section.

Sections "FAQ", "Conference", "MAC Description" as well as a support team and maintenance services contact details are listed on the website.

If the equipment connection seems difficult to you, please contact our service department for an advice and / or installation of the equipment by our mobile teams.

FOR NOTES



## FOR NOTES

## SPECIFICATION

Number  
S/N \_\_\_\_\_

Model     
PRO HYBRID DOMINATOR

Voltage, V      
12 24 48 96

Power, kW     
1.3 2 3  
    
4.5 6 9  
   
15 20



[www.invertor.ru](http://www.invertor.ru)

## WARRANTY CARD (ON THE MODEL OF MAC INVERTER PASSPORT)

Date of sale \_\_\_\_\_ 20 \_\_\_\_ г.

Price \_\_\_\_\_

Sellers signature \_\_\_\_\_

Price \_\_\_\_\_

Date of production \_\_\_\_\_ 20 \_\_\_\_ г.



Warranty period – 1 year 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 \_\_\_\_

Repair support: +7 (499) 180-40-91, +7 (499) 180-85-98.

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.*