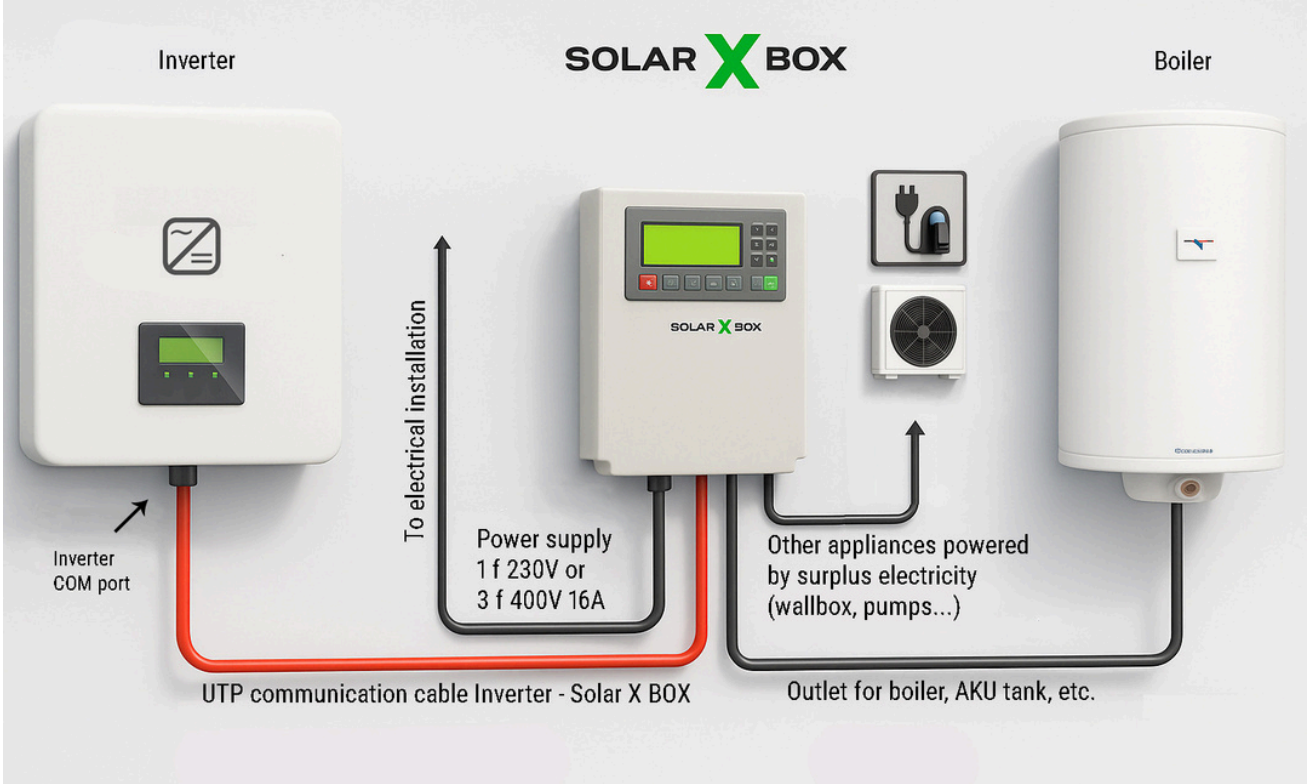
Instructions



Graphical representation of the connection

Solar X BOX – what is it and what is it for?

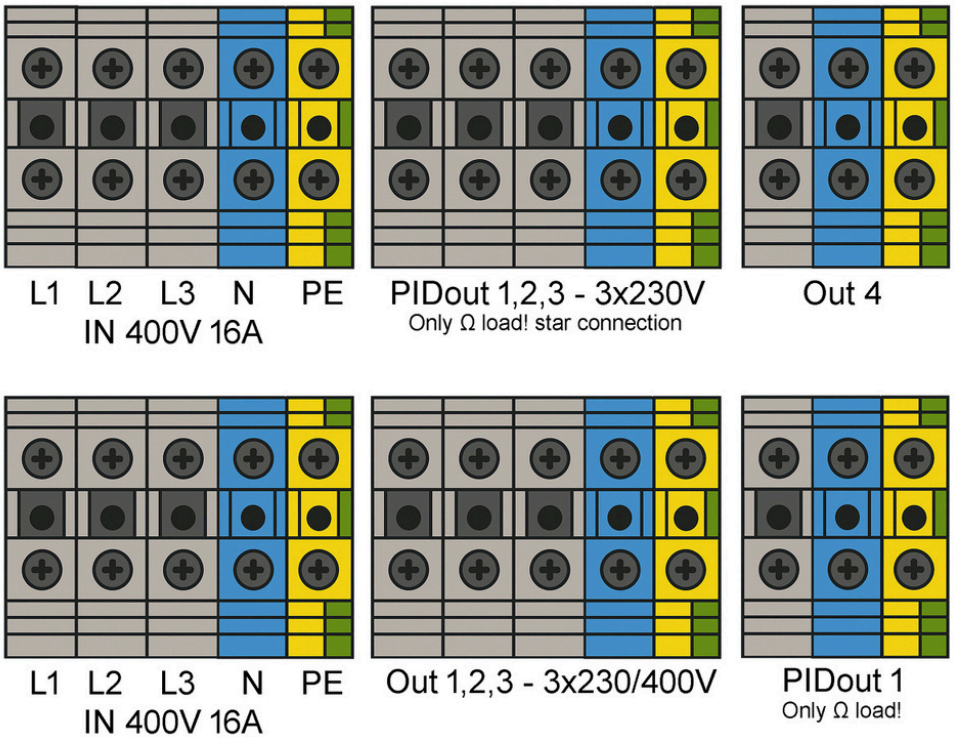
Solar X BOX is a **plug-and-play wattrouter, surplus regulator and energy manager** for photovoltaic power plants. Its task is to **effectively use the excess energy** that a photovoltaic power plant can currently produce, but cannot utilize.

The device is designed to be **as easy to install and set up as possible - without the need for a specialized company.** Thanks to robust industrial control and advanced regulation (including PID regulation), it adapts production output to current consumption in real time, thereby maximizing its own energy consumption and improving the economics of the entire photovoltaic system.

Each piece is custom-made according to the needs of a specific customer. How a specific piece is equipped is always the subject of communication before production begins. This manual is therefore of a more general nature, describing the main elements and basic principles of operation of the **Solar X BOX** device. The specific design, connections and available functions may vary depending on the chosen configuration, the type of photovoltaic system and the customer's requirements. This manual therefore serves as a **general guide**, explaining the common features of the device, its main components and control logic. For specific connections or individual modifications, always follow the manufacturer's instructions.

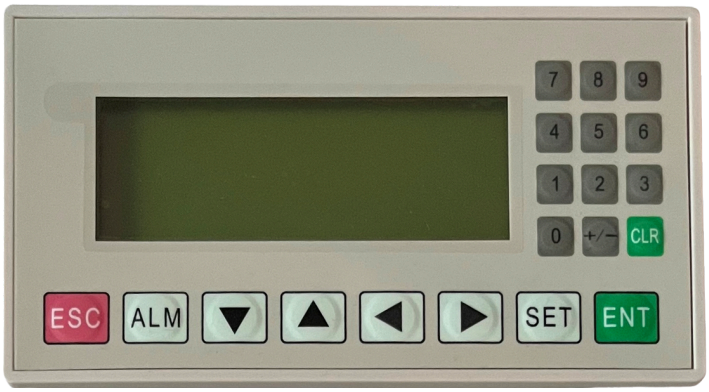
Chapter list

1. Electrical connection of the power supply of the box and appliances powered by surplus power (examples)



Depending on the specific configuration of the box, it is equipped with either terminal blocks or sockets. When connected using terminals, these terminals are described similarly to the picture. IN is the box power supply, single-phase 230V or three-phase 400V. The outputs from the box are described depending on whether they are with continuous regulation (PIDout 1,2...) or with on/off switching (out 1,2...) and are either single-phase or three-phase 3x230V with star connection. Only resistive appliances can be connected to outputs with continuous regulation!

2.Control



Two basic types of displays are used to control the controller, depending on what the customer orders. The newer type of display is touch-sensitive. The older type is button-based. The arrow/up/down keys are used to scroll between individual screens. The SET key is used to change parameters. If there are multiple parameters on the screen that can be changed, press SET repeatedly until the parameter you want to change flashes. The numeric keypad is used to overwrite parameter values. ENT is used to confirm the change.

3.Setting up communication with the inverter or smart meter

3.1 Supported devices and MODBUS RTU communication principle

Solar X BOX can communicate with inverters or smart meters that have a MODBUS RTU. (most common grid and hybrid inverters Solax, Goodwe, Deye, Solis, Growatt, Fronius, Huawei, etc. and smart meters such as Chint DTSU666, Chint DDSU666, Goodwe EM1000, EM3000, etc.) The SxB control unit has a user-addressable architecture. It can therefore be addressed and configured for different brands of inverters and smart meters.

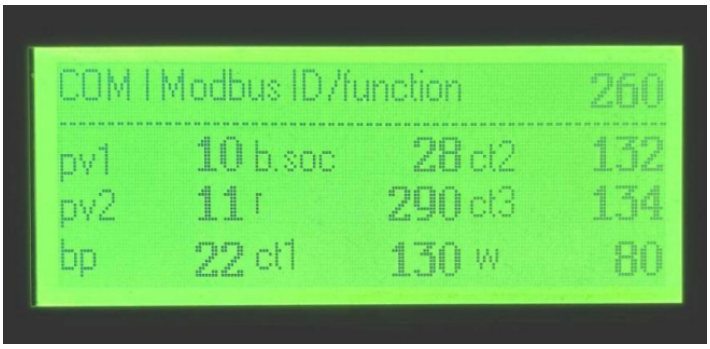
Speed and period settings

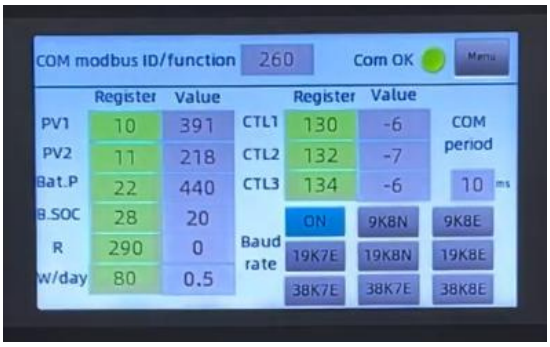
3.2 Setting the communication speed and period (baud rate, Com period)

For most of these devices, the communication settings are as shown in Figure 9K7E. This corresponds to a baud rate of 9600 baud, 7 data bits, Even parity, 1 stop bit.

Com period - is the communication period in milliseconds - the speed at which the box sends queries to the inverter. At a higher period, the data in the box and on the box display is updated more slowly. The goal is to update the data as quickly as possible, but at the same time avoid communication errors. (The picture shows a Solax X3 with a 10ms period.

3.3 Setting the slave device address and MODBUS read type (03 / 04)





Setting the Modbus reading type, inverter address (slave) and reading individual registers (set for Solax X3 hybrid in the picture) for older and newer display types.

Depending on the brand and type of inverter, there are two basic types of commands that SOLAR X BOX uses to read individual registers in the inverters that it needs for its proper function.

It is reading the so-called holding registers 03 and reading the input registers 04.

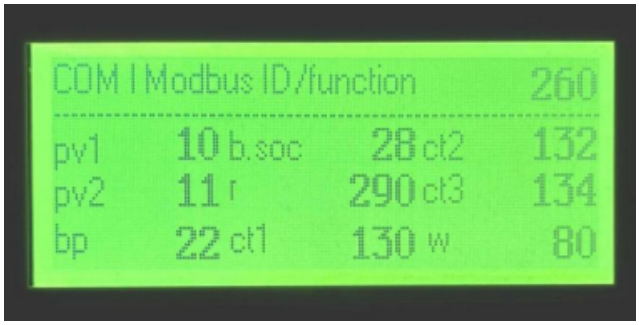
- Setting the decimal number 259 in the Modbus ID/function line corresponds to hexadecimal H103 (Slave address: 1, Function code: 03, Read Holding Registers reads data from so-called holding registers. (for example Goodwe EM, ET, Deye...)

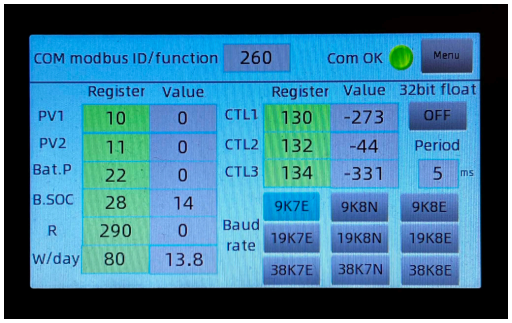
- Setting the decimal number 260 in the Modbus ID/function line corresponds to hexadecimal H104 (Slave address: 1, Function code: 04, Read Holding Registers reads data from the so-called input registers (for example Solax X3, X1...)

Setting a different slave address is possible. For example, if it were necessary to read the input registers (command 04) to slave address 2, this would correspond to the number 516, which would need to be set in the Modbus ID/function line. The following table shows the logic and examples that the Solar X Box control unit can be addressed to read holding or input registers and the different slave addresses of devices (inverters, energy meters / smart meters...)

Slave	FC03 (reading holding registers)	FC04 (reading input registers)
1	259 (H103)	260 (H104)
2	515 (H203)	516 (H204)
3	771 (H303)	772 (H304)
4	1027 (H403)	1028 (H404)
5	1283 (H503)	1284 (H504)
10	2563 (H903)	2564 (H904)
50	12763 (H1F03)	12764 (H1F04)
100	25563 (H3F03)	25564 (H3F04)
200	51163 (H7F03)	51164 (H7F04)
247	63235 (HF03)	63236 (HF04)

3.4 Registers used for correct Solar X BOX function and examples





Solar X BOX, I need to read several key registers for its proper functioning. These are mainly data from CT coils, respectively measuring energy flowing from or to the house / facility and SOC. batteries (if installed)

The other data is not critical for the function and is more of an informational nature. Inverter manufacturers have protocols for these registers available, according to which the settings are made.

The Solar X BOX is factory-set for the inverter types, see table.

Description and examples of register addresses for some inverters:

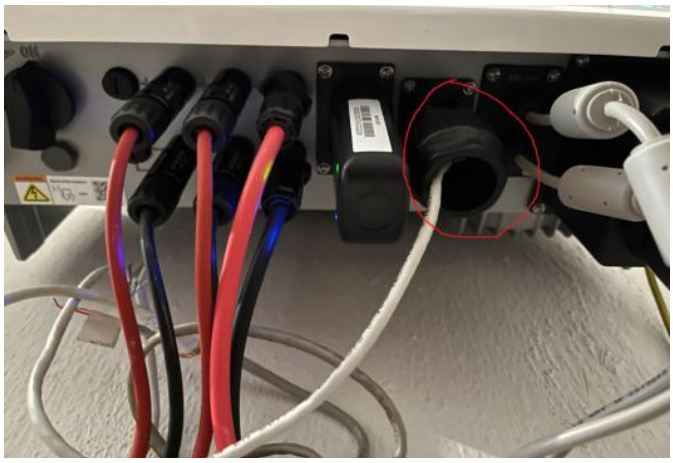
	SOLAX X3	SOLAX X1	GOODWE-ET	SUN3F	SUN1F	GM3000
PV1 production string 1	**10**	**10**	**35106**	**672**	**186**	
PV2 production string 2	**11**	**11**	**35110**	**673**	**187**	
bp - battery power	**22**	**22**	**35183**	**590**	**190**	
b.soc. - capacity	**28**	**28**	**37007**	**588**	**184**	
r -reserve	**290**	**8**	**35174**	**541**	**184**	
ct1 - phase L1	**130**	**70**	**36006**	**616**	**169**	**103**
ct2 - phase L2	**132**	**70**	**36007**	**617**	**169**	**104**
ct3 - phase L3	**134**	**70**	**36008**	**618**	**169**	**105**
W - production today	**80**	**80**	**35194**	**529**	**108**	

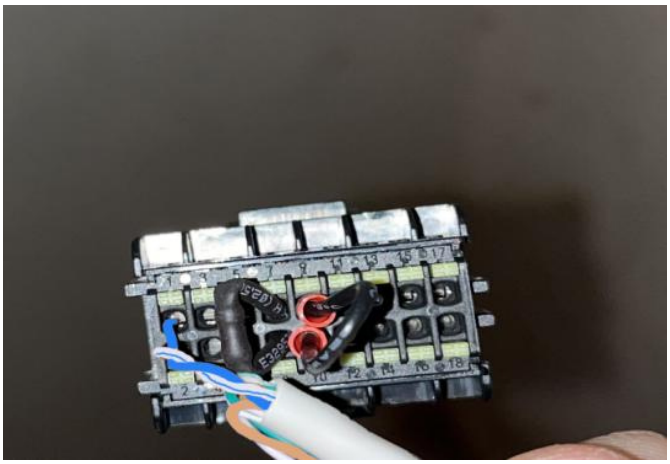
3.5 Setting up communication in the inverter and connecting RS485

The output for communication from SxB -> inverter is the RJ45 socket or internal terminals in the box described as RS485 AB. If the box is equipped with an RJ45 socket, RS485 communication takes place on pins 4 and 5 (blue, blue-white).

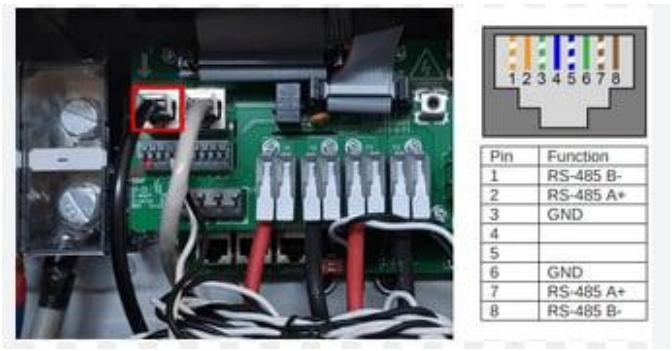
Solax - The communication cable is connected to the RJ45 port marked COM, which is located on the bottom of the inverter. Communication settings are accessible in the inverter menu. To call up the menu, press the enter key. Click on the settings tab (the factory password is 2014) / advanced settings / Modbus - here RS485, speed 9600 and address 1 should be set. The connection is via a standard UTP cable.

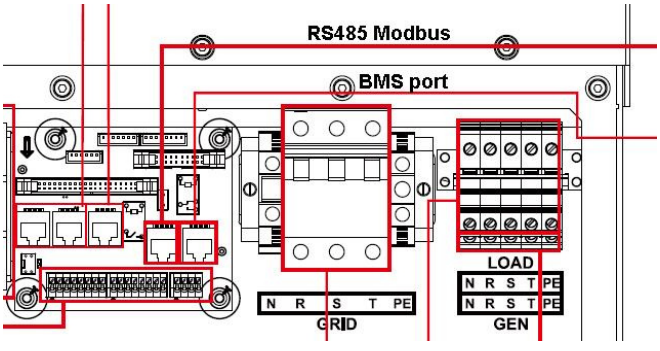
Goodwe - Settings are accessible in the PV master / advanced settings application - Com address needs to be set from factory 247 to 1. Speed, if it can be set, is again 9600. The communication cable for Goodwe inverters is connected to the 18-pin connector, see photo. It is necessary to connect the colors blue - PIN 1, blue-white - PIN 2. On the Solar x Box side, the RJ45 port connection is standard. Other types of Goodwe inverters that do not have an 18-pin connector have a communication port with RS485 called EMS.



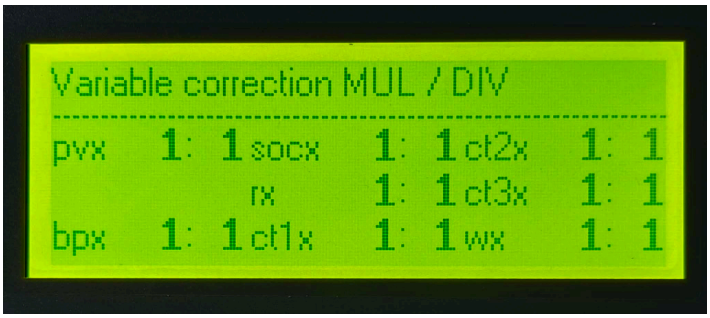


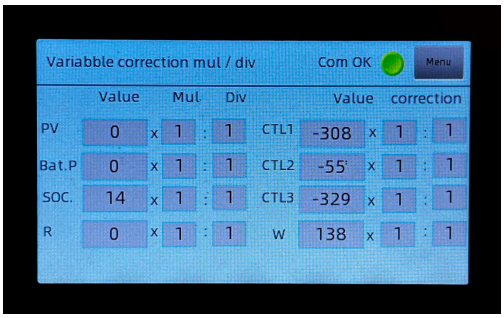
Deye - depending on the exact type of inverter, these inverters have a communication port under the terminal cover, most often marked as MODBUS. The communication is on pins 1,2 or 7,8. On the Solar X box, the communication is on pins 4 and 5. It is therefore necessary to connect the communication to the correct pins (1,2 or 7,8) on the Deye inverter side.





4.Variable correction





Value correction

Different inverter manufacturers use different directions of currents and powers in their devices (different signs for CT measurement values or battery power), or different scales (e.g. different number of decimal places).
In order for the Solar X Box to display the correct values and control and regulate correctly, these differences need to be corrected.

This is done using the Variable Correction parameters, which multiply or divide the given value by the specified number:

Examples:

1 = no correction (the value is taken as sent by the inverter)

–1 = reversed sign (e.g. opposite direction of energy flow)

–10 = adjust both scale and sign

: 10 = the value is divided by ten

x-1 : 10 = reverse sign and divide value by ten (reverse direction of energy flow and change scale of value)

Without a correctly set correction, the Solar X Box would not be able to correctly evaluate the data and the device would not function properly. It always applies that for CT values, negative values must mean energy flow from the grid to the object and positive values that energy flows to the distribution grid. For battery performance, positive values mean its charging and negative values mean its discharging.

5.Home screen

Here you will find selected information about the power plant, which, if everything is set up correctly, should be displayed immediately after connecting the power cable and communication cable to the port.

On the main screen, there is a communication status icon at the top right. If communication with the inverter is OK, the round box is on and the values on the display change.

Explanations -

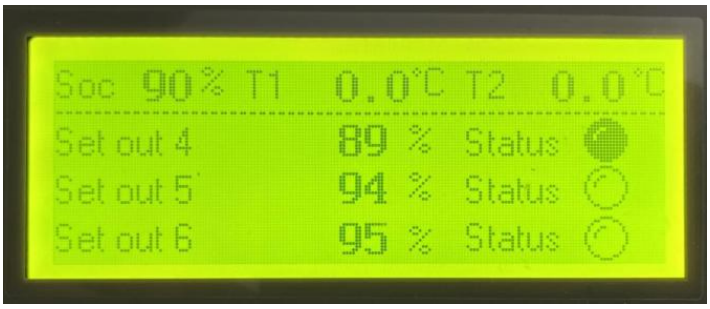
PV Power - total current power, energy produced by the panels

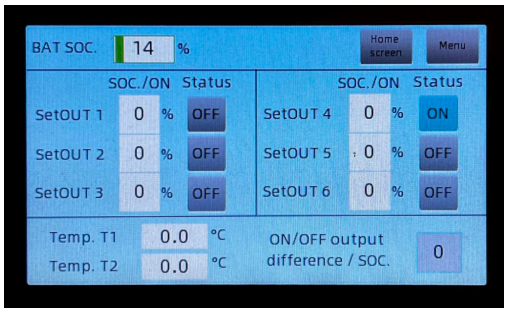
Bat. SOC % - current battery charge status

Bat. P - battery power. Positive values mean battery charging, negative values mean battery discharging.

CT L1, CT L2, CT L3 - status of individual inverter measuring coils. Negative values - how much energy flows from the grid to the house. Positive values - how much energy flows from the house to the grid.

6.Screen with switching settings according to battery SOC - cascade switching.



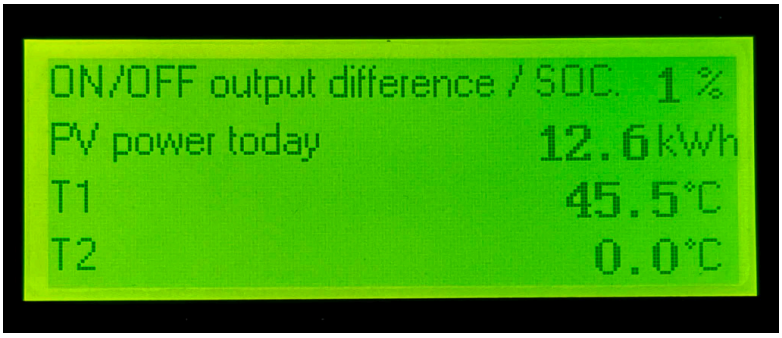


In the figure, the utilization is set so that body 1 switches on when the battery SOC reaches 89%, body 2 at SOC 94% and body 3 at SOC 95%.

If you want to change this setting, press SET (for body 1 - 1x, for body 2 - 2x, for body 3 - 3x), make the change using the numeric keypad and confirm with the ENT key.

The number of bodies is standardly 3 or 6 and accordingly they are either on one or two screens.

7. Screen with settings for tripping differences.



Here is the setting of the switch-off difference of the elements according to the SOC of the battery. The minimum can be set to 1%. This means that if, for example, element 1 switches on at 90% SOC, it will switch off only when the SOC is less than 89%.

These differences are necessary to prevent the harvester outputs from cycling. When connecting larger loads, the battery SOC value may change in percentages.

8. Boiler sensor

If the box is equipped with a temperature sensor in the battery container and the sensor is connected, the display shows the temperature T1 or T2. Otherwise, zero is displayed.

The sensor is connected using the included connector. The cable can be extended using shielded wires. The polarity does not matter. The sensor's measurement range is approximately 0-95 degrees.

9.HDO/SPOTS function

If the box is equipped with the HDO "cheap electricity" switching function, it is possible to configure each of the outputs so that if there is not enough solar energy, it will follow the HDO signal and the temperature in the accumulator tank / boiler.

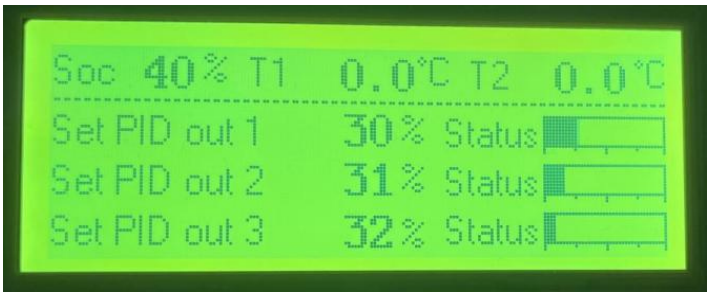
These outputs are connected to the temperature control T1. The HDO in icon indicates whether the HDO (cheap electricity) input is active. In the picture, under the inscription - Set HDO outputs, there are three individual outputs (up to 6 can be controlled as standard). Outputs 2 and 3 are set to 0 and are controlled exclusively according to the SOC setting. battery - excess solar energy or overflow to the network. Output 1 is set to 1 and this means that if there is not enough solar energy and the temperature in the boiler is lower than the set minimum T1, the HDO signal will arrive, these outputs will switch on and heat the boiler to the temperature Min. T1 (35 degrees in the picture). Min T1+ is the output switch-off difference according to the temperature T1. (in the picture, the output would switch off when the temperature reaches 36 degrees) The HDO function forces the relevant outputs to switch on when the temperature on the T1 sensor is lower than the set minimum. Furthermore, these outputs can be controlled manually in modes 0 (off) - 1 (on - works permanently as with the HDO signal) 2 - (automatic according to the HDO signal and the temperature in the boiler) The value of Min. T1 and Min. T1+ can be changed.

10.Continuously PID regulated outputs

Solar X box units can be equipped with continuously PID regulated outputs.

What is PID control? It is a continuous / smooth control, where the power to the coils is sent continuously in the range of 0-100%. The principle of PID is the continuous comparison of measured values with the desired and automatic adaptation of the controller to the given conditions. Not only short control times can be achieved, but also high accuracy without permanent control deviation.

The basis of PID control is three components - proportional P, integral I and derivative D.



Outputs 1-3 - general settings according to battery SOC value + output status

Screen 1:

Set PID out 1,2,3 (can be changed with the SET key) - setting from which SOC. battery value the controller starts sending power to individual outputs / coils**. The controller can send power to the heating elements even if the set battery charge is not reached, at the moment when there is an energy overflow towards the network and it depends on the difference between the measured and set SOC., on the setting of the GRID+ parameter (see detailed PID output settings) and on the size of this overflow**

Status - graphical representation of the size of the sent power 0-100%.

The controller will start sending power to the heating coils if the battery charge exceeds the specified value Bat. set. or, according to the setting, if there is an energy overflow towards the distribution network, according to the setting of the Grid + parameter. Thanks to this, smooth control is also a solution for battery-free systems. On the other hand, smooth control will reduce the power if the sum of the power of all appliances in the house exceeds the capabilities of the power plant and the values from the coils / smart meter of the inverter reach negative values. This depends on the setting of the Grid - parameter. This achieves management only with surplus energy.

10.1 Detailed PID control settings

Output 1 - detailed settings of PID control of output no. 1

PIDout1 - percentage value of the power that the controller sends to the coil at output 1 at a given moment.

CT - is the current value - the sum of the values from the measuring coils L1, L2, L3 or the smart meter of the inverter. It is therefore the total power supplied from or to the distribution network.

Bat. SOC - current battery capacity value

Bat.P - battery power. Positive values mean battery charging, negative values mean battery discharging.

Bat. set. - setting from which SOC. battery value, the controller starts sending power to the coil, provided that the CT energy meter coils are at 0 or close to 0. (Applies when the wattrouter mode is set to CT+BAT)

G - and G + is the coefficient of influence of the measured values from the CT coils / smart meter of the inverter on the controller. In technical terms, this is the offset.

1=maximum sensitivity and influence on the controller.

1 and above reduces the sensitivity of the influence of CT coil values on the regulator. When set to high values, the regulator will no longer take into account the values from the CT coils and will regulate only based on the SOC. of the battery.

We recommend setting the Grid - and Grid + parameters to values around 30-60 for systems without switched-on overflows to the grid. Excessive sensitivity to CT values can cause unwanted oscillations of the outputs. For systems with switched-on overflows, it may be desirable to set Grid + higher so that the controller makes changes to the outputs more slowly and the throttle

Bkoef - the degree of influence of battery discharge on the controller. It indicates the sensitivity of the controller to the battery discharge power. **The setting range is 0 to -30000.**

0 = battery influence disabled, (in this setting the controller will extract surpluses only based on the difference between BAT. SOC and BAT set, or when overflowing into the network)

-1 = maximum sensitivity, moving further towards negative values, the sensitivity decreases and the controller allows more power to be drawn from the battery.

Excessive sensitivity to battery power values can cause unwanted output oscillations. It is recommended to stay away from values between -30-100.

PIDout mode - This is the setting of the characteristics of the PIDout1 and PIDout2 outputs. The outputs can be set separately either for use with SSR relays, when they have a modified characteristic so that the percentage value of the output on the display corresponds to the power that the SSR actually sends, or they operate linearly 0-10V, for example for controlling other appliances (EV chargers, heat pumps...) when the output is a linear control signal. **For older types of displays, this setting is on a separate screen together with wattrouter mode.**

Example 1: If BAT SOC. is measured at 90% and BAT set is requested at 89% - (the controller will therefore want to extract excess energy from the battery), the Grid setting will be 40, then after exceeding the -40W power limit from the grid, the controller will stop, after exceeding the -80W limit it will start to decrease and the speed of decreasing power per spiral will be proportional to the size of the increase in power from the grid. (for example, a cloud comes or several appliances are switched on in the house at the same time and the power plant cannot cover this change).

Example 2: Setting Grid + to low values increases the controller's sensitivity to overcurrents. The controller will then take minimal account of how charged the battery is and may send power to the coils well before the battery reaches the BAT SET value. These overcurrents are often generated by inverters before the battery is fully charged and may be due to the limitation of the maximum battery charging current, which is below the capabilities of what the panels can produce.

10.2 PID parametry

These parameters affect the behavior of the controller as a whole. They change its behavior or speed of reaction to the difference between BAT SOC. and BAT SET. as well as to the values from the CT coils and the battery power values.

P - Is the proportional component of the controller. It is a simple amplifier. The action variable is directly proportional to the control deviation. **The higher the value of P, the more robustly the controller will react to the deviation of the desired SOC. From the current SOC. of the battery and to changes in the values of the measuring coils / smart meter.**

I - controller, is a controller where the action variable is directly proportional to the integral of the control deviation. In other words, integration takes into account the time for which the controller is outside the setpoint and tries to gradually add or subtract so that the deviation is as low as possible. **Higher setting values = faster response of the controller to changes in SOC. and CT coil values. Lower values = slower response.**

D - controller, is a controller where the actuating variable is directly proportional to the derivative of the control deviation. D setting improves the dynamic properties of the controller and "damps" the controller.

LO and HI - parameters LO and HI are the lower and upper limits of the controller's power. For example, if you set LO to 10% and HI to 50%, the controller will always drive the relevant output to at least 10% and at most 50%. If you set both parameters to 50%, the controller will permanently supply half the power to that output. If you set both parameters to 0%, this controller output will be permanently switched off. With this setting, the outputs can also be controlled manually.

Everything is set at the factory. If you want to change the settings, do so gradually and carefully, and always note the default settings.

By combining correctly set parameters, the controller can be used for systems with enabled, disabled supply to the grid with or without batteries.

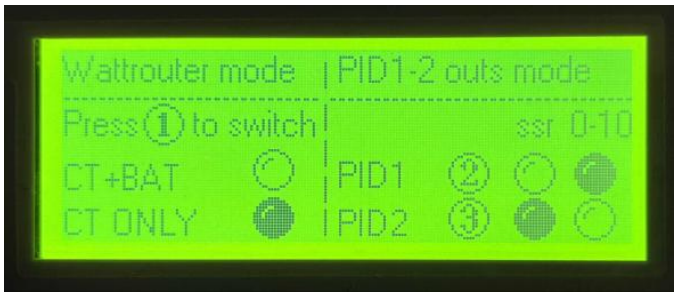
When using manual control, it is necessary to take into account that if the box is equipped with the HDO function, this function takes precedence and when activated, the outputs are forced to switch on according to the temperature in the battery/boiler, regardless of manual control.

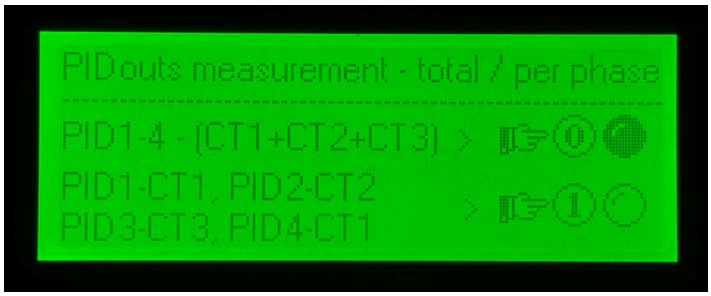
11. Operation without batteries.

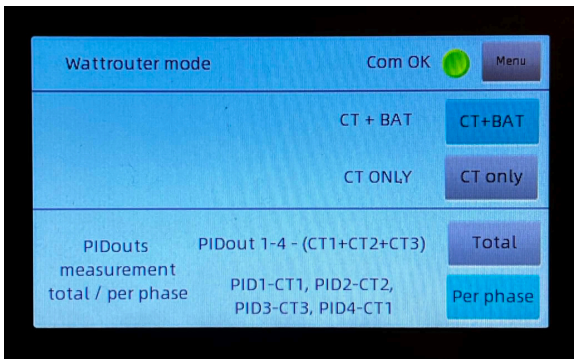
If overflows are allowed, set the "Wattrouter Mode" on the wattrouter mode screen to CT Only. The controller will start modulating (gradually adding) power only according to the amount of overflow into the grid.

If overflows are disabled, set the CT+BAT mode on the wattrouter mode screen and BAT on individual PID controllers. SET to -1. This setting ensures that the controller tries to add power permanently even without overflow with respect to the values from the CT coils. If the values from the CT coils get below the Grid setting - it waits to see if the inverter catches up with the deficit. If so, it starts adding again. If not, it reduces. This ensures that the controller forces the inverter to produce sensitively if the sun is shining and when a cloud comes or the consumption in the house increases, it will go down with the power so that it does not heat the water from the network.

12. Wattrouter mode and PID1 and PID2 output mode







Wattrouter mode selection is available for versions with PID control and is only valid for continuously regulated outputs.

1 - CT + Bat. mode works in such a way that the wattrouter takes into account the battery charge state, or the battery discharge power and the CT coil states. This mode is selected for non-overflow power plants. However, it will also work for power plants with overflows turned on

2 - CT only mode sends power outputs only based on overflow to the grid. In this setting, the Grid+ and Grid - parameters represent watts. This mode may be more advantageous for power plants with allowed overflows. It does not take into account the battery status and sends power only when there is overflow to the grid.

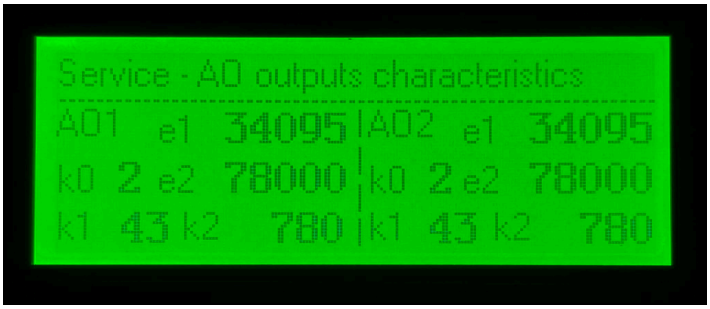
PIDout mode - This is the setting of the characteristics of the PIDout1 and PIDout2 outputs. The outputs can be set separately either for use with SSR relays, when they have a modified characteristic so that the percentage value of the output on the display corresponds to the power that the SSR actually sends, or they operate linearly 0-10V, for example for controlling other appliances (EV chargers, heat pumps...) when the output is a linear control signal. For newer types of displays, this setting is in the detailed settings section of PID outputs.

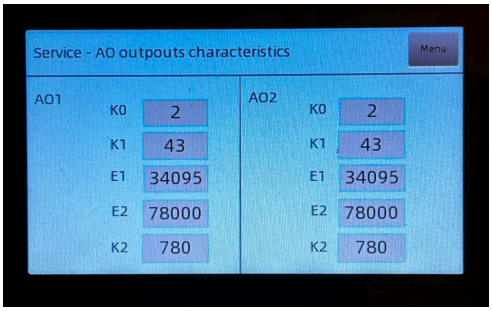
PIDoutsmeasurement - total / per phase

per phase - the controller can send power during overflow to individual SSRs either in total **-total** (calculates total power on CT coils) or per phase

Phase-by-phase measurement and control is suitable for symmetrical converters that cannot distribute the power to individual phases according to their load and send the same power to all phases. For asymmetrical converters

Service 13





In this section, it is possible to adjust the curve (characteristic) of the analog outputs when running in SSR mode, according to the type of SSR used, so that the power output is as linear as possible. It is factory-set for a specific type of SSR relay and we recommend not to adjust it.