BMS Main X 1.x

Strings controller

CONFIGURATION MANUAL

Revision 1 (15-November-2021)

Contents

1 General information ... 3
2 BMS and battery state ... 8
2.1 BMS state ... 8
2.2 Battery state ... 14
3 Input and output signals ... 22
3.1 Input signals ... 22
3.2 Output signals and relays ... 22
4 Battery parameters ... 25
4.1 Modules' settings ... 25
4.2 Calculation of parameters ... 25
4.3 Modules balancing ... 26
5 Charging and discharging the battery ... 28
5.1 Charging control ... 28
5.2 Discharging control ... 30
5.3 Manual control ... 33
6 Protections ... 35
6.1 Battery cover protection ... 35
6.2 Module offline protection ... 36
6.3 Voltage unbalance protection ... 36
6.4 Current unbalance protection ... 38
6.5 Charging current unbalance protection ... 39
6.6 Discharging current unbalance protection ... 40
6.7 Critical error ... 41
6.8 Fault simulation ... 42
7 External equipment ... 44
7.1 BKM controller ... 44
8 Communication ... 46
8.1 Ethernet ... 46
8.2 CAN ... 46
8.3 Modbus ... 48
8.4 Wi-Fi ... 49
8.5 Sending log files to a remote FTP server ... 49
9 Maintenance ... 53

9.1 Restarting the device 53
9.2 Importing, exporting, and locking device settings 53
9.3 Real-time clock 55
9.4 SD card logging 56
9.5 User settings 56
10 Contacts 58
11 Revision history 59

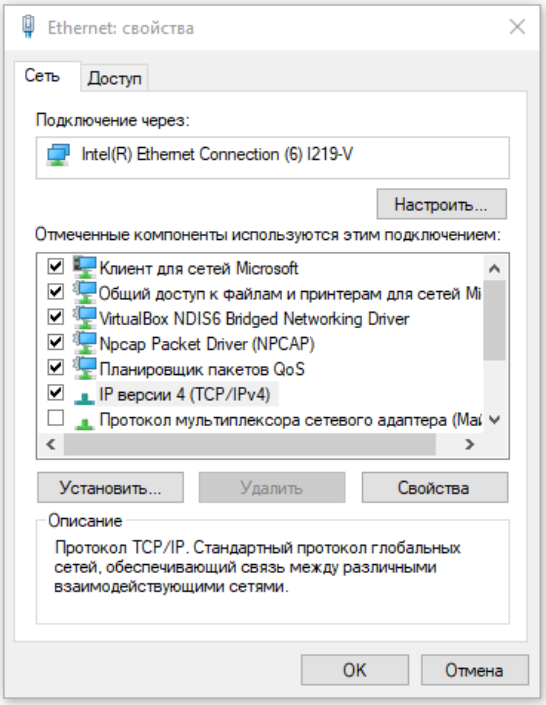
1 General information

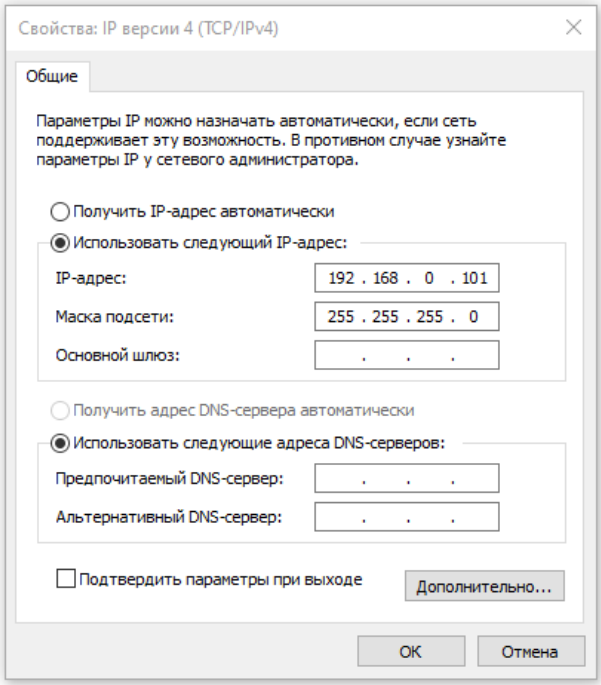
This document describes how to configure the BMS Main X 1.x board. Configuring can be done using the web interface available via Ethernet or Wi-Fi.

Default connection settings for Ethernet are:

- IP address – 192.168.0.100
- Network Mask – 255.255.0.0
- Default gateway – 192.168.0.1

Note – To connect via Ethernet, the computer through which the BMS Main X 1.x is configured must be in the same subnet as the target board. The figure below shows an example of the settings for an Ethernet network adapter:



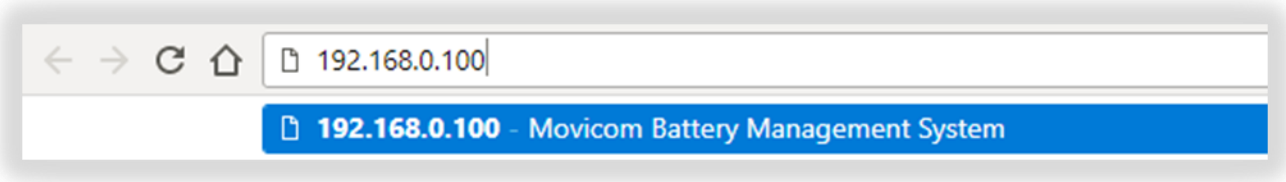


To connect via Wi-Fi use the IP address which an access point gave to the device (see Wi-Fi for configuring the connection and the "System → Overview" section to find out the IP address).

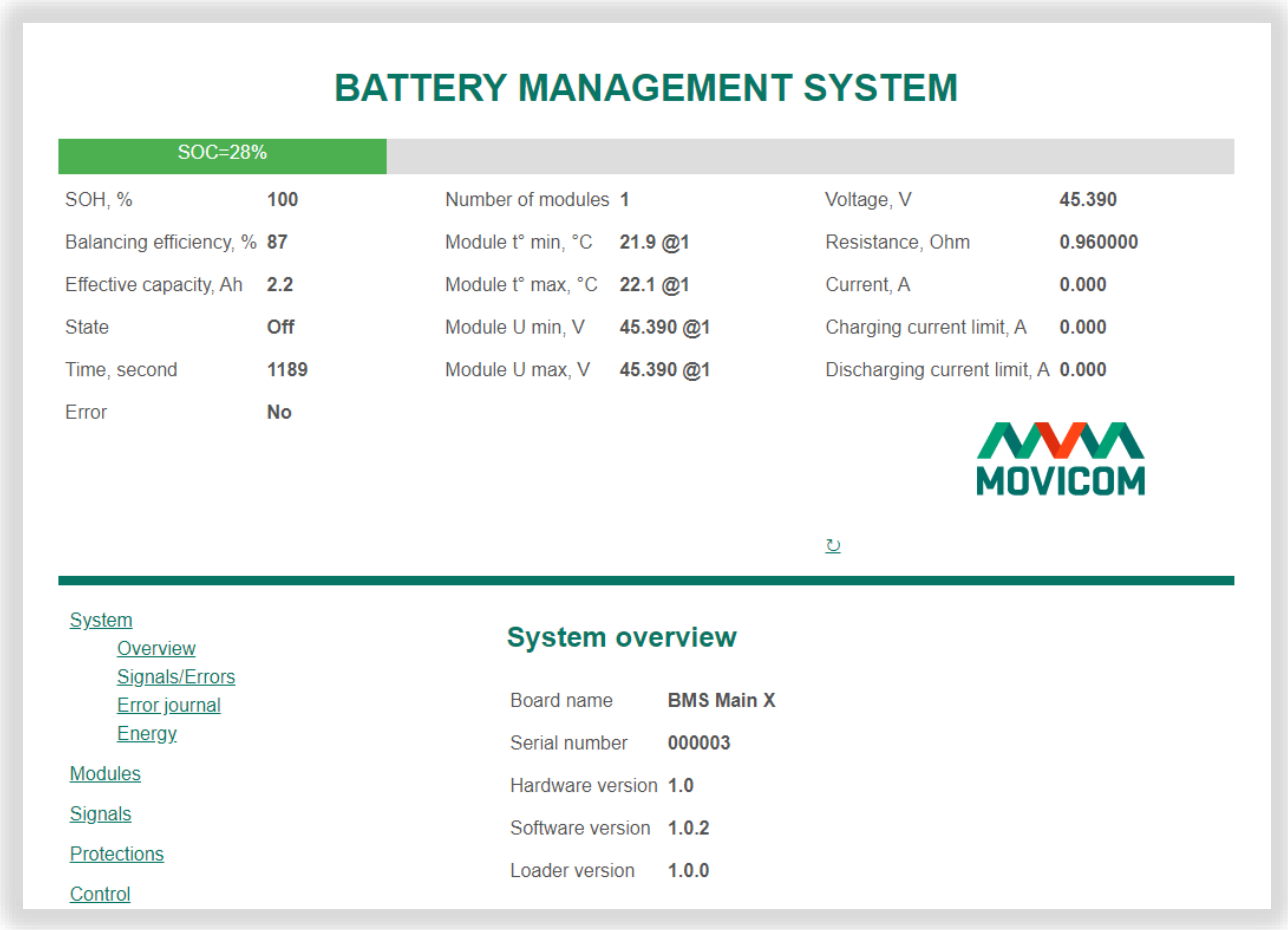
Default credentials for changing board settings using the web interface are:

- Login – user
- Password – mainx

To access the web interface, enter the IP address of the board in the address bar of the browser:



Start page of the web interface will open:



At the top of the page there is a block in which the main parameters of the battery system are displayed (updated 1 time per second):

- SOC – State of Charge, %;
- SOH – State of health, %;
- Balancing efficiency, %;
- Effective capacity, A×h;
- State:
    - Off – battery modules are disconnected from the common bus;
    - Balancing – battery modules are interconnected and balancing;

    - Idle – the main charging or discharging contactor are closed but there is no charging or discharging current;
    - Charging – the main charging contactor is closed and the charging current is detected;
    - Discharging – the main discharging contactor is closed and the discharging current is detected;
- Time – duration of staying in the current state, second;
- Error – detected error:
    - No – no errors;
    - Battery cover – battery cover is open;
    - Module offline – connection with some battery module is lost;
    - Voltage unbalance (CH) – battery modules have different voltages (charging circuit);
    - Voltage unbalance (DCH) – battery modules have different voltages (discharging circuit);
    - Current unbalance (CH) – self-balancing currents are too high (charging circuit);
    - Current unbalance (DCH) – self-balancing currents are too high (discharging circuit);
    - Charging current unbalance – significant difference between the charging currents;
    - Discharging current unbalance – significant difference between the discharging currents;
    - Critical error;
- Number of modules;
- Module t°C min – a minimum temperature among the battery modules, °C;
- Module t°C max – a maximum temperature among the battery modules, °C;
- Module U min – a minimum voltage among the battery modules, V;
- Module U max – a maximum voltage among the battery modules, V;
- Voltage – battery voltage, V;
- Resistance – battery resistance, Ohm;
- Current – current flowing through the battery, A;
- Charging current limit – a maximum allowable charging current, A;

- Discharging current limit – a maximum allowable discharging current, A.

In the lower (main) part of the page there is a block that serves to configure the device and read detailed information about the battery and the BMS. On the left side of this block there is a menu for selecting sections, on the right side – an area with controls specific to the selected section.

The menu for selecting sections has the following structure:

- System – information about the system:
    - Overview – general data about the device and connection parameters;
    - Signals/Errors – state of input and output signals, error flags;
    - Error journal – a list of errors generated during BMS work;
    - Energy – counters of received and consumed energy;
- Modules – information about battery modules:
    - Details – detail information about battery modules;
    - Summary – summary information about all battery modules;
- Signals – settings for input and output signals:
    - Input signals – settings for the discrete input signals;
    - Output signals – settings for the output discrete signals and relays;
- Protections – settings for protections:
    - Battery cover protection – settings for protection against opening the battery cover;
    - Module offline protection – settings for protection against loss of communication with battery modules;
    - Voltage unbalance protection – settings for protection against voltage unbalance;
    - Current unbalance protection – settings for protection against current unbalance;
    - Charging current unbalance protection – settings for protection against too different charging currents;
    - Discharging current unbalance protection – settings for protection against too different discharging currents;
    - Critical error parameters – setting for generation of the critical error;
    - Fault simulation – simulation the errors;

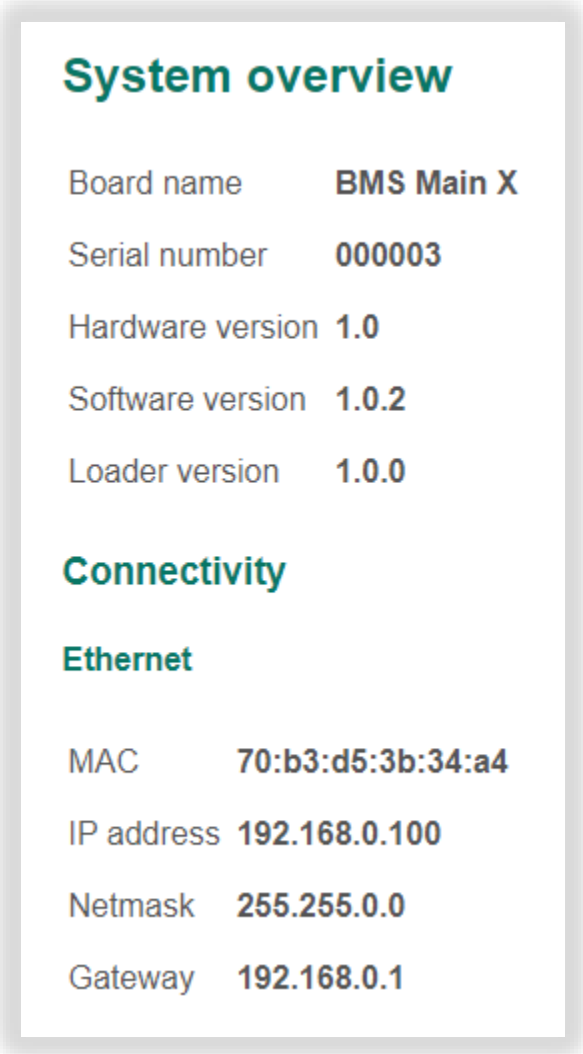
- Control – settings for battery control algorithms:
    - Modules settings – settings for battery modules;
    - Calculation of parameters – settings for calculation battery parameters;
    - Charging control – settings for the algorithm of battery charging;
    - Discharging control – settings for the algorithm of battery discharging;
    - Modules balancing – settings for active balancing of the battery;
    - Manual control – means for manual control of the battery;
- External equipment – communication with external equipment:
    - BKM controller – settings for communication with the EV-controller by BKM;
- Connectivity – connection settings:
    - Ethernet – settings for Ethernet;
    - CAN (external) – settings for the CAN (EXT) bus used for communication with a top-level system;
    - CAN (internal) – settings for the CAN (INT) bus used for communication with battery modules;
    - Modbus – settings for the RS-485 bus;
    - Wi-Fi – settings for Wi-Fi;
    - FTP synchronization – settings for sending log files to a remote FTP server;
- Service – service settings:
    - Device – commands to reboot the device;
    - Settings – commands to import/export and reset the device settings;
    - Clock – settings for the real time clock;
    - SD-card logging – settings for logging to an SD card;
    - File browser – browser for files stored on the SD card;
    - User – user settings;
    - Admin – manufacture settings.

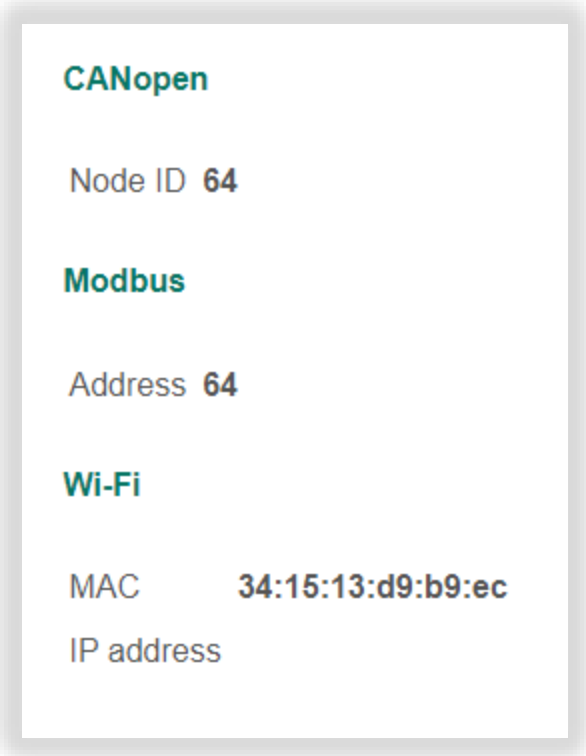
2 BMS and battery state

The BMS Main X 1.x continuously evaluates the state of the battery system.

2.1 BMS state

To display information about the device including connection parameters select the menu item “System → Overview”:





This section contains:

- Board name ("BMS Main X");
- Serial number – serial number of the device assigned by the manufacturer;
- Hardware version – revision of the device;
- Software version – revision of the firmware;
- Loader version – revision of the bootloader;
- Ethernet connection settings;
- CANopen identifier;
- Device address according to the Modbus RTU specification;
- Wi-Fi information.

To display the state of input and output signals and error flags, select the menu "System → Signals / Errors":

System signals

Discrete input

- Battery cover

Errors

- Battery cover
- Module offline
- Critical error

Voltage unbalance (charge)

1 2 3 4
5 6 7 8

Voltage unbalance (discharge)

1 2 3 4
5 6 7 8

Charging current unbalance

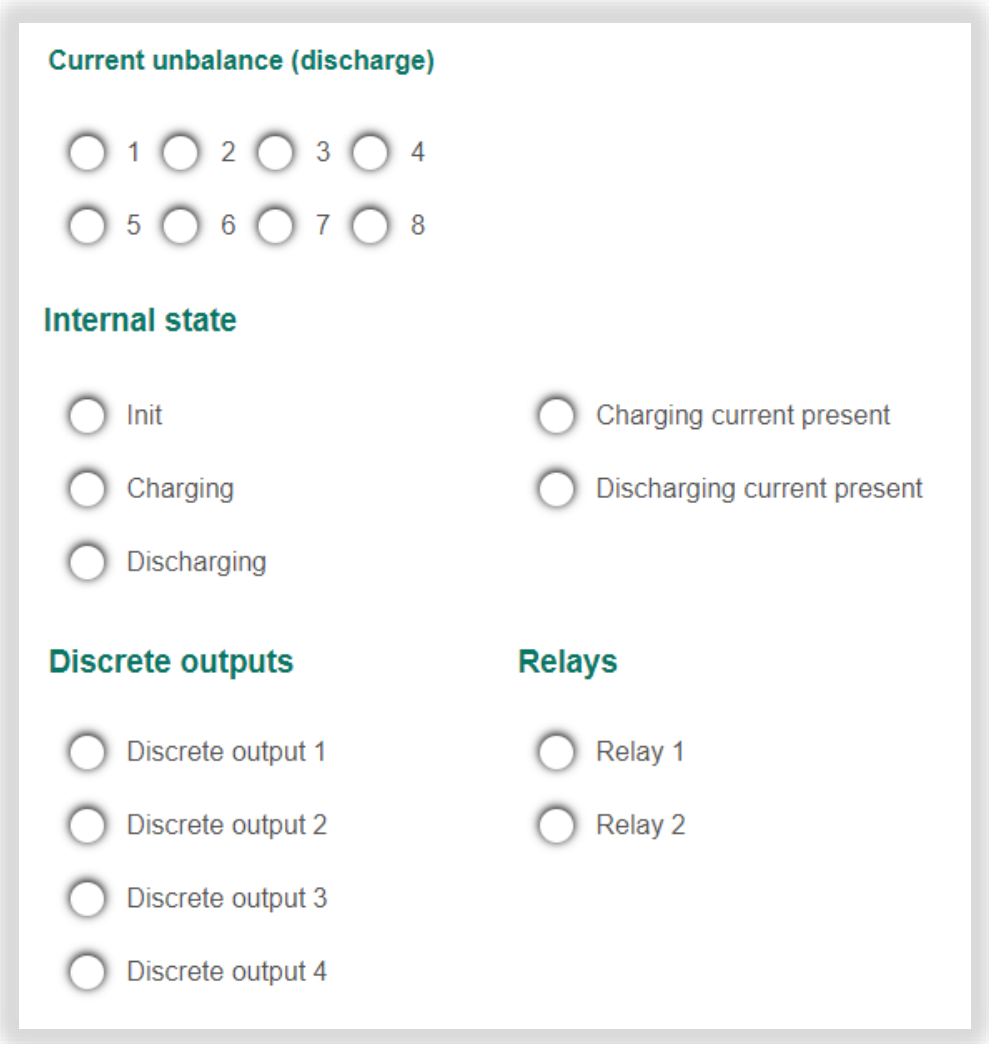
1 2 3 4
5 6 7 8

Current unbalance (charge)

1 2 3 4
5 6 7 8

Discharging current unbalance

1 2 3 4
5 6 7 8



Discrete signals and error flags are displayed in the form of color indicators. If there is a signal (error), the indicator changes its color to green (red).

In this section:

- Input signals:
  - Battery cover – battery cover is open;
- Errors:
  - Battery cover error – battery cover is open;
  - Module offline – connection with a battery module is lost;
  - Critical error;
  - Voltage unbalance (charging) – battery modules have different voltages (charging circuit);

    - Voltage unbalance (discharging) – battery modules have different voltages (discharging circuit);
    - Current unbalance (charging) – self-balancing currents are too high (charging circuit);
    - Current unbalance (discharging) – self-balancing currents are too high (discharging circuit);
    - Charging current unbalance – significant difference of charging currents;
    - Discharging current unbalance – significant difference of discharging currents;
- Internal state:
    - Init – initialization of the device (scanning battery modules);
    - Charging – state of the main charging contactor;
    - Discharging – state of the main discharging contactor;
    - Charging current present – charging current is detected;
    - Discharging current present – discharging current is detected;
- Output signals:
    - Discrete output 1..4 – states of the discrete outputs;
    - Relay 1..2 – states of the relays.

To display the content of the errors journal, select the menu “System → Error journal”:

Error journal

Num.	Date and time	Error	Need acknowledge
1	01.01.34 04:00:48	Battery cover	☐
2	01.01.34 04:00:51	No errors	☐
3	01.01.34 04:00:54	Battery cover	☐
4	01.01.34 04:00:56	No errors	☐
5	01.01.34 04:01:00	Battery cover	☐
6	01.01.34 04:01:03	No errors	☐
7	01.01.34 04:01:06	Battery cover	☐
8	01.01.34 04:01:08	No errors	☐
9	01.01.34 04:03:22	Battery cover	☐
10	01.01.34 04:03:24	No errors	☐
11	01.01.34 04:03:28	Battery cover	☐
12	01.01.34 04:03:30	No errors	☐

The table contains detected errors.

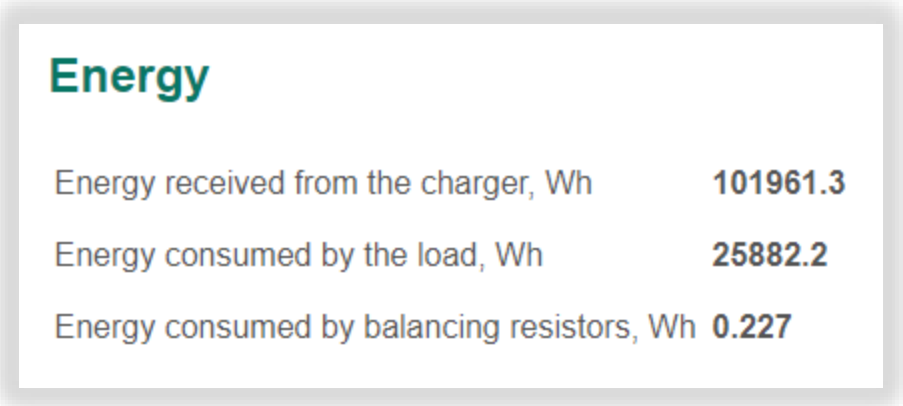
Header columns:

- Num. – number of a record (from 1 to 32);
- Date and time – date and time of a record;
- Error – error names;
- Need acknowledge – flag showing the need to acknowledge a record.

The errors journal is cyclical: after all 32 positions are filled, a new record will be placed at position “1”. The last entry is marked bold.

When adding a new record to the journal, the flag "Need acknowledge" is set and the corresponding error is generated. To clear the “Need acknowledge” error, you need to clear the “Need acknowledge” flags for all journal entries and click on the “Acknowledge” button.

To display information about the received and consumed energy, select the menu “System → Energy”:



Energy

Energy received from the charger, Wh	**101961.3**
Energy consumed by the load, Wh	**25882.2**
Energy consumed by balancing resistors, Wh	**0.227**

In this section:

- Energy received from the charger (energy of the positive direction), Wh;
- Energy consumed by the load (energy of negative direction), Wh;
- Energy consumed by balancing resistors, Wh.

Note – The energy values are calculated as the sum of the values received from the battery modules.

2.2 Battery state

To display the detailed information about concrete battery module, select the menu "Modules → Details":

Module details

1 2 3 4 5 6 7 8

Module #1

State **Online** Firmware **1.50.1**

SOC=28%

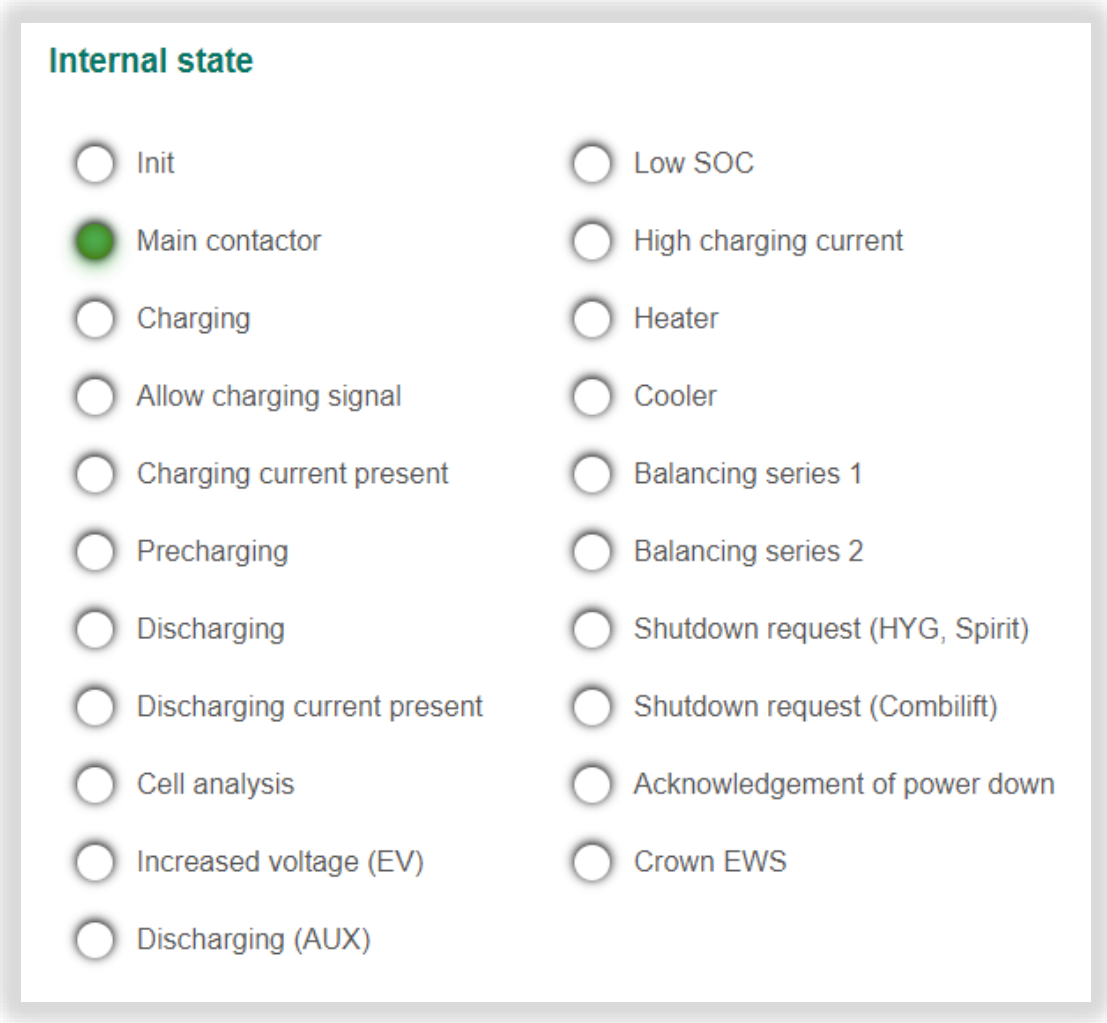
SOH, %	**100**	Voltage, V	**45.382**
Balancing efficiency, %	**87**	Current, A	**0.000**
Effective capacity, Ah	**2.2**	Resistance, Ohm	**0.960000**
Charging current limit, A	**0**	Minimum temperature, °C	**21.8**
Discharging current limit, A	**0**	Maximum temperature, °C	**21.9**
Energy+, Wh	**101961.3**	Minimum cell voltage, V	**3.770**
Energy-, Wh	**25882.2**	Maximum cell voltage, V	**3.795**
Energy dissipated, Wh	**0.2**		

Discrete signals

- ○ Battery cover
- ○ Charger connected
- ○ Power down request
- ● Inhibit charging
- ● Inhibit discharging

Errors

- Overcurrent
- Undervoltage
- Overvoltage
- Low CH temperature
- High CH temperature
- Low DCH temperature
- High DCH temperature
- Battery cover error
- High humidity
- Water
- Short circuit
- Contactor high temperature
- Unallowable charging
- CH contactor cycles error
- DCH contactor cycles error
- Logic high temperature
- Logic offline
- Crown error
- Cell count error
- Logic count error
- HYG offline
- Combilift offline
- Spirit offline
- ADC error
- Current sensor error
- Shunt offline
- Shunt error
- Settings error
- WDT reset
- No temp. sensors
- Temp. sensor is shorted
- Critical error
- Need acknowledge



The section contains the following information received from the selected battery module:

- State – state of the battery module:
  - Not present – the battery module is not detected;
  - Present – the battery module is detected;
  - Online – the battery module is detected, and the connection with the module is established;
  - Offline – the battery module is detected, but the connection with the module is lost;
- Firmware – firmware revision of the module's BMS;
- SOC – battery module state of charge, %;
- SOH – battery module state of health, %;
- Balancing efficiency, %;

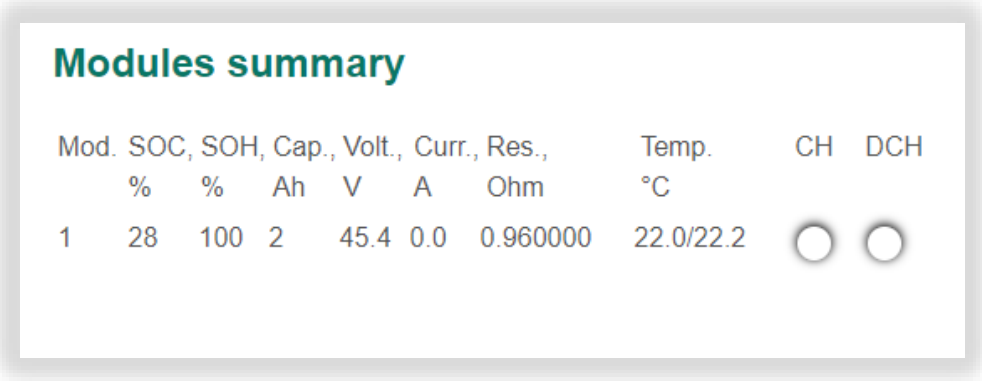
- Charging current limit – maximum allowable charging current of the battery module, A;
- Discharging current limit – maximum allowable discharging current of the battery module, A;
- Energy+ – energy received from the charger, Wh;
- Energy- – energy consumed by the load , Wh;
- Energy dissipated – energy consumed by balancing resistors, Wh;
- Voltage – battery module voltage, V;
- Current – current flowing through the battery module, A;
- Resistance – battery module resistance, Ohm;
- Minimum temperature – minimum cell temperature, °C;
- Maximum temperature – maximum cell temperature, °C;
- Minimum cell voltage, V;
- Maximum cell voltage, V;
- Discrete signals:
    - Battery cover – battery cover is open;
    - Charger connected – charger is connected to the battery;
    - Power down request – a signal to power down the BMS;
    - Inhibit charging – a command to inhibit closing the charging relay;
    - Inhibit discharging – a command to inhibit closing the discharging relay;
- Errors:
    - Overcurrent;
    - Undervoltage;
    - Overvoltage;
    - Low CH temperature – temperature is too low for charging;
    - High CH temperature – temperature is too high for charging;
    - Low DCH temperature – temperature is too low for discharging;
    - High DCH temperature – temperature is too high for discharging;
    - Battery cover error – battery cover is open;
    - High humidity;
    - Water – there is water in the battery enclosure;

- Short circuit – short circuit in the charging or discharging buses;
- Contactor high temperature – contactor is overheated;
- Unallowable charging – charging the battery through the discharging contactor;
- CH contactor cycles error – switching frequency of the charging contactor is too high;
- DCH contactor cycles error – switching frequency of the discharging contactor is too high;
- Logic high temperature – some BMS Logic board is overheated;
- Logic offline – connection with some BMS Logic board is lost;
- Crown error – connection with a Crown forklift is lost;
- Cell count error – number of cells does not match the specified value;
- Logic count error – number of BMS Logic boards does not match the specified value;
- HYG offline – connection with a HYG forklift is lost;
- Combilift offline – connection with a Combilift forklift is lost;
- ADC error – current cannot be measured;
- Current sensor error – error in the current sensor circuit;
- Shunt offline – connection with the shunt current sensor is lost;
- Shunt error – internal error of the shunt current sensor;
- Settings error – wrong checksum of the BMS settings;
- WDT reset – watchdog timer reset the board;
- No temp. sensors – some BMS Logic board has no temperature sensors connected;
- Temp. sensor is shorted – some temperature sensors are shorted;
- Critical error;
- Need acknowledge – it is required to acknowledge the entries in the error journal;

- Internal state:
  - Init – initialization of the board (calibration of the current sensor and scanning of BMS Logic boards);
  - Main contactor – state of the main contactor;
  - Charging – state of the charging relay;

- Allow charging signal – signal allowing the operation of the charger;
- Charging current present – charging current is detected;
- Precharging – state of the precharge relay;
- Discharging – state of the discharging relay;
- Discharging current present – discharging current is detected;
- Cell analysis – operation of the algorithm for determining the discharge characteristics;
- Enhanced/Increased voltage (EV) – voltage is too high for charging (see Charging control);
- Discharging (AUX) – state of the discharging (AUX) relay (power of an external equipment is on);
- Low SOC – low level of the state of charge;
- High charging current – charging current is too high;
- Heater –signal to turn on heater;
- Cooler – signal to turn on cooler;
- Balancing series 1 – signal to balance series of cells 1;
- Balancing series 2 – signal to balance series of cells 2;
- Shutdown request (HYG, Spirit) – request to open the discharging relay received from the HYG forklift;
- Shutdown request (Combilift) – request to open the discharging relay received from the Combilift forklift;
- Acknowledgement of power down – signal to acknowledge powering down the battery system;
- Crown EWS – signal sent to the Crown truck before opening the discharging relay.

To display summary information about all battery modules, select the menu “Modules → Summary”:



Modules summary

Mod.	SOC, %	SOH, %	Cap., Ah	Volt., V	Curr., A	Res., Ohm	Temp. °C	CH	DCH
1	28	100	2	45.4	0.0	0.960000	22.0/22.2		

This section contains the summary table with battery module parameters:

- Mod. – number of the battery module for which the data is shown;
- SOC – battery module state of charge, %;
- SOH – battery module state of health, %;
- Cap. – effective capacity of the battery module, Ah;
- Volt. – battery module voltage, B;
- Curr. – current flowing through the battery module, A;
- Res. – battery module resistance, Ohm;
- Temp. – minimum and maximum temperature among the cells of the battery module, °C;
- CH – state of the charging relay (green light corresponds to the closed relay);
- DCH – state of the discharging relay (green light corresponds to the closed relay).

3 Input and output signals

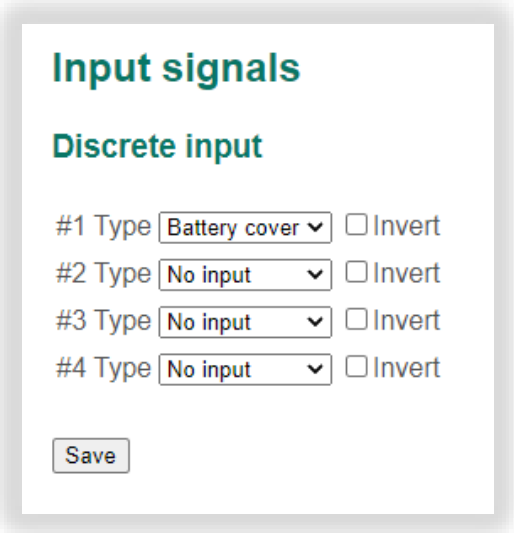
3.1 Input signals

The BMS Main X 1.x has 4 discrete inputs of the “dry contact” type. For each discrete input, its purpose and the inversion requirement are specified. The following discrete input assignment options are supported:

- no signal;
- battery cover.

If the "battery cover" assignment is selected, the discrete input is used to monitor the state of the battery cover (see Battery cover protection).

To configure the input discrete signals, select the menu "Signals → Input signals":



The order of the numbering of the discrete and analog inputs corresponds to the order of the numbering on the device.

In this section:

- Discrete input:
  - No input;
  - Battery cover – a signal from the battery cover.

Here and further saving settings occurs by clicking the "Save" button.

3.2 Output signals and relays

The BMS Main X 1.x has 4 discrete outputs. For each discrete output, its purpose and

inversion requirement are specified. The following discrete output assignment options are supported:

- no output.

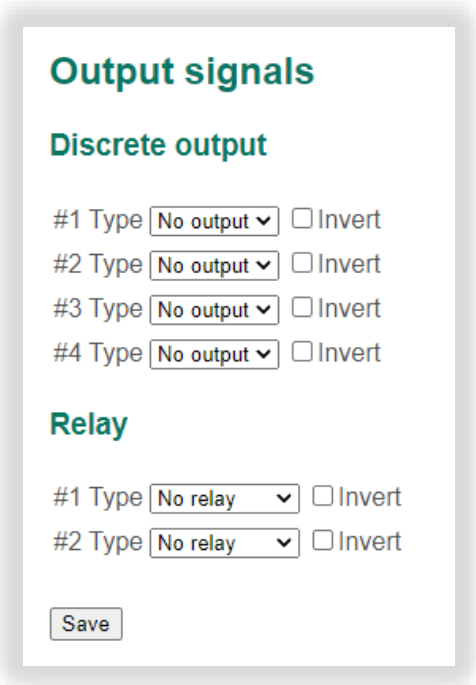
The BMS Main X 1.x has 2 solid-state relays. For each relay, its purpose and inversion requirement are specified. The following relay assignment options are supported:

- no relay;
- charging;
- discharging.

If the "charging" assignment is selected, the relay is used to control the main charging contactor of the battery (see Charging control**Ошибка! Источник ссылки не найден.**).

If the "discharging" assignment is selected, the relay is used to control the main discharging contactor of the battery (see Discharging control**Ошибка! Источник ссылки не найден.**).

To configure output discrete signals and relays, select the menu "Signals → Output signals:



The order of the numbering of the discrete outputs and the relays corresponds to the order of the numbering on the device.

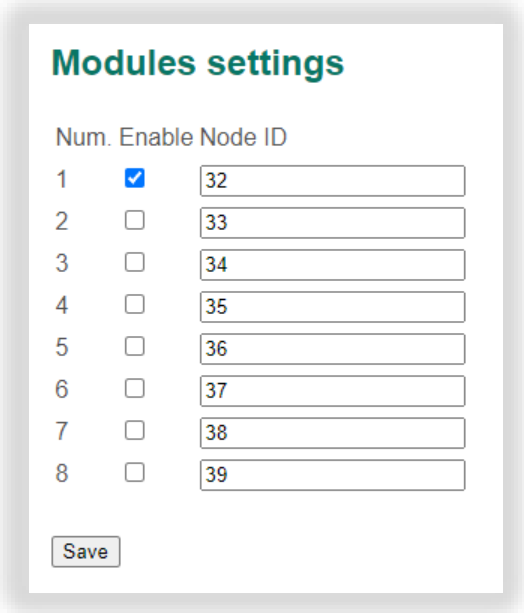
In this section:

- Discrete output:
    - No output;
- Relay:
    - No relay;
    - Charging;
    - Discharging.

4 Battery parameters

4.1 Modules' settings

To change the settings of the battery modules, select the menu "Control → Module settings":

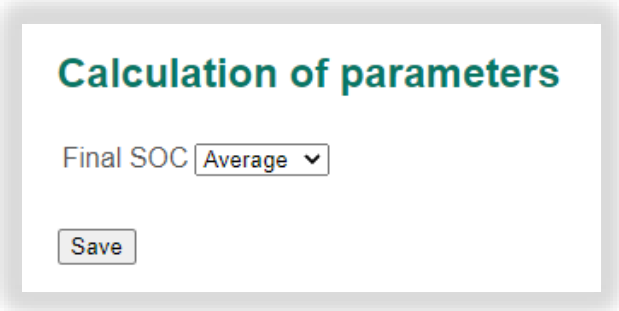


The list of modules comprising the battery is set in this section:

- Num. – a number of a battery module;
- Enable – a flag to enable the battery module;
- Node ID – CANopen identifier of the battery module. Each module must have a unique identifier. To change the module identifier, see the "Connectivity → CAN" section (for the BMS Main 2.x) or the "Connectivity → CAN (internal)" (for the BMS Mini 1.x).

4.2 Calculation of parameters

To change the settings for calculation of the battery parameters, select the menu "Control → Calculation of parameters":



In this section:

- Final SOC – a method to calculate the final battery SOC:
  - Minimum – the battery SOC equals to the minimum SOC among the battery modules;
  - Average – the battery SOC calculates as the average of the battery modules SOC.

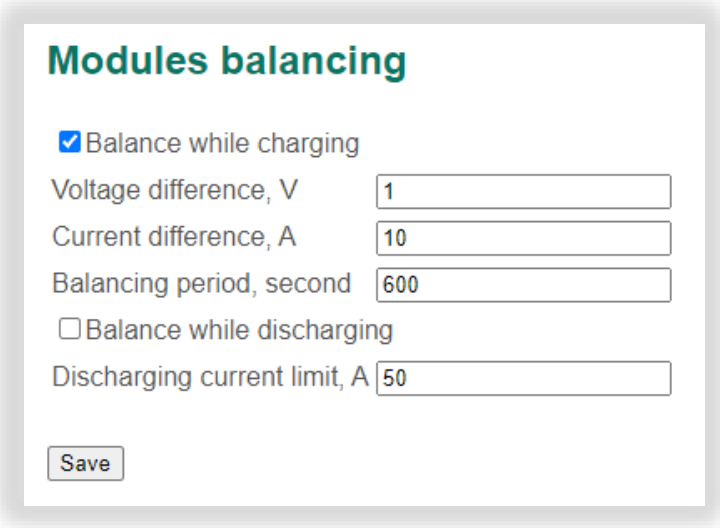
4.3 Modules balancing

The BMS Main X 1.x supports active balancing of the battery modules during both charging and discharging.

When charging the battery, balancing is performed by disconnecting the most charged battery modules from the common bus. Before disconnecting the modules, BMS Main X 1.x sends a request to a top-level system (charger) to reduce the charging current to zero, and after decreasing the current it disconnects the most charged battery modules.

When discharging the battery, balancing is performed by disconnecting the most discharged battery modules from the common bus. The battery modules are disconnected only if the battery discharge current has dropped to the threshold value set in the device settings.

To change the settings for modules balancing, select the menu “Control → Modules balancing”:



In this section:

- Balancing while charging – a flag to enable balancing during charging the battery;
- Voltage difference – a voltage difference between the battery modules, at which the most charged modules are disconnected (those modules are disconnected whose voltage exceeds the minimum voltage among the modules by the "Voltage difference" value), V;
- Current difference – a difference in charging currents at which the most charged modules are disconnected (those modules are disconnected whose charging current is less than the maximum charging current among the modules by the "Current difference" value), A;
- Balancing period – a time spent by the battery modules in the disconnected state (after this time, the modules that were previously disconnected during the balancing process are reconnected to the common bus), second;
- Balancing while discharging – a flag to enable balancing during discharging the battery;
- Discharging current limit – a discharge current value at which the device will disconnect the most discharged battery modules, A.

5 Charging and discharging the battery

5.1 Charging control

The BMS Main X 1.x manages the parallel connection of the battery modules and the connection of the battery to the charging circuit.

The battery is controlled in one of the following modes:

1. Charging is always allowed (Mode 1) – the device ignores the voltage and current unbalance of the battery modules and commands to close the battery modules charging contactors and the main charging contactor.
2. Charging is allowed if all battery modules are balanced (Mode 2).
3. Charging is allowed for most balanced battery modules (Mode 3). Unbalanced modules are disconnected from the common bus and do not participate in charging.

The charging process is controlled by the following algorithm:

1. If permission to charge the battery is obtained and the voltage and current unbalance errors are cleared, go to step 2.
2. Checking the voltage unbalance of battery modules (the duration of the test is set in the settings). If there is no unbalance or ignoring errors (Modes 1 and 3), go to step 3, otherwise open all charging contactors, and go to step 1.
3. Closing the charging contactors of the battery modules. The battery modules are self-balancing. Go to step 4.
4. Checking inter-module balancing currents (the duration of the check is set in the settings). If there is no current unbalance or errors are ignored (Modes 1 and 3), go to step 5, otherwise open all charging contactors, and go to step 1.
5. Closing the main charging contactor. Go to step 6.
6. Checking the occurrence of a significant deviation in the charging currents of the battery modules (the "Charging current unbalance" error). If the error occurs, all charging contactors are disconnected, and go to step 1 (the duration of the delay before disconnecting the contactors is set in the settings).

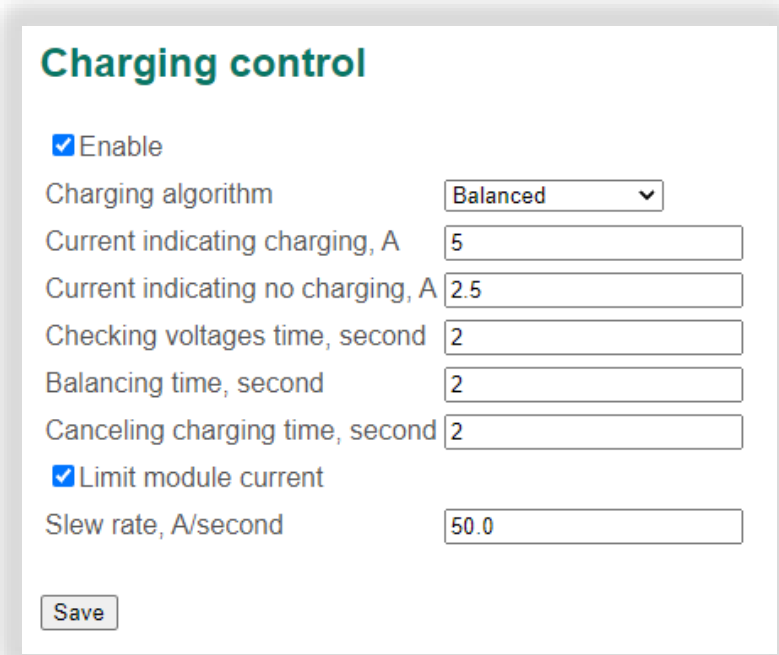
Permission to charge the battery is issued by a top-level system, with which communication is established via the CAN bus (EXT).

The command to close the main charging contactor (Charging) can be issued both to a top-level system via the CAN bus (EXT), and on the solid-state relay of the device, which serves to directly control the main charging contactor.

if the critical error occurs, the device opens all charging contactors.

In addition to controlling the charging contactors, the device calculates and transfers to a top-level system the value of the maximum allowable charging current. The calculation of the charging current of the entire battery is carried out based on the number of battery modules and the values of the maximum charging currents transmitted by them.

To change the settings for the charging controller, select the menu "Control → Charging control":



In this section:

- Enable – a flag to enable the charging controller;
- Charging algorithm:
    - Always on;
    - Balanced – charging is allowed if all battery modules are balanced;
    - Partially balanced – charging is allowed for most of balanced battery modules;

- Current indicating charging – a current threshold to generate the "Charging current present" signal, A;
- Current indicating no charging – a current threshold to clear the "Charging current present" signal, A;
- Checking voltages time – a time for checking voltages of battery modules, second;
- Balancing time – a time for self-balancing of the battery modules (for checking inter-module balancing currents), second;
- Canceling charging time – a delay before the opening the main charging relay, second;
- Limit charging current – a flag that allows to limit the charging current of the battery so that the current of each battery module does not exceed its maximum allowable charging current;
- Slew rate – a rate of changing of the required maximum charging current of the battery if the “Limit charging current” flag is set, A/second.

5.2 Discharging control

The BMS Main X 1.x manages the parallel connection of the battery modules and the connection of the battery to the discharging circuit.

The battery is controlled in one of the following modes:

1. Discharging is always allowed (Mode 1) – the device ignores the voltage and current unbalance of the battery modules and commands to close the battery modules discharging contactors and the main discharging contactor.
2. Discharging is allowed if all battery modules are balanced (Mode 2).
3. Discharging is allowed for most balanced battery modules (Mode 3). Unbalanced modules are disconnected from the common bus and do not participate in discharging.

The discharging process is controlled by the following algorithm:

1. If permission to discharge the battery is obtained and the voltage and current unbalance errors are cleared, go to step 2.
2. Checking the voltage unbalance of battery modules (the duration of the test is set in the settings). If there is no unbalance or ignoring errors (Modes 1 and 3), go to step 3, otherwise open all discharging contactors, and go to step 1.
3. Closing the discharging contactors of the battery modules. The battery modules are

self-balancing. Go to step 4.

4. Checking inter-module balancing currents (the duration of the check is set in the settings). If there is no current unbalance or errors are ignored (Modes 1 and 3), go to step 5, otherwise open all discharging contactors, and go to step 1.
5. Closing the main discharging contactor. Go to step 6.
6. Checking the occurrence of a significant deviation in the discharging currents of the battery modules (the "Discharging current unbalance" error). If the error occurs, all discharging contactors are disconnected, and go to step 1 (the duration of the delay before disconnecting the contactors is set in the settings).

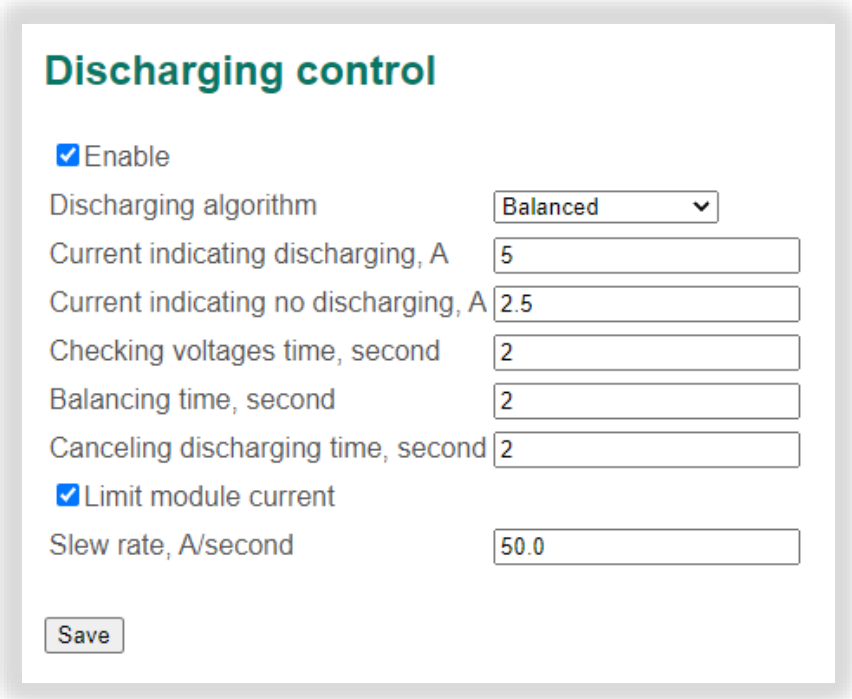
Permission to discharge the battery is issued by a top-level system, with which communication is established via the CAN bus (EXT).

The command to close the main discharging contactor (Discharging) can be issued both to a top-level system via the CAN bus (EXT), and on the solid-state relay of the device, which serves to directly control the main discharging contactor.

if the critical error occurs, the device opens all discharging contactors.

In addition to controlling the discharging contactors, the device calculates and transfers to a top-level system the value of the maximum allowable discharging current. The calculation of the discharging current of the entire battery is carried out based on the number of battery modules and the values of the maximum discharging currents transmitted by them.

To change the settings for the discharging controller, select the menu "Control → Discharging control":



In this section:

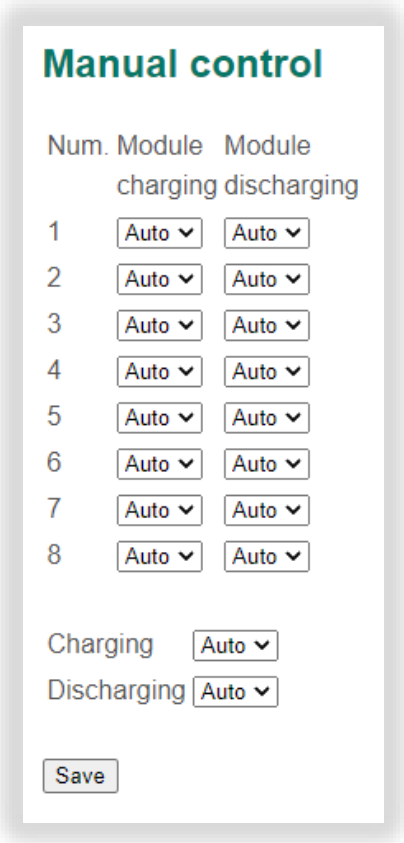
- Enable – a flag to enable the charging controller;
- Discharging algorithm:
  - Always on;
  - Balanced – discharging is allowed if all battery modules are balanced;
  - Partially balanced – discharging is allowed for most of balanced battery modules;
- Current indicating discharging – a current threshold to generate the "Discharging current present" signal, A;
- Current indicating no discharging – a current threshold to clear the "Discharging current present" signal, A;
- Checking voltages time – a time for checking voltages of battery modules, second;
- Balancing time – a time for self-balancing of the battery modules (for checking inter-module balancing currents), second;
- Canceling discharging time – a delay before the opening the main discharging relay, second;
- Limit module current – a flag that allows to limit the discharging current of the battery so that the current of each battery module does not exceed its maximum allowable discharging current;

- Slew rate – a rate of changing of the required maximum discharging current of the battery if the “Limit module current” flag is set, A/second.

5.3 Manual control

The BMS Main X 1.x allows to manually control the charging and discharging contactors of the battery modules.

To control the battery charging and discharging, select the menu “Control → Manual control”:



In this section:

- Num. – a number of a battery module;
- Module charging:
    - Auto – use the charging controller (see Charging control);
    - YES – close the module’s charging contactor;
    - NO – open the module’s charging contactor;
- Module discharging:
    - Auto – use the discharging controller (see Discharging controlDischarging

control);

  - YES – close the module's discharging contactor;
  - NO – open the module's discharging contactor;

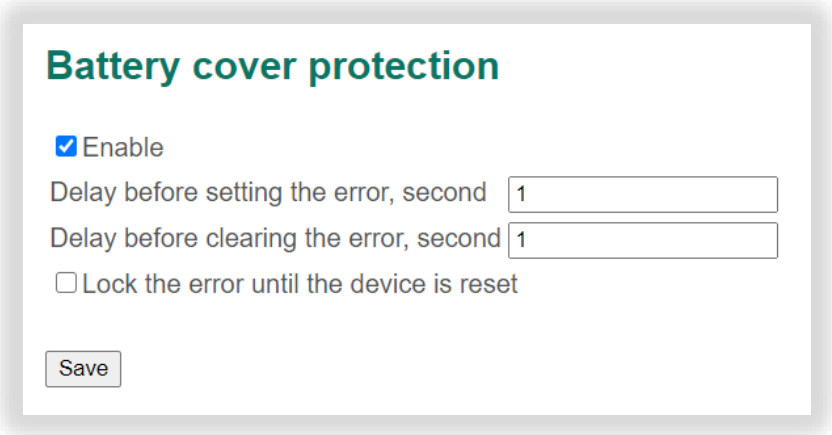
- Charging:
  - Auto – use the charging controller (see Charging control);
  - YES – close the main charging contactor;
  - NO – open the main charging contactor;
- Discharging:
  - Auto – use the discharging controller (see Discharging control);
  - YES – close the main discharging contactor;
  - NO – open the main discharging contactor.

6 Protections

The BMS Main X 1.x controls battery modules, compares their voltages and currents, and protects the battery from damage.

6.1 Battery cover protection

To change the parameters for protection against opening the battery cover, select the menu "Protections → Battery cover protection":



In this section:

- Enable – a flag to enable the protection;
- Delay before setting the error, second;
- Delay before clearing the error, second;
- Lock the error until the device is reset.

As a result of the operation of the protection against opening the battery cover, the “Battery cover error” is generated.

Error generation conditions:

- there is a signal from the battery cover during the “Delay before setting the error” time.

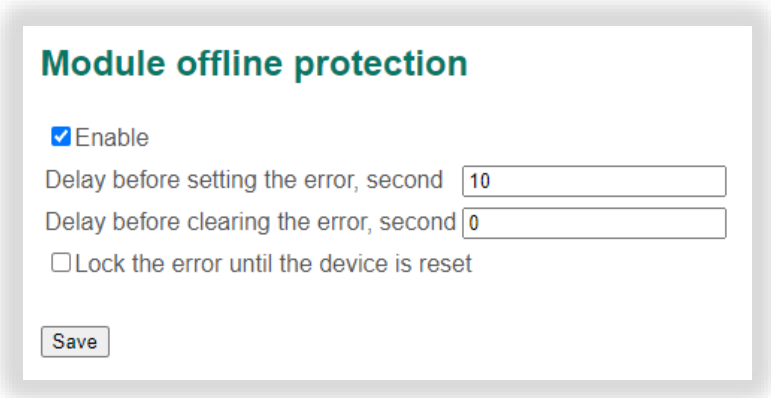
Conditions for removing the error:

- no signal from the battery cover during the “Delay before clearing the error” time.

If there is the "Battery cover error", the “Critical error” is generated and all relays open.

6.2 Module offline protection

To change the parameters for protection against loss of communication with battery modules, select the menu "Protections → Module offline protection":



In this section:

- Enable – a flag to enable the protection;
- Delay before setting the error, second;
- Delay before clearing the error, second;
- Lock the error until the device is reset.

As a result of the protection against loss of communication with battery modules, the "Module offline" error is generated.

Error generation conditions:

- at least one of the connected battery modules does not respond to the commands of the BMS Main X 1.x during the “Delay before setting the error” time.

Conditions for removing the error:

- all connected battery modules respond to the commands of the BMS Main X 1.x during the “Delay before clearing the error” time.

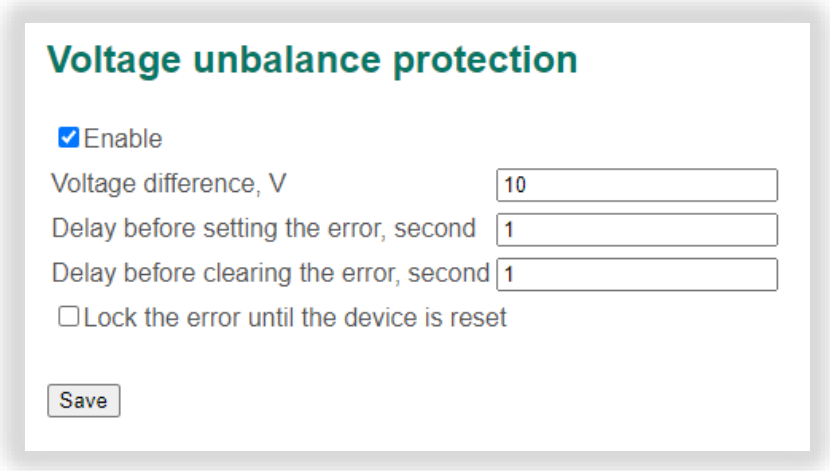
If there is the "Battery cover error", the “Critical error” is generated and all relays open.

6.3 Voltage unbalance protection

Before the charging and discharging contactors of battery modules are closed, the BMS Main X 1.x detects modules, the voltage of which significantly differs from the others. For unbalanced modules, the “Voltage unbalance” errors are generated.

To change the parameters for protection against the voltage unbalance, select the menu

“Protections → Voltage unbalance protection”:



In this section:

- Enable – a flag to enable the protection;
- Voltage difference – maximum allowable difference between voltages of battery modules, V;
- Delay before setting the error, second;
- Delay before clearing the error, second;
- Lock the error until the device is reset.

As a result of the operation of the protection against the voltage unbalance, the “Voltage unbalance” errors for battery modules are generated.

Error generation conditions:

- the battery module doesn’t belong to the largest group of modules, the voltages of which differ from each other by no more than the "Voltage difference", during the "Delay before setting the error" time.

Conditions for removing the error:

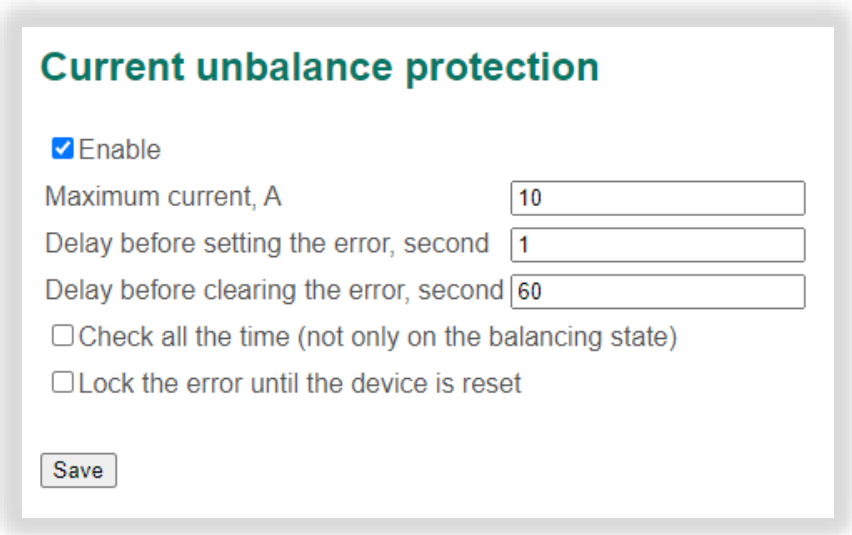
- the battery module belongs to the largest group of balanced modules during the “Delay before clearing the error” time.

If there is the “Voltage unbalance” error, the charging (discharging) contactor of the battery module opens.

6.4 Current unbalance protection

When the battery modules are connected in parallel, the most charged modules give charge to the least charged modules. The charge transfer process is accompanied by the flow of balancing currents. The BMS Main X 1.x device detects modules with high balancing currents and generates “Current unbalance” errors for them.

To change the parameters for protection of battery modules against high self-balancing current, select the menu "Protections → Current unbalance protection":



In this section:

- Enable – a flag to enable the protection;
- Maximum current – a maximum allowable self-balancing current of battery modules, V;
- Delay before setting the error, second;
- Delay before clearing the error, second;
- Check all the time (not only on the balancing state) – a flag to check self-balancing currents not only before closing the main charging or discharging contactor but also in the idle state of the battery;
- Lock the error until the device is reset.

As a result of the operation of the protection against high self-balancing currents, the “Current unbalance” errors for battery modules are generated.

Error generation conditions:

- the battery module current exceeds the “Maximum current” during the “Delay before

setting the error" time.

Conditions for removing the error:

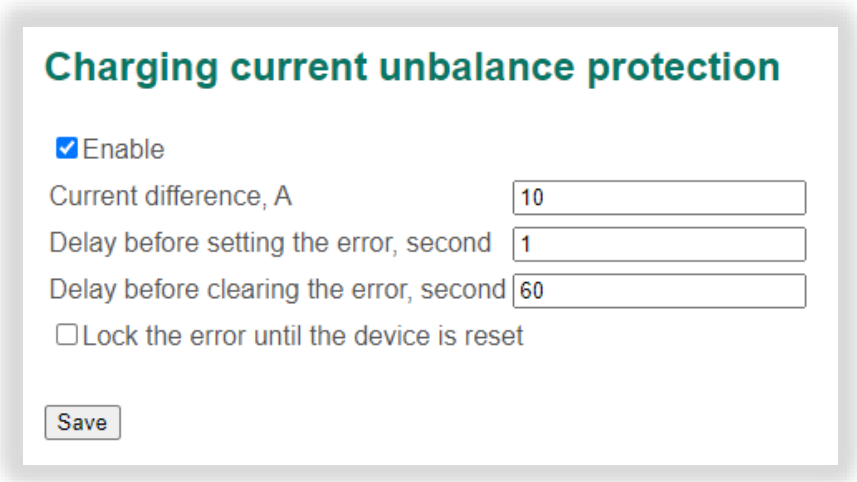
- the battery module current is less than the "Maximum current" during the "Delay before clearing the error" time.

If there is the "Current unbalance" error, the charging (discharging) contactor of the battery module opens.

6.5 Charging current unbalance protection

In the process of charging the battery, the currents of the battery modules may differ. The BMS Main X 1.x detects modules, the charging currents of which differ significantly from the currents of other modules and generates the "Charging current unbalance" errors for them.

To change the parameters for protection against different charging currents of the battery modules, select the menu "Protections → Charging current unbalance protection":



In this section:

- Enable – a flag to enable the protection;
- Current difference – a maximum allowable difference between the charging currents, A;
- Delay before setting the error, second;
- Delay before clearing the error, second;
- Lock the error until the device is reset.

As a result of the operation of the protection against different charging currents, the “Charging current unbalance” errors for battery modules are generated.

Error generation conditions:

- the battery module doesn’t belong to the largest group of modules, the charging currents of which differ from each other by no more than the “Current difference” value, during the “Delay before setting the error” time.

Conditions for removing the error:

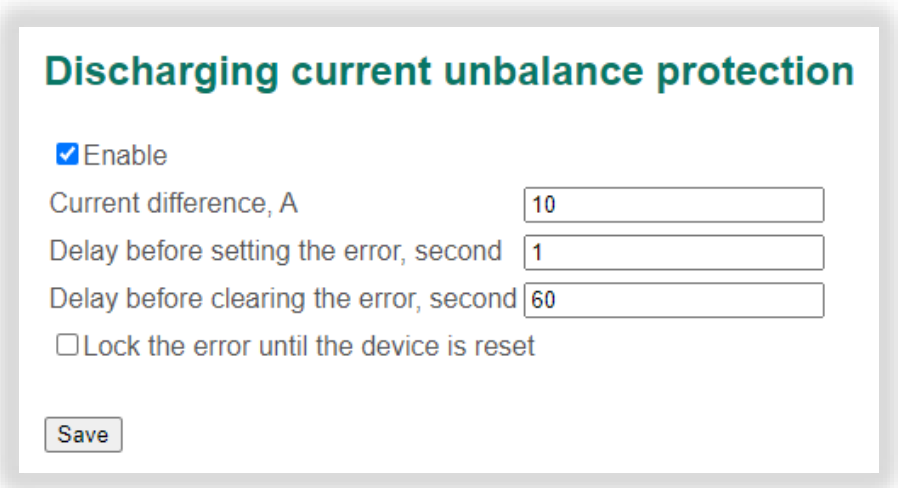
- the battery module belongs to the largest group of modules with similar charging currents during the “Delay before clearing the error” time.

If there is the “Charging current unbalance” error, the charging contactor of the battery module opens.

6.6 Discharging current unbalance protection

In the process of discharging the battery, the currents of the battery modules may differ. The BMS Main X 1.x detects modules, the discharging currents of which differ significantly from the currents of other modules and generates the “Discharging current unbalance” errors for them.

To change the parameters for protection against different discharging currents of the battery modules, select the menu "Protections → Discharging current unbalance protection":



In this section:

- Enable – a flag to enable the protection;

- Current difference – a maximum allowable difference between the discharging currents, A;
- Delay before setting the error, second;
- Delay before clearing the error, second;
- Lock the error until the device is reset.

As a result of the operation of the protection from different discharging currents, the “Discharging current unbalance” errors for battery modules are generated.

Error generation conditions:

- the battery module doesn’t belong to the largest group of modules, the discharging currents of which differ from each other by no more than the “Current difference” value, during the “Delay before setting the error” time.

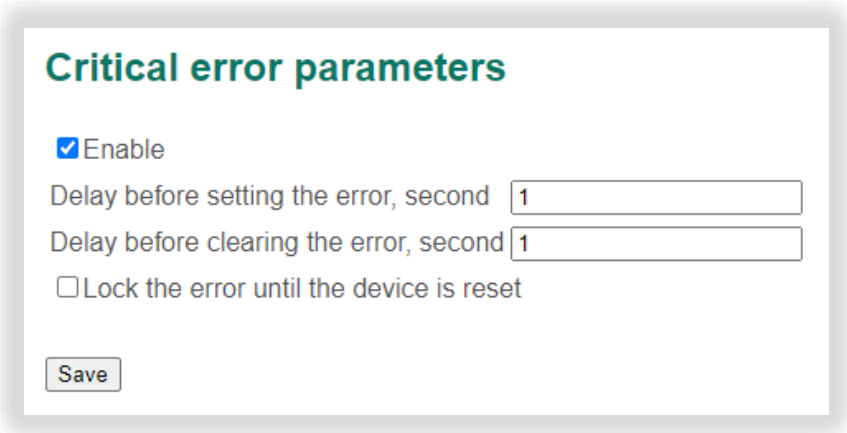
Conditions for removing the error:

- the battery module belongs to the largest group of modules with similar discharging currents during the “Delay before clearing the error” time.

If there is the “Discharging current unbalance” error, the discharging contactor of the battery module opens.

6.7 Critical error

To change the critical error parameters, select the menu "Protections → Critical error parameters":



In this section:

- Enable – a flag to enable the protection;

- Delay before setting the error, second;
- Delay before clearing the error, second;
- Lock the error until the device is reset.

The critical error flag is generated if at least one of the following errors is generated during the “Delay before setting the error” time:

- “Battery cover error”;
- “Module offline”.

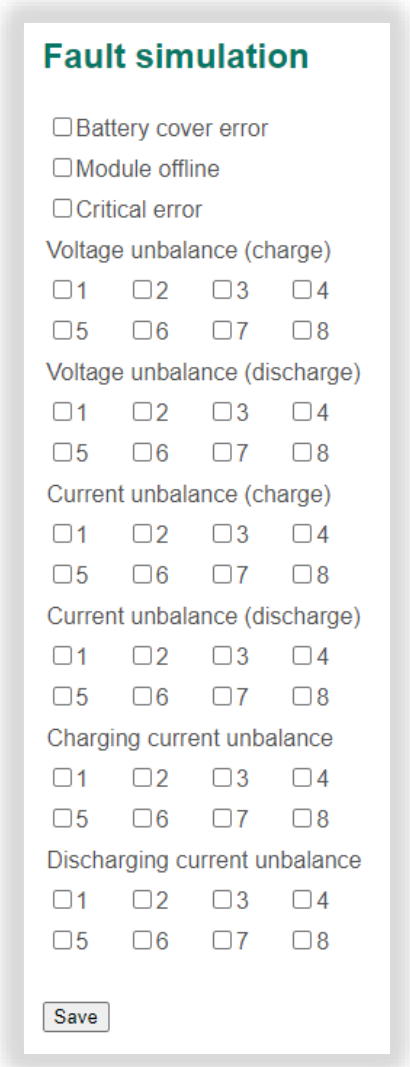
The “Critical error” is cleared if there are no errors from the list above during the “Delay before clearing the error” time.

If there is the “Critical error”, all relays open.

6.8 Fault simulation

The BMS Main X 1.x provides the ability to manually generate error flags bypassing the protection algorithms. This functionality is intended for commissioning.

To simulate battery and BMS errors, select the menu "Protections → Fault simulation":



In this section:

- Battery cover error;
- Module offline;
- Voltage unbalance (charge);
- Voltage unbalance (discharge);
- Current unbalance (charge);
- Current unbalance (discharge);
- Charging current unbalance;
- Discharging current unbalance.

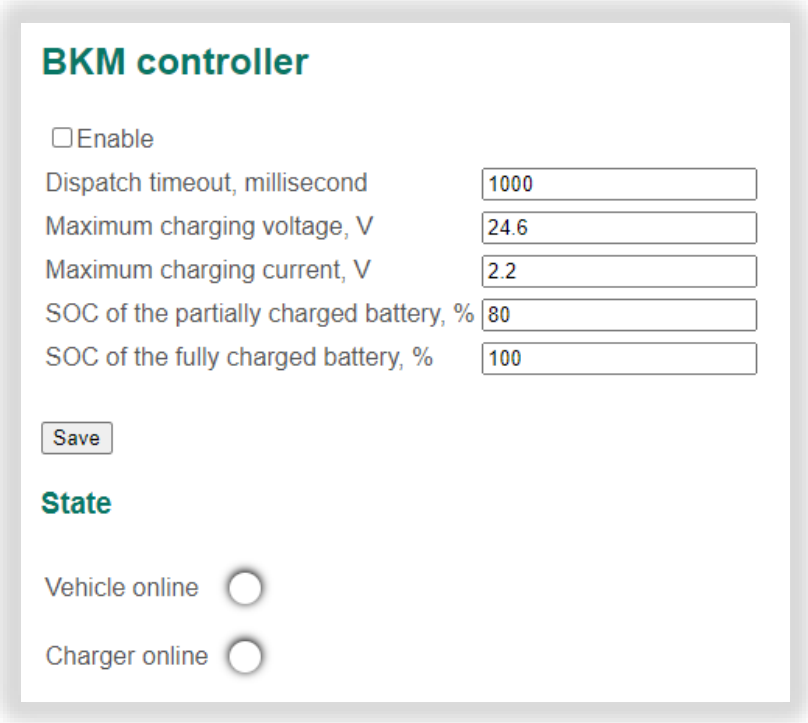
To simulate errors, set the necessary flags and click the "Save" button.

7 External equipment

The BMS Main X 1.x can communicate with EV-controllers.

7.1 BKM controller

To change the parameters of communication with the BKM controller, select the menu "External equipment → BKM controller":



In this section:

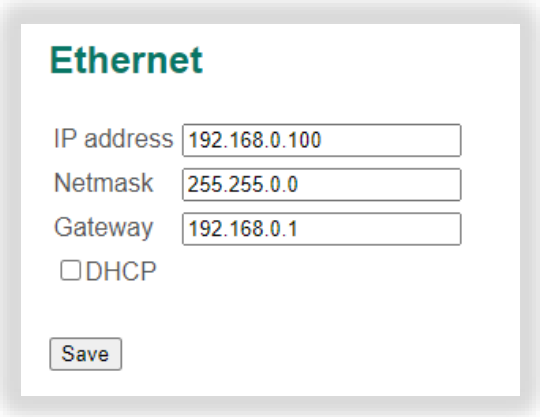
- Settings:
  - Enable – a flag to enable communication with the controller;
  - Dispatch timeout – a timeout of the dispatching of packets from the controller (if there is no data being received from the BKM controller for a given time, the connection loss flag is set), millisecond;
  - Maximum charging voltage, V;
  - Maximum charging current, V;
  - SOC of the partially charger battery, %;
  - SOC of the fully charge, %;
- State:
  - Vehicle online – a flag of normal communication with the EV;

- Charger online – a flag of normal communication with the charger.

8 Communication

8.1 Ethernet

To change the parameters of the connection to the Ethernet network, select the menu "Connectivity → Ethernet":



In this section:

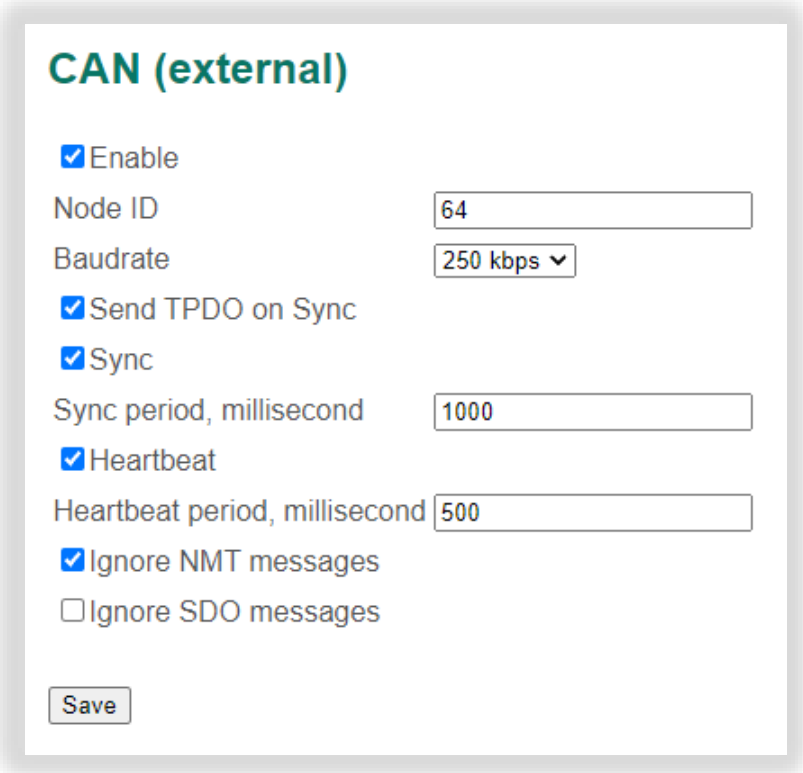
- IP address – static IP address of the device;
- Netmask – static netmask of the device;
- Gateway – default gateway;
- DHCP – a flag to enable IP address determination via DHCP protocol.

After changing the settings, restart the BMS Main X 1.x.

8.2 CAN

8.2.1 CAN (external)

To change the connection parameters for the CAN bus used for configuring the device and communication with a top-level system (e.g., an EV-controller), select the menu "Connectivity → CAN (external)":



In this section:

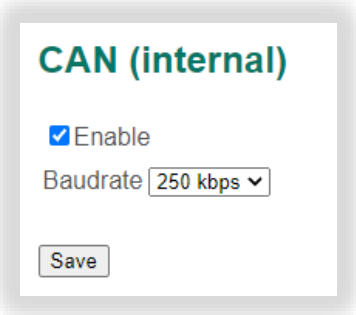
- Enable – a flag to enable communication via the CAN (external) bus;
- Node ID – a device identifier in the CANopen network;
- Baudrate – CAN bus speed;
- Send TPDO on Sync – a flag to enable sending TPDO messages on each synchronization message;
- Sync – a flag to enable sending synchronization messages (CANID = 0x80, data length 0 bytes);
- Sync period – synchronization messages sending period, millisecond;
- Heartbeat – a flag to enable sending Heartbeat messages;
- Heartbeat period – Heartbeat sending period, millisecond;
- Ignore NMT messages – a flag to ignore CANopen command messages;
- Ignore SDO messages – a flag to ignore CANopen SDO messages.

After changing the settings, restart the BMS Main X 1.x.

8.2.2 CAN (internal)

To change the connection parameters for the CAN bus used for communication with

battery modules, select the menu "Connectivity → CAN (internal)":



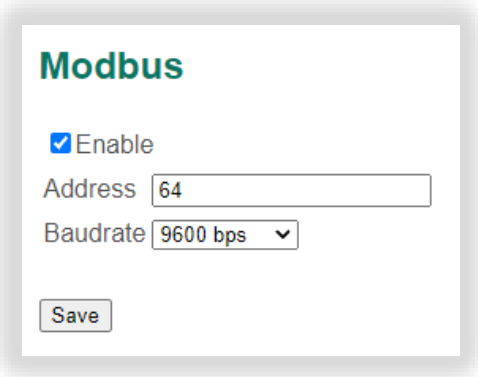
In this section:

- Enable – a flag to enable communication via the CAN (internal) bus;
- Baudrate – CAN bus speed.

8.3 Modbus

The BMS Main X 1.x supports Modbus RTU and Modbus TCP protocols.

To change the connection parameters for the RS-485 bus, select the menu "Connectivity → Modbus":



In this section:

- Enable – a flag to enable communication via the RS-485 bus;
- Address – a network address of the device;
- Baudrate – RS-485 bitrate.

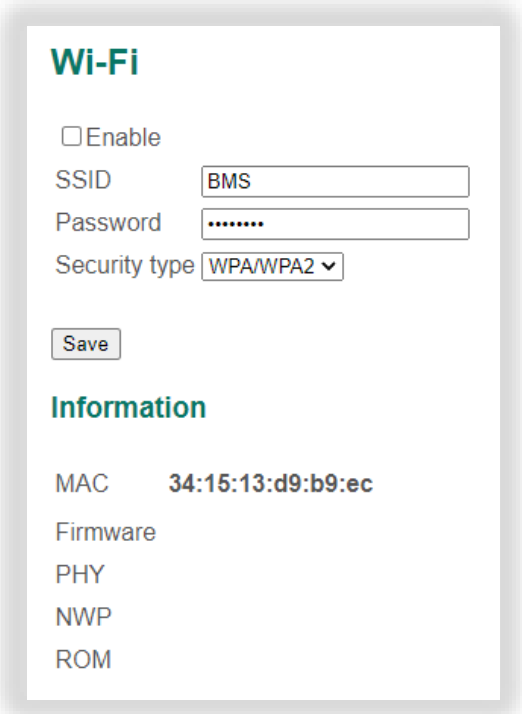
After changing the settings, restart the BMS Main X 1.x.

To work with the device using the Modbus TCP protocol, use the standard port 502.

8.4 Wi-Fi

Using BMS Wi-Fi, BMS Main X 1.x supports a connection to a Wi-Fi network.

To change the settings for connecting to a Wi-Fi network, select the menu "Connectivity → Wi-Fi":



In this section:

- Enable – a flag to enable Wi-Fi;
- SSID – a name of a Wi-Fi network;
- Password – a password to connect to a Wi-Fi network;
- Security type – a type of secure connection;
- MAC – a MAC-address of the BMS Wi-Fi;
- Firmware, PHY, NWP, ROM – software versions of the BMS Wi-Fi.

After changing the settings, restart the BMS Main X 1.x board.

8.5 Sending log files to a remote FTP server

The BMS Main X 1.x supports the periodic sending of log files stored on the SD card to a remote FTP server **over a Wi-Fi** network. The BMS has two schemes of sending log files:

sending files collected yesterday and today; sending all log files.

The algorithm for sending files collected yesterday and today:

1. If the time $T \geq T_{send}$ has elapsed since the last success transmission, the transition to step 2, otherwise exit.
2. Connect to a remote FTP server.
3. If the log file for the current (previous) day with the number NUMBER was not sent, then go to step 4, otherwise exit.
4. Create a file named "SNXXXXX_LOGYYYYMMDDCC.TXT" on the server, where XXXXX is the serial number of the board; YYYY, MM, DD – respectively, the year, month and day of the current (previous) day; CC = NUMBER - the number of the log file.
5. Copy to the created data file from the log file named "SNXXXXX_LOGYYYYMMDDCC.TXT" with the parameters of the battery and BMS for the current (previous) day.
6. Closing the file. Increment of the number of the log file (NUMBER = NUMBER + 1).
7. Closing a connection to a remote FTP server.

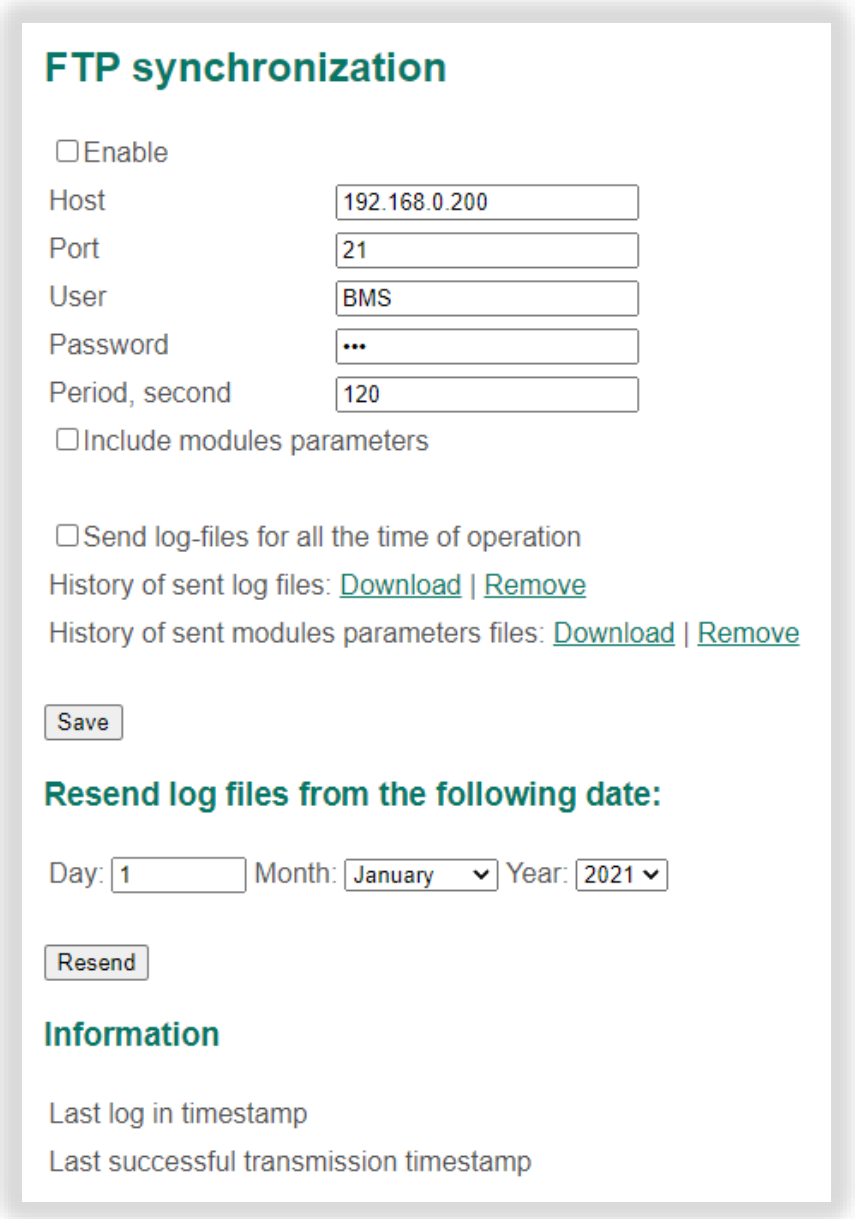
Note – Data is sent in passive mode.

The algorithm for sending all log files differs from the algorithm for sending files collected yesterday and today in that the history of the sent files is kept.

The history is represented as a text file on the SD card: for the common log files, the file with the sending history is named “LOGSENT.TXT”, for the log files with battery modules parameters – “MODSENT.TXT”.

After sending the next log file to the file with history, a new record with the date and number of the sent log file is added. During the next communication session, the system will try to send a log file that follows the previous one – this is a log file with either a large number (NUMBER) or a late date and NUMBER=1.

To change the settings for sending log files to a remote FTP server, you must select the menu "Connectivity → FTP synchronization":



In this section:

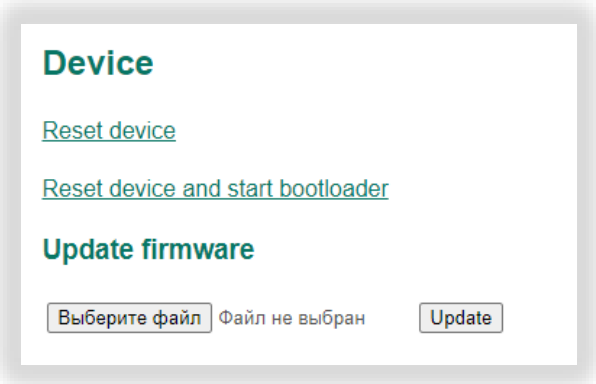
- Enable – a flag to enable sending log files;
- Host – a name of the remote host on which the FTP server is running;
- Port – a port number of the FTP server;
- User – user name;
- Password – user password;
- Period – period T_{send} sending log files to the FTP server, second;
- Include modules parameters – a flag to send also all battery modules parameters to the FTP server;

- Send log-files for all the time of operation – a flag to send to the FTP server all log files accumulated during the operation of the BMS;
- Send log-files for all the time of operation – a flag to send to the FTP server all log files accumulated during the operation of the BMS;
- History of sent log files – operations on the file with the history of sending the common log files: download and remove (if the file is removed, the log files will be sent from the current date to the FTP server);
- History of sent modules parameters files – operations on the file with the history of sending log files with battery modules parameters: download and remove (if the file is removed, the log files will be sent to the FTP server starting from the current date);
- Resend log files from the following date – a form to resend log files starting from the selected date;
- Last log in timestamp – a time of the last connection to the FTP server;
- Last successful transmission timestamp – a time of the last successful transfer of a log file to the FTP server.

9 Maintenance

9.1 Restarting the device

To restart the device, select the menu "Service → Device":



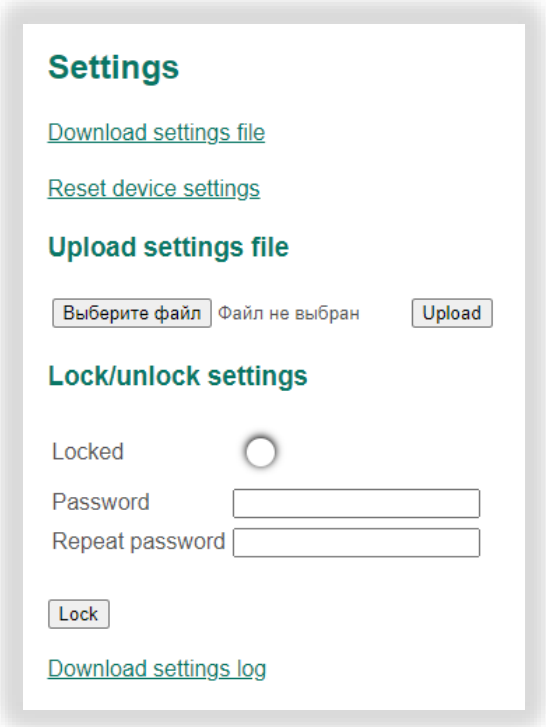
In this section:

- Reset device;
- Reset device and start bootloader;
- Update firmware – a form for updating the device firmware (to use this function it must be enabled in the user settings – see User settings).

When you select the “Reset device and start bootloader” option, the bootloader is activated, which is used to update the firmware of the device.

9.2 Importing, exporting, and locking device settings

The BMS Main X 1.x provides options for resetting, exporting, importing, and locking the BMS settings. To perform these actions, select the menu "Service → Settings":



In this section:

- Download settings file – a link to save (export) a file with device settings to a PC;
- Reset device settings – a link to reset device settings to default values;
- Upload settings file – a form for loading (importing) the device settings from a settings file;
- Lock/unlock settings – a form to lock or unlock the device settings:
    - Locked – a state of settings;
    - Password – a field with a password to protect settings from changing (optional);
    - Repeat password – a field to repeat the password (optional).

To lock the BMS settings, click on the “Lock” button. Locked settings cannot be changed. In addition to the prohibition on changing settings, the system calculates a checksum across the entire BMS configuration. When starting the BMS checks the checksum settings. If the checksum does not match the required value, then the “Settings error” is generated. At the same time, a critical error flag is generated and all relays open.

To unlock the BMS settings, click on the Unlock button.

Locking settings can be password protected. Attention – if the password is lost, the BMS settings can be unlocked only by the BMS manufacturer.

To reset the settings, select “Reset device settings”. This operation will not be performed

when the BMS settings are locked.

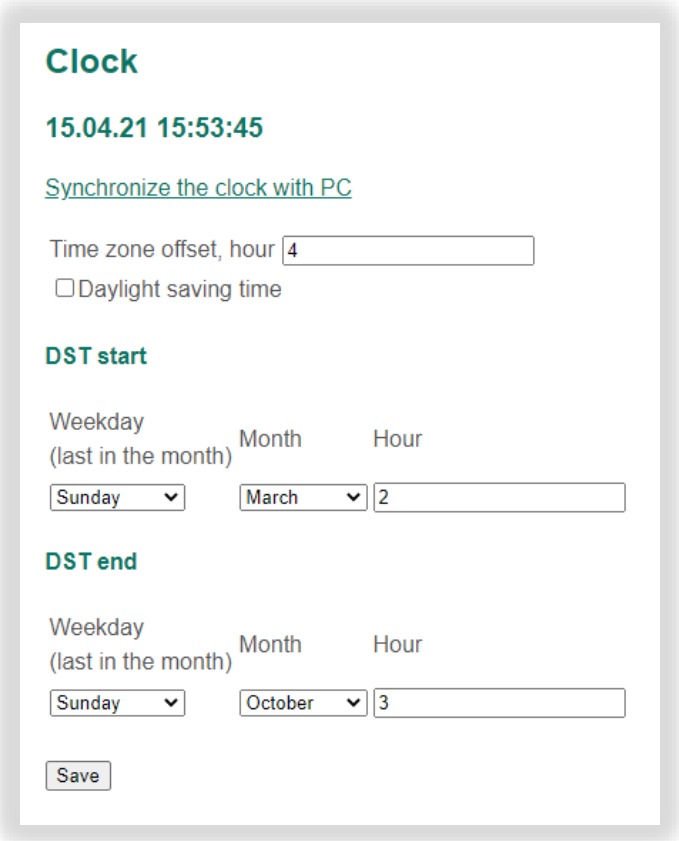
Attention! To perform the following steps, you must have an SD card inserted in the card slot.

To export settings, select the “Download settings file”. In this case, a file with the name "settings.txt" will be downloaded from the device, in which all the parameters of the BMS Main X 1.x are written in text form.

To import the settings, click the "Select a file" button, specify the previously saved "settings.txt" file and click the "Upload" button. This operation will not be performed when the BMS settings are locked.

9.3 Real-time clock

To set the current time and the time zone, select the menu "Service → Clock":



In this section:

- Synchronize the clock with PC – a link to set the device clock;
- Timezone offset, hours;
- Daylight saving time – a flag to enable the DST rule;

- DST start – daylight saving time policy (start),
- DST end – daylight saving time policy (end):
    - Weekday (last in the month);
    - Month;
    - Hour.

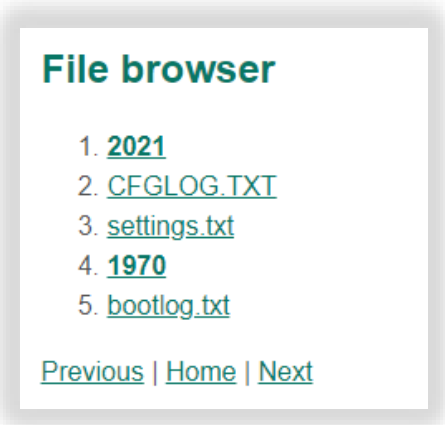
The "Sunday, March, 2" line in DST start means that the clock is switched to summer time at 02:00 on the last Sunday in March.

The clock is used for logging.

9.4 SD card logging

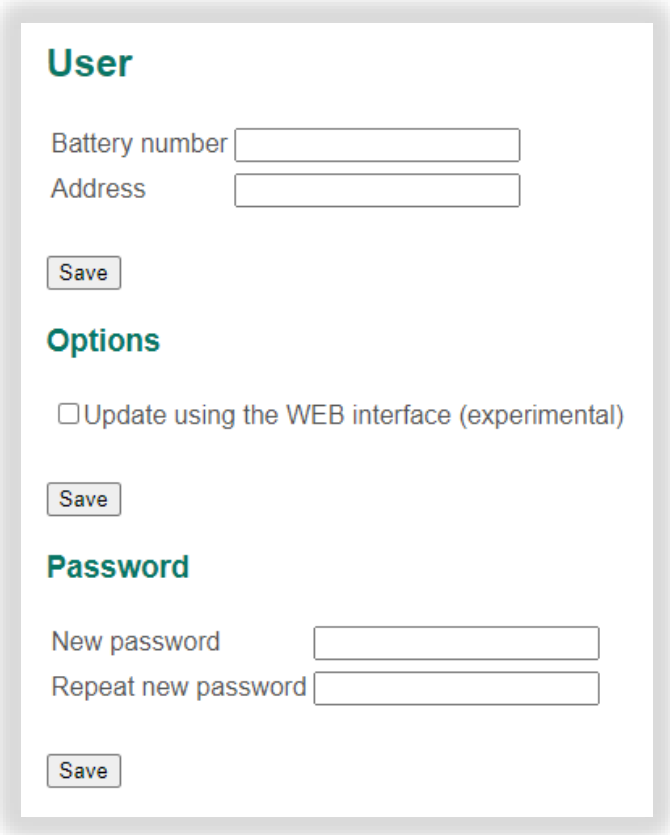
The BMS Main X 1.x supports the preservation of the battery and BMS state in the form of log files to the SD card.

It is possible to download a log file from the SD-card. To do this, select the menu "Service → File browser":



9.5 User settings

User settings include the battery number, the address of the battery, the password for accessing the WEB interface, and the device options. To go to the user settings, select the menu "Service → User":



In this section:

- Battery number – a number of battery (displayed in the log file);
- Address – a battery location address;
- Update using the WEB interface (experimental) – a flag to enable experimental function of updating the firmware of the device via the WEB interface (if this function is enabled, the update can be performed from the menu "Service → Device");
- New password – a field with new password;
- Repeat new password – a field to repeat the new password.

10 Contacts

Movicom Electric LLC

117246, Russia, Moscow, Nauchniy proezd, 20-2

+7 (495) 989-56-47

electric@movicom.com
movicomelectric.com

11 Revision history

Rev. number	Rev. date	Changes
1	15-November-2021	First revision