Battery Monitoring System

(Battery monitoring system for larger UPS systems)

TUTORIALS

V3.0

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Table of content

1 System description

This system comprehensively measures the battery performance and displays the real-time parameters and real-time alarm for the failed battery to realize the automation of battery detection and failure expected detection. Through real-time monitoring of the battery power parameters and operating status obtained by the Controller, the actual operating status and health status of the battery pack can be accurately grasped, and problems existing in the use of the battery pack can be found in time.

The HMI touch display displays the power data, health status and alarm reminder of each battery in real time. The cell sensors detect the condition of each battery in real time, and gives a timely alarm to the bad battery, so as to accurately grasp the actual running state and health of the battery pack in real time, and to timely find problems in the use of the battery pack.
This not only effectively extends the backup time and operating life of the battery pack, but also greatly reduces the maintenance costs such as manpower and material resources. It also improves the safety of battery use, reduces the accident rate and effectively saves energy and reduces emissions, creating for the user and create good economic and social benefits for the users.

Dictionary of terms and abbreviations

BTMS	Battery Monitoring System	Battery monitoring system for larger UPS systems.
battery	-	Lead-acid rechargeable battery stores electricity to operate the UPS during a power outage.
cell	-	Basic battery building. A battery usually consists of several cells connected in series.
string	-	Multiple batteries connected in series.
UPS	Uninterruptible Power Supply	A device that provides battery backup when the electrical power fails or drops to an unacceptable voltage level.
BM-AG	BTMS Aggregator	When several BM-GW's are needed at the Datacenter, aggregate all BM-GW and provide site functionality + Cloud connectivity and alarming.'
BM-GW	BTMS Gateway	Visualization (browser) of batteries and installed systems connected to the GW logically grouped into strings and UPS's in real time and their historical data. Alarming, Cloud connectivity
SCADA	3rd party SCADA	Any SCADA that accesses battery, stringig and/or UPS data via Modbus TCP/IP protocol.
PC web	PC with WEB Browser	Viewing the user interface from BM-AG or BM-GW via any web browser.
BM-MC	BTMS Master Controller	It allows the connection of BM-TH sensors and configurable digital inputs for monitoring additional alarm signals and outputs for alarming or switching off strings where an error occurs.
BM-HMI	BTMS Human-Machine Interface	Local display of the state of the batteries inside the UPS, string and by battery.
CAD	BTMS HMI interface	Communication interface for connecting BM-HMI to BM-CS
BM-LC	BTMS IO Module	Expansion for MC with additional digital inputs and outputs.

BM-TH	BTMS Temperature and Humidity sensor	Ambient temperature and relative humidity sensor.
BM-SS	BTMS String Master	It monitors the string (string current), aggregates battery data (total string voltage, average SOC, Balance) and enables monitoring of data from BM-CSs.
BM-HS	BTMS Hall Sensor	It measures the string current
BM-CS	BTMS Cell / Battery Sensor	Control of each individual battery / cell. It allows monitoring the status, voltage, internal resistance, temperature of the cell and calculates SOC and SOH.
SOC	State Of Charge	Calculated battery charge; it is calculated from the actual voltage on the battery and by integrating the charge and discharge current.
SOH	State Of Health	Informative battery state calculation that takes into account internal resistance, battery temperature, rise/fall of voltage during charge/discharge and other parameters that affect battery performance.
Balance	Voltage balance within string	Calculation of voltage inequality on the batteries within the string. Battery sensors can actively equalize the voltage between the batteries within the string during the floating charge phase.

1.1 System Features

Highlights

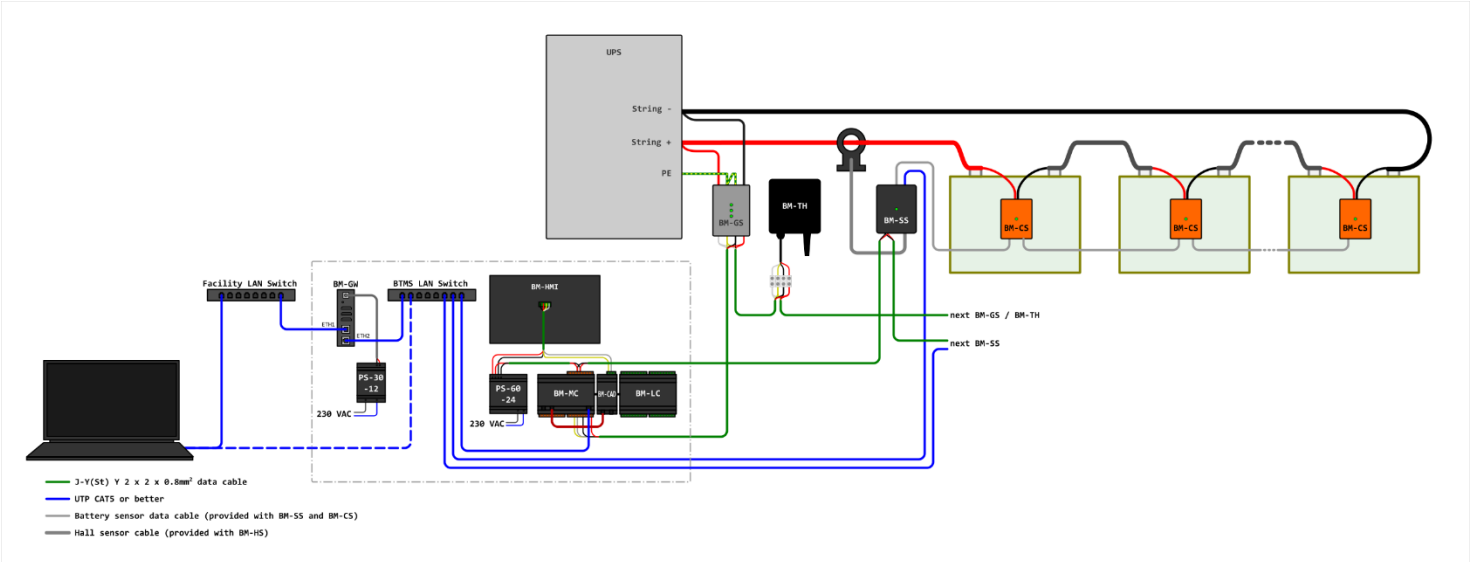
- **monitoring** of all important **battery** parameters of larger **UPS systems** in order to ensure operational reliability
- **simple** and **fast installation** on existing or new UPS systems
- very **reliable operation**
- simple and intuitive **WEB user interface**
- automatic **logging** of data and storage for a period of one year
- easy **download of all displayed data** for further processing in **standard format** (csv)
- easy connectivity to 3rd party SCADA, BMS, … systems via standard **Modbus TCP/IP protocol**

System functionality

Data		Real-time data	History data	Alarming		Range	Accuracy	Resolution
				Low	High			
Per Battery (cell)	Voltage	✓	✓	✓	✓	2V battery…… 1.6 .. 2.6 V 12V battery…. 7.5 .. 15.6 V	±0.2 %	0.001 V
	Resistance	✓	✓		✓	0.1 .. 50 mΩ	±(1.5 % + 25 µΩ)	0.001 mΩ
	Temperature	✓	✓		✓	-20 .. +85 °C	±0.5 %	0.1 °C

	SOC	✓	✓	✓		0 .. 100 %		1 %
	SOH	✓	✓	✓		0 .. 100 %		1 %
Per string	Voltage	✓	✓	✓	✓	20 .. 800 V	± 0.5 %	0.01 V
	Current	✓	✓	✓	✓	-1000 .. 1000 A	± 2 %	0.01 ADC
	State	✓				floating charge, equalizing charge, discharge, idle		
	SOC	✓	✓	✓		0 .. 100 %		1 %
	Balance	✓	✓			0 .. 100 %		0.01 %
	Ambient temperature	✓				-40 .. +80 °C	± 0.5 °C	0.1 °C
	Ambient hmidity	✓				0 .. 100 % RH	±3 %RH	0.1 %RH
	Hall sensor state			✓				
Per UPS	Voltage	✓				Average of string voltages		
	Current	✓				Sum of string currents		
	SOC	✓				Average of string SOC		

1.2 System wiring diagram



1.3 Modules description

BTMS Gateway

Highlights & Features

- Local WEB UI
  - real-time data display
  - data logging
  - history data display (tables, time-plots)
  - history and real-time data download
  - e-mail, SMS alarming
- Robust and safe connection of BTMS system to BTMS cloud platform.
- Secure access and communication (TLS encryption)
- Local data buffer, no data loss
- User data safety according to GDPR
- Secure remote access to BM-C controllers

BTMS String Master

Highlights & Features

- Real-time monitoring of string voltage, charge-discharge current, charge-discharge state and string SOC.
- Monitor the voltage, impedance, temperature, SOC and SOH of each battery with BM-CS cell sensors and the specially designed isolated power bus.
- Advanced one-step auto-sensing for individual address. No more manual intervention and setupneeded, reducing workload and setup errors.
- Advanced measurement algorithm, no need to discharge large current and measurement can belossless.
- Balancing function: Keep voltage balanced during the floating charge process of battery pack, keeping the individual battery in the best state, extending backup time and life span of battery pack.
- Communication is based on power-isolated RS 485. Secure and stable.
- Quickly locate the alarmed or faulty battery packin machine room.
- External open Hall Sensor, measuring charge-discharge current in different ranges.
- Isolated voltage in communication interface: AC3750 V
- Supports up to 120 batteries (BM-CS)

BTMS Hall Sensor

Highlights & Features

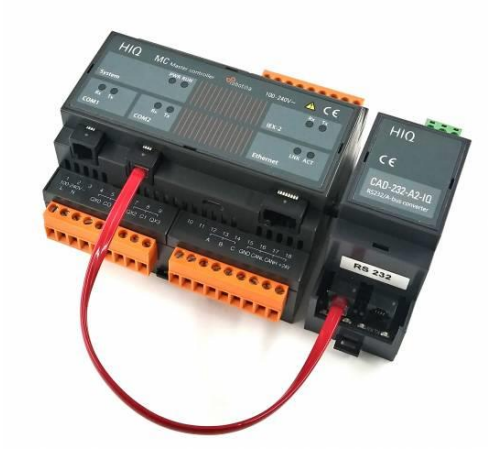
- easy installation (split core)
- wide current range of application

BTMS Cell Sensor

Highlights & Features

- Real-time cell voltage measurement
- Internal resistance measurement on line
- Negative pole temperature measurement
- Balancing function

BTMS Master Controler



Highlights & Features

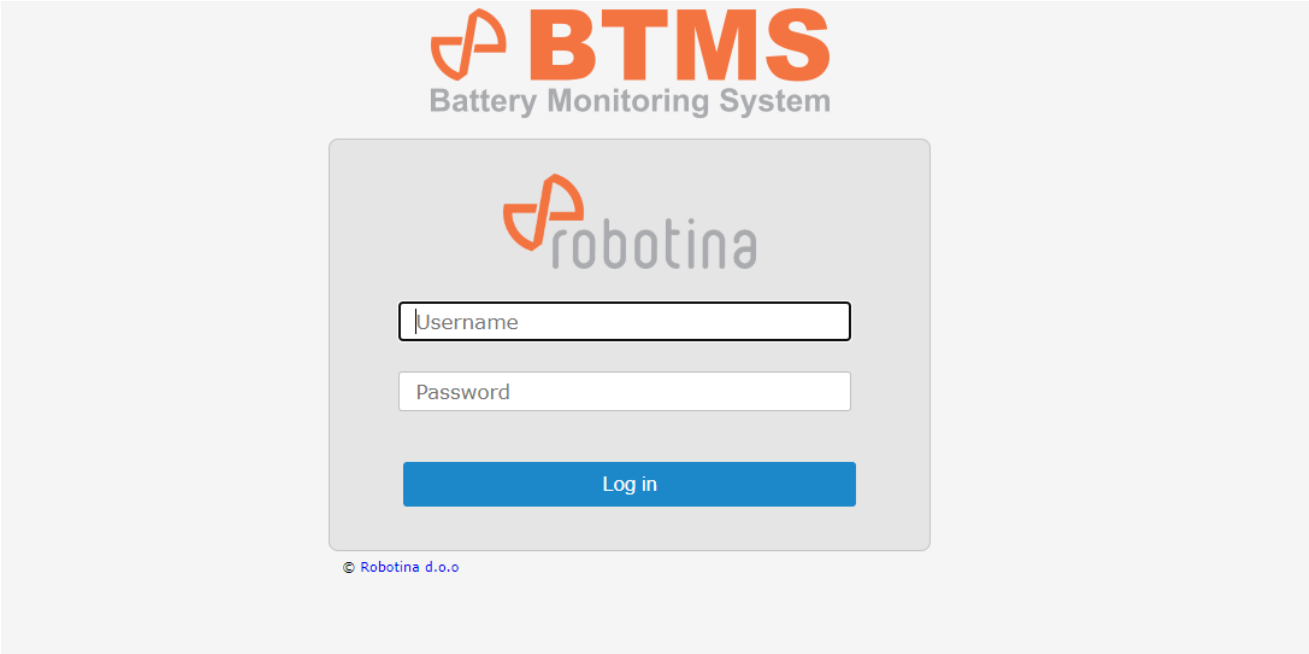
- Communication with temperature and humidity sensors
- Additional digital inputs for connecting various sensors (leakage, gas,…)
- Additional digital outputs for disconnecting strings with an error or for alarming
- Supports up to:
- 32 strings (BM-SS)
- 4 Digital IO modules (BM-LC) with 8 DI and 8 DO each

BTMS 7’’ HMI Touch Display

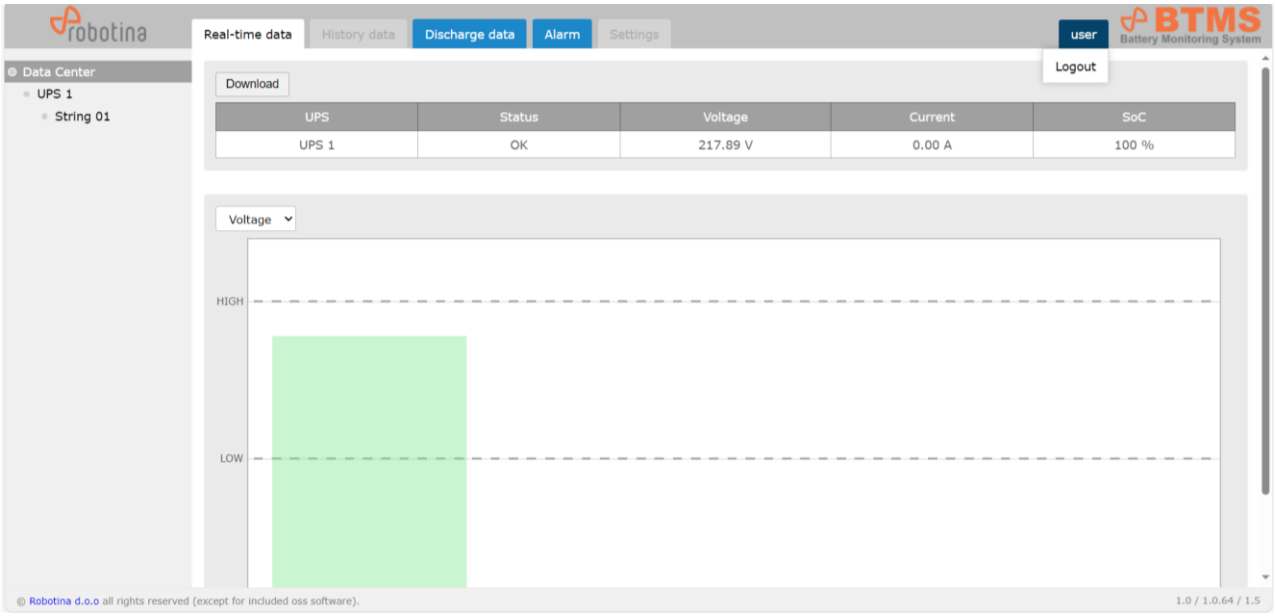
Highlights & Features

- 7” capacitive touch screen
- Supports up to:
  - 32 strings (arbitrary arranged in UPS)
  - 3840 batteries (8 BM-SS × 120 BM-CS)

2 Logging in / out



Insert your Username and Password and press Log in button

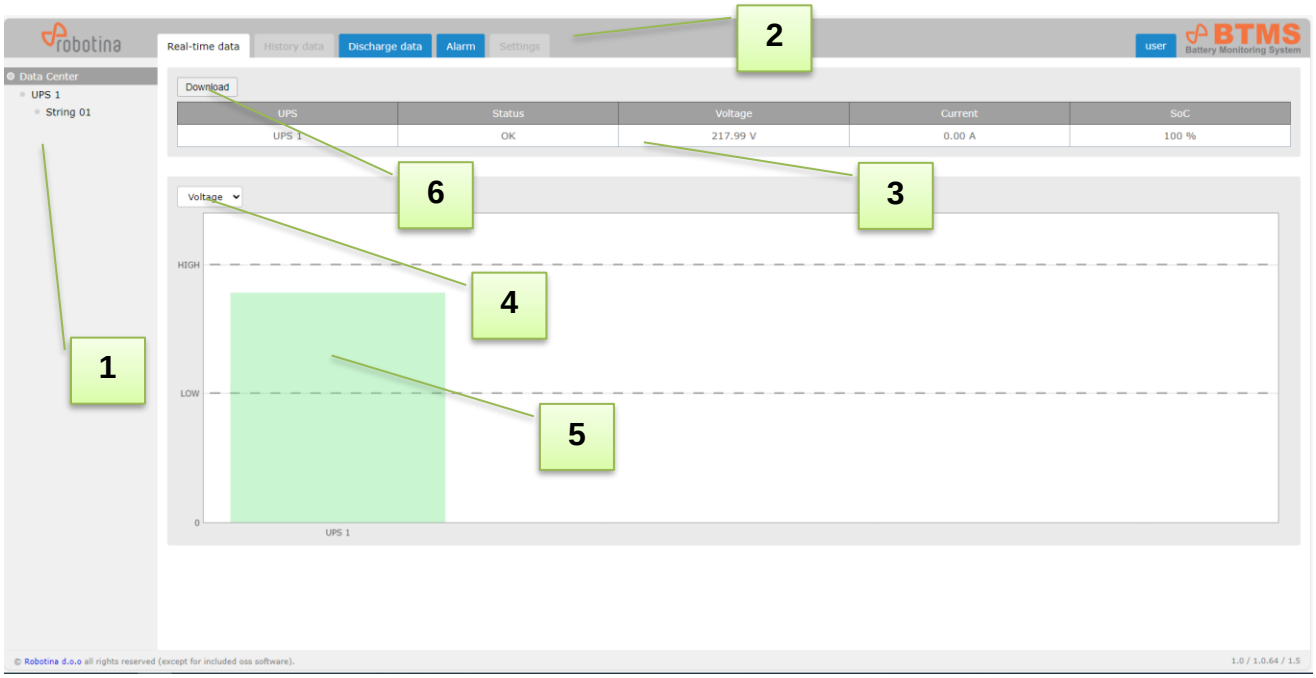


For Log out place your Cursor on User field and press Logout.

3 BTMS Monitoring Functionality

3.1 Monitoring Features

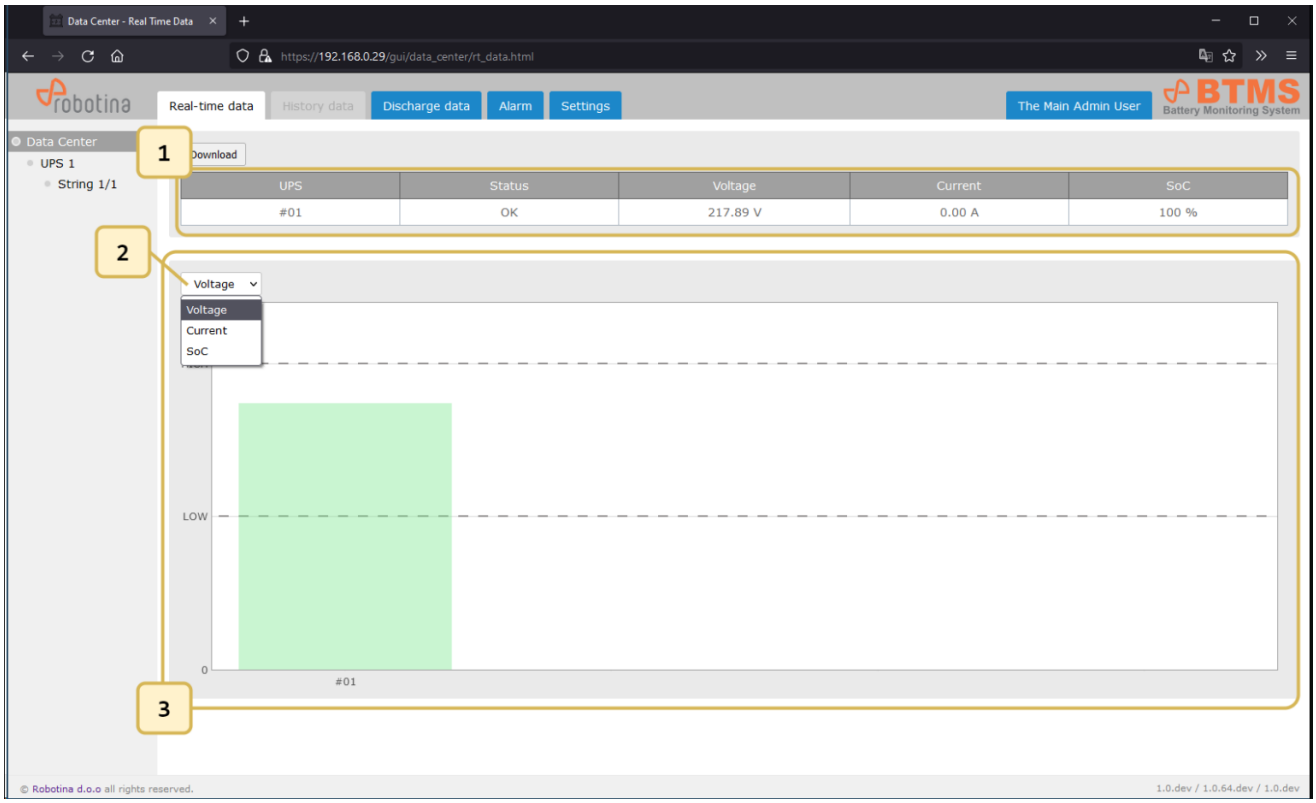
After successful log in following (main) screen appears:



1	Data Center tree structure
2	Tabs, Real time data, History data, Discharge data, Alarms, Settings (admin only)
3	Display of data
4	Data selection
5	Graphical display
6	Download button (download selected data int CSF file for your further use)

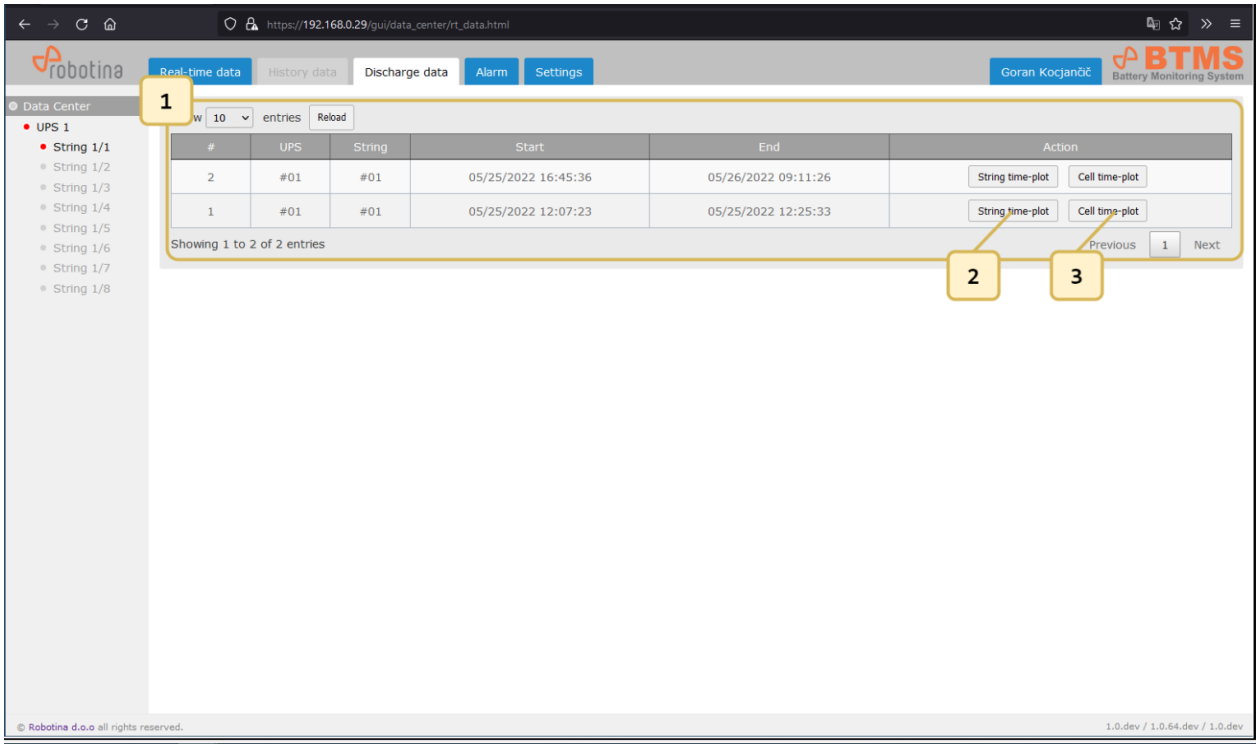
3.2 Data Center view

Real-time data



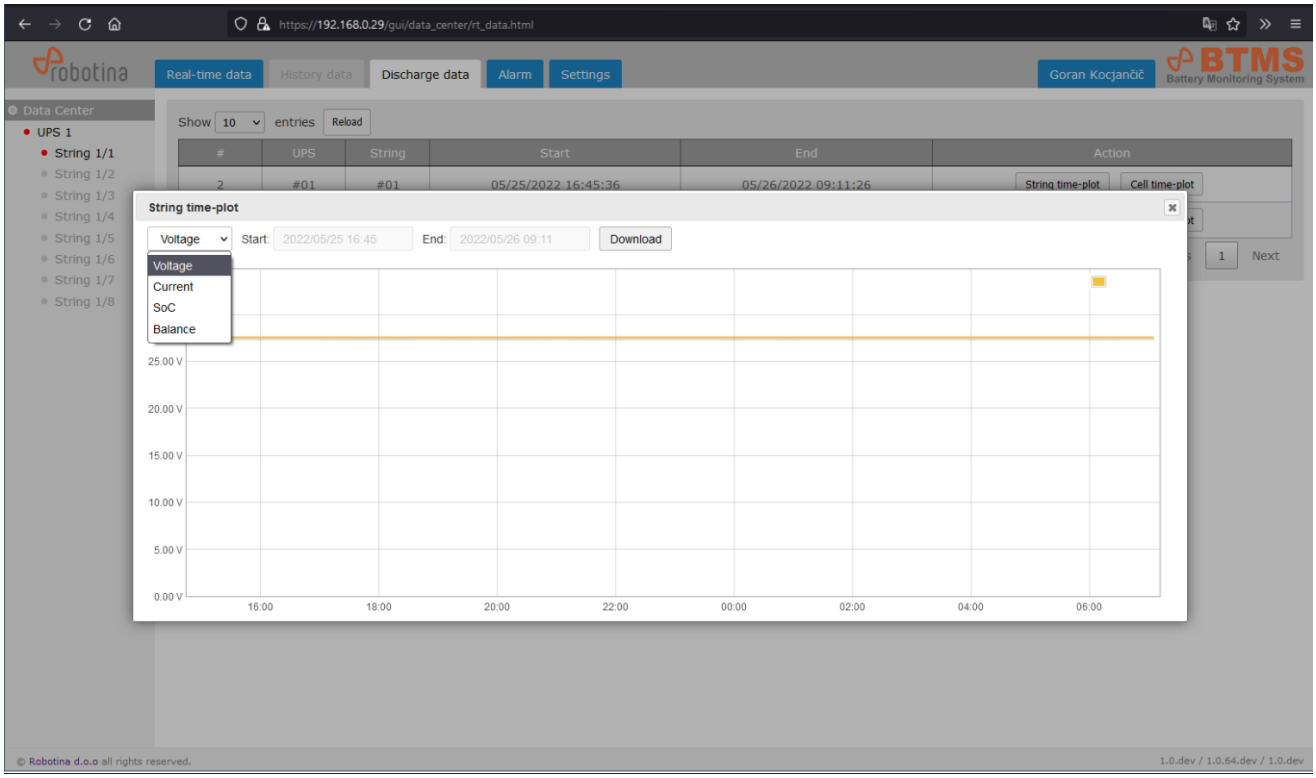
1	Tabular display of data for the Data Center
2	Select a parameter for the graphic display
3	Graphic bar-graph data display for the data center

Discharge data

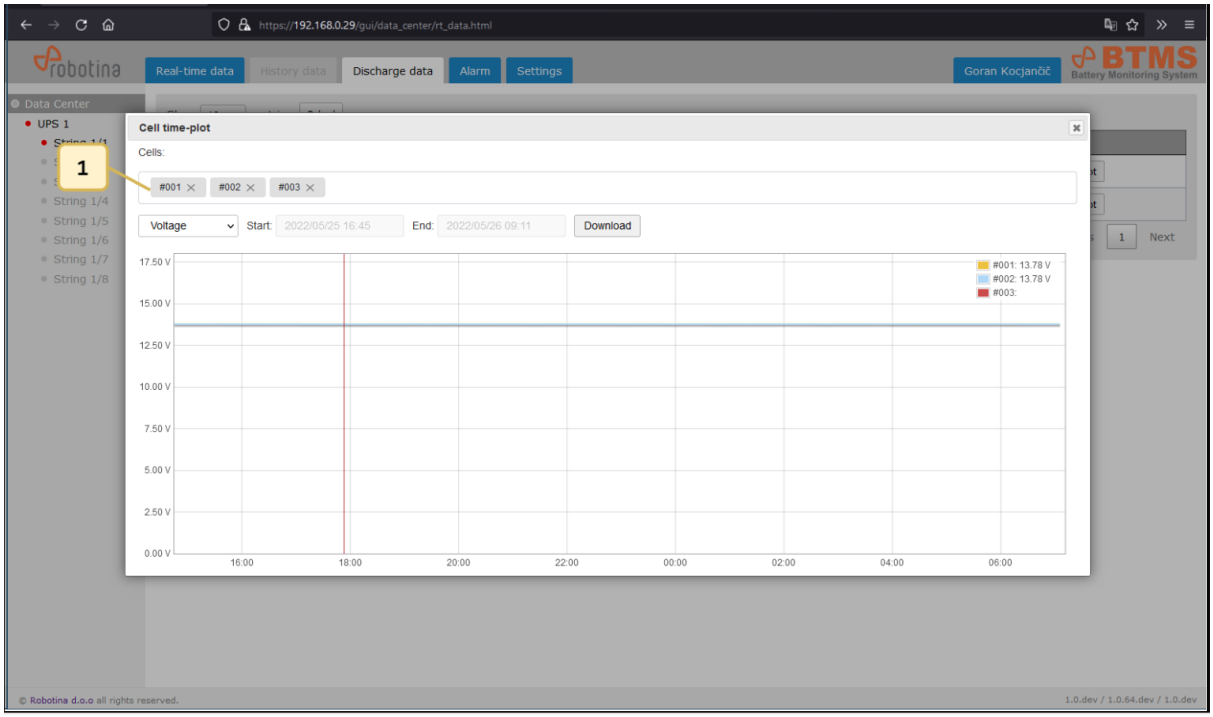


1	Discharge events table
2	String time-plot for discharge event
3	Cell time-plot for discharge event

String time-plot for discharge event

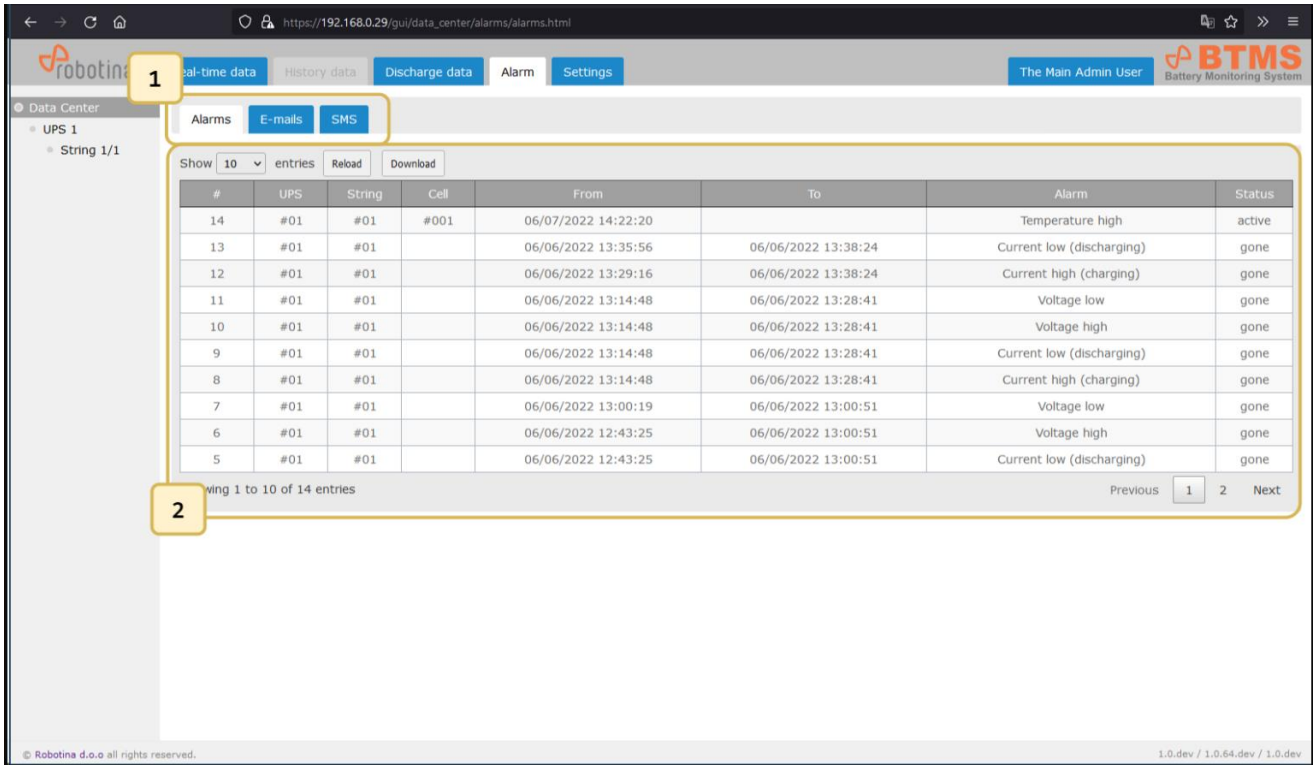


Cell time-plot discharge event



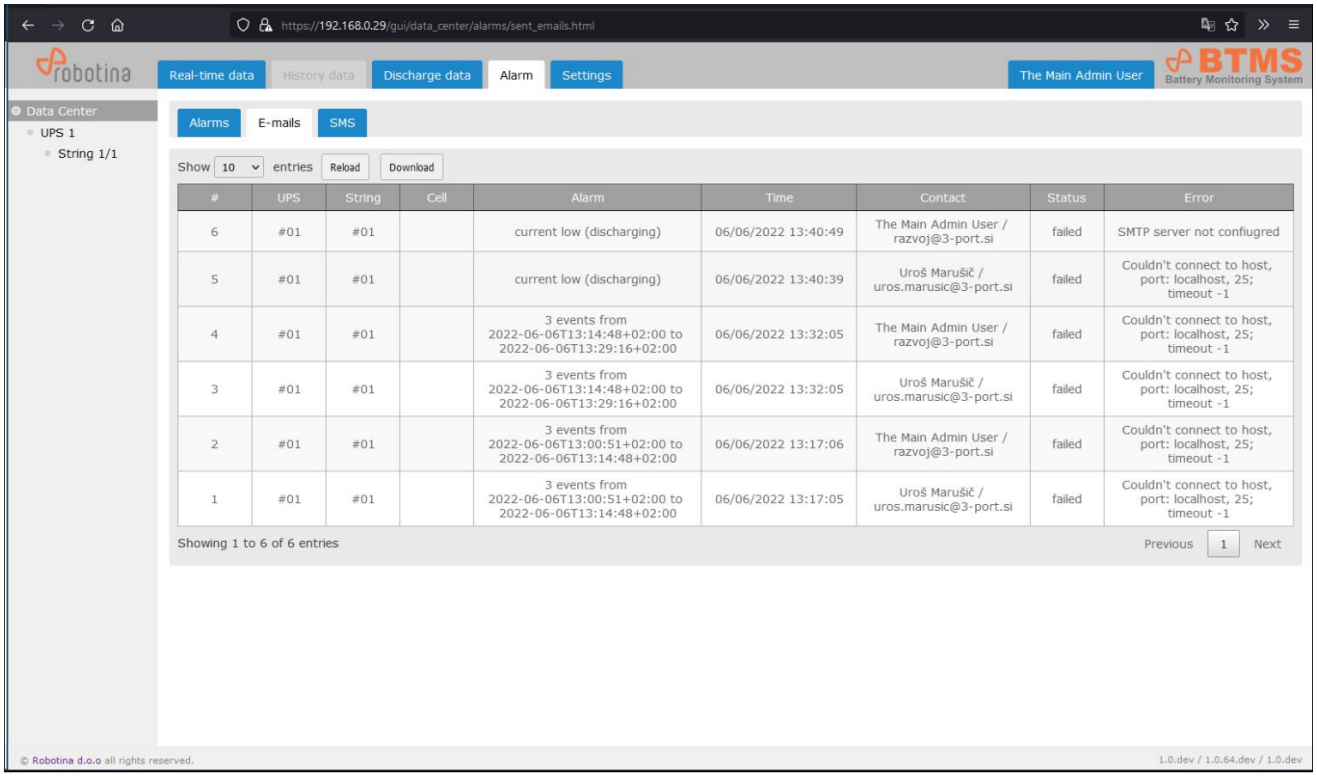
1	Cell selection

Alarm



1	Alarms sub-page selection
2	Alarms table

E-mails


https://192.168.0.29/gui/data_center/alarms/sent_emails.html
Real-time data
History data
Discharge data
Alarm
Settings
The Main Admin User
BTMS
Battery Monitoring System
Data Center
UPS 1
String 1/1
Alarms
E-mails
SMS
Show 10 entries
Reload
Download
| UPS | String | Cell | Alarm | Time | Contact | Status | Error
6 | #01 | #01 | | current low (discharging) | 06/06/2022 13:40:49 | The Main Admin User / razvoj@3-port.si | failed | SMTP server not configured
5 | #01 | #01 | | current low (discharging) | 06/06/2022 13:40:39 | Uroš Marušič / uros.marusic@3-port.si | failed | Couldn't connect to host, port: localhost, 25; timeout -1
4 | #01 | #01 | | 3 events from 2022-06-06T13:14:48+02:00 to 2022-06-06T13:29:16+02:00 | 06/06/2022 13:32:05 | The Main Admin User / razvoj@3-port.si | failed | Couldn't connect to host, port: localhost, 25; timeout -1
3 | #01 | #01 | | 3 events from 2022-06-06T13:14:48+02:00 to 2022-06-06T13:29:16+02:00 | 06/06/2022 13:32:05 | Uroš Marušič / uros.marusic@3-port.si | failed | Couldn't connect to host, port: localhost, 25; timeout -1
2 | #01 | #01 | | 3 events from 2022-06-06T13:00:51+02:00 to 2022-06-06T13:14:48+02:00 | 06/06/2022 13:17:06 | The Main Admin User / razvoj@3-port.si | failed | Couldn't connect to host, port: localhost, 25; timeout -1
1 | #01 | #01 | | 3 events from 2022-06-06T13:00:51+02:00 to 2022-06-06T13:14:48+02:00 | 06/06/2022 13:17:05 | Uroš Marušič / uros.marusic@3-port.si | failed | Couldn't connect to host, port: localhost, 25; timeout -1
Showing 1 to 6 of 6 entries
Previous
1
Next
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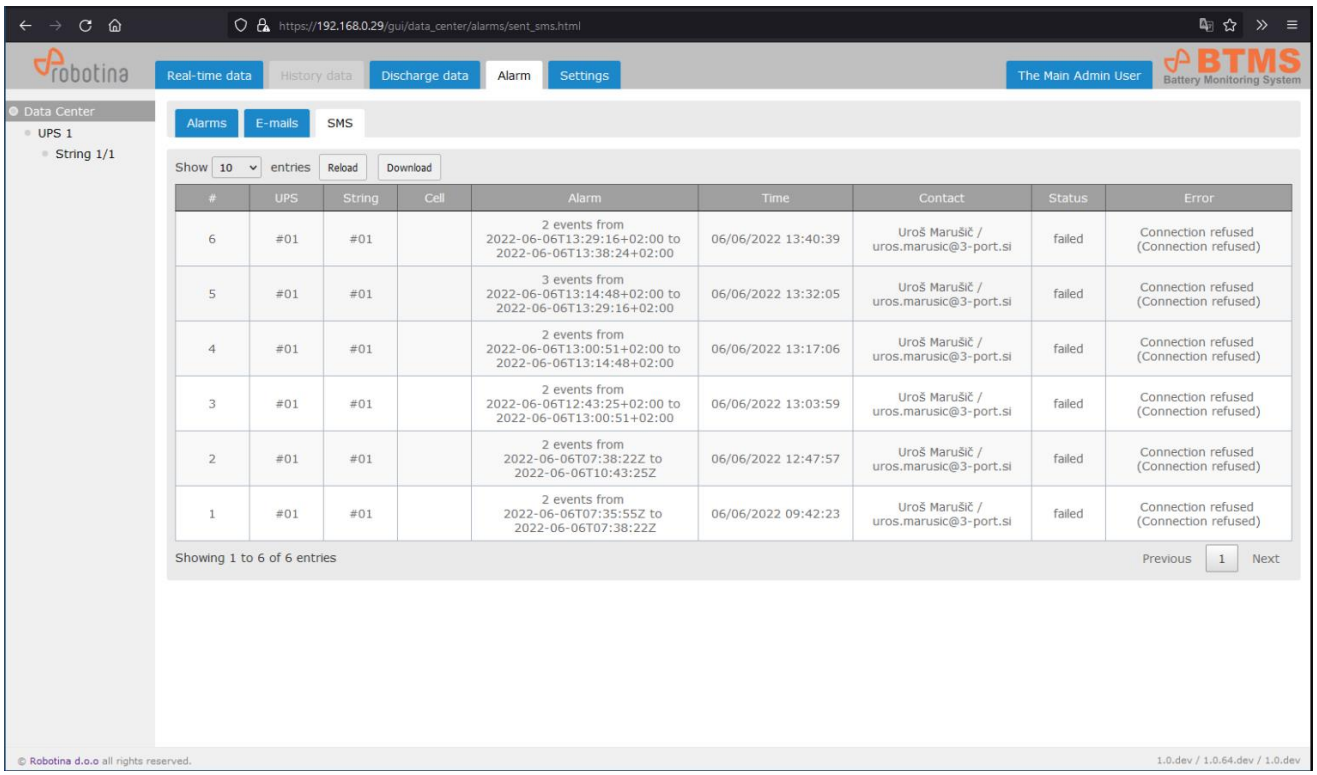
1.0.dev / 1.0.64.dev / 1.0.dev

SMS


https://192.168.0.29/gui/data_center/alarms/sent_sms.html
Real-time data
History data
Discharge data
Alarm
Settings
The Main Admin User
BTMS
Battery Monitoring System
Data Center
UPS 1
String 1/1
Alarms
E-mails
SMS
Show 10 entries
Reload
Download
| UPS | String | Cell | Alarm | Time | Contact | Status | Error
6 | #01 | #01 | | 2 events from 2022-06-06T13:29:16+02:00 to 2022-06-06T13:38:24+02:00 | 06/06/2022 13:40:39 | Uroš Marušič / uros.marusic@3-port.si | failed | Connection refused (Connection refused)
5 | #01 | #01 | | 3 events from 2022-06-06T13:14:48+02:00 to 2022-06-06T13:29:16+02:00 | 06/06/2022 13:32:05 | Uroš Marušič / uros.marusic@3-port.si | failed | Connection refused (Connection refused)
4 | #01 | #01 | | 2 events from 2022-06-06T13:00:51+02:00 to 2022-06-06T13:14:48+02:00 | 06/06/2022 13:17:06 | Uroš Marušič / uros.marusic@3-port.si | failed | Connection refused (Connection refused)
3 | #01 | #01 | | 2 events from 2022-06-06T12:43:25+02:00 to 2022-06-06T13:00:51+02:00 | 06/06/2022 13:03:59 | Uroš Marušič / uros.marusic@3-port.si | failed | Connection refused (Connection refused)
2 | #01 | #01 | | 2 events from 2022-06-06T07:38:22Z to 2022-06-06T10:43:25Z | 06/06/2022 12:47:57 | Uroš Marušič / uros.marusic@3-port.si | failed | Connection refused (Connection refused)
1 | #01 | #01 | | 2 events from 2022-06-06T07:35:55Z to 2022-06-06T07:38:22Z | 06/06/2022 09:42:23 | Uroš Marušič / uros.marusic@3-port.si | failed | Connection refused (Connection refused)
Showing 1 to 6 of 6 entries
Previous
1
Next
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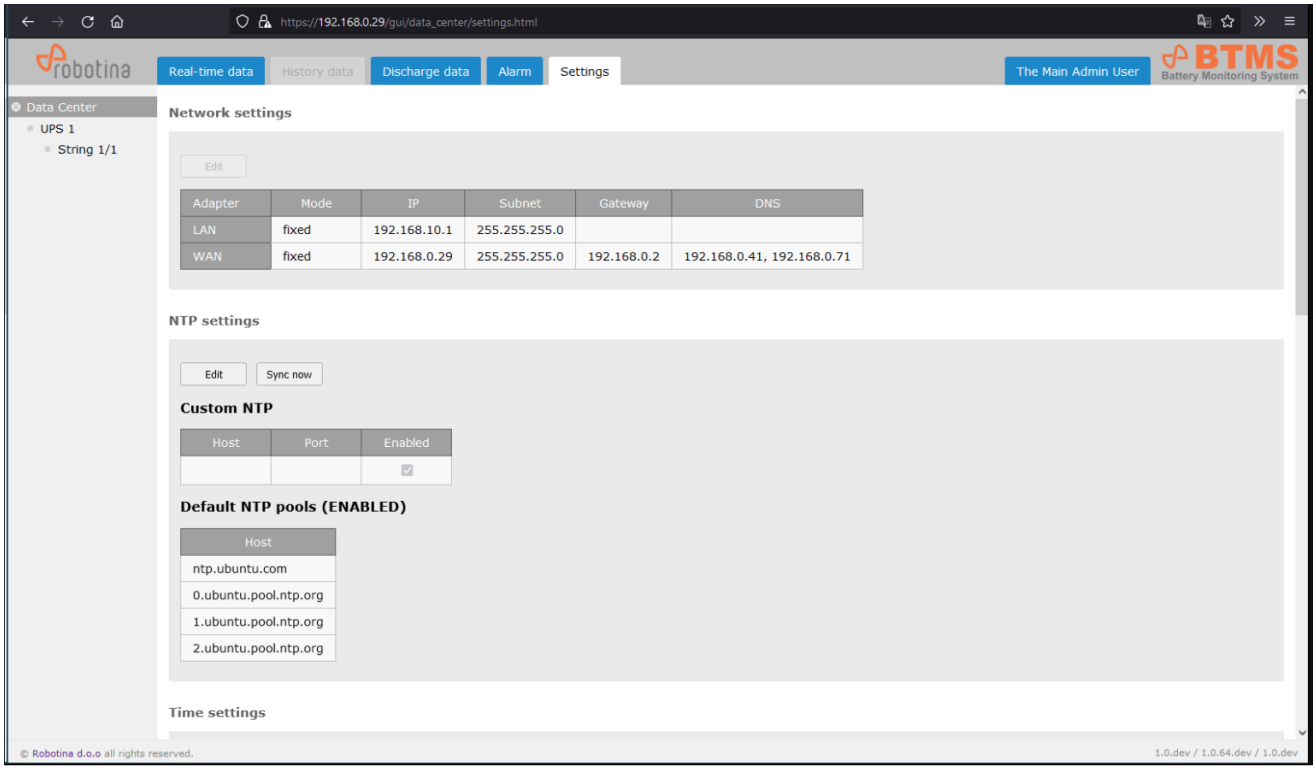
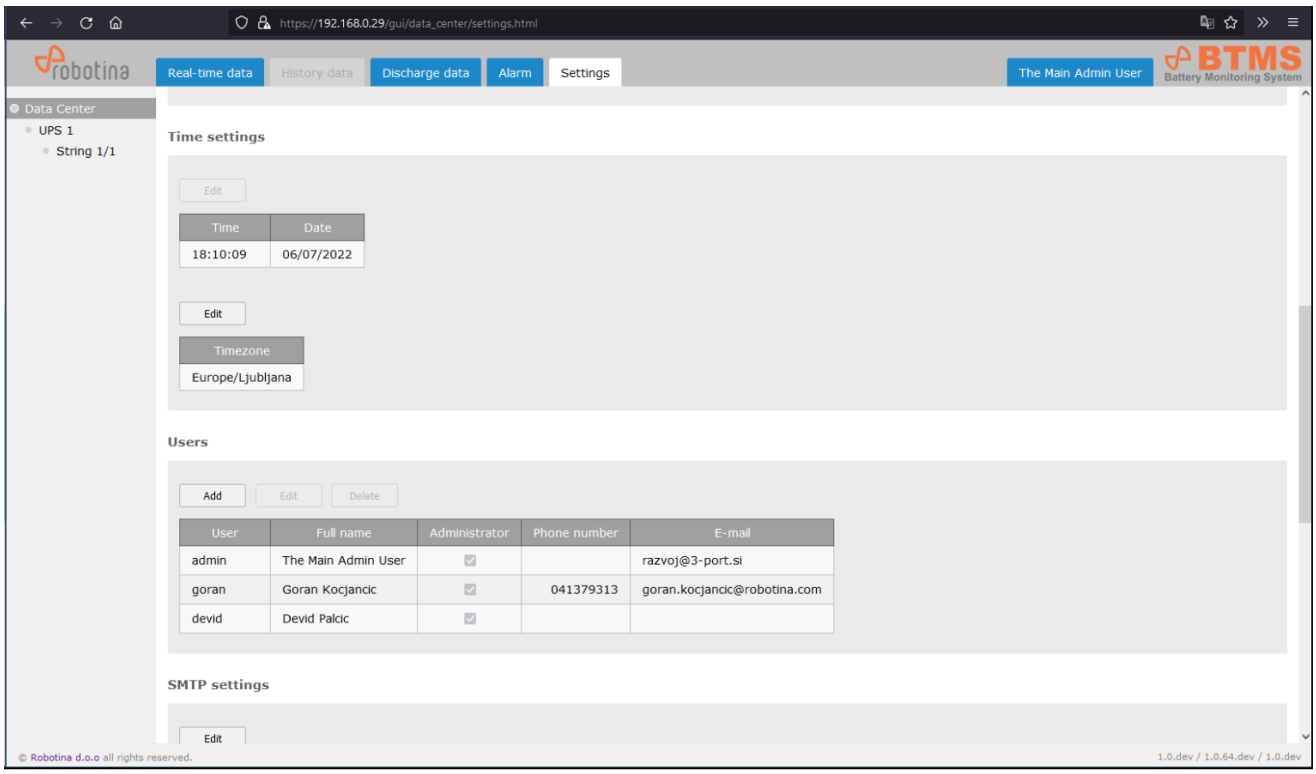
1.0.dev / 1.0.64.dev / 1.0.dev

Settings

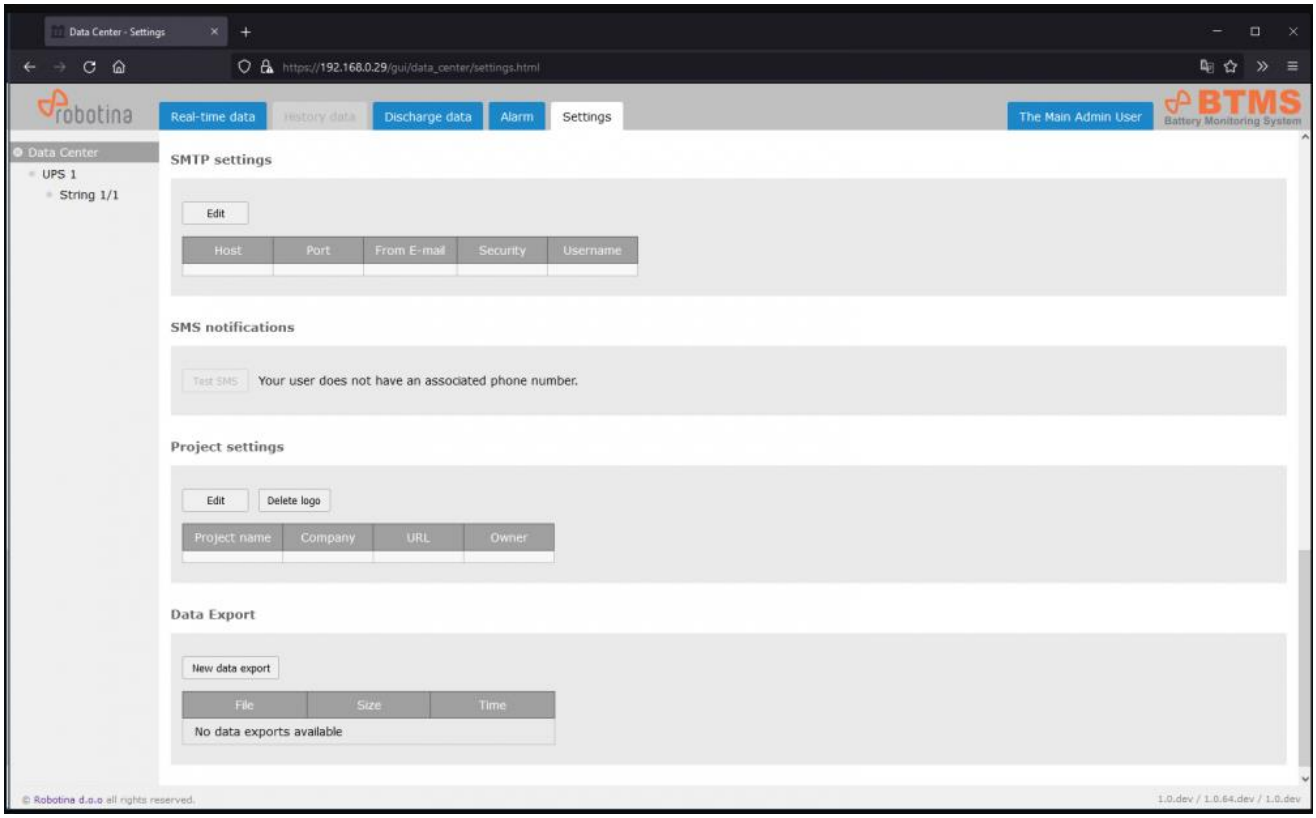
Network settings, TNP settings



Time settings, Users

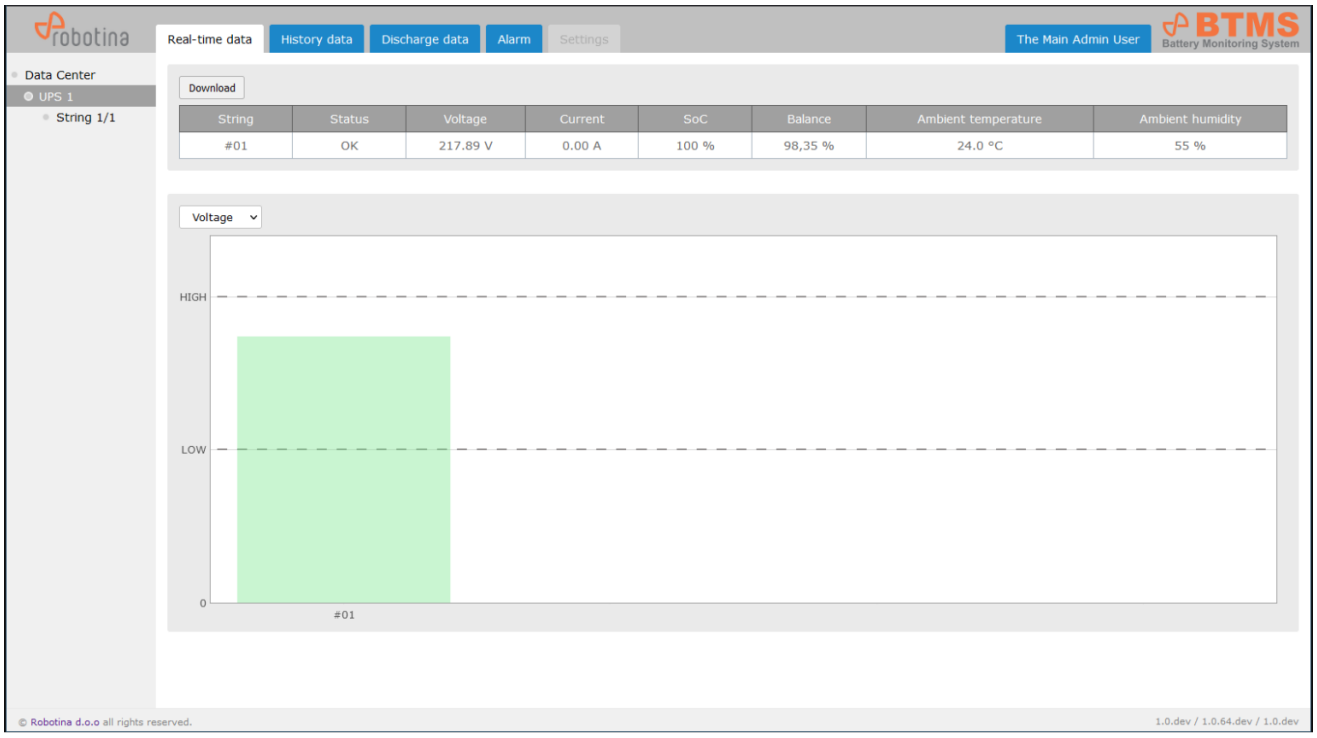


SNTP settings, SMS notifications, Project settings, Data export

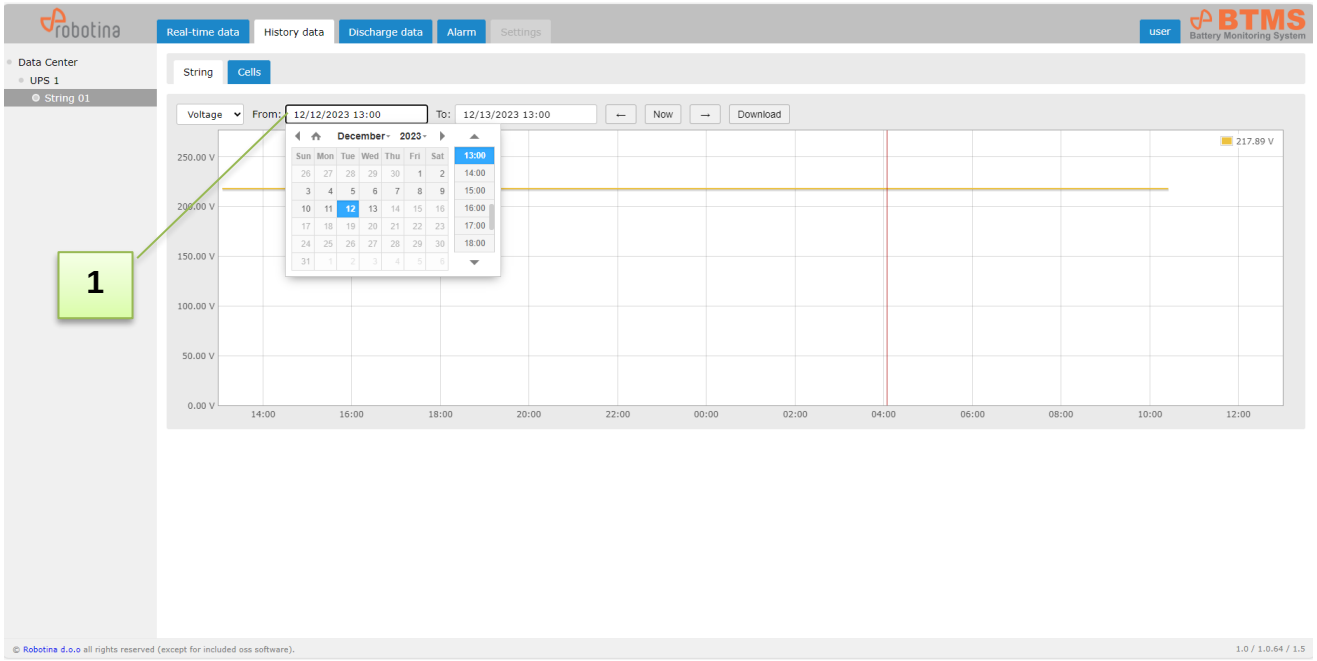


3.3 UPS View

Real time data

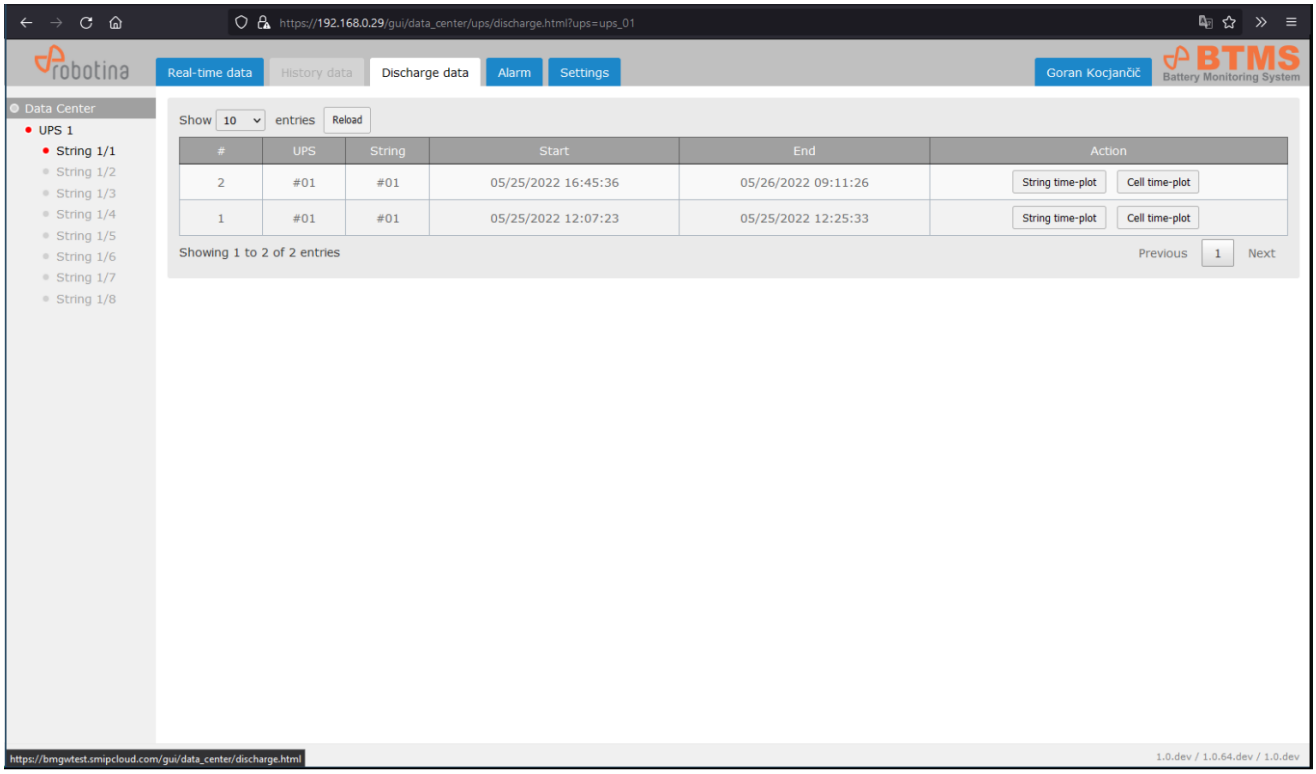


History data

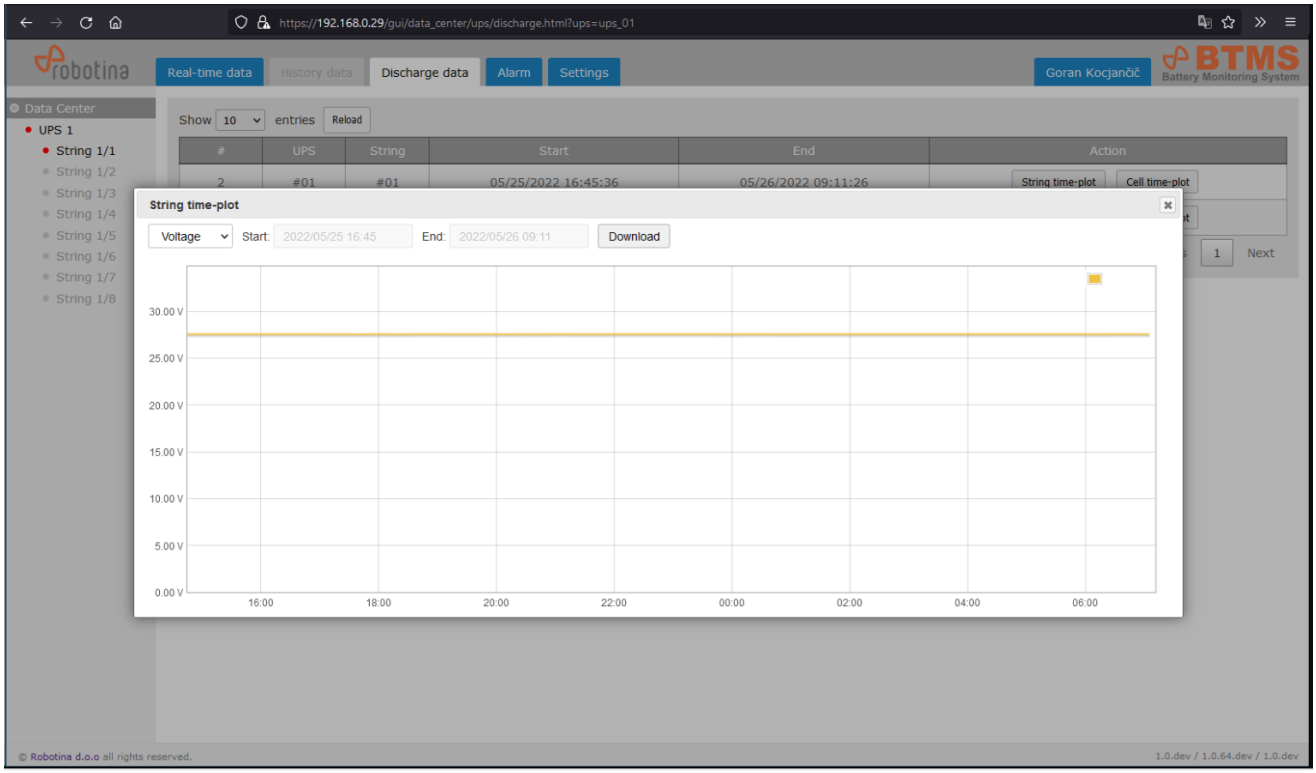


1	Select timespan

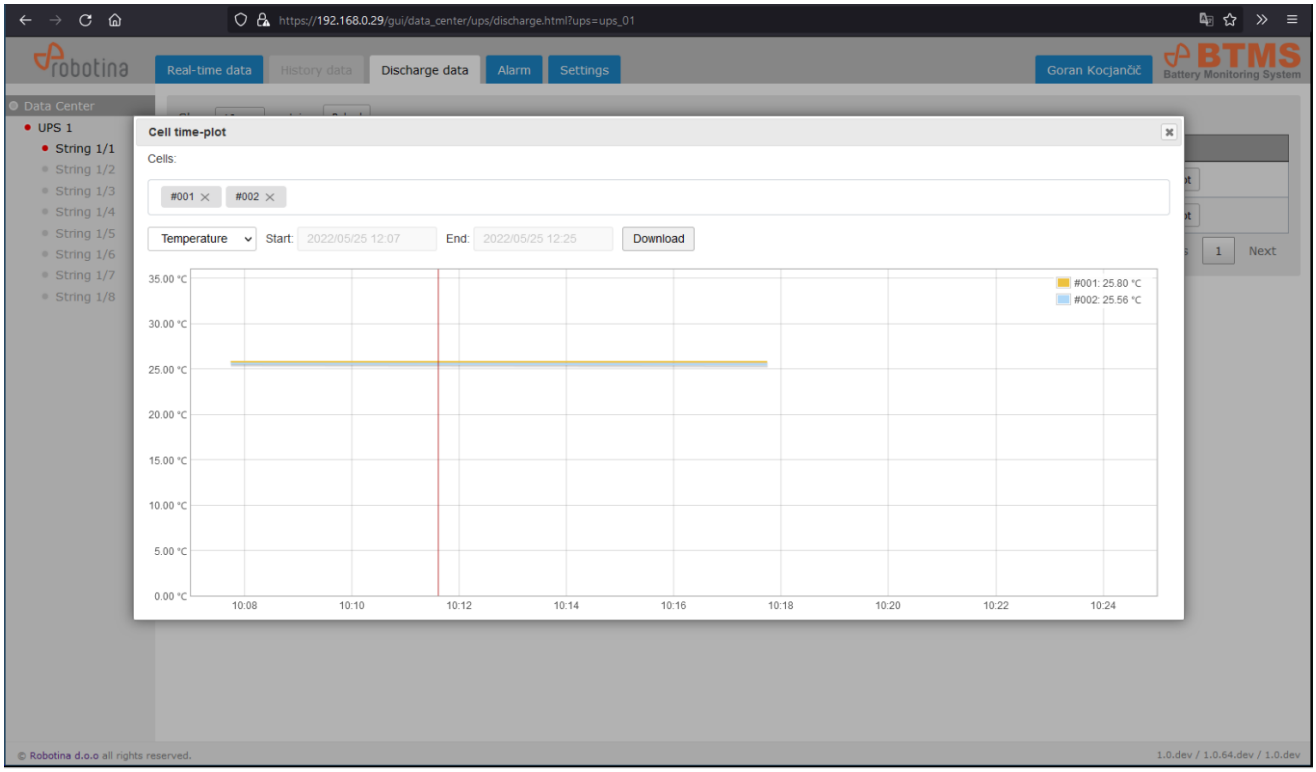
Discharge data



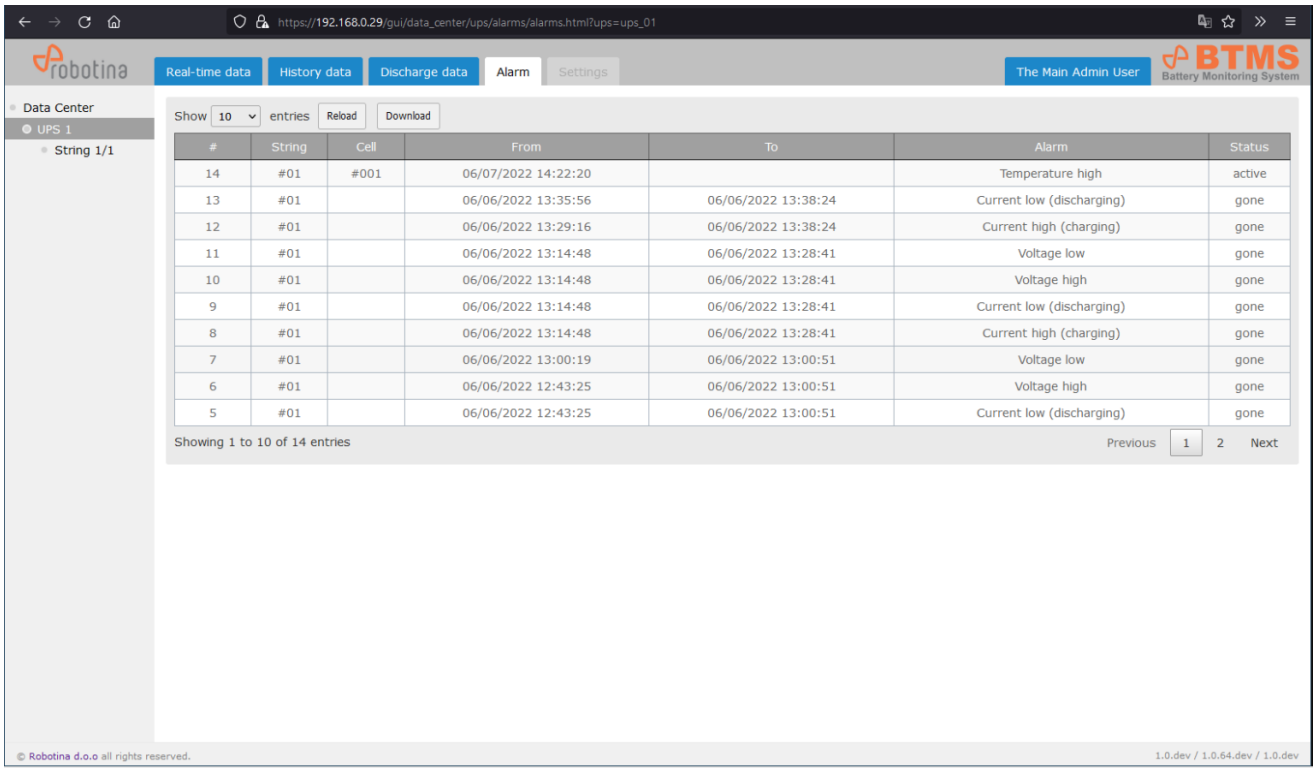
String time.plot



Cell time-plot



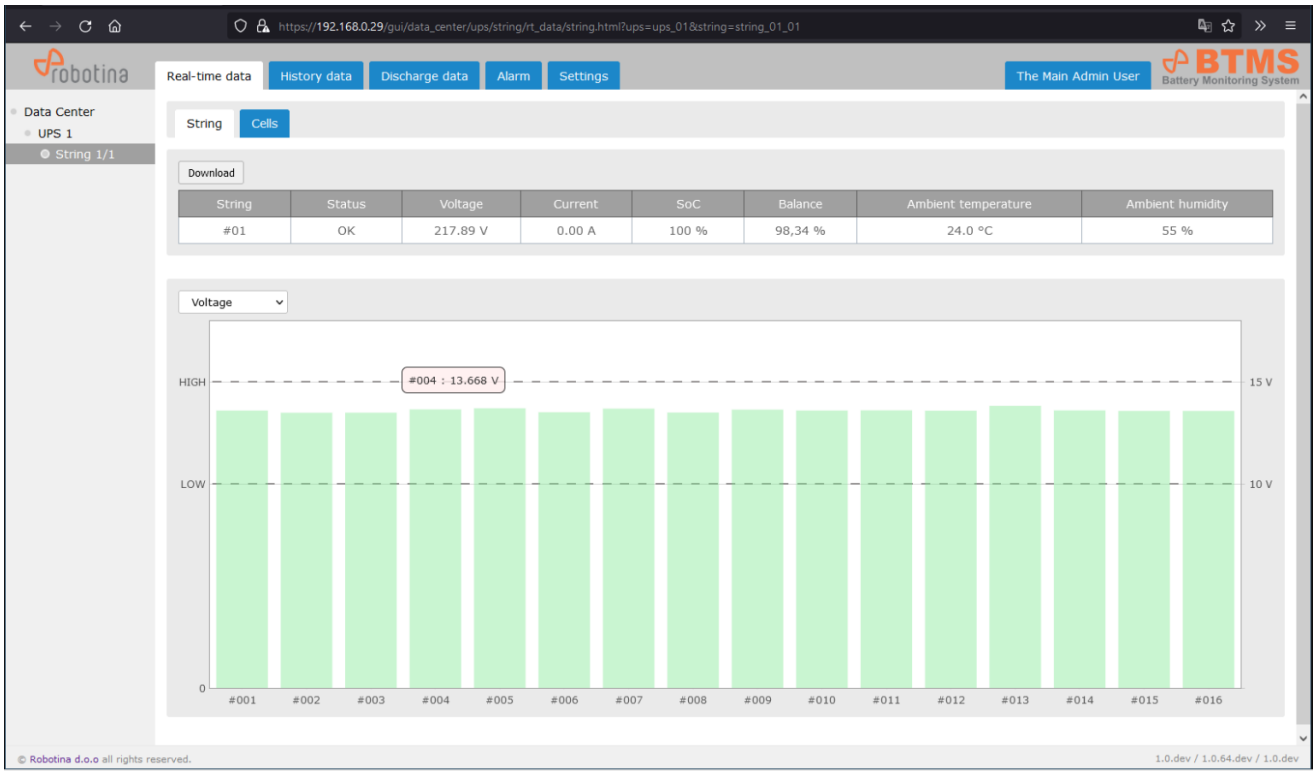
Alarm



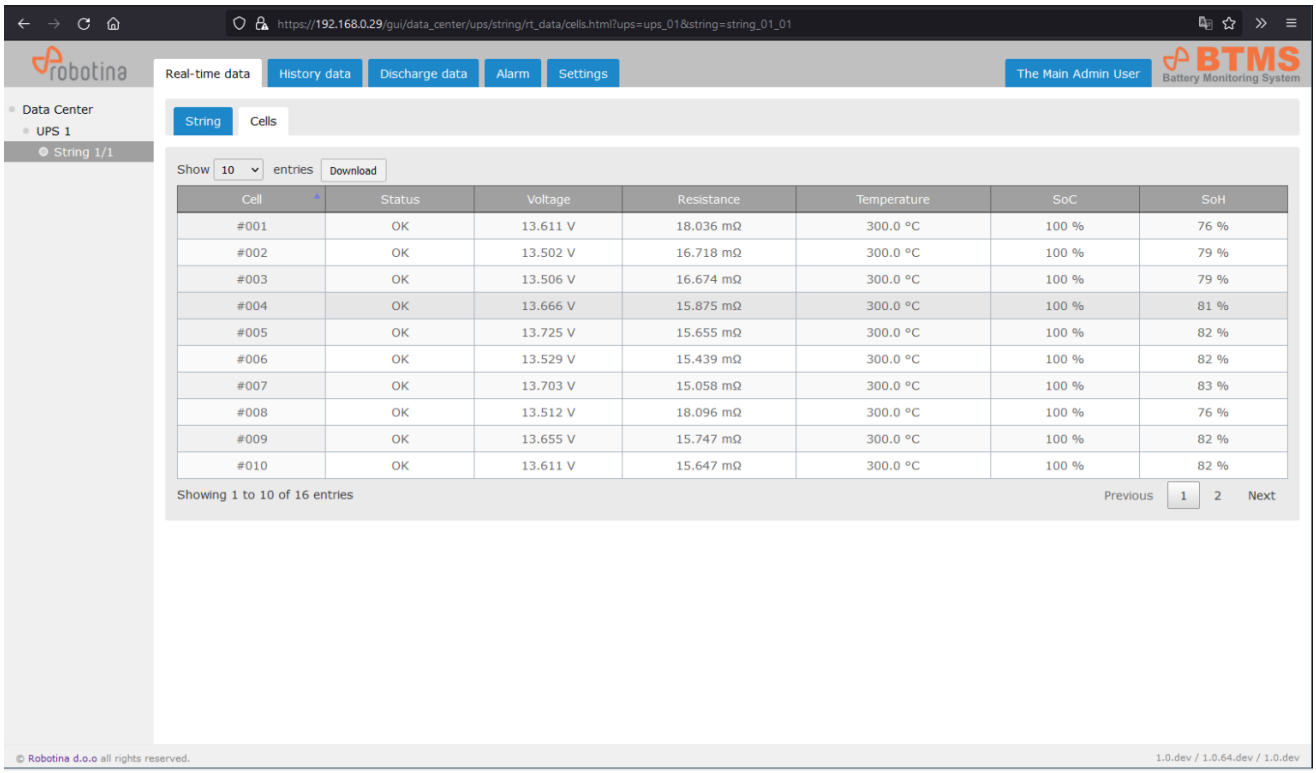
#	String	Cell	From	To	Alarm	Status
14	#01	#001	06/07/2022 14:22:20		Temperature high	active
13	#01		06/06/2022 13:35:56	06/06/2022 13:38:24	Current low (discharging)	gone
12	#01		06/06/2022 13:29:16	06/06/2022 13:38:24	Current high (charging)	gone
11	#01		06/06/2022 13:14:48	06/06/2022 13:28:41	Voltage low	gone
10	#01		06/06/2022 13:14:48	06/06/2022 13:28:41	Voltage high	gone
9	#01		06/06/2022 13:14:48	06/06/2022 13:28:41	Current low (discharging)	gone
8	#01		06/06/2022 13:14:48	06/06/2022 13:28:41	Current high (charging)	gone
7	#01		06/06/2022 13:00:19	06/06/2022 13:00:51	Voltage low	gone
6	#01		06/06/2022 12:43:25	06/06/2022 13:00:51	Voltage high	gone
5	#01		06/06/2022 12:43:25	06/06/2022 13:00:51	Current low (discharging)	gone

3.4 String view

Real-time data

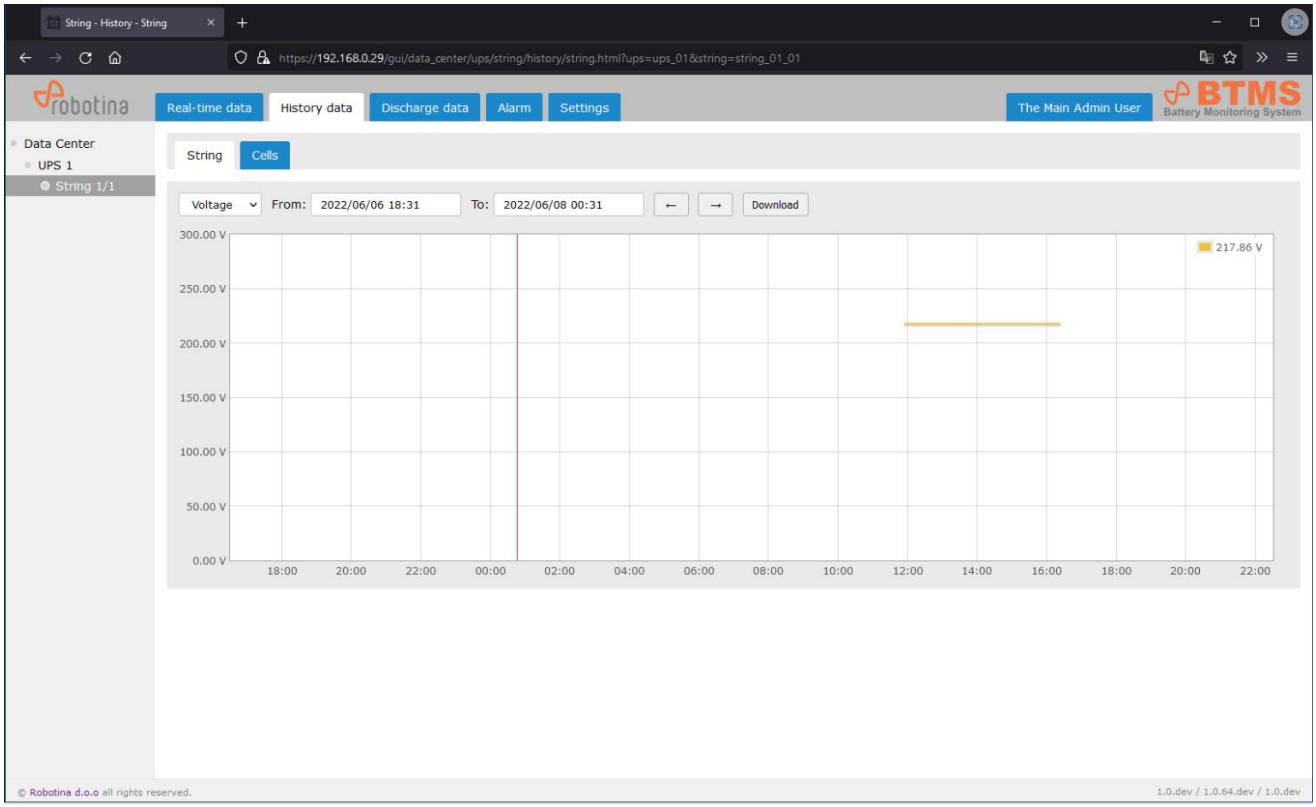


Cells

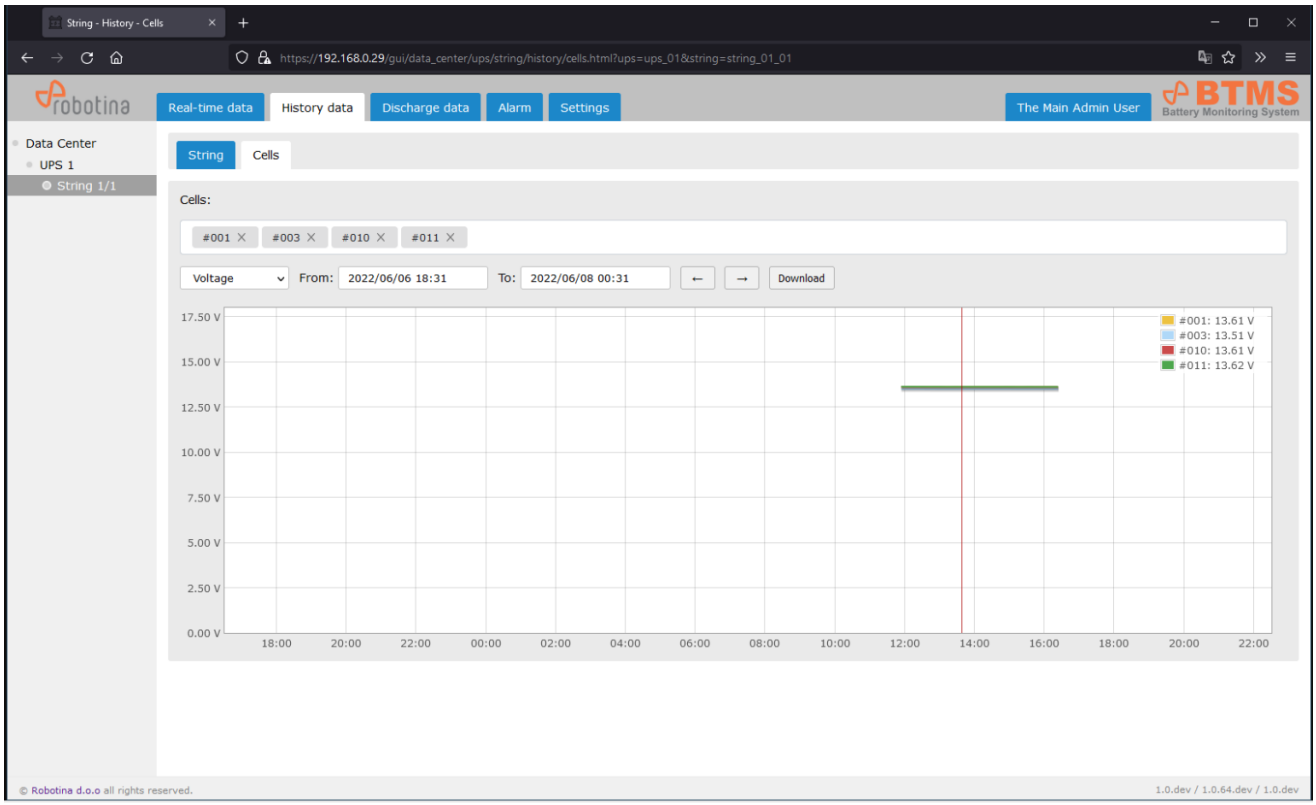


History data

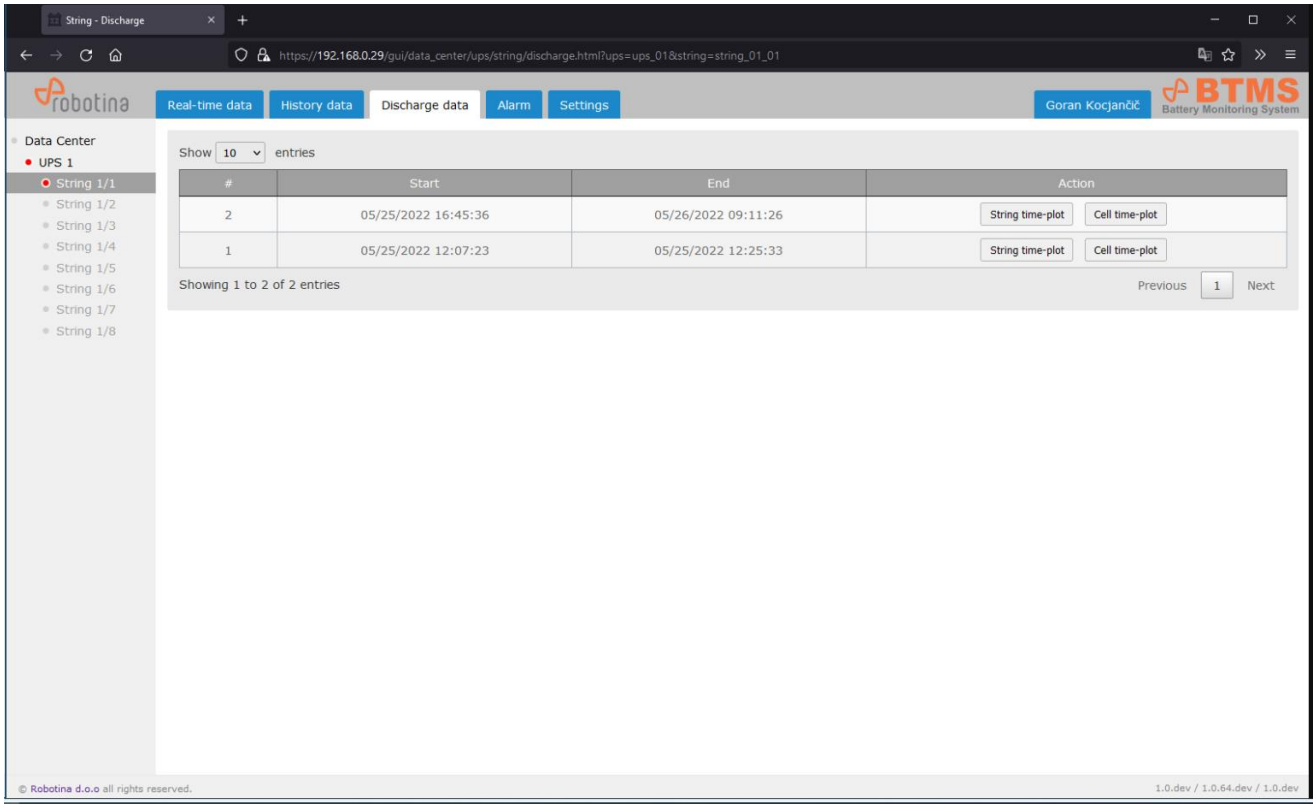
String



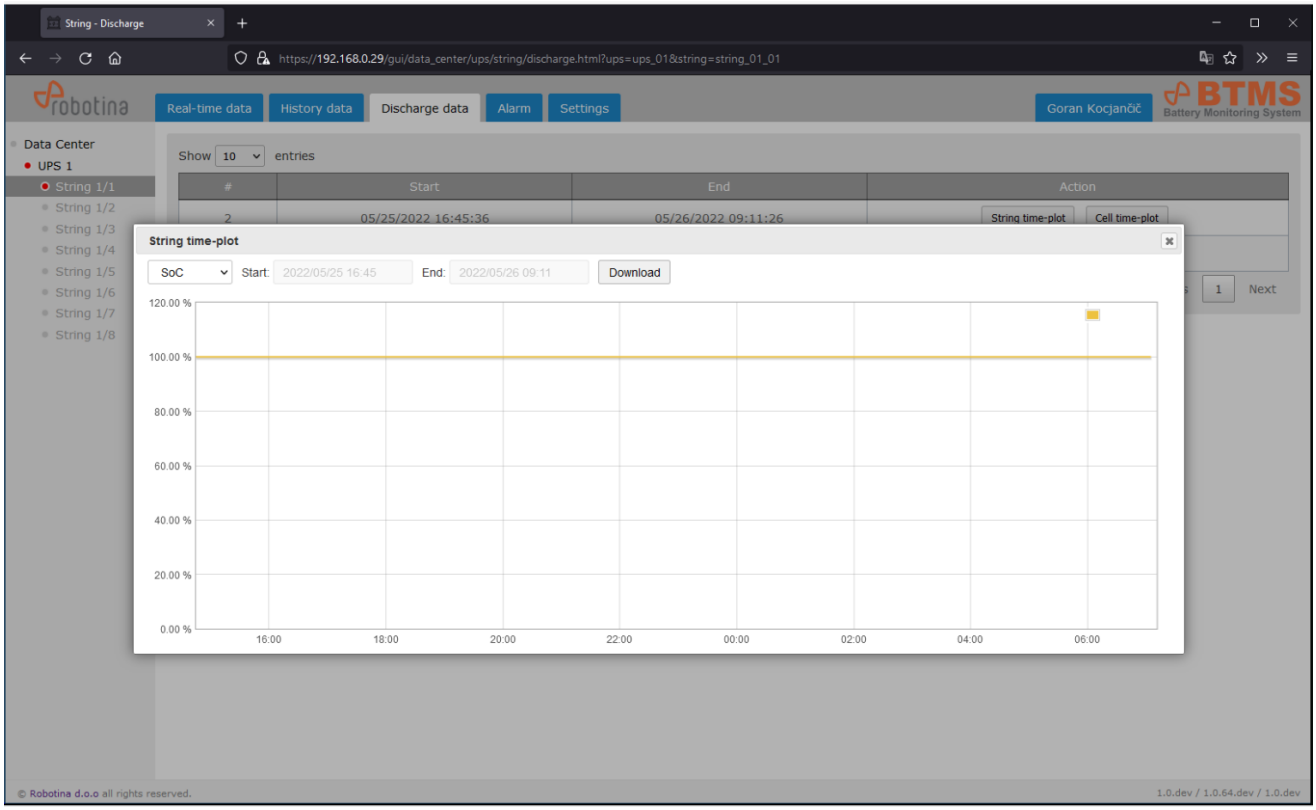
Cells



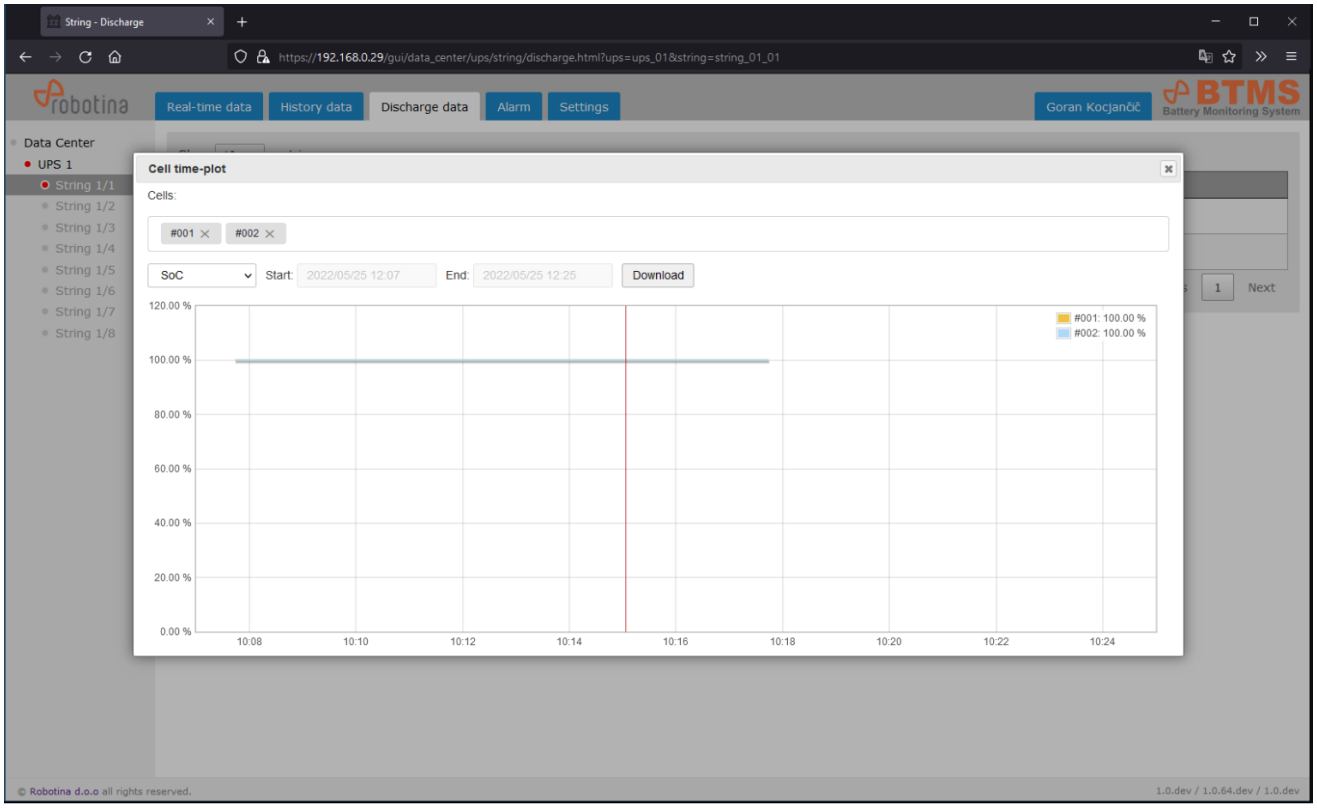
Discharge data



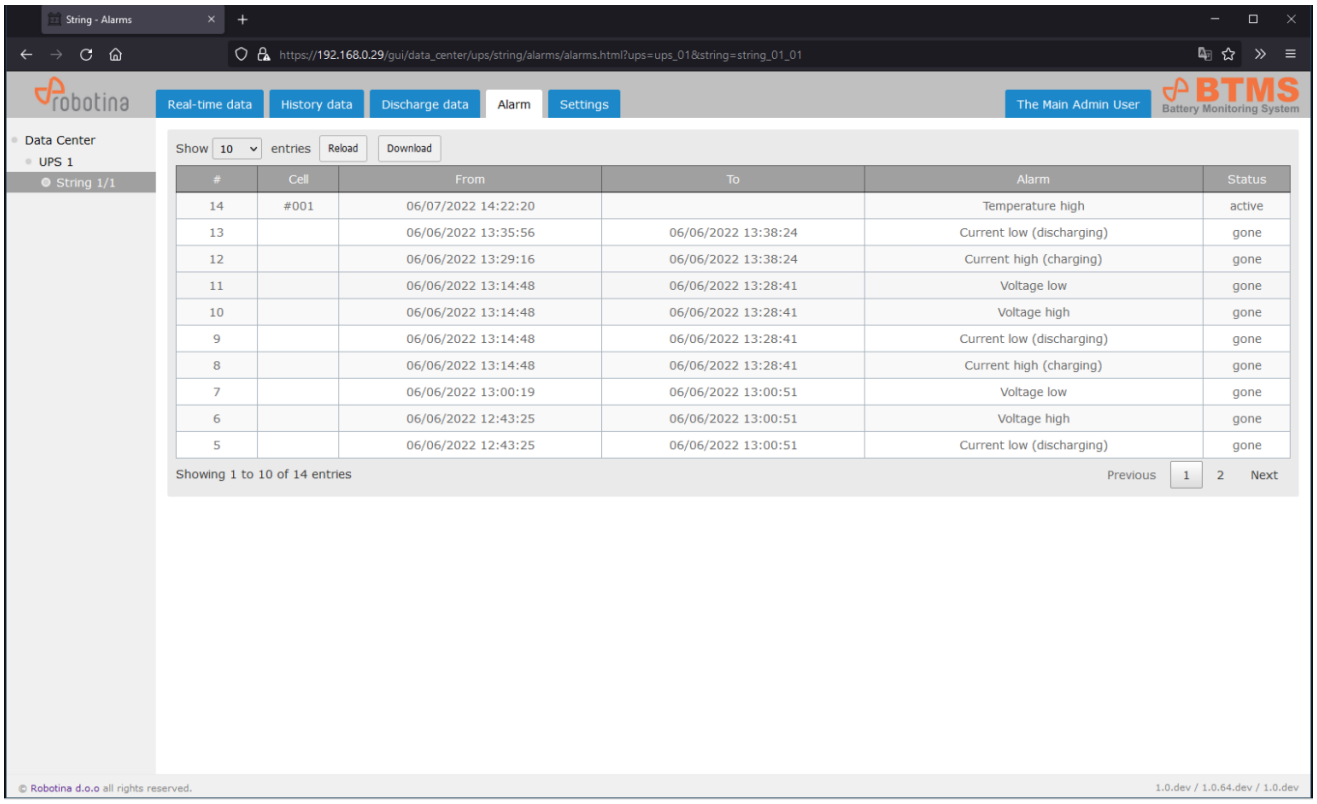
String time-plot



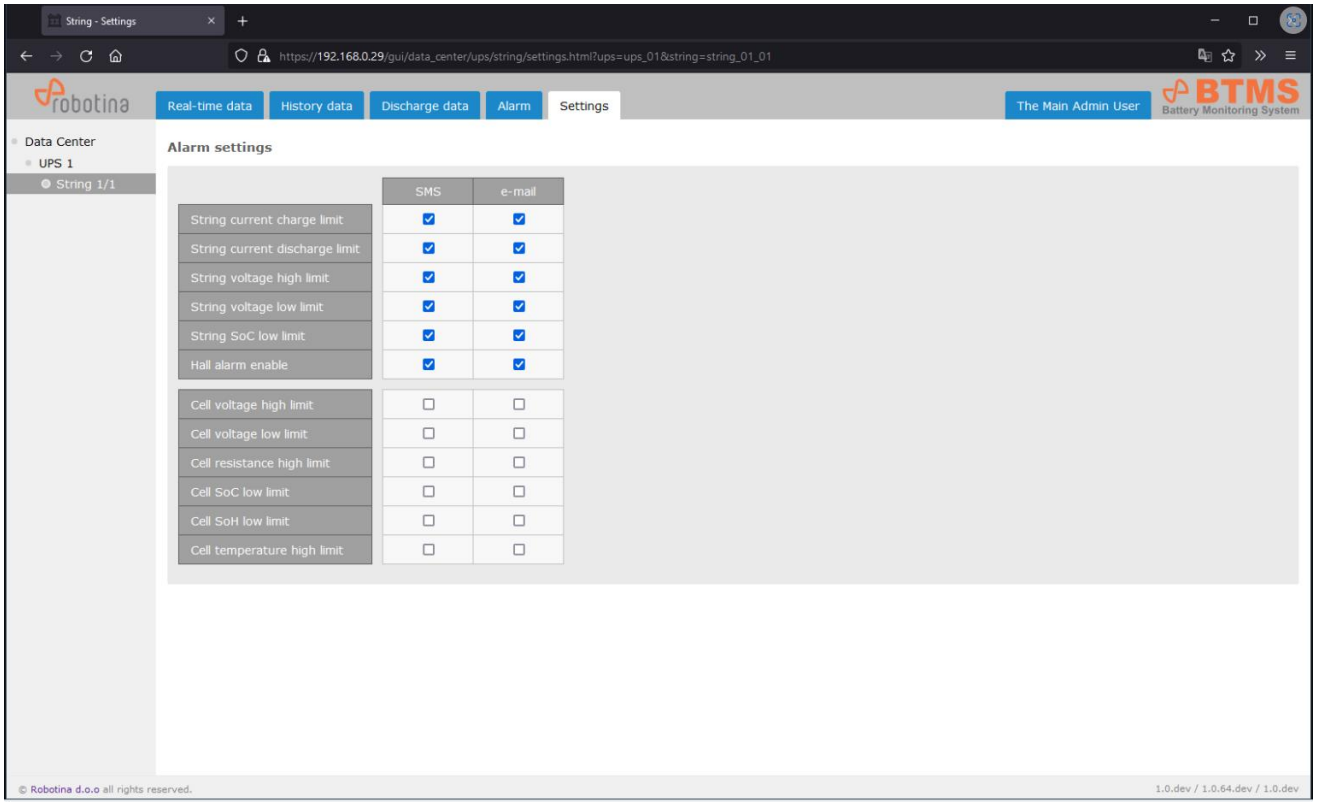
Cell time-plot



Alarm

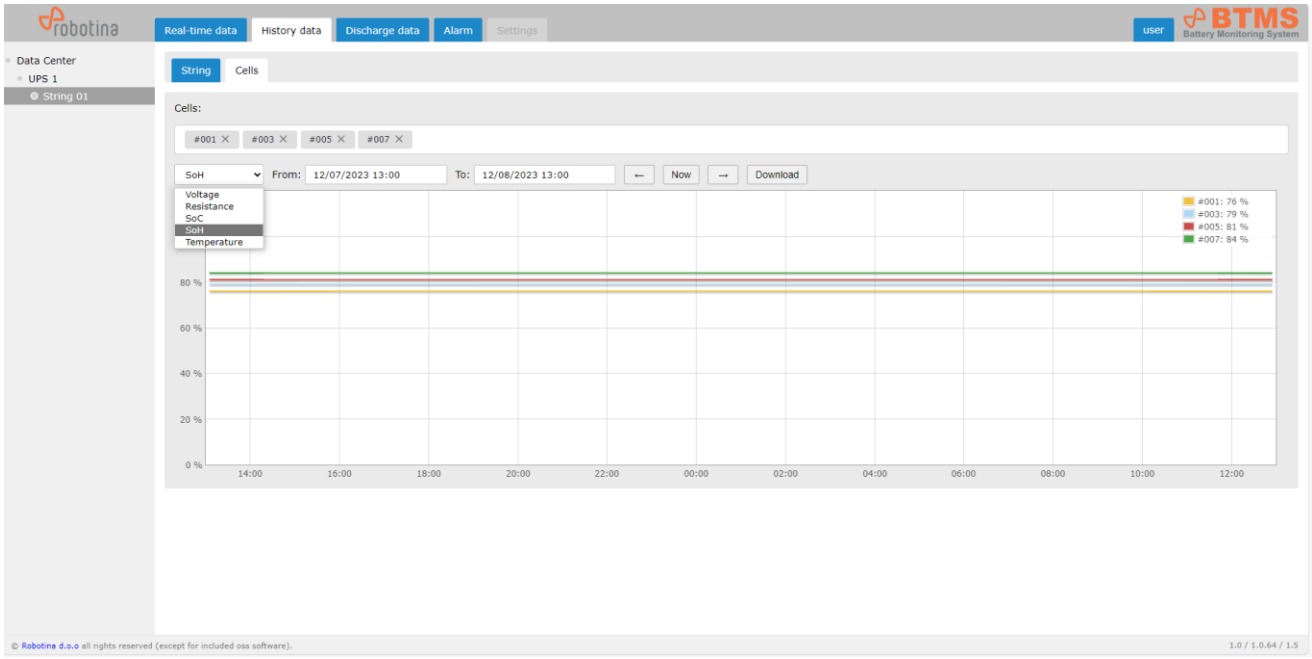


Settings

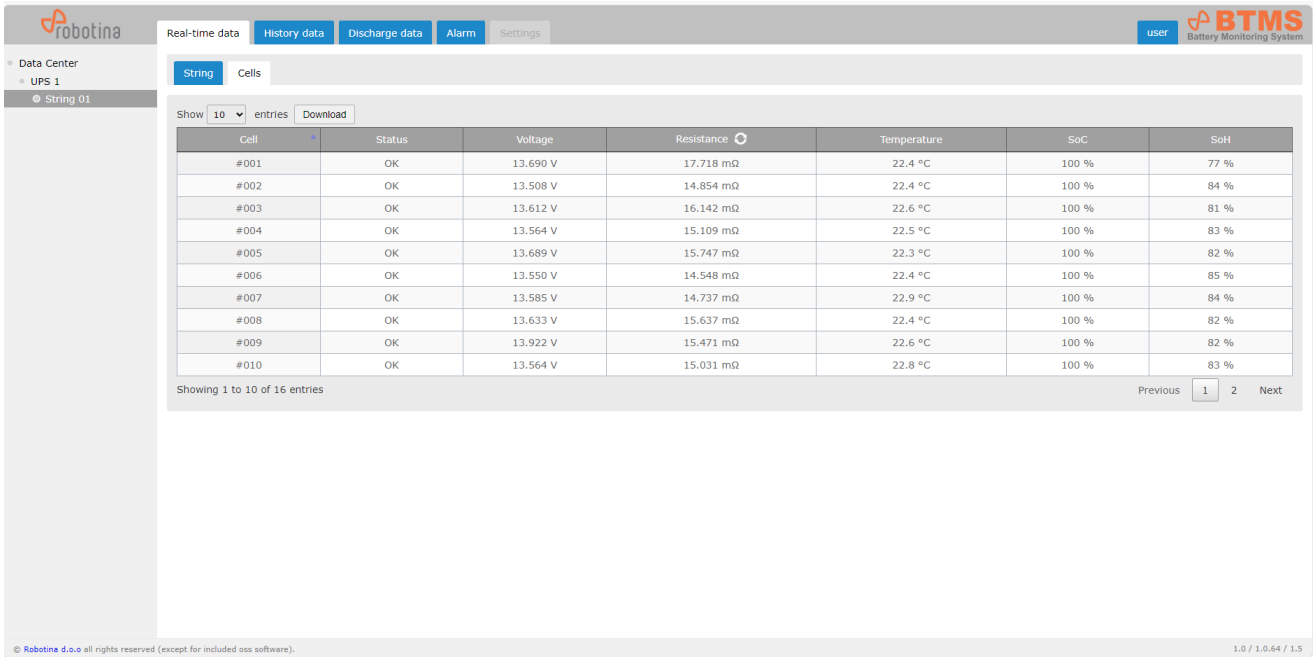


3.5 Examples

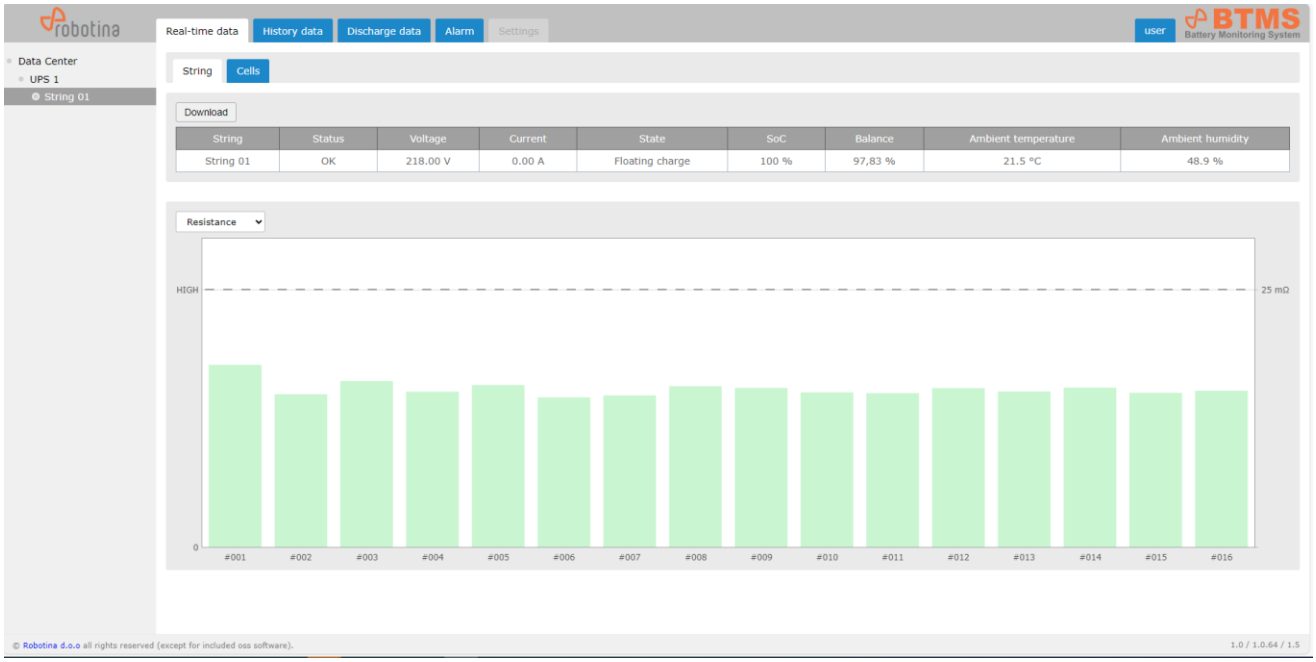
Example History data SOH



Cell data overview:



String Real time data resistance:



Downloaded data into CSF file:

```
String,Timestamp,Voltage [V]
string_01_01,2023-12-12T12:05:03.433Z,217.89
string_01_01,2023-12-12T12:15:03.433Z,217.88
string_01_01,2023-12-12T12:25:03.433Z,217.88
string_01_01,2023-12-12T12:35:03.433Z,217.88
string_01_01,2023-12-12T12:45:03.433Z,217.88
string_01_01,2023-12-12T12:55:03.433Z,217.89
string_01_01,2023-12-12T13:05:03.433Z,217.89
string_01_01,2023-12-12T13:15:03.433Z,217.89
string_01_01,2023-12-12T13:25:03.434Z,217.89
string_01_01,2023-12-12T13:35:03.434Z,217.89
string_01_01,2023-12-12T13:45:03.435Z,217.89
string_01_01,2023-12-12T13:55:03.433Z,217.89
string_01_01,2023-12-12T14:05:03.433Z,217.89
string_01_01,2023-12-12T14:15:03.433Z,217.89
string_01_01,2023-12-12T14:25:03.434Z,217.88
string_01_01,2023-12-12T14:35:03.433Z,217.89
string_01_01,2023-12-12T14:45:03.433Z,217.89
string_01_01,2023-12-12T14:55:03.433Z,217.89
string_01_01,2023-12-12T15:05:03.433Z,217.89
string_01_01,2023-12-12T15:15:03.434Z,217.90
string_01_01,2023-12-12T15:25:03.433Z,217.90
string_01_01,2023-12-12T15:35:03.433Z,217.90
string_01_01,2023-12-12T15:45:03.434Z,217.90
string_01_01,2023-12-12T15:55:03.433Z,217.89
string_01_01,2023-12-12T16:05:03.433Z,217.90
string_01_01,2023-12-12T16:15:03.433Z,217.89
string_01_01,2023-12-12T16:25:03.434Z,217.90
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string_01_01,2023-12-12T16:45:03.434Z,217.90
string_01_01,2023-12-12T16:55:03.434Z,217.90
string_01_01,2023-12-12T17:05:03.433Z,217.90
string_01_01,2023-12-12T17:15:03.433Z,217.91
string_01_01,2023-12-12T17:25:03.433Z,217.90
string_01_01,2023-12-12T17:35:03.433Z,217.91
string_01_01,2023-12-12T17:45:03.433Z,217.91
string_01_01,2023-12-12T17:55:03.433Z,217.91
string_01_01,2023-12-12T18:05:03.433Z,217.90
string_01_01,2023-12-12T18:15:03.433Z,217.91
string_01_01,2023-12-12T18:25:03.433Z,217.91
string_01_01,2023-12-12T18:35:03.433Z,217.91
string_01_01,2023-12-12T18:45:03.433Z,217.91
string_01_01,2023-12-12T18:55:03.433Z,217.91
string_01_01,2023-12-12T19:05:03.433Z,217.92
string_01_01,2023-12-12T19:15:03.433Z,217.91
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string_01_01,2023-12-12T20:15:03.433Z,217.92
string_01_01,2023-12-12T20:25:03.433Z,217.92
```
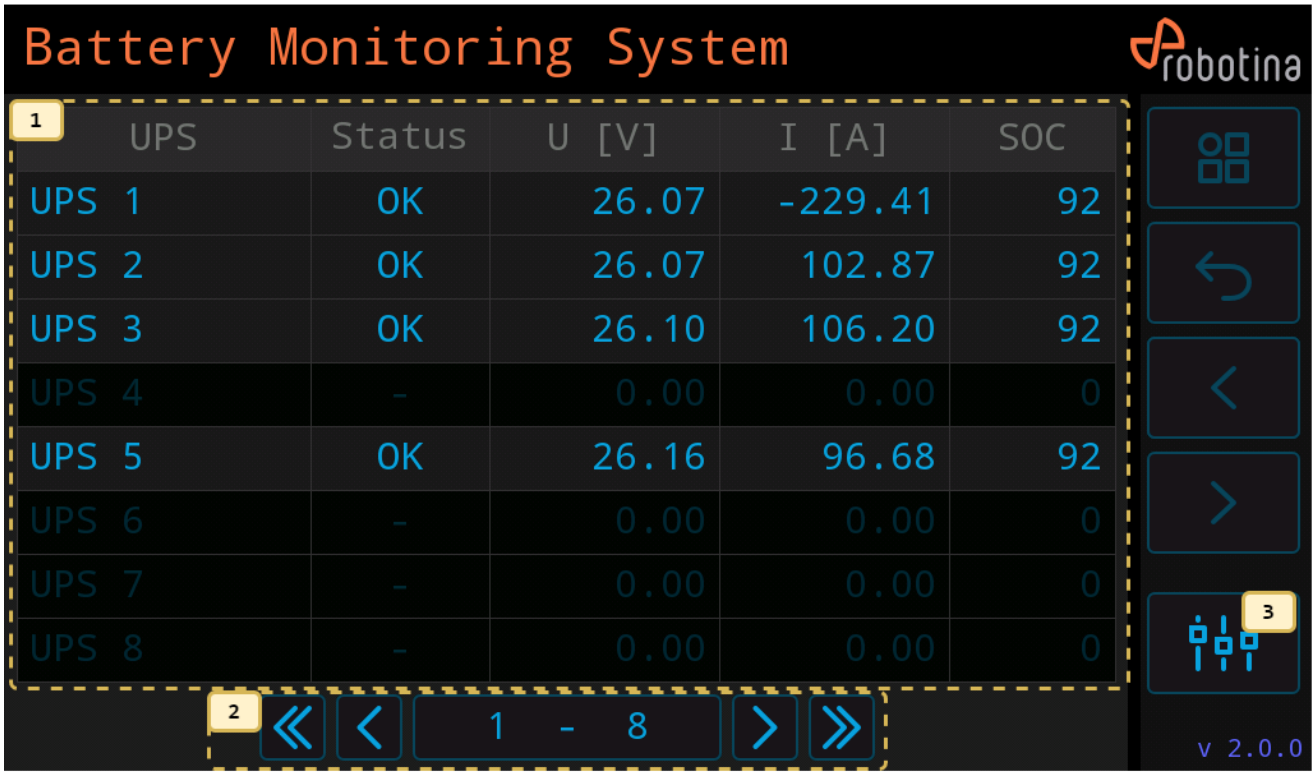
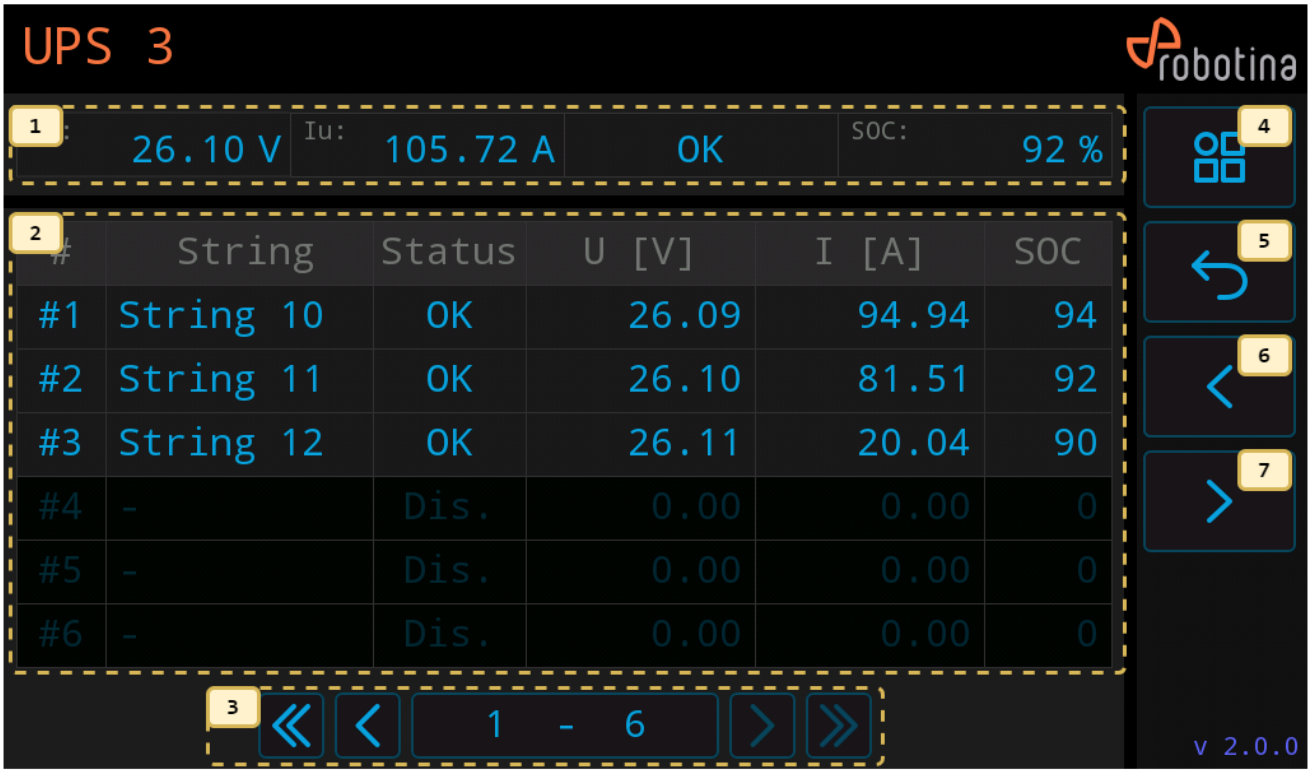

4 HMI User Interface

4.1 Main Screen



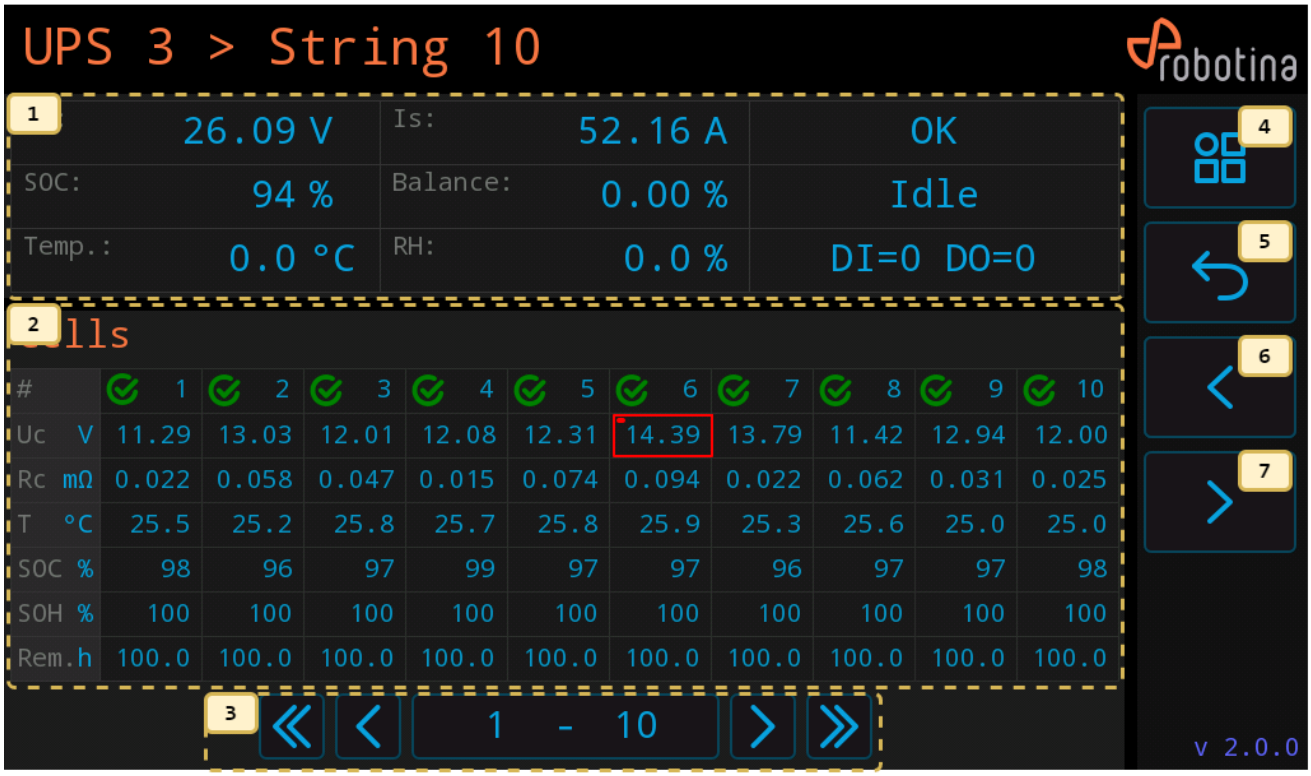
1	UPS data
	- tap to display UPS details
2	UPS navigation buttons
	- first ups
	- previous 8 UPS
	- next 8 UPS
	- last 8 UPS
3	Settings screen

4.2 UPS Screen



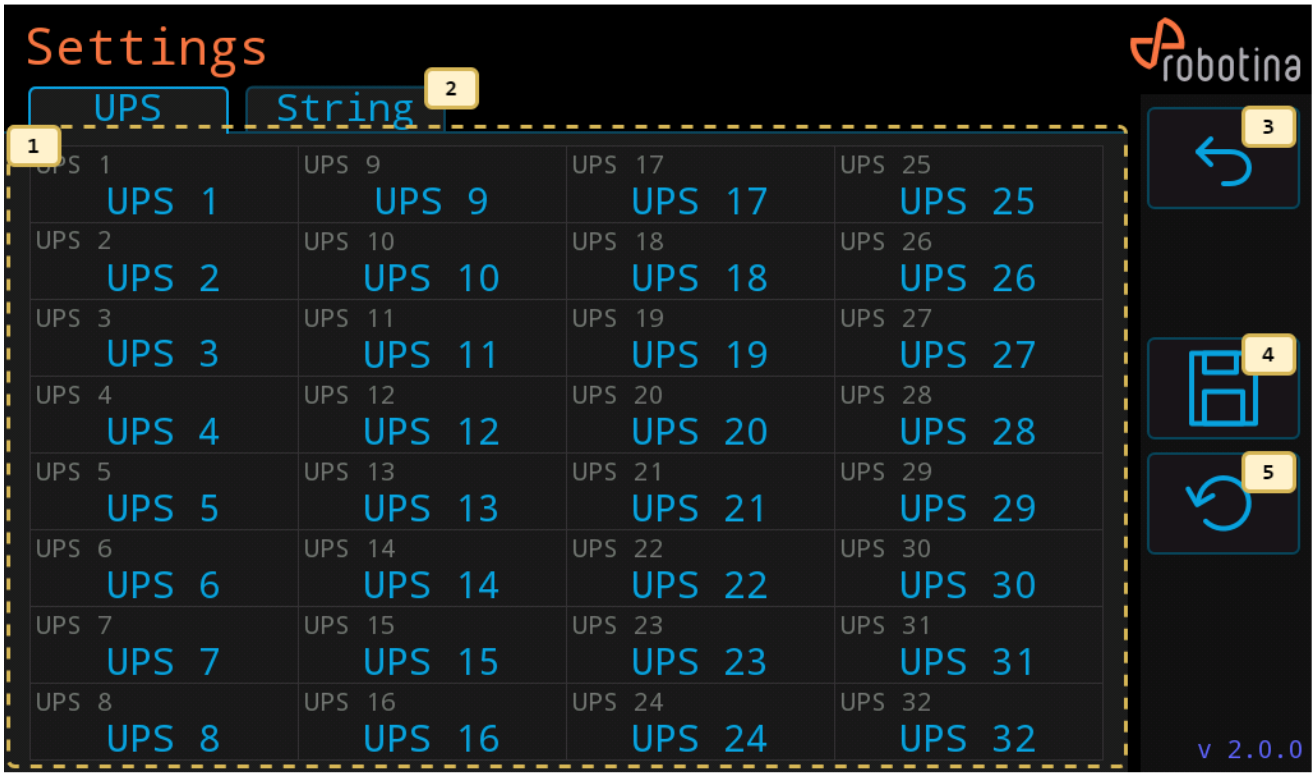
1	UPS data
2	String data
	- tap to display String details
3	String navigation
4	Main screen
5	Previous screen
6	Previous UPS
7	Next UPS

String screen



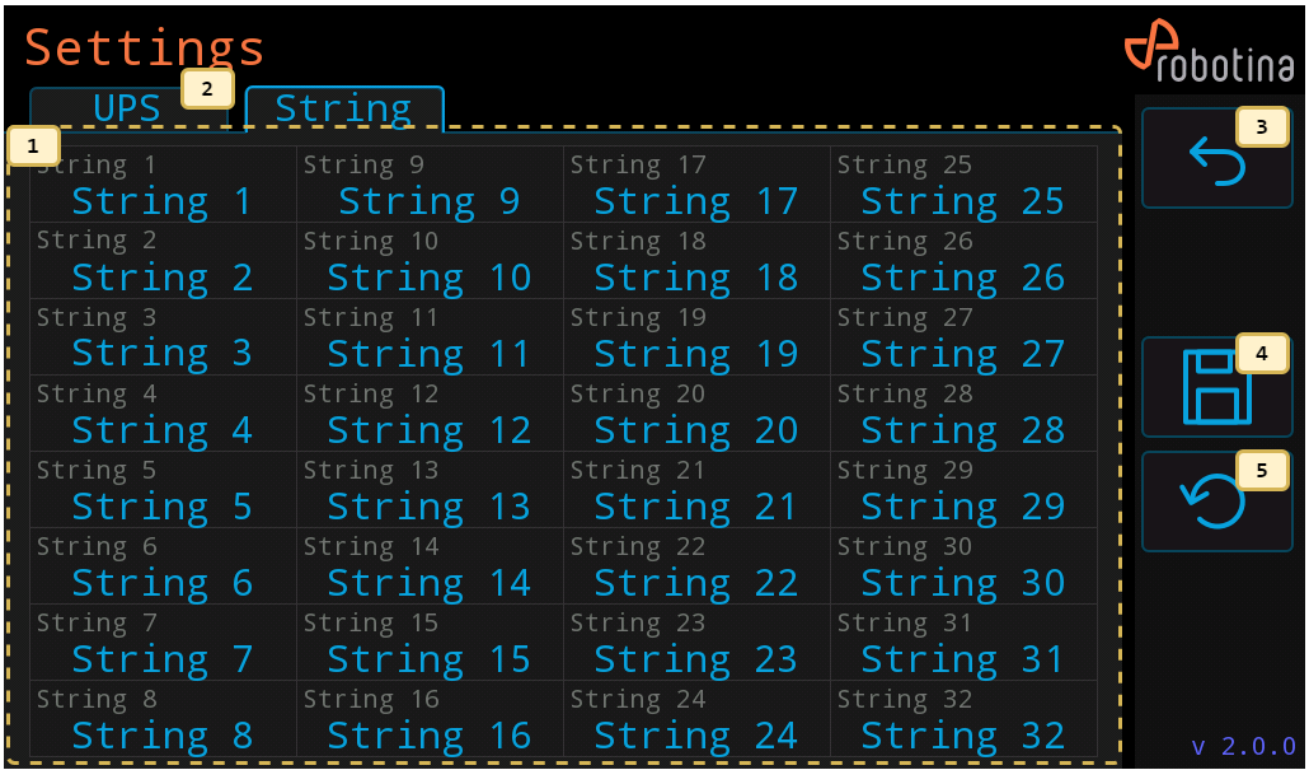
1	String detailed data
2	Cells data
3	Cell navigation
4	Main screen
5	Previous screen
6	Previous String
7	Next String

UPS names screen



1	UPS names
	- tap to edit name
2	go to String names screen
3	Previous page
4	Save names to Flash memory
5	Restore default names

String names screen



1	String names
	- tap to edit name
2	go to String names screen
3	Previous page
4	Save names to Flash memory
5	Restore default names

5 Troubleshooting

5.1 Alarms

If you notice any alarm check the BTMS Alarm list for further action. Alarm list is attached at the end of the document.

5.2 System malfunctions

If you are having problems with the system, try the appropriate solutions below. This may fix a system error that is the result of one of the most common system failures or installation mistakes.

- Check the power supply and the power supply of all components are connected correctly
- Check communication cables are properly connected (it is best to check each one step by step)
- Check that the hall sensor is facing correctly (there is an arrow on it showing the direction of the electric current)
- Check LED on Cell sensor and String master (is green breathing mode or constant red)

5.3 Support

In any case, our technical support will be able to help you, it is at in http://support.robotina.com.
By trying the solutions listed above, our technical support will also be more effective in identifying errors and will help you more effectively.
One of the possible causes of malfunction may also be incorrect initial system configuration.
The initial configuration of the system can only be done by an authorized person!
Contact an authorized person for any problems.

Robotina Help Desk in http://support.robotina.com

6 Appendix: BTMS Alarm List

Alarm	Alarm trigger	Alarm clear	Action
String current charge limit	String charging current over alarm trigger threshold	Automatically String charging current below alarm clear threshold	Turn off the UPS Check the UPS settings Verify string current
String current discharge limit	String discharging current over alarm trigger threshold	Automatically String discharging current below alarm clear threshold	Turn off UPS Check wiring Verify UPS settings Verify string current
String voltage high limit	String voltage over alarm trigger threshold	Automatically String voltage below alarm clear threshold	Turn off the UPS Check the UPS settings Verify string voltage
String voltage low limit	String voltage below alarm trigger threshold	Automatically String voltage over alarm clear threshold	Turn off the UPS Check the UPS settings Check the condition of the batteries in the string Verify string voltage
String SoC low limit	String SOC below alarm trigger threshold	Automatically String SOC above alarm clear threshold	Check the operation of the UPS Check the string breaker Check the condition of the batteries in the string
Hall alarm enable	Hall sensor faulty or disconnected	Automatically Hall sensor is working correctly	Check the Hall sensor connection
Cell voltage high limit	Battery voltage over alarm trigger threshold	Automatically Battery voltage below alarm clear threshold	Check the UPS settings
Cell voltage low limit	Battery voltage below alarm trigger threshold	Automatically Battery voltage over alarm clear threshold	Check the condition of the other batteries in the string, if they are all at the limit, the problem is in the UPS settings; if the other batteries are within the expected values, the cause is most likely in the battery.

Alarm	Alarm trigger	Alarm clear	Action
Cell resistance high limit	Battery internal resistance over alarm trigger threshold	Automatically Battery internal resistance below alarm clear threshold	Check the wiring of the battery and the battery sensor. Manually checks the battery's internal resistance. Replace the battery.
Cell SoC low limit	Battery SOC below alarm trigger threshold	Automatically Battery SOC over alarm clear threshold	Check the condition of the other batteries in the string, if they are all at the limit, the problem is in the UPS settings or operation; if the other batteries are within the expected values, the cause is most likely in the battery.
Cell SoH low limit	Battery SOH below alarm trigger threshold	Automatically Battery SOH over alarm clear threshold	Check the wiring of the battery and the battery sensor. Replace the battery.
Cell temperature high limit	Battery temperature over alarm trigger threshold	Automatically Battery temperature below alarm clear threshold	Turn off the UPS and wait for the temperature to drop to normal. Check the battery wiring (power part). If the problem persists, replace the battery.,
Cell disabled	At least 1 battery (cell) sensor is disabled.	Automatically Battery (cell) sensor enabled again	Check battery sensor wiring. Check battery voltage. If the problem persists, replace the battery or battery sensor.

NOTES: