Reference Guide

What Is The BMS?

Directly

Via Cloud.Zcell.Com

Overview

The main status screen of the BMS provides a summary of your Z-Cell battery system. While it is possible to obtain more detailed battery information, in most cases everything you need to know can be found on this screen.

Components

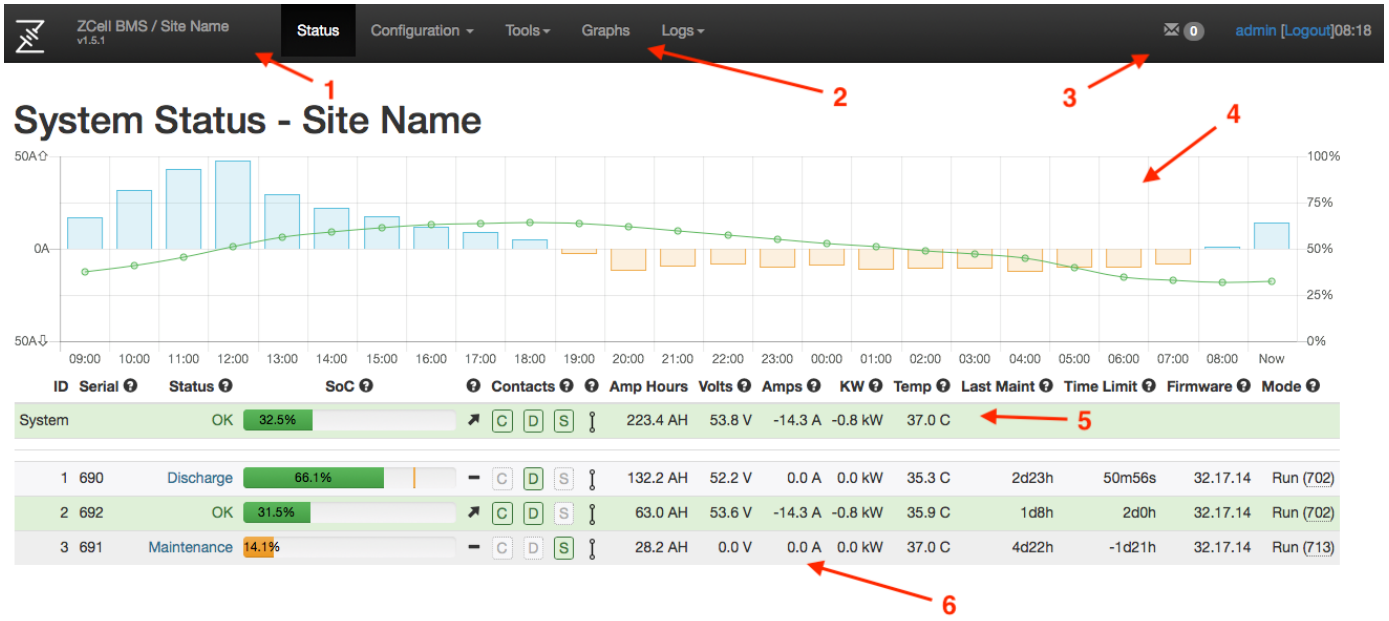


Figure 1: Main status screen

BMS and site information

See “1” on fig. 1.

This shows the version of the BMS software, and the site name that you are looking at. If you are managing several sites, checking the site name here is a good way to ensure you are configuring the correct one!

Menu

See “2” on fig. 1.

The menubar is the same across the entire BMS web interface - providing access to the various configuration and status functions. Any menus with a small inverted triangle next to them have selections available beneath them - click or tap on them to reveal those entries.

Notifications

See “3” on fig. 1.

Various warnings or configuration errors can be detected by the BMS - a number other than ‘0’ here may indicate that something needs to be investigated or checked. Click the number to check these notifications.

Next to that is the logged in username, and the time.

The time shown is the local time (of the BMS) - be aware of this if you are in a different time zone.

System status graph

See “4” on fig. 1.

The status graph gives a snapshot of the system state for the last 24 hours. The graph periodically automatically refreshes if you leave your browser open - there is no need to refresh the web page.

The graph shows:

- several bars (either above or below the horizontal axis) showing charging/discharging amps
- a line showing overall state of charge

The current flow bars are either blue (for charging) or yellow (for discharging). The axis labels on the left hand side of the graph show the actual current measurements - the graph is adaptive and will scale depending on the system size.

The state of charge line shows the overall state of charge of all batteries (average). The axis labels and scale for state of charge is on the right hand side.

System and battery summary lines

See “5” and “6” on fig. 1.

Each line in this section shows the status of a battery.

The columns of data shown are as follows:

- ID - Battery modbus address (shows “System” on the aggregated overall energy system entry)
- Serial - Battery serial number (you can match this number with the physical unit - the serial number is printed on the plastic tank, directly under the control box
- Status - Battery status
- SoC - State of Charge
- Current flow (charge/discharge rate)
- Contacts - Contactor status
- Amp hours
- Volts - Stack voltage (bus voltage on “System” line)
- Amps - instantaneous current flow for this battery
- KW - Kilowatts - instantaneous current flow in kilowatts
- Temp - Electrolyte (internal tank) temperature
- Last Maint - time since the last maintenance cycle ran
- Time Limit - time until the next maintenance cycle is required
- Firmware - firmware version
- Mode - internal number for the current running state of the battery

The first line represents the overall energy system. It shows all the batteries data combined as a single entity. The values shown aggregate the rest of the batteries in meaningful ways:

- State of Charge - average
- Voltage - shows bus voltage, not stack voltage
- Amp hours - sum of all batteries
- Current flow - sum of all batteries
- Temperature - highest temperature shown

Clicking on any part of the line for a battery (real or the System virtual battery) will take you to a information page showing a complete breakdown of all the information on that battery.

The BMS site configuration page contains several key parameters, essential for both the operation and management of the BMS. Ensure these details are filled out correctly.

The configuration page can be reached by choosing “Configuration” and then “Site” in the top menu bar. See fig. 2 for an example.

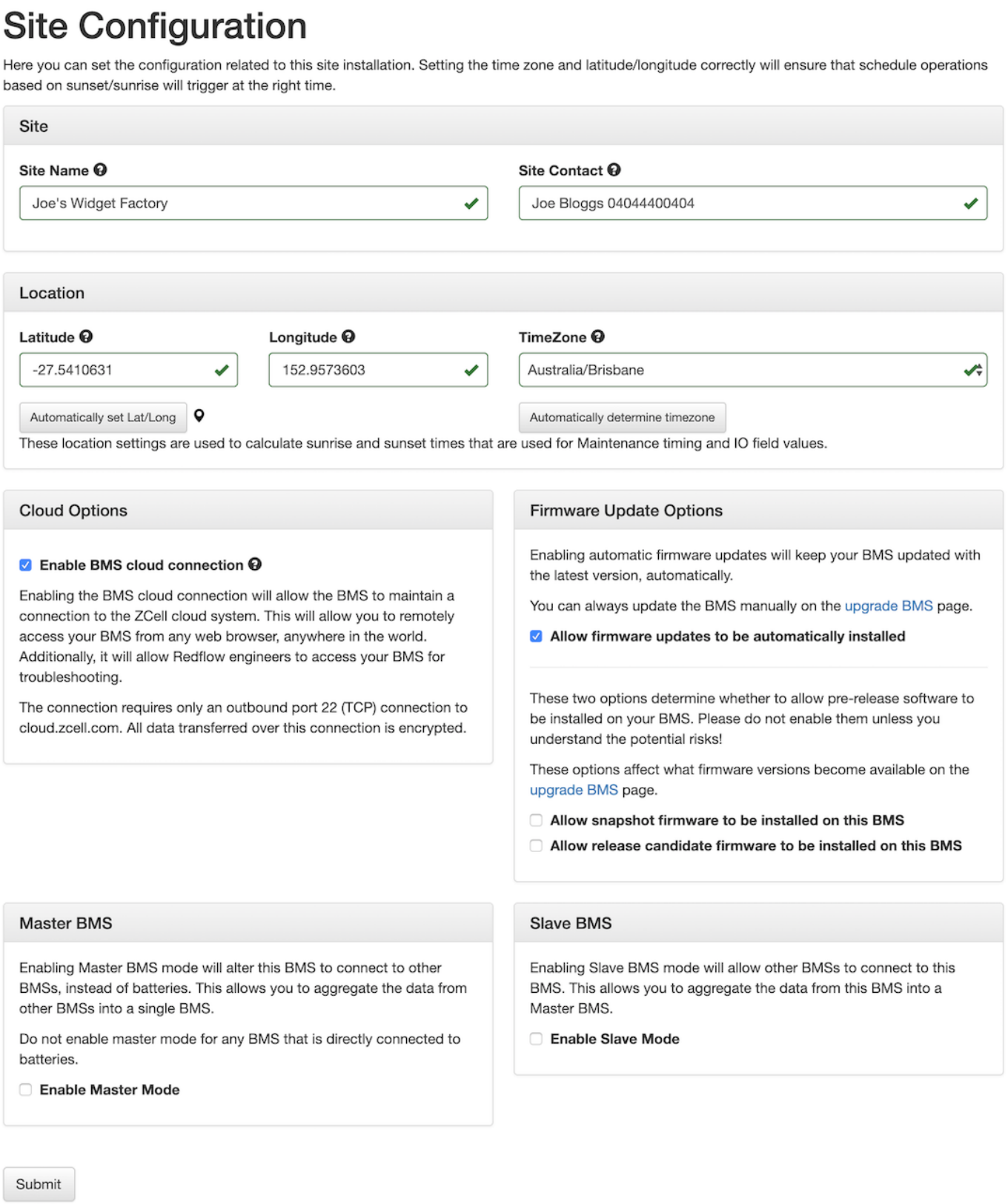


Figure 2: Site configuration page

After making changes to any of the settings on this page, press the Submit button at the bottom to save the configuration to the BMS.

Name And Contact Details

The “Site Name” and “Site Contact” details should be filled in with a descriptive name of the site, and relevant contact details for the primary contact. They are freeform text fields.

Getting these details correct is important for both your own benefit (being able to easily differentiate between multiple systems you manage) and Redflow being able to reach the system contact in the event of some sort of problem.

Site Location

The site location is determined by the latitude and longitude settings. These settings allow the system to accurately compute the sunset and sunrise times - which is very important to be able to properly schedule battery maintenance - ensuring it lines up with the solar day.

As it is used for that purpose, there is no need for it to be extremely accurate. If you are concerned about the privacy implications, feel free to obfuscate the accuracy of the lat/long values there to a nearby location, or just reduce the number of decimal places stored. This should have a minimal effect on the accuracy of the sunset/sunrise calculations.

There is a button to set the lat/long automatically - this uses your web browser on your device to fetch that information (when you press it you may be prompted to allow the page to access this information).

NOTE that this sets the latitude/longitude based on the *device you are currently using*. If you are accessing the BMS remotely, this will result in an *incorrect* setting.

Next to the button there is a small map icon - clicking this will result in a window popping up with that location on google maps - use this to confirm the latitude and longitude you have entered are correct.

Just as with the other settings on this page, if you make changes here click the “Submit” button to save them.

Time Zone

The BMS will automatically keep its internal clock accurate via the internet, if available. Setting the time zone accurately has no bearing on the internal time used, but will affect the display of the time on the BMS, and the display of logs. Use the time zone that makes the most sense - typically whatever the local time zone is where the BMS is located.

See the Date and time configuration section for details on setting the date and time manually.

Cloud

The “Enable BMS cloud connection” option is on by default.

If you do not want your BMS to be available via the cloud, you can untick this option and click “Submit”. If you are currently accessing the BMS via the cloud then this will result in you no longer being able to do so!

Undoing this will require local access to the BMS.

Note that this will also prevent Redflow engineers from being able to access the BMS, or pro-actively identify any problems with your system.

Consult the Network configuration section for more information on configuring networking.

BMS Firmware Update Options

There are several firmware update options. These options apply to the BMS firmware, not the battery firmware.

The first “Allow firmware updates to be automatically installed” indicates to Redflow that you permit the BMS to be automatically upgraded. If you have this checkbox ticked, and we deem a remote upgrade to be essential for correct operation we will automatically upgrade your BMS software. If not, upgrades will have to be performed manually.

The last two options, “Allow snapshot” and “Allow release candidate” dictate whether or not this BMS is eligible for upgrading to non-release firmware versions. Typically you would not change these unless instructed by Redflow engineers.

BMS Master

This option turns the BMS into a BMS Master. This allows aggregation of data from other BMSs to be displayed and used in the BMSs. Note the ‘BMS Slave’ option must be enabled on the slave BMSs.

BMS Slave

This option allows other BMSs to collect data from this BMS.

It is important that the BMS be configured with the correct date and time. It uses this internally for many important functions, including scheduling battery maintenance and logging. If the time and/or date are incorrect, these functions will not work correctly.

That said, the default configuration is for the date and time to be set automatically via the internet, and if an internet connection is available, no manual setting of these values is necessary.

The configuration page can be reached via the top menu - choose “Configuration” and then “Date and Time”.

Setting The Date And Time

The ‘Date and Time’ configuration section has several standard pull-down widgets to select the current date and time, and a button to set the time automatically from your browser.

Note that when setting the time from your browser, care should be taken if you are accessing the BMS remotely and are located in a different time zone to the BMS.

See fig. 3.

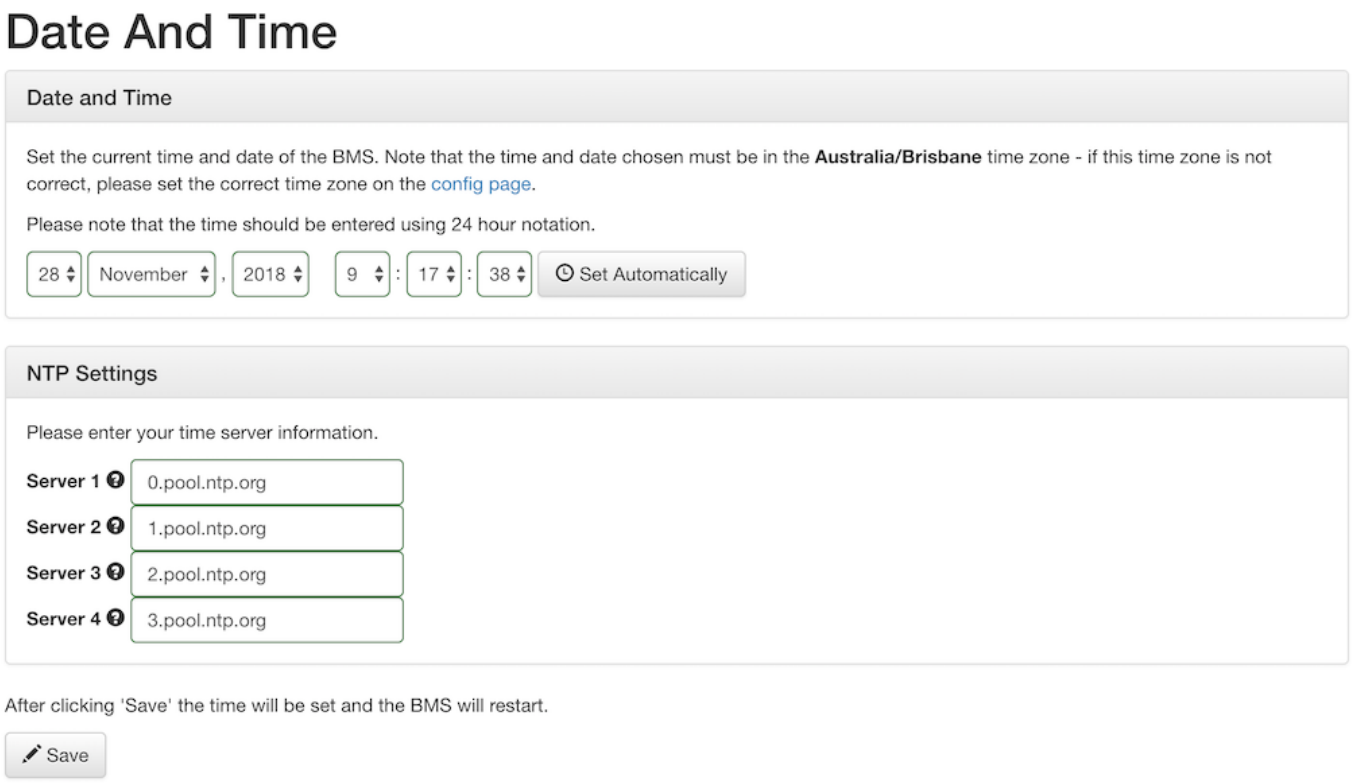


Figure 3: Date and time configuration
When the correct time has been set click the ‘Save’ button - this will set the values and restart the BMS.

Note that for the time and date to be set correctly the BMS time zone must also be correct. If the time zone setting displayed here is not correct, click the link shown on the page to reach the site configuration page and set that correctly first.

NTP Settings

The BMS also uses NTP to keep the time up to date. The ‘NTP Settings’ section can be used to configure your own NTP servers. You can usually leave these settings as the defaults, but some network configurations will block NTP requests but provide an internal server. Please contact your network administrator if this is the case.

Note that you can check the status of NTP on the ‘System Information’ page.

When the correct NTP servers have been set click the ‘Save’ button - this will set the values and restart the BMS.

Overview

The BMS is a fully network-enabled device. It is remotely accessible, to give you the ability to access your system from anywhere in the world, and to enable Redflow engineers to pro-actively monitor for faults.

The options available in the BMS allow it to integrate with the vast majority of existing network environments. Networking is a complex topic and this document can not hope to be an exhaustive guide on all possible options. Integration with most “standard” network environments should be easy, however in all cases you should seek both permission and guidance from the local network administrator before connecting anything to the network.

While we refer to the “network” in this chapter we are referring to the local network infrastructure, not the internet (though that local network infrastructure may also provide internet access).

Unsupported technologies

- 802.1X

802.1X authentication is not supported by the BMS.

- WEP authentication (WiFi)

WEP is an outdated and insecure encryption standard and is not supported by the BMS.

Making Configuration Changes

There may exist a “chicken and egg” problem with respect to configuring the network. Since the BMS has no screen or keyboard, there is no way to configure the network without an existing network connection. The BMS offers several solutions to this problem:

- Use an ethernet connection, at least temporarily

Ethernet connections are generally plug and play. It may be useful to plug the BMS into a hard-wired connection, configure the wifi correctly, and then relocate it to the ultimate destination.

- Use the built in wifi access point

The built in wifi of the BMS is initially configured as an access point (as opposed to a wifi client) - this allows you to connect directly to it with your computer or mobile device, and then reconfigure it as a wifi client to connect to the real access point.

Both of these options are discussed below.

Ethernet Connections

Ethernet is the easiest and most reliable way to connect the BMS to the network. In addition to being reliable by virtue of being a hard-wired connection (as opposed to a wireless connection), ethernet networks are almost always “plug and play” - no configuration is needed.

As such, an ethernet connection is always the preferred option, when the option is available.

The BMS has an on-board 10/100 ethernet port. It can be connected to a network switch via a standard UTP patch cable.

Once physically connected, check the LED indicators on the BMS. There are two LED indicators - green and yellow - they are physically located on the network port.

The green LED will be either lit or flashing for a connected ethernet connection. If the LED is not lit, there is a fundamental cabling problem - things to check:

- bad/unplugged cable
- remote switch port is not enabled

The yellow LED may or may not be lit. If it is lit it indicates the presence of a 100M connection. Not lit indicates a 10M connection. There are no significant bandwidth requirements for the BMS, and there is no need to provision a 100M connection over a 10M connection.

When the BMS is connected to a network with internet access, it will automatically make a connection to the Z-Cell cloud. You can use the Z-Cell cloud service to determine the local IP address for the BMS. Providing your device (computer or mobile device) is connected to the same network, you can visit the following page:

```
https://cloud.zcell.com/where
```

If there are any BMS's on the same network, you will see them listed here.

You may also be able to discover the IP address from the local router or network administrator, though there is no standard way to do that - consult the router documentation or talk to the local network administrator.

Once you have discovered the local IP address by either means, you can connect to the BMS directly via the following address:

```
http://x.x.x.x:3000
```

Where x.x.x.x is the IP address.

Setting custom ethernet settings

Once the BMS is connected to the network and accessible in the web browser, it is possible to set custom settings. It might be required to set a static IP address, or some other custom settings.

Access the BMS (as detailed above), and click Configuration -> Network in the top menu. Click the "Ethernet" tab. See fig. 4.

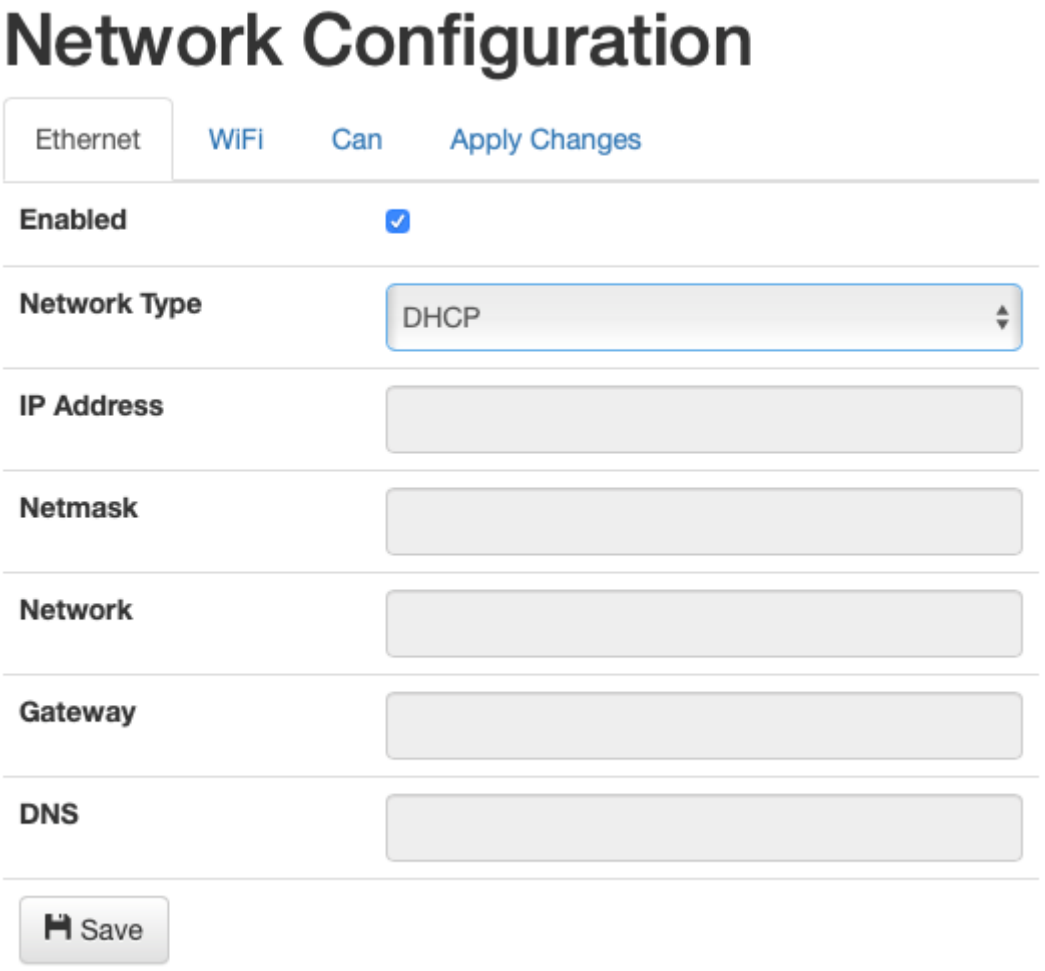


Figure 4: DHCP Ethernet Configuration
The default is for DHCP to be used - which automates all aspects of the network configuration as per the policy of the local network.

Click on the dropdown for "Network Type" and choose "Static" if you need to setup a static configuration. An example is shown in fig. 5.

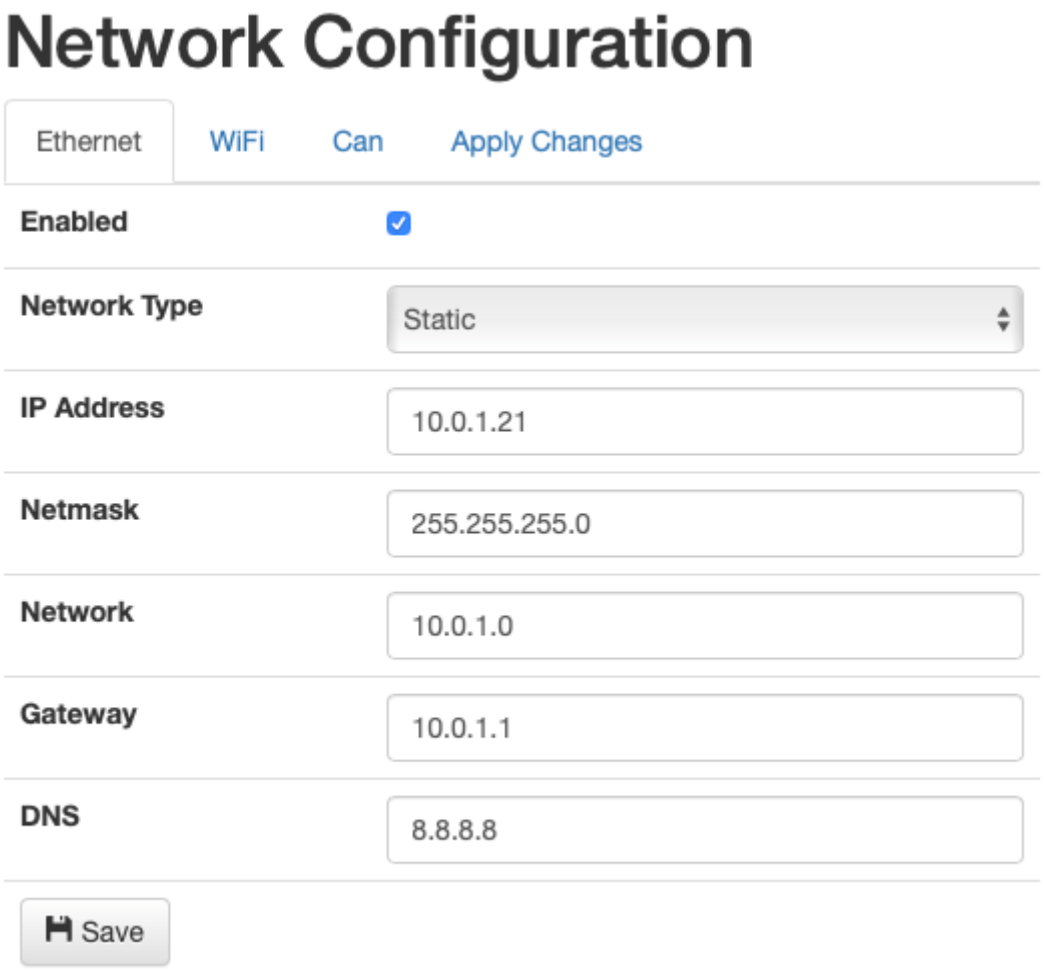


Figure 5: Static Ethernet Configuration
Please note that static configuration should be done with care and in consultation with the administrator of the network. Incorrect values not only are unlikely to work, they may actually cause problems with other devices on the network.

After making changes, click “Save”, change to the “Apply Changes” tab and hit “Restart”.

WiFi

By default, the BMS is setup as a wifi access point - this means you can use your computer or mobile device to connect directly to it.

Enable the wifi and search for access points - you should see one of the form:

```
zcell-bms-xxxx
```

Where ‘xxxx’ is 4 random characters. Connect to this access point, using a password of:

```
zcellzcell
```

Once connected, open your web browser and go to:

```
http://zcell:3000
```

If that does not work, try:

```
http://172.16.29.241:3000
```

Setting custom wifi settings

Once the BMS is connected to the network and accessible in the web browser, it is possible to change the wifi settings.

Access the BMS (as detailed above), and click Configuration -> Network in the top menu. Click the “WiFi” tab. See fig. 6.

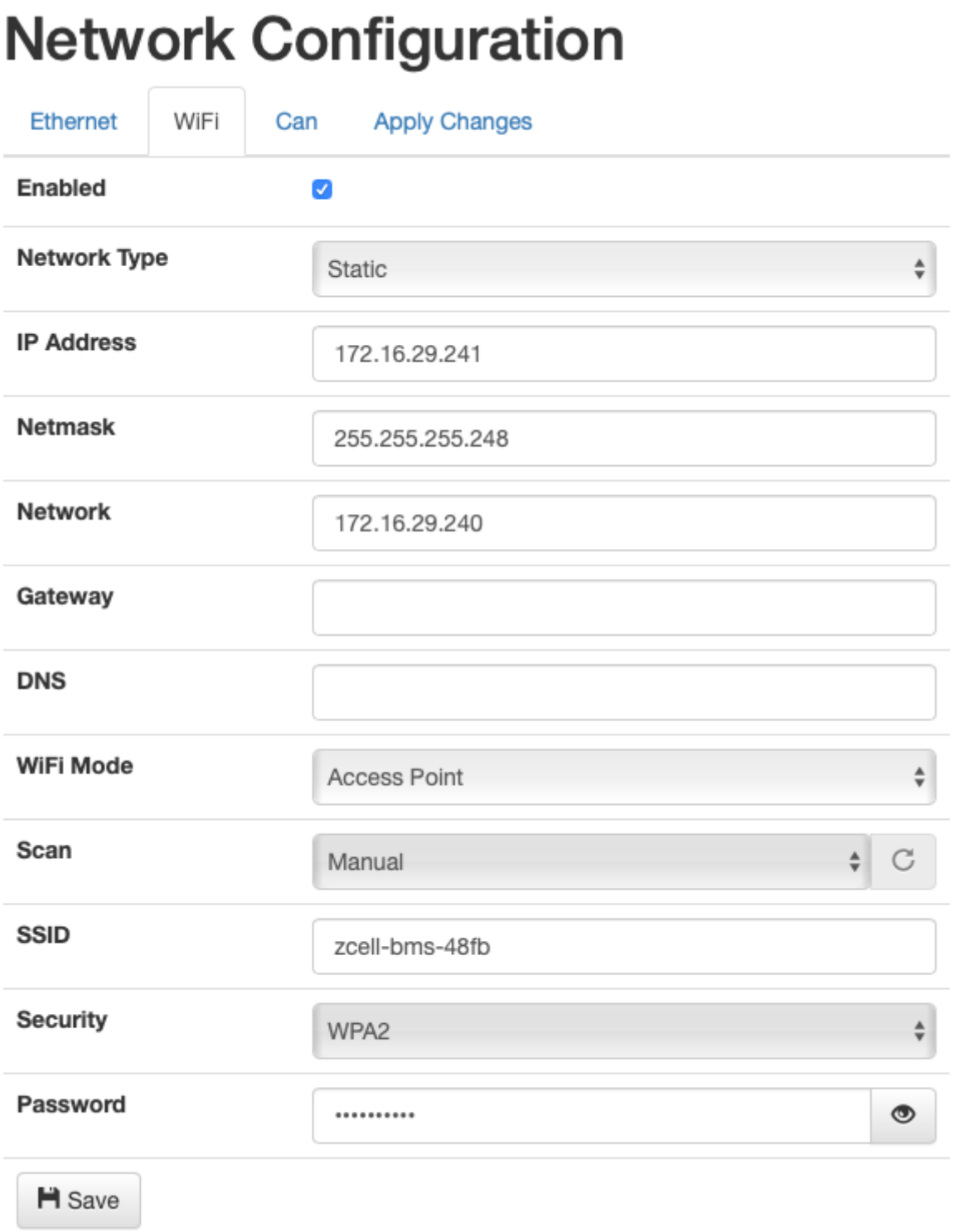


Figure 6: Default wifi configuration (AP mode)

In this default mode, the BMS acts as an access point, allowing you to connect to it via your computer or mobile device. Unless you are connecting the BMS via ethernet, you will generally want to change these settings to put the BMS into client mode, and connect to another AP.

Follow these steps:

- Change the “Network Type” to “DHCP”
- Change “WiFi Mode” to “Client”
- Click the “scan” button to the right of the “Scan” section - it should start spinning for a moment
- Once the scan is complete, click on the left hand part of the “Scan” section - it should contain a list of the local AP’s that can be detected. Choose the appropriate one. This will fill out the “SSID” field
- In the (unlikely) case that you need to connect to an AP with a hidden SSID, you can just type the SSID in directly instead of scanning.

- Choose the appropriate Security type (almost always WPA2) and type in the password. Click the “eye” icon next to the password to make the password visible.

At this point you can click “Save”, switch to the “Apply Changes” tab and press “Restart”.

Resetting Network Settings

If network settings are incorrectly entered, it may be necessary to reset the settings to defaults to regain access. Doing so will not lose any other settings.

See the Resetting the BMS settings chapter for details on restoring the network settings to defaults.

Cloud Access

Getting remote access to the BMS is easy via the Z-Cell cloud service.

After getting local access to the BMS, contact Redflow to have the BMS added to your account.

CAN

The CAN network is for the BMS to communicate with other CAN-equipped devices (such as inverters).

CAN networks are much simpler to configure than TCP/IP networks, and as such there are only two options available. See fig. 7.

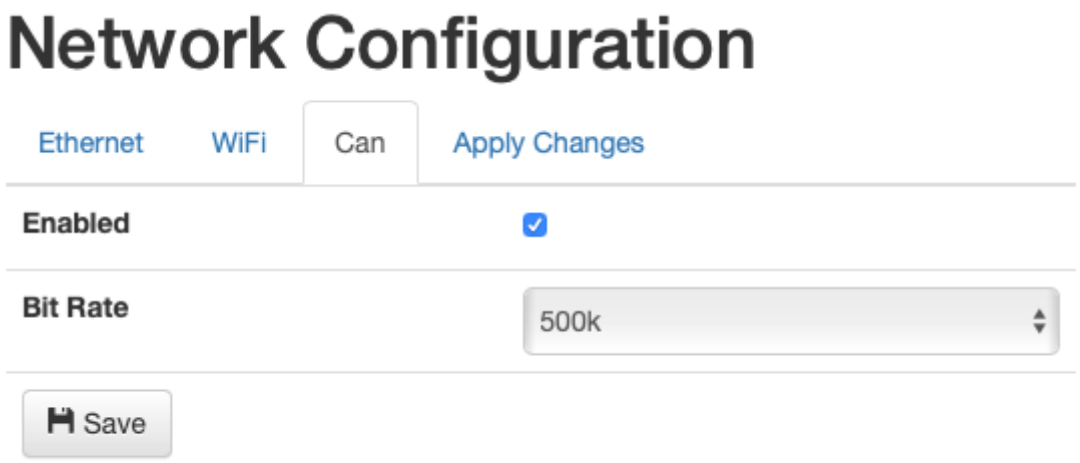


Figure 7: CAN configuration
The Bit Rate should match the equipment you are connecting it to - consult the documentation for the other device.

You can also disable the interface if you choose. However, there is no harm in leaving the CAN interface enabled, even if there is no CAN network attached.

Modbus Concepts

The BMS communicates with the ZBMs via the Modbus protocol. While an in-depth knowledge of Modbus is not required to use the BMS and connect the ZBMs, a few key concepts are necessary to assist with having a smooth installation, and dealing with any troubleshooting that is required.

- Modbus is a single master/many slave protocol

The BMS is the master, and the ZBM’s are the slaves. The BMS is the initiator of all communications, and will address queries to individual ZBM’s as necessary.

- ZBM’s must each have a unique Modbus address

Each ZBM is assigned a Modbus address, and this is the identifier that the BMS will used to communicate with that battery.

- If two devices have the same Modbus address, *neither device* will be able to communicate

From the BMS's point of view, neither of those devices will be on the bus at all. To remediate this, it will be necessary to unplug one device, renumber the other, then reconnect the first device.

- The Modbus RTU (serial) connection is a single, daisy-chained twisted pair bus

Each battery connects to either the next battery in the chain, or to a BMS, and may connect to another "downstream" battery.

These connections are via the RJ-45 connections on the underside of the control box on the front of the battery.

Note that the order that the batteries are connected in physically is *entirely* unrelated to the number that is assigned to them, though it is prudent to number them sequentially, as they are physically connected.

- All ZBM's come from the factory configured with a Modbus address of "99".

This means that if you are installing more than one battery, you must connect one at a time, renumber it and then add the next.

The numbering scheme is arbitrary, so number batteries in the way that makes the most sense for your installation.

Adding Batteries

The BMS makes it simple to add batteries.

Click the Configuration => Battery Setup menu.

You will be presented with an interactive page for adding batteries - see fig. 8.

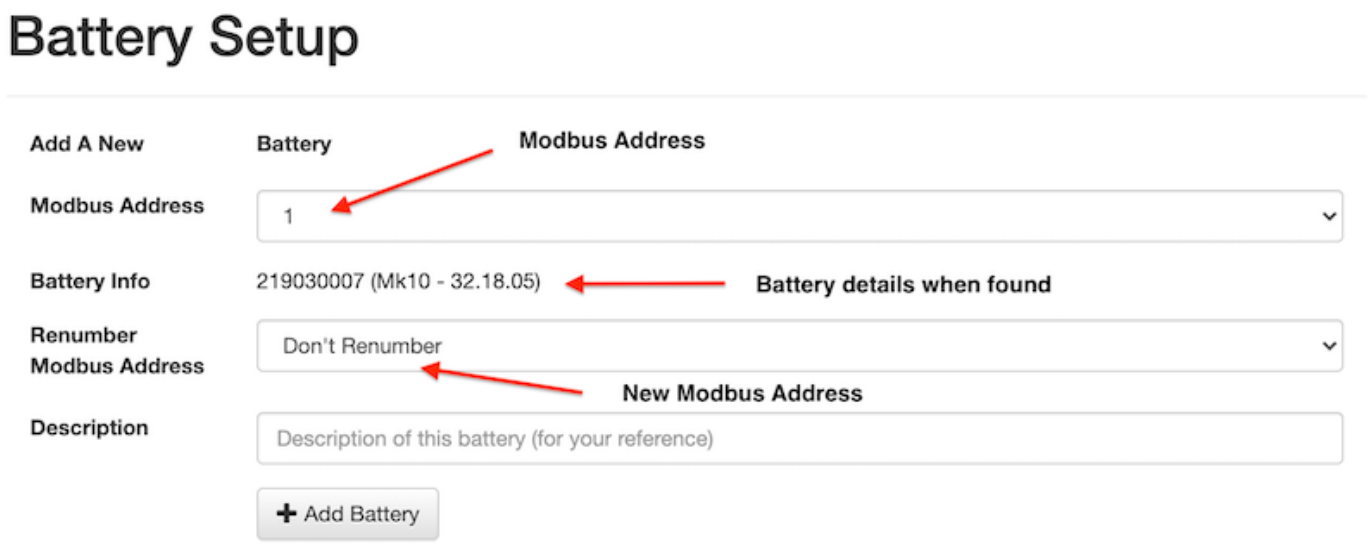


Figure 8: Adding batteries
At this point, you need to ensure the DC bus is energised so that the battery control electronics will be powered and communications are possible.

Each time you choose a number in the "Modbus Address" field, the BMS will continually scan for a battery with that number. When it finds a battery, you will see the "Battery Info" field change to show the serial number, controller type, and firmware version of the discovered battery.

Additionally, the BMS will automatically scan for a battery with a modbus id of '99'. If one is found, it will select that modbus adddress immediately. In this case it will automatically select the next available modbus address for the "Renumber" field.

Note that if you see "No Battery Found" after choosing a Modbus Address, the BMS cannot communicate with a battery at that address, and there is no point continuing until you have resolved the communications problem.

There are several potential reasons for this failure:

- incorrect Modbus address chosen (does not match battery)
- Modbus address conflict (more than one battery on communications bus with that number)
- DC power down or insufficient to power battery electronics
- bad RS-485 wiring

The serial number field refreshes every few seconds to assist in debugging the problem.

Once the battery is detected, you may want to choose a new Modbus address for this battery (in the "Renumber" field) and

optionally type in a description.

Clicking “Add battery” will add the battery to the system, and you can repeat the process for the next (if any).

Typically, for a new installation, you will have several batteries all on the same Modbus address - #99.

In that case, it will not be possible to add them unless you disconnect all but one. The easiest way to achieve that is to disconnect all but the battery closest to the BMS, add and renumber it, then connect just the next one, add and renumber, and so on until all batteries are numbered. There is no need to disconnect the DC power, just the communications cable.

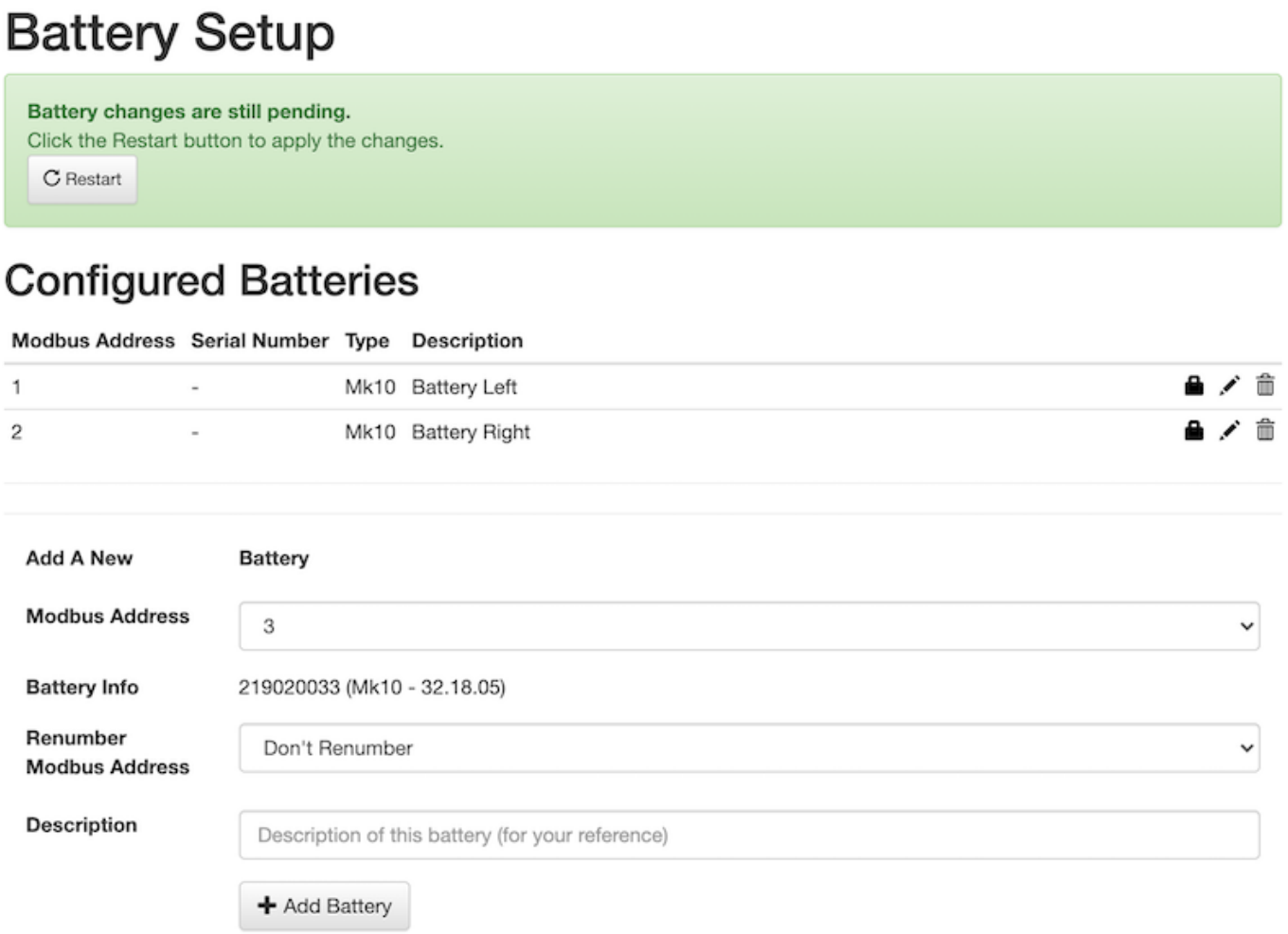


Figure 9: Adding batteries - finishing

Once the process is complete, you must restart to finalise the changes - see fig. 9. Click the “Restart” button and the BMS will restart with the new battery configuration.

Bringing Them Online

New batteries will start in an “offline” state. To bring your batteries online, follow the following steps.

Click the “Status” menu to return to the main status screen.

You will see a status line for each battery - showing as “offline”. Click anywhere on the line to show the battery detail page. It will look like fig. 10.

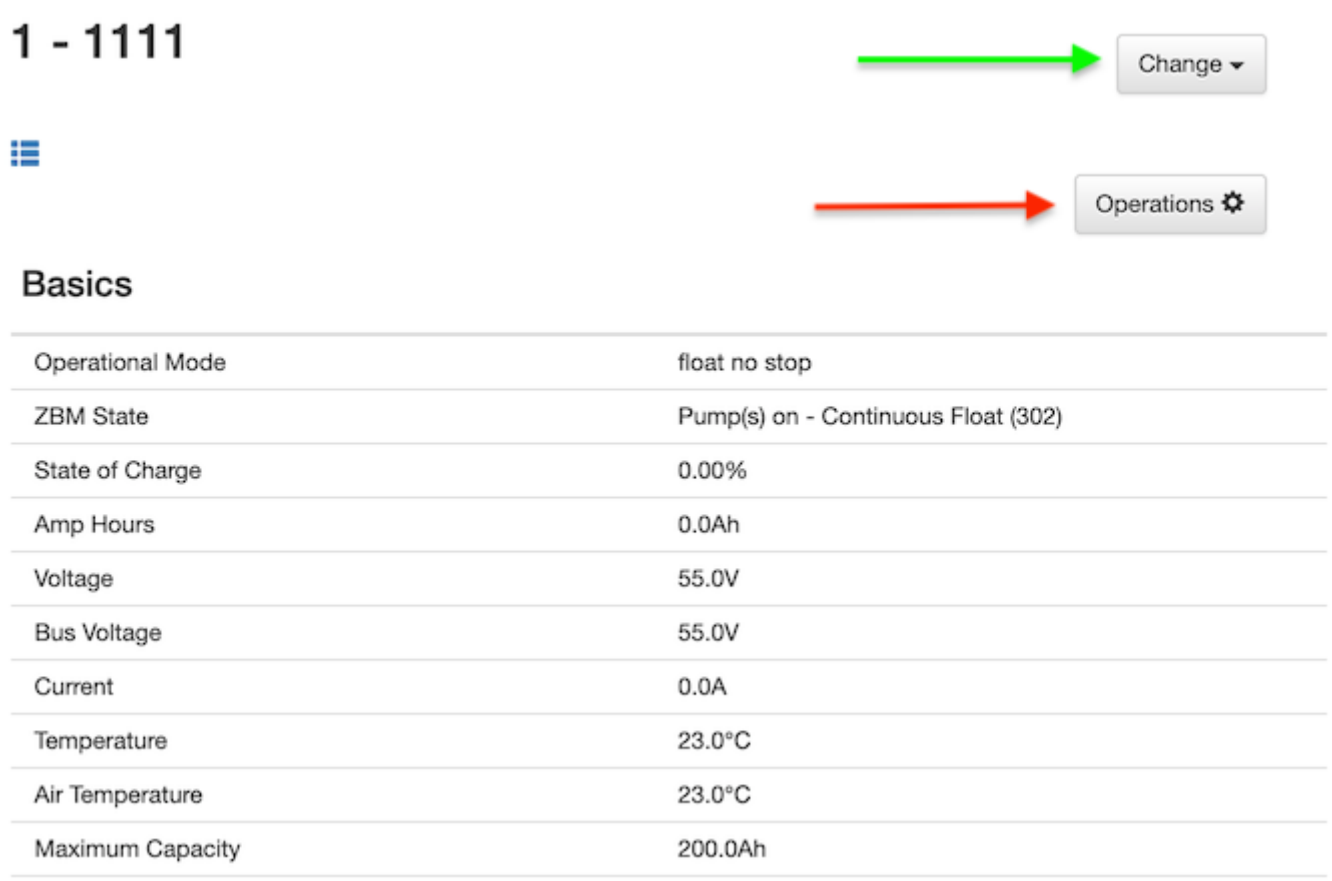


Figure 10: Bringing batteries online
As a shortcut, you can change between batteries with the dropdown in the top right hand corner (green arrow).

As shown by the red arrow, click the ‘Operations’ button to go to the battery operations page - see fig. 11

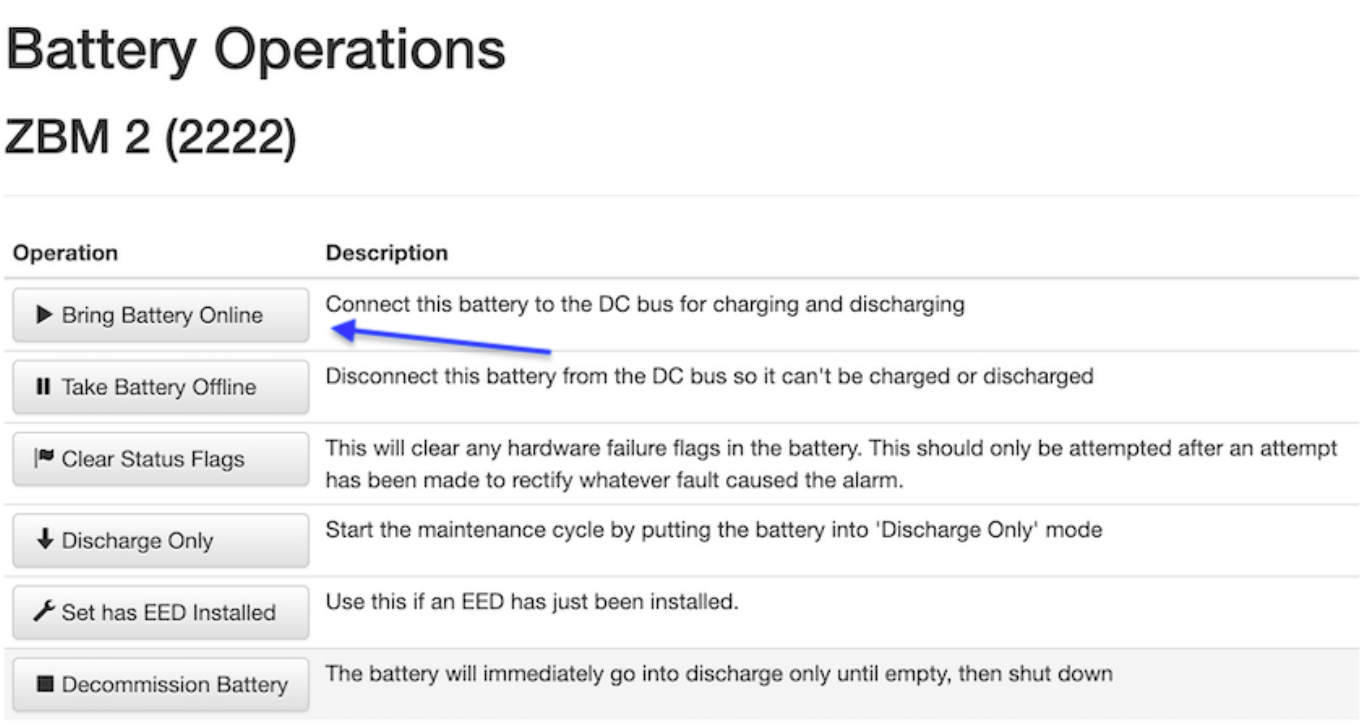


Figure 11: Battery Operations
As shown by the blue arrow, click the ‘Bring Battery Online’ button.

Once online, the batteries will connect to the bus, and if sufficient voltage is available, start charging.

Editing Batteries

You can change the configuration of existing batteries in two ways - you can change the description, or controller type, or renumber them.

All of these options are available by clicking the edit (pencil) link for the battery you wish to modify. The editing screen will be displayed, see fig. 12.

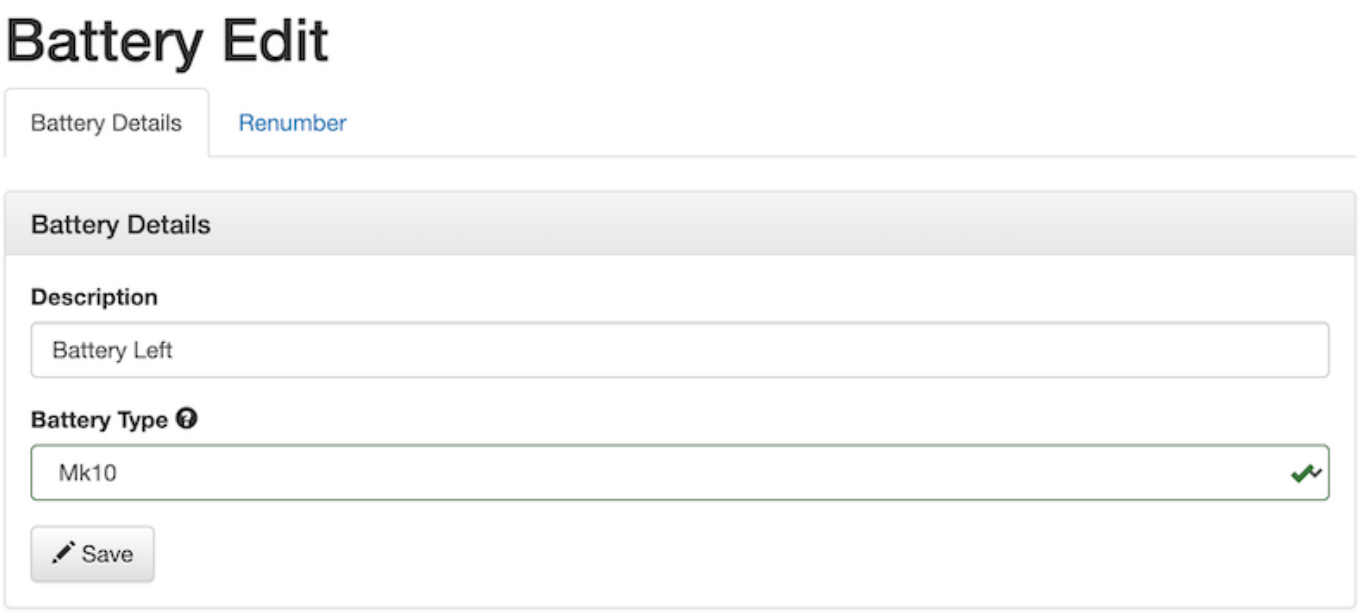


Figure 12: Battery Editing

Changing the description

To alter the description, simply type a new description in the field and press the “Save” button.

Renumbering a battery

Clicking the ‘Renumber’ tab will display the renumber page, see fig. 13.

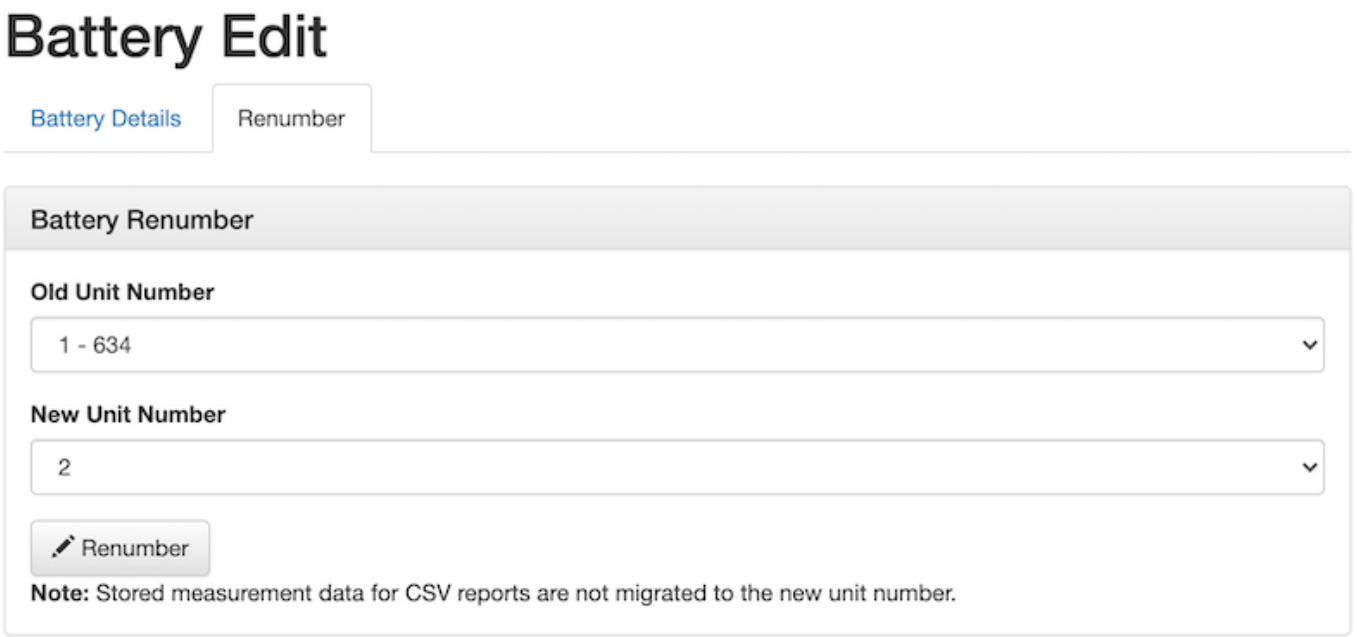


Figure 13: Battery Renumber
Sometimes you may need to renumber batteries (for example, if you are installing a new battery, or to match your physical battery installation).

Renumbering a battery is actually performing two operations:

- renumbering the physical battery (its modbus address)
- renumbering the battery in the BMS config

If these two operations are not done at the same time, communications with the battery will be lost. Renumbering via this tool will perform both operations.

Ensure the correct battery is chosen in the “Old Unit Number” selection, and choose the desired “New Unit Number”.

When you press “Renumber”, both operations will take place and the BMS configuration will be saved.

Removing Batteries

It is important to remove batteries from the configuration if they are not in use by the energy system (due to a fault, or deliberate de-commissioning). If the battery is still configured but not operational, the BMS will not be able to make correct decisions in the scheduler and other parts of the system.

To remove a battery from the BMS configuration, simply click the delete button in the configured battery list. See fig. 14.

Figure 14: Deleting a battery
Deleting a battery does not affect its operation in any way. If you intend to remove a battery due to a fault, contact a Redflow engineer first to ascertain the correct decommissioning procedure.

Overview Of Battery Maintenance

For peak performance of the battery it is important that regular maintenance is performed. The BMS can automatically schedule and trigger this maintenance based on the use and work load of individual sites.

To perform this maintenance the battery must drain all of its energy and will not be able to be charged or discharged during the maintenance window which is usually around 2 hours.

As the battery must be discharged to perform the maintenance, the first stage of the maintenance is a discharge only state where the battery cannot be charged. This discharge cycle can either be scheduled by time, or triggered by when a battery starts discharging. See Discharge Cycle Triggers section for more details.

Once a battery has started it’s Discharge Cycle, there are various conditions that must be met before the BMS will move the battery to its full Maintenance Cycle.

Newer batteries should be shipped with Energy Extraction Devices (EED) installed. The EED helps to discharge the battery once they enter the full Maintenance Cycle. EEDs do have current limitations, so if a site has a high load, it may be useful to delay the full Maintenance Cycle.

Basic Maintenance Configuration

The basic maintenance section contains the most commonly changed settings. See fig. 15

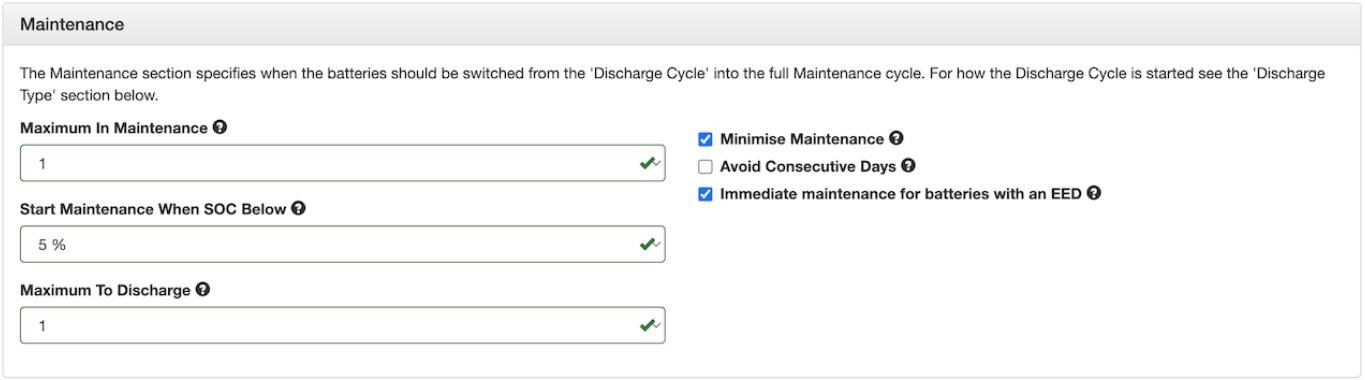


Figure 15: Battery Maintenance
“Maximum In Maintenance” will limit the number of batteries that the BMS will change from the Discharge Cycle to full Maintenance state at once. Care must be taken when setting this number on larger systems to make sure all batteries can perform their maintenance in the frequency and window required. The rule of thumb for this value is usually the number of batteries in

the system divided by 3 rounded up.

“Maximum In Discharge” will limit the number of batteries that the BMS will trigger into the Discharge Cycle at once. Either by the Schedule or the Discharge Events components. In most cases this number should be the same as the “Maximum In Maintenance” setting above, but can be used to make batteries perform their full maintenance with the EED enabled in series rather then in parallel.

“Minimise Maintenance” provides an option to push out maintenance for a long as possible while still conforming to other settings. In ‘Event Based’ mode, batteries will only be put into the Discharge Cycle when within 24 hours of their maintenance timer. In ‘Scheduled’ mode this will push the Discharge Cycle out as close as possible to the maintenance timer without going over.

“Avoid Consecutive Days” is only applicable to ‘Scheduled’ Discharge triggering and will cause the BMS to do it’s best to spread the maintenance out with a day in between triggering the Discharge Cycle.

“Start Maintenance When SOC Below” specifies the state of charge a battery must be below before the BMS changes the battery from the Discharge Cycle to the full Maintenance Cycle. This setting will be ignored when a battery has an EED installed and the “Immediate maintenance for batteries with an EED” setting is enabled.

“Immediate maintenance for batteries with an EED” will make the BMS change the battery from the Discharge Cycle to the full Maintenance Cycle as soon as possible when an EED is installed.

Note that the transition from the Discharge Cycle to the full Maintenance Cycle will be delayed until the discharging current drops below 20A for batteries with an EED installed and 5A for batteries without an EED installed.

All settings except “Maximum In Maintenance” should be left as the defaults for most installations.

Maintenance Timing

This section allows for the changing of the maximum time between maintenance cycles. This should be left as the default unless instructed by Redflow Engineers.

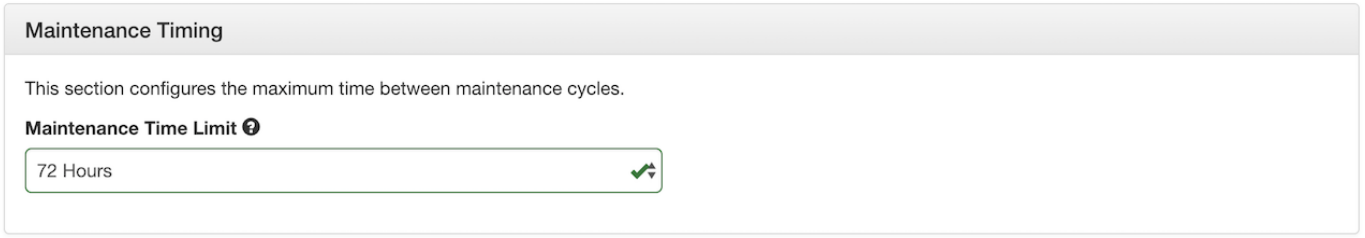


Figure 16: Maintenance Timing

Capacity Limiting

As the batteries need to be discharged before the maintenance cycle, it can be useful on low load systems to limit the battery’s capacity leading up the the maintenance cycle. See fig. 17

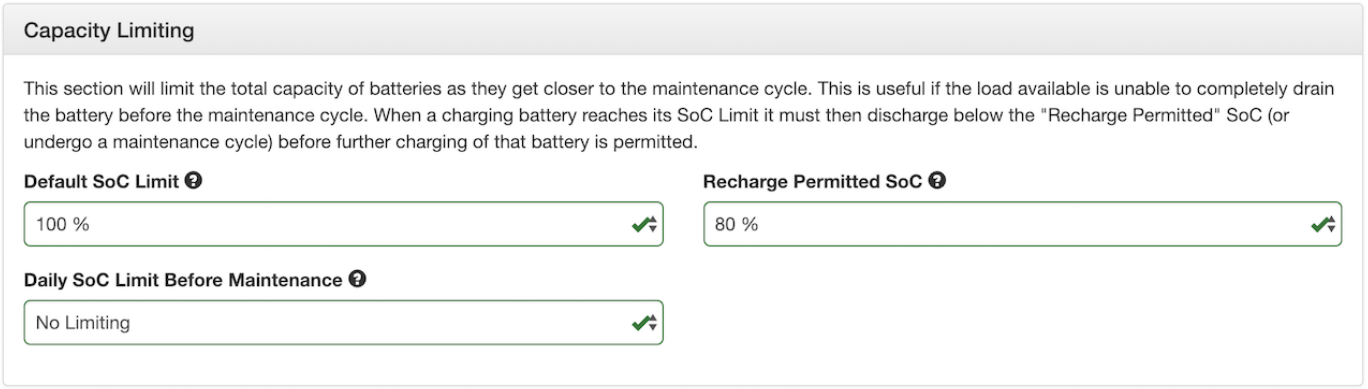


Figure 17: Capacity Limiting
“Default SoC Limit” is the default maximum state of charge for a battery. A battery will stop charging once the state of charge reaches this value.

“Recharge Permitted SoC” is the state of charge before a battery will start charging again after reaching the “Default SoC

Limit". Note that when the state of charge limit is dynamically changed, charging will start at at least 5% less than the SoC limit. e.g. if the State of Charge is dynamically limited to 50%, charging will only be permitted again once the state of charge reached 45%.

"Daily SoC Limit Before Maintenance" determines how much the state of charge will be limited by leading up to maintenance. The state of charge will be dynamically limited by this amount each 24 hours before the maintenance cycle is due for up to 3 days. e.g. if the Default SoC Limit is 100% and this value is 10%, 1 day before maintenance the SoC will be limited to 70%, 2 days before maintenance 80%, and 3 days before maintenance 90%.

The limit change is only applied when a battery is discharging, as some systems can experience issues if charging is stopped abruptly.

System Charge/Discharge Limiting

Another way to help discharge batteries before maintenace is to limit the entire system's capacity. This can leave one or more batteries with available capacity for another battery to dicharge into. See fig. 18

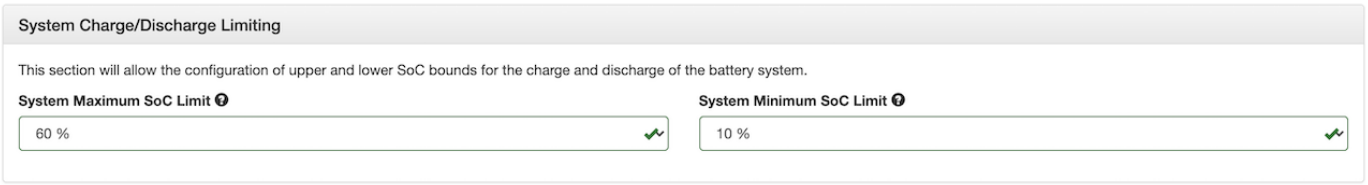


Figure 18: System Capacity Limiting
"System Maximum SoC Limit" is the level above which the BMS will signal a permitted charge rate of zero, in order to stop further battery charging. This setting can be reduced from the default of 100% if the overall battery system must have some 'headroom' left in it at all times. This headroom can then allow battery maintenance processes to operate normally - without 'discharge deadlock' - on a site where there is very low (or no) typical overnight energy discharge occurring into customer loads and where no alternative destination for battery discharge energy is routinely available (e.g. UPS applications and/or off-grid sites).

"System Minimum SoC Limit" is the level below which the BMS will signal a permitted discharge rate of zero. The intention is to use this setting if a multiple-battery system needs to be operated such that at least one battery has at least some charge in it at all times. This can ease system integration in some energy systems that are unable to smoothly manage having all batteries completely discharged at the same time.

Discharge Cycle Triggers

This is to select the type of Discharge Cycle triggering that is appropriate for a sites operation. There are several factors that determine which type of trigger is best for a site, these include but are not limited to; the load characteristics, energy source, grid connection, and availability requirements.

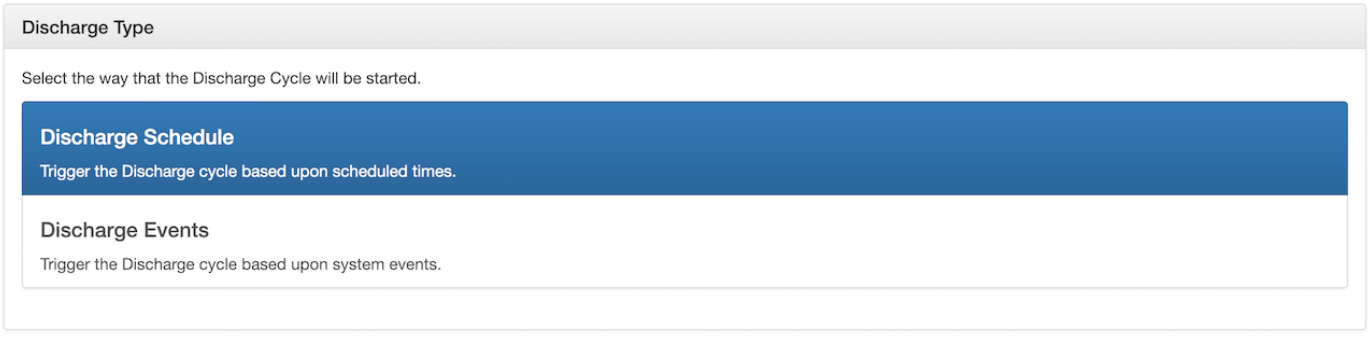


Figure 19: Discharge Cycle Triggers
The selected type will be highlighted in blue, and the form below will change automatically depending on the type selected.

Scheduled

Scheduled maintenance is the most common type of triggering and can by used in most types of installations. It allows for solar energy shifting, and time of day availability. It is important that the correct time zone and location are set in the Date and time configuration and Site configuration sections respectively.

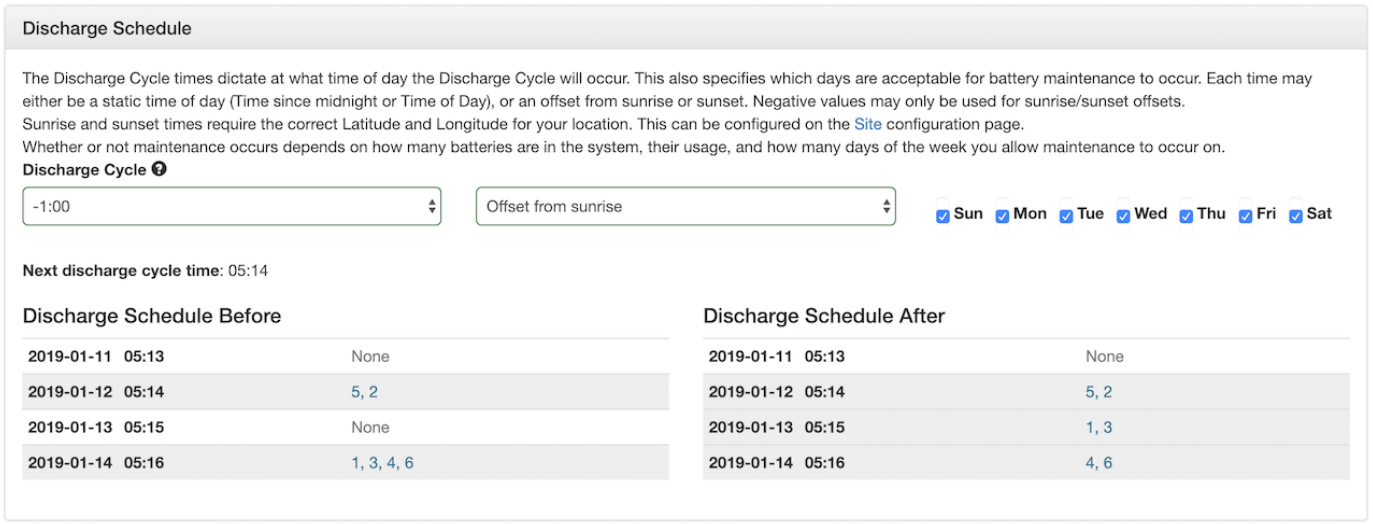


Figure 20: Scheduled Triggers

The first thing that needs to be selected is the time the maintenance should be scheduled. This can be at a time of day, or relative to sunrise or sunset. The first drop down will select the time, while second one selects what the time is relative to. e.g. To select at 1 hour before sunset, select '-1:00' in the first drop down and 'Offset from sunset' in the second. To select at 2pm every day, select '14:00' and 'Time of Day'.

The final configuration section allows the selection of which days of the week the maintenance should be scheduled. Note that the "Avoid Consecutive Days" setting above, which if enabled, will automatically insert days between maintenance times without the need to select specific days.

The last section is an informational display as to what the scheduler is expecting to perform. In this example, the maintenance of batteries is bought forward to conform with the "Maximum in Maintenance" of 2.

Event based

Event based maintenance is the less common type of triggering, but can be used to synchronise the maintenance to when the system is discharging rather than a time of day.

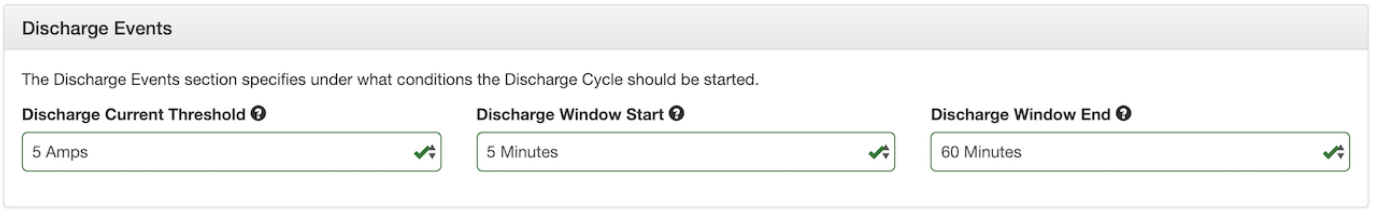


Figure 21: Event Triggers

The first setting is the current threshold. This is the rate at which the entire system must be discharging before any batteries are considered for maintenance.

The second two settings are related to time after the current threshold has been reached in which batteries will put into their Discharge Cycle. During this window, batteries will be put into the Discharge Cycle until the "Maximum in Maintenance" number has been reached.

Overview

The Digital IO system allows the BMS to interact with external devices, be that external devices responding to BMS data or the BMS responding to external devices.

Devices

This is the list of IO devices connected to or part of the BMS. See fig. 22

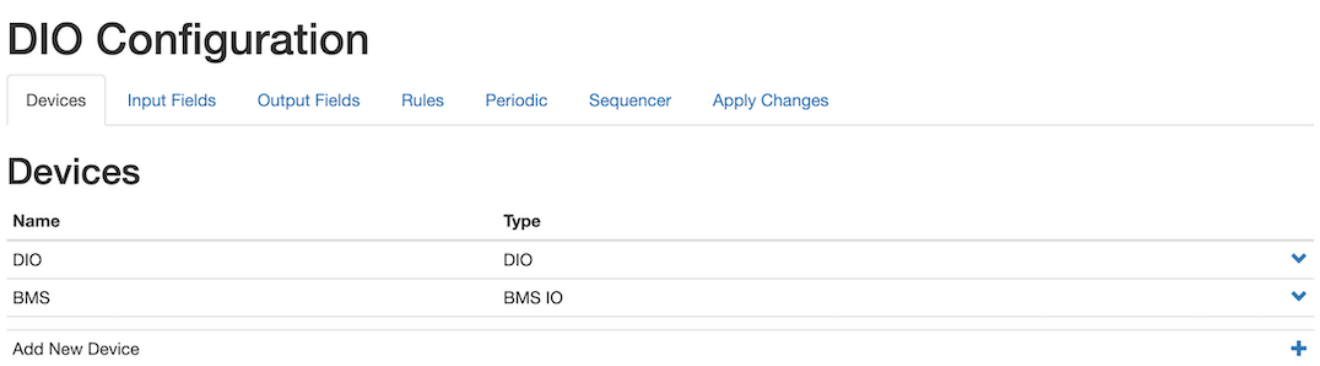


Figure 22: DIO Devices
There are 2 special devices.

The first ‘DIO’ which is a group of fields that contain aggregated and useful information as input into decisions the BMS can make. These include, but is not limited to things like ‘System State of Charge’, ‘Bus Voltage’, ‘Time of Day’, ‘Time till next Sunset’, etc. This device is configured and enabled by default.

The second special device is ‘BMS’, this contains access to the BMS’s hardware, including but not limited to, ‘Internal Buzzer’, ‘On Board Relays’, etc. This is not configured or enabled by default.

Other devices include, external (ftdi or usbhid) USB based relays, Acces IO USB devices, devices with modbus-tcp interfaces, and ZBM batteries.

Adding a Device

To add a device click the ‘+’ symbol at the bottom right of the ‘Devices’ tab. See fig. 23

Figure 23: DIO Device Add
Select the type of device to add, fill in it’s details, choose a name, and hit ‘Add’. Note the the ‘key’ should automagically be filled out from the name.

Note: The round question mark icon can be clicked on to view information about the device and fields.

Editing a Device

To edit a device, click the down arrow on the right of the screen. See fig. 24 The devices details will be displayed, and can be edited in place. Hit ‘Save’ to commit the changes. Note: ‘key’ cannot be changed after creation.

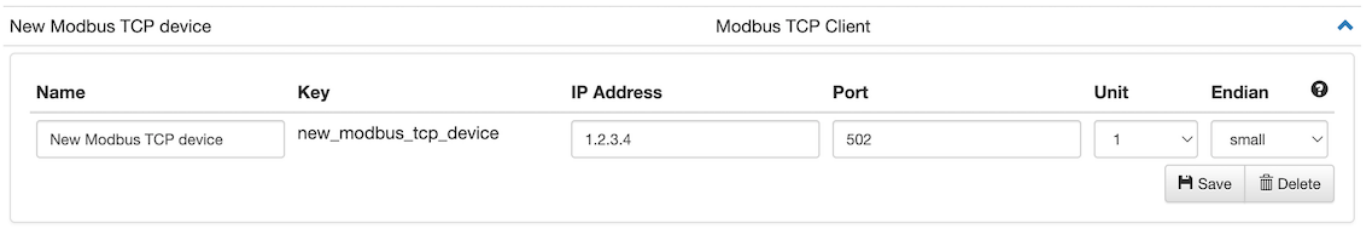


Figure 24: DIO Device Edit

Removing a Device

As the same as editing a device, click the down arrow on the right, and click the ‘Delete’ button. Note: the device must not be in use by any Rules or Periodic entries to be able to delete the device.

Input Fields

Input Fields can be created, edited and removed in the same fashion as devices, except you must select which device the field is for upon creation. See fig. 25

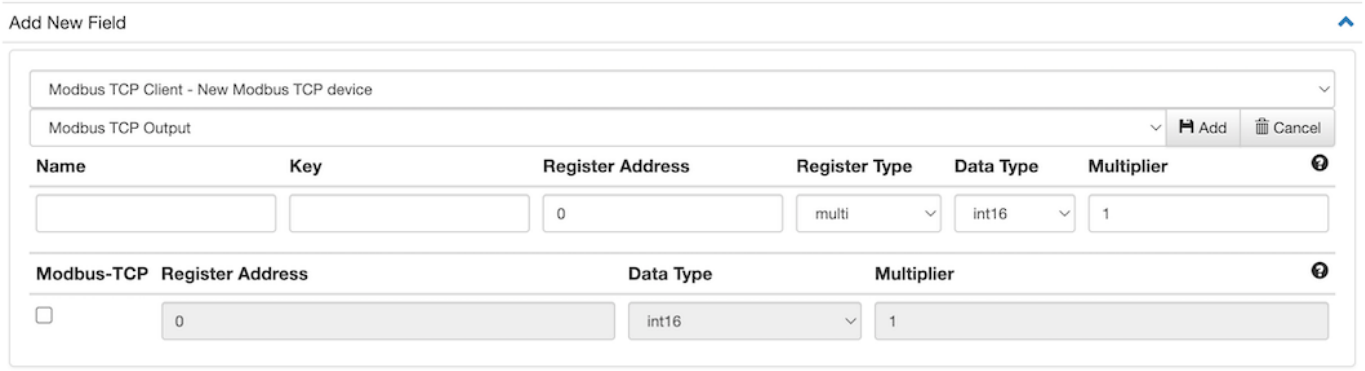


Figure 25: DIO Field Add

Optional ModbusTCP output

Just below the fields details is configuration for the BMS's internal ModbusTCP server. This enables this field to be able to be read by external devices over Modbus-TCP using unit number '201' and requesting 'holding' registers. If this field does not need to be read by an external device it can be left disabled.

Output Fields

Output Fields can be created, edited, and removed the same way as input fields. However they are used to as output's from the BMS. i.e. writing to external 'Modbus TCP devices' or 'Switch relays On and 'Off'. These will appear in the 'Destination' section of Rules Periodic entries.

Rules

Rules allow the BMS to control the output devices and field using the input devices and fields to make decisions. See fig. 26

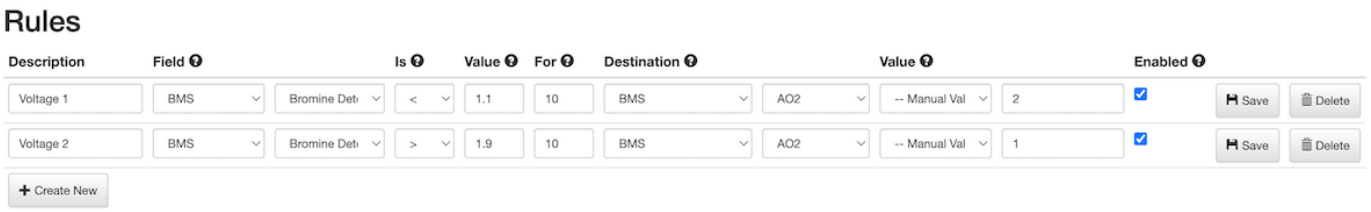


Figure 26: DIO Rules
To create a new Rule, hit the 'Create New' button, fill in the details and hit 'Create'.

The values can be edited in place and when finished making changes, hit 'Save' to commit the changes, or hit 'Delete' to remove to the Rule.

- The description should be the name of the rule, so it's purpose can be easily determined.
- The Field, Is, Value and For entries are used by the BMS to determine when this rule should trigger. Field is the device/field used to compare the Value to. Note that the rule will only trigger at the exact point when this logic evaluates to true.
- Destination is the device/field that should be changed when the rule is triggered.
- Value, is either a 'Manual Value', or an Input Field that will be written out to the Destination.
- Enabled allows the Rule to be disabled without having to delete it.

Periodic

Periodic entries allow values to be written to devices/fields at regular intervals. See fig. 27

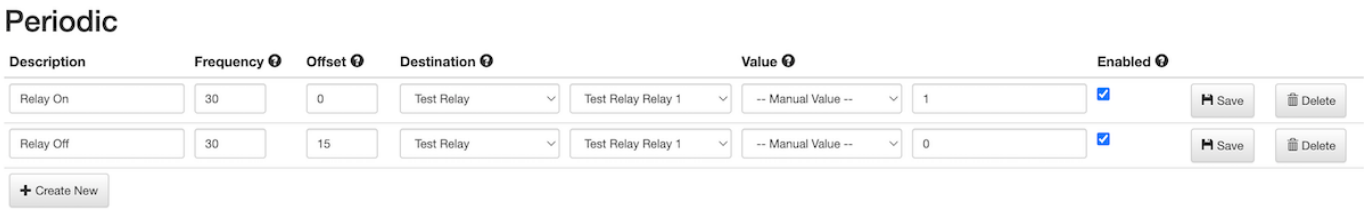


Figure 27: Periodic

To create a new Periodic, hit the ‘Create New’ button, fill in the details and hit ‘Create’.

The values can be edited in place and when finished making changes, hit ‘Save’ to commit the changes, or hit ‘Delete’ to remove to the Periodic.

- The description should be the name of the Periodic, so it’s purpose can be easily determined.
- Frequency and Offset control when and how often this Periodic should trigger. Frequency determines how long in between triggers, while Offset allow different Periodic to be spread out.
- Destination is the device/field that should be changed when the Periodic is triggered.
- Value is either a ‘Manual Value’, or an Input Field that will be written out to the Destination.
- Enabled allows the Periodic to be disabled without having to delete it.

Sequencer

This is currently only used by RedFlow Engineers. If interested in more complex decision making by the BMS, please contact RedFlow.

Apply Changes

Once finished making changes, the changes need to be applied to several services in the BMS. To do this, navigate to the ‘Apply Changes’ and hit the ‘Restart’ button.

Overview

Schedule

Charge Settings

Discharge Settings

Pre-Charge Settings

Introduction

Standby Power System (SPS) mode is a novel software-controlled operating mode that is supported by Redflow’s ZBM2/ZCell battery technology.

A battery in SPS mode acts less like a battery, and more like a software-driven, non-fossil-fuel, backup generator.

Once it is fully charged, an SPS battery can remain in its ‘hibernation/standby’ mode for extended periods (months) with no internal self-discharge.

Once called upon, the SPS battery starts up rapidly and then delivers all of its stored energy to support site energy requirements. Once fully discharged, the SPS battery completes routine maintenance and is then ready to recharge.

The typical use case for SPS mode is in multi-battery sites where a subset of batteries are charged and held in SPS mode as a ‘reserve power supply’. Routine site operation occurs with batteries in the standard ‘RUN’ mode, until or unless a deficit of site energy exists. This may be because of an extended period of low solar generation, or because of the failure of the on-site grid and/or generator systems.

In response to such an energy deficit, the BMS automatically activates one more more SPS batteries to deliver energy and support site operations with their stored energy.

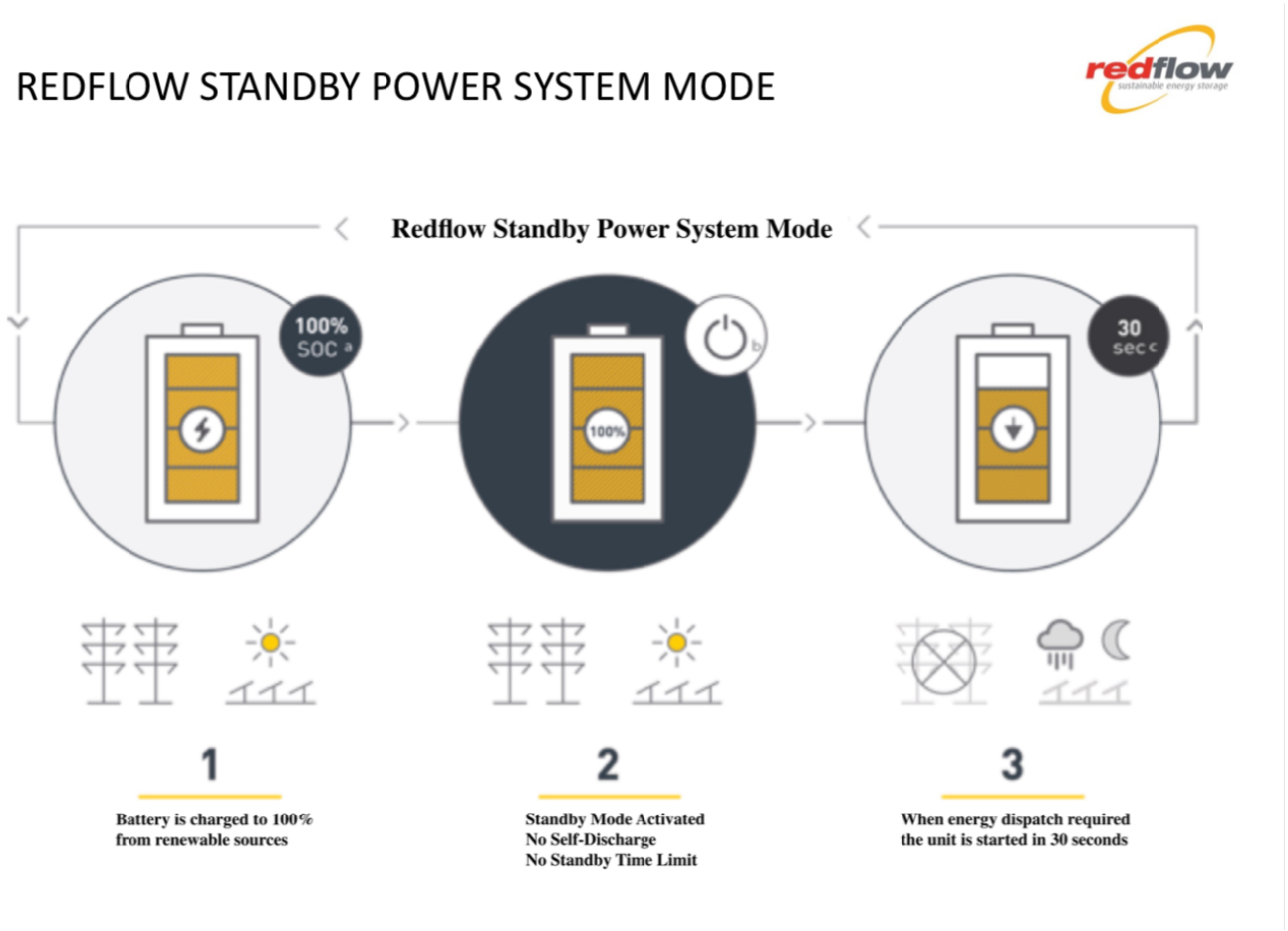


Figure 28: Redflow SPS Cycle Diagram

Prerequisites

Use of this feature requires the Redflow BMS to be running version 1.9 and Battery Controller firmware version 32.18.04 or later.

You can upgrade the BMS using the “Tools->Upgrade BMS” BMS menu.

Once the BMS is upgraded, use the “Tools->Upgrade Battery” menu to load the latest battery controller firmware into each connected battery.

SPS Operational Sequence

Once placed into SPS mode, a ZBM2 initially acts like any other ZBM2. It starts up and commences charging when energy is available on the DC bus to allow it to do so.

SPS batteries are shown separately, below batteries in the standard ‘RUN’ mode, on the BMS status page, like this:

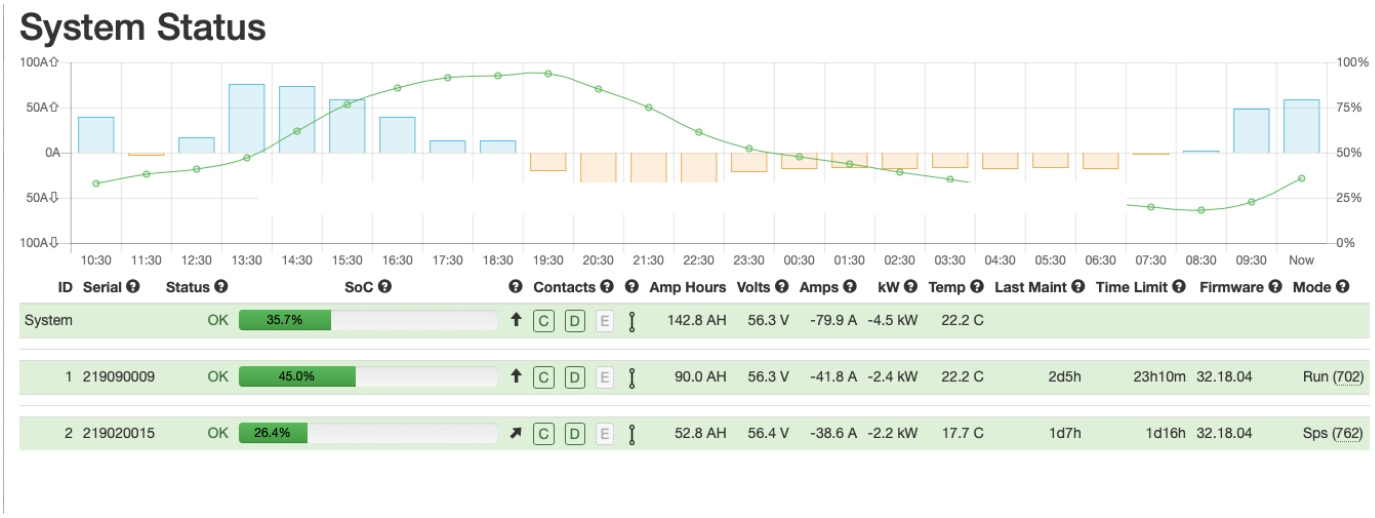


Figure 29: BMS Status SPS Example

Once the battery is completely full, it automatically enters the SPS ‘Hibernation’ mode.

In SPS hibernation mode:

- The battery flow pumps are completely stopped and electrolyte drains away from the stack
- The battery retains its stored energy with no background self-discharge of stored energy, just like a standby generator (but with no fossil fuel required!)
- When called upon at a future time to provide energy, the battery restarts its pumps and becomes capable of supplying its full rated energy output within 15-20 seconds (typical) and within 60 seconds (worst case)

Once the battery is re-activated to supply energy to the site load, the requirement is that the battery must fully discharge and undergo a normal ZBM2 maintenance cycle before returning to service.

To ensure the battery energy is delivered fully to the site loads and to allow the battery to recharge as soon as practicable (ready for next time), the discharge process is assisted with the use of the EED (Energy Extraction Device) included with all new ZBM2’s. This device assists in attaining a minimum output rate of 1kW per ZBM2, and a maximum discharge rate consistent with ZBM2 specifications. If site demands are below 1kW, the EED can also ‘cross-charge’ into other running batteries.

SPS Battery Designation, Activation, And Rotation

When a subset of batteries on a site are to be operated in SPS mode, the BMS arranges to automatically ‘rotate’ batteries between ‘RUN’ and ‘SPS’ mode over time. This rotation is intended to ensure that there is ‘wear levelling’ across the site, with all batteries taking turns to be designated as ‘RUN’ vs ‘SPS’ batteries over the passage of time.

The desired number of SPS batteries is configured as a target value on the SPS configuration page in the BMS.

Transitions between RUN and SPS mode occur only at the end of a battery maintenance cycle.

Each time a battery in RUN mode completes maintenance, it becomes a candidate to be added to the SPS pool. If the SPS pool needs more batteries to reach its target count and a battery in RUN mode completes its maintenance cycle, the BMS can move it to SPS mode.

Each time an SPS battery (having been awoken from hibernation) completes energy discharge and maintenance, it becomes a candidate to leave the SPS pool at the end of the maintenance cycle.

Accordingly, it can take several days for changes in the target number of SPS batteries to be reflected in the running system when it is first configured.

Activations of SPS batteries to service site load, that result in the battery being rotated out of the SPS pool, can (again) take a few days to be replaced in the SPS pool by other RUN mode batteries.

SPS Mode Configuration

There are two pages on the BMS that are central to the operation of SPS mode under BMS control.

The primary configuration of SPS operation is achieved via the “Configuration->SPS page”:

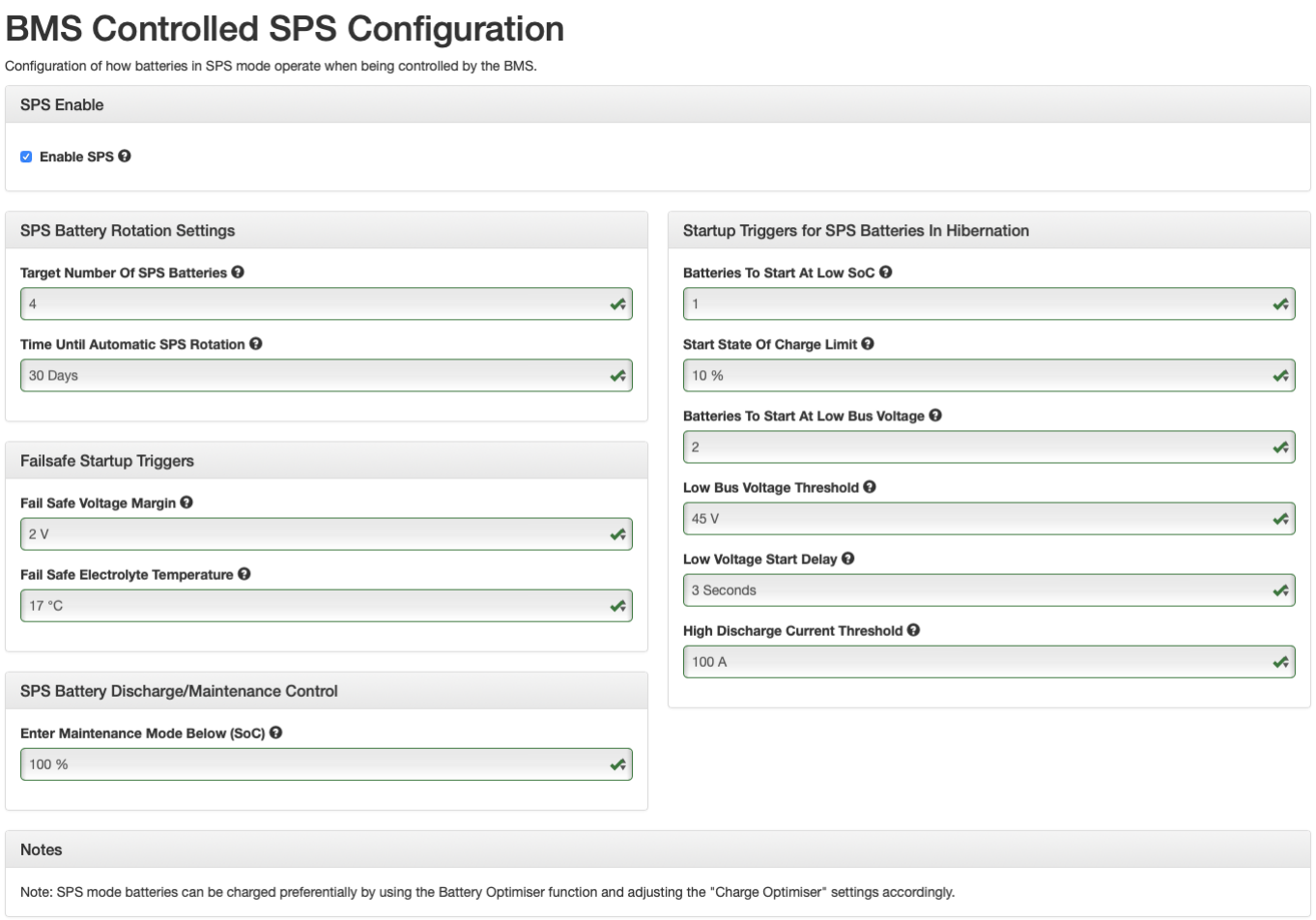


Figure 30: BMS SPS GUI

The second other page related to SPS automatic operation is the “Configuration->Battery Optimisation” page:

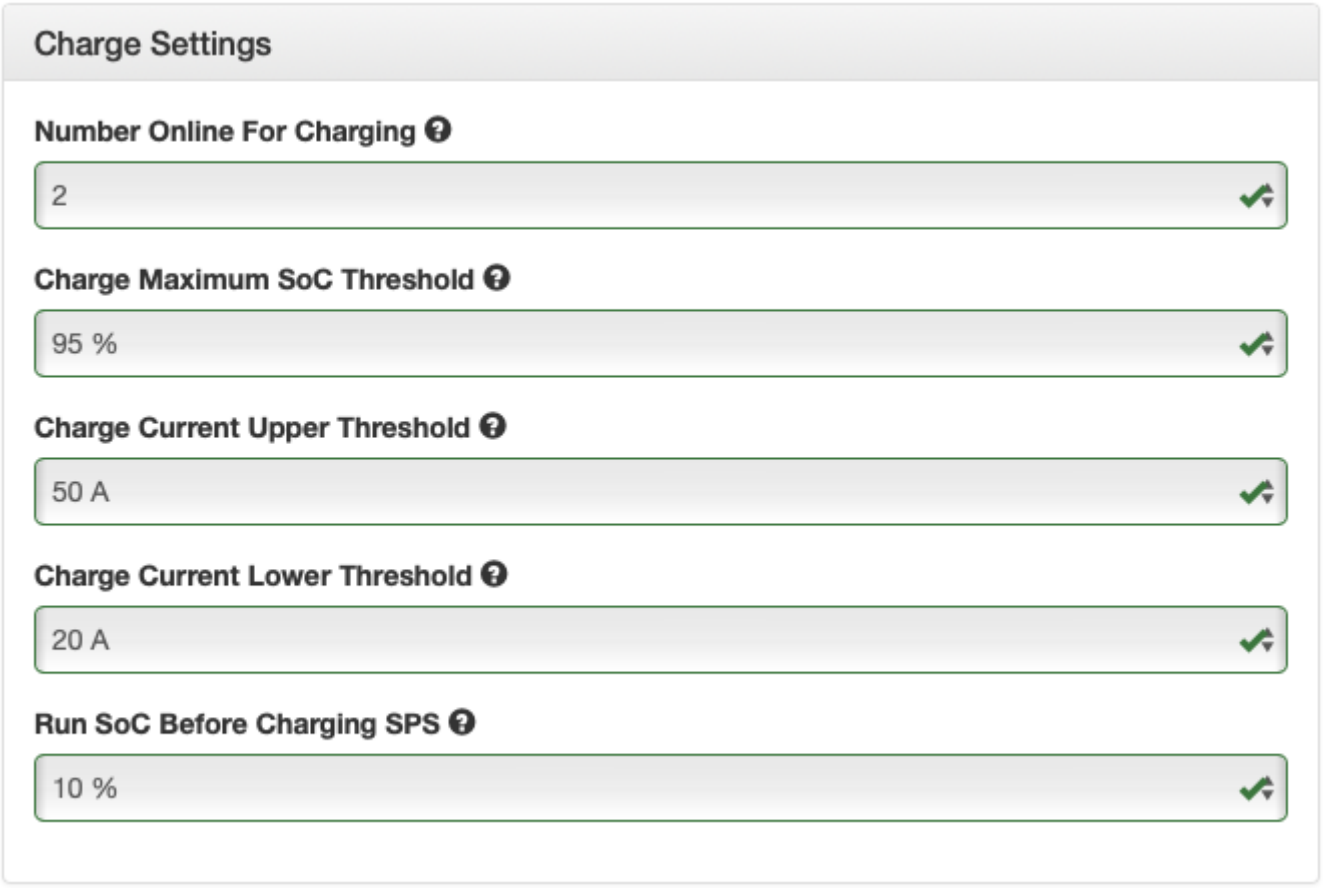


Figure 31: BMS Optimiser SPS Charging

SPS Configuration

To enable BMS controlled SPS operations, go to the “Configuration->SPS” page.

Select the *Enable SPS* checkbox at the top to start the configuration process. Once all desired changes have been made, press the *Submit* button at the bottom of the page to commit them.

SPS Battery Rotation Settings

Choose the *Target Number of SPS Batteries* to suit your application. If you select ‘Disabled’ the system will progressively move all SPS batteries back to RUN mode as they complete their maintenance cycles.

The Time Until Automatic SPS Rotation defines how long a battery can be in SPS Hibernation before the BMS activates it proactively (without an external energy demand). The intention of this function is to ensure that SPS batteries progressively cycle back through to RUN mode in the medium term.

The default is 30 days, and it can be raised or lowered to suit site requirements up to a maximum of 60 days

Failsafe Triggers

There are two mechanisms that will trigger the waking of an SPS battery due to abnormal conditions.

The *Fail Safe Voltage Margin* sets a buffer voltage that is the specified number of volts below the value in the *Low Bus Voltage Threshold* setting. For instance if the *Low Bus Voltage Threshold* setting is 45V and this Margin value is 2V, then the Fail Safe Voltage will become 43V.

This value is programmed into the battery controller directly. If the DC bus voltage ever falls below this value then all SPS batteries will self-activate. The intention of this function is to ensure that if the BMS is unavailable or disconnected, then all SPS batteries will self-wake before the DC bus entirely depletes.

The *Fail Safe Electrolyte Temperature* defines the temperature (of battery electrolyte, not ambient air temperature) below which an SPS battery will be automatically activated and discharged into the site load.

If SPS mode is intended to be used in a physical environment in which the ambient temperature experienced by the battery array will be below 15C for any significant period of time, a cabinet heater is required in order to ensure that a suitable electrolyte temperature for SPS batteries can be maintained.

Redflow ZBM2 batteries require an electrolyte temperature of 10C or above to charge, and 15C or above to discharge. Batteries in RUN mode can generally keep their electrolyte warm even during extended low ambient temperature periods, due to internal heating effects that are the normal consequence of their routine operation.

However, batteries in SPS mode are not consuming energy and hence are not capable of creating any internal heating to maintain their electrolyte temperature during extended periods of low ambient temperature.

Failure to keep the electrolyte temperature in the appropriate range means that the SPS battery would not be able to successfully awaken and deliver energy when subsequently required.

If this trigger activates, it should be taken as confirmation that cabinet heating needs to be installed in the site concerned.

SPS Battery Discharge/Maintenance Control

Once activated for any reason, an SPS mode battery is automatically placed into ‘Discharge-Only’ mode. This ensures that no battery recharging takes place until the SPS battery has completely discharged and undertaken a self-maintenance cycle.

The initial Discharge-Only mode allows battery energy to be consumed but it does not actively drive energy out of the SPS battery if there is insufficient site load to require that energy. Hence the battery can remain in the Discharge-Only mode, slowly self-discharging, for an extended period of time.

In most applications, having an SPS battery at a low state of charge, unable to recharge, and yet not actively discharging, creates the potential for reduced storage array availability over time. It is generally preferable to proactively discharge the battery in order to allow it to complete its maintenance cycle and recharge again - ready for the next demand upon its stored energy.

The *Enter Maintenance Below (SoC)* setting defines the SPS battery state-of-charge below which the battery will be switched

into Maintenance Discharge mode. In this mode, the on-board Energy Extract Device (EED) on the battery is activated. This device is a DC/DC converter that delivers a higher DC output voltage (typically 57V) to the DC bus.

In most sites, this results in battery energy being proactively delivered into site loads, or into other ZBM2 batteries, or (where present) into an external grid, at a minimum output level of 1kW (hence a maximum of circa 10 hours to fully drain the battery), rather than having the battery potentially remain idle for an extended period in discharge-only mode.

Note that this function does not limit output power to only 1kW; If the site energy demand is higher, the battery will deliver energy out at up to the full rated output power possible for the ZBM2 to supply.

The default (and normal) value for this setting is 100%, which means the battery (once activated) is immediately promoted into Maintenance mode, for the most timely delivery of energy and the most timely return to service of the SPS battery.

However, in sites where an extended period in non-EED ‘DIscharge-Only’ mode is desirable, this SoC threshold can be reduced to a lower level. The battery will then operate in Discharge-Only mode initially, before switching to EED-augmented ‘Maintenance’ mode when the SoC threshold is reached.

Startup Triggers For SPS Batteries In Hibernation

This configuration section controls the normal start triggers to take one or more batteries out of SPS hibernation and commence their delivery of energy to the site. Note that the BMS dynamically selects the most appropriate SPS battery or batteries to activate when required, favouring the activation of those batteries that have been hibernating for the longest period to date.

The first pair of settings, *Batteries To Start At Low SoC* and the *Start State Of Charge Limit* will activate the specified number of SPS batteries if the aggregate SoC of all actively running batteries in the system falls below the specified level.

This is the typical start mechanism for SPS batteries - causing them to be activated in response to a low level of remaining energy in the active batteries on the system, in just the same way that a generator can be triggered due to low site SoC. You should consider the interaction between this setting and the start thresholds configured any actual generators on the site, to ensure that the desired energy delivery sequence occurs.

By activating a subset of the overall number of SPS batteries, site energy demand can be progressively supported by multiple SPS batteries in an energy-efficient manner.

The next three settings, namely *Batteries To Start At Low Bus Voltage*, *Low Bus Voltage Threshold* and *Low Voltage Start Delay* collectively define the criteria to activate one or more SPS batteries in response to sustained low DC bus voltage.

Low DC bus voltage can be caused by imminent depletion of running battery energy or it can be caused by a substantial increase in site energy demand that in turn drives DC bus voltage lower regardless of running battery SoC.

The *Low Voltage Start Delay* setting is intended to allow for transient high energy demand on the battery array without necessarily activating SPS batteries in immediate response. A sustained Low Bus Voltage condition (longer than this delay setting) will result in the activation of the specified number of SPS batteries (if available).

The *High Discharge Current Threshold* functions independently to the previous settings, and is a distinct activation control for SPS batteries. If the BMS observes any running battery delivering energy at above the specified current level (default 100A) for more than one minute, the BMS will activate one SPS battery (if it is able to), in order to help to support the site load. In sustained (very) high load conditions, this may result in more than one SPS battery being activated over time (on a progressive basis) until the highest observed battery discharge current falls below this threshold.

SPS Battery Charge Optimisation

The BMS supports an optional Battery Optimisation feature set (“Configuration->Battery Optimisation”). This feature set is able (amongst other things) to optimise charging outcomes on sites where the maximum charge power available is not sufficient to charge all site batteries at once.

To allow the BMS to assist with the timely recharging and hibernation of SPS batteries for later use, on sites that can not charge all connected batteries efficiently at once, it is possible to selectively prioritise SPS vs RUN-mode batteries during the battery charging process.

This prioritisation is achieved using the BMS Battery Optimiser page, and specifically the Charge Optimisation settings on that page:

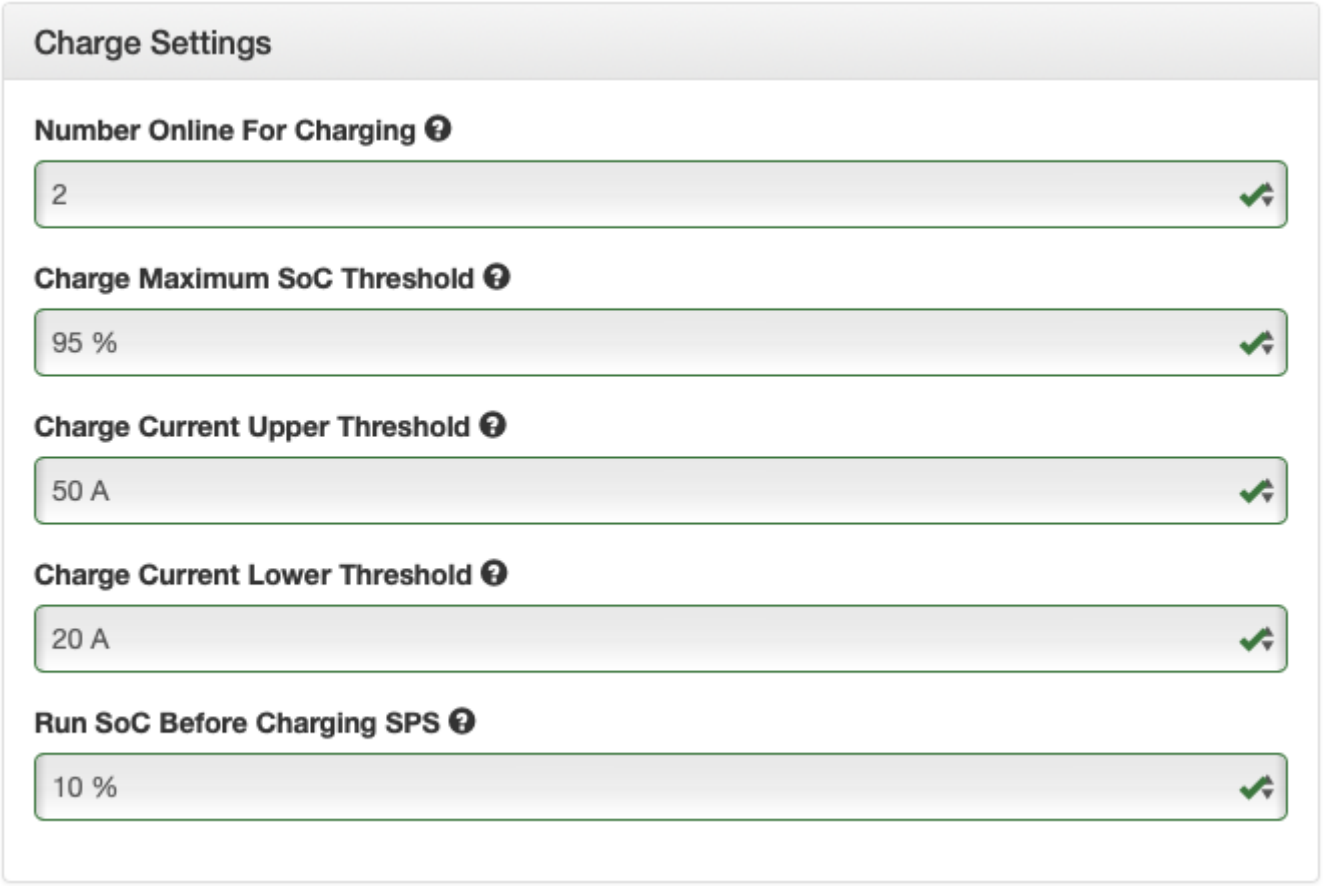


Figure 32: BMS Optimiser SPS Charging
If the Battery Optimiser is activated, the Charge Settings panel (as shown above) can be used to accelerate the charging of SPS batteries, so they can be fully charged and hibernated as a priority, if desired.

First, consider changing the *Number Online For Charging* value from its default (All). Setting a lower number here will result in the BMS permitting charge for only that specified number of batteries.

As battery charge level reaches the specified *Charge Maximum SoC Threshold*, additional batteries are allowed to charge. Additional batteries can also be added and removed from the set being charged on a dynamic basis, using the *Charge Current Upper Threshold* and *Charge Current Lower Threshold* settings. In this way, optimum charging rates can be achieved in sites with insufficient charging energy sources to charge all connected batteries at full rate at once.

These are general Charge Optimiser functions which apply to any site with batteries in RUN mode.

SPS Specific Charge Prioritisation

The *Run SoC Before Charging SPS* is used to prioritise the timely charging of SPS mode batteries, relative to the charging of RUN mode batteries.

This setting drives specific behaviour to optimise overall energy availability across the entire charging cycle, and it works as follows:

Initially - when the overall SoC of the overall system is below this threshold (10% by default), all RUN mode (non-SPS) batteries are charged first, with SPS batteries left disconnected. The intention of this initial charging phase is to ensure that at least some energy is stored in active, instantly available, RUN mode batteries to ensure that energy is available for instant and/or transient site energy demands.

Once the system SoC reaches the specified threshold level, however, the optimiser then switches to proactively charging SPS batteries as the priority. It dynamically defers further charging of RUN mode batteries to the extent required to achieve this prioritisation of SPS battery charging.

This results in all SPS batteries being fully charged and automatically hibernated as soon as practicable, so the SPS battery pool can be available to be called upon if required.

As SPS mode batteries become fully charged and hibernated, RUN mode batteries are progressively added back to the charging set until all of the batteries in the whole energy system are fully charged.

Manual Configuration And SPS Startup Diagnostics

If required, batteries can be manually transitioned at any time between RUN and SPS mode using the BMS.

This is achieved by clicking on the required battery on the BMS status page, selecting the ‘Operations’ button at the top right of the battery data screen that appears, and then selecting the option to ‘Take Battery Online’ or ‘Take Battery to SPS mode’ (as appropriate).

If an SPS battery is triggered to leave hibernation and the reason for this is unclear, note that these event triggers are logged in the primary BMS event log.

This log can be found by selecting the ‘Logs->BMS Logs’ menu item and then clicking on the ‘Event’ link on the page that appears.

The BMS has a configuration backup function to allow you to download a snapshot of the current configuration. This can be restored onto a new BMS at a future point in time, or used on the same BMS in the unlikely event of some data loss or SD card failure.

It is recommended to make a backup of your configuration before making any significant configuration changes, and before doing an upgrade.

NOTE - backups are only configuration - other data like graphs, ZBM log data and so on are not saved in the backup.

Creating A Configuration Backup

Click the “Configuration” menu and choose “Backup/Restore”. A page with two options will be shown. See fig. 33.

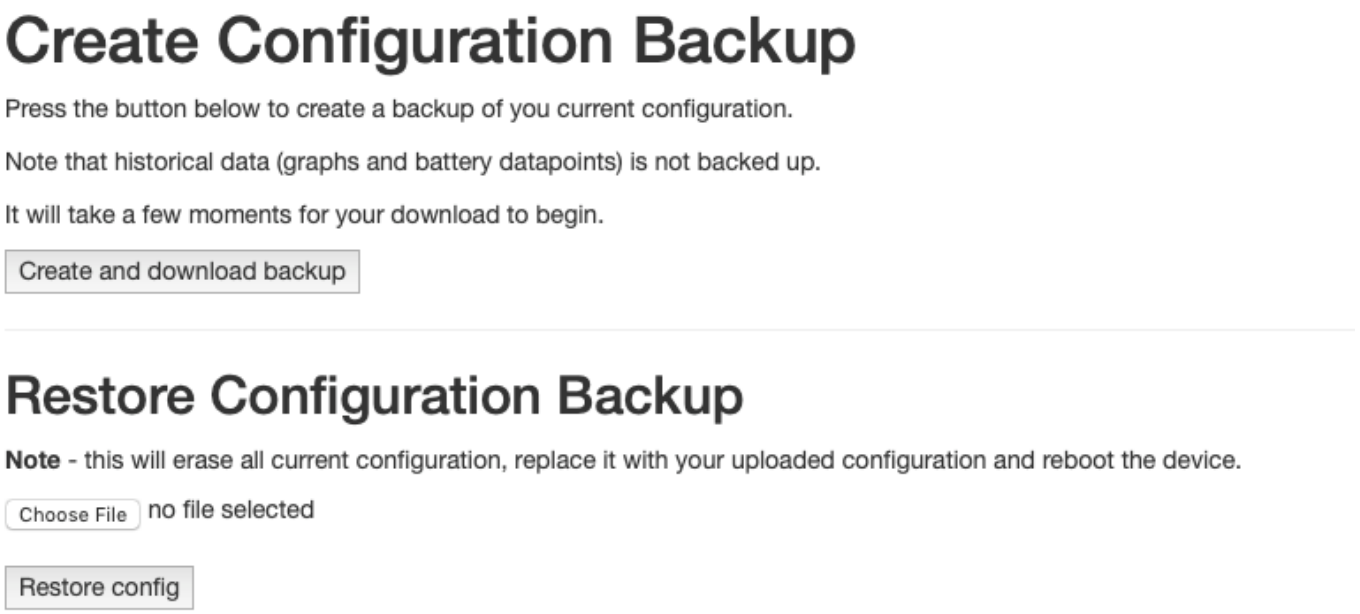


Figure 33: Backup and Restore
To create a configuration backup, just click “Create and download backup”. The backup file will be downloaded to your computer.

Note that mobile devices do not always make it easy (or sometimes, possible) to download a file and save it to local storage. We recommend using a computer for this operation.

The file will be named something like:

```
site_name-backup-yyyy-mm-dd.bin
```

Where ‘site_name’ is the name of the BMS site and ‘yyyy-mm-dd’ is todays date.

This makes the files easy to manage, even if you manage multiple sites.

Backups will generally only be a few kilobytes in size.

Restoring A Backup

Before restoring a backup, if it is being restored on a fresh BMS it is important to note that a backup can only be restored on a BMS that is either the same version or a newer version as the one from which the backup was made.

If you are restoring a backup on a fresh BMS, ensure you upgrade it to the latest version before starting the process.

Once prepared, on the new BMS click “Configuration” and then “Backup/Restore”. Click on the file chooser “Choose File” and select the backup you made earlier. Then click “Restore config”.

The BMS will upload the file, apply it to the system and restart with the restored configuration.

Note that networking settings are part of the configuration. If the network settings restored are not appropriate for the site, it may be necessary to reset the network settings to restore connectivity. To do so, see resetting the BMS settings.

Overview

As it is often useful for the battery data to be used by other parts of the energy system, the BMS provides a mechanism for remote systems to reach into the BMS and access data.

There are 2 types of data that are accessible. The Field Data which is the same data that can be used as decision points in the DIO system. And the Battery Data, which reflects an individual battery’s data.

Details about how to access this data and what data is available can be found in the ‘Data Access Information’ page under the ‘Help’ menu on the BMS.

Field Data

The BMS provides 2 ways of external systems accessing battery data: Modbus-TCP, and HTTP.

Modbus-TCP access

The BMS has a Modbus-TCP slave that uses TCP port 502, the unit number to access the BMS data is 201, and the values can be fetched from holding registers (type 4).

Each of the fields is stored in 16 bit integers as either signed on unsigned, and will have a multipler applied to the values as well.

For example, when requesting the Bus Voltage, which is uint16 with a multipler of 10, value returned will be between 0 and 65536, with a voltage range of 0 to 6553.6V. e.g. A value of 535 equates to 53.5V. When requesting the Temperature, type of int16 and multiplier of 10, the range of the value returned will be -32768 to 32767 corresponding to a temperature range of -3276.8℃ to 3276.7℃. e.g. A value of 237 equates to 23.7℃.

If the field is not defined the value returned will be -1 where the type is int16 and 65535 when it’s uint16.

JSON/Text HTTP access

The same data can also be accessed by HTTP. The URLs to fetch this data can be found via the ‘JSON’ and ‘Text’ links on the ‘Data Access Information’ page.

The ‘Text’ URL will send an ASCII text representation of the value, while the JSON URL will return the data in a parsable JSON format.

Example JSON Output

```
{
  "id": 1,
  "name": "State Of Charge (all)",
  "short_name": "soc_all",
  "value": 0.33
}
```

Battery Data

Modbus-TCP access

Available via the same Modbus-TCP slave as above, individual battery data is available as well. The Modbus unit number is the same as the Battery's Modbus/RTU unit number, with the unit number '200' used for 'System' information, and values are in holding registers.

The value in each register is a 16 bit integers and can be multiplied by the multiplier listed, or combinied with other registers with the supplied bit offset value. These modifiers are listed on the 'Data Access Information Page'.

Where a unit number or register contains no data, a Modbus Illegal Data Address Exception will be returned.

HTTP REST JSON data

Available by the link on the 'Data Access Information' page, it is a list of all the batteries and their attributes in JSON format.

Example JSON Output

```
{
  "list": [
    {
      "air_temperature": 19.6,
      "air_temperature_sensor_failure": false,
      "alarm_status": false,
      "alarm_status_timeout": 30,
      ....
    },
    {
      "alarm_status_timeout": 30,
      "amp_hours": 0.3,
      "attr_state": "Run Mode (classic)",
      ....
    },
  ],
  "system": {
    "ah_all": 0.4,
    "ah_charging": 0.4,
    "ah_discharging": 0,
    "air_temperature": 19.8,
    "amp_hours": 0.4,
    "battery_temperature_failure": false,
    "battery_temperature_warning": false,
    ....
  }
}
```

Overview

Keeping your BMS system up-to-date is important. Each release offers new features, and fixes bugs in older versions. Additionally, your ZBM battery firmware is bundled with the BMS firmware, and when the BMS is upgraded you may be offered upgrades for the battery firmware as well.

Upgrading To The Latest Version

Upgrading to the latest version of the BMS is easy if your BMS is connected to the Internet.

Click on "Tools" and "Upgrade BMS" - fig. 34.

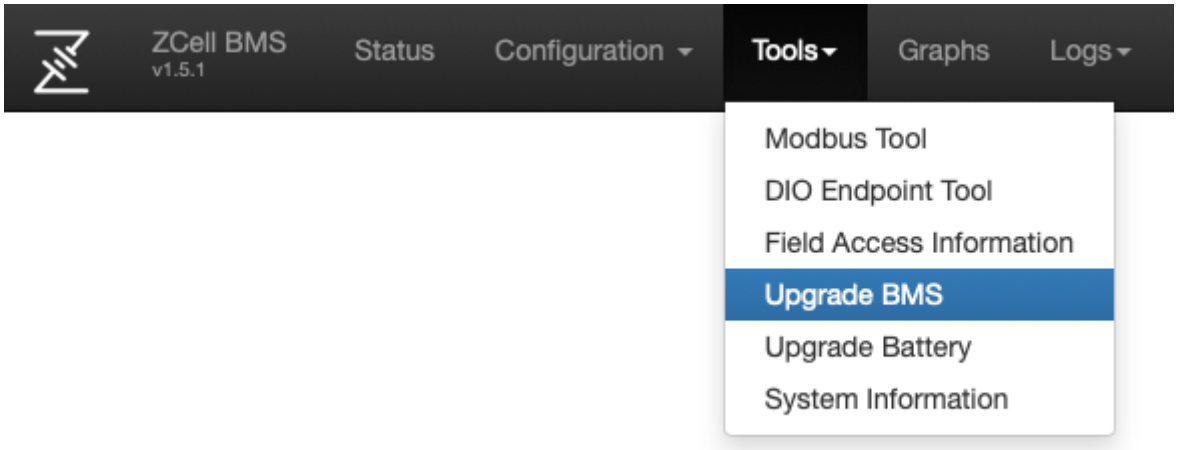


Figure 34: Upgrade BMS menu
At this point you will see a list of available upgrades (it may take a moment or two to fetch from the server).

Each possible upgrade will have two links - one to view the ChangeLog (the list of changes to the software), and another link to initiate the download. See fig. 35.

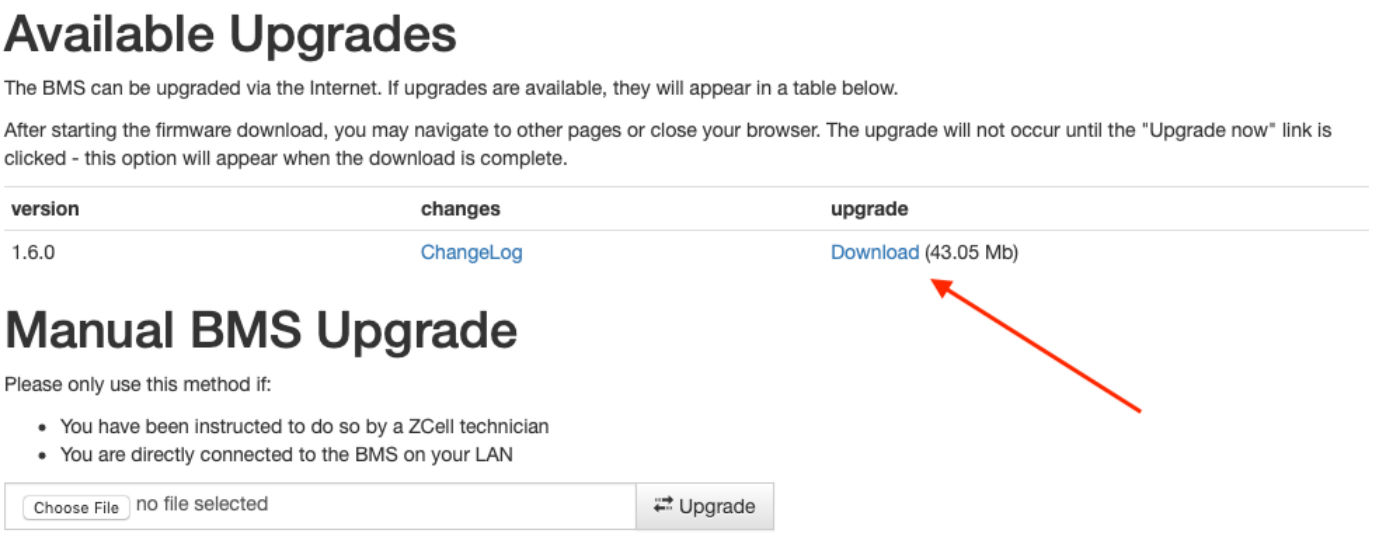


Figure 35: Upgrade BMS options
Once you click the “Download” link, the firmware will begin downloading in the background. The page will automatically refresh to show the progress (see fig. 36). If the Internet connection is slow, you can also close your browser and return to this page at a later time. The downloaded firmware will be stored, and the upgrade can be initiated at any time.

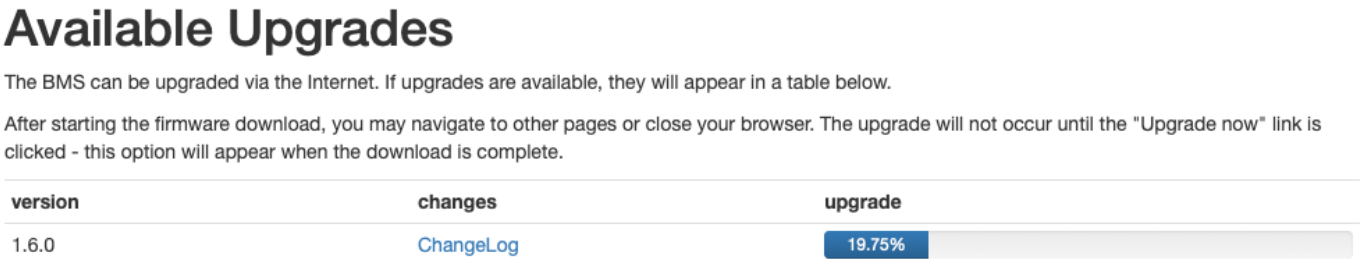


Figure 36: BMS upgrade downloading
Note that if the BMS is restarted before the firmware is updated, the download will have to be restarted.

Once the firmware has been downloaded, click the “Complete - Upgrade now” link to complete the process. This will cause the BMS to update, and restart with the new firmware - see fig. 37.

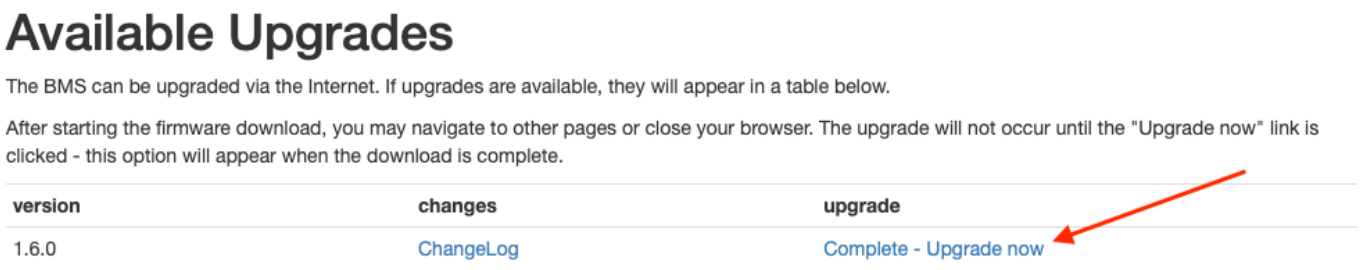


Figure 37: BMS upgrade complete link
This process will take several minutes.

Upgrading to snapshot or release candidate versions

Note that this should only be done under instruction from Redflow engineers.

By default, snapshot or release candidate versions will not be available for upgrades. To change this, see the site configuration chapter.

Once snapshot and/or release candidates upgrades are enabled there, they will appear in the available upgrade list above.

Manual Upgrades

If firmware upgrades are not possible via the Internet, you can upgrade the firmware manually.

Firmware files can be downloaded at:

```
https://firmware.zcell.com/releases/
```

The file required for upgrades is called:

```
redflow-bms-strato-X.Y.Z.upgrade.bin
```

Where X.Y.Z is the version number.

Do *not* try to upgrade with the .sdimg file - it will not work.

Typically you will want the latest version (at the bottom of the list).

When upgrading manually is necessary, always consult a Redflow engineer first - not all manual upgrades paths are possible.

To upgrade, click the “choose file” button (it may be slightly different in your web browser) and choose the file you downloaded above. Then click the “Upgrade” button - see fig. 38.

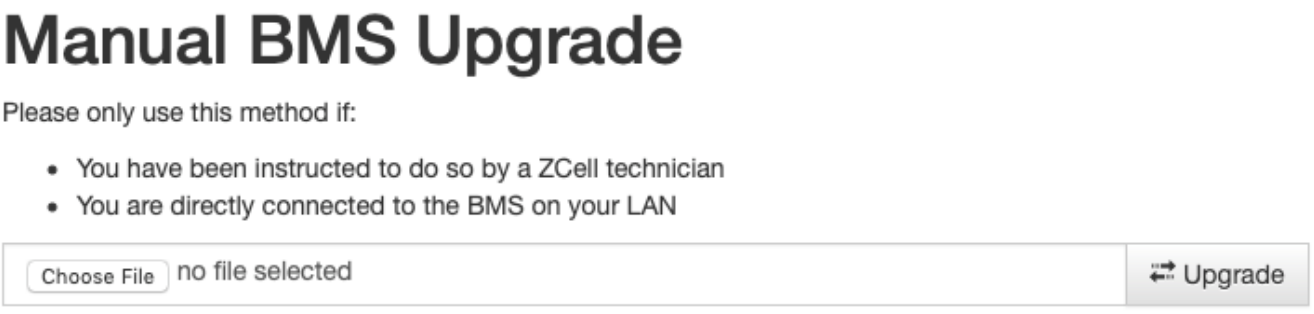


Figure 38: BMS manual upgrade

Determining If An Upgrade Is Available.

Battery firmware is supplied with the BMS. Thus, when the BMS software is upgraded, you may find that a battery firmware upgrade becomes available. See the “Upgrading the BMS” chapter for more information on upgrading the BMS.

On the BMS status screen, any batteries that can be upgraded will show their version number with a yellow warning triangle

next to them, as seen in fig. 39.

You can click on the symbol to take you straight to the upgrade screen, or navigate there using the menu (see the next section).

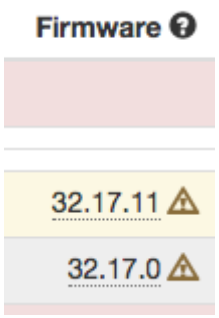


Figure 39: Upgrade available

Upgrading The Battery

On the upgrade battery screen (Tools => Upgrade Battery) you will see the following display (fig. 40).

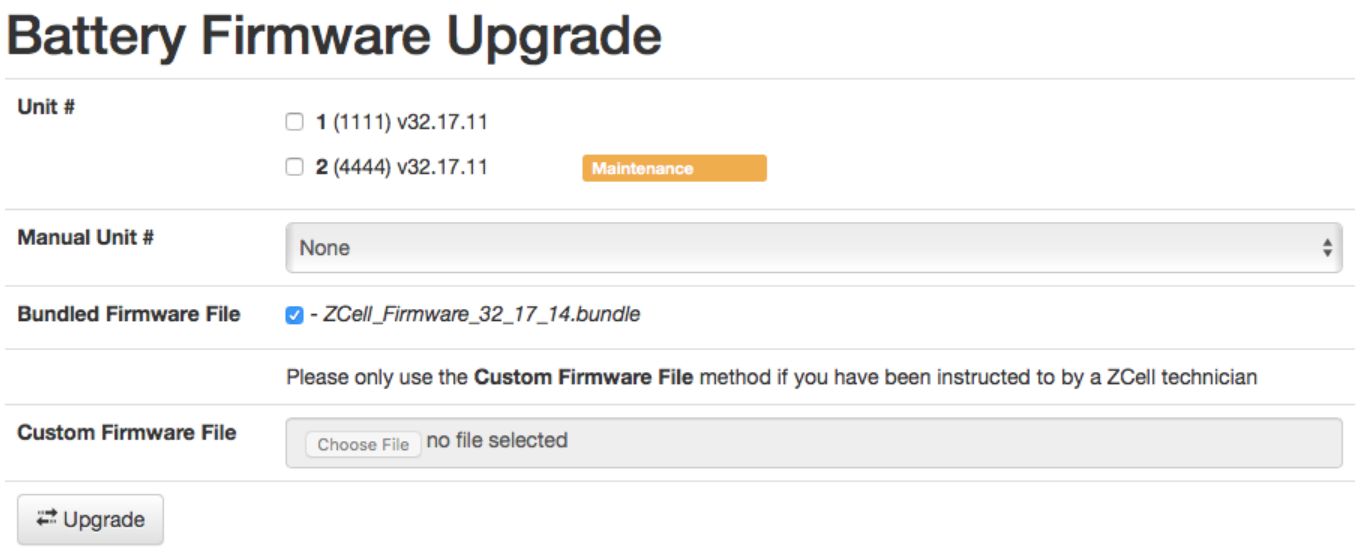


Figure 40: Upgrading one or more batteries
On the upgrade screen, you will see a list of batteries (and their current firmware version), and any notes relevant to that battery, with respect to upgrading.

In this example, one of the two batteries is undergoing maintenance, and should not be upgraded at this time.

You can select more than one battery at a time, however it is generally recommended to only upgrade one at a time to ensure there is minimal disruption to the energy system.

Use the bundled firmware as shown, unless you have been specifically instructed to do otherwise.

Click “Upgrade” to move to the final part of the upgrade process (fig. 41).

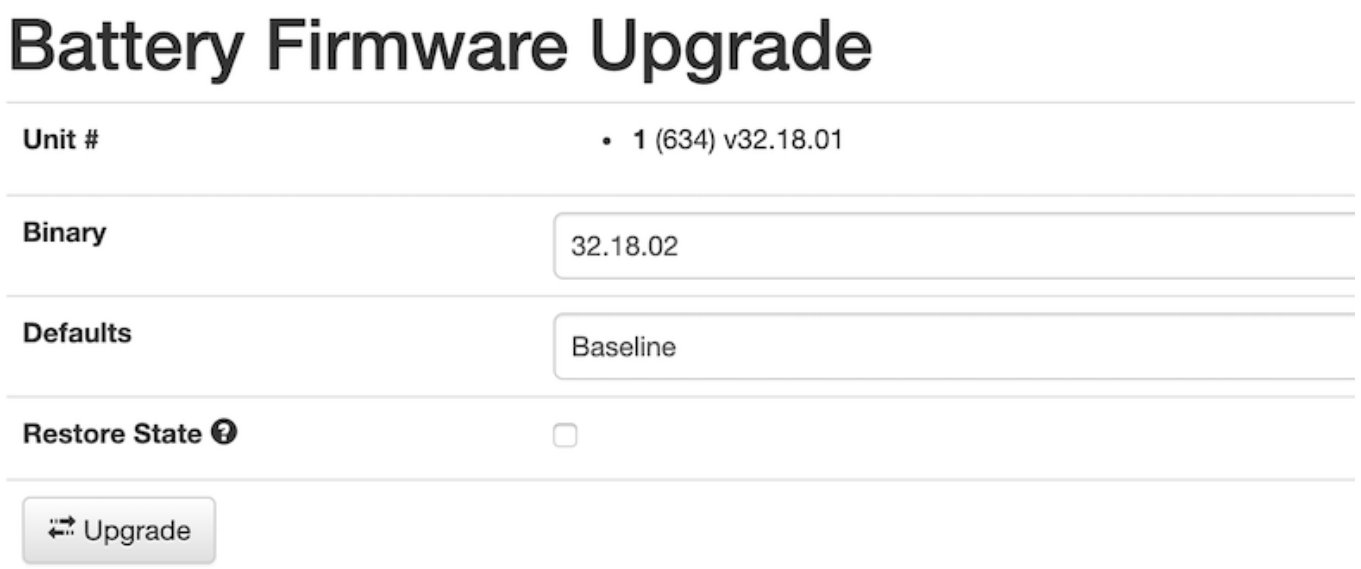


Figure 41: Completing the upgrade
On the final screen, confirm the new firmware version and the batteries it will be applied to.

Ensure you choose the correct defaults setting, either “Baseline” or “Baseline with EED”. If in doubt about which baseline to use, check the “Contacts” column on the main battery status screen. The third symbol will be either an “E” or an “S”. If an “E” is present, use the EED baseline, otherwise, the standard baseline.

If you are still in doubt over the defaults setting required, please contact Redflow.

You can choose to restore the state of the battery after upgrade. By default, the battery will be offlined after the firmware upgrade.

Press Upgrade to begin. The upgrade will take several minutes per battery, and as it consumes a large amount of comms bandwidth it is possible that other batteries will appear to stop responding. Be patient and wait for the process to complete.

During this process, a dialog will show the upgrade process in real-time (fig. 42).

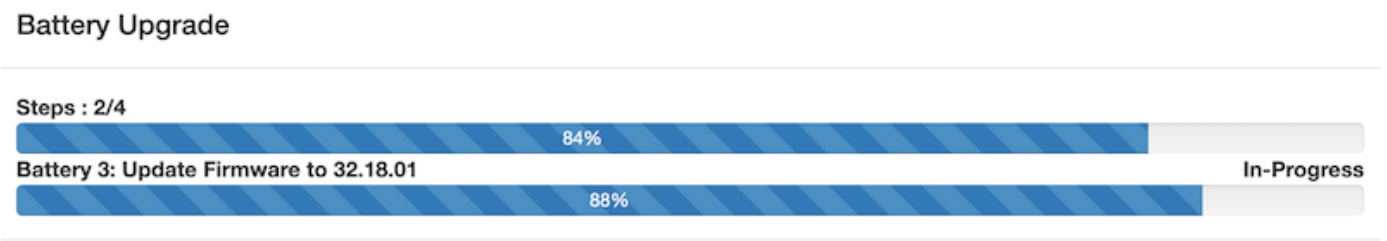


Figure 42: Completing the upgrade
Once completed, close the dialog to return to the upgrade screen, where you may choose to upgrade more batteries.

The system information page displays low-level diagnostic information of the BMS. It does not display anything related to the energy system, it is purely a diagnostic tool if there are problems with the BMS itself. Redflow support may direct you to check the information here if remote access is not possible and you suspect problems with your system.

Overview

The system information can be shown by clicking on the “Tools” menu and selecting “System Information”. See fig. 43.

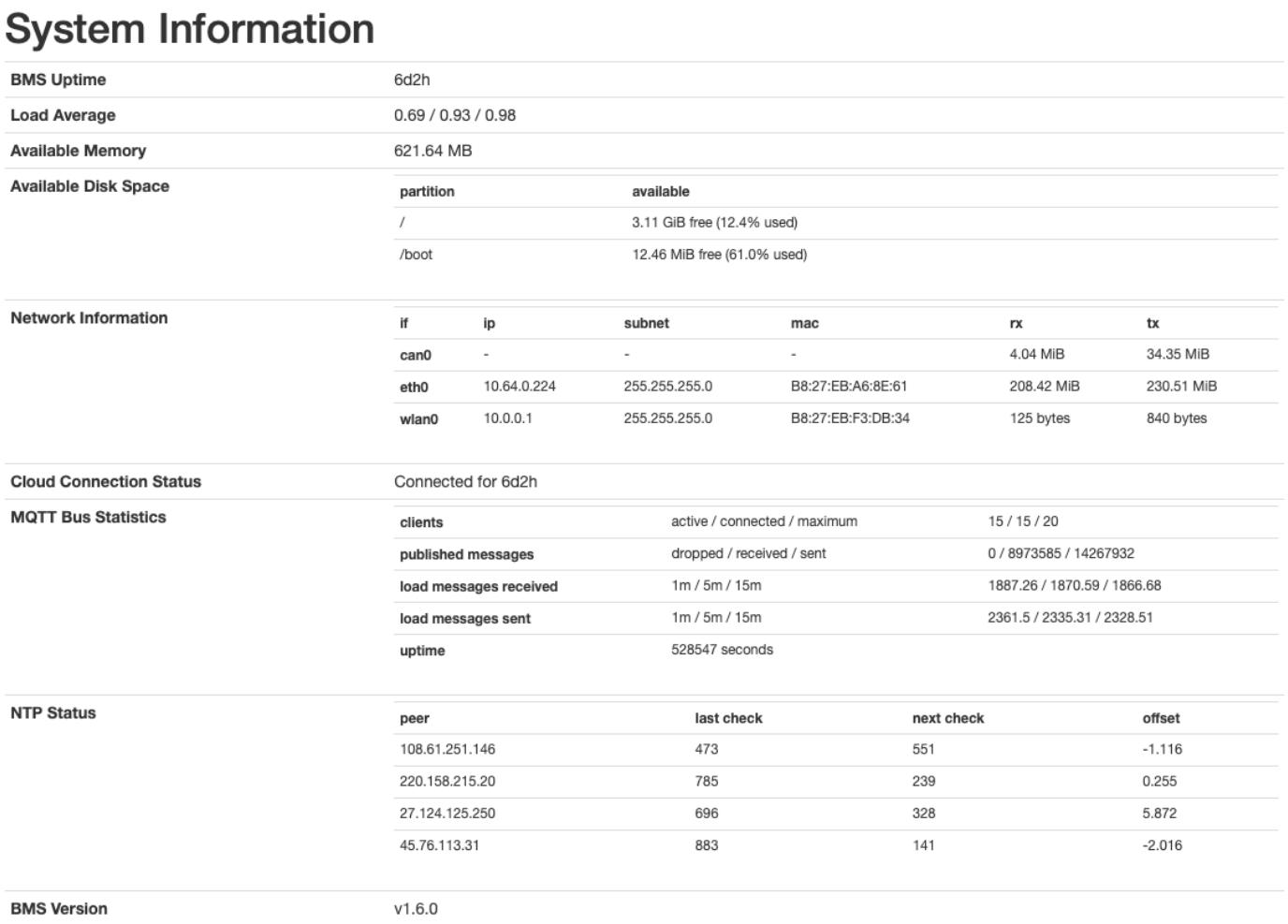


Figure 43: System information page

The data on this page refreshes regularly - it is not necessary to reload the page to see the latest information.

As this page is mostly a remote diagnostics tool, this document will not go into detail on all of the elements. There are a few things which the end user can check:

BMS Uptime

The uptime represents how long the BMS has been “up” - i.e. how long since it was powered on and operational. Generally speaking the BMS should be powered on 24/7, though there may be certain offgrid configurations where this is not the case.

If you expect that the BMS is always powered on, but the uptime here does not indicate that, you may want to check how the BMS is powered.

Available Disk Space

The BMS self-manages it’s disk space, and there should always be space available.

Network Information

In some circumstances it may be useful to see the low-level network information for the wifi and ethernet networks.

The rx and tx columns also show how much data has been transferred since the BMS was booted. This will roughly equate to the amount of internet traffic used as well, though it is not a 1:1 relationship and may be significantly different in certain network environments.

The network connection may be named either ‘eth0’ or ‘wlan0’, depending on whether it is a hard-wired ethernet connection, or a wifi connection respectively.

You should also see a ‘can0’ connection if your BMS is equipped with a CAN bus connection. It will have no IP address information, but the rx and tx numbers will change based on traffic flow between the BMS and other CAN bus connected equipment.

Cloud Connection Status

This shows how long the BMS has been connected to the Z-Cell cloud system. If the connection often resets, it may indicate a reliability problem with your internet connection.

NTP Status

NTP stands for Network Time Protocol and this data indicates the “health” of the BMS with respect to fetching network time from the Internet.

If the BMS detects a problem with NTP you will receive a notification - there is no need to check this page. Generally this would indicate that your router is blocking NTP requests.

BMS version

The BMS version is displayed on the bottom of the page.

The graphs page displays charts on both individual battery metrics, and also metrics of the overall system.

From any BMS page click the “Graphs” menu on the top menubar to reach the graphs interface.

Display

The first page displayed shows all the individual graphs for all configured batteries, and a “System” battery which is an aggregated display of all the other batteries together (in the same way as it is on the main BMS status page).

See fig. 44.

Figure 44: Graphs for a single battery
Note that the display may be different depending on your device’s screen width.

Zooming

Each graph has a small “zoom” link at the bottom - click that link to show that single graph at a higher resolution.

Click “back” in your browser to return to the index.

Changing the time and date shown

Figure 45: Graphs index
The graphs displayed default to a 24 hour range, starting at midnight of today's date. It is possible to change this to show various ranges:

- 4-hourly
- Daily
- Weekly
- Monthly
- Yearly

See fig. 45. Click on the range you would like to view to change the display.

You can also change the starting point of the graphs - which will vary depending on the range shown. For example, when viewing by day, you can choose either the next day or the previous day.

- 4-hourly - navigate in 4 hour "slices" - midnight to 4am, 4am to 8am and so on
- Daily - navigate by days
- Weekly - navigate by weeks (weeks start on Sunday and are numbered starting with 1 at the beginning of the year)
- Monthly - navigate by months (calendar months)
- Yearly - navigate by calendar years

Finally, there is a link at the top called "Today" which switches back to "daily" view, with today's date.

Graph types

There are several graphs shown. They are:

- State of charge
- Temperatures
- Voltages
- Current
- Pump/fan speeds (not on the System graphs)

You can click on any of these graphs to show just that metric across all the batteries in your energy system - ie clicking on the Voltage graph on a 4 battery system would show 4 graphs on a single page - the voltage graph for each battery.

State of charge graph

The state of charge graph shows several things:

- Battery state of charge (percentage)
- Battery discharge-only and strip periods

See fig. 46 for an example. In this example, the SOC is changing over the day, showing charging and discharging activity. At 8:00PM the battery is put into discharge only mode (light grey background) and around 9:00PM the battery starts the maintenance cycle (dark grey).

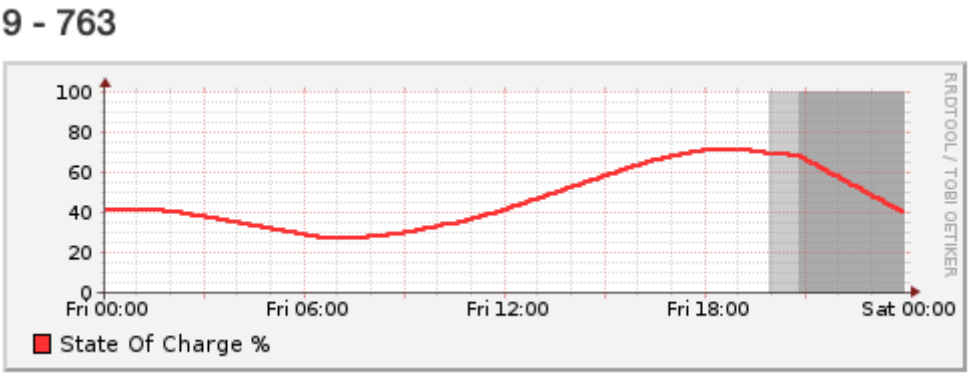


Figure 46: SOC graph

Temperatures

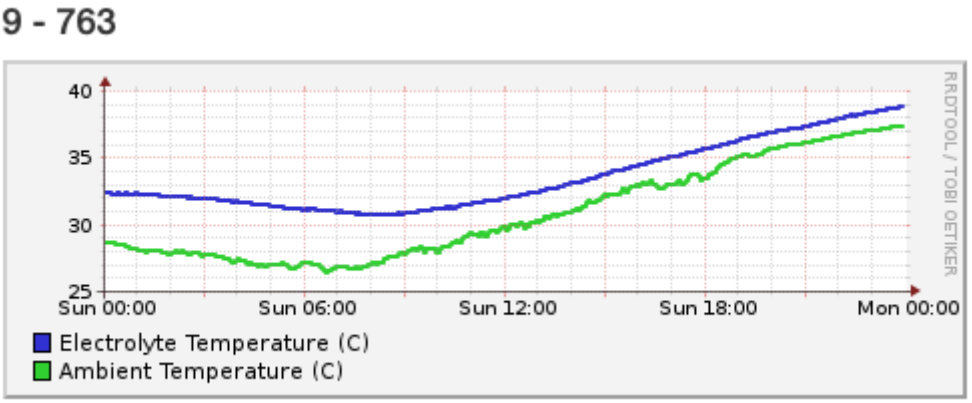


Figure 47: Battery temperatures
In the example seen in fig. 47, the two recorded temperatures are shown. The electrolyte temperature is the “internal” temperature of the battery.

The ambient temperature is shown as well.

Remember that the battery is self-protecting, and will automatically shut down if temperatures ever reach an unsafe level.

It is normal for temperatures to vary depending on operation.

Voltage

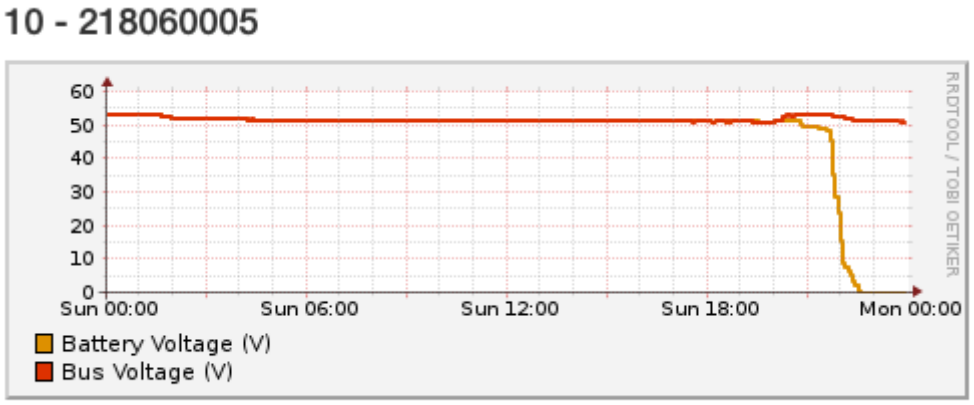


Figure 48: Battery voltages
The battery voltages graph (see fig. 48) shows the two voltages that the battery monitors.

The “battery voltage” is the internal stack voltage.

The “bus voltage” is the measured bus voltages.

When the battery is connected to the bus (online and not performing maintenance), these voltages will be similar.

Note, unlike other battery technologies, it is perfectly normal for the internal battery voltage to drop all the way to 0 volts during maintenance. This does not indicate any sort of failure.

Current

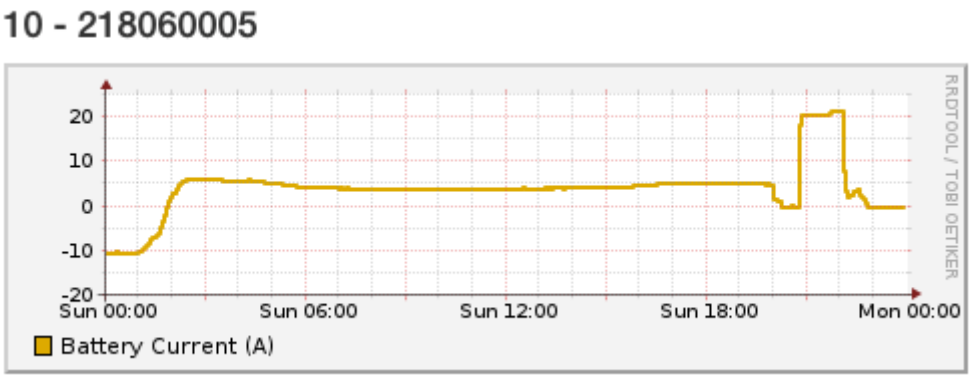


Figure 49: Battery current flow
The current flow graphs (fig. 49) show the flow of energy in and out of the battery. The units are in amps, current flow above the 0A line of the graph indicates discharging, below the line indicates charging.

Pump/fan speeds

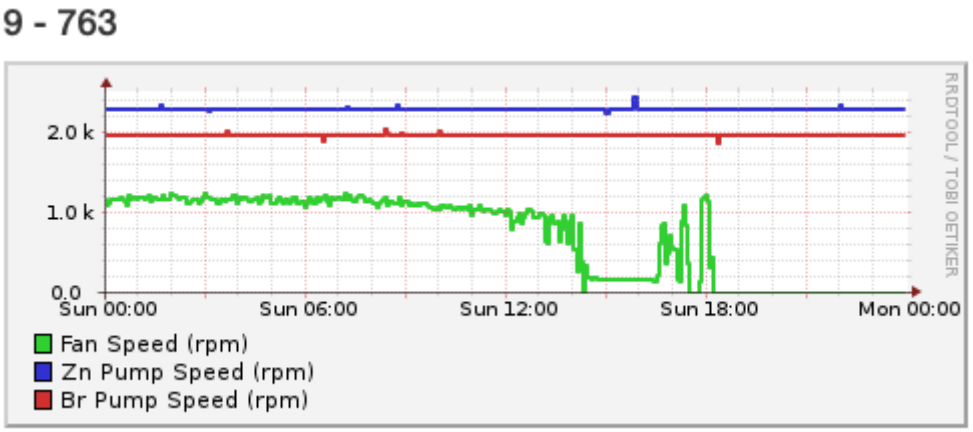


Figure 50: Pump and fan speeds
The pump and fan speeds are shown on this single graph (fig. 50). Both are measured in RPM. As with the temperatures, the battery is self-protecting and will monitor the pumps and fans for problems.

Limitations

The graph data is stored using an efficient “round robin” database, which coalesces old data into lower-granularity data points. This means that the data storage size is fixed, but resolution is lost when looking at old data.

For example, data shown on a “daily” graph today would have samples around every 5 minutes. Looking at that same day in a few months time would display a “blocky” graph, where the resolution has been reduced to 1 sample per hour.

The graph data collection occurs independently from the ZBM logs data - if you are interested in long term data storage, please see that chapter for details on capturing the data periodically.

Overview

The BMS keeps detailed logs of each connected battery - a detailed snapshot of many data points, recorded at 60 second intervals.

This data is kept by the BMS for a period, and is available for interactive inspection in the web interface or for downloading in CSV format.

Accessing Via The Web Interface

From the main battery status overview screen, click on the battery you want to view data from. You will see the last fetched information on many data points on this page. See fig. 51.

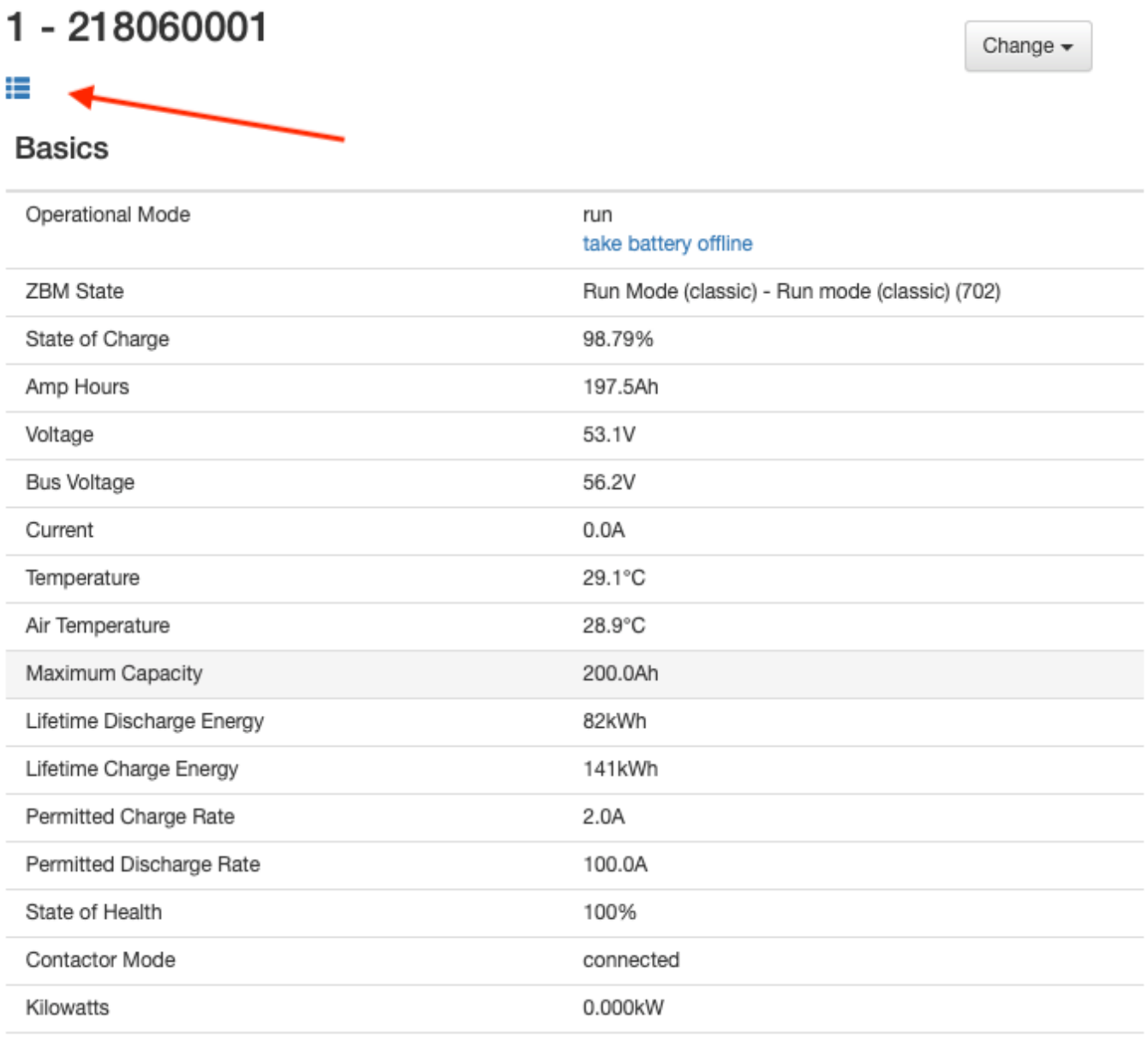
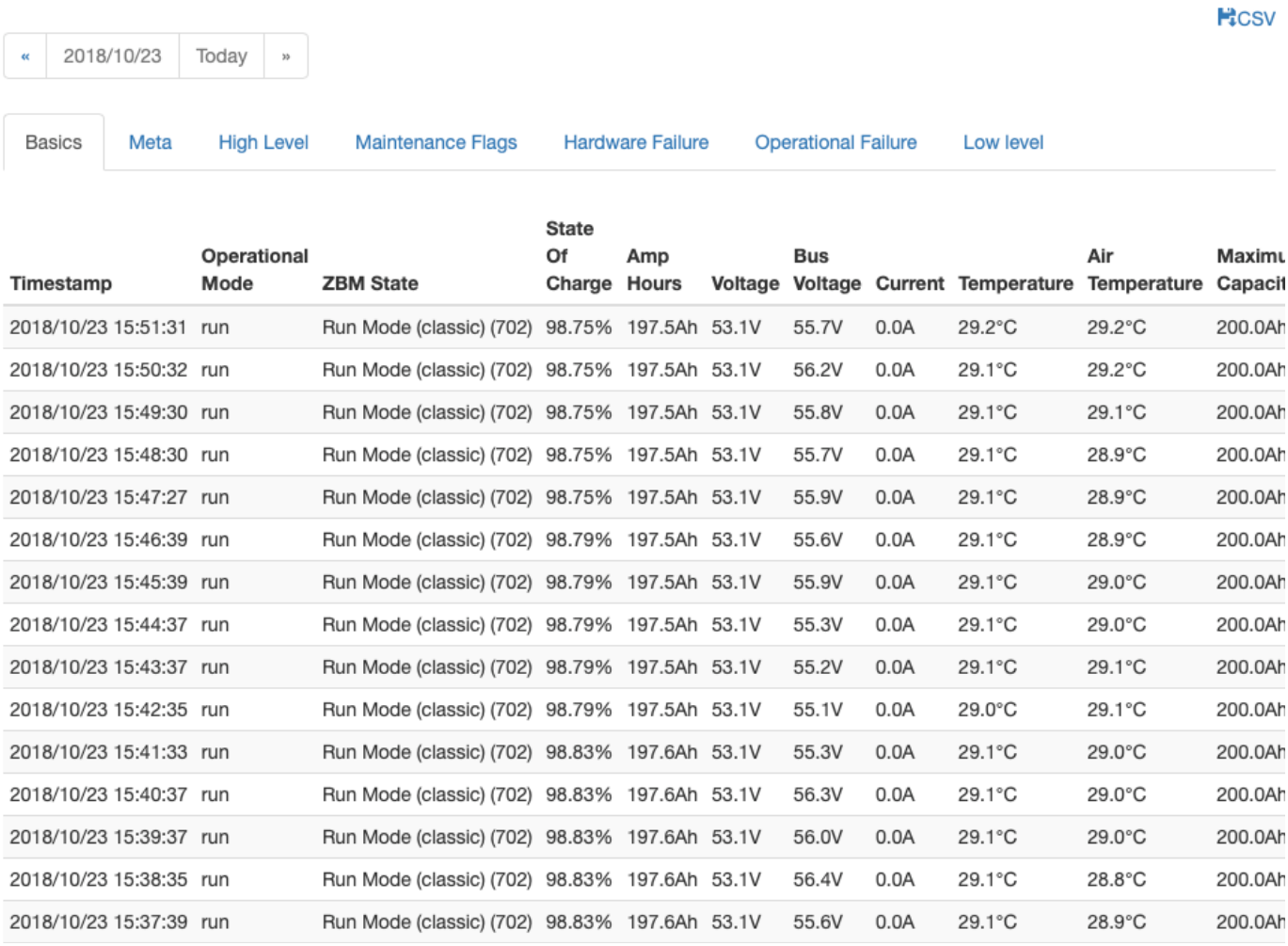


Figure 51: Battery status page

Click the “battery logs” icon (three horizontal bars) - just below the battery number and serial (see the red arrow on fig. 51). This takes you to the interactive log display - fig. 52.



Timestamp	Operational Mode	ZBM State	State Of Charge	Amp Hours	Voltage	Bus Voltage	Current	Temperature	Air Temperature	Maximu Capacit
2018/10/23 15:51:31	run	Run Mode (classic) (702)	98.75%	197.5Ah	53.1V	55.7V	0.0A	29.2°C	29.2°C	200.0Ah
2018/10/23 15:50:32	run	Run Mode (classic) (702)	98.75%	197.5Ah	53.1V	56.2V	0.0A	29.1°C	29.2°C	200.0Ah
2018/10/23 15:49:30	run	Run Mode (classic) (702)	98.75%	197.5Ah	53.1V	55.8V	0.0A	29.1°C	29.1°C	200.0Ah
2018/10/23 15:48:30	run	Run Mode (classic) (702)	98.75%	197.5Ah	53.1V	55.7V	0.0A	29.1°C	28.9°C	200.0Ah
2018/10/23 15:47:27	run	Run Mode (classic) (702)	98.75%	197.5Ah	53.1V	55.9V	0.0A	29.1°C	28.9°C	200.0Ah
2018/10/23 15:46:39	run	Run Mode (classic) (702)	98.79%	197.5Ah	53.1V	55.6V	0.0A	29.1°C	28.9°C	200.0Ah
2018/10/23 15:45:39	run	Run Mode (classic) (702)	98.79%	197.5Ah	53.1V	55.9V	0.0A	29.1°C	29.0°C	200.0Ah
2018/10/23 15:44:37	run	Run Mode (classic) (702)	98.79%	197.5Ah	53.1V	55.3V	0.0A	29.1°C	29.0°C	200.0Ah
2018/10/23 15:43:37	run	Run Mode (classic) (702)	98.79%	197.5Ah	53.1V	55.2V	0.0A	29.1°C	29.1°C	200.0Ah
2018/10/23 15:42:35	run	Run Mode (classic) (702)	98.79%	197.5Ah	53.1V	55.1V	0.0A	29.0°C	29.1°C	200.0Ah
2018/10/23 15:41:33	run	Run Mode (classic) (702)	98.83%	197.6Ah	53.1V	55.3V	0.0A	29.1°C	29.0°C	200.0Ah
2018/10/23 15:40:37	run	Run Mode (classic) (702)	98.83%	197.6Ah	53.1V	56.3V	0.0A	29.1°C	29.0°C	200.0Ah
2018/10/23 15:39:37	run	Run Mode (classic) (702)	98.83%	197.6Ah	53.1V	56.0V	0.0A	29.1°C	29.0°C	200.0Ah
2018/10/23 15:38:35	run	Run Mode (classic) (702)	98.83%	197.6Ah	53.1V	56.4V	0.0A	29.1°C	28.8°C	200.0Ah
2018/10/23 15:37:39	run	Run Mode (classic) (702)	98.83%	197.6Ah	53.1V	55.6V	0.0A	29.1°C	28.9°C	200.0Ah

Figure 52: Battery interactive log viewer

At the top of this page is a date selector - you can click the “«” or “»” symbols to navigate to different dates - the date shown is displayed in the same location, and there is a “today” link to jump back to today’s date.

The data displayed is broken down into several subsections:

- Basics

Core data points, like battery state of charge, bus and stack voltage, temperature sensor readings.

- Meta

Battery serial numbers, modbus address and firmware version.

- High Level

Global flags for reporting failures.

- Maintenance Flags

Flags reporting on whether the battery is in discharge only or maintenance mode.

- Hardware Failure

If the global “hardware failure” flag is set, one of more of the sub-flags designating the actual reason will be set here.

- Operational Failure

As per the above, but for operational failures. Note that most operational failures are self-recovering, but may require intervention to correct the problem that caused the failure (for instance, an overcurrent situation).

- Low Level

All other data points. Low level data such as pump speeds, time before maintenance is required, runtimes, charge/discharge counts.

Click on each tab to display that data. Note that on most screens, the data will be more than can be displayed horizontally, scroll

sideways to see all fields.

The BMS will automatically load more data if you scroll to the bottom of the page, assuming there is more data to load. Note that data is display in a reverse chronological order - the most recent data is at the top of the page. Roughly an hours worth of data is loaded each time you scroll to the bottom.

Downloading CSV Data

It is also possible to download the data in CSV format for loading into a spreadsheet or similar tool. It allows you to specify the date range for the data to download, and whether or not you want to include all battery data, or just a single unit.

There are two ways to do get to this download screen - from the interactive viewer, click the “CSV” link in the top right. This will result in the date range being populated with today’s date.

Alternatively, click “Logs” and then “Measurement Logs” from the top menubar. This will result in a date range of 1 month.

In either case, you can change both the requested dates (in YYYY-MM-DD format) and which batteries to download data for (either “All” or choose the unit id).

Once these choices have been made, click “Generate Report”

The BMS will process the request and generate a download file. This may take some time, but a progress report is displayed. See fig. 53.

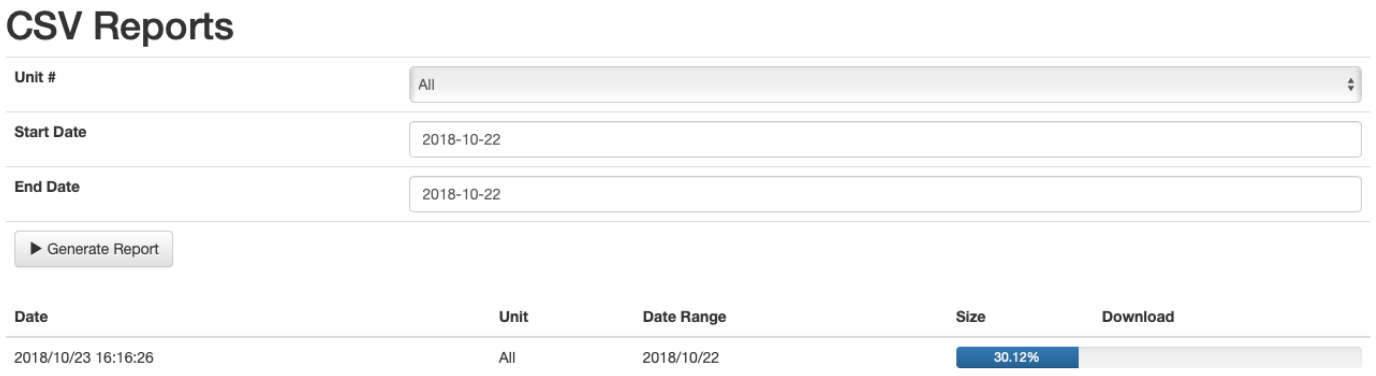


Figure 53: Battery log download
When the processing is complete, the file will be ready for download. Click on the provided link - see fig. 54.

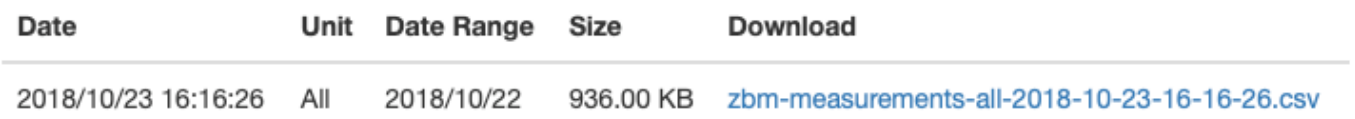


Figure 54: Battery log ready for download
The BMS keeps extensive logs of its operation. Generally speaking you will not need to access the logs, however during setup or while debugging a problem you may find it useful to do so.

The logs are all accessible via the web interface, which can be accessed locally, or remotely via the Z-Cell cloud portal.

Note that all critical problems that are logged will also be accompanied by a notification - which appears on all BMS screens. See the Notifications chapter for more information.

Note

Do not confuse these logs with the data logging of the ZBM batteries - this is covered in the ZBM Logs chapter.

Types Of BMS Logs

Event log

The event log covers, as the name suggests - “events” - which have been noticed by the system. They need not be indicative of a problem - in most cases they are reporting normal behaviour. Some examples include:

- a battery becoming fully discharged
- a battery becoming fully charged
- a battery entering discharge-only or maintenance mode
- a user logging into the BMS
- batteries entering or leaving a warning or failure state
- scheduled operations

Logic Engine log

The logic engine is the “heart” of the BMS. It is responsible for many aspects of the BMS operation, such as scheduling maintenance, checking battery health and battery optimisation.

The events logged to this log are generally informational, however it things are not behaving as you expect, it may be useful to look here to see the reasons why the BMS has made a particular decision.

Main log

The main log is “everything else”. System startup messages, other internal diagnostics and so on. Generally speaking, this log will be of most use in debugging BMS problems, not for debugging energy system behaviours.

Accessing The Logs

Click the “Logs” menu and Choose “BMS Logs”.

This will take you to an index page showing the different types of logs you can display.

Clicking through to the desired log will open today’s log file (starting at midnight).

At this point you can navigate through the logs timeline with the links at the top of the screen. See fig. 55.

Figure 55: Log navigation
You can change the period shown with the bottom part of the navigation, choose from:

- 4 hourly
- Daily
- Weekly
- Monthly
- Yearly

The top navigation line navigates “forwards” or “backwards” - how far depends on what period is selected.

The default is “Daily”, so you move forwards or backwards through the log one day at a time.

If you choose a large period, or if there are a lot of logs to display, the display will be limited. When scrolling to the bottom you will see a spinning “refresh” widget and the new data will be loaded, as shown in the example in fig. 56.

2018-01-02 05:39:05	ERROR ZBM:8 (SoC:48.0%)(50.7V) has indicated 'comms_failure' state
2018-01-02 05:39:05	ERROR ZBM:9 (SoC:47.8%)(50.7V) has indicated 'comms_failure' state
2018-01-02 05:39:06	INFO ZBM:2 (SoC:48.5%)(50.6V) is no longer in 'comms_failure' state

Figure 56: Loading more logs
Depending on the selection, it may take some time to load the logs for display.

Linking to logs

For support purposes it may be useful to show the logs to Redflow support staff or someone else. At any point you can capture the current URL in your browser and provide that link to someone else - it will automatically “jump” straight to that time and display period when clicked on by another party.

Overview

The BMS has a built in notification system to inform you of events.

The notifications displayed range from informational (advisory) to important. However, the BMS will never use a notification to display critical, action-dependant information, and in general, the battery is self-protecting and will disconnect from the bus in cases of over-current, over-voltage and similar critical events.

Some sort of things that the BMS may show notifications for:

- Incorrect/incomplete configurations
- Available firmware upgrades
- Unavailable network services

When one or more notifications are available, the BMS will show a number next to the “envelope” icon in the top menu bar (on any screen). See fig. 57.

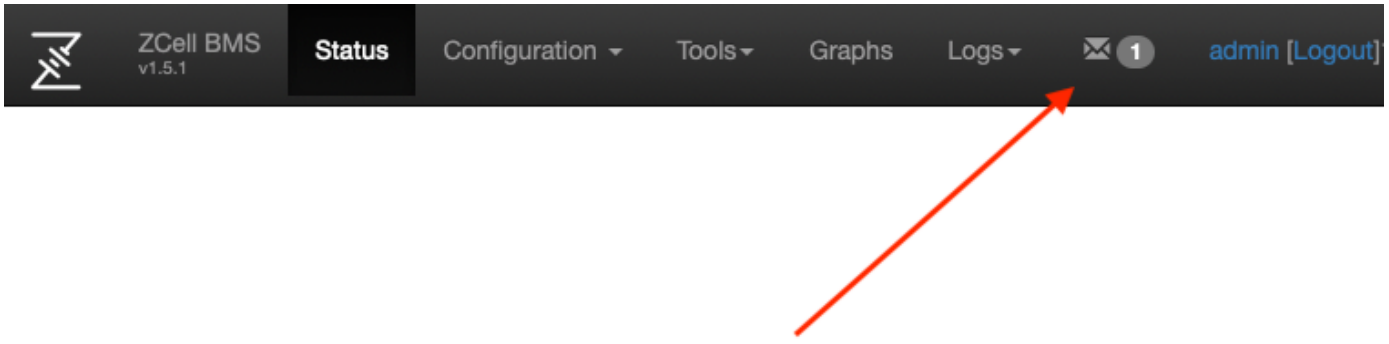


Figure 57: Notification 1
Clicking on the envelope will “popup” the notification(s). In the example shown in fig. 58, there is a single notification for a new firmware upgrade available.

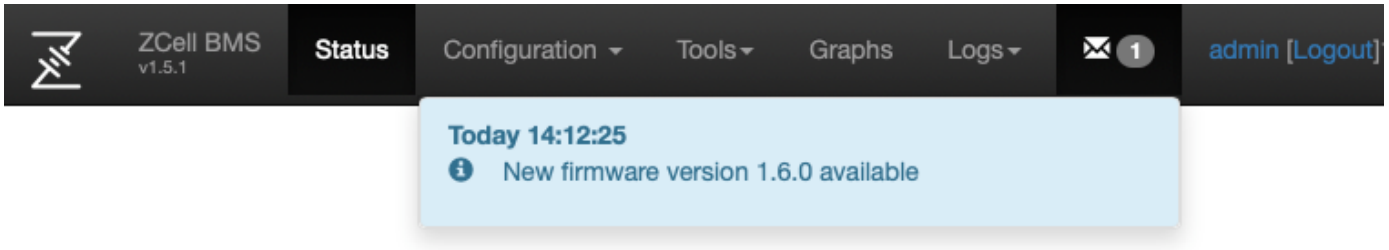


Figure 58: Notification 2
In fig. 59 we can see a more important notification (coloured red) for an incomplete configuration.

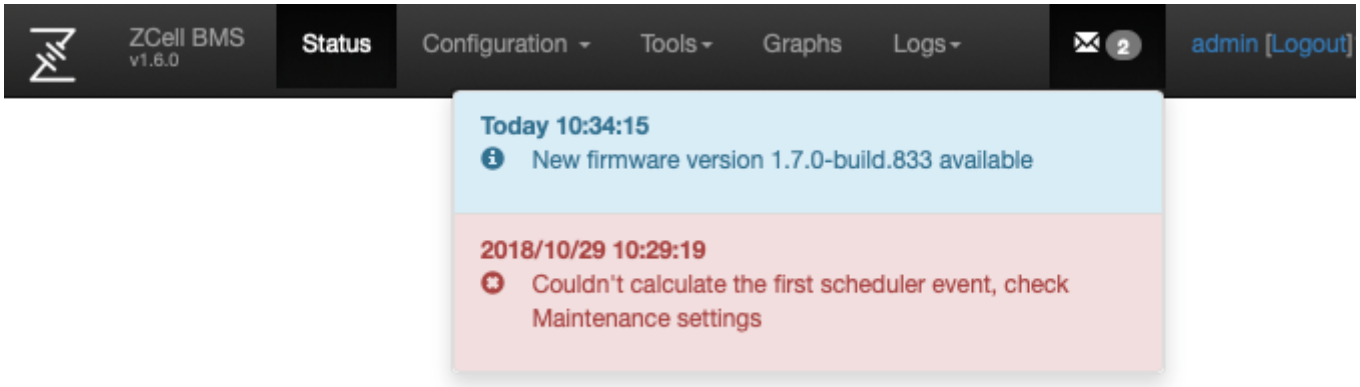


Figure 59: Notification 3

Clearing Notifications

It is not necessary to clear notifications manually. Notifications are automatically cleared after a length of time (for simple advisory notifications) or when the problem is resolved (for example, after a firmware upgrade is completed, or a configuration error is resolved).

Changing Credentials

Notes on changing the password

Overview

If network access is lost, the BMS provides 2 ways of resetting the configuration in order to gain access again. These are via USB keyboards and USB drives.

See the Network Configuration section for the default network settings, and the Site Configuration on the cloud connection setting.

USB Keyboard

To perform the various reset commands, a USB keyboard can be plugged into any the BMS's USB ports. Most USB keyboards should work. When pressing keys on the keyboard the BMS will make a beeping sound to confirm that the input has been registered. If unsure, press the 'esc' key and the BMS should beep.

Use the following 2 character commands to perform the various reset commands:

- *rw* to reset the WiFi settings back the their defaults as an access point.
- *re* to reset the Ethernet interface back to the default of DHCP.
- *rf* to reset the entire BMS back to the factory defaults.
- *ce* to reenable the BMS's cloud connection.

Once a valid command has been entered, a long beep will occur to indicate that confirmation of the command is required. Press 'y' to confirm the command, or press 'n' to cancel.

Once the command has been confirmed the BMS will be reboot and the new settings will take affect.

If a mistake has been made or there is need to start the input sequence again, either press the 'esc' key or wait a few seconds and the input buffer will be cleared. A quick double beep will occur to indicate this the input buffer has been cleared.

USB Drives

To perform the various reset commands a USB drive can be used with a specially crafted text file on it.

The file should be named *RESET* or *RESET.TXT* and be in the root directory of the USB drive.

The contents of the files should be one of the following:

- *wifi* to reset the WiFi settings back the their defaults as an access point.
- *ethernet* to reset the Ethernet interface back to the default of DHCP.
- *factory* to reset the entire BMS back to the factory defaults.
- *cloud* to reenable the BMS's cloud connection.

Once the USB drive has been configured it can be inserted into any of the BMS's USB ports. The BMS will beep with 3 short beeps and a long beep to confirm that it has recognised the drive.

When the BMS reads the RESET file, it will beep once a second to indicate that the reset is pending. This will be followed by long beep, then the actual reset will occur. The USB drive can be removed at any time during this period to cancel the reset operation. You have 30 seconds to cancel the operation by removing the USB drive.

After the long beep the BMS will restart, making the changes according to the reset file contents as documented above. The USB drive should now be removed.