



Nuvation Energy Battery Control Panel

Product Manual

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The content in this document must be followed in order to ensure safe operation of Nuvation Energy BMS.



Do **NOT** energize the system until all connections to the Battery Control Panel have been made.



Properly insulate or remove any unused wires. Unused wires can couple excessive system noise into Nuvation Energy BMS which can disrupt communication and lead to undesirable behaviors.



Please be aware of high voltages present in your system and follow all necessary safety precautions.



The provided module enclosures are not fire enclosures.

1. Introduction

Thank you for choosing Nuvation Energy BMS.

Nuvation Energy BMS is an enterprise-grade battery management system with features that extend battery life, ensure pack-level safety, provide data analytics, and allow remote management.

The Nuvation Energy Battery Control Panel aggregates information and provides a unified interface to a multi-stack battery system.

You can take advantage of the highly configurable browser-based user interface and custom-tune Nuvation Energy Battery Control Panel to your specific target application.

1.1. About this Manual

This *Nuvation Energy Battery Control Panel: Product Manual* is a comprehensive manual, providing:

- Details about all the features offered by your Nuvation Energy Battery Control Panel
- Mounting and wiring instructions to install this product safely
- Guidance on operating the device to control your multi-stack energy storage system



This document applies to Nuvation Energy BMS Curie Update 2 software release (Firmware version 4.106.2, Multi-Stack Operator Interface version 0.56.1). Content may be inaccurate or incomplete for other versions.



We thrive on your feedback and what we build is driven by your input. Please submit support tickets to support@nuvationenergy.com.

2. Battery Topology Terminology

Energy storage systems are hierarchical in nature. Nuvation Energy has adopted the following definitions for battery pack topology:

Cell

A Cell is the smallest unit of energy storage distinguishable by the battery management system. One Cell, as defined from the perspective of the BMS, may actually consist of one or more electrochemical cells connected in parallel. This subtlety is reflected in the nomenclature for completeness. For example, a "1p" Cell refers to a single electrochemical cell, while a "2p" Cell refers to two electrochemical cells connected together in parallel. From the perspective of the BMS, these topologies appear identical except for the capacity of the Cells.

Group

A Group is a set of Cells connected in series and managed together. For example, 12 "1p" Cells in series are referred to as a "12s1p" Group, while 16 "2p" Cells in series are referred to as a "16s2p" Group. Grouping of Cells is highly application-specific and is defined in how BMS hardware interfaces are physically wired up to Cells.

Stack

A Stack is one or more Groups connected in series. For example, five "14s2p" Groups connected in series are referred as a "5g14s2p" Stack. This Stack may also be described as a "70s2p" Stack.

Bank

A Bank is one or more stacks connected in parallel. For example, three "5g14s2p" Stacks are referred to as a "3x5g14s2p" Bank or simply a "3x70s2p" Bank.

Pack

A Pack is one or more Banks connected in series.

3. System Overview

The Nuvation Energy Battery Control Panel aggregates all battery stacks within a multi-stack energy storage system. It enables operation of the overall system as a single unified battery, while still providing stack-level control.

This product functions as a central battery-control hub for all other energy control systems. These may include power conversion systems and/or energy controllers. Through this hub, such control systems can obtain and respond to battery data and send control commands to the battery system.

The Battery Control Panel can be used to manage up to 36 battery stacks in parallel, and will bring up stacks in the sequence best suited to the immediate use-case requirement, i.e. power, energy, or capacity.

The Battery Control Panel provides two crucial battery-level software interfaces for large, multi-stack battery applications:

1. Modbus TCP:

- Unified view of the entire battery conforming to open energy standards.
- Conforms to MESA (Draft 3) Models: S801, S802 and S803
- Used directly by inverters and other grid infrastructure implementing the MESA (Draft 3) standard

2. Web-based configuration and diagnostics:

- Hosts web-based tools that can be accessed from common web browsers
- Used to provision firmware upgrades, configure settings and view diagnostic information for the entire battery system

A few key system-level features that are also provided are:

- System-wide statistics for voltages, temperature and currents
- Current limiting algorithms for multi-stack battery systems
- State-of-Charge algorithms for multi-stack battery systems
- NTP client for BMS time synchronization



Figure 1. Nuvation Energy Battery Control Panel

3.1. Multi-Stack System Architecture

A typical multi-stack system, equipped with Nuvation Energy’s suite of BMS products, is illustrated in [Figure 2](#). There is a hierarchy of battery management involved, each product fulfilling its role at a different level:

- At the cell level, a Nuvation Energy Cell Interface module measures voltage/temperature and balances cells as required.
- At the stack level, a Nuvation Energy Stack Switchgear unit measures current and connects/disconnects its stack as required, as well as incorporates other stack safety features. Battery safety is handled at the stack level.
- At the system level, a Nuvation Energy Battery Control Panel unit manages all stacks as described above.

For a given stack, the daisy-chained Cell Interface modules report data to and receive direction from the Stack Switchgear. In turn, the Stack Switchgear reports data to and receives direction from the Battery Control Panel. Here, a unified view and central control of the multi-stack system is provided to the user as well as any external devices.



Nuvation Energy Cell Interface modules and Nuvation Energy Stack Switchgear units are sold separately. Datasheets, along with product manuals, are available online at <https://www.nuvationenergy.com/technical-resources>.

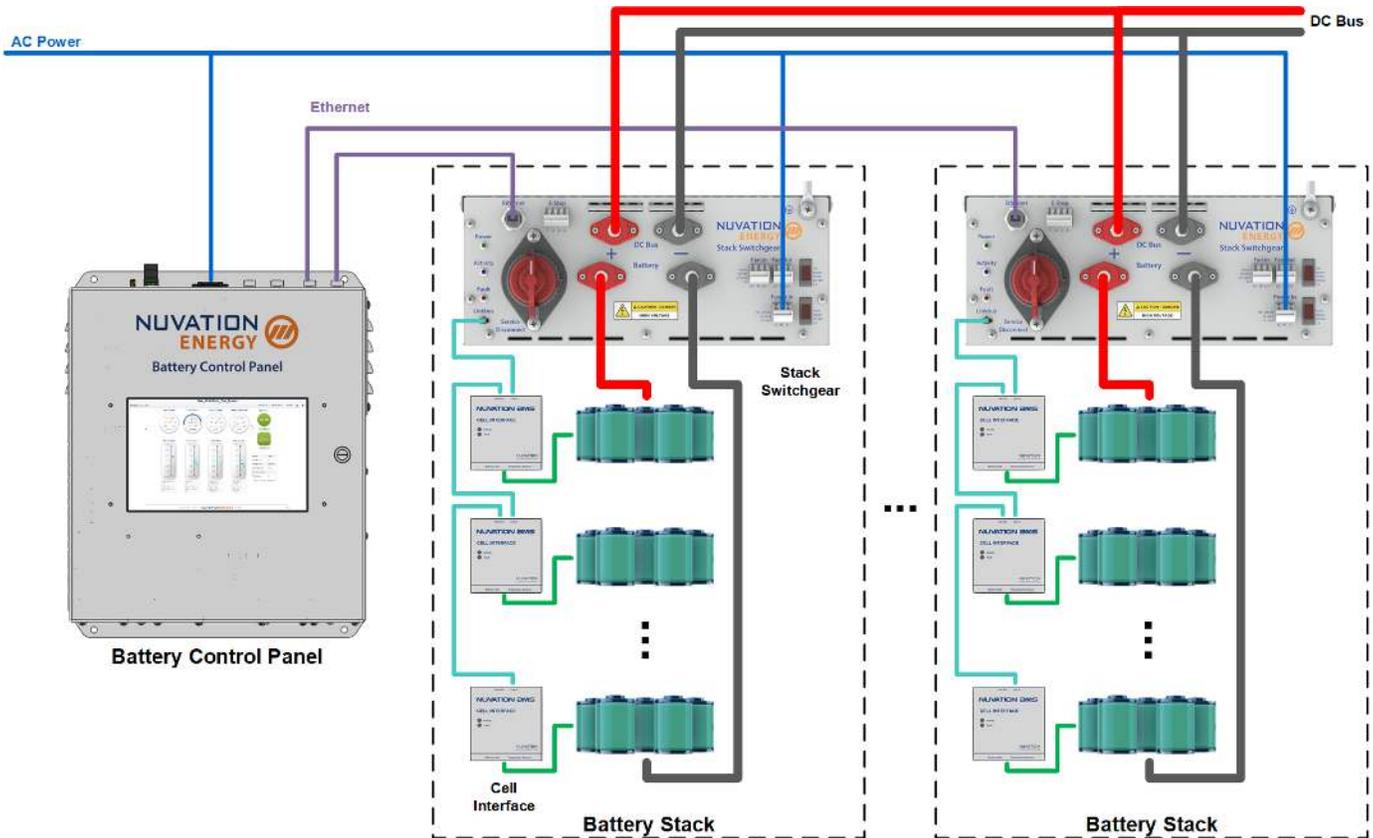


Figure 2. Battery Control Panel multi-stack diagram

Battery Control Panel is offered in variants based on the number of battery stacks to which it will be connected. Variants are available in 4-stack increments, up to a maximum of 36 stacks.

Designed in compliance with MESA (Modular Energy Storage Architecture) Open Standards for Energy Storage (mesastandards.org, draft 3), the Nuvation Energy Battery Control Panel was created specifically for integration with a wide range of batteries and inverters, and is designed to work with Nuvation Energy Stack Switchgear, Nuvation Energy High-Voltage BMS and Nuvation Energy Low-Voltage BMS.

Orderable part numbers are listed in [Appendix B](#).

3.2. Features

3.2.1. Main Functions

Manages multiple stacks

Manage up to 36 stacks.

Provides Unified View of Entire Battery

Access diagnostics and performance data of entire multi-stack battery from a single unified user interface.

Provides Remote Access

Remote access for data analytics or for viewing and adjusting battery operation remotely via web browser on a PC, tablet computer or even on a smartphone.

Automates System-Wide Fault Response

Manually or automatically identify and act upon faults anywhere in the battery pack.

Communications

Communicate securely over Ethernet. Provides unified interface for site controllers to multiple stacks.

Automatic Pack Connection

Allows the BMS to manage the connected state of all battery stacks within the pack. When requested, the Battery Control Panel will connect all stacks if they do not violate the pack connection voltage limit. Stacks are automatically connected when the limit is no longer violated (i.e. when the stack voltage becomes close enough to the pack voltage that is safe to connect).

Maximize Pack Uptime and Connection

Provides a flexible configuration to manage battery stack faults at a pack level. An operator can configure a battery pack to tolerate a specified number of stacks that fault and disconnect from the DC bus. The Battery Control Panel allows the pack to remain operational and manage the reduced power capacity of the battery.

3.2.2. Unified View Operator Interface

Browser user interface, which supports Chrome and Firefox, provides a view of:

Statistics View

Monitor pack-level statistics for voltage, temperature, and current across all cells.

Real-Time View

Monitor measurement and control information in real-time.

Aggregate State-of-Charge

View State-of-Charge calculated values for the entire battery.

Flow-Through I/O

Control all points in the BMS from a single interface.

Communications Status

Reports networking communication status and communication issues from stacks within the pack.

Faults and Warnings

Monitor all system-wide faults and warnings or—for a finer level of control—drill down into detailed battery pack diagnostics.

3.2.3. Communications & Data Analytics

Isolated BMS Network Traffic

Separate Gigabit Ethernet ports isolate BMS network traffic from external network traffic, helping ensure your energy storage system is hardened and reliable.

Inverter Support

Modbus TCP supports MESA Draft 3 storage models for connection to power conversion systems as well as other external systems through multiple concurrent client connections.

3.2.4. Maintenance and Management

Multi-Stack Current Limiting

Determine operating current for entire pack and use this data to control the inverter, protecting the battery pack from over-charging or discharging.

Pack-Level Safety

A highly configurable architecture allows the operator to specify system faults and desired responses. The Battery Control Panel flags faults anywhere in the battery pack and automatically takes preventive action to keep the battery safe and healthy.

Servicing

Bring stacks online/offline for service, maintenance, modifications, etc. Selectively connect multiple stacks to the DC power bus.

Network Environment Flexibility

A multi-socket Ethernet interface allows concurrent operation of both local and remote operator panels, monitoring data and controlling inverters over Modbus TCP.

Battery Performance Tuning

Low-level, fine tuning controls enable optimization and on-the-fly experimentation. Update fault voltages, temperature levels, and more in seconds from the Operator Interface GUI.

Provides Remote Support

The Battery Control Panel provides a secure VPN connection to a Nuvation Energy server and grants Nuvation Energy support engineers remote access to check on the health of the battery pack and aid the local site commissioning team.

3.2.5. Hardware Overview

The block diagram in [Figure 3](#) depicts the interconnection of these components and how they make up the Battery Control Panel system.

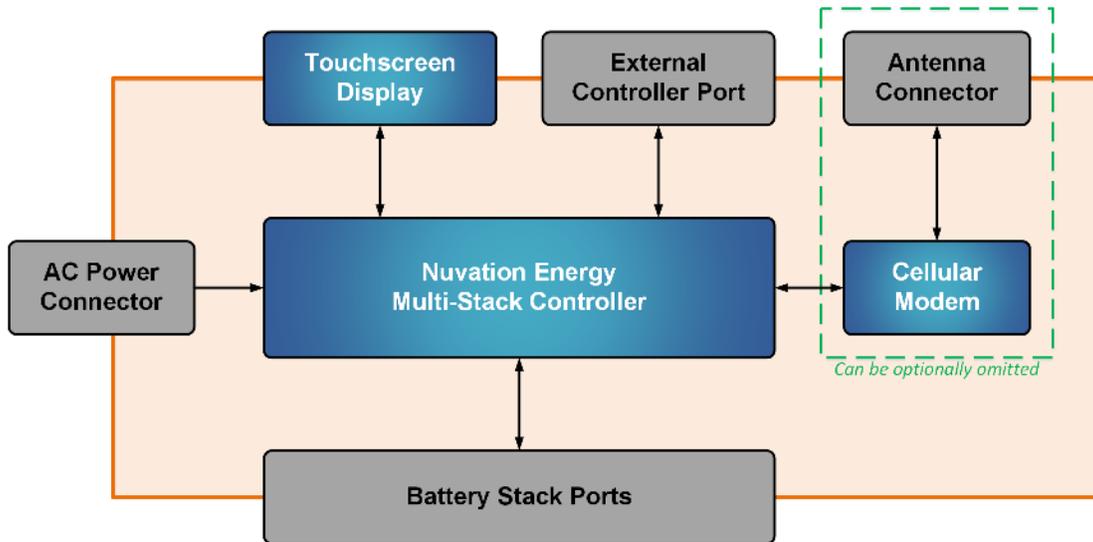


Figure 3. Battery Control Panel block diagram

3.2.6. Nuvation Energy Multi-Stack Controller

At the core of the Battery Control Panel is the Nuvation Energy Multi-Stack Controller which is responsible for the management of multiple battery stacks via their Stack Switchgear units. It is the central computing component inside the Battery Control Panel. It aggregates all the battery stacks in the energy storage system and manages them as a single battery. Key features include:

- Sequencing the connection and disconnection of stacks during bring up and operation
- Providing battery data to energy management and environmental control systems
- Reporting system faults and warnings
- Making BMS configuration updates

Users can remotely access the Multi-Stack Controller to perform system changes or to observe battery performance at the system, stack, and cell level. Users can also view aggregate or granular voltage, current, temperature, and State-of-Charge data in real-time.

The Multi-Stack Controller includes internal storage for battery performance data logs. These data logs may be used to:

- Support warranty claims by comparing actual and predicted battery degradation curves, based on time and throughput
- Understand how different energy storage applications impact battery life
- Track down the cause and location of a performance issue

3.2.7. LCD Touchscreen

A 10.1" LCD touchscreen display on the front of the unit provides an at-a-glance view of the battery system as well as provides access to the Nuvation Energy BMS Operator Interface, making it possible to access performance data and user controls directly at the Battery Control Panel.

The touchscreen display presents the Multi-Stack Operator Interface dashboard which is the default view; it is the central, unified interface that allows access to Multi-Stack Controller features. From this screen a local technician can monitor the running state of the system, connect and disconnect the battery from the system to perform maintenance.

While the touchscreen display provides access to a sub-set of the Multi-Stack Operator Interface features, the full Multi-Stack Operator Interface feature-set with many additional functions may be accessed remotely, via a web-browser.

3.2.8. External Ethernet

The External Ethernet interface is a standard Cat5e-rated RJ45 jack, supporting Gigabit speeds. It is used as the primary means of connecting the Battery Control Panel to an external system, such as:

- Energy control systems, such as power conversion systems and energy controllers
- A laptop, to configure operating parameters and observe status
- A local area network (LAN) connection, for wired internet access
- An Ethernet switch, to access any number of the above devices

3.2.9. Local Ethernet

The Local Ethernet interfaces are standard Cat5e-rated RJ45 jacks. This bank of Ethernet ports are used to connect the battery stacks—that is, the Stack Switchgear units—to the Battery Control Panel. The number of ports available depends on the Battery Control Panel purchased.

3.2.10. Cellular Network Modem

The primary means of internet access is a wired connection to the "External Ethernet" interface ([Section 3.2.8](#)). If this becomes unavailable for any reason, the internal cellular modem provides redundant connectivity. This facilitates remote access to the system for product support and off-site monitoring.

A Battery Control Panel purchase includes 1 year of cellular data-access for installations in the USA or Canada. Most 3G and 4G networks in these regions are supported by the modem; refer to [Cellular Specifications](#) for further details.

An external antenna is provided to strengthen the signal between the internal modem and the local cell tower.



The cellular modem is compatible with network carriers in the USA and Canada only. [Section 10.1](#) instructs how to request the omission of this feature.

4. Installation Instructions

During all stages of the installation, use the appropriate Personal Protective Equipment (PPE) and ensure that all battery stacks are offline.



Do **NOT** energize the system until all connections to the Battery Control Panel have been made.

4.1. Mechanical Installation

4.1.1. Dimensions and Weight

The unit weighs approximately 13.6 kg [30 lbs].



Figure 4. Nuvation Energy Battery Control Panel Dimensions

4.1.2. Installation Location and Position

The Battery Control Panel is rated to operate in the temperature range of 10 °C to 40 °C. It is designed to be vertically wall-mounted in an indoor location.

It is recommended to install the Battery Control Panel with the display at eye level to allow operating conditions to be read at all times.

4.1.2.1. Mounting Clearances

It is recommended to leave 300 mm [12 in] of clearance on all sides (above, below, left, and right) of the mounted Battery Control Panel unit. This facilitates airflow through the Battery Control Panel for better thermal performance as well as for easy access to connectors for installation.

4.1.3. Mounting Instructions

Procure Fasteners

Ensure appropriate fasteners (not included) for are used to mount the Battery Control Panel. These fasteners will vary depending on the material and construction of the mounting surface.

It is recommended to use M6 mounting bolts with a washer for the 4 mounting holes on the top and bottom flanges of the unit.

If used to tap into a wall or anchors, the mounting bolts should be at least 25 mm [1 in] long. If required, install anchors in the wall to mate with the mounting bolts.

Mount unit

Ensure the intended mounting surface is sturdy enough to secure the unit to it. Ensure the path for the fasteners in the intended mounting surface is safe and free of electrical or other cables.

It is recommended that the installation be performed by two people—one person to hold the unit in place, while another person fastens the unit.

4.2. Electrical Connections



Before making any connections, ensure that the power switch in [Figure 5](#) is in the OFF position.

4.2.1. Getting Started

To complete the electrical installation of Battery Control Panel you need to:

1. [Connect Stack Switchgear communications](#)
2. [Connect external network or system](#)
3. [Connect cellular antenna](#)
4. [Verify grounding](#)
5. [Connect power](#)

Below is a overview image of the external interfaces available on the top of the Battery Control Panel.

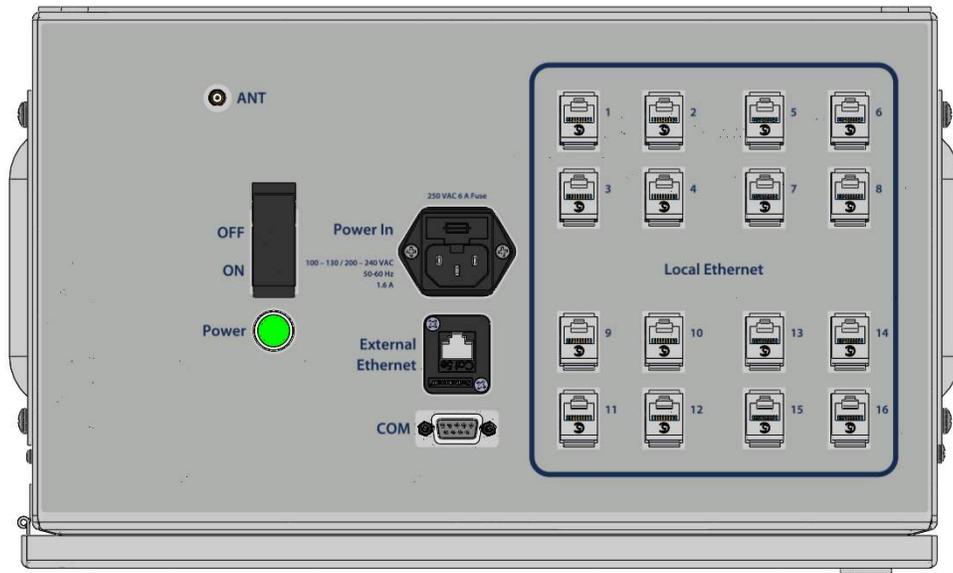


Figure 5. Battery Control Panel external interfaces

4.2.2. Step 1: Connect Stack Switchgear communications

Connect the Stack Switchgear units to the 'Local Ethernet' RJ45 jacks using Cat5e-rated or higher Ethernet cables of suitable lengths.

The number of ports available for connection depends on the Battery Control Panel variant purchased. External or third-party equipment should not be connected to the 'Local Ethernet' ports.

4.2.3. Step 2: Connect external network or system

The 'External Ethernet' RJ45 jack may be used to connect the Battery Control Panel to an external system, such as:

- Energy control systems, such as power conversion systems and energy controllers
- A laptop, to configure operating parameters and observe status
- A local area network (LAN) connection, for wired internet access
- An Ethernet switch, to access any number of the above devices

The External Ethernet interface is a standard Cat5e-rated RJ45 jack, supporting Gigabit speeds.

Any Cat5e-rated or higher Ethernet cable of suitable length may be used to connect to this RJ45 jack.

4.2.4. Step 3: Connect cellular antenna



This step applies to Battery Control Panel units with the Cellular Network Modem option.

Connect the supplied screw-in mating antenna to the Cellular Antenna ('ANT') interface. This interface is a standard SMA jack and it connects to the Battery Control Panel's internal cellular modem discussed in [Section 3.2.10](#).

This external antenna is provided to strengthen the signal between the internal modem and the local cell tower. For installation sites and rooms with weak cellular reception, an extension SMA cable (not provided) may be used to route the antenna to an area with superior network coverage.



The cellular modem is compatible with network carriers in the USA and Canada only. Most 3G and 4G networks in these regions are supported by the modem.

Refer to [Cellular Specifications](#) for further details.

4.2.5. Step 4: Verify grounding

All components internal to the Battery Control Panel, as well as the enclosure itself, are grounded to the Protective Earth line of the AC power connector.

These instructions assume that attention is paid to proper grounding instructions and best practices for any and all Stack Switchgear units and Cell Interface modules. Please refer to the Nuvation Energy Stack Switchgear: Product Manual for this information.

It is also assumed that similar measures are taken for other components of the battery energy storage system such as the batteries and the power conversion system.

4.2.6. Step 5: Connect Power



Before making any connections, ensure that the power switch in [Figure 5](#) is in the OFF position.

Identify an appropriate AC power source

The AC power source must not be derived from the energy system itself without an ability to maintain (or turn on) the supply when the energy system is powered off.

An external UPS can be used between the energy system-derived AC source and the supply providing power to the Battery Control Panel when an external AC power source is not available.

Connect the power cable to the 'Power In'

The 'Power In' interface is an IEC 320-C14 connector requiring external 120/240 V AC power. It is compatible with locally-sourced AC line cords and features: line filtering, a built-in 4 A breaker, and an illumination LED to indicate power presence.

4.2.7. Note on Communication ('COM') interface

The Communication ('COM') interface is a D-Sub connector that should be treated as a NC (no-connect).

4.3. First-time Power-up

Powering up the system

Verify that all the mechanical and electrical installation steps are completed and the Battery Control Panel is connected to the Stack Switchgear units, network, and power.

When ready to power on the Battery Control Panel, toggle the power switch to the 'ON' position. The 'Power LED' besides the switch should light up, followed by the touchscreen display on the front of the unit.

The Battery Control Panel will emit a 4-tone startup chime when low-level software has started. This will be followed by a 3-tone chime once all software has been initialized. The Nuvation Energy BMS Operator Interface will become visible shortly after this chime.



When toggling the power switch, ensure that it remains in the 'OFF' position for 30 seconds. This will allow the unit to completely power down.



Cycling the power of Battery Control Panel on and off 10 times in a row, without the unit starting up completely, will restore the unit to a factory default state. If this is not intended, please ensure that the unit is fully powered up before power cycling.

In the event the unit is reset to factory defaults, please contact support@nuvationenergy.com to bring the unit back to a functional state.

Viewing the Dashboard

Once the system is fully booted up, the dashboard will load on the touchscreen display.

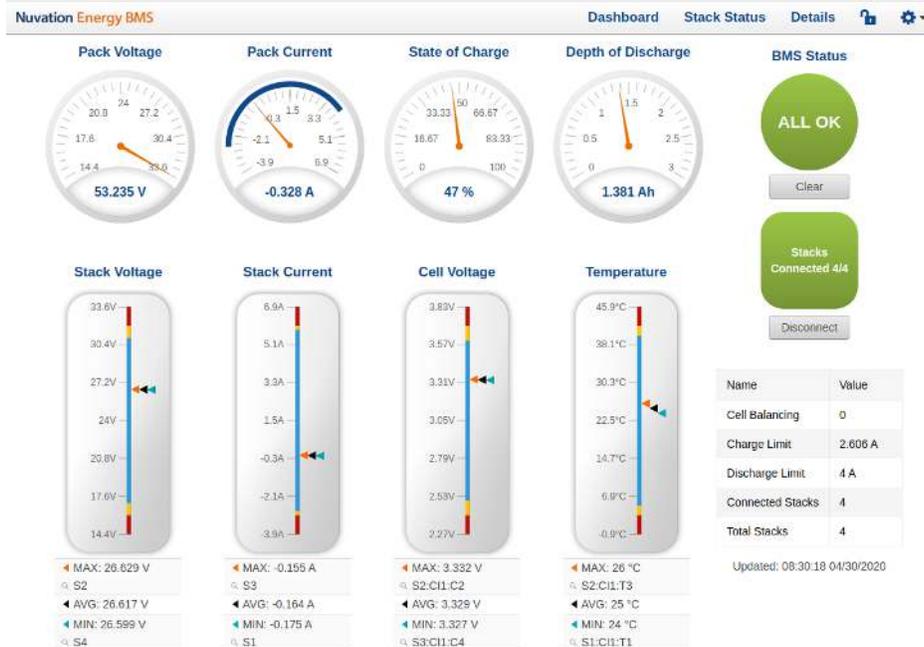


Figure 6. Multi-Stack Operator Interface Dashboard

5. Setup and Configuration

Your Battery Control Panel enables control of multiple Stack Switchgear units. Each Stack Switchgear will need to be installed and set up individually before setting up the Battery Control Panel.



For instructions on how to install Stack Switchgear units, please refer to the *Nuvation Energy Stack Switchgear: Product Manual*.

5.1. Getting Started

Overview of steps:

1. [External Network Configuration](#)
2. [Stack Network Configuration](#)
3. [Connecting the Battery Stacks](#)

5.2. External Network Configuration

Overview of steps:

1. [Select external computer to connect](#)
2. [Launch Platform Interface](#)
3. [Verify Platform Settings](#)

5.2.1. External Computer Requirements

An external computer with a keyboard, like a laptop or a PC, is recommended to perform the setup steps. Ensure the following 3 requirements have been met when selecting a computer.

Network Connection

Ensure the computer is connected to the same network as the *External Ethernet* on the Battery Control Panel.



An internet connection is not required for the product to function. However it does use the Network Timing Protocol (NTP) to maintain its clock accuracy.

Computer OS Compatibility

Ensure the Operating System of the laptop/computer supports multi-cast DNS (mDNS).

Table 1. Operating Systems that support mDNS

OS	Version	Additional Software Required
Windows	10	N/A
Windows	8 and lower	Apple Bonjour
MacOS	10.2 and higher	N/A
Linux	N/A	Avahi



mDNS is also operational when a Static IP is configured.

Manual IP Discovery



In the event that the computer does not support mDNS, the MAC address for the external network port is labeled on the exterior of the Battery Control Panel.

Look for this MAC address in the DHCP server to determine which IP address was assigned to the Battery Control Panel and navigate to 'https://<ip-address>' from a compatible web browser.

5.2.2. Launch Platform Interface

Navigate to [http://ncontroller-
<serial number>.local/platform](http://ncontroller-
<serial number>.local/platform) from a compatible computer (see [Section 6.1.1](#)). Replace <serial number> with the Battery Control Panel serial number - this can be

found on a label on the exterior of the product.



The Platform Interface currently supports the most recent versions of Mozilla Firefox and Google Chrome. Other browsers such as Internet Explorer are not supported.

5.2.3. Verify Platform Settings

Networks

On the Platform Interface, from the left-hand menu, select Networks to bring up the network configuration page. Review the network details on this page.

If any changes are necessary, refer to [Section 7.3](#) for instructions and guidance on changing networking settings.



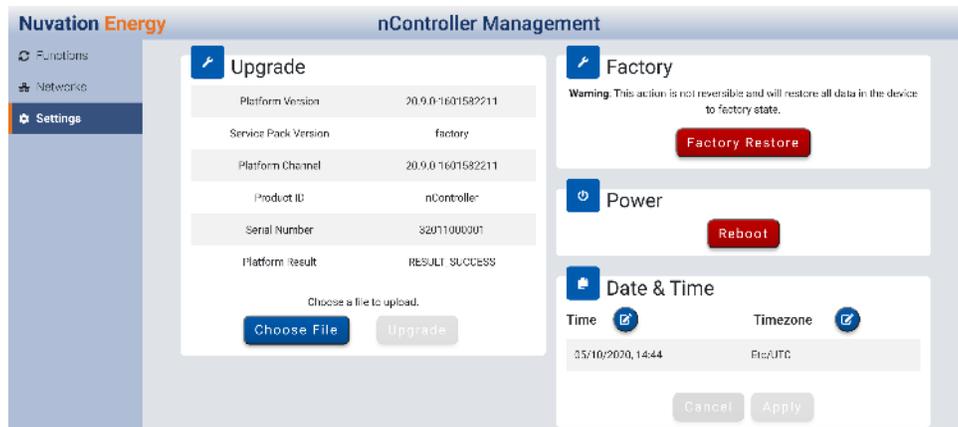
Record the 'Bridge' IP address, netmask, and gateway settings. This is needed for provisioning the stacks



Date and Timezone

On the Platform Interface, from the left-hand menu, select Settings to bring up the settings page. Review the date/time and timezone information.

If any changes are necessary, refer to [Section 7.4.4](#) for instructions and guidance on changing the date/time and timezone values.



5.3. Stack Network Configuration

Overview of steps:

1. [Determine the valid IP Address range for Stack Switchgear units](#)
2. [Update Network Settings for Stack Switchgear units](#)

5.3.1. Determine the valid IP Address range

Please refer to the *Nuvation Energy Stack Switchgear: Product Manual* to setup and provision the individual Stack Switchgear units. Once each stack is set up and configured you can change the network configuration for the individual Stack Switchgear to communicate with Battery Control Panel. All Stack Switchgear units connect to Battery Control Panel via the *Local Ethernet* ports.

The IP address for each Stack Switchgear must be consistent with the internal network configuration. The details of this internal network configuration are available in the Platform Interface Networks page under the 'Bridge' card. See [Section 7.3](#) for details on how to access this information.

For example, if the ip_address of the internal network was set to 192.168.4.10 and the netmask was set to 255.255.255.0, then the valid IP address range for Stack Switchgear units would be 192.168.4.x where x cannot be 0, 10 or 255.

5.3.1.1. Update Network Settings for Stack Switchgear units



Be sure to record the updated IP address, netmask, and gateway settings if you decide to make changes to these settings.

Perform the following for each Stack Switchgear that is managing a stack:

1. Launch the Operator Interface for the Stack Switchgear.
2. Refer to the *Nuvation Energy Stack Switchgear: Product Manual* for instructions on how to access the Operator Interface.
3. Unlock the Operator Interface by clicking the menu and Unlock.
4. From the menu, select Registers to bring up the register browser page.
5. Under the Manual Register Configuration panel, expand the row for Component Name sc_ethernet.



Use the find feature (Ctrl + F) in your browser to locate components in the page

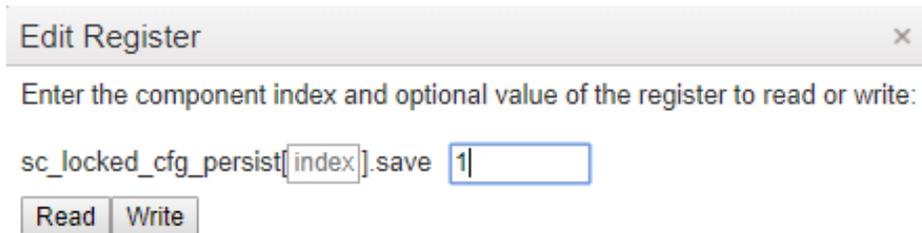
Register Offset	Register Name	Description	Type	Units	Storage	
0x0	use_dhcp	Flag indicating if DHCP is used	Boolean	Flag	Configuration	<input type="button" value="Edit"/>
0x1	ip_address	IP address to be used in static configuration	IpAddress	IP	Configuration	<input type="button" value="Edit"/>
0x2	net_mask	Network mask to be used in static configuration	IpAddress	IP	Configuration	<input type="button" value="Edit"/>
0x3	gateway	Gateway address to be used in static configuration	IpAddress	IP	Configuration	<input type="button" value="Edit"/>
0x4	mac	MAC address of this board	UInt64	Value	Manufacturing	<input type="button" value="Edit"/>

- Click the Edit button on the ip_address register. This will bring up the Edit Register dialog box.
- Change the IP address according to the constraints discussed in [Section 5.3.1](#). Then click Write.



The index field may be left blank for all operations.

- Confirm that the value has been updated by clicking Read.
- Under the Manual Register Configuration panel, expand the row for component name sc_locked_cfg_persist.
- Click the Edit button for the save register and write a value of 1.

A screenshot of a software dialog box titled "Edit Register" with a close button (x) in the top right corner. Below the title bar, the text reads "Enter the component index and optional value of the register to read or write:". The text "sc_locked_cfg_persist[index].save" is displayed, with "index" enclosed in a small rectangular box. To the right of this text is an input field containing the number "1". Below the text and input field are two buttons: "Read" and "Write".

- Verify that the configuration has been saved correctly by reading the error register. The value will be 0 if no errors have occurred.

The network configuration settings have been updated.

Power cycle the Stack Switchgear for the updated network settings to take effect.



Improperly modifying the network settings can result in a Stack Switchgear that cannot communicate over Ethernet. To restore Stack Switchgear to its default IP address (192.168.1.21), you must initiate a factory reset action—refer to the *Nuvation Energy Stack Switchgear: Product Manual* for instructions.

5.4. Connect the Battery Stacks

Topics covered in this section:

1. [Compose the Configuration File](#)
2. [Import the Configuration File](#)
3. [Enable the Stacks](#)
4. [Stack Connection Modes](#)
5. [Automatic Stack Connection](#)
6. [Manual Stack Connection](#)

5.4.1. Compose the Configuration File

Before the stacks can be connected, the Battery Control Panel must be configured properly. Stack configuration is accomplished via configuration registers, which may be edited either by importing a configuration file or by manually editing configuration registers. Refer to [Section 8.1](#) to learn more about configuration registers and configuration files.

Stack configuration involves two main steps, installing and enabling. Installing a stack allows the Battery Control Panel to communicate with it, while enabling a stack allows the Battery Control Panel to control it. Refer to [Section 8.2](#) to learn more about stack states.

Sample Configuration File



As a starting point, a sample configuration file is shown in [Appendix E](#). It is also available for download at <https://www.nuvationenergy.com/technical-resources> under the Battery Control Panel section.

The values in the sample configuration file are generic, and should be updated to accurately reflect the electrical properties of site equipment.

You may use any standard text editor to edit the contents of the configuration file to meet the requirements of the application. Open the sample config file and edit the following named sections to match your application for safe initial site setup:

Network Settings

- Update the stack IP addresses in this section using the addresses determined by [Section 5.3](#). Refer to [Section 8.3](#) for more information on network settings.

Pack Topology

- Update this section to match the topology of the pack, i.e. the number of stacks installed and enabled. It is recommended to begin with all stacks disabled, then enable one stack at a time during site commissioning. Refer to [Section 8.4](#) for more information on battery pack topology settings.

Control Settings

- These can be left as the default settings. Refer to section [Section 8.5](#) for more information on

control settings.

Operational Limits

- These can be left as the default settings. Refer to section [Section 8.6](#) for more information on operational limits.

Auto Connection Config

- Update this section with the current and resistance values for your battery stacks, as well as the desired connection delay and policy.
- It is recommended to begin with auto-connection disabled for all stacks until they have been manually tested. To enable auto connect, uncomment the indicated lines and set the desired stacks to 1 to enable auto-connect. For example, to enable auto-connect for stacks 1 through 4, use the following configuration:

```
pack_stack[*].enable = 0
pack_stack[*].auto_connect = 0
pack_stack[0:4].enable = 1
pack_stack[0:4].auto_connect = 1
```

- Refer to section [Section 8.5](#) for more information on control settings.

MESA

- To use the MESA Draft 3, update the system topology.
- Note that what is referred to as a "stack" in Nuvation Energy documentation is referred to as a "string" in the MESA nomenclature.

5.4.2. Import the Configuration File

Your Battery Control Panel needs a valid configuration file to operate.

For instructions on how to create and modify the configuration file, and to understand the various registers please refer to [Section 8](#).

5.4.2.1. Import the Configuration file

1. [Launch the Multi-Stack Operator Interface](#) from a compatible computer with a compatible web browser (see [Section 6.1.1](#))
2. From the menu, select Service



3. Ensure Persist Configuration to BMS is checked

Persist Configuration to BMS

Enabling this option tells the controller to persist the imported configuration file. If you are using known good configuration files you should check this box.



Disabling this option tells the controller to not persist the newly imported configuration file. On reboot, the controller will revert to the previous configuration file. This is useful when tweaking and testing configuration files. It allows you to recover from incorrect configuration settings by rebooting the controller



Only registers that are prefixed with pack* and gbc* will be persisted on the controller.

4. Click Import Configuration
5. Select the configuration file to use and click Open
6. A dialog indicating progress will pop-up



7. Wait until a dialog box appears with the configuration import result. It should indicate that the import was successful.



5.4.2.2. Configuration File Import Troubleshooting

During the configuration file import, if you receive a Register Write failure error, ensure you have valid entries in your configuration file. For details on the various registers and their intended use, please refer to [Section 8](#).



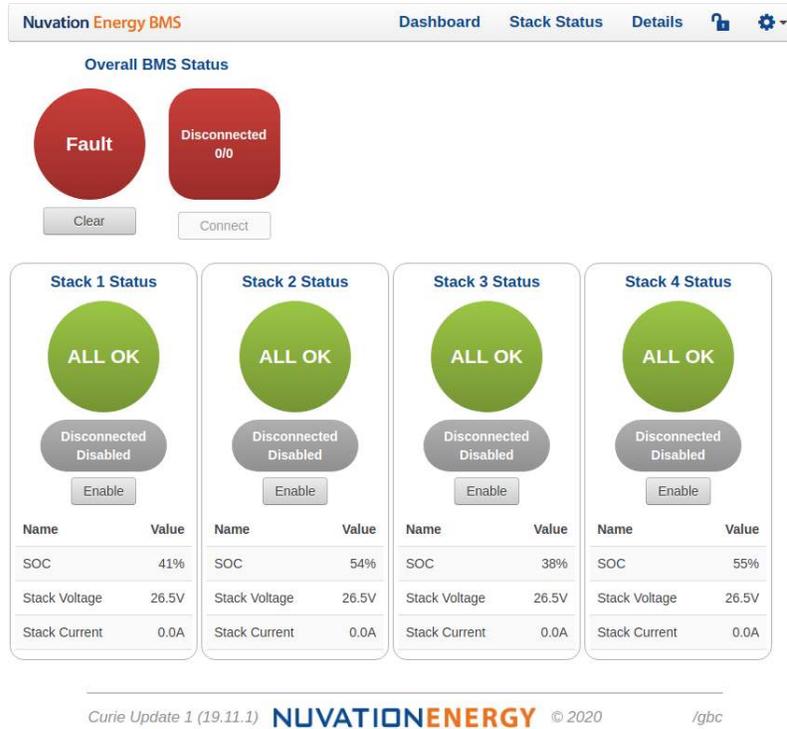
If the failures persist, please submit a support ticket with as much detail as possible to support@nuvationenergy.com.

5.4.3. Enable the Stacks

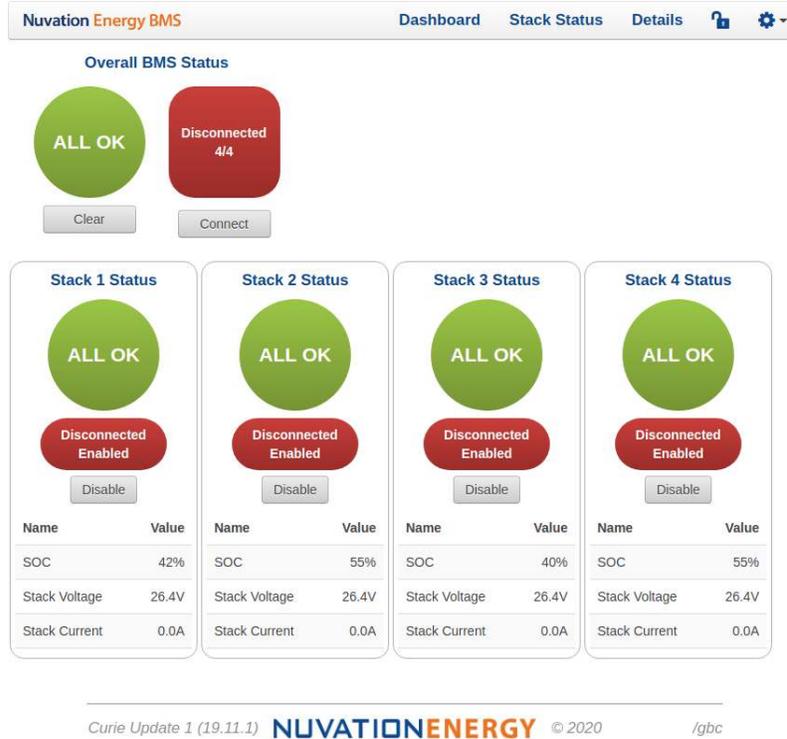
The stacks within the pack need to be *enabled* to allow them to be connected.

In the Multi-Stack Operator Interface:

1. Navigate to the Stack Status tab. You should see details of the stacks that the Battery Control Panel can communicate with (i.e. they have been previously configured as *installed*).



2. For each stack, click the Enable button. When all stacks are enabled the screen should look like this:



Manually updating the *enabled* state of stacks through the Multi-Stack Operator Interface will be lost if the Battery Control Panel were to power cycle. Once the final enabled state of all stacks is determined, the pack configuration file should be updated and reloaded.

5.4.4. Stack Connection Modes

There are two modes of stack connection:

1. Automatic connection
2. Manual connection

The automatic connection mode is recommended, and provides the following advantages:

- Simple one-button connection operation
- Connects stacks in preparation for a charge/discharge operation of a battery pack
- Connects only stacks that will not violate a maximum connection current
- Automatic pack connection when the controller is brought online from a power cycle

The configuration of the pack connection is detailed in [Section 8](#).

The *Connect* button for the pack (at the top of the Stack Status tab) will only be accessible when the [Automatic Stack Connection](#) is configured.

The *Connect* button per stack will only be displayed when the [Manual Stack Connection](#) is configured.

5.4.5. Automatic Stack Connection

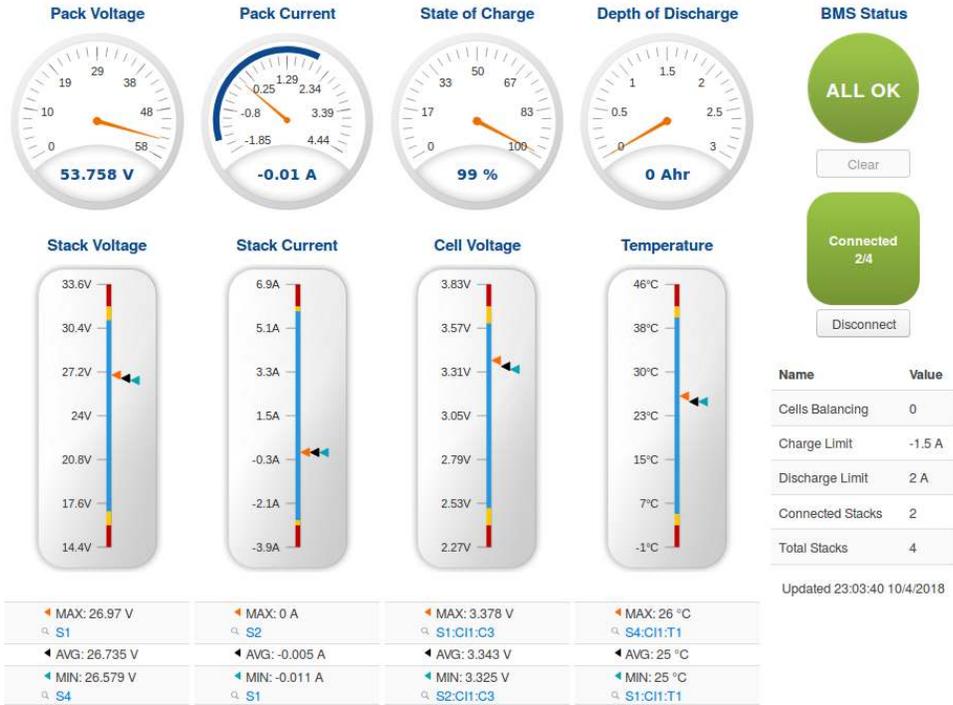
Navigate to the Dashboard tab and click on the Connect button to initiate a pack connection. The stack(s) that meet the pack connection criteria will be sequentially connected.

If all the stacks are connected, the dashboard screen will look like this:



Refer to the *Total Stacks* and the *Connected Stacks* values displayed to the right of the display. If they are not equal in value, not all stacks could be connected due to an unbalanced number of stack(s). Connecting these unbalanced stacks would have violated a stack connection current that has been configured. The pack is now waiting for a charge/discharge operation from an external Power Control System (PCS) to bring the connected stacks closer to the unconnected stack voltage(s).

When the pack is in this partially connected state, the dashboard would appear like this:



Navigate to the Stack Status tab. This tab will show all the stacks which have connected or remain disconnected. An operator can monitor the stack voltages of the connected stacks while the PCS is charging/discharging the pack. As the pack voltage changes the unconnected stacks will begin to meet the pack connection criteria and these stacks would then be automatically connected.

One or more stacks may be in faulted state and cannot be connected. The *Stack Status* page allows the monitoring and identification of these faulted stacks. Refer to [Section 6.4.4](#) for details on how to address stack faults.

5.4.6. Manual Stack Connection

1. Navigate to the Stack Status tab.
2. For each stack, click the Connect button. When all stacks are connected your screen should look like this:

The screenshot shows the 'Stack Status' tab of the Nuvation Energy BMS interface. At the top, there is a navigation bar with 'Nuvation Energy BMS', 'Dashboard', 'Stack Status', and 'Details'. Below this is the 'Overall BMS Status' section, which includes a green circle labeled 'ALL OK' and a green rounded rectangle labeled 'Connected 2/4'. A 'Clear' button is positioned below these indicators.

Below the overall status are four panels, each representing a stack's status:

- Stack 1 Status:** Shows 'ALL OK' in a green circle, a red 'Disconnected Enabled' button, and a 'Connect' button. Below is a table with SOC (41%), Stack Voltage (26.4V), and Stack Current (0.0A).
- Stack 2 Status:** Shows 'ALL OK' in a green circle, a green 'Connected Enabled' button, and a 'Disconnect' button. Below is a table with SOC (54%), Stack Voltage (26.8V), and Stack Current (-0.3A).
- Stack 3 Status:** Shows 'ALL OK' in a green circle, a green 'Connected Enabled' button, and a 'Disconnect' button. Below is a table with SOC (39%), Stack Voltage (26.6V), and Stack Current (-0.1A).
- Stack 4 Status:** Shows 'ALL OK' in a green circle, an orange 'Connecting Enabled' button, and a 'Disconnect' button. Below is a table with SOC (55%), Stack Voltage (26.6V), and Stack Current (-0.2A).

At the bottom of the interface, there is a footer with the text 'Curie Update 1 (19.11.1) NUVATIONENERGY © 2020 /gbc'.



Be mindful of your stack voltages when manually connecting. A warning will appear if the stack connection criteria is violated.



The pack-level *Connect* button on the Dashboard and the Stack Status displays will be removed while in the Manual Connection mode.

6. Using the Multi-Stack Operator Interface

6.1. Access the Multi-Stack Operator Interface

The Multi-Stack Operator Interface is accessible on the Battery Control Panel unit’s front panel touchscreen display. Alternatively, it can be accessed from any compatible computer/tablet with the latest Firefox or Chrome web browser.

6.1.1. External Computer Requirements

An external computer with a keyboard, like a laptop or a PC, is recommended to perform the setup steps. Ensure the following 3 requirements have been met when selecting a computer.

Network Connection

Ensure the computer is connected to the same network as the *External Ethernet* on the Battery Control Panel.



An internet connection is not required for the product to function. However it does use the Network Timing Protocol (NTP) to maintain its clock accuracy.

Computer OS Compatibility

Ensure the Operating System of the laptop/computer supports multi-cast DNS (mDNS).

Table 2. Operating Systems that support mDNS

OS	Version	Additional Software Required
Windows	10	N/A
Windows	8 and lower	Apple Bonjour
MacOS	10.2 and higher	N/A
Linux	N/A	Avahi



mDNS is also operational when a Static IP is configured.



Manual IP Discovery

In the event that the computer does not support mDNS, the MAC address for the external network port is labeled on the exterior of the Battery Control Panel.

Look for this MAC address in the DHCP server to determine which IP address was assigned to the Battery Control Panel and navigate to 'https://<ip-address>' from a compatible web browser.

6.1.2. Launch Multi-Stack Operator Interface

Navigate to http://ncontroller-<serial_number>.local from a compatible computer (see [Section 6.1.1](#)). Replace <serial number> with the Battery Control Panel serial number - this can be found on a label on

the exterior of the product.



The Multi-Stack Operator Interface currently supports the most recent versions of Mozilla Firefox and Google Chrome. Other browsers such as Internet Explorer are not supported.

6.2. The Dashboard Tab

The default tab of the Operator Interface is the Dashboard. The Dashboard contains a high-level overview on the state of the battery pack. This is the only page required for daily monitoring of the battery pack.

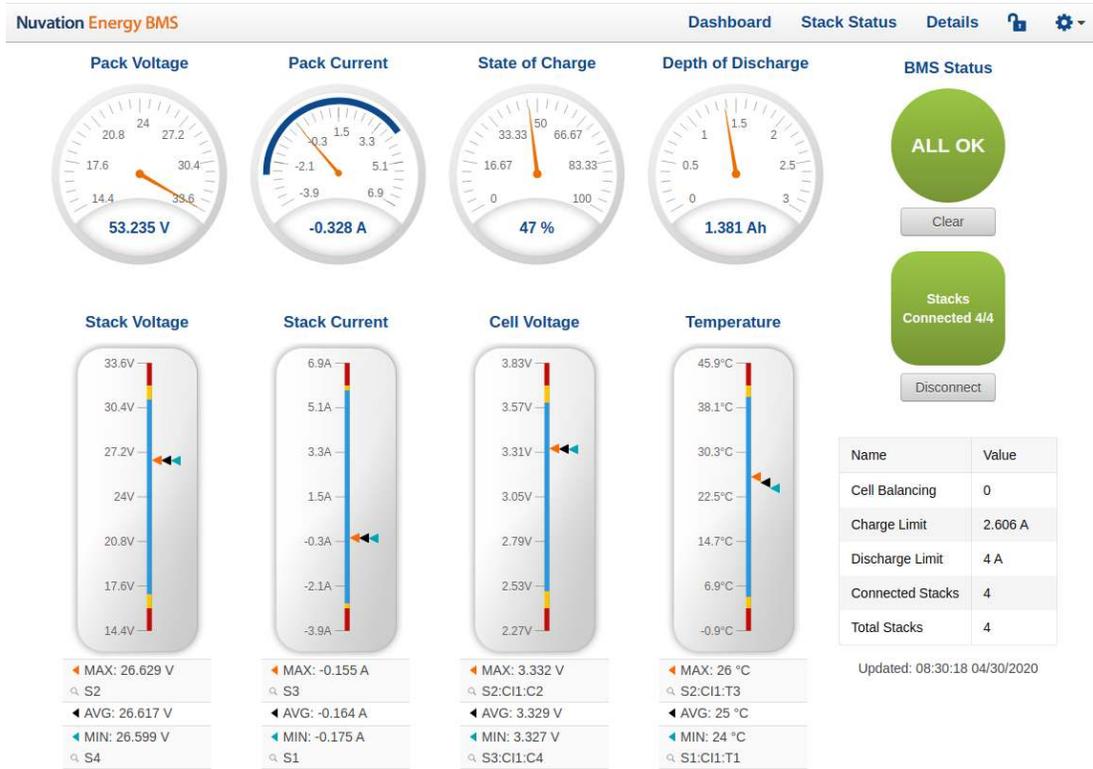


Figure 7. Nuvation Energy BMS Operator Interface Dashboard screenshot

6.2.1. Warnings and Faults

Before going into the details of the gauges and information presented in the dashboard, it is important to understand what a fault and a warning Nuvation Energy BMS status means.



An ALL OK indicates that there are no faults or warning. This is the normal state for Nuvation Energy BMS.



A Warning indicates the state of the battery system has been detected outside of its normal operational range. The cause of the warning should be identified and a corrective action should be performed. For instance, if the warning is a thermistor temperature measurement has become too hot, the battery system should be cooled to bring the measurement back into the normal operational range.



A Fault indicates the state of the battery system has been detected outside of its safe operational range. The cause of the fault must be identified and a corrective action must be performed. For instance, if the fault is a cell voltage measurement has become too low, the cell maintenance manual must be reviewed to identify what remedial actions are required.

A Fault is more severe than a Warning and the source of the fault must be discovered and resolved before attempting to clear and continue operating the battery system.

6.2.2. Pack Voltage

The pack voltage radial gauge shows the average stack voltage of the stacks connected to the common DC bus.



6.2.3. Pack Current

The pack current radial gauge shows the battery pack current which is the addition of each stack current that are connected to the common DC bus. The maximum charge current limit and the maximum discharge current limit is also shown. The acceptable current range is visualized on the gauge by the blue arc. An absence of the blue arc indicates the battery pack cannot be charged or discharged in its present condition.

A negative current value indicates the battery pack is charging. A positive current value indicates the battery pack is discharging.



6.2.4. State of Charge

The State-of-Charge radial gauge shows the battery stack's State-of-Charge, which is an average SOC of the stacks connected to the common DC bus. The battery stack is empty when the State-of-

Charge value is 0% and full when the State-of-Charge value is 100%.



6.2.5. Depth of Discharge

The Depth-of-Discharge radial gauge shows how much energy has been taken out of the battery stack. It is the sum of all stacks connected to the common DC bus. In an ideal energy storage system, defined as a system with no power losses, the amount of energy shown in this gauge needs to be added back into the battery pack to fill it back up to 100% SOC.



6.2.6. Stack Voltage

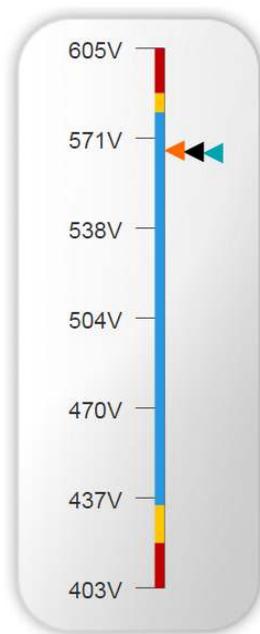
The stack voltage bar gauge shows the maximum, minimum and average stack voltage measurements within the battery pack.

The high stack voltage and low stack voltage warning and fault threshold is visualized on the gauge with yellow and red segments. The blue segment depicts the acceptable stack voltage range.

If a triangle enters the yellow segment, a warning has occurred. If a triangle enters the red segment, a fault has occurred.

The maximum and minimum stack location in the pack and their voltage value are shown below the gauge, along with the average stack voltage value.

Stack Voltage



◀ MAX: 566.58 V
🔍 S2
◀ AVG: 566.055 V
◀ MIN: 565.6 V
🔍 S1

6.2.7. Stack Current

The stack current bar gauge shows the maximum, minimum and average stack current measurements within the battery pack.

The high stack discharge current and high stack charge current warning and fault thresholds are visualized on the gauge with yellow and red segments. The blue segment depicts the acceptable stack current range.

If a triangle enters the yellow segment, a warning has occurred. If a triangle enters the red segment, a fault has occurred.

The maximum and minimum stack location in the pack and their current value are shown below the gauge, along with the average stack current value.

Stack Current



◀	MAX: -15.034 A
🔍	S3
◀	AVG: -15.266 A
◀	MIN: -15.442 A
🔍	S2

6.2.8. Cell Voltage

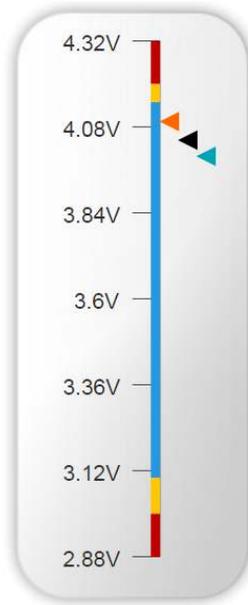
The cell voltage bar gauge shows the maximum, minimum and average cell voltage measurements within the pack.

The high cell voltage and low cell voltage warning and fault threshold is visualized on the gauge with yellow and red segments. The blue segment depicts the acceptable cell voltage range.

If a triangle enters the yellow segment, a warning has occurred. If a triangle enters the red segment, a fault has occurred.

The maximum and minimum cell location in the pack and their voltage values are shown below the gauge, along with the average cell voltage value.

Cell Voltage



◀	MAX: 4.095 V
🔍	S3:C13:C5
◀	AVG: 4.043 V
◀	MIN: 3.998 V
🔍	S1:C14:C5

6.2.9. Temperature

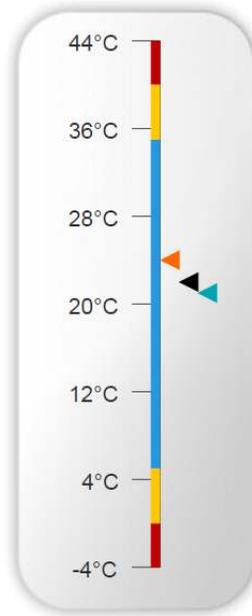
The temperature bar gauge shows the maximum, minimum and average cell temperature measurements within the pack.

The high cell temperature and low cell temperature warning and fault threshold is visualized on the gauge with yellow and red segments. The blue segment depicts the acceptable cell temperature range.

If a triangle enters the yellow segment, a warning has occurred. If a triangle enters the red segment, a fault has occurred.

The maximum and minimum cell location in the pack and their temperature values are shown below the gauge, along with the average cell temperature value.

Temperature



◀	MAX: 24 °C
🔍	S1:CI1:T2
◀	AVG: 22 °C
▶	MIN: 21 °C
🔍	S1:CI1:T3

6.2.10. Nuvation Energy BMS Status

Nuvation Energy BMS status information contains information on the overall safety status of the battery stack, the battery stack connection state, number of cells balancing, maximum charge current limit, maximum discharge current, number of stacks connected, number of stacks installed in the battery pack, and the time and date of the last update of the Dashboard.

6.2.10.1. Operation Status

Nuvation Energy BMS operation state is shown in the big status circular indicator.



Figure 8. Three possible Nuvation Energy BMS operation states

The normal state is All OK and the color of the indicator will be green. The warning state is Warning and the color of the indicator will be orange. The fault state is Fault and the color of the indicator will be red.

Clicking on the indicator will jump to a comprehensive status list of all warnings and faults active in the battery pack.

Clicking on the Clear button below the state will cancel any warnings and faults that are not self-clearing.

6.2.10.2. Connection State

The battery stack connection state is shown in the oval indicator.



Figure 9. Three possible connection states

Stack Disconnected in a red oval indicates the battery stack is unavailable to be charged or discharged.

Stack Pre-charging in an orange oval indicates the battery stack has connected its pre-charge circuit and is attempting to equalize the battery stack voltage to the system DC bus voltage.

Stack Connected in a green oval indicates the battery stack is available to be charged or discharged.

Clicking the Connect button initiates the stack connection sequence of events. Nuvation Energy BMS must be in the All OK state for the Connect button to be available.

Clicking the Disconnect button will disconnect the battery stack from the system DC bus.

6.2.10.3. Information Table

The information table shows the number of cells that are having excess energy bled off to maintain a balanced battery stack.

Name	Value
Cells Balancing	70
Charge Limit	-32.266 A
Discharge Limit	132 A

The Charge Limit shows the maximum charge current limit value. The Discharge Limit shows the maximum discharge current limit value.

The Charge Limit and Discharge Limit values are visualized on the Stack Current radial gauge as the limits of the blue arc.

6.2.10.4. Last Update

The Updated time and date shows the last time the Operator Interface had successfully communicated with Nuvation Energy BMS and updated all items in the Dashboard with values from Nuvation Energy BMS. The time and date is based on the local computer/tablet; it does not come from Nuvation Energy BMS.

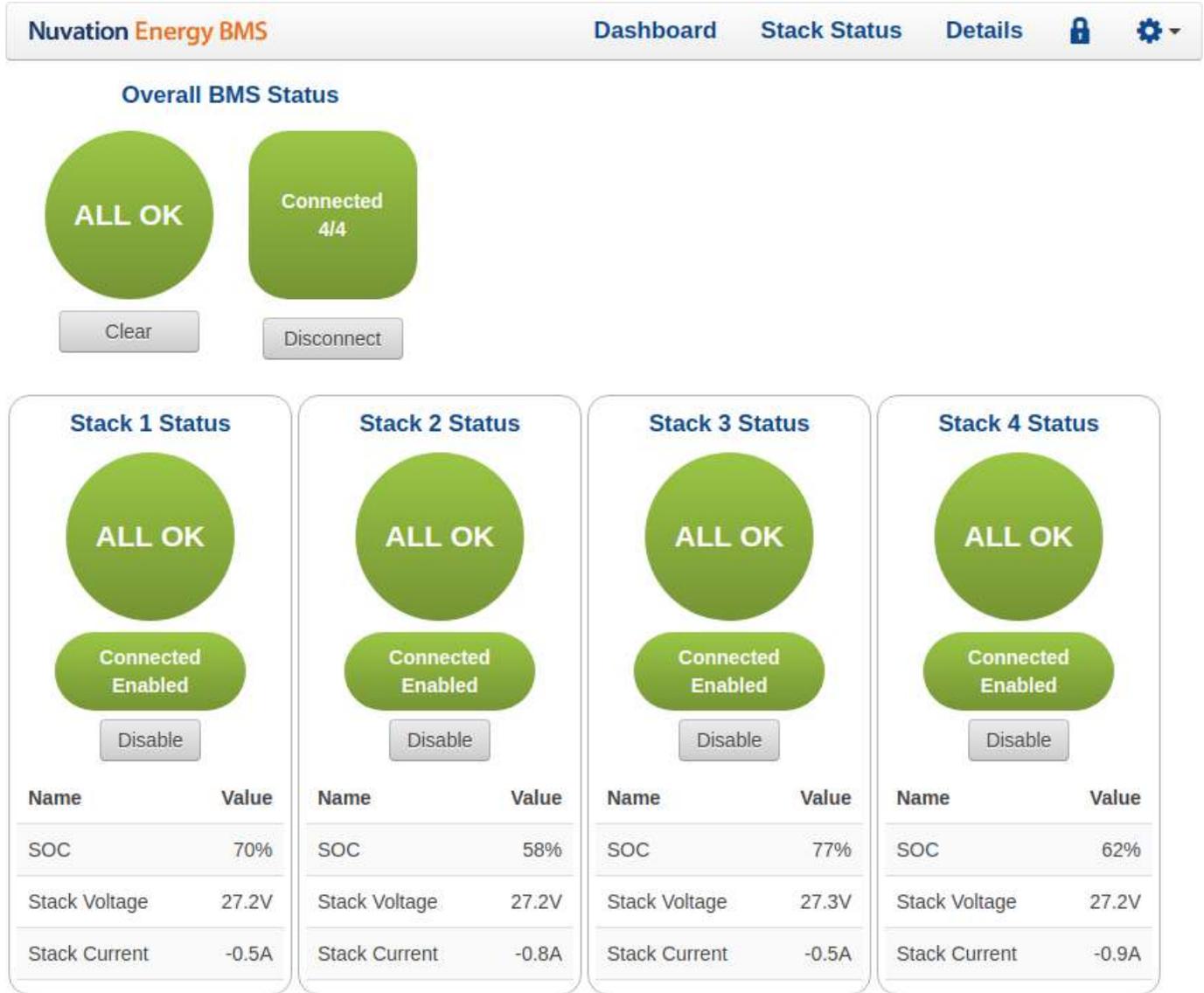
Updated 21:42:07 4/6/2017

Error: Register read error

If a communication timeout has occurred, a notification appears beneath the Updated time and date. If a timeout has occurred, the information shown on the Dashboard is no longer recent.

6.3. The Stack Status Tab

The Stack Status tab contains a detailed view for each installed stack in the Nuvation Energy BMS. The status of each stack is graphically represented on this page as shown below.



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Figure 10. Multi-Stack Operator Interface Stack Status Tab Screenshot

The following information is available on each stack status.

- Overall stack status (OK/Warning/Fault/COM Fault/Service Lockout)
- Whether the stack is Enabled or Disabled

- Whether the stack is connected or disconnected to the DC bus.
- Stack measurements for SOC, voltage and current

6.3.1. Pack Connection/Status

The overall controller operation and connection status is displayed in the upper left corner of the screen. The behavior of this graphic is the same as described in the dashboard [Section 6.2.10](#). A connect button is available when automatic pack connection has been enabled. When manual connection of a pack is configured, this connect button is removed.

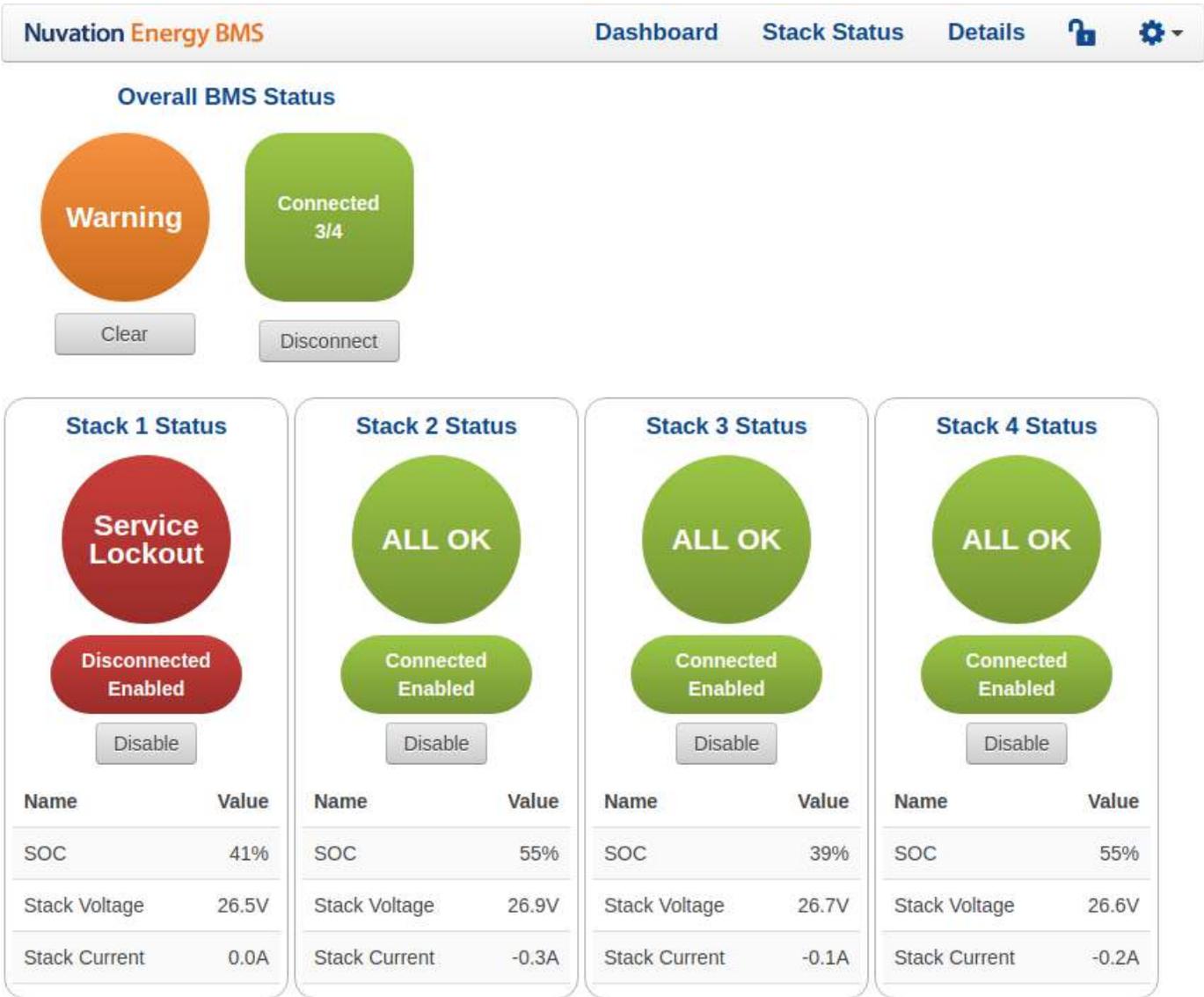
6.3.2. Stack Enable and Connection

The *connected* and *enable* state of each stack is displayed in the red/green oval. A grey button labelled *Enable* or *Disable* is located below this status. The button will toggle the enable state of a stack. When a stack is changed from *enabled* to *disabled* state, the stack is immediately disconnected from the DC bus. When a non-faulted stack is toggled from *disabled* to *enabled* there will be one of two possible outcomes

1. If pack auto connection is enabled, the stack is considered a candidate for connecting to the pack. Refer to [Automatic Stack Connection](#) for further details.
2. If manual pack connection is configured, a connect button will appear on the stack status. Refer to [Manual Stack Connection](#) for details of this operation.

6.3.3. Stack Service Lockout

If a stack were to enter its *Service Lockout* state (refer to *Operator Interface Manual: Single-Stack* for details), the stack status will be updated as shown below.

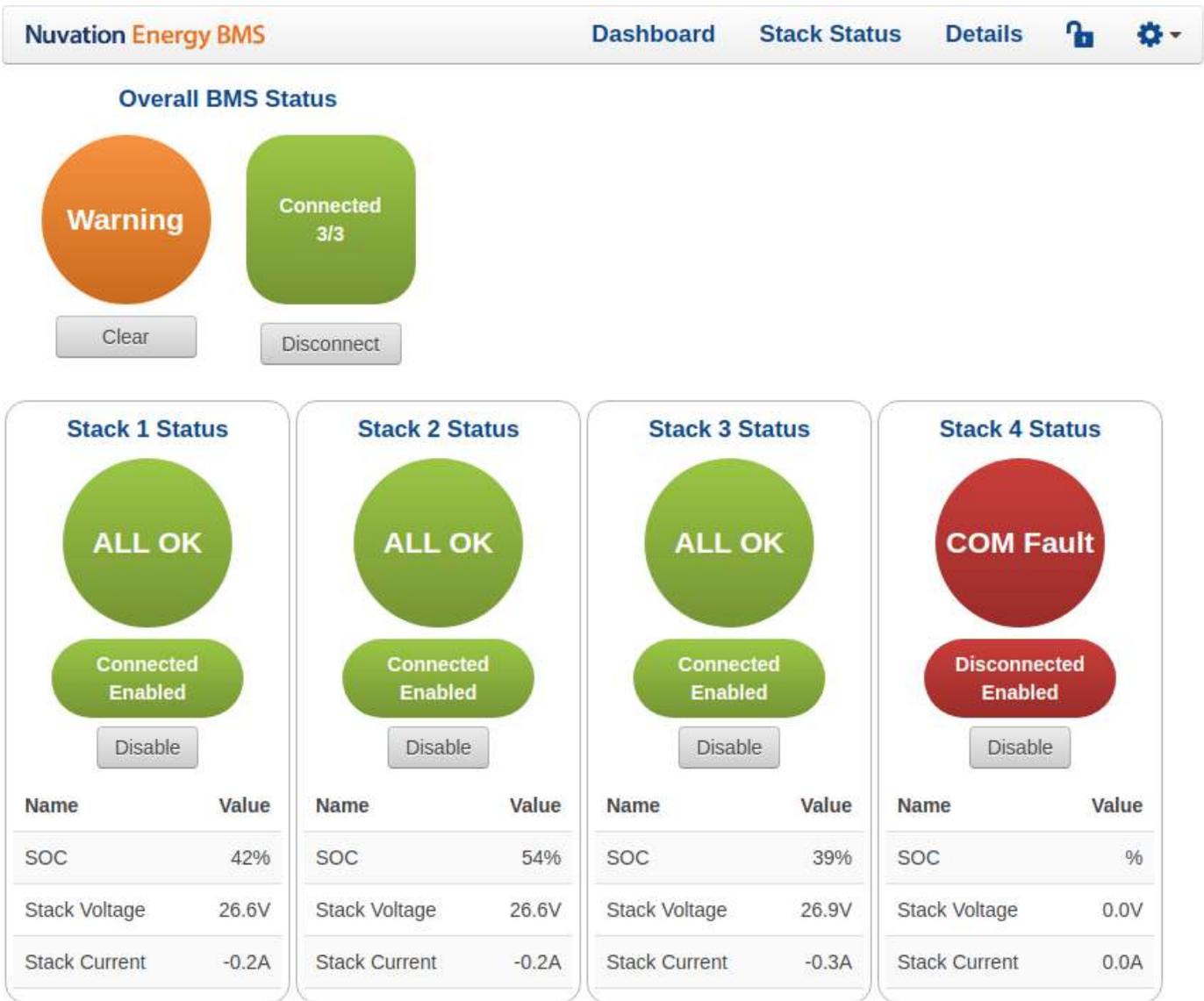


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Figure 11. Stack in Service Lockout

6.3.4. Stack COM Fault

If there is a communication failure with a stack (i.e. the Battery Control Panel loses communication with the stack), the stack status will be updated as shown below.



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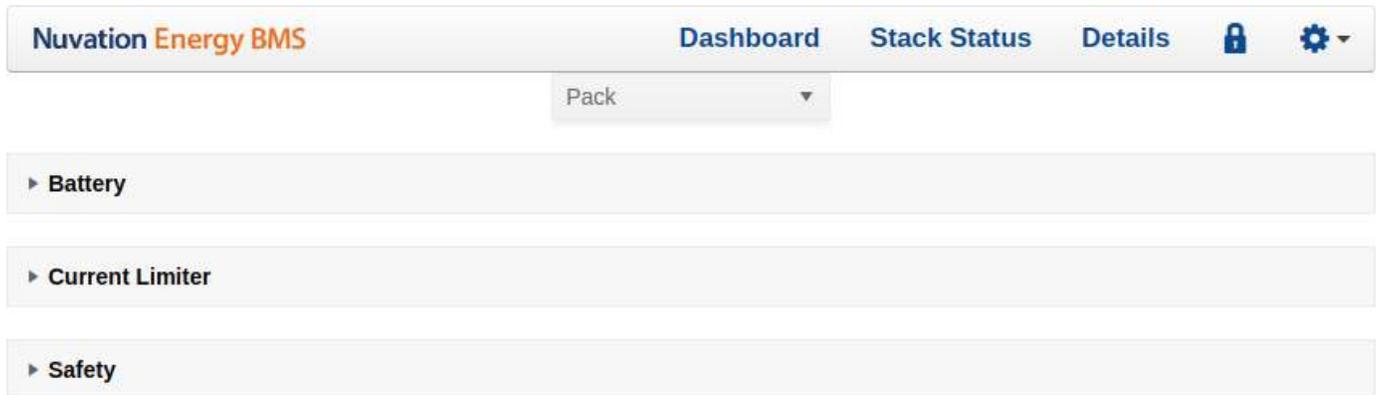
/gbc

Figure 12. Stack with COM Fault

6.4. The Details Tab

The Details tab contains a much more detailed view into the status of Nuvation Energy BMS. The data values shown in this tab can be easily copied into a spreadsheet as a means of capturing the current state of Nuvation Energy BMS for manual data recording purposes.

The Details tab has multiple sub-sections called *accordions* that can be expanded to reveal more information. You can have multiple accordions expanded at the same time.



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/gbc

Figure 13. Nuvation Energy BMS Operator Interface Details tab screenshot

6.4.1. Information Selector

The drop-down list at the top-center of the Details tab selects what content to display in the tab.

The Pack is the default option and it presents information on the overall battery pack.

The Stack option presents information on that specific battery stack.

6.4.2. Battery

The Battery accordion contains values on the overall battery pack. This information is identical to the values shown in the radial gauges and bar gauges on the Dashboard, except that the stack voltage and stack current bar gauge information is omitted.

▼ Battery Last update: Thu Apr 06 2017 22:04:47 GMT-0400 (Eastern Daylight Time)	
Register Name	Value
Pack Voltage	566.055 V
State of Charge	97 %
Pack Current	-61.064 A
Depth of Discharge	5.28 Ahr
Average Cell Voltage	4.043 V
Maximum Cell Voltage	4.095 V
Minimum Cell Voltage	3.998 V
Average Temperature	22 C
Maximum Temperature	24 C
Minimum Temperature	21 C

Figure 14. Battery accordion in Details Tab

6.4.3. Current Limiter

The Current Limiter accordion contains the maximum charge current limit, maximum discharge current limit. This information is identical to the values shown in the Information Table on the Dashboard. The unit of the current limit values is mA.

▼ Current Limiter Last update: Thu Apr 06 2017 22:11:39 GMT-0400 (Eastern Daylight Time)	
Register Name	Value
Charge Limit	129064
Discharge Limit	528000

Figure 15. Current Limiter accordion in Details Tab

6.4.4. Safety

The Safety accordion contains a summary list of the number of Nuvation Energy BMS faults and warnings active in the battery pack well as the overall status of the battery pack. An active fault or warning is shown as Tripped. In normal operation, all warnings and faults should be clear and the battery stack can be charged and discharged.

▼ Safety Last update: Sat Aug 18 2018 01:44:25 GMT-0400 (EDT)		
Register Name	Value	Initialized
Overall Safe	Safe	Unknown
gbc_fault_eth_conn[0].trig	Clear	Yes
gbc_fault_fw_mismatch[0].trig	Clear	Yes
gbc_fault_controller_wdt[0].trig	Clear	Yes
pack_fault_ready_stacks[0].trig	Clear	Yes
gbc_warn_eth_conn[0].trig	Clear	Yes
gbc_warn_fw_mismatch[0].trig	Clear	Yes
gbc_warn_controller_wdt[0].trig	Clear	Yes
pack_warn_ready_stacks[0].trig	Clear	Yes
pack_warn_stacks[0].trig	Clear	Yes

Figure 16. Safety accordion in Details Tab

Clicking on the Clear Faults and Warnings button at the bottom of this accordion will clear any faults that are not self-clearing. It will not clear any warnings that are not self-clearing; the Clear button on the Dashboard must be used to clear warnings that are not self-clearing.

6.5. The Menu Options

The menu to the right of the Operator Interface provides access to tools and advanced options. Some of these options may be locked to prevent accidental changes.



The menu will not be visible, and this section and following sub-sections will not be accessible when the Operator Interface is loaded on the Battery Control Panel display.

6.5.1. Registers

This screen allows you to change registers and customize your Nuvation Energy BMS to your needs.

6.5.2. Service

This screen allows you to import and export configuration file.

6.5.2.1. Importing a Configuration File

This menu option allows you to import a configuration file.

If you have a configuration file ready to import, refer to [Import the Configuration File](#) for instructions.

6.5.2.2. Exporting a Configuration File



Nuvation Energy BMS doesn't preserve the originally imported configuration file with comments and formatting. The export feature will export a configuration file with an alphabetical listing of all registers and their set values.

To export your configuration file:

1. From the menu, select Service
2. Click Export Configuration

6.5.3. Connection

The connection screen allows you to change the IP address and timeout of the Nuvation Energy BMS that you are trying to access.



If the Operator Interface loads properly, but fails to establish a connection, try increasing the timeout value.



This connection screen should not be used for changing the IP address. You may use this screen to change the timeout.

6.5.4. Logging

Log data can be viewed and downloaded at the URL http://ncontroller-<serial_number>.local/log. This URL can be accessed via a [compatible computer](#). Replace <serial number> with the Battery Control Panel serial number - this can be found on a label on the exterior of the product.

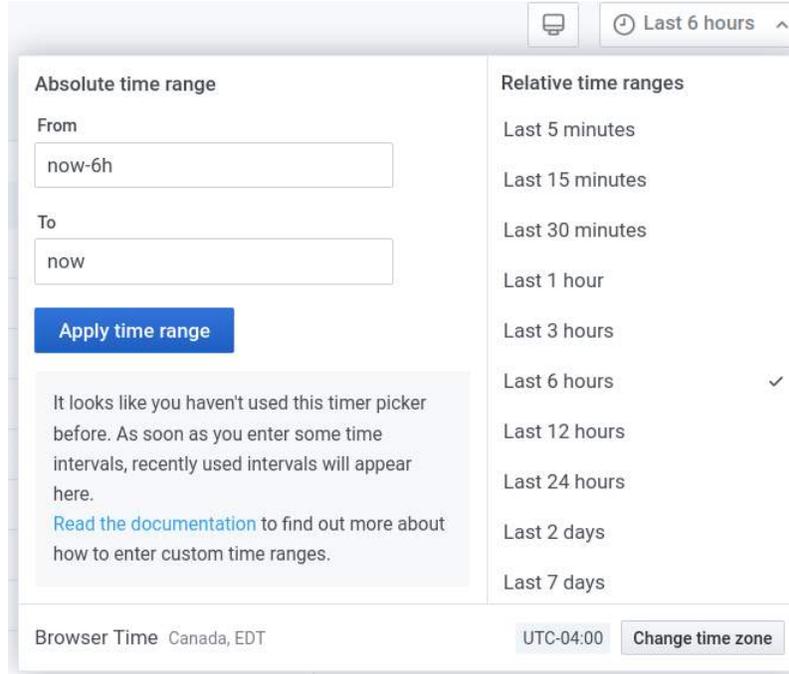
Data will be automatically logged every one second (1 s) and each minute it is aggregated into "Minimum", "Maximum", and "Average" values over each one minute interval.

This section highlights the key aspects of the local logging feature on the device. An example of the log view and download screen is below.

Time	Field	Average	Minimum	Maximum
2020-10-02 18:19:20	Available Capacity (Ah)	0	0	0
2020-10-02 18:19:20	Capacity (Ah)	2147484	2147484	2147484
2020-10-02 18:19:20	Capacity (kWh)	0	0	0
2020-10-02 18:19:20	Cell Temperature Average (C)	-273	-273	-273
2020-10-02 18:19:20	Cell Voltage Average (V)	0	0	0
2020-10-02 18:19:20	Cell Temperature Maximum (C)	-273	-273	-273
2020-10-02 18:19:20	Cell Voltage Maximum (V)	0	0	0
2020-10-02 18:19:20	Cell Temperature Minimum (C)	-273	-273	-273
2020-10-02 18:19:20	Cell Voltage Minimum (V)	0	0	0
2020-10-02 18:19:20	Charge Limit (C)	0	0	0
2020-10-02 18:19:20	Connected Status	0	0	0
2020-10-02 18:19:20	Current (A)	0	0	0
2020-10-02 18:19:20	Discharge Limit (A)	0	0	0
2020-10-02 18:19:20	Depth of Discharge (d.o.d)	0	0	0
2020-10-02 18:19:20	Flux	1	1	1
2020-10-02 18:19:20	Power (W)	0	0	0
2020-10-02 18:19:20	State of Charge (S)	100	100	100
2020-10-02 18:19:20	Voltage (V)	0	0	0
2020-10-02 18:19:20	Warning	1	1	1
2020-10-02 18:19:20	Available Capacity (kWh)	0	0	0
2020-10-02 18:19:20	Capacity (Ah)	2147484	2147484	2147484
2020-10-02 18:19:20	Capacity (kWh)	0	0	0
2020-10-02 18:19:20	Cell Temperature Average (C)	-273	-273	-273

On the top right of the screen there is a small icon with circular arrows  which will refresh the data on the screen.

Beside the refresh button on the top right of the screen is the interval picker, which will help select the time interval over which the data can be queried.



The date picker enables selecting time intervals between any two dates and times, or relative to the current time and date.

6.5.4.1. Pack Logs

The first table displayed on the page is the pack data which is the aggregate for all stacks in the system. It is collapsible, sortable, and contains the following columns:

- **Time:** the timestamp of the data, aligned to the minute
- **Field:** the name of the data field
- **Average:** the average value across the minute for the data row
- **Minimum:** the minimum value across the minute for the data row
- **Maximum:** the maximum value across the minute for the data row

The "Field" column contains the following distinct values for the pack:

- Voltage (V)
- Current (A)
- Power (kW)
- Charge Limit (A)
- Discharge Limit (A)
- State of Charge (%)
- Depth of Discharge (Ah)
- Connection Status

- Fault
- Warning
- Available Capacity (kWh)
- Capacity (Ah)
- Capacity (kWh)
- Cell Temperature Average (C)
- Cell Temperature Maximum (C)
- Cell Temperature Minimum (C)
- Cell Voltage Average (V)
- Cell Voltage Maximum (V)
- Cell Voltage Minimum (V)

6.5.4.2. Stack Logs

The next table displayed on the page is the stack data which is the logged for each stacks in the system. It is collapsible, sortable, and contains the following columns:

- **Time:** the timestamp of the data, aligned to the minute
- **Field:** the name of the data field
- **Stack:** the stack index associated with the data field, starting at '0' for the 1st stack
- **Average:** the average value across the minute for the data row
- **Minimum:** the minimum value across the minute for the data row
- **Maximum:** the maximum value across the minute for the data row

The "Field" column contains the following distinct values for each stack:

- Voltage (V)
- Current (A)
- Power (kW)
- Charge Limit (A)
- Discharge Limit (A)
- State of Charge (%)
- Depth of Discharge (Ah)
- Connection Status
- Fault
- Warning
- Available Capacity (kWh)
- Capacity (Ah)

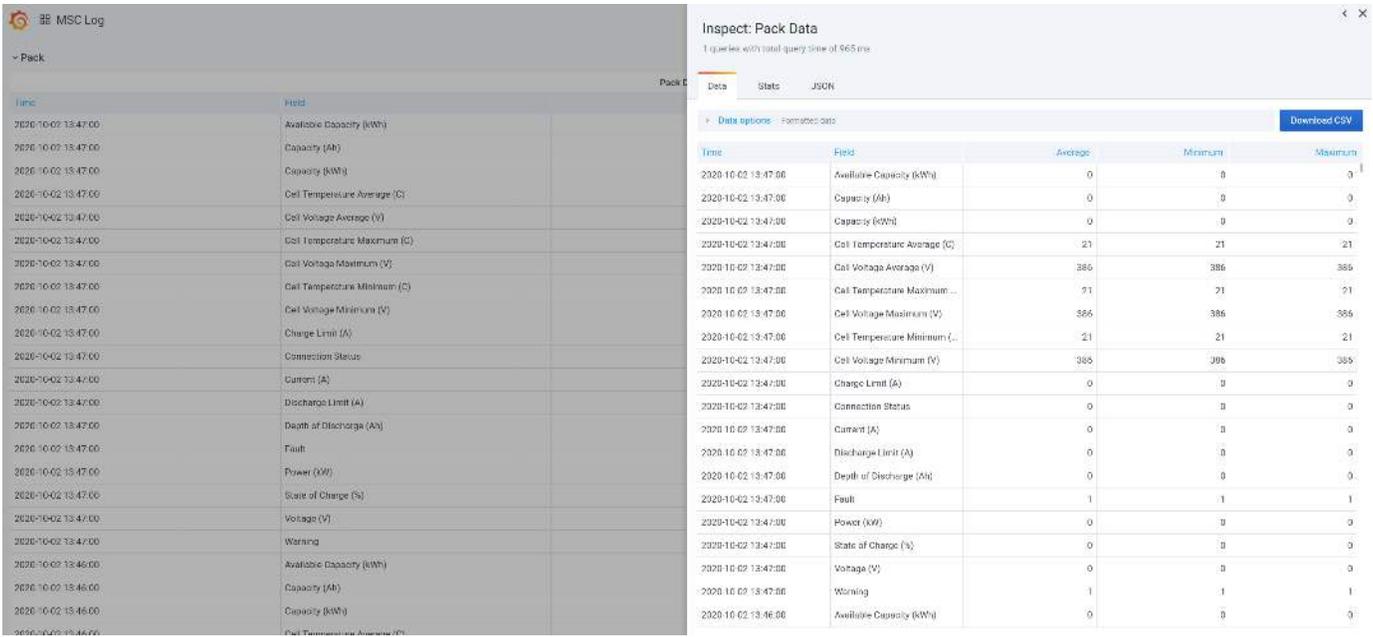
- Capacity (kWh)
- Cell Temperature Average (C)
- Cell Temperature Maximum (C)
- Cell Temperature Minimum (C)
- Cell Voltage Average (V)
- Cell Voltage Maximum (V)
- Cell Voltage Minimum (V)

6.5.4.3. Downloading Logs

To download all the data for any of the tables above, click the table title which should bring up a list of options:

		Pack Data ▾	
		<ul style="list-style-type: none"> 👁 View v 🔗 Share p s 📘 Inspect i > 	Average
			0
			0
			0
			21
			386

In the options menu select "Inspect" then in the sub-menu select "Data". This will bring up a panel on the right:



In the panel there is a button on the far right labeled "Download CSV":



Clicking on this button will trigger a download of the CSV file. An example of downloaded pack data is below:

```
"Time","Field","Average","Minimum","Maximum"
2020-10-02 13:47:00,Available Capacity (kWh),0,0,0
2020-10-02 13:47:00,Capacity (Ah),0,0,0
2020-10-02 13:47:00,Capacity (kWh),0,0,0
2020-10-02 13:47:00,Cell Temperature Average (C),21,21,21
2020-10-02 13:47:00,Cell Voltage Average (V),386,386,386
```

6.5.5. Locking and Unlocking

When the Operator Interface is unlocked, the lock indicator will be replaced with an unlock indicator.



Figure 17. Operator Interface Lock indicator



Figure 18. Operator Interface Unlock indicator

6.5.5.1. Lock the Operator Interface

To lock the Operator Interface bring up the settings menu and select Lock.



To prevent accidental changes to your Nuvation Energy BMS, always lock the Operator Interface after making your changes.

It is possible to require a password to unlock the Operator Interface.



The lock/unlock feature is not visible when the Operator Interface is loaded on the Battery Control Panel display.

6.5.5.2. Unlock the Operator Interface

To Unlock the Operator Interface bring up the settings menu and select Unlock

6.5.6. About

This screen display version details for the underlying software for your Nuvation Energy BMS. The name and number of the current software release is displayed at the top of the About screen.

In the screenshot below, the release name is at the top in large blue letters. The version number following the release name has a format of yy.mm with yy representing the year and mm representing the month within that year that this Nuvation Energy BMS package was released.

The version numbers below the release name are the version numbers of the individual software packages running on your Nuvation Energy BMS.

When contacting support, please include the details in your About screen.

Curie Update 1 (19.11.1)



Figure 19. Sample About screen

7. Using the Platform Interface

7.1. Overview

The Platform Interface accessible by navigating to [http://ncontroller-
<serial number>.local/platform](http://ncontroller-
<serial number>.local/platform) and enables configuration and management of the Nuvation Energy Battery Control Panel. This URL can be accessed via a [compatible computer](#). Replace <serial number> with the Battery Control Panel serial number - this can be found on a label on the exterior of the product.

There are three main pages that can be navigated to by using the menu on the left side of the page:

- Functions
- Networks
- Settings

7.2. Functions

The Functions page is responsible for installing, uninstalling, and upgrading 'Functions' and 'Bundles'.

Functions

Functions are self-contained software that serve a specific function on the Battery Control Panel. Functions may operate independently, or may depend on other Functions to work. Functions with dependencies are defined in a bundle.

Bundles

Bundle are a collection of dependent 'Functions' to serve a broader purpose on the Battery Control Panel . There are two types of Bundles that may be installed based on the Battery Control Panel unit's hardware configuration; either the msc_bundle or the bcp_bundle may be installed.



Do not, under any circumstance, install both the bcp_bundle and the msc_bundle on the same Battery Control Panel. This will render the Battery Control Panel inoperable.

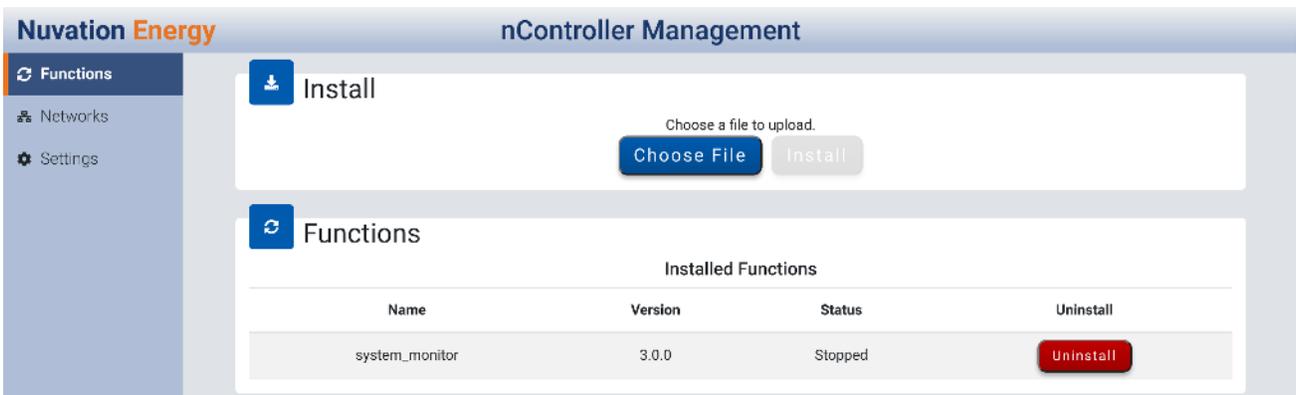


Figure 20. Nuvation Energy Platform Interface Function

7.2.1. Installing a Function

1. Use the "Choose File" button to select a file with the extension .fn or .fns.
2. Click "Install" to install the function.

7.2.2. Upgrading a Function

1. Functions or Bundles may be upgraded in place by installing a newer version without uninstalling the older version.

7.2.3. Uninstalling a Function

1. Click the "Uninstall" button to uninstall Functions or Bundles on the Battery Control Panel.



If the intent is to upgrade a Function or Bundle, do not uninstall first. Uninstalling will permanently delete all data associated with the Functions and/or Bundle.

7.3. Networks

The networks page shows the current network status of the Battery Control Panel and allows for configuration of the network interfaces.

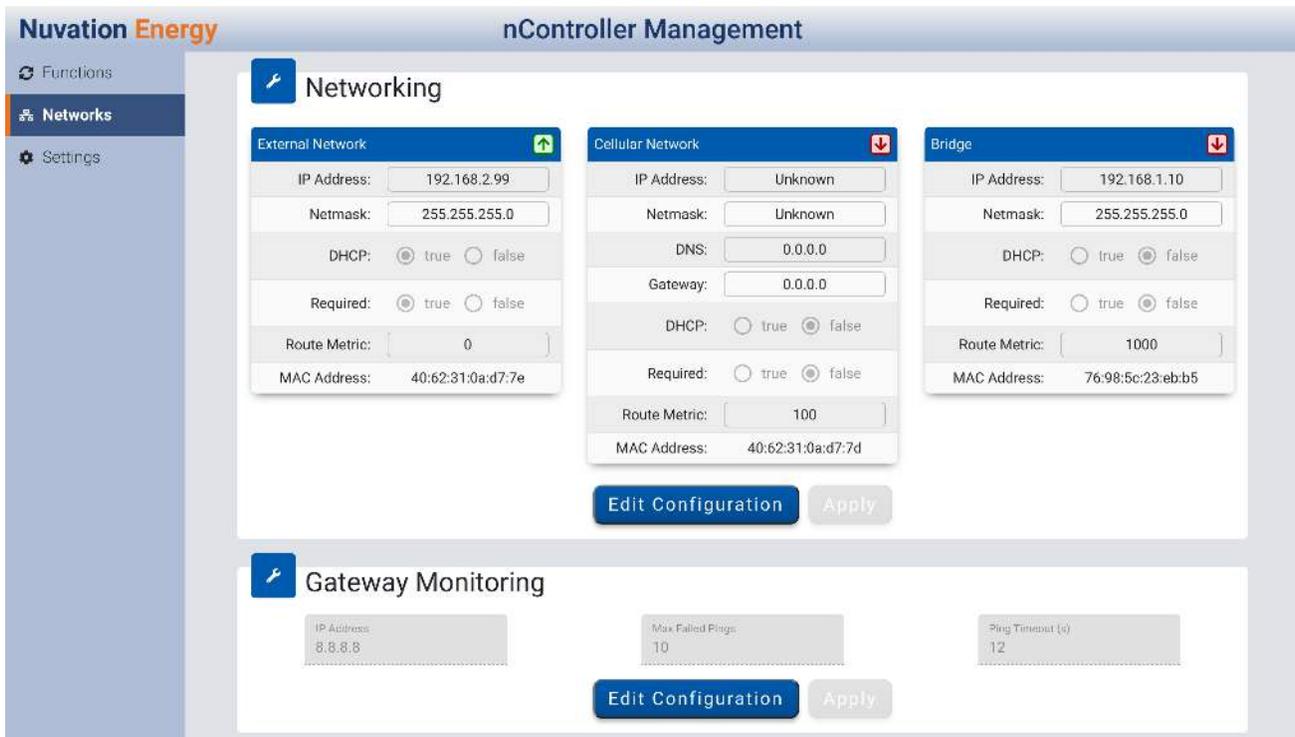


Figure 21. Nuvation Energy Platform Interface Networks

7.3.1. Networking

There are 3 configuration cards on this page:

- External Network: Controls the External Ethernet network on the Battery Control Panel
- Cellular Network: Controls the communication interface to the Cellular Modem
- Bridge: Controls the Internal Ethernet network on the Battery Control Panel

Each card shows the following information:

- IP Address: The current IP of the Battery Control Panel on that network. Displays Unknown if no address is assigned
- Netmask: The current netmask of the connected network. Displays Unknown if no address is assigned
- DHCP: Whether DHCP will be used to acquire an address. Displays true for yes, false for no
- Required: Whether the network interface is required to be up for proper operation. The Battery Control Panel will wait for up to 2 minutes during power-up for interfaces marked 'required' to come up before continuing with system startup
- Route Metric: The priority of this interface in the internal routing table. Lower values are higher priority. It is not recommended to change this setting unless advised by Nuvation Energy
- MAC Address: The MAC address of the Battery Control Panel on the network. This address is not modifiable
- *Arrow in the header:* A green up-arrow indicates the network interface has a carrier. A red down-arrow indicates no carrier

If DHCP is disabled on the External or Cellular Networks, the following options will become available:

- DNS: The nameserver address to use for hostname lookups. If no DNS is available, set to 0.0.0.0 to disable
- Gateway: The gateway address to access the Internet from this network. If no gateway is available, set to 0.0.0.0 to disable

Clicking the Edit Configuration button switches from showing the current status to showing the configured values. Values can be edited in the fields directly. The field will change from green to red if an invalid value is entered. Click Apply to apply and save the configuration.



The Platform Interface only supports configuring IPv4 networks. Operation of the Battery Control Panel on IPv6-only networks is not supported.



The DNS server will receive queries for Internet addresses (for example NTP server addresses), so the DNS server should forward queries to root nameservers for proper operation.



If 2 or more networks overlap with each other, the message "Error: Conflicting Networks" will appear. This may cause undesirable operation.



When applying External and Cellular network settings involving DHCP, the old IP address will not be released, and this may be reflected by the status IP address not matching the configured value. This ensures that the device will always be reachable. A reboot of the device will release the old address.

7.3.2. Gateway Monitoring

Gateway Monitoring is a feature that allows the Battery Control Panel to automatically failover from the External to the Cellular network, and back again in the event connectivity to the Internet is lost over a particular network. These settings control how the device monitors network connectivity on the External and Cellular interfaces.

- IP Address: The IP address which receives a periodic ICMP echo request (ping) from the Battery Control Panel
- Max Failed Pings: The number of pings in a row which must be unanswered in order to trigger a failover event
- Ping Timeout: The number of seconds to wait for a reply to an unanswered ping before considering it failed

The maximum time for failover in seconds is calculated as Max Failed Pings × Ping Timeout. To increase responsiveness in a failure scenario, the values can be reduced. Since it is possible for ICMP packets to be lost occasionally, reducing the Max Failed Pings value to too low of a number can cause false positives.



The address set for pings must be on the Internet and reachable by the Battery Control Panel, and must reliably respond to ICMP messages for this feature to work correctly. A failure to meet any of these criteria will result in the Cellular network being used all the time.

7.4. Settings

The settings page is responsible for the following:

- Upgrading the Battery Control Panel
- Factory Restoring the Battery Control Panel
- Rebooting the Battery Control Panel
- Setting Date, Time, and Timezone

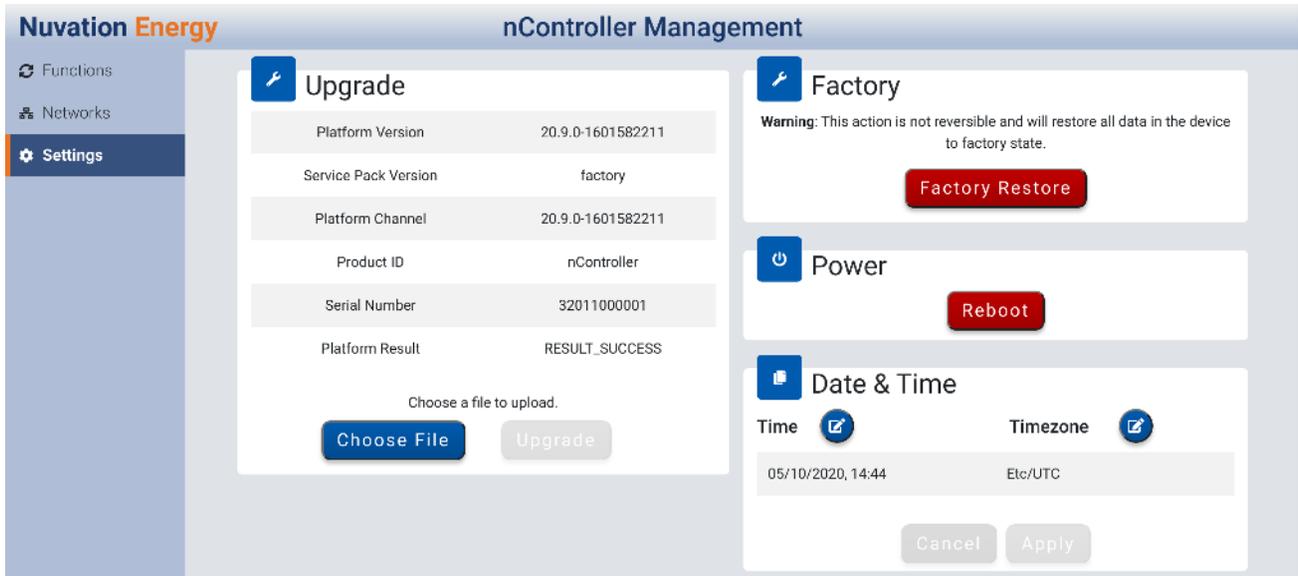


Figure 22. Nuvation Energy Platform Interface Settings

7.4.1. Upgrading the Battery Control Panel

To upgrade the Battery Control Panel, click the "Choose File" button to select a file with an extension of .nup. Then, click "Upgrade" to upgrade the unit.



The upgrade process may take a couple minutes, so please wait for the upgrade process to complete. The page will automatically refresh once the platform upgrade is complete.



Downgrading the Battery Control Panel is not a user-accessible feature. Please contact support@nuvationenergy.com for assistance with downgrading.

7.4.2. Factory Restore

Factory restoring the Battery Control Panel will revert the unit to the state it was in at the factory. To factory restore the Battery Control Panel, click on the "Factory Restore" button.



Factory Restore action is irreversible

All data, including the pre-installed Bundles, Functions, and other configuration that the Battery Control Panel arrived with, will be permanently deleted. If this happens, the unit will become non-functional. Please contact support@nuvationenergy.com to bring the unit back to a functional state.

7.4.3. Rebooting the System

To reboot the Battery Control Panel, click on the "Reboot" button and wait until the unit has been rebooted.



The UI will not be functional while the Battery Control Panel is rebooting.

7.4.4. Setting the Date, Time, and Timezone

The Timezone and Date/Time are individually configurable.

Setting the Date and Time

1. Click the blue edit-button to the right of the "Time" label.
2. Select the date and time by clicking on the field that is shown.
3. Click "Apply" to save the changes or "Cancel" to discard the changes.

Setting the Timezone

1. Click on the blue edit-button to the right of the "Timezone" label
2. Select the desired timezone from the dropdown list.
3. Click "Apply" to save the changes or "Cancel" to discard the changes.

8. Configuration Settings

This section highlights the most important settings required to achieve a working Battery Control Panel configuration for your system.

To operate your Battery Control Panel each stack must meet the following requirements:

- It must be running the same firmware version as the Battery Control Panel
- It must be configured for the battery stacks in use in the pack
- It must be assigned a unique network address on the Battery Control Panel unit's internal network

Please refer to your stack-level *Product Manual* for instructions on upgrading, configuring, and assigning addresses at the stack level.

The most important aspects of a Battery Control Panel configuration file are discussed in the following sections.

8.1. Background and Terminology

Terminology and technical concepts critical to the operation and configuration of Nuvation Energy BMS are presented in this section.

8.1.1. Register Data Model

8.1.1.1. Registers and Components

Understanding the Register Data Model is key to understanding how to configure Nuvation Energy BMS.

Nuvation Energy BMS implements all data storage and processing using two important software building blocks.

Register

A register is the fundamental unit of data storage within the system. Each register has a unique name and associated type that defines how the value is interpreted. Registers range in size from as small as one byte up to as large as eight bytes.

Component

A component combines a set of related registers with processing rules that operate on those registers to implement a particular BMS function for the system. A given component may have many instances throughout the system. In this case, its associated registers will have the same number of instances.

Complex behavior within the system is achieved by connecting multiple components together, either through configuration or through hard-wired connections in the firmware itself.

Configuration for a system is completely determined by the state of all configuration registers present within the system. Configuration registers are persisted in non-volatile memory and are loaded

automatically upon reset.

External protocols are implemented by mapping (and in some cases aggregating) the appropriate BMS registers to CAN bus messages or Modbus registers.

8.1.1.2. Index versus Location

Internally to Nuvation Energy BMS firmware, all register indexing is zero-based. That is, if multiple instances of the same register are present, the first instance is always indexed at zero. This convention is reflected in all register expressions and configuration files.

Operator-facing tools such as Nuvation Energy BMS Operator Interface or the MESA Modbus models use one-based location identifiers to refer to physical, countable entities.

For example, the location of the first cell within a stack is defined as Cell Interface 1, Cell 1—i.e. it is the first cell in the first Cell Interface. The index of this first cell is defined as zero within the firmware.

8.1.1.3. Register Expressions

Registers are accessed by name in Nuvation Energy BMS tools and configuration. Each register also has a unique address that is used internally within the BMS.

8.1.1.3.1. Single Register Instance

This expression is used when assigning to or reading from a single register in the system and is of the form:

```
component_name.register_name
```

where:

- **component_name** is the name of the component within the system
- **register_name** is the name of the register within the component

8.1.1.3.2. Range of Register Instances

These expressions build on the single register references by adding an additional range expression in square brackets:

```
component_name[range_expression].register_name
```

The **range_expression** may take any of the following forms:

- **index** - A single instance of component_name.register_name at index. Note that cell[0].voltage is equivalent to cell.voltage.

- **start_index:end_index** - All instances from start_index through end_index. The expression `cell[0:3].voltage` expands into:

```
cell[0].voltage
cell[1].voltage
cell[2].voltage
cell[3].voltage
```

- **start_index:end_index:block_length** - All instances from start_index through end_index within a repeating block of block_length across all instances of the register. The expression `cell[0:3:16].voltage` expands into:

```
cell[0].voltage
cell[1].voltage
cell[2].voltage
cell[3].voltage
cell[16].voltage
cell[17].voltage
cell[18].voltage
cell[19].voltage
cell[32].voltage
cell[33].voltage
cell[34].voltage
cell[35].voltage
cell[N-16].voltage
cell[N-15].voltage
cell[N-14].voltage
cell[N-13].voltage
```

where N is the total number of instances of the register `cell.voltage` within the system.

- **start_index:end_index:block_length:block_count** - All instances from start_index through end_index within a repeating block of block_length repeated block_count times. The expression `cell[0:3:16:2].voltage` expands into:

```
cell[0].voltage  
cell[1].voltage  
cell[2].voltage  
cell[3].voltage  
cell[16].voltage  
cell[17].voltage  
cell[18].voltage  
cell[19].voltage
```

In this case, only the first 2 blocks of 16 instances are included, rather than all blocks of 16 instances.

8.1.1.3.3. All Register Instances

A compact syntax can be used to expand to all instances of a given register within the system. The expression:

```
component_name[*].register_name
```

expands to all instances of **component_name.register_name** within the system. For example, the expression `cell[*].voltage` expands into:

```
cell[0].voltage  
cell[1].voltage  
cell[2].voltage  
cell[3].voltage  
cell[4].voltage  
cell[5].voltage  
cell[6].voltage  
cell[7].voltage  
cell[8].voltage  
cell[9].voltage  
cell[10].voltage  
cell[11].voltage  
cell[12].voltage  
cell[13].voltage  
cell[14].voltage  
cell[15].voltage  
cell[16].voltage  
.  
.  
.  
cell[N-3].voltage  
cell[N-2].voltage  
cell[N-1].voltage
```

where N is the total number of instances of the register `cell.voltage` within the system.

8.1.1.3.4. Register Address

In some cases, it is necessary to use the address of a register as a configuration value for another register in the system. This is required when assigning input and output pins to functions within the BMS, for example.

The expression:

```
@component_name.register_name
```

expands to the address of the register in the system. The single-instance range expression may be used for register addresses. For example:

```
@component_name[index].register_name
```

expands to the address of **component_name.register_name** at index in the system.

8.1.2. Units

A standard set of types/units has been adopted for use within Nuvation Energy BMS for the measurements and configuration settings. Unless otherwise noted, the units used within the firmware should be assumed as defined below.

Table 3. Standard Types and Units

Type	Units	Variable Type	Application
Address	none	uint32	BMS register address
Boolean	false=0, true=1	uint8	Logic value
Charge	mAh	int32	Depth of discharge and throughput
Count	number	uint32	A positive count of some event
Crc16	none	uint16	Used to verify persistent data
Current	mA	int32	Stack and pack currents
Energy	Wh	uint32	Energy capacity of a stack
Int64	value	int64	Signed 64 bit integer
ImpedanceMili	mΩ	uint32	Resistance of a stack
IpAddress	IP	uint32	IP4 address for a stack
LogLevel	none	uint32	Log level applied the BMS firmware
MicroOhms	μΩ	uint32	Resistance of a cell
Microseconds	μs	uint64	Time measurement or period
Percentage	%	uint8	Percentage of a full scale value (e.g. SoC)
PowerW	W	int32	Rated power of a stack
SoftwareId	enum	uint32	Enumeration for type of Cell Interface
Temperature	°C	int16	Thermistor temperatures
String	none	char[8]	Storage for 8 characters
UInt16	value	uint16	Unsigned 16 bit integer
UInt64	value	uint64	Unsigned 64 bit integer
Voltage	mV	int32	Cell and stack voltages

Every register within the firmware has an associated type that defines the expected units for that register.



A negative value for *Current* and *Charge* represents a charge direction while a positive value represents a discharge direction with respect to the cell/stack.

8.1.3. Storage Types

Each register in Nuvation Energy BMS can be one of five storage types.

Volatile

- Data that is not persisted across a system reset

Configuration

- Data that is persisted when requested and is typically set in field

Persistent

- Data that is persisted and regularly saved

Factory

- Data that is persisted when requested and is typically set at the factory

Manufacturing

- Data that is persisted and saved at manufacturing time

These types of storage can be read directly from the Operator Interface *Registers* menu option as discussed in [Section 6.5.1](#).

8.1.4. Configuration File

Configuration is stored externally to Nuvation Energy BMS in a plain-text file. This file defines the state of configuration registers as required for a particular system.

The Operator Interface provides tools for importing and exporting configuration files to and from Nuvation Energy BMS as a way to set or retrieve the state of all configuration registers.

The configuration file format is plain ASCII text with the following syntax:

- Any lines starting with a leading # are treated as comments.
- Each non-comment line is treated as a register assignment statement.

A register assignment takes on the form `register_expression = value` where:

- `register_expression` is one of the valid [Register Expressions](#) previously defined.
- `value` is either a numerical constant, quoted string, IP address, or a valid [Register Address](#).

Any standard text editor can be used to edit configuration files (e.g. Notepad++, etc.).



A configuration file cannot be used to configure the IP settings of a stack. Stack IP configuration is detailed in the *BMS Network Configuration* section of your stack-level *Product Manual*.

8.2. Stack States

Stacks in the pack are managed by the Battery Control Panel through distinct states defined for each stack. These states are outlined in the table below.

Table 4. Stack States

State	Description
Uninstalled	A stack is not available for communication or functionality of any kind
Installed	A stack is physically installed in the system and available for communication
Enabled	A stack is included in both aggregation and control operations at the pack level

State	Description
Ready	A stack is enabled, within operating limits, ready to be connected to the DC bus, and has established communication with the Battery Control Panel
Connected	A stack is ready and electrically connected to the DC bus

The above states are integrated into all aspects of pack level functionality and are referenced throughout the following sections.

8.3. Network Settings

The Ethernet IP addressing used by each stack in the pack must match the network configuration of the Battery Control Panel.

The recommended network topology has each stack connected the Battery Control Panel’s internal network ports (labeled Local Ethernet).

The Battery Control Panel internal network interface has the following settings by default:

- IP: 192.168.1.10
- Subnet: 255.255.255.0
- Gateway: None

Each stack is assigned a static IP address on the Battery Control Panel internal 192.168.1.0/24 subnet.

The Battery Control Panel Ethernet bridges must be configured to match this IP address assignment. There is one instance of the Ethernet bridge component for each stack in the pack.

Network settings can be viewed and modified either through the [Networks Page](#) in the Platform Interface or via the Configuration Registers below.

`gbc_eth_bridge[n].ip_address`

- The IP address of stack n. This is set to the stack’s IP address.

`gbc_eth_bridge[n].port`

- The port of the stack n request bridge. This should be set to 8080.

`gbc_eth_bridge[n].publish_port`

- The port of the stack n publish bridge. This should be set to 8081.

8.4. Pack Topology

Battery pack topology configuration is required to specify which stacks are connected in each bank as well as the number of banks within the pack. The following registers must be configured for each stack in the pack (the pack_stack component instances correspond in order to the gbc_eth_bridge component instances).

pack_stack[n].installed

- Flag indicating if stack n is [installed](#) or [uninstalled](#). Set to 1 if the stack is present.

pack_stack[n].enabled

- Flag indicating if stack n is [enabled](#). Set to 1 to actually use the stack.

pack_stack[n].bank_index

- The index of the bank where stack n is located. Set to 0 if only one bank is in use.

Stacks that are installed are considered physically present in the system. The Battery Control Panel will attempt to connect to and communicate with the stacks using the corresponding gbc_eth_bridge configuration.

A stack must be enabled before the Battery Control Panel will aggregate that stack's data into pack-level view or connect the stack to the DC bus.

8.5. Control Settings

Nuvation Energy Battery Control Panel includes a pack connection routine that intelligently manages connection and disconnection of all [enabled](#) stacks in a pack. The connection routine will guarantee no stack is connected if its connection will cause excessive in-rush current due to voltage imbalances. During the charging and discharging of the stacks, the routine will automatically connect stacks when appropriate. It is guaranteed that if 1 stack is [ready](#), that stack can be connected. Configuration of this routine is achieved through the following registers.

pack_control.enabled

- Set to 1 to enable automatic control of stack connection
- Set to 0 to require manual control of stack connection

pack_control.auto_connect

- Setting this to 1 will connect on boot. It will also re-connect after a fault condition has cleared.
- Setting this to 0 will require operator triggered connection on boot. It will also require operator triggered connection after a fault condition has been cleared.

pack_control.stack_delay

- Set to the settling delay in microseconds. This prevents multiple stacks from connecting in rapid succession.

pack_control.stack_nominal_resistance

- The nominal total ohmic resistance of a stack in milliohms. It is assumed all stacks have equivalent resistance.

pack_control.max_connect_current

- The maximum allowable stack inrush current during connection in milliamps. Typically this should be set below the smallest absolute fault threshold for stack current.

pack_control.connect_policy

- The connection policy which dictates which stack will be the first to connect.
- Set to 0 for the 'maximum power' policy. This will first connect the [ready](#) stack with the median stack voltage. Typically this is used when it is unknown whether the pack will be charging or discharging in the near future.
- Set to 1 for the 'charge' policy. This will first connect the [ready](#) stack with the lowest stack voltage. Typically this is used when the pack will be charged in the near future.
- Set to 2 for the 'discharge' policy. This will first connect the [ready](#) stack with the highest stack voltage. Typically this is used when the pack will be discharged in the near future.

By default, this feature is disabled. When disabled, stacks must be connected and disconnected individually through the Operator Interface or via one of the supported Communication Protocols.



When the Battery Control Panel pack connection routine is disabled, *NO* validation of stack voltages occurs before connecting stacks. Unless each stack is using a pre-charge circuit designed with this behavior in mind, use of the pack connection routine is recommended.

8.6. Operational Limits

The operational limits of the pack are primarily defined by the configuration at the stack level. The Battery Control Panel aggregates the limits and signals from each stack to produce overall pack-level limits and signals automatically.

A number of additional triggers are present within the Battery Control Panel itself that define fault thresholds at the pack level.

8.6.1. Stack Operation

Each enabled stack fault and warning states propagate up to the Battery Control Panel through triggers. These triggers provide flexible error handling and allow stack level redundancy so a single stack fault will not cause a pack fault and halt the entire system. The triggers which are the most important in handling pack operation are described below.

Table 5. Stack Operational Limits

Register	Setting
pack_fault_ready_stacks.thresh	The minimum number of stacks in the ready state required for the pack to be operational. For no fault tolerance this should be set to (enabled stack count - 1). For full fault tolerance this should be set to 0.
pack_warn_ready_stacks.thresh	The minimum number of stacks in the ready state required for the pack to indicate a warning. Typically this is set to (enabled stack count - 1).
pack_warn_stacks.thresh	The count of enabled stacks in the warning state, above which the pack will indicate a warning. Typically this is set to 0, which results in any enabled stack warning indicating a pack warning.

With the above triggers any system can be configured to tolerate some stacks faulting. For example: a 4 stack system which can still operate with at least two stacks [ready](#) would set pack_fault_ready_stacks.thresh = 1. This indicates that a pack fault should stop operation if only one

stack is [ready](#). In another example: a 4 stack system which cannot operate unless all 4 stacks are [ready](#) would set `pack_fault_ready_stacks.thresh = 3`. This indicates that if only 3 stacks were [ready](#) (i.e. a single stack had faulted) it is considered a pack fault and should stop operating. In general the formula for this is: (minimum ready stacks - 1).

8.6.2. Pack Full and Empty Conditions

The Battery Control Panel provides an aggregate of the SoCs for all stacks in the pack by reading either the Modbus point *801 SoC* or register *pack_charge[0].soc*. It is assumed that the SoC configuration for each stack is the same. Refer to your stack-level *Product Manual* for details on stack SoC configuration.

A battery pack can be determined to be full or empty using the following conditions of the pack SoC data:

- That all stacks are at 0% SoC when the pack SoC reads 0%. Otherwise the pack SoC remains at 1%.
- That all stacks are at 100% SoC when the pack SoC reads 100%. Otherwise the pack SoC remains at 99%.



The full/empty pack condition noted above is specific to Curie Update 2 release.



It is assumed that all stacks have similar capacity and usage to use this measurement for charging/discharging a battery pack. If the stacks are imbalanced in capacity or SoC, relying on the pack SoC measurement could overcharge/discharge the battery stacks. If the battery stacks are properly configured, the battery management system firmware will protect the stacks if such an over charge/discharge were to happen.

8.6.3. Communication Safety

Pack level communication must be stable and error free to ensure the battery is safely operating. Faults are tripped if any of the [installed](#) stack's Ethernet bridges experience connectivity issues. Fault behavior is tuned using the following trigger registers.

`gbc_fault_eth_conn.thresh`

- The threshold that is tripped when a bridge fault occurs.

`gbc_fault_eth_conn.time_hyst`

- The microsecond duration that the fault must be present before it trips.

`gbc_fault_eth_conn.end_time_hyst`

- The microsecond duration that the fault must be cleared before it resets.



This fault needs to be disabled if a pack needs to tolerate stacks that can experience communication faults. Even when this fault is disabled, a COM status for a stack will be reported on the Stack Status page as described in the Operator Interface Manual: Multi-Stack. A stack that does not communicate with a Battery Control Panel is not considered a ready stack (as per the definition of [ready](#)).

8.6.4. Stack Watchdog

Nuvation Energy Battery Control Panel will periodically update the watchdogs timers (`sc_controller_wdt`) of all stacks that are connected to the Battery Control Panel. If an Stack Controller becomes disconnected from the Battery Control Panel, this local Stack Controller watchdog can be configured to trip a fault at the stack level.

`gbc_sc_wdt_reset.period`

- The period at which all connected Stack Controller watchdogs will be reset.

`gbc_sc_wdt_reset.enable`

- Set this to 1 to enable the update of stack watchdogs by the Battery Control Panel.

If this feature is enabled, then it assumes that the [external controller heartbeat](#) is not in use and its fault should be disabled.

8.6.5. External Controller Heartbeat

Nuvation Energy Battery Control Panel can be configured to require a heartbeat signal from an external controller in order to keep all stacks online and out of fault state. A write to the MESA controller heartbeat register is expected at least once during the watchdog period. The Battery Control Panel will write to all enabled stacks watchdog registers (`sc_controller_wdt`) to keep them stack out of fault state.

`gbc_controller_wdt.period`

- Trip time for watchdog if heartbeat disappears
- Set to 5 seconds or as per application requirements

`gbc_fault_controller_wdt.disabled`

- Set to 0 to enable controller watchdog
- Set to 1 to disable controller watchdog

If this feature is not used, the watchdog fault should be disabled and the [stack watchdog](#) should be enabled.

9. Communication Protocols

9.1. Modbus Protocol Support

Nuvation Energy BMS implements the SunSpec battery models defined in the Modular Energy Storage Architecture (MESA) as the top-level Modbus interface to the product. Specifically the BMS implements the MESA Draft 3 Storage models (800 Series)

These specifications are available for download at <http://mesastandards.org/mesa-device>.



MESA Draft 3 is currently implemented on Nuvation Energy BMS. Be sure to download the correct draft of the standard from the MESA website.

A system-level summary of all of the MESA standards can be found at <http://mesastandards.org/mesa-standards>.

9.1.1. Modbus TCP

This protocol is used for communications over TCP/IP networks. A single Modbus TCP connection is supported over port 502 for read and write access. Additionally, the Battery Control Panel supports as many as 16 read-only Modbus TCP connections on port 11503.

9.1.2. Implemented MESA Models

The MESA standards contain a number of 'models' that can be implemented by vendors to describe a storage device at various levels of detail. The models implemented by Nuvation Energy BMS are described in the sections below.

Detailed register maps for all Draft 3 models are found in the document *MESA-Energy-Storage-Information-Models_Draft_3.xlsx* found at the Nuvation Energy technical resources located at <https://www.nuvationenergy.com/technical-resources>.

9.1.2.1. Common Model

This model primarily contains information to identify the device (e.g. manufacturer, model, serial number) as well as the version of software running on the device. A full description of the Common Model can be found in the SunSpec specification bundle.

9.1.2.2. S801

This model describes an energy storage device at the highest possible level. State of charge and overall alarm and warning states are found here. All mandatory points are implemented. The Modbus address of this model is 40070.

9.1.2.3. S802

This model describes a battery storage device. At this level, the critical operational information

includes the charge and discharge current limits. All mandatory points are implemented. The Modbus address of this model is 40094.

9.1.2.4. S803

This model describes a lithium-ion battery in detail. Voltage, temperature, and current statistics are available at the pack and stack level within this model. All mandatory and most optional points are implemented. The Modbus address of this model is 40116.

9.1.2.5. End Model

This model marks the end of the implemented Modbus address space.

9.1.3. MESA Model Structure and Nomenclature

This section is a clarification of terms used to describe a MESA model. It is used to understand the terminology in the spreadsheet presented in the previous section.

9.1.3.1. Points

All MESA models are a collection of points (i.e. Modbus registers). These points can be one or more Modbus registers in length. By definition, each Modbus register is 16 bits wide. For points that are larger than 16 bits, partial read accesses are not allowed. A Modbus read/write error is returned on such an access.

9.1.3.2. Fixed/Repeating Blocks

MESA models are described as collections of Fixed and Repeating blocks of points. A Fixed block is a set of points that is always defined and never changes in its size. A Repeating block describes a set of related points (i.e. usually for a string of batteries) of which there could be multiple instances of the Repeating blocks. The points within a repeating block are the same but these sets of blocks are concatenated sequentially.

For example in the 803 model, there is a set of repeating blocks that describe data for a particular stack/string of batteries. Accessing the 803 repeating block corresponds to using a stack/string index (0, 1, 2, ...) to access the desired repeating block.

For a single-stack Nuvation Energy BMS there is only one 803 repeating block. For a multi-stack Nuvation Energy BMS there are 36 stack/string repeating blocks. If a stack/string is configured in Nuvation Energy BMS software to be installed, then accessing its 803 repeating block will provide a valid Modbus response.

For stacks or strings that are not installed, accessing the corresponding repeating block will result in an unimplemented point response. Repeating blocks are taken into account in the length indicated in the model header.

9.1.3.3. Unimplemented Points

Any MESA point that is not implemented by a vendor will generate an unimplemented response. The response will be a valid Modbus read response but all point data returned will report unimplemented values. The unimplemented values vary by type as listed in the following table.

Table 6. Unimplemented Point Values

Type	Width (bits)	Unimplemented Value (hexadecimal)
signed int	16	0x8000
unsigned int	16	0xFFFF
signed int	32	0x80000000
unsigned int	32	0xFFFFFFFF
enumeration	16	0xFFFF
enumeration	32	0xFFFFFFFF

A write to a writeable MESA point that is unimplemented will generate a Modbus write error.

The MESA implementation on Nuvation Energy BMS has unimplemented points as follows:

Table 7. Unimplemented MESA Points

Model	Point Name	Description
801	Evt	Event status bit field
801	DisChaRate	Self Discharge Rate
801	MaxRsvPct	Maximum Reserve Percent
801	MinRsvPct	Minimum Reserve Percent
801	ChaSt	Charge Status
801	DerAlarmReset	Alarm Reset (read is unimplemented)
802	CycleCt	Cycle Count
802	WMaxDisChaRte	NamePlate Max Discharge Rate
802	SoH	State of Health (reported in 803 model per string)
802	BatReqPCSSSt	PCS State Request
802	BatReqW	Battery Power Request
802	SoH_SF	State of Health Scale Factor
802	BatReqW_SF	Battery Power Request Scale Factor
803	StrEvt2	String Event 2
803	StrConFail	String Connection Fail

9.1.3.4. Scale Factors

All MESA points are integer values (signed or unsigned). To account for different range values beyond the data size (i.e. greater than 65535 for an unsigned 16 bit value) or some fractional value (i.e. 1.1), some MESA points have scale factors associated with them. The scale factor is another point within the model which contains a signed integer exponent of base 10 that scales a corresponding point value. For example, a scale factor of 2 would result in multiplying the corresponding point by 100. Likewise a scale factor of -3 would result in a scale factor of 0.001. Refer to the prior MESA Draft 3 spreadsheet for the relationship between MESA points and their scale factors. All scale factors are

fixed for a model and do not change in value.

9.1.4. Operational Cases for MESA

There are two main operational cases for the control of Nuvation Energy BMS over its MESA interface:

1. An external controller (sometimes called "Energy Storage Controller") is used to coordinate power control functions of the BMS in conjunction with some other equipment (such as an inverter). This controller requires periodic and rapid responses of MESA point reads as well as some control over the operation of the BMS (such as stack connectivity). If there is a loss of communication between this controller and the BMS, the BMS will disconnect the stack(s) as a safety precaution.
2. An owner/operator of a battery system requires control of the BMS to monitor the activity of the batteries and track battery usage and its charge/discharge activities. This information can then be used to characterize the usage of the battery management system and to validate battery warranties of a vendor.

Read and write Modbus TCP operations can be performed over the standard Modbus port 502 (only a single connection is supported on this port). In the scenario where the MESA interface must be accessed by multiple devices, the Battery Control Panel provide a secondary port (11503) for read-only Modbus TCP operations.

These two operational cases will be discussed in detail in the following sections.

9.1.4.1. External Controller Communicating Over MESA Interface

An external controller typically polls Nuvation Energy BMS battery control points at a rate of 2–4 Hz. This controller reads data points required to manage current flow in the system. The following table summarizes the most important points an external controller may want to read from the BMS.

Table 8. MESA Points Read by an External Controller

Model	Block	Point Name	Address	Scale Factor	Purpose
801	Fixed	DERHb	40086	No	BMS Heartbeat counter incremented every second
802	Fixed	Evt1	40101	No	Bit field of all faults/warnings of a the BMS
802	Fixed	Vol	40105	Yes	External DC voltage of the battery system
802	Fixed	MaxBatACha	40106	Yes	Charge current limit calculated by the BMS
802	Fixed	MaxBatADischa	40107	Yes	Discharge current limit calculated by the BMS
803	Fixed	BTotDCCur	40127	Yes	Total DC current of the battery system

A controller may also want to command Nuvation Energy BMS to perform certain actions, such as connecting/disconnecting all stacks/strings. The following table provides the different writeable points in the MESA interface for different control functions:

Table 9. MESA Points Written to by an External Controller

Model	Block	Point Name	Address	Purpose
801	Fixed	ControllerHb	40087	Heartbeat register for external controller
801	Fixed	DERAlarmReset	40088	Clears all latched alarms in the BMS

Model	Block	Point Name	Address	Purpose
802	Fixed	BSetOperation	40110	Commands Nuvation Energy BMS to connect/disconnect all stacks/strings

When configured, the heartbeat controller can be used to update the watchdog timer of Nuvation Energy BMS on single-stack and multi-stack implementations. If the heartbeat point is not updated within the watchdog timer period, a fault will be generated on the BMS stack(s) and their corresponding contactors will be opened. The value written to the heartbeat point must increase in value and roll over to zero when the 16 bit range limit is reached.

The clearing of alarms of Nuvation Energy BMS is accomplished by writing a value of 1 to the DERAlarmReset point. This point is erroneously identified as read-only in the Mesa Draft 3 spreadsheet referenced earlier. Note that alarm will not be cleared if the alarm condition is still present.

Commanding all stacks/strings of a Nuvation Energy BMS system to connect/disconnect is accomplished through the BSetOperation point. This point accepts the enumerated values for these connect/disconnect operations. Additional connection logic (such as separate pre-charge circuitry) is managed automatically by the BMS when it is configured for such an operation.

9.1.4.2. External Nuvation Energy BMS Monitoring Over MESA Interface

An external data logger may want to access a variety of data from the BMS. In general, a data logger will not actively manage Nuvation Energy BMS; normally, it will not initiate actions such as connecting a battery stack to the DC voltage bus or clearing faults. A data logger should connect to one of the read-only Modbus connections (if available) to allow the writable Modbus connection to be available for separate external control functions. The following table contains the MESA data points exposed by the BMS that could be collected for logging purposes.

Table 10. MESA Points Read by External Data Logger

Model	Block	Point Name	Address	Scale Factor	Purpose
801	Fixed	SoC	40081	Yes	BMS State of Charge
801	Fixed	DERHb	40086	No	BMS Heartbeat counter incremented every second
802	Fixed	Evt1	40101	No	Bit field of all faults/warnings of a BMS
802	Fixed	Vol	40105	Yes	External DC voltage of the battery system
802	Fixed	MaxBatACha	40106	Yes	Charge current limit calculated by BMS
802	Fixed	MaxBatADischa	40107	Yes	Discharge current limit calculated by BMS
802	Fixed	BSetOperation	40110	No	BMS requested connection state of all stacks/strings
803	Fixed	BConStrCt	40118	No	Number of stacks/strings with contactor closed
803	Fixed	BMaxCellVol	40119	Yes	Maximum cell voltage measured
803	Fixed	BMaxCellVolLoc	40120	No	Module/String location of maximum cell voltage
803	Fixed	BMinCellVol	40121	Yes	Minimum cell voltage measured
803	Fixed	BMinCellVolLoc	40122	No	Module/String location of minimum cell voltage
803	Fixed	BMaxModTmp	40123	Yes	Maximum module temperature
803	Fixed	BMaxModTmpLoc	40124	No	Module/String location for maximum module temperature
803	Fixed	BMinModTmp	40125	Yes	Minimum module temperature
803	Fixed	BMaxModTmpLoc	40126	No	Module/String location for minimum module temperature

Model	Block	Point Name	Address	Scale Factor	Purpose
803	Fixed	BTotDCCur	40127	Yes	Total DC current of the battery system
803	Fixed	BMaxStrCur	40128	Yes	Largest DC current reported by a stack/string
803	Fixed	BMinStrCur	40129	Yes	Smallest DC current reported by a stack/string
803	Repeat	StrSoC	40135 +Index	No	State of charge for a stack/string
803	Repeat	StrSoH	40136 +Index	Yes	State of health for a stack/string
803	Repeat	StrCur	40137 +Index	Yes	Current of a stack/string
803	Repeat	StrMaxCellVol	40138 +Index	Yes	Maximum cell voltage of a stack/string
803	Repeat	StrMinCellVol	40139 +Index	Yes	Minimum cell voltage of a stack/string
803	Repeat	StrCellVolLoc	40140 +Index	No	Location of min/max cell voltages of a stack/string
803	Repeat	StrMaxModTmp	40141 +Index	Yes	Maximum module temperature of a stack/string
803	Repeat	StrMinModTemp	40142 +Index	Yes	Minimum module temperature of a stack/string
803	Repeat	StrModTmpLoc	40143 +Index	No	Location of min/max module temperatures of a stack/string
803	Repeat	StrEvt1	40144 +Index	No	Alarms warnings and status bit field of a stack/string



The term Index in the Repeating block addresses used in the above table refers to a calculation of $\text{Index} = \text{Stack Index} * \text{Length of Repeating block}$. By definition, the 803 Repeating block is 16 Modbus registers in length.

9.1.5. Accessing MESA Models

MESA models are located contiguously in the Modbus address space starting at a base address of 40000. The Common Model is always located first in this space. The End Model is always last and is used to denote the end of MESA Modbus registers. Each model located between the Common Model and the End Model has a numeric identifier as well as a length. A handy tool that can be used to explore the MESA Modbus registers for Nuvation Energy BMS is modpoll.exe. It is available for free download at <http://www.modbusdriver.com/modpoll.html>.

Using modpoll.exe, the Common Model can be polled from a using the following command (assuming the device has an IP address of 192.168.1.21)

```
modpoll.exe -m tcp -0 -r 40000 -c 70 {default-ip}
```

```
modpoll 3.4 - FieldTalk(tm) Modbus(R) Master Simulator  
Copyright (c) 2002-2013 proconX Pty Ltd  
Visit http://www.modbusdriver.com for Modbus libraries and tools.
```

```
Protocol configuration: MODBUS/TCP  
Slave configuration...: address = 1, start reference = 40000 (PDU), count = 70  
Communication.....: {default-ip}, port 502, t/o 1.00 s, poll rate 1000 ms  
Data type.....: 16-bit register, output (holding) register table
```

```
-- Polling slave... (Ctrl-C to stop)
```

```
[40000]: 21365
```

```
[40001]: 28243
```

```
[40002]: 1
```

```
[40003]: 66
```

```
.
```

```
.
```

```
.
```

```
[40068]: 4660
```

```
[40069]: -32768
```

As another example, the complete S802 model for a system with one stack could be polled using the following command:

```
modpoll.exe -m tcp -0 -r 40094 -c 22 {default-ip}
```

```
modpoll 3.4 - FieldTalk(tm) Modbus(R) Master Simulator  
Copyright (c) 2002-2013 proconX Pty Ltd  
Visit http://www.modbusdriver.com for Modbus libraries and tools.
```

```
Protocol configuration: MODBUS/TCP  
Slave configuration...: address = 1, start reference = 40094 (PDU), count = 22  
Communication.....: {default-ip}, port 502, t/o 1.00 s, poll rate 1000 ms  
Data type.....: 16-bit register, output (holding) register table
```

```
-- Polling slave... (Ctrl-C to stop)
```

```
[40094]: 802
```

```
[40095]: 20
```

```
.
```

```
.
```

```
.
```

```
[40114]: -2
```

```
[40115]: -32768
```

10. Options

The Nuvation Energy Battery Control Panel offers the following options:

- Cellular Modem: Removal

Part numbers to order any of these can be found in [Appendix B](#).

10.1. Cellular Modem: Removal

If the functionality of a cellular connection is not needed, the modem and antenna can be removed altogether. Also note that the cellular modem is only compatible with network carriers in the USA and Canada. Installation sites outside these regions should request this option.

11. Troubleshooting

11.1. Faults

When a pack level fault occurs, all stacks are disconnected. The following sections describe the different faults and the conditions that trigger them. In general, all warnings have a similar trigger condition as their corresponding fault. The following discussion will focus on the term fault and all descriptions can be applied to the compatible warning.

11.1.1. Ethernet Connection

This fault is related to communication faults between the Battery Control Panel and any of the stack-level BMS that is configured as `installed_pack_stack[n].installed`.

`gbc_fault_eth_conn`

- The Battery Control Panel could not communicate with one or more installed stacks

This fault is usually triggered due to:

- Battery Control Panel network configuration issues. Refer to [Section 8.3](#) for details.
- IP networking configuration is different between the Battery Control Panel and the stack-level BMS. Verify that `gbc_int_ethernet` register settings are compatible with the stack-level IP register settings.
- The expected stack-level BMS is not on the network or receiving power

To find the stack-level BMS that has a connection fault, refer to the register `gbc_eth_bridge_status[*].is_connected`. The pattern of data should match the [installed](#) stacks at `pack_stack[*].installed`.

11.1.2. Controller Heartbeat

`gbc_fault_controller_wdt`

- Fault indicating that an external controller did not provide a heart beat update within the configured period. Refer to [Section 8.6.5](#) on details of this configuration.

11.1.3. Ready Stacks

This fault represents a configurable minimum limit to how many stacks must be [ready](#) and still have the pack remain connected and manage the battery power. Refer to [Section 8.6](#) for details of this operation and configuration.

`pack_fault_ready_stacks`

- Fault indicating that the minimum number of [ready](#) stacks for the pack has been exceeded

Refer the Stack Status page ([Section 6.3](#)) on the Operator Interface to observe which stacks have been either disabled or have faulted.

11.1.4. Firmware Mismatch

`gbc_fault_fw_mismatch`

- Fault indicating that the difference between the Battery Control Panel and the expected stack-level BMS firmware versions. Perform a firmware upgrade on the affected stacks.

To determine which stacks have this particular fault, refer the component `gbc_fw_mismatch[].mismatch`.

11.2. Lost/Forgotten IP Address

The Battery Control Panel is resolvable using mDNS via a compatible computer. Refer to [Section 6.1.1](#) for details.



Depending on the network interface used on the PC, this process may not work due to differing security and IP configurations. If the only IP discovered is the IP of the PC, the network interface is not suitable and another one will need to be used. This issue is most common with USB to Ethernet dongles.

11.2.1. Wireshark (Windows/Linux)

1. Download/install Wireshark on a PC (<https://www.wireshark.org/>)
2. Connect the PC directly to the Ethernet port on the device
3. Start a Wireshark capture on the network interface connected to the device
4. In the 'filter' field, enter in `arp.isgratuitous` and press enter
5. Either reboot the device, or unplug/plug the Ethernet cable
6. The device should send a 'Gratuitous ARP' on the Ethernet network. In Wireshark the 'Info' field looks like: Gratuitous ARP for <IP> (Request) where the <IP> is the address for the device
7. Once that is complete, update the PC network settings to match the device and connect the UI to re-configure

11.2.2. Netdiscover (Linux only)

1. Install netdiscover on a PC (on Debian based systems use: `sudo apt install netdiscover`)
2. Connect the PC directly to the Ethernet port on the device
3. Run `sudo netdiscover -i <interface> -p` where <interface> is the network interface connected to the device
4. Either reboot the device, or unplug/plug the Ethernet cable
5. The device address and MAC will show up in netdiscover once an ARP packet is sent
6. Once that is complete, update the PC network settings to match the device and connect the UI to re-configure

Appendix A: Operating Limits

This section outlines the operating limits of the Battery Control Panel.



Exceeding these ratings may damage the system.

Input AC Power Specifications

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{supply}	Supply Voltage	60 Hz	85	120	132	V AC
	Supply Voltage	50 Hz	187	240	264	V AC
I_{inrush}	Inrush Current (Max)	115 V AC	-	-	13	A AC
	Inrush Current (Max)	230 V AC	-	-	25	A AC
P_{supply}	Supply Power	-	-	115	144	W
f_{supply}	Supply Frequency	-	47	50/60	63	Hz

Ethernet Specifications

Parameter	Min	Typ	Max	Units
Data Speeds	10	-	1000	Base-T
Jack Rating	-	Cat5e	-	-

Cellular Specifications

Parameter	Min	Typ	Max	Units
3G HSPA+ Bands	-	850, 1900	-	MHz
4G LTE Cat 1 Bands	-	B2, B4, B5, B12, B13	-	-
Data Rate (Up/Down)	-	-	5/10	Mbps
Coverage Area	-	USA, CAN	-	-

Environmental Conditions

Symbol	Parameter	Min	Typ	Max	Units
Thermal Specifications					
T_a	Operating Temperature	10	-	40	°C
	Storage Temperature	10	-	40	°C
Humidity Specifications					
RH	Operating Relative Humidity	25	-	85	%
	Storage Relative Humidity	25	-	85	%

Appendix B: Ordering Information

This section provides orderable part numbers for Nuvation Energy’s offerings of Battery Control Panel units.

Battery Control Panel - Base Product Variants

Battery Control Panel Variant	Part Number
Battery Control Panel, up to 4 Stacks	NUVBCP-4S
Battery Control Panel, up to 8 Stacks	NUVBCP-8S
Battery Control Panel, up to 12 Stacks	NUVBCP-12S
Battery Control Panel, up to 16 Stacks	NUVBCP-16S
Battery Control Panel, up to 20 Stacks	NUVBCP-20S
Battery Control Panel, up to 24 Stacks	NUVBCP-24S
Battery Control Panel, up to 28 Stacks	NUVBCP-28S
Battery Control Panel, up to 32 Stacks	NUVBCP-32S
Battery Control Panel, up to 36 Stacks	NUVBCP-36S



Systems involving more than 16 battery stacks will require an external network (Ethernet) switch to be connected to the Battery Control Panel. This external switch is not provided; an industrial grade, unmanaged switch is recommended.

Battery Control Panel - Options

Option	Part Number
Cellular Modem: Removal	NUVBCP-OPT-M



The 'Cellular Modem: Removal' option should be specified for site locations outside the USA and Canada.

Appendix C: Servicing

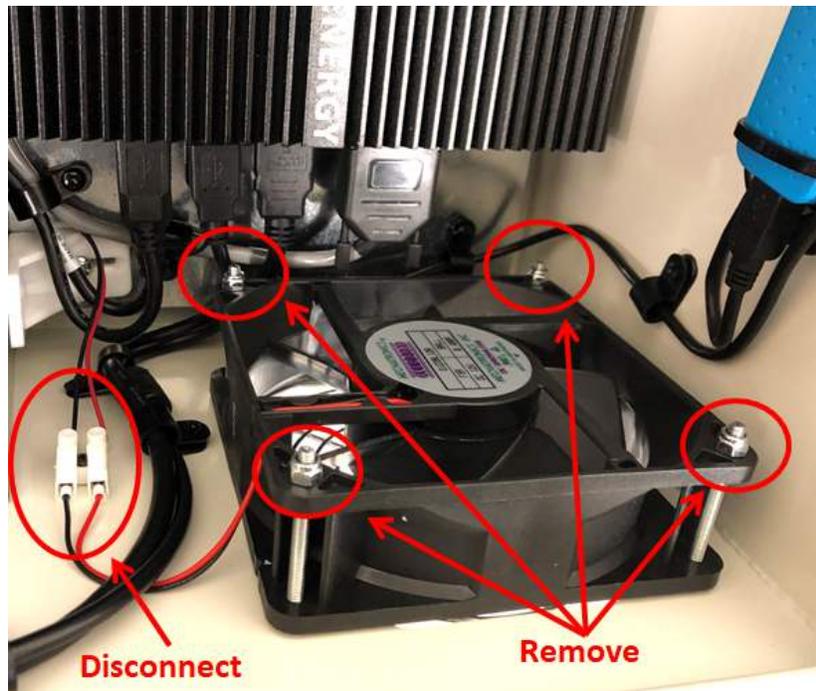
Stack Servicing

In order to service the stack (including the battery itself), refer to the *Nuvation Energy Stack Switchgear: Product Manual*.

Fan replacement

Fan model for replacement: Orion Fans – G109-15A

1. Ensure power to the unit is power off. This includes both the power rocker switch set to the off position and the AC power cable is unplugged.
2. Open up the Battery Control Panel using a flat head screwdriver to unlock the door.
3. At the bottom right of the unit is the cooling fan. At the terminal block, disconnect the two power wires that go to the fan using a small flat head screwdriver.
4. Using a PH2 screwdriver and M7 socket remove the four screws and nuts securing the fan to the bottom of the Battery Control Panel.
5. Reinstall the new fan ensuring it is installed in the same orientation as the removed fan. Ensure the fan guard is properly installed and use the same hardware as was originally used.
6. Reconnect the fan power connections to the terminal block ensuring the correct polarity and secure using the small flat head screwdriver.



Appendix D: Best Practices

This section describes important concepts which need special attention to achieve a reliable installation.

Excess Cable Management

During the first prototype system build, it is possible to encounter cable lengths that are too long for your system. Leaving the excess cable length unmanaged can result in a messy system installation.

If reducing the cable length is not feasible or if there is no time to physically modify the lengths, a common solution is to wrap the excess cable length in a coil and fasten the wire loop in the cabinet. This basic tactic has the undesirable effect of creating an air-core transformer which will couple EMI into the cable extremely well.

The best solution to cable length management is to bundle the excess length in a figure-8 pattern. This prevents the bundle from turning into an air-core transformer since the direction of current in one side of the figure-8 turns opposite to the current in the other side. It is recommended to use the figure-8 method if physically reducing the cable length is not possible.

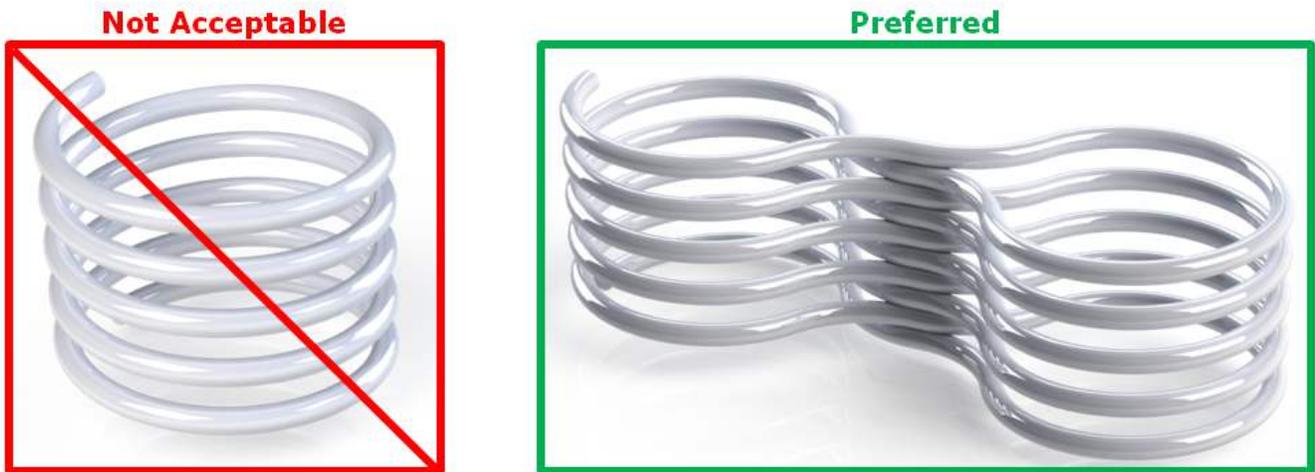


Figure 23. Excess Cable Management Examples

Appendix E: Example Configuration File



The example configuration file shown below may also be downloaded from <https://www.nuvationenergy.com/technical-resources>.

This sample configuration file is compatible with Nuvation Energy BMS Curie Update 2 Release (Firmware 4.106.2)

nuvation_energy_bcp_example.cfg

```
#####
#
# Example configuration for Battery Control Panel
#
# Battery Pack with 4 Stacks installed in a single Bank
#
# NOTE: This configuration is intended as an example and has NO WARRANTY
# or guarantee of correctness for a particular application.
#
#####
# NETWORK SETTINGS
#####
#
# Stack IP addresses
#
gbc_eth_bridge[*].port = 8080
gbc_eth_bridge[*].publish_port = 8081
gbc_eth_bridge[*].ip_address = 0.0.0.0
gbc_eth_bridge[0].ip_address = 192.168.1.21
gbc_eth_bridge[1].ip_address = 192.168.1.22
gbc_eth_bridge[2].ip_address = 192.168.1.23
gbc_eth_bridge[3].ip_address = 192.168.1.24
#
#####
# PACK TOPOLOGY
#####
#
# Enabled and Installed Stacks
#
pack_stack[*].installed = 0
pack_stack[*].enabled = 0
pack_stack[0:3].installed = 1
pack_stack[0:3].enabled = 1
pack_stack[0:3].bank_index = 0
#
```

```
pack_stack_summary.bank_count = 1
#
#####
# CONTROL SETTINGS - Pack Connection Sequencing
#
# WARNING: DO NOT CHANGE without carefully reviewing the
#   'Configuration Settings' section of the Product Manual.
#####
#
pack_control.enabled = 0
pack_control.stack_delay = 5000000
#
#####
# OPERATIONAL LIMITS - Controller Watchdog Fault
#
# WARNING: DO NOT CHANGE without carefully reviewing the
#   'Configuration Settings' section of the Product Manual.
#####
#
gbc_controller_wdt.period = 5000000
gbc_fault_controller_wdt.thresh = 1
gbc_fault_controller_wdt.time_hyst = 0
gbc_fault_controller_wdt.end_time_hyst = 0
gbc_fault_controller_wdt.latched = 1
#
#####
# OPERATIONAL LIMITS - SC Ethernet communication faults, watchdogs and ready stacks
#
# WARNING: DO NOT CHANGE without carefully reviewing the
#   'Configuration Settings' section of the Product Manual.
#####
#
gbc_fault_eth_conn.thresh = 1
gbc_fault_eth_conn.time_hyst = 0
gbc_fault_eth_conn.end_time_hyst = 5000000
gbc_fault_eth_conn.latched = 0
#
gbc_warn_eth_conn.thresh = 1
gbc_warn_eth_conn.time_hyst = 0
gbc_warn_eth_conn.end_time_hyst = 5000000
gbc_warn_eth_conn.latched = 0
#
gbc_sc_controller_wdt_reset.period = 1000000
gbc_sc_controller_wdt_reset.enable = 1
#
```

```
# Set for full ready stack fault tolerance
pack_fault_ready_stacks.thresh = 0
pack_warn_ready_stacks.thresh = 3
#
#####
# AUTO CONNECTION CONFIG - configuration on how stacks are auto-connected.
#
# Uncomment to enable auto connect
#pack_control.enabled = 1
#pack_control.auto_connect = 1
#
# 1.0 Amp tolerance
pack_control.max_connect_current = 1000
# 1.0 Ohm stack resistance
pack_control.stack_nominal_resistance = 1000
# 1.0 second delay between stack connections
pack_control.stack_delay = 1000000
# "Maximum power" connect policy
pack_control.connect_policy = 0
#
#####
# MESA - System topology
mesa_counts.num_strings = 1
mesa_counts.modules_per_string = 1
mesa_counts.cells_per_module = 1
```

From time to time Nuvation Energy will make updates to Nuvation Energy BMS in response to changes in available technologies, client requests, emerging energy storage standards, and other industry requirements. The product specifications in this document, therefore, are subject to change without notice.

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