



Nuvation Energy Multi-Stack Controller

Product Manual

Document ID: NE-PM-004 | Revision: 2.0, 2022-05-18

BMS Software Version: Curie Update 3
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Table of Contents

- 1. Introduction 2
 - 1.1. About this Manual 2
- 2. Battery Topology Terminology 3
- 3. System Overview 4
 - 3.1. Multi-Stack System Architecture 5
 - 3.2. Features 7
 - 3.2.1. Main Functions 7
 - 3.2.2. Unified View Operator Interface 7
 - 3.2.3. Communications & Data Analytics 8
 - 3.2.4. Maintenance and Management 8
- 4. Installation Instructions 9
 - 4.1. Mechanical Installation 9
 - 4.1.1. Dimensions and Weight 9
 - 4.1.2. Installation Location and Position 9
 - 4.2. Multi-Stack Controller Electrical Connections 11
 - 4.2.1. Getting Started 11
 - 4.2.2. Step 1: Connect Stack Switchgear Communications 11
 - 4.2.3. Step 2: Connect External Network or System 12
 - 4.2.4. Step 3: Verify Grounding 13
 - 4.3. Multi-Stack Controller First Power-Up 14
 - 4.3.1. Connect Power 14
 - 4.3.2. Status LEDs 15
- 5. Using the Multi-Stack Operator Interface 17
 - 5.1. Access the Multi-Stack Operator Interface 17
 - 5.1.1. External Computer Requirements 17
 - 5.1.2. Launch Multi-Stack Operator Interface 17
 - 5.2. The Status Banner 19
 - 5.2.1. Communication Loss 19
 - 5.3. The Dashboard Tab 20
 - 5.3.1. Warnings and Faults 20
 - 5.3.2. Pack Voltage 21
 - 5.3.3. Pack Current 21
 - 5.3.4. State-of-Charge 22
 - 5.3.5. Depth-of-Discharge 22
 - 5.3.6. Stack Voltage 22
 - 5.3.7. Stack Current 23
 - 5.3.8. Cell Voltage 24
 - 5.3.9. Temperature 25
 - 5.3.10. Nuvation Energy BMS Status 26
 - 5.4. The Stack Status Tab 29
 - 5.4.1. Pack Connection/Status 30
 - 5.4.2. Stack Enable and Connection 30

- 5.4.3. Stack Service Lockout 30
- 5.4.4. Stack COM Fault 31
- 5.5. The Details Tab 33
 - 5.5.1. Information Selector 33
 - 5.5.2. Battery 33
 - 5.5.3. Current Limiter 34
 - 5.5.4. Safety 34
- 5.6. The Menu Options 36
 - 5.6.1. Registers 36
 - 5.6.2. Service 36
 - 5.6.3. Connection 37
 - 5.6.4. Logging 37
 - 5.6.5. Locking and Unlocking 42
 - 5.6.6. About 43
- 6. Using the Platform Interface 44
 - 6.1. Overview 44
 - 6.2. Functions 45
 - 6.2.1. Installing a Function 45
 - 6.2.2. Upgrading a Function 45
 - 6.3. Networks 46
 - 6.3.1. Networking 46
 - 6.4. Backups 48
 - 6.4.1. Create a System Backup 48
 - 6.4.2. Upload a backup file 48
 - 6.4.3. Backup Restore 49
 - 6.5. Settings 50
 - 6.5.1. Upgrading the Multi-Stack Controller 50
 - 6.5.2. Factory Reset the System 51
 - 6.5.3. Rebooting and Powering off the System 51
 - 6.5.4. Setting the Date, Time, and Timezone 51
- 7. Communication Protocols 52
 - 7.1. Modbus Protocol Support 52
 - 7.1.1. Modbus TCP 52
 - 7.1.2. Implemented MESA Models 52
 - 7.1.3. MESA Model Structure and Nomenclature 53
 - 7.1.4. Operational Cases for MESA 55
 - 7.1.5. Accessing MESA Models 57
- 8. External Interfaces 60
 - 8.1. Ethernet 60
 - 8.2. SFP+ Interfaces 60
 - 8.3. Power Button 60
 - 8.4. DC Power Connector 60
- 9. Troubleshooting 61
 - 9.1. Faults 61

9.1.1. Ethernet Connection	61
9.1.2. Controller Heartbeat	61
9.1.3. Ready Stacks	62
9.1.4. Firmware Mismatch	62
9.2. Lost/Forgotten IP Address	63
9.2.1. Wireshark (Windows/Linux)	63
9.2.2. Netdiscover (Linux only)	63
Appendix A: Operating Limits	64
Electrical Characteristics	64
Environmental Conditions	64
Standards and Certifications	64
Appendix B: Ordering Information	66
Power Adapters	66
Appendix C: Best Practices	67
Excess Cable Management	67

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 Multi-Stack Controller 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.

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

The Nuvation Energy Multi-Stack Controller aggregates information and provides a unified interface to a large multi-stack battery system.

1.1. About this Manual

This *Nuvation Energy Multi-Stack Controller: Product Manual* is a comprehensive manual, providing:

- Details about all the features offered by your Nuvation Energy Multi-Stack Controller
- 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 3 software release (Firmware version 4.106.3, 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 could be described as a "5g14s2p" Stack. However, it is far more common to describe it as a "70s2p" Stack.

Bank

A Bank is one or more stacks connected in parallel. For example, three "70s2p" Stacks connected in parallel are referred to as a "3x70s2p" Bank.

Pack

A Pack is one or more Banks connected in series.

3. System Overview

The Nuvation Energy Multi-Stack Controller 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 other 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 Multi-Stack Controller 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 Multi-Stack Controller 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 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, temperatures, 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 Multi-Stack Controller

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 Multi-Stack Controller 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 Multi-Stack Controller. 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>.

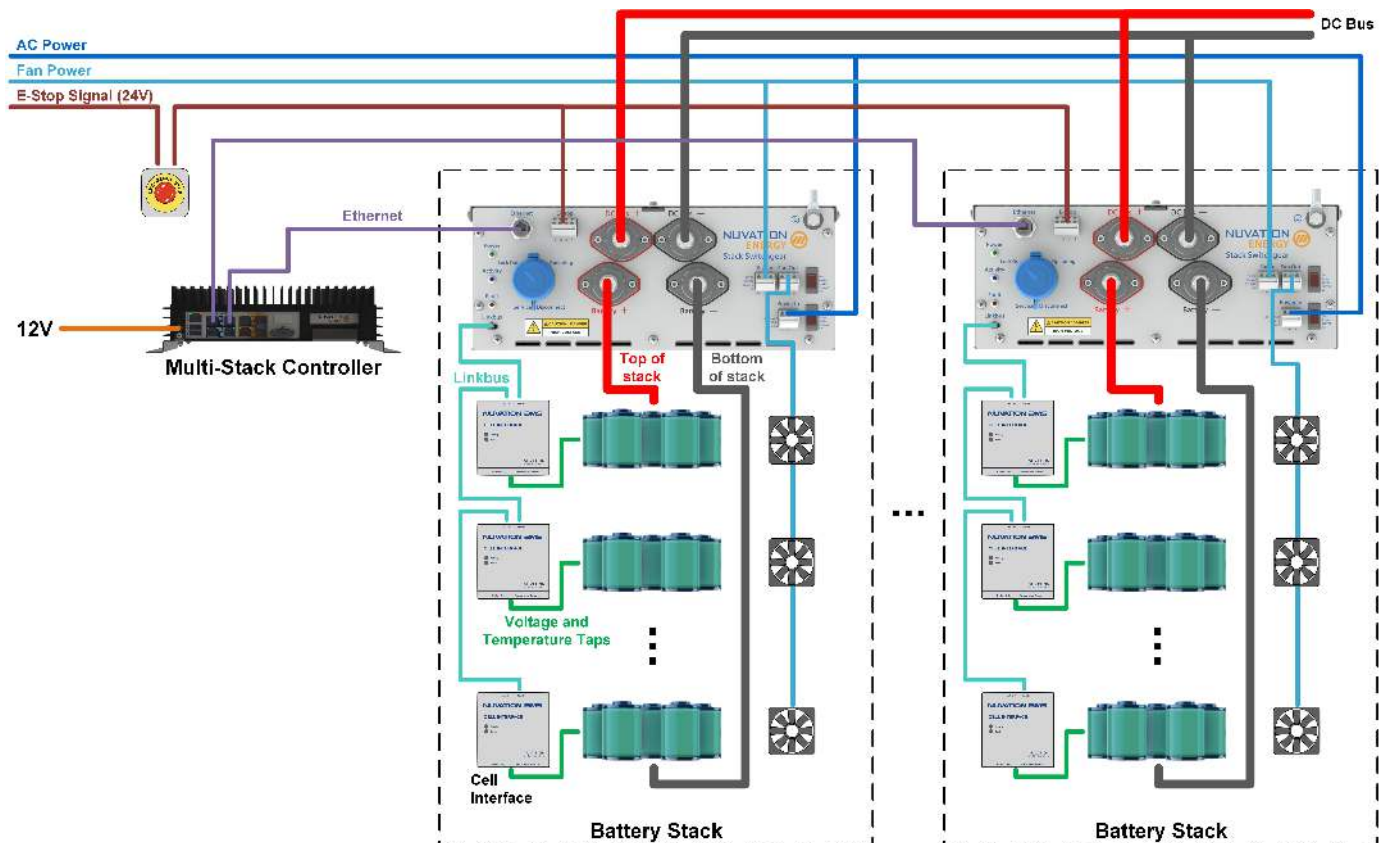


Figure 2. Multi-Stack Controller system diagram

The Multi-Stack Controller 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.

The Multi-Stack Controller is available in a compact hardware form-factor or in a rack-mounted hardware form-factor. This document describes the compact form-factor. The document for the rack-mount form-factor is available upon request.

Designed in compliance with MESA (Modular Energy Storage Architecture) Open Standards for Energy Storage (<http://mesastandards.org/>, draft 3), the Nuvation Energy Multi-Stack Controller 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 Multi-Stack Controller 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. A Nuvation Energy support technician can configure a battery pack to tolerate a specified number of stacks that fault and disconnect from the DC bus. The Multi-Stack Controller allows the pack to remain operational and manage the reduced power capacity of the battery.

3.2.2. Unified View Operator Interface

A 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 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 limits for entire pack, which can be read by the external system to control the inverter, protecting the battery pack from over-charging or discharging.

Pack-Level Fault Response

A highly configurable architecture allows a Nuvation Energy support technician to specify system faults and desired responses. The Multi-Stack Controller flags faults anywhere in the battery pack and automatically takes preventive action to keep the battery functional 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 interfacing with inverters over Modbus TCP. SFP+ interfaces allow long-distance fibre connectivity without external hardware.

Provides Remote Support

The Multi-Stack Controller provides the option of a secure VPN connection to a Nuvation Energy server which grants Nuvation Energy support engineers remote access to check on the health of the battery pack and aid the local site commissioning team.

4. Installation Instructions

4.1. Mechanical Installation

4.1.1. Dimensions and Weight

The overall dimensions of the Multi-Stack Controller are 340mm × 218.5mm × 89.8mm.

The Multi-Stack Controller module weighs approximately *TBD* kg.

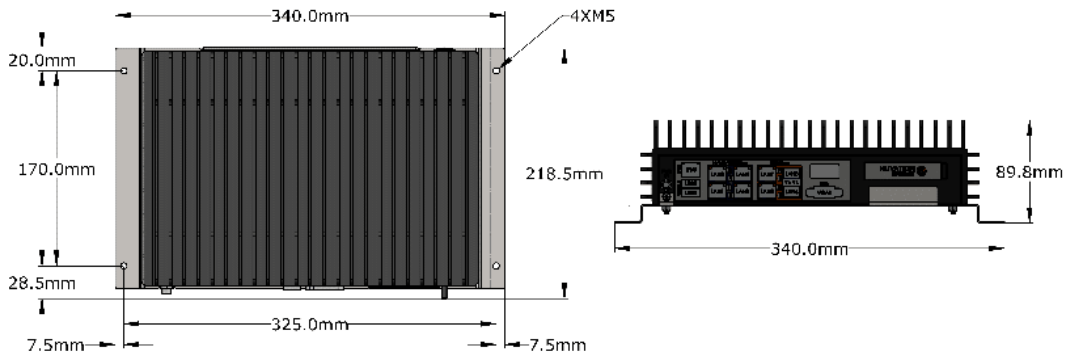


Figure 3. Mechanical Drawing of Multi-Stack Controller

4.1.2. Installation Location and Position

The Multi-Stack Controller is rated to operate in the temperature range of 5°C to 40°C. It is designed for indoor use.

For best thermal performance, the Multi-Stack Controller should be mounted to a flat vertical surface such that the face with the Ethernet / Power connectors is pointing up.

The Multi-Stack Controller can be mounted using 4 M5 screws, as illustrated in [Figure 3](#).

4.1.2.1. Mounting Clearances

Extra space should be provided around the module to allow for cable connections, easy installation/maintenance and to provide adequate fan-less cooling. The spatial clearance is illustrated below.

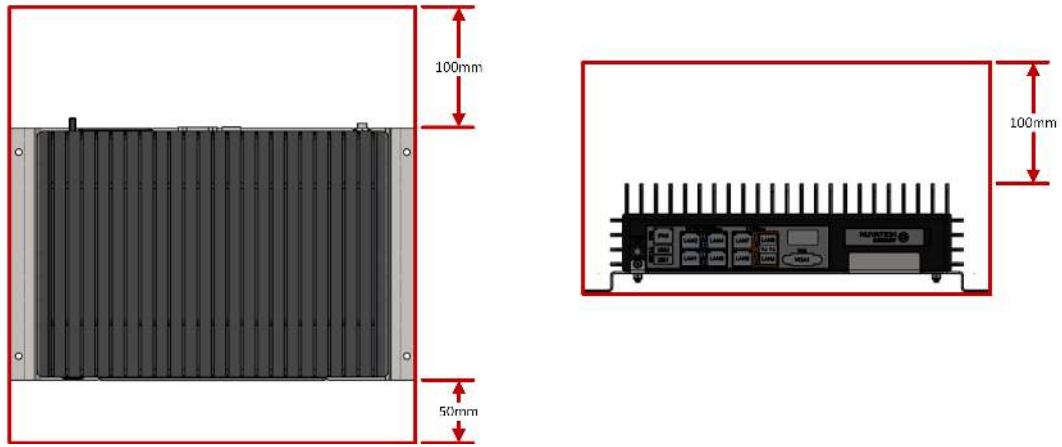


Figure 4. Multi-Stack Controller Restricted Areas

4.2. Multi-Stack Controller Electrical Connections



Before making any connections, ensure that power is not applied to the Multi-Stack Controller.

4.2.1. Getting Started

Before connecting power to the Multi-Stack Controller you need to:

1. [Connect Stack Switchgear communications](#)
2. [Connect external network or system](#)
3. [Verify grounding](#)

Below are images of the external interfaces available on the front and back of the Multi-Stack Controller.



Figure 5. Multi-Stack Controller external interfaces (front)



Figure 6. Multi-Stack Controller external interfaces (back)

4.2.2. Step 1: Connect Stack Switchgear Communications

Connect the Stack Switchgear units to the Ethernet RJ45 ports labelled 1 to 4 using Cat5e-rated or higher Ethernet cables of suitable lengths. Refer to the network port connection map [Table 1](#).



The Stack Switchgear only supports ports at 10/100 Mbps Ethernet. To connect a Stack Switchgear to port 5 or 6, an Ethernet switch supporting 1 Gbps and 10/100 Mbps is required.

Table 1. Network Port Connection Map

Port Name	Function	Port Label	Port Speed
External	Manage network traffic external to the Multi-Stack Controller. Operator Interface is accessed from this port.	7 & 8	1/10 Gbps
Internal	Manage traffic from battery management system stacks.	1-4	10/100/1000 Mbps
		5 & 6	1/10 Gbps

Figure 7 is an image of the MSC front panel, pointing out the different types of ports the Multi-Stack Controller supports:

- 4x internal Ethernet ports at 10/100/1000 Mbps (ports 1-4)
- 1x internal Ethernet port at 1/10 Gbps (port 5)
- 1x internal SFP+ port at 1/10 Gbps (port 6)
- 1x external Ethernet port at 1/10 Gbps (port 7)
- 1x external SFP+ port at 1/10 Gbps (port 8)

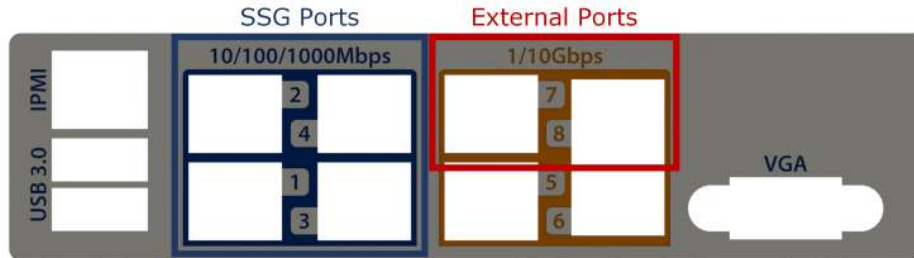


Figure 7. Multi-Stack Controller port types

Depending on the Multi-Stack Controller variant purchased, you may also use an external unmanaged network switch to connect more than 4 Stack Switchgear products to the Multi-Stack Controller.



The *external* and *internal* networks of the Multi-Stack Controller should remain separated and independent for the best operation of the battery pack. Excessive network traffic on the *internal* network can interfere with the Multi-Stack Controller management of the stacks.

4.2.3. Step 2: Connect External Network or System

The Ethernet RJ45 port labelled 7 or the SFP+ port labelled 8 may be used to connect the Multi-Stack Controller 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 only 1 and 10 Gigabit

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



Connecting both ports 7 & 8 at the same time will create a loop and will cause interference with the operation of the external network.

No connection should be made to the IPMI port, unless directed by Nuvation Energy.

Refer to the network port connection map [Table 1](#).

Below is a diagram of the installation of the Multi-Stack Controller with the Stack Switchgear. In case the external controller does not support 1 Gbps (shown below), and only supports 10/100 Mbps, an Ethernet switch must be added.

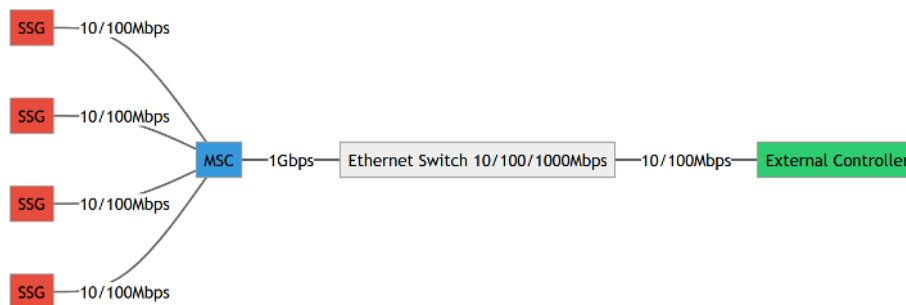


Figure 8. Multi-Stack Controller recommended installation

4.2.4. Step 3: Verify Grounding

The Multi-Stack Controller must be mounted to an Earth bonded metal structure to maintain a reliable ground. This references all components internal to the Multi-Stack Controller to earth ground, as the negative input of the DC power connector is also connected to the chassis. Earth ground is also passed along to shielded connectors (e.g. Ethernet and USB).



The external supply has its negative input connected to earth ground through the Multi-Stack Controller module's chassis.

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 stack-level *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.

4.3. Multi-Stack Controller First Power-Up

4.3.1. Connect Power

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 (i.e. black start).

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

[Table 2](#) shows the specifications of the 12V power supply that can be ordered with the Multi-Stack Controller. If using a different 12V power source, the supply must meet the power requirements listed in [Appendix A](#).

Table 2. 12 V Power Supply Specifications

Symbol	Parameter	Min	Typical	Max	Units
V_{input_AC}	Input Voltage AC	90		264	V AC
f_{input_AC}	Input Frequency	47	50/60	63	Hz
I_{input_AC}	Input Current AC			2	A AC
V_{output_DC}	Output Voltage DC		12		V DC
I_{output_DC}	Output Current DC			12.5	A DC
P_{output}	Output Power			150	W

Powering up the system

Verify that all the mechanical and electrical installation steps are completed and the Multi-Stack Controller is connected to the Stack Switchgear units, network, and power.

When ready to power on the Multi-Stack Controller, connect the DC power connector and then enable AC power. The Multi-Stack Controller turns on automatically when power is applied; however, following a shutdown, the power button can be used to manually turn on the Multi-Stack Controller as an alternative method to simply power-cycling the device.

The Multi-Stack Controller 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 be accessible shortly after this chime.

To shutdown the system, momentarily press the power button to initiate a graceful shutdown of the Multi-Stack Controller. A graceful shutdown is always recommended before unplugging the power supply.



The Multi-Stack Controller initiates a factory restore after 10 sequential unsuccessful boot sequences. To avoid this situation, ensure that the unit is fully powered up before power cycling.

In the event the unit has initialized a factory restore, please contact support@nuvationenergy.com to bring the unit back to a functional state.

4.3.2. Status LEDs

When the Multi-Stack Controller is powered up, its status LEDs provide indication of the functional status of the module and its interfaces. The Operator Interface provides additional information.

The Power LED indicates the status of the Multi-Stack Controller.



Figure 9. Multi-Stack Controller Power LED

Table 3. Power LED Description

LED	Colour	Status
Power LED	Solid Blue	Multi-Stack Controller State: Operational
	Solid Teal	Multi-Stack Controller State: Reading/Writing to the Internal Storage Media
	Solid Red	Multi-Stack Controller State: Overheating or Critical Hardware Fault.
	Flashing Red	Multi-Stack Controller State: Hardware Fault

The Port LEDs indicate the status and speed of each interface.



Figure 10. Multi-Stack Controller Port LEDs

Table 4. Port LEDs Description

LED	Colour	Status
LAN1 - LAN4 Activity (A1 - A4)	Flashing Orange	LAN# State: Active
LAN1 - LAN4 Link (L1 - L4)	Solid Green	LAN# Speed: 10/100 Mbps
	Solid Orange	LAN# Speed: 1000 Mbps

LED	Colour	Status
LAN5 & LAN7 Activity (A5 & A7)	Flashing Orange	LAN# State: Active
LAN5 & LAN7 Link (L5 & L7)	Solid Orange	LAN# Speed: 1 Gbps
	Solid Green	LAN# Speed: 10 Gbps
LAN6 & LAN8 Activity (A6 & A8)	Flashing Green	LAN# State: Active
LAN6 & LAN8 Link (L6 & A8)	Solid Orange	LAN# Speed: 1 Gbps
	Solid Green	LAN# Speed: 10 Gbps
IPMI Activity (A0)	Flashing Orange	IPMI State: Active
IPMI Link (L0)	Solid Green	IPMI Speed: 10/100 Mbps
	Solid Orange	IPMI Speed: 1000 Mbps

5. Using the Multi-Stack Operator Interface

5.1. Access the Multi-Stack Operator Interface

The Multi-Stack Operator Interface can be accessed from any computer/tablet with the latest Firefox or Chrome web browser.

5.1.1. External Computer Requirements

An external computer, like a laptop or a PC, is required to perform the setup steps. Ensure the following 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 Multi-Stack Controller.



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 5. 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 Multi-Stack Controller.



Look for this MAC address in the DHCP server to determine which IP address was assigned to the Multi-Stack Controller and navigate to 'http://<ip-address>' from a compatible web browser rather than the mDNS URL http://ncontroller-<serial_number>.local.

5.1.2. Launch Multi-Stack Operator Interface

Navigate to http://ncontroller-<serial_number>.local from a compatible computer (see [Section 5.1.1](#)). Replace <serial number> with the Multi-Stack Controller 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.

5.2. The Status Banner

The banner at the top of the screen is used to indicate high level changes in system status. During typical operation nothing is displayed and this indicates the Multi-Stack Operator Interface is communicating with the BMS and the BMS is fully operational with no major diagnostics problems.

5.2.1. Communication Loss

When the Multi-Stack Operator Interface can no longer communicate with the battery management system, a communication lost banner is displayed at the top of the display. It will provide the amount of time since disconnected and updates each second.



Communication to BMS lost: Data last updated 4 seconds ago

Figure 11. Multi-Stack Operator Interface Communication lost indicator

5.3. 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.

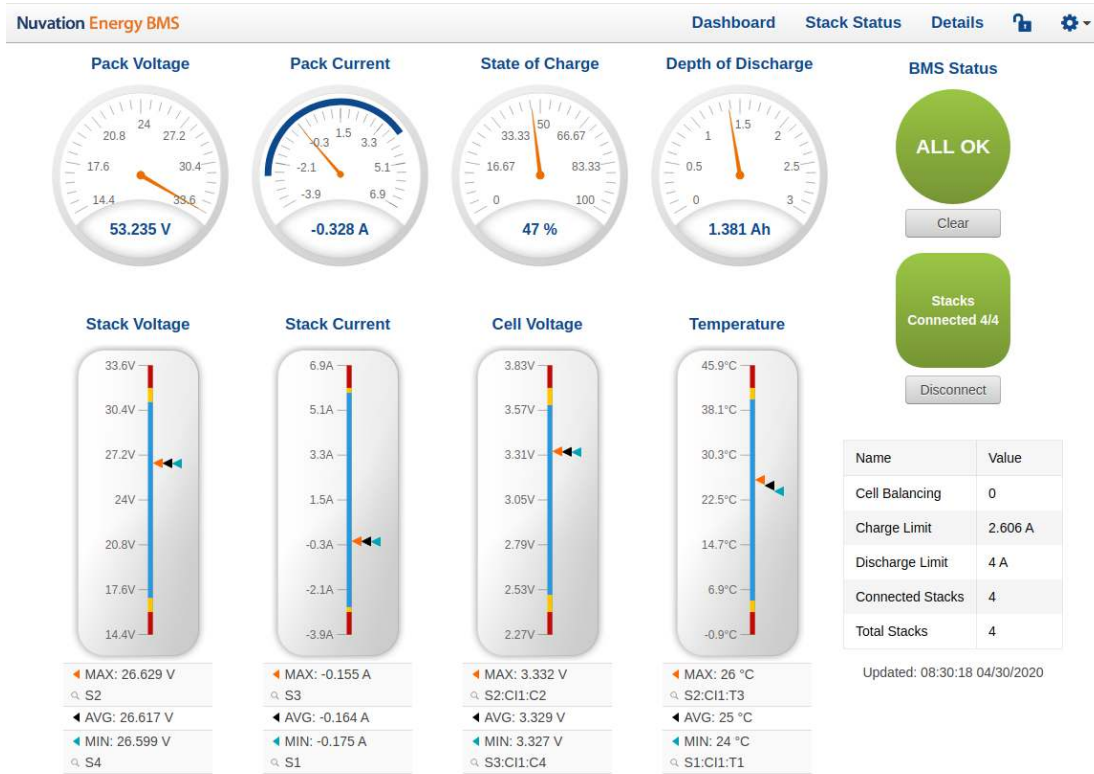


Figure 12. Nuvation Energy BMS Operator Interface Dashboard screenshot

5.3.1. 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.



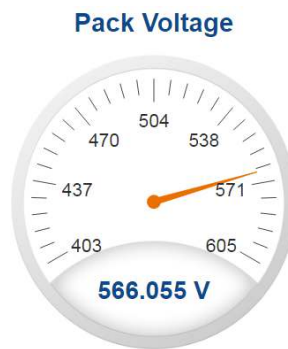
A Fault indicates the state of the battery system has been detected outside of its safe operational range. The cause of the fault must be identified and a corrective action must be performed. For instance, if the fault is a cell voltage measurement has become too low, the cell maintenance manual must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

5.3.2. Pack Voltage

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

If no stacks are connected, a value of 0 V is displayed.



5.3.3. 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.

If no stacks are connected, a value of 0 A is displayed.



5.3.4. State-of-Charge

The State-of-Charge radial gauge shows the battery stack's State-of-Charge, which is an average State-of-Charge 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%.

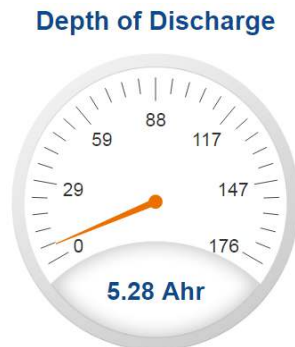
If no stacks are connected, a value of 0% is displayed.



5.3.5. 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% State-of-Charge.

If no stacks are connected, a value of 0 Ah is displayed.



5.3.6. Stack Voltage

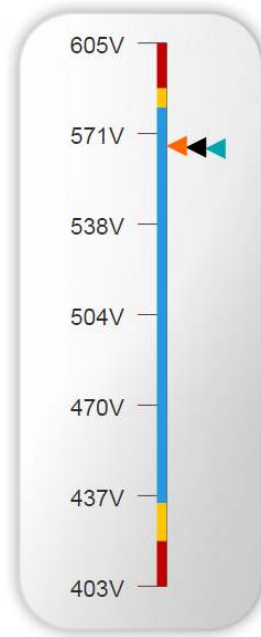
The stack voltage bar gauge shows the maximum, minimum, and average stack voltage measurements for all enabled stacks within the battery pack.

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

5.3.7. Stack Current

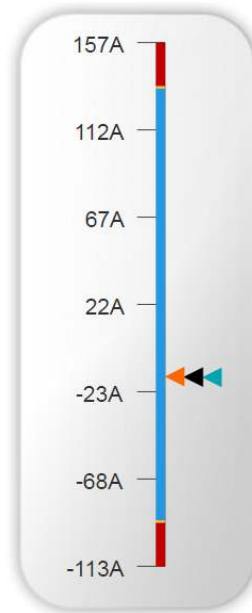
The stack current bar gauge shows the maximum, minimum, and average stack current measurements for all enabled stacks within the battery pack.

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

5.3.8. Cell Voltage

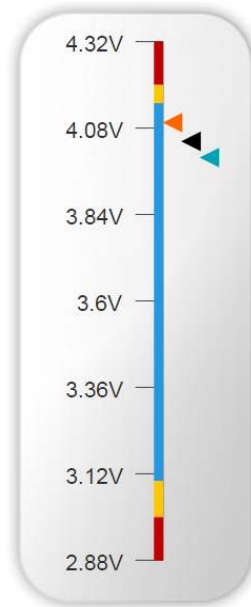
The cell voltage bar gauge shows the maximum, minimum, and average cell voltage measurements within the pack. Only data from enabled stacks is aggregated.

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

5.3.9. Temperature

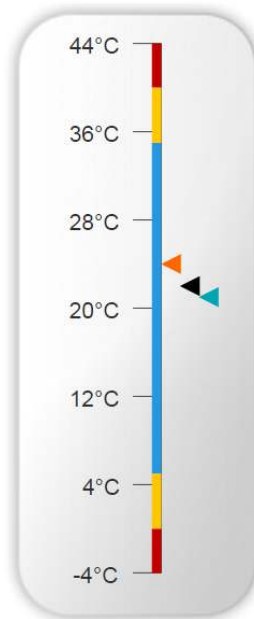
The temperature bar gauge shows the maximum, minimum, and average cell temperature measurements within the pack. Only data from enabled stacks is aggregated.

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

5.3.10. Nuvation Energy BMS Status

Nuvation Energy BMS status information contains information on the overall safety status of the battery stacks, 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.

5.3.10.1. Operation Status

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



Figure 13. 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 the [Section 5.4](#) tab where the overall fault status as well as the fault status of each stack is displayed.

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

5.3.10.2. Connection State

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



Figure 14. 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.

5.3.10.3. 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
Cell Balancing	0
Charge Limit	7 A
Discharge Limit	8 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.

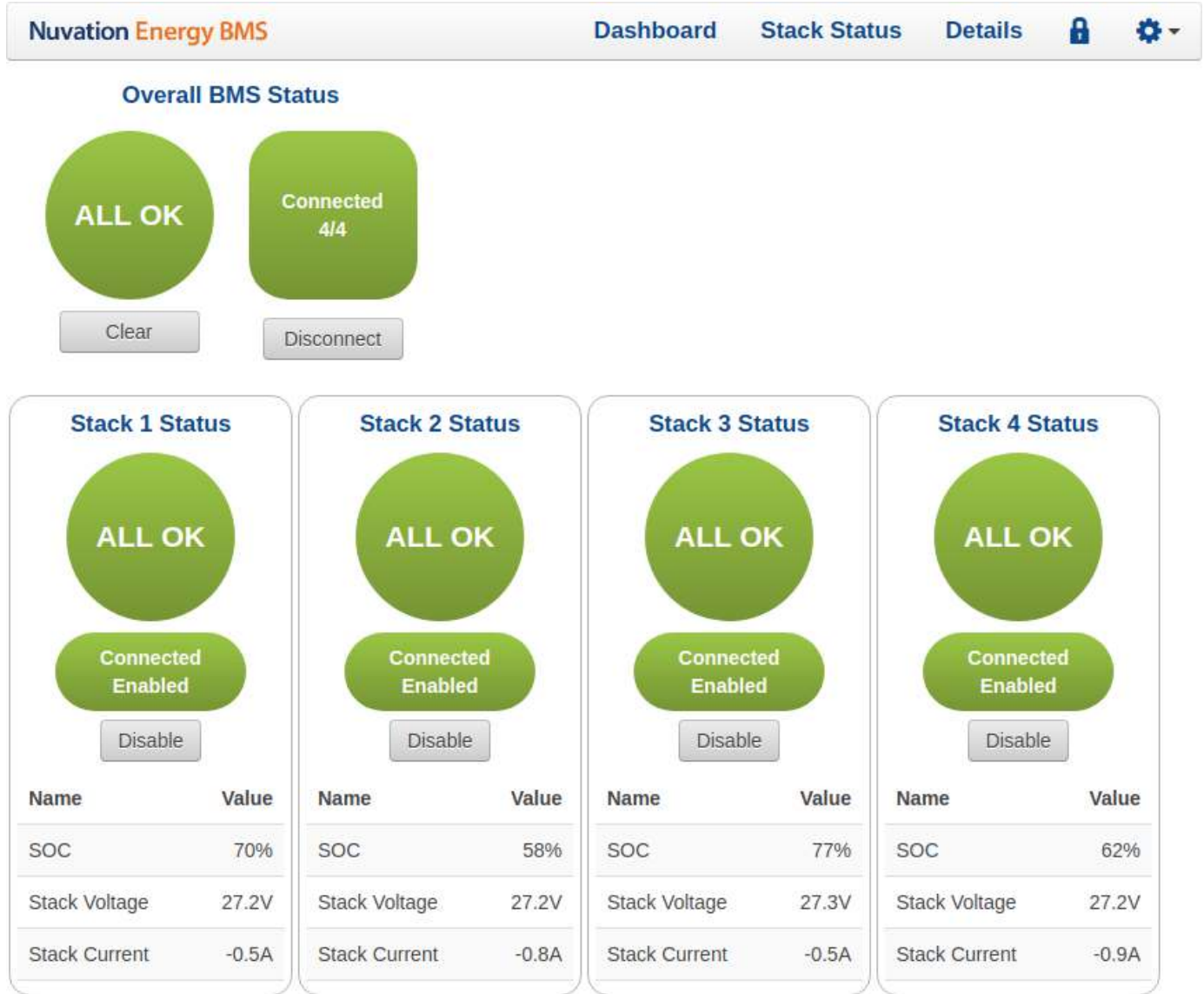
5.3.10.4. Last Update

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.

If the communication with a Nuvation Energy BMS is lost, a notification banner appears at the top of the display screen. The information shown on the Dashboard represents the last data received and is no longer recent. Refer to [Section 5.2.1](#) for more details.

5.4. 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 15. 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

5.4.1. 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 5.3.10](#). The BMS statuses of the pack or any stack is clickable to navigate to the [Safety Accordion](#) for details of all warnings and faults for the pack or a specific stack. 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.

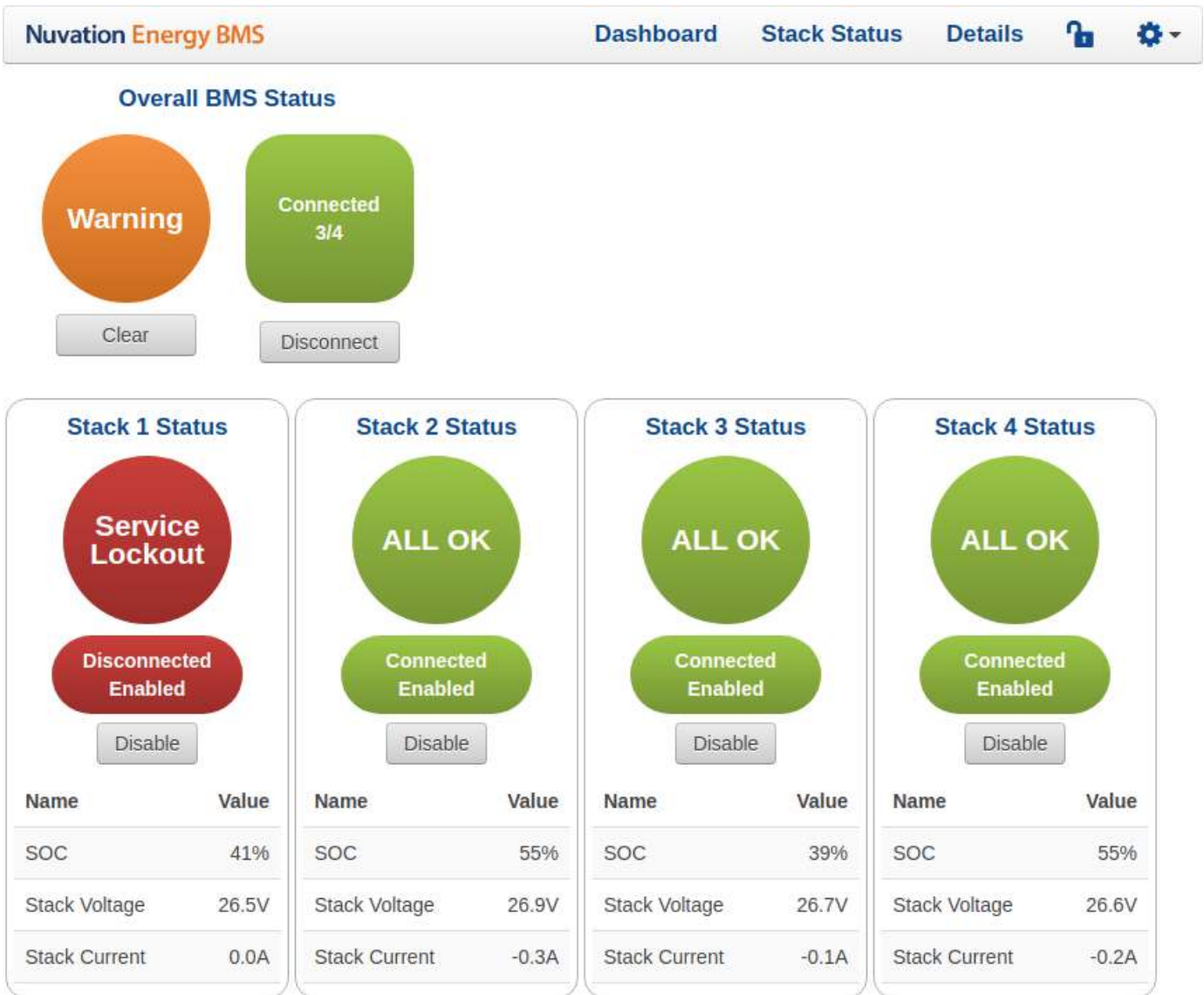
5.4.2. Stack Enable and Connection

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. Please contact support@nuvationenergy.com for further details.
2. If pack manual connection is configured, a connect button will appear on the stack status. Please contact support@nuvationenergy.com for further details.

5.4.3. Stack Service Lockout

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

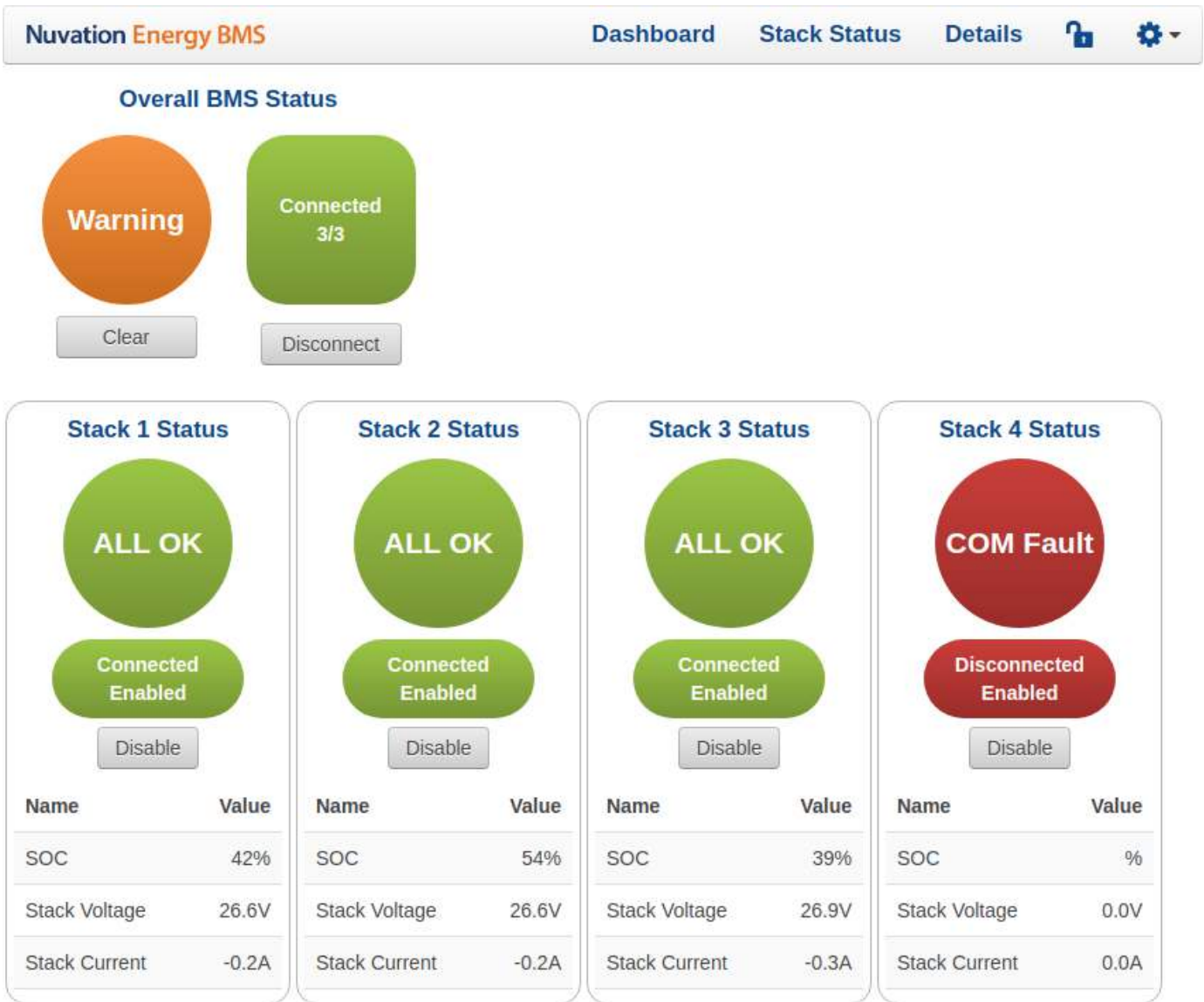


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Figure 16. Stack in Service Lockout

5.4.4. Stack COM Fault

If there is a communication failure with a stack (i.e. the Multi-Stack Controller loses communication with the stack), the stack status will be updated as shown below.



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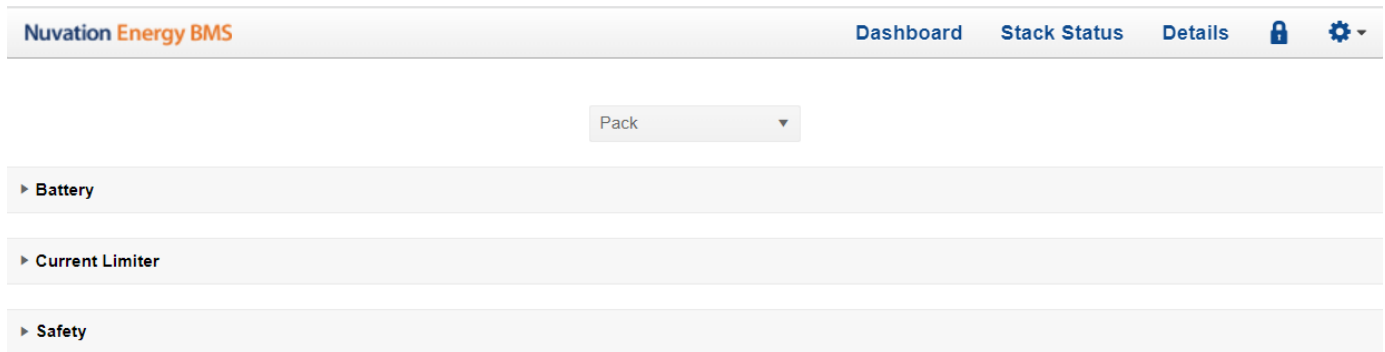
/gbc

Figure 17. Stack with COM Fault

5.5. 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 18. Nuvation Energy BMS Operator Interface Details tab screenshot

5.5.1. 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.

5.5.2. 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.

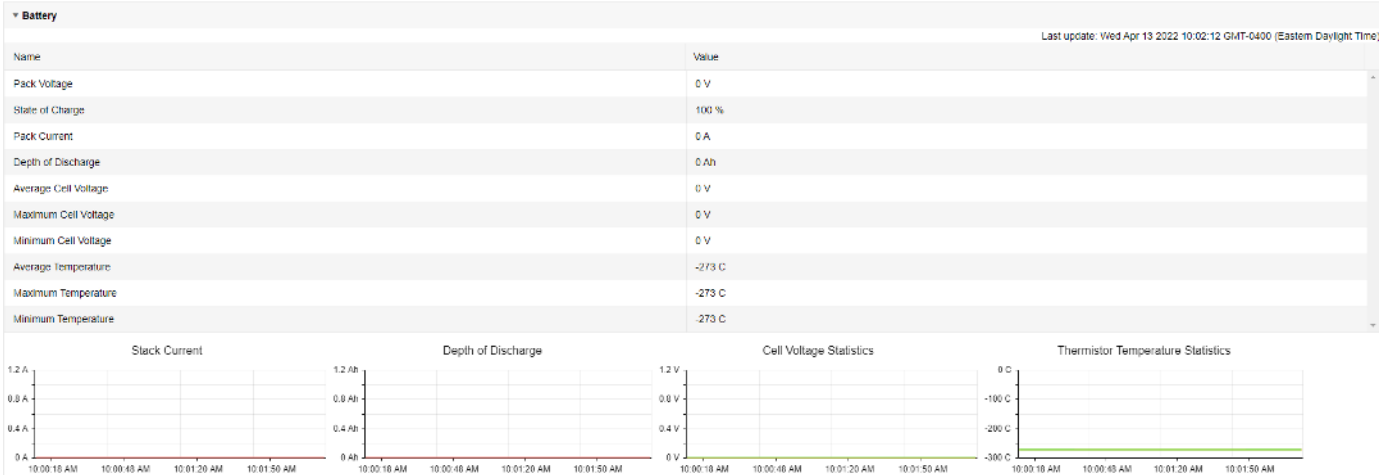


Figure 19. Battery accordion in Details Tab

5.5.3. Current Limiter

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



Figure 20. Current Limiter accordion in Details Tab

5.5.4. 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.

Some faults and warnings at the pack level are due to stack level faults and warnings. To see a summary of the faults and warnings for all the stacks, navigate to the [Stack Status Tab](#).

▼ 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

Clear Faults and Warnings

Figure 21. 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.

5.6. 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 following options are available:

- Registers
- Service
- Connection
- Unlock
- About

5.6.1. Registers

This menu option navigates to the Register Browser. This screen allows you to read and write to registers.

When the Operator Interface is locked, the Register Browser is in a view-only mode, restricting the editing of registers.



It is possible to edit registers on multiple stacks using this interface, which can result in unintended behavior. It is recommended to only edit registers that start with pack_ or gbc_ using this interface. Use the stack-level Operator Interface to make edits to a connected stack.

Component Name	Description	Base Address	Instance Count per Stack
+ sc_clock	Clocking Component	0x29000	1

Figure 22. Register Browser

5.6.2. Service

This screen allows you to import and export a configuration file.

5.6.2.1. Importing a Configuration File



This is a restricted option requiring the Operator Interface to be unlocked to access this option.

This menu option allows you to import a configuration file.

Please contact support@nuvationenergy.com for more instructions on generating configuration files.

5.6.2.2. Exporting a Configuration File



Nuvation Energy BMS does not 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

5.6.3. 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 must not be used for changing the IP address. You may only use this screen to change the timeout.


5.6.4. 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 Multi-Stack Controller serial number - this can be found on a label on the exterior of the product.

Data will be automatically logged and aggregated for each minute into "Minimum", "Maximum", and "Average" values over each minute interval. All logged data is numeric, including boolean values, which are represented as 'true = 1' and 'false = 0'.

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	Data Date	Average	Minimum	Maximum
2022-10-02 18:19:20	Available Capacity (kWh)		0	0	0
2022-10-02 18:19:20	Capacity (kWh)		2147484	2147484	2147484
2022-10-02 18:19:20	Capacity (kWh)		0	0	0
2022-10-02 18:19:20	Cell Temperature Average (°C)		-273	-273	-273
2022-10-02 18:19:20	Cell Voltage Average (V)		0	0	0
2022-10-02 18:19:20	Cell Temperature Maximum (°C)		-273	-273	-273
2022-10-02 18:19:20	Cell Voltage Maximum (V)		0	0	0
2022-10-02 18:19:20	Cell Temperature Minimum (°C)		-273	-273	-273
2022-10-02 18:19:20	Cell Voltage Minimum (V)		0	0	0
2022-10-02 18:19:20	Charge Limit (A)		0	0	0
2022-10-02 18:19:20	Connected on State		0	0	0
2022-10-02 18:19:20	Current (A)		0	0	0
2022-10-02 18:19:20	Discharge Limit (A)		0	0	0
2022-10-02 18:19:20	Depth of Discharge (%)		0	0	0
2022-10-02 18:19:20	Power (W)		1	1	1
2022-10-02 18:19:20	Power (kW)		0	0	0
2022-10-02 18:19:20	State of Charge (%)		100	100	100
2022-10-02 18:19:20	Voltage (V)		0	0	0
2022-10-02 18:19:20	Warning		1	1	1
2022-10-02 18:19:20	Available Capacity (kWh)		0	0	0
2022-10-02 18:19:20	Capacity (kWh)		2147484	2147484	2147484
2022-10-02 18:19:20	Capacity (kWh)		0	0	0
2022-10-02 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.

🖨️ 🕒 Last 6 hours ^

Absolute time range

From

To

Apply time range

It looks like you haven't used this timer picker before. As soon as you enter some time intervals, recently used intervals will appear here. [Read the documentation](#) to find out more about how to enter custom time ranges.

Relative time ranges

- Last 5 minutes
- Last 15 minutes
- Last 30 minutes
- Last 1 hour
- Last 3 hours
- Last 6 hours ✓
- Last 12 hours
- Last 24 hours
- Last 2 days
- Last 7 days

Browser Time: Canada, EDT UTC-04:00 Change time zone

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

5.6.4.1. 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)

5.6.4.2. 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:

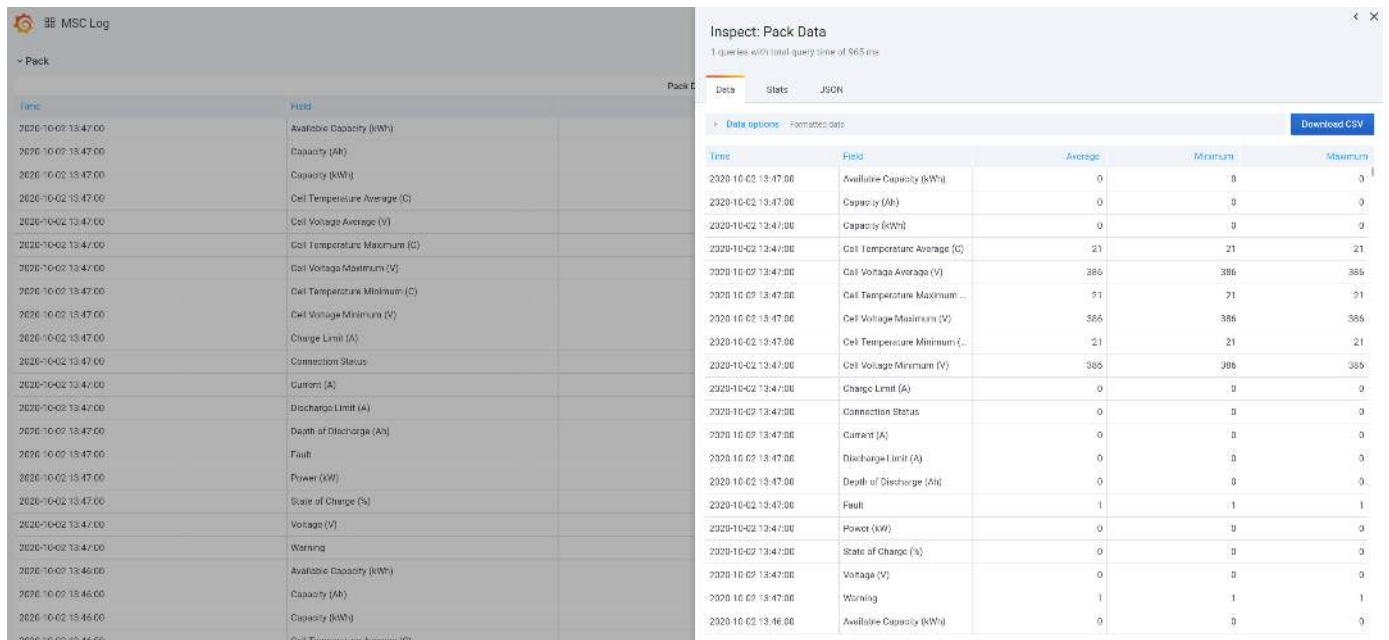
- Voltage (V)
- Current (A)
- Power (kW)
- Charge Limit (A)
- Discharge Limit (A)
- State of Charge (%)
- Depth of Discharge (Ah)
- Connection Status
- Fault
- Warning
- Available Capacity (kWh)
- Capacity (Ah)
- Capacity (kWh)
- Cell Temperature Average (C)
- Cell Temperature Maximum (C)
- Cell Temperature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

5.6.4.3. 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 ▾	Average	
		View  v	0	
		Share  p s	0	
		Inspect  i >	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:



The screenshot shows a software interface with a main table on the left and a right-hand panel titled "Inspect: Pack Data". The right panel has tabs for "Data", "Stats", and "JSON", with "Data" selected. Below the tabs are "Data options" and "Formatted data" sections, and a "Download CSV" button. The main table lists various battery metrics over time, such as Available Capacity, Capacity, Cell Temperature, Cell Voltage, and Charge Limit.

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
```

5.6.5. Locking and Unlocking

The Operator Interface can be locked to prevent accidental or unintentional changes that could have serious impacts on the system. To further secure the system, a password can be set to ensure only authorized individuals can access these critical sections of the Operator Interface

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



Figure 23. Operator Interface Locked indicator



Figure 24. Operator Interface Unlocked indicator

5.6.5.1. Lock the Operator Interface

To lock the Operator Interface, simply click the Unlocked indicator or 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.

5.6.5.2. Unlock the Operator Interface

To Unlock the Operator Interface, simply click the Locked indicator or bring up the settings menu and select Unlock. If a password has been set, the correct password will need to be entered to complete the unlocking process.

5.6.6. About

This screen displays version details for the underlying software for your Nuvation Energy BMS. The name and number of the current software release are 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.

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Figure 25. Sample About screen

6. Using the Platform Interface

6.1. Overview

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

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

- Functions
- Networks
- Backups
- Settings

6.2. Functions

The Functions page is responsible for installing and upgrading application software.



It is highly recommended to only install/upgrade software under guidance from Nuvation Energy. Incorrectly installing/upgrading software could render the Multi-Stack Controller inoperable.

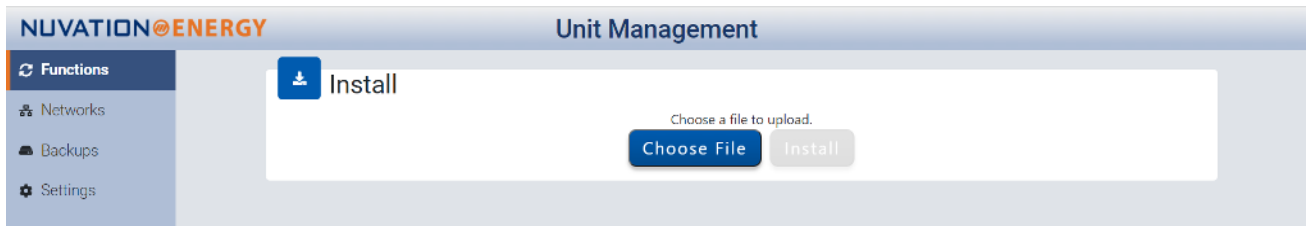


Figure 26. Nuvation Energy Platform Interface Function

6.2.1. 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.

6.2.2. Upgrading a Function

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

6.3. Networks

The networks page shows the current network status of the Multi-Stack Controller and allows for configuration of the network interfaces.

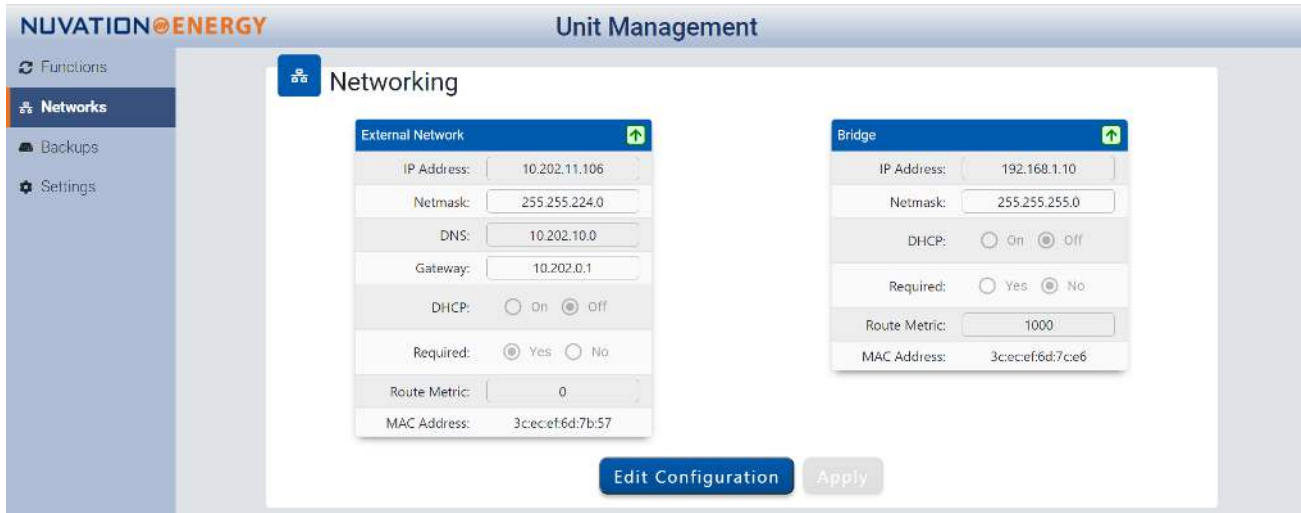


Figure 27. Nuvation Energy Platform Interface Networks

6.3.1. Networking

There are two configuration cards on this page:

- External Network: Controls the External Ethernet network on the Multi-Stack Controller
- Bridge: Controls the Internal Ethernet network on the Multi-Stack Controller

Each card shows the following information:

- IP Address: The current IP of the Multi-Stack Controller 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 Multi-Stack Controller 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 Multi-Stack Controller 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 Network, 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



To communicate with the Multi-Stack Controller while the gateway is set to 0.0.0.0, the Multi-Stack Controller must be on the same subnet as the gateway.

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 Multi-Stack Controller 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 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.

6.4. Backups

The Backups page is responsible for creating and restoring a state for the Multi-Stack Controller. That state includes configured settings, installed functions, and all logged data at the time of the backup creation.

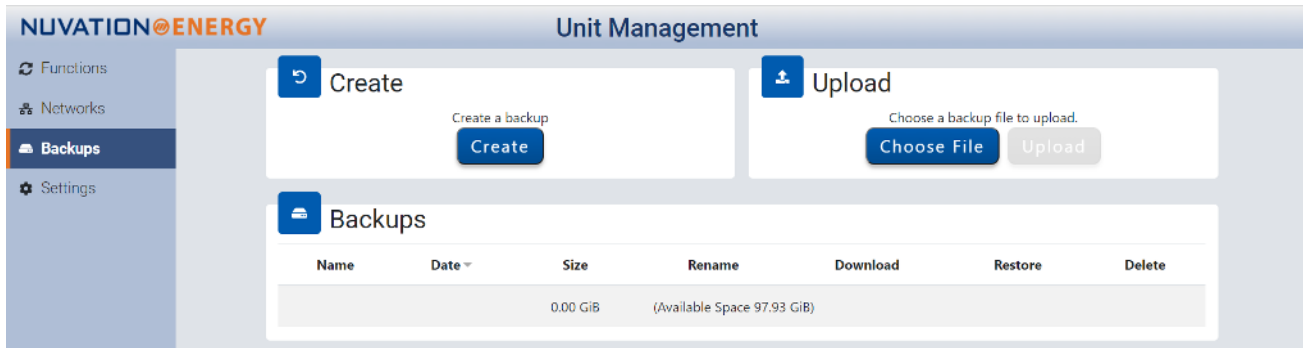


Figure 28. Nuvation Energy Platform Interface Backups

6.4.1. Create a System Backup

To create a backup of the current state of the system, click on "Create". After a few minutes, a new backup file will be displayed under Backups with a name, creation date and size. To rename the file, click on "Rename" and input the name when prompted.

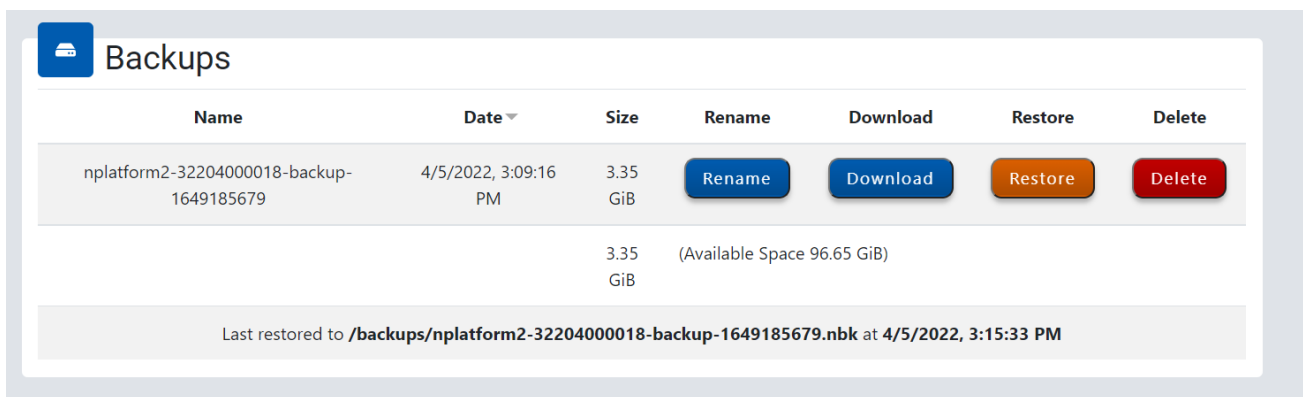


Figure 29. Nuvation Energy Platform Interface Backup file

A copy of the backup file can be downloaded on a [compatible computer](#) by clicking the "Download" button. At anytime, a backup file can be deleted by clicking the "Delete" button.

6.4.2. Upload a backup file

To upload an existing backup file, click on "Choose file" and select a .nbk file, then click the "Upload" button.



These files are relatively large and might take time to upload and download to the system.

6.4.3. Backup Restore

To restore the Multi-Stack Controller to a previous state, click the "Restore" button that corresponds to the .nbk file with the desired state.



Restoring will delete all current data on the device. Other backups will not be deleted.

6.5. Settings

The settings page is responsible for the following:

- Upgrading the Multi-Stack Controller
- Factory Resetting the Multi-Stack Controller
- Rebooting and Powering off the Multi-Stack Controller
- Setting Date, Time, and Timezone

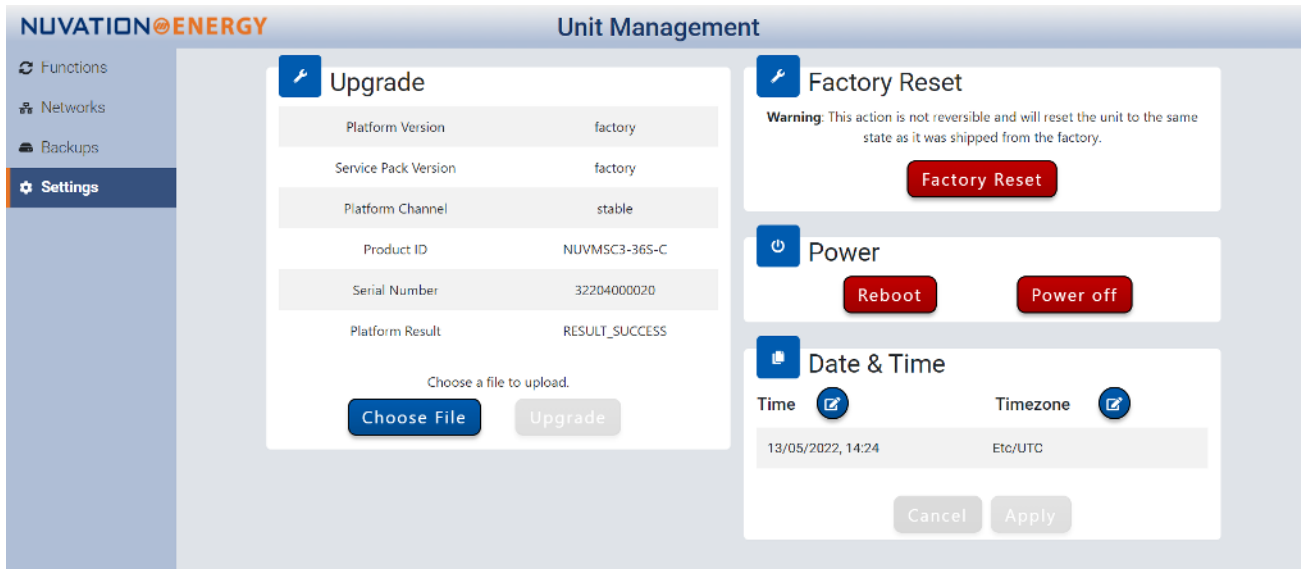


Figure 30. Nuvation Energy Platform Interface Settings

6.5.1. Upgrading the Multi-Stack Controller



It is highly recommended to only upgrade software under guidance from Nuvation Energy. Incorrectly upgrading software could render the Multi-Stack Controller inoperable.

To upgrade the Multi-Stack Controller, click the "Choose File" button to select a file with an extension of .nup or .nosp. Then, click "Upgrade" to upgrade the unit.



It is always recommended to create a backup before upgrading.



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



Downgrading the Multi-Stack Controller is not an accessible feature. To revert to a previous version, please use the backup/restore feature. Please contact support@nuvationenergy.com for assistance with downgrading.

6.5.2. Factory Reset the System



It is highly recommended to only factory reset the unit under guidance from Nuvation Energy. This action is not reversible and will reset the unit to the same state as it was shipped from the factory.

To reset the Multi-Stack Controller, click the "Factory Reset" button.



The reset process may take a few minutes, so please wait for it to complete. The page will automatically refresh once the reset is complete. However, the process will reset all network settings, so the Multi-Stack Controller may no longer be reachable without adjusting the computer's network settings.

6.5.3. Rebooting and Powering off the System

To reboot the Multi-Stack Controller, click on the "Reboot" button and wait until the unit has been rebooted. To power off the Multi-Stack Controller, click on the "Power off" button. Following a shut down, the power button can be used to restart the Multi-Stack Controller.



The UI will not be functional while the Multi-Stack Controller is rebooting.

6.5.4. 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.

7. Communication Protocols

7.1. 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).

The specifications for these models are available for download at <https://www.nuvationenergy.com/technical-resources>.



MESA Draft 3 is currently implemented on Nuvation Energy BMS.

7.1.1. 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. All register data is transmitted as big endian (most significant byte first).

Additionally, the Multi-Stack Controller supports as many as 16 read-only Modbus TCP connections on port 11503.

7.1.2. 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>.

7.1.2.1. 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.

7.1.2.2. 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.

7.1.2.3. 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.

7.1.2.4. 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.

7.1.2.5. End Model

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

7.1.3. 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.

7.1.3.1. 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.

7.1.3.2. 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 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.

7.1.3.3. 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	BatReqPCSSt	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

7.1.3.4. 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.

7.1.4. 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 Multi-Stack Controller provides a secondary port (11503) for read-only Modbus TCP operations.

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

7.1.4.1. 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 the battery. 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
802	Fixed	BSetOperation	40110	Commands Nuvation Energy BMS to connect/disconnect the battery

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 and its 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 the alarm will not be cleared if the alarm condition is still present.



Only BMS Faults are cleared using this point. BMS Warnings are not cleared.

Commanding the Nuvation Energy BMS stack/string 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.

7.1.4.2. 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
803	Fixed	BTotDCCur	40127	Yes	Total DC current of the battery system

Model	Block	Point Name	Address	Scale Factor	Purpose
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.

7.1.5. 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)

Polling example with BMS IP address of 192.168.1.21

```
modpoll.exe -m tcp -0 -r 40000 -c 70 192.168.1.21

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.....: 192.168.1.21, 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:

Example with BMS IP address of 192.168.1.21

```
modpoll.exe -m tcp -0 -r 40094 -c 22 192.168.1.21
```

```
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.....: 192.168.1.21, 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
```

8. External Interfaces

8.1. Ethernet

Four 10/10/1000 Mbps and two 1/10 Gbps, Cat6-rated Ethernet jacks are provided. Any Cat5e-rated or higher Ethernet cable of suitable length may be used to connect to these jacks.

Refer to the network port connection map [Table 1](#) and [Figure 7](#).

8.2. SFP+ Interfaces

Two SFP+ ports are provided. These ports can be equipped with any suitable transceiver depending on the application.

Refer to the network port connection map [Table 1](#) and [Figure 7](#).

8.3. Power Button

This button is a momentary tactile switch that powers the Multi-Stack Controller **ON** and **OFF**. Holding this button for several seconds causes a *forced shutdown*.

8.4. DC Power Connector

The DC Power connector accepts a standard locking male barrel plug (2.5 mm I.D × 5.5mm O.D, positive center, 5/16"-32 threaded nut).

The DC Power connector provides a nominal 12 V DC to the Multi-Stack Controller, but will tolerate an input voltage between 11.4 and 12.6 V DC.



The external supply has its negative input connected to earth ground through the Multi-Stack Controller's chassis.

9. Troubleshooting

9.1. 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. For faults observed at the stack level please refer to the *Troubleshooting* section in the Nuvation Energy High-Voltage BMS: Product Manual.

9.1.1. Ethernet Connection

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

`gbc_fault_eth_conn`

- The Multi-Stack Controller could not communicate with one or more installed stacks

This fault is usually triggered due to:

- Multi-Stack Controller network configuration issues. Please contact support@nuvationenergy.com for details.
- IP networking configuration is different between the Multi-Stack Controller and the stack-level BMS. Verify that the settings in the [Networks Page](#) in the Platform Interface are compatible with the stack-level IP register settings.
- The expected stack-level BMS:
 - Has recently power cycled
 - Has recently entered service lockout
 - Is undergoing a FW upgrade
 - Is not on the network
 - Is not receiving power

To find the stack-level BMS that has a connection fault, refer to the register `gbc_eth_bridge_status[*].is_connected`. Please contact support@nuvationenergy.com for more details.

9.1.2. Controller Heartbeat

`gbc_fault_controller_wdt`

- Fault indicating that an external controller did not provide a heartbeat update within the configured period. Please contact support@nuvationenergy.com for details of this configuration.

9.1.3. Ready Stacks

This fault represents a configurable minimum limit of how many stacks must be ready and still have the pack remain connected and manage the battery power. Please contact support@nuvationenergy.com for details of this operation and configuration.

`pack_fault_ready_stacks`

- Fault indicating that the minimum number of ready stacks for the pack has not been satisfied

Refer the Stack Status page ([Section 5.4](#)) on the Operator Interface to observe which stacks have been either disabled, are in Service Lockout, or have faulted.

9.1.4. Firmware Mismatch

`gbc_fault_fw_mismatch`

- Fault indicating that the difference between the Multi-Stack Controller 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`.

9.2. Lost/Forgotten IP Address

The Multi-Stack Controller is resolvable using mDNS via a compatible computer. Refer to [Section 5.1.1](#) 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.

9.2.1. 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 Multi-Stack Controller
3. Start a Wireshark capture on the network interface connected to the Multi-Stack Controller
4. In the 'filter' field, enter in arp.isgratuitous and press enter
5. Either reboot the Multi-Stack Controller, 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 Multi-Stack Controller
7. Once that is complete, update the PC network settings to match the Multi-Stack Controller and connect the Operator Interface.

9.2.2. 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 Multi-Stack Controller
3. Run `sudo netdiscover -i <interface> -p` where <interface> is the network interface connected to the Multi-Stack Controller
4. Either reboot the Multi-Stack Controller, 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 Multi-Stack Controller and connect the Operator Interface.



In the event the IP address cannot be discovered, a factory reset operation must be carried out to restore the BMS to its default IP configuration.

Appendix A: Operating Limits



Exceeding the maximum ratings will damage the module.

Electrical Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Power Specifications						
+Vin	Input Voltage	-	11.4	12	12.6	V DC
	Input Current	+Vin = 12 V DC	-	7.5	12.5	A DC
Ethernet Specifications						
ETH _{RJ45: 1-4}	Ethernet Connection Speed	10BASE-T 100BASE-TX 1000BASE-T	10	-	1000	Mb/s
ETH _{RJ45: 5,7}	Ethernet Connection Speed	1GBASE-T 10GBASE-T	1	-	10	Gb/s
ETH _{Twisted_Pair: 1-4}	Ethernet Cable Rating	-	Cat 5e	-	Cat 6	
ETH _{Twisted_Pair: 5,7}	Ethernet Cable Rating	-	Cat 6	-	-	
ETH _{SFP+: 6,8}	SFP+ Port Speed	-	1	-	10	Gb/s
ETH_Connector	Ethernet jack rating	-	-	Cat6	-	

Environmental Conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Thermal Specifications						
T _a	Operating Temperature	-	5	25	40	°C
	Storage Temperature	-	-40	25	70	°C
Humidity Specifications						
RH	Operational RH	Non-Condensing	8	-	90	%
	Storage RH	Non-Condensing	5	-	95	%
Shock and Vibration Specifications						
Vertical	Vertical Shock/Vibration	-	-	-	10	m/s ²
Longitudinal	Longitudinal Shock/Vibration	-	-	-	10	m/s ²
Transverse	Transverse Shock/Vibration	-	-	-	10	m/s ²
Pulse Vibration	On each axis	-	-	-	245	m/s ²

If the Multi-Stack Controller is stored at temperatures below 5°C, it must be warmed up in a 20°C or warmer environment for 45 minutes before applying power. Powering the unit below 5°C may impact data logging or cause other unexpected behaviour.

Standards and Certifications

The Multi-Stack Controller has been designed to meet the requirements of SAE J2464 (shock) and SAE J2380 (random vibration).

The following directives and standards apply to the Multi-Stack Controller:

- EMC/EMI: 2014/30/EU (EMC Directive)
- Electromagnetic Compatibility Regulations 2016
- FCC Part 15 Subpart B
- ICES-003
- VCCI 32-1
- AS/NZS CISPR 32
- BS/EN55032
- BS/EN55035
- BS/EN 61000-3-2
- BS/EN 61000-3-3
- BS/EN 61000-4-2
- BS/EN 61000-4-3
- BS/EN 61000-4-4
- BS/EN 61000-4-5
- BS/EN 61000-4-6
- BS/EN 61000-4-8
- BS/EN 61000-4-11
- Green Environment: 2011/65/EU (RoHS Directive)
- EC 1907/2006 (REACH)
- 2012/19/EU (WEEE Directive)
- Product Safety: 2014/35/EU (LVD Directive)
- Electrical Equipment (Safety) Regulations 2016
- UL/CSA 62368-1 (USA and Canada)
- IEC 62368-1

Appendix B: Ordering Information

This section provides orderable part numbers for Nuvation Energy’s offerings of Multi-Stack Controller modules and related accessories.

Product Part Number	Product Name
NUVMSC3-04S-C	Multi-Stack Controller, Compact, up to 4 stacks
NUVMSC3-08S-C	Multi-Stack Controller, Compact, up to 8 stacks
NUVMSC3-12S-C	Multi-Stack Controller, Compact, up to 12 stacks
NUVMSC3-16S-C	Multi-Stack Controller, Compact, up to 16 stacks
NUVMSC3-20S-C	Multi-Stack Controller, Compact, up to 20 stacks
NUVMSC3-24S-C	Multi-Stack Controller, Compact, up to 24 stacks
NUVMSC3-28S-C	Multi-Stack Controller, Compact, up to 28 stacks
NUVMSC3-32S-C	Multi-Stack Controller, Compact, up to 32 stacks
NUVMSC3-36S-C	Multi-Stack Controller, Compact, up to 36 stacks

Power Adapters

The Multi-Stack Controller does not ship with a power adapter by default. The following power adapter options are available at no extra cost.

Product Part Number	Product Name
NUVP-NC3C-PA-N	NEMA 5-15P 150W 12V Lockable DC Power Adapter
NUVP-NC3C-PA-C	CEE 7/7 150W 12V Lockable DC Power Adapter

Contact Nuvation Energy to order a power adapter not in the above list.

Appendix C: 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.

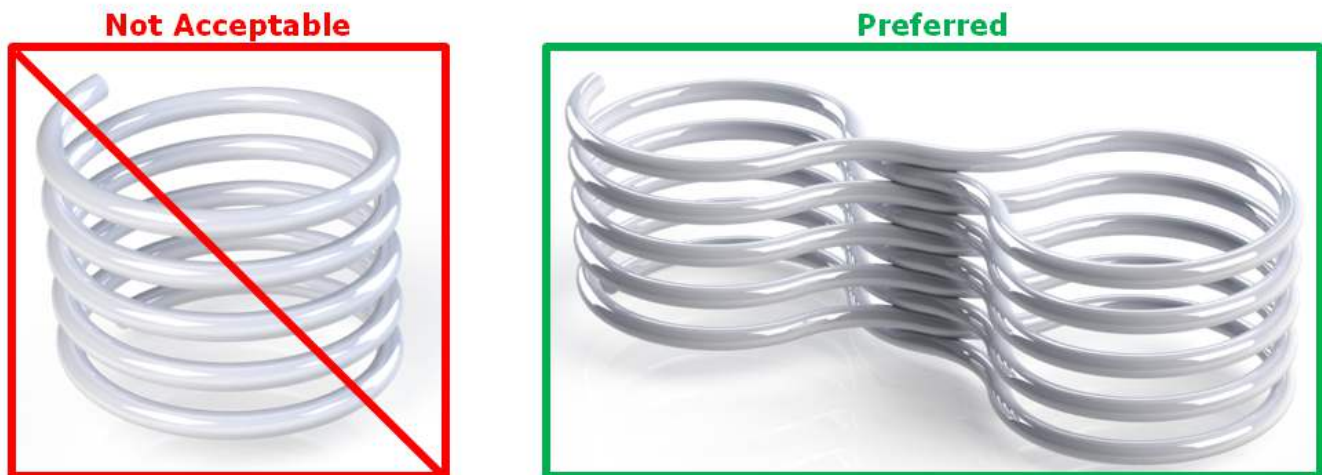


Figure 31. Excess Cable Management Examples

From time to time Nuvation Energy will make updates to products 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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